REPORT

Detailed Design
Tailings Storage Facility and Waste Rock Dump
Grassy Mountain Mine

Malheur County, Oregon

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The following Design Report has been prepared by the staff of Golder Associates Inc. under the professional supervision of the engineers whose signatures appear herein.

The findings, design, and recommendations presented in this Design Report are within the scope of services requested by Calico Resources USA Corp. and have been prepared in accordance with generally accepted profession engineering principles and practices.

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Executive Summary

This report presents the geotechnical field investigations, laboratory testing, detailed calculations, technical analyses, design drawings, technical specifications, construction quality assurance plan, geotechnical monitoring plan, and dam breach assessment to support design of the Grassy Mountain Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) at the Grassy Mountain Mine.

The TSF has been designed using downstream construction concepts to allow for the installation of a continuous lining system within the TSF. The TSF has a maximum embankment height of 84 feet at the deepest point along the North embankment and provides approximately 3.67 million tons of tailings storage.

The design incorporates the following design components:

- Phased construction of the TSF embankments and basin in a total of three stages
- Dual containment geosynthetic lining, leak detection, leakage collection recovery systems within the TSF basin, on the TSF embankments, TSF underdrain channel, TSF reclaim pond, WRD pad, and process water piping systems
- Gravity underdrain collection piping systems within the TSF impoundment and WRD pad
- Process fluid management systems
- Permanent and temporary stormwater diversion structures
- Geotechnical monitoring instrumentation

To support the complex geotechnical analyses required for the design, Golder conducted three comprehensive field investigations which included borings, test pits, and cone penetrometer testing within the TSF, WRD, and below the TSF embankments. Field measurements and laboratory tests results on samples obtained during the investigations were used to determine material properties and behavior of the materials when subject to seismic loading.

The seismic hazard evaluation provides earthquake ground motions using the latest ground motion prediction equations and latest probabilistic seismic hazard model and takes advantage of improved site-to-source distance estimates from accurate fault maps provided by the United States Geological Survey.

Static and pseudo-static stability analyses evaluate the geotechnical stability of the embankment under both static and simulated earthquake conditions. Settlement analyses assess post-settlement grades of the gravity underdrain system and dam crest elevation.

The design presented herein provides a safe and stable dam in accordance with the guidelines set forth by the Oregon Administrative Rules Division 20 as regulated by the State of Oregon Water Resources Department and Division 43 as regulated by the State of Oregon Department of Environmental Quality.

This report and accompanying design drawings present the detailed design and technical analyses needed to permit, construct, and operate the Grassy Mountain Tailings Storage Facility in accordance with OAR guidelines.

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1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this report to present the construction-level detailed design of the tailings storage facility (TSF) and waste rock dump (WRD) for Calico Resources USA Corp.'s (Calico's) Grassy Mountain Project (Project) located in Malheur County in southeastern Oregon.

Calico plans to construct a lined impoundment to contain approximately 3.67 million short dry tons (M tons) of processes tailings to be generated by milling operations. The TSF is designed to be constructed in a total of three stages.

This report presents the design work of Stages 1 through 3 for the TSF conducted by Golder for Calico. Specifically, this report describes the results of Golder's site explorations, dam design methodology, and presents design calculations, construction drawings, technical specifications, dam breach analysis, and geotechnical monitoring plan which are appended to this design report.

- The TSF is designed as a "zero discharge" facility in accordance with the Oregon Administrative Rules (OAR) Division 43 – Chemical Mining as administered by the Department of Environmental Quality (ODEQ) and OAR Division 20 – Dam Safety as administered by the Department of Water Resources (OWRD).

1.1 Project Description

The Grassy Mountain Mine is a proposed gold mining and milling operation located approximately 20 miles south of Vale, Oregon in Malheur County as shown on the Design Drawings. Ore processing will incorporate gravity gold recovery, and leaching. The ore grind is anticipated to be 80 percent passing (P_{80}) the 110 microns. Milling operations will produce and estimated 1.8M tons of tailings with a nominal mill throughput rate of 680 dry short tons per day (tpd) Although the current life of mine estimate is for 1.8M tons, the TSF has been designed in three stages to accommodate up to 3.67M tons of tailings storage at an estimated settled dry density of 80 pounds per cubic foot (pcf).

1.2 Scope of Services

Golder has performed the following work related to the design of the TSF and WRD:

- Subsurface geotechnical investigations of the TSF foundation:
  - December 2017 – 15 geotechnical boreholes, 44 test pits and six field falling head permeability tests were conducted in boreholes
  - March 2019 – Six geotechnical boreholes
  - July 2019 – 11 cone penetration test soundings
- Geotechnical laboratory testing performed on soil samples collected from the subsurface investigations for soil classification. Laboratory testing included grain size analyses, Atterberg Limits, moisture content and density, triaxial strength testing, and consolidation testing.
- Geotechnical laboratory testing performed on pilot tailings samples to estimate post deposition characteristics of the tailings mass for settled dry density, surface slope parameters, water recover, seepage rates, soil-water characteristics, and long-term consolidation.
- Volumetric sizing of Stages 1 through 3.

- Geotechnical analyses were performed in support of the TSF and WRD design. Analyses included slope stability and settlement calculations using the final dam geometries and estimated/measures material properties.
- Hydrologic analysis of the TSF and hydraulic design of stormwater control structures.
- Hydraulic design of the TSF and WRD underdrain collection and drainage layer systems.
- Water balance of the TSF and WRD including design of the reclaim pond and return water pumping requirements.
- Dual containment system designs for the TSF basin, embankments, underdrain channel, reclaim pond, WRD pad, and pipelines to and from the mill.
- Leak detection and leakage collection recovery systems to monitor and manage potential leakage in areas where concentrated flows are expected.
- Civil engineering design including layout of the impoundment, reclaim water systems, and stormwater control structures.
- Design drawings and technical specification.
- Geotechnical monitoring plan of the TSF and WRD.
- Dam breach analysis to estimate inundation area and depths based on a “worst case” scenario failure mechanism.

This final design report was prepared to present the design and document Golder’s design calculations and support work for construction-level design of the TSF and WRD. This report is in a format that can be utilized by Calico for permitting, construction, and operations.

1.3 Battery Limits

This design report has been prepared by Golder to include construction-level design of the TSF and WRD only. Excluded from this design report are detailed designs for the following:

- Mill containment facilities
- Underground mining operations and surface containment facilities
- Tailings delivery and distribution pumping and piping systems
- Supernatant pool returns water pumping and piping systems
- Reclaim water pumping and piping systems
- Mechanical, structural, and electrical designs

The battery limits for the TSF and WRD containment systems start at the western edge of the process facility site as shown on the Design Drawings. The TSF and WRD containment systems are interconnected and continuous to provide secondary containment in all areas of the TSF and WRD.

2.0 DESIGN CRITERIA

The design criteria presented below are based on Oregon Administrative Rules (OAR), requirements of the Project as defined by Calico, and Golder's experience designing and constructing TSFs and waste rock dumps (WRDs) in similar environments. The following OAR Divisions have been used to develop minimum acceptable design levels:

- Water Resources Department, Dam Safety Regulations, OAR 690, Division 20
- Department of Geology and Minerals Industries (DOGAMI), Chemical Process Mine Regulations, OAR 632, Division 37
- Department of Fish and Wildlife (ODFW), Chemical Process Mining Consolidated Application and Permit Review Standards, OAR 635, Division 420
- Department of Environmental Quality (DEQ), Chemical Mining, OAR Chapter 340, Division 43

2.1 Hazard Classification

The TSF has been designed based on the assumption that a hazard rating of "Low" will be assigned by the OWRD. Based on Golder's understanding of OAR 690-020-0022 (22), the guidelines support the use of a Low Hazard designation by stating:

> *If the dam were to fail, loss of life would be unlikely and damage to property would not be extensive*.

The use of a Low Hazard designation is based on the knowledge that there are no structures or dwellings downgradient of the TSF that would be at risk of inundation or damage in the unlikely event of dam failure. The stability analyses completed for the project and discussed in Section 8.0 indicate that for the design criteria listed in Section 2.2, the TSF design meets or exceeds the design factor-of-safety requirements for stability.

Although not required for a Low Hazard classification dam, Golder performed a dam breach analysis on the ultimate TSF configuration and is discussed in further detail in Section 11.0.

2.2 Design Criteria for the Tailings Storage Facility

The following tables present the minimum design criteria for the TSF.

Table 1: General TSF Design Criteria

Parameter	Value	Reference or Regulation
Capacity	3.67 million dry tons	Calico
Life of Mine	~15 years	Calico
Average Tailings Deposition Rate	248,200 tons/year (680 tons/day)	Ausenco (others)
Tailings Slurry Concentration	46% solids (by weight)	Ausenco (others)
Settled Tailings Density	80 lb/ft^3	Golder
Slope of Tailings Surface estimated	1.0%	Golder
Dam Construction Method	Staged Downstream Construction	Golder
Dam Construction Material	Heterogeneous rock fill and/or soil fill	Golder
Tailings Deposition System	Subaerial discharge spigots	Golder
Reclaim Water System	Decant pumping and gravity underflow reclaim pond	Golder
Supernatant Pool Location	East side hill, not in contact with dam	Golder

Table 2: Division 20 - Dam Safety Minimum Design Criteria

Parameter	Value	Reference or Regulation
Embankment Geometry		
Upstream Slope Angle	Overall 3 horizontal to 1 vertical (3H:1V) or flatter Local slopes 2.5H:1V	OAR 690-020-0038
Downstream Slope Angle	2.5H:1V	OAR 690-020-0038
Geotechnical Criteria		
Hazard Classification	Low	OAR 690-020-0100 Golder recommended

Parameter		Value	Reference or Regulation
Design Earthquake During Closure	Event	Median Maximum Credible Earthquake (MCE)	Exceeds OAR 690-020-0038 for Low Hazard Dams
	PGA	0.15g	Golder
Horizontal PGA Factor, k, for pseudo-static stability analyses		½ of the PGA	Haynes and Franklin (1984) and Seed (1982)
Static Stability, Factor of Safety		1.5 (minimum)	Golder[1]
Closure Seismic Stability (pseudo-static), Factor of Safety		1.1 (minimum)	Golder[1]
Impoundment Storage Requirement			
Watershed and Hydrologic Inflows		Precipitation on TSF, small area of run-on into impoundment	Golder
Minimum Freeboard Above Supernatant Pool[2]		3 feet above supernatant pool operating depth for peak design storm event and wave action	Golder and Partial OAR 690-020-0042
Minimum Freeboard Above Tailings Beach		2 feet against dam embankment	Golder
Peak Design Storm Event		500-year, 24-hour plus wave run-up above supernatant pool operating depth	Exceeds OAR 690-020-0037 and OAR 340-043-0090
Process Water Conveyance			
Tailings Underflow Collection System		Perforated and solid CPE and HDPE gravity draining piping network	OAR 690-020-0038

1) Minimum factors of safety are not presented in OAR Division 20. Therefore, Golder has selected factors of safety that meet or exceed industry standard of care for similar seismic activity and hazard classification.
2) Although a minimum freeboard for free water against the embankment is provided, the TSF is designed to so that after initial deposition, no free water during normal operation is against the embankment.

Table 3: Division 43 - Chemical Mining Minimum Containment Design Criteria

Parameter	Value	Reference or Regulation
Containment and Leak Detection		
Facility Discharge	Zero discharge facility	Calico, Golder, and OAR 340-043-0000
TSF Basin and WRD Pad Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder and OAR 340-043-0130
TSF Reclaim Pond Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geonet leak collection and recovery system (LCRS), 60-mil HDPE geomembrane	Golder
Overall TSF and WRD Leak Detection System	Perforated 2-inch diameter Schedule 80 PVC pipe network and monitoring/evacuation ports	OAR 340-043-0000
Underdrain Channel Leak Detection System	Geomembrane lined channel will provide secondary containment, leak detection will be visual	Golder
Reclaim Pond Leak Detection System	LCRS between two geomembranes, and evacuation port	Golder and OAR 340-043-0000
Process Water Management		
Tailings Underflow Collection System	– Perforated and solid CPE and HDPE gravity piping network in 18-inch thick drainage layer – 6-inch thick filter layer – Gravity flow to reclaim pond	Golder and OAR 340-043-0050
Tailings Delivery and Distribution System	– 4-inch diameter HDPE DR17 carrier pipe inside 8-inch diameter HDPE DR17 containment pipe – Pumping system, if any (designed by others)	Ausenco (others)/Golder
Supernatant Water System	– Decant pumping system (designed by others) – 4-inch diameter HDPE DR17 carrier pipe inside 8-inch diameter HDPE DR17 containment pipe	Ausenco (others)/Golder
Reclaim Water System	– Pumping system (designed by others) – 4-inch diameter HDPE DR17 carrier pipe inside 8-inch diameter HDPE DR17 containment pipe	Ausenco (others)/Golder
Surface Water Management		

Parameter	Value	Reference or Regulation
Perimeter Diversion Channels	100-year, 24-hour storm event plus 9-inches freeboard or 500-year, 24-hour storm event to channel crest	OAR 340-043-0090
Temporary Diversion Channels	25-year, 24-hour storm event plus 9-inches of freeboard, or 100-year, 24-hour storm event to channel crest	Golder

2.3 Design Criteria for the Waste Rock Dump

Table 4 presents the minimum design criteria for the Waste Rock Dump (WRD) facility.

Table 4: WRD Design Criteria

Parameter	Value	Reference or Regulation
Capacity	200,000 tons	Ausenco/MDA others)
WRD Containment System (top to bottom)	Continuous 80-mil HDPE geomembrane, geosynthetic clay liner (GCL), prepared subgrade	Golder
WRD Underflow Collection System	Perforated and solid CPE and HDPE gravity draining piping network	OAR 690-020-0038
WRD Leak Detection System	Perforated 2-inch diameter Schedule 80 PVC pipe network and monitoring ports	OAR 340-043-0000
WRD Underflow Collection System	– Perforated and solid CPE and HDPE gravity piping network in 18-inch-thick drainage layer – 6-inch-thick filter layer Gravity flow to reclaim pond	Golder and OAR 340-043-0050
WRD Design Earthquake, Operational	475-year return period	Golder
Peak Ground Acceleration, PGA	0.08g	Golder
Horizontal PGA Factor, k, for pseudo-static stability analyses	½ of the PGA	Haynes and Franklin (1984) and Seed (1982)

Parameter	Value	Reference or Regulation
Static Stability, Factor of Safety	1.5 (minimum)	Golder[1]
Seismic Stability (pseudo-static), Factor of Safety	1.1 (minimum)	Golder[1]

1) Golder has assigned these minimum factor of safety values for geotechnical stability of the WRD. Minimum factors of safety are not presented in the OAR. Therefore, Golder has selected minimum FOS values that meet or exceed industry standard of care for similar seismic activity.

3.0 SITE CONDITIONS

3.1 Physical setting

In general, the mine site and surrounding area has rolling topography with bedrock exposed at or near the ground surface in upland and hill areas, including Grassy Mountain proper. Within the TSF area, as topographic elevation drops, the surrounding hills transition into broad valleys with shallow alluvial soils overlying deeper lacustrine clays.

The TSF generally slopes from south to north at about two percent along the valley floor. Valley wall slopes to the east and west ranging from about 10 percent to 15 percent, and about 5 percent in the south along the higher valley slopes in the southern portion of the TSF basin.

Vegetation across the site generally consisted of moderately dense native shrubs and grasses. No surface water, perennial streams, or springs were observed within the TSF footprint or WRD areas at the time of the geotechnical field investigations.

3.2 Climate

3.2.1 Development of Climate Data

There is no weather station located at the project site. Climate data for the site was developed using nearby weather station data, regression analyses, and elevation of the TSF. Daily recorded data from two Remote Automated Weather Stations (RAWS), one Cooperative Observer Network (COOP) station, and PRISM Climate spatial data were used as the base climate data sets. The overlapping data set between all stations was January 1, 1987 through December 31, 2017.

Golder used statistical regression analyses to develop a factor based on measured annual average precipitation and station elevation for each of the three data sets in relation to the project site. That factor was used to predict the average monthly precipitation for the project site used for hydrologic analyses. Based on available data and unknown properties of the future supernatant pool, evapotranspiration data was used to predict average monthly evaporation used for the TSF water balance. Supporting calculations and discussions about the predicted climate data are presented in Appendix F.

Based on the results of Golder's analysis, a regression function estimated from the average annual precipitation and elevations of the Owhyee Ridge RAWS, Kelsay Butte RAWS, and Owhyee Dam COOP, the Owhyee Ridge RAWS has the best monthly average precipitation correlation to the project site. Therefore, the Owyhee Ridge

RAWS station's average monthly precipitation values were multiplied by 1.01 to obtain the predicted average monthly precipitation values for the site.

Monthly climate data from the Owhyee Ridge RAWS was used to calculate evaporation rates using the Penman-Monteith equation for the available data set between April 1998 and May 2019.

Table 5: Factor-predicted Average Monthly Climate Data

Month	Precipitation (in)	Evaporation (in)
January	0.93	0.85
February	0.62	1.31
March	0.97	2.69
April	1.14	3.81
May	1.49	5.28
June	0.89	6.37
July	0.51	8.16
August	0.31	7.04
September	0.46	4.39
October	0.83	2.95
November	0.73	1.31
December	0.89	0.79
Annual	**9.77**	**44.97**

In addition to developing site specific average monthly precipitation and evaporation climate data, extreme wet and dry climate data sets were developed. Extreme climate data sets were calculated using the factor predicted monthly average precipitation and evaporation rates presented in Table 5.

The Log Pearson III method, determined to be the best-fit for the data set, was used to calculate the average monthly precipitation and evaporation rates for both extreme wet and dry climate scenarios for the 100-year return period. These extreme climate data sets were used in preparation of the TSF to estimate season and extreme fluctuations in the supernatant pool as discussed in Section 6.8 and presented in detail in Appendix F.

3.3 Regional Geology

The project site is located within in the Columbia Plateau, a physiographic province of the United States that comprises thick sequences of basalt flows (Columbia River Basalt) from about 17.5 to 6 million years ago (Ma). The Columbia River Basalts are part of long-lived volcanic activity related to the mantle "hot spot" that is now

located below Yellowstone National Park. The relatively unaltered basalt flows in the Payette section range in elevation from about 3,800 feet to about 4,500 feet above sea level (asl).

The project site is located about 15 mi (24.5 km) southwest of the Snake River plain near Adrian, Oregon. At this location, some dissection of the basalt flow-dominated landscape has occurred, exposing the underlying sedimentary units of the Grassy Mountain Formation. The site is located within a north-flowing drainage at an elevation of about 3,700 feet asl northwest of Schweizer Reservoir as presented in Appendix B.

3.4 Site Geology

The geology of the region surrounding the project site is a sequence of sedimentary and volcanic deposits within the Oregon-Idaho Graben. Contemporaneous deposition of sandstone and conglomerate (Tgs), olivine basalt emplacement (Tbi), and repeated episodes of calc-alkaline lava eruption and flow (Tgb) occurred during middle to upper Miocene time. The volcanoes of west-central to southeastern Oregon range in age from 15 to 2 Ma. The Payette section of the Columbia Plateau, where the site is located, is a relatively uniform area of basalt flows that overlie and cap the underlying older sedimentary deposits.

Grassy Mountain itself is mapped by Ferns et al. (1993) as underlain by calc-alkaline rich volcanic flow deposits (Tgb) and associated olivine basalt that crops out farther northeast. Ferns et al. (1993) geologic map presented in Appendix A indicates that the TSF and WRD site is located on a thick sequence of arkosic sandstones containing interbeds of conglomerate separated by the tuff of Kern Basin. Geologically, the site is within the upper arkosic (mid- to upper Miocene) and the lower (mid-Miocene) arkosic units. Erosion over about the last 11 Ma has removed some of the volcanic deposits that overlie and cap the sedimentary units to expose the upper arkosic unit at the site.

Bedrock outcrops within the site expose siltstone, sandstone, and conglomerate of the late Miocene Grassy Mountain Formation. These units are also exposed in the northeast–southwest trending drainage that the TSF will partially fill. Olivine-rich basalts are present immediately to the east and south. Igneous intrusions (Tbi) are mapped as isolated bodies surrounded by the sedimentary units (Tgs). The intrusive bodies are in places aligned along the mapped pre-Quaternary faults that may have controlled the locations and extent of these shallow intrusions.

Golder's subsurface investigation discussed in Section 4.0 identified unconsolidated alluvium and colluvium overlying previously unmapped Miocene-aged lacustrine clays underlying most of the TSF and WRD sites. The lacustrine deposits are generally characterized as fat clay (with variable quantities of fine- to medium-grained sand, dark tan to brown with some blue-gray deposits) with lesser amounts of lean clay and poorly graded sand lenses. Similar deposits were mapped by Ferns et al. (1993) approximately 2 miles (3 km) northeast of the TSF site. Gray et al. (1989) considers that the clay was deposited during the Upper Miocene within alkaline lakes subjected to regular volcanic ash fall and/or hydrothermal alteration.

The Grassy Mountain mine is located on a 150-foot high, highly resistant, silicified and iron-stained knoll. Bedding within the sandstone unit appears unaltered at the hilltop, dips at 10° to 25° toward the north-northeast on the northern and eastern flanks of the hill and steepens to 30° to 40° on the west side of the hill due to drag folding in the footwall along a fault striking about N20°W (Paramount 2017). Normal faulting of the Miocene-age units is common, with most faults striking either northwest–southeast or northeast–southwest (most common).

Also, a number of mapped older faults strike approximately north–south, but these faults are generally located west of the TSF site and are not considered seismogenic under the current tectonic environment.

3.5 Seismic Hazard Assessment

Golder completed a preliminary seismic hazard analysis (SHA) for the project in 2017 (Golder 2017). Subsequent to additional geotechnical field investigations in 2019, the preliminary SHA was updated to support this detailed design of the TSF. The updated SHA is presented in detail in Appendix B.

The purpose of the SHA was to identify faults that have the potential for surface rupture and to estimate earthquake ground motions for the operational and closure design earthquakes at the site for input into stability modelling. The site is located in the Columbia Plateau, a region of relatively low historical earthquake activity.

This SHA updates the earthquake ground motions presented in Golder (2017) with a deterministic seismic hazard analysis (DSHA) and probabilistic seismic hazard analysis (PSHA) for the TSF site. This SHA provides earthquake ground motion values for two assumed shear wave velocity values equivalent to the mid-point of a soil Site Class D as defined in ASCE/SEI 7-16. These lower values are considered appropriate for design of the TSF structure given the known subsurface conditions.

A probabilistic analysis using the USGS 2014 National Seismic Hazard Model indicates mean PGAs for Site Soil Class D for return periods of 475-, 2,475-, and 4,975 years. The following table presents PGA and spectral accelerations for the referenced return periods:

Table 6: Peak Ground Acceleration, 0.2- and 1.0-second Spectral Accelerations (Sa) for Selected Return Periods at the Grassy Mountain Tailings Storage Facility Site, Malheur County, Oregon

Probability of Exceedance (return period in years)[1]	Mean PGA (g)	0.2 second Sa (g)	1.0 second Sa (g)
10% in 50 years (475)	0.08	0.20	0.10
2% in 50 years (2,475)	0.20	0.50	0.23
1% in 50 years (4,975)	0.27	0.69	0.31

1. Values from the 2014 USGS national probabilistic model (Dynamic; Conterminous v.4.1.1) for a site location of 43.6728°N, 117.36437°W

A deterministic analysis was used to estimate the maximum credible earthquake (MCE) that could be experienced at the site. The MCE is the largest possible earthquake that may reasonably occur along a recognized fault or within a geographically defined tectonic province, under the presently known or presumed tectonic framework. Little regard is given to the earthquake recurrence interval, which may vary from less than a hundred years to more than ten thousand years, depending on the geologic and tectonic environment under consideration.

Median (50th percentile) values of PGA are sometimes used for analysis and design of low failure consequence structures, while 84th percentile values are often used for high consequence failure structures.

Median (50th percentile) PGA values were calculated because the earthquakes originate on faults with average slip rates less than 0.3 mm/yr as recommended in Idriss et al. (2018). Soil Site Class D values range from 0.03 to 0.15 g. The largest median PGA values result from an **M**7.2 earthquake occurring along the Cottonwood Mountain fault north of the TSF site. The median MCE PGAs of 0.15 g indicates a relatively low level for the deterministic hazard at the TSF site.

4.0 GEOTECHNICAL FIELD INVESTIGATION

The following sections present the general subsurface soil and groundwater conditions encountered at the TSF and WRD sites based on geotechnical field investigations and laboratory testing programs performed to support design of the TSF embankments and WRD facility. Detailed descriptions of conditions and materials encountered are presented in Appendix A.

Subsurface soil and water conditions described herein are based on the field exploration and laboratory testing performed for the project to-date. The following subsurface geotechnical field investigation and laboratory testing programs were conducted at the TSF and WRD site:

- December 2017 – 15 geotechnical boreholes, 44 test pits and six field falling head permeability tests were conducted in boreholes and laboratory testing
- March 2019 – Six geotechnical boreholes and laboratory testing
- July 2019 – 11 cone penetration test soundings

During the December 2017, Golder identified clay materials (lacustrine deposits) below the foundation of the TSF embankments that were visually observed to have high plasticity. These were classified as Lacustrine Deposits and discussed in Section 4.2

As the design progressed, further characterization and evaluation of the Lacustrine Deposits resulted in the completion of the March and July 2019 field investigations.

Findings from the geotechnical field investigations are discussed in detail in Appendix A.

4.1 Geotechnical Laboratory Testing Program

Geotechnical laboratory testing was performed on selected soil samples deemed representative of the materials encountered during the investigation. The geotechnical laboratory testing program, summarized in Table 1, was developed to focus on classifying and characterizing the engineering properties of the foundation soils and potential construction materials.

Geotechnical laboratory testing was completed at Golder's Lakewood, Colorado geotechnical testing laboratory. Selected samples were also subjected to x-ray diffraction (XRD) mineral composition testing. These tests were performed by Miles Industrial Mineral Research of Denver, Colorado, subcontracted to Calico. All geotechnical laboratory testing results are presented in Appendix A.

Table 7: Summary of Laboratory Testing Program

Laboratory Test	Test Method	Quantity
Grain Size Analysis	ASTM D 421/D 422	81
Moisture Content	ASTM D 2216	72
Atterberg Limits	ASTM D 4318	81
Flexible Wall Permeability	ASTM D 5084	5
Moisture-Density Relationship (Modified Proctor)	ASTM D 1557	1
Consolidated-Undrained Triaxial Shear Strength	ASTM D 4767	6
1-Dimensional Consolidation	ASTM D 2435	6
X-ray Diffraction	N/A	15

Index tests (grain size, moisture, and Atterberg Limits tests) were performed on selected subsurface soils encountered during the investigations to assist in classifying the soils in accordance with ASTM D 2487 and the Unified Soil Classification System (USCS) for verification of soil descriptions logged in the field.

Hydraulic conductivity (permeability) tests were run on both relatively undisturbed samples and a remolded sample using a flexible wall permeameter. The remolded sample was tested to assess the permeability of the lacustrine deposits if the material were to be excavated and used during construction. The relatively undisturbed samples were tested to provide the permeability of in-situ lacustrine soils beneath the TSF. The modified Proctor (moisture-density relationship test) was utilized to obtain parameters for remolding the permeability sample.

Consolidated-undrained triaxial shear strength tests (CUTX) were performed on relatively undisturbed samples extruded from the MC and Shelby tubes to assess the in-situ strength of the lacustrine deposits. A majority of the MC and some of the Shelby tube samples delivered to the laboratory were too disturbed or too fractured to be utilized for CUTX testing. This was most likely due to disturbance while driving the samplers into stiff to hard clays.

One-dimensional consolidation tests were conducted on relatively undisturbed lacustrine clay samples to determine the estimated pre-consolidation pressure and soil parameters for use in assessing settlement of the soils under loading conditions.

In addition, XRD mineral composition testing was performed on 15 samples to determine montmorillonite and accessory mineral concentrations.

4.2 Subsurface Conditions

In general, site soils consisted of surficial alluvial and colluvial deposits across the site with thicknesses ranging from about 0 to 25 feet below the existing ground surface (bgs). These deposits were generally comprised of a mixture of stiff to hard silt and clay and dense to very dense sand and gravel. The surficial soils were generally

underlain by relatively weak lacustrine deposits classified as very stiff to hard, lean to fat clay with varying fine to medium sand content. Laboratory testing of the lacustrine clays indicate a range of plasticity index (PI) from 25 to 198, with several samples having plasticity index values over 100.

Within the clay lacustrine deposits, zones of relatively clean sand varying in thickness from less than one foot to 20 feet were encountered below the TSF. These sand zones were generally comprised of medium dense to dense poorly graded and silty or clayey sands, with the sand content mainly consisting of fine to medium sand. These lacustrine deposits with sand zones were encountered up to depths of 120 feet bgs (maximum depth of exploration) within the footprint of the TSF and may extend deeper. Site soils were generally observed to be moist. No groundwater was encountered in the borings.

Relatively shallow (less than 15 feet) weathered arkosic sandstone was observed within the north-central portion of the TSF and west portion of the mine process facilities. The sandstone is similar to a silty- to poorly-graded sand. In general, the west portion of the mine process facilities consisted of Quaternary deposits underlain by weathered arkosic sandstone, and the east portion of the mine process facilities area consisted of Quaternary deposits overlying fat clay lacustrine deposits.

The subsurface profile at the site generally consisted of alluvial and colluvial deposits underlain by lacustrine deposits, sandstone, and basalt as presented on the geologic sections shown on Figures 2B and 2C. Subsurface stratigraphy at the site is described as follows:

- **TOPSOIL:** Topsoil was estimated to have an average thickness of about ½ foot across a majority of the site. Dense rootlets were observed in the topsoil with scattered roots observed up to ¼-inch thick in the upper 2 to 3 feet of the subsurface profile. Topsoil was generally comprised of dark brown, silty- to clayey-sands with non-plastic to low plastic fines, and observed to contain few to little gravel, cobbles, and boulders in the south and northeast portions of the TSF and potential borrow areas.
- **QUATERNARY DEPOSITS:** These deposits include unconsolidated sediments deposited by water (alluvium) and accumulated material on exposed slopes (colluvium). Based on the previously-referenced mapped geology, these units are estimated to be Quaternary-age deposits. These materials were encountered across the site consisting of variable sands, gravels, clays, and silts with thicknesses ranging from ground surface to 25 feet bgs. Generally, the upper portion of the deposit was described as fine-grained soils classified as lean and fat clay with varying amounts of sand and gravel, which were underlain by more coarse-grained soils classified as clayey- to silty-sand, clayey- to silty-gravel, and poorly- to well-graded sand and gravel.
- **OLDER DEPOSITS:** These deposits include Miocene-age lacustrine, alluvial, beach, and sandstone deposits described as:
  - **LACUSTRINE DEPOSITS:** Underlying the Quaternary Deposits, Lacustrine deposits were encountered across a majority of the site and primarily classified as lean- to high-plasticity clay with varying sand content. Abundant evaporites were often found in the upper three (3) feet of the deposit and were occasionally observed throughout the formation. As previously discussed, these deposits were not identified on the referenced surface geologic map; however, based on similar units in the region, these units are estimated to be Miocene-age deposits.
  - **ALLUVIUM AND BEACH SAND DEPOSITS:** Discontinuous alluvium and beach sand deposits were observed within the lacustrine clay deposits generally consisting of poorly-graded sand and silty sand.

Due to the location of these deposits within the lacustrine clays, these deposits were estimated to be Miocene-age deposits.

- **ARKOSIC SANDSTONE:** Part of the Grassy Mountain Formation was encountered generally along the higher elevations with the valley the TSF is situated and was identified in Borehole BH-10 at a depth of 10 feet bgs and in Test Pits TP-13, 14, 16, 20, 26, 27, 30, and 40 at depths ranging between 2.5 feet 12 feet bgs. Arkosic sandstone generally consisted of silty sand to fine- to coarse-grained sands and mapped as mid-Miocene in age (Ferns et al, 1993).
- **BASALT:** Upper Miocene olivine basalt flows were observed in the geotechnical coreholes advanced for the proposed Basalt Borrow Quarry (Golder 2019a) and is generally encountered in the hills east of the project area (Ferns et al, 1993).

4.2.1 Subsurface Water Conditions

No subsurface water was encountered during the field explorations to the maximum depth of the boreholes of approximately 120 feet bgs. In the *Groundwater Characterization Data Report*, prepared by SPF Water Engineering, LLC (SPF), it was reported that the ground water depth beneath the southern portion of the TSF basin ranged between 155 feet at the BLM well located within the TSF footprint and 232 feet at the GW-3 well located just southwest of the TSF (SPF 2019).

Inferred ground water contours presented in the same report indicate ground water beneath the reclaim pond area may be as shallow as 55-feet; however, no ground water was encountered in Golder's borehole BH-05 which were drilled to maximum depth of 100 feet bgs.

Ground water depths in the TSF area will be refined after the installation of proposed ground water monitoring wells as presented in SPF's report. In addition, no springs were observed in the TSF or mine facility areas during the field investigation.

5.0 TAILINGS TESTING AND CONSOLIDATION MODELING

To support detailed design of the TSF, Golder conducted a geotechnical laboratory testing program on representative tailings samples. Using the test results, Golder performed consolidation and thin lift modeling to estimate water seepage rates from the tailings mass and ultimate settled dry density and beach slope angles relationships of the TSF. Detailed discussion of the laboratory testing program and analyses are presented in Appendix D.

Estimated water seepage rates from the thin lift and consolidation modeling were used in preparation of the TSF water balance discussed in Section 6.8. Settled dry density and beach slope angles estimated in the consolidation modeling were used in estimating the stage-storage capacity relationship and stage expansion design discussed in Section 6.0.

5.1 Sample Preparation

Metallurgical testing to support the project was performed by SGS Canada Inc. (SGS) in 2018 (SGS 2018). Test specimens were prepared from residual head samples to represent a mixture of the main lithologies that comprise the bulk of the ore domains that are expected to be disposed of in the TSF.

During sample preparation, SRK Consulting (US), Inc. (SRK) conducted geochemical testing on the test specimens to determine the minimum required lime additional and blending required to produce tailings that are

net neutralizing based on the criteria specified in the OAR 340-043-0130 (2) guideline. Based on this evaluation, lime rates required to produce a net neutralizing potential (NNP) greater than 20 kg $CaCO_3$/t were determined for the dominate ore domain Mixed Lithology (ML), (SRK 2019).

Prior to Golder receiving tailings samples from SGS in Vancouver, British Columbia, Canada, SGS blended two Mixed Lithology tailings samples (GMTC-1 and GMTC-2) with 15.9 g/kg of hydrated lime.

Representative, lime treated, tailings samples were then shipped to Golder's Denver, Colorado geotechnical laboratory for testing. Detailed discussions on the laboratory classification, consolidation properties and results of the consolidation and thin lift modelling are included in Appendix D.

As specified by Ausenco Engineering Canada Inc. (Ausenco), the estimated solids concentration of the tailings slurry during transport and deposition will be 46 percent solids, by weight (w/w), (Ausenco 2018). The samples received by Golder contained slightly higher water contents, therefore, prior to any testing, Golder adjusted the slurry concentrations to 46 percent solids (w/w).

5.2 Tailings Testing

Laboratory testing performed on GMTC-1 and GMTC-2 samples was conducted in two phases. The Phase 1 testing program was conducted to determine classification properties, settled density, compressibility and permeability characteristics and to evaluate the potential for tailings to segregate. The Phase 1 testing included:

- Particle size distribution (PSD) – ASTM D 422 (historic)
- Atterberg limits – ASTM D4318
- Specific gravity – ASTM D854
- Settling column testing – Golder procedure
- Slurry consolidation testing – Golder procedure

The Phase 2 testing was conducted to determine parameters required for the thin-lift deposition modeling, and to determine beach angles and the segregation potential during the deposition process. The Phase 1 test results indicated that the GMTC-1 and GMTC-2 specimens have very similar geotechnical properties. Therefore, the GMTC-1 and GMTC-2 samples were composited into a single specimen (GMTC Composite). The Phase 2 testing included:

- Soil water characteristic curves (SWCC) determination – ASTM D 6836
- Shrinkage curve – Golder procedure
- Flume test – Golder procedure

Detailed descriptions of the testing program and results are presented in Appendix D.

5.3 Consolidation and Thin Lift Model

5.3.1 Consolidation Model

Consolidation modeling was performed by Golder using CONDES (Yao and Znidarcic 1997) and FSConsol (GWP 2014) model codes. CONDES is used to estimate time-dependent void ratio distribution and later thickness. FSConsol is used to estimate pore pressure distribution and void ration profiles as a function of time. A

detailed discussion of the consolidation model, inputs, and assumptions is presented in Appendix D. The following table present the estimated settled dry density per stage of operation:

Table 8: Average Dry Density Estimates

Stage	Top of Tailings Elevation (ft)	Model Column Height (ft)	Average Dry Density (pcf)	
			FSConsol	CONDES
1	3,592	46	80.62	81.0 – 82.2
2	3,605	60	81.98	79.4 – 80.4
3	3,617	>63	>82.26	79.8 – 80.8

Based on the dry density estimates above, Golder selected an average settled dry density of 80 pcf for use in estimating the stage-storage relationship for the TSF.

Additionally, the consolidation model estimated the amount of seepage water reporting to both the supernatant pool and underdrain collection system during active deposition and consolidation. Approximately 50 percent or more of the consolidation water (interstitial) is expected to be intercepted by the underdrain system at the beginning of impoundment filling. As the tailings cover the TSF basin drainage layer, the amount of water conveyed by the underdrain collection system is expected to decrease to approximately 30 to 40 percent of the total consolidation water (interstitial) with the potential for further reduction as the tailings height in the impoundment increases.

5.3.2 Thin Lift Model

Due to the arid environment, tailings surface area, and relatively low tailings deposition rate into the TSF, Golder performed a thin-lift evaluation to determine if additional water loss can be expected beyond those estimated in the consolidation models.

Thin-lift deposition assumes that the tailings are deposited in a controlled manner allowing for the fresh tailings to desiccate in a climate characterized by relatively high net evaporation losses. As the tailings' densities increase, a large amount of water from the porous matrix is lost to the atmosphere. Consequently, water inflows to the supernatant pool are significantly reduced as compared to conventional deposition practices or in areas where net evaporation losses are lower.

To evaluate impacts of the seasonal effects on tailings deposition, the thin-lift model needs to account for the continuous deposition (tailings accretion) and the tailings interaction with the atmosphere. The thin-lift accretion model used in this study allows for the interaction of the deposited tailings with the atmosphere. The accretion model geometry is updated in daily increments and is accompanied with adjustments of the SWCC determined from laboratory testing discussed in Section 5.2. The outputs from the accretion model include evaporation and drainage losses reported in daily increments. The simplified and the accretion models were developed for two case scenarios:

- Case 1 – assume that all tailings water entering the TSF is initially contained within the soil matrix.
- Case 2 – assume that a portion of the tailings discharge water is lost during the sedimentation process and reports directly to the tailings pool. Consequently, the initial amount of porous water, at the onset of the thin-

lift modeling process, is reduced by the estimated initial bleed. The initial bleed estimates used for the thin-lift analyses were selected based on the settling column test results.

To estimate the minimum TSF area required for thin-lift deposition, a simplified model based on net evaporation requirements was utilized. Based on the assumption that all water (in excess of the amount contained in the pores of a fully saturated tailings deposit) is expelled by evaporation until reaching tailings' shrinkage limit, the minimum required TSF area is estimated using the average annual net evaporation rate presented in Section 3.2. The simplified thin-lift deposition model results are summarized in the following Table:

Table 9: Minimum TSF Area for Thin-Lift Management

Scenario	Production Rate (t/day)	Solids Volume Rate (yd^3/day)	Evaporation Demand (yd^3/day)	Minimum TSF Management Area (acre)	Dry Density[1] (pcf)
Case 1	680	307	635	49	81.2
Case 2	680	307	322	25	81.2

The simplified thin-lift model predictions for underdrain drainage rates presented in Table 10 are based on the design annual tailings deposition rate and the average annual net evaporation. These rates are annual average flow rates that can be expected from the TSF underdrain collection system reporting the TSF reclaim pond. Immediate or season fluctuations can vary between 2 gallons per minute (gpm) to 99 gpm with an overall average rate of 21 gpm over the modeled deposition period (~15 years).

Table 10: Underdrain Drainage Rates

Year	Case 2 – Drainage Rate (gpm)		
	Minimum	Maximum	Average
1	2.3	99.3	13.5
2	3.3	30.3	12.5
3	5.1	72.1	20.7
4	4.3	52.4	16.6
5	4.9	73.5	19.5
6	5.7	46.3	18.3
7	6.5	57.8	24.6
8	7.9	47.0	20.3
9	8.0	91.4	25.0
10	8.6	58.4	21.7
11	9.1	65.7	26.4
12	10.9	58.8	25.3
13	12.6	64.7	27.0
14	13.7	63.1	28.8
Average	16	21	26

6.0 TSF DESIGN

The TSF will be a continuous geomembrane-lined facility with continuous primary and secondary containment as discussed in Section 6.3. Process solution will be managed with two independent underdrain and supernatant pool decant return water systems as discussed in Section 6.4. Anticipated maximum flow rates for each system have been estimated using a monthly time-step water balance discussed in Section 6.8. The supernatant pool will be maintained away from the embankment on the eastern side of the facility as shown on the Design Drawings.

The TSF has been designed as a zero-discharge facility capable of storing the 500-year, 24-hour storm and an allowance for wave action and to meet the minimum requirements for a Low Hazard Dam as discussed in Section 2.1. Permanent and temporary stormwater diversions will collect and divert a majority of the stormwater runoff around the facility to a natural drainage on the north side of the TSF.

6.1 Site Layout

The TSF will be located in the broad valley immediately east of the Grassy Mountain mine portal and process facilities. Native slopes within the valley range between approximately one and 20 percent. Embankments will be required on the north and west sides to impound tailings. The main North embankment will span the width of the valley while the smaller West embankment will be used to bridge saddles along the western ridge. The TSF will cover an approximate area of about 108 acres and has been designed to accommodate 3.67M tons of tailings at a settled dry density of 80 pcf. An overall layout of the site is presented on the Design Drawings.

6.2 Embankments and Storage Capacity

A shown on the Design Drawings, embankments will be constructed to impound the tailings on the north and west sides. The main embankment will cross the natural drainage to the north, and small secondary embankments will be constructed across saddles along the western ridge. The embankments with have a maximum overall upstream slope of flatter than 3H:1V (with staged benching) with a downstream slope of 2.5H:1V. The north and West embankment will have a maximum height of 84-feet and 30-feet, respectively. The crest width of the North embankment will be 50-feet, with a 30-foot wide crest for the smaller West embankment. To provide geotechnical stability for operation and long-term closure of the main embankment, a small downstream buttress will be constructed during Stages 2 and 3 at the tallest section to provide additional resisting mass at the downstream toe. A detailed discussion of the stability analyses is presented in Section 8.0.

The upstream slope of the embankments will be geomembrane-lined to maintain the continuous lining within the facility. A discussion on the lining system is presented in Section 6.3.

The TSF will be constructed in a maximum three stages (Stages 1 through 3) utilizing downstream construction techniques as shown on the Design Drawings. Embankment fill construction materials will be soil or rock fill sourced from on-site borrow areas as discussed in Section 9.0

Stages 1 and 2 will each provide between approximately 1.0M and 2.07M dry tons of tailings storage for between 5 and 9.3 years of operating capacity per stage, with a smaller Stage 3 adding an additional 1.6M tons of capacity equaling an additional 6.5 years of operating capacity. The stage-capacity relationship is based on an average tailings deposition rate of 680 dry short tons per day. The storage volume of the TSF has been calculated based on a settled dry density weight of 80 pcf estimated in the tailings consolidation modeling discussed in Section 5.3. A summary of the height-area-volume relationship for the TSF is presented in Table 11 below and is graphically presented on the Design Drawings.

Table 11: Stage Capacity Relationship Summary

Stage	Main Embankment Crest Elevation (ft)	Maximum Tailings Surface Elevation (ft)	Maximum Tailings Surface Area (acres)	Stage Storage Capacity (M tons)	Cumulative Storage Capacity (M tons)
1	Varies (Min. 3595)	3593	37.0	1.00	1.00
2	Varies (Min. 3609)	3607	59.5	1.07	2.07
3	Varies (Min. 3622)	3620	83.0	1.60	3.67

6.3 Lining System

The TSF impoundment area and upstream embankment slopes will be continuously lined with both primary and secondary lining systems to provide dual containment of process solution. The containment system is consistent throughout the facility, but the drainage system above the primary geomembrane liner will vary depending on the location as described in Section 6.4 and presented on the Design Drawings.

To meet the minimum guidelines of OAR 340-043-0130 (3), the secondary containment layer of the TSF dual containment system will be an enhanced geosynthetic clay liner (GCL) with a maximum hydraulic conductivity of 1×10^{-10} cm/sec. The enhanced GCL provides a slower conductivity than a compacted soil with a thickness of 36 inches and permeability of 1×10^{-7} cm/sec. Hydraulic conductivity comparison calculations for the enhanced GCL are presented in Appendix E.

Within the impoundment, the lining system will consist of (from bottom to top) a 6 to 12-inch thick native prepared subgrade, a 300-mil thick enhanced GCL, 80-mil high density polyethylene (HDPE) geomembrane liner, an 18-inch-thick drainage layer, and a 6 inch thick filter layer. Perforated piping will be located within the drainage layer to promote drainage of the tailings. The same lining system will be used for the waste rock dump (WRD).

On the upstream embankment slopes, the lining system will be the same, but without the overlying piping, drainage layer, and filter layer. Placement of a drainage layer above the geomembrane on the upstream embankment slopes will be impractical due to the relatively steep side slopes and erosion potential of a cover from tailings deposition. Additionally, the TSF underdrain channel, WRD underdrain channel, and tailings delivery channel from the process area will utilize the same lining system as the TSF embankment slopes.

6.4 Underdrain Collection System

As deposition continues, the tailings will consolidate due to increased vertical pressure as the tailings surface elevation increases. In addition to water bleeding upward into the tailings surface, water will also be released from the tailings downward. To reduce hydraulic head on the geomembrane liner and promote drainage of the tailings, the water released downward will be captured in an underdrain collection piping system installed above the geomembrane liner within the drainage layer in the TSF basin as shown on the Design Drawings.

This network of perforated pipes will capture and convey underflow via gravity to the reclaim pond located downstream of the main embankment as shown on the Design Drawings. The underdrain collection system will consist of variable diameter and pipe types depending on their location and vertical pressure. In general, primary collection pipes will be perforated 6-inch diameter HDPE DR17, secondary collection pipes will be perforated 6-inch diameter double-wall corrugated polyethylene (CPE), and tertiary collections pipes will be 4-inch diameter double-wall CPE. Tertiary collection pipes will be installed with greater density adjacent to the North embankment and beneath the supernatant pool.

Prior to passing below the North embankment, the perforated CPE primary collection pipes will transition to solid wall HDPE DR17 underdrain outlet pipes. The underdrain outlet pipes will penetrate through the geomembrane liner at the upstream toe of the North embankment and pass under the dam where they will convey all underdrain flows from the TSF and WRD to the reclaim pond.

Within the TSF, a total of four primary collection pipes exit the basin and report to the reclaim pond. The four primary collection pipes each independently collect or convey flows from the following areas:

- Within the TSF basin
- Below the supernatant pool
- Upstream toe of the North embankment
- WRD containment pad

Independently, each of the primary collection and underdrain outlet pipes has a full flow capacity of 249 gpm at the minimum one percent post-settlement grade. Golder used a maximum design flow rate of 99 gpm to account for potential pipe deformation and long-term scale build-up. Based the tailings consolidation modeling discussed in Section 5.0, the maximum anticipated steady-state seepage rate from the tailings mass is estimated to be about 21 gpm during operation, significantly lower than the design flow rate for each pipe. The peak underdrain flow rate estimated from the tailings consolidation modeling discussed in Section 5.0 is 99 gpm, which is lower than the design full flow rate for each pipe.

Since the primary collection pipes are perforated to the upstream toe of the North embankment, each pipe provides redundant capacity to the others in the event that one or more become blocked. Hydraulic sizing of the primary collection and underdrain outlets pipes is presented in Appendix H. As embankment construction and tailings deposition progresses, the primary underdrain outlets pipes will experience grade flattening due to foundation settlement of the embankments. The primary underdrain pipes are designed to accommodate the maximum design flow rate at a post-settlement grade of one percent. Foundation settlement is discussed in further detail in Section 8.2 and presented in Appendix C.

Where the underdrain outlets pipes pass beneath the embankment, they are located above a geomembrane-lined channel that provides secondary containment. Within this underdrain outlet channel, the outlet pipes are encased in reinforced concrete to protect against deformation and maintain the integrity of the pipes. The reinforced concrete encasement terminates beyond the ultimate Stage 3 downstream toe. Design of the reinforced concrete encasement is presented in Appendix H.

The underdrain outlet pipes will continue to the reclaim pond within the geomembrane lined underdrain channel. Prior to discharging into the reclaim pond, each underdrain pipe will enter a flume where flows can be measured and monitored. Additionally, upstream of the monitoring flumes, 6-inch diameter knife gate valves will be installed that can be used to restrict flow or closed in case of emergency.

6.4.1 Reclaim Pond

The reclaim pond will have double containment geomembrane liners and a leakage collection and recovery system (LCRS). The pond lining system, as shown on the Design Drawings, will consist of (from bottom to top):

- A compacted subgrade
- A minimum 6-inch thick soil bedding (Prepared Subgrade), either compacted in-place or from the identified borrow sources within the TSF basin
- A single secondary 60 mil HDPE single sided textured geomembrane liner, textured side up
- A 2-foot deep by 15-foot square leak detection sump with a 10-inch diameter HDPE DR17 leak detection riser extending up the side slope of the pond – the leak detection sump is filled with clean, free draining, gravel (Drain Gravel)

- An HDPE geonet liner above the secondary geomembrane
- A single primary 80 mil HDPE single sided textured geomembrane liner, textured side up

The reclaim pond is sized to contain, at a minimum, the total volume of water generated during the following:

- Gravity underdrain flow from the TSF for the duration of a 48-hour power outage
- 500-year, 24-hour design storm event falling on the surface of the reclaim pond
- Volume of water within the entire length of the reclaim water pipe between the reclaim pond and the mill

The reclaim pond has a total storage capacity of 146,000 gallons to the underdrain channel invert elevation which is 3.6 feet below the pond crest. The total storage capacity of the reclaim pond is 215,000 gallons while maintaining two feet of freeboard beneath the pond crest. In this scenario, water in the pond would also back up into a portion of the lined underdrain channel for additional emergency storage above the minimum required. Pond storage requirement calculations are presented in Appendix F.

6.5 Reclaim and Supernatant Return Water Pipelines

Water from the reclaim pond will be pumped back to the mill for reuse in the process circuit. The reclaim water pipe will be constructed beyond the toe of the Stage 3 embankment as shown on the Design Drawings. The reclaim pipe will be a dual containment pipe consisting of a 4-inch HDPE DR17 carrier pipe inside an 8-inch HDPE DR17 containment pipe. The reclaim pipe will be located along the light vehicle access road at the toe of the Stage 3 North embankment and continue to the northeast corner of the TSF. Hydraulic design of the reclaim water piping and pumping system is being performed by other parties and is not included in this design.

Near the crest of the TSF for each stage, the 8-inch diameter containment pipe will terminate above the TSF basin geomembrane liner and run adjacent to the tailings distribution line along the eastern impoundment access road as shown on the Design Drawings.

Water from the supernatant pool is evacuated utilizing a submersible or floating pumping system. Return water is pumped through a 4-inch diameter HDPE DR17 pipe from the supernatant pool to the eastern impoundment access roads as shown on the Design Drawings. Hydraulic design of the return water piping and pumping system is being performed by other parties and is not included in this design.

Along the eastern impoundment access road near the supernatant pool, the 4-inch diameter HDPE DR17 reclaim water and supernatant return water pipes will combined into single 4-inch diameter by 8-inch diameter HDPE DR17 dual containment pipe installed parallel to the tailings delivery pipe located along the access road from the mill to the TSF as shown on the Design Drawings.

At all times, process fluid pipelines will be located above secondary containment that consists of either geomembrane liners or concrete containment structures.

6.6 Tailings Distribution System

Tailings will be delivered to the TSF from the mill via the 6-inch diameter DR17 HDPE tailings delivery pipe. The tailings delivery pipe will be located within a HDPE-lined containment channel in the alignment shown on the Design Drawings. The tailings delivery pipe will route along the TSF perimeter access road where tailings will be deposited via discharge points called spigots. Spigots are 1-inch diameter drop pipes with manual control valves and are spaced at regular intervals to allow for tailings deposition as needed to maintain the appropriate

supernatant pool configuration and location. Hydraulic design of the tailings delivery pumping, piping, and discharge spigots is being performed by other parties and is not included in this design.

As the tailings are deposited and the solids settle out of the slurry, free water will accumulate at the low point on the tailings surface. This is referred to as the supernatant pool. The supernatant pool will be maintained on the eastern side of the facility away from the main embankments.

Water from the supernatant pool will be extracted via pumping and delivered back to the mill for reuse through a return water pipe. The supernatant pool is designed to fluctuate seasonally depending on climatological conditions. The supernatant pool will have an average operating depth of 5-feet that is controlled by the pumping system and is adequately deep enough to prevent drawing tailings solids from the pool bottom.

6.7 Leak Detection

6.7.1 TSF Basin and WRD

Independent leak detection and leakage collection recovery systems (LCRS) will be installed to monitor and manage potential leakage between primary and secondary containment layers within the TSF basin, underdrain outlet pipes and channel, reclaim pond, and WRD containment pad.

Below the primary geomembrane liner of the TSF and WRD, perforated 2-inch diameter schedule 80 polyvinyl chloride (PVC) piping will be installed immediately below the primary collection pipes and primary geomembrane as shown on the Design Drawings to monitor potential leak where concentrated flows are expected.

As perforated leak detection piping continues downgradient toward the downstream toe of the North embankment, the pipes transition to solid wall and additional perforated piping will start at each transition as shown on the Design Drawings. This provides leakage isolation to different areas within the TSF and WRD.

Each leak detection pipe will report to an independent leak detection riser near the reclaim pond and the WRD containment berm as shown on the Design Drawings. The leak detection risers will provide access for both monitoring of leakage flows and allow for the installation of small submersible pumps to evacuate any observed flows.

6.7.2 TSF Reclaim Pond

The reclaim pond is designed to include an independent LCRS between the primary 80 mil HDPE and secondary 60 mil HDPE geomembrane liners. The LCRS includes a geonet drainage layer and a LCRS collection sump and riser pipe. The riser consists of a 10-inch diameter HDPE DR17 pipe that extends from the LCRS sump along the slope of the reclaim pond to the pond crest for leakage monitoring and fluid evacuation as shown on the Design Drawings. The LCRS collection sump provides a storage capacity of 620 gallons within the Drainage Gravel, assuming a porosity of 0.3.

6.8 Water Balance

A deterministic spreadsheet-based monthly time step water balance was developed for each stage based on the proposed tailings deposition rate of 680 dry short tons per day. The inflows to the system include precipitation above lined areas, surface water run-on from up-gradient catchment areas below the permanent and temporary stormwater diversions, and water being deposited within the tailings slurry at a rate of 133 gpm.

Losses include evaporation from the tailings beach area, evaporation from the supernatant pool area, and interstitial water permanently stored within the tailings mass. Water will be pumped from the supernatant pool to

the mill for make-up water at a rate that maintains the minimum pool operating level. The underdrain flow rate from the collection system will drain into the reclaim pond and will be pumped to the mill to use as make-up water.

The average reclaim rate from the supernatant pool to the mill is 49 gpm for Stages 1 through 3 and varies between zero during summer months (July and August) and 106 gpm during winter months (December and January). Make-up water required was defined as the rate of evaporation from the tailings beach and supernatant pool (outflow) plus interstitial water loss (outflow) minus precipitation (inflow). The make-up water rate is less than or equal to the rate that water is reporting to the TSF in the tailings slurry. The average make-up water rate is 69 gpm for Stages 1 through 3 and varies between 133 gpm during summer months (July and August) to 1 gpm during winter months (December and January).

The water balance spreadsheet and supporting discussions are presented in Appendix F.

6.8.1 Freeboard

For tailings storage facilities (non-water impounding structures), freeboard is generally defined separately for the area with free water in the supernatant pool and dry tailings beach areas. The minimum freeboard definition presented in OAR 690-020-0042 is generally intended for water storage reservoirs where water is in contact with the embankments. However, for tailings storage facilities in arid climates, tailings deposition and reclaim water are managed to maintain specific supernatant pool geometries, similar to the TSF, as shown on the Design Drawings.

The TSF is designed to provide a minimum freeboard depth of five feet above the maximum operating supernatant pool water surface where it is impounded against the geomembrane-lined southern hillside. This freeboard will provide suitable dam storage height above the maximum water surface elevation to contain wave action above the 500-year, 24-hour storm event falling on the TSF impoundment and the up-gradient catchment areas below the permanent and temporary diversion channels. Wave run-up calculations were developed assuming the TSF had experienced a 500-year, 24-hour storm with waves generated from sustained wind loading using the average wind speed in the prevailing wind direction. Supernatant pool storage and wave run-up calculations have been included in Appendix G.

Tailings beach areas are defined as areas where the impoundment surface is free of pooled water and only comprised of tailings. The TSF is designed so that only tailings will impound against the embankments. In the tailings beach areas, a minimum freeboard of two feet will be provided from the highest beach elevation to the lowest dam crest elevation.

In addition to the above freeboard dimensions, the TSF is designed such that the lowest tailings surface and pool elevation is away from the perimeter embankments. This results in the overall tailings surface sloping away from the perimeter embankments southeast toward the supernatant pool. With appropriate fluid management, overtopping or freeboard encroachment is not expected. Therefore, an emergency spillway has not been included in the design.

6.9 Hydrologic Assessment and Stormwater Control

6.9.1 Synthetic Storm Events

The National Oceanic and Atmospheric Administration (NOAA) Atlas 2 was used to develop the probabilistic-based synthetic storm events for the calculation of the peak flows. Atlas 2, Volume 10 (Oregon) contains precipitation frequency estimates for the western United States (NOAA 1973). Atlas 2 generates the precipitation frequency estimates based on analysis of previously recorded weather patterns.

A frequency analysis was conducted to determine annual extreme daily rainfall depths for the 1 in 25-year, 24-hour and 1 in 500-year, 24-hour storm events that were not presented in the NOAA Atlas 2. Thirty-three years of maximum daily annual precipitation data from 1986 through 2018 was obtained from the Owyhee Ridge Oregon Remotely Automated Weather Station (RAWS) located approximately 8 miles southeast of the project site. Table 12 presents the precipitation data for the storms used in this analysis. Detailed synthetic storm development is presented in Appendix G.

Table 12: 24-Hour Storm Event Precipitation Depths

Recurrence Interval (years)	Precipitation Depth (in)	
	NOAA Atlas 2	Lognormal Analysis
2	0.99	-
25	Not Available	1.87
100	2.28	-
500	Not Available	3.03

6.9.2 Hydrologic Analysis

Peak stormwater runoff flows generated from the 25-year, 100-year, and 500-year, 24-hour storm events, presented in Table 12, were calculated using methodologies published in Technical Release 55 (TR-55) by the USDA NRCS (USDA 2011) and HEC-HMS Version 4.1, utilizing the SCS Rainfall Distribution Method (Type II), by the USACE (HEC 2015). Malheur County, Oregon is located in the western United States where there are distinct dry and wet seasons and the Type II SCS Rainfall Distribution Method is most applicable. Type II rainfall distribution was used for the hydrologic models presented in this report.

Soil characteristic curve numbers (CNs) used to predict stormwater run-off potential were determined using the WIN TR-55 software for each hydrologic basin using a weighted average of natural soil, vegetation, and ground conditions. Using the NRCS TR-55 Method and Golder's knowledge of the site conditions, CNs were assigned for the revegetated closure cover (placed above the TSF during closure), undisturbed existing ground, and newly graded areas.

Times of Concentration values (Tc) were calculated for each hydrologic catchment area using WIN TR-55 by inputting the longest flow path in each basin and the calculated composite CNs discussed in Section 3.2 (USDA 2011).

Temporary and permanent stormwater diversion channels were designed using the Manning's Equation via Bentley's hydraulic modeling software FlowMaster (FlowMaster 2009). Manning's roughness coefficients were selected for multiple channel lining systems based on Golder's experience and review of various technical publications.

Golder developed two hydrologic basin models for the Grassy Mountain TSF:

- Permanent Stormwater Diversion: The permanent stormwater diversion channels will collect stormwater runoff generated up-gradient of the TSF and divert the collected water around the TSF to existing natural

drainages. This scenario includes all channels that will remain in place during closure along with the drainage swale that will be constructed across the top of the reclaimed surface of the TSF during closure.

- Temporary Stormwater Diversion: During operation, temporary diversion channels will be constructed to divert stormwater falling downgradient of the permanent diversion channels around the TSF. These channels will be constructed during each stage.

The hydrologic assessment is presented in detail in Appendix G.

6.9.3 Stormwater Channel Hydraulic Design

Permanent and temporary stormwater diversion channels are designed to convey surface water run-off from up gradient catchment areas around the TSF to decrease the amount of run-on water that needs to be managed within the TSF. The stormwater channels are sized to contain the following:

- Permanent Channels: 100-year, 24-hour storm event with 9 inches of freeboard, or 500-year, 24-hour storm event without overtopping.
- Temporary Channels: 25-year, 24-hour storm event with 9 inches of freeboard, or 100-year, 24-hour storm event without overtopping.

A detailed summary of the hydraulic calculations is presented in Appendix G.

The initial upgradient portions of each permanent diversion channel will have a V-ditch shape with 2.5H:1V side slopes with channel grades along the flowline no steeper than one percent. The total depth of the V-ditch channels will range between 1.75 feet and 2.5 feet. As contributing areas and flow rates increase, the channel sections will transition to 10-foot wide trapezoidal channels with 2.5H:1V side slopes. The trapezoidal channel will have slopes ranging between one and five percent, with channel depths ranging between 1.75 feet and 4 feet. Typical channel cross sections are presented on the Design Drawings.

Channel velocities were reviewed during hydraulic design of the stormwater diversion channels to determine appropriate channel lining systems for erosion protection. In most areas, unless noted on the Design Drawings, the permanent diversion channels will either unlined or riprap-lined with variable stone sizes. In areas where channel velocities exceeded the reliability limits of a natural soil lining, riprap lining systems were used. Detailed discussion and design of the channel erosion protection are presented in Appendix G and detailed on the Design Drawings.

Dissipation aprons have been designed at two locations around the TSF where run-off is being discharged into existing natural drainages to encourage a smooth transition into the existing drainage and minimize erosion to the natural slopes. Detailed discussion and design of these structures are presented in Appendix G. Locations of the outlet dissipation aprons are shown on the Design Drawings.

7.0 WASTE ROCK DUMP FACILITY

Waste rock materials generated during mining will be stockpiled in a waste rock dump facility (WRD) near the TSF for use as either cement rock backfill to support the underground mining operation or as an operational layer above the tailings surface for closure as discussed in Section 12.0. The WRD is designed for an estimated storage capacity of 200,000 cubic yards. Geotechnical stability of the WRD is discussed in Section 0.

Waste rock will be stored above a geomembrane lined pad located south of the TSF as shown on the Design Drawings. The WRD pad will utilize the same lining system as the TSF basin as discussed in Section 6.3. The WRD pad is designed to capture and convey any precipitation infiltrating the waste rock to the TSF reclaim pond for independent monitoring and management. Generally, the WRD pad is slopes from south to north at an approximate one percent grade.

An underdrain collection system will be installed above the geomembrane liner similar to the TSF underdrain collection system (perforated piping within a drainage layer above the geomembrane liner). The collection system will consist of a series of perforated pipes installed within the drainage layer above the geomembrane liner. A single 6-inch diameter perforated double wall CPE primary collection pipe will capture flows from 4-inch diameter perforated double wall CPE pipes within the drainage layer.

Prior to exiting the WRD, the perforated 6-inch CPE primary collection pipe will transition to a solid-wall dual containment 6-inch diameter HDPE DR17 by 10-inch diameter HDPE DR17 pipe. The dual containment underdrain outlet pipe will penetrate through the lined perimeter berm of the WRD and travel above ground between the WRD and the edge of the TSF Stage 1 geomembrane liner limits.

At the Stage 1 TSF basin liner limits, the 10-inch diameter containment pipe will terminate, and the 6-inch diameter carrier pipe will continue to the TSF reclaim pond above the TSF basin geomembrane liner. The WRD underdrain collection system is presented in detail on the Design Drawings.

8.0 GEOTECHNICAL ANALYSES

8.1 TSF Embankment Slope Stability

Stability analyses were completed for cross-sections of the North and West TSF embankments and are presented in detail in Appendix C. The analyses were performed using the 2-D limit equilibrium methods provided by the software package Slide 2018 (Rocscience 2018). The analyzed cross-sections were evaluated for both static and pseudo-static loading conditions using the Morgenstern-Price Method of slices to calculate the FOS against failure along the critical surface (i.e., the failure surface with the minimum calculated FOS) that was identified through an automated search algorithm.

Based on the design criteria presented in Table 2, a minimum factor of safety of 1.5 is required for stability of the TSF embankments under static loading and a factor of safety of 1.1 is required for pseudo-static loading conditions. Both effective stress analysis (drained conditions) and total stress analysis (undrained conditions) were analyzed using the material properties summarized in Appendix C**.**

For pseudo-static stability analysis, a horizontal seismic coefficient (k) of half the design PGA was used (Hynes and Franklin 1984, and Seed 1982). For the TSF site, the seismic coefficient used is 0.075g, corresponding to half of the median MCE design seismic event.

Cross sections include the maximum embankment and dump heights of each facility, with additional sections developed at the North embankment to refine the need for a downstream buttress. Figure 1 in Appendix C presents the location of the cross sections analyzed for geotechnical stability assessment of the TSF embankments. Section A is within the North embankment and Section D is within the West embankment.

Section A extends through the highest North embankment height of 84 feet. Section D extends through the highest West embankment height of 30 feet.

The controlling method analysis was determined to be the static effective stress condition for all stages of both the North and West embankment. All minimum calculated factors of safety for Stage 1 (with downstream slope of 2.5H:1V) were found to be higher than the minimum criterion for both static and pseudo-static analyses for Sections A and D.

To achieve geotechnical stability, a small downstream buttress will be constructed for Stage 2 and 3. Sections B and C were used to determine the extents of the downstream buttress for the controlling condition (static, effective stress). The downstream buttress will be 15 feet high by 30 feet wide and constructed at the downstream toe as shown on the Design Drawings.

Stability analysis results for the TSF embankments are presented in Table 13 for effective stress analyses and Table 14 for total stress analyses .

Table 13: Summary of Critical Stability Results of TSF Embankments for Effective Stress Analyses

Stage	Static FOS (Target design minimum is 1.5)				Pseudo-static FOS (k = 0.075 g) (Target design minimum is 1.1)			
	North Embankment			West Embankment	North Embankment			West Embankment
	Section A	Section B	Section C	Section D	Section A	Section B	Section C	Section D
1	1.5	1.7	1.6	1.9	1.2	-	-	1.4
2	1.5	1.6	1.6	1.7	1.2	-	-	1.3
3	1.5	1.5	1.5	1.5	1.2	-	-	1.2

Table 14: Summary of Critical Stability Results of TSF Embankments for Total Stress Analyses

Stage	Static FOS (Target design minimum is 1.5)				Pseudo-static FOS (k = 0.075 g) (Target design minimum is 1.1)			
	North Embankment			West Embankment	North Embankment			West Embankment
	Section A	Section B	Section C	Section D	Section A	Section B	Section C	Section D
1	2.1	-	-	-	1.7	-	-	-
2	1.8	-	-	-	1.3	-	-	-
3	1.5	-	-	-	1.1	-	-	-

8.2 TSF Embankment Foundation Settlement

Settlement analysis was performed using Settle3D 4.0 (Rocscience 2019) software for a 150-foot thick clay layer with material properties summarized in Appendix C. The clay layer has been observed in boreholes down to the depth of about 120 feet below the North embankment as presented in Appendix A.

The actual thickness of the clay layer is not known. However, since the induced stresses, and consequently the settlements within the foundation caused by placement of the embankment fill material decrease with depth and the soil at depth is much stiffer, a thickness of 150 feet for compressible clay layer is considered to be sufficient for settlement estimations. Both elastic compression and primary consolidation were included in the settlement analysis presented in Appendix C. Settlements were estimated along the underdrain channel and pipe corridor (with maximum embankment height) of the North embankment of TSF.

A maximum settlement of about 3 feet was estimated under the crest of the embankment. Supporting figures and calculations are presented in Appendix C. To achieve the minimum underdrain pipe design grade of one percent, the underdrain piping will be installed below the North embankment at between 1.0 and 2.5 percent slopes. All calculated post-settlement grades meet the minimum required values for positive flow of the underdrain collection piping as discussed in Section 6.4.

8.3 TSF Embankment Crest Settlement

As staged construction progresses, primary settlements within the foundation and embankment will occur. Placement of subsequent construction fill lifts will be performed up to the final Stage 3 design crest elevation as shown on the Design Drawings. The consolidation of the foundation due to the additional lift at each stage of construction will take place after the immediate settlement and continue at a decreasing rate.

The minimum design freeboard of 2 feet from the maximum tailings surface to the dam crest will be large enough that long-term settlement of the embankment and foundation after tailings deposition is compete will not reduce the dam crest elevation such that it encroaches on the final tailings surface.

Upon completion of tailings deposition and during the active water management closure period, free water on the tailings surface will be evaporated and any settlement of the dam crest as a result of embankment and foundation settlement is expected to be less than settlement due to the foundation and tailings consolidation.

During long-term closure, once the tailings have consolidated and the closure cover installed, precipitation falling on the tailings surface will be routed through a closure spillway at the eastern abutment of the North embankment, as discussed Section 12.0. After installation of the closure cover, the impoundment surface and dam crest will be at the same relative elevation. The final closed TSF will not provide any water retention capacity above the closure cover.

8.4 WRD Stability Analysis

Stability analyses were completed for the WRD and are presented in detail in Appendix C. The analyses were performed using the 2-D limit equilibrium methods provided by the software package Slide 2018 (Rocscience 2018). Cross sections were evaluated for both static and pseudo-static loading conditions using the Morgenstern-Price Method of slices to calculate the FOS against failure along the critical surface identified through an automated search algorithm.

Based on the design criteria presented in Table 4, a minimum factor of safety of 1.5 is required for stability of the TSF embankments under static loading and a factor of safety of 1.1 is required for pseudo-static loading conditions.

The WRD is designed to remain in place during operation only. Due to the temporary nature of the WRD, geotechnical stability of the WRD was performed for static and pseudo-static conditions using an operational basis earthquake (OBE) with a return period of 475 years instead of the median MCE used for the TSF.

For pseudo-static stability analysis, a horizontal seismic coefficient (k) of half the design PGA was used (Hynes and Franklin 1984, and Seed 1982). For the WRD site, the seismic coefficient used is 0.04g, corresponding to half of the median 475-year return period.

The analyzed cross section (Section E) includes the maximum waste rock dump height of 35 feet. Figure 1 in Appendix C presents the location of the cross section analyzed for geotechnical stability assessment of the WRD.

To achieve stability of the WRD along the northern slope, the maximum height of the WRD is limited to 35 feet. Additionally, waste rock is required to be stacked against the geomembrane-lined perimeter containment berm with a maximum vertical separation of 2 feet from the crest of the berm to the toe waste rock dump slope as shown on the Design Drawings

Stability of the WRD should be reassessed if higher waste rock heights are to be constructed. Stability analysis results for the WRD are presented in Table 15 below.

Table 15: Summary of Critical Stability Analysis Results of WRD

Static FOS (Target design minimum is 1.5)		**Pseudo-static FOS (475-year, k = 0.04 g) (Target design minimum is 1.1)**	
Failure through Foundation	Waste Rock Slide over the Liner	Failure through Foundation	Waste Rock Slide over the Liner
1.8	1.6	1.5	1.3

9.0 CONSTRUCTION MATERIALS AND MONITORING

Detailed specifications for all construction materials required to construct the facilities discussed in this Report are presented in Appendix I.

The quality of the constructed facilities will be critical to the success of this project. Calico will assure that qualified personnel under the direction of an engineer registered in the State of Oregon will be on the site full-time during critical phases of construction. Their role will be to observe and/or provide quality assurance testing for topsoil stripping, subgrade preparation, basin/pad grading, fill placement, geomembrane bedding layer placement, geosynthetics installation, collection piping installation, drainage layer placement, filter fill placement, and piping installation. Recommendations provided by the Engineer of Record concerning suitability of construction materials, compaction, and liner construction will help expedite the project and help Calico ensure compliance with the technical specifications presented in Appendix I.

A Construction Quality Assurance (CQA) plan has been prepared to supplement and highlight the testing and verification requirements during construction outlined in the technical specification. The plan includes: type and

frequency of testing of materials during manufacturing and installation; guidelines on reporting and correcting deficiencies observed during construction or identified during materials testing; embankment material test fill procedures, daily field observation and material test documentation forms; and as-built documentation requirements for the completed project. The CQA plan for Appendix J.

Borrow material will be required for construction of the TSF embankments, TSF basin, WRD pad, containment systems, reclaim pond, and access roads. The following section presents general descriptions of each primary construction material used to construct the TSF embankments, TSF basin, and WRD pad.

9.1 Embankment Fill

Materials used as embankment fill are expected to vary in composition depending on their source but are expected to vary between blasted run-of-quarry rockfill compositions of poorly graded high quality angular rock containing few fine (passing the No. 200 screen) material (less than 20 percent) produced in the Basalt Borrow Quarry, and silty to clayey sand with varying amounts of gravel generated during grading operations within the TSF basin area.

Materials encountered in the Basalt Borrow Quarry may require ripping and/or blasting. Native foundation clay soils underlying the surficial alluvium within the TSF basin and blow the TSF embankments, described in Section 4.2, are not suitable for embankment fill construction.

Weathered arkosic sandstone is considered to be unsuitable for embankment as the material is generally brittle and erosive. If material meeting the requirements for embankment fill is used as fill beneath planned structures, screening may be required to remove over-sized material.

Technical specification for Embankment Fill construction material and placement methods are presented in Appendix I.

9.2 Grading Fill

General shape grading will be required within the TSF basin and WRD pad area to promote positive drainage to the designed low points of each facility. Within the TSF basin and in areas designated on the Design Drawings, excavations up to 9 feet and fills as high as 6 feet will be required. During Stage 2, an excavation of 13 feet will be required to construct the perimeter road between the North and West embankments along the northern portion of the facility.

During on-site grading operations, materials excavated will be used as fill to achieve the design grades. These native alluvial materials within the upper several feet are expected to be vary between high plasticity fine-grained soils to non-plastic coarse grained poorly graded sand with gravel. All native alluvial materials encountered during on-site basin grading operations may be used as Grading Fill.

Native foundation clay soils underlying the surficial alluvium within the TSF basin and blow the TSF embankments, described in Section 4.2, are not suitable for use as Grading Fill. If, during on-site grading operations, the underlying foundation clay soils are exposed, the exposed areas are to be graded to prevent water ponding. Within the TSF basin, Grading Fill will be placed over the foundation clay soils a minimum thickness of 12 inches.

Technical specification for Grading Fill construction material and placement methods are presented in Appendix I.

9.3 Prepared Subgrade

A smooth surface free of rocks greater than 1-inch diameter is required for placement of the geosynthetic lining systems. Native alluvial materials near surface within the TSF and WRD basin are suitable for use as Prepared Subgrade. In general, Prepared Subgrade will have a maximum particle size of 3-inches and may have a fines (No. 200 screen) content as high as 50 percent by weight, and a Plasticity Index less than or equal to 20.

In areas where native ground requires only smoothing and no fill placement, only surface preparation is required for geosynthetics placement. In areas where Grading Fill is placed to achieve the design grades, the upper surface will proof-rolled and areas not suitable for geosynthetics placement will be over excavated and native fill materials meeting the specifications for Prepared Subgrade will be placed to the design lines and grades.

Technical specification for Prepared Subgrade construction material and placement methods are presented in Appendix I.

9.4 Drainage Layer

The Drainage Layer above the geomembrane liner within the TSF basin and WRD pad are critical to the performance of the facilities. The Drainage Layer provides protection of the geomembrane liner from damage and promotes drainage of the tailings and waste rock stockpile. The Drainage Layer will be placed in a single 18-inch loose lift. The Drainage Layer will be uncompacted and placed using low ground pressure tracked equipment. After placement, the top surface of the Drainage Layer will be ripped or bladed to be free of ridges, mounds, or ponding areas.

The Drainage Layer material will be a processed material either from the Basalt Borrow Quarry or excavated during on-site grading operations. The Drainage Layer will have a maximum particle size of 3-inches and a maximum fines (No. 200 screen) content of 15 percent by weight, with a Plasticity Index less than or equal to 10. The Drainage Layer will have a hydraulic conductivity faster than 5×10^{-3} cm/sec when measured in a laboratory rigid wall permeameter per ASTM D5856.

Technical specification for Drainage Layer construction material and placement methods are presented in Appendix I.

9.5 Filter Layer

A filter layer will be placed above the Drainage Layer to restrict tailings migration into the Drainage Layer. The Filter Fill will be placed in a single 6-inch loose lift. The Filter Fill will be uncompacted and placed using low ground pressure tracked equipment. After placement, the top surface of the Filter Fill will be ripped or bladed to be free of ridges, mounds, or ponding areas.

The Filter Fill material is to be either a processed material from the Basalt Borrow Quarry or during on-site grading operations. The Filter Fill will have a maximum particle size of 1½-inches and a fines (No. 200 screen) content between 10 and 30 percent, but weight, with a Plasticity Index less than or equal to 10. The Filter Fill will have a hydraulic conductivity faster than 5×10^{-4} cm/sec when measured in a laboratory rigid wall permeameter per ASTM D5856.

Technical specification for Filter Fill construction material and placement methods are presented in Appendix I.

9.6 Drain Gravel

Drain Gravel will be placed around the primary underdrain collection pipes, within the underdrain outlet channel, and within the reclaim pond LCRS sump.

Drain Gravel will be crushed and screen material from the Basalt Borrow Quarry with a maximum particle size of 2-inches and a maximum fines (No. 200 screen) content of 5 percent by weight, with a Plasticity Index of less than or equal to 10.

Technical specification for the Drain Gravel construction material and placement methods are presented in Appendix I.

9.7 Leak Detection Fill

Leak Detection Fill will be placed around the perforated leak detection pipes between the primary and secondary liners of the TSF basin, underdrain channel, and WRD pad.

Leak Detection Fill will be crushed and screen material from the Basalt Borrow Quarry with a maximum particle size of 1-inch with a maximum fines (No. 200 screen) content of 10 percent, but weight, with a Plasticity Index of less than or equal to 5.

Technical specification for Leak Detection Fill construction material and placement methods are presented in Appendix I.

10.0 GEOTECHNICAL MONITORING

To monitor the performance and stability of the TSF and WRD during construction and operation, a geotechnical monitoring plan was prepared and is presented in Appendix K. The goals of monitoring the Grassy Mountain TSF and WRD are to:

- Monitor pore pressure in the foundation clay to detect development of excess pore pressures during the construction of the Stages 1 through 3 North Embankment to confirm short-term construction stability and to monitor pore pressures throughout the operating life of the facility.
- Monitor the pore pressure at the base of the impounded tailings above the toe drain pipe and primary underdrain collection pipes in the TSF and WRD to confirm that the drainage system continues to operate within design parameters.
- Monitor pore pressures in the foundation below the TSF basin and WRD pad lining systems to confirm the proper containment performance.
- Monitor leakage flow rates between the primary and secondary containment layers in the TSF and WRD liner systems.
- Monitor flow rates from the primary TSF collection pipes, and the TSF toe drain pipe, prior to discharge into the reclaim pond to verify proper functioning of the pipes and to support water balance estimates.
- Monitor displacements of the TSF dam embankment crest that could indicate instability and/or excessive settlement.

- Monitor potential subsurface displacements within the TSF dam embankment and in the underlying foundation soils to provide early indication of potential instability prior to development of evidence that can be measured or recognized at the surface.
- Visually inspect the operation and general condition of the TSF and WRD during operation and construction to monitor the overall performance of the facilities.

Monitoring is accomplished through both measurements of the monitoring points presented in Appendix K and visual observations of surface conditions. For the purposes of the geotechnical monitoring plan, a monitoring point is defined as any geotechnical instrument or dam crest survey monument installed to monitor the geotechnical field conditions at the TSF and WRD.

The geotechnical monitoring plan further defines the roles and responsibilities of key stakeholders for safe and stable construction and operation of the TSF and WRD. These include, the Owner/Operator, Engineer, Monitor, and Surveyor.

11.0 DAM BREACH ANALYSIS

As discussed in Section 2.1, based on Golder's assessment of the existing downstream conditions (habitable structures, utilities, life lines, and public access roads), the hazard rating is recommended to be "Low."

Although a dam breach inundation analysis is not required for low Hazard Dams per OAR 690-020-0120, Golder completed one for the ultimate Grassy Mountain TSF with the intent that it be used as a guide for OWRD in selecting an appropriate hazard rating for the TSF.

It is important to note that the purpose of this analysis is to evaluate the consequence of failure, and not the probability of failure. The simulated dam breach scenario presented is hypothetical and is not a reflection of the embankment integrity or stability of the TSF. Detailed discussion and results of the dam breach inundation analysis are presented in Appendix L.

Golder utilized two hydrodynamic model software packages to estimate the inundation area. These included FLDWAV (1998), and FLO-2D (2009). FLDWAV was used to model the potential breach North embankment. FLO-2D was used to route the non-Newtonian tailings dam breach flood hydrographs from the TSF along the downstream study reaches.

FLO-2D is a two-dimensional hydraulic model with an unsteady-state flow routing component. FLO-2D has been approved by the U.S. Federal Emergency Management Agency (FEMA) for riverine studies and unconfined flood analyses. FLO-2D can be applied to a number of complex flood problems including mud and debris consisting of non-homogenous, non-Newtonian flows. The high solids content of a tailings flow categorizes it as a non-Newtonian flow; therefore, FLO-2D is considered an appropriate method for tailings flood routing and has gained wide acceptance for routing of tailings.

For this analysis, Golder evaluated the following critical scenario:

- Full Capacity Breach: The TSF is filled to the ultimate capacity at the end of Stage 3 with a maximum operating pool.
- Rainy Day Breach Event: The breach would occur concurrent with the addition of water from the Inflow design flood generated from the 500-year, 24-hour storm event (storm depth of 2.91 inches) during operation of the facility.

- Full-Depth Breach: To justify use of a full-depth breach from an engineering view, Golder assumed that the embankment breach would occur due to piping failure at a location along the downstream toe of the North embankment corresponding to the location of the maximum embankment height.

In this scenario, an estimated total volume of 1.07 M cubic yards would be released. This volume includes tailings, embankment material, and free water on the tailings surface. The findings from the inundation analysis include:

- The TSF flood flows would follow an existing ephemeral drainage running adjacent to Rock Canyon Road.
- The total tailings slurry deposition area inundated would be approximately 834 acres.
- Golder reviewed aerial imagery, and it is our understanding that there are no occupied structures within the tailings slurry inundation area.
- The modeled maximum tailings runout distance from the TSF is approximately 12 miles, beyond which flows would not pose a significant risk to human life.
- The peak flood travel time from the TSF to the maximum tailings runout distance (12 miles) would be approximately 48 hours.
- No habitations or lifelines would be impacted by the simulated event.
- Public access to the project site and areas south along Rock Canyon Road and Twin Springs would either be inaccessible, or access limited, until tailings solids could be removed. Alternative public access routes would remain operational.

The results of this analysis will be incorporated into a facility-specific Emergency Action Plan (EAP) prepared prior to construction of the facility. The EAP will prepared in accordance with FEMA's *Federal Guidelines for Dam Safety, Emergency Action Planning for dams*, FEMA 64 (FEMA 2013).

12.0 CLOSURE

The conceptual closure design of the TSF is intended to meet the OAR requirements. In accordance with the OAR 340-043-0140 (5) requirement, the tailings surface will be covered with a composite cover designed to prevent water and air infiltration. Upon completion of mining operations, active deposition into the TSF will cease. During this time, water collected in the TSF reclaim pond will be recirculated to the supernatant pool for active water management. Over time, the supernatant pool will evaporate and the underdrain flows reporting from the TSF will reduce as the tailings consolidate and drain. This is considered the active management period of closure.

Once the tailings surface no longer has a free water surface and the tailings continue to desiccate and densify, a closure cover can be constructed over the tailings surface and TSF embankments. The closure cover should be installed at a point in time where the majority of tailings consolidation has occurred and is not expected to negatively impact drainage of the closure cover.

The TSF closure cover is presented on the Design Drawings and will be constructed with the following (bottom to top):

- Operational layer of waste rock (if available) or other materials to provide vehicle access
- 4 to 12 inches of Liner bedding (if required)

- Geomembrane liner
- 12 to 18 inches of non-acid generating drainage layer
- 12 to 24 inches of growth medium

Upon cessation of mining operations, the remaining waste rock (if any) stockpiled on the WRD will be removed and placed as an operation layer above the tailings surface when it is safe to do so. The WRD lining system will either be removed or buried upon completion of mining operations.

During this time, water collected in the TSF reclaim pond will be recirculated to the supernatant pool for active water management. Over time, the supernatant pool will evaporate and the underdrain flows reporting from the TSF will reduce as the tailings consolidate and drain. This is considered the active management period of closure.

Once tailings underdrain flow rates reduce to levels considered appropriate for passive water management, the reclaim pond will be retrofitted to a geomembrane-lined evaporation pond. With installation of the closure cover and gravity drainage from the underdrain collection system, it is expected that underdrain flows from the TSF will cease.

Upon completion of closure cover construction, stormwater falling on the TSF and upgradient catchment areas below the permanent diversion channels, will be routed over the covered impoundment surface to a closure drop chute channel located at the eastern abutment of the North embankment. The closure drop chute and impoundment surface swale are designed to safely convey stormwater flows resulting from the 500-year, 24-hour storm. Conceptual closure of the TSF and WRD are presented on the Design Drawings.

13.0 REFERENCES

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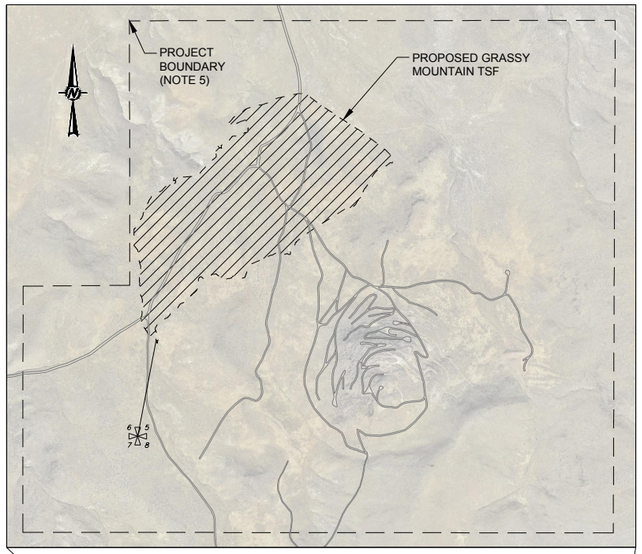
CJM/MDB/RAB/kg

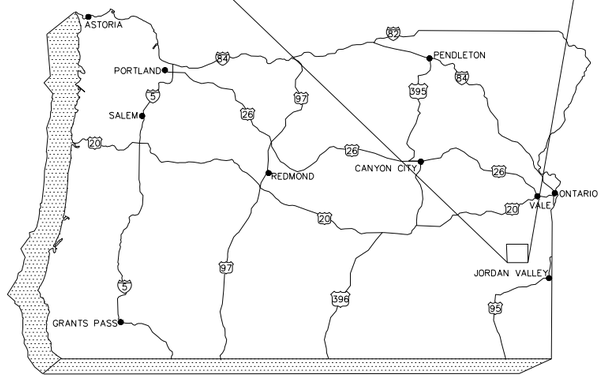
Design Drawings



SITE LOCATION MAP

(NOT TO SCALE)

NEAREST TOWNSHIP AND RANGE LOCATED IN S8 T22S R44E



STATE OF OREGON

(NOT TO SCALE)

CALICO RESOURCES USA CORP.

GRASSY MOUNTAIN PROJECT

TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP

MALHEUR COUNTY, OREGON

Sheet List Table	
Sheet Number	Sheet Title
T1	TITLE SHEET
G1	TSF STORAGE CAPACITY CURVE
G2	GEOTECHNICAL EXPLORATION LOCATION MAP
C1	OVERALL FACILITY LAYOUT
C2	TAILINGS STORAGE FACILITY LAYOUT - STAGE 1 BASIN GRADING
C3	UNDERDRAIN CHANNEL LAYOUT
C4	RECLAIM POND LAYOUT
C5	TAILINGS STORAGE FACILITY LAYOUT - STAGE 1
C6A	EMBANKMENT AND ROAD PROFILE (1 OF 2) - STAGE 1
C6B	EMBANKMENT AND ROAD PROFILE (2 OF 2) - STAGE 1
C7	PERMANENT ACCESS ROAD PROFILE
C8	TAILINGS FACILITY LAYOUT - STAGE 2
C9A	EMBANKMENT AND ROAD PROFILE (1 OF 2) - STAGE 2
C9B	EMBANKMENT AND ROAD PROFILE (2 OF 2) - STAGE 2
C10	TAILINGS STORAGE FACILITY LAYOUT - STAGE 3
C11A	EMBANKMENT AND ROAD PROFILE (1 OF 2) - STAGE 3
C11B	EMBANKMENT AND ROAD PROFILE (2 OF 2) - STAGE 3
C12	TAILINGS STORAGE FACILITY OVERALL SECTIONS
C13	TAILINGS STORAGE FACILITY EMBANKMENT SECTIONS
C14	WASTE ROCK DUMP LAYOUT
C15	UNDERDRAIN COLLECTION SYSTEM LAYOUT

Sheet List Table (Continued)	
Sheet Number	Sheet Title
C16	LEAK DETECTION SYSTEM LAYOUT
C17	CONCEPTUAL CLOSURE PLAN
D1	DETAILS (1 OF 9) - TAILINGS STORAGE FACILITY
D2	DETAILS (2 OF 9) - UNDERDRAIN COLLECTION SYSTEM
D3	DETAILS (3 OF 9) - UNDERDRAIN COLLECTION SYSTEM
D4	DETAILS (4 OF 9) - UNDERDRAIN COLLECTION SYSTEM, RECLAIM WATER, AND TAILINGS DISTRIBUTION
D5	DETAILS (5 OF 9) - UNDERDRAIN FLUME
D6	DETAILS (6 OF 9) - RECLAIM POND
D7	DETAILS (7 OF 9) - WASTE ROCK DUMP
D8	DETAILS (8 OF 9) - WASTE ROCK DUMP
D9	DETAILS (9 OF 9) - STRUCTURAL CONCRETE
SW1	EAST PERMANENT DIVERSION CHANNEL ALIGNMENT
SW2	WEST PERMANENT DIVERSION CHANNEL ALIGNMENT
SW3	STORMWATER DIVERSION CHANNEL PROFILES
SW4	STORMWATER DIVERSION DETAILS (1 OF 2)
SW5	STORWATER DIVERSION DETAILS (2 OF 2)
I1	GEOTECHNICAL INSTRUMENTATION LAYOUT (1 OF 2)
I2	GEOTECHNICAL INSTRUMENTATION LAYOUT (2 OF 2)
I3	GEOTECHNICAL INSTRUMENTATION SECTIONS
I4	GEOTECHNICAL INSTRUMENTATION DETAILS (1 OF 2)
I5	GEOTECHNICAL INSTRUMENTATION DETAILS (2 OF 2)

GENERAL NOTES

1. EXISTING GROUND TOPOGRAPHY PROVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf".
2. AERIAL IMAGERY PROVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "Orthophoto_1ft_ExpandedArea.tif".
3. PROJECT AREA BOUNDARY PROVIDED BY CALICO RESOURCES USA CORP. ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".
4. DRAWINGS PRESENTED IN NAD83 DATUM, ZONE 11, VERTICAL DATUM (NAVD) 88.
5. UNLESS OTHERWISE NOTED, ALL ELEVATIONS ARE TO LINER SURFACE OR FINISH GROUND IN UNLINED AREAS.

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TITLE SHEET

PROJECT NO. 1663241 | REV. 0 | 1 of 42 | DRAWING T1

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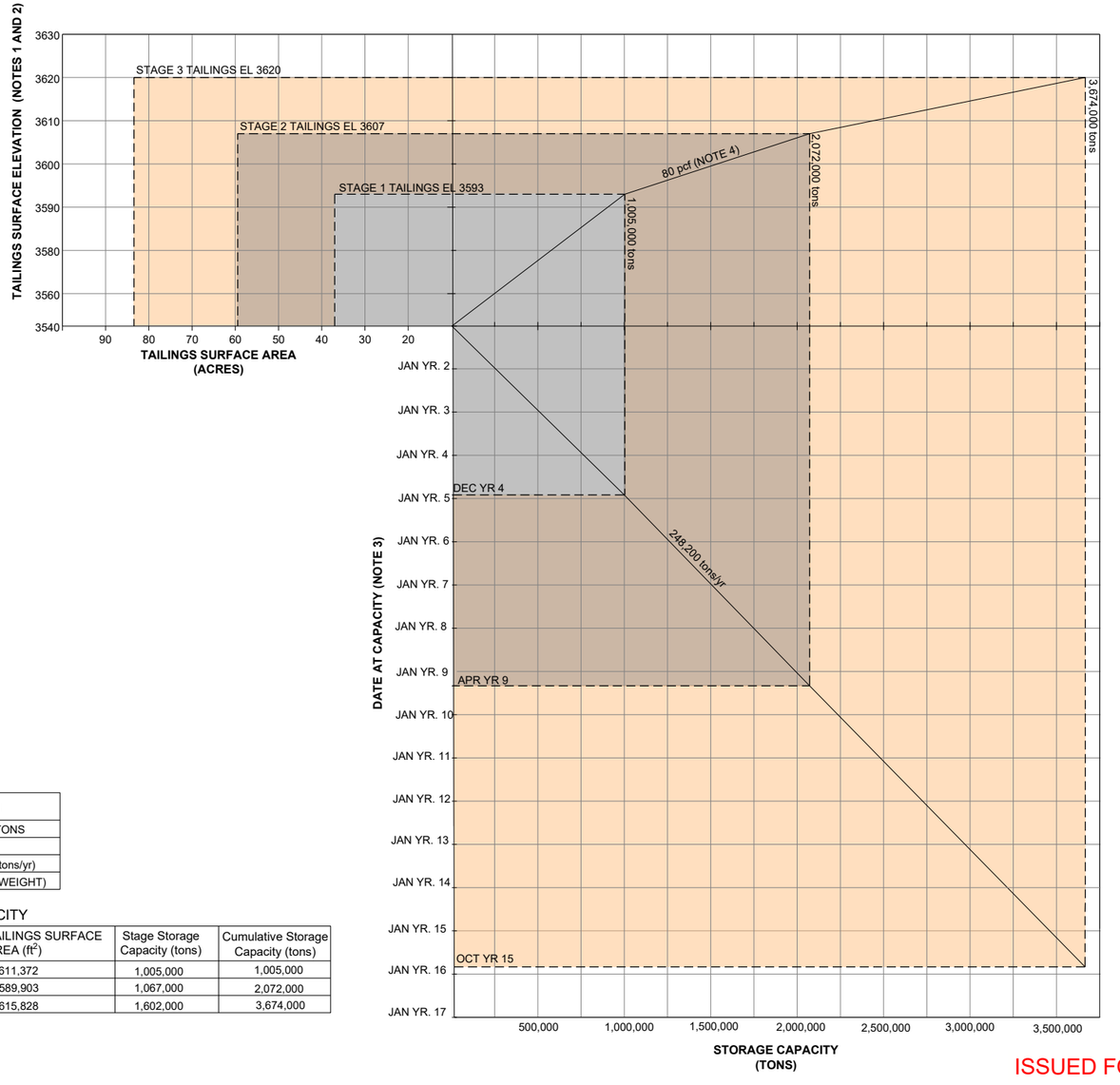
ABBREVIATIONS	
UNIT	TERMINOLOGY
DWG	DRAWING
ft	FEET
ft²	SQUARE FEET
PCF	POUND-FORCE PER CUBIC FOOT
mi	MILES
TP	TEST PIT
BH	BOREHOLE
CPT	CONE PENETRATION TEST
℄	REFERENCE LINE
CP	CONTROL POINT
YR	YEAR
N	NORTHING
E	EASTING
EL	ELEVATION
ST.	STAGE
STA.	STATION
INC	INCLINOMETER
SM	SURVEY MONUMENT
PZ-TF	FOUNDATION PIEZOMETER - BELOW TSF EMABNKMENTS
PZ-TI	IMPOUNDMENT PIEZOMETER - DRAINAGE LAYER ABOVE TSF LINING SYSTEM
PZ-TU	UNDERLINER PIEZOMETER - BELOW TSF LINING SYSTEM
PZ-WI	IMPOUNDMENT PIEZOMETER - DRAINAGE LAYER ABOVE WRD LINING SYSTEM
PZ-WU	UNDERLINER PIEZOMETER - BELOW WRD LINING SYSTEM
CPP	RECLAIM POND CONTROL POINTS
CPU	UNDERDRAIN CHANNEL CONTROL POINTS
CPW	WASTE ROCK DUMP CONTROL POINTS
C/C	CENTER-ON-CENTER
MIN	MINIMUM
MAX	MAXIMUM
DR	DIMENSION RATIO
S.S.	STAINLESS STEEL
STD.	STANDARD
MIL	MILLIMETER
GCL	GEOSYNTHETIC CLAY LINER
HDPE	HIGH-DENSITY POLYETHYLENE
CPE	CORRUGATED POLYETHYLENE
DIA.	DIAMETER
IN.	INCHES
SCH.	SCHEDULE

DESIGN PARAMETER

PARAMETERS	DESIGN
TARGET TAILINGS CAPACITY	3.67 MILLION TONS
AVERAGE TAILINGS DRY DENSITY	80 PCF
MAXIMUM THROUGHPUT RATE	680 tpd (248,200 tons/yr)
DESIGN SLURRY CONCENTRATION	~46% SOLIDS (BY WEIGHT)

PHASE ELEVATIONS AND CAPACITY

STAGE	MAXIMUM EMBANKMENT HEIGHT (ft)	MAIN EMBANKMENT CREST ELEVATION (ft)	MAXIMUM TAILINGS SURFACE AREA (ft²)	Stage Storage Capacity (tons)	Cumulative Storage Capacity (tons)
1	53	Varies (Max. 3595)	1,611,372	1,005,000	1,005,000
2	68	Varies (Max. 3609)	2,589,903	1,067,000	2,072,000
3	84	Varies (Max. 3622)	3,615,828	1,602,000	3,674,000



LEGEND

- STAGE I TAILINGS STORAGE
- STAGE II TAILINGS STORAGE
- STAGE III TAILINGS STORAGE

NOTES

1. TAILINGS SURFACE ELEVATION IS THE MAXIMUM ELEVATION OF THE TAILINGS ADJACENT TO THE NORTH EMBANKMENT.
2. MINIMUM FREEBOARD AT NORTH EMBANKMENT IS 2 FEET ABOVE MAXIMUM TAILINGS SURFACE ELEVATION.
3. ASSUMES TAILINGS DEPOSITION BEGINS JANUARY OF YEAR 1.
4. ASSUMED TAILS DENSITY BASED ON GOLDER'S 2019 CONSOLIDATION TESTING AND MODELING PROGRAM.

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TSF STORAGE CAPACITY CURVE

PROJECT NO. 1663241 | REV. 0 | 2 of 42 | DRAWING G1

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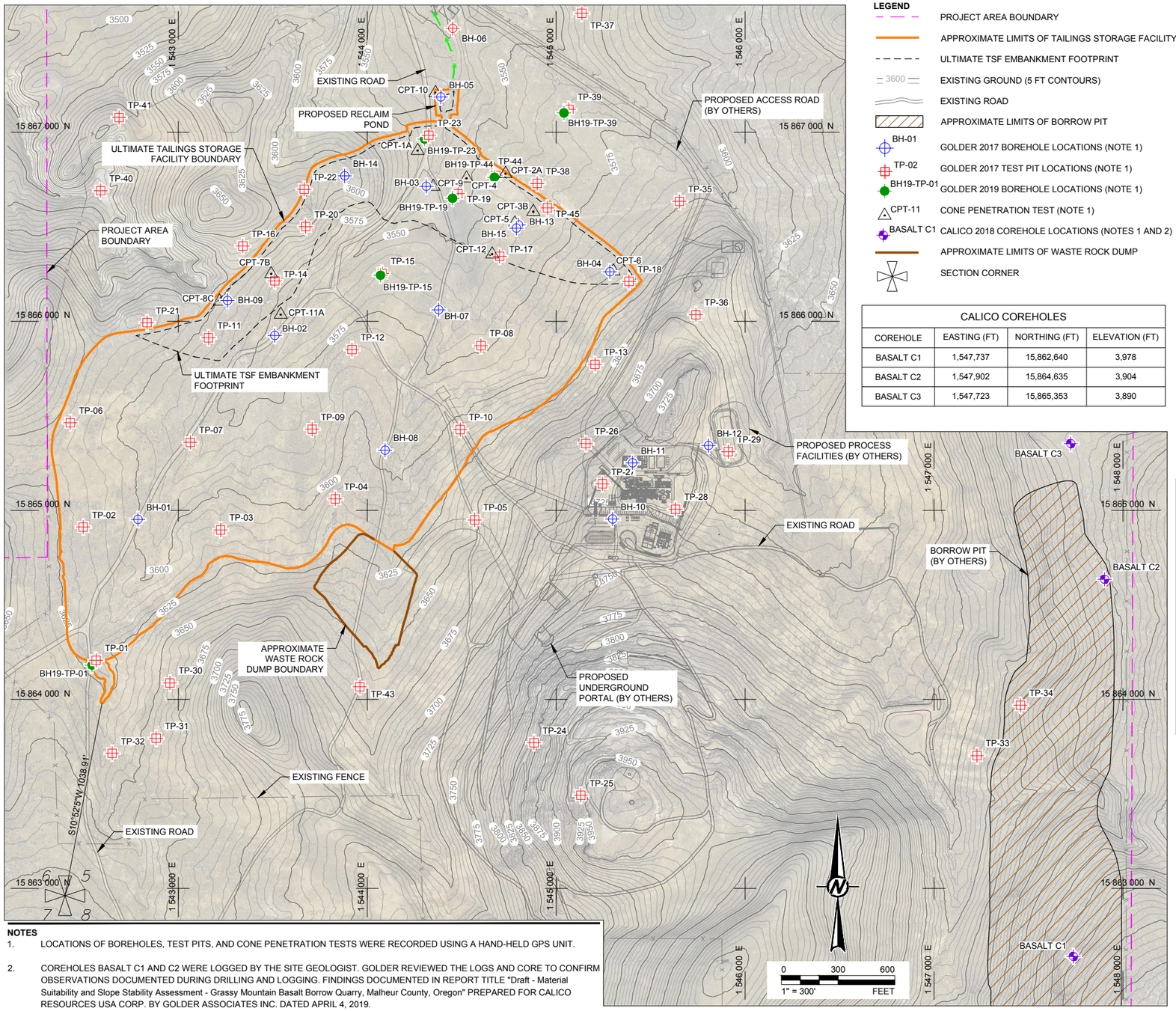

LEGEND

- PROJECT AREA BOUNDARY
- APPROXIMATE LIMITS OF TAILINGS STORAGE FACILITY
- ULTIMATE TSF EMBANKMENT FOOTPRINT
- 3600 EXISTING GROUND (5 FT CONTOURS)
- EXISTING ROAD
- APPROXIMATE LIMITS OF BORROW PIT
- BH-01 GOLDER 2017 BOREHOLE LOCATIONS (NOTE 1)
- TP-02 GOLDER 2017 TEST PIT LOCATIONS (NOTE 1)
- BH19-TP-01 GOLDER 2019 BOREHOLE LOCATIONS (NOTE 1)
- CPT-11 CONE PENETRATION TEST (NOTE 1)
- BASALT C1 CALICO 2018 COREHOLE LOCATIONS (NOTES 1 AND 2)
- APPROXIMATE LIMITS OF WASTE ROCK DUMP
- SECTION CORNER

CALICO COREHOLES			
COREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BASALT C1	1,547,737	15,862,640	3,978
BASALT C2	1,547,902	15,864,635	3,904
BASALT C3	1,547,723	15,865,353	3,890

TEST PIT COORDINATES			
TEST PIT	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
TP-01	1,542,565	15,864,207	3,618
TP-02	1,542,497	15,864,912	3,617
TP-03	1,543,224	15,864,896	3,609
TP-04	1,543,831	15,865,060	3,614
TP-05	1,544,568	15,864,949	3,648
TP-06	1,542,429	15,865,463	3,617
TP-07	1,543,064	15,865,360	3,622
TP-08	1,544,601	15,865,871	3,573
TP-09	1,543,709	15,865,430	3,586
TP-10	1,544,492	15,865,427	3,607
TP-11	1,543,160	15,865,912	3,595
TP-12	1,543,919	15,865,850	3,586
TP-13	1,545,206	15,865,772	3,634
TP-14	1,543,511	15,866,214	3,582
TP-15	1,544,079	15,866,253	3,565
TP-16	1,543,342	15,866,398	3,617
TP-17	1,544,701	15,866,344	3,559
TP-18	1,545,385	15,866,211	3,611
TP-19	1,544,480	15,866,675	3,546
TP-20	1,543,674	15,866,501	1,099
TP-21	1,542,835	15,865,993	3,619
TP-22	1,543,667	15,866,698	3,615

TEST PIT COORDINATES			
TEST PIT	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
TP-23	1,544,326	15,866,983	3,541
TP-24	1,544,883	15,863,771	3,840
TP-25	1,545,130	15,863,493	3,943
TP-26	1,545,157	15,865,353	3,697
TP-27	1,545,245	15,865,140	3,719
TP-28	1,545,631	15,865,005	3,722
TP-29	1,545,911	15,865,310	3,680
TP-30	1,542,956	15,864,087	3,659
TP-31	1,542,882	15,863,794	3,657
TP-32	1,542,650	15,863,715	3,637
TP-33	1,547,227	15,863,702	3,789
TP-34	1,547,458	15,863,969	3,826
TP-35	1,545,653	15,866,634	3,597
TP-36	1,545,740	15,866,034	3,669
TP-37	1,545,136	15,867,629	3,562
TP-38	1,544,900	15,866,729	3,563
TP-39	1,545,067	15,867,121	3,565
TP-40	1,542,589	15,866,691	3,501
TP-41	1,542,687	15,867,078	3,550
TP-43	1,543,961	15,864,067	3,662
TP-44	1,544,680	15,866,772	3,554
TP-45	1,544,954	15,866,599	3,564

BOREHOLE COORDINATES			
BOREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BH-01	1,542,787	15,864,952	3,600
BH-02	1,543,510	15,865,924	3,571
BH-03	1,544,313	15,866,714	3,531
BH-04	1,545,284	15,866,262	3,598
BH-05	1,544,389	15,867,186	3,528
BH-06	1,544,452	15,867,549	3,530
BH-07	1,544,378	15,866,060	3,567
BH-08	1,544,094	15,865,318	3,597
BH-09	1,543,260	15,866,110	3,597
BH-10	1,545,298	15,864,954	3,733
BH-11	1,545,404	15,865,251	3,718

BOREHOLE COORDINATES			
BOREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BH-12	1,545,806	15,865,342	3,691
BH-13	1,544,801	15,866,510	3,558
BH-14	1,543,881	15,866,769	3,601
BH-15	1,544,789	15,866,492	3,558
BH19-TP-01	1,542,543	15,864,181	3,618
BH19-TP-15	1,544,070	15,866,243	3,565
BH19-TP-19	1,544,451	15,866,651	3,546
BH19-TP-23	1,544,304	15,866,964	3,541
BH19-TP-39	1,545,041	15,867,102	3,565
BH19-TP-44	1,544,673	15,866,762	3,554

CONE PENETRATION TEST COORDINATES			
NAME	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
CPT-1A	1,544,267	15,866,903	3,545
CPT-2A	1,544,732	15,866,781	3,557
CPT-3B	1,544,879	15,866,580	3,560
CPT-4	1,544,525	15,866,756	3,548
CPT-5	1,544,781	15,866,518	3,558
CPT-6	1,545,303	15,866,264	3,599
CPT-7B	1,543,492	15,866,250	3,586
CPT-8C	1,543,219	15,866,106	3,599
CPT-9	1,544,351	15,866,712	3,542
CPT-10	1,544,361	15,867,209	3,538
CPT-11A	1,543,542	15,866,035	3,571
CPT-12	1,544,661	15,866,355	3,558

NOTES

1. LOCATIONS OF BOREHOLES, TEST PITS, AND CONE PENETRATION TESTS WERE RECORDED USING A HAND-HELD GPS UNIT.
2. COREHOLES BASALT C1 AND C2 WERE LOGGED BY THE SITE GEOLOGIST. GOLDER REVIEWED THE LOGS AND CORE TO CONFIRM OBSERVATIONS DOCUMENTED DURING DRILLING AND LOGGING. FINDINGS DOCUMENTED IN REPORT TITLE "Draft - Material Suitability and Slope Stability Assessment - Grassy Mountain Basalt Borrow Quarry, Malheur County, Oregon" PREPARED FOR CALICO RESOURCES USA CORP. BY GOLDER ASSOCIATES INC. DATED APRIL 4, 2019.

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REGISTERED PROFESSIONAL ENGINEER
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

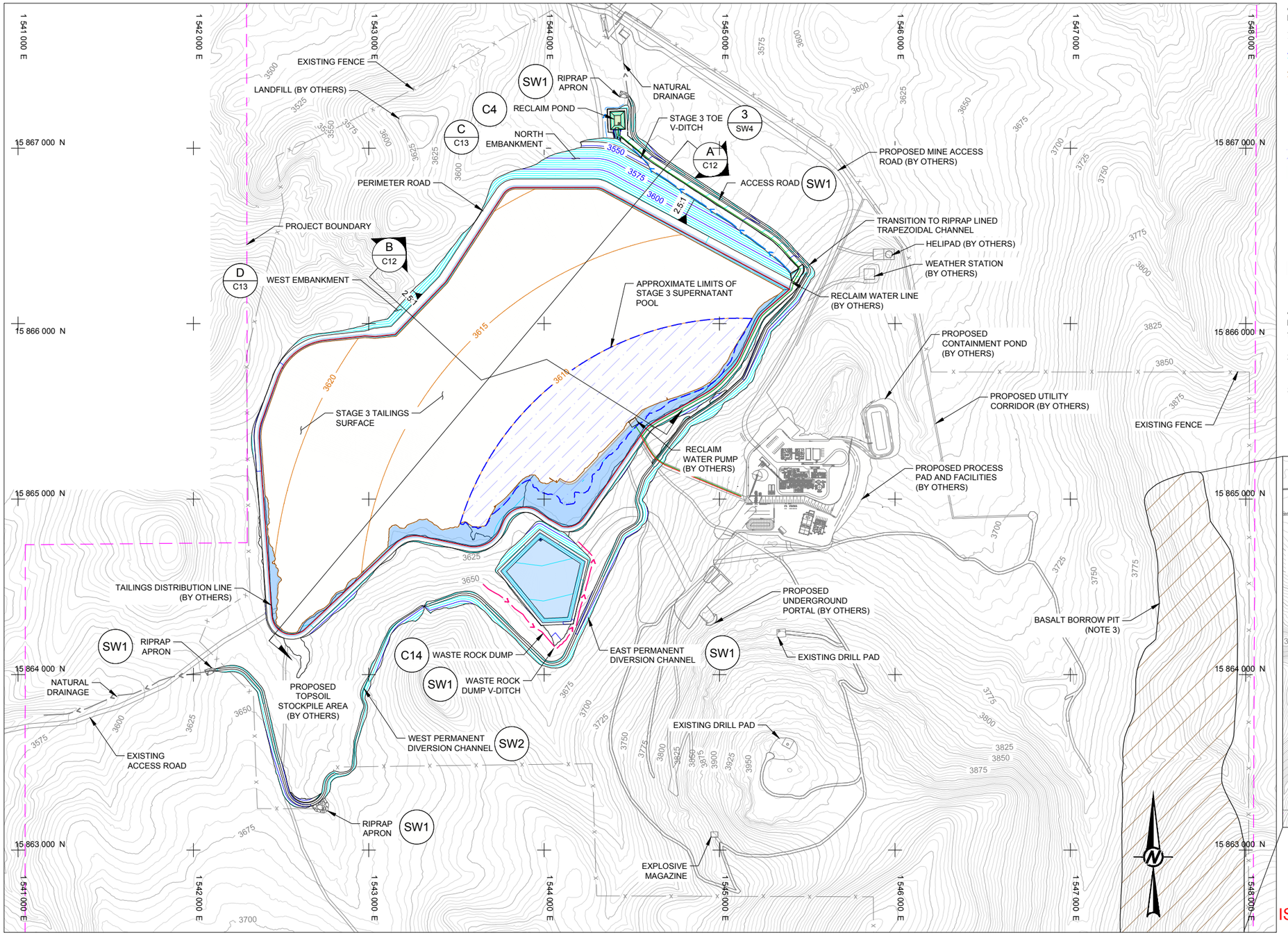
TITLE
GEOTECHNICAL EXPLORATION LOCATION MAP

PROJECT NO. 1663241
REV. 0

DRAWING G2

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

Path: \\enodata\MIDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: 1663241_G_001_Geotechnical drilling and site layout.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:11:27:25 AM | Printed By: JePrice Date: 2019-11-06 Time:2:59:29 PM



LEGEND

- EXISTING GROUND CONTOURS (5 FT CONTOURS) (GENERAL NOTE 1)
- PROPOSED CONTOURS (5 FT CONTOURS)
- PROPOSED TAILINGS SURFACE (5 FT CONTOURS)
- TAILINGS DISTRIBUTION LINE (BY OTHERS)
- RECLAIM WATER LINES (BY OTHERS)
- PROJECT BOUNDARY
- APPROXIMATE LIMITS OF SUPERNATANT POOL
- LIMITS OF RECLAIM POND LINING SYSTEM (42 / D6)
- EXISTING FENCING
- PERMANENT V-DITCH (3 / SW4)
- TEMPORARY V-DITCH
- NATURAL DRAINAGE
- LIMITS OF BASALT BORROW PIT
- LIMITS OF LINING SYSTEM (5 / D1)

NOTES

1. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
2. LAYOUT AND TOPOGRAPHY SHOWN FOR MINE WASTE FACILITIES REPRESENT FINAL CONDITIONS AT THE END OF OPERATIONS.
3. PROPOSED BASALT QUARRY DESIGN PREPARED BY MINE DEVELOPMENT ASSOCIATES AND GOLDER IS PRESENTED AS APPENDIX V OF THE GRASSY MOUNTAIN PROJECT CONSOLIDATED PERMIT APPLICATION. DOCUMENT TITLED "ABBREVIATED OPERATING PERMIT APPLICATION - GRASSY MOUNTAIN BASALT BORROW QUARRY," REVISION 0. DATED MAY 2, 2019.

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON

ISSUED FOR CONSTRUCTION

EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
OVERALL FACILITY LAYOUT

PROJECT NO.	REV.		DRAWING
1663241	0	4 of 42	C1

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

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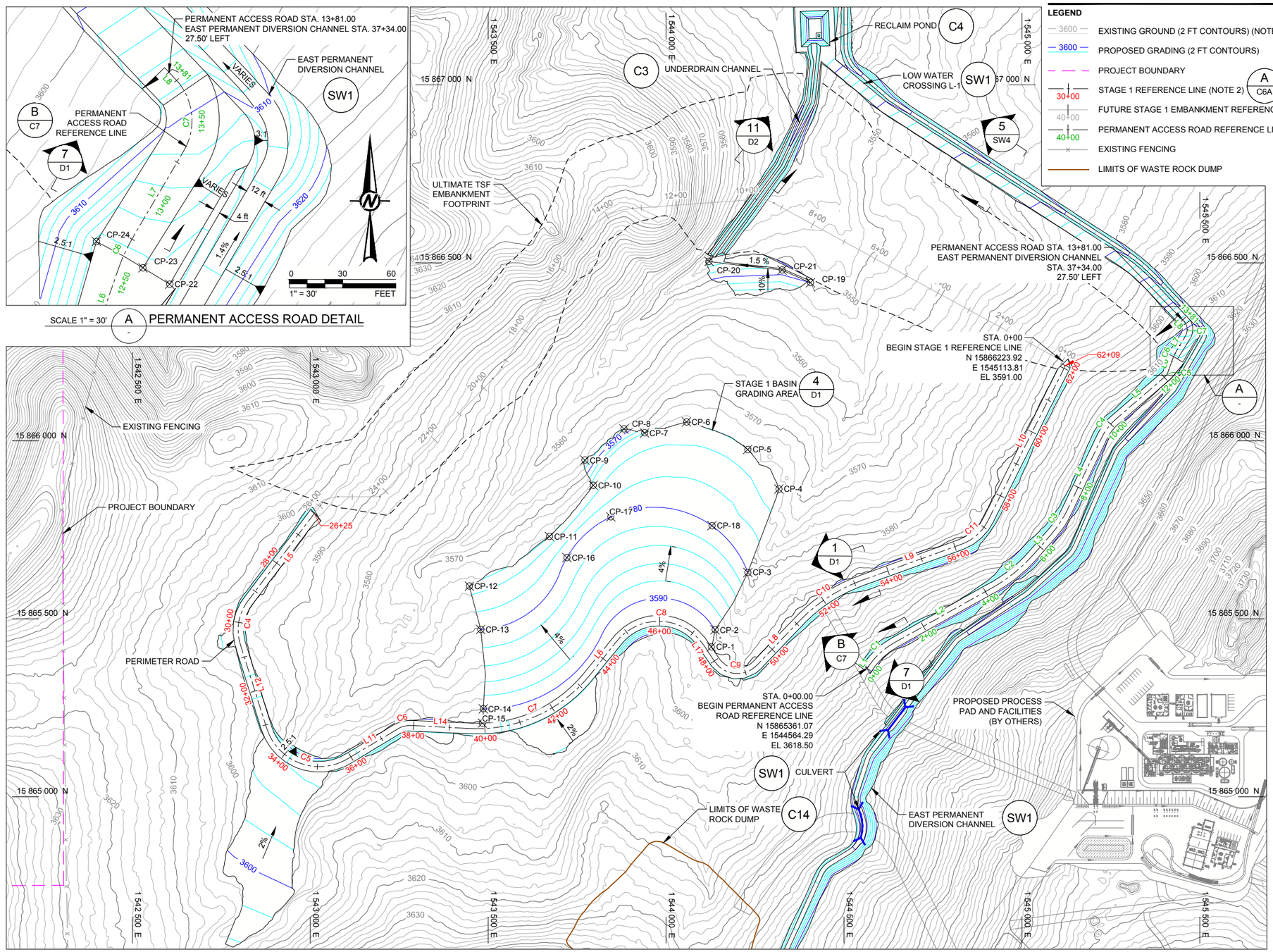
SCALE 1" = 30'

A -

PERMANENT ACCESS ROAD DETAIL



LEGEND

- EXISTING GROUND (2 FT CONTOURS) (NOTE 1)
- PROPOSED GRADING (2 FT CONTOURS)
- PROJECT BOUNDARY
- STAGE 1 REFERENCE LINE (NOTE 2) — A C6A
- FUTURE STAGE 1 EMBANKMENT REFERENCE LINE
- PERMANENT ACCESS ROAD REFERENCE LINE — B C7
- EXISTING FENCING
- LIMITS OF WASTE ROCK DUMP

STAGE 1 BASIN GRADING CONTROL POINTS

POINT NO.	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
CP-1	15865421.13	1544126.96	3591.98
CP-2	15865469.36	1544137.33	3590.00
CP-3	15865630.16	1544229.52	3580.00
CP-4	15865864.52	1544316.92	3575.00
CP-5	15865975.56	1544229.39	3574.00
CP-6	15866053.06	1544057.28	3575.00
CP-7	15866022.28	1543939.56	3574.00
CP-8	15866033.31	1543881.66	3568.00
CP-9	15865945.89	1543771.69	3565.82
CP-10	15865875.18	1543795.20	3575.00
CP-11	15865731.56	1543671.71	3576.00
CP-12	15865591.78	1543447.11	3575.00
CP-13	15865470.19	1543478.86	3580.00
CP-14	15865247.26	1543486.08	3590.00
CP-15	15865207.14	1543483.47	3591.97
CP-16	15865672.16	1543721.00	3580.00
CP-17	15865786.47	1543844.54	3580.00
CP-18	15865761.56	1544128.73	3580.00
CP-19	15866444.40	1544405.67	3550.01
CP-20	15866504.28	1544120.60	3544.50
CP-21	15866479.94	1544325.73	3548.70
CP-22	15866220.82	1545452.04	3618.51
CP-23	15866230.02	1545437.00	3618.54
CP-24	15866244.81	1545410.86	3618.59

NOTES

1. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
2. SURVEY LAYOUT FOR STAGE 1 EMBANKMENT AND PERIMETER ROAD SHOWN ON DRAWING C6B AND C7, RESPECTIVELY.
3. OUTSIDE OF DEFINED GRADING AREAS, EXISTING TOPOGRAPHY IS TO BE CLEARED AND GRUBBED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. FINAL GRADES TO BE BETWEEN 1% AND 10% AS SHOWN ON DETAIL 7/D1. TO PREVENT AREAS OF PONDING, POSITIVE DRAINAGE TO BE IN A GENERAL SOUTH TO NORTH DIRECTION.

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY LAYOUT
STAGE 1 BASIN GRADING

PROJECT NO. 1663241 | REV. 0 | 5 of 42 | DRAWING C2

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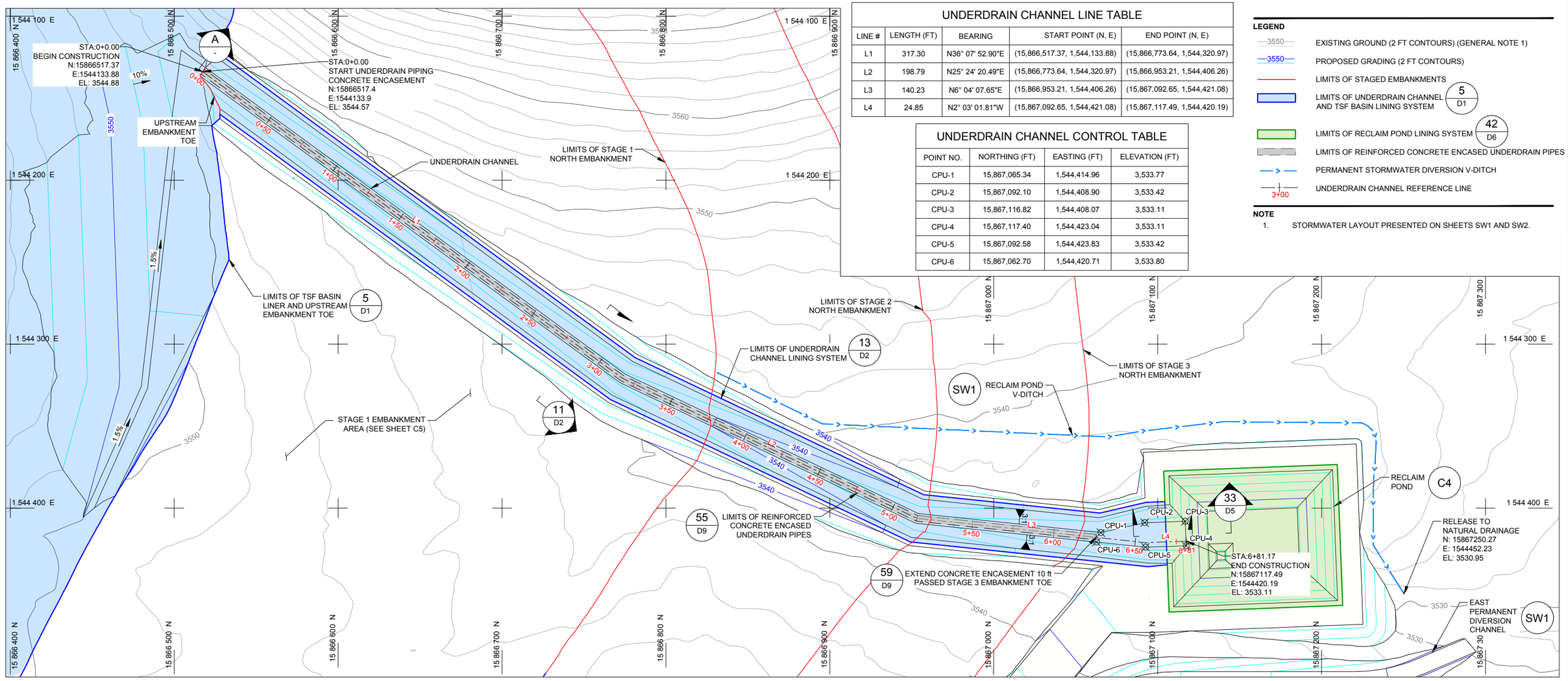


UNDERDRAIN CHANNEL LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	317.30	N36° 07' 52.90"E	(15,866,517.37, 1,544,133.88)	(15,866,773.64, 1,544,320.97)
L2	198.79	N25° 24' 20.49"E	(15,866,773.64, 1,544,320.97)	(15,866,953.21, 1,544,406.26)
L3	140.23	N6° 04' 07.65"E	(15,866,953.21, 1,544,406.26)	(15,867,092.65, 1,544,421.08)
L4	24.85	N2° 03' 01.81"W	(15,867,092.65, 1,544,421.08)	(15,867,117.49, 1,544,420.19)

UNDERDRAIN CHANNEL CONTROL TABLE

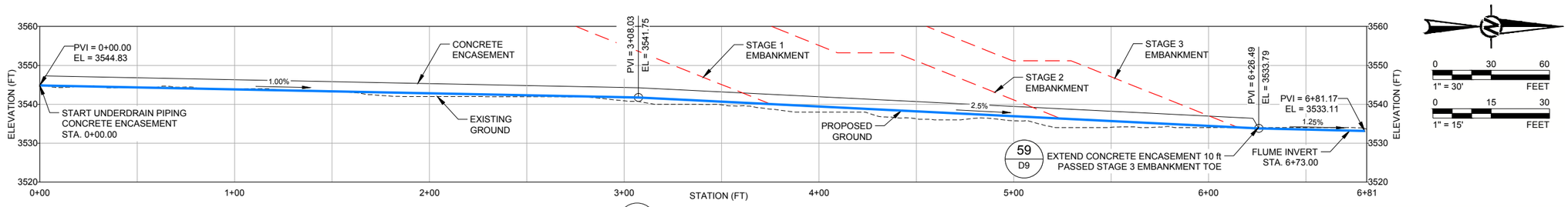
POINT NO.	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
CPU-1	15,867,065.34	1,544,414.96	3,533.77
CPU-2	15,867,092.10	1,544,408.90	3,533.42
CPU-3	15,867,116.82	1,544,408.07	3,533.11
CPU-4	15,867,117.40	1,544,423.04	3,533.11
CPU-5	15,867,092.58	1,544,423.83	3,533.42
CPU-6	15,867,062.70	1,544,420.71	3,533.80

LEGEND

- EXISTING GROUND (2 FT CONTOURS) (GENERAL NOTE 1)
- PROPOSED GRADING (2 FT CONTOURS)
- LIMITS OF STAGED EMBANKMENTS
- LIMITS OF UNDERDRAIN CHANNEL AND TSF BASIN LINING SYSTEM (5 / D1)
- LIMITS OF RECLAIM POND LINING SYSTEM (42 / D6)
- LIMITS OF REINFORCED CONCRETE ENCASED UNDERDRAIN PIPES
- PERMANENT STORMWATER DIVERSION V-DITCH
- UNDERDRAIN CHANNEL REFERENCE LINE (3+00)

NOTE

1. STORMWATER LAYOUT PRESENTED ON SHEETS SW1 AND SW2.



SCALE 1" = 30' / VERT. SCALE 1" = 15' — A / - — UNDERDRAIN CHANNEL PROFILE

0 30 60 FEET (1" = 30')
0 15 30 FEET (1" = 15')

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON

ISSUED FOR CONSTRUCTION 11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
UNDERDRAIN CHANNEL LAYOUT

PROJECT NO. 1663241 | REV. 0 | 6 of 42 | DRAWING C3

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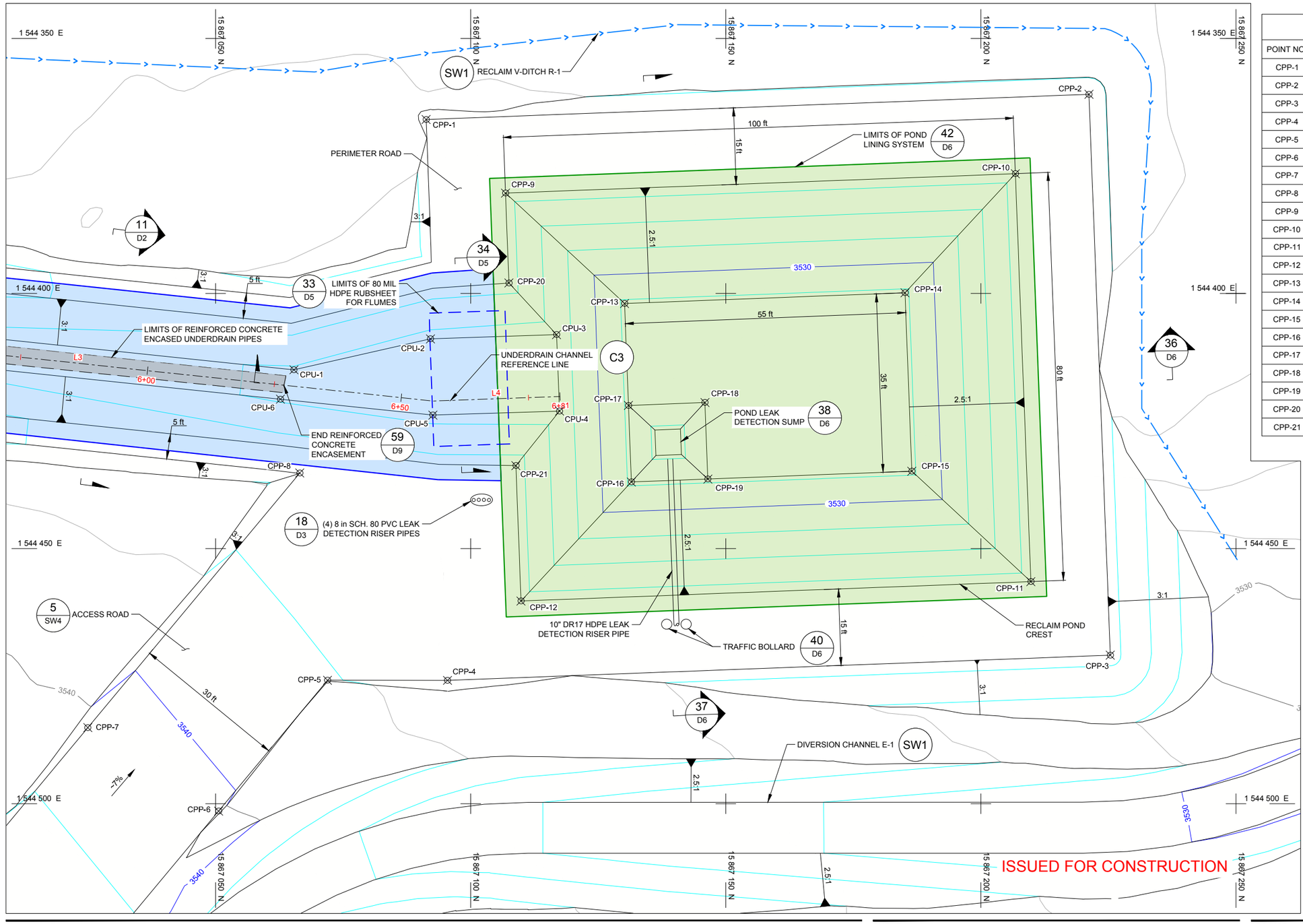

RECLAIM POND CONTROL TABLE

POINT NO.	NORTHING (FT)	EASTING (FT)	DESCRIPTION	ELEVATION (FT)
CPP-1	15,867,091.26	1,544,365.91	POND CREST	3,536.69
CPP-2	15,867,221.16	1,544,360.97	POND CREST	3,536.69
CPP-3	15,867,225.35	1,544,470.89	POND CREST	3,536.69
CPP-4	15,867,095.44	1,544,475.83	ACCESS ROAD TIE IN	3,536.69
CPP-5	15,867,071.93	1,544,475.80	ACCESS ROAD CREST	3,538.19
CPP-6	15,867,050.59	1,544,501.44	ACCESS ROAD CREST	3,540.34
CPP-7	15,867,024.94	1,544,485.09	ACCESS ROAD CREST	3,540.95
CPP-8	15,867,066.49	1,544,435.19	ACCESS ROAD TIE IN	3,536.78
CPP-9	15,867,106.81	1,544,380.33	POND CREST	3,536.69
CPP-10	15,867,206.74	1,544,376.53	POND CREST	3,536.69
CPP-11	15,867,209.79	1,544,456.47	POND CREST	3,536.69
CPP-12	15,867,109.86	1,544,460.27	POND CREST	3,536.69
CPP-13	15,867,130.15	1,544,401.96	POND TOE	3,527.69
CPP-14	15,867,185.12	1,544,399.87	POND TOE	3,527.69
CPP-15	15,867,186.45	1,544,434.84	POND TOE	3,527.69
CPP-16	15,867,131.49	1,544,436.93	POND TOE	3,527.69
CPP-17	15,867,130.92	1,544,421.94	SUMP CREST	3,527.69
CPP-18	15,867,145.91	1,544,421.37	SUMP CREST	3,527.69
CPP-19	15,867,146.48	1,544,436.36	SUMP CREST	3,527.69
CPP-20	15,867,107.49	1,544,397.95	CHANNEL TIE-IN	3,536.69
CPP-21	15,867,108.85	1,544,433.73	CHANNEL TIE-IN	3,536.69

LEGEND

- 3550 — EXISTING GROUND (2 FT CONTOURS) (GENERAL NOTE 1)
- 3550 — PROPOSED GRADING (2 FT CONTOURS)
- LIMITS OF UNDERDRAIN CHANNEL AND TSF BASIN LINING SYSTEM (13 D2, 5 D1)
- LIMITS OF POND LINING SYSTEM (42 D6)
- PERMANENT STORMWATER DIVERSION V-DITCH
- LIMITS OF REINFORCED CONCRETE ENCASED UNDERDRAIN PIPES
- UNDERDRAIN CHANNEL REFERENCE LINE (3+00) (C3)
- LIMITS OF 80 MIL HDPE RUBSHEET (33 D5)

NOTE

1. STORMWATER LAYOUT PRESENTED ON SHEETS SW1 AND SW2.

0 10 20
1" = 10' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
RECLAIM POND LAYOUT

PROJECT NO.	REV.	DRAWING
1663241	0	C4

7 of 42

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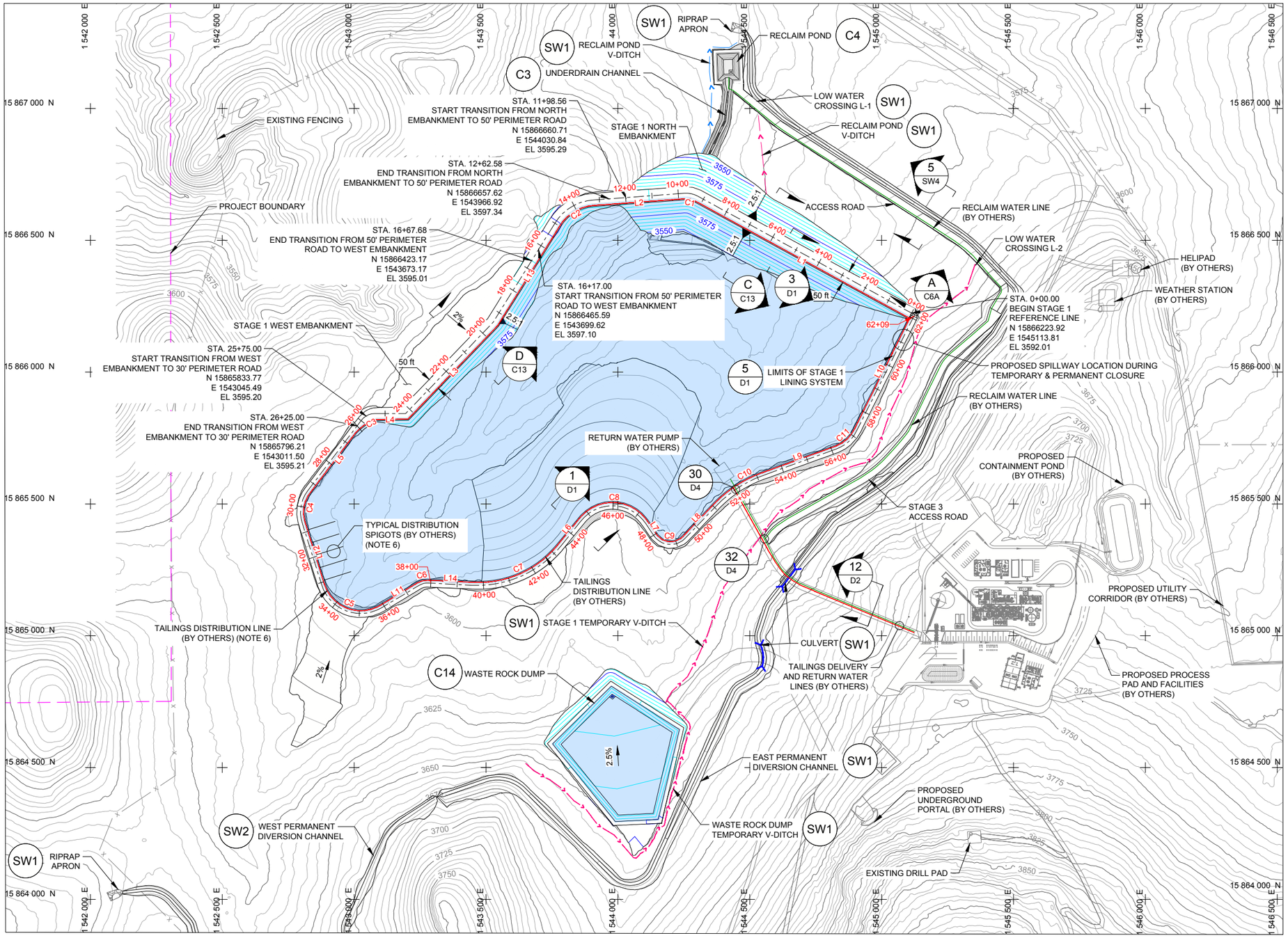

LEGEND

- EXISTING GROUND CONTOURS (5 FT CONTOURS) (GENERAL NOTE 1)
- PROPOSED GRADING (5 FT CONTOURS)
- TAILINGS DISTRIBUTION LINE (BY OTHERS)
- RECLAIM WATER LINE (BY OTHERS)
- PROJECT BOUNDARY
- LIMITS OF LINING SYSTEM (5 / D1)
- STAGE 1 REFERENCE LINE (NOTE 3) (30+00) (A / C6A)
- EXISTING FENCING
- PERMANENT V-DITCH (SW1)
- TEMPORARY V-DITCH (SW1)
- CULVERT
- LIMITS OF EXISTING LINING SYSTEM

NOTES

1. PERIMETER ACCESS ROAD CROSS SECTION SCHEDULE SHOWN ON DRAWING D1.
2. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
3. SURVEY LAYOUT FOR STAGE 1 EMBANKMENT AND PERIMETER ROAD SHOWN ON DRAWING C6B.
4. IN AREAS WITH CONCENTRATED RUN-ON TO PERIMETER ROAD, TRAVEL SURFACE TO BE GRADED TO DRAIN INTO IMPOUNDMENT ABOVE GEOMEMBRANE LINER. ROAD SURFACE TO BE PROTECTED AS NEEDED FROM EROSION.
5. OUTSIDE OF DEFINED GRADING AREAS, EXISTING TOPOGRAPHY IS TO BE CLEARED AND GRUBBED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. FINAL GRADES TO BE 1% AND 10% AS SHOWN ON DETAIL 4/D1. TO PREVENT AREAS OF PONDING, POSITIVE DRAINAGE TO BE MAINTAINED IN A GENERAL SOUTH TO NORTH DIRECTION.
6. TAILINGS DISTRIBUTION AND SPIGOTS TO EXTEND AROUND ENTIRE IMPOUNDMENT DESIGN BY OTHERS.

ISSUED FOR CONSTRUCTION

0 200 400 600
1" = 200' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY LAYOUT
STAGE 1

PROJECT NO.	REV.	8 of 42	DRAWING
1663241	0		C5

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

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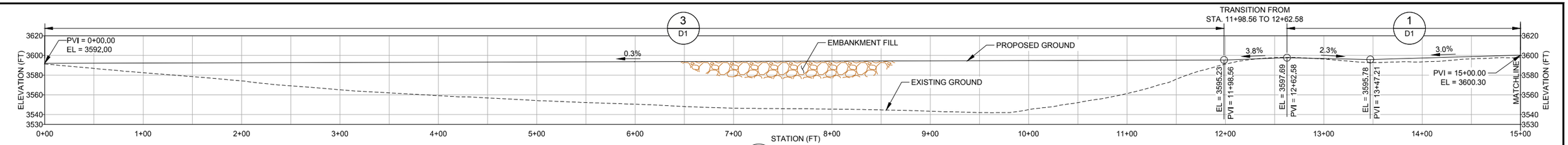
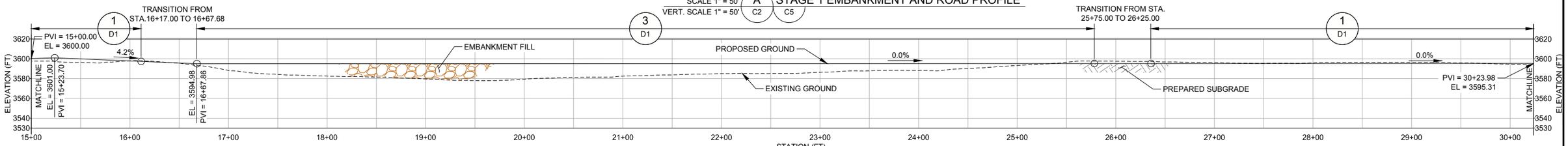


SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C5) — STAGE 1 EMBANKMENT AND ROAD PROFILE



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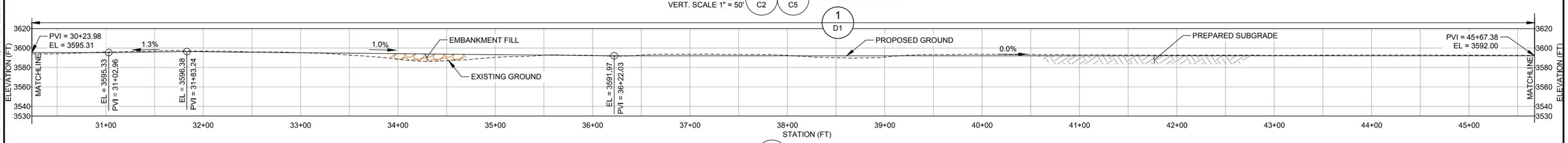
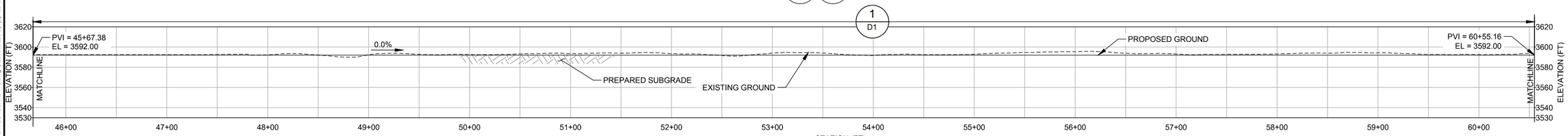
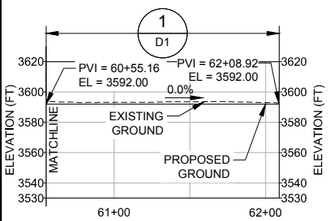


SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C5) — PROFILE CONTINUED



SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C5) — PROFILE CONTINUED



SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C5) — PROFILE CONTINUED

LEGEND

PROPOSED GROUND

EXISTING GROUND

ISSUED FOR CONSTRUCTION

0 50 100 150
1" = 50' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (1 OF 2)
STAGE 1

PROJECT NO. 1663241 | REV. 0 | 9 of 42 | DRAWING C6A

Path: \\envidata\MIDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: 1663241_C_010_UNDERDRAINPONDLAYOUT&GRADING.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:9:12:38 AM | Printed By: JePrice Date: 2019-11-06 Time:3:05:42 PM
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
0 1 in

STAGE 1 EMBANKMENT AND ROAD CURVE TABLE

CURVE	RADIUS (FT)	LENGTH (FT)	CHORD LENGTH (FT)	DELTA	CENTER (N)	CENTER (E)	START (N, E)	END (N, E)
C1	92.22	52.96	52.23	032°53'57.53"	15,866,586.62	1,544,258.98	(15,866,667.52,1,544,303.25)	(15866678.60,1544252.21)
C2	183.99	172.92	166.63	053°50'55.51"	15,866,469.59	1,543,918.94	(15,866,653.08,1,543,905.43)	(15866566.93,1543762.80)
C3	62.50	57.56	55.55	052°46'23.16"	15,865,780.48	1,543,078.04	(15,865,842.98,1,543,078.04)	(15865818.29,1543028.27)
C4	134.28	128.14	123.33	054°40'27.29"	15,865,468.76	1,542,931.37	(15,865,549.99,1,542,824.44)	(15865428.50,1542803.27)
C5	154.93	279.42	243.06	103°20'02.56"	15,865,239.60	1,543,025.05	(15,865,193.14,1,542,877.25)	(15865106.50,1543104.35)
C6	63.57	37.50	36.96	033°48'05.46"	15,865,136.92	1,543,279.62	(15,865,191.53,1,543,247.08)	(15865200.40,1543282.96)
C7	409.39	389.99	375.41	054°34'49.70"	15,865,600.60	1,543,468.19	(15,865,191.77,1,543,446.64)	(15865346.10,1543788.87)
C8	152.31	286.41	246.04	107°44'26.36"	15,865,340.99	1,543,979.26	(15,865,435.68,1,543,859.96)	(15865425.77,1544105.80)
C9	76.89	137.45	119.86	102°25'25.07"	15,865,423.22	1,544,200.06	(15,865,380.43,1,544,136.18)	(15865370.05,1544255.59)
C10	462.37	212.28	210.42	026°18'19.65"	15,865,173.19	1,544,707.24	(15,865,492.95,1,544,373.26)	(15865607.84,1544549.55)
C11	132.83	100.90	98.49	043°31'19.99"	15,865,834.73	1,544,785.43	(15,865,709.86,1,544,830.74)	(15865775.38,1544904.27)

STAGE 1 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	924.01	N61° 18' 31.78"W	(15,866,223.92, 1,545,113.81)	(15,866,667.52, 1,544,303.25)
L2	347.71	S85° 47' 30.69"W	(15,866,678.60, 1,544,252.21)	(15,866,653.08, 1,543,905.43)
L3	479.64	S43° 46' 40.21"W	(15,866,189.31, 1,543,527.36)	(15,865,842.99, 1,543,195.51)
L4	117.47	S89° 59' 50.46"W	(15,865,842.99, 1,543,195.51)	(15,865,842.98, 1,543,078.04)
L5	336.94	S37° 13' 27.30"W	(15,865,818.29, 1,543,028.27)	(15,865,549.99, 1,542,824.44)
L6	114.36	N38° 26' 13.21"E	(15,865,346.10, 1,543,788.87)	(15,865,435.68, 1,543,859.96)
L7	54.58	S33° 49' 20.43"E	(15,865,425.77, 1,544,105.80)	(15,865,380.43, 1,544,136.18)
L8	170.15	N43° 45' 14.50"E	(15,865,370.05, 1,544,255.59)	(15,865,492.95, 1,544,373.26)
L9	299.12	N70° 03' 34.15"E	(15,865,607.84, 1,544,549.55)	(15,865,709.86, 1,544,830.74)
L10	487.62	N26° 32' 14.16"E	(15,865,775.38, 1,544,904.27)	(15,866,211.62, 1,545,122.13)
L11	166.15	N59° 12' 57.46"E	(15,865,106.50, 1,543,104.35)	(15,865,191.53, 1,543,247.08)

STAGE 1 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L12	246.71	S17° 26' 59.98"E	(15,865,428.50, 1,542,803.27)	(15,865,193.14, 1,542,877.25)
L13	445.02	S31° 56' 35.18"W	(15,866,566.93, 1,543,762.80)	(15,866,189.31, 1,543,527.36)
L14	163.91	S86° 58' 57.08"E	(15,865,200.40, 1,543,282.96)	(15,865,191.77, 1,543,446.64)

ISSUED FOR CONSTRUCTION

0 50 100 150
1" = 50' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (2 OF 2)
STAGE 1

PROJECT NO. 1663241
REV. 0

DRAWING C6B

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

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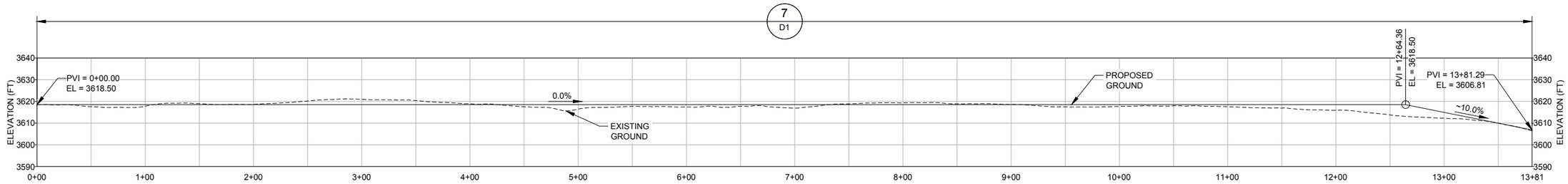

SCALE 1" = 50' / VERT. SCALE 1" = 25' — B (C5) PERMANENT ACCESS ROAD PROFILE

PERMANENT ACCESS ROAD LINE TABLE				
LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	12.36	N35° 51' 16.75"E	(15,865,360.90, 1,544,564.53)	(15,865,370.92, 1,544,571.77)
L2	311.33	N60° 45' 46.62"E	(15,865,433.45, 1,544,641.97)	(15,865,585.51, 1,544,913.64)
L3	68.92	N41° 11' 19.78"E	(15,865,685.19, 1,545,036.63)	(15,865,737.05, 1,545,082.02)
L4	224.42	N25° 29' 05.33"E	(15,865,806.10, 1,545,127.44)	(15,866,008.69, 1,545,224.00)
L5	181.60	N49° 11' 21.86"E	(15,866,061.44, 1,545,264.24)	(15,866,180.12, 1,545,401.69)
L6	39.82	N19° 15' 00.00"E	(15,866,193.36, 1,545,410.69)	(15,866,230.95, 1,545,423.82)
L7	57.92	N30° 23' 56.09"E	(15,866,245.81, 1,545,430.69)	(15,866,295.77, 1,545,460.00)
L8	5.48	N43° 26' 38.87"W	(15,866,335.85, 1,545,455.41)	(15,866,339.83, 1,545,451.64)

PERMANENT ACCESS ROAD CURVE TABLE								
CURVE #	RADIUS (FT)	LENGTH (FT)	CHORD LENGTH (FT)	DELTA	CENTER (N)	CENTER (E)	START POINT (N, E)	END POINT (N, E)
C1	217.96	94.75	94.01	024°54'29.87"	15,865,243.25	1,544,748.43	(15,865,370.92, 1,544,571.77)	(15,865,433.45, 1,544,641.97)
C2	465.67	159.09	158.31	019°34'26.84"	15,865,991.85	1,544,686.20	(15,865,585.51, 1,544,913.64)	(15,865,685.19, 1,545,036.63)
C3	302.48	82.91	82.65	015°42'14.45"	15,865,936.25	1,544,854.38	(15,865,737.05, 1,545,082.02)	(15,865,806.10, 1,545,127.44)
C4	161.50	66.82	66.34	023°42'16.53"	15,865,939.20	1,545,369.79	(15,866,008.69, 1,545,224.00)	(15,866,061.44, 1,545,264.24)
C5	30.99	16.19	16.01	029°56'21.86"	15,866,203.58	1,545,381.43	(15,866,180.12, 1,545,401.69)	(15,866,193.36, 1,545,410.69)
C6	84.27	16.40	16.37	011°08'56.09"	15,866,203.17	1,545,503.37	(15,866,230.95, 1,545,423.82)	(15,866,245.81, 1,545,430.69)
C7	33.58	43.28	40.35	073°50'34.96"	15,866,312.76	1,545,431.03	(15,866,295.77, 1,545,460.00)	(15,866,335.85, 1,545,455.41)

LEGEND

PROPOSED GROUND

EXISTING GROUND

0 25 50 — 1" = 25' FEET

0 50 100 — 1" = 50' FEET

ISSUED FOR CONSTRUCTION

11/6/19

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
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USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
PERMANENT ACCESS ROAD PROFILE

PROJECT NO. 1663241 | REV. 0 | 11 of 42 | DRAWING C7

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

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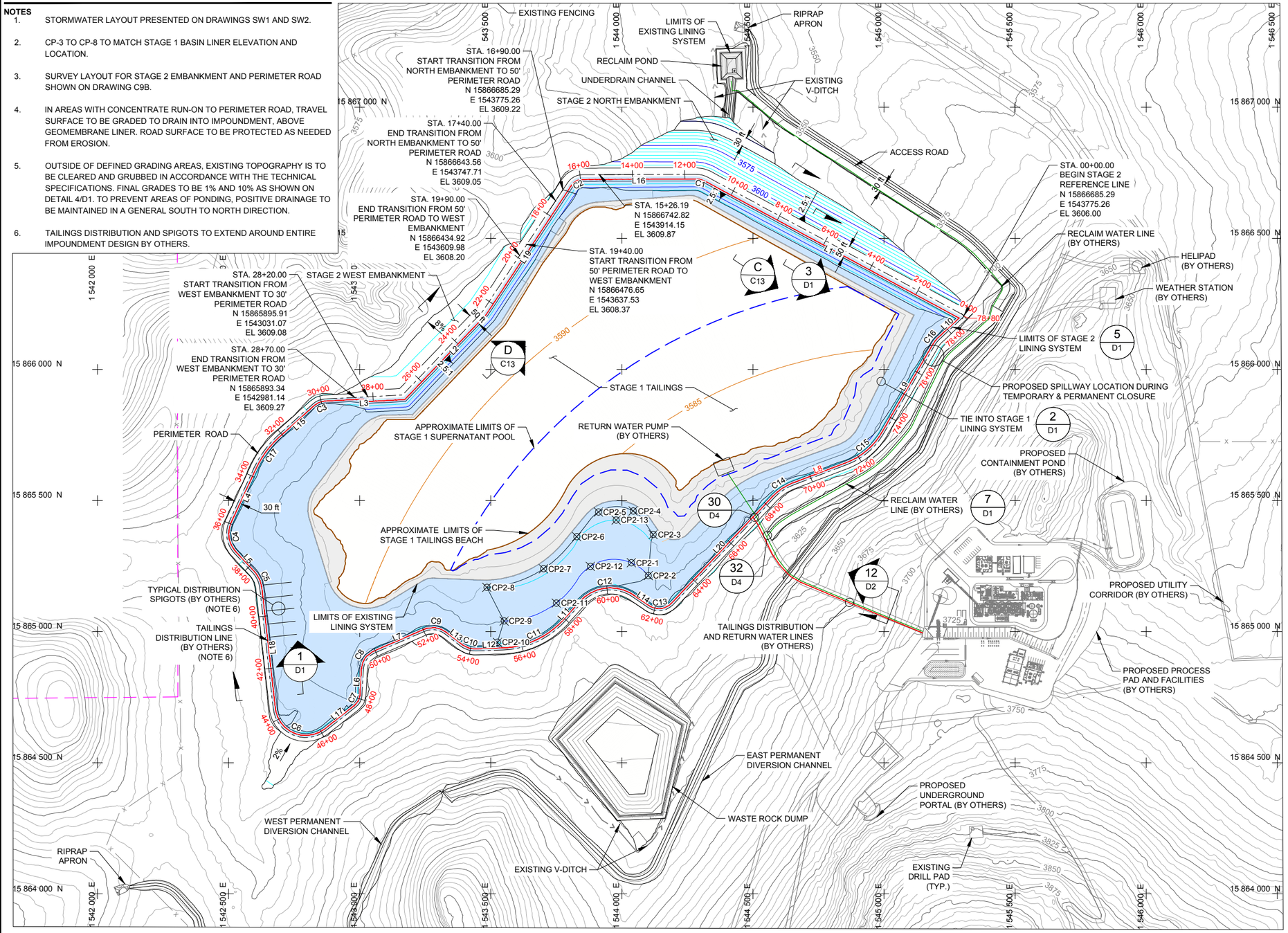
NOTES

1. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
2. CP-3 TO CP-8 TO MATCH STAGE 1 BASIN LINER ELEVATION AND LOCATION.
3. SURVEY LAYOUT FOR STAGE 2 EMBANKMENT AND PERIMETER ROAD SHOWN ON DRAWING C9B.
4. IN AREAS WITH CONCENTRATE RUN-ON TO PERIMETER ROAD, TRAVEL SURFACE TO BE GRADED TO DRAIN INTO IMPOUNDMENT, ABOVE GEOMEMBRANE LINER. ROAD SURFACE TO BE PROTECTED AS NEEDED FROM EROSION.
5. OUTSIDE OF DEFINED GRADING AREAS, EXISTING TOPOGRAPHY IS TO BE CLEARED AND GRUBBED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. FINAL GRADES TO BE 1% AND 10% AS SHOWN ON DETAIL 4/D1. TO PREVENT AREAS OF PONDING, POSITIVE DRAINAGE TO BE MAINTAINED IN A GENERAL SOUTH TO NORTH DIRECTION.
6. TAILINGS DISTRIBUTION AND SPIGOTS TO EXTEND AROUND ENTIRE IMPOUNDMENT DESIGN BY OTHERS.



LEGEND

- 3600 — EXISTING GROUND (5 FT CONTOURS) (GENERAL NOTE 1)
- 3600 — PROPOSED GRADING (5 FT CONTOURS)
- 3600 — STAGE 1 TAILINGS SURFACE (5 FT CONTOURS)
- TAILINGS DISTRIBUTION LINE (BY OTHERS)
- RETURN AND RECLAIM WATERS LINE (BY OTHERS)
- PROJECT BOUNDARY
- APPROXIMATE LIMITS OF STAGE 1 TAILINGS BEACH
- LIMITS OF EXISTING LINING SYSTEM
- LIMITS OF STAGE 2 LINING SYSTEM (5 / D1)
- EXISTING V-DITCH
- APPROXIMATE LIMITS OF SUPERNATANT POOL
- EXISTING FENCING
- 30+00 — STAGE 2 REFERENCE LINE (NOTE 3) (A / C9A)

STAGE 2 BASIN GRADING CONTROL POINTS (NOTE 2)

POINT NO.	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
CP2-1	15,865,262.95	1,544,036.20	3,600.00
CP2-2	15,865,213.74	1,544,100.94	3,600.00
CP2-3	15,865,370.74	1,544,119.44	3,593.86
CP2-4	15,865,460.29	1,544,043.31	3,593.17
CP2-5	15,865,456.37	1,543,910.81	3,593.41
CP2-6	15,865,362.28	1,543,828.02	3,594.48
CP2-7	15,865,240.02	1,543,701.34	3,593.91
CP2-8	15,865,169.09	1,543,485.20	3,595.00
CP2-9	15,865,040.87	1,543,550.93	3,600.00
CP2-10	15,864,959.52	1,543,525.66	3,605.00
CP2-11	15,865,109.10	1,543,750.00	3,600.00
CP2-12	15,865,249.16	1,543,879.91	3,600.00
CP2-13	15,865,425.73	1,543,978.16	3,595.00

ISSUED FOR CONSTRUCTION

0 200 400 600
1" = 200' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY LAYOUT
STAGE 2

PROJECT NO.	REV.		DRAWING
1663241	0	12 of 42	C8

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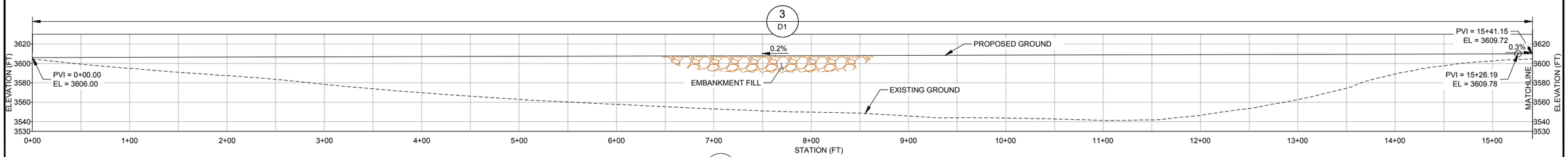
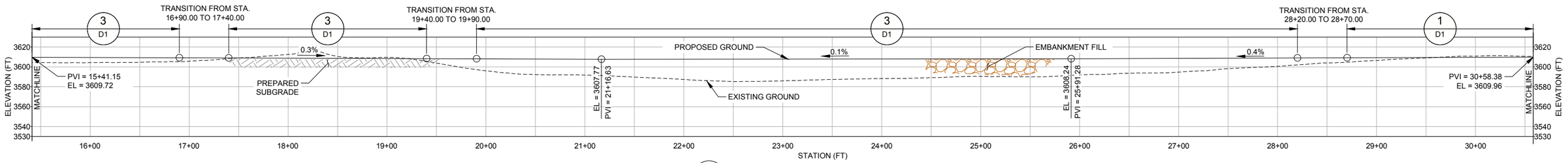


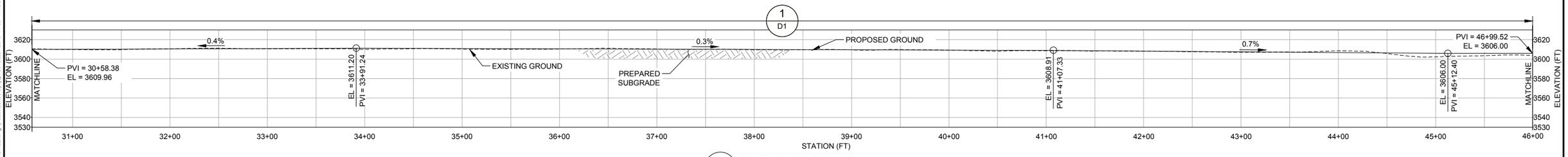
SCALE 1" = 50' (A C8)
VERT. SCALE 1" = 50'

STAGE 2 EMBANKMENT AND ROAD PROFILE



SCALE 1" = 50' (A C8)
VERT. SCALE 1" = 50'

PROFILE CONTINUED



SCALE 1" = 50' (A C8)
VERT. SCALE 1" = 50'

PROFILE CONTINUED

LEGEND

PROPOSED GROUND

EXISTING GROUND

ISSUED FOR CONSTRUCTION

0 50 100 150
1" = 50' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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USA
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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (1 OF 2)
STAGE 2

PROJECT NO. 1663241
REV. 0
13 of 42
DRAWING C9A

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

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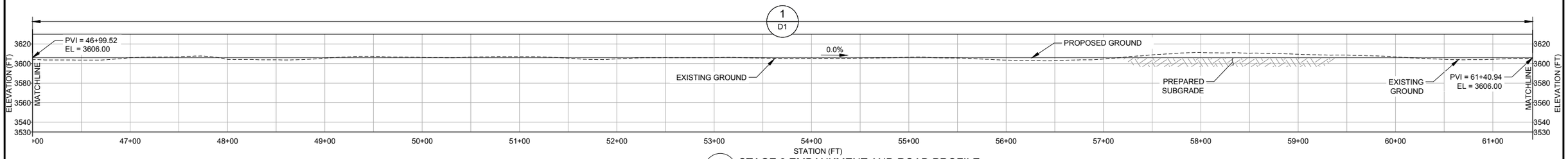
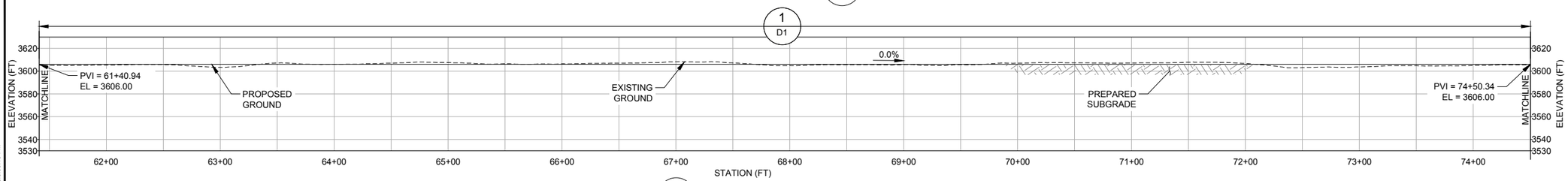


SCALE 1" = 50'
VERT. SCALE 1" = 50'

A
C8

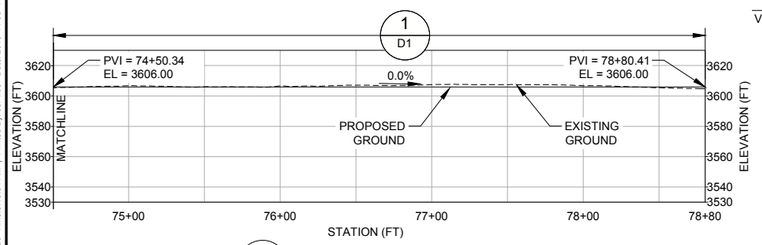
STAGE 2 EMBANKMENT AND ROAD PROFILE



SCALE 1" = 50'
VERT. SCALE 1" = 50'

A
C8

PROFILE CONTINUED



SCALE 1" = 50'
VERT. SCALE 1" = 50'

A
C8

PROFILE CONTINUED

STAGE 2 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	1108.32	N61° 39' 57.22"W	(15,866,206.04, 1,545,305.58)	(15,866,732.07, 1,544,330.04)
L2	439.49	S43° 49' 19.75"W	(15,866,219.84, 1,543,468.01)	(15,865,902.75, 1,543,163.69)
L3	296.39	S87° 02' 46.97"W	(15,865,902.75, 1,543,163.69)	(15,865,887.48, 1,542,867.69)
L4	225.49	S24° 44' 42.64"W	(15,865,624.21, 1,542,596.87)	(15,865,419.43, 1,542,502.48)
L5	104.90	S42° 57' 52.02"E	(15,865,300.34, 1,542,521.58)	(15,865,223.58, 1,542,593.07)
L6	101.81	N3° 14' 04.89"E	(15,864,756.70, 1,543,008.92)	(15,864,858.35, 1,543,014.67)
L7	209.44	N66° 29' 45.38"E	(15,864,918.18, 1,543,056.35)	(15,865,001.71, 1,543,248.41)
L8	219.21	N69° 11' 47.36"E	(15,865,559.63, 1,544,654.54)	(15,865,637.49, 1,544,859.46)
L9	389.78	N30° 03' 21.90"E	(15,865,756.03, 1,544,998.88)	(15,866,093.40, 1,545,194.10)
L10	130.77	N46° 46' 22.22"E	(15,866,113.59, 1,545,210.11)	(15,866,203.15, 1,545,305.39)

STAGE 2 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L11	92.30	N41° 51' 24.16"E	(15,865,041.50, 1,543,784.62)	(15,865,110.25, 1,543,846.21)
L12	104.60	N88° 00' 26.86"E	(15,864,926.70, 1,543,442.42)	(15,864,930.33, 1,543,546.95)
L13	77.19	S52° 17' 22.95"E	(15,864,992.22, 1,543,324.52)	(15,864,945.01, 1,543,385.59)
L14	73.42	S55° 42' 08.00"E	(15,865,133.75, 1,544,039.78)	(15,865,092.38, 1,544,100.43)
L15	178.90	S47° 58' 08.24"W	(15,865,868.23, 1,542,821.20)	(15,865,748.46, 1,542,688.32)
L16	432.14	S89° 45' 53.02"W	(15,866,744.33, 1,544,281.04)	(15,866,742.55, 1,543,848.90)
L17	146.74	N51° 40' 35.78"E	(15,864,623.29, 1,542,871.76)	(15,864,714.28, 1,542,986.88)
L18	463.16	S6° 24' 42.32"E	(15,865,167.41, 1,542,618.89)	(15,864,707.15, 1,542,670.61)
L19	590.21	S33° 25' 46.23"W	(15,866,712.41, 1,543,793.16)	(15,866,219.84, 1,543,468.01)
L20	563.82	N43° 28' 35.63"E	(15,865,102.45, 1,544,194.47)	(15,865,511.60, 1,544,582.41)

STAGE 2 EMBANKMENT AND ROAD CURVE TABLE

CURVE #	RADIUS (FT)	LENGTH (FT)	CHORD LENGTH (FT)	DELTA	CENTER (N)	CENTER (E)	START POINT (N, E)	END POINT (N, E)
C1	102.36	51.04	50.51	028°34'09.76"	15,866,641.97	1,544,281.46	(15,866,732.07, 1,544,330.04)	(15,866,744.33, 1,544,281.04)
C2	67.12	66.00	63.37	056°20'06.79"	15,866,675.43	1,543,849.18	(15,866,742.55, 1,543,848.90)	(15,866,712.41, 1,543,793.16)
C3	75.22	51.30	50.32	039°04'38.73"	15,865,812.36	1,542,871.57	(15,865,887.48, 1,542,867.69)	(15,865,868.23, 1,542,821.20)
C4	108.25	127.92	120.61	067°42'34.66"	15,865,374.12	1,542,600.79	(15,865,419.43, 1,542,502.48)	(15,865,300.34, 1,542,521.58)
C5	98.56	62.88	61.82	036°33'09.71"	15,865,156.40	1,542,520.95	(15,865,223.58, 1,542,593.07)	(15,865,167.41, 1,542,618.89)
C6	124.64	265.20	217.92	121°54'41.90"	15,864,721.07	1,542,794.47	(15,864,707.15, 1,542,670.61)	(15,864,623.29, 1,542,871.76)
C7	58.26	49.26	47.80	048°26'30.90"	15,864,759.99	1,542,950.75	(15,864,714.28, 1,542,986.88)	(15,864,756.70, 1,543,008.92)
C8	69.51	76.75	72.91	063°15'40.49"	15,864,854.43	1,543,084.07	(15,864,858.35, 1,543,014.67)	(15,864,918.18, 1,543,056.35)
C9	75.32	80.48	76.70	061°12'51.68"	15,864,932.63	1,543,278.45	(15,865,001.71, 1,543,248.41)	(15,864,992.22, 1,543,324.52)
C10	87.91	60.91	59.70	039°42'10.19"	15,865,014.55	1,543,439.36	(15,864,945.01, 1,543,385.59)	(15,864,926.70, 1,543,442.42)

STAGE 2 EMBANKMENT AND ROAD CURVE TABLE

CURVE #	RADIUS (FT)	LENGTH (FT)	CHORD LENGTH (FT)	DELTA	CENTER (N)	CENTER (E)	START POINT (N, E)	END POINT (N, E)
C11	334.72	269.61	262.38	046°09'02.71"	15,865,264.85	1,543,535.32	(15,864,930.33, 1,543,546.95)	(15,865,041.50, 1,543,784.62)
C12	147.95	212.88	194.99	082°26'27.84"	15,865,011.53	1,543,956.41	(15,865,110.25, 1,543,846.21)	(15,865,133.75, 1,544,039.78)
C13	72.95	102.90	94.58	080°49'16.37"	15,865,152.65	1,544,141.53	(15,865,092.38, 1,544,100.43)	(15,865,102.45, 1,544,194.47)
C14	194.68	87.39	86.66	025°43'11.73"	15,865,377.65	1,544,723.68	(15,865,511.60, 1,544,582.41)	(15,865,559.63, 1,544,654.54)
C15	273.18	186.61	183.01	039°08'25.46"	15,865,892.85	1,544,762.43	(15,865,637.49, 1,544,859.46)	(15,865,756.03, 1,544,998.88)
C16	88.62	25.86	25.77	016°43'00.32"	15,866,049.01	1,545,270.80	(15,866,093.40, 1,545,194.10)	(15,866,113.59, 1,545,210.11)
C17	383.24	155.34	154.28	023°13'25.60"	15,865,463.79	1,542,944.91	(15,865,748.46, 1,542,688.32)	(15,865,624.21, 1,542,596.87)

LEGEND

PROPOSED GROUND

EXISTING GROUND

ISSUED FOR CONSTRUCTION

0 50 100 150

1" = 50' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (2 OF 2)
STAGE 2

PROJECT NO. 1663241

REV. 0

14 of 42

DRAWING C9B

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

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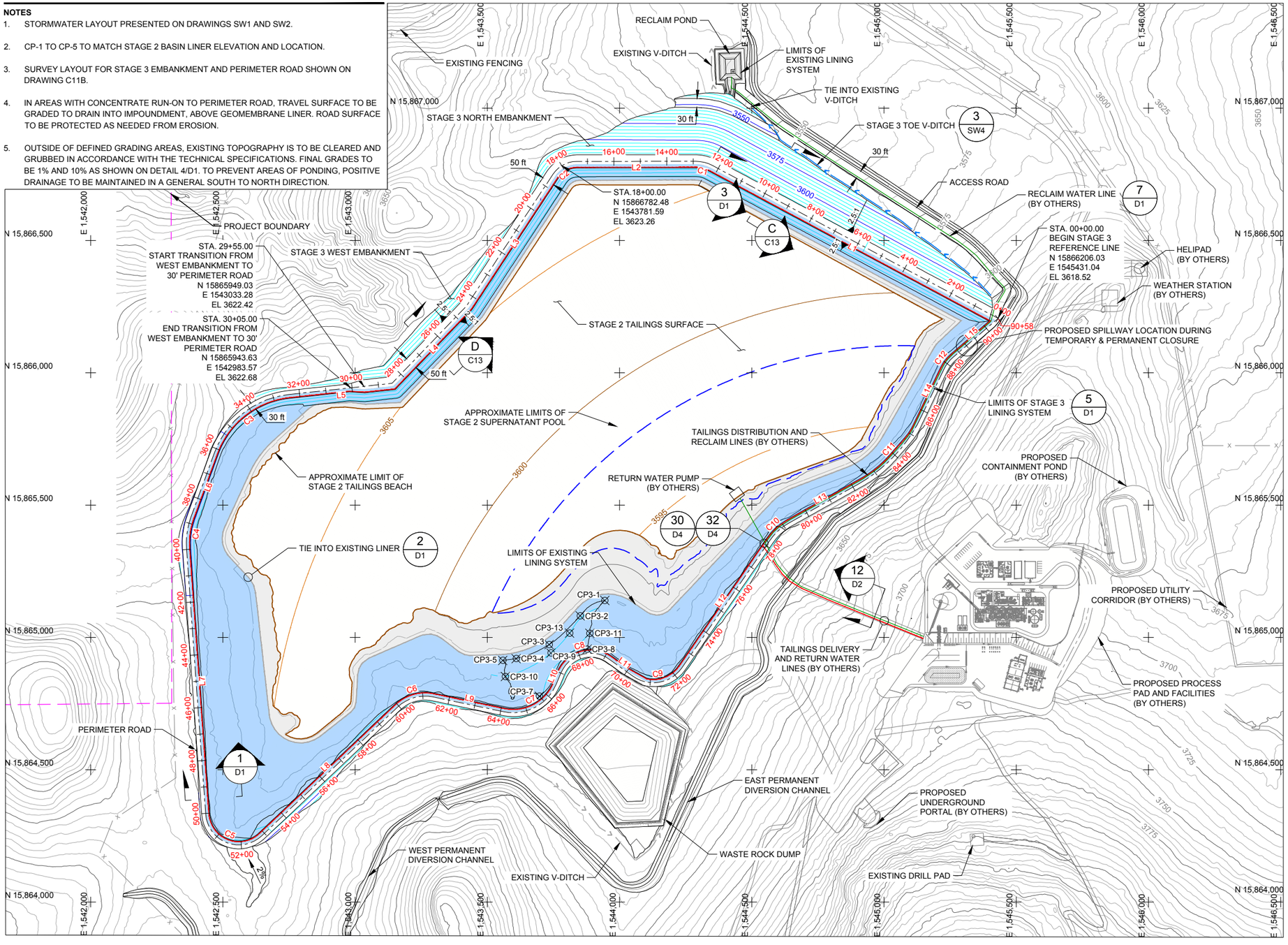
NOTES

1. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
2. CP-1 TO CP-5 TO MATCH STAGE 2 BASIN LINER ELEVATION AND LOCATION.
3. SURVEY LAYOUT FOR STAGE 3 EMBANKMENT AND PERIMETER ROAD SHOWN ON DRAWING C11B.
4. IN AREAS WITH CONCENTRATE RUN-ON TO PERIMETER ROAD, TRAVEL SURFACE TO BE GRADED TO DRAIN INTO IMPOUNDMENT, ABOVE GEOMEMBRANE LINER. ROAD SURFACE TO BE PROTECTED AS NEEDED FROM EROSION.
5. OUTSIDE OF DEFINED GRADING AREAS, EXISTING TOPOGRAPHY IS TO BE CLEARED AND GRUBBED IN ACCORDANCE WITH THE TECHNICAL SPECIFICATIONS. FINAL GRADES TO BE 1% AND 10% AS SHOWN ON DETAIL 4/D1. TO PREVENT AREAS OF PONDING, POSITIVE DRAINAGE TO BE MAINTAINED IN A GENERAL SOUTH TO NORTH DIRECTION.



LEGEND

- EXISTING GROUND (5 FT CONTOURS) (GENERAL NOTE 1)
- PROPOSED GRADING (5 FT CONTOURS)
- STAGE 2 TAILINGS SURFACE (5 FT CONTOURS)
- TAILINGS DISTRIBUTION LINE (BY OTHERS)
- RECLAIM WATER LINE (BY OTHERS)
- APPROXIMATE LIMITS OF STAGE 2 TAILINGS BEACH
- LIMITS OF EXISTING LINING SYSTEM
- LIMITS OF STAGE 3 LINING SYSTEM (5/D1)
- PROJECT BOUNDARY
- EXISTING V-DITCH (3/SW4)
- PERMANENT V-DITCH (3/SW4)
- APPROXIMATE LIMITS OF SUPERNATANT POOL
- EXISTING FENCING
- STAGE 3 REFERENCE LINE (NOTE 3) (A/C11A)

STAGE 3 BASIN GRADING CONTROL POINTS

POINT NO.	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
CP3-1	15,865,139.60	1,543,944.04	3,607.64
CP3-2	15,865,081.63	1,543,850.95	3,609.05
CP3-3	15,864,972.99	1,543,733.71	3,607.28
CP3-4	15,864,919.99	1,543,609.09	3,606.94
CP3-5	15,864,913.47	1,543,558.28	3,606.99
CP3-7	15,864,778.03	1,543,696.58	3,614.28
CP3-8	15,864,955.74	1,543,877.48	3,618.21
CP3-9	15,864,941.32	1,543,740.56	3,610.00
CP3-10	15,864,852.20	1,543,568.02	3,610.00
CP3-11	15,865,015.83	1,543,887.30	3,615.00
CP3-13	15,865,016.46	1,543,810.93	3,610.00

ISSUED FOR CONSTRUCTION

0 200 400 600
1" = 200' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY LAYOUT
STAGE 3

PROJECT NO. 1663241 | REV. 0 | 15 of 42 | DRAWING C10

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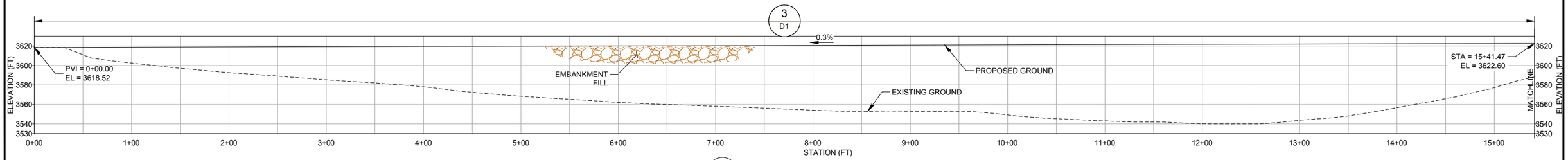

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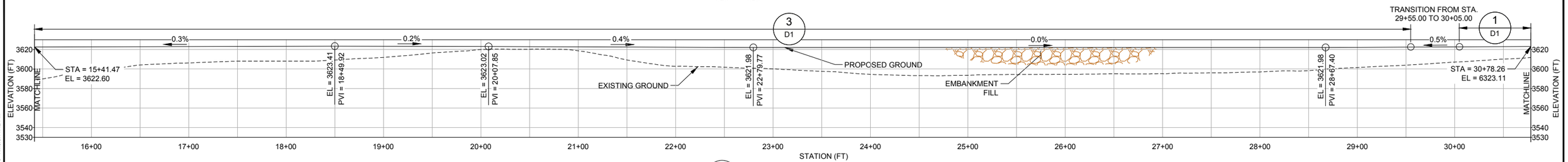

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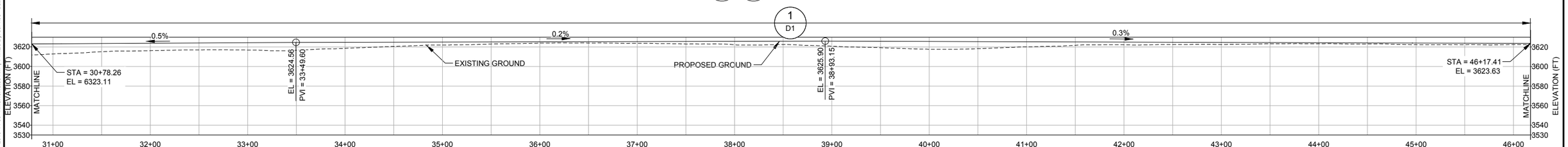
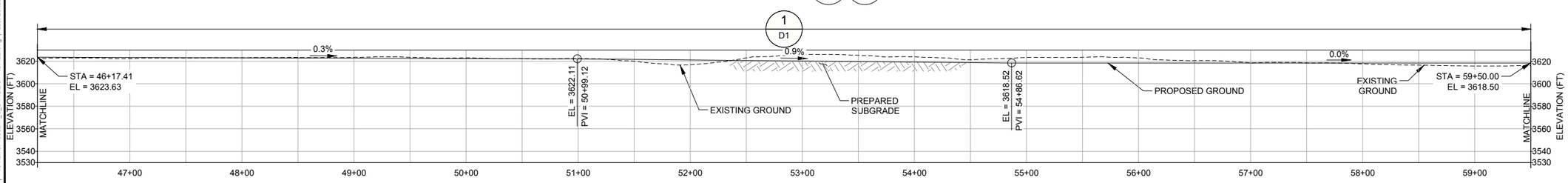


SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C10) — PROFILE CONTINUED



SCALE 1" = 50' / VERT. SCALE 1" = 50' — A (C2, C10) — PROFILE CONTINUED

LEGEND

PROPOSED GROUND

EXISTING GROUND

ISSUED FOR CONSTRUCTION

0 50 100 150
1" = 50' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

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[+1] (775) 828-9604
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (1 OF 2)
STAGE 3

PROJECT NO. 1663241 | REV. 0 | 16 of 42 | DRAWING C11A

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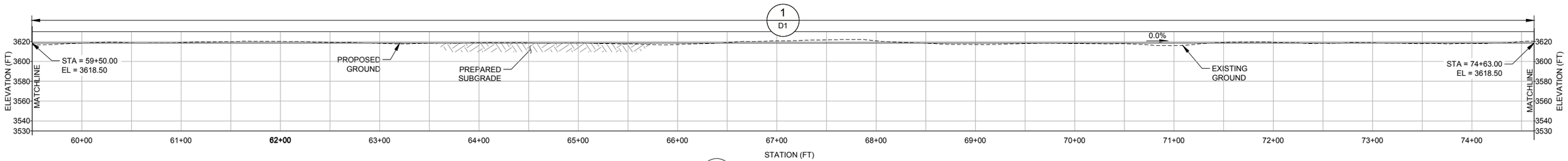
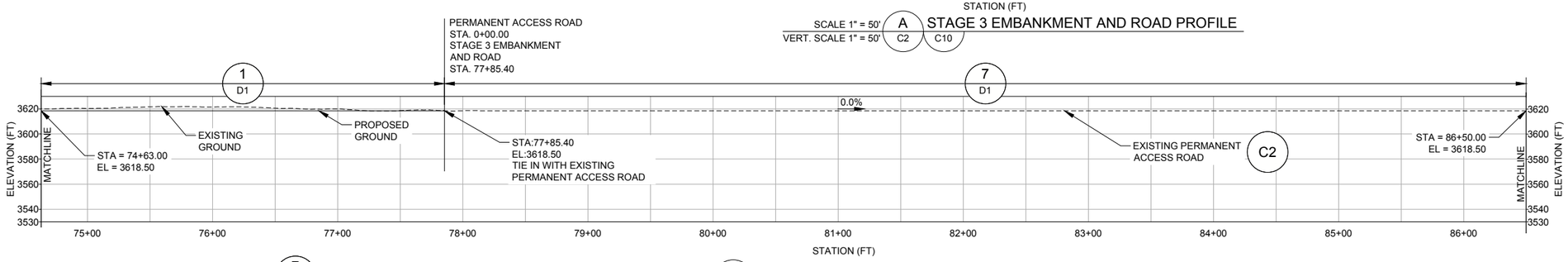


SCALE 1" = 50' / VERT. SCALE 1" = 50' — A — C2 — C10 — STAGE 3 EMBANKMENT AND ROAD PROFILE



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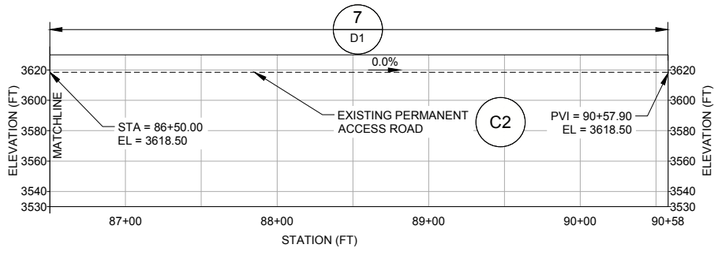

SCALE 1" = 50' / VERT. SCALE 1" = 50' — A — C2 — C10 — PROFILE CONTINUED

STAGE 3 EMBANKMENT AND ROAD CURVE TABLE

CURVE #	RADIUS (FT)	LENGTH (FT)	CHORD LENGTH (FT)	DELTA	CENTER (N)	CENTER (E)	START POINT (N, E)	END POINT (N, E)
C1	130.55	64.3	63.62	028°12'14.52"	15,866,668.81	1,544,288.90	(15,866,783.92, 1,544,350.48)	(15,866,799.35, 1,544,288.76)
C2	108.32	107.1	102.80	056°39'27.37"	15,866,690.57	1,543,838.33	(15,866,798.89, 1,543,838.22)	(15,866,750.01, 1,543,747.78)
C3	339.28	377.3	358.15	063°42'58.23"	15,865,580.97	1,542,786.53	(15,865,918.26, 1,542,749.91)	(15,865,697.49, 1,542,467.90)
C4	288.75	122.1	121.16	024°13'14.68"	15,865,356.17	1,542,650.53	(15,865,455.35, 1,542,379.35)	(15,865,335.36, 1,542,362.53)
C5	125.77	283.8	227.32	129°18'06.60"	15,864,341.80	1,542,560.44	(15,864,332.73, 1,542,434.99)	(15,864,250.47, 1,542,646.91)
C6	149.28	144.0	138.45	055°15'20.25"	15,864,629.26	1,543,264.10	(15,864,737.66, 1,543,161.47)	(15,864,775.38, 1,543,294.68)
C7	176.37	242.8	224.10	078°53'07.78"	15,864,892.07	1,543,598.07	(15,864,719.44, 1,543,561.95)	(15,864,823.34, 1,543,760.50)
C8	121.19	217.8	189.64	102°57'52.83"	15,864,819.54	1,543,890.49	(15,864,866.76, 1,543,778.88)	(15,864,917.71, 1,543,961.55)
C9	132.22	210.6	189.02	091°15'03.53"	15,864,960.98	1,544,127.25	(15,864,853.88, 1,544,049.72)	(15,864,885.81, 1,544,236.02)
C10	217.39	99.1	98.23	026°06'49.40"	15,865,243.31	1,544,747.35	(15,865,366.91, 1,544,568.51)	(15,865,433.01, 1,544,641.17)
C11	581.76	358.2	352.56	035°16'38.41"	15,866,085.78	1,544,616.27	(15,865,578.13, 1,544,900.43)	(15,865,835.46, 1,545,141.43)
C12	142.80	59.1	58.66	023°42'16.53"	15,865,950.79	1,545,354.59	(15,866,012.23, 1,545,225.69)	(15,866,058.87, 1,545,261.27)

STAGE 3 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	1225.39	N61° 51' 17.45"W	(15,866,205.89, 1,545,430.97)	(15,866,783.92, 1,544,350.48)
L2	450.55	S89° 56' 28.03"W	(15,866,799.35, 1,544,288.76)	(15,866,798.89, 1,543,838.22)
L3	593.80	S33° 17' 00.67"W	(15,866,750.01, 1,543,747.78)	(15,866,253.62, 1,543,421.91)
L4	406.79	S43° 55' 03.84"W	(15,866,253.62, 1,543,421.91)	(15,865,960.59, 1,543,139.75)
L5	392.13	S83° 48' 12.09"W	(15,865,960.59, 1,543,139.75)	(15,865,918.26, 1,542,749.91)
L6	257.83	S20° 05' 13.86"W	(15,865,697.49, 1,542,467.90)	(15,865,455.35, 1,542,379.35)
L7	1005.25	S4° 08' 00.82"E	(15,865,335.36, 1,542,362.53)	(15,864,332.73, 1,542,434.99)
L8	708.61	N46° 33' 52.58"E	(15,864,250.47, 1,542,646.91)	(15,864,737.66, 1,543,161.47)
L9	273.06	S78° 10' 47.18"E	(15,864,775.38, 1,543,294.68)	(15,864,719.44, 1,543,561.95)
L10	47.15	N22° 56' 05.05"E	(15,864,823.34, 1,543,760.50)	(15,864,866.76, 1,543,778.88)
L11	108.85	S54° 06' 02.13"E	(15,864,917.71, 1,543,961.55)	(15,864,853.88, 1,544,049.72)
L12	584.81	N34° 38' 54.35"E	(15,864,885.81, 1,544,236.02)	(15,865,366.91, 1,544,568.51)

STAGE 3 EMBANKMENT AND ROAD LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L13	297.11	N60° 45' 43.75"E	(15,865,433.01, 1,544,641.17)	(15,865,578.13, 1,544,900.43)
L14	195.83	N25° 29' 05.33"E	(15,865,835.46, 1,545,141.43)	(15,866,012.23, 1,545,225.69)
L15	224.67	N49° 11' 21.86"E	(15,866,058.87, 1,545,261.27)	(15,866,205.71, 1,545,431.31)

LEGEND

PROPOSED GROUND

EXISTING GROUND

ISSUED FOR CONSTRUCTION

1" = 50' (0, 50, 100, 150 FEET)

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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PROJECT
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TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EMBANKMENT AND ROAD PROFILE (2 OF 2)
STAGE 3

PROJECT NO. 1663241 | REV. 0 | 17 of 42 | DRAWING C11B

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

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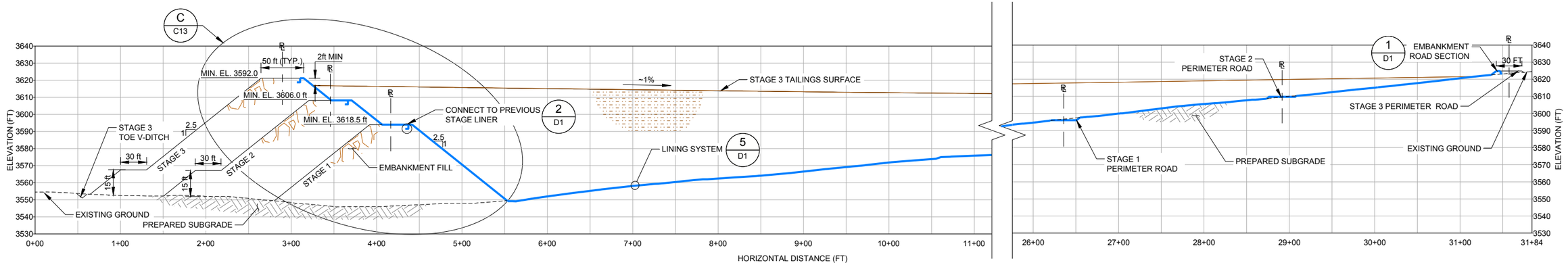
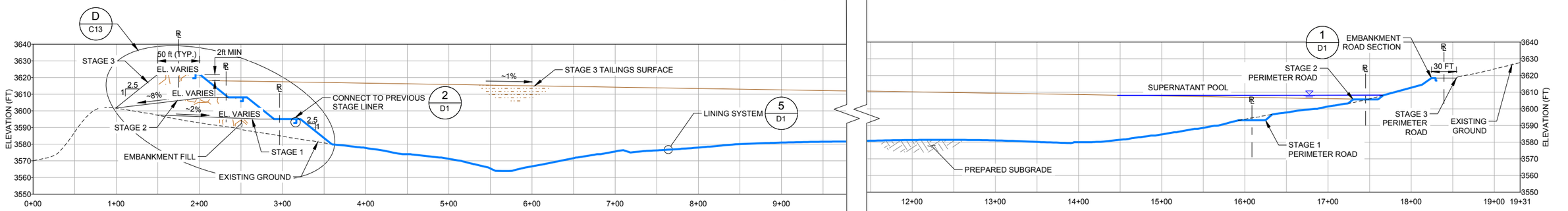


SCALE 1" = 60'
VERT. SCALE 1" = 30'

A C1 NORTH TO SOUTH TYPICAL SECTION



SCALE 1" = 60'
VERT. SCALE 1" = 30'

B C1 WEST TO EAST TYPICAL SECTION

LEGEND

- LINING SYSTEM (5 / D1)
- EXISTING GROUND
- TAILINGS SURFACE
- SUPERNATANT POOL SURFACE

ISSUED FOR CONSTRUCTION

0 30 60
1" = 30' FEET

0 60 120
1" = 60' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY OVERALL SECTIONS

PROJECT NO. 1663241
REV. 0

DRAWING C12

Path: \\reno\data\MDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: C7 TAILINGS FACILITY OVERALL SECTIONS.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:3:41:24 PM | Printed By: JePrice Date: 2019-11-06 Time:4:07:08 PM
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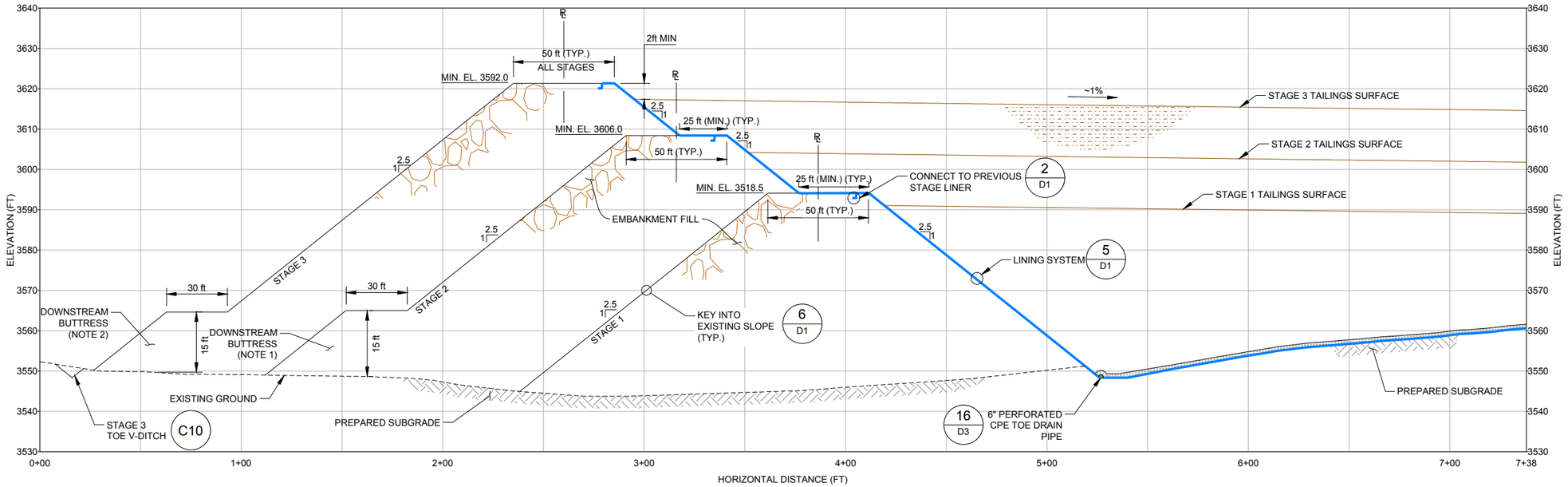
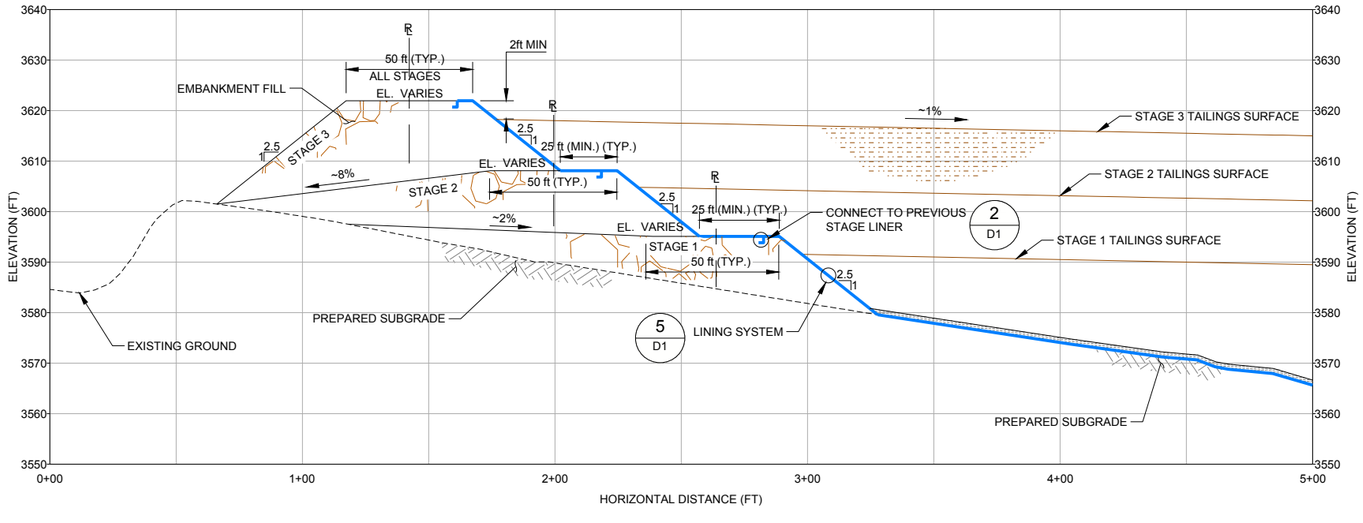


SCALE 1" = 30'
VERT. SCALE 1" = 15'

C NORTH EMBANKMENT TYPICAL SECTION

C1 C5 C8 C10 C12



SCALE 1" = 30'
VERT. SCALE 1" = 15'

D WEST EMBANKMENT TYPICAL SECTION

C1 C5 C8 C10 C12

LEGEND

- LINING SYSTEM (5 / D1)
- EXISTING GROUND
- TAILINGS SURFACE

NOTES

1. DOWNSTREAM BUTTRESS FROM STAGE 2 REFERENCE LINE STATIONS 9+16.00 TO 12+17.00 ONLY.
2. DOWNSTREAM BUTTRESS FROM STAGE 3 REFERENCE LINE STATIONS 10+48.00 TO 13+67.00 ONLY.

ISSUED FOR CONSTRUCTION

0 15 30 45
1" = 15' FEET

0 30 60 90
1" = 30' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TAILINGS STORAGE FACILITY EMBANKMENT SECTIONS

PROJECT NO. 1663241
REV. 0

DRAWING C13

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

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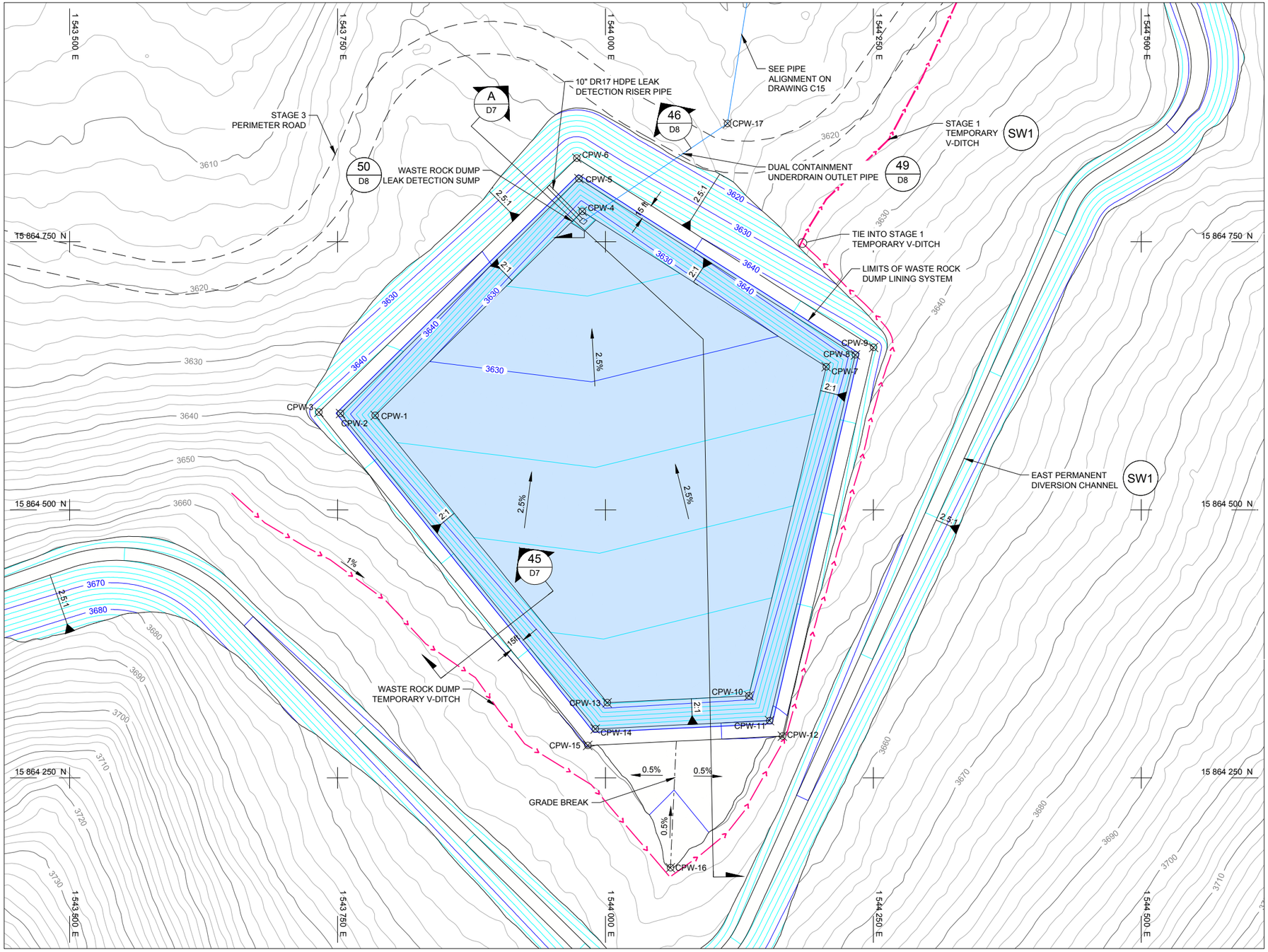

LEGEND

- 3600 — EXISTING GROUND (2 FT CONTOURS) (GENERAL NOTE 1)
- 3600 — PROPOSED GRADING (2 FT CONTOURS)
- TEMPORARY V-DITCH SW1
- LIMITS OF WASTE ROCK DUMP LINING SYSTEM 5 / D1
- STAGE 3 PERIMETER ROAD

NOTE

1. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.

WASTE ROCK DUMP CONTROL TABLE

POINT NO.	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)	DESCRIPTION
CPW-1	15,864,588.04	1,543,785.09	3,631.43	BERM TOE
CPW-2	15,864,589.87	1,543,752.75	3,643.43	BERM CREST
CPW-3	15,864,591.02	1,543,732.54	3,643.43	BERM CREST
CPW-4	15,864,778.44	1,543,978.41	3,626.02	BERM TOE
CPW-5	15,864,808.95	1,543,975.19	3,638.02	BERM CREST
CPW-6	15,864,828.02	1,543,973.17	3,638.02	BERM CREST
CPW-7	15,864,633.47	1,544,205.90	3,630.98	BERM TOE
CPW-8	15,864,644.56	1,544,233.16	3,642.98	BERM CREST
CPW-9	15,864,651.49	1,544,250.19	3,642.98	BERM CREST
CPW-10	15,864,326.45	1,544,133.84	3,638.13	BERM TOE
CPW-11	15,864,303.35	1,544,153.07	3,650.13	BERM CREST
CPW-12	15,864,288.91	1,544,165.09	3,650.13	BERM CREST
CPW-13	15,864,320.11	1,544,001.63	3,637.49	BERM TOE
CPW-14	15,864,295.55	1,543,990.43	3,649.49	BERM CREST
CPW-15	15,864,280.20	1,543,983.43	3,649.49	BERM CREST
CPW-16	15,864,166.13	1,544,060.60	3,650.33	EXISTING GROUND TIE-IN
CPW-17	15,864,860.29	1,544,113.85	3,613.99	UNDERDRAIN OUTLET PIPE HINGE

0 50 100
1" = 50' FEET

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

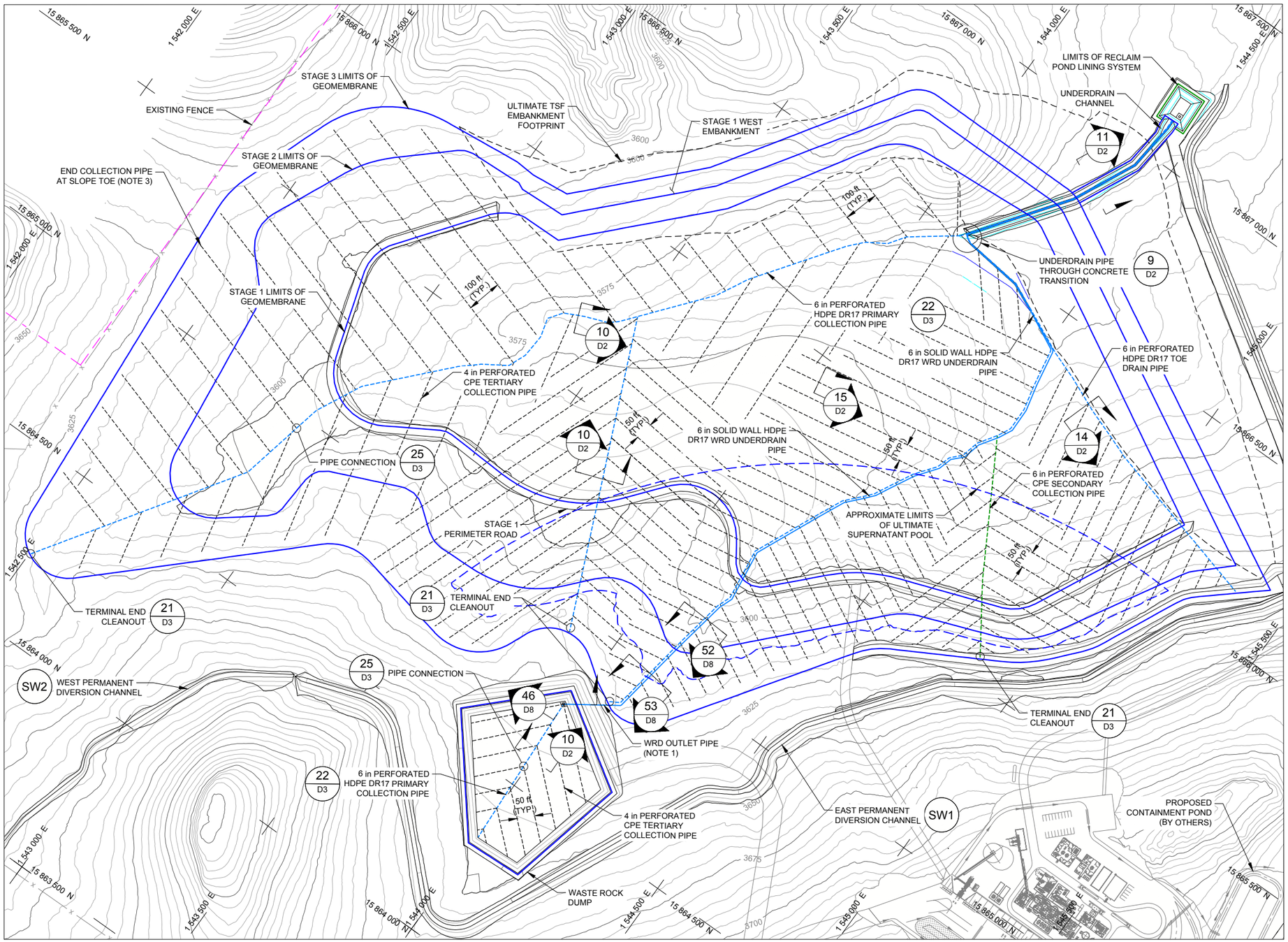
TITLE
WASTE ROCK DUMP LAYOUT

PROJECT NO. 1663241
REV. 0

DRAWING C14

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

Path: \\enodata\MDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: 1663241_C_x_WASTE ROCK DUMP LAYOUT.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:3:45:15 PM | Printed By: JePrice Date: 2019-11-06 Time:4:09:03 PM



LEGEND

- EXISTING GROUND CONTOURS (5 FT CONTOURS) (GENERAL NOTE 1)
- PROJECT BOUNDARY
- 6 in SOLID WALL HDPE DR17 PRIMARY COLLECTION PIPE
- 4 in PERFORATED CPE TERTIARY COLLECTION PIPE
- 6 in PERFORATED CPE SECONDARY COLLECTION PIPE
- 6 in PERFORATED HDPE DR17 PRIMARY COLLECTION PIPE
- LIMITS OF RECLAIM POND LINING SYSTEM (42 / D6)
- LIMITS OF STAGED GEOMEMBRANE (5 / D1)
- EXISTING FENCE
- ULTIMATE TSF EMBANKMENT FOOTPRINT

NOTES

1. WASTE ROCK DUMP UNDERDRAIN OUTLET PIPE CONSTRUCTED DURING STAGE 1.
2. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.
3. EXTEND COLLECTION PIPING TO UPSTREAM TOE OF PERIMETER ROAD.

ISSUED FOR CONSTRUCTION

0 150 300 450
1" = 150' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
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www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
UNDERDRAIN COLLECTION SYSTEM LAYOUT

PROJECT NO.	REV.		DRAWING
1663241	0	21 of 42	C15

Path: \\reno\data\MDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: C2 OVERALL FACILITY-WITH UNDERDRAIN.dwg | Last Edited By: mstengraeber Date: 2019-11-06 Time:10:26:49 AM | Printed By: JaPrice Date: 2019-11-06 Time:3:15:44 PM
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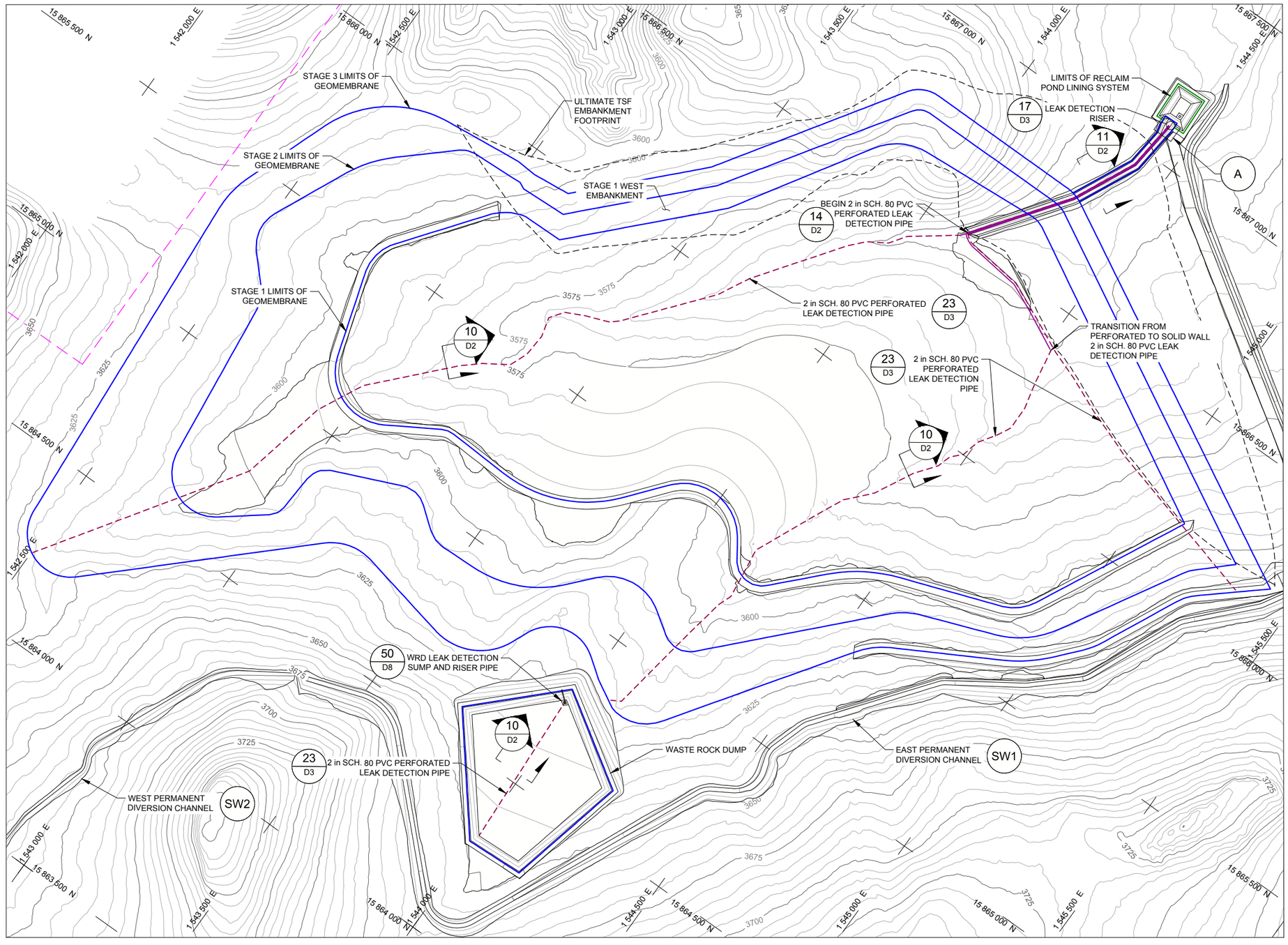
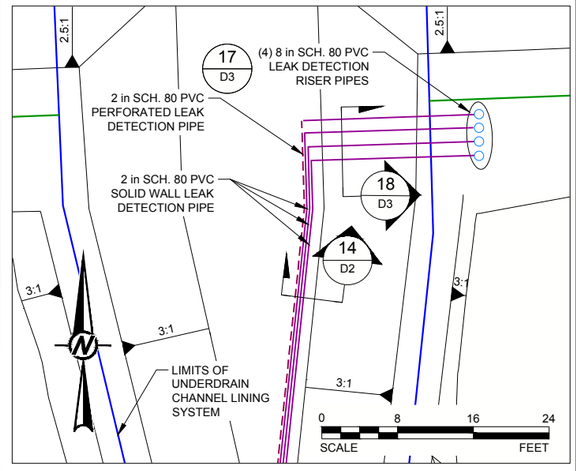


LEGEND

- 3600 — EXISTING GROUND CONTOURS (5 FT CONTOURS) (GENERAL NOTE 1)
- PROJECT BOUNDARY
- LIMITS OF RECLAIM POND LINING SYSTEM — 42 / D6
- LIMITS OF STAGED GEOMEMBRANE — 5 / D1
- 2 in SCH. 80 PVC PERFORATED LEAK DETECTION PIPE — 23 / C13
- 2 in SCH. 80 PVC SOLID WALL LEAK DETECTION PIPE
- ULTIMATE TSF EMBANKMENT FOOTPRINT

NOTE

1. STORMWATER LAYOUT PRESENTED ON SHEETS SW1 AND SW2.



NTS A - LEAK DETECTION RISER DETAIL

ISSUED FOR CONSTRUCTION

0 150 300 450
1" = 150' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
LEAK DETECTION SYSTEM LAYOUT

PROJECT NO. 1663241 | REV. 0 | 22 of 42 | DRAWING C16

Path: \\env\data\MDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: 1663241_C_x_LEAK DETECTION LAYOUT.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:3:47:33 PM | Printed By: JePrice Date: 2019-11-06 Time:4:09:53 PM
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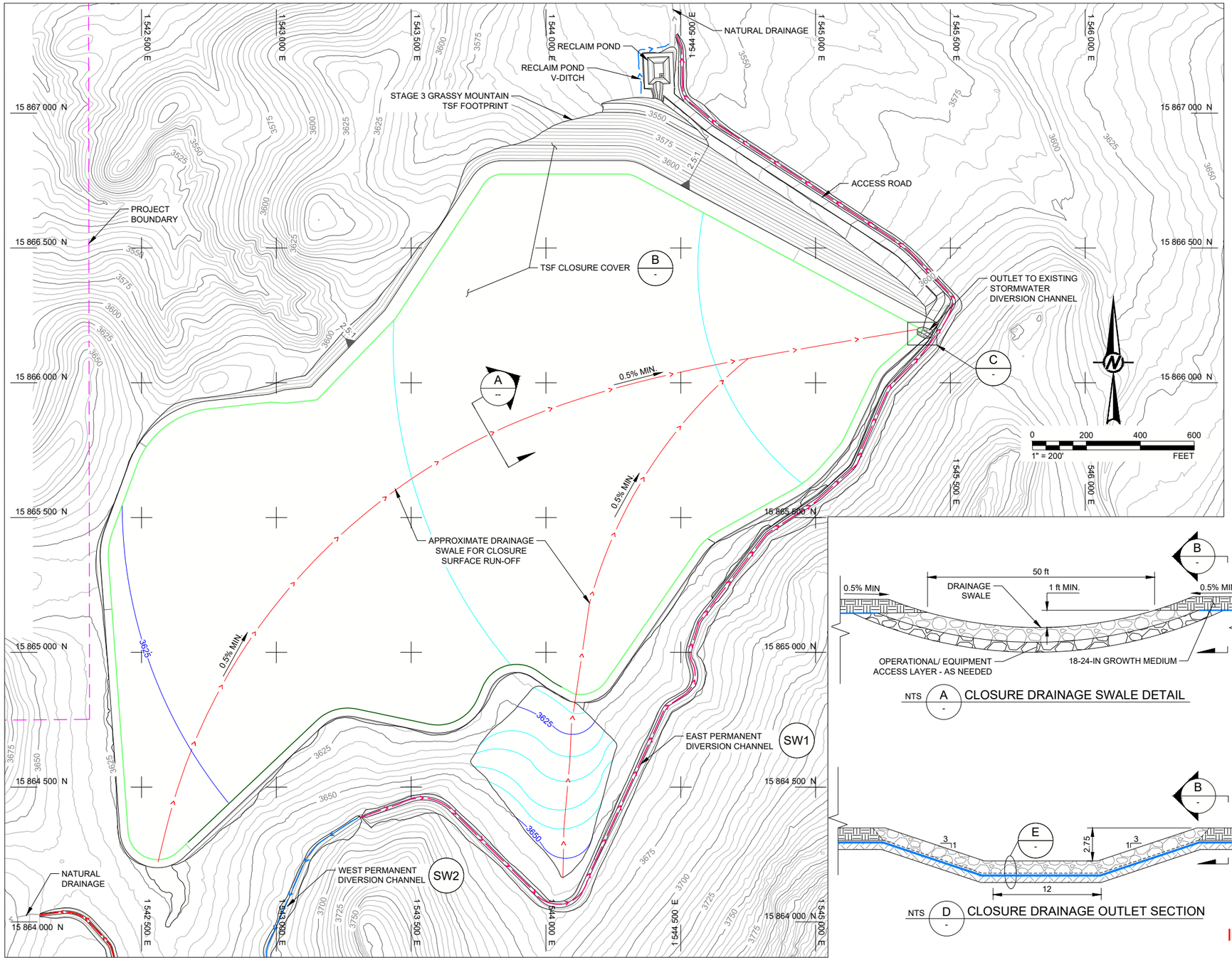
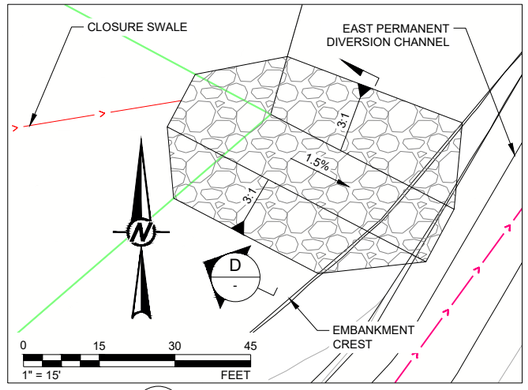


LEGEND

- 3600 — EXISTING GROUND CONTOURS (5 FT CONTOURS) (NOTE 1)
- PROJECT BOUNDARY
- PERMANENT TRAPEZOIDAL STORMWATER DIVERSION CHANNEL
- PERMANENT V-DITCH STORMWATER DIVERSION CHANNEL
- CLOSURE DRAINAGE SWALE
- 3600 — CONCEPTUAL CLOSURE GRADING (5 FT CONTOURS)
- NATURAL DRAINAGE
- LIMITS OF CLOSURE COVER — B / -

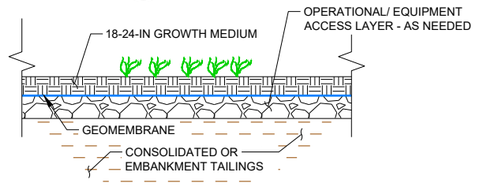
NOTES

1. EXISTING GROUND AS SHOWN COMPRISED OF 2017 TOPOGRAPHY (REFER TO GENERAL NOTE 1) AND THE STAGE 3 TSF LAYOUT.
2. STORMWATER LAYOUT PRESENTED ON DRAWINGS SW1 AND SW2.

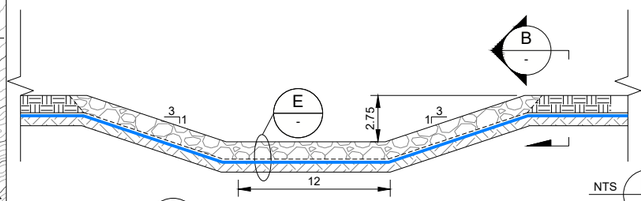


SCALE 1" = 15' C - CLOSURE DRAINAGE OUTLET DETAIL

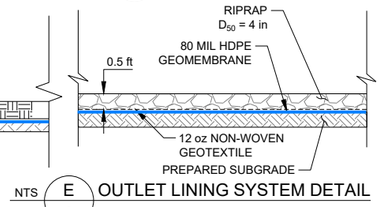
NTS A - CLOSURE DRAINAGE SWALE DETAIL



NTS B - TSF CLOSURE COVER SYSTEM DETAIL



NTS D - CLOSURE DRAINAGE OUTLET SECTION



NTS E - OUTLET LINING SYSTEM DETAIL

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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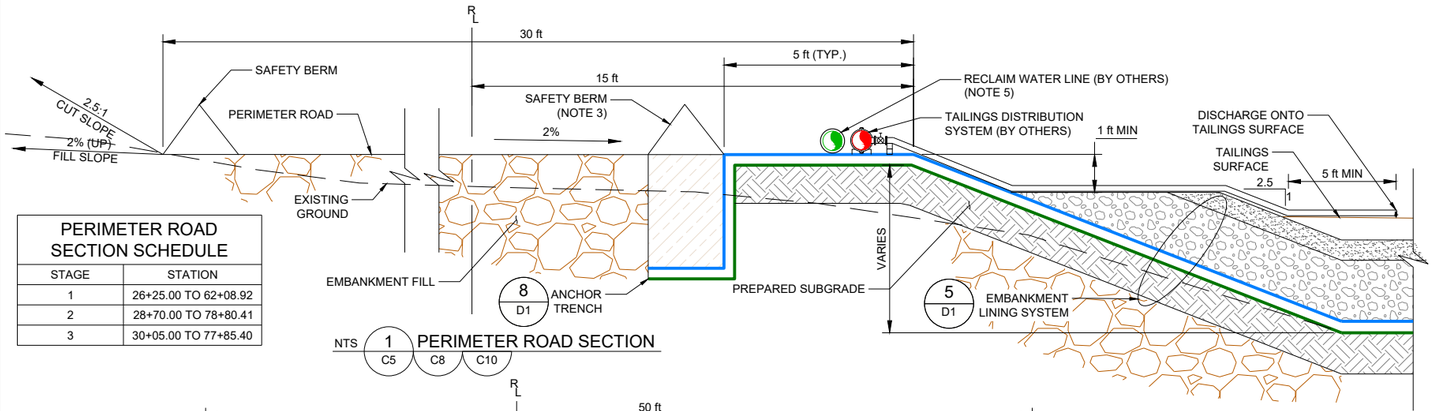
PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
CONCEPTUAL CLOSURE PLAN

PROJECT NO. 1663241 | REV. 0 | 23 of 42 | DRAWING C17

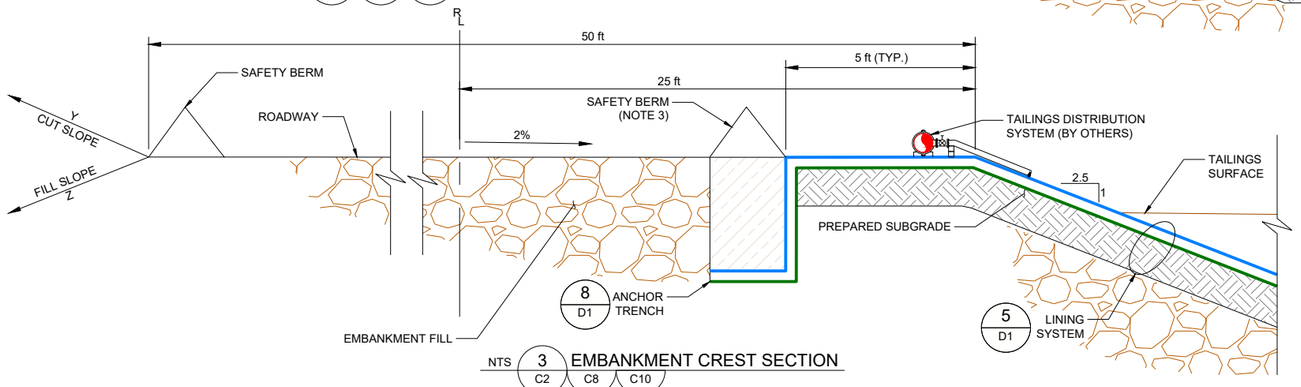
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

Path: \\reno\data\MDA\1663241 Grassy Mountain PFS\600 Drawings\PROJUCTION\CONSOLIDATED PERMITI\ | File Name: C10 CONCEPTUAL CLOSURE_PLAN.dwg | Last Edited By: mstelngraeber Date: 2019-11-06 Time:3:42:32 PM | Printed By: MSteingraeber Date: 2019-11-06 Time:4:04:09 PM



NTS 1 C5 C8 C10 PERIMETER ROAD SECTION

PERIMETER ROAD SECTION SCHEDULE	
STAGE	STATION
1	26+25.00 TO 62+08.92
2	28+70.00 TO 78+80.41
3	30+05.00 TO 77+85.40

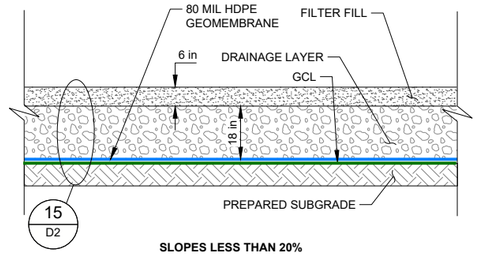


NTS 3 C2 C8 C10 EMBANKMENT CREST SECTION

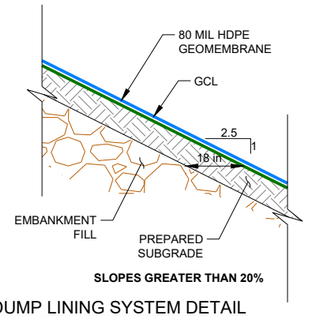
STAGE 1 EMBANKMENT CREST SECTION SCHEDULE		
STATION	CUT SLOPE (Y)	FILL SLOPE (Z)
0+00.00 TO 11+98.56 AND 16+67.68 TO 25+75.00	~2%	2.5:1
12+62.58 TO 16+17.00	2.5:1	2.5:1

STAGE 2 EMBANKMENT CREST SECTION SCHEDULE		
STATION	CUT SLOPE (Y)	FILL SLOPE (Z)
0+00.00 TO 16+90.00	~2%	2.5:1
17+40.00 TO 19+40.00	2.5:1	2.5:1
19+90.00 TO 28+20.00	2.5:1	~ 8%

STAGE 3 EMBANKMENT CREST SECTION SCHEDULE		
STATION	CUT SLOPE (Y)	FILL SLOPE (Z)
0+00.00 TO 29+55.00	~2%	2.5:1

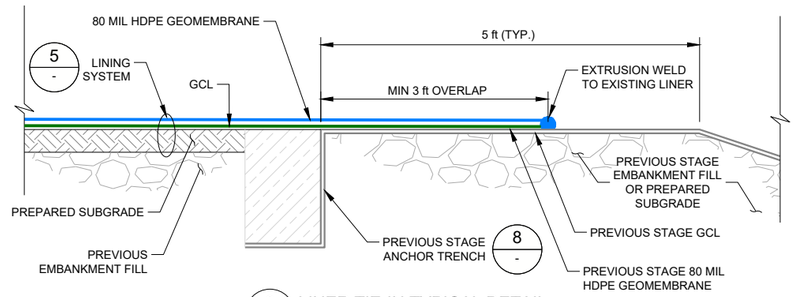


SLOPES LESS THAN 20%

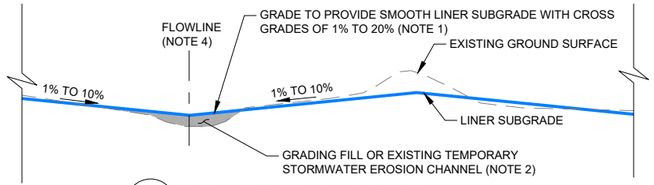


SLOPES GREATER THAN 20%

NTS 5 C1 C4 C5 C8 C10 C12 C13 C14 C15 C16 D2 D8 TYPICAL TSF BASIN AND WASTE ROCK DUMP LINING SYSTEM DETAIL



NTS 2 C8 C10 C12 C13 LINER TIE-IN TYPICAL DETAIL



NTS 4 C2 BASIN SITE GRADING SECTION

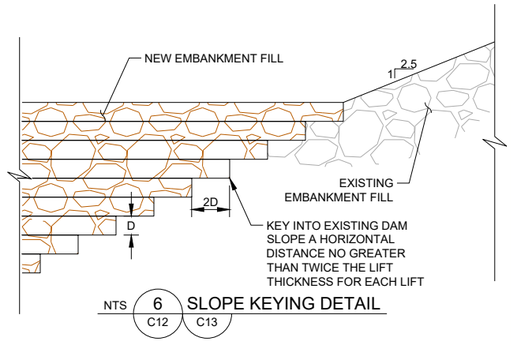
NOTES

1. TAILINGS STORAGE FACILITY SITE GRADING TO MAINTAIN A GENERAL SOUTHWEST TO NORTHEAST DIRECTION OF FLOW.
2. EXISTING TEMPORARY STORMWATER DIVERSION CHANNELS SHALL BE BACKFILLED.
3. CUT OPENINGS IN SAFETY BERM AS NEEDED TO PROMOTE ACCESS ROAD DRAINAGE INTO IMPOUNDMENT.
4. EXCAVATE FLOWLINE BETWEEN CONTROL POINT 19 AND CONTROL POINT 21 WITH A MINIMUM EXCAVATION WIDTH OF 10 FEET.
5. RECLAIM WATER LINE ONLY PRESENT ON STAGE 3 PERIMETER ROAD.

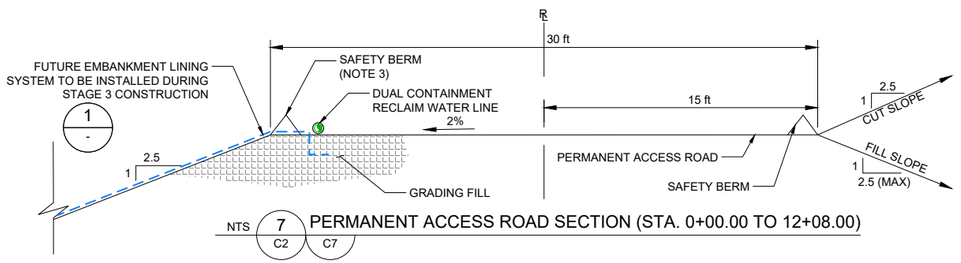
LEGEND

- GCL
- 80 MIL HDPE GEOMEMBRANE
- EXISTING LINING SYSTEM
- TAILINGS SURFACE

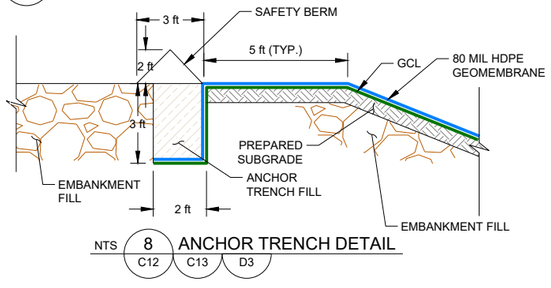
ISSUED FOR CONSTRUCTION



NTS 6 C12 C13 SLOPE KEYING DETAIL



NTS 7 C2 C7 PERMANENT ACCESS ROAD SECTION (STA. 0+00.00 TO 12+08.00)



NTS 8 C12 C13 D3 ANCHOR TRENCH DETAIL

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

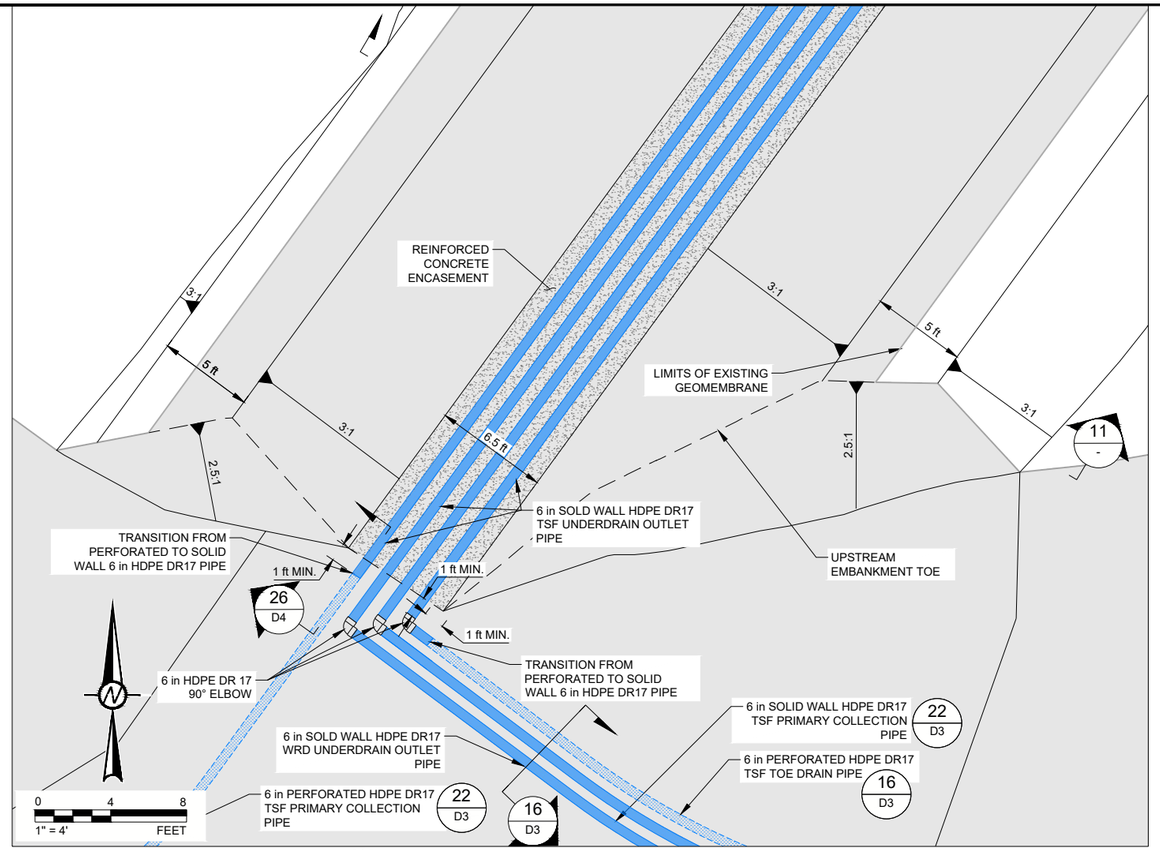
PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (1 OF 9)
TAILINGS STORAGE FACILITY

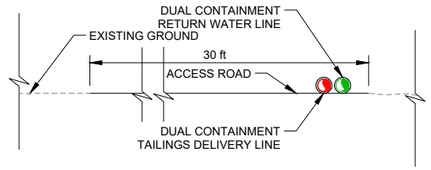
PROJECT NO. 1663241 | REV. 0 | 24 of 42 | DRAWING D1

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

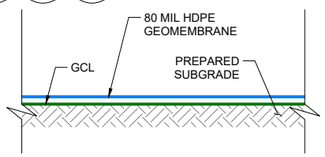
Path: \\env\data\MDA\1663241 Grassy Mountain PFS\600_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: D1 DETAILS.dwg | Last Edited By: msteingraeber Date: 2019-11-06 Time:3:45:46 PM | Printed By: MSteingraeber Date: 2019-11-06 Time:4:04:51 PM



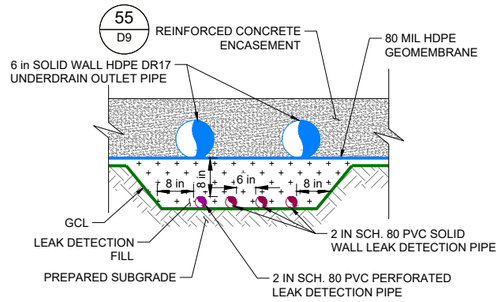
SCALE 1" = 4' 9 C15 UNDERDRAIN CHANNEL INLET



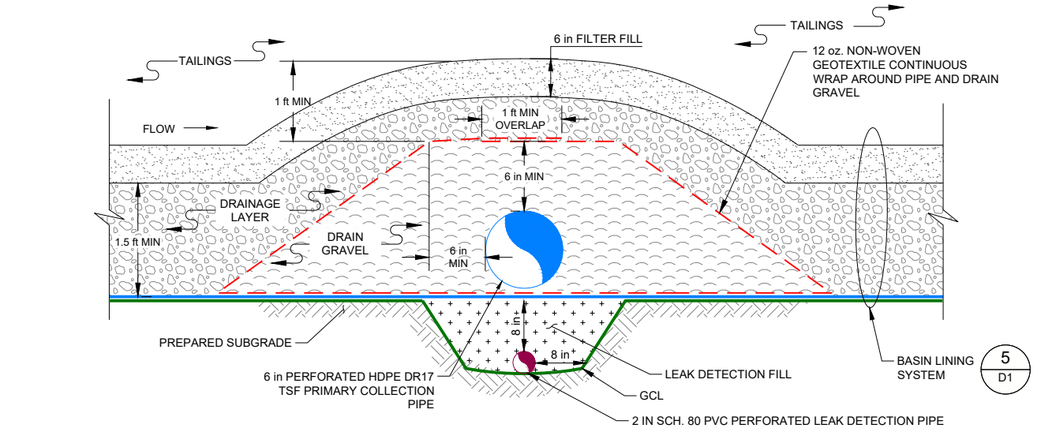
NTS 12 C5 C8 C10 PERMANENT ACCESS ROAD SECTION



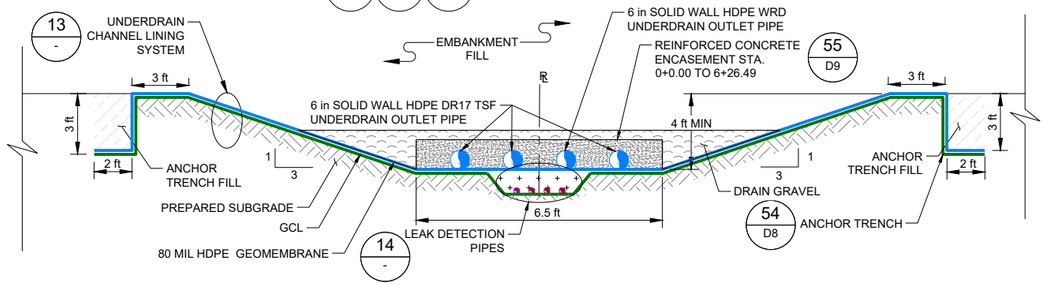
NTS 13 D1 D6 UNDERDRAIN CHANNEL LINING SYSTEM



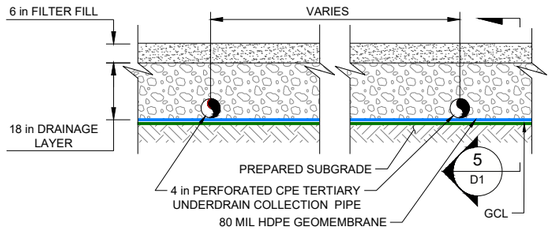
NTS 14 D9 LEAK DETECTION PIPES BENEATH CHANNEL DETAIL



NTS 10 C15 C16 D8 UNDERDRAIN COLLECTION PIPE TYPICAL DETAIL



NTS 11 C2 C3 C4 C15 C16 UNDERDRAIN CHANNEL BENEATH EMBANKMENT TYPICAL SECTION



NTS 15 C15 D1 BASIN PIPING AND LINING SYSTEM DETAIL

LEGEND

- 12 oz. NON-WOVEN GEOTEXTILE
- 80 MIL HDPE GEOMEMBRANE
- GCL
- EXISTING GROUND
- LIMITS OF EXISTING GEOMEMBRANE

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (2 OF 9)
UNDERDRAIN COLLECTION SYSTEM

PROJECT NO. 1663241 | REV. 0 | 25 of 42 | DRAWING D2

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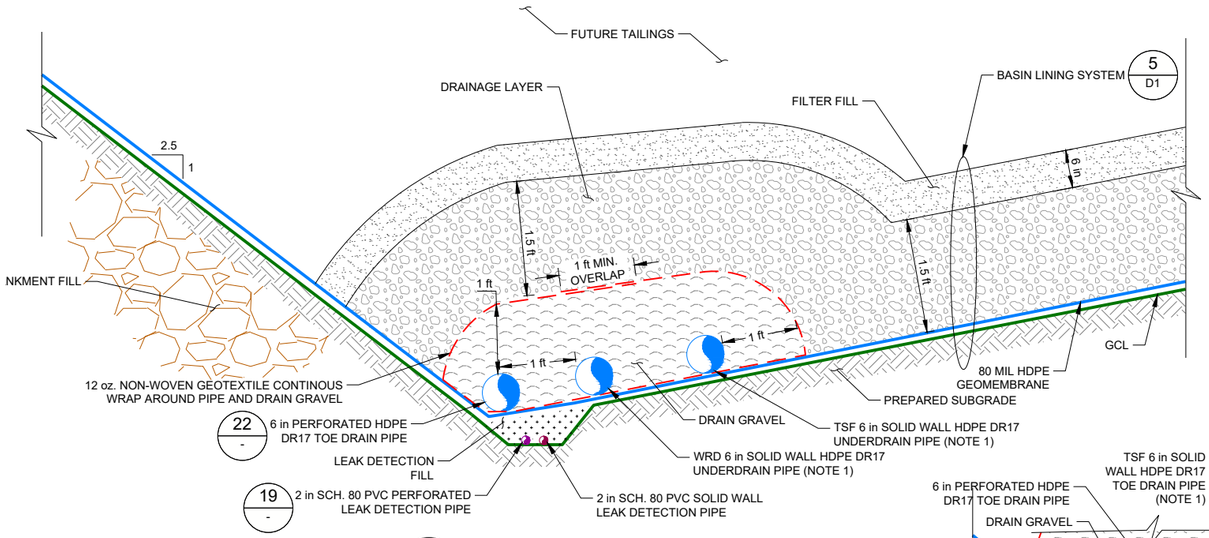
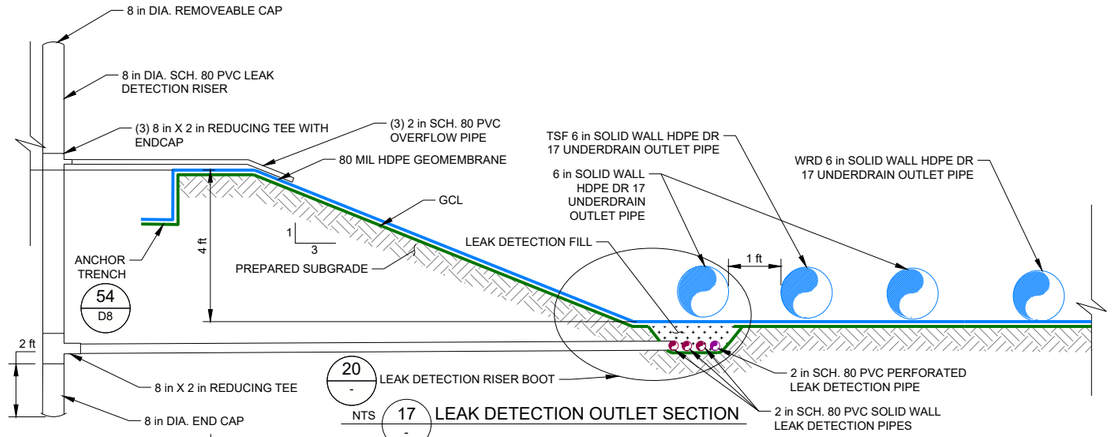
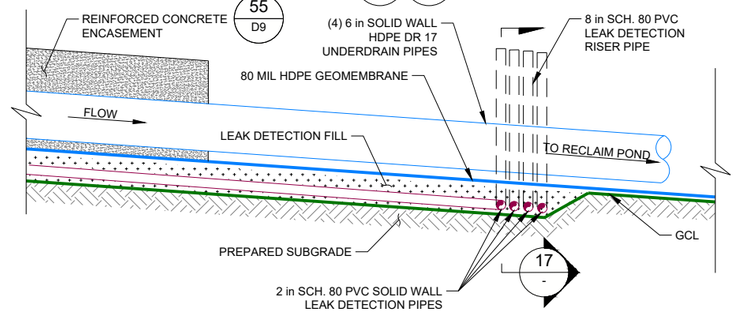


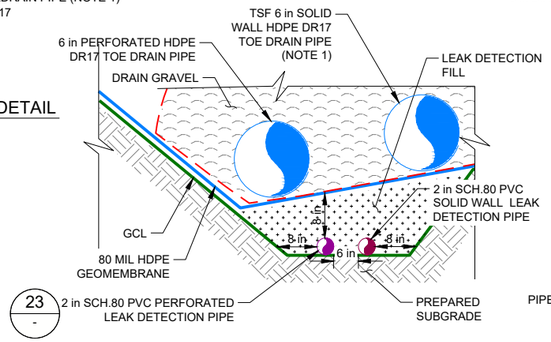
SCALE 1"=1' 16 C13 D2 TAILINGS STORAGE FACILITY BASIN TOE-DRAIN DETAIL



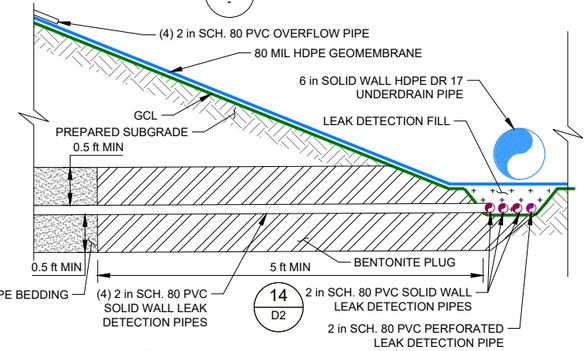
NTS 17 - LEAK DETECTION OUTLET SECTION



NTS 18 C16 LEAK DETECTION RISER DETAIL



NTS 19 - TOE DRAIN LEAK DETECTION DETAIL



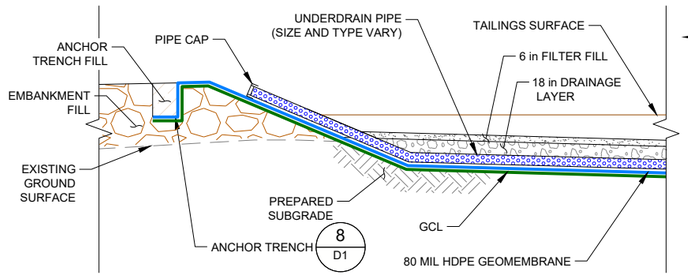
NTS 20 - LEAK DETECTION RISER BOOT DETAIL

LEGEND

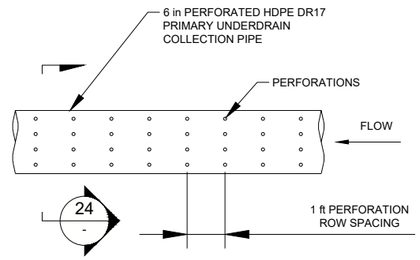
- GCL
- 80 MIL HDPE GEOMEMBRANE
- 12 oz. NON-WOVEN GEOTEXTILE

NOTE

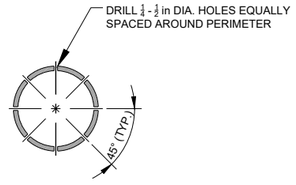
1. TSF AND WRD UNDERDRAIN PIPES ONLY WHERE SHOWN ON SHEET C15.



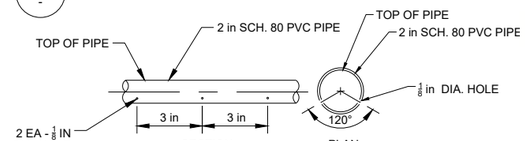
NTS 21 C15 TERMINAL END CLEANOUT DETAIL



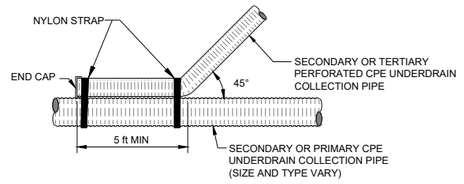
NTS 22 C15 D2 HDPE PERFORATED PIPE DETAIL



NTS 24 - HDPE PERFORATED PIPE SECTION



NTS 23 C16 LEAK DETECTION PIPE PERFORATION DETAIL



NTS 25 C15 UNDERDRAIN COLLECTION PIPE CONNECTION DETAIL

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (3 OF 9)
UNDERDRAIN COLLECTION SYSTEM

PROJECT NO. 1663241
REV. 0

DRAWING D3

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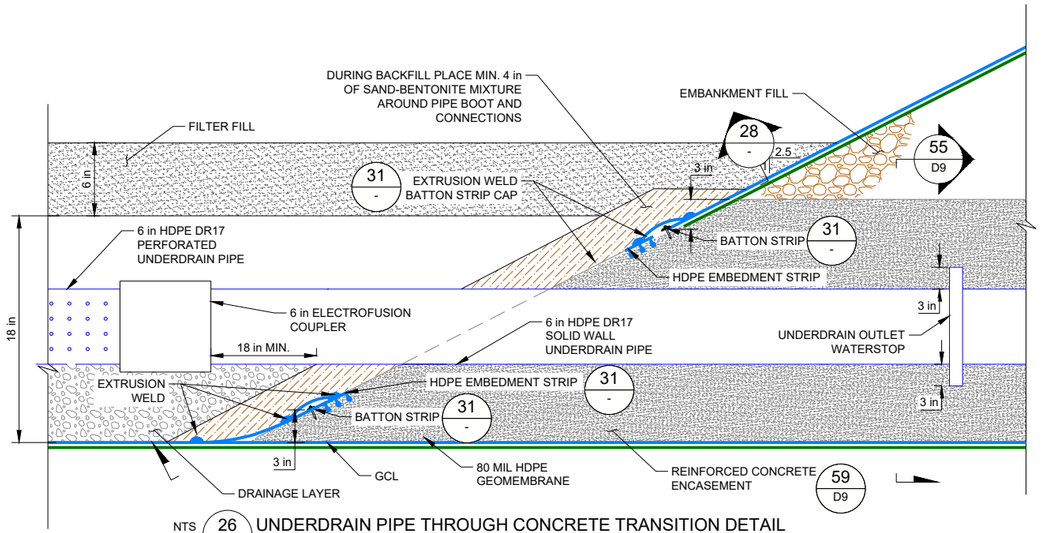
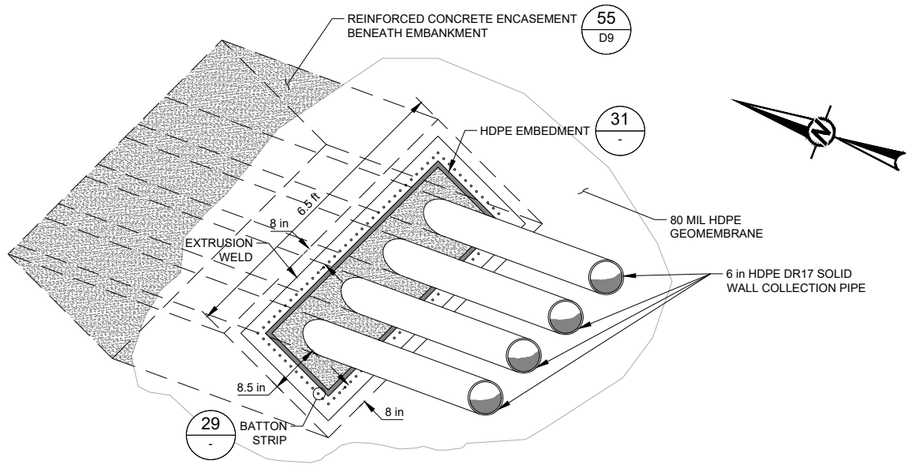
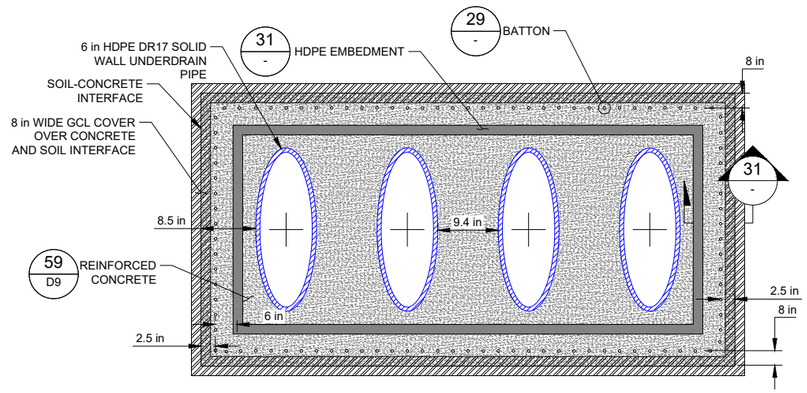


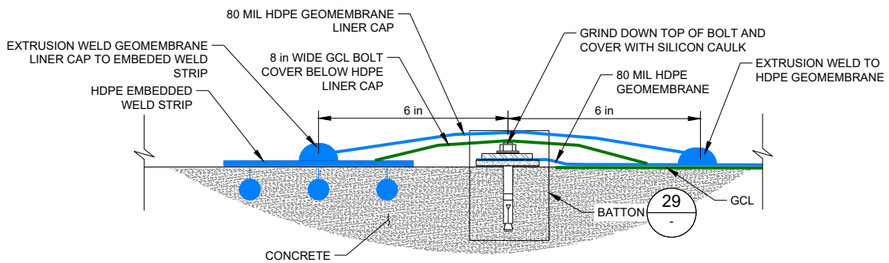
NTS 26 C15 UNDERDRAIN PIPE THROUGH CONCRETE TRANSITION DETAIL



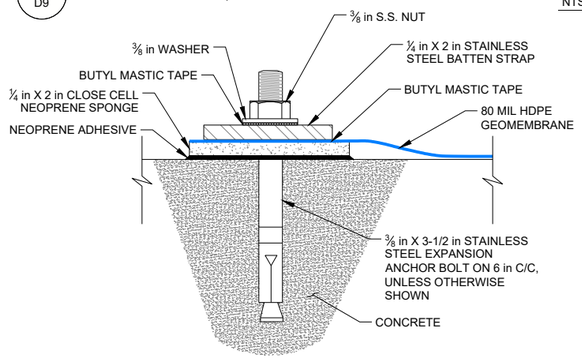
NTS 27 - UNDERDRAIN PIPE THROUGH CONCRETE TRANSITION ISOMETRIC



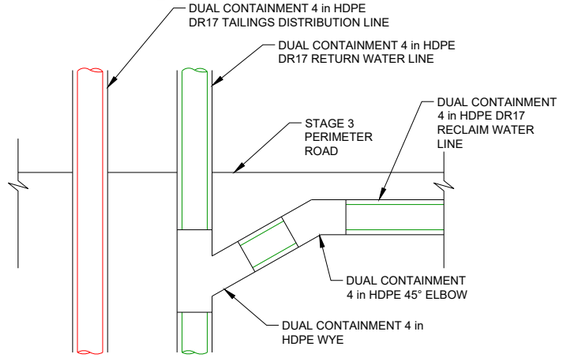
NTS 28 - ANCHOR BLOCK EMBED PLAN VIEW



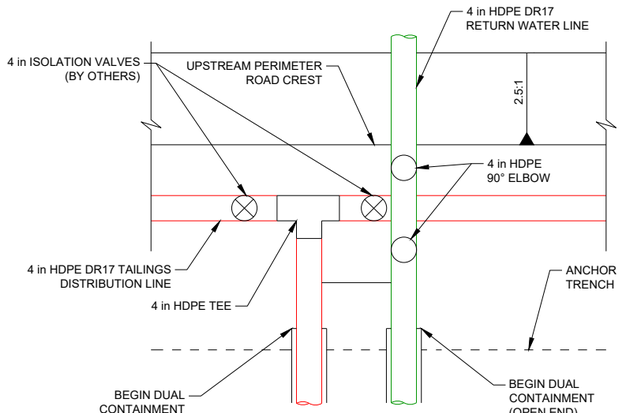
NTS 31 - BATTON STRIP CAP DETAIL



NTS 29 - BATTON STRIP DETAIL



NTS 32 C5 C8 C10 RECLAIM WATER LINE DETAIL



NTS 30 C5 C8 C10 TAILINGS DELIVERY LINE DETAIL

LEGEND

GCL

80 MIL HDPE GEOMEMBRANE

NOTE

1. TSF AND WRD UNDERDRAIN PIPES ONLY WHERE SHOWN ON SHEET C15.

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

GOLDER ASSOCIATES INC.
595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (4 OF 9)
UNDERDRAIN COLLECTION SYSTEM, RECLAIM WATER, AND TAILINGS DISTRIBUTION

PROJECT NO.	REV.		DRAWING
1663241	0	27 of 42	D4

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

0 1 in

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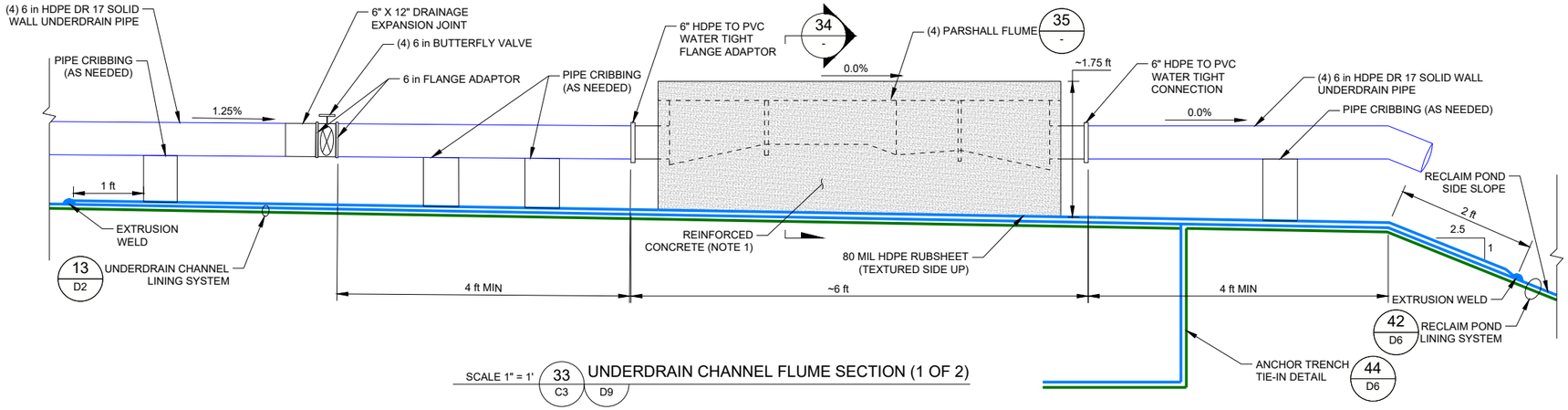
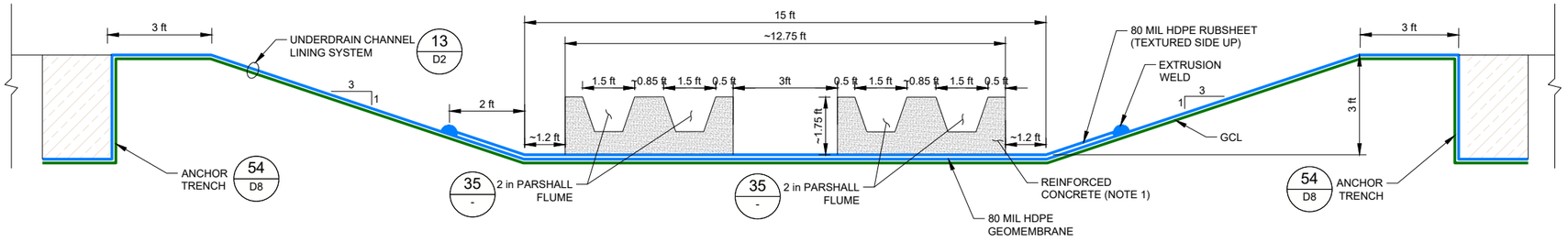
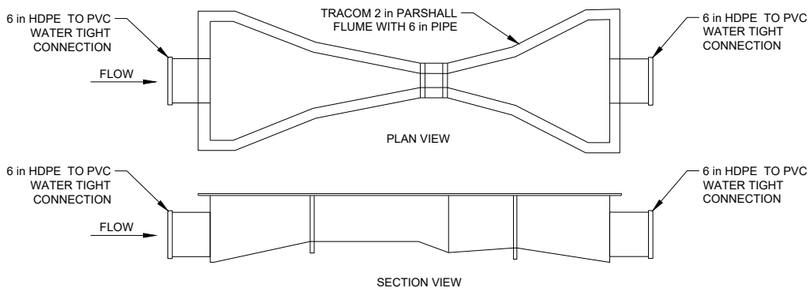


SCALE 1" = 1' 33 C3 D9 UNDERDRAIN CHANNEL FLUME SECTION (1 OF 2)



SCALE 1" = 2' 34 C4 UNDERDRAIN CHANNEL FLUME SECTION (2 OF 2)



NTS 35 - 2 in PARSHALL FLUME DETAIL

NOTE

1. CONCRETE REINFORCEMENT DETAILS SHOWN ON DRAWING D9.

LEGEND

80 MIL HDPE GEOMEMBRANE

GCL

0 1 2
1" = 1' FEET

0 1 2
1" = 1' FEET

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

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595 DOUBLE EAGLE COURT, SUITE 1000
RENO, NV 89521
USA
[+1] (775) 828-9604
www.golder.com

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (5 OF 9)
UNDERDRAIN FLUME

PROJECT NO. 1663241 | REV. 0 | 28 of 42 | DRAWING D5

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0 1 in

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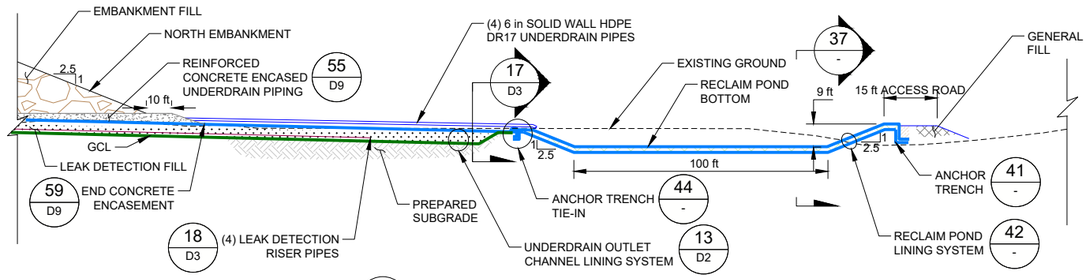
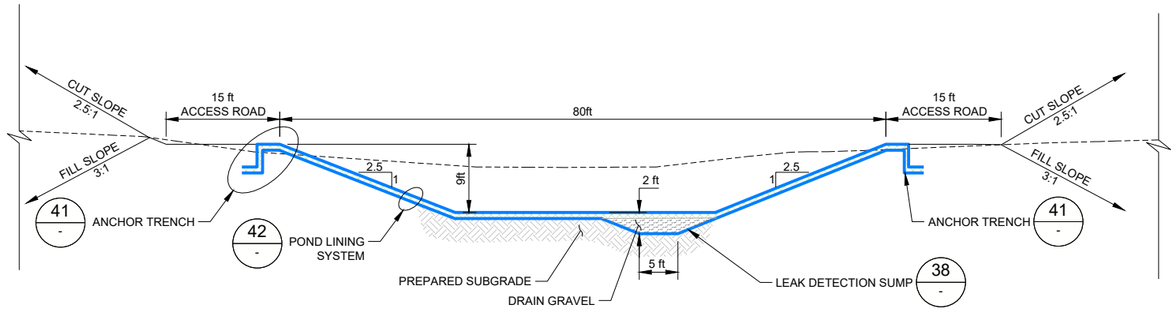
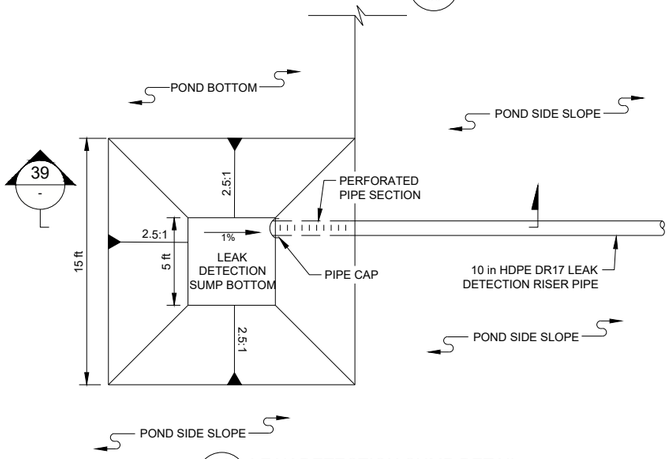


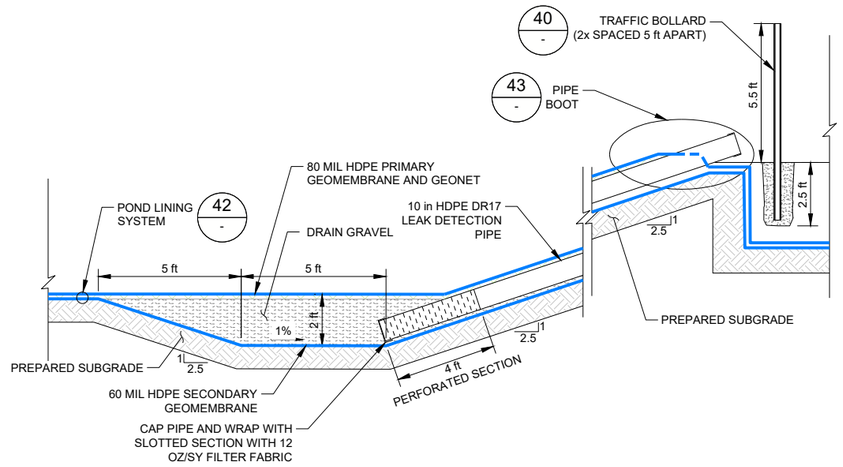
NTS 36 C3 RECLAIM OUTLET CHANNEL AND POND SECTION



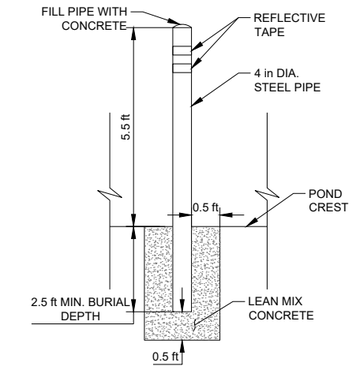
SCALE: 1" = 10' 37 C4 RECLAIM POND SECTION



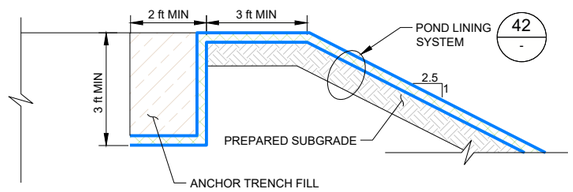
NTS 38 C3 LEAK DETECTION SUMP DETAIL



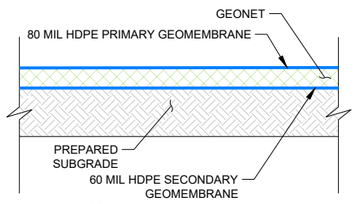
NTS 39 C3 LEAK DETECTION SUMP SECTION



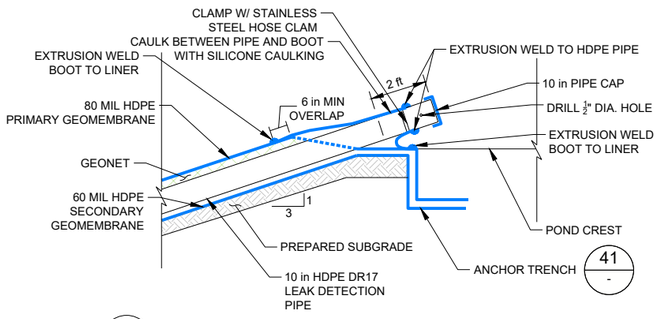
NTS 40 C4 D8 TRAFFIC BOLLARD TYPICAL DETAIL



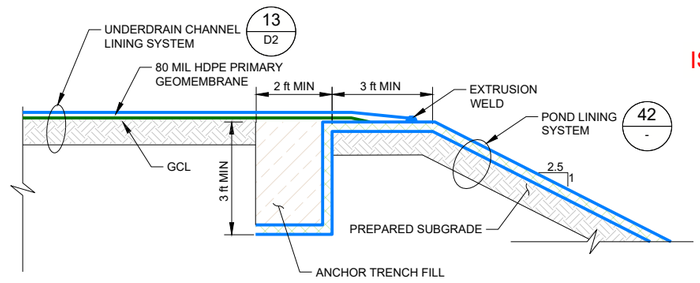
NTS 41 - POND ANCHOR TRENCH DETAIL



NTS 42 C1 C3 POND LINING SYSTEM



NTS 43 - POND LEAK DETECTION RISER PIPE BOOT DETAIL



NTS 44 - ANCHOR TRENCH TIE IN DETAIL

LEGEND

GCL

80 MIL HDPE GEOMEMBRANE

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (6 OF 9)
RECLAIM POND

PROJECT NO. 1663241 | REV. 0 | 29 of 42 | DRAWING D6

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

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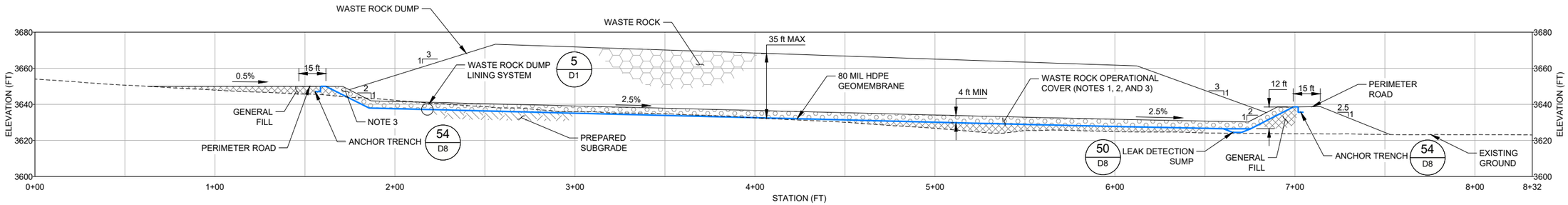
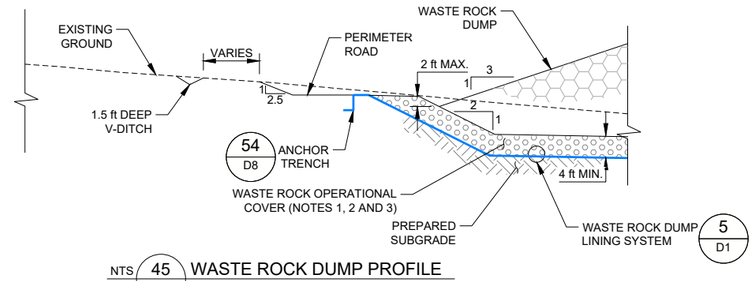


SCALE 1" = 30'
VERT. SCALE 1" = 15'
A
C14
WASTE ROCK DUMP PROFILE



NTS
45
C14
WASTE ROCK DUMP PROFILE

NOTES

1. MINIMUM 4 FT WASTE ROCK OPERATIONAL COVER SHALL REMAIN AT ALL TIMES DURING OPERATION TO BE REMOVED DURING RECLAMATION OF WASTE ROCK DUMP.
2. OPERATIONAL COVER SHALL BE WASTE ROCK WITH LESS THAN 3 in MAX PARTICLE SIZE.
3. OPERATIONAL COVER ON PAD SIDE SLOPES SHALL BE DOZER PLACED FROM TOE UP TO DESIGN ELEVATION.

LEGEND

WASTE ROCK DUMP LINING SYSTEM 5 D1

EXISTING GROUND

0 15 30
1" = 15' FEET

0 30 60
1" = 30' FEET

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

GOLDER ASSOCIATES INC.
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[+1] (775) 828-9604
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (7 OF 9)
WASTE ROCK DUMP

PROJECT NO. 1663241
REV. 0

DRAWING D7

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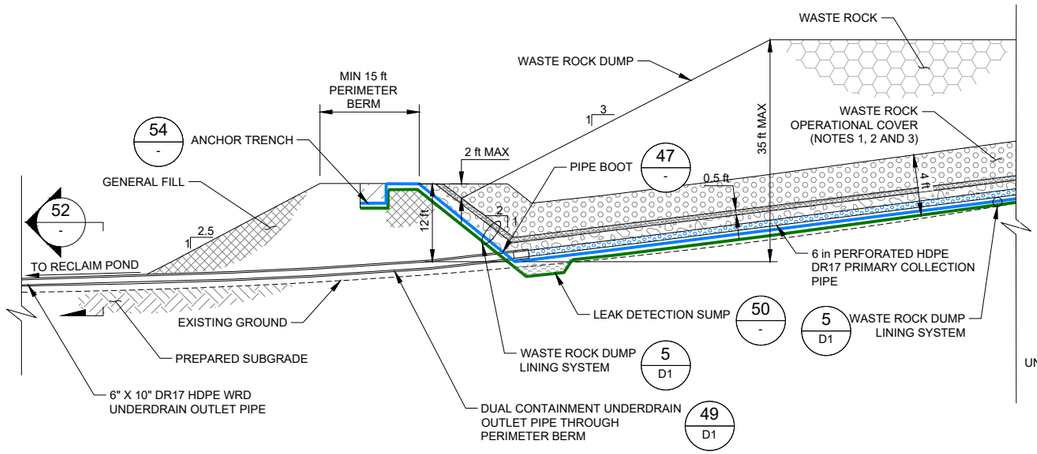
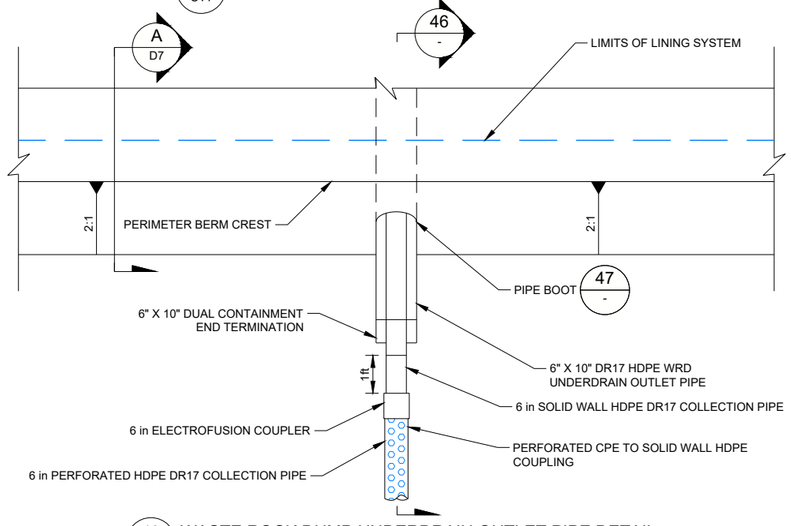
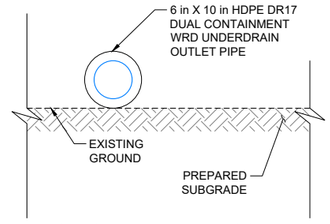


NTS 46 C14 WASTE ROCK DUMP AND UNDERDRAIN OUTLET SECTION

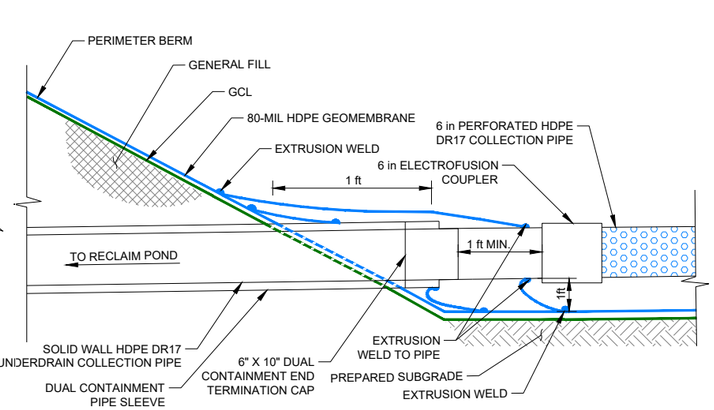


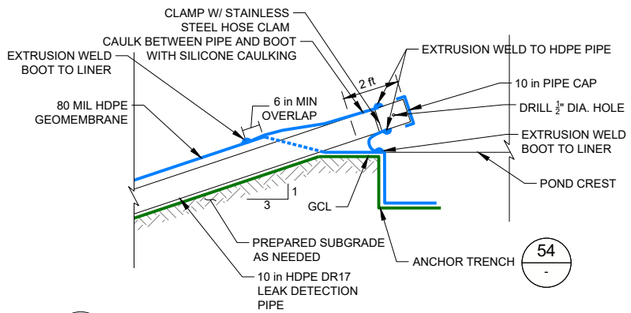
NTS 49 C14 WASTE ROCK DUMP UNDERDRAIN OUTLET PIPE DETAIL



STAGE 1 WRD DUAL CONTAINMENT UNDERDRAIN OUTLET PIPE DETAIL (NOTE 4)

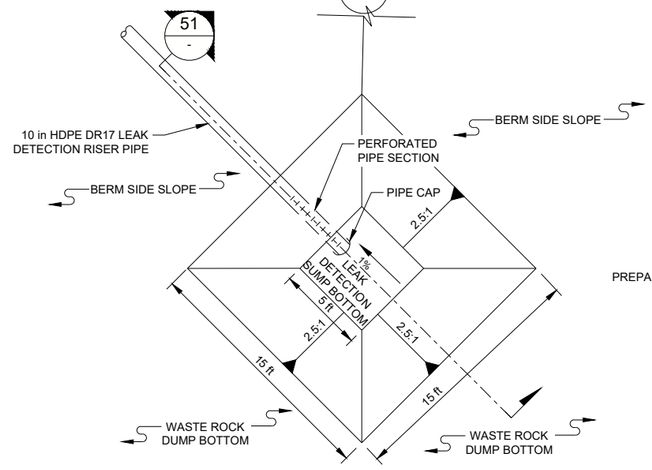
NTS 52 C15



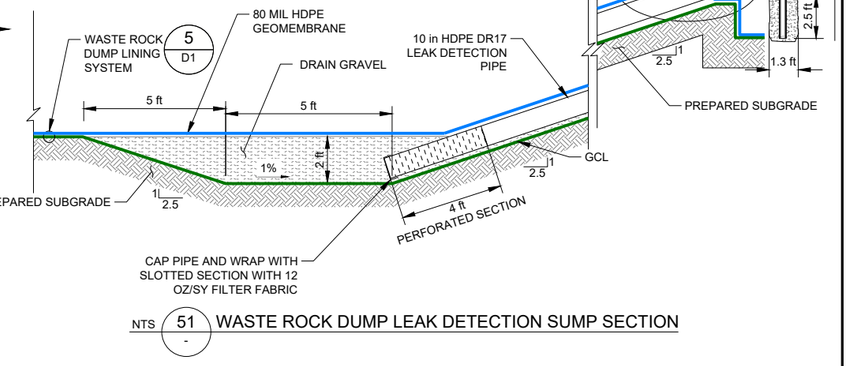


NTS 48 - WASTE ROCK DUMP LEAK DETECTION RISER PIPE BOOT DETAIL

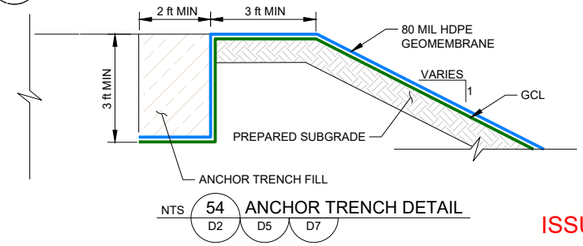
NTS 47 - WRD PIPE BOOT DETAIL



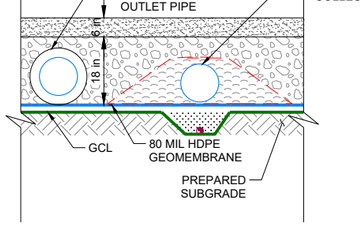
NTS 50 C14 WASTE ROCK DUMP LEAK DETECTION SUMP DETAIL



NTS 51 - WASTE ROCK DUMP LEAK DETECTION SUMP SECTION



NTS 54 D2 D5 D7 ANCHOR TRENCH DETAIL



STAGE 2 AND 3 WRD DUAL CONTAINMENT UNDERDRAIN OUTLET PIPE DETAIL

NTS 53 C15

NOTES

1. MINIMUM 4 FT WASTE ROCK OPERATIONAL COVER SHALL REMAIN AT ALL TIMES DURING OPERATION TO BE REMOVED DURING RECLAMATION OF WASTE ROCK DUMP.
2. OPERATIONAL COVER SHALL BE WASTE ROCK WITH LESS THAN 3 in MAX PARTICLE SIZE.
3. OPERATIONAL COVER ON PAD SIDE SLOPES SHALL BE DOZER PLACED FROM TOE UP TO DESIGN ELEVATION.
4. IN STAGES 2 AND 3 BASINS PRIOR TO STAGE.

LEGEND

GCL

80 MIL HDPE GEOMEMBRANE

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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MALHEUR COUNTY, OREGON

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (8 OF 9)
WASTE ROCK DUMP

PROJECT NO. 1663241 | REV. 0 | 31 of 42 | DRAWING D8

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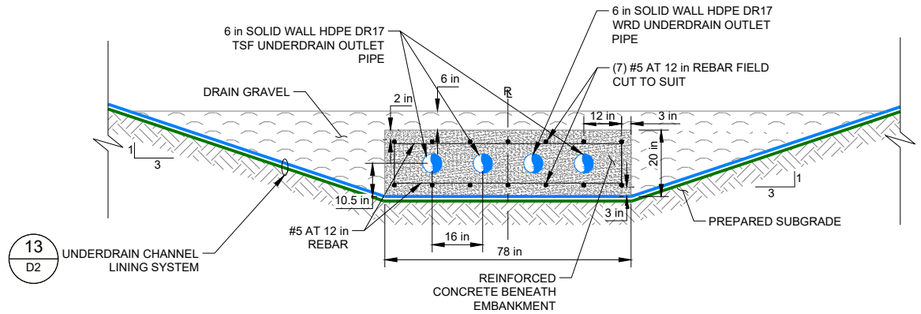
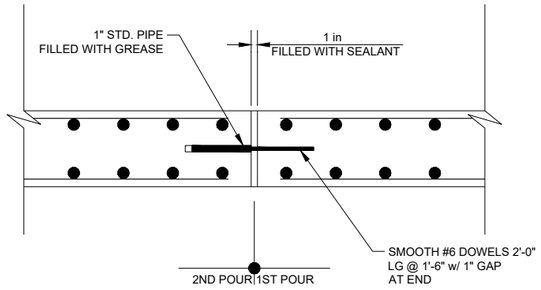
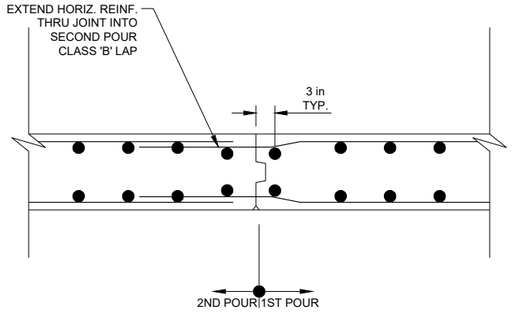


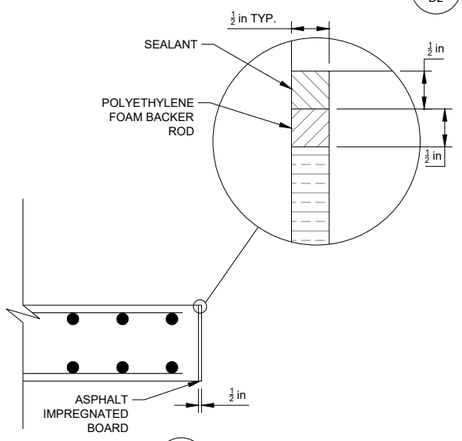
NTS 55 (D2 D4) CONCRETE ENCASED PIPES DETAIL



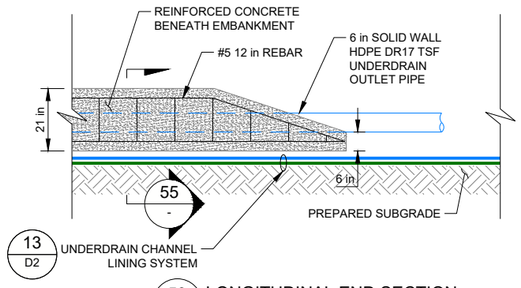
NTS 56 (-) FOUNDATION EXPANSION JOINT DETAIL



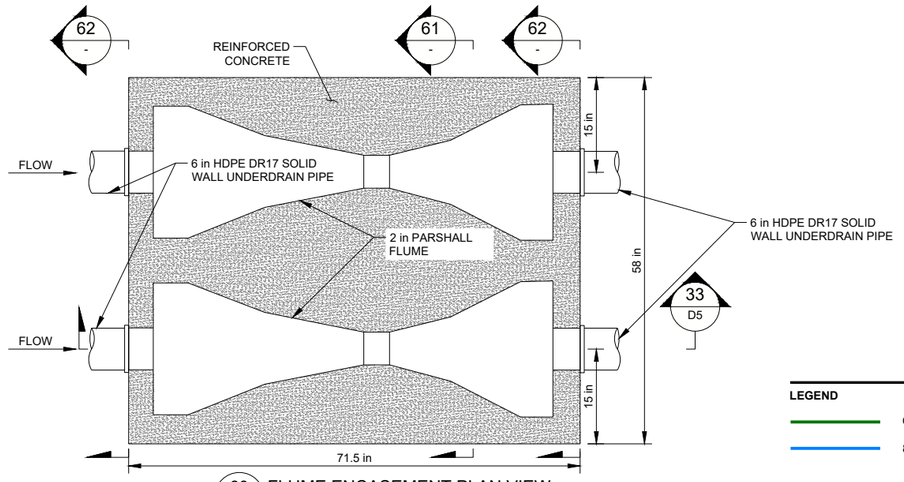
NTS 57 (-) CONSTRUCTION JOINT



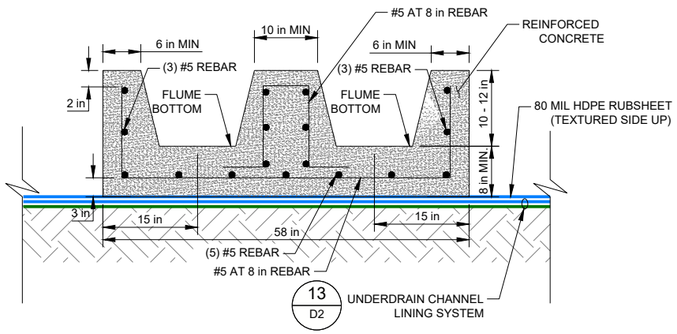
NTS 58 (-) ISOLATION JOINT



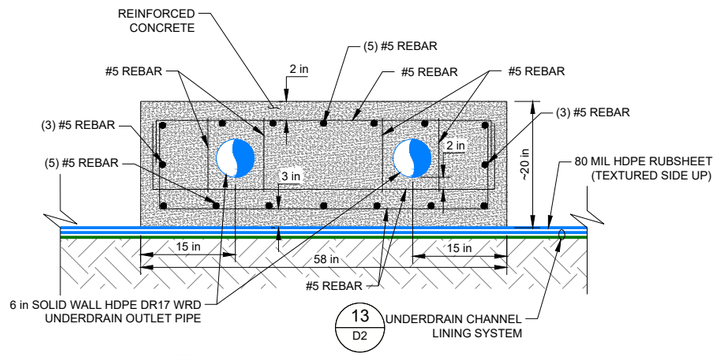
NTS 59 (C3 C4 D4) LONGITUDINAL END SECTION



NTS 60 (D5) FLUME ENCASEMENT PLAN VIEW



NTS 61 (-) FLUME ENCASEMENT SECTION



NTS 62 (-) FLUME ENCASEMENT END SECTION

LEGEND

GCL

80 MIL HDPE GEOMEMBRANE

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
DETAILS (9 OF 9)
STRUCTURAL CONCRETE

PROJECT NO. 1663241 | REV. 0 | 32 of 42 | DRAWING D9

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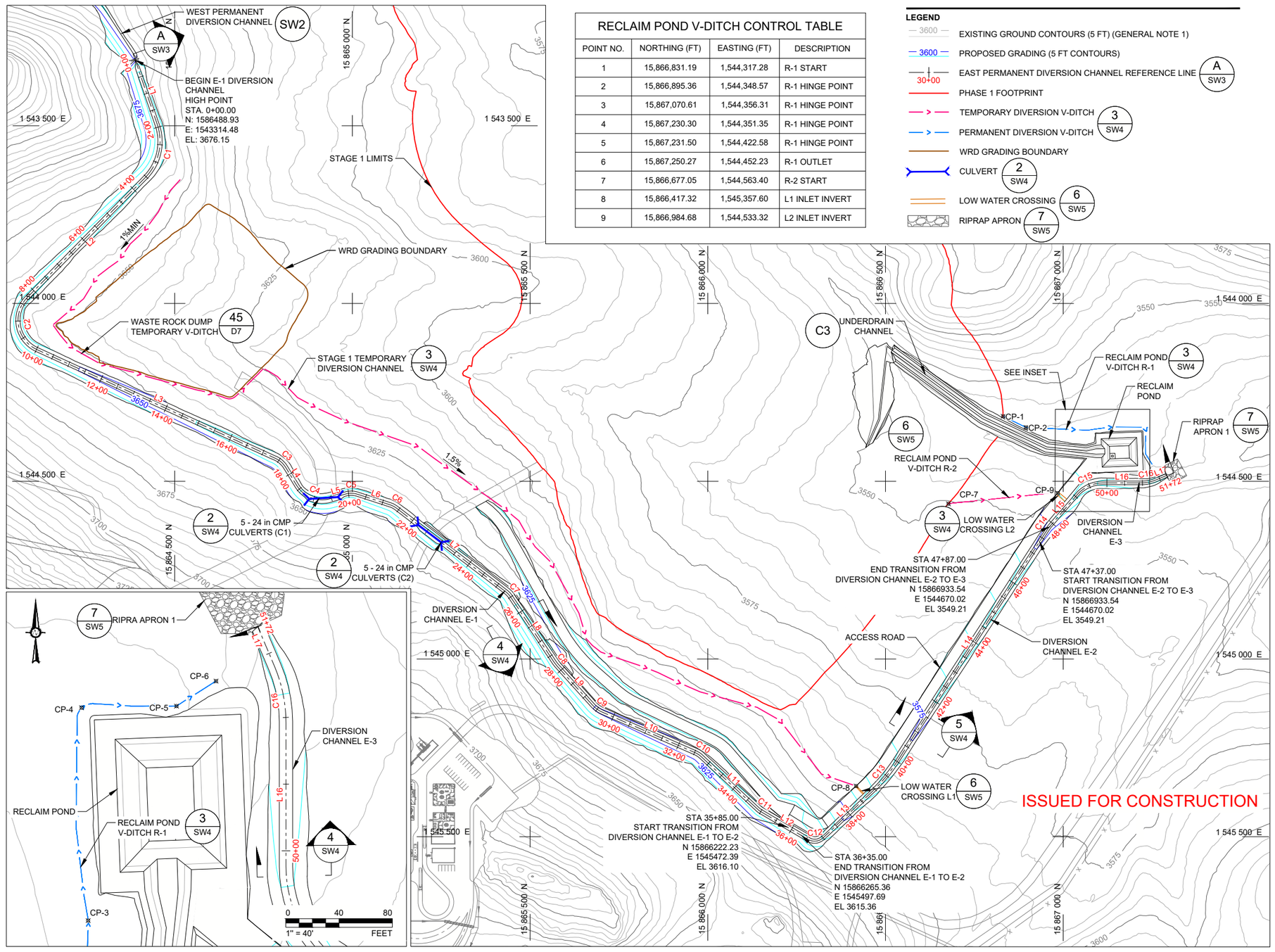

RECLAIM POND V-DITCH CONTROL TABLE

POINT NO.	NORTHING (FT)	EASTING (FT)	DESCRIPTION
1	15,866,831.19	1,544,317.28	R-1 START
2	15,866,895.36	1,544,348.57	R-1 HINGE POINT
3	15,867,070.61	1,544,356.31	R-1 HINGE POINT
4	15,867,230.30	1,544,351.35	R-1 HINGE POINT
5	15,867,231.50	1,544,422.58	R-1 HINGE POINT
6	15,867,250.27	1,544,452.23	R-1 OUTLET
7	15,866,677.05	1,544,563.40	R-2 START
8	15,866,417.32	1,545,357.60	L1 INLET INVERT
9	15,866,984.68	1,544,533.32	L2 INLET INVERT

LEGEND

- EXISTING GROUND CONTOURS (5 FT) (GENERAL NOTE 1)
- PROPOSED GRADING (5 FT CONTOURS)
- EAST PERMANENT DIVERSION CHANNEL REFERENCE LINE — A SW3
- PHASE 1 FOOTPRINT
- TEMPORARY DIVERSION V-DITCH — 3 SW4
- PERMANENT DIVERSION V-DITCH — 3 SW4
- WRD GRADING BOUNDARY
- CULVERT — 2 SW4
- LOW WATER CROSSING — 6 SW5
- RIPRAP APRON — 7 SW5

EAST DIVERSION CHANNEL CURVE TABLE

CURVE #	RADIUS (FT)	LENGTH (FT)	START POINT (N, E)	END POINT (N, E)
C1	145.24	160.68	(15,864,451.19, 1,543,496.75)	(15,864,417.28, 1,543,645.55)
C2	91.10	174.93	(15,864,085.47, 1,543,982.86)	(15,864,112.62, 1,544,129.63)
C3	64.03	38.13	(15,864,784.11, 1,544,435.78)	(15,864,812.22, 1,544,460.71)
C4	83.84	111.62	(15,864,843.62, 1,544,512.22)	(15,864,940.63, 1,544,548.47)
C5	62.33	38.77	(15,864,977.42, 1,544,536.76)	(15,865,015.57, 1,544,536.87)
C6	53.87	18.26	(15,865,106.98, 1,544,566.55)	(15,865,123.08, 1,544,575.00)
C7	60.58	19.99	(15,865,431.69, 1,544,811.02)	(15,865,445.29, 1,544,825.54)
C8	107.28	15.89	(15,865,567.11, 1,545,008.30)	(15,865,576.87, 1,545,020.82)
C9	81.80	34.60	(15,865,675.43, 1,545,129.63)	(15,865,703.32, 1,545,149.67)
C10	57.67	19.54	(15,865,965.10, 1,545,263.98)	(15,865,981.36, 1,545,274.65)
C11	34.36	7.56	(15,866,141.70, 1,545,424.19)	(15,866,147.75, 1,545,428.70)
C12	35.76	46.01	(15,866,282.37, 1,545,507.67)	(15,866,325.00, 1,545,502.84)
C13	474.84	113.90	(15,866,460.77, 1,545,374.80)	(15,866,533.52, 1,545,287.52)
C14	55.01	7.57	(15,866,956.03, 1,544,635.30)	(15,866,960.57, 1,544,629.25)
C15	94.55	81.15	(15,867,039.84, 1,544,537.47)	(15,867,111.39, 1,544,504.72)
C16	108.93	43.77	(15,867,219.05, 1,544,504.71)	(15,867,261.65, 1,544,496.03)

EAST DIVERSION CHANNEL LINE TABLE

LINE #	LENGTH (FT)	BEARING	START POINT (N, E)	END POINT (N, E)
L1	192.61	N71° 08' 28.55"E	(15,864,388.93, 1,543,314.48)	(15,864,451.19, 1,543,496.75)
L2	473.16	S45° 28' 13.55"E	(15,864,417.28, 1,543,645.55)	(15,864,085.47, 1,543,982.86)
L3	737.99	N24° 30' 33.79"E	(15,864,112.62, 1,544,129.63)	(15,864,784.11, 1,544,435.78)
L4	60.33	N58° 37' 48.37"E	(15,864,812.22, 1,544,460.71)	(15,864,843.62, 1,544,512.22)
L5	38.61	N17° 39' 09.23"W	(15,864,940.63, 1,544,548.47)	(15,864,977.42, 1,544,536.76)
L6	96.11	N17° 59' 14.29"E	(15,865,015.57, 1,544,536.87)	(15,865,106.98, 1,544,566.55)
L7	388.52	N37° 24' 31.45"E	(15,865,123.08, 1,544,575.00)	(15,865,431.69, 1,544,811.02)
L8	219.64	N56° 18' 51.85"E	(15,865,445.29, 1,544,825.54)	(15,865,567.11, 1,545,008.30)
L9	146.81	N47° 49' 35.02"E	(15,865,576.87, 1,545,020.82)	(15,865,675.43, 1,545,129.63)
L10	285.65	N23° 35' 19.29"E	(15,865,703.32, 1,545,149.67)	(15,865,965.10, 1,545,263.98)
L11	219.25	N43° 00' 09.68"E	(15,865,981.36, 1,545,274.65)	(15,866,141.70, 1,545,424.19)
L12	156.08	N30° 23' 46.91"E	(15,866,147.75, 1,545,428.70)	(15,866,282.37, 1,545,507.67)
L13	186.62	N43° 19' 15.91"W	(15,866,325.00, 1,545,502.84)	(15,866,460.77, 1,545,374.80)
L14	777.11	N57° 03' 52.62"W	(15,866,533.52, 1,545,287.52)	(15,866,956.03, 1,544,635.30)
L15	121.28	N49° 10' 51.37"W	(15,866,960.57, 1,544,629.25)	(15,867,039.84, 1,544,537.47)
L16	107.66	N0° 00' 23.68"W	(15,867,111.39, 1,544,504.72)	(15,867,219.05, 1,544,504.71)
L17	31.85	N23° 01' 49.58"W	(15,867,261.65, 1,544,496.03)	(15,867,290.97, 1,544,483.57)

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
EAST PERMANENT DIVERSION CHANNEL ALIGNMENT

PROJECT NO. 1663241 | REV. 0 | 33 of 42 | DRAWING SW1

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

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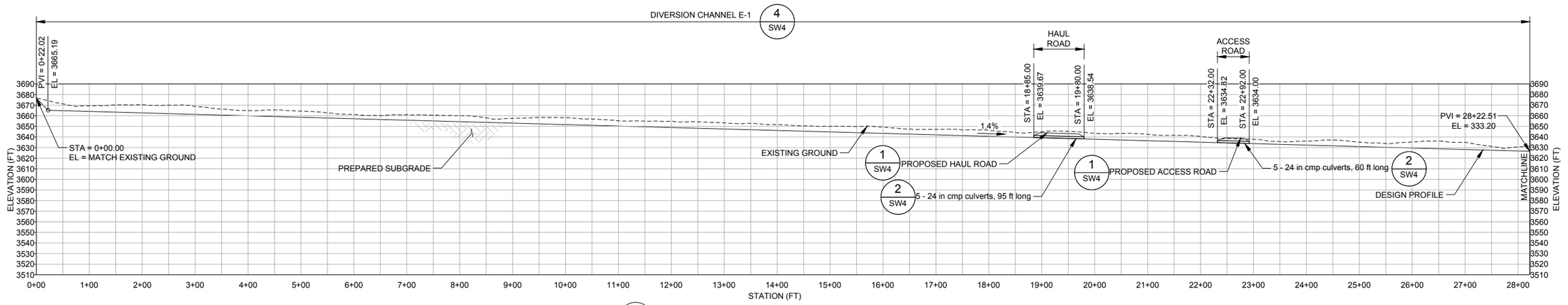
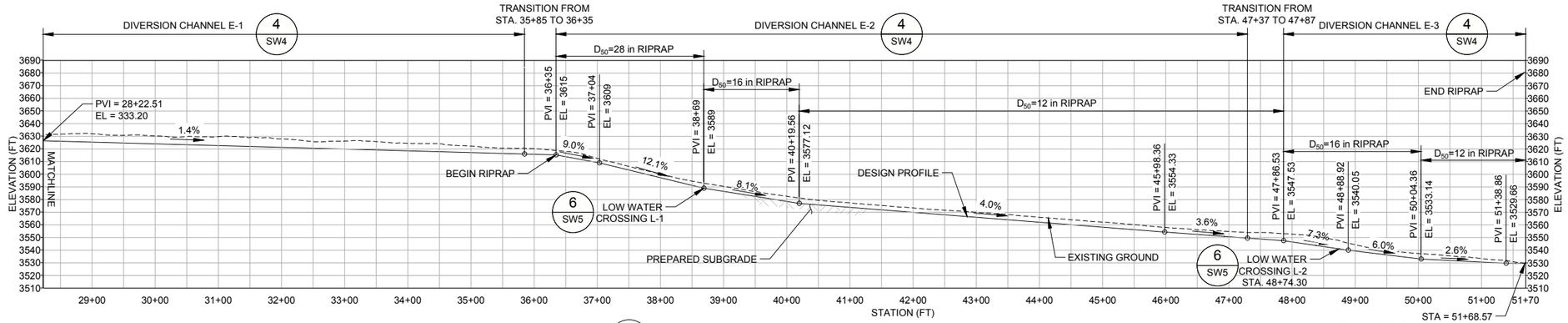


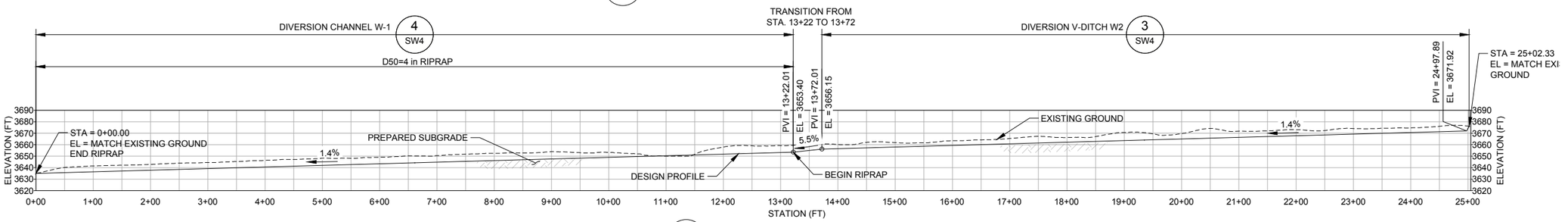
HORIZ. SCALE: 1"=100' / VERT. SCALE: 1"=50'

A SW1 EAST PERMANENT DIVERSION CHANNEL PROFILE



HORIZ. SCALE: 1"=100' / VERT. SCALE: 1"=50'

A SW1 EAST PERMANENT DIVERSION CHANNEL PROFILE



HORIZ. SCALE: 1"=100' / VERT. SCALE: 1"=50'

B SW2 WEST PERMANENT DIVERSION CHANNEL PROFILE

LEGEND

DESIGN PROFILE

EXISTING GROUND

0 100 200
1" = 100' FEET

0 50 100
1" = 50' FEET

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
STORMWATER DIVERSION CHANNEL PROFILES

PROJECT NO. 1663241
REV. 0
35 of 42
DRAWING SW3

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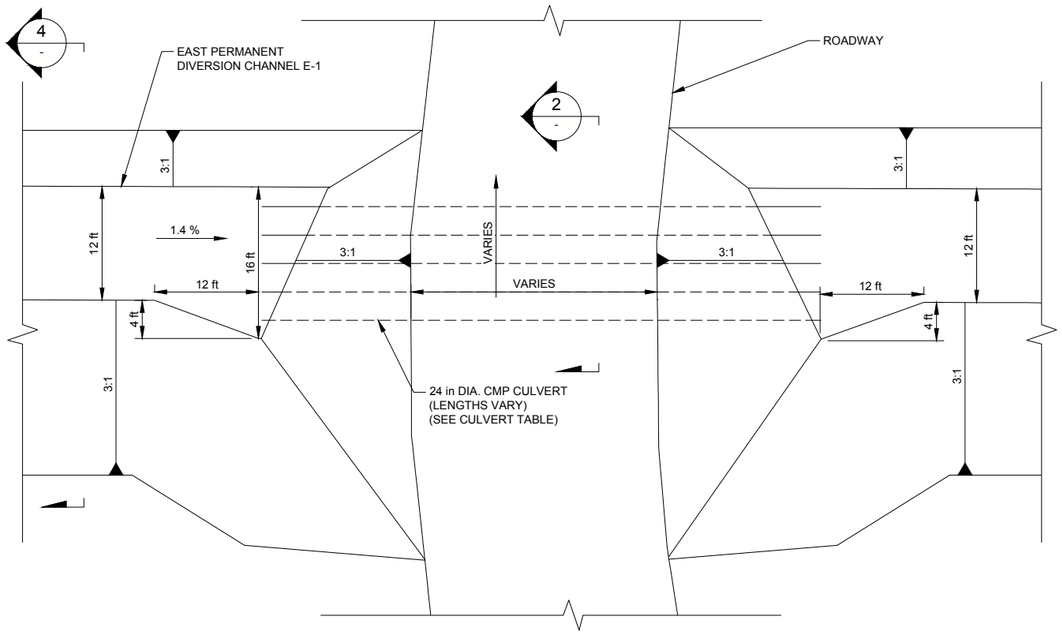
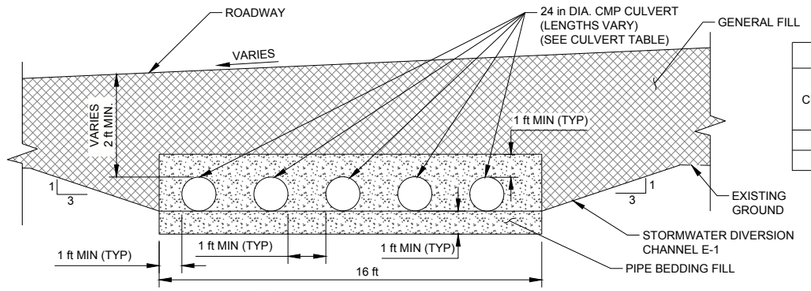
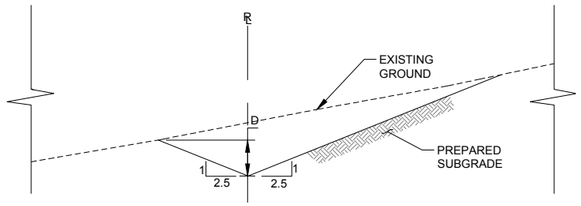


NTS 1 SW3 CULVERT CROSSING TYPICAL DETAIL



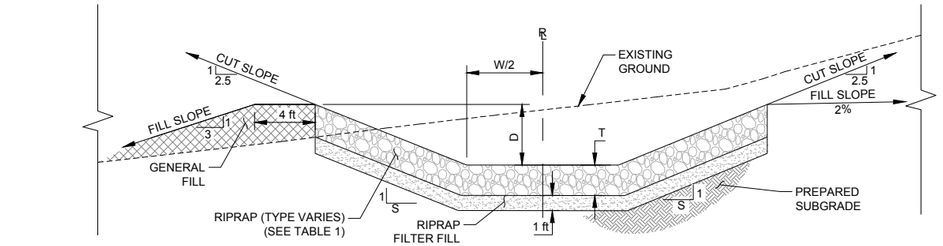
NTS 2 SW1 SW3 CULVERT SECTION

CULVERT TABLE				
CULVERT	BARREL DIAMETER (IN)	BARREL LENGTH (FT)	# BARRELS	CULVERT GRADE
C1	24	95	5	1.4 %
C2	24	60	5	1.4 %



SCALE 1:5 3 SW1 SW2 STORMWATER DIVERSION V-DITCH TYPICAL SECTION

STORMWATER DIVERSION V-DITCH TABLE					
CHANNEL	RPRAP TYPE (IN)	RIPRAP THICKNESS (T) (IN)	CHANNEL DEPTH (D) (FT)	WEST PERMANENT DIVERSION CHANNEL STATIONING	DETAIL
W-2	-	-	2.25	13+72 TO 25+04	3/SW4
STAGE 1 TEMPORARY	-	-	1.75	-	3/SW4
STAGE 3 TOE	-	-	1.75	-	3/SW4
R-1	-	-	1.50	-	3/SW4
R-2	-	-	1.75	-	3/SW4



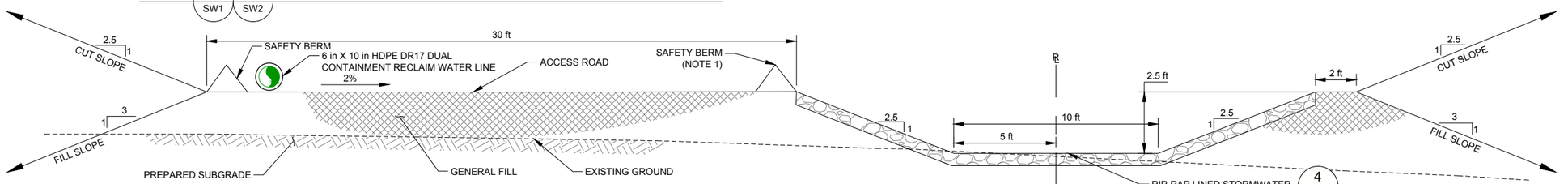
SCALE 1:5 4 SW1 SW2 STORMWATER DIVERSION TRAPAZOIDAL CHANNEL TYPICAL SECTION

STORMWATER DIVERSION TRAPAZOIDAL CHANNEL TABLE								
CHANNEL	SIDE SLOPE (S:1)	RIPRAP TYPE (IN)	RIPRAP THICKNESS (IN)	BOTTOM WIDTH (W) (FT)	CHANNEL DEPTH (D) (FT)	EAST PERMANENT DIVERSOIN CHANNEL STATIONING	WEST PERMANENT DIVERSION CHANNEL STATIONING	DETAIL
E-1	3.00	-	-	12.00	2.25	0+00 TO 35+85	-	4/SW4
E-1		-	-	16.00	2.25			
E-2	2.50	SEE CHANNEL RIPRAP TABLE		10.00	3.00	36+35 TO 47+37	-	4/SW4
E-3	2.50	SEE CHANNEL RIPRAP TABLE		10.00	3.00	47+87 TO 51+69	-	4/SW4
W-1	2.50	D_{50}=4	6	10.00	4.25	-	0+00 TO 13+22	4/SW4

CHANNEL RIPRAP TABLE		
SLOPE RANGE	RIPRAP TYPE (IN)	RIPRAP THICKNESS (T) (IN)
2-6%	D_{50} = 12	18
6-8.5%	D_{50} = 16	24
>8.5%	D_{50} = 28	40

NOTE

1. CUT OPENINGS IN SAFETY BERM AS NEEDED TO PROMOTE ACCESS ROAD DRAINAGE INTO IMPOUNDMENT.



NTS 5 C1 C2 C5 C8 C10 C15 C17 STORMWATER DIVERSION CHANNEL & ACCESS ROAD SECTION (STA. 37+35.00 TO 49+23.00)

0 5 10
1" = 5' FEET

0 6 12
1" = 6' FEET

ISSUED FOR CONSTRUCTION

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
STORMWATER DIVERSION DETAILS (1 OF 2)

PROJECT NO. 1663241
REV. 0

DRAWING SW4

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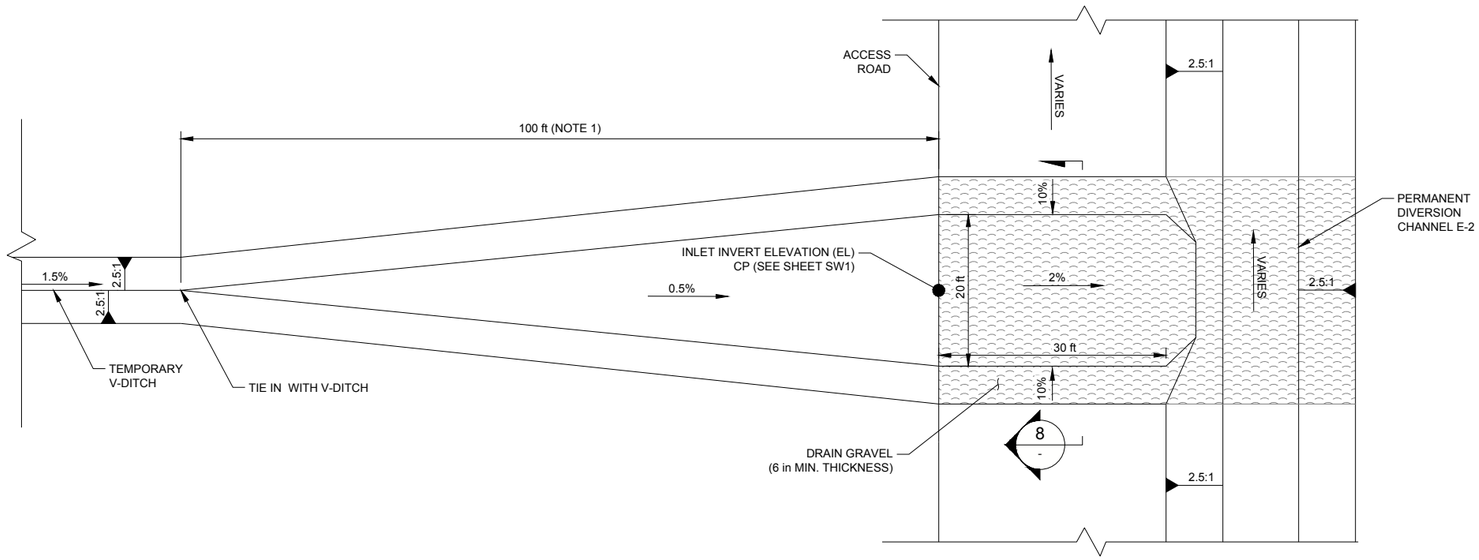
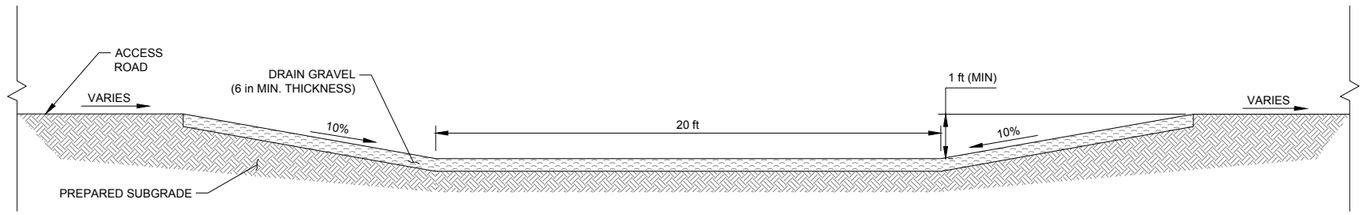
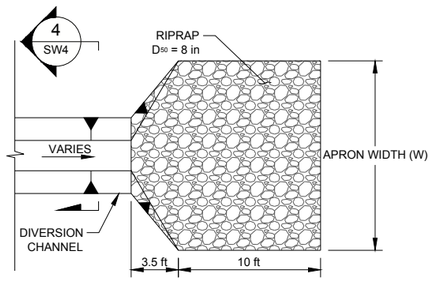


SCALE 1" = 10' 6 SW1 LOW WATER CROSSING TYPICAL DETAIL

LOW WATER CROSSING TABLE			
LOW WATER CROSSING	UPSTREAM V-DITCH	DOWNSTREAM DIVERSION CHANNEL	INLET INVERT ELEVATION (EL) (FT)
L1	STAGE 1 TEMPORARY DIVERSION CHANNEL	DIVERSION CHANNEL E-2	3691.67
L2	RECLAIM POND V-DITCH R-2	DIVERSION CHANNEL E-3	3544.07



NTS 8 - LOW WATER CROSSIN TYPICAL SECTION



NTS 7 SW1 RIPRAP APRON DETAIL

RIPRAP APRON TABLE		
APRON #	APRON WIDTH (W) (FT)	RIPRAP THICKNESS (IN)
1	30	12
2	30	12
3	40	12

NOTE
1. TRANSITION UNIFORMLY BETWEEN 2.5H:1V CHANNEL AND 5H:1 CROSSING.

ISSUED FOR CONSTRUCTION

0 10 20
1" = 10' FEET

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
STORMWATER DIVERSION DETAILS (2 OF 2)

PROJECT NO. 1663241 | REV. 0 | 37 of 42 | DRAWING SW5

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0 1 in

INCLINOMETERS CONTROL POINT TABLE

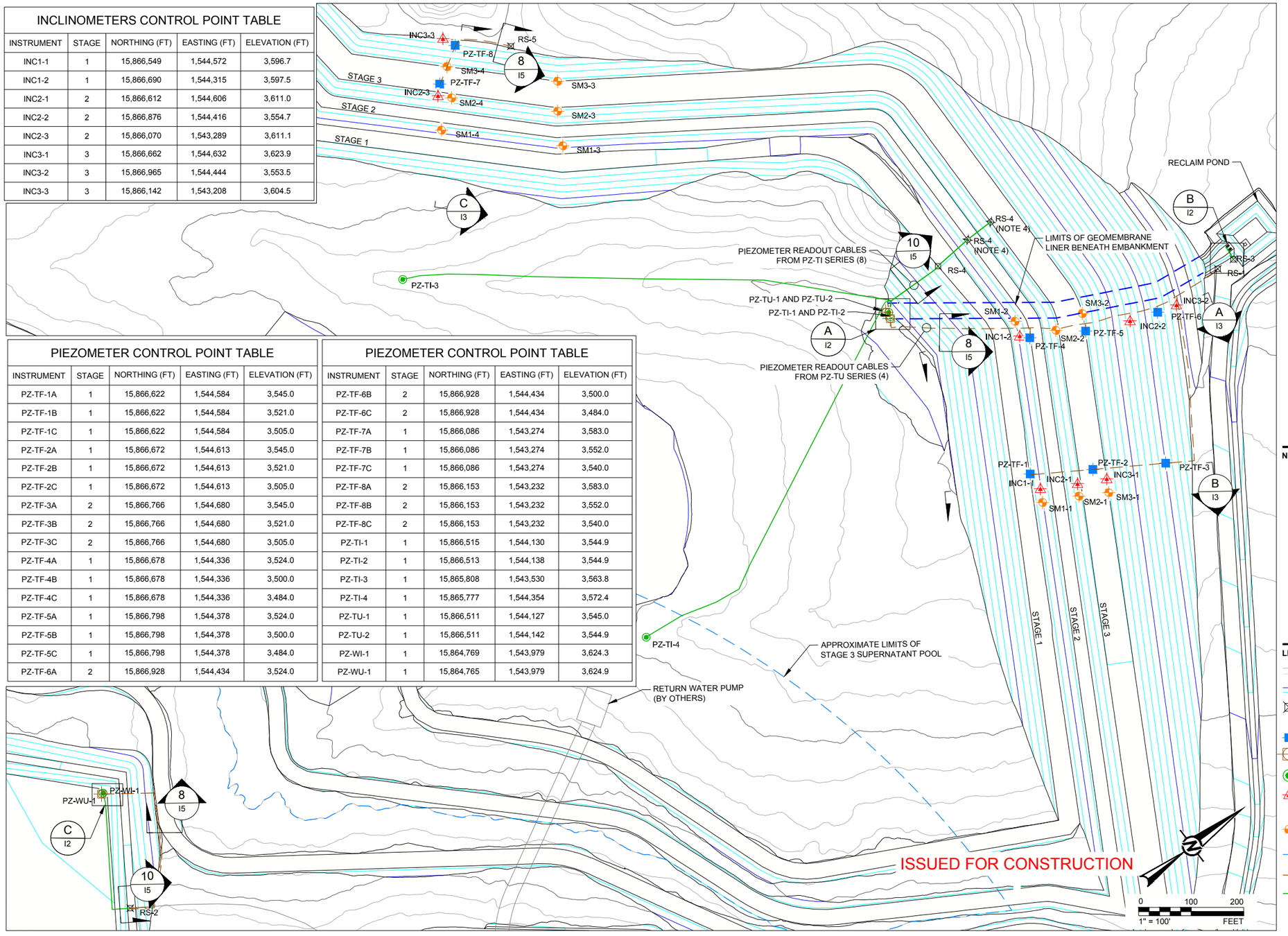
INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
INC1-1	1	15,866,549	1,544,572	3,596.7
INC1-2	1	15,866,690	1,544,315	3,597.5
INC2-1	2	15,866,612	1,544,606	3,611.0
INC2-2	2	15,866,876	1,544,416	3,554.7
INC2-3	2	15,866,070	1,543,289	3,611.1
INC3-1	3	15,866,662	1,544,632	3,623.9
INC3-2	3	15,866,965	1,544,444	3,553.5
INC3-3	3	15,866,142	1,543,208	3,604.5

PIEZOMETER CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
PZ-TF-1A	1	15,866,622	1,544,584	3,545.0
PZ-TF-1B	1	15,866,622	1,544,584	3,521.0
PZ-TF-1C	1	15,866,622	1,544,584	3,505.0
PZ-TF-2A	1	15,866,672	1,544,613	3,545.0
PZ-TF-2B	1	15,866,672	1,544,613	3,521.0
PZ-TF-2C	1	15,866,672	1,544,613	3,505.0
PZ-TF-3A	2	15,866,766	1,544,680	3,545.0
PZ-TF-3B	2	15,866,766	1,544,680	3,521.0
PZ-TF-3C	2	15,866,766	1,544,680	3,505.0
PZ-TF-4A	1	15,866,678	1,544,336	3,524.0
PZ-TF-4B	1	15,866,678	1,544,336	3,500.0
PZ-TF-4C	1	15,866,678	1,544,336	3,484.0
PZ-TF-5A	1	15,866,798	1,544,378	3,524.0
PZ-TF-5B	1	15,866,798	1,544,378	3,500.0
PZ-TF-5C	1	15,866,798	1,544,378	3,484.0
PZ-TF-6A	2	15,866,928	1,544,434	3,524.0

PIEZOMETER CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
PZ-TF-6B	2	15,866,928	1,544,434	3,500.0
PZ-TF-6C	2	15,866,928	1,544,434	3,484.0
PZ-TF-7A	1	15,866,086	1,543,274	3,583.0
PZ-TF-7B	1	15,866,086	1,543,274	3,552.0
PZ-TF-7C	1	15,866,086	1,543,274	3,540.0
PZ-TF-8A	2	15,866,153	1,543,232	3,583.0
PZ-TF-8B	2	15,866,153	1,543,232	3,552.0
PZ-TF-8C	2	15,866,153	1,543,232	3,540.0
PZ-TI-1	1	15,866,515	1,544,130	3,544.9
PZ-TI-2	1	15,866,513	1,544,138	3,544.9
PZ-TI-3	1	15,865,808	1,543,530	3,563.8
PZ-TI-4	1	15,865,777	1,544,354	3,572.4
PZ-TU-1	1	15,866,511	1,544,127	3,545.0
PZ-TU-2	1	15,866,511	1,544,142	3,544.9
PZ-WI-1	1	15,864,769	1,543,979	3,624.3
PZ-WU-1	1	15,864,765	1,543,979	3,624.9



READOUT STATION CONTROL POINT TABLE

READOUT STATION	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)	STAGE
RS-1	15,867,069	1,544,436	3,536.8	1
RS-2	15,864,680	1,544,186	3,642.2	1
RS-3	15,867,104	1,544,439	3,536.7	1
RS-4	15,866,643	1,544,116	3,595.0	1
RS-5	15,866,237	1,543,296	3,601.8	1

SURVEY MONUMENT CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
SM1-1	1	15,866,537	1,544,596	3,593.4
SM1-2	1	15,866,699	1,544,287	3,594.6
SM1-3	1	15,866,204	1,543,507	3,595.0
SM1-4	1	15,866,036	1,543,346	3,595.1
SM2-1	2	15,866,600	1,544,627	3,608.0
SM2-2	2	15,866,751	1,544,347	3,608.7
SM2-3	2	15,866,236	1,543,448	3,607.9
SM2-4	2	15,866,088	1,543,308	3,608.1
SM3-1	3	15,866,649	1,544,655	3,620.9
SM3-2	3	15,866,811	1,544,351	3,621.8
SM3-3	3	15,866,269	1,543,402	3,622.0
SM3-4	3	15,866,116	1,543,255	3,622.0

NOTES

1. AT EACH DESIGNATED MONITORING POINT FOR PZ-TI, PZ-TU, PZ-WI, PZ-WU SERIES PLACE 2 PIEZOMETERS APPROXIMATELY 1 ft APART.
2. SEE DRAWING C15 FOR DETAILS AND UNDERDRAIN PIPING SYSTEM.
3. INCLINOMETER ELEVATIONS REPRESENT COLLAR ELEVATION 3 FT ABOVE PROPOSED GROUND.
4. READOUT STATION RS-4 AND REQUIRED CABLES TO BE RELOCATED TO NEW UPSTREAM DAM CREST WITH EACH DAM RAISE.
5. SURVEY MONUMENTS LOCATED ALONG DOWNSTREAM CREST OF EACH STAGE.

LEGEND

- 3600 — EXISTING GROUND (5 FT CONTOURS) (GENERAL NOTE 1)
- 3600 — PROPOSED GRADING (5 FT CONTOURS)
- RS-1 — READOUT STATION (9 / I5)
- PZ-TF1 — FOUNDATION PIEZOMETER (7 / I5)
- PZ-TU-1 — UNDERLINER PIEZOMETER (5 / I5)
- PZ-TI-1 — IMPOUNDMENT PIEZOMETER
- INC1-1 — INCLINOMETER (NOTE 3) (1 / I4)
- SM1-1 — SURVEY MONUMENT (3 / I4)
- LIMITS OF SUPERNATANT POOL
- CABLE ROUTES BELOW LINER (8 / I5)
- CABLE ROUTES ABOVE LINER (10 / I5)

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PROJECT
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TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL INSTRUMENTATION LAYOUT (1 OF 2)

PROJECT NO.	REV.		DRAWING
1663241	0	38 of 42	I1

Path: \\enodata\MDA\1663241 Grassy Mountain PFS\900_Drawings\PRODUCTION\CONSOLIDATED PERMIT\ | File Name: 1663241_I_001_Geotechnical Instrumentation Layout.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:3:53:33 PM | Printed By: jePrice Date: 2019-11-06 Time:4:00:47 PM
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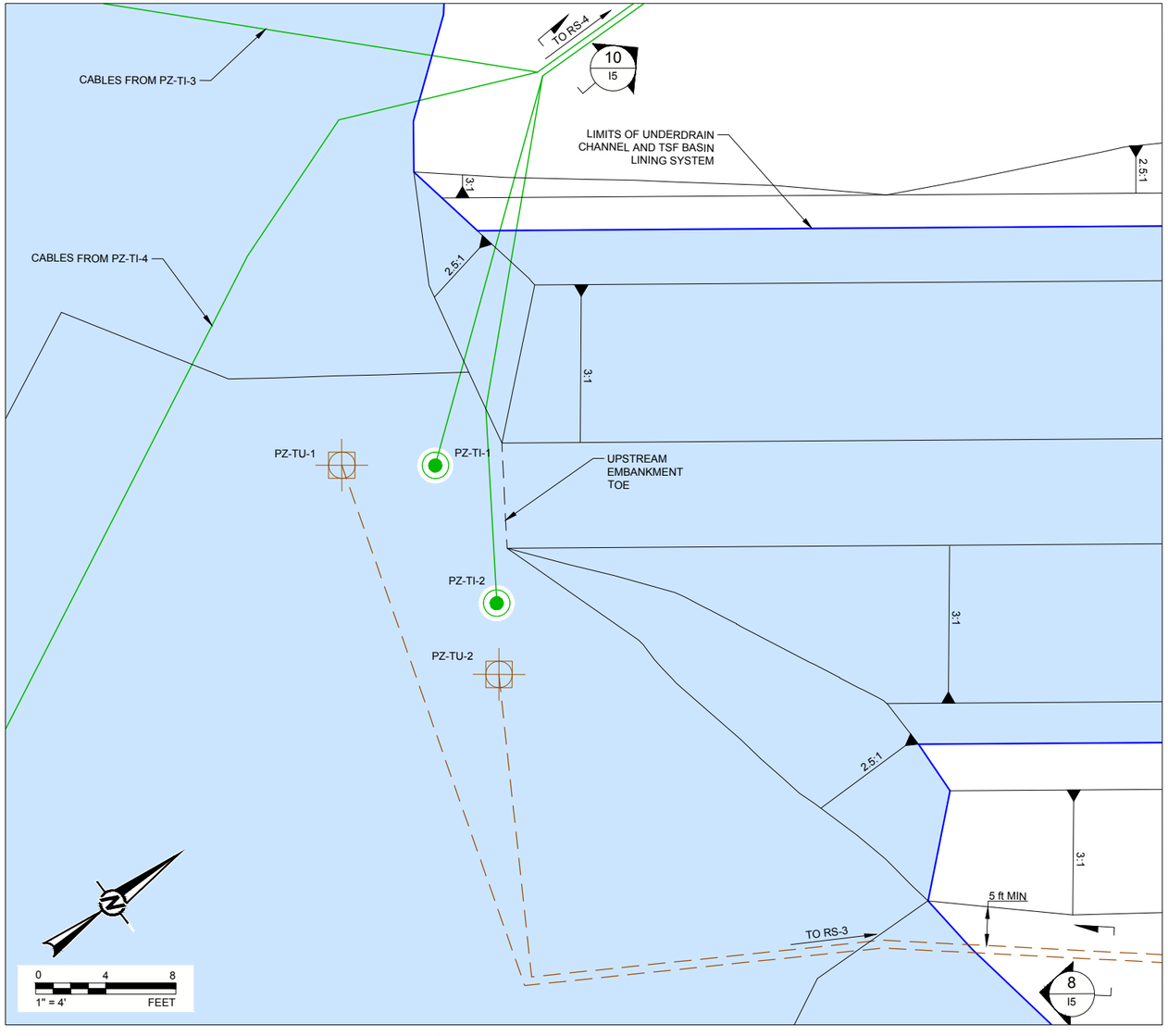
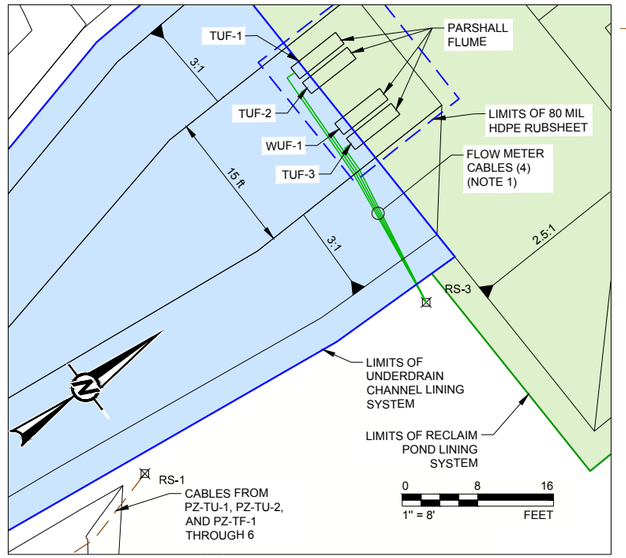


SCALE 1" = 4' (A, I1) INSTRUMENTATION DETAIL (1 OF 3)



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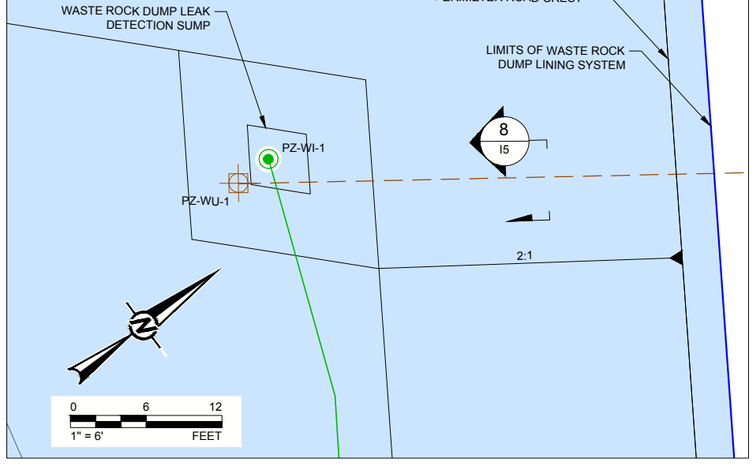

SCALE 1" = 6' (C, I1) INSTRUMENTATION DETAIL (3 OF 3)

LEGEND

- RS-1 — READOUT STATION (9 / I5)
- PZ-TU-1 — UNDERLINER PIEZOMETER (5 / I5)
- PZ-TI-1 — IMPOUNDMENT PIEZOMETER
- CABLE ROUTES BELOW LINER (NOTE 2) (8 / I5)
- CABLE ROUTES ABOVE LINER (10 / I5)
- LIMITS OF UNDERDRAIN CHANNEL, WASTE ROCK DUMP, AND TSF BASIN LINING SYSTEM
- LIMITS OF RECLAIM POND LINING SYSTEM
- LIMITS OF 80 MIL HDPE RUBSHEET

ISSUED FOR CONSTRUCTION

NOTES

1. SIGNAL CABLES FOR FLUME SONIC TRANSDUCERS TO ROUTE ALONG GEOMEMBRANE LINER TO RS-3.
2. DETAILED SURVEY OF AS INSTALLED CABLE TRENCHES TO BE PERFORMED PRIOR TO BACKFILLING.

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OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
11/6/19
EXPIRES: 12/31/2020

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0	2019-11-06	ISSUED FOR CONSTRUCTION	MDB	JRP	CJM	RAB

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL INSTRUMENTATION LAYOUT (2 OF 2)

PROJECT NO.	REV.	DRAWING
1663241	0	39 of 42 I2

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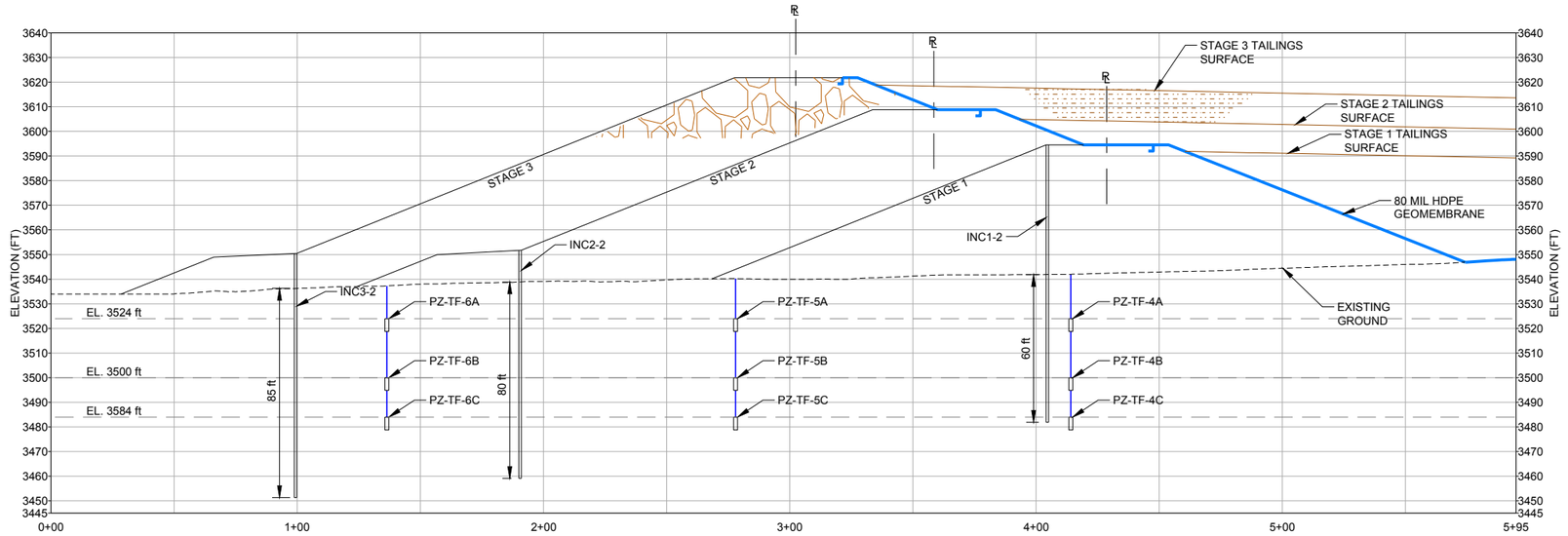

SCALE 1" = 30' (A / I1) NORTH EMBANKMENT PIEZOMETER LOCATIONS (1 OF 2)

LEGEND

- EMBANKMENT LINING SYSTEM (5 / D1)
- EXISTING GROUND
- TAILINGS SURFACE
- FOUNDATION PIEZOMETER (PZ-TF SERIES) (7 / I5)
- INCLINOMETER (1 / I4)

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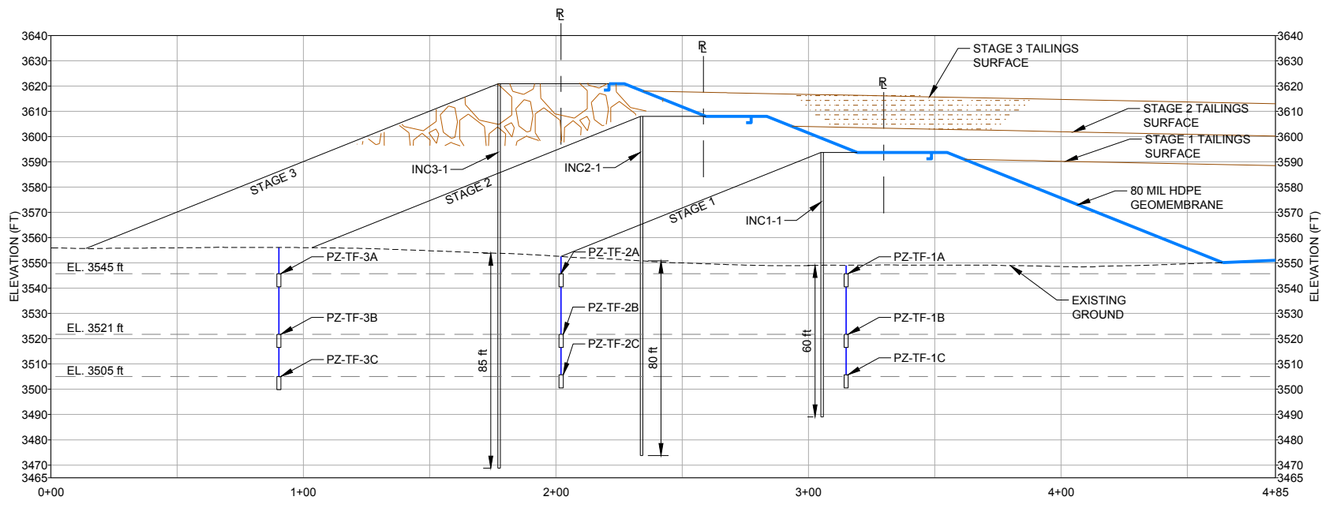
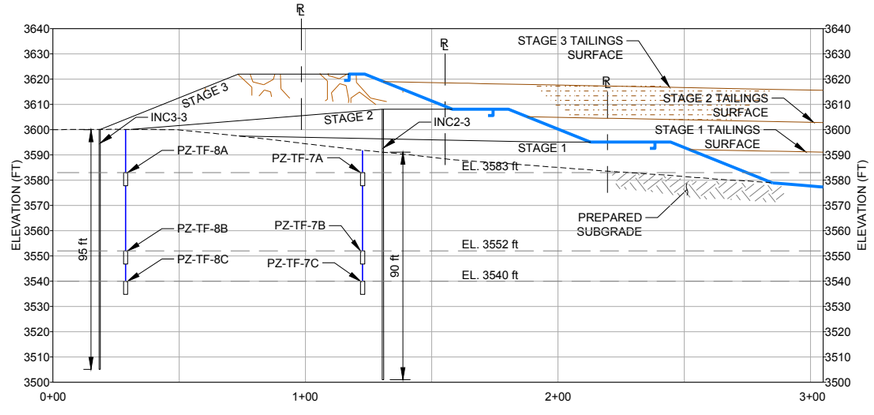
1" = 30' (0, 30, 60, 90 FEET)



SCALE 1" = 30' (B / I1) NORTH EMBANKMENT PIEZOMETER LOCATIONS (2 OF 2)



SCALE 1" = 30' (C / I1) WEST EMBANKMENT PIEZOMETER LOCATIONS

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PROJECT
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TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
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TITLE
GEOTECHNICAL INSTRUMENTATION SECTIONS

PROJECT NO. 1663241 | REV. 0 | 40 of 42 | DRAWING I3

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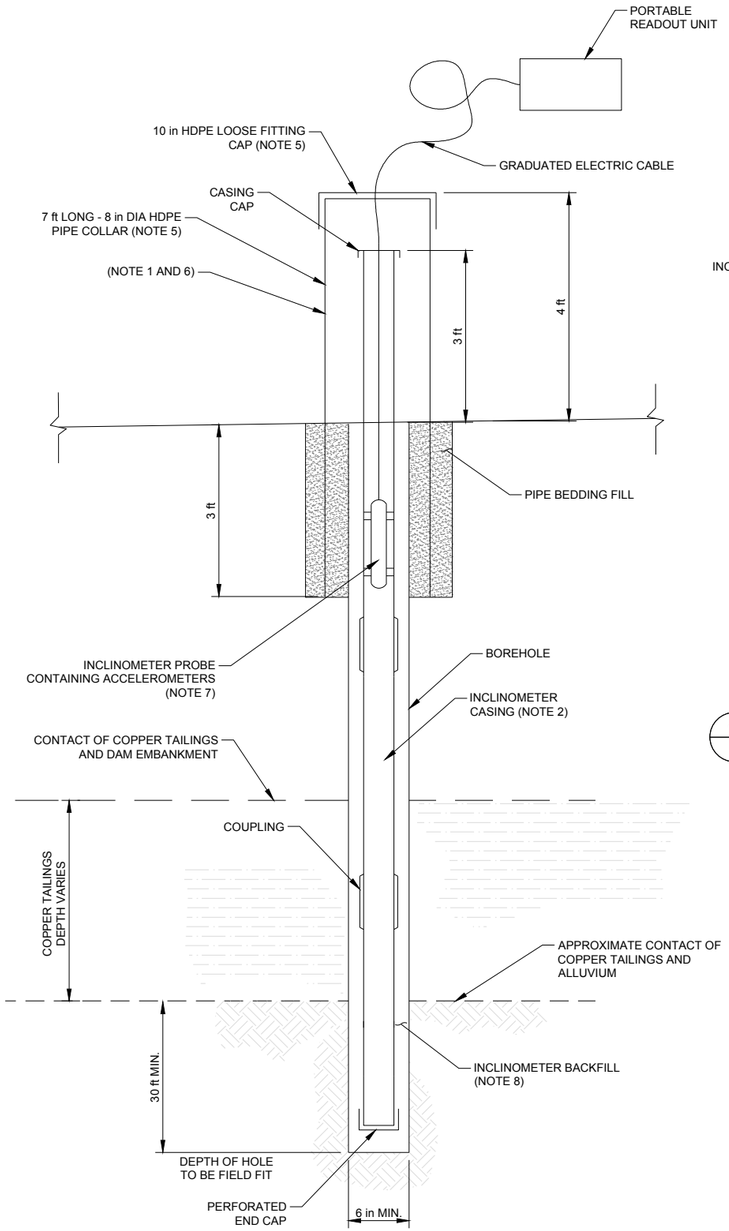
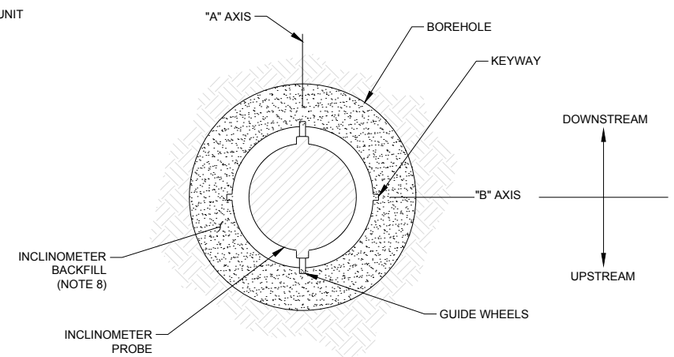
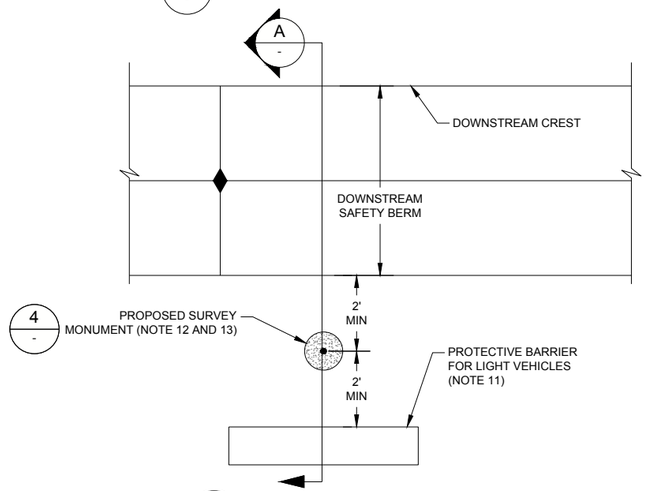


NTS 1 / I1 TYPICAL INCLINOMETER INSTALLATION DETAIL

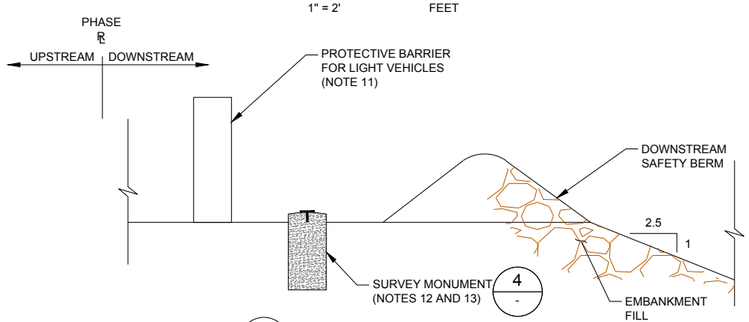


NTS 2 / - TYPICAL INCLINOMETER CASING DETAIL

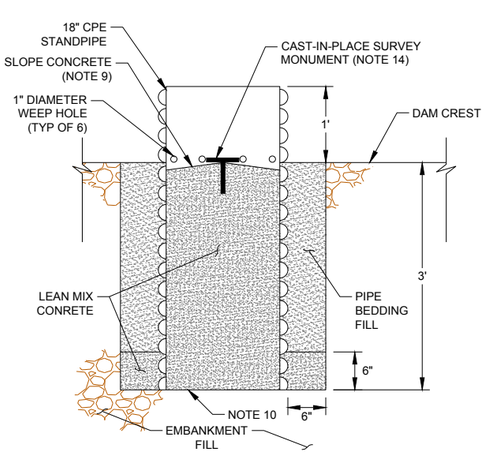


1" = 2' 3 / I1 TYPICAL SURVEY MONUMENT PLAN

0 2 4
1" = 2' FEET



NTS A / - SURVEY MONUMENT SECTION



NTS 4 / - SURVEY MONUMENT TYPICAL DETAIL

NOTES

1. THE LOCATION OF THE INCLINOMETERS ARE SHOWN ON DRAWING I1A.
2. 2.75" O.D. INCLINOMETER CASING SHALL INCLUDE FOUR KEYWAYS SET AT THE RIGHT ANGLES TO EACH OTHER AND SHALL BE SUPPLIED IN 10 FT LENGTHS WITH COUPLING AND END CAPS. THE KEYWAYS SHALL BE ORIENTATED SUCH THAT MOVEMENTS ARE MEASURED IN THE DIRECTIONS PERPENDICULAR AND PARALLEL TO THE REFERENCE LINE OF THE DAM WITH THE "A" AXIS ALWAYS PERPENDICULAR TO THE R_0. USE A COMPASS OR SURVEYING EQUIPMENT TO DOCUMENT THE BEARING OF THE "A" AXIS AFTER INSTALLATION.
3. THE ASSEMBLED TUBE SHALL BE LOWERED INTO A 6 INCH MIN. DIAMETER BOREHOLE.
4. ALL EQUIPMENT AND PERMANENT MATERIALS SHALL BE REVIEWED AND APPROVED BY THE ENGINEER BEFORE INSTALLATION.
5. THE INCLINOMETER CASING SHALL BE CASED AND PROTECTED AS SHOWN IN THE FIGURE AND SURROUNDED BY A SAFETY BERM. PAINT EXPOSED COLLAR AND CAP WITH ORANGE PAINT.
6. CLEARLY MARK THE INSTRUMENT NUMBER ON THE PIPE COLLAR.
7. ALTERNATIVE INCLINOMETER TYPES AND CONFIGURATIONS MAY BE EVALUATED FOR USE AND INSTALLED WITH THE APPROVAL OF THE ENGINEER.
8. ANNULAR SPACE BETWEEN BOREHOLES AND INCLINOMETERS SHALL BE BACKFILLED IN ACCORDING WITH MANUFACTURER RECOMMENDATIONS.
9. GRADE CONCRETE SURFACE TO CONVEY WATER AWAY FROM CENTER.
10. LEVEL BASE OF EXCAVATION AND BACKFILL MONUMENT WITH PIPE BEDDING FILL. HAND TAMP TO PROVIDE UNIFORM AND DENSE FILL.
11. AFTER INSTALLATION, PROTECT SURVEY MONUMENTS FROM DAMAGE FROM TRAFFIC AND CONSTRUCTION OPERATIONS.
12. CLEARLY MARK THE MONUMENT NUMBER ON TOP OF THE CONCRETE PIPE BACKFILL.
13. THE LOCATION OF EMBANKMENT CREST SURVEY MONUMENTS ARE SHOWN ON DRAWING I1.
14. CAST-IN-PLACE SURVEY MONUMENTS SHALL BE BRASS SURVEY MARKER MODEL NO. M/M/BCS-2½F (2-1/2 in) AS MANUFACTURED BY SURV-KAP, OR EQUIVALENT APPROVED BY THE ENGINEER.

REGISTERED PROFESSIONAL ENGINEER
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11/6/19
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL INSTRUMENTATION DETAILS (1 OF 2)

PROJECT NO.	REV.		DRAWING
1663241	0	41 of 42	I4

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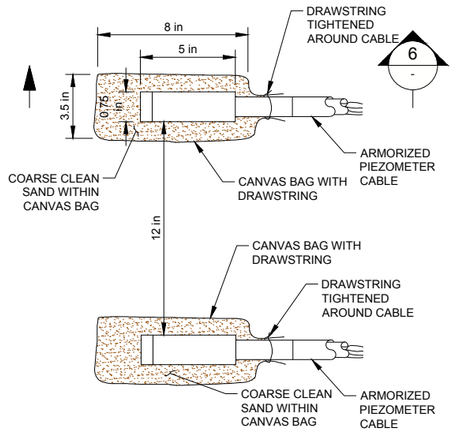
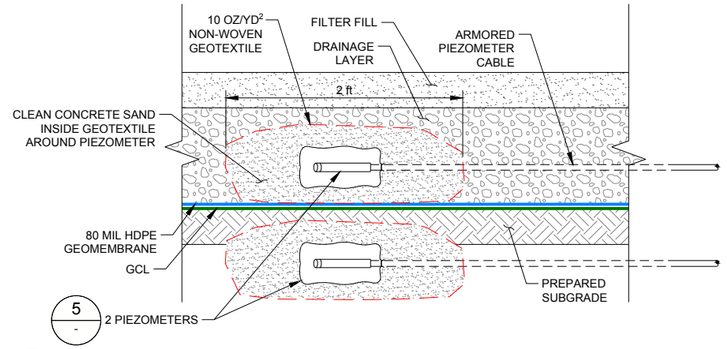


NTS 5 I1 IMPOUNDMENT AND UNDERLINER VIBRATING WIRE PIEZOMETER TYPICAL DETAIL



NTS 6 - IMPOUNDMENT AND UNDERLINER PIEZOMETER INSTALLATION TYPICAL DETAIL

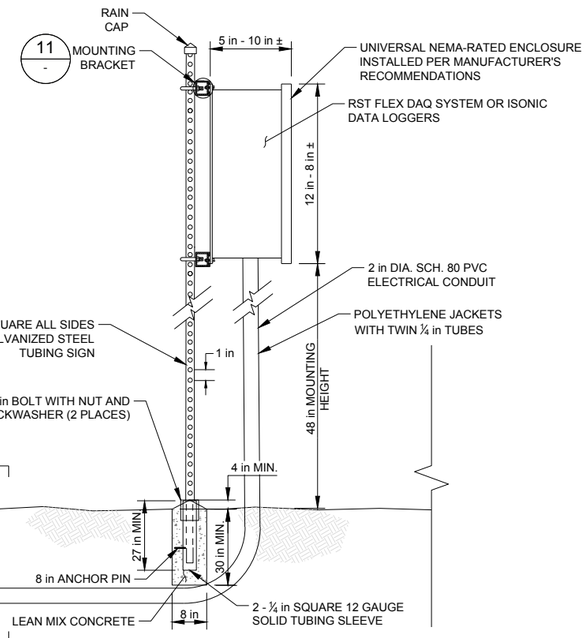
NOTES

1. REFER TO DRAWING I1A FOR SENSOR ELEVATION AND VERTICAL SPACING.
2. NESTED PIEZOMETERS AND CABLES SHALL BE PRE FABRICATED TO DESIGNED VERTICAL INTERVAL.

LEGEND

GCL

80 MIL HDPE GEOMEMBRANE



NTS 9 I1 I2 READOUT STATION DETAIL

NTS 8 I1 CABLE BEDDING OVER NATURAL GROUND DETAIL

NTS 7 I1 PIEZOMETER SAND FILTER ZONE

NTS 10 I1 CABLES ON EMBANKMENT DETAIL

NTS 11 - MOUNTING BRACKET DETAIL

ISSUED FOR CONSTRUCTION

11/6/19

REGISTERED PROFESSIONAL ENGINEER
92393PE
OREGON
JULY 11, 2017
CHRISTOPHER J. MacMAHON
EXPIRES: 12/31/2020

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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL INSTRUMENTATION DETAILS (2 OF 2)

PROJECT NO.	REV.		DRAWING
1663241	0	42 of 42	I5

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APPENDIX A

Geotechnical Data Report

November 6, 2019 Project No. 1663241-054-L-Rev0

Nancy Wolverson
Calico Resources USA Corp.
665 Anderson Street
Winnemucca, NV 89445

GEOTECHNICAL DATA REPORT
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
GRASSY MOUNTAIN MINE, MALHEUR COUNTY, OREGON

Dear Ms. Wolverson

This letter presents geotechnical data collected by Golder Associates Inc. (Golder) for Calico Resources USA Corp. (Calico) for the Grassy Mountain Mine located in Malheur County, Oregon. This letter documents the findings of geotechnical field exploration and laboratory testing programs conducted by Golder to support detailed design of the proposed tailings storage facility (TSF), waste rock dump (WRD) and mine process facilities, as well as assess potential soil borrow areas.

Golder has completed three geotechnical investigations between November 2017 and August 2019 to characterize the subsurface beneath the proposed TSF, WRD and process facilities.

1.0 SITE DESCRIPTION

The Grassy Mountain Mine site is located approximately at 43.673°N latitude, 117.364°W longitude in Malheur County, Oregon. The proposed TSF will be located in a broad valley immediately west of the proposed underground portal and process facilities. The TSF will fill the valley and require embankments on the north and west sides, with the main embankment located at the north end of the valley. The proposed WRD will be located immediately west of the underground portal, while the processing facilities will be located north of the underground portal. Figure 1 presents proposed facility locations as well as existing site topography.

The overall ground surface within the TSF footprint drains from the southwest to the north embankment at about two (2) percent, with valley wall slopes to the east and west ranging from about 10 percent to 15 percent, and about 5 percent in the south (refer to Figure 1). The north TSF embankment will extend east-west across the valley and will have an approximate maximum height of about 84 feet. Additional embankments will be required along the western boundary of the impoundment and will range in height from about 10 feet to about 30 feet.

The proposed WRD will be located immediately southeast and upslope from the TSF. The native slopes beneath the WRD generally slope between 10 and 12 percent in both the northwest and northeast directions.

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The mine process facilities will be situated east of the TSF on a saddle between the underground portal and a knoll about 600 feet north of the portal.

Vegetation across the site generally consisted of moderately dense native shrubs and grasses. No surface water, perennial streams, or springs were observed within the TSF footprint, WRD, or process facilities area.

2.0 SCOPE OF GEOTECHNICAL CHARACTERIZATION

Golder has completed three geotechnical investigations in support of the design of the surface facilities at the Grassy Mountain Mine. The purpose for the investigations included characterizing the subsurface conditions, identifying potential construction material borrow sources, and supporting preliminary foundation recommendations for the proposed process facilities.

The first investigation, completed in December 2017, investigated the subsurface beneath the proposed locations of the TSF, WRD and process facilities. Two additional geotechnical investigations were completed in 2019 to refine the geotechnical characterization of the lacustrine clay deposit beneath the TSF that was first identified in 2017.

The scope of the three geotechnical investigations is summarized below:

- November 30 to December 8, 2017 – Initial surface geology mapping and subsurface geotechnical investigation beneath the TSF, WRD and process facilities.
  - TSF and Permanent Stormwater Diversion Channel
    - **BH-01 through BH-09 and BH-13 through BH-15:** Drill twelve (12) hollow stem auger boreholes to depths ranging from 40 to 100 ft below the ground surface (bgs)
    - **TP-01 through -4, -14 through -23, -38, -44 and -45:** Excavate 24 test pits to depths of up to 20 ft bgs
    - Perform six (6) falling head permeability tests in completed boreholes to provide field permeability estimates of the various geologic units encountered in the subsurface exploration
  - Mine Processing/Admin/Maintenance Facilities
    - **BH-10 through BH-12:** Drill three (3) boreholes to depths ranging from 20 to 40 ft bgs
    - **TP-26 through TP-29:** Excavate four (4) test pits to depths of up to 15 ft bgs
  - Waste Rock Dump Area
    - **TP-05 and TP-43:** Excavate two test pits to a depth of 15 ft bgs
  - Borrow Source Areas
    - **TP-13, -24, -25, -30 through -37, and -39 through -41:** Excavate 14 test pits to depths of up to 10 ft bgs to assess the suitability of onsite material for use as various construction materials for the TSF

- March 19 to 30, 2019 – Geotechnical drilling program to obtain samples for laboratory testing to refine the geotechnical characterization of the clay beneath the North embankment of the TSF. These 6 boreholes were drilled at the same location as previously permitted and excavated test pits.
  - **BH19-TP-01, -15, -19, -23, -39, -44:** Drill six (6) boreholes to depths ranging from 50 to 120 bgs
- August 16 to 20, 2019 – Cone penetration test (CPT) program to investigate the presence of groundwater and to support the selection of material strength properties for the subsurface materials beneath the TSF embankments. Each CPT sounding was advanced to gather additional information at critical locations coinciding with previously permitted and investigated locations.
  - **CPT-1A through CPT-12:** Advance twelve (12) CPT's to depths ranging from approximately 11 to 61 feet bgs
    - Pore pressure dissipation tests were performed at depths chosen by Golder's field engineer
    - Seismic shear wave velocity tests were performed during five (5) of the CPT's at approximate 5-foot intervals

Calico provided utility clearance for all investigation locations in addition to surveying the location of all boreholes and test pits in the field. The geotechnical investigation locations are presented on Figure 1.

2.1 Drilling

Haz-Tech Drilling Inc (Haz-Tech) of Meridian, Idaho, a subcontractor of Calico and Golder, advanced boreholes for both the December 2017 and March 2019 geotechnical investigations to depths ranging between 25 to 100 feet below the ground surface (bgs) using a CME 75 truck-mounted drill rig with a 4.25-inch inner diameter (approx. 8-inch outer diameter) hollow stem auger.

Standard Penetration Testing (SPT, ASTM D 1586) was conducted in soils using a 140-pound automatic hammer with a drop height of 30 inches, driving either a 2-inch (outer diameter O.D.) split spoon or a 3-inch O.D. Modified California Sampler (MC). Each SPT and MC was driven with the hammer 18 inches in accordance with ASTM D1586. The SPTs were performed at 5-foot intervals until the borehole was advanced to depths between 30 to 50 feet bgs, with samples then collected at 10-foot intervals until the borehole was terminated. Disturbed SPT samples were collected and sealed in waterproof bags.

The number of blows for each 6-inches of penetration was recorded. The penetration resistance (N-value) of the soil is calculated by summing the total number of blows required to drive the sampler the final 12-inches. The N-value is an indication of the relative density of cohesionless soils and the relative consistency of cohesive soils. If a total of 50 blows was recorded for a 6-inch interval, the test was terminated, and blow count was recorded as 50 blows per the depth driven in that interval. All blow counts presented on the borehole logs are uncorrected values.

When using the MC sampler, 6-inch long steel tubes were inserted inside the sampler to obtain relatively undisturbed samples for testing. The MC sampler was utilized more frequently during the March 2019 investigation to obtain more samples for relatively undisturbed strength testing. When soil conditions allowed, Shelby tube (thin-walled tube) samples were advanced hydraulically to try to take relatively undisturbed samples of sensitive subsurface soils.

The boreholes were backfilled with bentonite chips upon completion. Standpipes installed in the boreholes for field permeability testing were also backfilled with bentonite chips following completion of the permeability tests. Borehole logs are presented in Attachment A. Prior to construction, the upper 10 feet of each borehole where a field falling head standpipe was installed should be excavated, removed, and replaced with compacted fill in accordance with Technical Specifications.

2.2 Test Pit Excavation

Test pit excavations were completed during the December 2017 geotechnical investigation by Andy Bentz, of Vale, Oregon, a subcontractor of Calico, using a Thunderbird 500RB tracked excavator with a 2.5-foot wide bucket. Test pits were excavated between 2 and 16 feet below ground surface. Each test pit was excavated o the maximum reach of the excavator or to practical refusal. Golder's field engineer gathered bulk bag samples of the varying soil types observed during the investigation. Upon completion, test pits were backfilled with the excavated material and tamped by the excavator.

Prior to construction, all loose material within test pits excavated below planned structures and facilities should be removed and replaced with compacted fill in accordance with project Specifications. Test pit logs are presented in Attachment B.

2.3 Logging and Sampling

All drilling and excavation activities were performed under the supervision of Golder field engineers and geologists. The borehole and test pit samples were logged in general accordance with ASTM D 2488 and photographed by Golder's field engineers and geologists. Stratigraphic contacts depicted in the logs represent approximate boundaries between geologic deposits, and actual transitions may be more gradual. Geologic conditions described are only for the dates and locations reported and, therefore, may not necessarily be representative of other locations and/or times.

Bulk and disturbed samples were placed in plastic bags or 5-gallon buckets and sealed to prevent moisture loss. Steel and Shelby tube samples collected during drilling were capped and sealed to reduce moisture loss and packaged to decrease the potential for additional disturbance during transport. At the completion of each of the programs, samples were transported to Golder's geotechnical laboratory located in Lakewood, Colorado for further classification and testing.

2.4 Field Hydraulic Conductivity Testing

Upon completion of drilling, hydraulic conductivity (permeability) testing was performed in selected boreholes within the footprint of the TSF to evaluate the unsaturated hydraulic conductivity of the encountered soils. The permeability testing focused on characterizing the major soil units and conditions encountered in the boreholes from the surface to a depth of approximately 100 feet bgs. Falling head tests were conducted in accordance with industry standard methods. The interval for each falling head permeability test was selected by Golder's field engineer based on the depth and soils encountered during the field investigation.

Falling head tests were conducted using a 2-inch diameter polyvinyl chloride (PVC) standpipe installed in the geotechnical boreholes. Perforated PVC pipe was installed at the chosen testing interval, with solid PVC pipe extending above the chosen interval to the ground surface.

The annular space between the standpipe and the borehole for the segments above and below the perforated portion of the PVC pipe were backfilled with ⅜-inch granular bentonite chips to form an impermeable plug. The annular space around the perforated portion of the pipe was backfilled with No. 30 concrete sand (a clean, free-draining sand). Once the pipe segments, bentonite plugs, and sand were in place, the pipe was filled with water to allow the bentonite plugs to hydrate overnight prior to testing. Testing involved completely filling the standpipe then measuring and recording the water level drop in the standpipe with time using a down-hole water level indicator. Multiple tests were completed within each standpipe and the average of the tests is presented as the estimated hydraulic conductivity in Section 5.1.1.

The hydraulic conductivity was calculated using the following equation (NAVFAC, 1986):

$$K = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Where: K = Mean Permeability, cm/s

r = Standpipe Radius, ft

L = Length of Perforated Pipe Section, ft

R = Radius of Borehole, ft

t = time, day

H = Head, ft

Δh = incremental water level drop, ft

Field permeability test results are presented in Attachment C.

2.5 Cone Penetration Test Program

A cone penetration testing (CPT) program was completed from August 16 to 20, 2019. The program consisted of advancing 11 CPTs to support geotechnical characterization of the clay within the TSF footprint and the selection of material strength properties for geotechnical stability modelling. CPTs were advanced by Taber Drilling (Taber) of Sacramento, California, subcontracted to Calico, by direct push of an instrumented cone at a controlled rate with continuous data collection, and included pore water dissipation testing to obtain static water levels and hydraulic conductivity data, as well as seismic testing to support selection of material density and modulus, and determine shear wave velocities. Taber recorded the cone resistance, unit sleeve friction resistance and pore water pressure at 2-cm increments.

All CPTs were advanced until refusal on native material. Native alluvium and lacustrine deposits were very hard in some areas requiring the advance of multiple CPTs at a specific location. When shallow refusal (<10 feet) occurred, the rig was shifted approximately 5 feet laterally before attempting to advance another CPT. Only the deepest CPT at each location has been presented on Figure 1 and summarized in this report.

A Golder field engineer was on site throughout the investigation to support the program and identity depth intervals for pore pressure dissipation and seismic shear wave velocity testing. Pore pressure dissipation tests were completed at selected depths during each CPT sounding while seismic shear wave velocity tests were

completed at approximate 5-foot intervals within five (5) CPTs (CPT-1a, -2a, -7b, -11a, and -12). Interpretation of the CPT soundings is presented in Golder's geotechnical stability and settlement evaluation for the TSF and WRD that is appended to the main Design Report.

The plots for the CPT soundings, pore pressure dissipation tests, and seismic shear wave velocity tests are presented in Attachment D.

3.0 LABORATORY TESTING PROGRAM

Geotechnical laboratory testing was performed on selected soil samples deemed representative of the materials encountered during the investigation. The geotechnical laboratory testing program, summarized in Table 1, was developed to focus on classifying and characterizing the engineering properties of the foundation soils and potential construction materials. Geotechnical laboratory testing was completed at Golder's Lakewood, Colorado geotechnical testing laboratory. Selected samples were also subjected to x-ray diffraction (XRD) mineral composition testing. These tests were performed by Miles Industrial Mineral Research of Denver, Colorado, subcontracted to Calico. All geotechnical laboratory testing results are presented in Attachment E.

Table 1: Summary of Laboratory Testing Program

Laboratory Test	Test Method	Quantity
Grain Size Analysis	ASTM D 421/D 422	81
Moisture Content	ASTM D 2216	72
Atterberg Limits	ASTM D 4318	81
Flexible Wall Permeability	ASTM D 5084	5
Moisture-Density Relationship (Modified Proctor)	ASTM D 1557	1
Consolidated-Undrained Triaxial Shear Strength	ASTM D 4767	6
1-Dimensional Consolidation	ASTM D 2435	6
X-ray Diffraction	N/A	15

Index tests (grain size, moisture, and Atterberg limits tests) were performed on selected subsurface soils encountered during the investigations to assist in classifying the soils in accordance with ASTM D 2487 and the Unified Soil Classification System (USCS) for verification of soil descriptions logged in the field.

Hydraulic conductivity (permeability) tests were run on both relatively undisturbed samples and a remolded sample using a flexible wall permeameter. The remolded sample was tested to assess the permeability of the lacustrine deposits if the material were to be excavated and used during construction. The relatively undisturbed samples were tested to provide the permeability of in-situ lacustrine soils beneath the TSF. The modified Proctor (moisture-density relationship test) was utilized to obtain parameters for remolding the permeability sample.

Consolidated-undrained triaxial shear strength tests (CUTX) were performed on relatively undisturbed samples extruded from the MC and Shelby tubes to assess the in-situ strength of the lacustrine deposits. A majority of the MC and some of the Shelby tube samples delivered to the laboratory were too disturbed or too fractured to be utilized for CUTX testing. This was most likely due to disturbance while driving the samplers into stiff to hard clays.

One-dimensional consolidation tests were conducted on relatively undisturbed lacustrine clay samples to determine the estimated pre-consolidation pressure and soil parameters for use in assessing settlement of the soils under loading conditions.

In addition, XRD mineral composition testing was performed on 15 samples to identify clay and accessory mineral concentrations. Results are presented in Attachment E.

4.0 SITE GEOLOGY AND GEOLOGIC HAZARDS

The information presented in this section is based on Golder's observations at the time of the field exploration program and a review of available published data.

4.1 Geology

As described by Paramount (2017), the geology of the region surrounding the TSF and WRD site is a sequence of sedimentary and volcanic deposits within the Oregon-Idaho Graben. Contemporaneous deposition of sandstone and conglomerate (Tgs), olivine basalt emplacement (Tbi), and repeated episodes of calc-alkaline lava eruption and flow (Tgb) occurred during middle to upper Miocene time. The volcanoes of west-central to southeastern Oregon range in age from 15 to 2 million years ago (Ma). The Payette section of the Columbia Plateau, where the TSF and WRD site is located, is a relatively uniform area of basalt flows that overlie and cap the underlying older sedimentary deposits.

Grassy Mountain itself is mapped as underlain by calc-alkaline rich volcanic flow deposits (Tgb) and associated olivine basalt that crops out farther northeast. The TSF and WRD sites are located on a thick sequence of arkosic sandstones containing interbeds of conglomerate separated by the tuff of Kern Basin. Geologically, the site is within the upper arkosic (mid- to upper Miocene) and the lower (mid-Miocene) arkosic units. Erosion over about the last 11 Ma has removed some of the volcanic deposits that overlie and cap the sedimentary units to expose the upper arkosic unit at the site.

Bedrock outcrops within the site expose siltstone, sandstone, and conglomerate of the late Miocene Grassy Mountain Formation. These units are also exposed in the northeast–southwest trending drainage that the TSF will partially fill. Olivine-rich basalts are present immediately to the east and south. Igneous intrusions (Tbi) are mapped as isolated bodies surrounded by the sedimentary units (Tgs). The intrusive bodies are in places aligned along the mapped pre-Quaternary faults that may have controlled the locations and extent of these shallow intrusions.

The Grassy Mountain mine is located on a 150-foot high, highly resistant, silicified and iron-stained knoll. Bedding within the sandstone unit appears unaltered at the hilltop, dips at 10° to 25° toward the north-northeast on the northern and eastern flanks of the hill and steepens to 30° to 40° on the west side of the hill due to drag folding in the footwall along a fault striking about N20°W (Paramount 2017). Normal faulting of the Miocene-age units is common, with most faults striking either northwest–southeast or northeast–southwest (most common).

Golder's subsurface geotechnical investigations identified unconsolidated alluvium and colluvium overlying previously unmapped Miocene-aged lacustrine clays underlying most of the TSF and WRD site area. The lacustrine deposits are generally characterized as fat clay (with variable quantities of fine- to medium-grained sand, dark tan to brown with some blue-gray deposits) with lesser amounts of lean clay and poorly graded sand lenses. Based on Golder's research, these lacustrine deposits had not been previously mapped at the site; however, such clay deposits are not uncommon in the region. Similar deposits in the region were described as typically formed during the Upper Miocene due to hydrothermal alteration or deposition of ash fall infilling basin alkaline lakes (Gray et al. 1989) and were mapped by Ferns et al. (1993) in a nearby basin approximately 2 miles northeast of the project.

4.2 Faulting and Seismicity

Normal faulting of the Miocene-age units is common, with most faults striking either northwest–southeast or northeast–southwest (most common). Also, a number of mapped older faults strike approximately north–south, but these faults are generally located west of the Site. Golder completed a seismic and faulting hazard assessment appended to the main Design Report. No faults with evidence for Quaternary surface rupture have been mapped through the footprint of the TSF or WRD, and the surface fault rupture hazard is considered negligible (Golder 2019b).

As described in Golder's updated seismic and faulting hazard assessment (Golder 2019b), a probabilistic analysis (PSHA) using the United States Geological Survey (USGS) 2014 National Seismic Hazard Model indicates that the earthquakes for the 475-year return period has a mean peak ground accelerations (PGAs) of 0.08g.

A deterministic analysis (DSHA) indicates that the Cottonwood Mountain fault is the controlling Maximum Credible Earthquake (MCE) for the Project TSF. The Cottonwood Mountain fault has a surface trace mapped about 18 miles (28 km) from the TSF at its closest approach and generates an MCE **M**7.2 earthquake. Using the geometric mean of four equally weighted ground motion models, the median PGA value for the MCE is 0.15g. The median deterministic PGA has return periods estimated from the 2014 USGS NSHM at about 1,500 years.

4.3 Rock Slides

A localized rock slide was observed on the southwestern slope of Grassy Mountain that measured about 550 feet long by 250 feet wide. The head scarp was observed immediately below the crest of the hill. The head area included large blocks of arkosic sandstone up to about 10 feet in diameter. Internally, the rock slide graded to smaller arkosic sandstone blocks at the toe of the slide of less than about one foot in diameter.

No evidence of seeps, springs, or surface water was observed in the area of the rock slide at the time of Golder's investigations. The potential failure mechanism is unclear; however, it is possible the rock slide is the result of ground shaking or different climatic conditions, i.e., a past wetter environment. The slide is observable on aerial imagery dating back to 1994; however, an exact date is uncertain.

Currently, no structures or facilities are planned in this area.

5.0 SITE SUBSURFACE WATER CONDITIONS

5.1 Ground Water

No subsurface water was encountered during the field explorations to the maximum depth of the boreholes of approximately 120 feet bgs. In the *Groundwater Characterization Data Report*, prepared by SPF Water Engineering, LLC (SPF), it was reported that the ground water depth beneath the southern portion of the TSF basin ranged between 155 feet at the BLM well located within the TSF footprint and 232 feet at the GW-3 well located just southwest of the TSF (SPF 2019).

Inferred ground water contours presented in the same report indicate ground water beneath the reclaim pond area may be as shallow as 55-feet; however, no ground water was encountered in Golder's borehole BH-05 which were drilled to maximum depth of 100 feet bgs.

Ground water depths in the TSF area will be refined after the installation of proposed ground water monitoring wells as presented in SPF's report. In addition, no springs were observed in the TSF or mine facility areas during the field investigation.

5.2 Hydraulic Conductivity Testing

Golder completed both field and laboratory hydraulic conductivity (permeability) testing to characterize the permeability of the soils encountered during the field investigation.

Field falling head permeability tests were completed in six (6) boreholes using PVC standpipe piezometers with a screened interval installed a depth selected by Golder's field engineer. The procedure used to complete the in-situ permeability tests was summarized in Section 2.4. Table 2 summarizes the results of field falling head permeability testing with test data and results presented in Attachment C.

Table 2: Summary of Falling Head Permeability Test Results

Borehole ID	Test Interval (feet bgs)	Material Description (USCS Classification)	Estimated Hydraulic Conductivity (cm/s)
BH-2	20 to 25	Poorly Graded Sand (SP)	2.7×10^{-6}
BH-3	2 to 4	Poorly Graded Sand (SP)	7.1×10^{-6}
BH-5	10 to 15	Poorly Graded Sand (SP)	1.7×10^{-6}
BH-6	22.8 to 24.8	Fat Clay (CH)	5.2×10^{-7}
BH-7	14.5 to 19.5	Poorly Graded Sand with Clay and Gravel (SP)	5.8×10^{-6}
BH-9	3.6 to 8.6	Poorly Graded Sand (SP)	3.7×10^{-5}

As discussed in Section 7.3, flexible wall permeability testing was performed on relatively undisturbed samples collected from the borings. Field falling head permeability tests performed predominately targeted in-situ zones of higher permeability poorly-graded sands and not the lacustrine clays. One falling head test was conducted on in-situ lacustrine clay in Borehole BH-6. The measured in-situ permeability from the falling head test was lower than laboratory measurements.

Several factors can lead to faster field-measured permeabilities than laboratory measurements. These can include, but not limited to, inadequate seal zone around the screened interval, test intervals too short, and field measurements include both horizontal and vertical hydraulic conductivity whereas laboratory flexible wall permeability measures only vertical conductivity.

6.0 SUBSURFACE CONDITIONS

The following subsections summarize the geotechnical subsurface conditions encountered at the time of the investigations. Borehole, test pit, and CPT locations are presented on Figure 1. Subsurface conditions have been classified in accordance with the USCS classification system (ASTM D 2487). The following attachments should be referenced when reviewing the subsurface conditions:

- Attachment A – Borehole Logs and Borehole Photos
- Attachment B – Test Pit Logs and Test Pit Photos
- Attachment D – CPT Logs

The subsurface profile at the site generally consisted of alluvial and colluvial deposits underlain by lacustrine deposits, sandstone, and basalt as presented on the geologic sections shown on Figures 2B and 2C. Subsurface stratigraphy at the site is described as follows:

- **TOPSOIL:** Topsoil was estimated to have an average thickness of about ½ foot across a majority of the site. Dense rootlets were observed in the topsoil with scattered roots observed up to ¼-inch thick in the upper 2 feet to 3 feet of the subsurface profile. Topsoil was generally comprised of dark brown, silty- to clayey-sands with non-plastic to low plastic fines, and observed to contain few to little gravel, cobbles, and boulders in the south and northeast portions of the TSF and potential borrow areas.
- **QUATERNARY DEPOSITS:** These deposits include unconsolidated sediments deposited by water (alluvium) and accumulated material on exposed slopes (colluvium). Based on the previously-referenced mapped geology, these units are estimated to be Quaternary-age deposits. These materials were encountered across the site consisting of variable sands, gravels, clays, and silts with thicknesses ranging from ground surface to 25 feet bgs. Generally, the upper portion of the deposit was described as fine-grained soils classified as lean and fat clay with varying amounts of sand and gravel, which were underlain by more coarse-grained soils classified as clayey- to silty-sand, clayey- to silty-gravel, and poorly- to well-graded sand and gravel.
- **OLDER DEPOSITS:** These deposits include Miocene-age lacustrine, alluvial, beach, and sandstone deposits described as:
  - **LACUSTRINE DEPOSITS:** Underlying the Quaternary Deposits, Lacustrine deposits were encountered across a majority of the site and primarily classified as lean- to high-plasticity clay with varying sand content. Abundant evaporites were often found in the upper three (3) feet of the deposit and were occasionally observed throughout the formation. As previously discussed, these deposits were not identified on the referenced surface geologic map; however, based on similar units in the region, these units are estimated to be Miocene-age deposits.

- **ALLUVIUM AND BEACH SAND DEPOSITS:** Discontinuous alluvium and beach sand deposits were observed within the lacustrine clay deposits generally consisting of poorly-graded sand and silty sand. Due to the location of these deposits within the lacustrine clays, these deposits were estimated to be Miocene-age deposits.
- **ARKOSIC SANDSTONE:** Part of the Grassy Mountain Formation was encountered generally along the higher elevations with the valley the TSF is situated and was identified in Borehole BH-10 at a depth of 10 feet bgs and in Test Pits TP-13, 14, 16, 20, 26, 27, 30, and 40 at depths ranging between 2.5 feet 12 feet bgs. Arkosic sandstone generally consisted of silty sand to fine- to coarse-grained sands and mapped as mid-Miocene in age (Ferns et al, 1993).
- **BASALT:** Upper Miocene olivine basalt flows were observed in the geotechnical coreholes advanced for the proposed Basalt Borrow Quarry (Golder 2019a) and is generally encountered in the hills east of the project area (Ferns et al, 1993).

Geologic sections showing these stratigraphic units through the TSF and mine process facilities area are presented on Figures 2B and 2C.

6.1 TSF Area

Subsurface conditions within the TSF footprint have been grouped into three distinct areas: 1) North Embankment (includes Reclaim Pond area); 2) West Embankment; and 3) Main TSF footprint (impoundment). The subsurface conditions encountered at each of these areas have been summarized in the following sections.

6.1.1 North Embankment

Explorations:

- Test Pits TP-17, -18, -19, -23, -38, -44, -45
- Boreholes: BH-03 through-06, -13, -15; and BH19-TP-19, -23, -44
- Cone Penetration Tests: CPT-1A, -2A, -3B, -4, -5, -6, -9, -10, -12

Subsurface soils encountered in the test pits and boreholes within the North Embankment and pond area of the TSF footprint are summarized in Table 4.

Table 4: Summary of North Embankment Subsurface Profile

Exploration ID	Subsurface Profile (Depth, feet bgs)[3]				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium/Beach	Sandstone/Basalt
TP-17	0 to 2	-	2 to 14	-	-
TP-18	0 to 3	-	3 to 15	-	-
TP-19	0 to 0.5	0.5 to 4	4 to 14	-	-
TP-23	0 to 0.3	0.3 to 10	10 to 15	-	-
TP-38	0 to 0.5	0.5 to 5	5 to 14.5	-	-
TP-44	0 to 2	2 to 13	-	-	-

Exploration ID	Subsurface Profile (Depth, feet bgs)[3]				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium/Beach	Sandstone/Basalt
TP-45	0 to 4	-	4 to 15	-	-
BH-03	0 to 0.5	0.5 to 8	8 to 100	-	-
BH-04	0 to 0.5	-	0.5 to 51.5	-	-
BH-05	0 to 0.5	-	0.5 to 10 20 to 41.5	10 to 20	-
BH-06	0 to 0.5	0.5 to 10	10 to 26.5	-	-
BH-13	0 to 0.5	-	0.5 to 45 65 to 101.5	45 to 65	
BH-15	0 to 0.5	0.5 to 8	8 to 26.5	-	-
BH19-TP-19	0 to 0.5	-	0.5 to 92 110 to 121	92 to 110	-
BH19-TP-23	0 to 10	-	10 to 110 120 to 121	110 to 120	

Notes:
1) Fine-grained soils include the thickness of topsoil (~0.5 feet). Below the topsoil the fine-grained soils at the site generally consisted of lean and fat clay with varying amounts of sand and gravel.
1) Coarse-grained soils at the site generally consisted of clayey to silt sand, clayey to silty gravel, and poorly to well graded sand and gravel.
2) Cone penetration test results are not included in the subsurface profile as the soil behavior type presented on the CPT logs in Attachment D is inferred based on mechanical characteristics of the soils, not physical characteristics as measured through laboratory testing or visual classifications.

A thin layer of topsoil with an estimated thickness of 0.5 feet covered the site. Beneath the topsoil, subsurface conditions were generally classified as both fine- and coarse-grained alluvium overlying lacustrine deposits. Few angular gravel and cobbles were observed within the topsoil of Test Pit TP-17 and TP-23. The alluvium consisted of lean to fat clay and silty sand or poorly graded sand with gravel, was moist, dense to very dense or hard, and was light brown and gray to brown and olive. The plasticity of the alluvium ranged from low to high, and few fine subangular to sub-rounded gravels and trace cobbles up to 4 inches were observed within the soils excavated from the test pits. The lacustrine deposits were classified as lean to fat clay and silt with varying sand content, and moist, very stiff to hard, olive, gray, and brown.

Older alluvium and beach sand deposits were observed at varying depths in four boreholes (BH-05, BH-13, BH19-TP19 and BH19-TP23) classified as poorly graded and silty sand, moist, dense to very dense, light brown and gray to tan.

6.1.2 West Embankment

Explorations:

- Test Pits: TP-11, -14, -16, -20, -21, -22
- Boreholes: BH-02, -09, -14
- Cone Penetration Tests: CPT-7B, -8C, -11A

Subsurface soils encountered in the test pits and boreholes within the west embankment area of the TSF are summarized in Table 5.

Table 5: Summary of Subsurface Profile at the West TSF Embankment

Exploration ID	Subsurface Profile (Depth, feet bgs)[3]				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium / Beach	Sandstone / Basalt
TP-11	0 to 3.5	3.5 to 12	12 to 14.5	-	-
TP-14	0 to 5	-	5 to 12	-	12 to 13 (sandstone) (refusal on sandstone)
TP-16	0 to 5	-	5 to 11	-	11 to 14 (sandstone)
TP-21	0 to 5	-	5 to 13.5	-	-
TP-22	0 to 1.5	-	1.5 to 11.5	-	-
BH-02	0 to 0.5	0.5 to 10	10 to 25 31 to 41.5	25 to 31	-
BH-09	0 to 0.5	0.5 to 25	25 to 50 70 to 101.5	50 to 70	-
BH-14	0 to 0.5	-	-	-	0.5 to 26 (sandstone)

Notes:
1) Fine-grained soils at the site generally consisted lean and fat clay with varying amounts of sand and gravel.
2) Coarse-grained soils at the site generally consisted of clayey to silt sand, clayey to silty gravel, and poorly to well graded sand and gravel.
2) Cone penetration test results are not included in the subsurface profile as the soil behavior type presented on the CPT logs in Attachment D is inferred based on mechanical characteristics of the soils, not physical characteristics as measured through laboratory testing or visual classifications.

Subsurface conditions to the north and south of the west embankment (TP-14, -16, -21 and -22, BH-14) consisted of fine-grained alluvium classified as moist, stiff to hard, brown to light brown, lean to fat clay with varying sand content and trace to few subangular to sub-rounded gravel. Beneath the alluvium, lacustrine deposits classified as fat to lean clay with trace to few fine sand, moist, stiff to hard, olive/brown/tan/light gray. Weathered arkosic sandstone was encountered below the lacustrine deposits in Test Pits TP-14 and TP-16 and was classified as a silty fine to coarse sand with low plasticity fines, moist, very dense, and tan with iron staining. Little fine to coarse, rounded to subangular, gravels were observed within the topsoil in Test Pit TP-14.

Subsurface conditions in the central and south-central portion of the embankment (TP-11, BH-02, and BH-09) generally consisted of coarse-grained overburden classified as poorly graded sand with varying silt content and clayey sand, characterized as moist, dense to very dense, and light tan to brown. Few angular gravel and cobbles were observed within the topsoil of Test Pit TP-11. The alluvium was underlain by lacustrine deposits classified as fat clay with trace to some fine sand, moist, very stiff to hard, and olive/brown/tan/light gray.

Within the dominant lacustrine clay, zones of Beach sand deposits were encountered within Borehole BH-02 from 25 to 31 feet bgs and from 50 to 70 feet bgs in BH-09. These beach sands were underlain by lacustrine deposits classified as lean to fat clay with trace to some fine sand, and as moist, very stiff to hard, and tan to very light gray.

6.1.3 TSF Basin

Explorations:

- Test Pits: TP-01 through -04, TP-06 through-10, -12, -15
- Boreholes: BH-01, -07, and -08, BH19-TP-01 and -15

Subsurface soils encountered in the test pits and boreholes within the TSF basin are summarized in Table 6.

Table 6: Summary of Subsurface Profile within TSF Basin

Exploration ID	Subsurface Profile (Depth, feet bgs)[3, 4]				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium / Beach	Sandstone / Basalt
TP-01	0 to 3	3 to 5	5 to 9.5 (refusal on hard clay)	-	-
TP-02	0 to 2	2 to 5	5 to 15.5	-	-
TP-03	0 to 2	2 to 11	11 to 15	-	-
TP-04	-	0 to 15	-	-	-
TP-06	0 to 4.5	4.5 to 14	-	-	-
TP-07	0 to 2	2 to 4.5	4.5 to 14.5	-	-
TP-08	0 to 4	4 to 8	8 to 11.5 (refusal on hard clay)	-	-
TP-09	0 to 2	-	2 to 15	-	-
TP-10	0 to 4.5	-	4.5 to 15	-	-
TP-12	0 to 2	2 to 5	5 to 13	-	-
TP-15	0 to 2	2 to 5	5 to 14	-	-
BH-01	-	0 to 10	10 to 101.5	-	-
BH-07	-	0 to 25	25 to 41.5	-	-
BH-08	-	0 to 10	10 to 51.5	-	-
BH19-TP-01			0 to 51.5		
BH19-TP-15		0 to 10.5	10.5 to 81.5 90 to 121.4	81.5 to 90	

Notes:
1) Fine-grained soils at the site generally consisted lean and fat clay with varying amounts of sand and gravel
2) Coarse-grained soils at the site generally consisted of clayey to silt sand, clayey to silty gravel, and poorly to well graded sand and gravel
3) Cone penetration test results are not included in the subsurface profile as the soil behavior type presented on the CPT logs in Attachment D is inferred based on mechanical characteristics of the soils, not physical characteristics as measured through laboratory testing or visual classifications.

The subsurface within the TSF basin generally consisted of fine-grained Quaternary Alluvium classified as fat to lean clay with varying sand content and trace fine to coarse subrounded to subangular gravel, moist, hard, light brown to dark brown/gray/tan. Coarse-grained Quaternary alluvial soils encountered beneath the fine-grained

surface soils classified as silty to clayey sand with varying gravel content, and poorly graded sand and gravel with varying amounts of non-plastic to low plasticity fines content. These soils were further classified as moist, medium dense to dense, light to dark brown and tan. Cobbles and boulders were observed in the coarse-grained overburden up to 18-inches in diameter within Test Pits TP-4, TP-10, TP-7, and TP-15. The fine-grained overburden was not identified in the boreholes likely due to the sampling interval utilized during the investigation; therefore, the test pits provide a better representation of the near surface (<10 feet bgs) soils.

The Quaternary Alluvium was underlain by Lacustrine deposits classified as fat clay to sandy lean clay, moist, hard, olive/gray with pink and yellow. The Lacustrine deposits extended to the bottom of each borehole advanced.

Beach deposits, classified as silty sand, moist, dense, and blue gray, were encountered in Borehole BH19-TP-15 from 81.5 to 90 bgs. These beach sands were underlain by lacustrine deposits that classified as fat clay with few fine sand, moist, very stiff to hard.

Gravel, cobbles, and boulders were observed at the ground surface in the vicinity of Test Pits TP-6 and TP-7 up to 18-inches in diameter.

6.2 Mine Process Facility Area

Explorations:

- Test pits: TP-26, -27, -28, -29
- Boreholes: BH-10, -11, and -12

Subsurface soils encountered in the test pits and boreholes within the mine process facility area are summarized in Table 7.

Table 7: Summary of Mine Process Facilities Subsurface Profile

Exploration ID	Subsurface Profile (Depth, feet bgs)				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium / Beach	Sandstone / Basalt
TP-26	0 to 2	2 to 9	-	-	(refusal on sandstone)
TP-27	0 to 3.5	-	-	-	(refusal on sandstone)
TP-28	0 to 2	-	2 to 14.5	-	-
TP-29	0 to 5	-	5 to 15	-	-
BH-10	0 to 10	-	-	-	10 to 20(sandstone)
BH-11	0 to 10	10 to 39	-	-	-
BH-12	-	-	0 to 31.5	-	-

Notes:
1) Fine-grained soils at the site generally consisted lean and fat clay with varying amounts of sand and gravel
2) Coarse-grained soils at the site generally consisted of clayey to silt sand, clayey to silty gravel, and poorly to well graded sand and gravel

The subsurface profile in the east part of the process area consisted of fine-grained Quaternary Alluvium generally comprised of lean to fat clay with varying sand, content and trace to few fine subangular to angular gravel, and was described as moist, stiff to hard, and gray to brown, and as overlying lacustrine deposits. The lacustrine deposits were classified as fat clay with trace to fine sand, moist, hard, and olive to gray in color.

The west side of the process area was generally comprised of fine-grained and coarse-grained Quaternary Alluvium over Arkosic Sandstone. The fine-grained Quaternary Alluvium was generally classified as lean clay with fine subangular to angular gravel, moist, moist, stiff to hard, and brown. The fine-grained Quaternary Alluvium was overlying coarse-grained Quaternary Alluvium classified as silty to clayey sand and poorly graded gravel and sand with varying high plasticity fines content, moist, and dense to very dense. Cobbles and boulders up to 12-inches in diameter were observed in the coarse-grained Quaternary Alluvium in Test Pits TP-26 and TP-27 and were also observed at and near the ground surface in Test Pit TP-26.

6.3 Waste Rock Dump Area

Explorations:

- Test Pits: TP-05 and -43

Subsurface soils encountered in the test pits near the WRD area are summarized in Table 8.

Table 8: Summary of Waste Rock Dump Subsurface Profile

Exploration ID	Subsurface Profile (Depth, feet bgs)				
	Quaternary Deposits		Older Deposits		
	Fine-grained[1]	Coarse-grained[2]	Lacustrine	Alluvium / Beach	Sandstone / Basalt
TP-05	0 to 3	3 to 15	-	-	-
TP-43	0 to 4.5	4.5 to 15	-	-	-

Notes:
1) Fine-grained soils at the site generally consisted lean clay and slit with varying amounts of sand and gravel
2) Coarse-grained soils at the site generally consisted of clayey and silty sand with gravel

A thin layer of topsoil with an estimated thickness of 0.5 feet covered the area. Beneath the topsoil, subsurface conditions generally comprised both fine- and coarse-grained alluvium to the bottom of the test pits at 15 feet depth. The fine-grained alluvium consisted of sandy lean clay with gravel and light tan to pink tan sandy silt, moist, stiff to very stiff, and brown to dark brown. The fine-grained alluvium also had trace to some fine to coarse, subrounded to subangular gravel. Beneath the fine-grained alluvium, the coarse-grained alluvium generally consisted of silty and clayey sand with gravel, and was moist, medium dense to dense, and tan to brown. Sands were fine to coarse, and gravels subrounded to subangular.

6.4 Potential Borrow Areas

At this time, the TSF embankments have been designed assuming that all Embankment Fill will be sourced from the Basalt Borrow Quarry located east of the process facilities as shown on Figure 1 (Golder 2019a). Since the original December 2017 geotechnical investigation was completed before this decision was made, test pits were excavated on the slopes surrounding the TSF for evaluation as potential borrow material for embankment

construction. Explorations at these locations showed the native materials to be less favorable for use as Embankment Fill than the Basalt Borrow Quarry material (Golder 2019a). However, some of the test pits did encounter materials that may be suitable sources for reclamation materials once mining has been completed. These borrow sources would require additional investigation near the end of operation to further define their suitability and use as reclamation materials. The following summarizes the potential borrow areas within the project boundary that may be suitable for reclamation material:

- ***Borrow Area Northwest of the TSF:*** Soils in this area generally consisted of alluvium and colluvium observed to be 4 to 8 feet thick in Test Pits TP-40 and TP-41 overlying arkosic sandstone. These soils classified as lean to fat clay with gravel, cobbles, and boulders up to 12-inches in diameter and clayey sand.
- ***Borrow Area South of the TSF*****:** This area appeared to be highly variable. Lean clay overburden was observed in Test Pit TP-30 to about 2½ feet bgs overlying weathered sandstone classified as poorly graded sand with silt, moist, dense. Sandy lean clay colluvium was observed in Test Pits TP-31 and TP-32 to depths of about 2½ to 3 feet bgs, and poorly-graded sand with gravel with cobbles and boulders up to 12-inches in diameter from 3 to 6 feet in Test Pit TP-32 overlying lacustrine deposits (fat clay).
- ***Borrow Area North of the TSF and mine process facilities:*** This area was characterized through Test Pits TP-13, -35, -36, -37, and -39. The Quaternary Alluvium in these areas ranged in depth from 3 feet to over 15 feet and generally comprised 1 to 2 feet of lean to fat clays overlying poorly graded sand, silty to clayey sand with varying amounts of gravel, silty gravel and varying amounts of cobbles and boulders with a maximum diameter of 14-inches.

7.0 LABORATORY TESTING RESULTS

7.1 Index Testing

Geotechnical index testing was performed on 82 samples collected during the geotechnical investigations to support characterization of the subsurface geology beneath the proposed facilities. The results of the index testing were used to calibrate the visual field soil classifications presented on the borehole and test pits logs presented in Attachments A and B, respectively. Extensive laboratory testing was completed on the lacustrine clay deposit encountered beneath the proposed location of the TSF embankments to adequately characterize the material to a level sufficient to support detailed design of the TSF. Laboratory test results of lacustrine samples indicated the following:

- Sand contents ranged from 0 to 57 percent
- Liquid limit (LL) ranged from 35 to 227, and Plasticity Index (PI) ranged from 25 to 198
- As-received moisture content ranged from about 9.6 percent to 47.9 percent, with lower moisture contents observed in the sandy materials and higher moisture contents observed in the fat clay materials

A summary table with the index testing is presented at the beginning of Attachment E, followed by the individual laboratory testing results.

7.2 Shear Strength Testing

Six (6) consolidated-undrained (CU) triaxial shear strength tests were performed on intact relatively undisturbed tube samples obtained during the geotechnical investigations. Five (5) of the tests were performed using

individual samples for each pressure interval, and a single 3-stage test (BH19-TP-44) was performed on a single sample by limiting strain to less than 5 percent for the first and second pressure intervals. The third and final pressure interval was limited to 15 percent strain. Effective confining pressures ranging between 35 psi and 150 psi were used for the testing to simulate the range of stress anticipated in the foundation of the TSF embankment during and after construction. Golder developed Mohr-Coulomb linear peak effective strength parameters for each CU test, which are summarized in Table 9 below. The laboratory data sheets are presented in Attachment E.

Table 9: Summary of Mohr-Coulomb Liner Strength Parameters

Borehole Number	Sample Depth Interval (ft bgs)	Material Description	Mohr-Coulomb Peak Strength Parameters	
			Effective Friction Angle (Φ') (degrees)	Effective Cohesion (c') (psi)
BH-06[1]	20 to 25	Sandy Fat Clay (CH)	4.3[2]	1351
BH-13	2 to 4	Fat Clay (CH)	22.4	396
BH-15	10 to 15	Fat Clay (CH)	15.1	2814
BH19-TP-23	15 to 17	Fat Clay (CH)	12.7	1042
BH19-TP-23[1]	20 to 22	Fat Clay (CH)	14.5	88
BH19-TP-44[1]	10 to 12	Fat Clay (CH)	21.2	516

Notes:
1) Linear peak strength envelope for these samples was based on only two points.
2) Sample BH-06 @ 20 to 25 feet appears to have a flaw in the testing. Lacustrine deposits appear to be massive with no indication of distinct layers weak layers.

7.3 Flexible Wall Permeability Testing

In addition to the field permeability tests, laboratory flexible wall permeability testing was performed on one remolded sample (TP-09, 2 to 15 feet) and four relatively undisturbed samples of the lacustrine deposit. The remolded sample was tested using a remolded relative compaction of 90 percent of the maximum dry density and near the optimum moisture (78.5 pounds per cubic foot (pcf) and 35.7 percent moisture content), as determined by ASTM D 1557. The in-situ samples were tested at confining pressures representing in-situ conditions. The results of the laboratory flexible wall permeability tests are presented in Table 10 below and in Attachment E.

Table 10: Laboratory Flexible Wall Permeability Test Results

Test Pit or Borehole Number	Sample Depth Interval (feet bgs)	Material Description (USCS Classification)	Hydraulic Conductivity (cm/s)
TP-09[1]	2 to 15	Fat Clay (CH)	5.6×10^{-9}
BH-06	10 to 11.5	Fat Clay (CH)	1.7×10^{-8}
BH-19-TP-01	45 to 46.5	Fat Clay with Sand (CH)	5.7×10^{-8}
BH-19-TP-39	25 to 26.5	Fat Clay (CH)	2.4×10^{-8}
BH19-TP-39	35 to 36.5	Fat Clay (CH)	5.4×10^{-8}

Notes:
1) Remolded test.

7.4 Consolidation Testing

Six (6) one-dimensional (1D) consolidation tests were performed on in-situ samples obtained during the two geotechnical drilling programs. The results of these tests were used to estimate the pre-consolidation pressure and develop soil modulus parameters necessary to calculate the potential settlement of the foundation soils due to loads imposed by the TSF embankment. Test procedures involve inundating the samples with water during testing, and it should be noted that high confining pressures ranging between 0.28 ksf (thousand pounds per square foot) and 12.3 ksf were required to prevent swelling of the material during inundation. Interpretation of the consolidation test results is presented in Golder's geotechnical stability and settlement evaluation for the TSF and WRD that is appended to the main Design Report.

7.5 Mineralogy Testing

In addition to the geotechnical laboratory testing, 15 lacustrine deposit samples were tested for x-ray diffraction to identify and quantify clay and accessory minerals. The results indicate the clay in these deposits consists of montmorillonite, with 14 samples having concentrations between 7 to 84 percent and an average content of about 30 percent. The samples also show the dominant interlayer cations are divalent cations, such as calcium. Additional constituents included quartz, illite, kaolin, albite, and other amorphous materials. X-ray diffraction test results are presented in Attachment E.

8.0 USE OF THIS REPORT

This report has been prepared exclusively for the use of Calico and their consultants for the project described.

Golder encourages review of this report as it relates to factual data only (borehole logs, laboratory test results, conclusions, etc.). The conclusions presented in this report are based on the explorations and observations completed for this study, conversations regarding the existing site conditions, and Golder's understanding of the planned project. The conclusions are not intended nor should they be construed to represent a warranty regarding the project, but they are included to assist in the planning and design process.

Judgment has been applied in interpreting and presenting the results. Variations in subsurface conditions outside the exploration locations are common. Actual conditions encountered during construction might be different from those observed in the explorations.

The explorations were advanced and logged in general accordance with locally-accepted and industry standard geotechnical engineering practices, subject to the time limits and financial and physical constraints applicable to the services for this project, to provide information for the areas explored. There are possible variations in the subsurface conditions between the borehole locations and variations over time.

The professional services retained for this project include only geotechnical aspects of the subsurface conditions at the site. Environmental services were not included in the scope of work. The presence or implications of possible surface and/or subsurface contamination resulting from previous site activities and/or resulting from the introduction of materials from off-site sources were not addressed in this report.

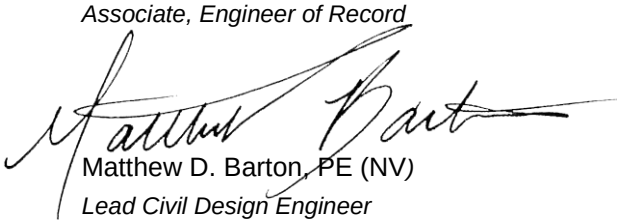
9.0 CLOSING

Golder is pleased to present this geotechnical data letter report for the proposed TSF at the Grassy Mountain Project. If you have any questions or comments regarding the information presented herein, please contact the undersigned at (775) 828-9604.

Golder Associates Inc.

Christopher MacMahon, PE
Associate, Engineer of Record

Russell A. Browne, PE (NV)
Principal and Senior Tailings Practice Leader



Matthew D. Barton, PE (NV)
Lead Civil Design Engineer

MDB/CJM/RAB/kg

Figures
Attachments: A – Borehole Logs and Photos
B – Test Pit Logs and Photos
C – Field Permeability Testing
D – CPT Logs
E – Geotechnical Laboratory Test Results

https://golderassociates.sharepoint.com/sites/17031g/1663241 grassy mountain tsf/500_reporting/520_letters/529_geotech data/detailed design/final/1663241.054.l.rev0.docx

10.0 REFERENCES

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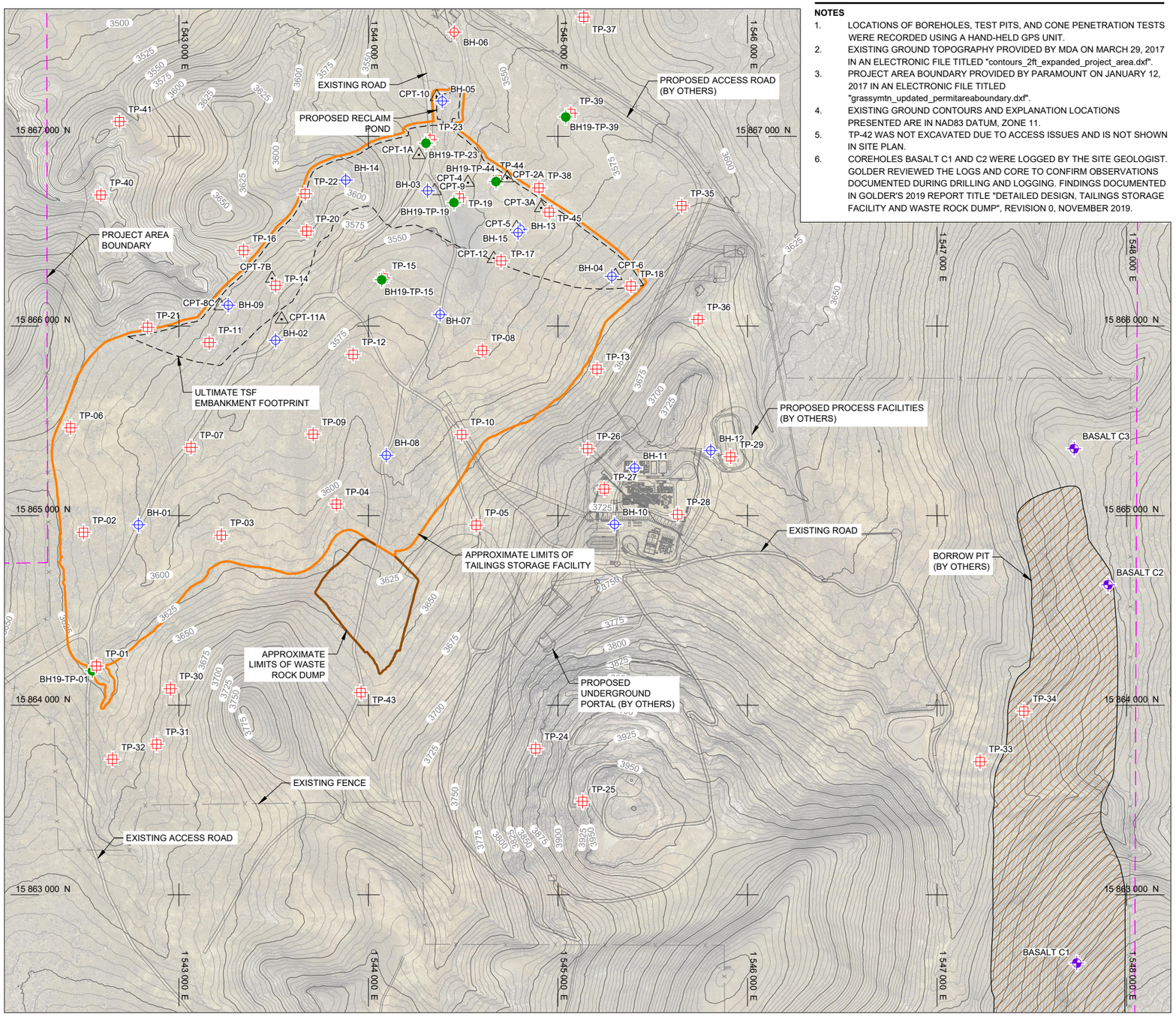
Figures



NOTES

1. LOCATIONS OF BOREHOLES, TEST PITS, AND CONE PENETRATION TESTS WERE RECORDED USING A HAND-HELD GPS UNIT.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY MDA ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf".
3. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".
4. EXISTING GROUND CONTOURS AND EXPLANATION LOCATIONS PRESENTED ARE IN NAD83 DATUM, ZONE 11.
5. TP-42 WAS NOT EXCAVATED DUE TO ACCESS ISSUES AND IS NOT SHOWN IN SITE PLAN.
6. COREHOLES BASALT C1 AND C2 WERE LOGGED BY THE SITE GEOLOGIST. GOLDER REVIEWED THE LOGS AND CORE TO CONFIRM OBSERVATIONS DOCUMENTED DURING DRILLING AND LOGGING. FINDINGS DOCUMENTED IN GOLDER'S 2019 REPORT TITLE "DETAILED DESIGN, TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP", REVISION 0, NOVEMBER 2019.

TEST PIT COORDINATES

TEST PIT	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
TP-01	1,542,565	15,864,207	3,618
TP-02	1,542,497	15,864,912	3,617
TP-03	1,543,224	15,864,896	3,609
TP-04	1,543,831	15,865,060	3,614
TP-05	1,544,568	15,864,949	3,648
TP-06	1,542,429	15,865,463	3,617
TP-07	1,543,064	15,865,360	3,622
TP-08	1,544,601	15,865,871	3,573
TP-09	1,543,709	15,865,430	3,586
TP-10	1,544,492	15,865,427	3,607
TP-11	1,543,160	15,865,912	3,595
TP-12	1,543,919	15,865,850	3,586
TP-13	1,545,206	15,865,772	3,634
TP-14	1,543,511	15,866,214	3,582
TP-15	1,544,079	15,866,253	3,565
TP-16	1,543,342	15,866,398	3,617
TP-17	1,544,701	15,866,344	3,559
TP-18	1,545,385	15,866,211	3,611
TP-19	1,544,480	15,866,675	3,546
TP-20	1,543,674	15,866,501	1,099
TP-21	1,542,835	15,865,993	3,619
TP-22	1,543,667	15,866,698	3,615

TEST PIT COORDINATES

TEST PIT	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
TP-23	1,544,326	15,866,983	3,541
TP-24	1,544,883	15,863,771	3,840
TP-25	1,545,130	15,863,493	3,943
TP-26	1,545,157	15,865,353	3,697
TP-27	1,545,245	15,865,140	3,719
TP-28	1,545,631	15,865,005	3,722
TP-29	1,545,911	15,865,310	3,680
TP-30	1,542,956	15,864,087	3,659
TP-31	1,542,882	15,863,794	3,657
TP-32	1,542,650	15,863,715	3,637
TP-33	1,547,227	15,863,702	3,789
TP-34	1,547,458	15,863,969	3,826
TP-35	1,545,653	15,866,634	3,597
TP-36	1,545,740	15,866,034	3,669
TP-37	1,545,136	15,867,629	3,562
TP-38	1,544,900	15,866,729	3,563
TP-39	1,545,067	15,867,121	3,565
TP-40	1,542,589	15,866,691	3,501
TP-41	1,542,687	15,867,078	3,550
TP-43	1,543,961	15,864,067	3,662
TP-44	1,544,680	15,866,772	3,554
TP-45	1,544,954	15,866,599	3,564

BOREHOLE COORDINATES

BOREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BH-01	1,542,787	15,864,952	3,600
BH-02	1,543,510	15,865,924	3,571
BH-03	1,544,313	15,866,714	3,531
BH-04	1,545,284	15,866,262	3,598
BH-05	1,544,389	15,867,186	3,528
BH-06	1,544,452	15,867,549	3,530
BH-07	1,544,378	15,866,060	3,567
BH-08	1,544,094	15,865,318	3,597
BH-09	1,543,260	15,866,110	3,597
BH-10	1,545,298	15,864,954	3,733
BH-11	1,545,404	15,865,251	3,718
BH-12	1,545,806	15,865,342	3,691

BOREHOLE COORDINATES

BOREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BH-13	1,544,801	15,866,510	3,558
BH-14	1,543,881	15,866,769	3,601
BH-15	1,544,789	15,866,492	3,558
BH19-TP-01	1,542,543	15,864,181	3,618
BH19-TP-15	1,544,070	15,866,243	3,565
BH19-TP-19	1,544,451	15,866,651	3,546
BH19-TP-23	1,544,304	15,866,964	3,541
BH19-TP-39	1,545,041	15,867,102	3,565
BH19-TP-44	1,544,673	15,866,762	3,554

CONE PENETRATION TEST COORDINATES

NAME	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
CPT-1A	1,544,267	15,866,903	3,545
CPT-2A	1,544,732	15,866,781	3,557
CPT-3A	1,544,911	15,866,623	3,563
CPT-4	1,544,525	15,866,756	3,548
CPT-5	1,544,781	15,866,518	3,558
CPT-6	1,545,303	15,866,264	3,599
CPT-7B	1,543,492	15,866,250	3,586
CPT-8C	1,543,219	15,866,106	3,599
CPT-9	1,544,351	15,866,712	3,640
CPT-10	1,544,361	15,867,209	3,538

CONE PENETRATION TEST COORDINATES

NAME	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
CPT-11A	1,543,542	15,866,035	3,571
CPT-12	1,544,661	15,866,355	3,558

CALICO COREHOLES

BOREHOLE	EASTING (FT)	NORTHING (FT)	ELEVATION (FT)
BASALT C1	1,547,737	15,862,640	3,978
BASALT C2	1,547,902	15,864,635	3,904
BASALT C3	1,547,723	15,865,353	3,890

LEGEND

- PROJECT AREA BOUNDARY
- APPROXIMATE LIMITS OF TAILINGS STORAGE FACILITY
- 3600 EXISTING GROUND (5 FT CONTOURS)
- EXISTING ROAD
- APPROXIMATE LIMITS OF BORROW PIT
- ULTIMATE TSF EMBANKMENT FOOTPRINT
- BH-01 GOLDER 2017 BOREHOLE LOCATIONS (NOTE 1)
- TP-02 GOLDER 2017 TEST PIT LOCATIONS (NOTE 1)
- BH19-TP-01 GOLDER 2019 BOREHOLE LOCATIONS (NOTE 1)
- CPT-11 CONE PENETRATION TEST (NOTE 1)
- BASALT C1 CALICO 2018 COREHOLE LOCATIONS (NOTES 1 AND 6)
- APPROXIMATE LIMITS OF WASTE ROCK DUMP

0 300 600
1" = 300' FEET

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
GEOTECHNICAL EXPLORATION LOCATION MAP

PROJECT NO. 1663241 | REV. 0 | FIGURE 1

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

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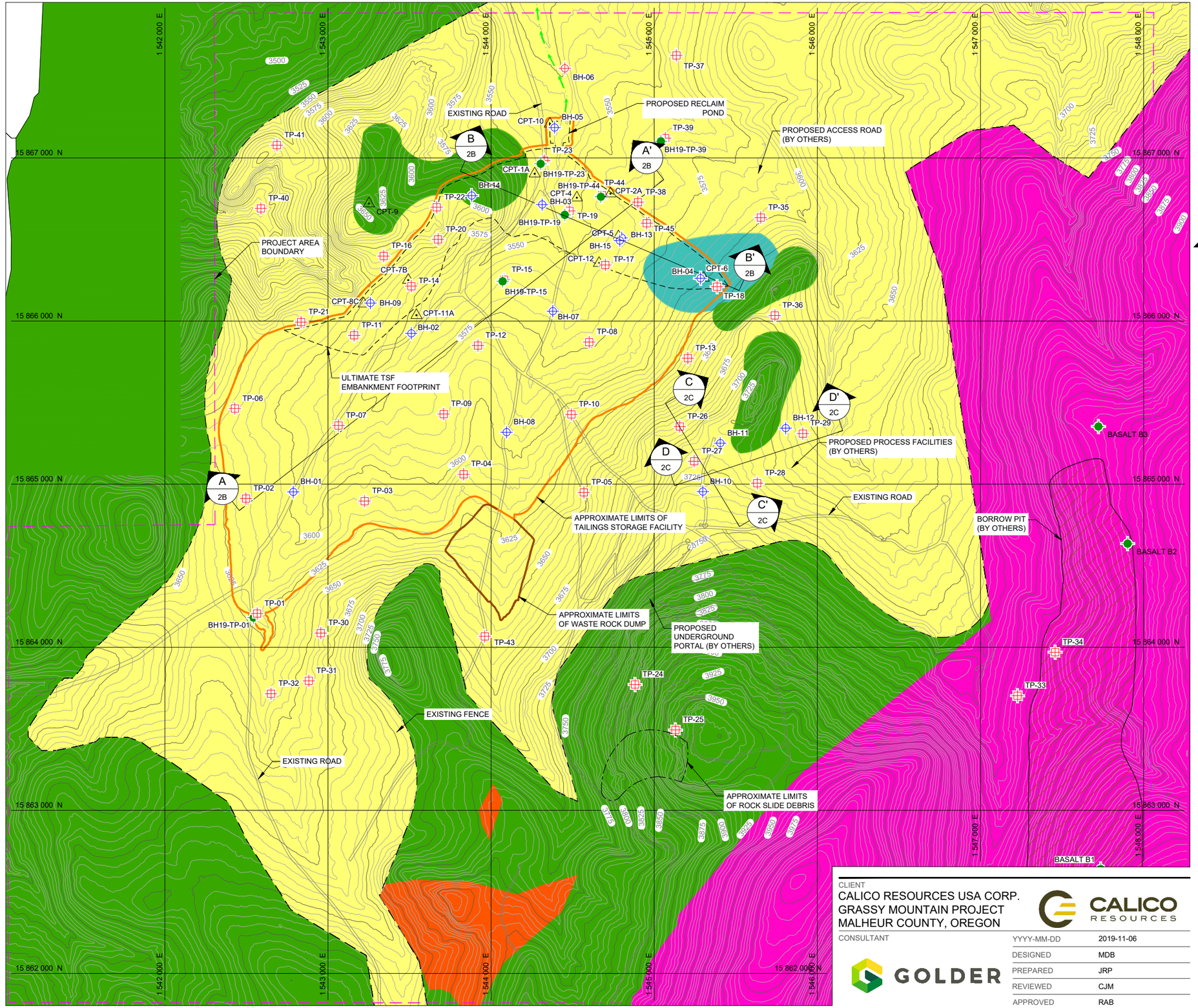

LEGEND

- PROJECT AREA BOUNDARY
- APPROXIMATE LIMITS OF TAILINGS STORAGE FACILITY
- 3600 EXISTING GROUND (5 FT CONTOURS)
- EXISTING ROAD
- APPROXIMATE LIMITS OF BORROW PIT
- ULTIMATE TSF EMBANKMENT FOOTPRINT
- APPROXIMATE LIMITS OF WASTE ROCK DUMP
- BH-01 GOLDER 2017 BOREHOLE LOCATIONS (NOTE 1)
- TP-02 GOLDER 2017 TEST PIT LOCATIONS (NOTE 1)
- BH19-TP-01 GOLDER 2019 BOREHOLE LOCATIONS (NOTES 1 AND 2)
- CPT-11 CONE PENETRATION TEST (NOTE 1)
- A / A' (2B) GEOLOGIC CROSS SECTION

SURFICIAL GEOLOGIC UNITS (NOTE 6)

- Qai - QUATERNARY ALLUVIUM / COLLUVIUM
- Tgb - UPPER MIOCENE OLIVINE BASALT FLOWS
- Tbi - MIOCENE MAFIC DIKES AND SILLS
- Tgs - MID-UPPER MIOCENE ARKOSIC SANDSTONE AND CONGLOMERATE (GRASSY MOUNTAIN FORMATION)
- TL - MIOCENE LACUSTRINE DEPOSITS

NOTE

1. LOCATIONS OF BOREHOLES, TEST PITS, AND CONE PENETRATION TESTS WERE RECORDED USING A HAND-HELD GPS UNIT.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY MDA ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf".
3. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".
4. EXISTING GROUND CONTOURS AND EXPLANATION LOCATIONS PRESENTED ARE IN NAD83 DATUM, ZONE 11.
5. TP-42 WAS NOT EXCAVATED DUE TO ACCESS ISSUES AND IS NOT SHOWN IN SITE PLAN.
6. SURFACE GEOLOGY BASED ON FIELD MAPPING AND GEOLOGY MAP REFERENCE: FERNS AND RAMP (1989).
7. BOREHOLES BASALT B1 AND B2 WERE LOGGED BY THE SITE GEOLOGIST. GOLDER REVIEWED THE LOGS AND CORE TO CONFIRM OBSERVATIONS DOCUMENTED DURING DRILLING AND LOGGING. FINDINGS DOCUMENTED IN GOLDER'S 2019 REPORT TITLED "DETAILED DESIGN, TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP", DATED OCTOBER 25, 2019.

0 300 600
1" = 300' FEET

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
SURFACE GEOLOGY MAP

PROJECT NO.	REV.	FIGURE
1663241	0	2A

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

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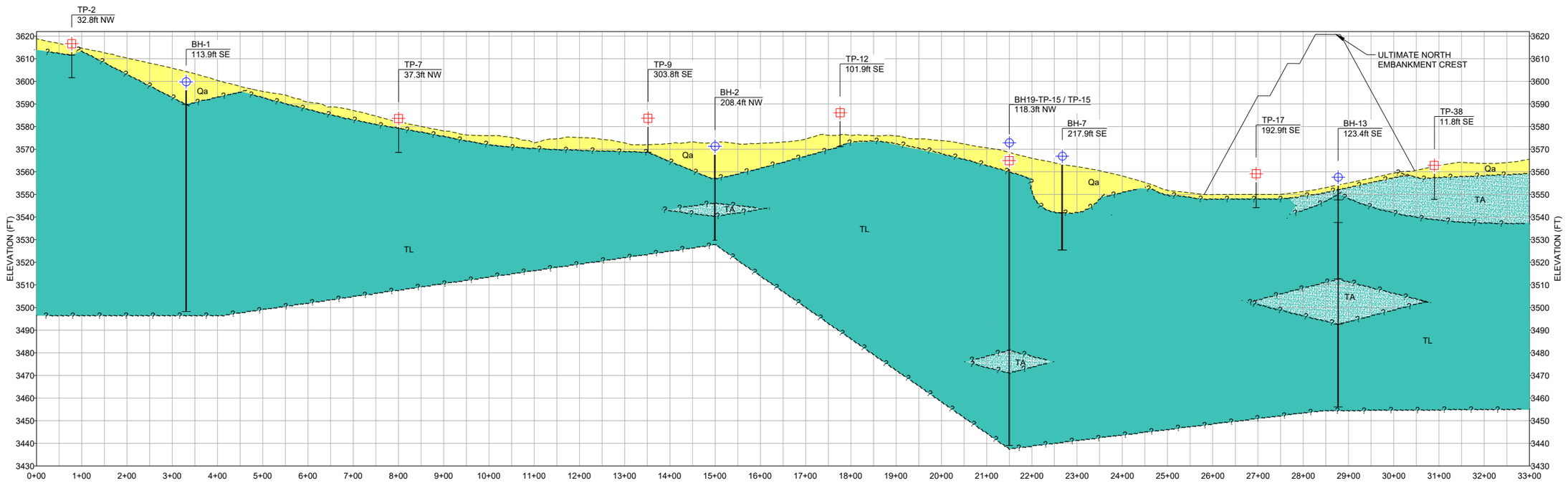
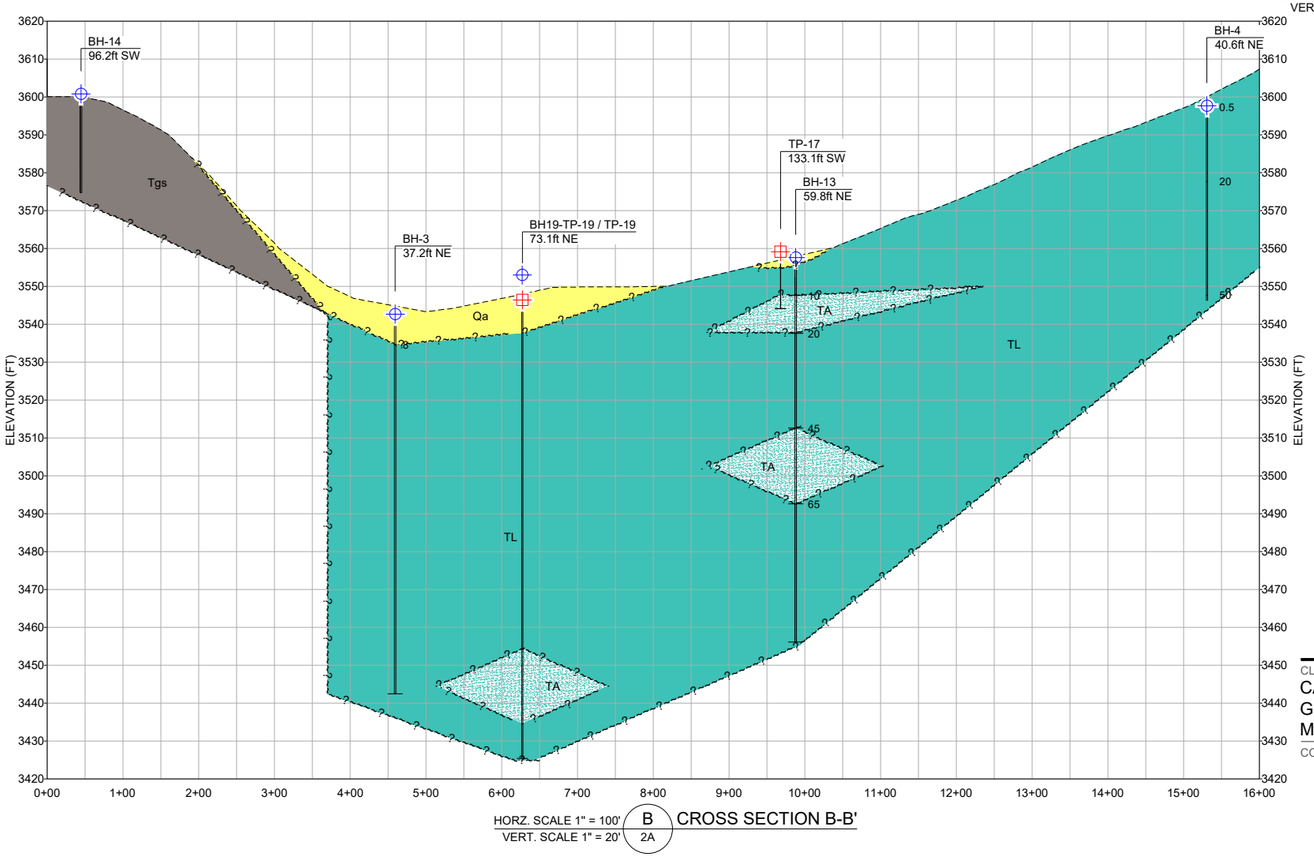


HORZ. SCALE 1" = 120' / VERT. SCALE 1" = 24' — A / 2A — CROSS SECTION A-A'



HORZ. SCALE 1" = 100' / VERT. SCALE 1" = 20' — B / 2A — CROSS SECTION B-B'

0 20 40 — 1" = 20' FEET

0 24 48 — 1" = 24' FEET

0 100 200 — 1" = 100' FEET

0 120 240 — 1" = 120' FEET

LEGEND

GEOLOGIC UNITS

- Qa - QUATERNARY ALLUVIUM / COLLUVIUM
- TL - MIOCENE LACUSTRINE DEPOSITS
- TA - MICOENE ALLUVIUM AND BEACH DEPOSITS
- Tgs - MID-UPPER MIOCENE ARKOSIC SANDSTONE AND CONGLOMERATE (GRASSY MOUNTAIN FORMATION)

BH-1 / XX.X — EXPLORATION NAME / OFFSET DISTANCE AND DIRECTION FROM CROSS SECTION LINE

?~~~~ — APPROXIMATE LITHOLOGIC CONTACT

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
GEOLOGIC CROSS SECTIONS A AND B
TAILINGS STORAGE FACILITY

PROJECT NO. 1663241 | REV. 0 | FIGURE 2B

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

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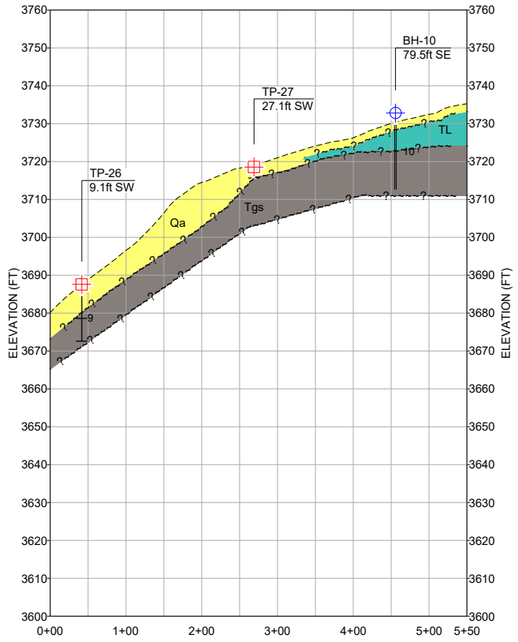
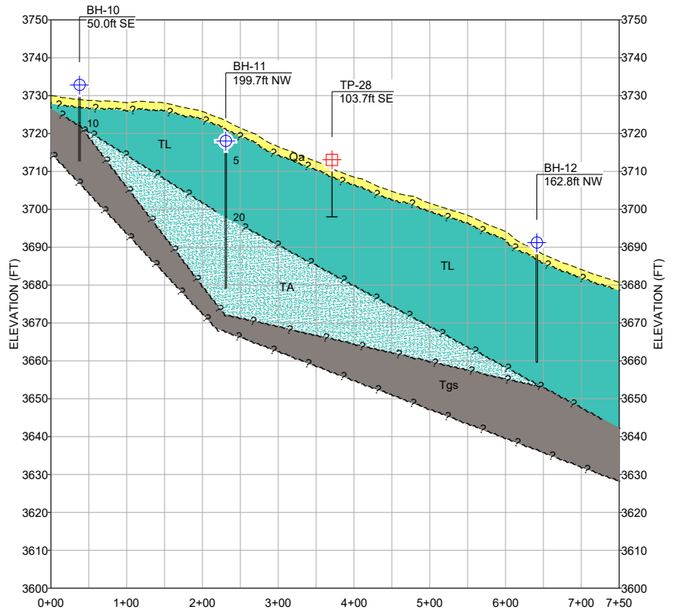


HORZ. SCALE 1" = 100' / VERT. SCALE 1" = 20' — C / 2A — CROSS SECTION C-C'



HORZ. SCALE 1" = 100' / VERT. SCALE 1" = 20' — D / 2A — CROSS SECTION D-D'

0 20 40
1" = 20' FEET

0 100 200
1" = 100' FEET

LEGEND

GEOLOGIC UNITS

- Qa - QUATERNARY ALLUVIUM / COLLUVIUM
- TL - MIOCENE LACUSTRINE DEPOSITS
- TA - MICOENE ALLUVIUM AND BEACH DEPOSITS
- Tgs - MID-UPPER MIOCENE ARKOSIC SANDSTONE AND CONGLOMERATE (GRASSY MOUNTAIN FORMATION)

BH-1 / XX.X — EXPLORATION NAME / OFFSET DISTANCE AND DIRECTION FROM CROSS SECTION LINE

?~~~~ — APPROXIMATE LITHOLOGIC CONTACT

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT

GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
GEOLOGIC SECTIONS C AND D
PROCESS FACILITIES

PROJECT NO. 1663241 | REV. 0 | FIGURE 2C

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

Path: \\env\data\MDA\1663241 Grassy Mountain PFS\900_Drawings\PRODUCTION\FIGURES\Geotech Figures\ | File Name: 1663241_GX_2B-2C.dwg | Last Edited By: jkprice Date: 2019-10-22 Time:11:28:05 AM | Printed By: JePrice Date: 2019-10-22 Time:11:30:31 AM

ATTACHMENT A

Borehole Logs

RECORD OF BOREHOLE BH-01

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 10:00
DRILLING END: December 6, 2017 15:45
COORDINATES: N: 15,864,952 E: 1,542,787

SHEET: 1 of 3
GS ELEV.: 3,599.7 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	TOPSOIL								
		0.5	(SP), SAND, fine to medium sand, trace low plasticity fines, homogeneous; dense, moist, (ALLUVIUM/COLLUVIUM)	SP		SS S1	11-19-22 **(41)**	14/18	41		
10		10.0	(CL), LEAN CLAY, few fine sand, gray-olive to brown, homogeneous; very stiff to hard, moist, (LACUSTRINE)			SS S2	13-43-49 **(92)**	19/18	92	Sample S2: %Fines = 89; %Sand = 11; PI = 25; LL = 46; %MC = 16	
15				CH		SS S3	19-25-29 **(54)**	18/18	54		
20		20.0	(CH), FAT CLAY, trace fine sand, blue-gray to brown, homogeneous; hard, moist, (LACUSTRINE)			SS S4	5-7-13 **(20)**	20/18	20		
25						SS S5	9-12-18 **(30)**	22/18	30		
30				CH		SS S6	6-10-12 **(22)**	24/18	22		
35											
40											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-01

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 10:00
DRILLING END: December 6, 2017 15:45
COORDINATES: N: 15,864,952 E: 1,542,787

SHEET: 2 of 3
GS ELEV.: 3,599.7 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY, trace fine sand, blue-gray to brown, homogeneous; hard, moist, (LACUSTRINE) *(continued)*	CH		SS S7	9-14-50/1" **(64/7")**	20 / 13	100		
45											
50						SS S8	8-15-38 **(53)**	22 / 18	53		
55											
60						SS S9	12-23-38 **(61)**	20 / 18	61		
65											
70						SS S10	38-50/1" **(50/1")**	7 / 7	100		
75											
80											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-01

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 10:00
DRILLING END: December 6, 2017 15:45
COORDINATES: N: 15,864,952 E: 1,542,787

SHEET: 3 of 3
GS ELEV.: 3,599.7 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
80		80.0									
	Hollow Stem Auger		(CH), FAT CLAY, trace fine sand, blue-gray to brown, homogeneous; hard, moist, (LACUSTRINE) *(continued)*	CH		SS S11	13-19-21 **(40)**	24/18	40		
85											
90						SS S12	9-13-47 **(60)**	20/18	60		
95											
100						SS S13	13-19-35 **(54)**	20/18	54		
		101.5	Bottom of borehole at 101.5 ft.								
105											
110											
115											
120											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-02

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 08:40
DRILLING END: December 6, 2017 09:30
COORDINATES: N: 15,865,924 E: 1,543,510

SHEET: 1 of 2
GS ELEV.: 3,571.3 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (SP), POORLY GRADED SAND WITH GRAVEL, fine to coarse sand, little fine to coarse subrounded to subangular gravel, trace high plasticity fines, light brown, heterogeneous, iron oxide staining; very dense, moist, (ALLUVIUM/COLLUVIUM)	SW		SS S1	12-22-33 **(55)**	18/18	55		
10		10.0	(SC), CLAYEY SAND, tan, friable; very dense, moist, (ALLUVIUM/COLLUVIUM)	SC		SS S2	15-24-43 **(67)**	19/18	67		
15		15.0	(CH), FAT CLAY, trace fine sand, tan-gray to pink-brown, homogeneous; hard, moist, (LACUSTRINE)	CH		SS S3	9-9-15 **(24)**	18/18	24		
20						SS S4	5-5-10 **(15)**	22/18	15		
25		25.0	(SP), POORLY GRADED SAND, fine to medium sand, trace low plasticity fines, very light gray, homogeneous; very dense, moist, (BEACH DEPOSITS)	SP		SS S5	8-24-37 **(61)**	20/18	61		
30		31.0	(CH), FAT CLAY, trace fine sand, light pink-brown to light tan, moderately fissured; hard, moist, (LACUSTRINE)	CH		SS S6	7-15-18 **(33)**	20/18	33	Increasing clay content with depth	
35											
40											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-02

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 08:40
DRILLING END: December 6, 2017 09:30
COORDINATES: N: 15,865,924 E: 1,543,510

SHEET: 2 of 2
GS ELEV.: 3,571.3 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40		40.0									
		41.5		CH		SS S7	14-24-29 **(53)**	22 / 18	53		
			Bottom of borehole at 41.5 ft.								
45											
50											
55											
60											
65											
70											
75											
80											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-03

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 5, 2017 08:40
DRILLING END: December 5, 2017 14:30
COORDINATES: N: 15,866,714 E: 1,544,313

SHEET: 1 of 3
GS ELEV.: 3,530.9 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (SP), POORLY GRADED SAND, fine to medium sand, few fine rounded to subrounded gravel, trace high plasticity fines, light brown, heterogeneous; dense, moist, (ALLUVIUM/COLLUVIUM)	SW							
5						SS S1	3-6-10 **(16)**	16/18	16		
		8.0	(CH), FAT CLAY WITH SAND, little fine to medium sand, dark tan and brown, homogeneous, iron oxide staining; very stiff to hard, moist, (LACUSTRINE)							Driller observed a change in material based on drill action Sample S2: %Fines = 78; %Sand = 22; PI = 55; LL = 89; %MC = 29.9	
10						SS S2	12-15-14 **(29)**	18/18	29		
15						SS S3	6-8-11 **(19)**	18/18	19		
20						SS S4	7-7-15 **(22)**	14/18	22		
25				CH		SS S5	8-7-10 **(17)**	18/18	17		
30						SS S6	8-13-16 **(29)**	20/18	29		
35											
40		40.0	Log continued on next page								

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-03

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 5, 2017 08:40
DRILLING END: December 5, 2017 14:30
COORDINATES: N: 15,866,714 E: 1,544,313

SHEET: 2 of 3
GS ELEV.: 3,530.9 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY, trace to few fine to medium sand, dark tan and brown, homogeneous, iron oxide staining; very stiff to hard, moist, (LACUSTRINE)	CH		SS S7	7-11-18 **(29)**	480 / 18	29	Sample S7: %Fines = 96; % Sand = 4; PI = 99; LL = 124;%MC = 34.7	
45											
50						SS S8	8-14-25 **(39)**	20 / 18	39	Sample S8: %Fines = 93; %Sand = 7; PI = 198; LL = 227; %MC = 34.5	
55											
60						SS S9	8-14-20 **(34)**	22 / 18	34		
65											
70						SS S10	13-25-49 **(74)**	20 / 18	74		
75											
80											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-03

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 5, 2017 08:40
DRILLING END: December 5, 2017 14:30
COORDINATES: N: 15,866,714 E: 1,544,313

SHEET: 3 of 3
GS ELEV.: 3,530.9 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
80		80.0									
	Hollow Stem Auger		(CH), FAT CLAY, trace to few fine to medium sand, dark tan and brown, homogeneous, iron oxide staining; very stiff to hard, moist, (LACUSTRINE) *(continued)*			SS S11	20-41-50/5" **(91/11")**	20/17	100		
85											
90				CH		SS S12	48-50/2" **(50/2")**	12/8	100		
95											
100		100.2				SS S13	50/2" **(50/2")**	2/2	100		
			Bottom of borehole at 100.2 ft.								
105											
110											
115											
120											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-04

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 14:40
DRILLING END: December 1, 2017 17:45
COORDINATES: N: 15,866,262 E: 1,545,284

SHEET: 1 of 2
GS ELEV.: 3,597.7 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL								
			(CH), FAT CLAY, light tan and light brown, moderately fissured, iron oxide staining; very stiff to hard, dry to moist, (LACUSTRINE)								
5						SS S1	6-7-16 **(23)**	18/18	23		
10				CH		SS S2	4-11-19 **(30)**	19/18	30		
15						SS S3	4-11-19 **(30)**	11/18	30		
20		20.0	(CH), FAT CLAY, few fine to medium sand, light tan and gray, homogeneous; hard, dry to moist, (LACUSTRINE)			SS S4	15-15-17 **(32)**	20/18	32		
25						SS S5	11-22-41 **(63)**	20/18	63		
30				CL		SS S6	5-12-15 **(27)**	20/18	27		
35						SS S7	10-22-28 **(50)**	20/18	50		
40											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-04

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 14:40
DRILLING END: December 1, 2017 17:45
COORDINATES: N: 15,866,262 E: 1,545,284

SHEET: 2 of 2
GS ELEV.: 3,597.7 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY, few fine to medium sand, light tan and gray, homogeneous; hard, dry to moist, (LACUSTRINE) *(continued)*	CL		SS S8	19-40-50/5" **(90/11")**	20 / 17	100	Sand content increases with depth	
45						SS S9	9-18-35 **(53)**	20 / 18	53		
50		51.5				SS S10	5-10-17 **(27)**	20 / 18	27		
			Bottom of borehole at 51.5 ft.								
55											
60											
65											
70											
75											
80											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-05

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 16:00
DRILLING END: December 6, 2017 17:30
COORDINATES: N: 15,867,186 E: 1,544,389

SHEET: 1 of 2
GS ELEV.: 3,528.2 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (CH), FAT CLAY, trace sand, brown, heterogeneous; hard, dry to moist, (LACUSTRINE)	CH		SS S1	9-13-18 **(31)**	12/18	31			
5												
10		10.0	(SP), POORLY GRADED SAND, fine to coarse sand, few fine rounded to subrounded gravel, trace high plasticity fines, light brown, heterogeneous; dense, moist, (ALLUVIUM/COLLUVIUM)	SP		SS S2	15-20-25 **(45)**	0/18	45			
15						SS S3	10-18-20 **(38)**	19/18	38			
20		20.0	(CH), FAT CLAY, few fine to medium sand, dark tan and brown, homogeneous, iron oxide staining; very stiff to hard, moist, (LACUSTRINE)	CH		SS S4	6-11-17 **(28)**	26/18	28			
25						SS S5	11-16-24 **(40)**	20/18	40			
30						SS S6	7-14-14 **(28)**	26/18	28			
35												
40												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-05

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 6, 2017 16:00
DRILLING END: December 6, 2017 17:30
COORDINATES: N: 15,867,186 E: 1,544,389

SHEET: 2 of 2
GS ELEV.: 3,528.2 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
40		40.0									
		41.5		CH		SS S7	20-31-30 **(61)**	19 / 18	61		
			Bottom of borehole at 41.5 ft.								
45											
50											
55											
60											
65											
70											
75											
80											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-05
2 of 2

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-06

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 7, 2017 15:00
DRILLING END: December 7, 2017 15:45
COORDINATES: N: 15,867,549 E: 1,544,452

SHEET: 1 of 1
GS ELEV.: 3,529.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	TOPSOIL								
		0.5	(SP), POORLY GRADED SAND WITH GRAVEL, fine to coarse sand, some fine to coarse, subangular to angular gravel, trace low plasticity fines, brown, heterogeneous; dense to very dense, moist, (ALLUVIUM/COLLUVIUM)	SP		SS S1	30-50/3" **(50/3")**	11 / 9	100		
10		10.0	(CH), FAT CLAY, tan to olive-green, homogeneous, iron oxide staining; very stiff to hard, dry to moist, (LACUSTRINE)	CH		MC S2	16-14-16 **(30)**	18 / 18	30		
15		15.0	(CH), FAT CLAY WITH SAND, little fine to medium sand, tan to light brown, homogeneous, iron oxide staining; hard, moist, (LACUSTRINE)	CH		MC S3	14-20-26 **(46)**	20 / 18	46		
20						SS S4	18-23-20 **(43)**	18 / 18	43		
25		25.0	(CH), FAT CLAY, olive-green, homogeneous, iron oxide staining; hard, dry to moist, (LACUSTRINE)	CH		MC S5	9-11-23 **(34)**	18 / 18	34		
		26.5	Bottom of borehole at 26.5 ft.								
30											
35											
40											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-06
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-07

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 11:40
DRILLING END: December 1, 2017 13:10
COORDINATES: N: 15,866,060 E: 1,544,378

SHEET: 1 of 2
GS ELEV.: 3,566.9 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) WATER CONTENT (%) W_p W W_l (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0									
		0.5	TOPSOIL								
			(SP-SC), POORLY GRADED SAND WITH GRAVEL AND CLAY, fine to coarse sand, little fine to coarse, subrounded to subangular gravel, few medium plasticity fines, light tan to gray, heterogeneous, iron oxide staining; very dense, dry to moist, (ALLUVIUM/COLLUVIUM)	SP-SC		SS S1	19-25-27 **(52)**	12 / 18	52		
5											
						SS S2	25-29-33 **(62)**	18 / 18	62		
10											
						SS S3	19-29-36 **(65)**	17 / 18	65	Stained red from 15 to 25 feet	
15											
						SS S4	23-28-30 **(58)**	20 / 18	58		
20											
		25.0									
			(CH), FAT CLAY, few fine sand, light gray-green to red-brown, moderately fissured, iron oxide staining; hard, moist, (LACUSTRINE)	CH		SS S5	13-18-20 **(38)**	20 / 18	38	Samples S5/S6/S7:% Fines = 91; %Sand = 9; PI = 45; LL = 66	
25											
						SS S6	9-11-19 **(30)**	20 / 18	30		
30											
						SS S7	8-12-24 **(36)**	22 / 18	36		
35											
40											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

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RECORD OF BOREHOLE BH-07

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 11:40
DRILLING END: December 1, 2017 13:10
COORDINATES: N: 15,866,060 E: 1,544,378

SHEET: 2 of 2
GS ELEV.: 3,566.9 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40		40.0									
		41.5		CH		SS S8	13-25-29 **(54)**	20 / 18	54		
			Bottom of borehole at 41.5 ft.								
45											
50											
55											
60											
65											
70											
75											
80											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-07
2 of 2

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-08

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 08:36
DRILLING END: December 1, 2017 10:50
COORDINATES: N: 15,865,318 E: 1,544,094

SHEET: 1 of 2
GS ELEV.: 3,596.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0										
		0.5	TOPSOIL									
			(SC), CLAYEY SAND, fine to coarse sand, fine subrounded to subangular gravel, high plasticity fines, brown, heterogeneous; medium dense, moist, (ALLUVIUM/COLLUVIUM)	SC		SS S1	6-11-6 **(17)**	12/18	17			
5												
10		10.0	(CH), FAT CLAY WITH SAND, little fine to medium sand, olive-brown brown, heterogeneous; very stiff to hard, moist, (LACUSTRINE)	CH		SS S2	5-8-10 **(18)**	18/18	18			
						SS S3	8-10-14 **(24)**	20/18	24			
15												
20						SS S4	6-10-14 **(24)**	19/18	24			
25						SS S5	7-16-26 **(42)**	19/18		42		
30						SS S6	6-10-10 **(20)**	20/18	20			
35						SS S7	8-13-17 **(30)**	20/18	30			
40												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-08

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 1, 2017 08:36
DRILLING END: December 1, 2017 10:50
COORDINATES: N: 15,865,318 E: 1,544,094

SHEET: 2 of 2
GS ELEV.: 3,596.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY WITH SAND, little fine to medium sand, olive-brown brown, heterogeneous; very stiff to hard, moist, (LACUSTRINE) *(continued)*	CH		SS S8	8-17-19 **(36)**	20/18	36		
45						SS S9	7-11-15 **(26)**	20/18	26		
50		51.5				SS S10	9-23-26 **(49)**	20/18	49		
			Bottom of borehole at 51.5 ft.								
55											
60											
65											
70											
75											
80											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

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RECORD OF BOREHOLE BH-09

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 7, 2017 08:30
DRILLING END: December 7, 2017 14:30
COORDINATES: N: 15,866,110 E: 1,543,260

SHEET: 1 of 3
GS ELEV.: 3,596.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (SP), POORLY GRADED SAND, fine to medium sand, few high plasticity fines, tan and dark brown, homogeneous, iron oxide staining; very dense, dry to moist, (ALLUVIUM/COLLUVIUM)	SP		SS S1	27-34-40 **(74)**	16/18	74			
5												
10						SS S13	9-13-33 **(46)**	20/18	46			
15						SS S3	50/2" **(50/2")**	1/2	100			
20						SS S4	41-50/5" **(50/5")**	14/11	100			
25		25.0	(CH), SANDY FAT CLAY, some fine to coarse sand, brown-yellowish and pink-brown, moderately fissured, iron oxide staining; very stiff, moist, (LACUSTRINE)	CH		SS S5	9-11-13 **(24)**	17/18	24		Sample S5: %Fines = 68; %Sand =32; PI = 62, LL = 96	
30						SS S6	8-11-13 **(24)**	20/18	24			
35												
40												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

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RECORD OF BOREHOLE BH-09

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 7, 2017 08:30
DRILLING END: December 7, 2017 14:30
COORDINATES: N: 15,866,110 E: 1,543,260

SHEET: 2 of 3
GS ELEV.: 3,596.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), SANDY FAT CLAY, some fine to coarse sand, brown-yellowish and pink-brown, moderately fissured, iron oxide staining; very stiff, moist, (LACUSTRINE) *(continued)*	CH		SS S7	6-10-14 **(24)**	26/18	24			
45												
50		50.0	(SP), POORLY GRADED SAND, fine to medium sand, trace medium plasticity fines, tan, homogeneous; very dense, moist, (BEACH DEPOSITS)	SP		SS S8	17-35-46 **(81)**	20/18		81		
55												
60						SS S9	48-50/5" **(50/5")**	12/11			100	
65												
70		70.0	(CL), SANDY LEAN CLAY, some fine to medium sand, gray and blue-gray, homogeneous, iron oxide staining; hard, moist, (LACUSTRINE)	CL		SS S10	17-24-29 **(53)**	20/18		53		
75												
80		80.0	Log continued on next page									

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

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RECORD OF BOREHOLE BH-09

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 7, 2017 08:30
DRILLING END: December 7, 2017 14:30
COORDINATES: N: 15,866,110 E: 1,543,260

SHEET: 3 of 3
GS ELEV.: 3,596.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
80		80.0							20 40 60 80; W_p W W_l 20 40 60 80		
	Hollow Stem Auger		(CH), FAT CLAY, light blue-gray and dark blue-gray, homogeneous; hard, dry to moist, (LACUSTRINE)			SS S11	50/5" **(50/5")**	6 / 5	100		
85											
90				CH		SS 12	12-19-30 **(49)**	20 / 18	49		
95											
100						SS S13	9-13-33 **(46)**	20 / 18	46		
		101.5	Bottom of borehole at 101.5 ft.								
105											
110											
115											
120											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

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RECORD OF BOREHOLE BH-10

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: November 30, 2017 11:15
DRILLING END: November 30, 2017 12:45
COORDINATES: N: 15,864,954 E: 1,545,298

SHEET: 1 of 1
GS ELEV.: 3,732.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	TOPSOIL			S1	0-0					
		1.0	(CL), LEAN CLAY WITH SAND, little fine sand, trace fine subrounded to subangular gravel, light tan, homogeneous; hard, moist, (ALLUVIUM/COLLUVIUM)									
5				CL		SS S2	10-15-18 **(33)**	16/18	33			
10		10.0										
			(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, light gray, heterogeneous, iron oxide staining; very dense, dry, (WEATHERED ARKOSIC SANDSTONE)			SS S3	12-19-33 **(52)**	16/18	52			
15				SM		SS S4	26-50/2" **(50/2")**	8/8		100		
20		20.2				SS	50/2" **(50/2")**	1/2		100		
			Bottom of borehole at 20.2 ft.									
25												
30												
35												
40												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-10
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-11

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: November 30, 2017 13:20
DRILLING END: November 30, 2017 15:00
COORDINATES: N: 15,865,251 E: 1,545,404

SHEET: 1 of 1
GS ELEV.: 3,718.0 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (CH), SANDY FAT CLAY, some fine to coarse sand, trace fine subrounded to subangular gravel, light tan to olive, homogeneous; stiff to hard, moist, (ALLUVIUM/COLLUVIUM)	CH		SS S1	7-5-8 **(13)**	20/18	13		Sample S2: %Fines = 60; %Sand = 37; %Gravel = 3%; PI = 62, LL = 97 S2 mottled with evaporite deposits but deposits do not react to HCL	
5												
10						SS S2	12-13-19 **(32)**	19/18	32			
15						SS S3	12-14-15 **(29)**	18/18	29			
20		20.0	(SC), CLAYEY SAND, fine to coarse sand, some high plasticity fines, light green-gray and, heterogeneous; very dense, dry, (ALLUVIUM/ COLLUVIUM)	SC		SS S4	50 **(50/")**	7/6		100		
25		25.0	(SP-SM), POORLY GRADED SAND WITH GRAVEL AND CLAY, fine to coarse sand, little fine subangular to angular gravel, few high plasticity fines, light brown, heterogeneous; very dense, moist, (ALLUVIUM/COLLUVIUM)	SP-SC		SS S5	50 **(50/")**	8/6		100	No recovery from 25 to 39 feet, grab samples of cuttings taken at about 30 and 39 feet	
30						SS S6	50/1" **(50/1")**	0/1		100		
35						SS S7	50/1" **(50/1")**	0/1		100		
		39.0				SS S8						
40			Bottom of borehole at 39.0 ft.									

PENETRATION RESISTANCE BLOWS / ft: 20 40 60 80
WATER CONTENT (%): W_p W W_l 20 40 60 80

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-11
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-12

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: November 30, 2017 15:40
DRILLING END: November 30, 2017 16:40
COORDINATES: N: 15,865,342 E: 1,545,806

SHEET: 1 of 1
GS ELEV.: 3,691.2 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0									
		0.5	TOPSOIL								
			(CH), FAT CLAY, trace fine to medium sand, gray to very dark gray, moderately fissured, iron oxide staining; very stiff to hard, moist, (LACUSTRINE)								
5						SS S1	12-12-11 **(23)**	10/18	23		
10						SS S2	5-10-13 **(23)**	19/18	23		
15			Color change to gray to dark gray.	CH		SS S3	9-13-14 **(27)**	22/18	27		
20						SS S4	10-14-17 **(31)**	19/18	31		
25						SS S5	11-12-16 **(28)**	21/18	28		
30						SS S6	9-14-18 **(32)**	20/18	32	Sample S6: %Fines = 97; %Sand = 3; PI = 62, LL = 103	
		31.5	Bottom of borehole at 31.5 ft.								
35											
40											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-12
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-13

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 2, 2017 08:30
DRILLING END: December 2, 2017 16:00
COORDINATES: N: 15,866,510 E: 1,544,801

SHEET: 1 of 3
GS ELEV.: 3,557.6 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL								
			(CH), FAT CLAY WITH SAND, little fine to medium sand, tan, moderately fissured, iron oxide staining; very stiff, moist, (LACUSTRINE)	CH		SS S1	7-9-11 **(20)**	18/18	20	Sample S1: %Fines = 86; %Sand = 14; PI = 63; LL = 92	
10		10.0	(CH), SANDY FAT CLAY, some fine to coarse sand, heterogeneous, iron oxide staining; medium dense to dense, moist, (LACUSTRINE)			SS S2	11-16-22 **(38)**	19/18	38		
15						SS S3	10-11-16 **(27)**	20/18	27	Sample S3: %Fines = 52; %Sand = 48; PI = 62; LL = 85	
20						SS S4	16-50/5" **(50/5")**	12/11	100		
25				SC		SS S5	10-12-18 **(30)**	24/18	30	Sample S5: %Fines = 67; %Sand = 33; PI = 55; LL = 77	
30						MC S6	10-12-18 **(30)**	18/18	30	Sample S6: %Fines = 97; %Sand = 3; PI = 62, LL = 103	
35						SS S7	6-10-18 **(28)**	20/18	28		
40											

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-13

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 2, 2017 08:30
DRILLING END: December 2, 2017 16:00
COORDINATES: N: 15,866,510 E: 1,544,801

SHEET: 2 of 3
GS ELEV.: 3,557.6 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), SANDY FAT CLAY, some fine to coarse sand, heterogeneous, iron oxide staining; medium dense to dense, moist, (LACUSTRINE) *(continued)*	SC		SS S8	8-13-23 **(36)**	20 / 18	36		
45		45.0	(SM), SILTY SAND, fine to medium, subangular to angular, and medium plasticity fines, tan, friable, iron oxide staining; dense, moist, (ALLUVIUM/ COLLUVIUM)	SM		SS S9	8-4-50/4" **(54/10")**	20 / 16	100		
50						SS S10	22-49-50/2" **(99/8")**	18 / 14	100		
55						SS S11	18-47-50/5" **(97/11")**	24 / 17	100		
60						SS S12	18-38-50/5" **(88/11")**	20 / 17	100		
65		65.0	(CH), FAT CLAY, gray and dark blue-gray, homogeneous; hard, moist, (LACUSTRINE)	CH		SS S13	9-13-47 **(60)**	20 / 18	60		
70											
75						SS S14	13-27-34 **(61)**	20 / 18	61		
80			Log continued on next page								

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-13

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 2, 2017 08:30
DRILLING END: December 2, 2017 16:00
COORDINATES: N: 15,866,510 E: 1,544,801

SHEET: 3 of 3
GS ELEV.: 3,557.6 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
80		80.0	(CH), FAT CLAY, gray and dark blue-gray, homogeneous; hard, moist, (LACUSTRINE) *(continued)*								
85	Hollow Stem Auger			CH		SS 15	28-34-38 **(72)**	24/18	72		
90											
95											
100						SS S16	11-18-34 **(52)**	20/18	52		
		101.5	Bottom of borehole at 101.5 ft.								
105											
110											
115											
120											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Clay Johnson
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
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RECORD OF BOREHOLE BH-14

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 8, 2017 08:45
DRILLING END: December 8, 2017 09:30
COORDINATES: N: 15,866,769 E: 1,543,881

SHEET: 1 of 1
GS ELEV.: 3,600.8 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL (SW-SM), WELL-GRADED SAND WITH SILT, fine to medium, well graded, some fine rounded to subrounded gravel, trace low plasticity fines, tan, homogeneous, iron oxide staining; dense to very dense, dry, trace gravel (ALLUVIUM/ COLLUVIUM)	SW-SM		S0						
5						SS S1	31-38-43 **(81)**	17/18	81			
10						SS S2	15-18-27 **(45)**	14/18	45			
15						SS S3	8-14-15 **(29)**	12/18	29			
20						SS S4	13-15-21 **(36)**	14/18	36			
25		26.1				SS S5	19-29-38 **(67)**	13/18	67		S5 mottled with calcite deposits (reacts to HCL)	
30			Bottom of borehole at 26.1 ft.									
35												
40												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Colin Bloom
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-14
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH-15

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: December 8, 2017 10:15
DRILLING END: December 8, 2017 10:45
COORDINATES: N: 15,866,714 E: 1,544,313

SHEET: 1 of 1
GS ELEV.: 3,532.1 ft
TOC ELEV.: na
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	0.5 TOPSOIL								
			(SC), CLAYEY SAND, fine to coarse sand, some high plasticity fines, trace fine rounded to subrounded gravel, light brown, heterogeneous; dense, moist, (ALLUVIUM/ COLLUVIUM)	SW							
5											
		8.0	(CH), FAT CLAY, trace fine to medium sand, dark tan and brown, homogeneous, iron oxide staining; very stiff to hard, moist, (LACUSTRINE)	CH							
10											
15						MC S1	9-11-18 **(29)**	18/18	29		
20											
25						MC S2	9-12-16 **(28)**	18/18	28	Sample S2:% Fines = 98; %Sand = 2%; PI = 157; PI = 191	
		26.5	Bottom of borehole at 26.5 ft.								
30											
35											
40											

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Colin Bloom
CHECKED: Margaret Pryor
REVIEWED: Russ Browne

Golder Associates

BH-15
1 of 1

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/15/19 08:39
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2016 FIELD PROGRAM\BORINGS\GRASSYMOUNTAINBORINGLOGS 5-1-2018.GPJ

RECORD OF BOREHOLE BH19-TP-01

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 09:30
DRILLING END: March 20, 2019 12:30
COORDINATES: N: 15,864,181.3 E: 1,542,543.4

SHEET: 1 of 2
GS ELEV.: 3590.0
TOC ELEV.: 3617.7
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(CH), FAT CLAY, high plasticity fines, some sand, some coarse subrounded to subangular gravel, tan; soft, moist, (LACUSTRINE)	3590.0	CH								
5			light gray mottled orange, hard				SS 1	12-10-28 **(38)**	18/18	38			
10			gray, blocky, stiff, moist, black stain on some joint surfaces				SS 2	3-5-8 **(13)**	18/18	13		Sample 2: %Fines= 96; %Sand= 3; PI=69; LL=97; %MC= 37.4	
		12.0		3578.0									
15			(SC), CLAYEY SAND, high plasticity fines, light gray mottled orange, very dense, moist, (LACUSTRINE)		SC		SS 3	19-50/4" **(50/4")**	10/10	100			
20							SS 4	15-20-39 **(59)**	18/18	59		Sample 4: %Fines= 48; %Sand= 52; PI=21; LL=36; %MC= 11.7	
25		25.0		3565.0									
			(CH), FAT CLAY, high plasticity fines, few fine sand, light gray mottled orange, hard, (LACUSTRINE)				SS 5	18-19-20 **(39)**	18/18	39		Sample 5: %Fines= 94; %Sand= 6; PI=58; LL=78; %MC= 29.0	
30			Becomes dark gray and olive green below ~26ft		CH		MC 6	22-32-50 **(82)**	17/18	82			
35		35.5		3554.5									
			(CH), FAT CLAY WITH SAND, medium plasticity fines, some fine sand, gray-green, hard, (LACUSTRINE)		CH		MC 7	15-18-32 **(50)**	18/18	50			
40			Log continued on next page										

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-01

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 09:30
DRILLING END: March 20, 2019 12:30
COORDINATES: N: 15,864,181.3 E: 1,542,543.4

SHEET: 2 of 2
GS ELEV.: 3590.0
TOC ELEV.: 3617.7
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40		40.0		3550.0								
	Hollow Stem Auger		(CH), FAT CLAY WITH SAND, high plasticity fines, gray mottled, hard, (LACUSTRINE)		CH		MC 8	15-21-50 **(71)**	17/18	71		
45							MC 9	15-32-50 **(82)**	17/18	82	Sample 9: %Fines= 82; %Sand= 15; PI=44; LL=68; %MC= 32.4	
50							MC 10	15-22-50 **(72)**	18/18	72		
		51.5	Bottom of borehole at 51.5 ft. Backfilled with bentonite chips.	3538.5								
55												
60												
65												
70												
75												
80												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-01
2 of 2

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-15

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 26, 2019 09:15
DRILLING END: March 26, 2019 15:45
COORDINATES: N: 15,866,243.5 E: 1,544,070.2

SHEET: 1 of 4
GS ELEV.: 3595.0
TOC ELEV.: 3564.9
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(SM), SILTY SAND WITH GRAVEL, fine to coarse sand, non plastic fines, yellow-brown, loose to dense, dry, density increasing with depth, (LACUSTRINE)	3595.0	SM		SS 1	16-20-30 **(50)**	16/18	50		
10		10.5	(CH), FAT CLAY, high plastic fines, trace fine sand, gray and white, hard, dry, sand content decreasing with depth, (LACUSTRINE)	3584.5			MC 2	8-16-25 **(41)**	13/18	41		
15			light brown-gray				MC 3	17-29-38 **(67)**	17/18	67	Sample 3: %Fines= 96; %Sand= 4; PI=38; LL=66; %MC= 18.9	
20			light gray mottled orange; very dense		CH		MC 4	13-38-48 **(86)**	16/18	86	Sample 4: %Fines= 90; %Sand= 10; PI=30; LL=52; %MC= 13.6	
25							MC 5	19-23-28 **(51)**	17/18	51	Sample 5: %Fines= 94; %Sand= 4; PI=40; LL=62; %MC= 15.0	
30		30.0	(CL), LEAN CLAY, high plasticity fines, trace fine sand, light gray, hard, orange stain on surfaces, (LACUSTRINE)	3565.0			MC 6	17-28-45 **(73)**	16/18	73	Sample 6: %Fines= 56; %Sand= 44; PI=29; LL=48; %MC= 13.4	
35		35.0	30-30.7 - mottled orange	3560.0	CL		MC 7	29-48-50/3" **(98/9")**	15/15	100	Sample 7: %Fines= 43; %Sand= 57; PI=14; LL=35; %MC= 9.6	
40		40.0	(SC), CLAYEY SAND, fine sand, medium to high plasticity fines, light gray, blocky, very dense, dry to moist, (LACUSTRINE)	3555.0	SC							

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-15

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 26, 2019 09:15
DRILLING END: March 26, 2019 15:45
COORDINATES: N: 15,866,243.5 E: 1,544,070.2

SHEET: 2 of 4
GS ELEV.: 3595.0
TOC ELEV.: 3564.9
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(SC), CLAYEY SAND, fine sand, medium to high plasticity fines, light gray and light yellow, hard, (LACUSTRINE)	3555.0	SC		MC 8	15-31-45 **(76)**	15/18	76	Sample 8: %Fines= 45; %Sand= 55; PI=17; LL=35; %MC= 11.5	
		42.0	40.5-41ft -very dense, dry	3553.0								
45			(CL), LEAN CLAY, low plasticity fines, trace fine sand, light brown-gray and dark brown, laminated, hard, (LACUSTRINE)		CL		MC 9	12-20-28 **(48)**	18/18	48		
			medium plasticity, olive-gray									
			50-51ft - mottled orange (~30%)									
50		50.0		3545.0								
			(CH), FAT CLAY, high plasticity fines, trace fine sand, brown-gray mottled orange; hard, (LACUSTRINE)		CH		MC 10	8-17-28 **(45)**	18/18	45	Sample 10: %Fines= 98; %Sand= 2; PI=62; LL=87; %MC= 32.3	
55												
60		60.0		3535.0								
			(CL), LEAN CLAY, low plasticity fines, some fine sand, gray with black; hard, (LACUSTRINE)		CL		MC 11	12-17-28 **(45)**	18/18	45		
65												
70		70.0		3525.0								
			(CH), FAT CLAY, high plasticity fines, little fine sand, dark brown, stratified, hard, (LACUSTRINE)		CH		MC 12	17-26-28 **(54)**	18/18	54	Sample 12: %Fines= 87; %Sand= 13; PI=78; LL=116; %MC= 47.9	
			dark blue-gray									
75												
80												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-15
2 of 4

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-15

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 26, 2019 09:15
DRILLING END: March 26, 2019 15:45
COORDINATES: N: 15,866,243.5 E: 1,544,070.2

SHEET: 3 of 4
GS ELEV.: 3595.0
TOC ELEV.: 3564.9
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
80	Hollow Stem Auger	80.0	(CH), FAT CLAY, high plasticity, little fine sand, blue-gray, hard, (LACUSTRINE) *(continued)*	3515.0	CH		MC 13	17-27-40 **(67)**	18/18		67		
		81.5	(SM), SILTY SAND, fine sand, low plasticity fines, dark blue-gray, very dense, dry to moist, (LACUSTRINE)	3513.5	SM								
85													
90		90.0	(CH), FAT CLAY, high plasticity fines, dark blue-gray, few fine sand, hard, white clay fleck and vein scattered throughout, (LACUSTRINE)	3505.0	CH		MC 14	21-43-50/5" **(93/11")**	17/17		100	Sample 14: %Fines= 92; %Sand= 8; LL=101; PI=65; %MC= 36.5	
95													
100			varying sand content				MC 15	17-28-32 **(60)**	18/18		60		
105			gray-blue										
110							MC 16	18-28-50/5" **(78/11")**	17/17		100	Sample 16: %Fines= 93; %Sand= 7; PI=64; LL=90; %MC= 33.6	
115													
120					CH								

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-15

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 26, 2019 09:15
DRILLING END: March 26, 2019 15:45
COORDINATES: N: 15,866,243.5 E: 1,544,070.2

SHEET: 4 of 4
GS ELEV.: 3595.0
TOC ELEV.: 3564.9
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
120		120.0		3475.0								
		121.4	(CH), FAT CLAY, high plasticity fines, few sand, green-gray, hard, white clay fleck scattered throughout , (LACUSTRINE) *(continued)*	3473.6	CH		MC 17	18-27-50/5" **(77/11")**	17 / 17	100	Sample 17: %Fines= 91; %Sand= 9; PI=43; LL=66; %MC= 24.6	
			Bottom of borehole at 121.4 ft. Backfilled with bentonite chips.									
125												
130												
135												
140												
145												
150												
155												
160												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-15
4 of 4

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-19

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 14:45
DRILLING END: March 23, 2019 13:45
COORDINATES: N: 15,866,650.7 E: 1,544,451.3

SHEET: 1 of 4
GS ELEV.: 3535.0
TOC ELEV.: 3546.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(CL), LEAN CLAY, low plasticity fines, gray and light gray,very stiff, density increasing with depth, (LACUSTRINE)	3535.0	CL								
							SS 1	8-11-13 **(24)**	12/18	24			
10		10.0	(CH), FAT CLAY, high plasticity fines, trace fine sand, light gray-green, stiff, white clay fleck scattered throughout (possible tuff/zeolite), (LACUSTRINE)	3525.0	CH		SH 2		22/24				
							SS 3	4-8-11 **(19)**	14/18	19		Sample 3: %Fines= 99; %Sand= 1; PI=72; LL=98; %MC= 27.4	
15			Increasing plasticity with depth				MC 4	9-11-13 **(24)**	14/18	24		Sample 4: %Fines= 99; %Sand= 1; PI=100; LL=133; %MC= 34.4	
							SH 5		18/24				
20							SS 6	4-7-9 **(16)**	18/18	16			
25		25.0	(CH), FAT CLAY WITH SAND, high plasticity fines, light grey-green, orange staining, hard, moist, (LACUSTRINE)	3500.0	CH		MC 7	10-24-28 **(52)**	18/18		52	Sample 7: %Fines= 84; %Sand= 6; PI=135; LL=158; %MC= 23.2	
30		30.0	(SC), CLAYEY SAND, fine to medium sand, high plasticity fines, light yellow-brown; very dense, moist, (LACUSTRINE)	3505.0	SC		SH 8		0/0				
							MC 9	19-24-28 **(52)**	18/18		52	Sample 9: %Fines= 41; %Sand= 57; PI=101; LL=127; %MC= 27.1	
35			37-42ft - gravelly layer				MC 10	16-32-32 **(64)**	18/18		64	Sample 10: %Fines= 49; %Sand= 51; PI=117; LL=137; %MC= 26.3	
40		40.0	40ft - few fine gravel	3495.0									

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-19

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 14:45
DRILLING END: March 23, 2019 13:45
COORDINATES: N: 15,866,650.7 E: 1,544,451.3

SHEET: 2 of 4
GS ELEV.: 3535.0
TOC ELEV.: 3546.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY, high plasticity fines, light gray, moist; hard, (LACUSTRINE) 40.5ft - some orange mottle	3495.0	CH		MC 11	19-21-25 **(46)**	18/18	46		Sample 11: %Fines= 100; %Sand= 0; PI=117; LL=141; %MC= 45.5	
45		45.0	(ML), SILT, non plastic fines, fine sand, olive-gray; hard, dry to moist, sand content increasing with depth, (LACUSTRINE)	3490.0	ML		MC 12	28-50 **(50/")**	12/12		100		
50		50.0	(CH), FAT CLAY, high plasticity fines, few fine sand, yellow-brown; hard, moist, (LACUSTRINE)	3485.0	CH		MC 13	10-19-22 **(41)**	18/18	41		Sample 13: %Fines= 93; %Sand= 7; PI=179; LL=206; %MC= 42.2	
55													
60			varying sand content, color changes to dark grey				MC 14	25-48-50 **(98)**	18/18		98	Sample 14: %Fines= 96; %Sand= 4; PI=51; LL=73; %MC= 22.1	
65													
70							MC 15	20-29-50 **(79)**	18/18		79	Sample 15: %Fines= 87; %Sand= 13; PI=61; LL=89; %MC= 30.3	
75		71.5 75.0	(CL), LEAN CLAY, low plasticity fines, fine sand, gray; hard, moist, (LACUSTRINE) (CH), FAT CLAY, high plasticity fines, dark gray; hard, moist, (LACUSTRINE)	3463.5 3460.0	CL CH								
80			Log continued on next page										

PENETRATION RESISTANCE BLOWS / ft: 20 40 60 80
WATER CONTENT (%): W_p W W_l 20 40 60 80

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-19

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 14:45
DRILLING END: March 23, 2019 13:45
COORDINATES: N: 15,866,650.7 E: 1,544,451.3

SHEET: 3 of 4
GS ELEV.: 3535.0
TOC ELEV.: 3546.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
80	Hollow Stem Auger	80.0	(CH), FAT CLAY, high plasticity fines, dark gray; hard, moist, (LACUSTRINE) *(continued)*	3455.0	CH		MC 16	21-39-50 **(89)**	18/18	89	Sample 16: %Fines= 97; %Sand= 3; PI=41; LL=62; %MC= 20.9	
85			87.5-88.5ft - drilling through cobble									
90			90-90.5ft - drilling through cobble				MC 17	50/4" **(50/4")**	4/4	100		
		92.0		3443.0								
95			(SP-SM), POORLY GRADED SAND WITH SILT, fine sand, poorly graded, some non plastic fines, light gray, homogeneous; very dense, dry, (LACUSTRINE)									
100					SP-SM		MC 18	49-50/3" **(50/3")**	9/9	100		
105												
110		110.0		3425.0			MC 19	28-38-50/3" **(88/9")**	15/15	100	Sample 19: %Fines= 99; %Sand= 1; PI=24; LL=48; %MC= 17.8	
			(CL), LEAN CLAY, high plasticity fines, gray; hard, moist, (LACUSTRINE)		CL							
115		115.0		3420.0								
120			(CH), FAT CLAY WITH SAND, high plasticity fines, little fine sand, gray; hard, moist, (LACUSTRINE)		CH							

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-19

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 14:45
DRILLING END: March 23, 2019 13:45
COORDINATES: N: 15,866,650.7 E: 1,544,451.3

SHEET: 4 of 4
GS ELEV.: 3535.0
TOC ELEV.: 3546.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
120		120.0		3415.0								
		121.4	(CH), FAT CLAY WITH SAND, high plasticity, gray; hard, moist, (LACUSTRINE) *(continued)*	3413.6	CH		MC 20	25-45-50/5" **(95/11")**	17 / 17	100	Sample 20: %Fines= 80; %Sand= 20; PI=37; LL=59; %MC= 20.9	
			Bottom of borehole at 121.4 ft. Backfilled with bentonite chips.									
125												
130												
135												
140												
145												
150												
155												
160												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 12:00
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\SCANNED LOGS\GRASSYMOUNTAINBORINGLOGS 3-29

RECORD OF BOREHOLE BH19-TP-23

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 13:30
DRILLING END: March 21, 2019 11:15
COORDINATES: N: 15,866,963.8 E: 1,544,303.6

SHEET: 1 of 4
GS ELEV.: 3550.0
TOC ELEV.: 3541.1
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	Depth	SOIL PROFILE DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(CH), FAT CLAY, high plasticity fines, coarse subrounded to subangular gravel, trace fine sand, light brown-gray; soft, (LACUSTRINE)	3550.0	CH							
5		5.0	(GC), CLAYEY GRAVEL WITH SAND, coarse, subrounded to subangular gravel, fine sand, high plasticity fines, gray, some boulders; dense, dry, (LACUSTRINE)	3545.0	GC		SS 1	12-50/4" **(50/4")**	10/10	100		
10		10.5	(CH), FAT CLAY, high plasticity fines, gray, stiff to very stiff, (LACUSTRINE)	3539.5	CH		SS 2	16-9-10 **(19)**	18/18	19		
15							SH 3		24/24			
							SS 4	5-6-6 **(12)**	18/18	12		
20							SH 5		24/24			
							SS 6	5-8-10 **(18)**	18/18	18		
25							SH 7		20/20			
		26.5	(SC), CLAYEY SAND, fine, high plasticity fines, light gray mottled orange, iron oxide staining, medium dense, moist, some black stain on surfaces, (LACUSTRINE)	3523.5	SC		SS 8	5-8-10 **(18)**	18/18	18		
30		30.0	(CH), FAT CLAY, high plasticity fines, trace fine sand, green-gray; hard, moist, (LACUSTRINE)	3520.0	CH		MC 9	17-25-18 **(43)**	18/18	43	Sample 9: %Fines= 97; %Sand= 3; PI=68; LL=99; %MC= 41.7	
35							MC 10	10-20-25 **(45)**	17/18	45	Sample 10: %Fines= 96; %Sand= 4; PI=101; LL=135; %MC= 41.7	
40												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSY MOUNTAIN\BORING LOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-23

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 13:30
DRILLING END: March 21, 2019 11:15
COORDINATES: N: 15,866,963.8 E: 1,544,303.6

SHEET: 2 of 4
GS ELEV.: 3550.0
TOC ELEV.: 3541.1
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(CH), FAT CLAY, high plasticity fines, green-gray; hard, moist, (LACUSTRINE) *(continued)* 40-41 ft - orange mottle, increasing with depth	3510.0	CH		MC 11	12-15-50/4" **(65/10")**	16/16		Sample 11: %Fines= 99; %Sand= 1; PI=58; LL=82; %MC= 29.4	
45		45.0	41.5ft - becomes pink gray	3505.0								
			(CL), LEAN CLAY, low to medium plasticity fines, few fine sand, light gray mottled orange, hard, moist, (LACUSTRINE)		CL		MC 12	15-28-48 **(76)**	18/18		Sample 12: %Fines= 93; %Sand= 7; PI=26; LL=49; %MC= 22.8	
50		50.0		3500.0								
			(CH), FAT CLAY WITH SAND, high plasticity fines, little fine sand, green-gray; hard, moist, (LACUSTRINE) 50ft - becomes dark gray 50.5ft - with trace fine sand		CH		MC 13	30-38-50/4" **(88/10")**	16/16		Sample 13: %Fines= 82; %Sand= 18; PI=50; LL=70; %MC= 19.5	
55												
60		60.0		3490.0								
			(MH), ELASTIC SILT, high plasticity fines, trace fine sand, light gray, hard, moist, (LACUSTRINE)		MH		MC 14	35-49-50 **(99)**	18/18		Sample 14: %Fines= 96; %Sand= 4; PI=21; LL=53; %MC= 26.0	
65		65.0		3485.0								
			(CH), FAT CLAY, gray, hard, moist, (LACUSTRINE)		CH							
70		70.0		3480.0								
			(SC), CLAYEY SAND, fine sand, low plasticity fines, light gray, very dense, dry, (LACUSTRINE)		SC		MC 15	50/5" **(50/5")**	0/5			
75												
80												

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSY MOUNTAIN\BORING LOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-23

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 13:30
DRILLING END: March 21, 2019 11:15
COORDINATES: N: 15,866,963.8 E: 1,544,303.6

SHEET: 3 of 4
GS ELEV.: 3550.0
TOC ELEV.: 3541.1
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
80	Hollow Stem Auger	80.0	(SC), CLAYEY SAND, fine sand, low plasticity fines, light gray; very dense,dry,(LACUSTRINE) *(continued)*	3470.0	SC		MC 16	49-50/4" **(50/4")**	10/10		100		
85													
90							MC 17	50/4" **(50/4")**	4/4		100		
95													
100		98.0	(CH), FAT CLAY, trace fine sand, dark brown, stratified; hard, moist, (LACUSTRINE)	3452.0	CH		MC 18	14-21-24 **(45)**	18/18	45		Sample 18: %Fines= 95; %Sand= 5; PI=45; LL=70; %MC= 26.1	
105													
110		110.0	(SP-SC), POORLY GRADED SAND WITH CLAY, fine sand, poorly graded, some low plasticity fines, light gray; very dense, moist, (LACUSTRINE)	3440.0	SP-SC		MC 19	37-50/3" **(50/3")**	9/9		100		
115													
120		120.0	Log continued on next page	3430.0									

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSY MOUNTAIN\BORING LOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-23

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 20, 2019 13:30
DRILLING END: March 21, 2019 11:15
COORDINATES: N: 15,866,963.8 E: 1,544,303.6

SHEET: 4 of 4
GS ELEV.: 3550.0
TOC ELEV.: 3541.1
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
120		120.0		3430.0								
			(CH), FAT CLAY, light gray; hard, moist		CH		MC 20	17-37-50/4" **(87/10")**	16 / 16	100	Sample 20: %Fines= 100; %Sand= 0; PI=40; LL=64; %MC= 25.1	
		121.3	(LACUSTRINE)	3428.7								
			Bottom of borehole at 121.4 ft. Backfilled with bentonite chips.									
125												
130												
135												
140												
145												
150												
155												
160												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-23
4 of 4

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSYMOUNTAINBORINGLOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-39

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 21, 2019 13:00
DRILLING END: March 21, 2019 15:15
COORDINATES: N: 15,867,102.0 E: 1,545,040.8

SHEET: 1 of 2
GS ELEV.: 3531.0
TOC ELEV.: 3565.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80) / WATER CONTENT (%) (W_p W W_l)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(SM), SILTY SAND, fine sand, non plastic fines, some coarse subrounded to subangular gravel, pink-gray, some cobbles; loose to medium dense, dry, , gravel and sand content decreasing with depth, (LACUSTRINE)	3531.0	SM							
5							SS 1	8-5-10 **(15)**	11/18	15		
		8.5		3522.5								
			(ML), SANDY SILT, low plasticity fines, trace gravel, trace fine sand, yellow-brown, hard,moist, (LACUSTRINE)		ML							
10							MC 2	20-29-45 **(74)**	15/18	74	Sample 2: %Fines= 54; % Sand= 44; PI=10; LL=36; %MC= 16.0	
15		15.5		3515.5			MC 3	39-48-50 **(98)**	17/18	98	Sample 3: %Fines= 37; % Sand= 63; PI=31; LL=80; %MC= 14.5	
			(SC), CLAYEY SAND, fine to medium sand, medium plasticity fines, light gray and white, very dense, dry to moist, some yellow mottle, coarser with depth, (LACUSTRINE)		SC							
20							MC 4	29-39-40 **(79)**	16/18	79		
		21.5	fine to coarse sand, rounded to subrounded, medium plasticity fines, yellow	3509.5								
			(CH), FAT CLAY, high plasticity fines, trace sand, olive-gray and dark red, cohesive, hard, some orange mottle		CH							
25			, becomes gray pink, (LACUSTRINE)				MC 5	17-29-13 **(42)**	18/18	42	Sample 5: %Fines= 88; %Sand= 12; PI=85; LL=120; %MC= 39.3	
		26.5		3504.5								
			(CL), LEAN CLAY, low plasticity fines, fine sand, gray with dark red, some orange mottle, (LACUSTRINE)		CL							
		29.0		3502.0								
30			(SC), CLAYEY SAND, fine to medium sand, low plasticity fines, gray, very dense, moist, (LACUSTRINE)		SC		MC 6	50/3" **(50/3")**	0/3	100		
35		35.0		3496.0								
			(CH), FAT CLAY, high plasticity fines, trace fine sand, gray to gray-olive, hard, moist, (LACUSTRINE)		CH		MC 7	10-11-15 **(26)**	17/18	26	Sample 7: %Fines= 98; % Sand= 2; PI=78; LL=109; % MC= 38.8	
40		40.0		3491.0								

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSYMOUNTAINBORINGLOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-39

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 21, 2019 13:00
DRILLING END: March 21, 2019 15:15
COORDINATES: N: 15,867,102.0 E: 1,545,040.8

SHEET: 2 of 2
GS ELEV.: 3531.0
TOC ELEV.: 3565.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft; WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(SC), CLAYEY SAND, fine sand, poorly graded, low plasticity fines, light gray with orange, very dense, dry to moist, (LACUSTRINE)	3491.0	SC		MC 8	39-50/4" **(50/4")**	10/10	100		
45							MC 9	50/4" **(50/4")**	0/4	100		
50		50.3	Bottom of borehole at 50.4 ft. Backfilled with bentonite chips.	3480.7			MC 10	50/4" **(50/4")**	0/4	100		
55												
60												
65												
70												
75												
80												

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-39
2 of 2

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSYMOUNTAINBORINGLOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-44

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 08:00
DRILLING END: March 22, 2019 14:00
COORDINATES: N: 15,866,761.8 E: 1,544,672.9

SHEET: 1 of 4
GS ELEV.: 3608.0
TOC ELEV.: 3554.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
0	Hollow Stem Auger	0.0	(ML), SANDY SILT, non plastic fines, fine to coarse subrounded to subangular gravel, fine sand, light yellow-brown; loose to medium dense, (LACUSTRINE)	3608.0	ML								
5		5.0	(SP), POORLY GRADED SAND, fine sand, poorly graded, trace non plastic fines, white and brown-gray; medium dense, dry, (LACUSTRINE)	3603.0	SP		SS 1	9-11-12 **(23)**	12/18	23			
10		9.0	(SC), CLAYEY SAND, fine sand, medium plasticity fines, yellow-brown; medium dense, dry to moist, (LACUSTRINE)	3599.0	SC								
		10.0	(CH), SANDY FAT CLAY, high plasticity fines, some fine sand, red-brown, stiff, moist, becomes yellow brown, (LACUSTRINE)	3598.0	CH		SH 2		24/24			Sample 2: %Fines= 56; %Sand= 44; PI=60; LL=82; %MC= 27.3	
							SS 3	5-6-7 **(13)**	16/18	13			
15							MC 4	40-50/3" **(50/3")**	9/9			100	
20		20.0	(CH), FAT CLAY, high plasticity fines, little fine sand, yellow-brown, very stiff to hard, moist, white clay fleck scattered throughout, (LACUSTRINE)	3588.0	CH		SH 5		24/24				
							SS 6	9-8-10 **(18)**	17/18	18		Sample 6: %Fines= 81; % Sand= 19; PI=90; LL=111; %MC= 35.5	
25							MC 7	8-12-14 **(26)**	17/18	26		Sample 7: %Fines= 95; %Sand= 5; PI=62; LL=92; %MC= 36.7	
30			decreasing sand content with depth				SH 8		24/24			Sample 9: %Fines= 97; %Sand= 3; PI=70; LL=98; %MC= 40.3	
							SS 9	8-9-11 **(20)**	18/18	20			
35							MC 10	11-16-21 **(37)**	18/18	37		Sample 10: %Fines= 97; %Sand= 3; PI=74; LL=103; %MC= 39.8	
40		38.0	(SC), CLAYEY SAND, fine sand, high plasticity fines, yellow-brown, very dense, moist, (LACUSTRINE)	3570.0	SC								

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-44
1 of 4

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSYMOUNTAINBORINGLOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-44

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 08:00
DRILLING END: March 22, 2019 14:00
COORDINATES: N: 15,866,761.8 E: 1,544,672.9

SHEET: 2 of 4
GS ELEV.: 3608.0
TOC ELEV.: 3554.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft	WATER CONTENT (%)	NOTES	ADDITIONAL LAB TESTING
40	Hollow Stem Auger	40.0	(SC), CLAYEY SAND, fine sand, high plasticity fines, yellow-brown, very dense, moist, (LACUSTRINE) *(continued)*	3568.0	SC		MC 11	16-24-29 **(53)**	18/18	53		Sample 11: %Fines= 36; %Sand= 64; PI=58; LL=84; %MC= 28.3	
45			fine to coarse sand, trace fine gravel				MC 12	29-47-50 **(97)**	15/18	97		Sample 12: %Fines= 28; %Sand= 72; PI=33; LL=55; %MC= 17.8	
50			fine sand, and medium plasticity fines				MC 13	15-32-40 **(72)**	18/18	72		Sample 13: %Fines= 26; %Sand= 74; PI=52; LL=79; %MC= 22.5	
55			decreasing sand content with depth										
60			becomes light gray with orange staining				MC 14	20-37-43 **(80)**	18/18	80		Sample 14: %Fines= 35; %Sand= 60; PI=66; LL=85; %MC= 21.0	
65													
70		70.0	(CH), FAT CLAY WITH SAND, high plasticity fines, fine to coarse sand, brown-gray mottled orange-red; hard, moist, (LACUSTRINE)	3538.0	CH		MC 15	17-27-50/5" **(77/11")**	17/17	100		Sample 15: %Fines= 84; %Sand= 15; PI=62; LL=86; %MC= 30.7	
75			gray-brown, white clay fleck scattered throughout										
80		80.0	Log continued on next page	3528.0									

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSY MOUNTAIN\BORING LOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-44

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 08:00
DRILLING END: March 22, 2019 14:00
COORDINATES: N: 15,866,761.8 E: 1,544,672.9

SHEET: 3 of 4
GS ELEV.: 3608.0
TOC ELEV.: 3554.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	REC / ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
80	Hollow Stem Auger	80.0	(CL), LEAN CLAY, high plasticity fines, few fine sand, becomes dark gray with white clay scattered throughout, moist, (LACUSTRINE)	3528.0	CL		MC 16	17-29-33 **(62)**	18/18	62		Sample 16: %Fines= 93; %Sand= 7; PI=40; LL=61; %MC= 24.9	
85													
90		90.0	(CH), FAT CLAY, high plasticity, trace fine sand, becomes black brown and stratified with white clay flecks throughout, moist, (LACUSTRINE)	3518.0	CH		MC 17	37-38-50 **(88)**	18/18	88		Sample 17: %Fines= 99; %Sand= 1; PI=48; LL=72; %MC= 26.3	
95													
100		100.0	(CL), LEAN CLAY, low to medium plasticity fines, trace fine sand, very light gray, hard, moist, (LACUSTRINE)	3508.0	CL		MC 18	41-50/3" **(50/3")**	6/9	100			
105													
110							MC 19	35-42-50 **(92)**	18/18	92		Sample 19: %Fines= 98; %Sand= 2; PI=16; LL=41; %MC= 17.9	
115													
120													

Log continued on next page

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241 GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSY MOUNTAIN BORING LOGS 3-29-2011.GPJ

RECORD OF BOREHOLE BH19-TP-44

PROJECT: Grassy Mountain
PROJECT NO.: 1663241
LOCATION: Vale, Oregon

DRILLING START: March 22, 2019 08:00
DRILLING END: March 22, 2019 14:00
COORDINATES: N: 15,866,761.8 E: 1,544,672.9

SHEET: 4 of 4
GS ELEV.: 3608.0
TOC ELEV.: 3554.4
DATUM: NAD83 Zone 11

DEPTH (ft)	BORING METHOD	SOIL PROFILE: Depth	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: Elev	USCS	GRAPHIC LOG	SAMPLES: SAMPLE TYPE & NUMBER	SAMPLES: BLOWS per 6 in (Automatic hammer 140 lb & 340 lb Hammer, 30 inch drop)	SAMPLES: REC ATT (in)	PENETRATION RESISTANCE BLOWS / ft (20 40 60 80)	WATER CONTENT (%) (W_p W W_l) (20 40 60 80)	NOTES	ADDITIONAL LAB TESTING
120		120.0		3488.0									
		120.4		3487.6			MC 20	50/5" **(50/5")**	0 5		100		
			Bottom of borehole at 120.5 ft. Backfilled with bentonite chips.										
125													
130													
135													
140													
145													
150													
155													
160													

DRILLING CO.: Haz Tech
DRILLER: Jerod Willard
DRILL RIG: CME-75, Truck Mount

LOGGED: Brenda Borer
CHECKED: Matt Barton
REVIEWED: Chris MacMahon

GOLDER

BH19-TP-44
4 of 4

01 - GOLDER - BOREHOLE RECORD - DF STD US LAB E-M.GDT - 10/11/19 15:16
C:\USERS\MSTEINGRAEBER\GOLDER ASSOCIATES\1663241, GRASSY MOUNTAIN - 1663241 GRASSY MOUNTAIN TSF\400_ENGINEERING\414_GEOTECH PROGRAM\2019 FIELD PROGRAM\BORING LOGS\GRASSYMOUNTAINBORINGLOGS 3-29-2011.GPJ

ATTACHMENT B

Test Pit Logs

Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-01

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,322.3 **Easting:** 1,542,563.2

Datum: NAD83 Zone 11

Elevation ft: 3614.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3614.0						
	0.5	TOPSOIL	3613.5						
		(SC) CLAYEY SAND, fine to coarse sand, some low plasticity fines, trace fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); medium dense, moist		SC		GB S1	medium dense	moist	PP=1.75 @ 2 ft.
		(CL) SANDY LEAN CLAY, some fine to medium sand, trace fine subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CL			stiff	moist	
		(CH) FAT CLAY WITH GRAVEL, little fine to coarse rounded to subrounded gravel, few fine to coarse sand, gray brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CH		GB S2	stiff	moist	
5	5.0	(GP) POORLY GRADED GRAVEL, fine to coarse rounded to subrounded gravel, few fine to coarse sand, trace low plasticity fines, brown; (ALLUVIUM/ COLLUVIUM); medium dense, moist	3609.0	GP			medium dense	moist	
		(CH), FAT CLAY, trace fine sand, olive with light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH		GB S3	hard	moist	PP=4.25 @ ~8 ft.
	9.5		3604.5						
10		Practical refusal at 9.5 ft on hard lacustrine deposits. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

03 - GOLDER - TEST PIT LOG WITH PHOTO - TEST V7 2012_01_22B E-M 1A.GPJ - 5/1/18 11:22
C:\USERS\CBLOOM\DESKTOP\GRASSYMTNLOGS\TP_LOGS_V2.GPJ

Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-02

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,912.3 **Easting:** 1,542,394.9

Datum: NAD83 Zone 11

Elevation ft: 3615.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3615.0						
	0.5	TOPSOIL	3614.5						
		(CH), FAT CLAY, few fine sand, trace gravel, light brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CH			stiff	moist	PP=1.25 @ 0.5 ft.
	2.0		3613.0						
		(SM), SILTY SAND WITH GRAVEL, fine to coarse sand, some fine to coarse subrounded to subangular gravel, some nonplastic fines, tan;(ALLUVIUM/COLLUVIUM); dense, moist		SM		GB S1	dense	moist	
	3.5		3611.5						
		(SP-SC), POORLY GRADED SAND WITH CLAY AND GRAVEL, fine to coarse sand, little fine to coarse subrounded to subangular gravel, little low plasticity fines, brown to light brown, iron oxide staining; (ALLUVIUM/COLLUVIUM); dense, moist		SP-SC		GB S2	dense	moist	
5	5.0		3610.0						
		(CL), SANDY LEAN CLAY, some fine to coarse sand, tan; (LACUSTRINE); stiff, moist		CL			stiff	moist	PP=1.75 @ ~ 8 ft.
10	10.0		3605.0						
		(CH), FAT CLAY, trace fine sand, very light brown; (LACUSTRINE); hard, moist		CH		GB S3	hard	moist	PP >4.5 @ ~ 12 ft.
	14.0		3601.0						
15		(CL), SANDY LEAN CLAY, some fine to coarse sand, very dark to very dark brown, laminated; (LACUSTRINE); stiff, moist		CL		GB S4	stiff	moist	PP=1.25 @ ~ 14 ft.
	15.5		3599.5						
		Bottom of test pit at 15.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-03

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,839.8 **Easting:** 1,543,301.9

Datum: NAD83 Zone 11

Elevation ft: 3614.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Johnson

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3614.9						
	0.5	TOPSOIL	3614.4						
		(CH), SANDY FAT CLAY, some fine to coarse sand, little fine to coarse subangular to angular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CH			hard	moist	PP=4.25 @ 1 ft.
	2.0		3612.9						
		(SC), CLAYEY SAND, fine to medium sand, some low plasticity fines, light brown to tan; (ALLUVIUM/COLLUVIUM); medium dense to dense, moist		SC		GB S1	medium dense to dense	moist	
5									
	8.0		3606.9						
		(SP-SC), POORLY GRADED SAND WITH CLAY, fine to medium sand, little low plasticity fines, tan, iron oxide staining; (ALLUVIUM/COLLUVIUM); dense, moist, moderately indurated		SP-SC		GB S2	dense	moist	
10	11.0		3603.9						
		(CH), FAT CLAY, trace fine sand, olive to gray, homogeneous; (LACUSTRINE); hard, moist		CH		GB S3	hard	moist	PP >4.5 @ ~13 ft.
15	15.0		3599.9						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-04

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,053.4 **Easting:** 1,543,846.7

Datum: NAD83 Zone 11

Elevation ft: 3615.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Johnson

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3615.1						
	0.5	TOPSOIL	3614.6						
		(GP-GC), POORLY GRADED GRAVEL WITH SAND AND CLAY, fine to coarse subrounded to subangular gravel, little fine to coarse sand, little low plasticity fines, light brown; subrounded to subangular cobbles and boulders up to 12 inches in diameter; (ALLUVIUM/COLLUVIUM); dense, moist		GP-GC		GB S2	dense	moist	
5	7.0		3608.1						
		(SP), POORLY GRADED SAND, fine to medium sand, trace low plasticity fines, red to light brown; (ALLUVIUM/COLLUVIUM); dense, moist, moderately indurated				GB S1			
10				SP			dense	moist	
15	15.0		3600.1						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-05

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,805.2 **Easting:** 1,544,478.4

Datum: NAD83 Zone 11

Elevation ft: 3613.2 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Johnson

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3613.2						
	0.5	TOPSOIL	3612.7						
		(CL), SANDY LEAN CLAY WITH GRAVEL, some fine to coarse sand, little fine to coarse subangular to angular gravel, brown; (ALLUVIUM/COLLUVIUM); very stiff, moist		CL			very stiff	moist	PP=3.5 @ 1 ft.
	3.0		3610.2						
5		(SC), CLAYEY SAND WITH GRAVEL, fine to coarse sand, some high plasticity fines, little fine to coarse subrounded to subangular gravel, few cobbles and boulders up to 18 inches in diameter, brown to olive-brown, heterogeneous; (ALLUVIUM/COLLUVIUM); medium dense, moist		SC		GB S1	medium dense	moist	
10		11.0-11.5 ft: Clay lens 11.5: Decrease in cobbles and boulders content				GB S2			
15	15.0		3598.2			GB S3			
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-06

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,452.0 **Easting:** 1,542,478.9

Datum: NAD83 Zone 11

Elevation ft: 3613.5 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3613.5						
	0.5	TOPSOIL	3613.0						
	1.5	(CL), LEAN CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); hard, moist	3612.0	CL			hard	moist	PP=4.25 @ 1 ft.
	4.5	(CL), SANDY LEAN CLAY, some fine to coarse sand, few fine to coarse subrounded to subangular gravel, brown-red to tan, iron oxide staining; (ALLUVIUM/COLLUVIUM); very stiff, moist	3609.0	CL		GB S1	very stiff	moist	PP=3.5 @ 3 ft.
5		(SP-SC), POORLY GRADED SAND WITH CLAY, fine to medium sand, few to little low plasticity fines, light brown-orange to pale tan; (ALLUVIUM/COLLUVIUM); dense, moist, increasing fines content with depth		SP-SC		GB S2	dense	moist	
10									
	14.0		3599.5			GB S3			
15		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-07

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,427.7 **Easting:** 1,543,085.7

Datum: NAD83 Zone 11

Elevation ft: 3581.6 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3581.6						
	0.5	TOPSOIL	3581.1						
		(CH), FAT CLAY, trace fine to coarse sand, trace fine to coarse subrounded to subangular gravel, brown, homogeneous; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CH			hard	moist	PP=3.5 @ 1 ft.
	2.0		3579.6						
		(GP), POORLY GRADED GRAVEL WITH SAND, fine to coarse subrounded to subangular gravel, cobbles, and boulders up to 18 inches in diameter, little fine to coarse sand, tan to pale tan; (ALLUVIUM/COLLUVIUM); dense, moist, calcite		GP			dense	moist	
	4.5		3577.1						
5		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	PP >4.5 @ ~ 8 ft.
10									
	14.5		3567.1						
15		Bottom of test pit at 14.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-08

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,870.8 **Easting:** 1,544,601.4

Datum: NAD83 Zone 11

Elevation ft: 3567.3 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3567.3						
	0.5	TOPSOIL	3566.8						PP >4.5 @ 1 ft.
		(CL), LEAN CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, gray to brown; (ALLUVIUM/COLLUVIUM); hard, moist		CL			hard	moist	
	2.0		3565.3						
		(CH), FAT CLAY, few fine to coarse sand, light brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CH			stiff	moist	
	4.0		3563.3						
5		(SM), SILTY SAND, fine to medium sand, some low plasticity fines, light tan; (ALLUVIUM/COLLUVIUM); dense, moist		SM			dense	moist	
	8.0		3559.3						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, mottled spots, calcite in top 2 ft, LACUSTRINE				GB S1			
10				CH			hard	moist	PP >4.5 @ 9 ft.
	11.5		3555.8						
		Practical refusal at 11.5 ft. on hard lacustrine deposits. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-09

DATE: 12-7-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,440.7 **Easting:** 1,543,675.0

Datum: NAD83 Zone 11

Elevation ft: 3581.8 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3581.8						
	0.5	TOPSOIL	3581.3						
		(CH), FAT CLAY, few fine to coarse sand, light brown; (ALLUVIUM/COLLUVIUM); stiff to very stiff, moist		CH			stiff to very stiff	moist	PP=1.75 @ 1 ft.
	2.0		3579.8						
		(CH), FAT CLAY, few to little fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH		GB BULK	hard	moist	
5									
10									PP=4.0 @ ~12 ft.
15	15.0		3566.8						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-10

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,452.5 **Easting:** 1,544,575.5

Datum: NAD83 Zone 11

Elevation ft: 3610.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3610.0						
	0.5	TOPSOIL	3609.5						
		(CL), SANDY LEAN CLAY WITH GRAVEL, little fine to coarse sand, little fine to coarse subrounded to subangular gravel and cobbles up to 4 inches in diameter, brown; (ALLUVIUM/COLLUVIUM); hard, moist,		CL			hard	moist	PP=4.0 @ 1 ft.
	2.0	Desiccated	3608.0						
		(CH), FAT CLAY, few fine to coarse sand, few to little fine to coarse subrounded to subangular gravel and subrounded cobbles up to 4 inches in diameter, very light brown to light tan; (ALLUVIUM/ COLLUVIUM); stiff, moist,		CH			stiff	moist	
	4.5		3605.5						
5		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules							
				CH			hard	moist	PP >4.5 @ ~6 ft.
10									
		13.0 ft: Increasing sand and gravel content							
15	15.0		3595.0						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-11

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,934.8 **Easting:** 1,543,212.8

Datum: NAD83 Zone 11

Elevation ft: 3591.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3591.7						
	0.5	TOPSOIL	3591.2						
		(CL), LEAN CLAY, trace to few fine to coarse sand, brown to light brown; (ALLUVIUM/COLLUVIUM); very stiff, moist		CL		GB S1	very stiff	moist	PP=3.25 @ 3 ft.
5									
	9.0		3582.7						
		(SC), CLAYEY SAND, fine to medium sand, some low plasticity fines, light tan, iron oxide staining; (ALLUVIUM/COLLUVIUM); dense, moist, indurated near bottom of layer		SC		GB S3	dense	moist	
10	12.0		3579.7						
		(CH), FAT CLAY WITH SAND, little fine to coarse sand, light brown to gray; (LACUSTRINE); hard, moist		CH		GB S2	hard	moist	
	14.5		3577.2						
15		Bottom of test pit at 14.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-12

DATE: 12-5-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,934.8 **Easting:** 1,543,212.8

Datum: NAD83 Zone 11

Elevation ft: 3586.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] [2] OR DENSITY	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3586.1						
	0.5	TOPSOIL	3585.6						
		(CH), FAT CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, brown, homogeneous; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CH			hard	moist	PP=4.25 @ 1 ft.
	2.0		3584.1						
		(SM), SILTY SAND WITH GRAVEL, fine to coarse sand, some low plasticity fines, little fine to coarse subrounded to subangular gravel, tan to light tan, heterogeneous; (ALLUVIUM/COLLUVIUM); stiff, moist, gravel lenses		SM			stiff	moist	
5	5.0		3581.1						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH		GB BULK	hard	moist	
10	12.0		3574.1						
		(CL), SANDY LEAN CLAY, some fine to medium sand, tan, homogeneous; (LACUSTRINE); stiff, moist		CL			stiff	moist	
	13.0		3573.1						
		Bottom of test pit at 13.0 ft. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-13

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,770.3 **Easting:** 1,545,200.7

Datum: NAD83 Zone 11

Elevation ft: 3610.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3610.0						
	0.5	TOPSOIL	3609.5						
		(CL), LEAN CLAY, few fine to coarse sand, few fine to coarse subrounded to subangular gravel, brown, homogeneous; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CL			hard	moist	PP=4.0 @ 1 ft.
	2.0		3608.0						
		(GM), SILTY GRAVEL WITH SAND, fine to coarse, subrounded to subangular gravel, some fine to coarse sand, little to some low plasticity fines, light brown; (ALLUVIUM/COLLUVIUM); dense, moist		GM			dense	moist	
	4.0		3606.0						
5		(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, tan-orange, iron oxide staining; (WEATHERED ARKOSIC SANDSTONE); dense, moist		SM			dense	moist	
	9.0		3601.0						
10		Practical refusal at 9.0 ft. on Arkosic Sandstone. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-14

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,182.7 **Easting:** 1,543,453.3

Datum: NAD83 Zone 11

Elevation ft: 3583.8 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3583.8						
	0.5	TOPSOIL	3583.3						
	1.0	(CH), FAT CLAY, trace fine to coarse sand, trace fine to coarse subrounded gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist	3582.8	CH		GB S1	hard	moist	
	3.5	(CL), LEAN CLAY, trace fine to coarse sand, trace fine to coarse subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); very stiff, moist	3580.3	CL		GB S2	very stiff	moist	PP=2.75 @ 2 ft.
5	8.0	(CH), FAT CLAY, trace fine sand, brown; (LACUSTRINE); stiff, moist	3575.8	CH			stiff	moist	PP=1.75@ ~6 ft.
10	12.0	(CH), FAT CLAY, high plasticity, trace fine sand, olive to light brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, heavily indurated	3571.8	CH		GB S3	hard	moist	PP >4.25 @ ~11 ft.
	13.0	(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, tan, iron oxide staining; (WEATHERED ARKOSIC SANDSTONE); very dense, moist	3570.8	SM			very dense	moist	
15		Practical refusal at 13.0 ft. on Arkosic Sandstone. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

03 - GOLDER - TEST PIT LOG WITH PHOTO - TEST V7 2012_01_22B E-M 1A.GPJ - 5/1/18 11:24
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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-15

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,253.4 **Easting:** 1,544,078.8

Datum: NAD83 Zone 11

Elevation ft: 3564.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3564.9						
	0.5	TOPSOIL	3564.4						
		(CL), LEAN CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CL			hard	moist	PP=4.0 @ 1 ft.
	2.0		3562.9						
		(GP), POORLY GRADED GRAVEL, fine to coarse subrounded to subangular gravel, few fine to coarse sand, trace low plasticity fines, light brown to tan; (ALLUVIUM/COLLUVIUM); dense, moist		GP			dense	moist	
5	5.0		3559.9						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	
10									PP=4.25 @ ~12 ft.
		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							
15	15.0		3549.9						

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-16

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,365.1 **Easting:** 1,543,303.2

Datum: NAD83 Zone 11

Elevation ft: 3616.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3616.1						
	0.5	TOPSOIL	3615.6						
		(CL), LEAN CLAY, few fine sand, trace fine subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CL		GB S1	stiff	moist	PP=1.25 @ 1.5 ft.
5	5.0		3611.1						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, heavily indurated		CH			hard	moist	PP=4.25 @ 8ft.
10	11.0		3605.1						
		(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, tan, iron oxide staining; (WEATHERED ARKOSIC SANDSTONE); very dense, moist		SM			very dense	moist	
	14.0		3602.1						
15		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-17

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,253.4 **Easting:** 1,544,658.7

Datum: NAD83 Zone 11

Elevation ft: 3561.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3561.7						
	0.5	TOPSOIL	3561.2						
		(CL), LEAN CLAY, few fine to coarse sand, light brown; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CL			hard	moist	PP=4.0 @ 1.5 ft.
	2.0		3559.7						
		(CH), FAT CLAY, little fine sand, tan to brown; (LACUSTRINE); hard, moist		CH		GB BULK	hard	moist	PP=4.25 @ 5 ft.
5									
10									
	14.0		3547.7						
15		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-18

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,144.4 **Easting:** 1,545,316.4

Datum: NAD83 Zone 11

Elevation ft: 3615.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3615.0						
	0.5	TOPSOIL	3614.5						
	1.5	(CL), LEAN CLAY, few fine to coarse sand, few fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated	3613.5	CL			hard	moist	PP=4.0 @ 1 ft.
	3.0	(CH), FAT CLAY, few fine to coarse sand, brown; (ALLUVIUM/COLLUVIUM); very stiff, moist, desiccated	3612.0	CH			very stiff	moist	
5		(CH), FAT CLAY, trace fine sand, olive to light red-brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	PP=4.0 @ ~8 ft.
10		10.0 - 12.0 ft: Layer of Elastic Silt, possibly diatoms.				GB S1			
15	15.0		3600.0						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-19

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,536.3 **Easting:** 1,544,410.1

Datum: NAD83 Zone 11

Elevation ft: 3549.8 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3549.8						
	0.5	TOPSOIL	3549.3						
	1.0	(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, few fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); dense, moist	3548.8	SM			dense	moist	
		(GC), CLAYEY GRAVEL WITH SAND, fine to coarse, subrounded gravel, little to some high plasticity fines, little fine to coarse sand, dark brown; (ALLUVIUM/COLLUVIUM); dense, moist, few cobbles up to 4 inches in diameter 3.0-4.0 ft: Approximately 10% cobbles		GC			dense	moist	
	4.0		3545.8						
5		(CH), FAT CLAY, trace fine sand, olive to light brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, mottled black 5.0-9.0 ft: Increase in sand content		CH			hard	moist	
10		9.0-14.0 ft: Heavily indurated							PP=4.25 @ ~12 ft.
	14.0		3535.8						
15		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-20

DATE: 12-7-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,483.7 **Easting:** 1,543,671.4

Datum: NAD83 Zone 11

Elevation ft: 3605.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3605.1						
	0.5	TOPSOIL	3604.6						
	1.5	(GM), SILTY GRAVEL WITH SAND, fine to coarse, rounded to subrounded gravel, some medium plasticity fines, little fine to coarse sand, brown-red, iron oxide staining; (ALLUVIUM/COLLUVIUM); dense, moist	3603.6	GM		GB S1	dense	moist	
5	5.0	(GP-GM), POORLY GRADED GRAVEL WITH SILT AND SAND, fine to coarse subrounded to rounded gravel, little fine to coarse sand, litte low plasticity fines, gray, stratified, iron oxide staining; (ALLUVIUM/COLLUVIUM); dense to very dense, moist	3600.1	GP-GM			dense to very dense	moist	
10		Practical refusal at 5.0 ft. on Arkosic Sandstone Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-21

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,022.8 **Easting:** 1,542,914.4

Datum: NAD83 Zone 11

Elevation ft: 3614.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3614.0						
	0.5	TOPSOIL	3613.5						
		(CL), SANDY LEAN CLAY, some fine to medium sand, trace to few fine subrounded to subangular gravel, brown-pink to tan; (ALLUVIUM/COLLUVIUM); very stiff, moist		CL		GB S1	very stiff	moist	PP=3.75 @ 2 ft.
5	5.0		3609.0						
		(CH), FAT CLAY, trace fine sand, olive to light brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist		CH			hard	moist	
	7.0		3607.0						
		(CH), SANDY FAT CLAY, some fine to coarse medium sand, gray-pink to tan, iron oxide staining; (LACUSTRINE); very dense, moist, heavily indurated near bottom of soil layer		CH			very dense	moist	
10	11.0		3603.0						
		(CH), FAT CLAY, trace fine sand, light gray; (LACUSTRINE); hard, moist		CH			hard	moist	PP=4.25 @ 12 ft.
	13.5		3600.5						
		Bottom of test pit at 13.5 ft. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-22

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,721.6 **Easting:** 1,543,826.3

Datum: NAD83 Zone 11

Elevation ft: 3602.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3602.9						
	0.5	TOPSOIL	3602.4						
	1.5	(CL), SANDY LEAN CLAY, some fine to coarse sand, brown-red; (ALLUVIUM/COLLUVIUM); hard, moist	3601.4	CL			hard	moist	
5		(CH), FAT CLAY, trace medium to coarse sand, light brown to pink, iron oxide staining; (LACUSTRINE); medium stiff, moist		CH		GB S1	medium stiff	moist	PP=0.75 @ 4 ft.
10	10.5		3592.4						
	11.5	(CH), FAT CLAY, trace fine sand, light gray to white, l(LACUSTRINE); hard, moist	3591.4	CH		GB S2	hard	moist	
15		Bottom of test pit at 11.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-23

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,882.6 **Easting:** 1,544,244.3

Datum: NAD83 Zone 11

Elevation ft: 3546.6 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3546.6						
	0.3	TOPSOIL	3546.4						
		(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, few fine to coarse subrounded to subangular gravel, light green-brown; (ALLUVIUM/COLLUVIUM); medium dense, moist		SM		GB S1 GB S2	medium dense	moist	
	4.5		3542.1						
5		(GP), POORLY GRADED GRAVEL, fine to coarse, subrounded to subangular gravel, few fine to coarse sand, trace low plasticity fines, light brown; (ALLUVIUM/COLLUVIUM); very dense, moist		GP			very dense	moist	
10	10.0		3536.6						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH		GB S3	hard	moist	
15	15.0		3531.6						
		Bottom of test pit at 16.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-24

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,770.9 **Easting:** 1,544,882.5

Datum: NAD83 Zone 11

Elevation ft: 3840.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3840.0						
	0.5	TOPSOIL	3839.5						
	1.0	(CH), FAT CLAY, few fine to coarse sand, few fine to coarse subrounded to subangular gravel, brown, homogeneous; (ALLUVIUM/COLLUVIUM); hard, moist	3839.0	CH			hard	moist	
		(CH), FAT CLAY, white to red-brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, heavily indurated near bottom of excavation				GB S1			
5									
				CH			hard	moist	
10									PP=4.25 @ 11 ft.
	13.0		3827.0						
		Practical refusal at 13.0 ft. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-25

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,492.7 **Easting:** 1,545,130.2

Datum: NAD83 Zone 11

Elevation ft: 3942.5 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3942.5						
	0.5	TOPSOIL	3942.0						
	1.5	(CL), LEAN CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light brown, iron oxide staining; (ALLUVIUM/COLLUVIUM); stiff, moist	3941.0	CL			stiff	moist	
	4.0	(CH), FAT CLAY, trace fine sand, gray-red to light olive-green, heterogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules	3938.5	CH			hard	moist	
5		Practical refusal at 4.0 ft. on hard lacustrine deposit. Backfilled with excavated material and tamped with bucket.							
10									
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-26

DATE: 12-7-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,223.0 **Easting:** 1,545,202.9

Datum: NAD83 Zone 11

Elevation ft: 3712.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3712.1						
	0.5	TOPSOIL	3711.6						
		(CL), LEAN CLAY, few fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel, brown, homogeneous; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CL			hard	moist	
	2.0		3710.1						
		(GP-GC), POORLY GRADED GRAVEL WITH SAND AND CLAY, fine to coarse subrounded to subangular gravel, little fine to coarse sand, little low plasticity fines, few cobbles and boulders up to 12 inches in diameter, light brown; (ALLUVIUM/COLLUVIUM); dense, moist,		GP-GC			dense	moist	
	4.0		3708.1						
5		(SM), SILTY SAND, fine to coarse sand, some low plasticity fines, few fine to coarse subrounded to subangular gravel and cobbles up to 9 inches in diameter, light brown; (ALLUVIUM/COLLUVIUM); medium dense, moist, few cobbles up to 6 inches in diameter		SM		GB S1	medium dense	moist	
	9.0		3703.1						
10		Practical refusal at 9.0 ft. on Arkosic Sandstone. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-27

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,972.9 **Easting:** 1,545,209.2

Datum: NAD83 Zone 11

Elevation ft: 3731.4 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3731.4						
	0.5	TOPSOIL	3730.9						
	1.5	(CL), LEAN CLAY, few fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel and cobbles up to 6 inches in diameter, brown; (ALLUVIUM/COLLUVIUM); hard, moist	3729.9	CL			hard	moist	
	3.5	(CH), FAT CLAY, few fine to coarse sand, trace fine to coarse angular gravel, light brown to green-gray; (ALLUVIUM/COLLUVIUM); stiff, moist	3727.9	CH			stiff	moist	
5		Practical refusal on Arkosic Sandstone at 3.5 ft. Backfilled with excavated material and tamped with bucket.							
10									
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-28

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,726.0 **Easting:** 1,545,505.1

Datum: NAD83 Zone 11

Elevation ft: 3747.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3747.9						
	0.5	TOPSOIL	3747.4						
		(CL), LEAN CLAY, few fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist		CL			hard	moist	PP=4.0 @ 1 ft.
	2.0		3745.9						
5		(CH), FAT CLAY, trace fine sand, olive to light brown, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	
10									PP=4.0 @ 10 ft.
	14.5		3733.4						
15		Bottom of test pit at 14.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-29

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,865,071.5 **Easting:** 1,545,819.2

Datum: NAD83 Zone 11

Elevation ft: 3697.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3697.0						
	0.5	TOPSOIL	3696.5						
		(CL), LEAN CLAY, few fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist		CL			hard	moist	
	2.0		3695.0						
		(CH), SANDY FAT CLAY, some fine to medium sand, trace fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); stiff, moist, gravel content increases with depth in soil layer		CH			stiff	moist	PP=1.5 @ 3 ft.
5	5.0		3692.0						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	PP=4.25 @ ~7 ft.
10									
15	15.0		3682.0						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-30

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,089.7 **Easting:** 1,543,057.8

Datum: NAD83 Zone 11

Elevation ft: 3673.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3673.7						
	0.5		3673.2						
		(CL), SANDY LEAN CLAY, some fine to coarse sand, few fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist		CL		GB S1 GB S2	hard	moist	PP=4.25 @ 1 ft.
	2.5		3671.2						
5		(SP-SM), POORLY GRADED SAND WITH SILT, fine to medium sand, little low plasticity fines, gray-white, heterogeneous; (WEATHERED ARKOSIC SANDSTONE); dense, moist		SP-SM		GB S3	dense	moist	
	9.0		3664.7						
10		Practical refsual at 9.0 ft. on Arkosic Sandstone. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-31

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,762.4 **Easting:** 1,543,067.5

Datum: NAD83 Zone 11

Elevation ft: 3679.5 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3679.5						
	0.5	TOPSOIL	3679.0						
	1.0	(CL), SANDY LEAN CLAY WITH GRAVEL, some fine to coarse sand, little fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); firm, moist	3678.5	CL			firm	moist	
	2.5	(CL), SANDY LEAN CLAY, some fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel, very light brown to tan; (ALLUVIUM/COLLUVIUM); hard, moist	3677.0	CL			hard	moist	
5		(CH), FAT CLAY, trace fine sand, olive to tan, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, variable coloring, heavily indurated at bottom		CH		GB S1	hard	moist	PP >4.5@ ~5 ft.
10	12.5		3667.0			GB S2			
15		Practical refusal at 12.5 ft. on hard lacustrine deposits. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-32

DATE: 12-2-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,714.5 **Easting:** 1,542,650.3

Datum: NAD83 Zone 11

Elevation ft: 3636.5 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3636.5						
	0.5	TOPSOIL	3636.0						
		(CL), SANDY LEAN CLAY WITH GRAVEL, some fine to coarse sand, few fine to coarse subrounded to subangular gravel, little fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); firm, moist		CL		GB S1 GB S2	firm	moist	
	3.0		3633.5						
5		(GP), POORLY GRADED GRAVEL WITH SAND, fine to coarse, subrounded to subangular gravel and cobbles up to 12 inches in diameter, little fine to coarse sand, trace low plasticity fines, tan-gray; (ALLUVIUM/COLLUVIUM); dense, moist		GP		GB S3	dense	moist	
	6.0		3630.5						
		(CH), FAT CLAY, trace fine sand, olive to tan, iron oxide staining; (LACUSTRINE); hard, moist, lime stringers and nodules, heavily indurated at bottom		CH			hard	moist	
10	11.5		3625.0						
		Practical refusal at 11.5 ft. on hard lacustrine deposits. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-33

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,702.5 **Easting:** 1,547,227.2

Datum: NAD83 Zone 11

Elevation ft: 3788.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3788.9						
	0.5	TOPSOIL	3788.4						
		(GM), SILTY GRAVEL, fine to coarse subrounded to subangular gravel,, cobbles, and boulders up to 12 inches in diameter, few elastic fines, few fine to coarse sand, brown; (ALLUVIUM/COLLUVIUM); dense, moist		GM			dense	moist	
	2.5		3786.4						
		(CL), LEAN CLAY WITH SAND, few fine to coarse sand, trace to few fine to coarse subrounded to subangular gravel, brown; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated		CL			hard	moist	
	4.0		3784.9						
5		(GM), SILTY GRAVEL, fine to coarse subrounded to subangular gravel, few low plastic fines, few fine to coarse sand, little cobbles and boulders up to 30 inches in diameter, brown; (ALLUVIUM/COLLUVIUM); very dense, moist, lime nodules, heavily indurated		GM		GB S1	very dense		
10		Practical refsual at 7.5 ft. on cobbles and boulders. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-34

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,863,968.9 **Easting:** 1,547,457.6

Datum: NAD83 Zone 11

Elevation ft: 3825.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3825.7						
	0.5	TOPSOIL	3825.2						
		(GM), SILTY GRAVEL, fine to coarse, subrounded to subangular gravel, few elastic plasticity fines, trace to few fine to coarse sand, light brown; (ALLUVIUM/COLLUVIUM); dense, moist		GM		GB S1	dense	moist	
	2.0		3823.7						
		Practical refusal 2.0 ft. on Basalt bedrock. Backfilled with excavated material and tamped with bucket.							
5									
10									
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-35

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,596.2 **Easting:** 1,545,659.3

Datum: NAD83 Zone 11

Elevation ft: 3613.1 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3613.1						
	0.5	TOPSOIL	3612.6						
	1.5	(CH), FAT CLAY, few fine to coarse sand, few fine to coarse subrounded to subangular gravel, cobbles, and boulders up to 12 inches in diameter brown-red; (ALLUVIUM/COLLUVIUM); hard, moist, desiccated	3611.6	CH			hard	moist	
5	7.0	(CH), FAT CLAY, trace fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light brown; (ALLUVIUM/COLLUVIUM); very stiff, moist	3606.1	CH			very stiff	moist	PP=3.25 @ 2 ft.
10	12.0	(SP), POORLY GRADED SAND WITH GRAVEL, fine to coarse sand, little fine to coarse rounded to subrounded gravel, light brown to olive-gray; (ALLUVIUM/COLLUVIUM); medium dense, moist	3601.1	SP		GB S1	medium dense	moist	
	13.0	(CH), FAT CLAY, trace fine to medium sand, olive; (LACUSTRINE); hard, moist	3600.1	CH			hard	moist	
15		Bottom of test pit at 13.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-36

DATE: 12-4-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,034.1 **Easting:** 1,545,739.5

Datum: NAD83 Zone 11

Elevation ft: 3665.8 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE: Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3665.8						
	0.5	TOPSOIL	3665.3						
	1.0	(CH), FAT CLAY, few fine to coarse sand, trace fine to coarse subrounded to subangular gravel, brown-red; (ALLUVIUM/COLLUVIUM); hard, moist	3664.8	CH		GB S1	hard	moist	
5		(SC), CLAYEY SAND, fine to medium sand, some low plasticity fines, gray, iron oxide staining; (ALLUVIUM/COLLUVIUM); medium dense, moist, decreasing fines content with depth		SC			medium dense	moist	
10									
15	15.5		3650.3						
		Bottom of test pit at 15.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-37

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,867,628.8 **Easting:** 1,545,135.8

Datum: NAD83 Zone 11

Elevation ft: 3550.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3550.7						
	0.5	TOPSOIL	3550.2						
	1.5	(CH), FAT CLAY, trace fine to coarse sand, brown;(ALLUVIUM/ COLLUVIUM); very stiff, moist	3549.2	CH			very stiff	moist	
5		(SM), SILTY SAND WITH GRAVEL, some fine to coarse sand, some fine to coarse subrounded to subangular gravel, little cobbles and boulders up to 12 inches in diameter, little nonplastic fines, very light brown; (ALLUVIUM/ COLLUVIUM); dense, moist,		SM		GB S1	dense	moist	
						GB S2			
10	11.0		3539.7						
		Practical refusal at 11.0 ft. oncobbles and boulders. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-38

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,756.3 **Easting:** 1,544,910.7

Datum: NAD83 Zone 11

Elevation ft: 3555.3 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3555.3						
	0.5	TOPSOIL	3554.8						
		(SC), CLAYEY SAND WITH GRAVEL, some fine to coarse, some fine to coarse subrounded to subangular gravel, cobbles and boulders up to 14 inches in diameter, little low plasticity fines, light brown; dense, moist (ALLUVIUM/COLLUVIUM)		SC			dense	moist	
5	5.0		3550.3						
		(CH), FAT CLAY, trace fine sand, olive to light gray, homogeneous, iron oxide staining; hard, moist, lime stringers and nodules (LACUSTRINE)		CH		GB S1	hard	moist	
10									
		13.5 ft: Increase in sand content and heavily indurated							
	14.5		3540.8						
15		Bottom of test pit at 14.5 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

03 - GOLDER - TEST PIT LOG WITH PHOTO - TEST V7 2012_01_22B E-M 1A.GPJ - 5/1/18 11:28
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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-39

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,867,121.1 **Easting:** 1,545,067.3

Datum: NAD83 Zone 11

Elevation ft: 3565.4 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	OTHER TESTS & NOTES
0	0.0		3565.4						
	0.5	TOPSOIL	3564.9						
	1.0	(CH), FAT CLAY, trace fine to coarse sand, brown; (ALLUVIUM/COLLUVIUM); hard, moist	3564.4	CH			hard	moist	
5		(GM), SILTY GRAVEL, fine to coarse, subrounded to subangular gravel, little low plasticity fines, few fine to coarse sand, very light brown; (ALLUVIUM/COLLUVIUM); very dense, moist		GM			very dense	moist	
	6.0		3559.4						
		(SP-SM), POORLY GRADED SAND WITH SILT, fine to coarse sand, few to little low plasticity fines, light brown; (ALLUVIUM/COLLUVIUM); medium dense, moist		SP-SM			medium dense	moist	
	9.5		3555.9						
10		(GP-GM), POORLY GRADED GRAVEL WITH SILT AND SAND, fine to coarse, subrounded to subangular gravel, little fine to coarse sand, little low plasticity fines, light brown; (ALLUVIUM/COLLUVIUM); dense, moist		GP-GM			dense	moist	
	11.0		3554.4						
		(CH), FAT CLAY, trace fine sand, olive; (LACUSTRINE); hard, moist		CH			hard	moist	
	12.0		3553.4						
15		Bottom of test pit at 12.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-40

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,701.9 **Easting:** 1,542,445.8

Datum: NAD83 Zone 11

Elevation ft: 3510.7 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0	TOPSOIL	3510.7						
	1.0	(CL), LEAN CLAY, light brown; (LACUSTRINE); hard, moist	3509.7	CL			hard	moist	
	4.0	Practical refusal at 4.0 ft. on Arkosic Sandstone. Backfilled with excavated material and tamped with bucket.	3506.7						
5									
10									
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-41

DATE: 12-1-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,867,078.2 **Easting:** 1,542,686.7

Datum: NAD83 Zone 11

Elevation ft: 3549.6 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3549.6						
	0.5	TOPSOIL	3549.1						
		(CH), FAT CLAY WITH GRAVEL, few fine to coarse sand, few fine to coarse subrounded to subangular gravel, cobbles and boulders up to 12 inches in diameter, brown; (ALLUVIUM/COLLUVIUM); hard, moist		CH			hard	moist	
	2.0		3547.6						
		(SC), CLAYEY SAND, fine to coarse sand, some low plasticity fines, trace coarse rounded to subrounded gravel, light brown, stratified; (ALLUVIUM/COLLUVIUM); medium dense, moist		SC		GB S1	medium dense	moist	
5	8.0		3541.6						
		(SP-SM), POORLY GRADED SAND WITH SILT, fine to coarse sand, little low plasticity fines, very light brown; (ALLUVIUM/COLLUVIUM); dense, moist		SP-SM		GB S2	dense	moist	
10	14.0		3535.6			GB S3			
		Bottom of test pit at 14.0 ft. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-43

DATE: 12-6-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,864,001.2 **Easting:** 1,544,016.8

Datum: NAD83 Zone 11

Elevation ft: 3659.9 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3659.9						
	0.5	TOPSOIL	3659.4						
		(CL), SANDY LEAN CLAY WITH GRAVEL, some fine to coarse sand, little fine to coarse subrounded to subangular gravel, dark brown; (ALLUVIUM/COLLUVIUM); stiff, moist		CL			stiff	moist	
	2.5		3657.4						
		(ML), SANDY SILT, some fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light tan to pink-tan; (ALLUVIUM/COLLUVIUM); stiff, moist		ML			stiff	moist	
	4.5		3655.4						
5		(SM), SILTY SAND WITH GRAVEL, fine to coarse sand, some low plasticity fines, trace fine to coarse subrounded to subangular gravel, light tan to pale tan; (ALLUVIUM/COLLUVIUM); dense, moist							
		9 ft: Gravel content decreases		SM			dense	moist	
10									
15	15.0		3644.9			GB S1			
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-44

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,688.5 **Easting:** 1,544,624.8

Datum: NAD83 Zone 11

Elevation ft: 3550.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3550.0						
	0.5	TOPSOIL	3549.5						
	1.5	(CH), FAT CLAY, trace fine to coarse sand, brown; (ALLUVIUM/COLLUVIUM); hard, moist	3548.5	CH			hard	moist	
	2.0	(CL), LEAN CLAY WITH SAND, medium plasticity, few fine to coarse sand, light brown; (ALLUVIUM/COLLUVIUM); hard, moist	3548.0	CL			hard	moist	
	3.0	(SM), SILTY SAND, fine to coarse, low plasticity fines, trace fine to coarse subrounded to subangular gravel, very light brown; (ALLUVIUM/COLLUVIUM); medium dense, moist	3547.0	SM			medium dense	moist	
5		(SM), SILTY SAND, fine to coarse, low plasticity fines, trace fine to coarse subrounded to subangular gravel, tan-green to pale tan; (ALLUVIUM/COLLUVIUM); dense, moist		SM			dense	moist	
10	13.0		3537.0						
		Bottom of test pit at 13.0 ft. Backfilled with excavated material and tamped with bucket.							
15									

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

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Golder Associates Inc

RECORD OF TEST PIT LOG

TEST PIT NUMBER TP-45

DATE: 11-30-17

PROJECT: MDA/Grassy Mountain

PROJECT No.: 1663241

LOCATION: Malheur County, OR

Northing: 15,866,480.6 **Easting:** 1,544,964.4

Datum: NAD83 Zone 11

Elevation ft: 3565.0 **Length x Width ft:** 20.0 x 4.5

Contractor: (Andy Bentz)

Logged By: C. Bloom

Equipment: RB 500

Water Conditions:
NA

Surface Conditions:
Scrub Brush

DEPTH (ft)	SOIL PROFILE Depth	DESCRIPTION	Elev	USCS	GRAPHIC LOG	SAMPLE TYPE & NUMBER	CONSISTENCY[1] OR DENSITY[2]	INSITU, LABORATORY TESTING[1] & NOTES: WATER CONTENT (%)	INSITU, LABORATORY TESTING[1] & NOTES: OTHER TESTS & NOTES
0	0.0		3565.0						
	0.5	TOPSOIL	3564.5						
		(ML), SILT, trace fine to coarse sand, trace fine to coarse subrounded to subangular gravel, light brown to tan; (ALLUVIUM/COLLUVIUM); very stiff, moist		ML		GB S1	very stiff	moist	
	4.0		3561.0						
5		(CH), FAT CLAY, trace fine sand, olive to light gray; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	
	6.0		3559.0						
		(CH), SANDY FAT CLAY, some fine sand, very light brown; (LACUSTRINE); hard, moist, lime stringers and nodules		CH			hard	moist	
10									
15	15.0		3550.0						
		Bottom of test pit at 15.0 ft. Backfilled with excavated material and tamped with bucket.							

Notes: [1] See Legend Sheet for Definition of Terms, Symbols and Abbreviations
[2] Consistency or Density values are estimated based on excavation resistance and/or visual/manual assessment of samples

Checked: MLP
Reviewed: RAB

03 - GOLDER - TEST PIT LOG WITH PHOTO - TEST V7 2012_01_22B E-M 1A.GPJ - 5/1/18 11:29
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ATTACHMENT C

Field Permeability Testing

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

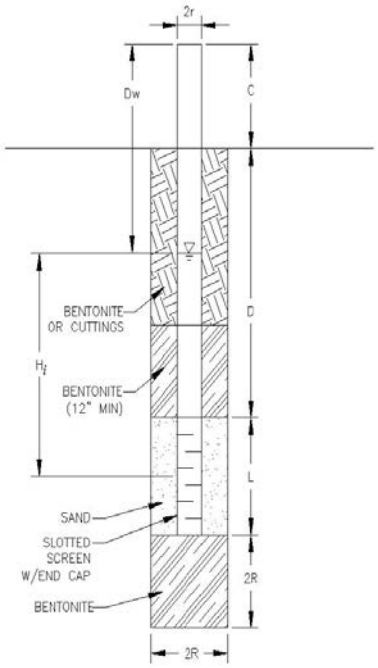
Borehole: BH-02 - Test 1

Setup Date Date: 12/6/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	20.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	3.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	5.0	0.21	0.00	---	---	---
1	10.0	0.33	0.12	25.2	25.1	9.0E-07
1	15.0	0.50	0.17	25.1	25.0	1.3E-06
1	20.0	0.70	0.20	25.0	24.8	1.5E-06
1	25.0	1.00	0.30	24.8	24.5	2.3E-06
1	30.0	1.20	0.20	24.5	24.3	1.6E-06
					Average:	1.5E-06

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

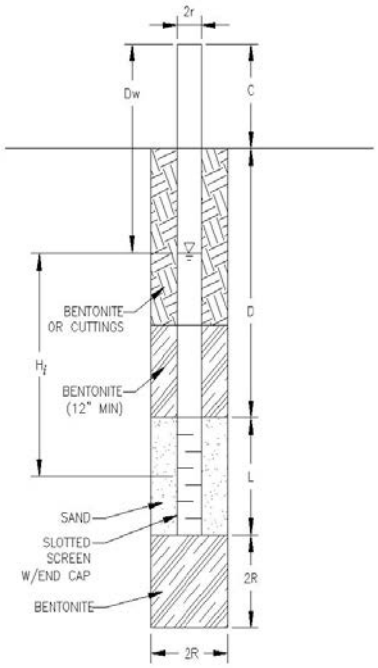
Borehole: BH-02 - Test 2

Setup Date Date: 12/6/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	20.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	3.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

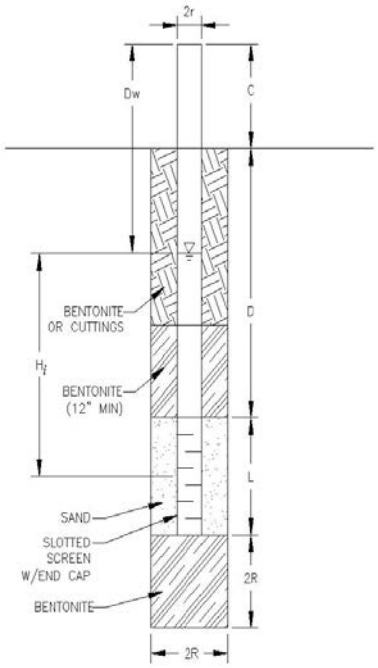
Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	5.0	0.0	0.0	---	---	---
2	19.0	1.5	1.5	25.5	24.0	4.1E-06
2	30.0	1.6	0.1	24.0	23.9	3.6E-07
2	35.0	1.9	0.3	23.9	23.6	2.4E-06
					Average:	2.3E-06

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-02 - Test 3
Setup Date Date: 12/6/2017
Test Date: 12/8/2017
Tested By: C. Johnson
Material Tested: Poorly Graded Sand

Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	20.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	3.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)



$$H_i = D + \frac{L}{2} + C - D_w$$

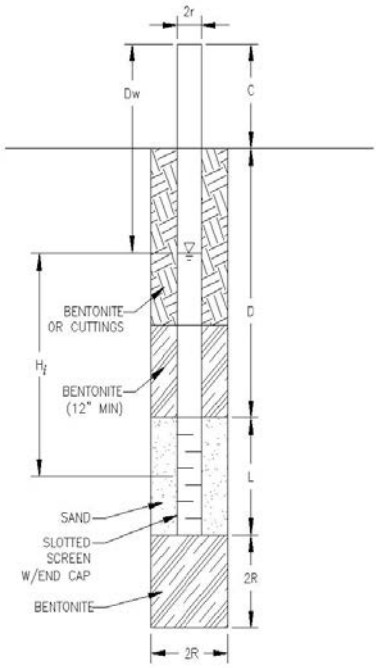
$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
3	0.5	0.3	0.0	---	---	---
3	1.0	0.4	0.1	25.2	25.1	7.5E-06
3	2.0	0.6	0.2	25.1	24.9	7.6E-06
3	4.0	0.9	0.3	24.9	24.6	5.7E-06
3	8.0	1.1	0.2	24.6	24.4	1.9E-06
3	16.0	1.4	0.3	24.4	24.1	1.5E-06
3	30.0	1.8	0.4	24.1	23.7	1.1E-06
					Average:	4.2E-06

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-03 - Test 1
Setup Date Date: 12/5/2017
Test Date: 12/6/2017
Tested By: C. Johnson
Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	2.0 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	1.5 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

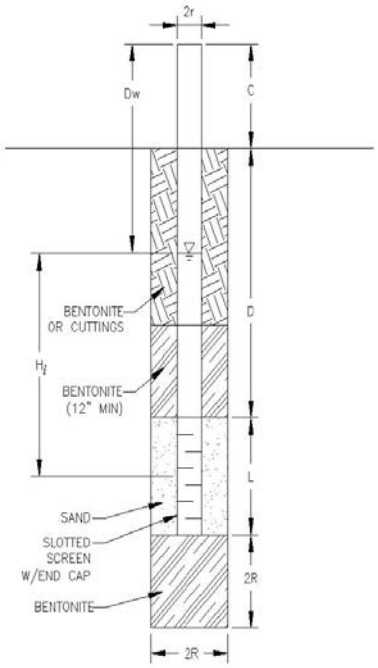
$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = $9.665x10^{-7}$

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	5.0	0.2	0.0	---	---	---
1	15.0	0.3	0.1	4.3	4.2	3.7E-06
1	20.0	0.5	0.2	4.2	4.0	1.5E-05
1	25.0	0.6	0.1	4.0	3.9	7.9E-06
1	30.0	0.8	0.2	3.9	3.7	1.6E-05
1	35.0	0.9	0.1	3.7	3.6	8.5E-06
1	40.0	1.1	0.2	3.6	3.4	1.8E-05
1	45.0	1.2	0.1	3.4	3.3	9.3E-06
1	50.0	1.2	0.0	3.3	3.3	0.0E+00
1	60.0	1.2	0.0	3.3	3.3	0.0E+00
1	55.0	1.2	0.0	3.3	3.3	0.0E+00
1	60.0	1.3	0.1	3.3	3.2	9.6E-06
1	65.0	1.4	0.2	3.3	3.1	1.9E-05
					Average:	9.0E-06

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-03 - Test 2
Setup Date Date: 12/5/2017
Test Date: 12/6/2017
Tested By: C. Johnson
Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	2.0 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	1.5 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

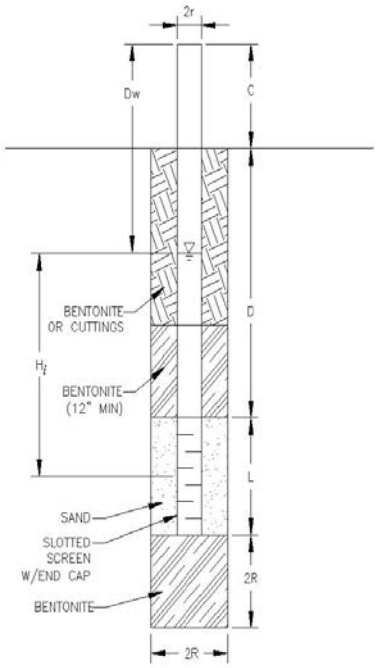
Note: ft/day to cm/s = $9.665x10^{-7}$

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	1.0	0.1	0.0	---	---	---
2	5.0	0.1	0.0	4.4	4.4	0.0E+00
2	10.0	0.2	0.1	4.4	4.3	7.1E-06
2	15.0	0.2	0.0	4.3	4.3	0.0E+00
2	20.0	0.2	0.0	4.3	4.3	0.0E+00
2	25.0	0.3	0.1	4.3	4.2	7.3E-06
2	30.0	0.3	0.0	4.2	4.2	0.0E+00
2	35.0	0.4	0.1	4.2	4.1	7.5E-06
2	40.0	0.5	0.1	4.1	4.0	7.7E-06
2	45.0	0.6	0.1	4.0	3.9	7.9E-06
2	50.0	0.6	0.0	3.9	3.9	0.0E+00
2	55.0	0.7	0.1	3.9	3.8	8.1E-06
2	60.0	0.8	0.2	3.9	3.7	8.2E-06
					Average:	4.5E-06

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

Borehole: BH-03 - Test 3

Setup Date Date: 12/5/2017
Test Date: 12/6/2017
Tested By: C. Johnson
Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	2.0 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	1.5 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

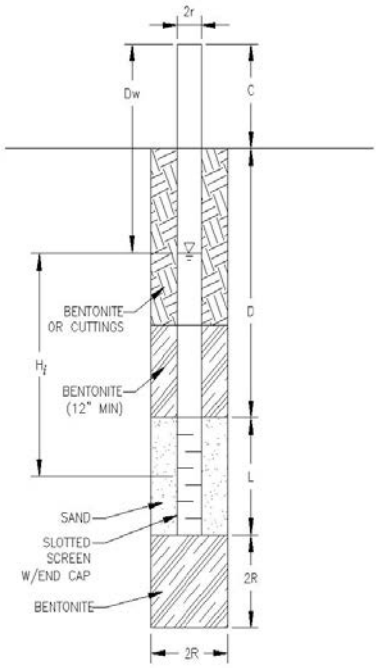
$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
3	0.0	0.3	0.0	---	---	---
3	5.0	0.4	0.1	4.2	4.1	7.5E-06
3	10.0	0.5	0.1	4.1	4.0	7.7E-06
3	15.0	0.6	0.1	4.0	3.9	7.9E-06
3	20.0	0.7	0.1	3.9	3.8	8.1E-06
					Average:	7.8E-06

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-05 - Test 1
Setup Date Date: 12/7/2017
Test Date: 12/8/2017
Tested By: C. Johnson
Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	10.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	1.8 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = $9.665x10^{-7}$

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	5.0	0.0	0.00	---	---	---
1	10.0	0.0	0.01	14.3	14.3	1.4E-07
1	16.0	0.0	0.01	14.3	14.3	1.1E-07
1	21.0	0.1	0.01	14.3	14.2	1.4E-07
1	27.0	0.1	0.01	14.2	14.2	1.2E-07
1	34.0	0.1	0.02	14.2	14.2	2.0E-07
					Average:	1.4E-07

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

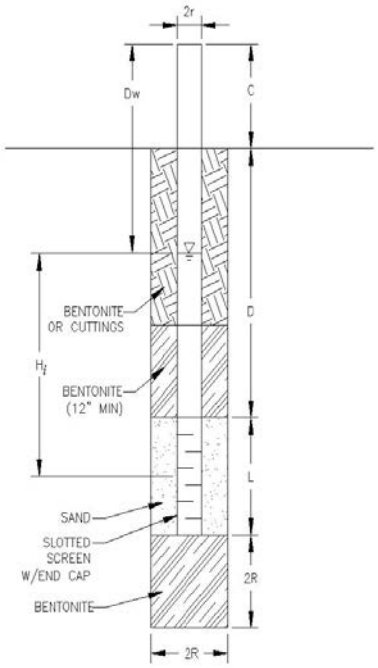
Borehole: BH-05 - Test 2

Setup Date Date: 12/7/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	10.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	1.8 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	5.0	0.0	0.00	---	---	---
2	10.0	0.1	0.08	14.3	14.2	1.1E-06
2	16.0	0.1	0.02	14.2	14.2	2.2E-07
2	22.0	0.1	0.02	14.2	14.2	2.2E-07
2	25.0	0.2	0.02	14.2	14.1	4.4E-07
2	30.0	0.2	0.05	14.1	14.1	6.7E-07
					Average:	5.2E-07

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

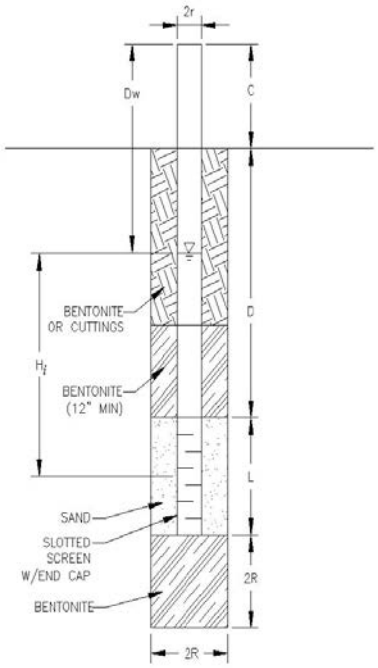
Borehole: BH-05 - Test 3

Setup Date Date: 12/7/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	10.0 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	1.8 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
3	5.0	0.0	0.0	---	---	---
3	10.0	0.4	0.4	14.3	13.9	5.1E-06
3	15.0	0.7	0.3	13.9	13.6	4.1E-06
3	20.0	1.0	0.3	13.6	13.3	4.2E-06
3	25.0	1.3	0.3	13.3	13.0	4.3E-06
3	33.0	1.8	0.5	13.0	12.5	4.6E-06
					Average:	4.5E-06

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

GOLDER

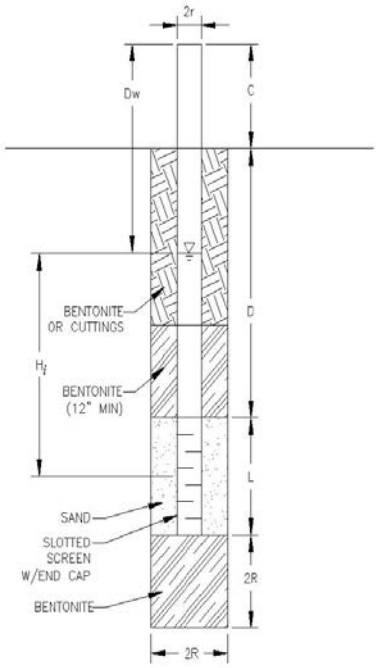
Borehole: BH-06 - Test 1

Setup Date Date: 12/7/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Fat Clay



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	22.8 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	0.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

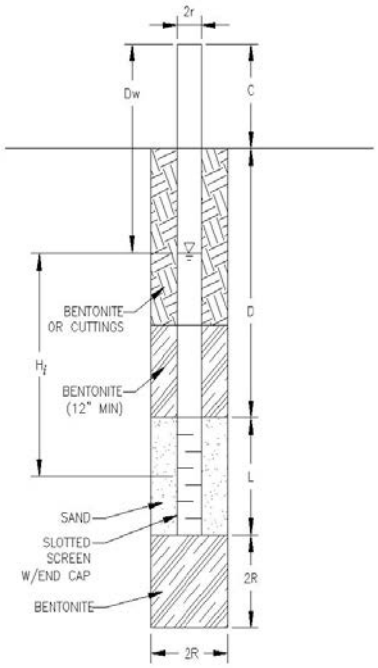
Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	5.0	0.1	0.0	---	---	---
1	10.0	0.1	0.0	23.8	23.7	1.3E-07
1	20.0	0.8	0.7	23.7	23.1	4.6E-06
1	26.0	0.8	0.1	23.1	23.0	5.6E-07
1	32.0	0.9	0.1	23.0	22.9	1.1E-06
1	39.0	1.0	0.0	22.9	22.9	4.8E-07
1	45.0	1.1	0.2	22.9	22.7	1.7E-06
1	50.0	1.2	0.0	22.7	22.7	6.8E-07
1	55.0	1.2	0.1	22.7	22.6	6.9E-07
1	60.0	1.3	0.1	22.6	22.6	6.9E-07
					Average:	1.2E-06

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-06 - Test 2
Setup Date Date: 12/7/2017
Test Date: 12/8/2017
Tested By: C. Johnson
Material Tested: Fat Clay

Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	22.8 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	3.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)



$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = $9.665x10^{-7}$

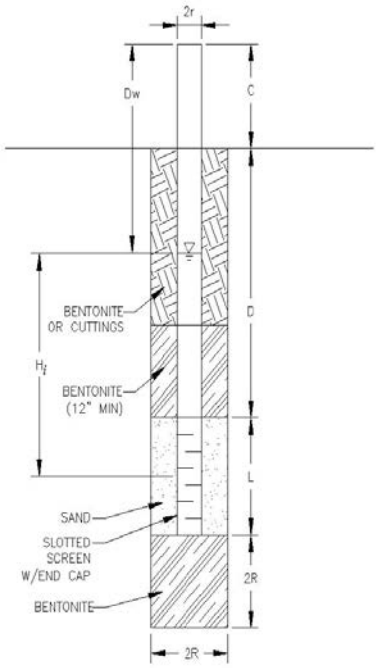
Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	5.0	0.02	0.00	---	---	---
2	10.0	0.03	0.01	26.8	26.8	1.2E-07
2	15.0	0.05	0.02	26.8	26.8	2.3E-07
2	20.0	0.08	0.03	26.8	26.7	3.5E-07
2	25.0	0.08	0.00	26.7	26.7	0.0E+00
2	30.0	0.09	0.01	26.7	26.7	1.2E-07
2	35.0	0.09	0.00	26.7	26.7	0.0E+00
2	40.0	0.09	0.00	26.7	26.7	0.0E+00
2	45.0	0.10	0.01	26.7	26.7	1.2E-07
2	50.0	0.11	0.01	26.7	26.7	1.2E-07
2	55.0	0.12	0.01	26.7	26.7	1.2E-07
2	60.0	0.13	0.01	26.7	26.7	1.2E-07
					Average:	1.2E-07

Date: 1/2/2018 Calculated By: CPJ
Proj. No.: 1663241 Checked By: MLP
Project : Grassy Mountain TSF Design

Borehole: BH-06 - Test 3
Setup Date Date: 12/7/2017
Test Date: 12/8/2017
Tested By: C. Johnson
Material Tested: Fat Clay

Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	22.8 ft	
length of Screen, L =	2.0 ft	
length of Collar, C =	3.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)



$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = $9.665x10^{-7}$

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	5.0	1.00	0.00	---	---	---
1	10.0	1.05	0.05	25.8	25.8	6.0E-07
1	15.0	1.07	0.02	25.8	25.7	2.4E-07
1	20.0	1.09	0.02	25.7	25.7	2.4E-07
1	25.0	1.10	0.01	25.7	25.7	1.2E-07
1	30.0	1.10	0.00	25.7	25.7	0.0E+00
1	35.0	1.12	0.02	25.7	25.7	2.4E-07
1	40.0	1.15	0.03	25.7	25.7	3.6E-07
1	45.0	1.20	0.05	25.7	25.6	6.1E-07
1	50.0	1.22	0.02	25.6	25.6	2.4E-07
1	55.0	1.23	0.01	25.6	25.6	1.2E-07
1	60.0	1.25	0.02	25.6	25.6	2.4E-07
					Average:	2.7E-07

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

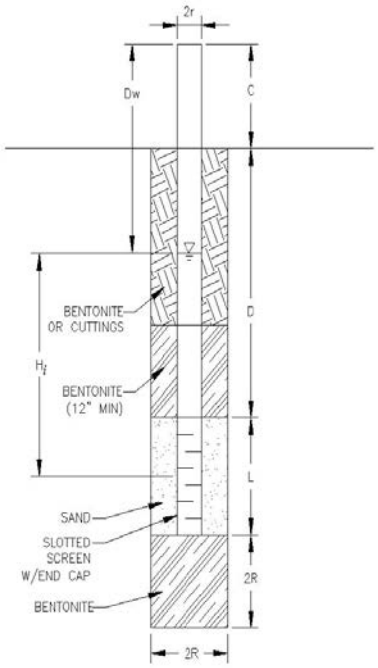
Borehole: BH-07 - Test 1

Setup Date Date: 12/1/2017

Test Date: 12/2/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand w/Gravel & Clay



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	14.5 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	1.7 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	1.0	0.2	0.0	---	---	---
1	2.0	0.4	0.2	18.5	18.3	1.0E-05
1	3.0	0.5	0.2	18.3	18.1	7.8E-06
1	4.0	0.6	0.1	18.1	18.0	5.2E-06
1	5.0	0.8	0.2	18.0	17.9	7.9E-06
1	12.0	1.6	0.9	17.9	17.0	6.6E-06
1	18.0	2.2	0.6	17.0	16.4	5.7E-06
1	32.0	3.4	1.2	16.4	15.2	5.1E-06
					Average:	6.9E-06

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

GOLDER

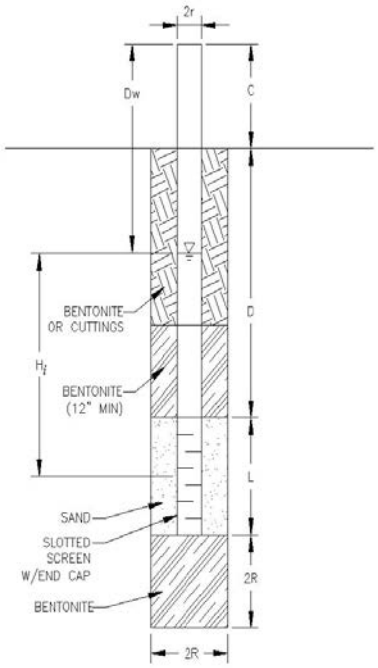
Borehole: BH-07 - Test 2

Setup Date Date: 12/1/2017

Test Date: 12/2/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand w/Gravel & Clay



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	14.5 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	1.7 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = $9.665x10^{-7}$

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	5.0	0.6	0.0	---	---	---
2	10.0	1.1	0.5	18.0	17.6	4.8E-06
2	15.0	1.5	0.5	17.6	17.1	4.9E-06
2	20.0	2.0	0.5	17.1	16.7	5.0E-06
2	25.0	2.4	0.4	16.7	16.3	4.6E-06
2	30.0	2.7	0.3	16.3	16.0	3.5E-06
					Average:	4.6E-06

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

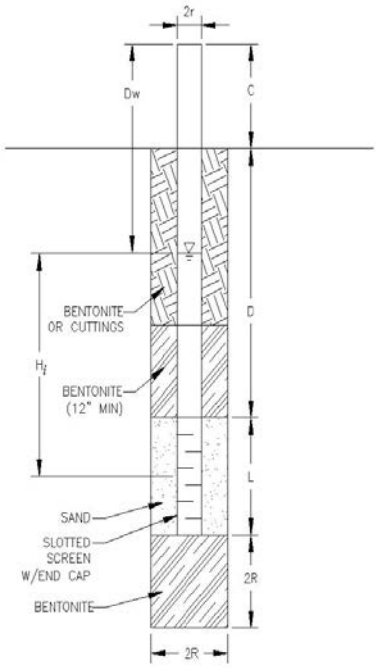
Borehole: BH-09 - Test 2

Setup Date Date: 12/7/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	3.6 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	2.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
1	1.0	1.6	0.0	---	---	---
1	3.0	3.8	2.1	6.5	4.4	1.9E-04
1	14.0	6.5	2.8	4.4	1.6	7.9E-05
1	20.0	6.7	0.2	1.6	1.4	2.1E-05
1	25.0	6.9	0.1	1.4	1.3	2.1E-05
1	33.0	7.1	0.2	1.3	1.1	2.1E-05
						2.1E-05

Date:	1/2/2018	Calculated By:	CPJ
Proj. No.:	1663241	Checked By:	MLP
Project :	Grassy Mountain TSF Design		

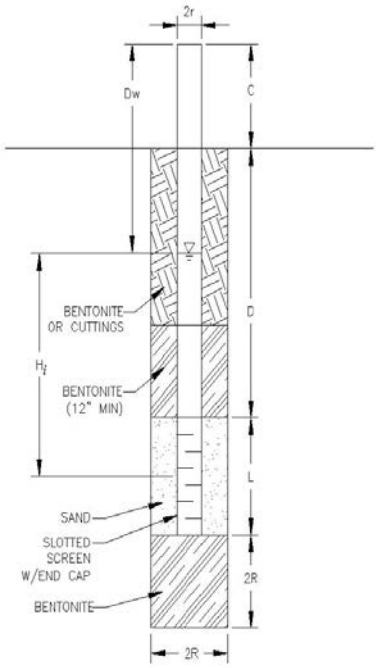
Borehole: BH-09 - Test 2

Setup Date Date: 12/7/2017

Test Date: 12/8/2017

Tested By: C. Johnson

Material Tested: Poorly Graded Sand



Well Dimensions

Standpipe Diameter, 2r =	0.17 ft	(2-inch PVC Pipe)
Depth to top of Screen, D =	3.6 ft	
length of Screen, L =	5.0 ft	
length of Collar, C =	2.0 ft	
Diameter of Borehole, 2R =	0.69 ft	(8.25-inches)

$$H_i = D + \frac{L}{2} + C - D_w$$

$$K(cm/s) = \left[\frac{\frac{365r^2}{L} Ln\frac{L}{R}}{t}\right]\left[\frac{\Delta h}{H_1 + H_2}\right]\left(9.665x10^{-7}\right)$$

Note: ft/day to cm/s = 9.665×10^{-7}

Test	Elapsed Time (min)	Depth of Water, D_w (ft)	Incremental Water Level Drop (ft)	Beginning Head (ft)	Ending Head (ft)	Hydraulic Conductivity, K (cm/s)
2	1.0	2.0	0.0	---	---	---
2	5.0	4.0	2.0	6.1	4.1	9.3E-05
2	12.0	5.6	1.6	4.1	2.5	6.5E-05
2	17.0	6.3	0.7	2.5	1.8	6.2E-05
2	25.0	7.1	0.8	1.8	1.0	6.7E-05
2	30.0	7.4	0.3	1.0	0.8	5.4E-05
						5.4E-05

ATTACHMENT D

CPT Logs

Taber
EXPLORATION & TESTING

536 Galveston Street
West Sacramento, CA 95691-2116
Office **(916) 371-8234**
Fax (916) 371-8283

October 2, 2019

Golder Associates, Inc.
Attention: Chris MacMahon, PE
595 Double Eagle Court, Suite 1000
Reno, Nevada 89521

Subject: CPT – Data Transmittal
Grassy Mountain Project
Malheur County, OR

Greetings:

This letter transmits the Data Results of Electronic Cone Penetrometer testing performed at your request on the Grassy Mountain Project during the period August 15-22, 2019. Results include data plots, seismic profiles and text files.

Testing is performed with equipment and in a manner consistent with the ASTM standard for Electronic Cone Penetrometer (CPT) developed in 1986, ASTM D3441. Equipment used includes a Standard 10-ton, 10sq cm cone tip (which measures tip resistance, cohesive strength [with a friction sleeve] and a pressure transducer [which determines pore water pressure], a rod system for pushing (3.6cm cross-section), a special 10-ton cone with geo-phones for developing seismic data (as required for the test program) and a ten-wheeled truck unit ballasted to 40,000lbs for push resistance with two hydraulic rams mounted inside the truck capable of generating 20-tons of downward push.

Data is collected by advancing the cone at a controlled rate (between 1.5-2.5cm per second) with measurements taken at 2cm increments. Seismic and pore pressure measurements are taken at discrete depths as dictated by the study program. Data is collected and recorded in real time and with Vertek-Hogentogler Electronics and processed and presented with Vertek-Hogentogler Software.

We appreciate this opportunity to be of service.

Very truly yours,
TABER DRILLING

Tim d'Arcy
Exploration Supervisor

Attachments: Data Plots
Text Files
Raw Data Files

Parameter	Description	Symbol / Equation	Reference
Depth	Depth of the centroid of the sensor		
Elevation	Elevation of centroid of the sensor	Ground Surface - Depth	
Sleeve Stress	Sleeve Stress – interpolated to the depth of the tip	f_s	
Tip Stress, Uncorrected	Measured Tip Stress	q_c	
Tip Stress, Corrected	Tip Stress, corrected for probe geometry	$q_t = q_c + u_2 \times (1 - a)$	
Friction Ratio	Friction Ratio	$R_f = \frac{f_s}{q_t} \times 100\%$	
Pore Pressure	Measured Pore Pressure	u_2	
Inclination X	Measured probe inclination in the X axis		
Inclination Y	Measured probe inclination in the Y axis		
Resistivity	Measured Soil Resistivity		

Soil Behavior Type	Soil Behavior Type Options • R_f Robertson 1986 • B_q Roberson 1986 • F_r Robertson 1990 • B_q Robertson 1990	SBT	Lunne, Roberson and Powell, 1997, Figures 5.7 and 5.8
Classification Index		$I_c = \sqrt{(1.95 - \log_{10} Q_t)^2 + (\log_{10} F_r + 1.78)^2}$	Frank Syms, Bechtel Corporation
Overburden		$\sigma_{vo} = \sum_{i=1}^{n} \gamma_i \times h_i$	
Effective Overburden		$\sigma'_{vo} = \sigma_{vo} - u_o$	
Normalized Tip Stress		$Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}}$	Lunne, Roberson and Powell, 1997, Equation 5.4
Parameter	**Description**	**Symbol / Equation**	**Reference**
Normalized Friction Ratio		$F_r = \frac{f_s}{q_t - \sigma_{vo}}$	Lunne, Roberson and Powell, 1997, Equation 5.5
Normalized Pore Pressure		$B_q = \frac{\Delta u}{q_t - \sigma_{vo}}$ where $\Delta u = u_2 - u_o$	Lunne, Roberson and Powell, 1997, Equation 5.6
Over Consolidation Ratio		$OCR = 0.33 \times \left(\frac{\Delta u}{\sigma'_{vo}} \right)^{1.42}$	InSitu '86, Mayne Equation 8, pg. 789
Undrained Shear Strength		$S_u = \frac{q_c - \sigma_{vo}}{N_k}$ where $N_k = 15$	Lunne, Roberson and Powell, 1997, Equation 5.16
Friction Angle		$\phi = \arctan\left[0.38 \times \log_{10}\left(\frac{q_c}{\sigma_{vo}} \right) + 0.1 \right] \times \frac{180}{\pi}$	Robertson and Campanella, 1988, pg. 94.

EQUATION USED TO CALCULATE SPT

Reference(s):

Equation:

if (SBT = 1, 5 or 12)	SPTRAT = 2.00
if (SBT = 2, 3 or 11)	SPTRAT = 1.00
if (SBT = 4)	SPTRAT = 1.50
if (SBT = 6)	SPTRAT = 2.50
if (SBT = 7)	SPTRAT = 3.00
if (SBT = 8)	SPTRAT = 4.00
if (SBT = 9)	SPTRAT = 5.00
if (SBT = 10)	SPTRAT = 6.00

$$N_{60} = \frac{q_t}{SPTRAT}$$

$$N_{60}Cor = N_{60} \times \sqrt{\left(\frac{1.0}{\sigma_{ve}}\right)}$$

Where:

SBT	= Soil Behavior Type (Friction Ratio, Robertson 1986)
SPTRAT	= SPT Ratio (used in calculation)
Q_t	= Corrected Tip Stress (tsf)
σ_{ve}	= Overburden (tsf)

HT Series™

10 cm² Digital Cone

Available in 2.5 Ton, 5 Ton, and 10 Ton Cone Configurations

The digital electronic 10 cm² cone is designed to address the accuracy, sensitivity and durability problems inherent in other cone designs of the same or lower capacity. This cone provides excellent data for softer materials and provides excellent resolution in most materials. This cone has a 10 sq. cm tip.

The Cones consists of two strain guage transducers, with the cone electronics packaged directly behind the transducers. In all configurations the cone channels are temperature compensated to provide stable readings during testing. The cone tip, sleeve (local friction element) and pore pressure element (filter) are easily and quickly changed when necessary by the operator.

The cone is available with our standard channels (tip, local friction, pore pressure, inclinometer, seismic, and temperature) and can be used in conjunction with our Vision or Resistivity modules.

Pore Pressure can be measured in either U1 or U2 position (on the face of the tip or just behind the tip) (U2 shown at left)

Cone Channels:
- Tip
- Local Friction
- Pore Pressure
- Temperature
- Inclination
- Seismic
- Resistivity Module (optional)
- Vision Module (optional)

CPTSound Penetration Screen

Calibration data for tip, local friction and pore pressure channels is stored in CPU nonvolatile memory. Digital cones conform to all international standards.

CERTIFIED ISO 9001:2008

HT Series™

10cm² Cone Specifications

Max Tip Force	2.5 Ton	5Ton	10Ton
Resolution	1.1uV	1.1uV	1.1uV
Maximum Sensor input	3.5V	3.5V	3.5V
Power Requirements	12VDC	12VDC	12VDC
Tip			
area	10cm²	10cm²	10cm²
range(kn)	22	45	100
range(lb)	5,000	10,000	22,000
range(mpa)	22	45	100
overload capacity	150%	150%	150%
accuracy	0.2%	0.2%	0.2%
Sleeve			
area	150cm²	150cm²	150cm²
range(kn)	20	20	20
range(lb)	4,400	4,400	4,400
range(mpa)	1.3	1.3	1.3
Pore Pressure Transducer			
standard range (kpa)	6,900	6,900	6,900
standard range (psi)	1,000	1,000	1,000
burst pressure	200%	200%	200%
accuracy	0.5%	0.5%	0.5%
Inclinator (Dual Axis)			
range (degrees)	15	15	15
resolution (degree)	0.1	0.1	0.1
Seismic			
standard tri-axial geophone			
true DC response			
capacity: +/-	2g	2g	2g

Seismic signal is gained downhole
by 1,10,100, or,100 and digitalized in the Datapack
no extra wires ir analog measurement required

CERTIFIED ISO 9001:2008

HT Series™

15 cm² Digital Cone

Available in 2.5 Ton, 5 Ton and 20 Ton Cone Configurations

The digital electronic 15 cm² cone is designed to address the accuracy, sensitivity and durability problems inherent in other cone designs of the same or lower capacity. This cone has a 15 sq. cm tip.

The Cones consists of two strain gauge transducers, with the cone electronics packaged directly behind the transducers. The cone channels are temperature compensated to provide stable readings during,testing. The cone tip, sleeve (local friction element) and pore pressure element (filter) are easily and quickly changed when necessary by the operator.

The cone is available with our standard channels (tip, local friction, pore pressure, inclinometer, seismic, and temperature) and can be used in conjunction with our Vision or Resistivity modules.

Pore Pressure can be measured in either U1 or U2 position (on the face of the tip or just behind the tip) (U2 shown at left)

Cone Channels:
- Tip
- Local Friction
- Pore Pressure
- Temperature
- Inclination
- Seismic

CPTSound Penetration Screen

Calibration data for tip, local friction and pore pressure channels is stored in CPU nonvolatile memory. Digital cones conform to all international standards.

CERTIFIED ISO 9001:2008

HT Series™

15cm² Cone Specifications

Max Tip Force	2.5 Ton	5 Ton	20 Ton
Resolution	1.1 uV	1.1 uV	1.1 uV
Maximum Sensor Input	3.5 V	3.5 V	3.5 V
Power Requirements	12 VDC	12 VDC	12 VDC
Tip			
area	15 cm^2	15 cm^2	15 cm^2
range (kn)	22	44	225
range (lb)	5,000	10,000	50,000
range (mpa)	15	30	150
overload capacity	150%	150%	150%
accuracy	0.2%	0.2%	0.2%
Sleeve			
area	225 cm^2	225 cm^2	225 cm^2
range (kn)	45	45	45
range (lb)	10,000	10,000	10,000
range (mpa)	2	2	2
overload capacity	150%	150%	150%
accuracy	0.5%	0.5%	0.5%
Pore Pressure Transducer			
standard range (kpa)	6,900	6,900	6,900
standard range (psi)	1,000	1,000	1,000
burst pressure	200%	200%	200%
accuracy	0.5%	0.5%	0.5%
Inclinometer (Dual Axis)			
range (degrees)	15	15	15
resolution (degree)	0.1	0.1	0.1
Seismic			
standard tri-axial geophone	2g	2g	2g
true DC response			
capacity: (+/-) -			

Seismic signals are gained downhole by 1, 10, 100, or 1,000 and digitized in the DataPack

CERTIFIED ISO 9001:2008

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION:

JOB NUMBER:
HOLE NUMBER: CPT-1a
TEST DATE: 8/16/2019 9:04:47 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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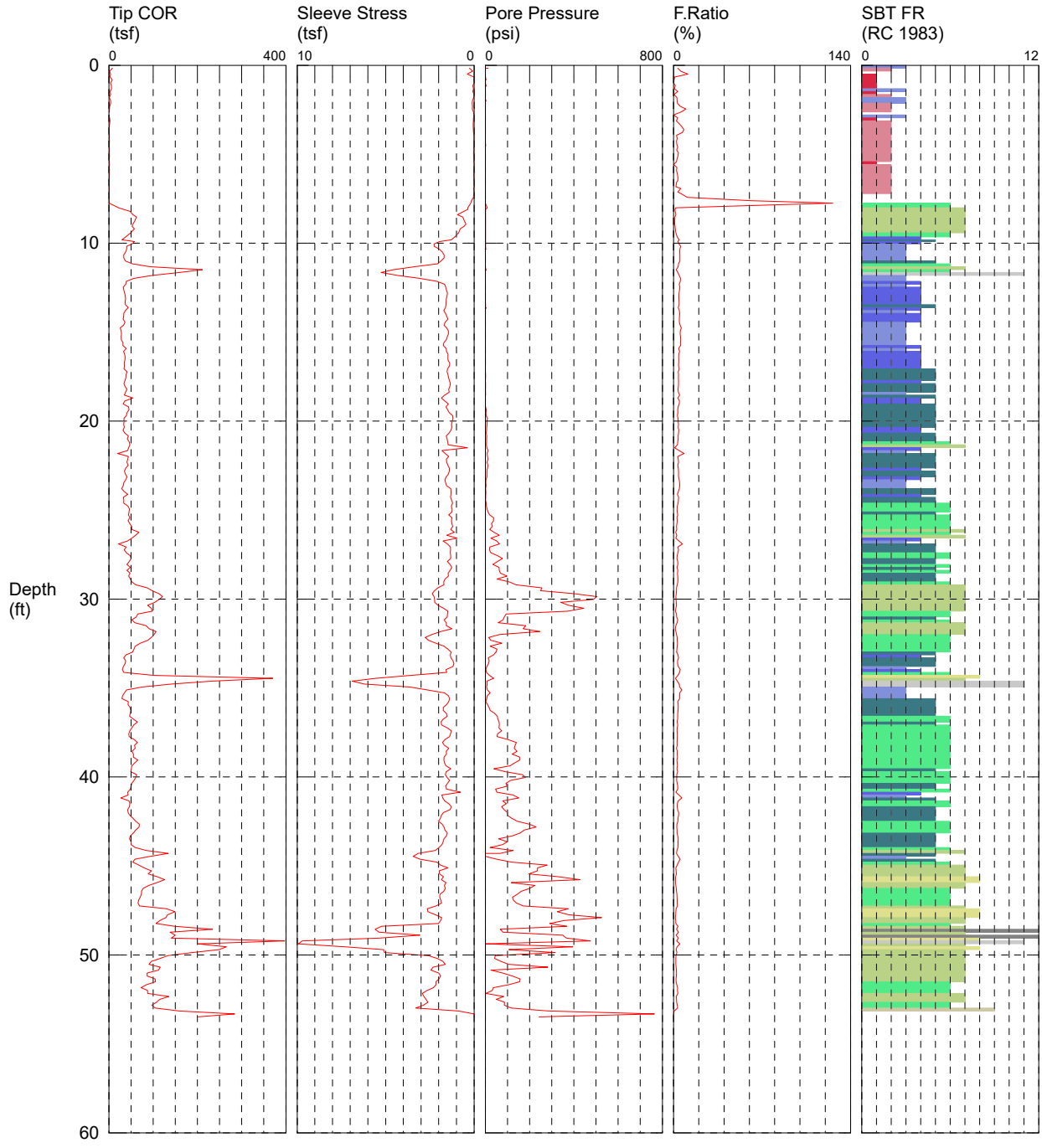
LOCATION:
LOCATION:
LOCATION:



1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION:

JOB NUMBER:
HOLE NUMBER: CPT-2a
TEST DATE: 8/16/2019 1:06:07 PM
COMMENT: Auto Enhance On
COMMENT: Filter On

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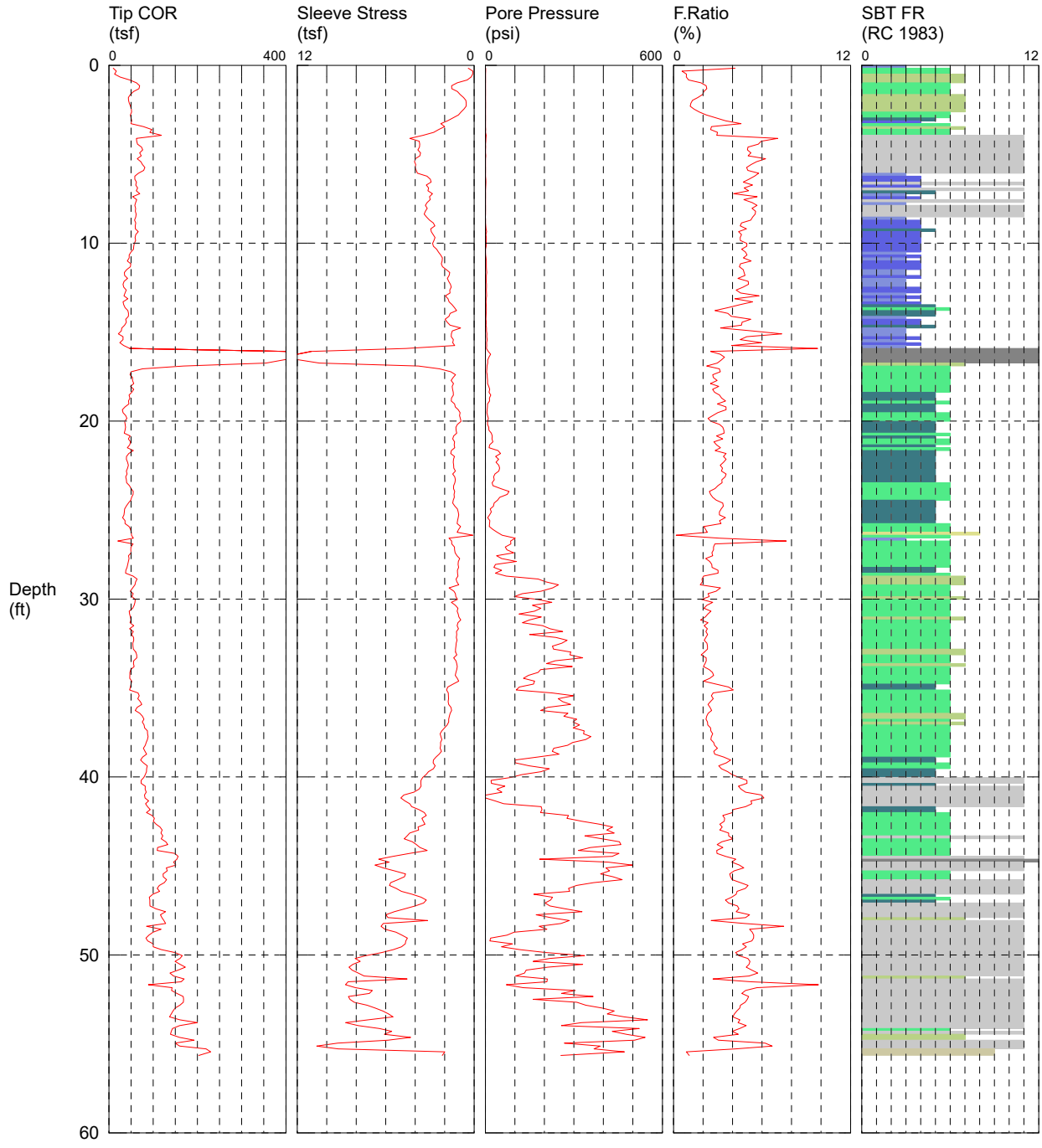

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11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: TP-45

JOB NUMBER:
HOLE NUMBER: CPT-3b
TEST DATE: 8/17/2019 9:07:47 AM
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COMMENT: Filter On

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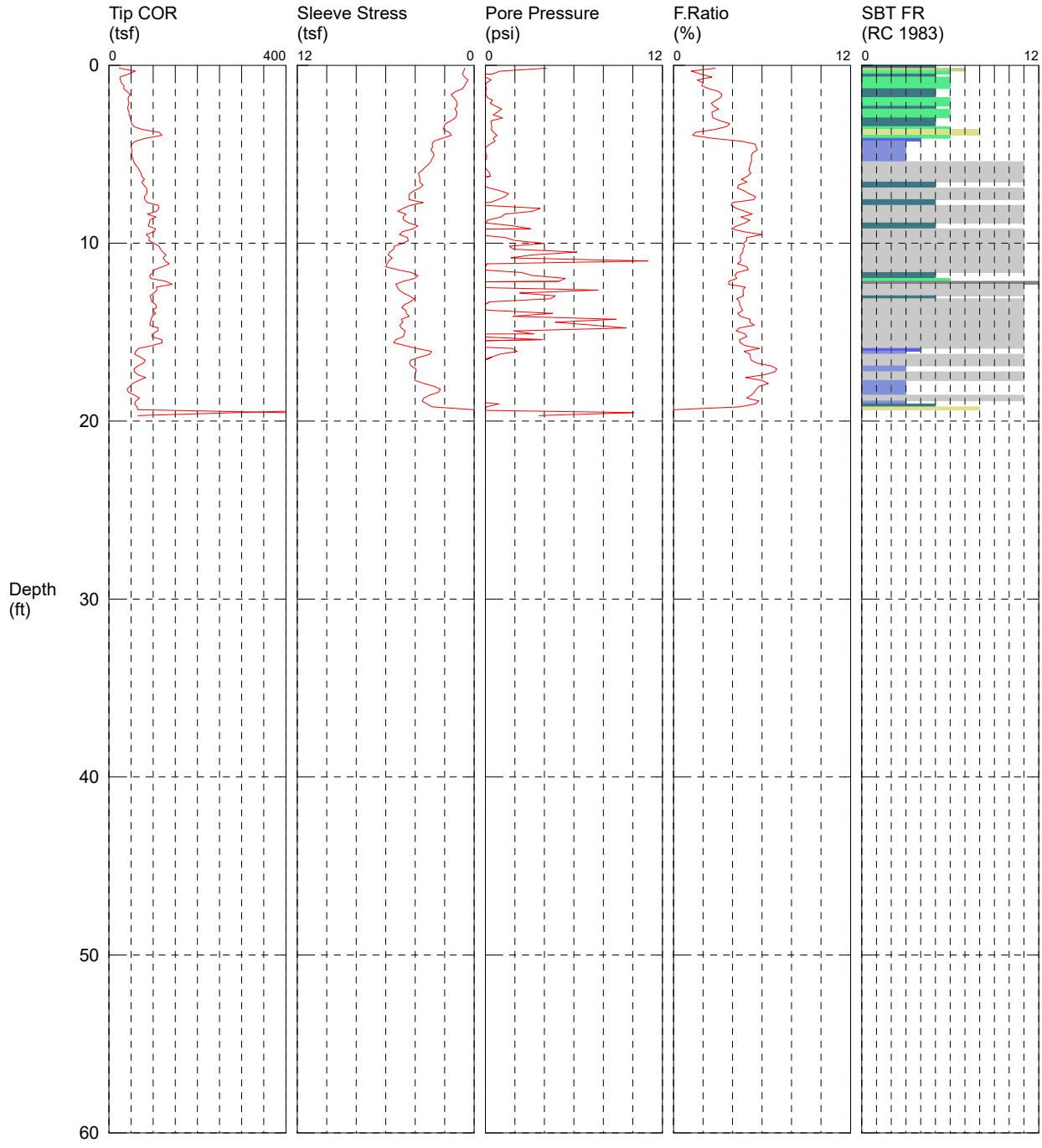

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12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: TP-19

JOB NUMBER:
HOLE NUMBER: CPT-4
TEST DATE: 8/17/2019 10:16:42 AM
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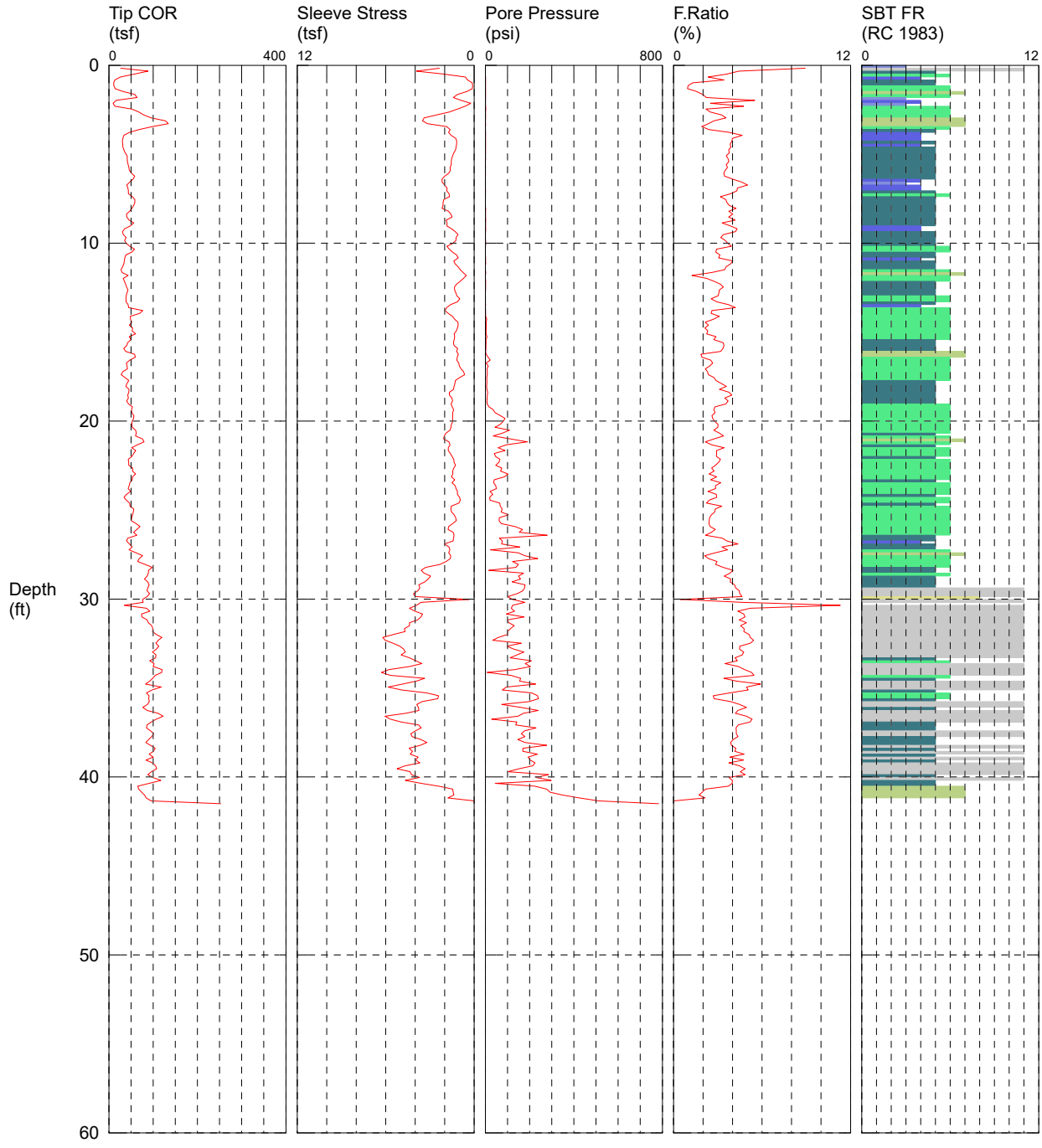

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-15

JOB NUMBER:
HOLE NUMBER: CPT-5
TEST DATE: 8/17/2019 11:58:32 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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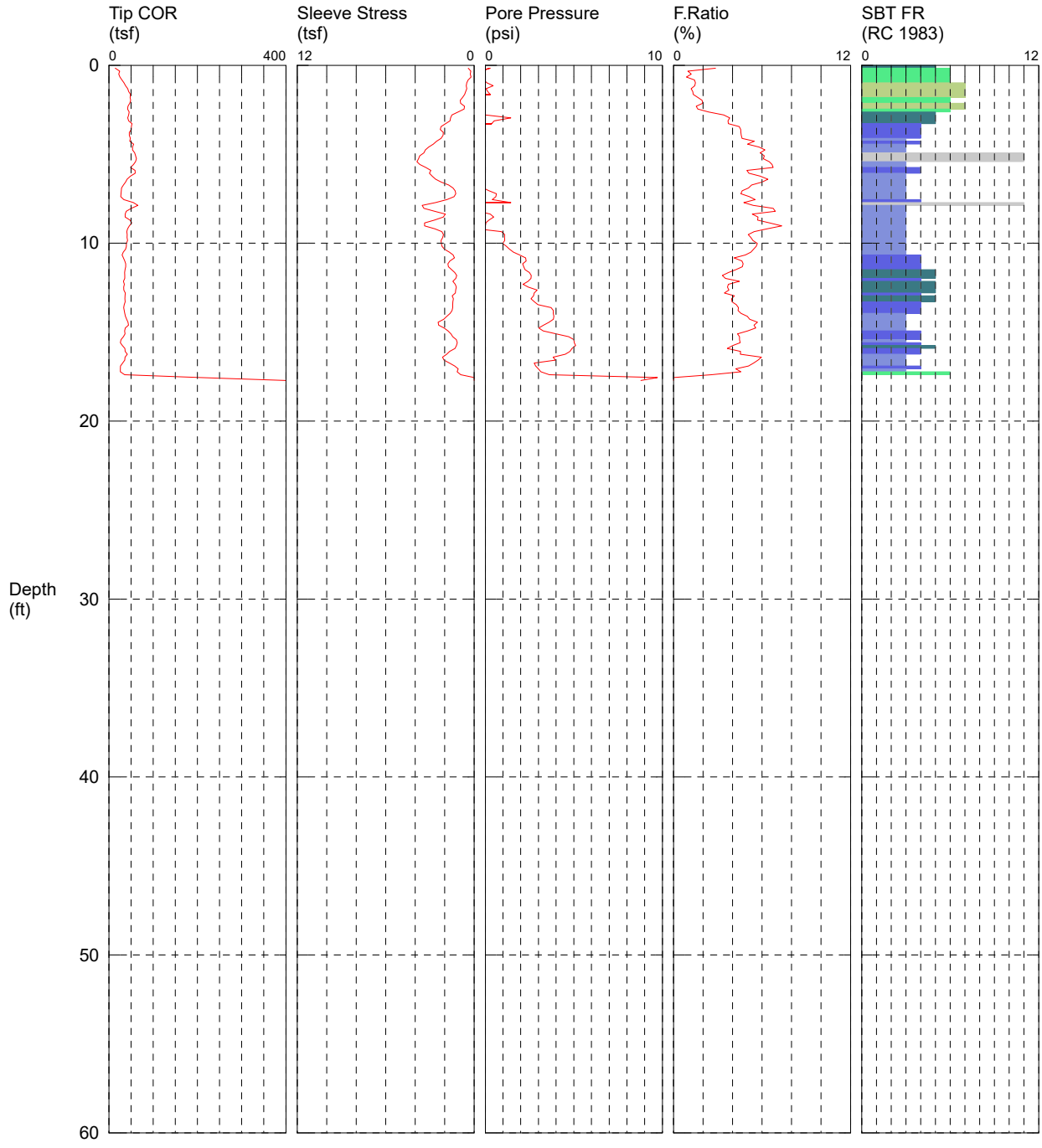

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-4

JOB NUMBER:
HOLE NUMBER: CPT-6
TEST DATE: 8/18/2019 8:17:17 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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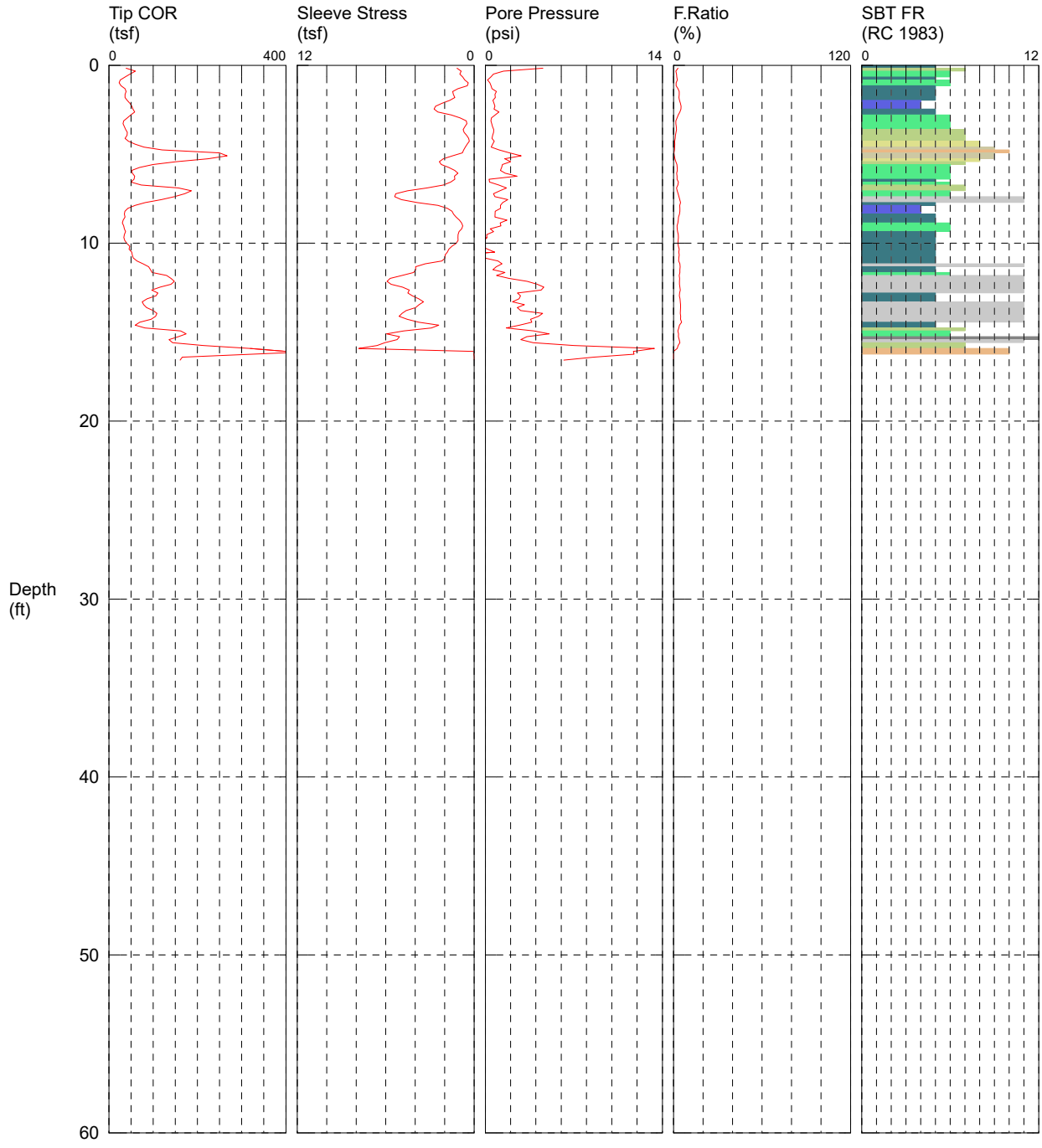

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: TP-14

JOB NUMBER:
HOLE NUMBER: CPT-7b
TEST DATE: 8/18/2019 11:02:13 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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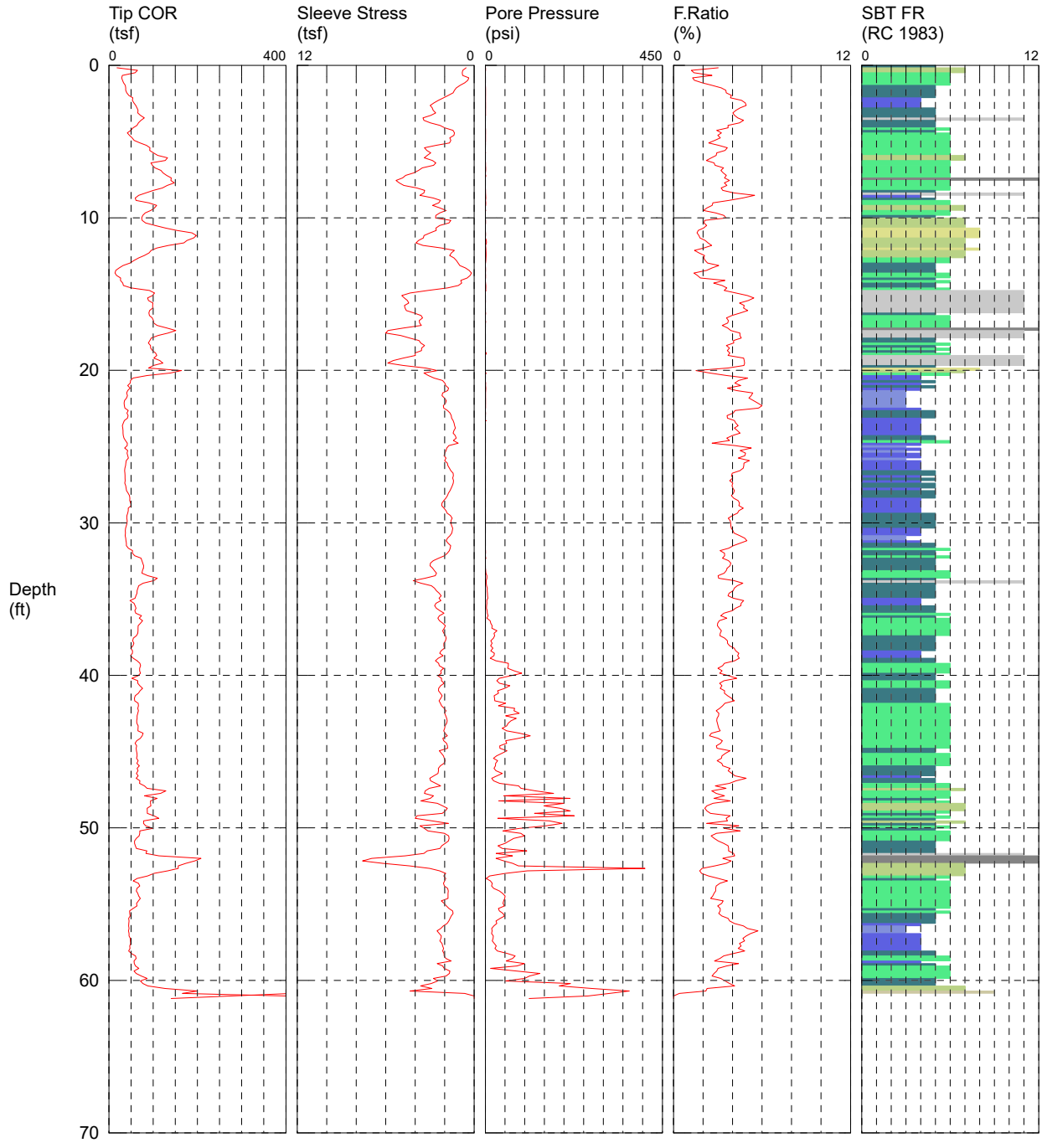

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-9

JOB NUMBER:
HOLE NUMBER: CPT-8c
TEST DATE: 8/19/2019 9:40:12 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

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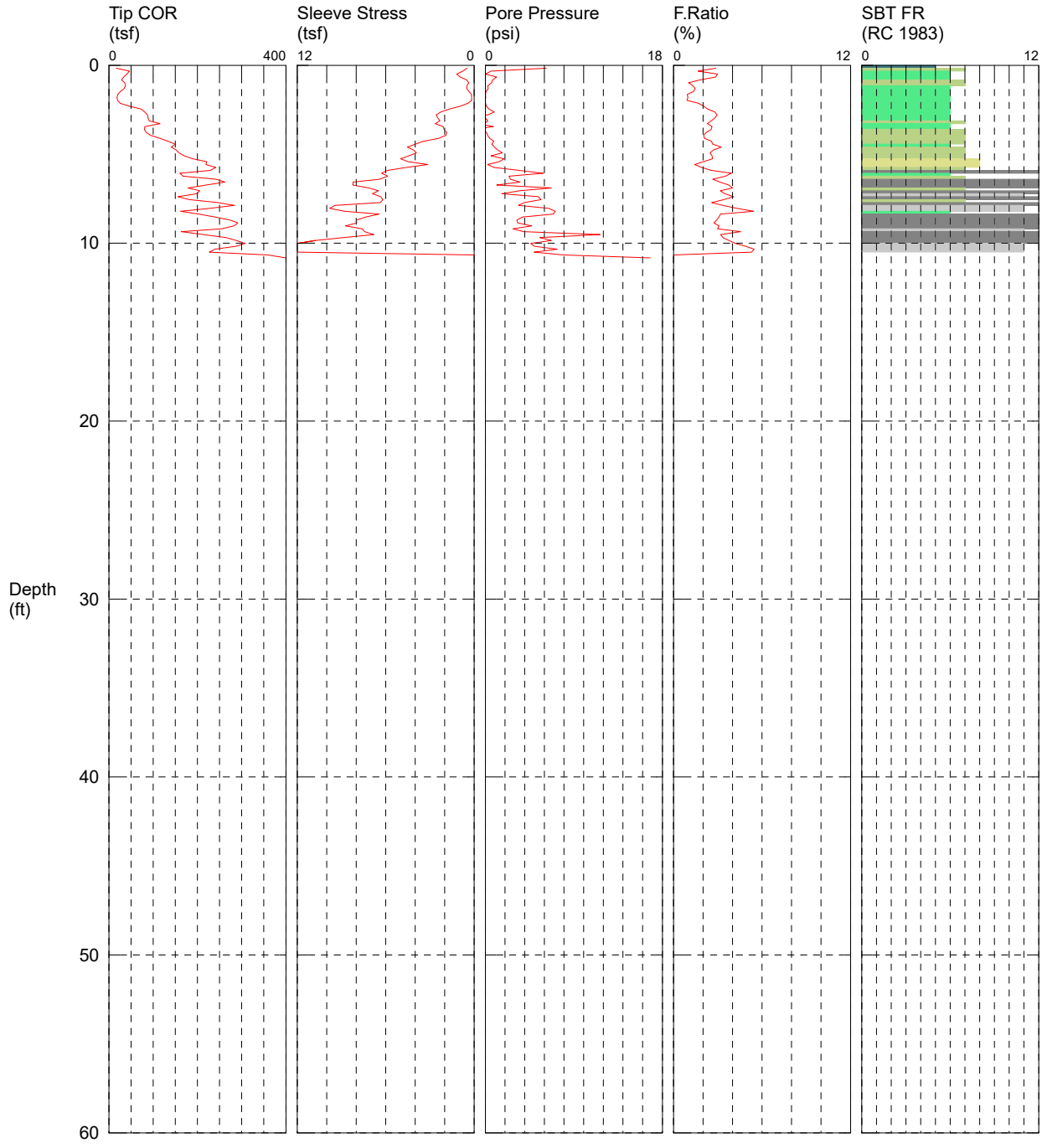

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-3

JOB NUMBER:
HOLE NUMBER: CPT-9
TEST DATE: 8/19/2019 10:26:31 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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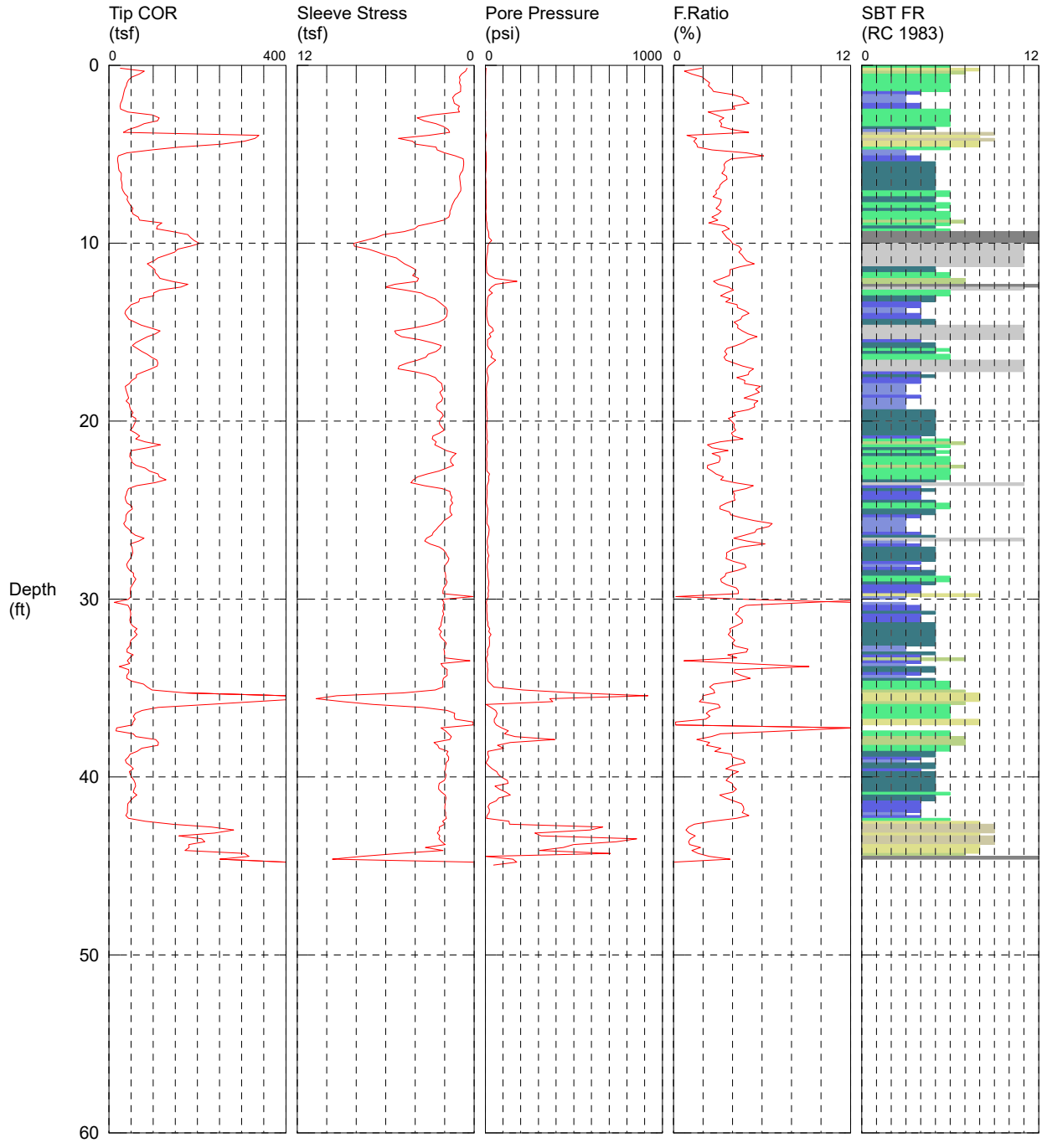

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-5

JOB NUMBER:
HOLE NUMBER: CPT-10
TEST DATE: 8/19/2019 1:36:02 PM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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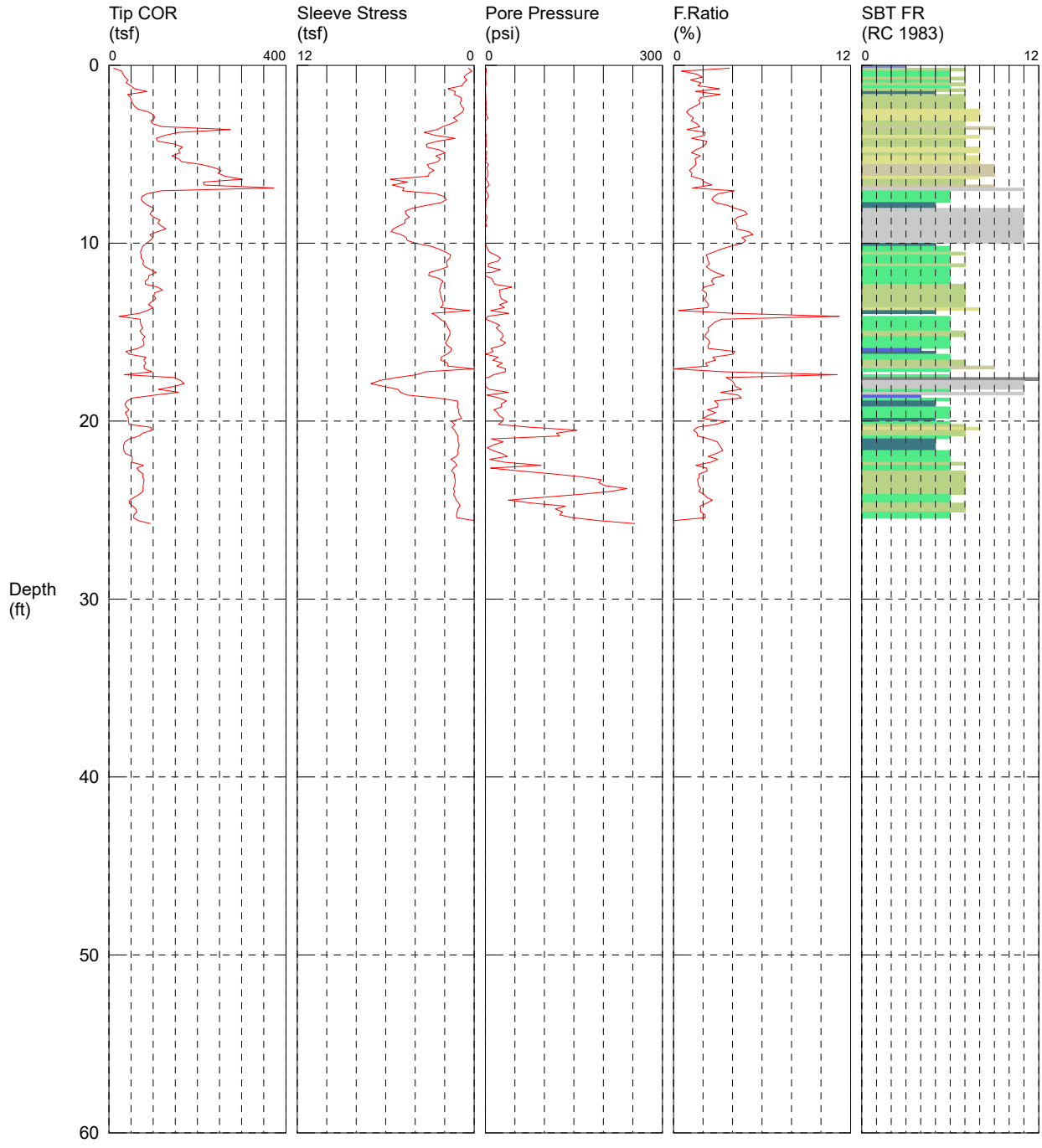

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*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: BH-7

JOB NUMBER:
HOLE NUMBER: CPT-11a
TEST DATE: 8/20/2019 8:29:13 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

COMMENT:
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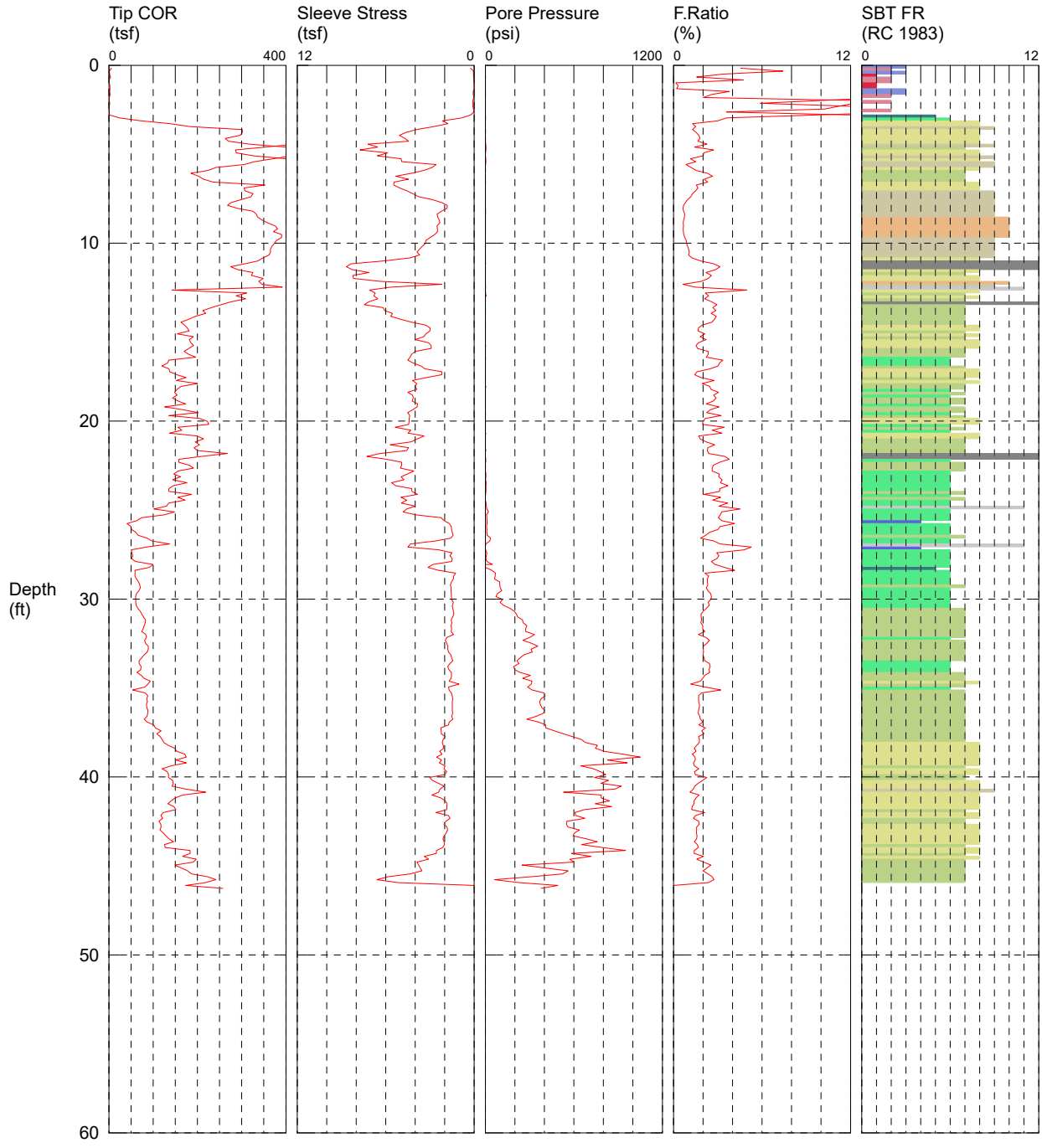

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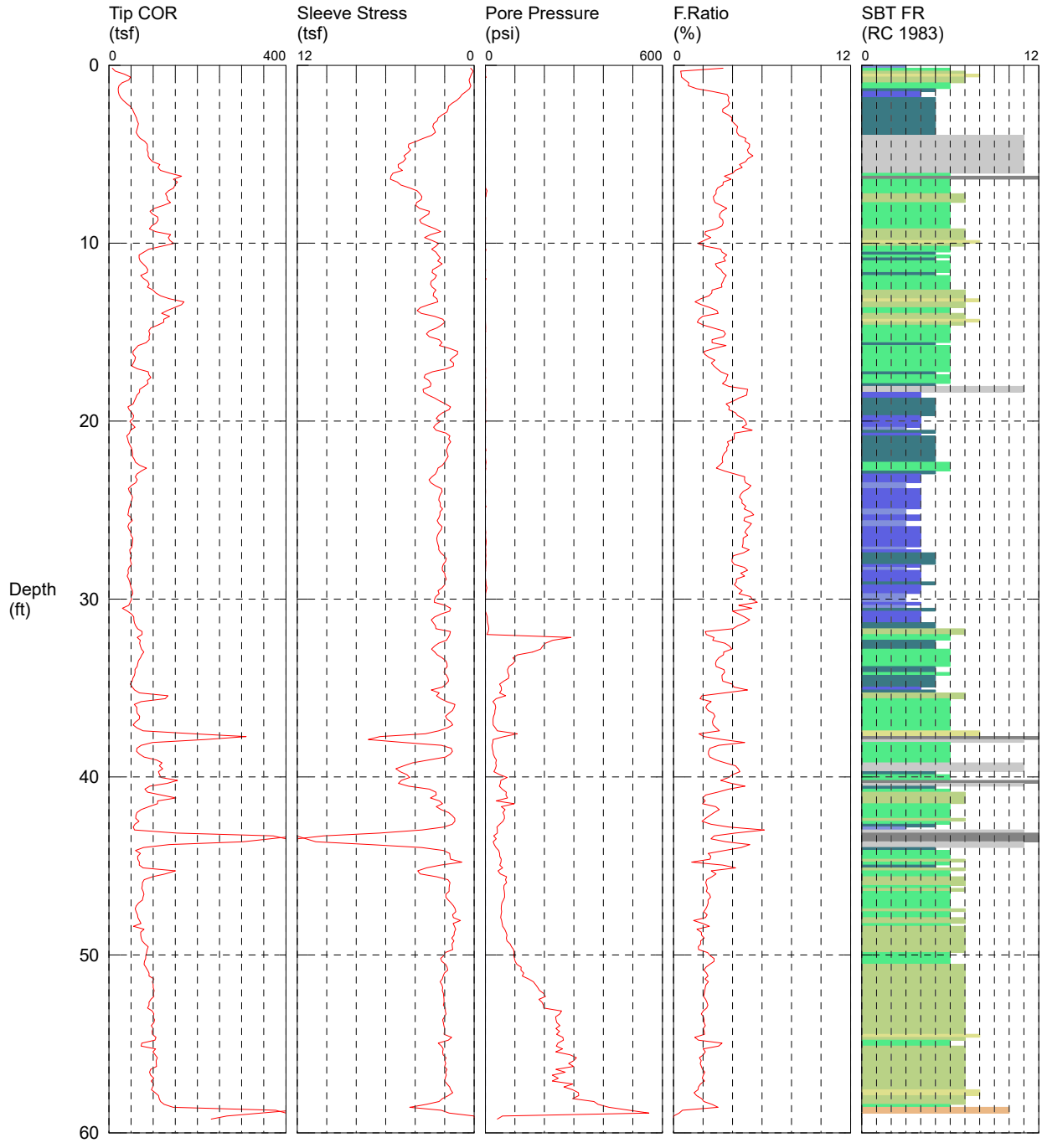
*SBT/SPT CORRELATION: UBC-1983

SOUNDING

SOUNDING
CUSTOMER: Taber Drilling
OPERATOR: Tim
CONE ID: DDG1361
LOCATION: TP-17

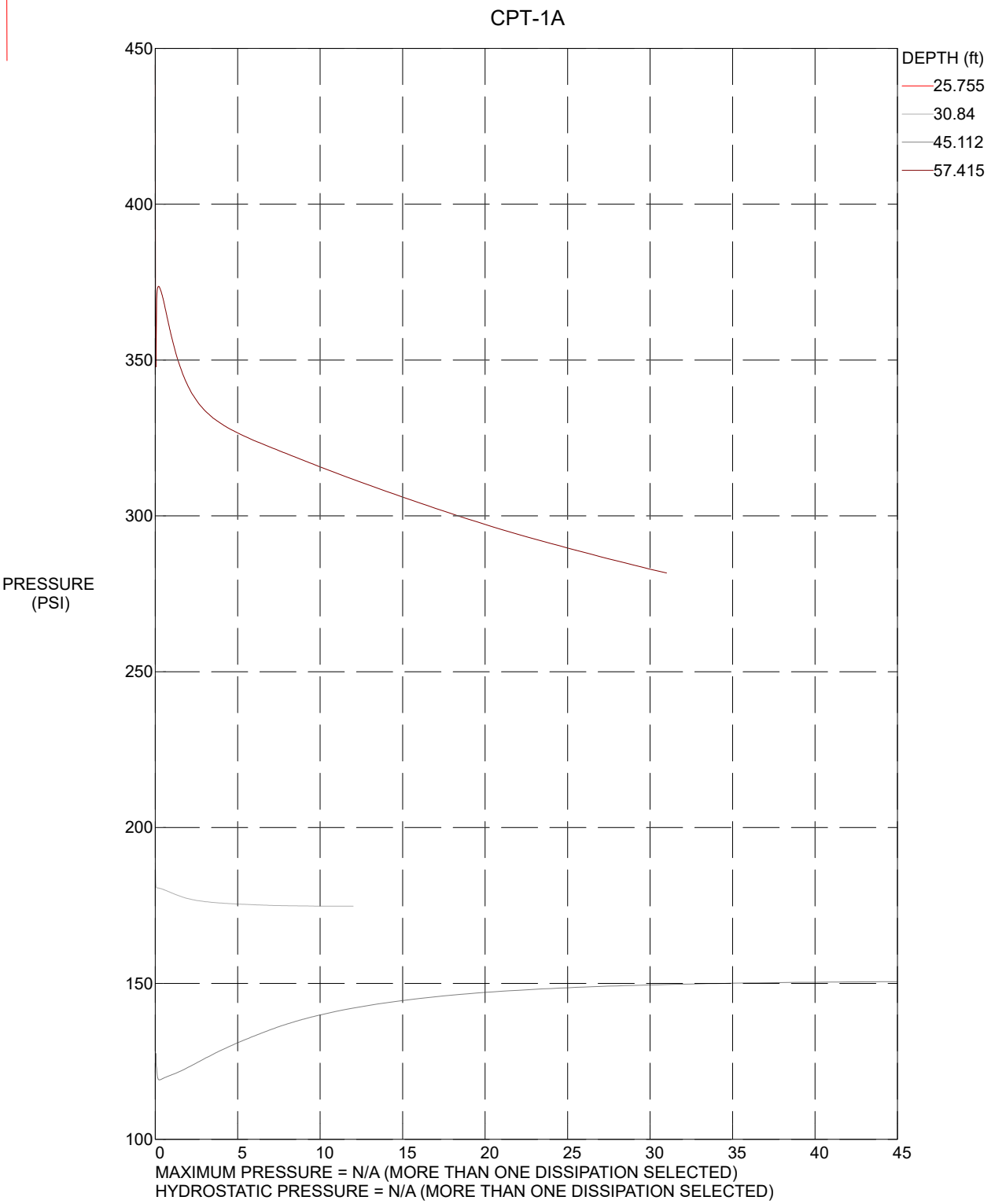
JOB NUMBER:
HOLE NUMBER: CPT-12
TEST DATE: 8/20/2019 9:53:20 AM
COMMENT: Auto Enhance On
COMMENT: Filter On

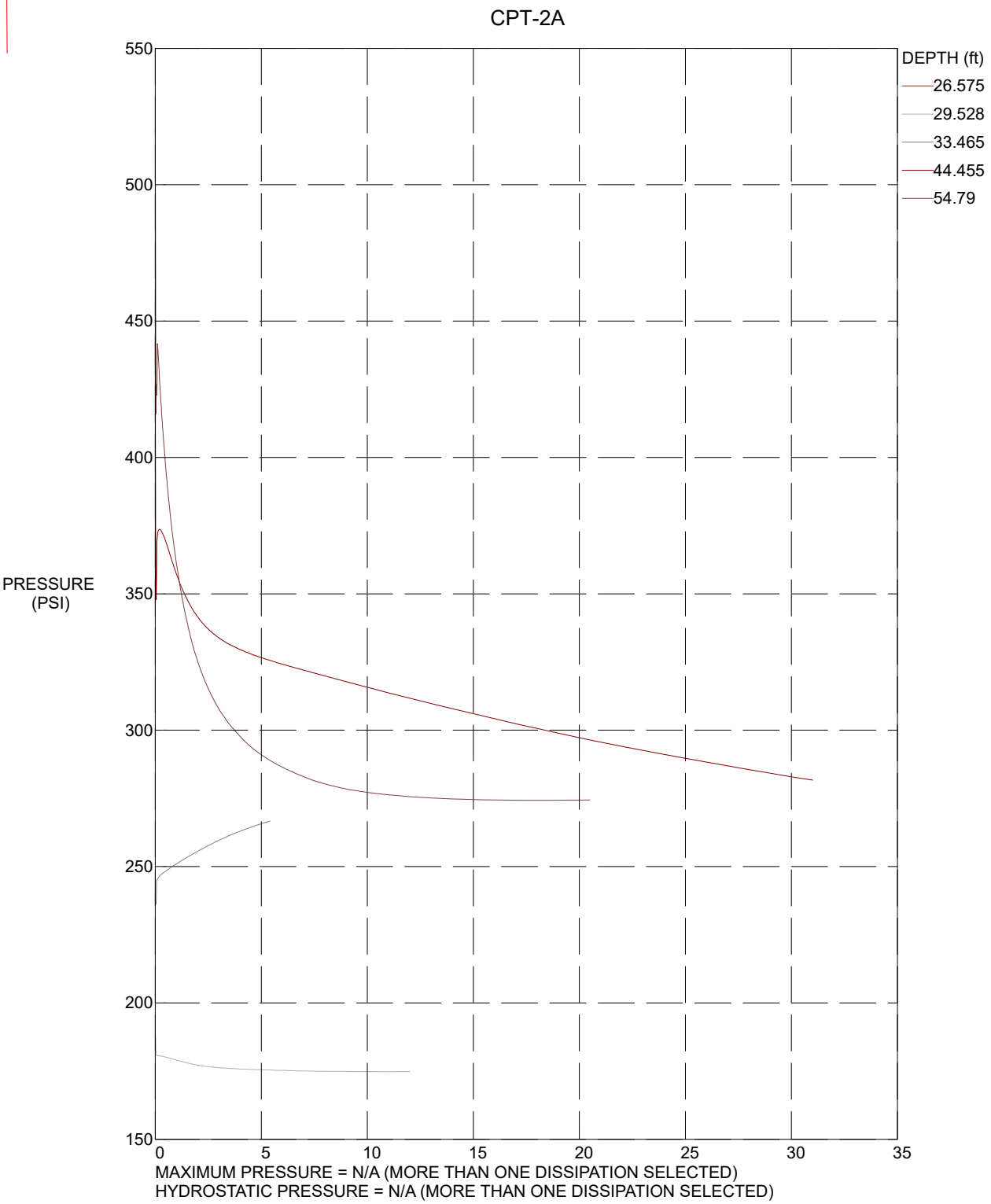
COMMENT:
GPS (LAT,LON,ALT): 0.00,0.00,0.0
LOCATION: TP-17
LOCATION: TP-17
LOCATION: TP-17



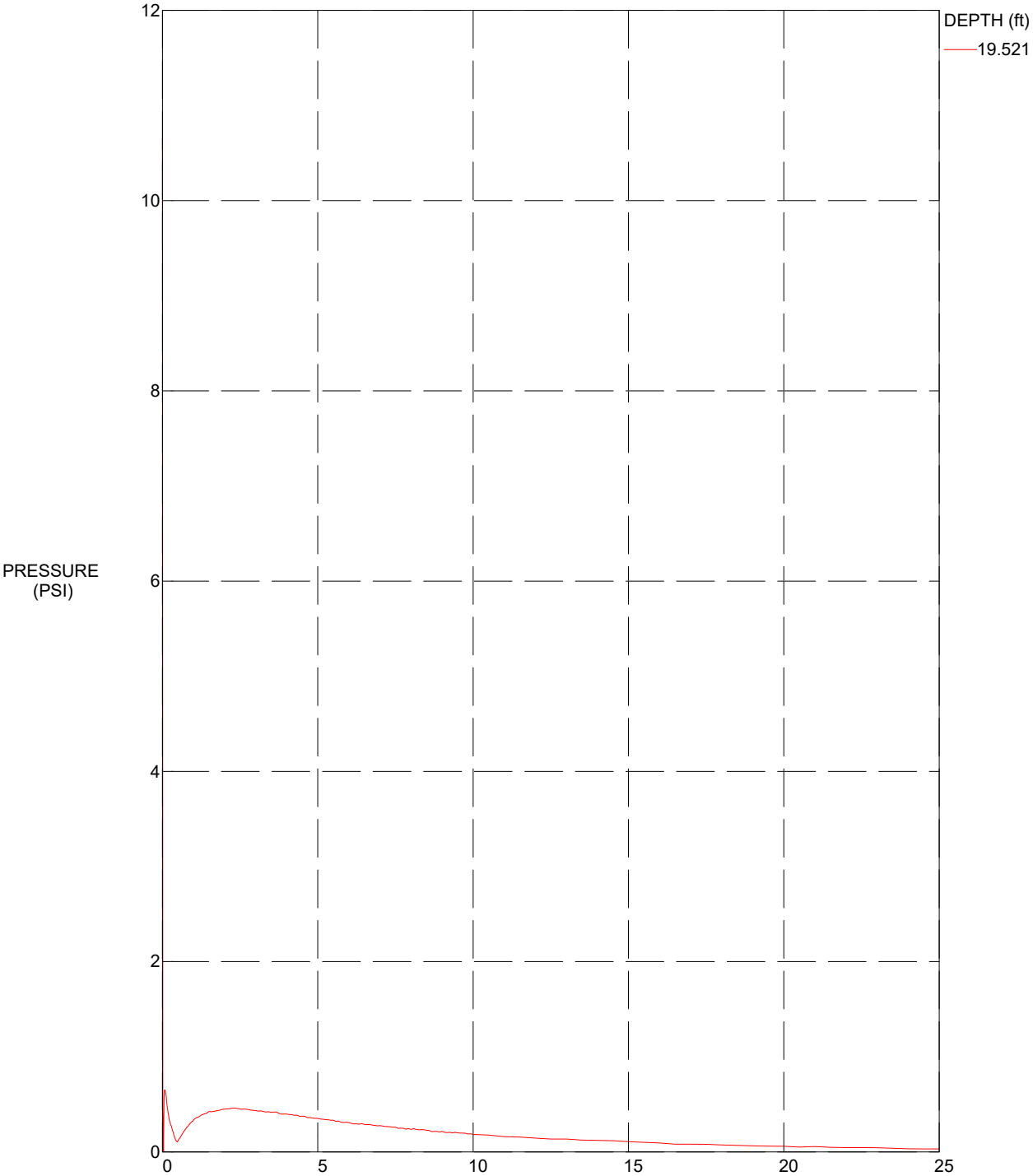
1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

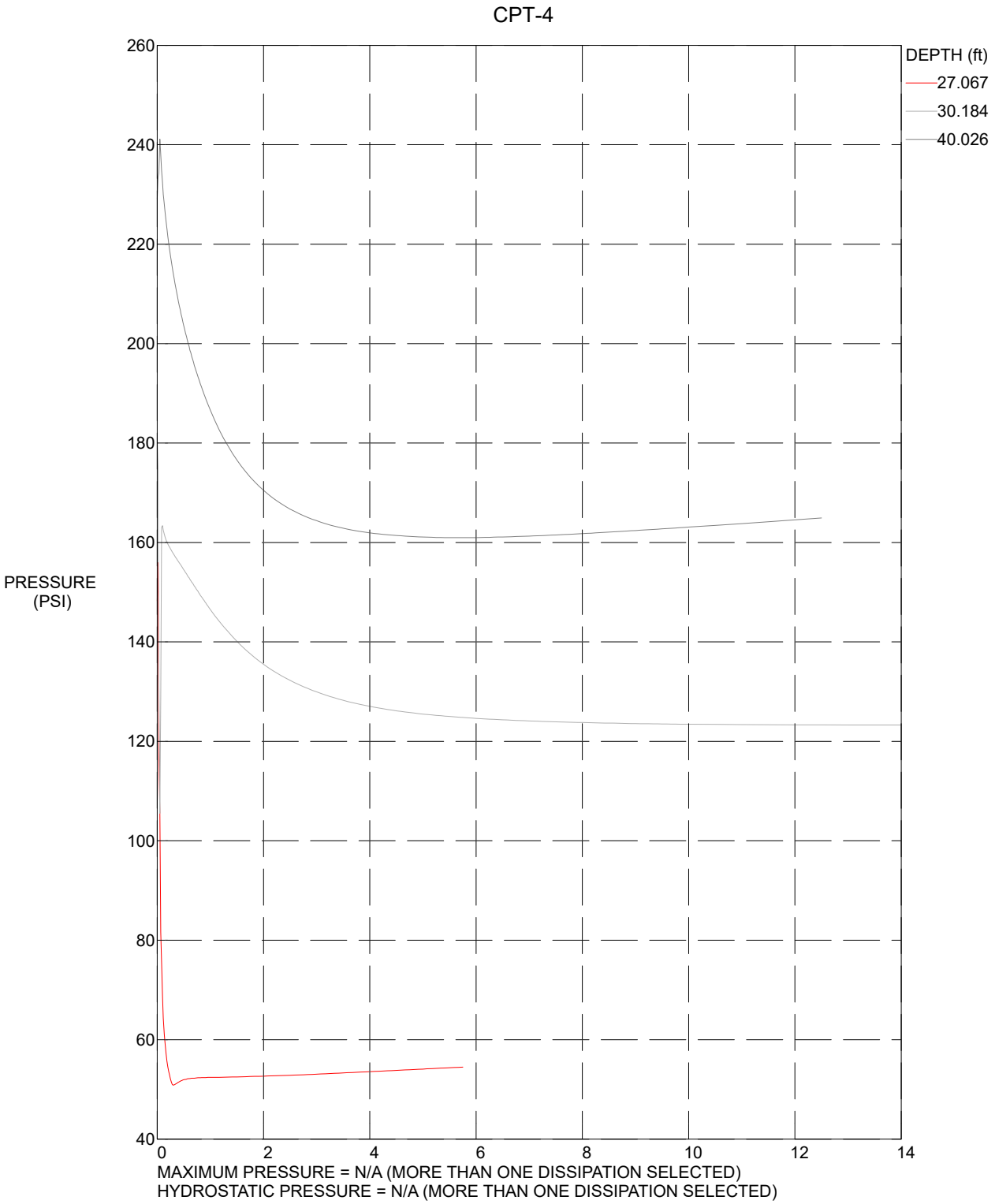

CPT-1A
DEPTH (ft)
25.755
30.84
45.112
57.415
PRESSURE (PSI)
450
400
350
300
250
200
150
100
0
5
10
15
20
25
30
35
40
45
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)


CPT-2A
DEPTH (ft)
26.575
29.528
33.465
44.455
54.79
PRESSURE (PSI)
550
500
450
400
350
300
250
200
150
0
5
10
15
20
25
30
35
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

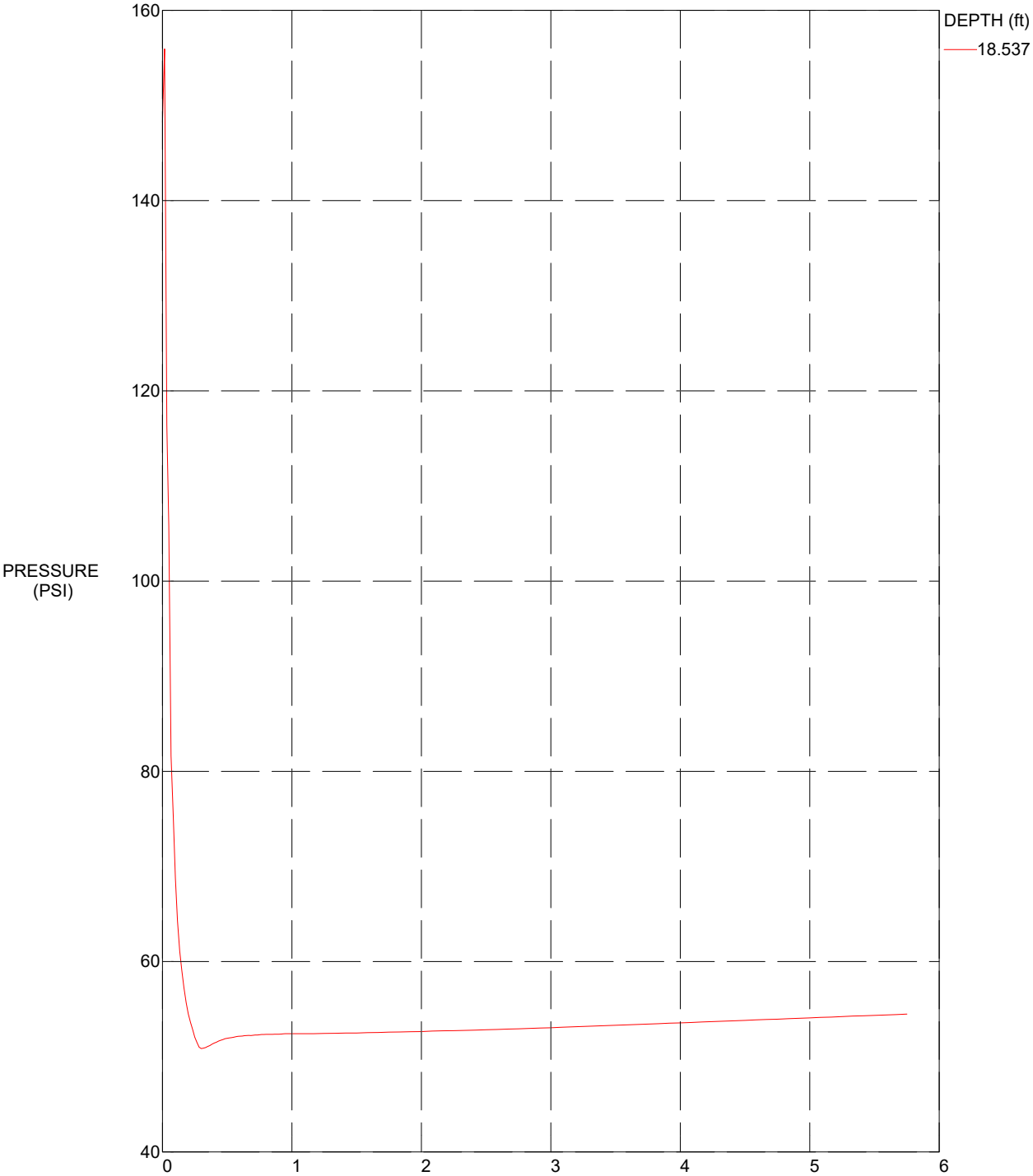
CPT-3B



MAXIMUM PRESSURE = 10.651 (PSI) TIME: (MINUTES)
HYDROSTATIC PRESSURE = 8.46 (PSI), WATER TABLE: 0.00 ft

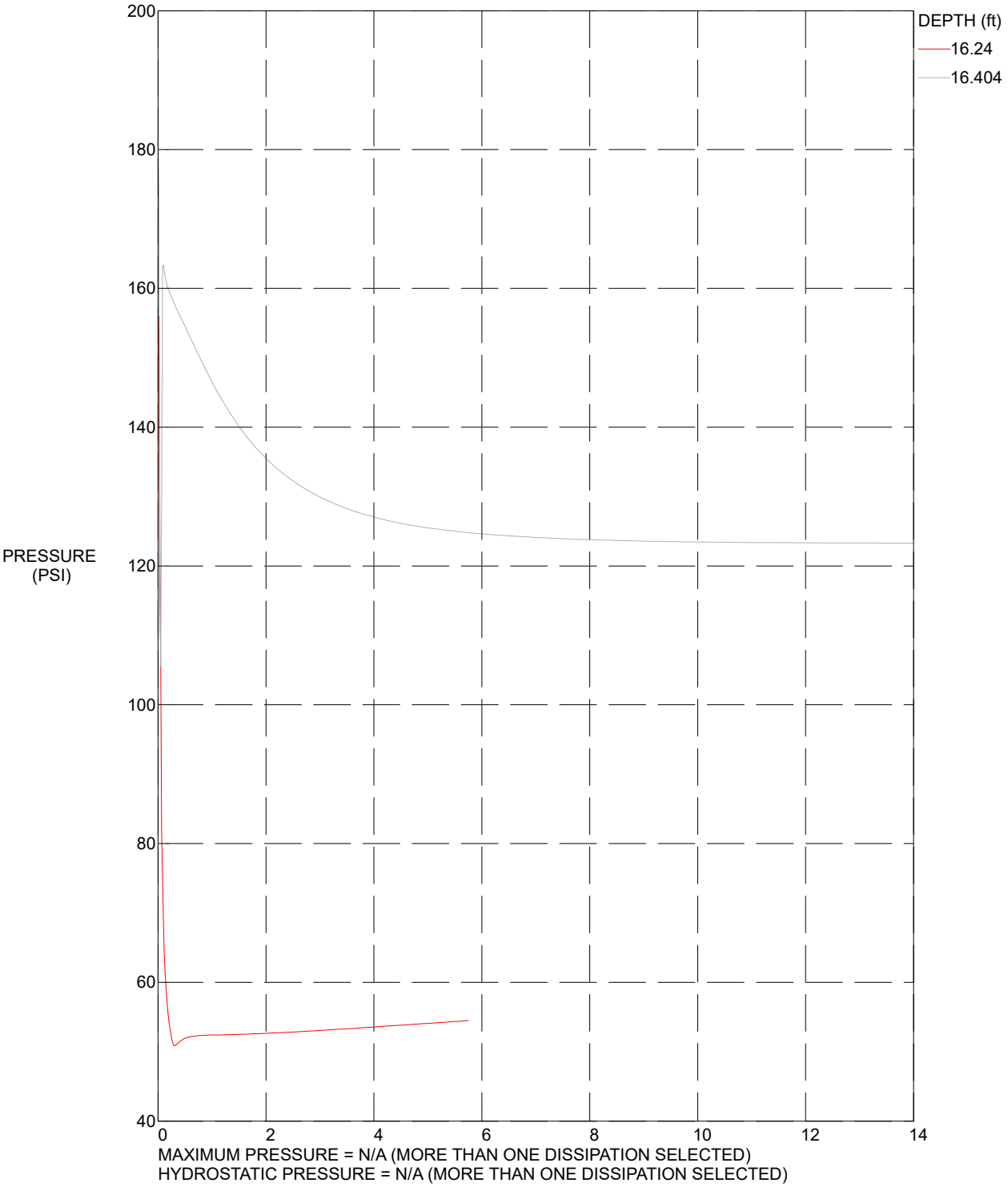

CPT-4
DEPTH (ft)
27.067
30.184
40.026
PRESSURE
(PSI)
260
240
220
200
180
160
140
120
100
80
60
40
0
2
4
6
8
10
12
14
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

CPT-5A

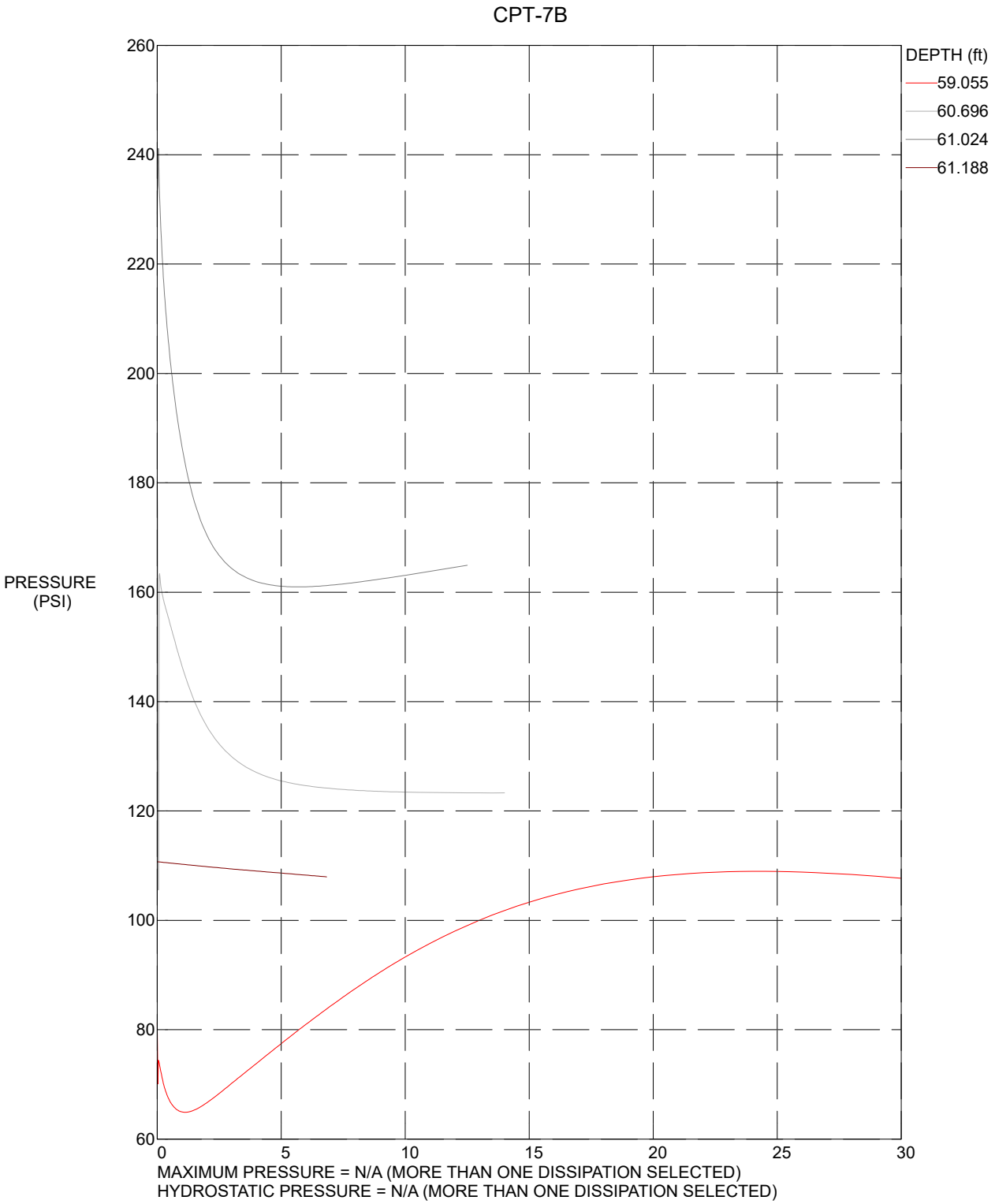


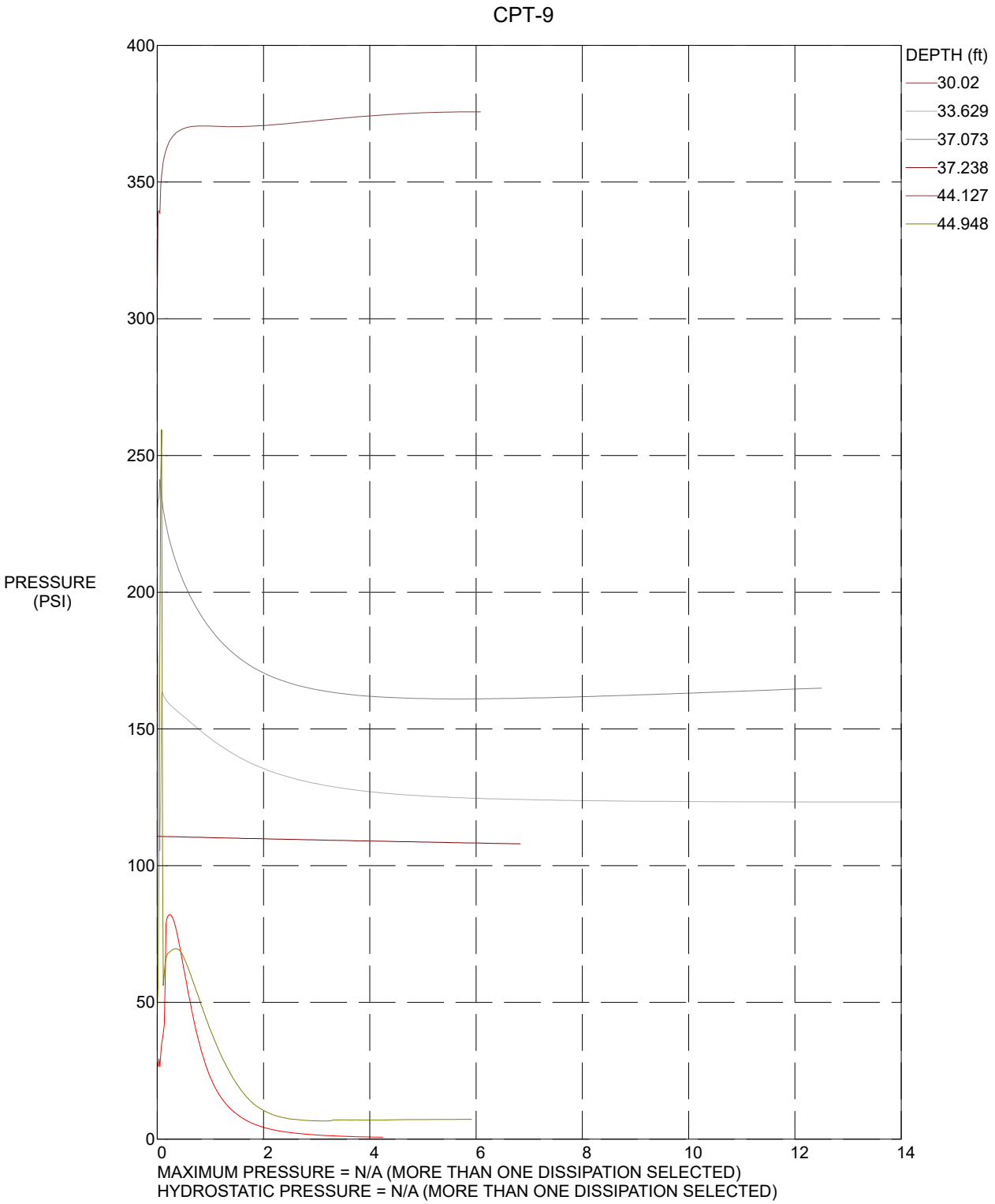
MAXIMUM PRESSURE = 155.929 (PSI)TIME: (MINUTES)
HYDROSTATIC PRESSURE = 8.034 (PSI), WATER TABLE: 0.00 ft

CPT-6

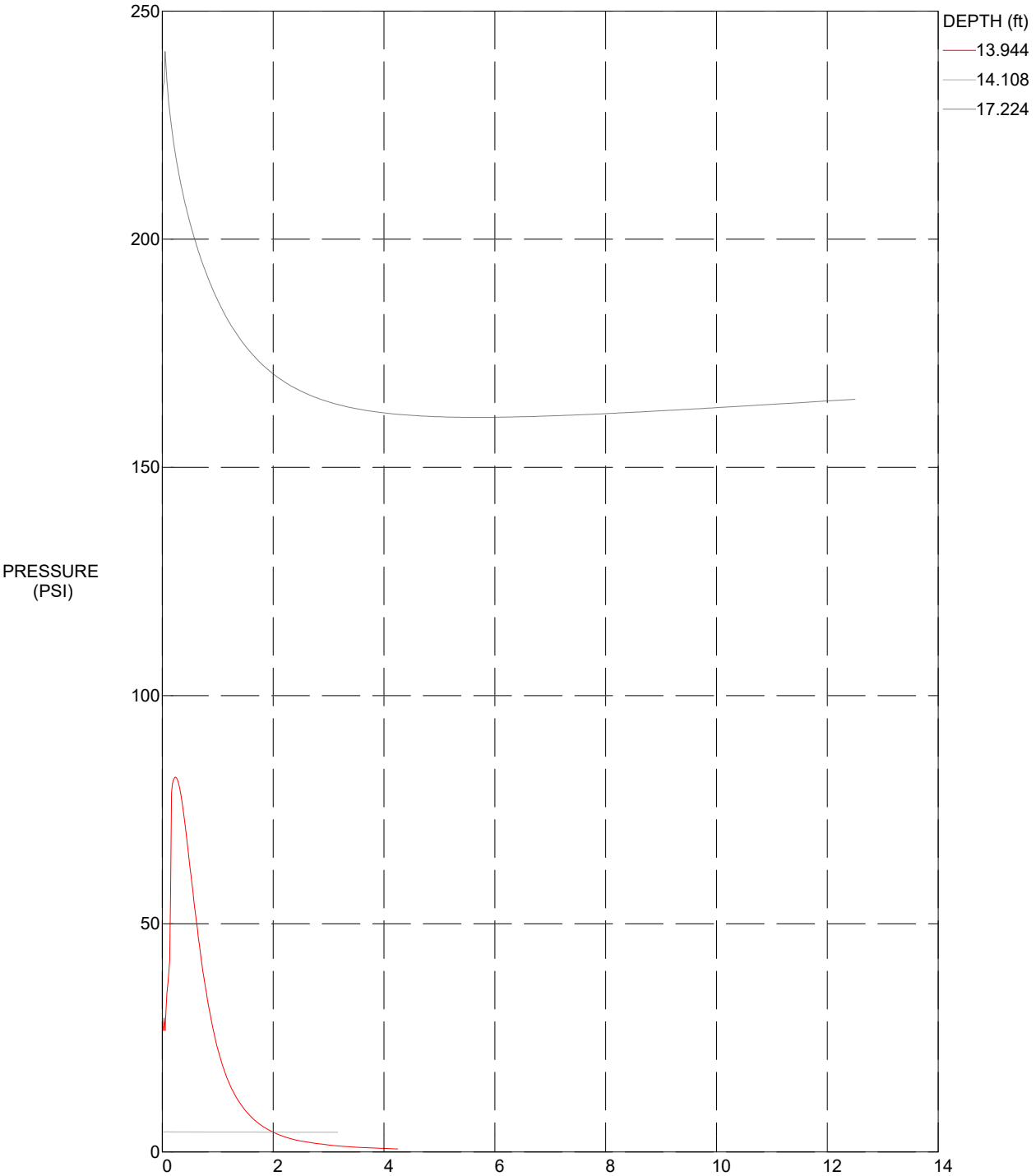


MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)


CPT-7B
DEPTH (ft)
59.055
60.696
61.024
61.188
PRESSURE (PSI)
260
240
220
200
180
160
140
120
100
80
60
0
5
10
15
20
25
30
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

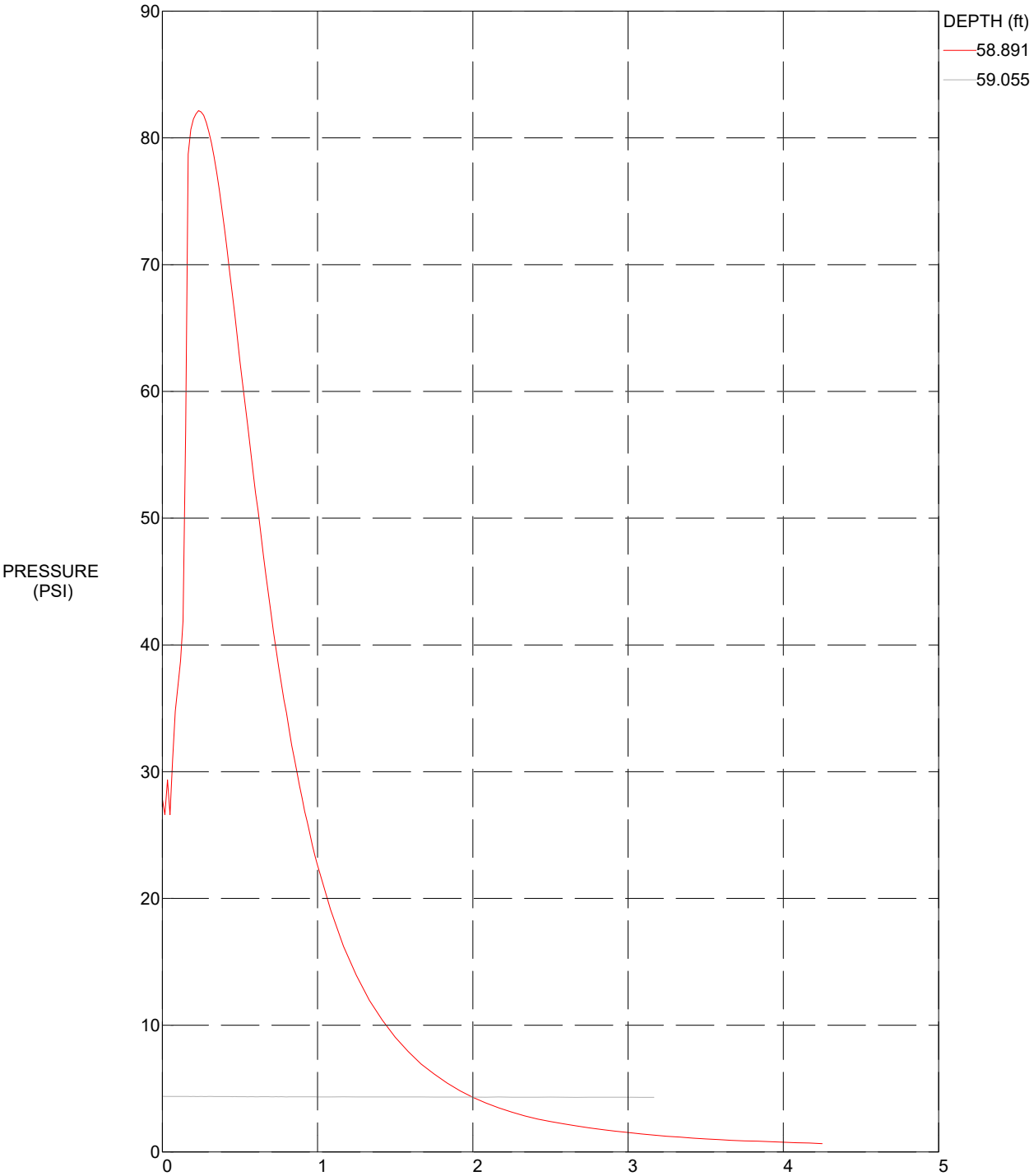

CPT-9
DEPTH (ft)
30.02
33.629
37.073
37.238
44.127
44.948
PRESSURE (PSI)
400
350
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

CPT-10



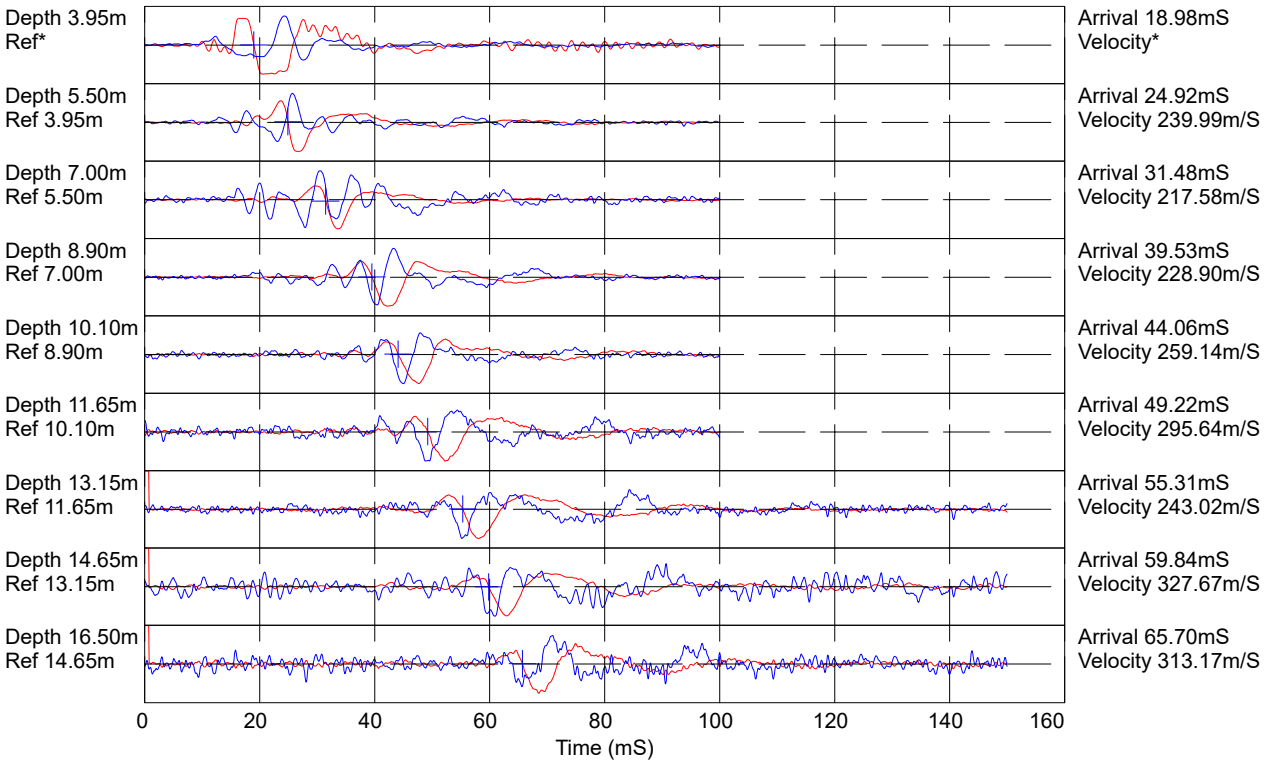
MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

CPT-12



MAXIMUM PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)
HYDROSTATIC PRESSURE = N/A (MORE THAN ONE DISSIPATION SELECTED)

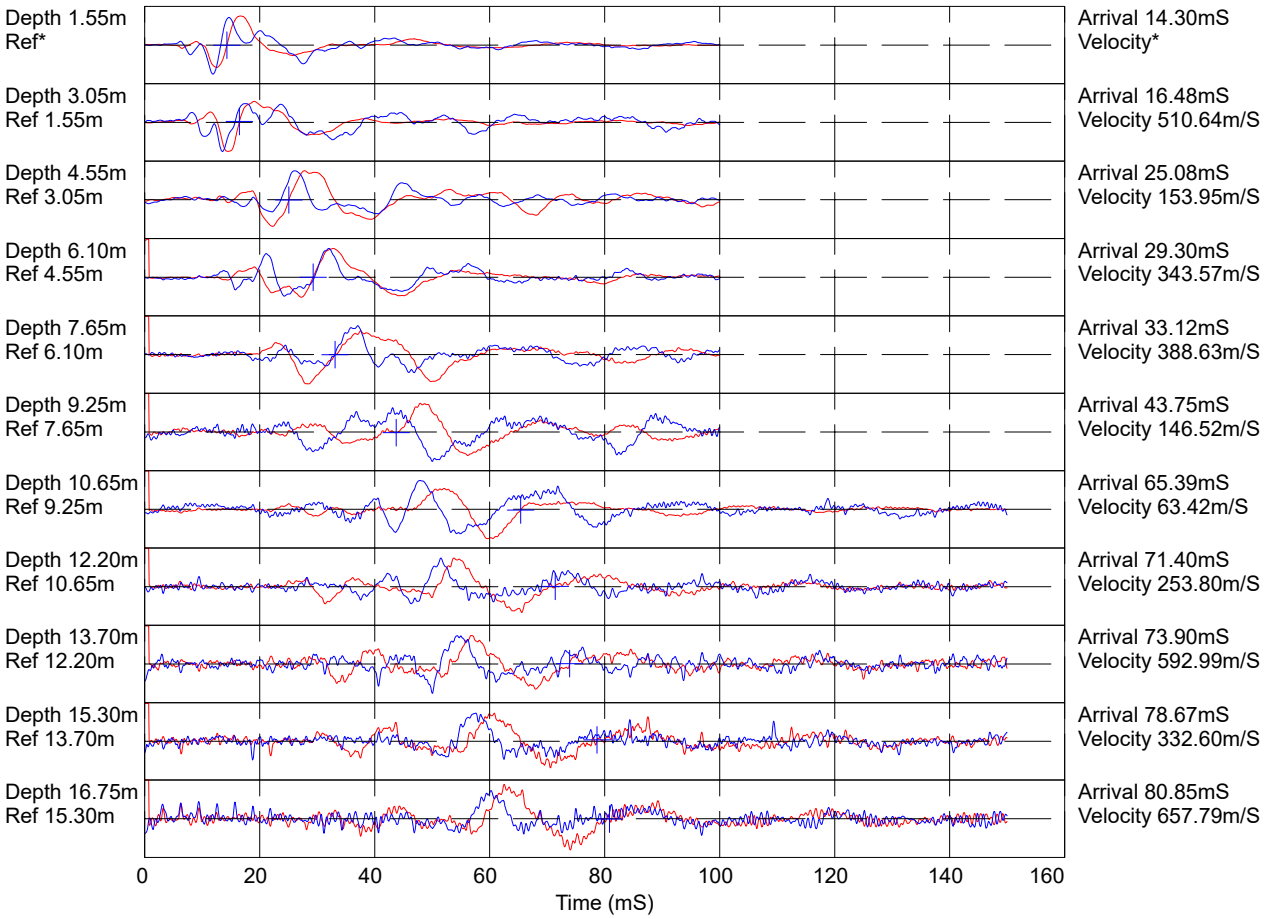
SEISMIC TEST



Hammer to Rod String Distance (m): 2.00
* = Not Determined

CPT-1a

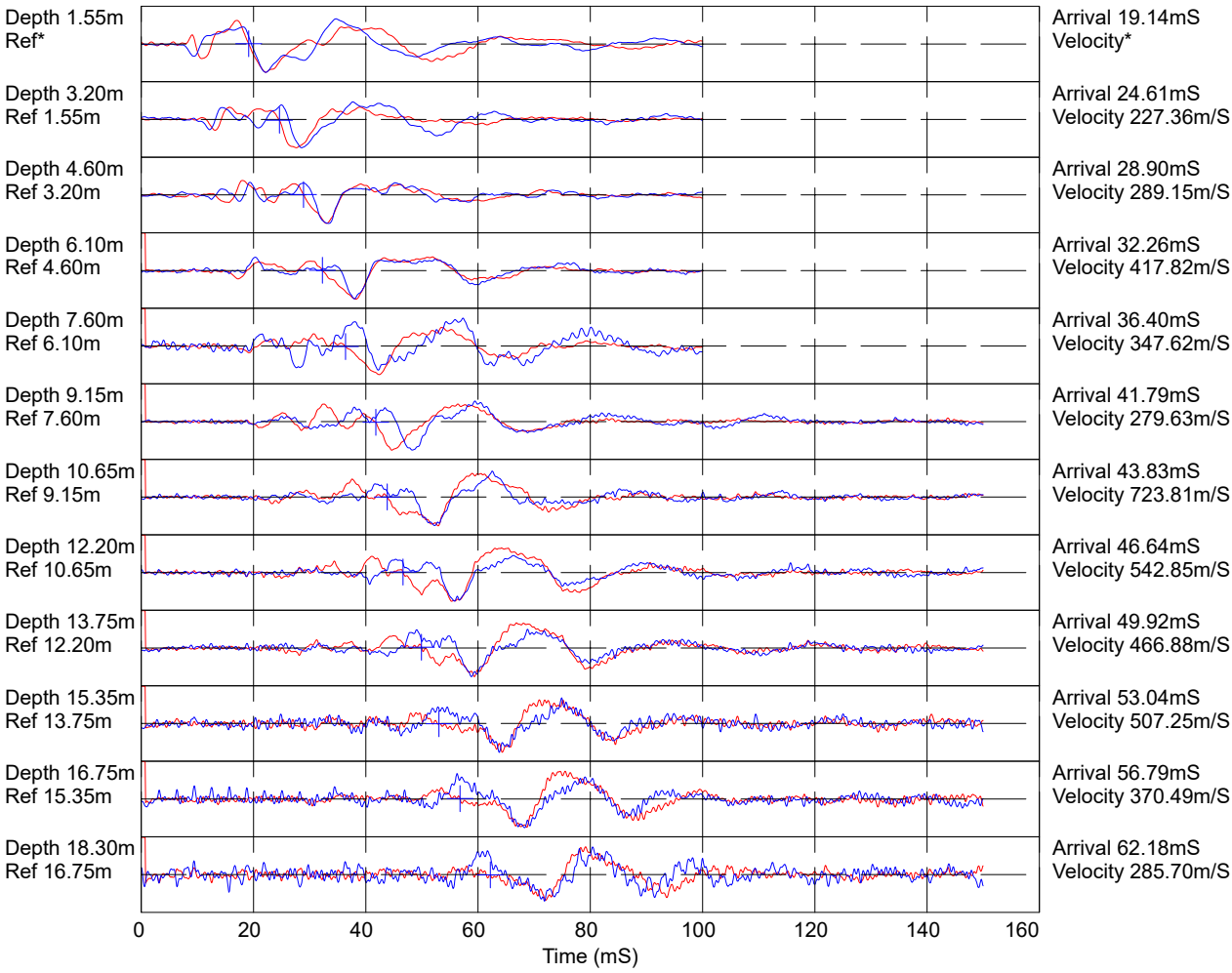
SEISMIC TEST



Hammer to Rod String Distance (m): 2.00
* = Not Determined

CPT-2a

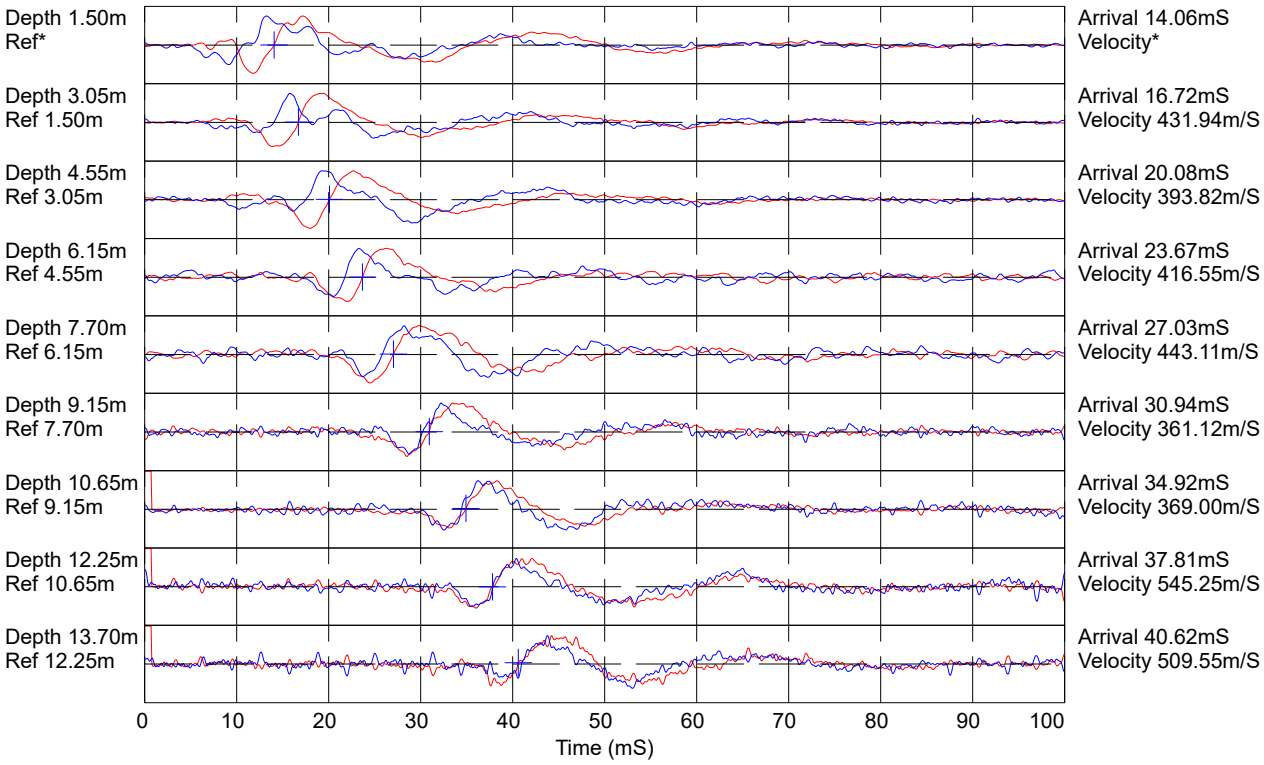
SEISMIC TEST



Hammer to Rod String Distance (m): 2.00
* = Not Determined

CPT-7b

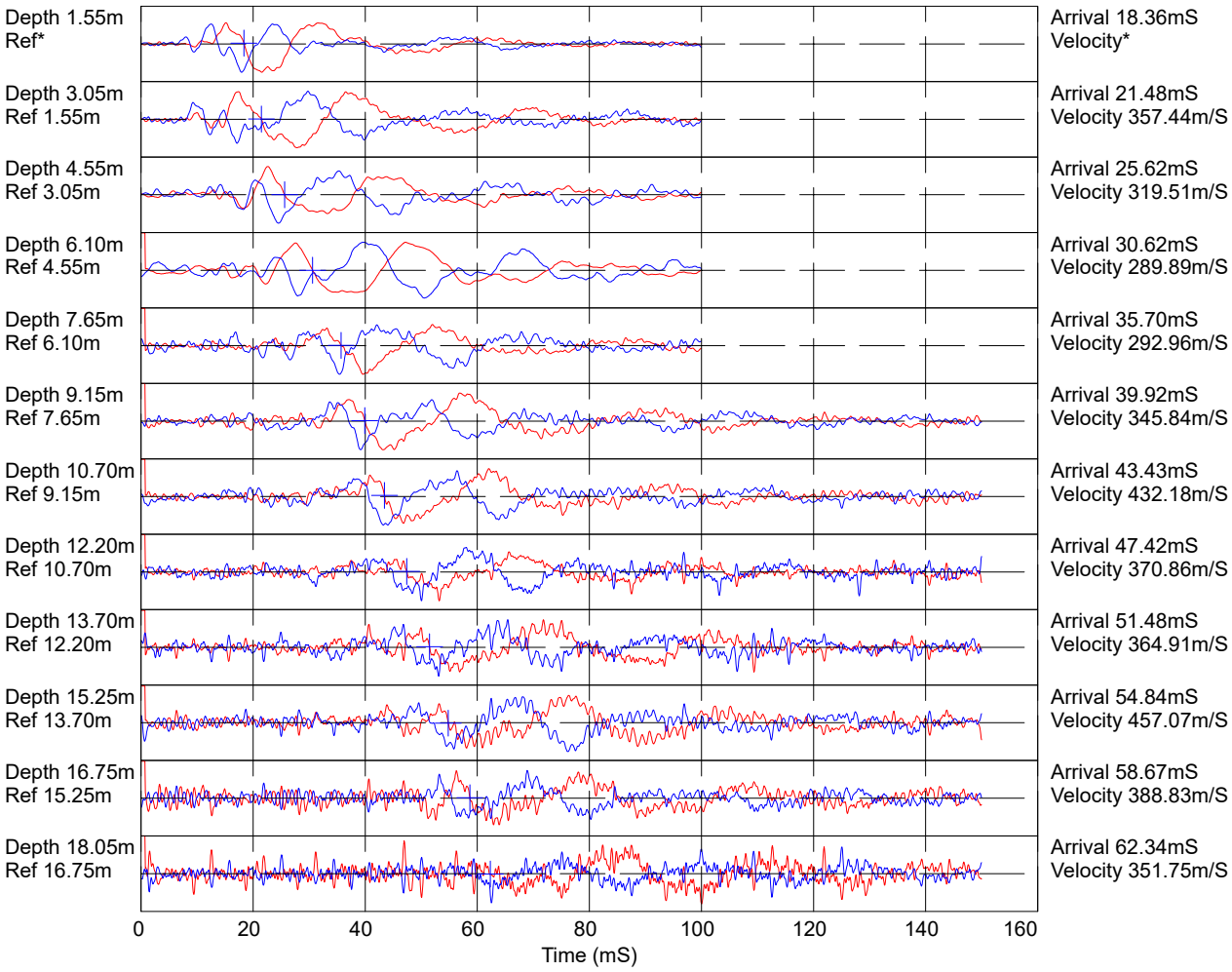
SEISMIC TEST



Hammer to Rod String Distance (m): 2.00
* = Not Determined

CPT-11a

SEISMIC TEST



Hammer to Rod String Distance (m): 2.00
* = Not Determined

CPT-12

ATTACHMENT E

Geotechnical Laboratory Test Results

GEOTECHNICAL LABORATORY TESTING
INDEX TESTING SUMMARY TABLE

Sample Type	Sample Identification	Sample Depth (ft.)	USCS Soil Classification	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Additional Tests/ Comments
					LL	PL	PI	% Finer 3/4"	% Finer #4	% Finer #200	
Bag	TP-02	2 - 3	SP-SM	--	NP	NP	NP	72	55	9	
Bag	TP-05	8 - 9, 13 - 14	SC	23.3	54	25	29	80	65	25	
Pail	TP-09	2 - 15	CH	35.7	104	29	75	100	100	88	Permeability: 5.6E-09 cm/s
Bag	TP-11	12-14.5	CH	--	118	40	78	100	100	79	
Pail	TP-17	2 - 14	CH	--	52	18	34	100	100	82	
Bag	TP-23	10 - 11	CH	35.8	206	33	173	100	100	95	
Bag	TP-23	2 - 3	SM	--	49	29	20	98	90	44	
Bag	TP-30	1.5 - 2.5	CL	11.9	47	22	25	97	92	50	
Bag	TP-33, TP-34	TP33: 4.5-5.5, TP34: 1-3	GM	19.8	58	32	26	22	19	10	
Bag	TP-37	3 - 9	SM	--	NP	NP	NP	81	69	14	
Bag	TP-41	2 - 3	SC	9.7	37	15	22	98	96	49	
Bag	BH-01	10 - 11.5	CL	15.8	46	21	25	100	100	89	
Bag	BH-03	10 - 11.5	CH	29.9	89	34	55	100	100	78	
Bag	BH-03	40 - 41.5	CH	34.7	124	25	99	100	100	96	
Bag	BH-03	50 - 51.5	CH	34.5	227	29	198	100	100	93	
Bag	BH-04	20 - 21.5	CH	--	68	20	48	100	100	91	
Tube	BH-06	10 - 11.5	CH	40.1	121	36	85	100	100	95	Permeability: 1.7E-08 cm/s
Tube	BH-06	20-21.5	CH	33	74	22	52	100	100	65	
Bag	BH-07	25-26.5, 30-31.5, 35-36.5	CH	--	66	21	45	99	99	91	
Bag	BH-9	25 - 26.5	CH	35.2	96	34	62	100	100	68	
Bag	BH-11	10 - 11.5	CH	--	78	29	49	100	98	57	
Bag	BH-12	30 - 31.5	CH	37.2	103	41	62	100	100	97	
Bag	BH-13	5 - 6.5	CH	22.8	92	29	63	100	100	87	
Bag	BH-13	15 - 16.5	CH	35.8	84	23	62	100	100	52	
Bag	BH-13	25 - 26.5	CH	--	77	22	55	100	100	67	
Bag	BH-13	30 - 31.5	--	33.2	--	--	--	--	--	--	
Bag	BH-14	10-11.5, 15-16.5	SW-SM	--	NP	NP	NP	100	100	10	
Tube	BH-15	15 - 16.5	CL	38.5	134	40	94	100	100	81	
Tube	BH-15	25 - 26.5	CH	38	191	34	157	100	100	98	
Bag	BH19-TP-01	10 - 11.5	CH	37.4	97	28	69	100	99	96	
Bag	BH19-TP-01	20 - 21.5	SC	11.7	36	15	21	100	100	48	
Bag	BH19-TP-01	25 - 26.5	CH	29.0	78	20	58	100	100	94	
Tube	BH19-TP-01	45 - 46.5	CH	32.4	68	24	44	100	97	82	Permeability: 5.7E-08 cm/s
Tube	BH19-TP-39	10 - 11.5	ML	16.0	36	26	10	100	98	54	
Tube	BH19-TP-39	15 - 16.5	SC	14.5	80	29	31	100	100	37	
Tube	BH19-TP-39	25 - 26.5	CH	39.3	120	35	85	100	100	88	Permeability: 2.4E-08 cm/s
Tube	BH19-TP-39	35 - 36.5	CH	38.8	109	31	78	100	100	98	Permeability: 5.4E-08 cm/s

GEOTECHNICAL LABORATORY TESTING
INDEX TESTING SUMMARY TABLE

Sample Type	Sample Identification	Sample Depth (ft.)	USCS Soil Classification	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Additional Tests/ Comments
								% Finer	% Finer	% Finer	
					LL	PL	PI	3/4"	#4	#200	
Tube	BH19-TP-15	10 - 11.5	CH	25.7	71	29	42	100	100	93	
Tube	BH19-TP-15	15 - 16.5	CH	18.9	66	28	38	100	100	96	
Tube	BH19-TP-15	20 - 21.5	CH	13.6	52	22	30	100	100	90	
Tube	BH19-TP-15	25 - 26.5	CH	15.0	62	22	40	100	100	94	
Tube	BH19-TP-15	30 - 31.5	CL	13.4	48	19	29	100	100	56	
Tube	BH19-TP-15	35 - 36.5	SC	9.6	35	21	14	100	100	43	
Tube	BH19-TP-15	40 - 41.5	SC	11.5	35	18	17	100	100	45	
Tube	BH19-TP-15	50 - 51.5	CH	32.3	87	25	62	100	100	98	
Tube	BH19-TP-15	70 - 71.5	CH	47.9	116	38	78	100	100	87	
Tube	BH19-TP-15	90 - 91.5	CH	36.5	101	36	65	100	100	92	
Tube	BH19-TP-15	110 - 111.5	CH	33.6	90	26	64	100	100	93	
Tube	BH19-TP-15	120 - 121.4	CH	24.6	66	23	43	100	100	91	
Bag	BH19-TP-19	12 - 13.5	CH	27.4	98	26	72	100	100	99	
Tube	BH19-TP-19	15 - 16.5	CH	34.4	133	33	100	100	100	99	
Tube	BH19-TP-19	25 - 26.5	CH	23.2	158	23	135	100	100	84	
Tube	BH19-TP-19	30.3 - 31.8	SC	27.1	127	26	101	100	98	41	
Tube	BH19-TP-19	35 - 36.5	SC	26.3	137	20	117	100	100	49	
Tube	BH19-TP-19	40 - 41.5	CH	45.5	141	24	117	100	100	100	
Tube	BH19-TP-19	50 - 51.5	CH	42.2	206	27	179	100	100	93	
Tube	BH19-TP-19	60 - 61.5	CH	22.1	73	22	51	100	100	96	
Tube	BH19-TP-19	70 - 71.5	CH	30.3	89	28	61	100	100	87	
Tube	BH19-TP-19	80 - 81.5	CH	20.9	62	21	41	100	100	97	
Tube	BH19-TP-19	110 - 111.5	CL	17.8	48	24	24	100	100	99	
Tube	BH19-TP-19	120 - 121.4	CH	20.9	59	22	37	100	100	80	
Tube	BH19-TP-23	30 - 31.5	CH	41.7	99	31	68	100	100	97	
Tube	BH19-TP-23	35 - 36.5	CH	41.7	135	34	101	100	100	96	
Tube	BH19-TP-23	40 - 41.5	CH	29.4	82	24	58	100	100	99	
Tube	BH19-TP-23	45 - 46.5	CL	22.8	49	23	26	100	100	93	
Tube	BH19-TP-23	50 - 51.5	CH	19.5	70	20	50	100	100	82	
Tube	BH19-TP-23	60 - 61.5	MH	26.0	53	32	21	100	100	96	
Tube	BH19-TP-23	100 - 101.5	CH	26.1	70	25	45	100	100	95	
Tube	BH19-TP-23	120 - 121.3	CH	25.1	64	24	40	100	100	100	

GEOTECHNICAL LABORATORY TESTING
INDEX TESTING SUMMARY TABLE

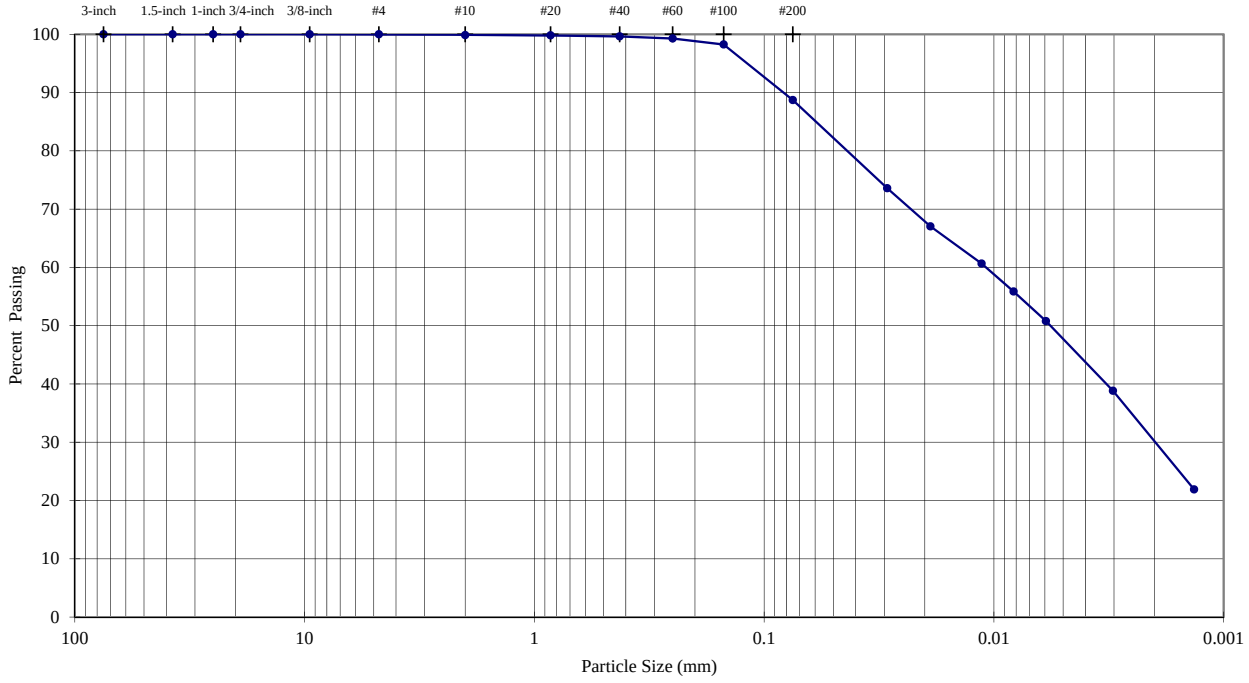
Sample Type	Sample Identification	Sample Depth (ft.)	USCS Soil Classification	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Additional Tests/ Comments
								% Finer	% Finer	% Finer	
					LL	PL	PI	3/4"	#4	#200	
Shelby Tube	BH19-TP-44	10 - 12	CH	27.3	82	22	60	100	100	56	
Bag	BH19-TP-44	22 - 23.5	CH	35.5	111	21	90	100	100	81	
Tube	BH19-TP-44	25 - 26.5	CH	36.7	92	30	62	100	100	95	
Bag	BH19-TP-44	32 - 33.5	CH	40.3	98	28	70	100	100	97	
Tube	BH19-TP-44	35 - 36.5	CH	39.8	103	29	74	100	100	97	
Tube	BH19-TP-44	40 - 41.5	SC	28.3	84	26	58	100	100	36	
Tube	BH19-TP-44	45 - 46.5	SC	17.8	55	22	33	100	100	28	
Tube	BH19-TP-44	50 - 51.5	SC	22.5	79	27	52	100	100	26	
Tube	BH19-TP-44	60 - 61.5	SC	21.0	85	19	66	100	95	35	
Tube	BH19-TP-44	70 - 71.5	CH	30.7	86	24	62	100	99	84	
Tube	BH19-TP-44	80 - 81.5	CL	24.9	61	21	40	100	100	93	
Tube	BH19-TP-44	90 - 91.5	CH	26.3	72	24	48	100	100	99	
Tube	BH19-TP-44	110 - 111.5	CL	17.9	41	25	16	100	100	98	

March-18 1663241

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

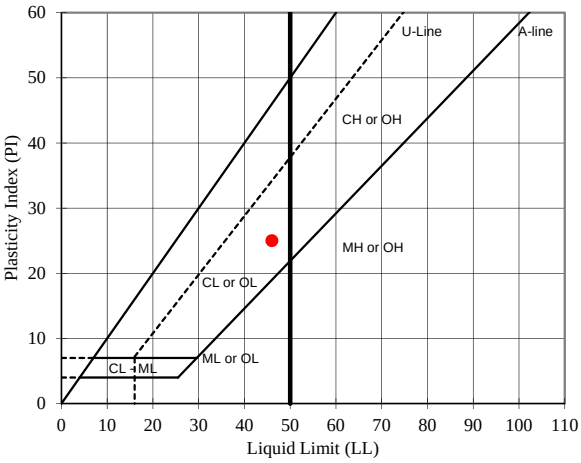
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-01 / S2** DEPTH (ft): **10-11.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.0	**99.9**	Coarse Sand	**0.14**
#20	0.85	**99.8**	Medium Sand	**0.22**
#40	0.425	**99.6**		
#60	0.25	**99.3**		
#100	0.15	**98.3**	Fine Sand	**10.93**
#200	0.075	**88.7**		
	0.029	**73.6**		
	0.019	**67.0**		
	0.011	**60.7**		
	0.008	**55.9**	Silt or Clay Fines	**88.71**
	0.006	**50.8**		
	0.003	**38.8**		
	0.001	**21.9**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



USCS Description (ASTM D 2487):

Lean clay, very pale brown, moist

LL	PL	PI	SpG
46	**21**	**25**	**0.00**

As-Received Moisture Content (%): **15.8**

USCS Group Symbol: CL

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

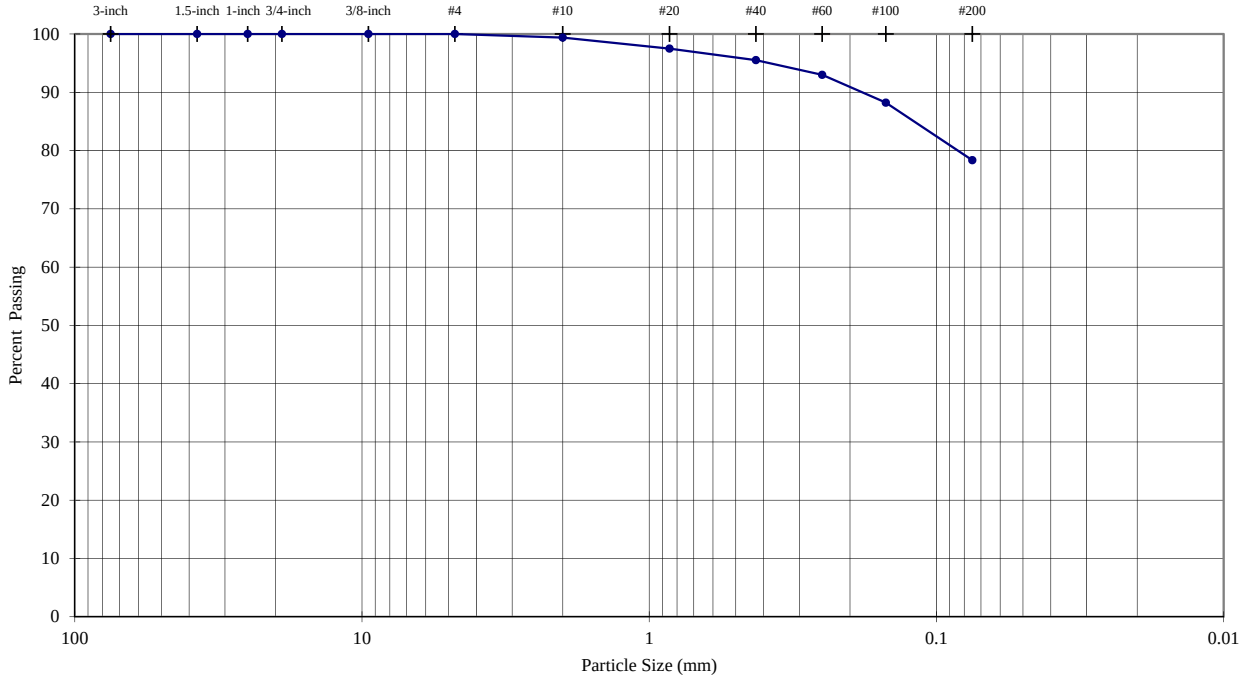
TECH	JP
DATE	22-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

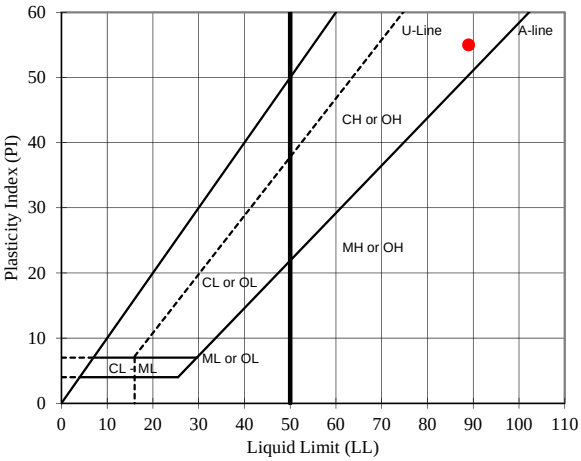
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-3 / S2** DEPTH (ft): **10-11.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.4**
#20	0.850	**97.5**
#40	0.425	**95.5**
#60	0.250	**93.0**
#100	0.150	**88.2**
#200	0.075	**78.3**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.61**
Medium Sand	**3.87**
Fine Sand	**17.18**
Silt or Clay Fines	**78.34**



USCS Description (ASTM D 2487):

Fat clay with sand, light yellowish brown, moist

LL	PL	PI
89	**34**	**55**

As-Received Moisture Content (%): **29.9**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

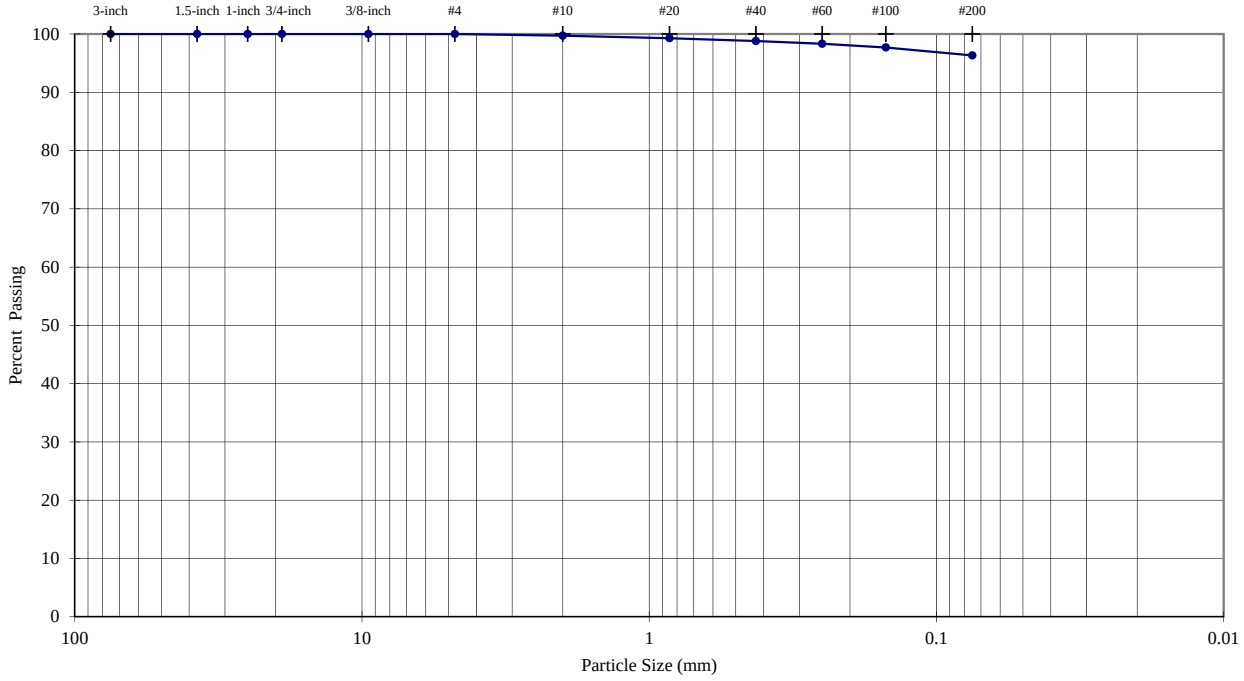
TECH	JP
DATE	24-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

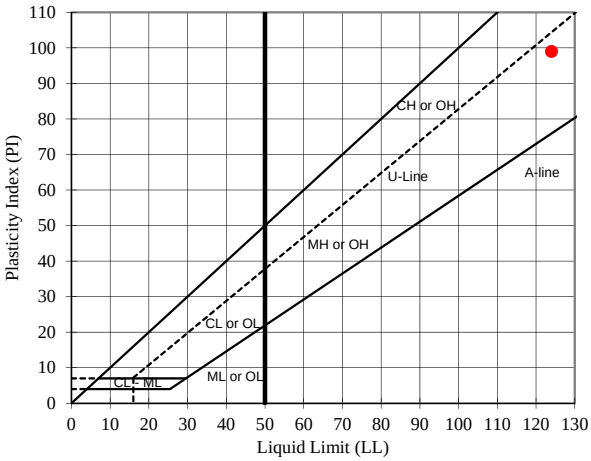
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-3 / S7** DEPTH (ft): **40-41.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.7**
#20	0.850	**99.3**
#40	0.425	**98.8**
#60	0.250	**98.3**
#100	0.150	**97.7**
#200	0.075	**96.3**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.29**
Medium Sand	**0.92**
Fine Sand	**2.48**
Silt or Clay Fines	**96.31**



USCS Description (ASTM D 2487):

Fat clay, grayish brown, moist

LL	PL	PI
124	**25**	**99**

As-Received Moisture Content (%): **34.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

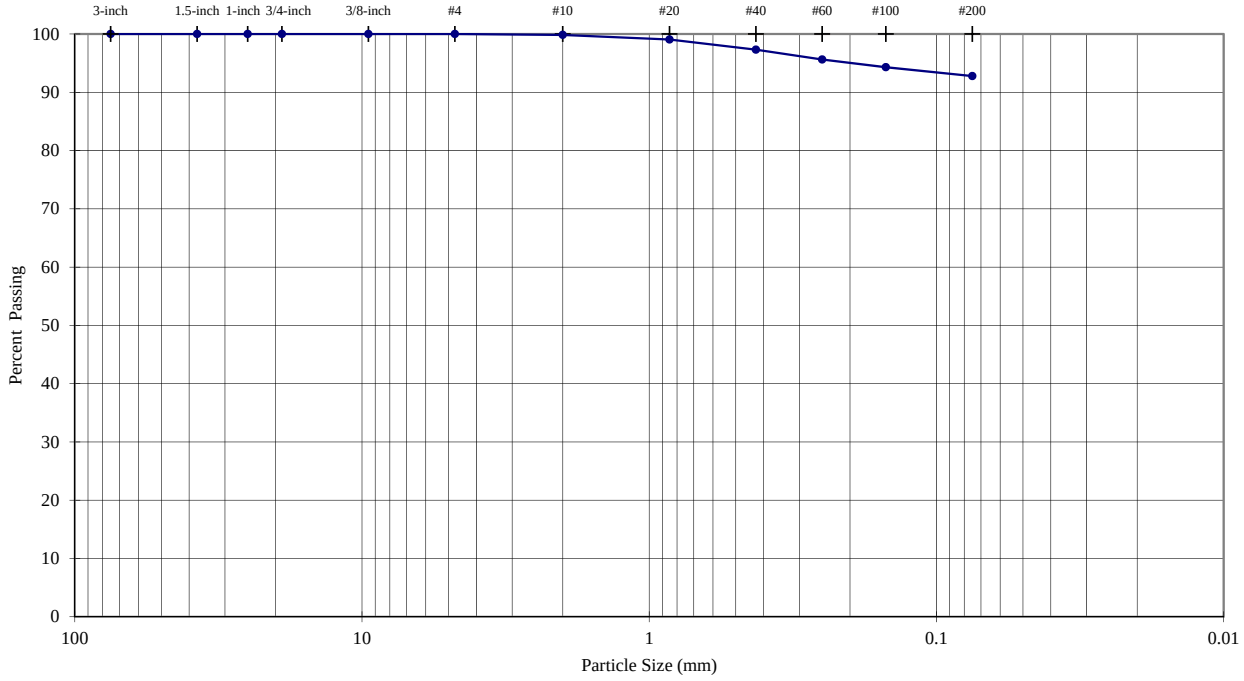
TECH	JP
DATE	23-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

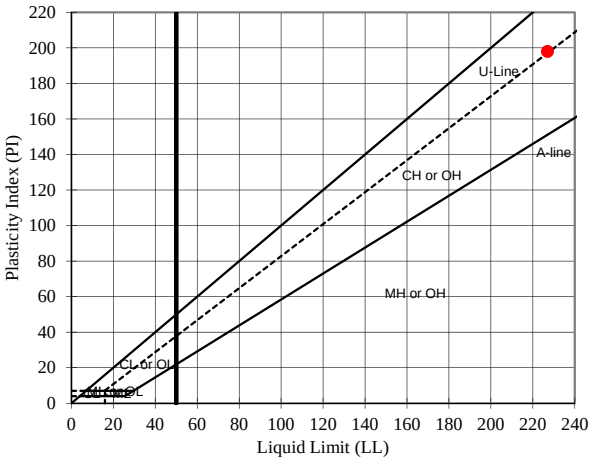
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-3 / S8** DEPTH (ft): **50-51.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.8**
#20	0.850	**99.1**
#40	0.425	**97.3**
#60	0.250	**95.6**
#100	0.150	**94.3**
#200	0.075	**92.8**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.16**
Medium Sand	**2.53**
Fine Sand	**4.54**
Silt or Clay Fines	**92.77**



USCS Description (ASTM D 2487):

Fat clay, grayish brown, moist

LL	PL	PI
227	**29**	**198**

As-Received Moisture Content (%): **34.5**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

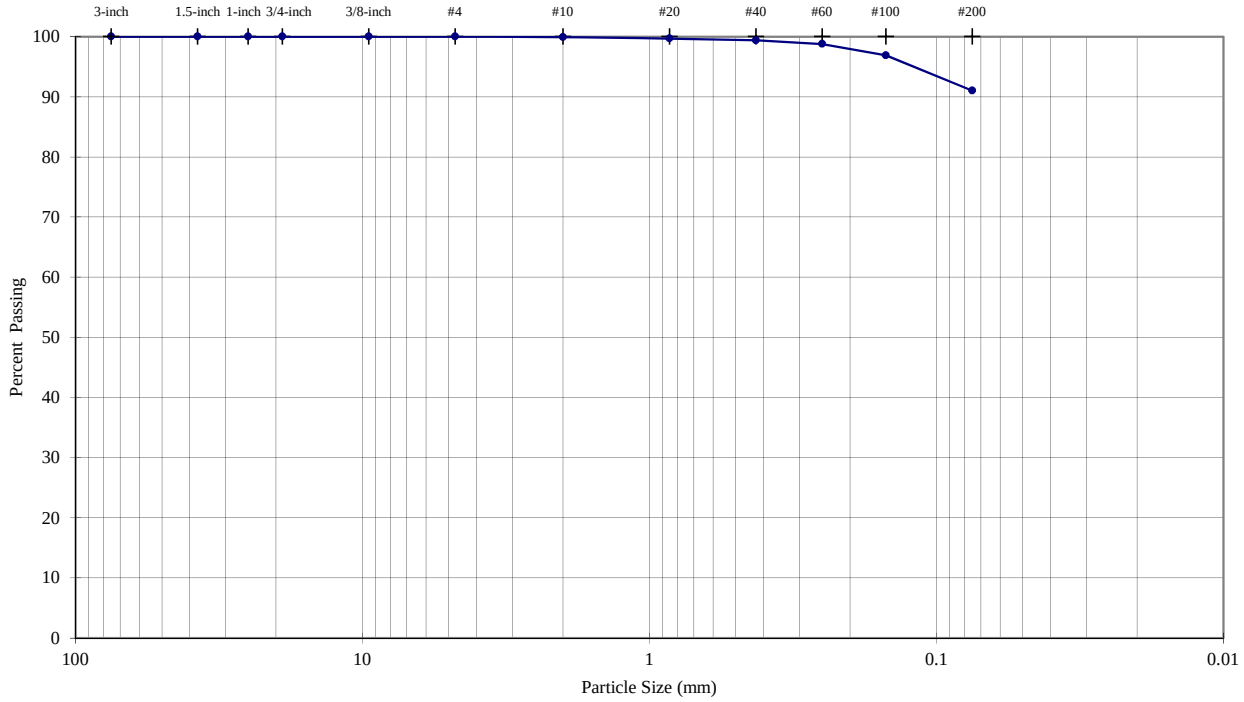
TECH	JP
DATE	23-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

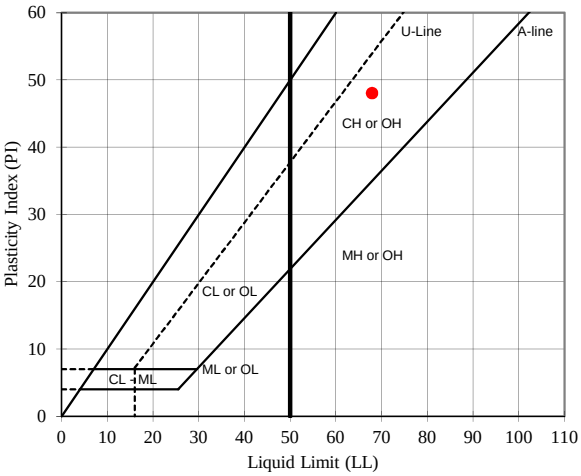
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-4 / S4** DEPTH (ft): **20-21.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.9**
#20	0.850	**99.7**
#40	0.425	**99.4**
#60	0.250	**98.8**
#100	0.150	**96.9**
#200	0.075	**91.0**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.10**
Medium Sand	**0.51**
Fine Sand	**8.37**
Silt or Clay Fines	**91.02**



USCS Description (ASTM D 2487):

Fat clay, light gray, moist

LL	PL	PI
68	**20**	**48**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	MGC
DATE	21-Mar-2018
REVIEW	MB

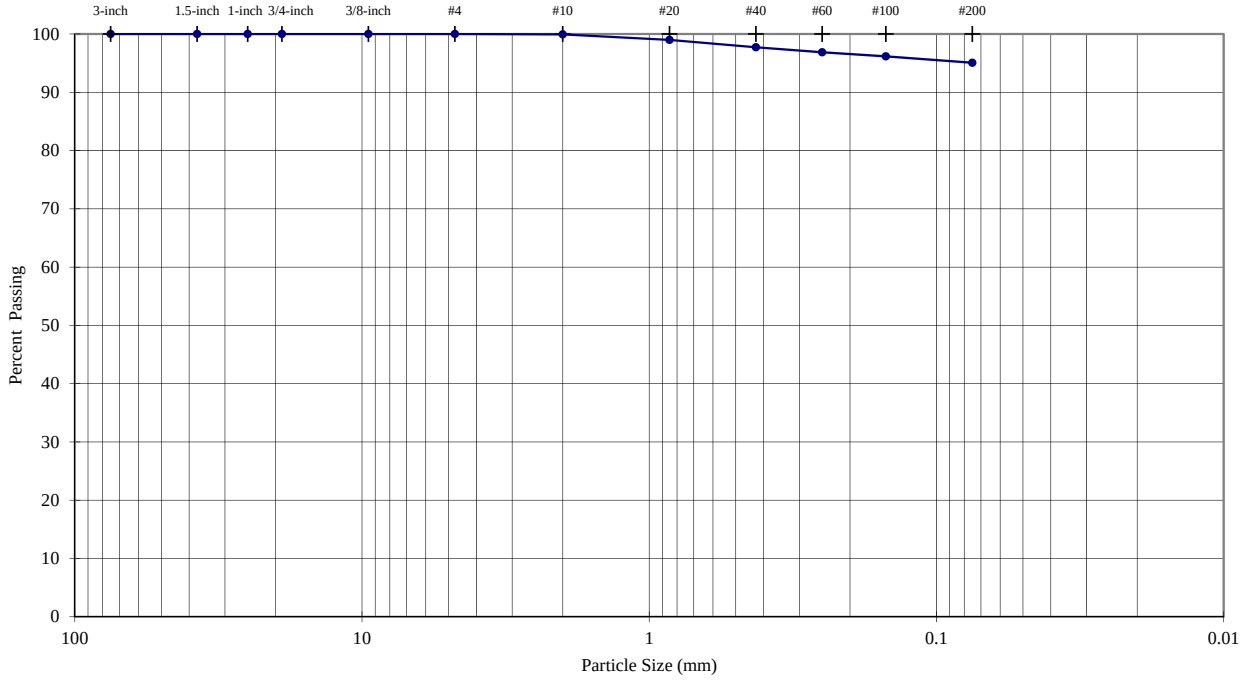
Golder Associates

April-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

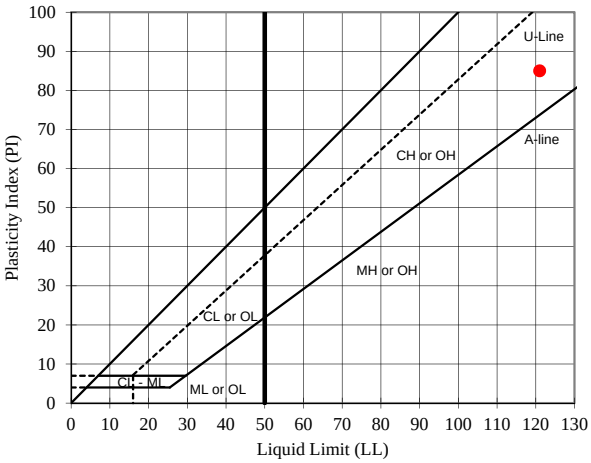
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-6 / S2** DEPTH (ft.): **10-11.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.9**
#20	0.850	**99.0**
#40	0.425	**97.7**
#60	0.250	**96.9**
#100	0.150	**96.2**
#200	0.075	**95.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.07**
Medium Sand	**2.21**
Fine Sand	**2.66**
Silt or Clay Fines	**95.06**



USCS Description (ASTM D 2487):

Fat clay, olive gray, moist

LL	PL	PI
121	**36**	**85**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	24-Apr-2018
REVIEW	MB

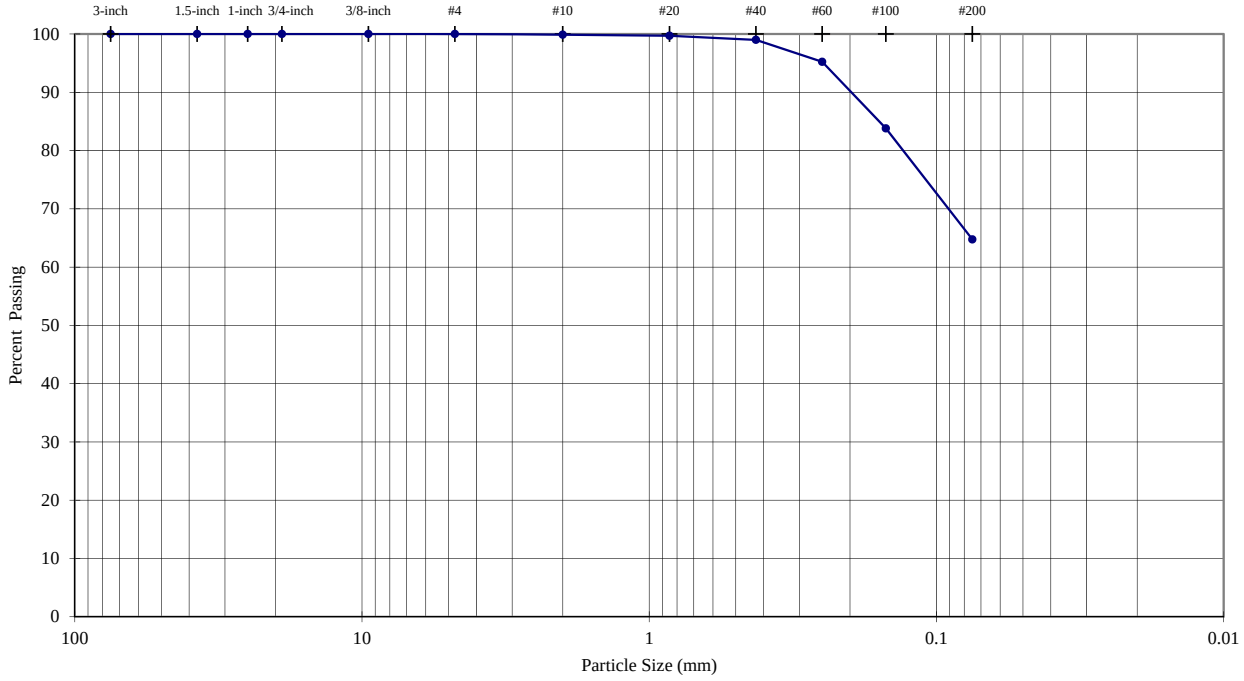
Golder Associates

April-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

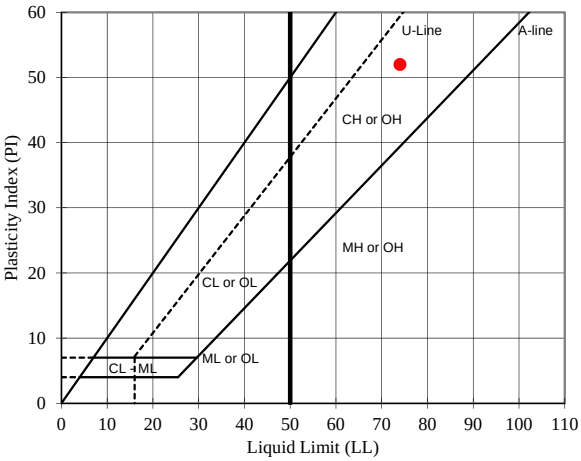
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-6 / S4** DEPTH (ft.): **20-21.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.9**
#20	0.850	**99.7**
#40	0.425	**99.0**
#60	0.250	**95.2**
#100	0.150	**83.8**
#200	0.075	**64.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.12**
Medium Sand	**0.89**
Fine Sand	**34.24**
Silt or Clay Fines	**64.75**



USCS Description (ASTM D 2487):

Sandy fat clay, light olive brown, dry

LL	PL	PI	SpG
74	**22**	**52**	**2.52**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

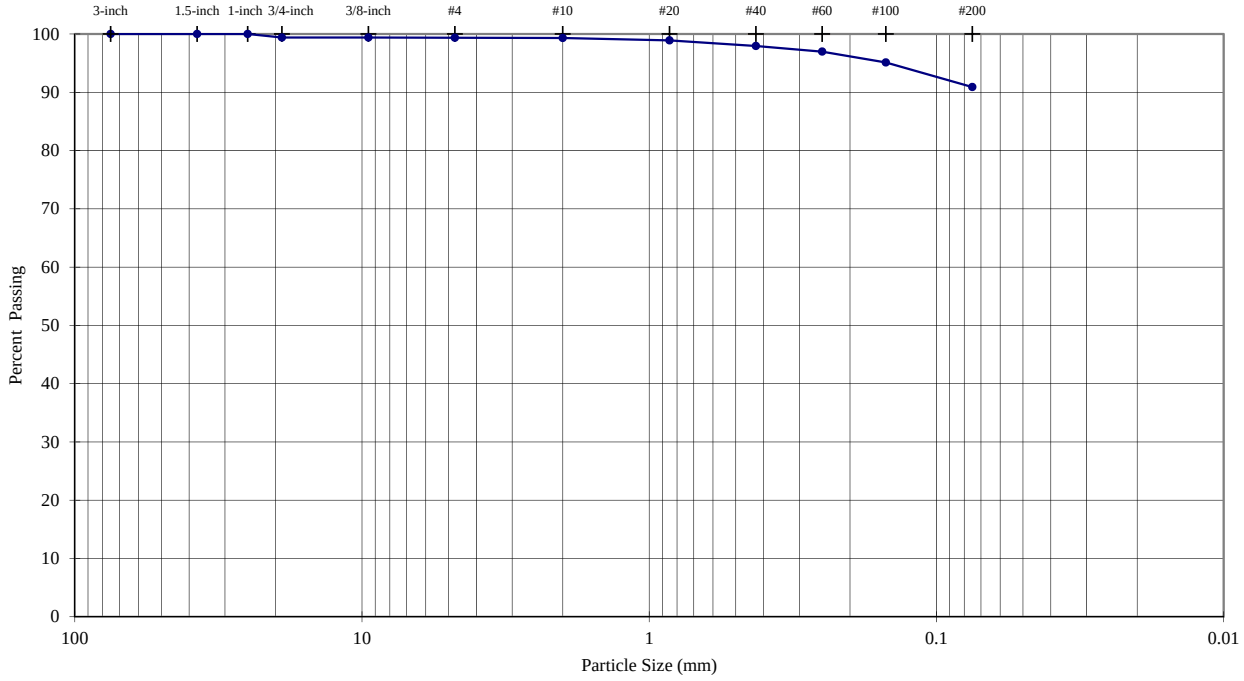
TECH	BC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

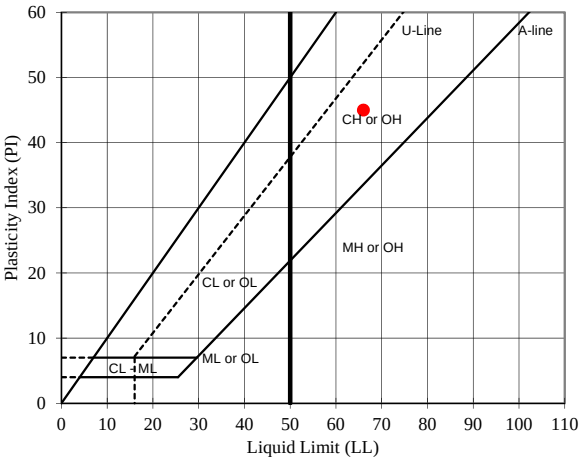
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-7 Combined / S5, S6 & S7** DEPTH (ft.): --
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**99.4**
3/8-inch	9.5	**99.4**
#4	4.75	**99.4**
#10	2.00	**99.3**
#20	0.85	**98.9**
#40	0.43	**97.9**
#60	0.25	**97.0**
#100	0.15	**95.1**
#200	0.075	**90.9**

Description	Percentage
Coarse Gravel	**0.60**
Fine Gravel	**0.04**
Coarse Sand	**0.05**
Medium Sand	**1.37**
Fine Sand	**7.05**
Silt or Clay Fines	**90.89**



USCS Description (ASTM D 2487):

Fat clay, light yellowish brown, moist

LL	PL	PI
66	**21**	**45**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 25.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

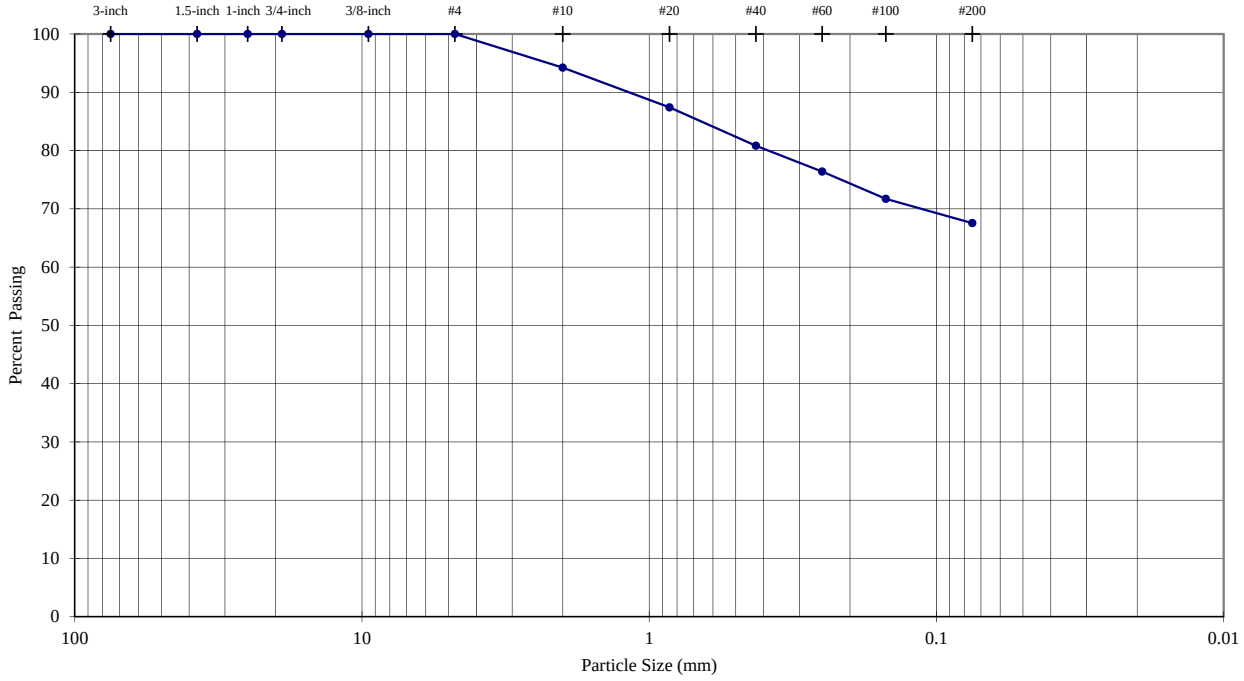
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

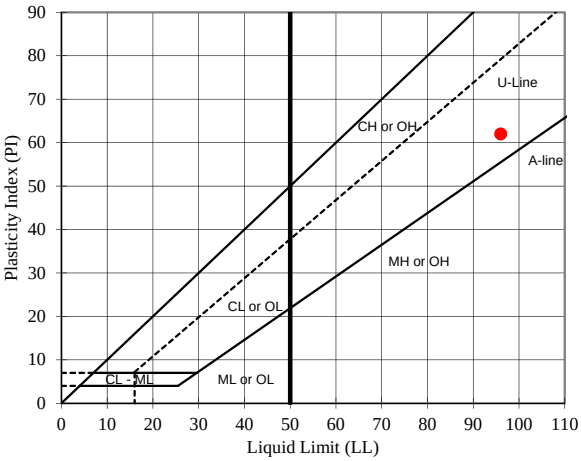
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-9/ S5** DEPTH (ft): **25-26.5**
TYPE: **Bag**



Sieve Analysis

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**94.2**
#20	0.850	**87.4**
#40	0.425	**80.8**
#60	0.250	**76.4**
#100	0.150	**71.7**
#200	0.075	**67.5**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**5.78**
Medium Sand	**13.41**
Fine Sand	**13.27**
Silt or Clay Fines	**67.54**



USCS Description (ASTM D 2487):

Sandy fat clay, dark yellowish brown, moist

LL	PL	PI
96	**34**	**62**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

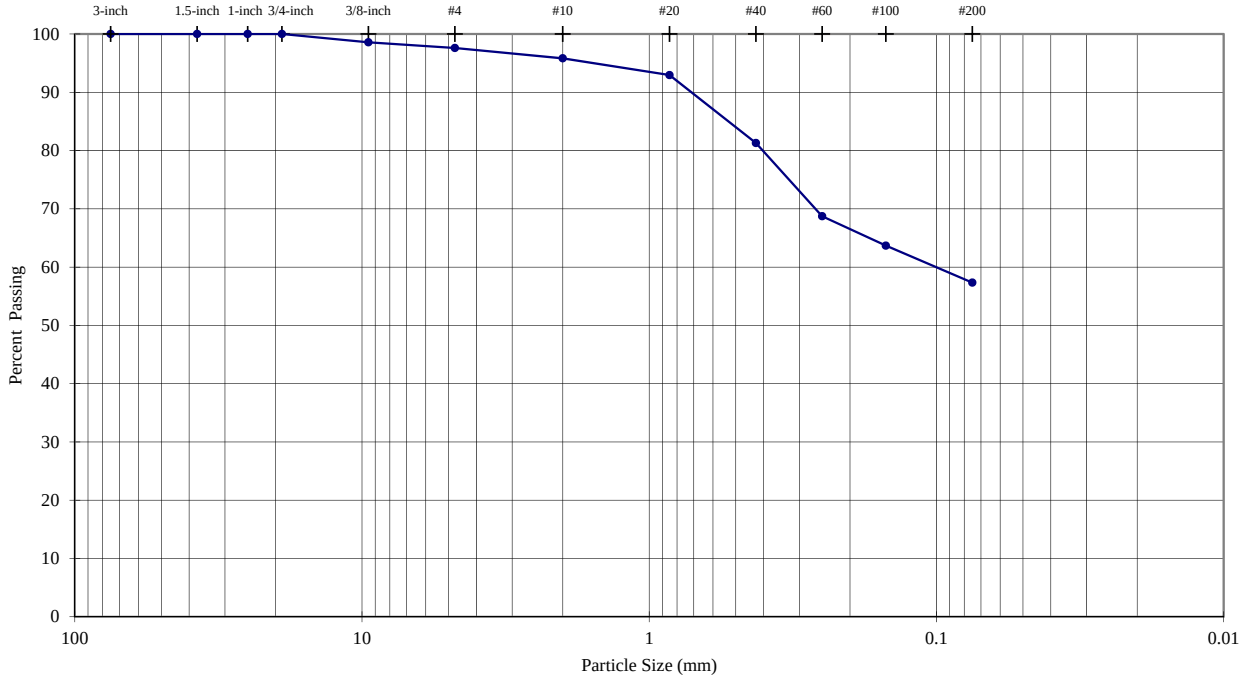
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

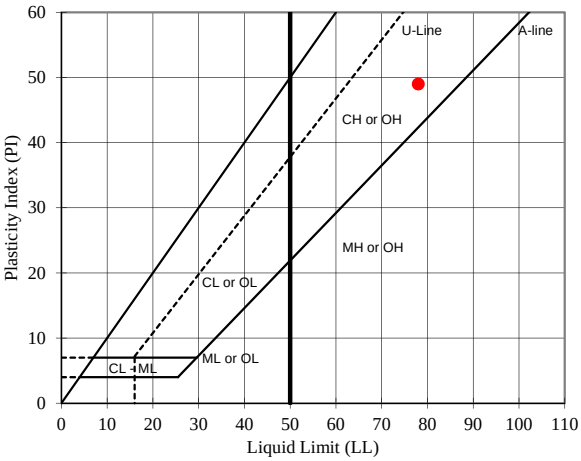
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-11/ S2** DEPTH (ft.): **10-11.5**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**98.6**
#4	4.75	**97.6**
#10	2.00	**95.8**
#20	0.85	**92.9**
#40	0.43	**81.3**
#60	0.25	**68.7**
#100	0.15	**63.7**
#200	0.075	**57.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**2.40**
Coarse Sand	**1.78**
Medium Sand	**14.53**
Fine Sand	**23.96**
Silt or Clay Fines	**57.33**



USCS Description (ASTM D 2487):

Sandy fat clay, light yellowish brown, moist

LL	PL	PI
78	**29**	**49**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

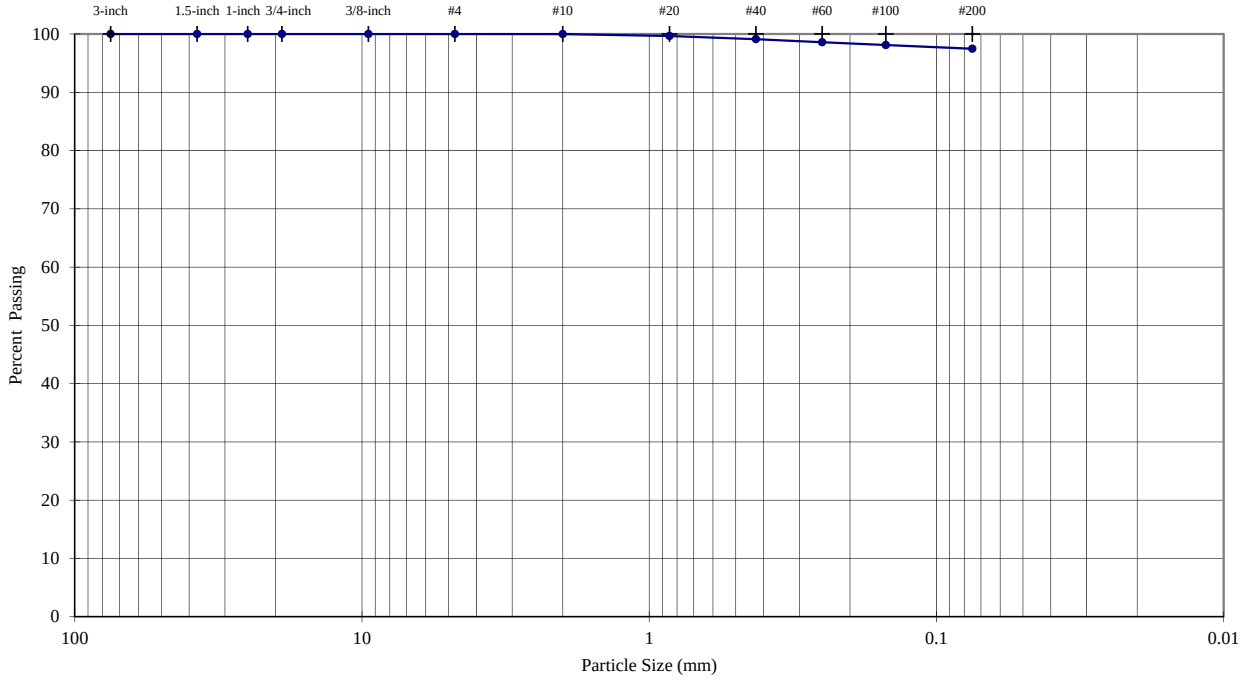
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

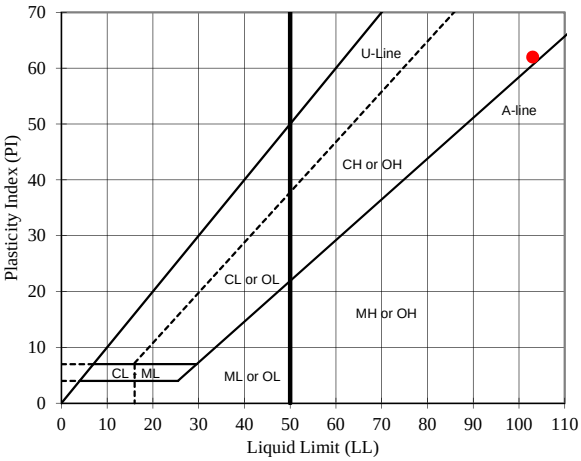
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-12 / S6** DEPTH (ft): **30-31.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**100.0**
#20	0.850	**99.7**
#40	0.425	**99.1**
#60	0.250	**98.6**
#100	0.150	**98.1**
#200	0.075	**97.5**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.01**
Medium Sand	**0.88**
Fine Sand	**1.65**
Silt or Clay Fines	**97.47**



USCS Description (ASTM D 2487):

Fat clay, gray, moist

LL	PL	PI
103	**41**	**62**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

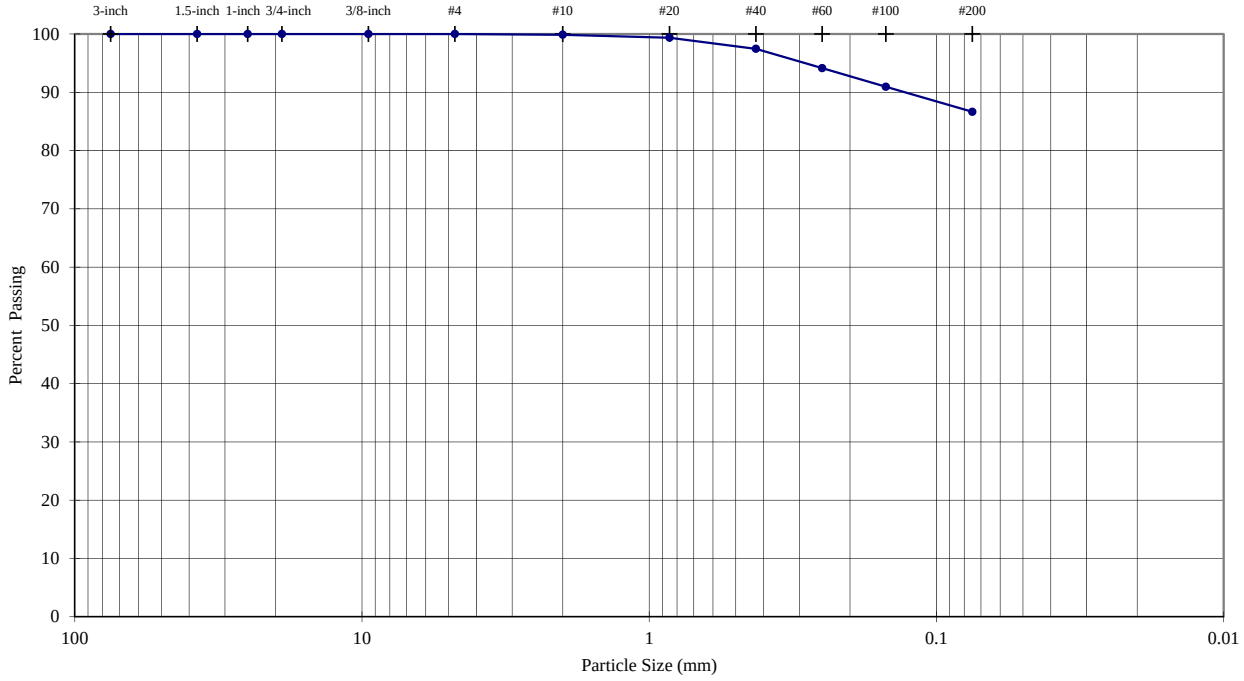
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

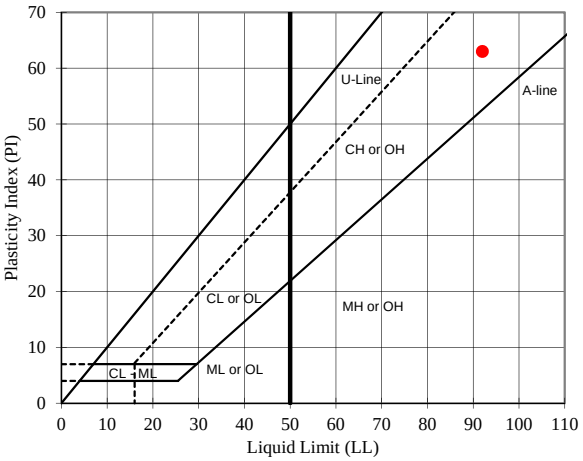
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-13 / S1** DEPTH (ft): **5-6.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**	Coarse Gravel	**0.00**
1.5-inch	37.5	**100.0**		
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**99.9**	Coarse Sand	**0.13**
#20	0.850	**99.4**	Medium Sand	**2.42**
#40	0.425	**97.5**		
#60	0.250	**94.1**	Fine Sand	**10.81**
#100	0.150	**90.9**		
#200	0.075	**86.6**		
			Silt or Clay Fines	**86.64**

Sieve Analysis



USCS Description (ASTM D 2487):

Fat clay, light yellowish brown, moist

LL	PL	PI
92	**29**	**63**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

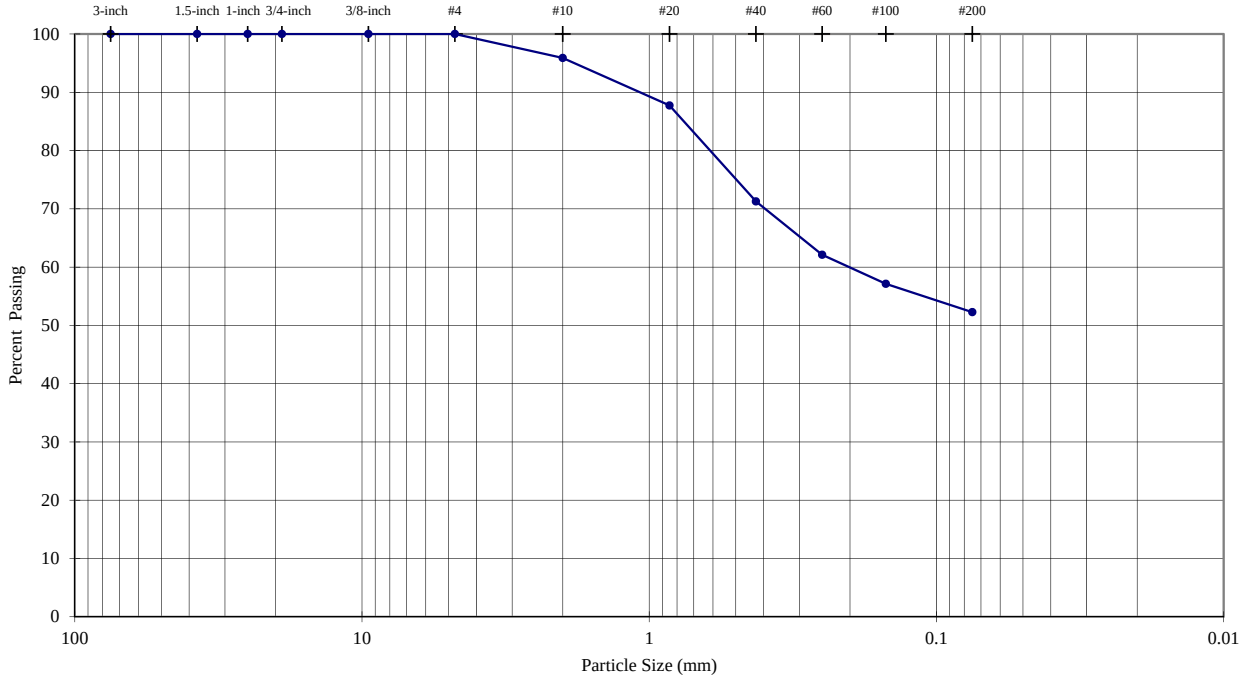
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

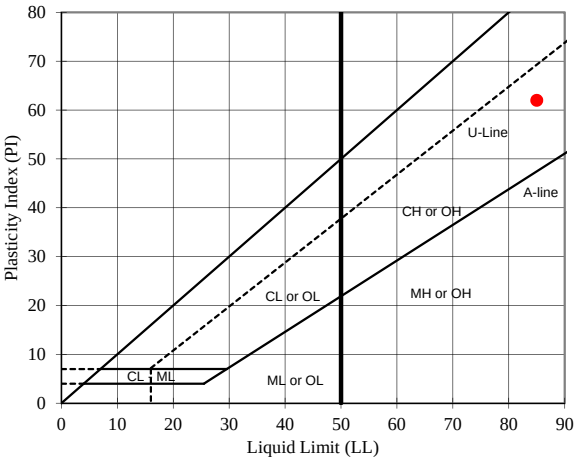
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-13 / S3** DEPTH (ft): **15-16.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**95.9**
#20	0.850	**87.7**
#40	0.425	**71.3**
#60	0.250	**62.1**
#100	0.150	**57.1**
#200	0.075	**52.3**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**4.12**
Medium Sand	**24.62**
Fine Sand	**19.00**
Silt or Clay Fines	**52.27**



USCS Description (ASTM D 2487):

Sandy fat clay, light brown, moist

LL	PL	PI
85	**23**	**62**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

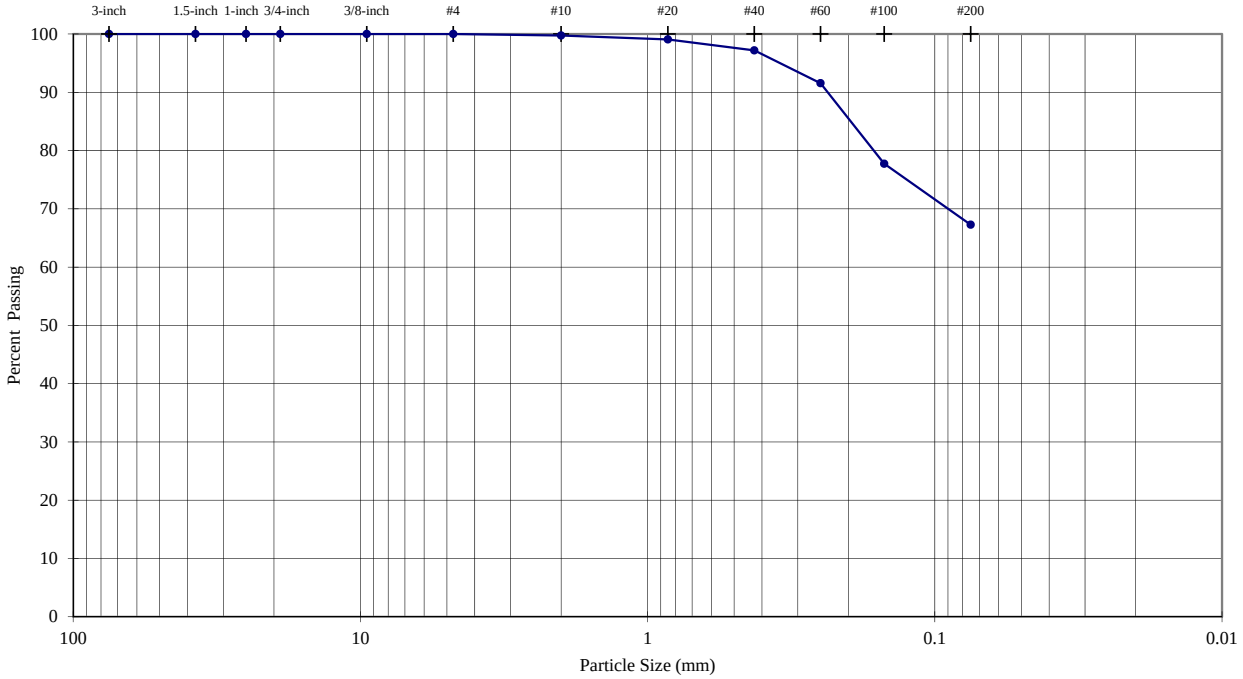
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

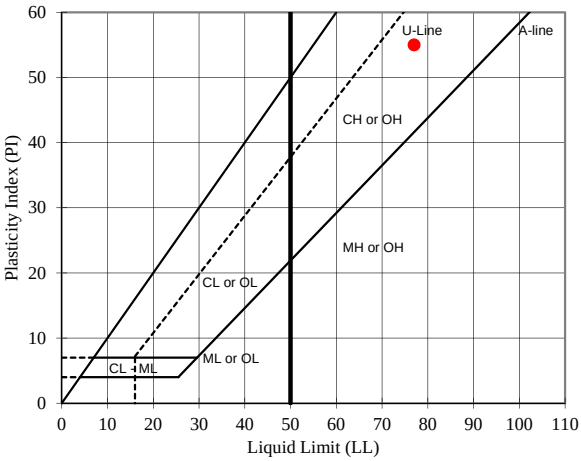
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-13 / S5** DEPTH (ft): **25-26.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.7**
#20	0.850	**99.1**
#40	0.425	**97.2**
#60	0.250	**91.5**
#100	0.150	**77.7**
#200	0.075	**67.3**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.26**
Medium Sand	**2.55**
Fine Sand	**29.92**
Silt or Clay Fines	**67.27**



USCS Description (ASTM D 2487):

Sandy fat clay, light yellowish brown, moist

LL	PL	PI
77	**22**	**55**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

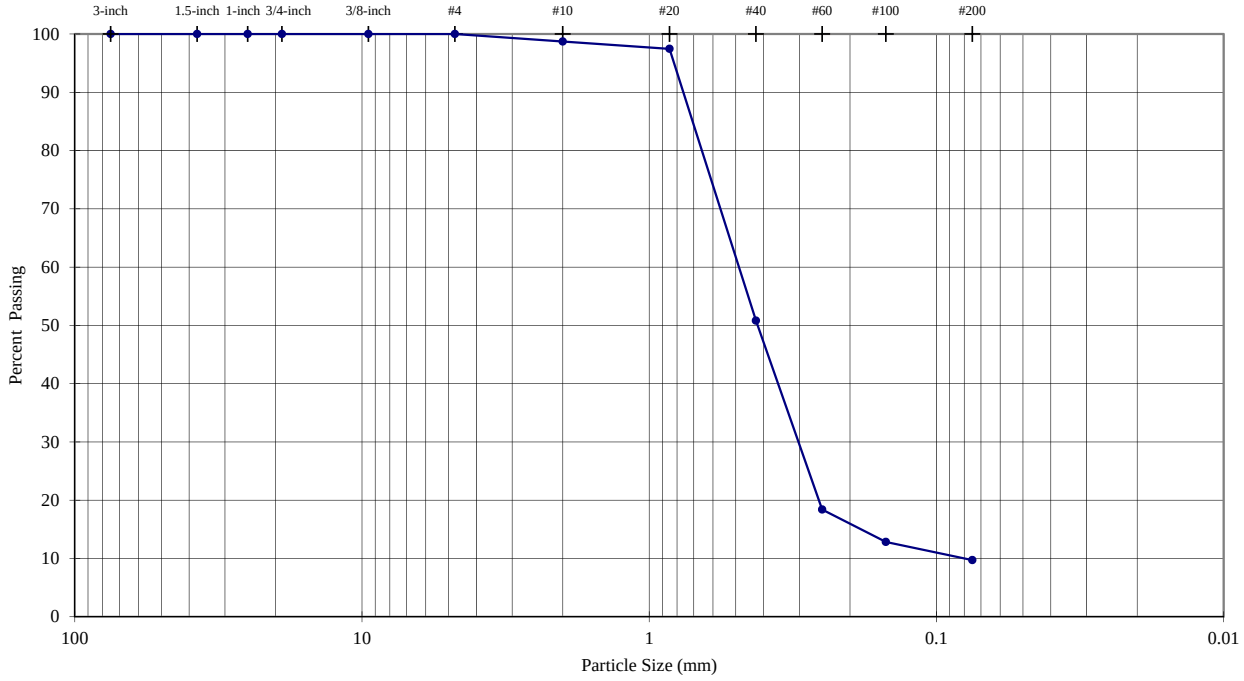
TECH	EH
DATE	13-Mar-2018
REVIEW	PRH

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

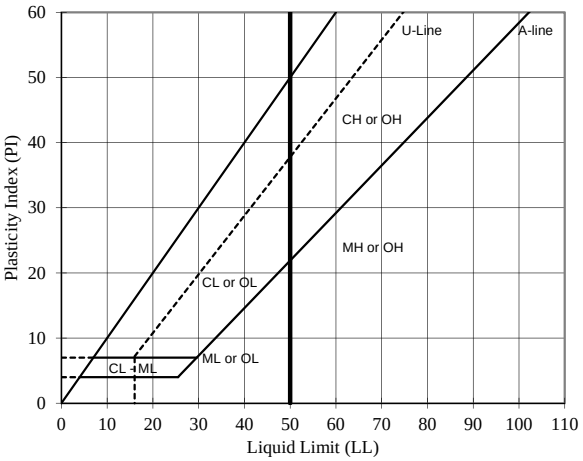
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-14 / S2, S3 COMB** DEPTH (ft): **10-11.5 & 15-16.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**98.7**
#20	0.850	**97.5**
#40	0.425	**50.8**
#60	0.250	**18.4**
#100	0.150	**12.8**
#200	0.075	**9.7**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**1.29**
Medium Sand	**47.90**
Fine Sand	**41.09**
Silt or Clay Fines	**9.72**



USCS Description (ASTM D 2487):

Well-graded sand with silt, tan, dry

LL	PL	PI
NP	**NP**	**NP**

As-Received Moisture Content (%): --

USCS Group Symbol: SW-SM

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

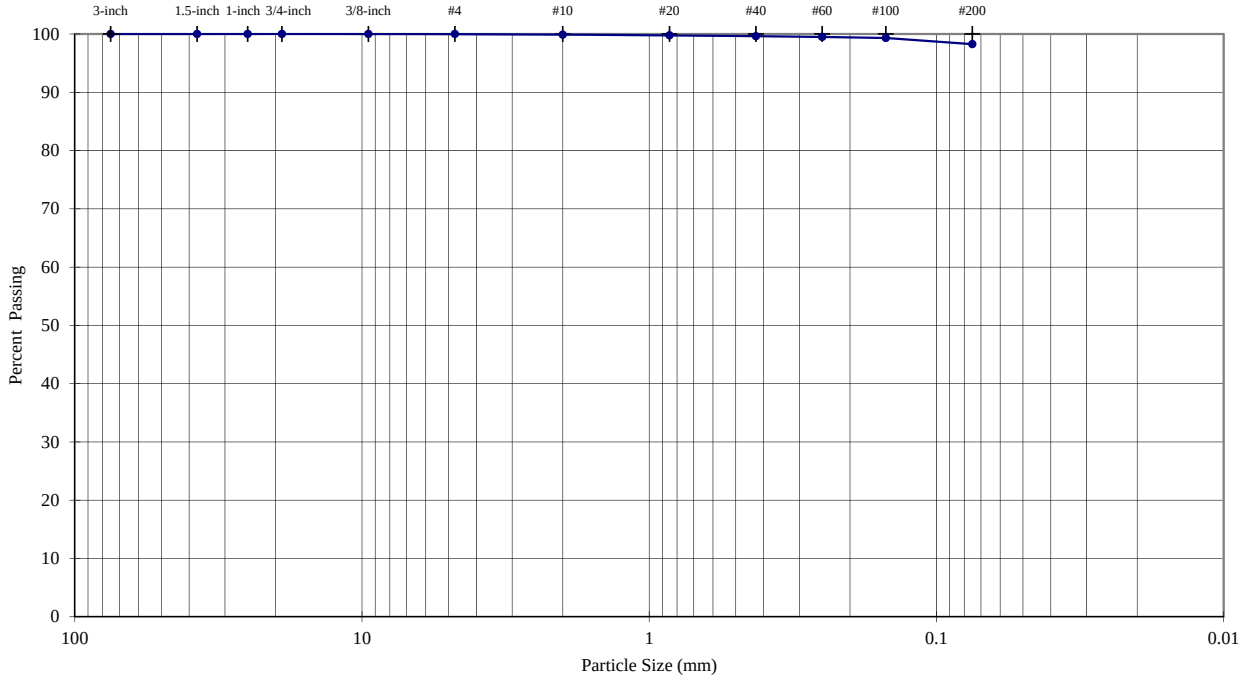
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

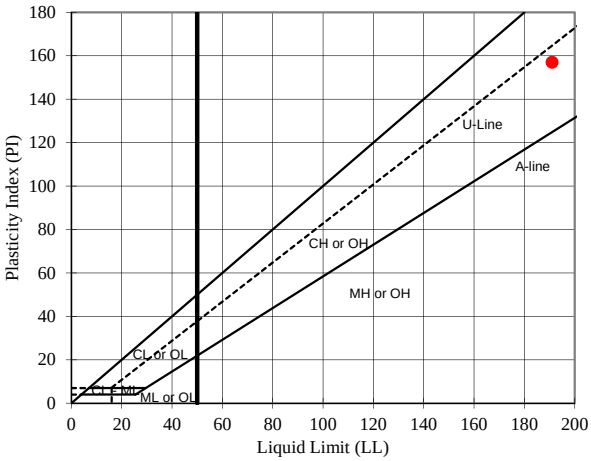
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-15 / S2** DEPTH (ft): **25-26.5**
TYPE: **Tube**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.9**
#20	0.850	**99.8**
#40	0.425	**99.6**
#60	0.250	**99.5**
#100	0.150	**99.3**
#200	0.075	**98.3**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.12**
Medium Sand	**0.27**
Fine Sand	**1.36**
Silt or Clay Fines	**98.25**



USCS Description (ASTM D 2487):

Fat clay, light olive gray, dry

LL	PL	PI	SpG
191	**34**	**157**	**2.76**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	12-Mar-2018
REVIEW	PRH

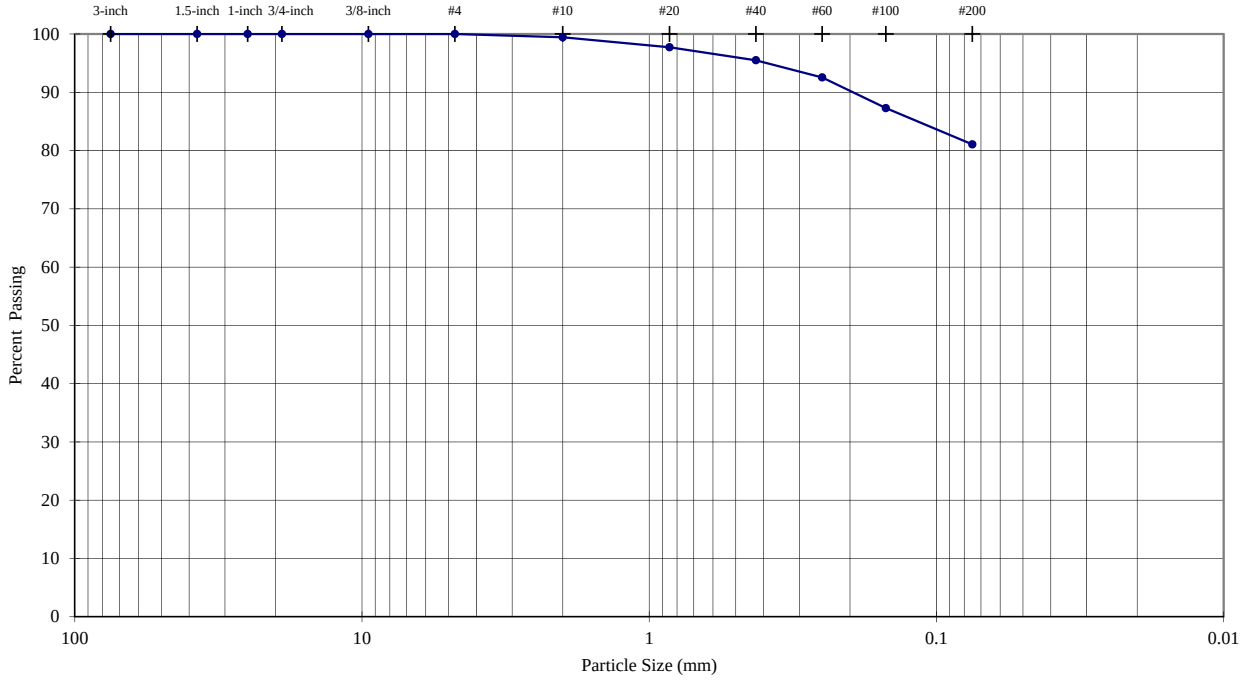
Golder Associates

April-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

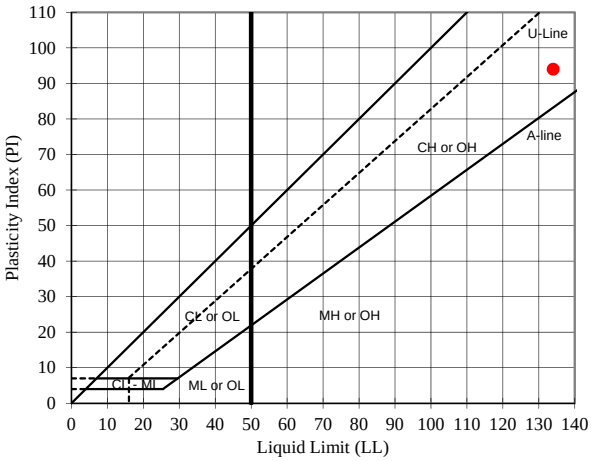
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH-15 / S-1** DEPTH (ft.): **15-16.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.4**
#20	0.850	**97.7**
#40	0.425	**95.5**
#60	0.250	**92.5**
#100	0.150	**87.3**
#200	0.075	**81.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.57**
Medium Sand	**3.94**
Fine Sand	**14.43**
Silt or Clay Fines	**81.06**



USCS Description (ASTM D 2487):

Lean clay with sand, olive, moist

LL	PL	PI
134	**40**	**94**

As-Received Moisture Content (%): --

USCS Group Symbol: CL

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

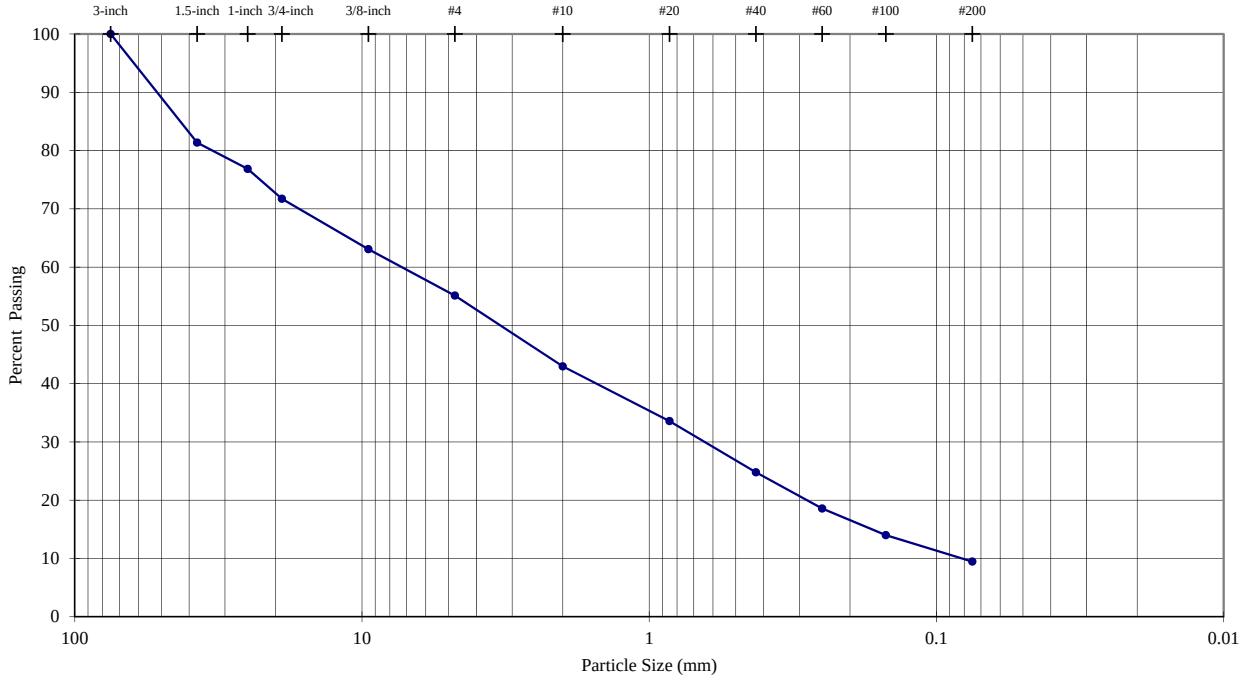
TECH	BC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

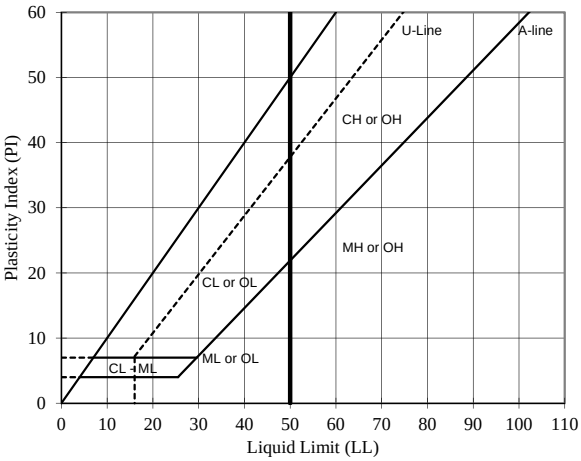
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-02** DEPTH (ft.): **2-3**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**81.4**
1-inch	25.0	**76.8**
3/4-inch	19.0	**71.7**
3/8-inch	9.5	**63.1**
#4	4.75	**55.1**
#10	2.00	**43.0**
#20	0.85	**33.6**
#40	0.43	**24.8**
#60	0.25	**18.6**
#100	0.15	**14.0**
#200	0.075	**9.5**

Description	Percentage
Coarse Gravel	**28.29**
Fine Gravel	**16.60**
Coarse Sand	**12.14**
Medium Sand	**18.18**
Fine Sand	**15.33**
Silt or Clay Fines	**9.46**



USCS Description (ASTM D 2487):

Poorly graded sand with silt and gravel, yellowish brown, moist

LL	PL	PI
NP	**NP**	**NP**

As-Received Moisture Content (%): --

USCS Group Symbol: SP-SM

Notes: 0 g of particles up to 75.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

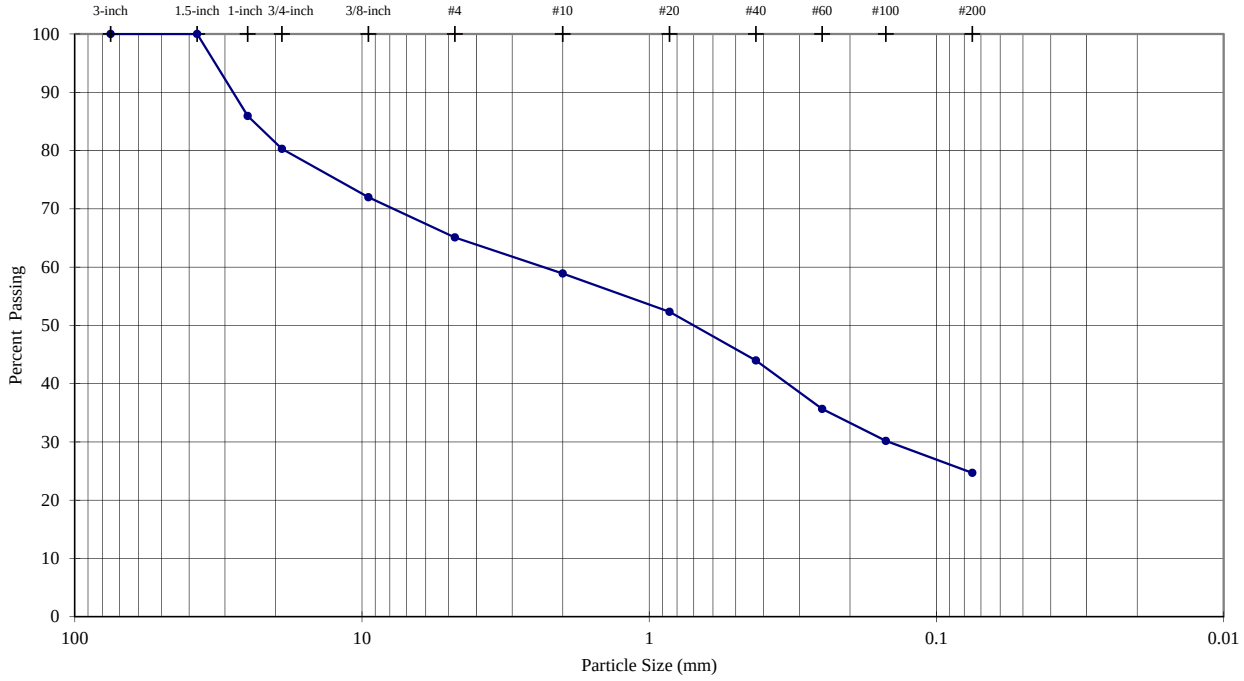
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

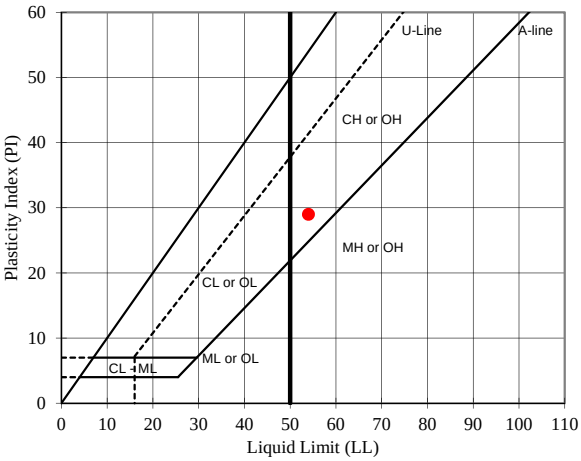
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-5** DEPTH (ft.): **8-9 & 13-14 COMB**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**85.9**
3/4-inch	19.0	**80.3**
3/8-inch	9.5	**72.0**
#4	4.75	**65.1**
#10	2.00	**58.9**
#20	0.850	**52.3**
#40	0.425	**44.0**
#60	0.250	**35.7**
#100	0.150	**30.2**
#200	0.075	**24.7**

Description	Percentage
Coarse Gravel	**19.71**
Fine Gravel	**15.20**
Coarse Sand	**6.18**
Medium Sand	**14.93**
Fine Sand	**19.29**
Silt or Clay Fines	**24.69**



USCS Description (ASTM D 2487):

Clayey sand with gravel, light olive brown, moist

LL	PL	PI
54	**25**	**29**

As-Received Moisture Content (%): **23.3**

USCS Group Symbol: SC

Notes: 0 g of particles up to 37.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

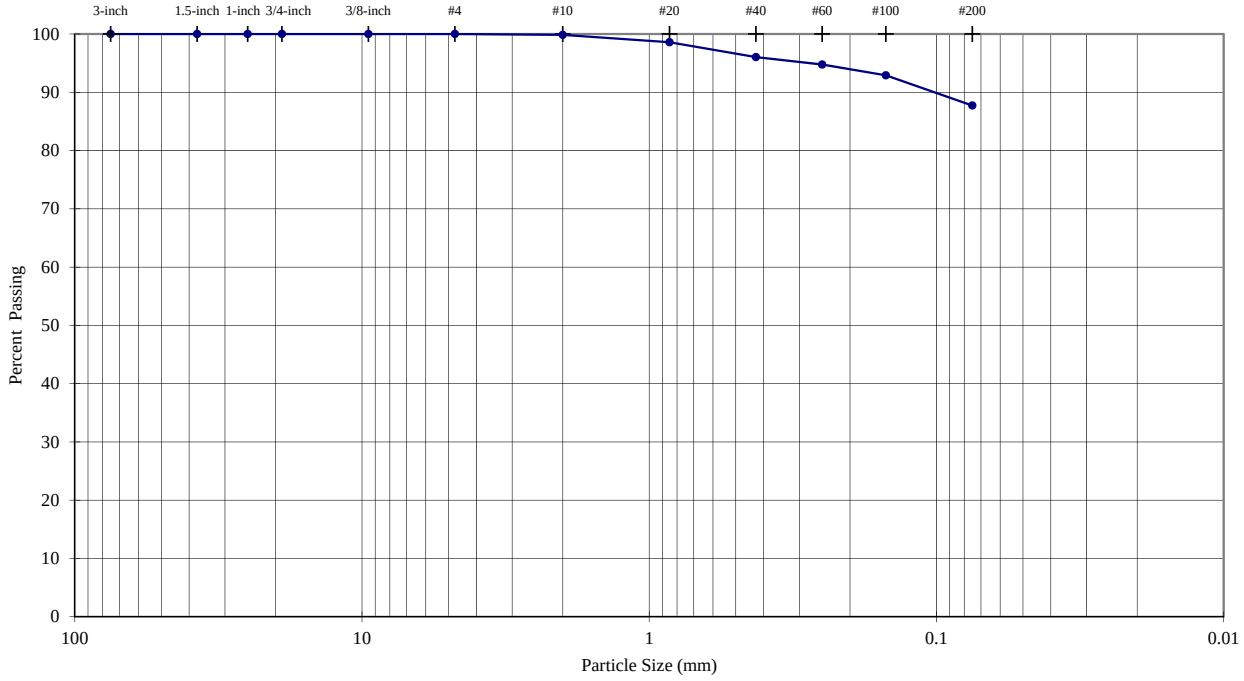
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

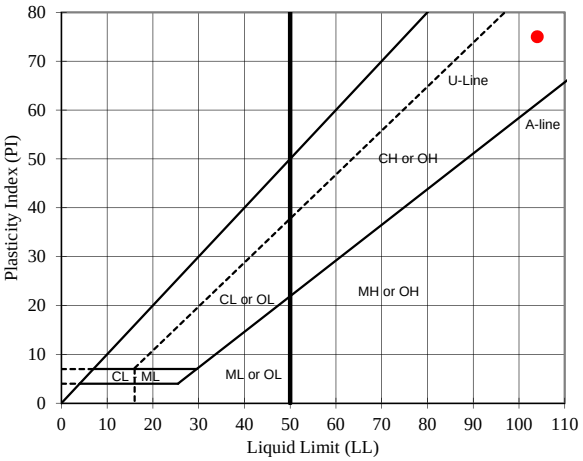
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-9** DEPTH (ft): **2-15**
TYPE: **Pail**



Sieve Analysis

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**99.8**
#20	0.850	**98.6**
#40	0.425	**96.0**
#60	0.250	**94.8**
#100	0.150	**92.9**
#200	0.075	**87.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.15**
Medium Sand	**3.81**
Fine Sand	**8.31**
Silt or Clay Fines	**87.72**



USCS Description (ASTM D 2487):

Fat clay, pale olive, moist

LL	PL	PI
104	**29**	**75**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

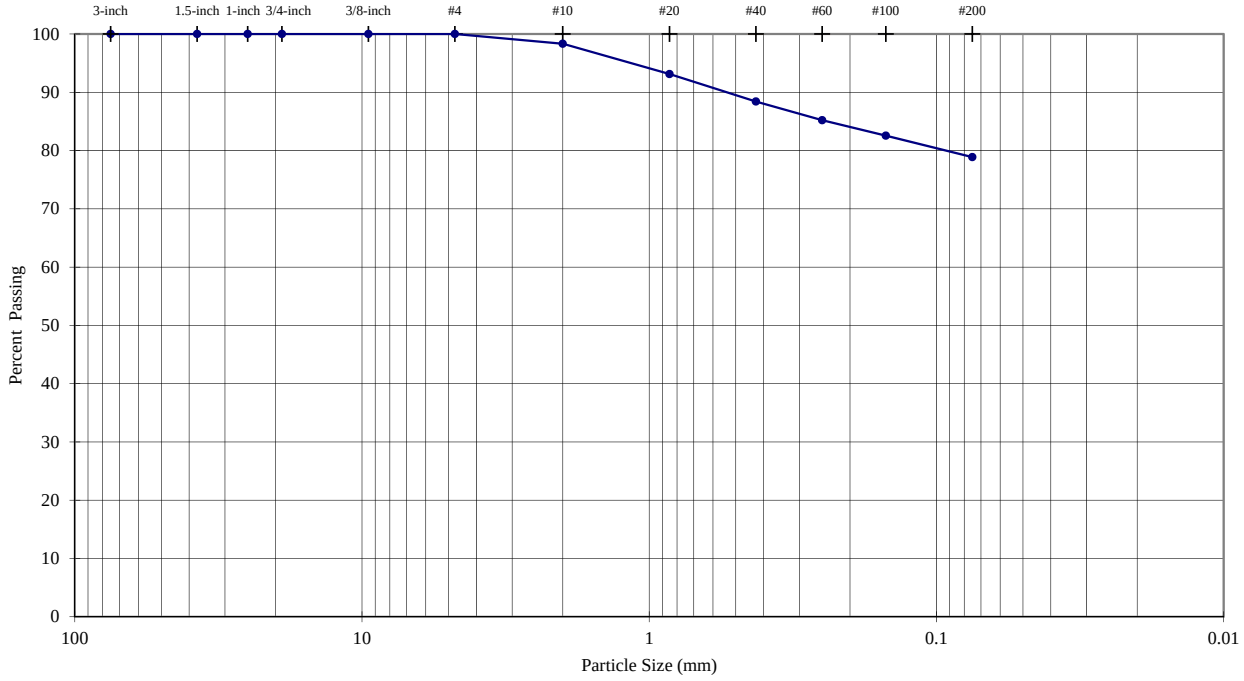
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

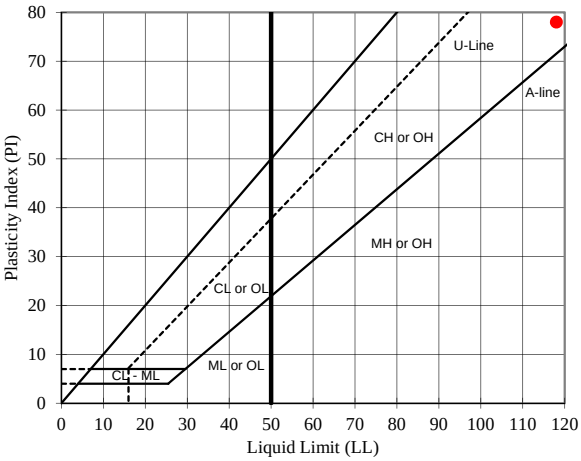
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-11 / S2** DEPTH (ft): **12-14.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**98.3**	Coarse Sand	**1.67**
#20	0.850	**93.1**	Medium Sand	**9.92**
#40	0.425	**88.4**		
#60	0.250	**85.2**	Fine Sand	**9.54**
#100	0.150	**82.6**		
#200	0.075	**78.9**		
			Silt or Clay Fines	**78.87**

Sieve Analysis



USCS Description (ASTM D 2487):

Sandy clay, light yellowish brown, moist

LL	PL	PI
118	**40**	**78**

As-Received Moisture Content (%): --

USCS Group Symbol: 0

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

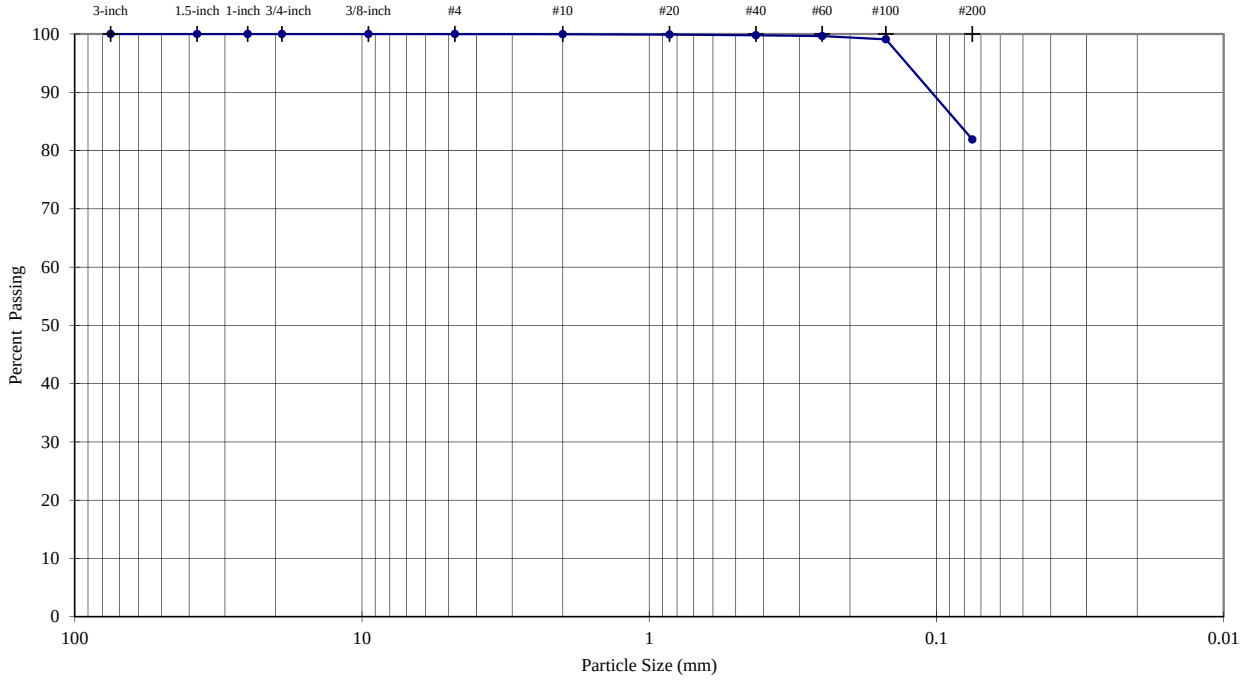
TECH	TC/JP
DATE	21-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

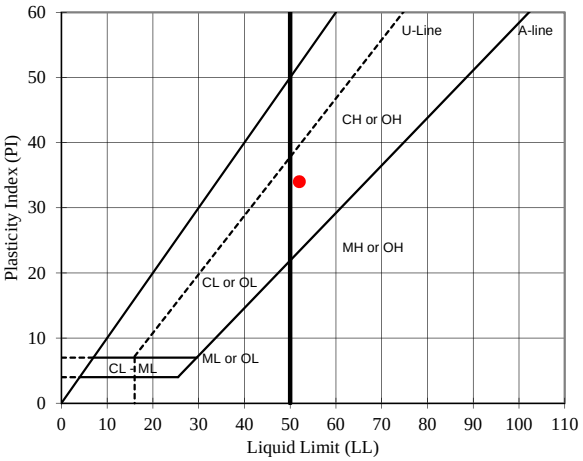
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-17** DEPTH (ft): **2-14**
TYPE: **Pail**



Sieve Analysis

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.8**
#60	0.250	**99.6**
#100	0.150	**99.1**
#200	0.075	**81.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.05**
Medium Sand	**0.17**
Fine Sand	**17.88**
Silt or Clay Fines	**81.90**



USCS Description (ASTM D 2487):

Fat clay with sand, light brown, moist

LL	PL	PI
52	**18**	**34**

As-Received Moisture Content (%): --

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

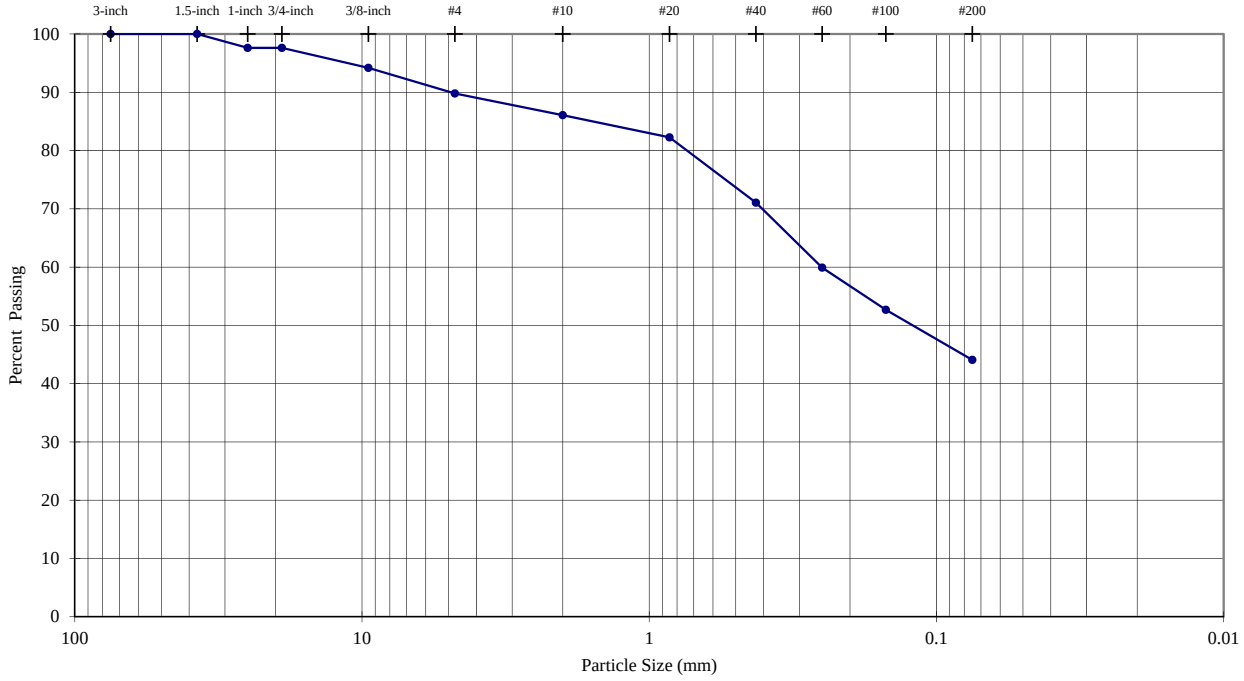
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

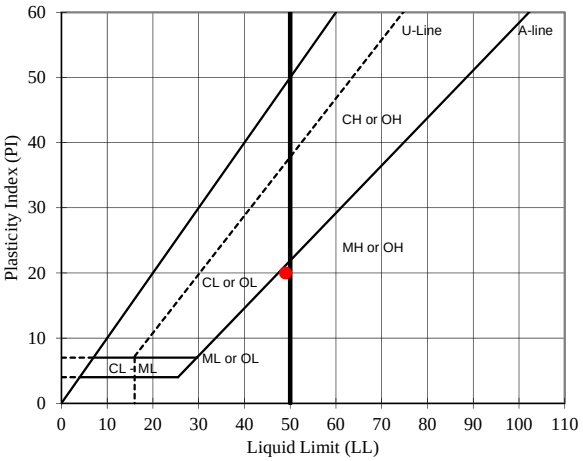
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-23** DEPTH (ft.): **2-3**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**2.39**
1-inch	25.0	**97.6**		
3/4-inch	19.0	**97.6**		
3/8-inch	9.5	**94.2**	Fine Gravel	**7.82**
#4	4.75	**89.8**		
#10	2.00	**86.1**	Coarse Sand	**3.73**
#20	0.85	**82.3**	Medium Sand	**15.02**
#40	0.43	**71.0**		
#60	0.25	**59.9**	Fine Sand	**26.98**
#100	0.15	**52.7**		
#200	0.075	**44.1**		
			Silt or Clay Fines	**44.07**

Sieve Analysis (Initial Separation on No. 4 Sieve)



USCS Description (ASTM D 2487):

Silty sand, light brown, dry

LL	PL	PI
49	**29**	**20**

As-Received Moisture Content (%): --

USCS Group Symbol: SM

Notes: 0 g of particles up to 37.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the wet/dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A/B Liquid Limit test performed using mechanical device

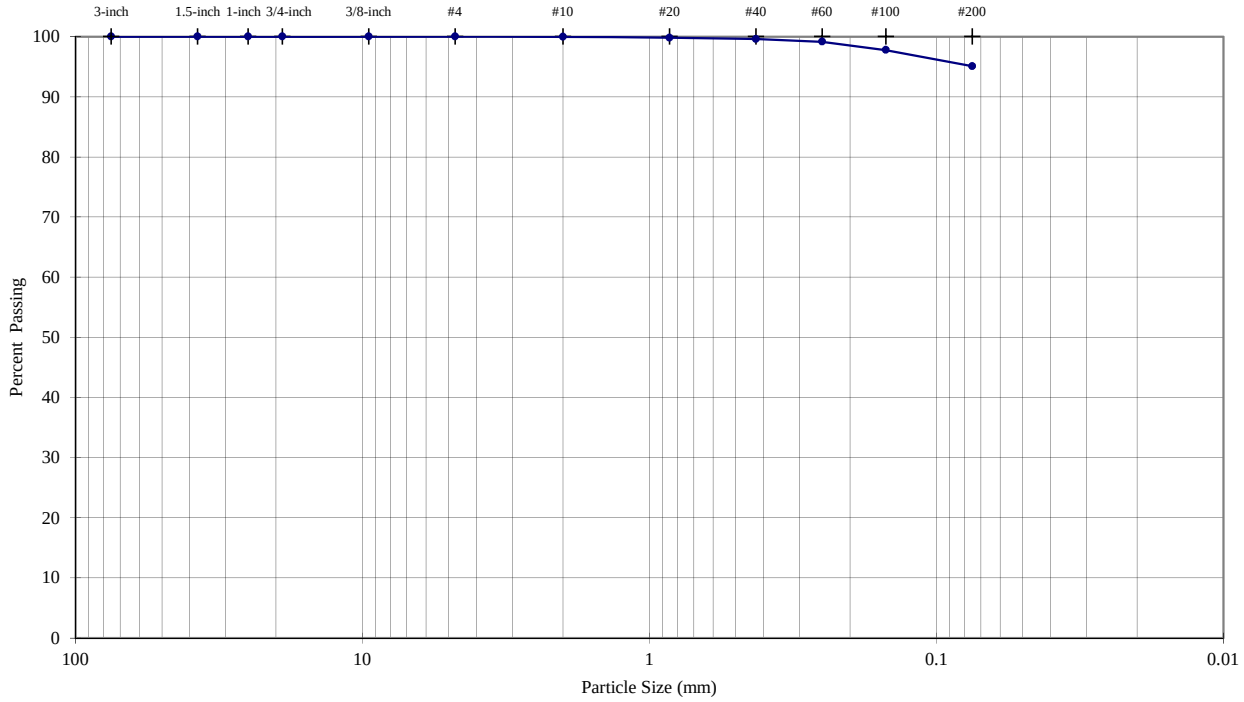
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

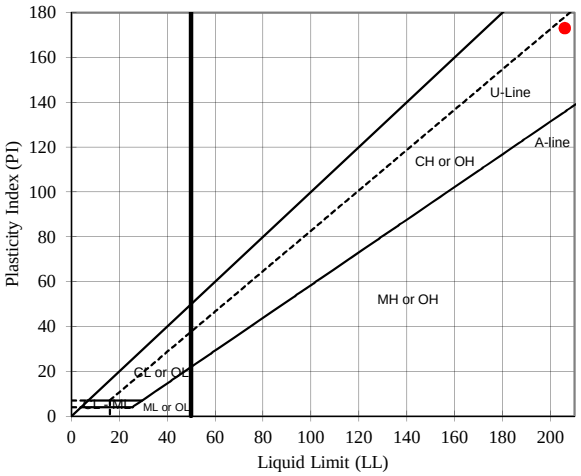
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-23** DEPTH (ft): **10-11**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.00	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.6**
#60	0.250	**99.1**
#100	0.150	**97.7**
#200	0.075	**95.1**

Sieve Analysis

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.03**
Medium Sand	**0.37**
Fine Sand	**4.52**
Silt or Clay Fines	**95.08**



USCS Description (ASTM D 2487):

Fat clay, light olive, dry

LL	PL	PI
206	**33**	**173**

As-Received Moisture Content (%): **35.8**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

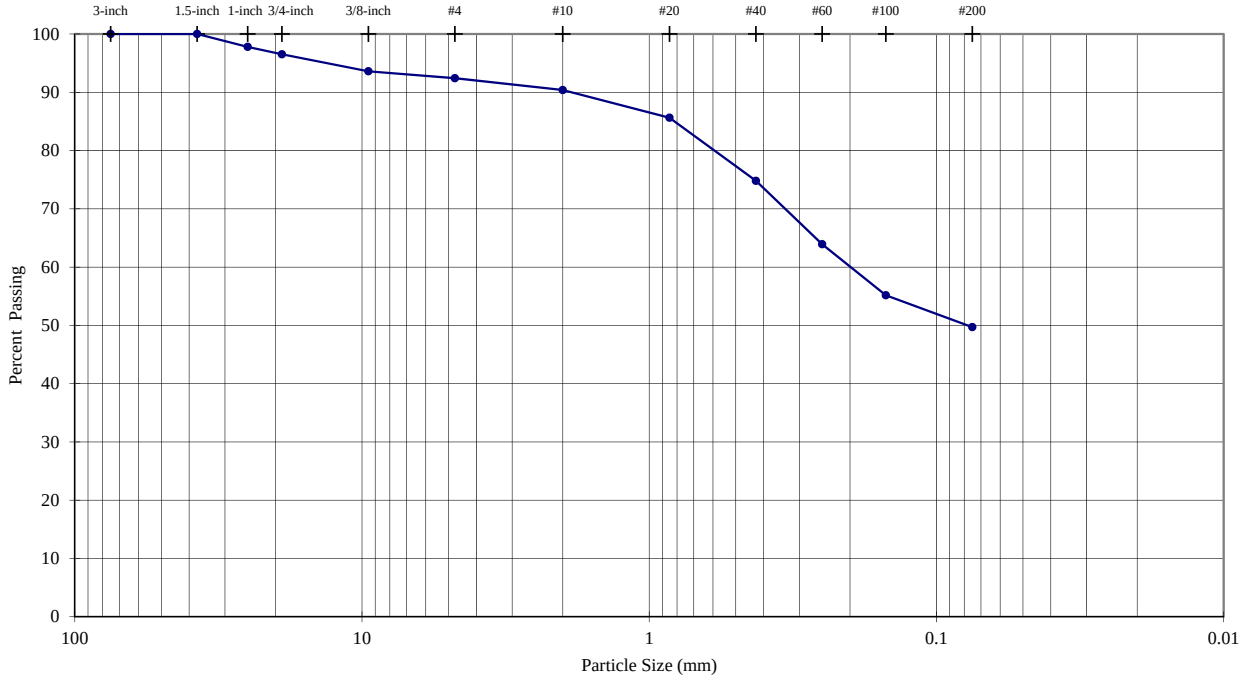
TECH	TC/JP
DATE	21-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

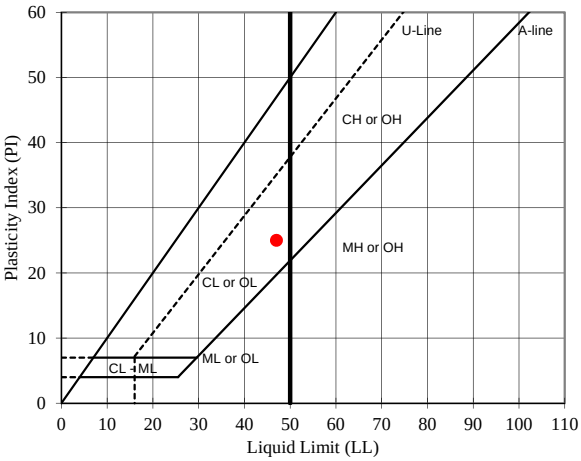
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-30** DEPTH (ft.): **1.5-2.5**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**97.8**
3/4-inch	19.0	**96.5**
3/8-inch	9.5	**93.6**
#4	4.75	**92.4**
#10	2.00	**90.4**
#20	0.850	**85.6**
#40	0.425	**74.8**
#60	0.250	**63.9**
#100	0.150	**55.2**
#200	0.075	**49.7**

Description	Percentage
Coarse Gravel	**3.48**
Fine Gravel	**4.11**
Coarse Sand	**2.03**
Medium Sand	**15.58**
Fine Sand	**25.10**
Silt or Clay Fines	**49.70**



USCS Description (ASTM D 2487):

Sandy lean clay, yellowish brown, moist

LL	PL	PI
47	**22**	**25**

As-Received Moisture Content (%): **11.9**

USCS Group Symbol: CL

Notes: 0 g of particles up to 37.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

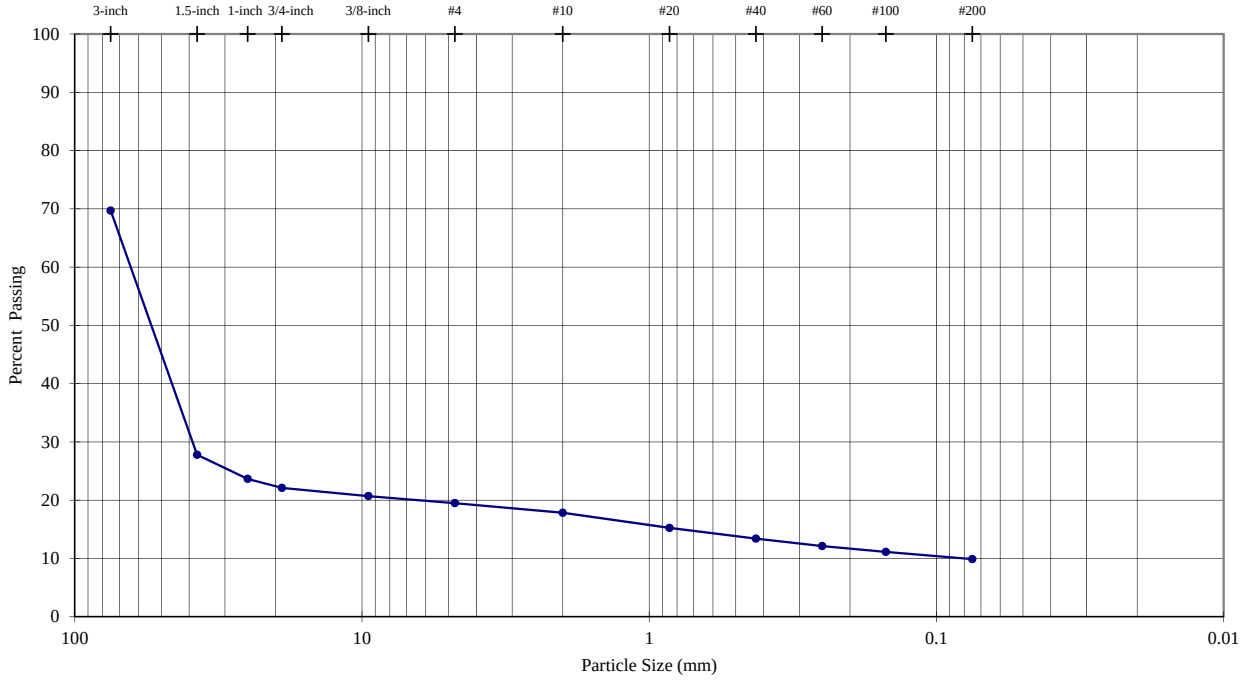
TECH	JP
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

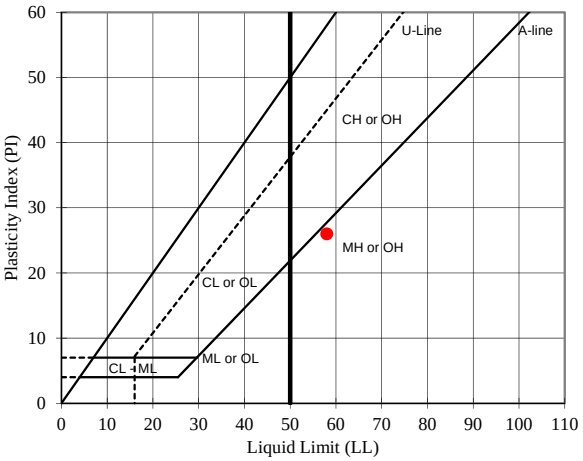
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-33 & TP-34** DEPTH (ft.): **4.5-5.5' & 1-3' COMB**
TYPE: **0**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**69.7**		
1.5-inch	37.5	**27.8**	Coarse Gravel	**47.58**
1-inch	25.0	**23.7**		
3/4-inch	19.0	**22.1**		
3/8-inch	9.5	**20.7**	Fine Gravel	**2.62**
#4	4.75	**19.5**		
#10	2.00	**17.8**	Coarse Sand	**1.65**
#20	0.850	**15.3**	Medium Sand	**4.44**
#40	0.425	**13.4**		
#60	0.250	**12.1**	Fine Sand	**3.51**
#100	0.150	**11.1**		
#200	0.075	**9.9**		
			Silt or Clay Fines	**9.89**

Sieve Analysis (Initial Separation on No. 4 Sieve)



USCS Description (ASTM D 2487):

Silty gravel with cobbles, brown, moist

LL	PL	PI
58	**32**	**26**

As-Received Moisture Content (%): **19.8**

USCS Group Symbol: GM

Notes: 0 g of particles up to 75.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

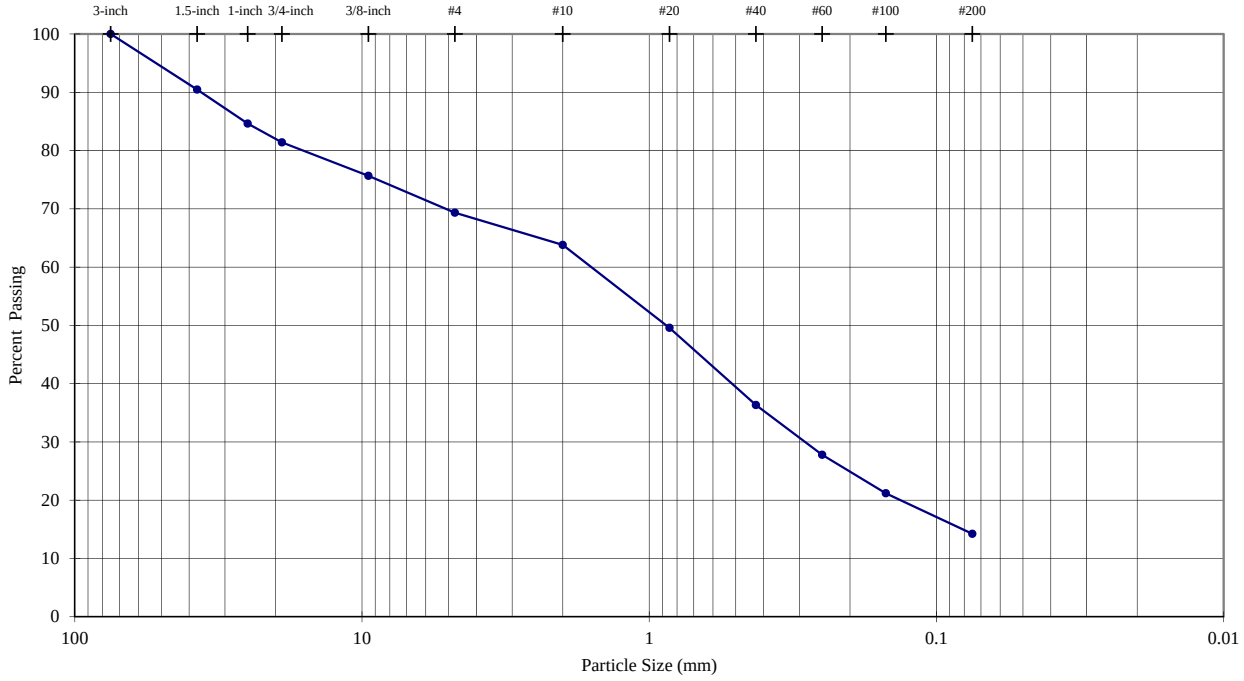
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

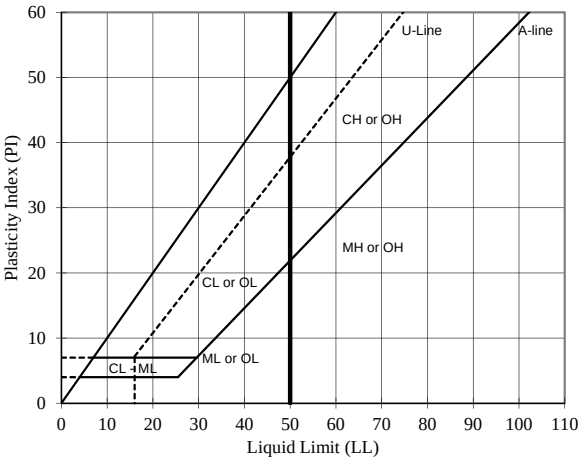
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-37** DEPTH (ft.): **3-9**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**90.5**
1-inch	25.0	**84.6**
3/4-inch	19.0	**81.4**
3/8-inch	9.5	**75.7**
#4	4.75	**69.3**
#10	2.00	**63.8**
#20	0.85	**49.6**
#40	0.43	**36.3**
#60	0.25	**27.8**
#100	0.15	**21.2**
#200	0.08	**14.2**

Description	Percentage
Coarse Gravel	**18.61**
Fine Gravel	**12.06**
Coarse Sand	**5.53**
Medium Sand	**27.47**
Fine Sand	**22.10**
Silt or Clay Fines	**14.23**



USCS Description (ASTM D 2487):

Silty sand with gravel, light brown, moist

LL	PL	PI
NP	**NP**	**NP**

As-Received Moisture Content (%): --

USCS Group Symbol: SM

Notes: 0 g of particles up to 75.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

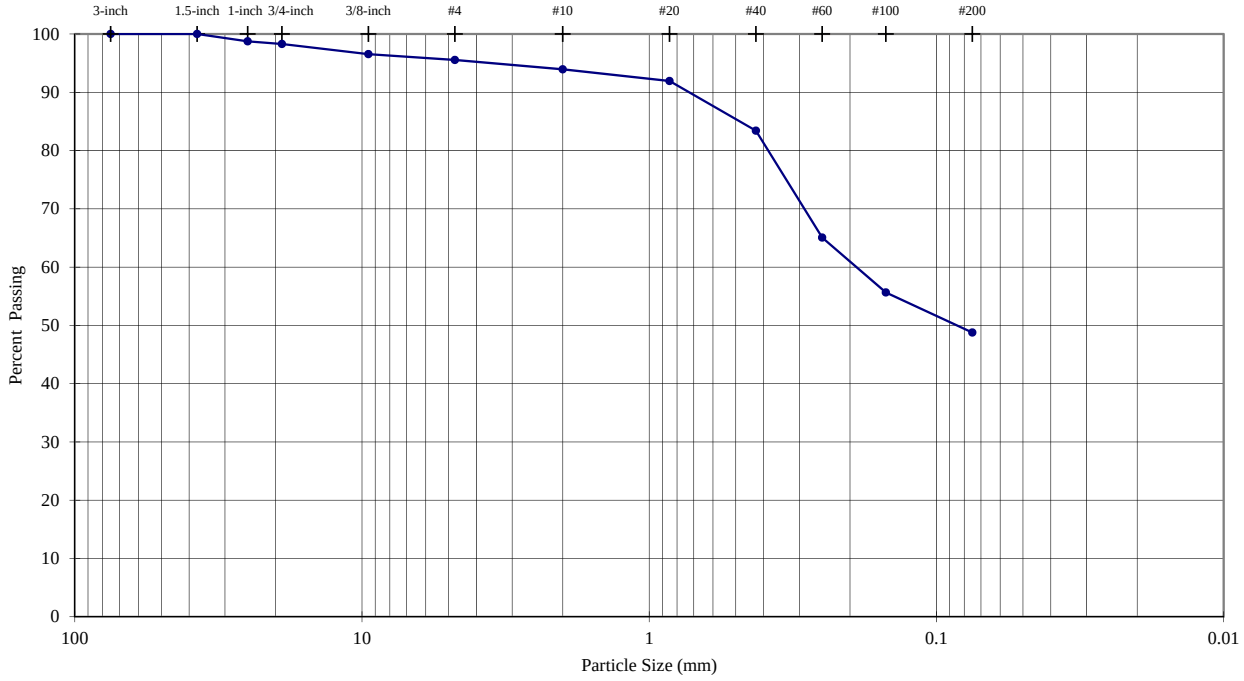
TECH	TC
DATE	20-Mar-2018
REVIEW	MB

March-18 **1663241.11000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

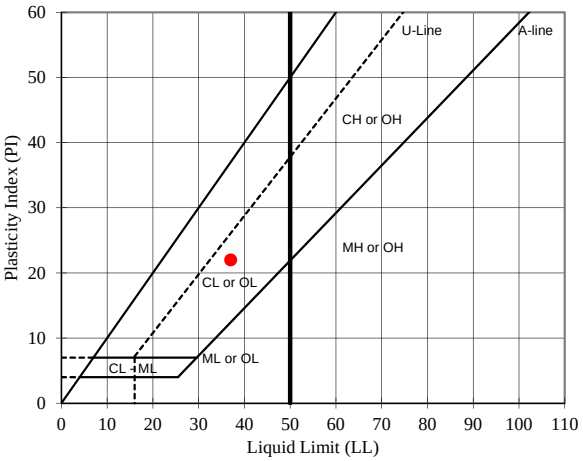
ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-41 / S1** DEPTH (ft.): **2-3**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**1.71**
1-inch	25.0	**98.7**		
3/4-inch	19.0	**98.3**		
3/8-inch	9.5	**96.5**	Fine Gravel	**2.74**
#4	4.75	**95.5**		
#10	2.00	**93.9**	Coarse Sand	**1.61**
#20	0.850	**91.9**	Medium Sand	**10.53**
#40	0.425	**83.4**		
#60	0.250	**65.1**	Fine Sand	**34.63**
#100	0.150	**55.6**		
#200	0.075	**48.8**		
			Silt or Clay Fines	**48.77**

Sieve Analysis (Initial Separation on No. 4 Sieve)



USCS Description (ASTM D 2487):

Clayey sand, dark brown, moist

LL	PL	PI
37	**15**	**22**

As-Received Moisture Content (%): **9.7**

USCS Group Symbol: SC

Notes: 0 g of particles up to 37.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	TC
DATE	20-Mar-2018
REVIEW	MB

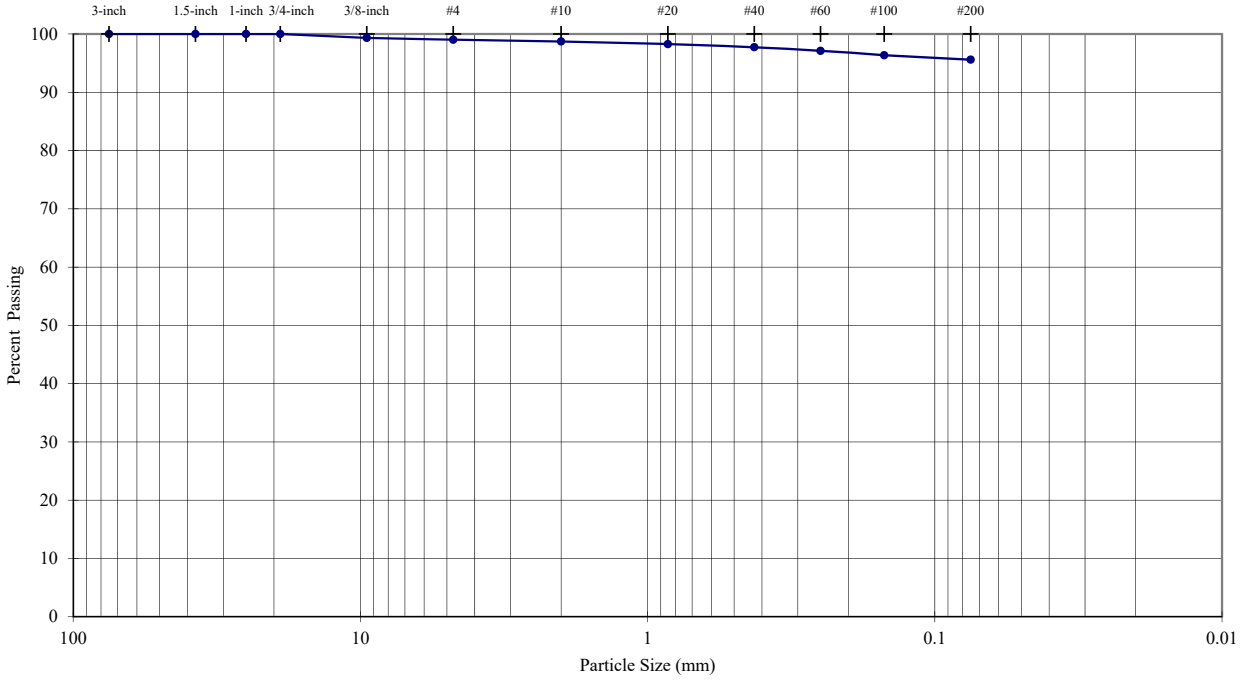
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

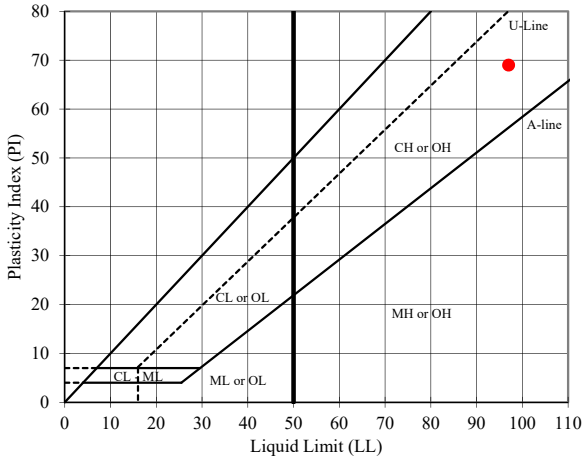
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-01** DEPTH (ft): **10 - 11.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**99.3**
#4	4.75	**99.0**
#10	2.0	**98.7**
#20	0.850	**98.3**
#40	0.425	**97.7**
#60	0.250	**97.1**
#100	0.150	**96.4**
#200	0.075	**95.6**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.99**
Coarse Sand	**0.29**
Medium Sand	**0.99**
Fine Sand	**2.15**
Silt or Clay Fines	**95.58**



USCS Description (ASTM D 2487):

Fat clay, light gray, moist

LL	PL	PI
97	**28**	**69**

As-Received Moisture Content (%): **37.4**

USCS Group Symbol: CH

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH
DATE	23-May-2019
REVIEW	MB

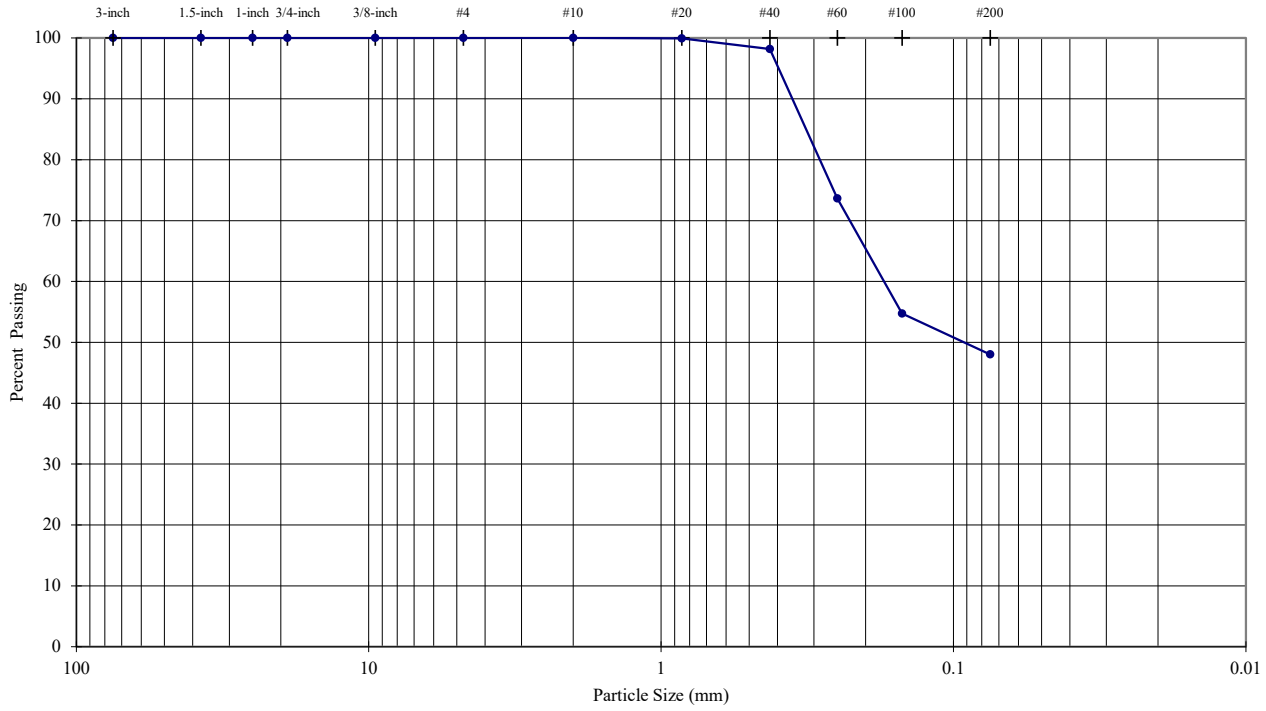
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

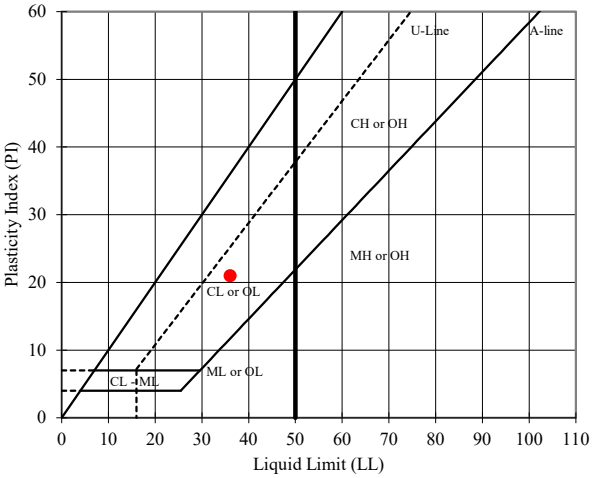
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-01** DEPTH (ft): **20 - 21.5**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**98.2**
#60	0.250	**73.6**
#100	0.150	**54.7**
#200	0.075	**48.0**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**1.80**
Fine Sand	**50.19**
Silt or Clay Fines	**48.01**



USCS Description (ASTM D 2487):

Clayey sand, yellowish brown, moist

LL	PL	PI
36	**15**	**21**

As-Received Moisture Content (%): **11.7**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	23-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

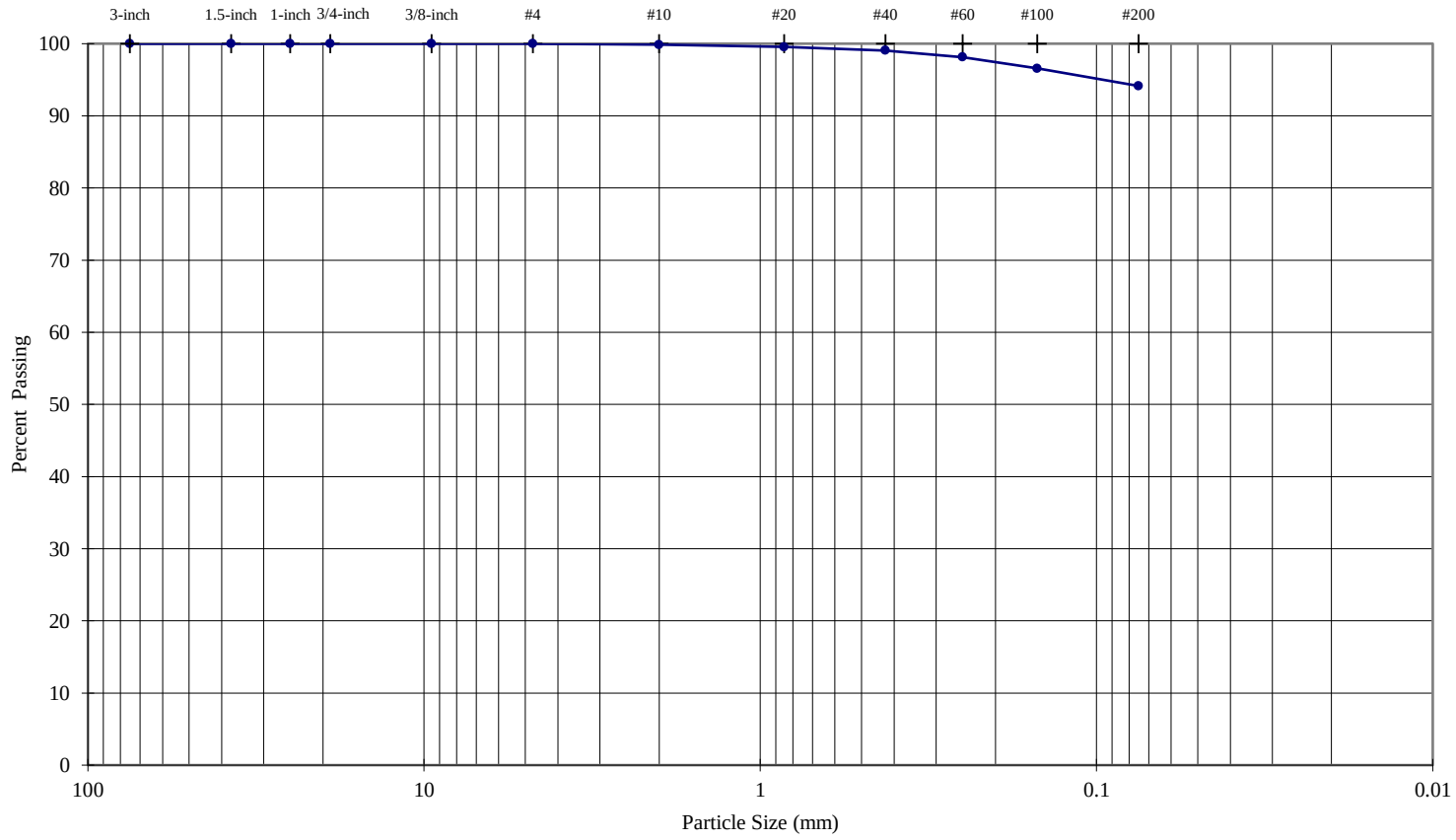
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-01** DEPTH (ft): **25 - 26.5**

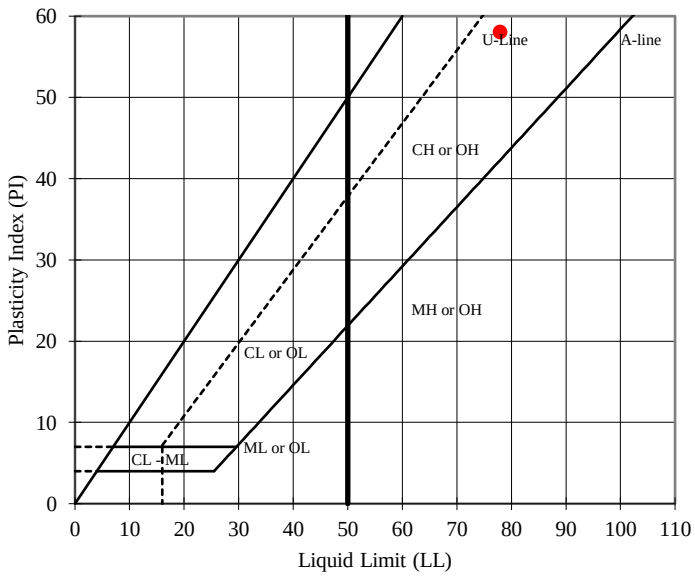
TYPE: **Bag**



Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**	Coarse Gravel	**0.00**
1.5-inch	37.5	**100.0**		
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.0	**99.9**	Coarse Sand	**0.14**
#20	0.850	**99.5**	Medium Sand	**0.79**
#40	0.425	**99.1**		
#60	0.250	**98.1**	Fine Sand	**4.92**
#100	0.150	**96.6**		
#200	0.075	**94.1**		
			Silt or Clay Fines	**94.14**



USCS Description (ASTM D 2487):

Fat clay, pale brown, moist

LL	PL	PI
78	**20**	**58**

As-Received Moisture Content (%): **29.0**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	23-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

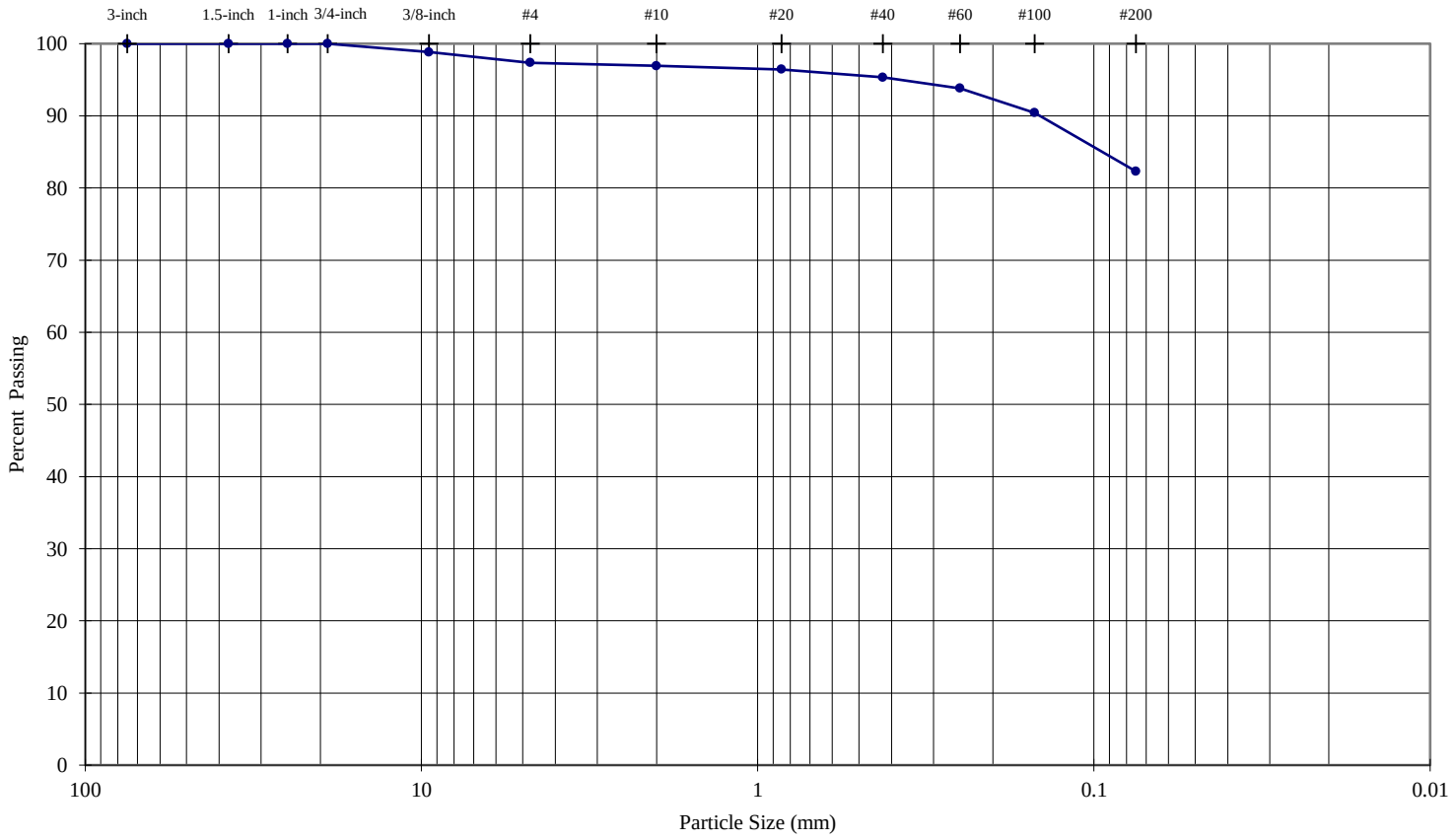
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-01** DEPTH (ft): **45 - 46.5**

TYPE: **Tube**

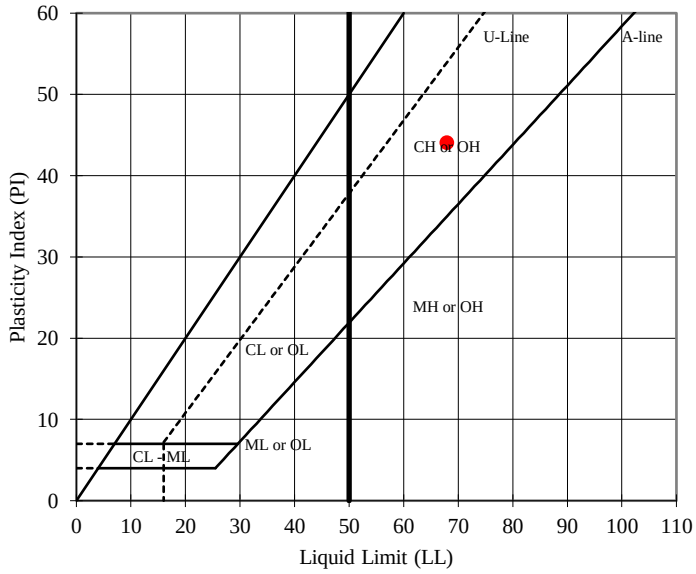


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**98.8**
#4	4.75	**97.4**
#10	2.0	**96.9**
#20	0.850	**96.4**
#40	0.425	**95.3**
#60	0.250	**93.8**
#100	0.150	**90.4**
#200	0.075	**82.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**2.63**
Coarse Sand	**0.45**
Medium Sand	**1.60**
Fine Sand	**13.02**
Silt or Clay Fines	**82.30**



USCS Description (ASTM D 2487):

Fat clay with sand, gray, moist

LL	PL	PI
68	**24**	**44**

As-Received Moisture Content (%): **32.4**

USCS Group Symbol: CH

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH
DATE	29-Apr-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

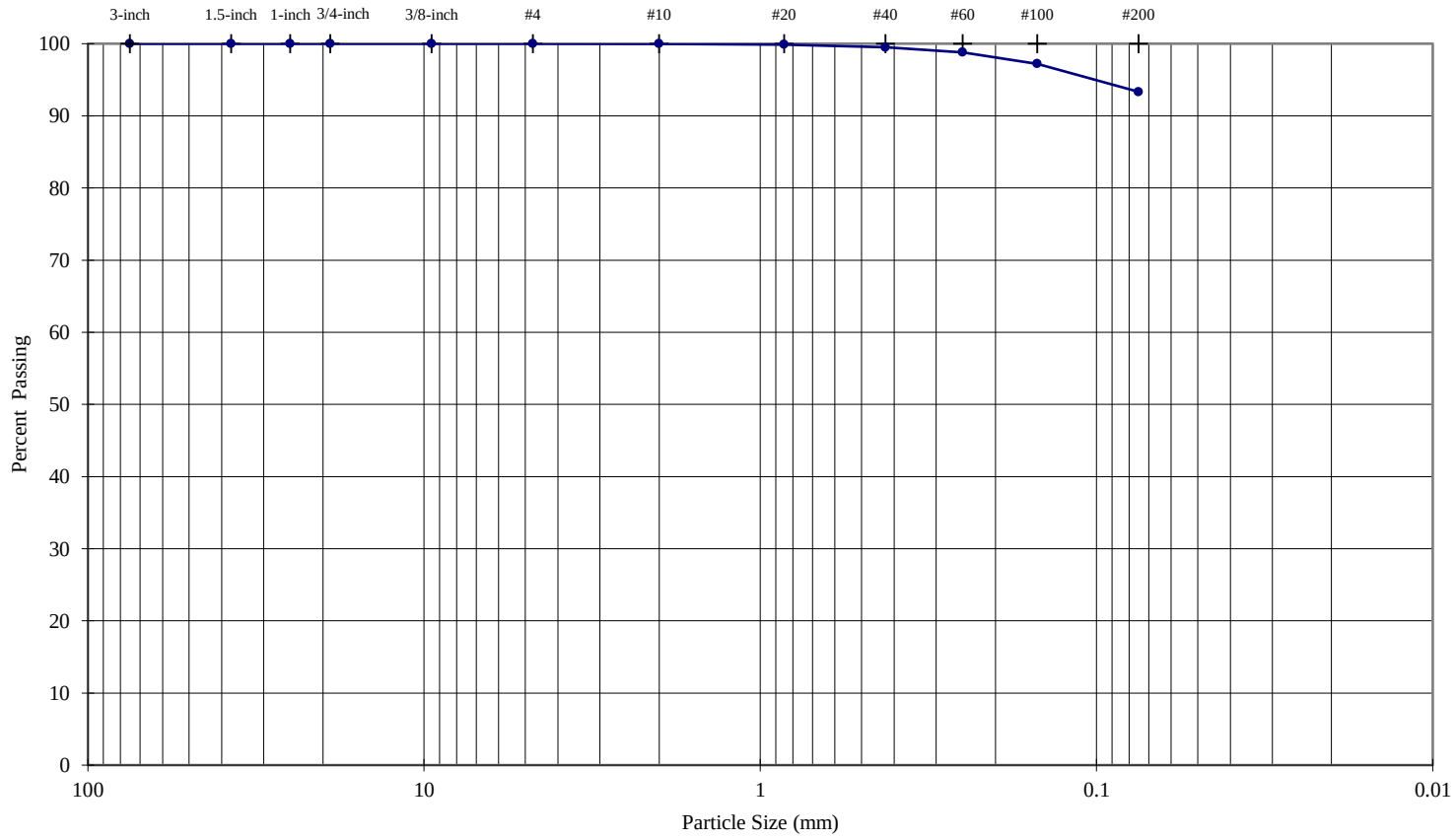
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **10.0-11.5**

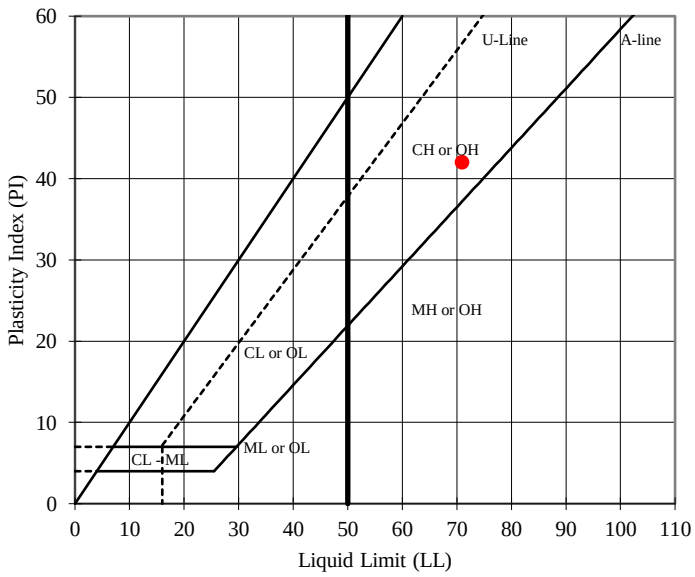
TYPE: **Tube**



Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**		
1-inch	25.0	**100.0**	Coarse Gravel	**0.00**
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**		
#4	4.75	**100.0**	Fine Gravel	**0.00**
#10	2.0	**100.0**	Coarse Sand	**0.02**
#20	0.850	**99.9**		
#40	0.425	**99.5**	Medium Sand	**0.47**
#60	0.250	**98.8**		
#100	0.150	**97.2**	Fine Sand	**6.17**
#200	0.075	**93.3**		
			Silt or Clay Fines	**93.33**



USCS Description (ASTM D 2487):

Fat clay, pale olive, moist

LL	PL	PI
71	**29**	**42**

As-Received Moisture Content (%): **25.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	6-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

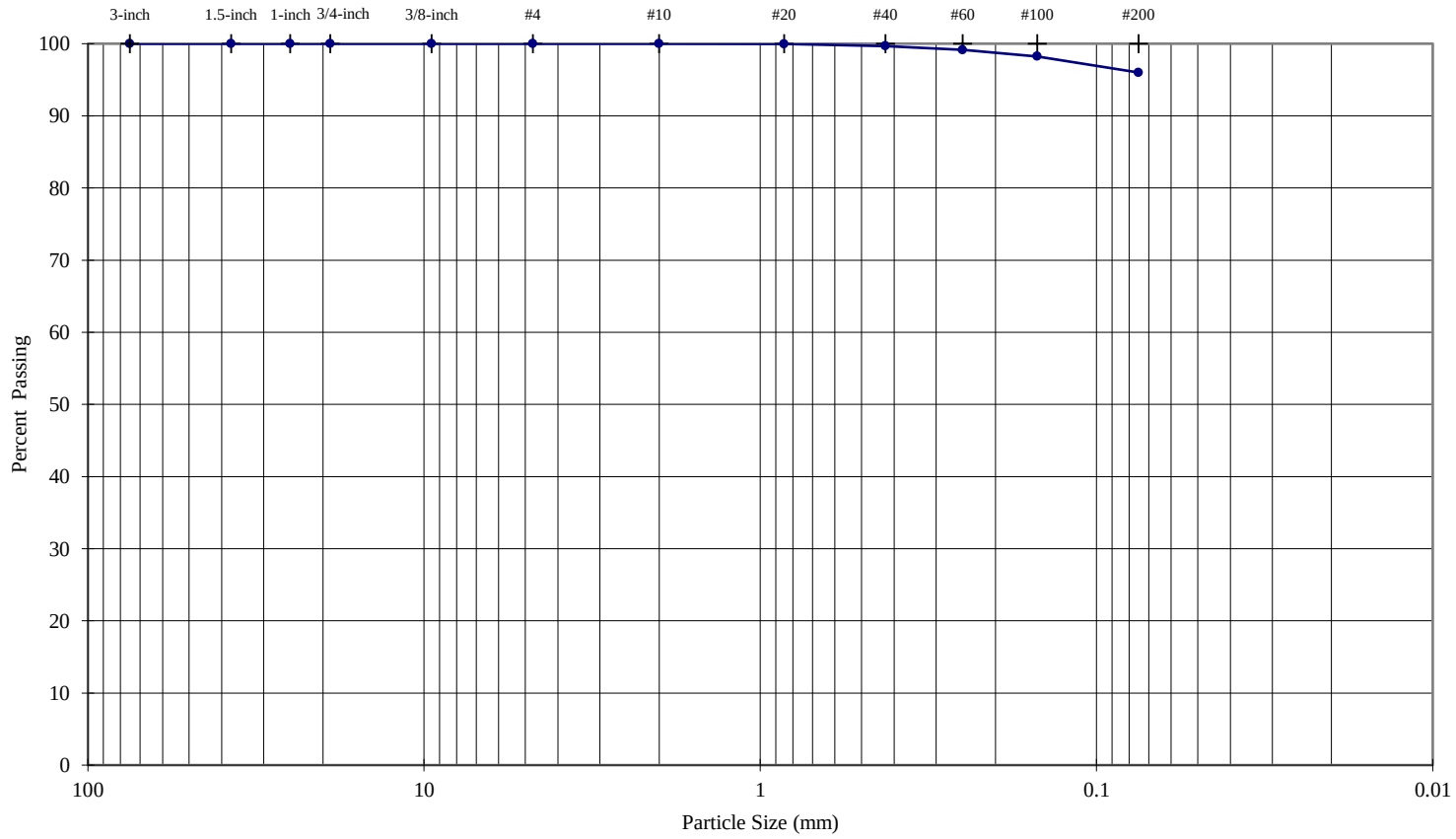
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **15-16.5**

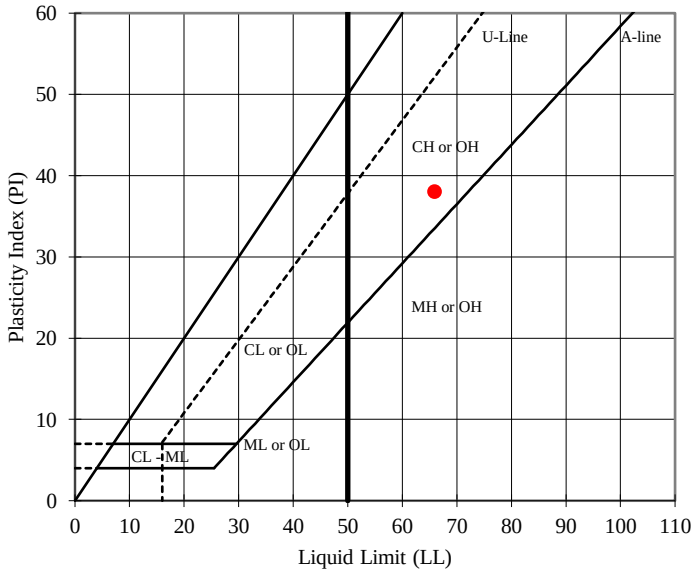
TYPE: **Tube**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.7**
#60	0.250	**99.1**
#100	0.150	**98.2**
#200	0.075	**96.0**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.31**
Fine Sand	**3.69**
Silt or Clay Fines	**96.00**



USCS Description (ASTM D 2487):

Fat clay, light brownish gray, moist

LL	PL	PI
66	**28**	**38**

As-Received Moisture Content (%): **18.9**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	30-Apr-2019
REVIEW	PRH

GOLDER

May-19 **1663241.22000**

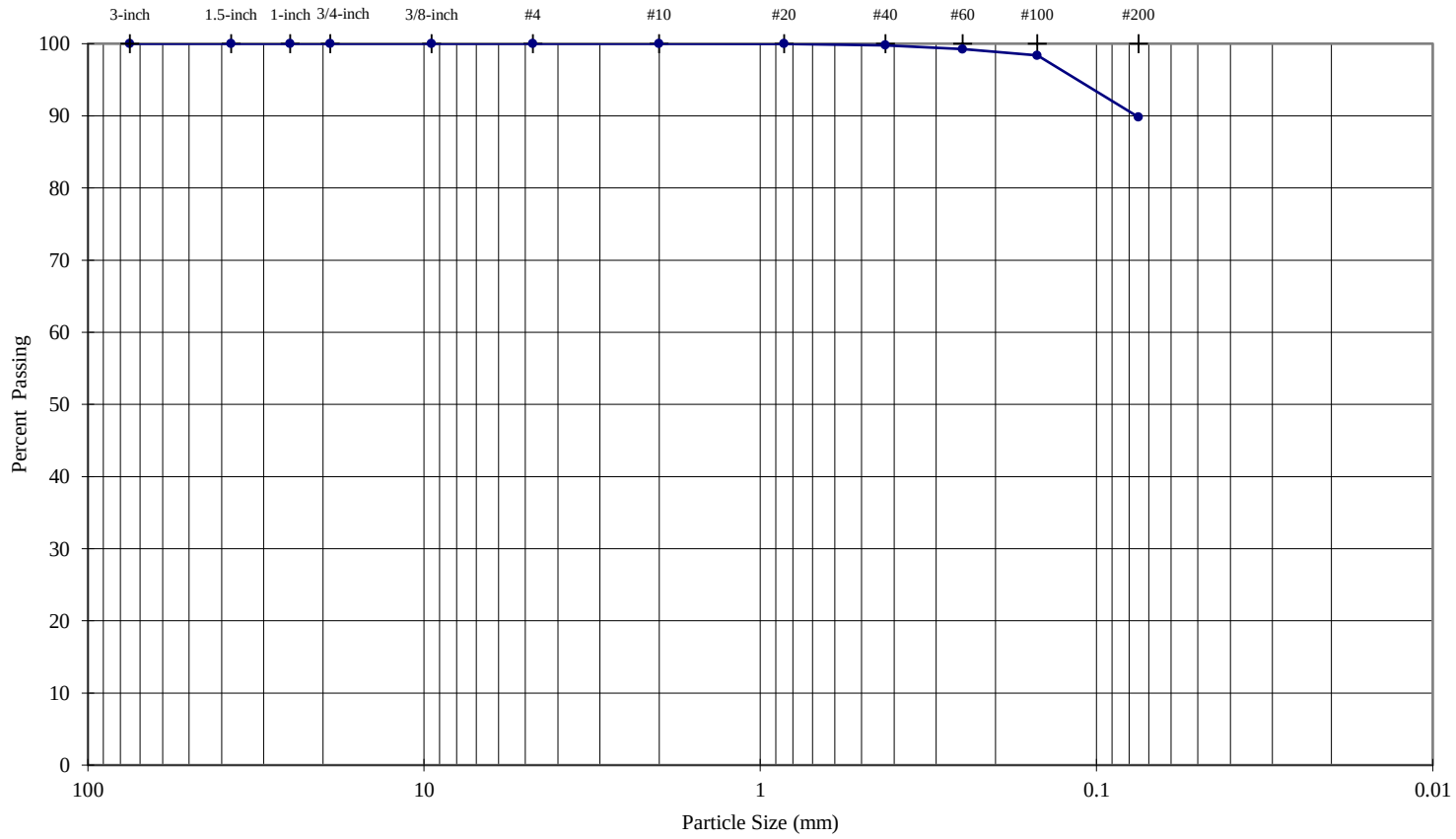
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **20 - 21.5**

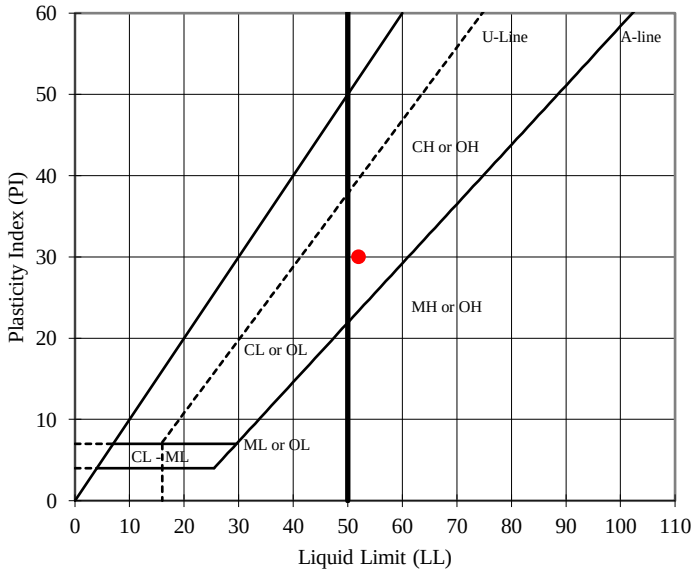
TYPE: **Tube**



Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**		
1-inch	25.0	**100.0**	Coarse Gravel	**0.00**
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**		
#4	4.75	**100.0**	Fine Gravel	**0.00**
#10	2.0	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**		
#40	0.425	**99.8**	Medium Sand	**0.21**
#60	0.250	**99.2**		
#100	0.150	**98.4**	Fine Sand	**9.97**
#200	0.075	**89.8**		
			Silt or Clay Fines	**89.82**



USCS Description (ASTM D 2487):

Fat clay, light gray, moist

LL	PL	PI
52	**22**	**30**

As-Received Moisture Content (%): **13.6**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	2-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

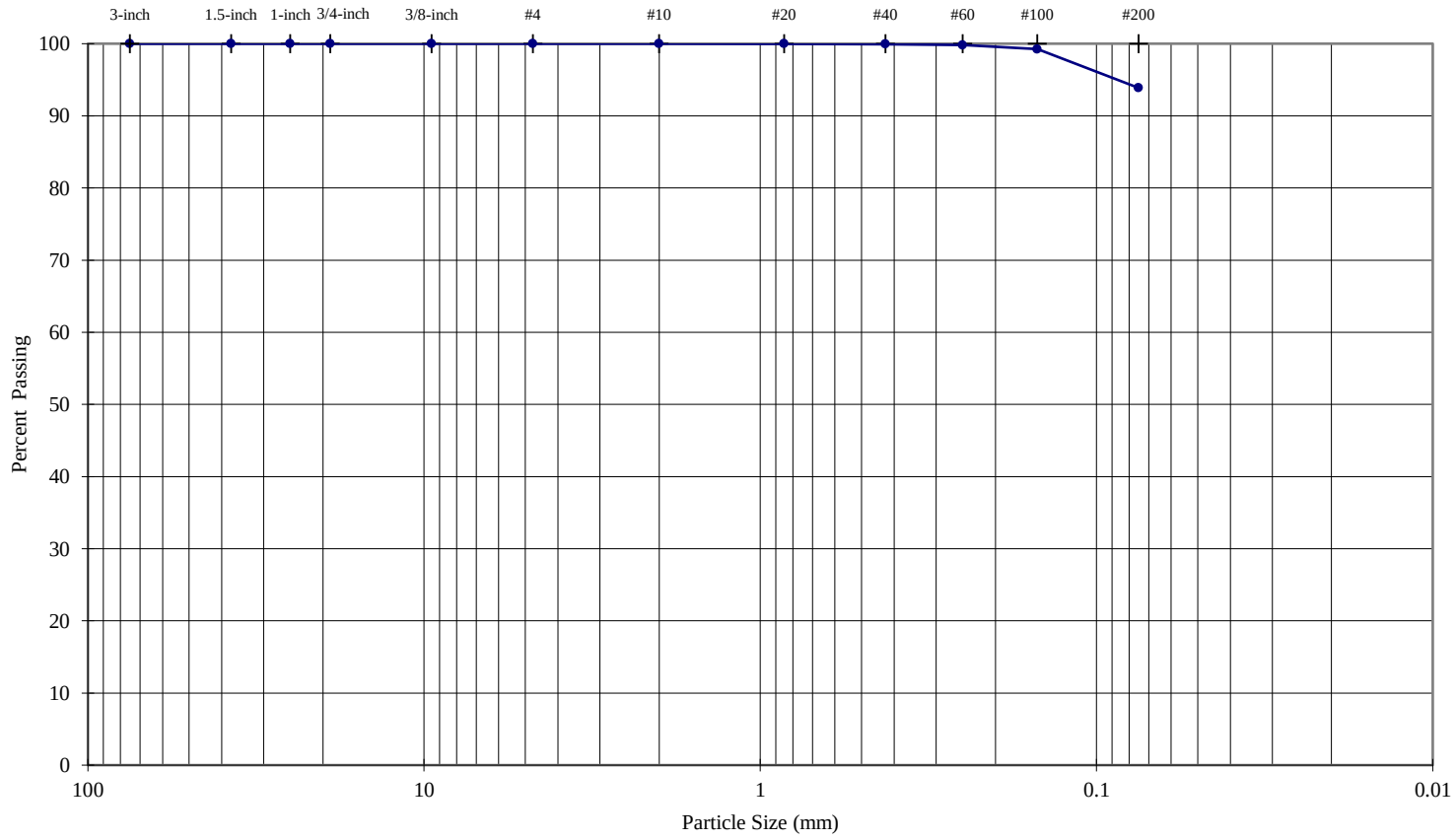
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **25 - 26.5**

TYPE: **Tube**

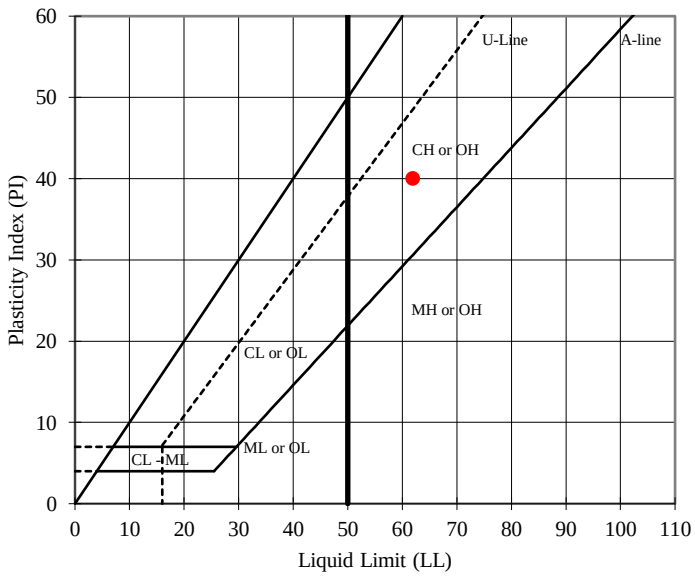


Particle Size (mm)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.8**
#100	0.150	**99.2**
#200	0.075	**93.9**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.06**
Fine Sand	**6.06**
Silt or Clay Fines	**93.88**



USCS Description (ASTM D 2487):

Fat clay, light gray, moist

LL	PL	PI
62	**22**	**40**

As-Received Moisture Content (%): **15.0**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	2-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

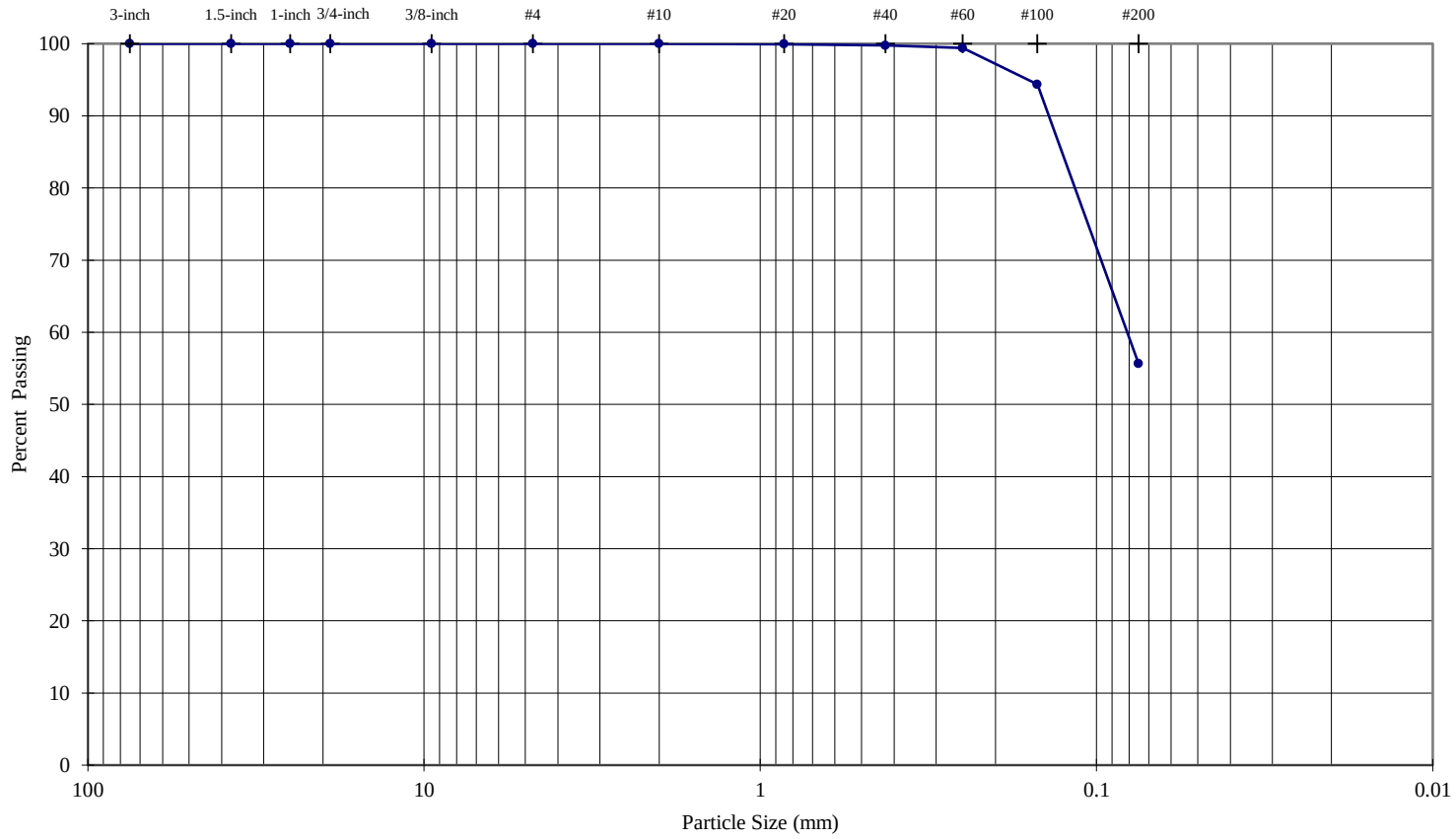
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **30 - 31.5**

TYPE: **Tube**

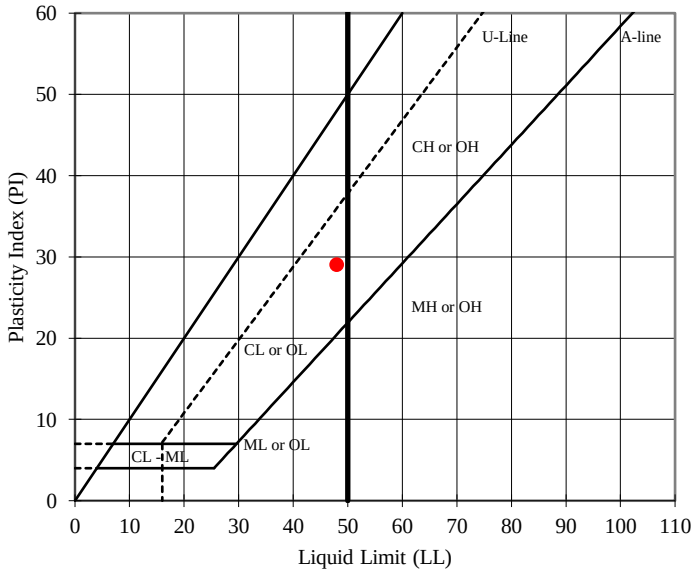


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.8**
#60	0.250	**99.4**
#100	0.150	**94.4**
#200	0.075	**55.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.25**
Fine Sand	**44.09**
Silt or Clay Fines	**55.67**



USCS Description (ASTM D 2487):

Sandy lean clay, light olive brown, moist

LL	PL	PI
48	**19**	**29**

As-Received Moisture Content (%): **13.4**

USCS Group Symbol: CL

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	30-Apr-2019
REVIEW	MB

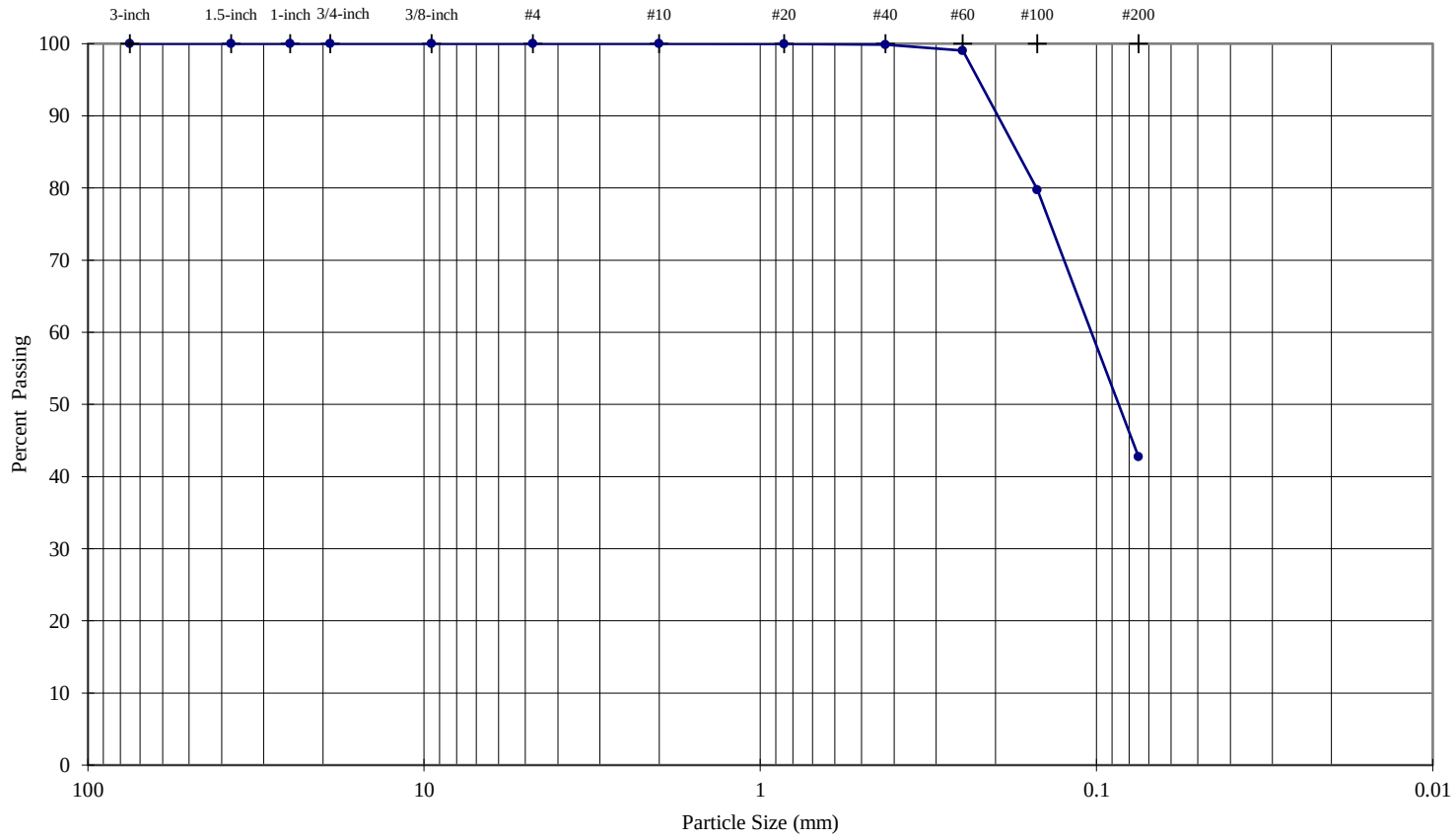
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-15** DEPTH (ft): **35 - 36.5**
TYPE: **Tube**

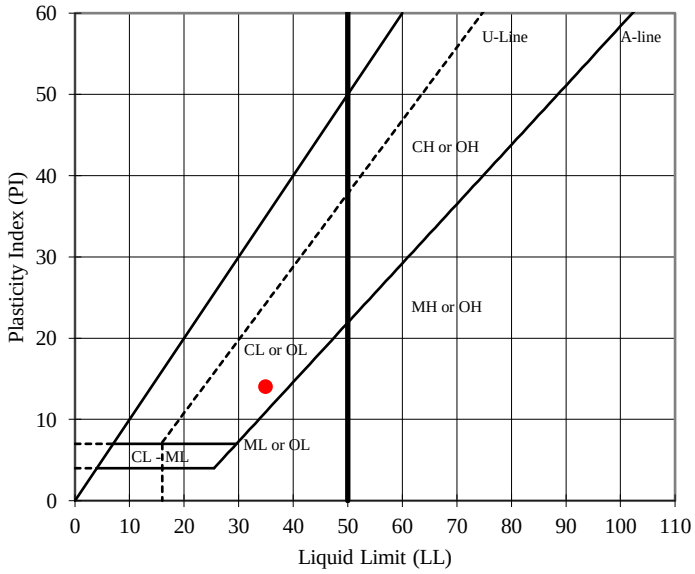


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.0**
#100	0.150	**79.7**
#200	0.075	**42.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.13**
Fine Sand	**57.13**
Silt or Clay Fines	**42.74**



USCS Description (ASTM D 2487):

Clayey sand, very pale brown, moist

LL	PL	PI
35	**21**	**14**

As-Received Moisture Content (%): **9.6**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	30-Apr-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

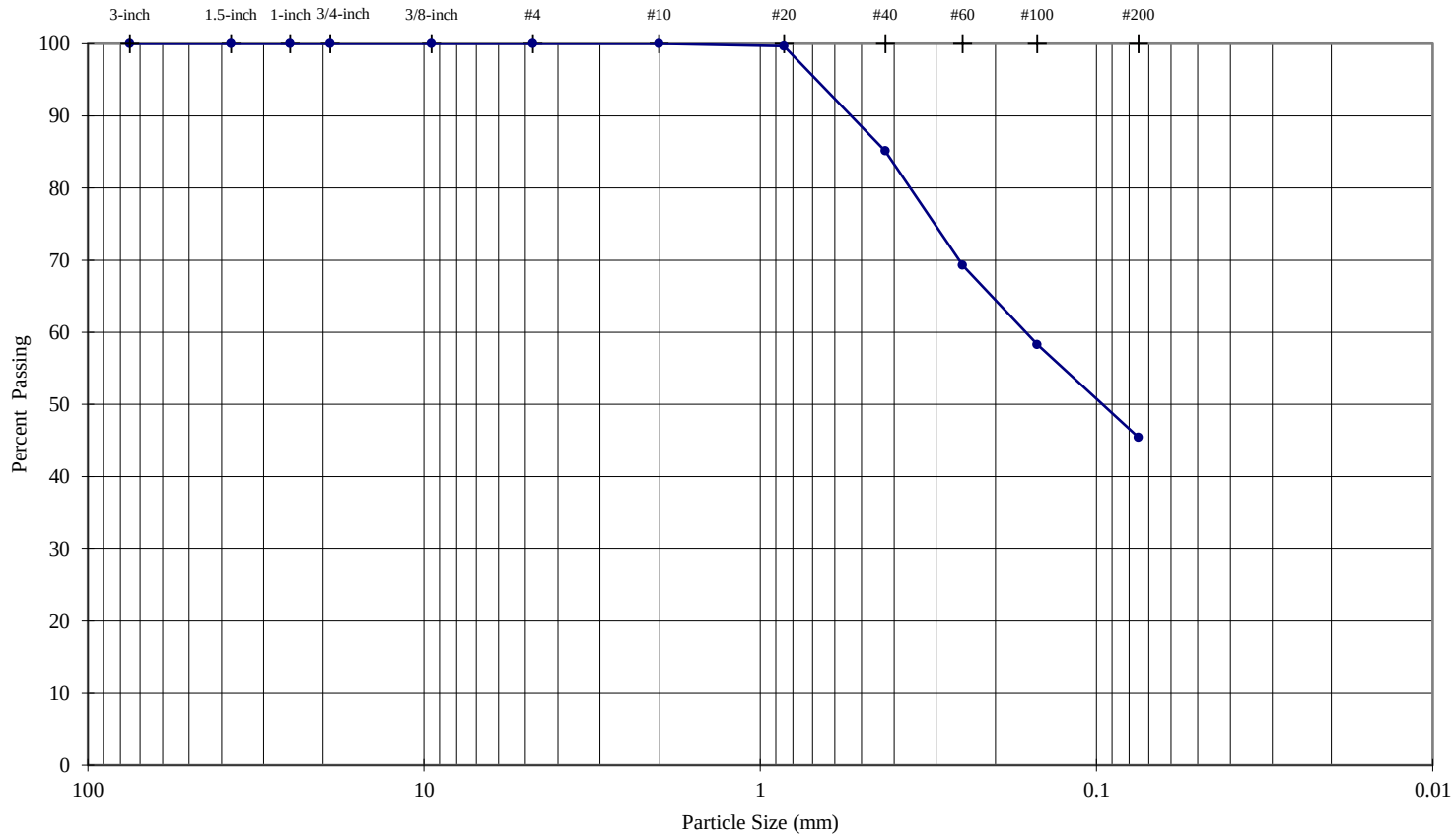
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **40 - 41.5**

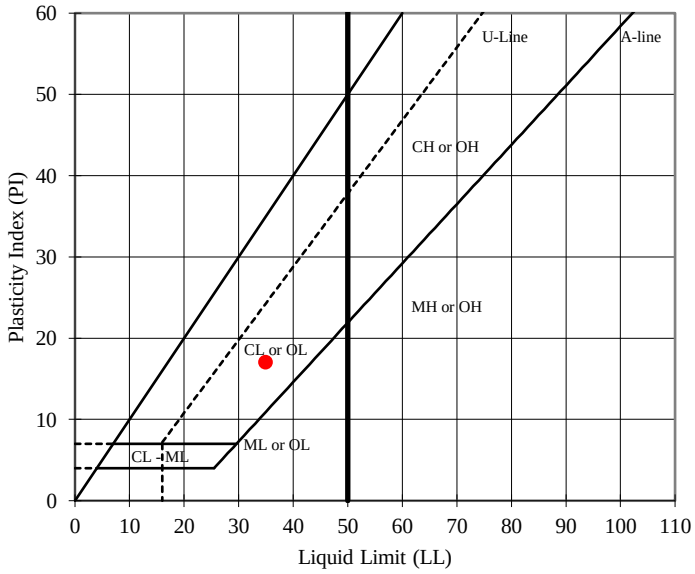
TYPE: **Tube**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.7**
#40	0.425	**85.1**
#60	0.250	**69.3**
#100	0.150	**58.3**
#200	0.075	**45.4**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**14.88**
Fine Sand	**39.70**
Silt or Clay Fines	**45.42**



USCS Description (ASTM D 2487):

Clayey sand, light gray, moist

LL	PL	PI
35	**18**	**17**

As-Received Moisture Content (%): **11.5**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	30-Apr-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

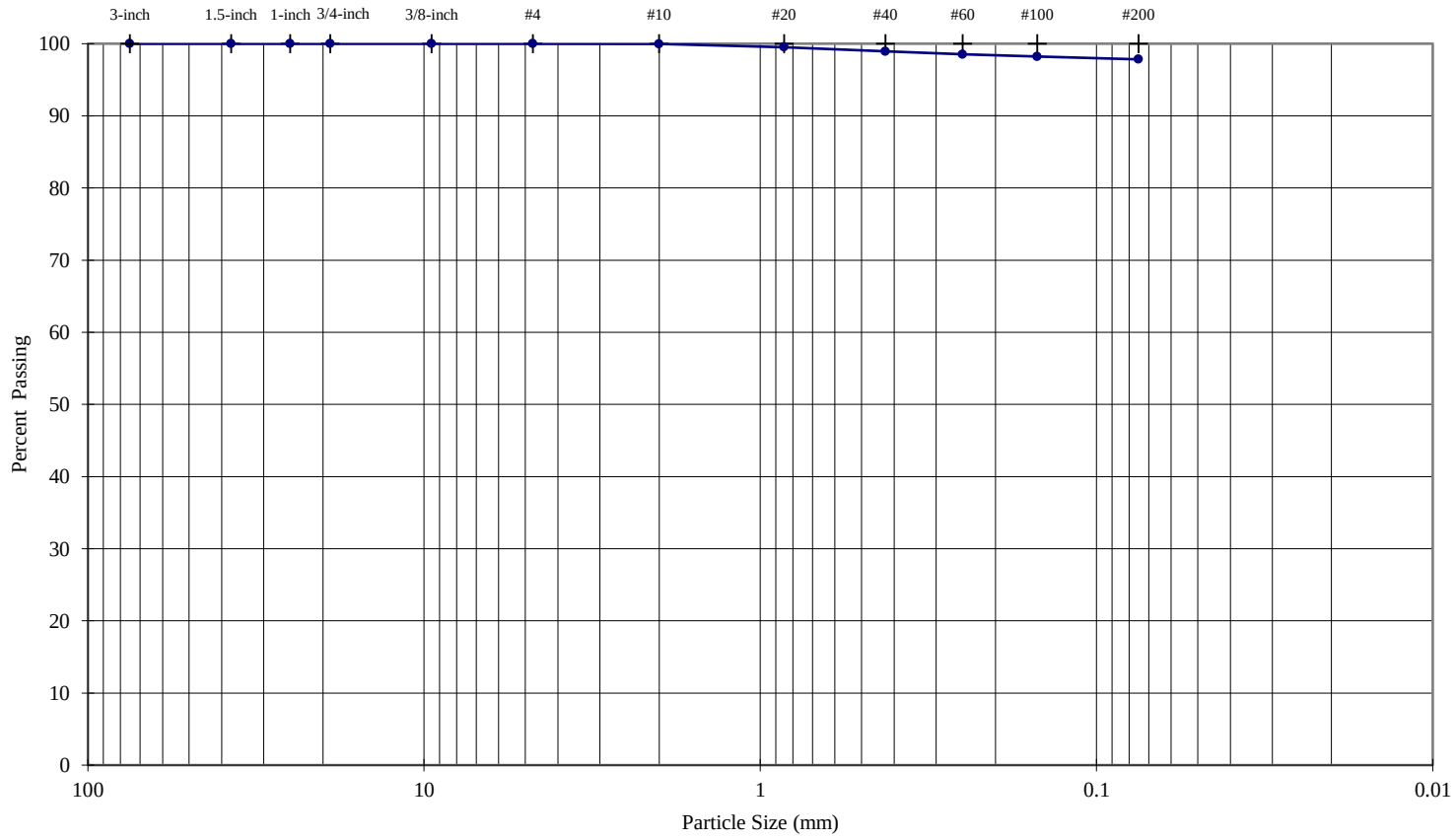
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **50 - 51.5**

TYPE: **Tube**

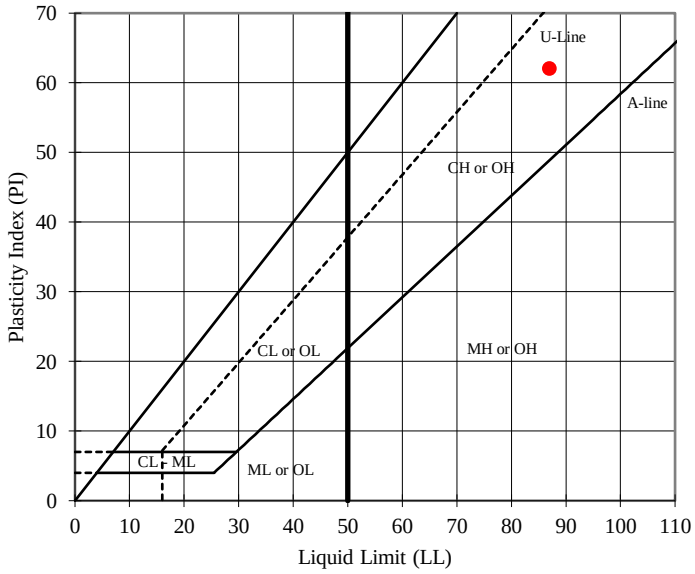


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.5**
#40	0.425	**98.9**
#60	0.250	**98.5**
#100	0.150	**98.2**
#200	0.075	**97.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.04**
Medium Sand	**1.02**
Fine Sand	**1.11**
Silt or Clay Fines	**97.83**



USCS Description (ASTM D 2487):

Fat clay, greenish gray, moist

LL	PL	PI
87	**25**	**62**

As-Received Moisture Content (%): **32.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	2-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

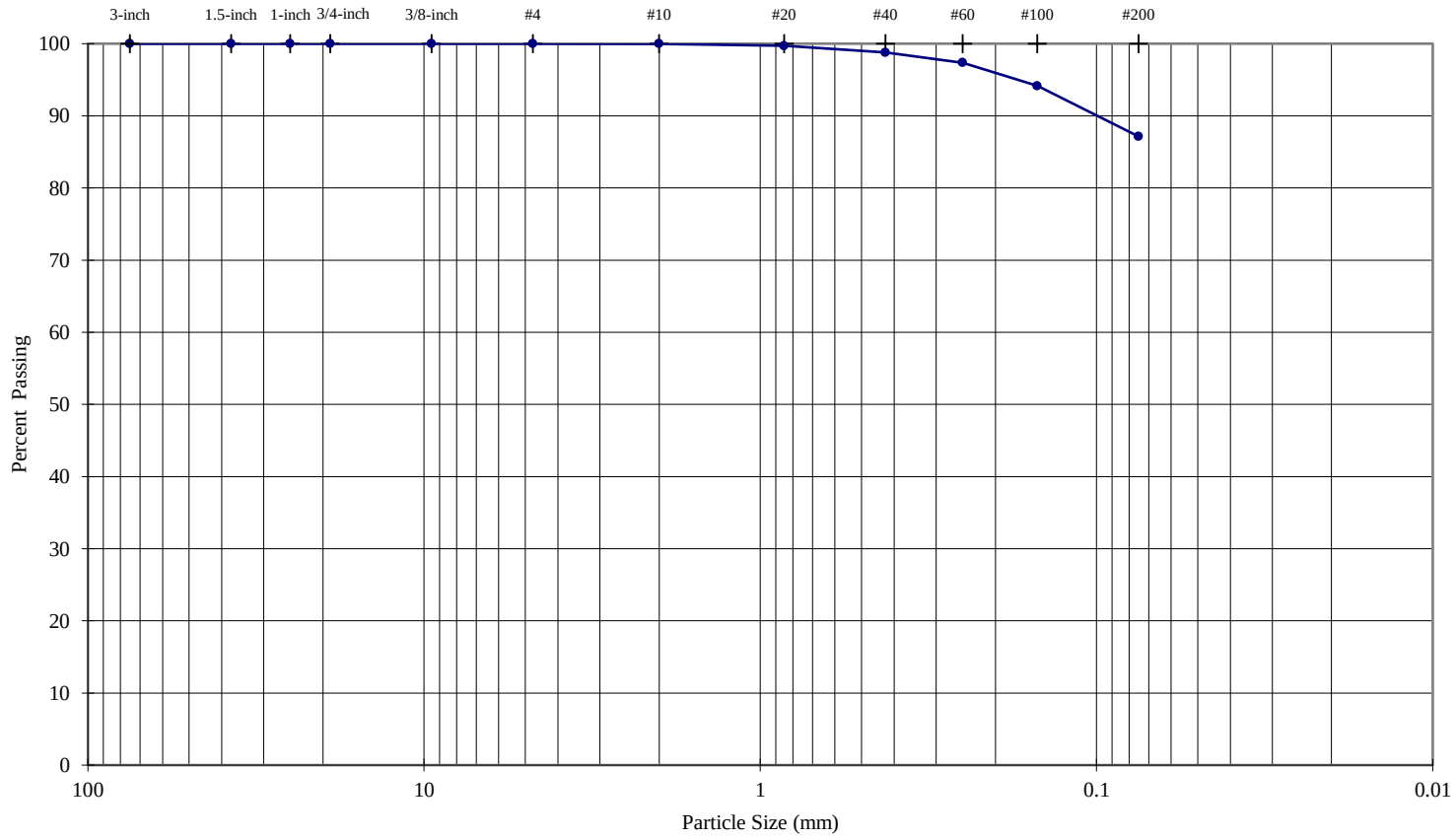
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **70 - 71.5**

TYPE: **Tube**

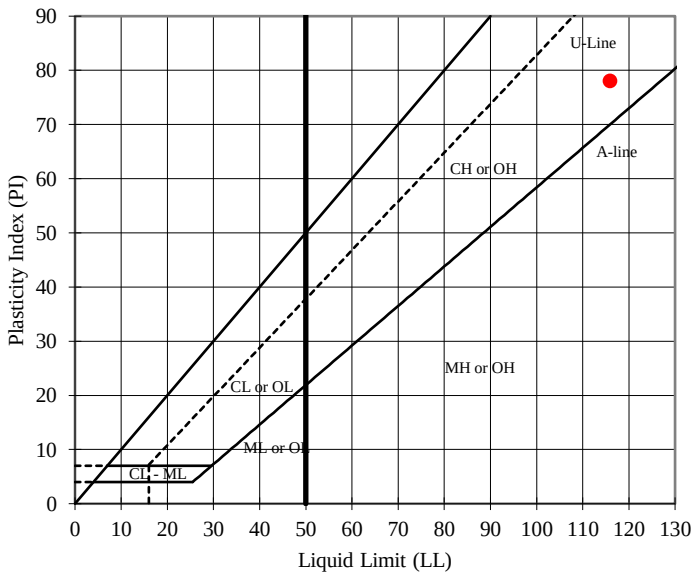


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.7**
#40	0.425	**98.8**
#60	0.250	**97.4**
#100	0.150	**94.2**
#200	0.075	**87.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.02**
Medium Sand	**1.21**
Fine Sand	**11.63**
Silt or Clay Fines	**87.14**



USCS Description (ASTM D 2487):

ELASTIC SILT, some sand, dark bluish gray, moist

LL	PL	PI
116	**38**	**78**

As-Received Moisture Content (%): **47.9**

USCS Group Symbol: MH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	2-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

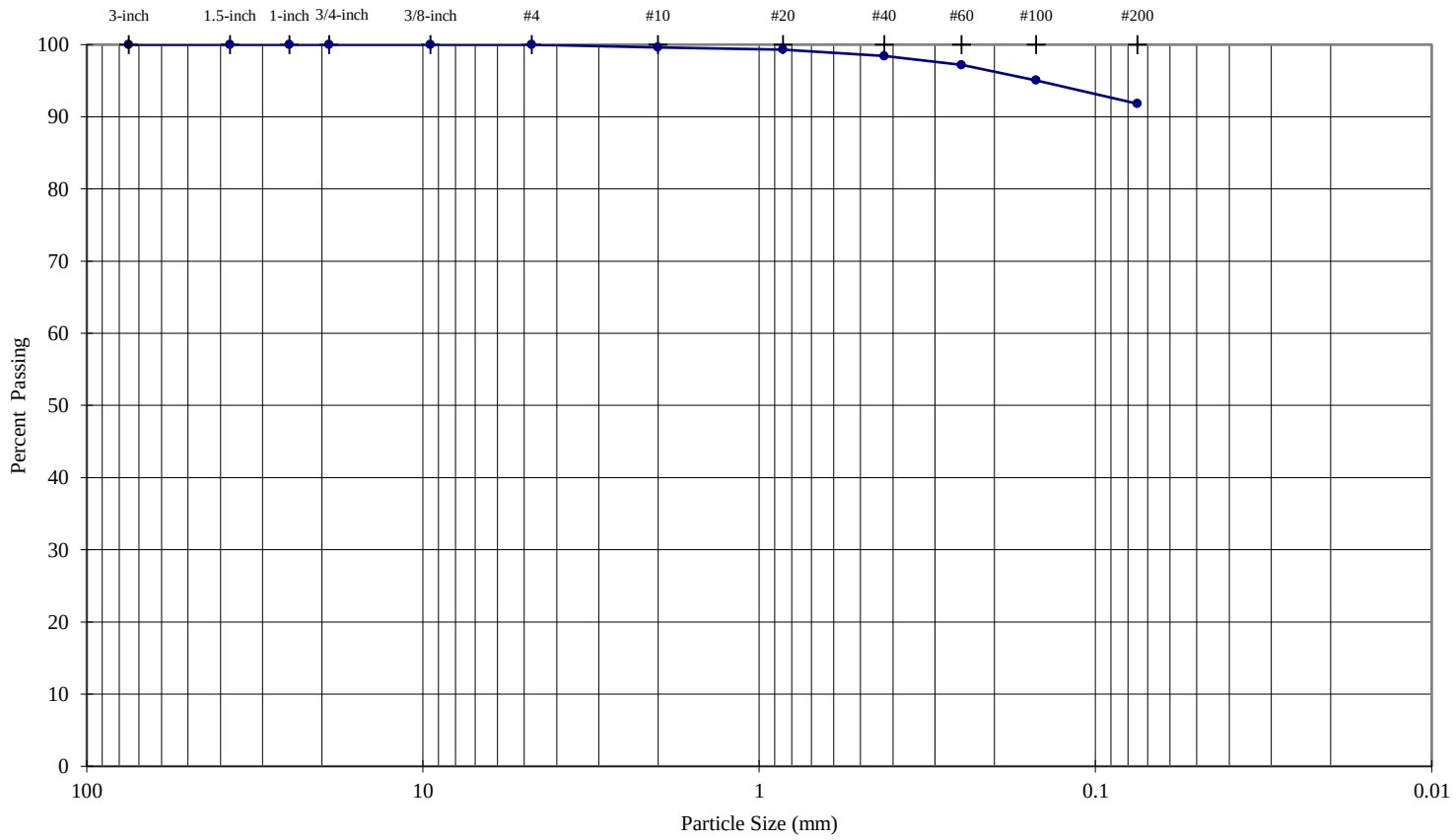
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **TP-15** DEPTH (ft): **90 - 91.5**

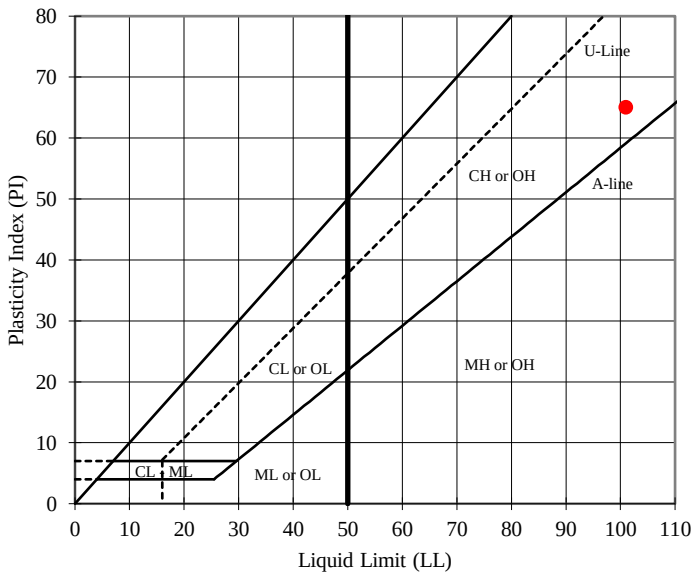
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.6**
#20	0.850	**99.3**
#40	0.425	**98.4**
#60	0.250	**97.2**
#100	0.150	**95.1**
#200	0.075	**91.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.38**
Medium Sand	**1.19**
Fine Sand	**6.62**
Silt or Clay Fines	**91.81**



USCS Description (ASTM D 2487):

Fat clay, dark bluish gray, moist

LL	PL	PI
101	**36**	**65**

As-Received Moisture Content (%): **36.5**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	3-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

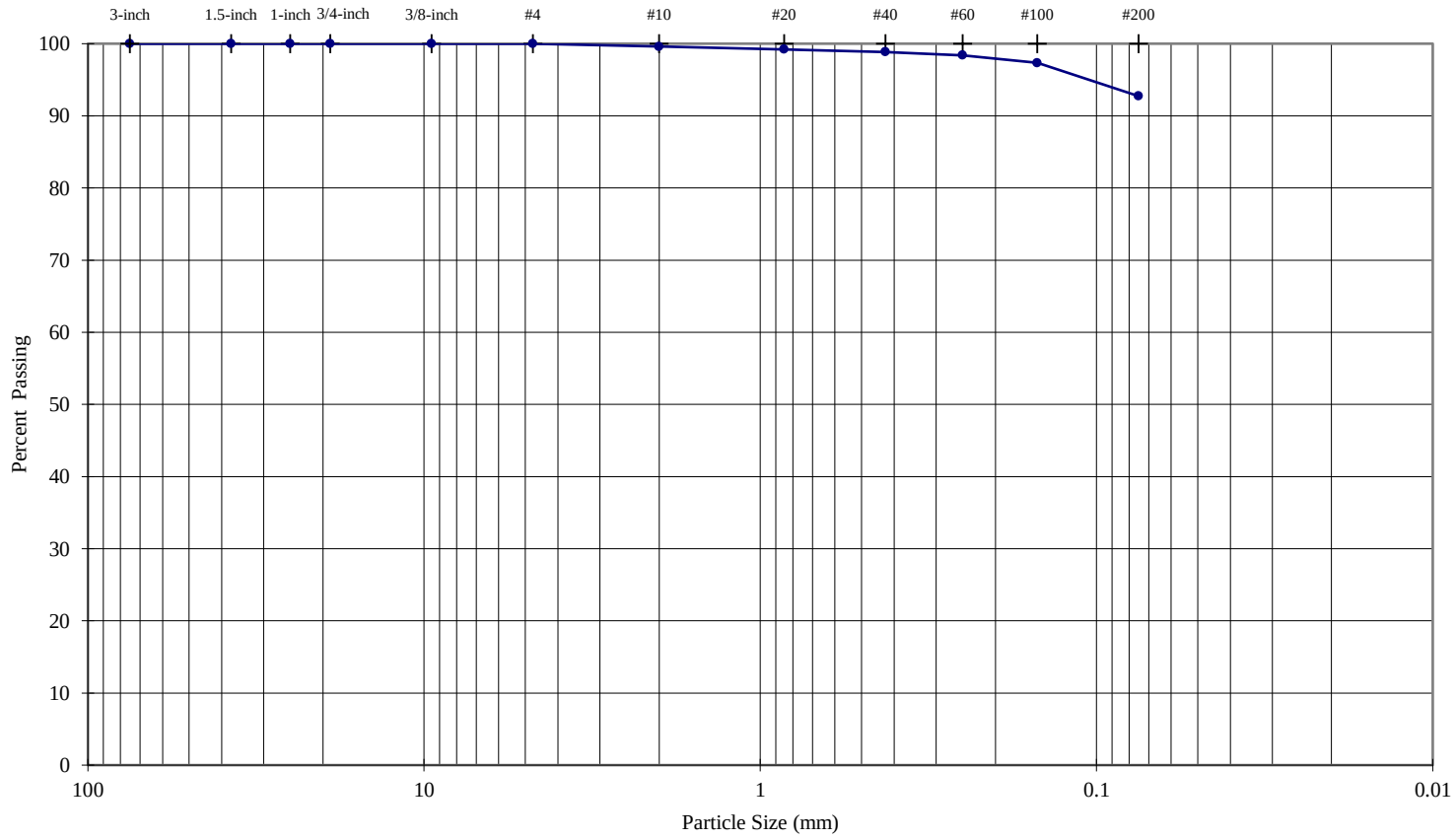
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **110-111.5**

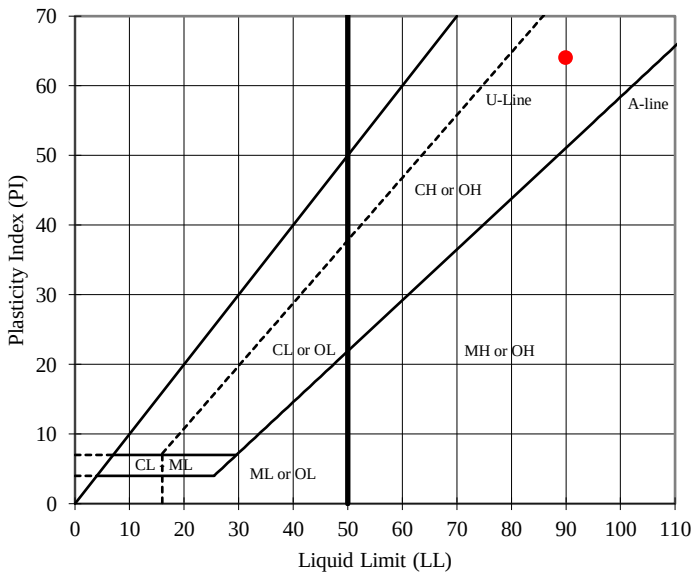
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.6**
#20	0.850	**99.2**
#40	0.425	**98.9**
#60	0.250	**98.4**
#100	0.150	**97.3**
#200	0.075	**92.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.40**
Medium Sand	**0.74**
Fine Sand	**6.12**
Silt or Clay Fines	**92.73**



USCS Description (ASTM D 2487):

Fat clay, bluish gray, moist

LL	PL	PI
90	**26**	**64**

As-Received Moisture Content (%): **33.6**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	6-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

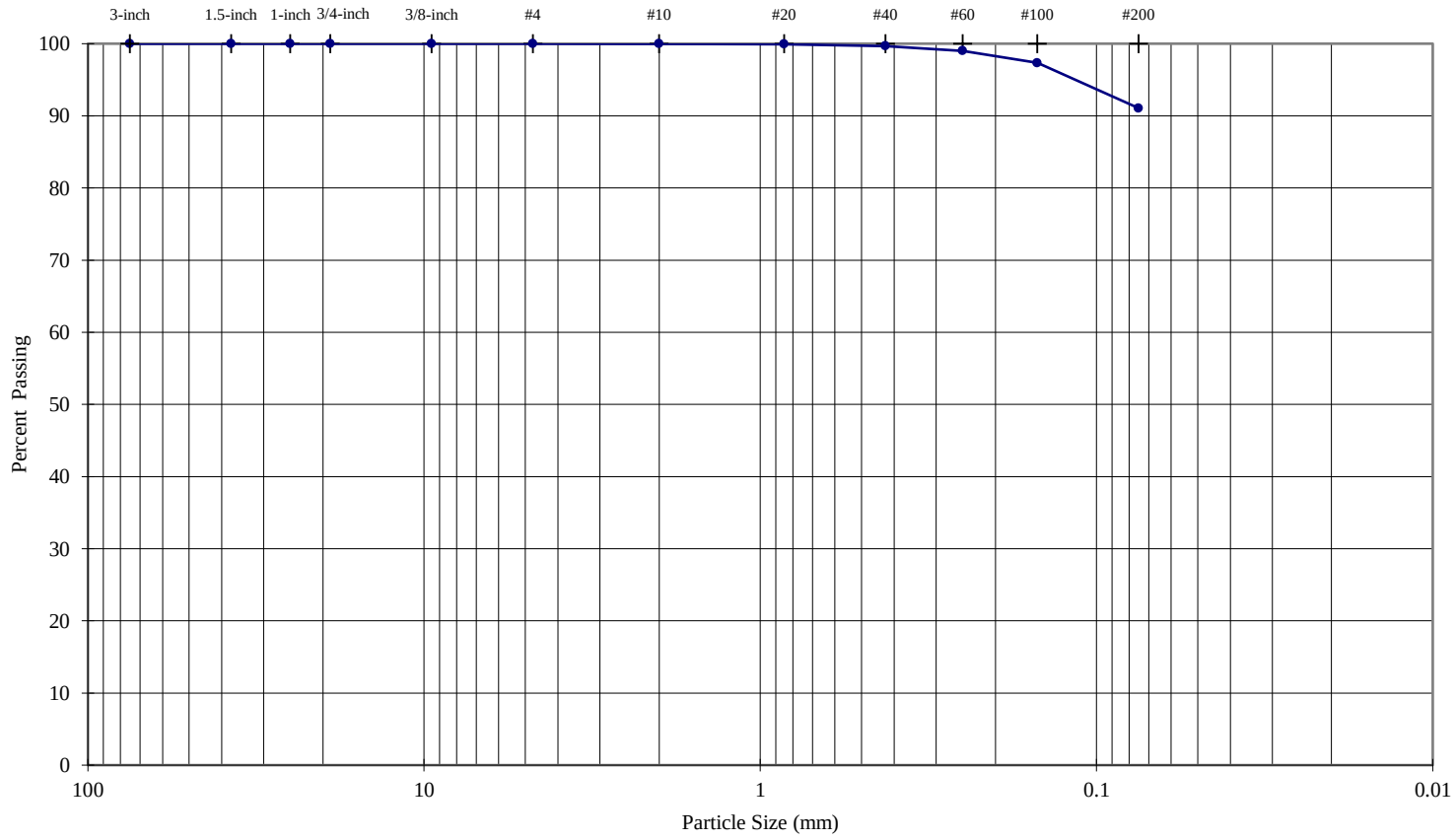
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-15** DEPTH (ft): **120-121.4**

TYPE: **Tube**

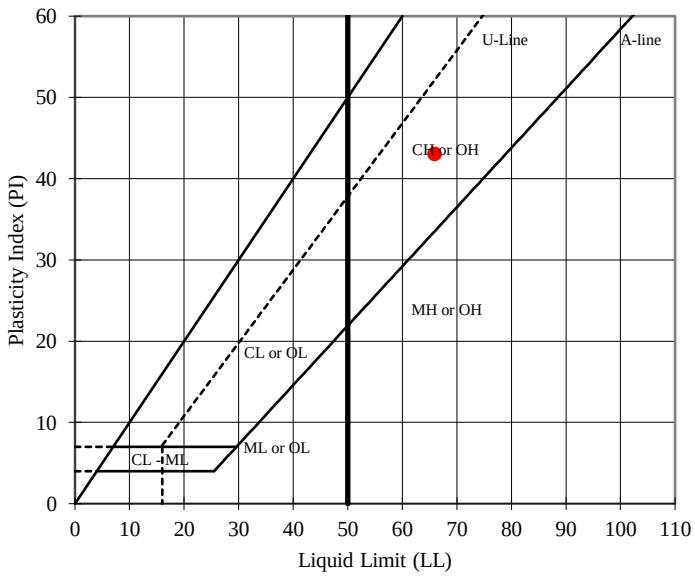


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.7**
#60	0.250	**99.0**
#100	0.150	**97.3**
#200	0.075	**91.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.02**
Medium Sand	**0.31**
Fine Sand	**8.60**
Silt or Clay Fines	**91.07**



USCS Description (ASTM D 2487):

Fat clay, greenish gray, moist

LL	PL	PI
66	**23**	**43**

As-Received Moisture Content (%): **24.6**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	7-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

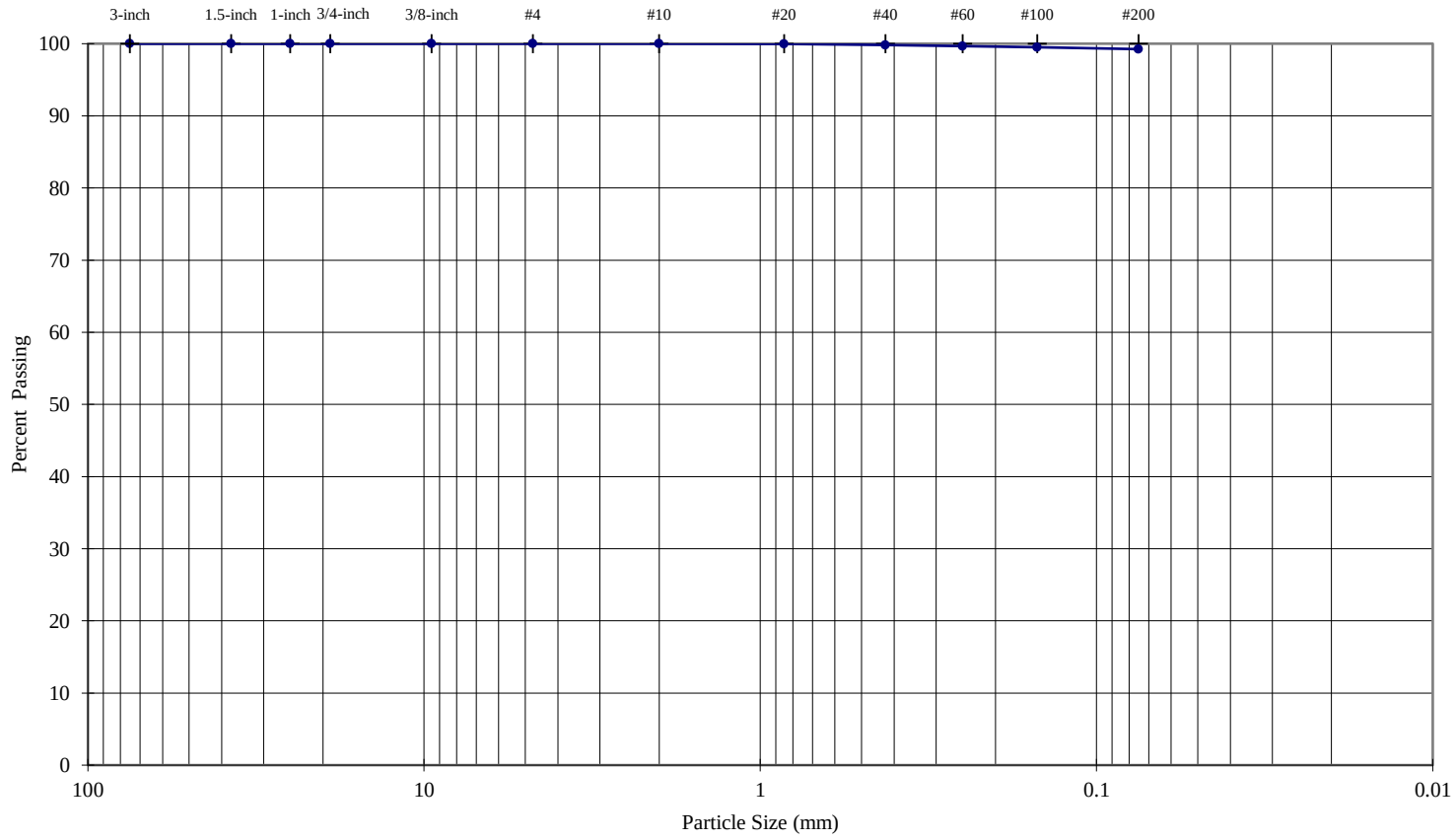
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-19** DEPTH (ft): **12 - 13.5**

TYPE: **Bag**

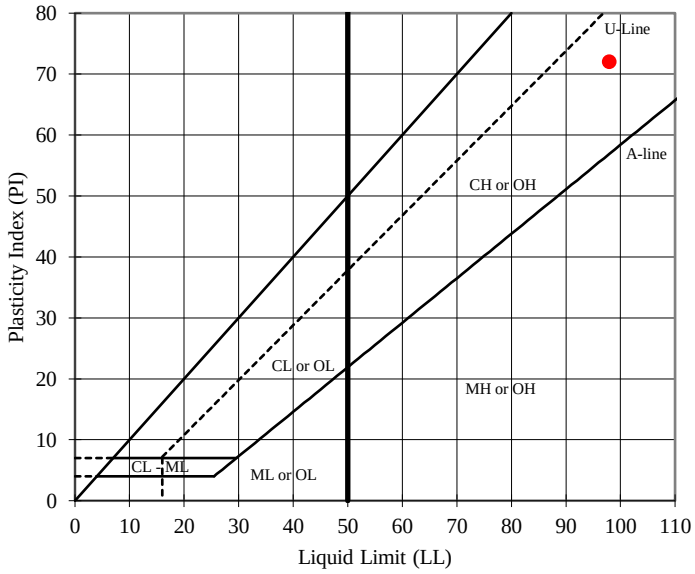


Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.8**
#60	0.250	**99.7**
#100	0.150	**99.5**
#200	0.075	**99.2**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.18**
Fine Sand	**0.57**
Silt or Clay Fines	**99.25**



USCS Description (ASTM D 2487):

Fat clay, white, moisst

LL	PL	PI
98	**26**	**72**

As-Received Moisture Content (%): **27.4**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	23-May-2019
REVIEW	MB

GOLDER

May-19 **1663241.22000**

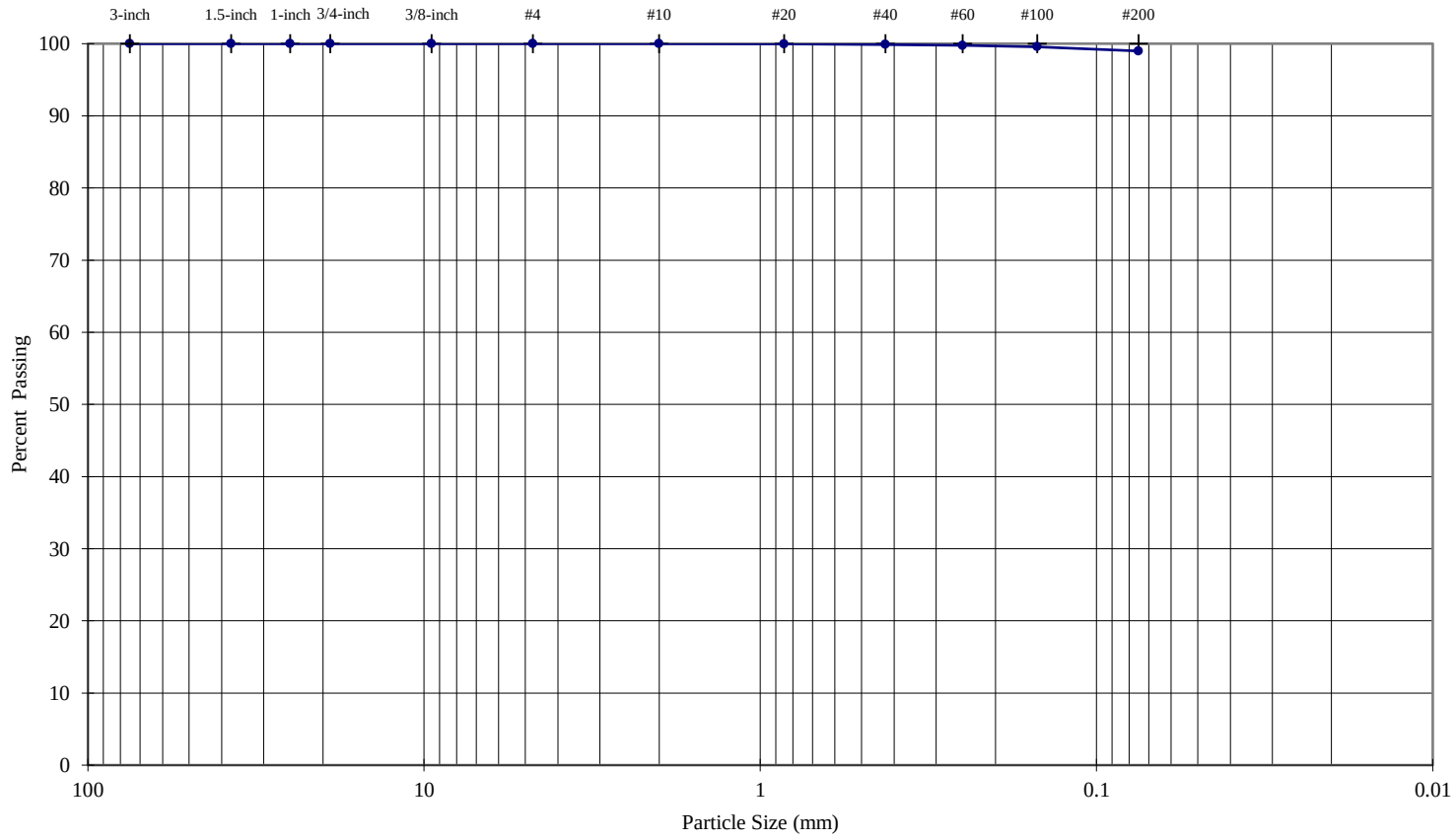
PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**

SAMPLE ID: **BH19-TP-19** DEPTH (ft): **15 - 16.5**

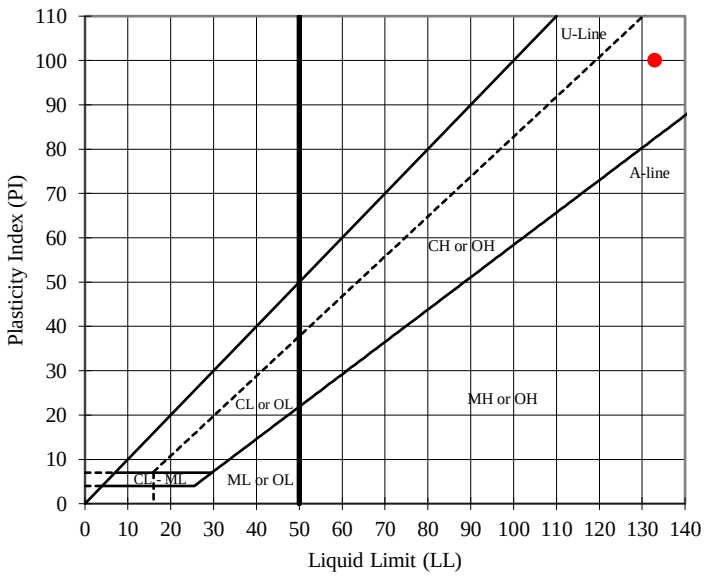
TYPE: **Tube**



Particle Size (mm)

Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**	Coarse Gravel	**0.00**
1.5-inch	37.5	**100.0**		
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.0	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.12**
#40	0.425	**99.9**		
#60	0.250	**99.8**	Fine Sand	**0.89**
#100	0.150	**99.6**		
#200	0.075	**99.0**		
			Silt or Clay Fines	**98.99**



USCS Description (ASTM D 2487):

Fat clay, light gray , moist

LL	PL	PI
133	**33**	**100**

As-Received Moisture Content (%): **34.4**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	6-May-2019
REVIEW	MB

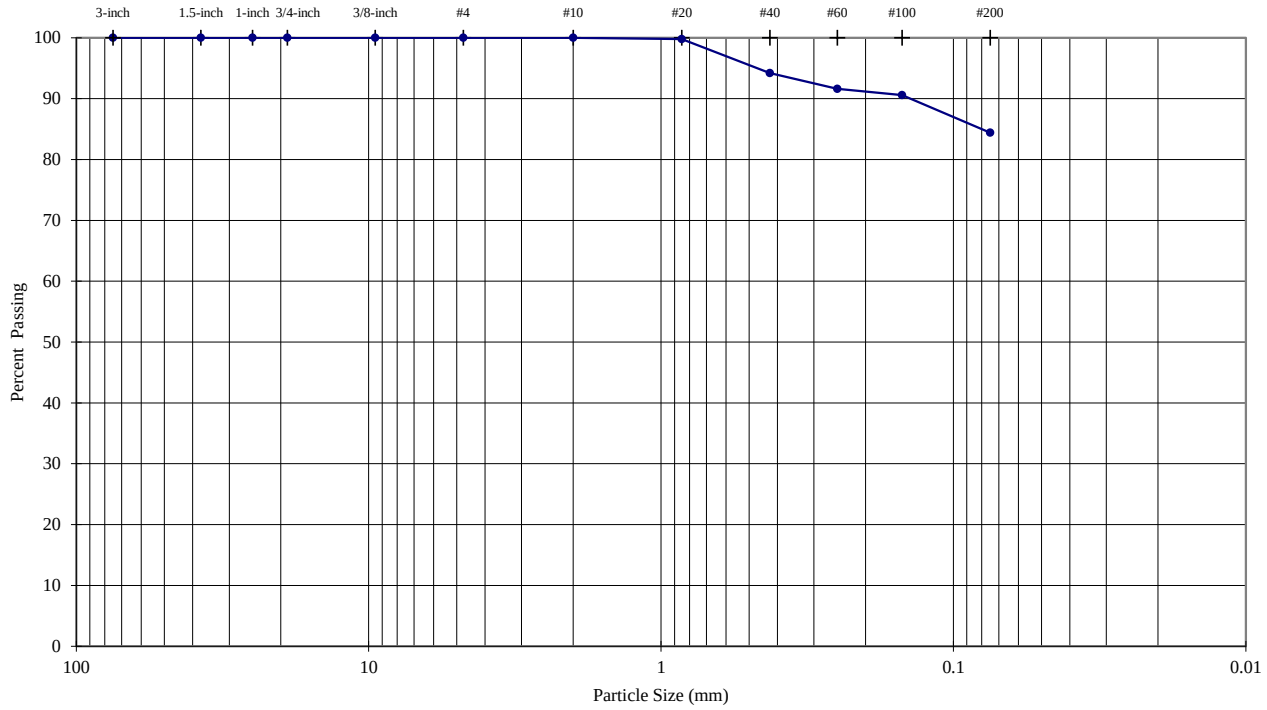
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

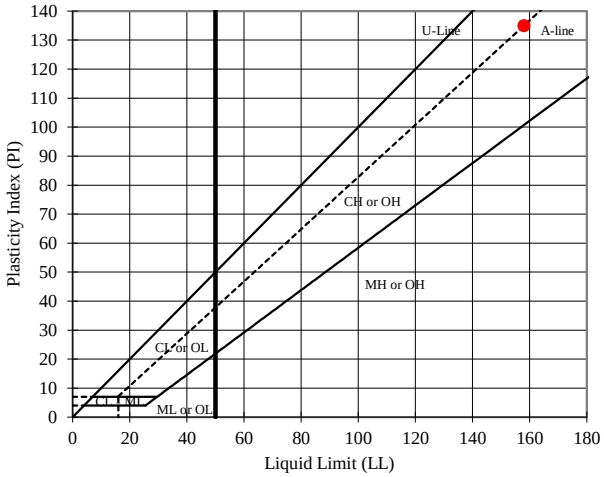
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **25 - 26.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**94.2**
#60	0.250	**91.6**
#100	0.150	**90.6**
#200	0.075	**84.4**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**5.80**
Fine Sand	**9.79**
Silt or Clay Fines	**84.42**



USCS Description (ASTM D 2487):

Fat clay with sand, pale yellow, moist

LL	PL	PI
158	**23**	**135**

As-Received Moisture Content (%): **23.2**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	7-May-2019
REVIEW	MB

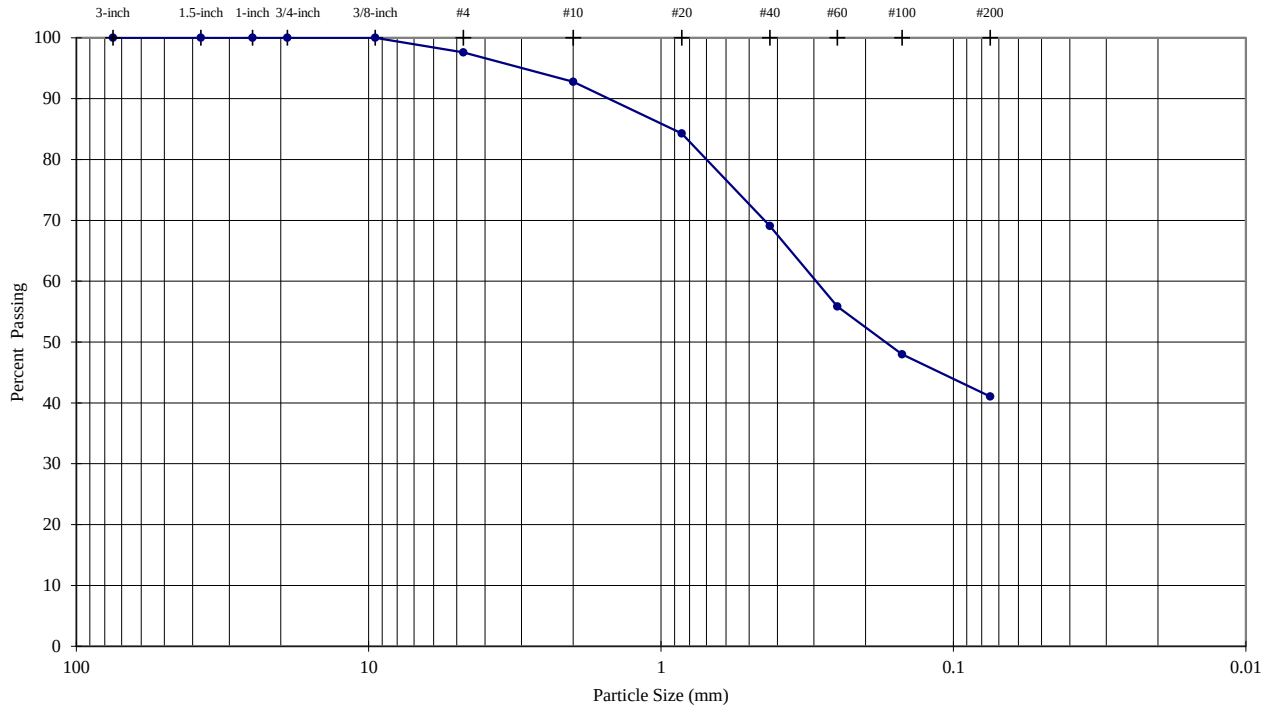
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

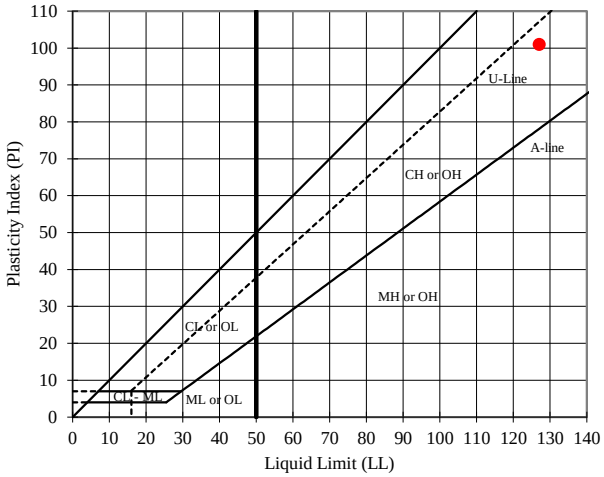
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **30.3 - 31.8**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**97.6**
#10	2.0	**92.8**
#20	0.850	**84.3**
#40	0.425	**69.1**
#60	0.250	**55.9**
#100	0.150	**48.0**
#200	0.075	**41.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**2.39**
Coarse Sand	**4.83**
Medium Sand	**23.68**
Fine Sand	**28.03**
Silt or Clay Fines	**41.06**



USCS Description (ASTM D 2487):

Clayey sand, pale yellow, moist

LL	PL	PI
127	**26**	**101**

As-Received Moisture Content (%): **27.1**

USCS Group Symbol: SC

Notes: 0 g of particles up to 9.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	7-Jun-2019
REVIEW	MB

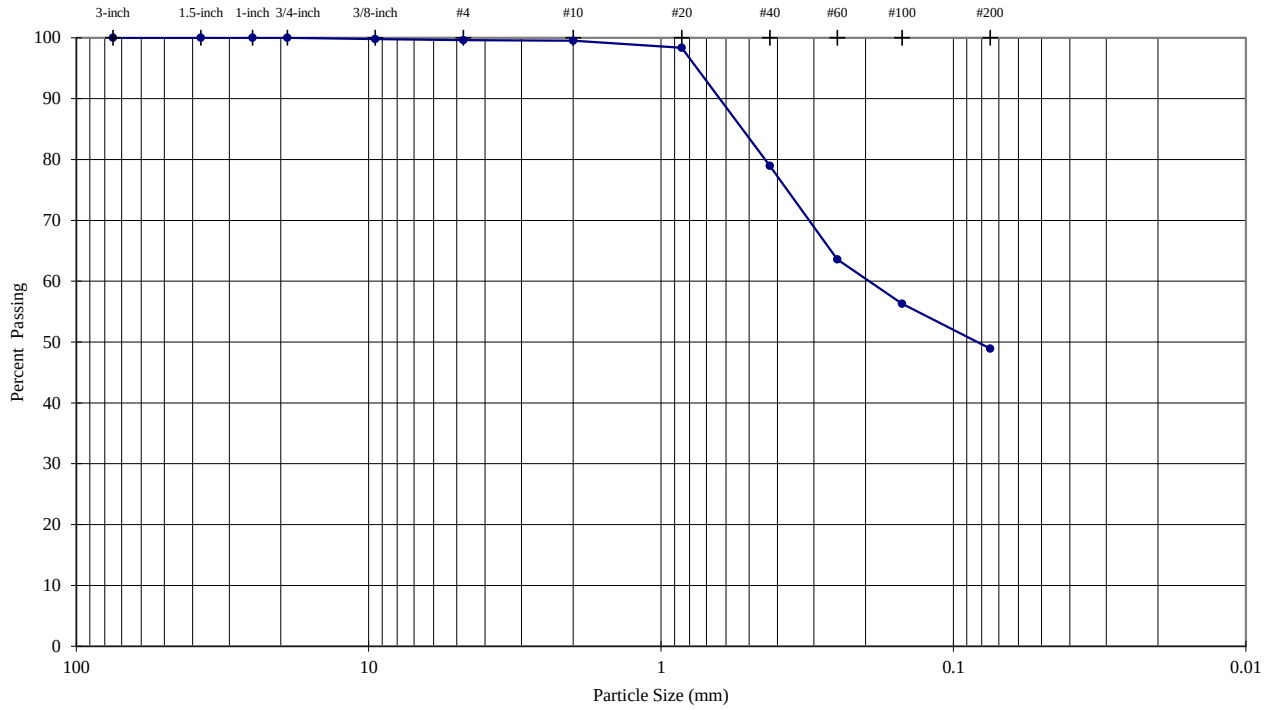
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

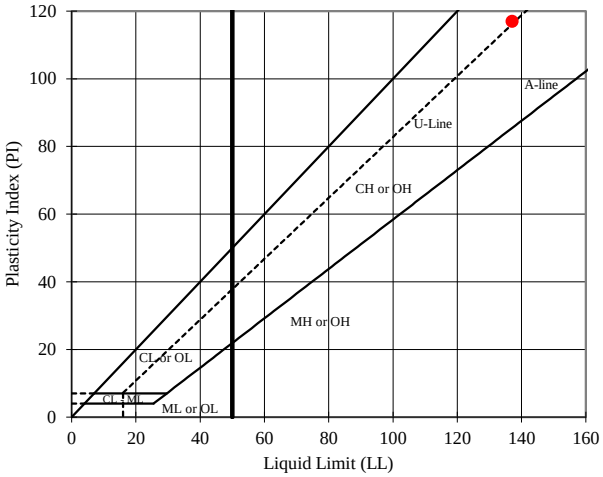
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **35 - 36.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**99.8**
#4	4.75	**99.6**
#10	2.0	**99.5**
#20	0.850	**98.4**
#40	0.425	**79.0**
#60	0.250	**63.6**
#100	0.150	**56.3**
#200	0.075	**48.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.40**
Coarse Sand	**0.08**
Medium Sand	**20.54**
Fine Sand	**30.04**
Silt or Clay Fines	**48.94**



USCS Description (ASTM D 2487):

Clayey sand, brownish yellow, moist

LL	PL	PI
137	**20**	**117**

As-Received Moisture Content (%): **26.3**

USCS Group Symbol: SC

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	9-May-2019
REVIEW	MB

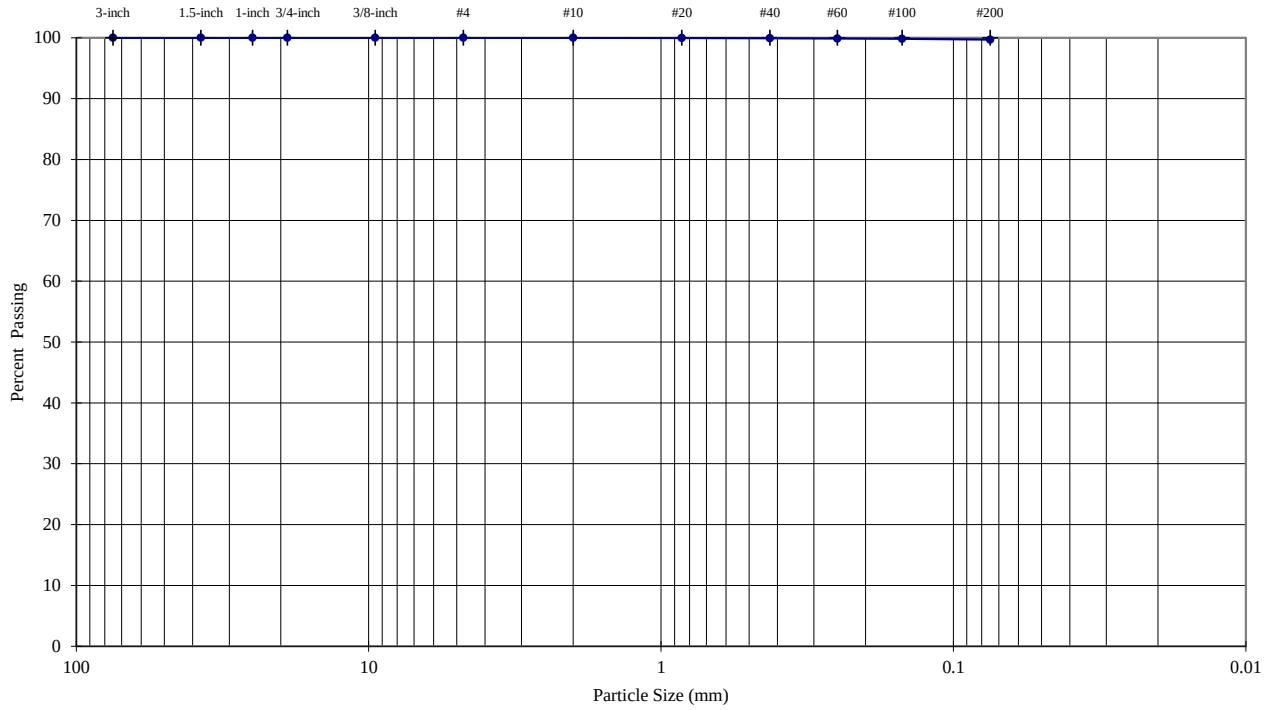
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

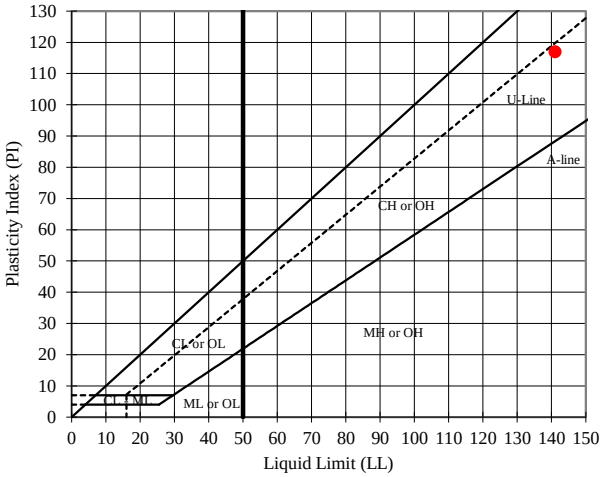
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **40.0 - 41.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.9**
#100	0.150	**99.9**
#200	0.075	**99.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.07**
Fine Sand	**0.22**
Silt or Clay Fines	**99.71**



USCS Description (ASTM D 2487):

Fat clay, grayish brown, moist

LL	PL	PI
141	**24**	**117**

As-Received Moisture Content (%): **45.5**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	13-May-2019
REVIEW	MB

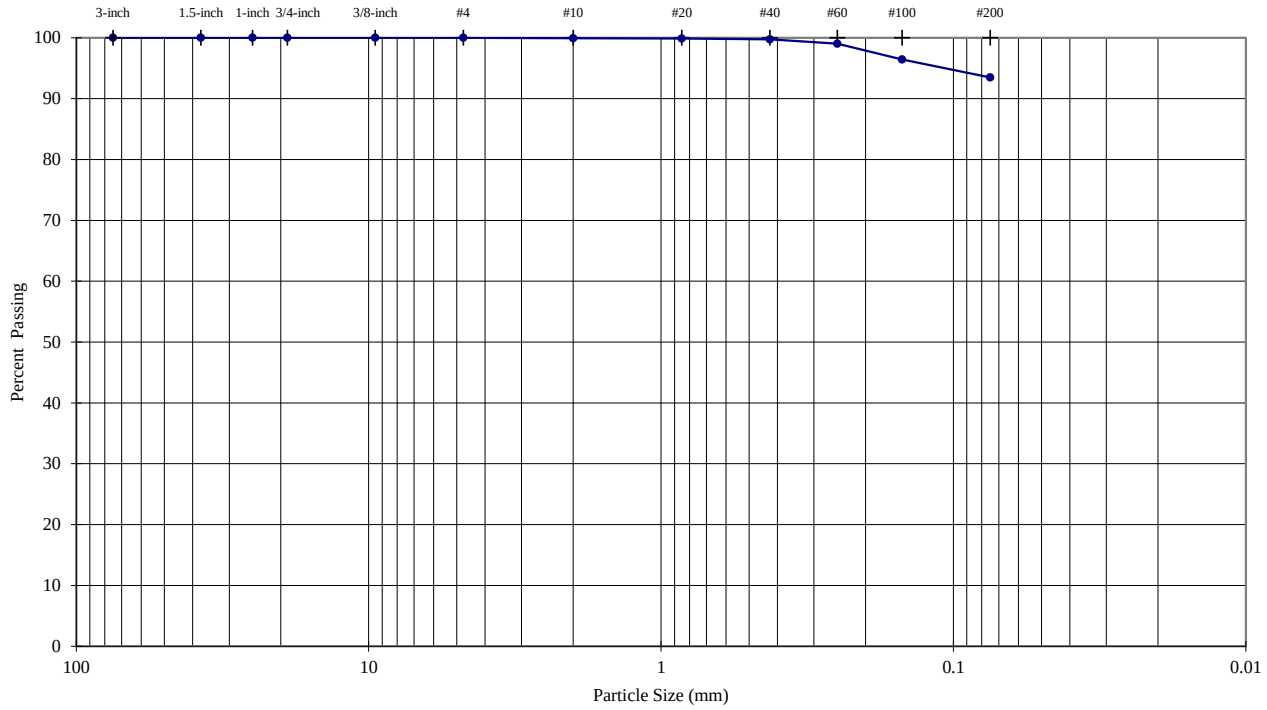
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

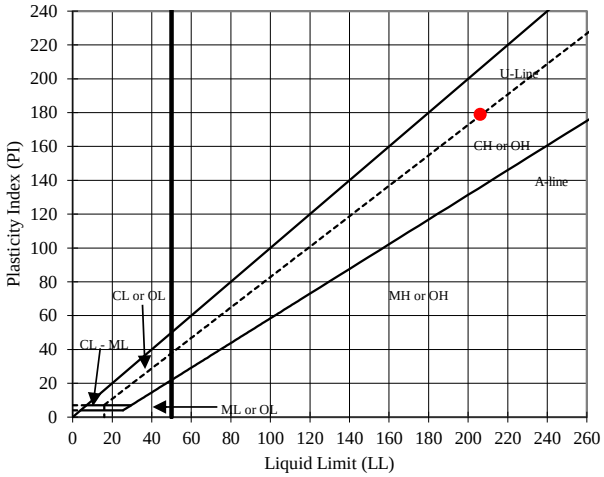
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **50 - 51.5**
TYPE: **Tube**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.9**
#20	0.850	**99.9**
#40	0.425	**99.8**
#60	0.250	**99.0**
#100	0.150	**96.4**
#200	0.075	**93.5**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.06**
Medium Sand	**0.19**
Fine Sand	**6.26**
Silt or Clay Fines	**93.49**



USCS Description (ASTM D 2487):

Fat clay, olive yellow, moist

LL	PL	PI
206	**27**	**179**

As-Received Moisture Content (%): **42.2**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	13-May-2019
REVIEW	MB

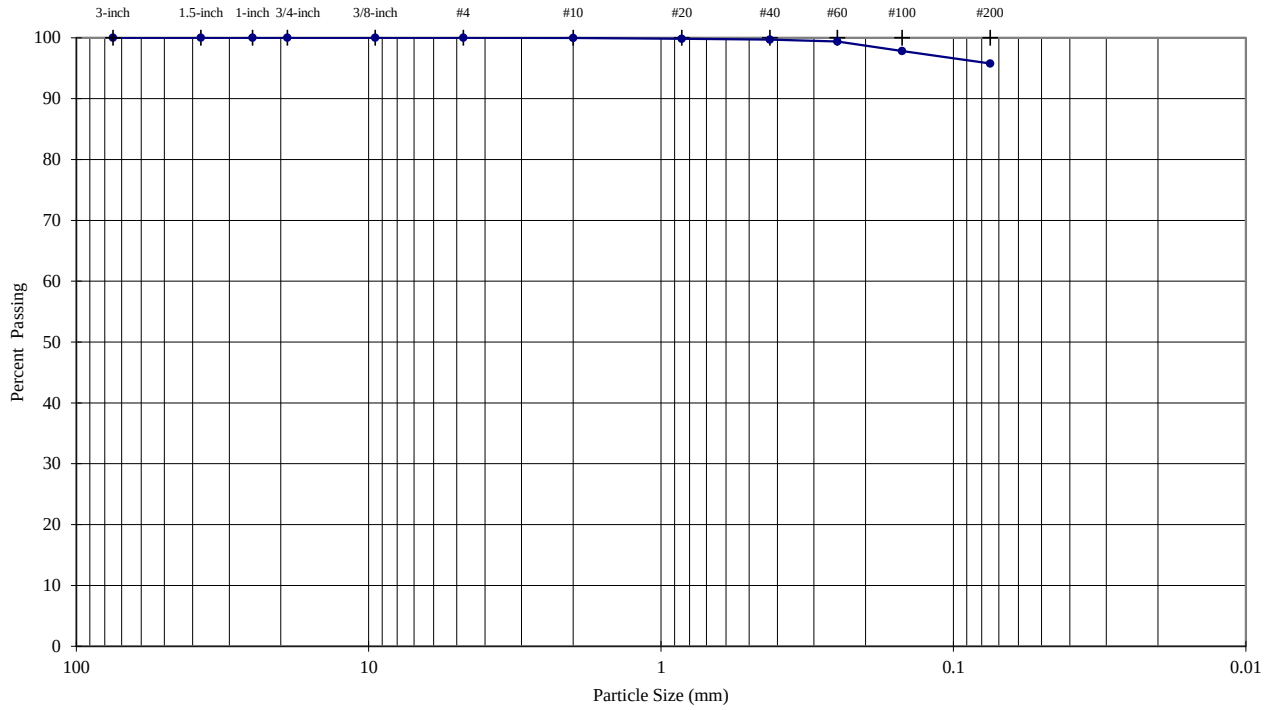
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

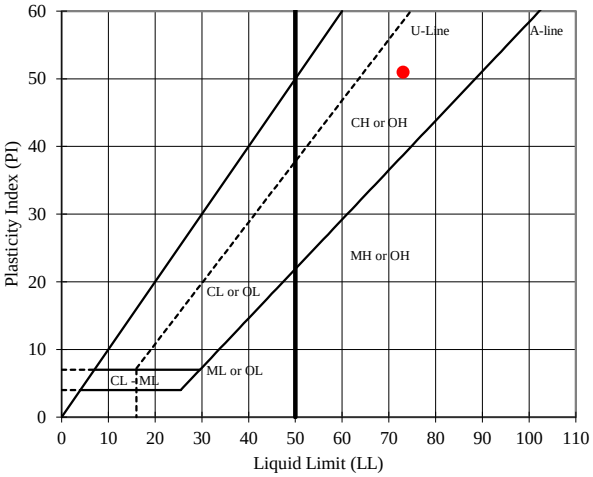
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **60 - 61.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.7**
#60	0.250	**99.4**
#100	0.150	**97.8**
#200	0.075	**95.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.03**
Medium Sand	**0.28**
Fine Sand	**3.91**
Silt or Clay Fines	**95.78**



USCS Description (ASTM D 2487):

Fat clay, very dark gray, moist

LL	PL	PI
73	**22**	**51**

As-Received Moisture Content (%): **22.1**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	13-May-2019
REVIEW	MB

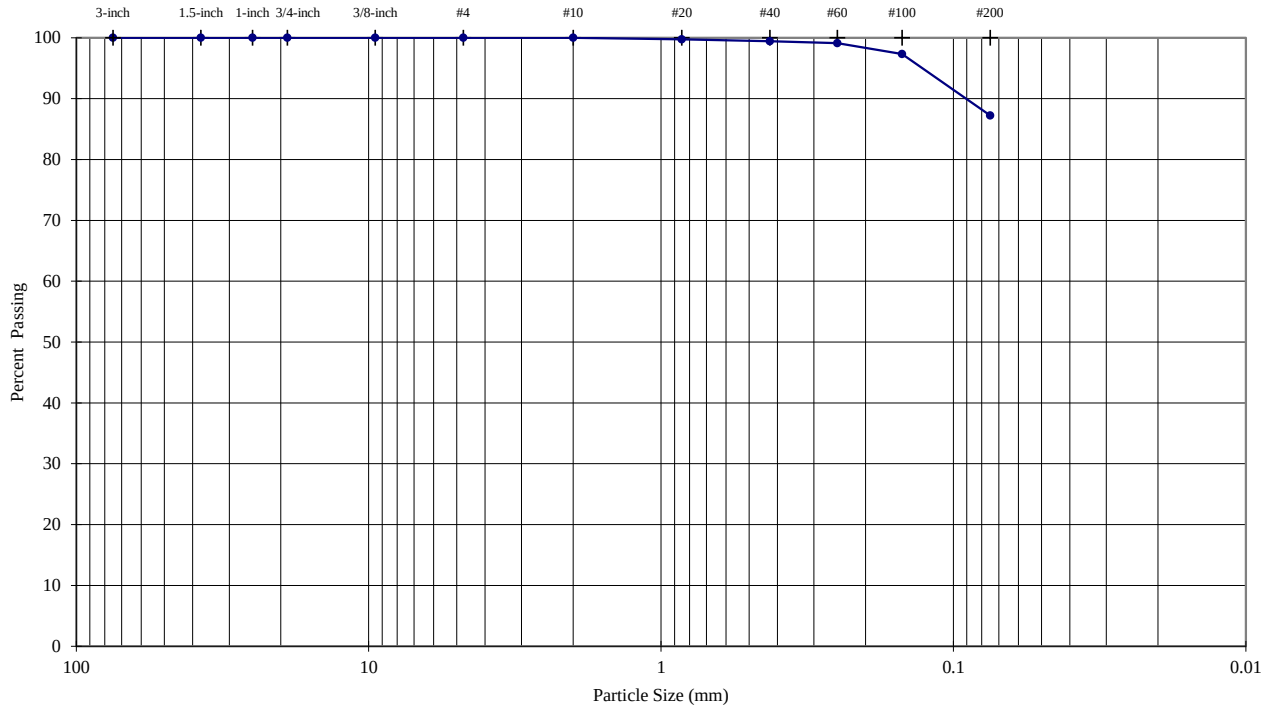
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

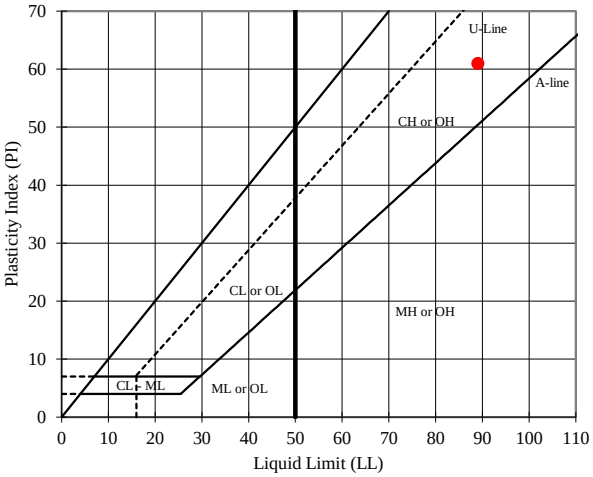
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **70 - 71.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.4**
#60	0.250	**99.1**
#100	0.150	**97.3**
#200	0.075	**87.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.56**
Fine Sand	**12.19**
Silt or Clay Fines	**87.25**



USCS Description (ASTM D 2487):

Fat clay, bluish gray, moist

LL	PL	PI
89	**28**	**61**

As-Received Moisture Content (%): **30.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	13-May-2019
REVIEW	MB

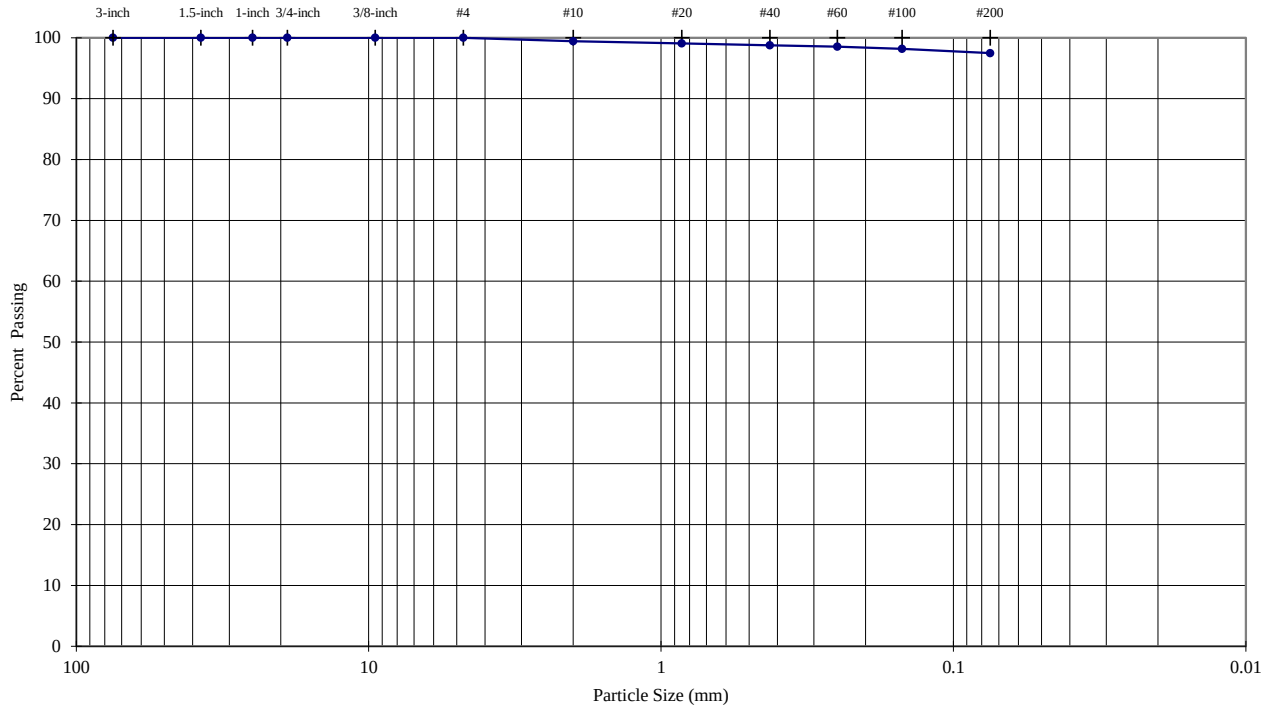
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

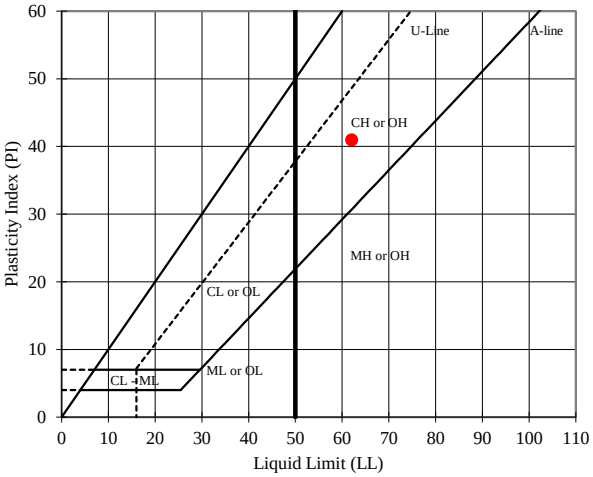
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **80 - 81.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.4**
#20	0.850	**99.1**
#40	0.425	**98.8**
#60	0.250	**98.6**
#100	0.150	**98.2**
#200	0.075	**97.5**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.56**
Medium Sand	**0.66**
Fine Sand	**1.29**
Silt or Clay Fines	**97.49**



USCS Description (ASTM D 2487):

Fat clay, bluish gray, moist

LL	PL	PI
62	**21**	**41**

As-Received Moisture Content (%): **20.9**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	26-Apr-2019
REVIEW	MB

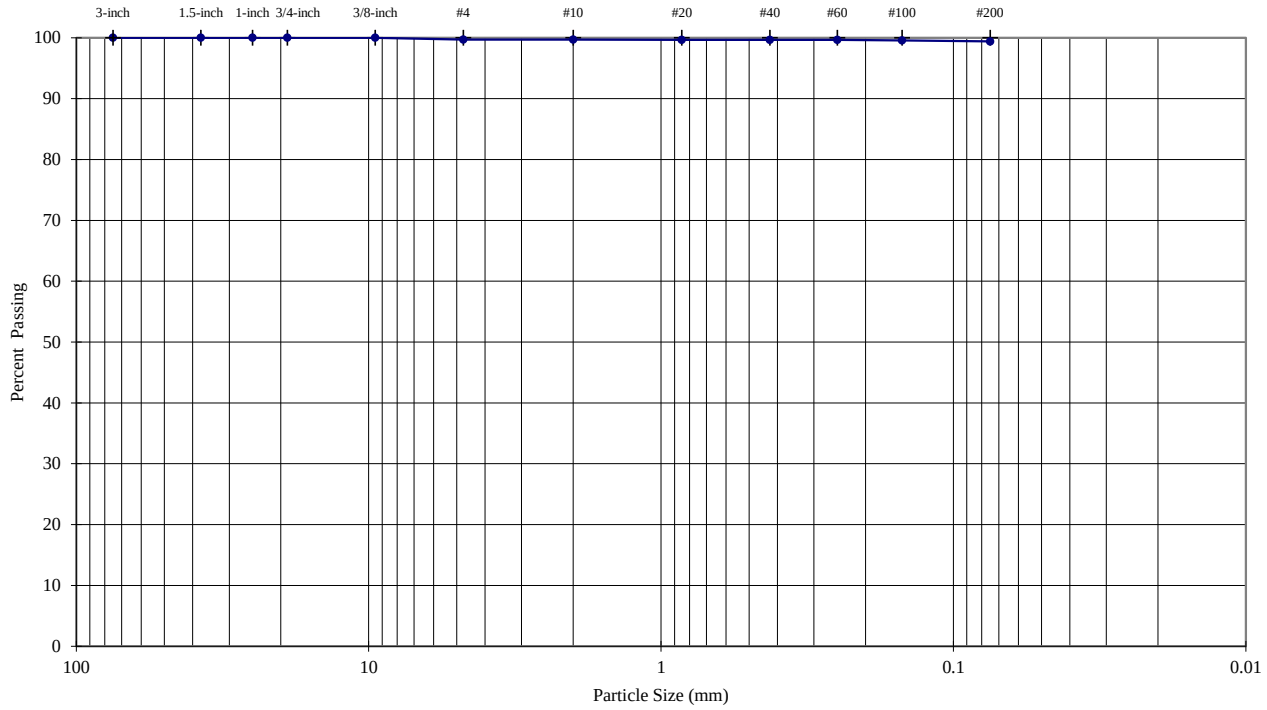
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

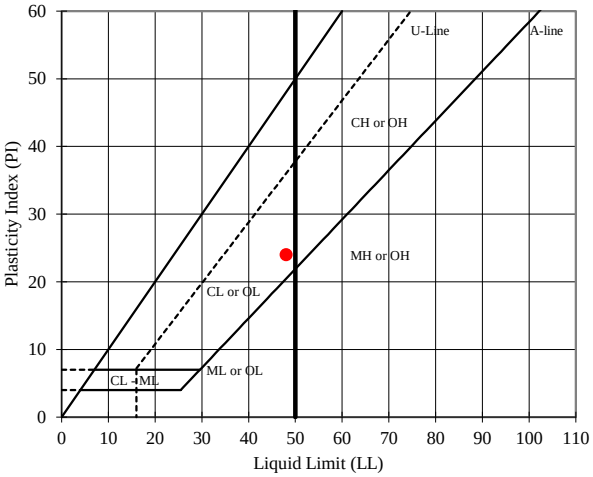
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **110.0 - 111.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**99.7**
#10	2.0	**99.7**
#20	0.850	**99.7**
#40	0.425	**99.7**
#60	0.250	**99.6**
#100	0.150	**99.6**
#200	0.075	**99.4**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.31**
Coarse Sand	**0.00**
Medium Sand	**0.03**
Fine Sand	**0.25**
Silt or Clay Fines	**99.41**



USCS Description (ASTM D 2487):

Lean clay, gray, moist

LL	PL	PI
48	**24**	**24**

As-Received Moisture Content (%): **17.8**

USCS Group Symbol: CL

Notes: 0 g of particles up to 9.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	13-May-2019
REVIEW	MB

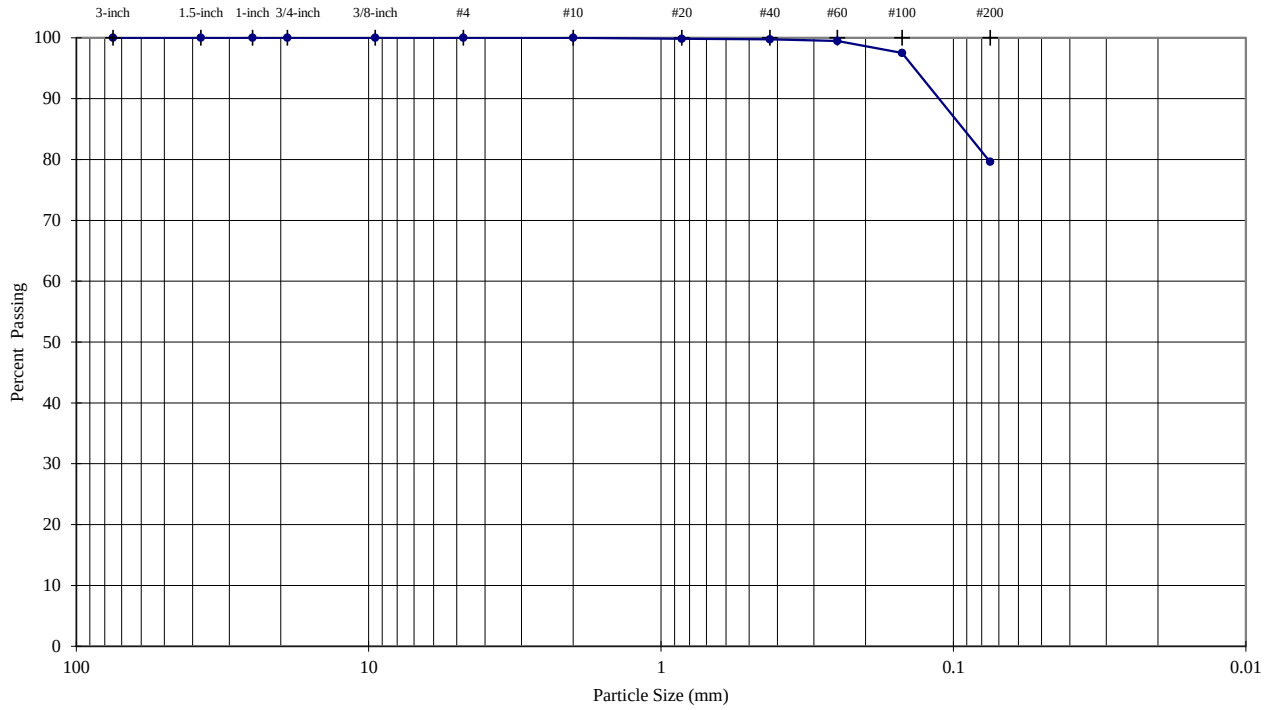
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

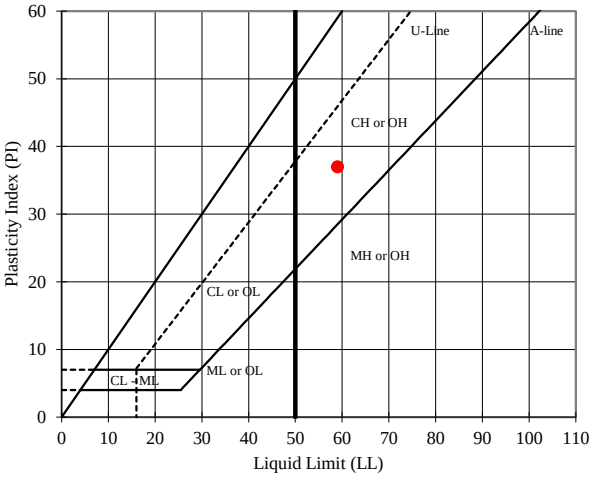
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-19** DEPTH (ft): **120 - 121.4**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.7**
#60	0.250	**99.5**
#100	0.150	**97.5**
#200	0.075	**79.6**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.26**
Fine Sand	**20.12**
Silt or Clay Fines	**79.61**



USCS Description (ASTM D 2487):

Fat clay with sand, light gray, moist

LL	PL	PI
59	**22**	**37**

As-Received Moisture Content (%): **20.9**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	15-May-2019
REVIEW	MB

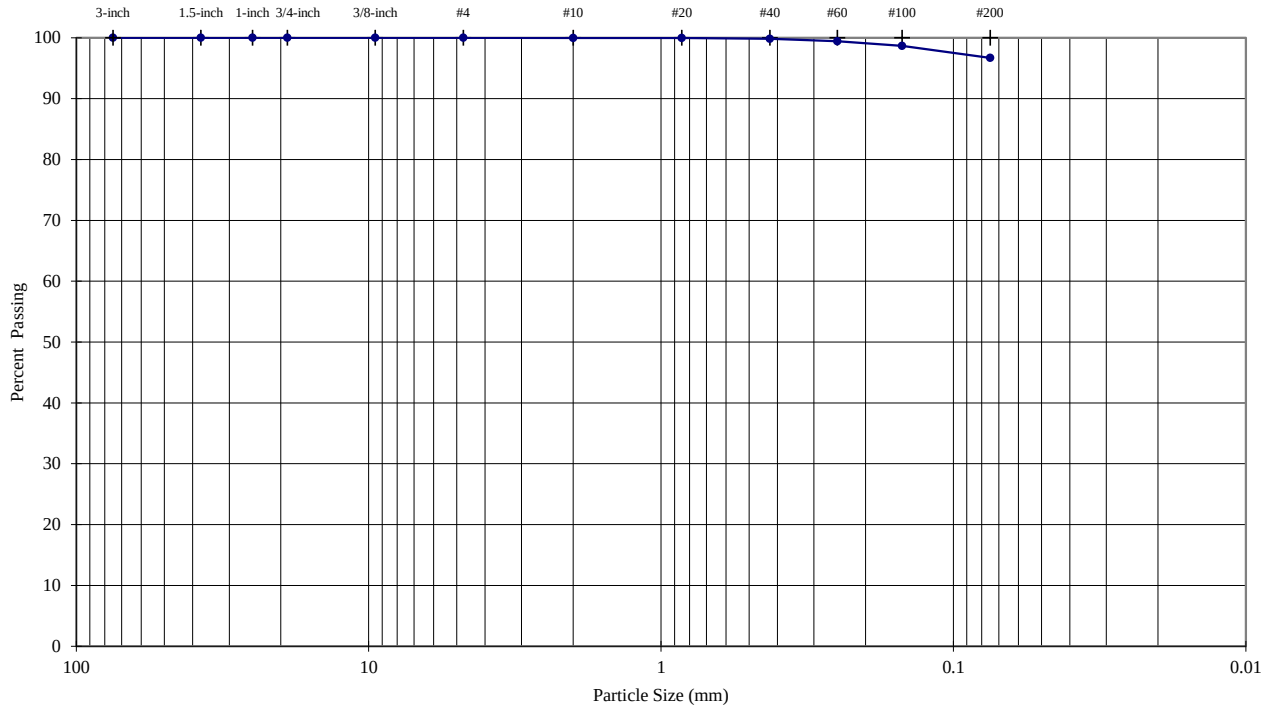
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

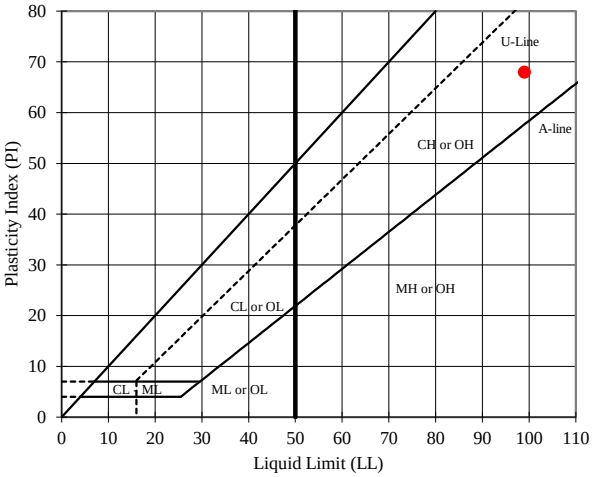
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **30-31.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.8**
#60	0.250	**99.4**
#100	0.150	**98.7**
#200	0.075	**96.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.01**
Medium Sand	**0.16**
Fine Sand	**3.13**
Silt or Clay Fines	**96.70**



USCS Description (ASTM D 2487):

Fat clay, olive brown, moist

LL	PL	PI
99	**31**	**68**

As-Received Moisture Content (%): **41.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	30-Apr-2019
REVIEW	PRH

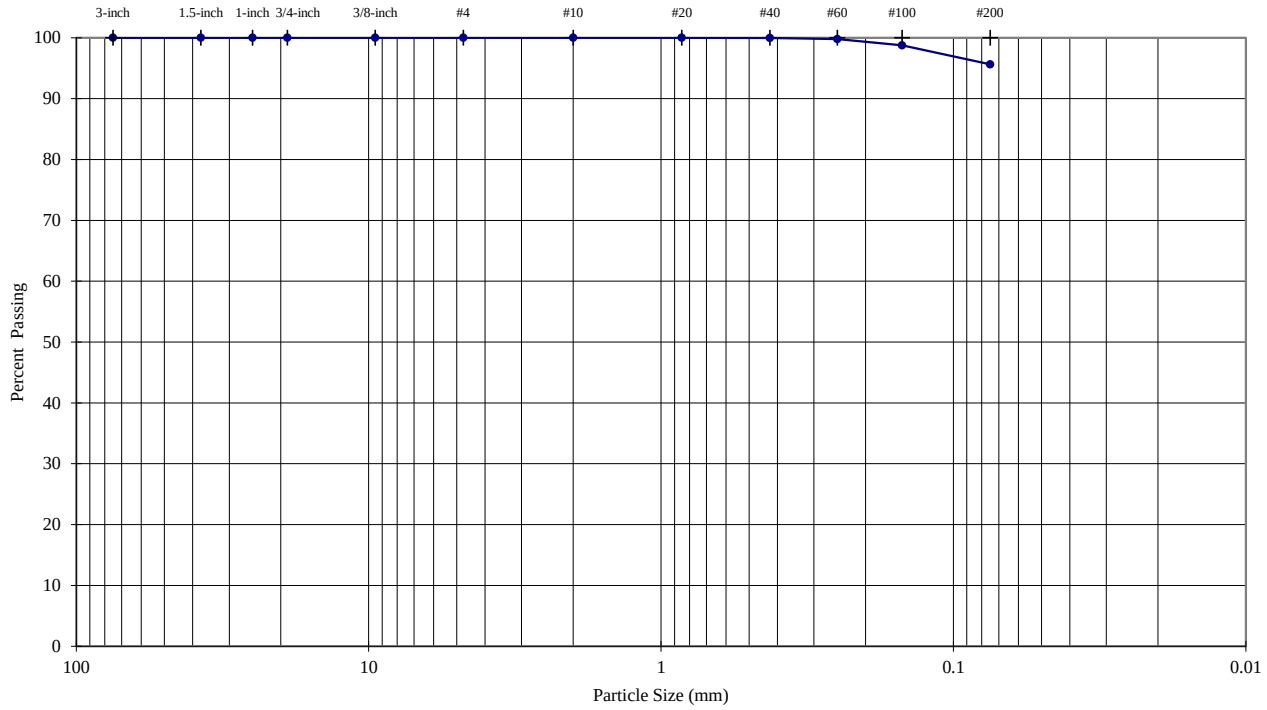
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

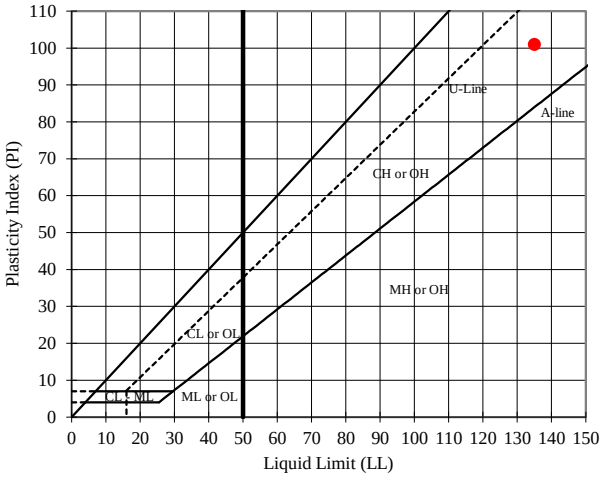
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **35 - 36.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**100.0**
#60	0.250	**99.8**
#100	0.150	**98.8**
#200	0.075	**95.6**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.02**
Fine Sand	**4.33**
Silt or Clay Fines	**95.65**



USCS Description (ASTM D 2487):

Fat clay, olive, moist

LL	PL	PI
135	**34**	**101**

As-Received Moisture Content (%): **41.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	30-Apr-2019
REVIEW	MB

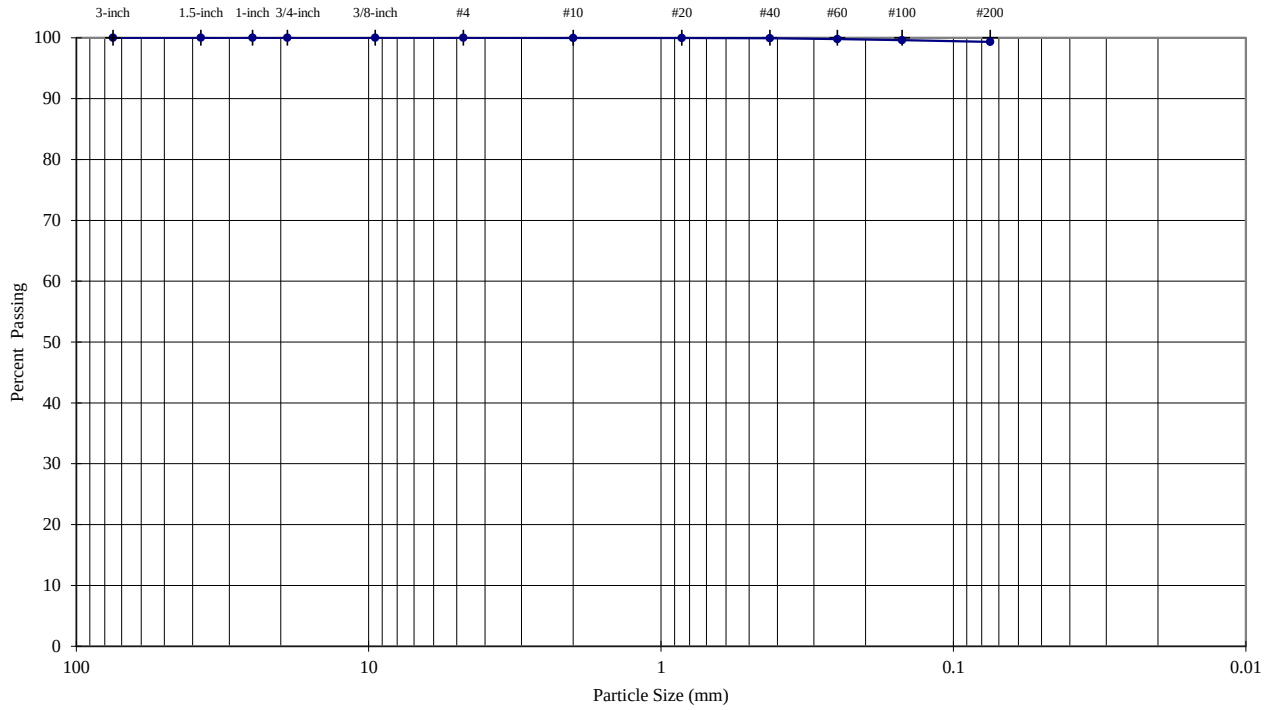
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

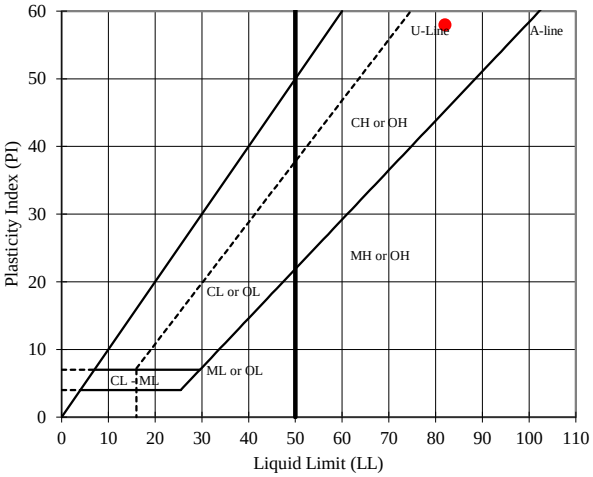
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **40 - 41.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.8**
#100	0.150	**99.6**
#200	0.075	**99.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.01**
Medium Sand	**0.08**
Fine Sand	**0.58**
Silt or Clay Fines	**99.33**



USCS Description (ASTM D 2487):

Fat clay, pale brown, moist

LL	PL	PI
82	**24**	**58**

As-Received Moisture Content (%): **29.4**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	30-Apr-2019
REVIEW	MB

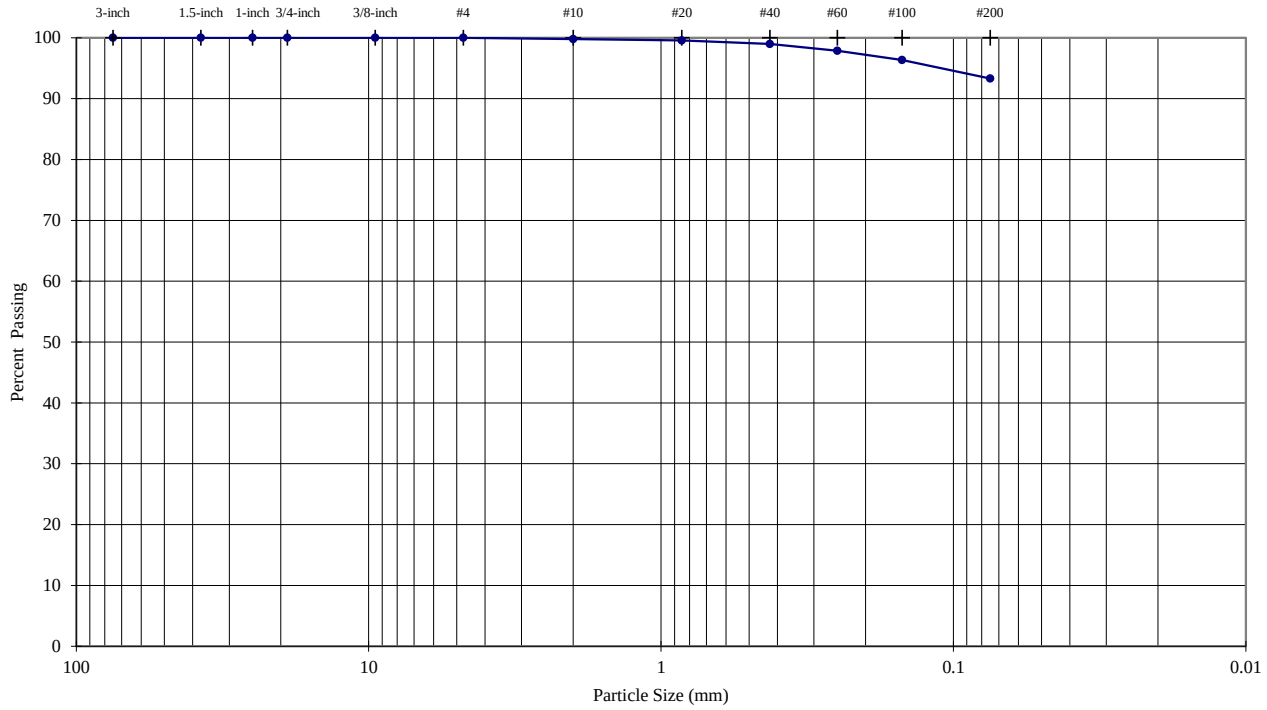
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

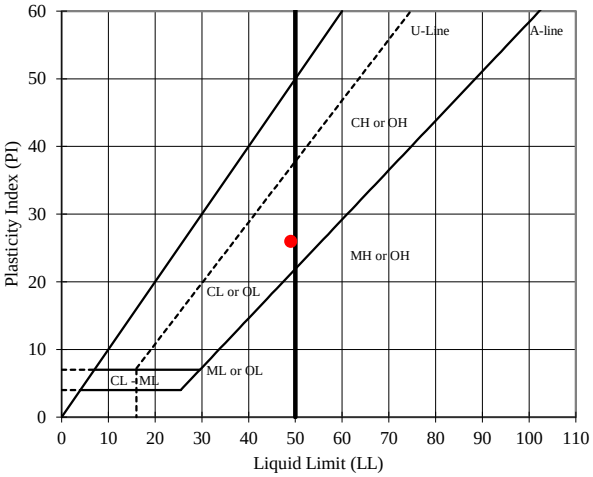
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **45-46.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.8**
#20	0.850	**99.6**
#40	0.425	**99.0**
#60	0.250	**97.9**
#100	0.150	**96.4**
#200	0.075	**93.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.21**
Medium Sand	**0.80**
Fine Sand	**5.68**
Silt or Clay Fines	**93.31**



USCS Description (ASTM D 2487):

Lean clay, pale brown, moist

LL	PL	PI
49	**23**	**26**

As-Received Moisture Content (%): **22.8**

USCS Group Symbol: CL

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	30-Apr-2019
REVIEW	PRH

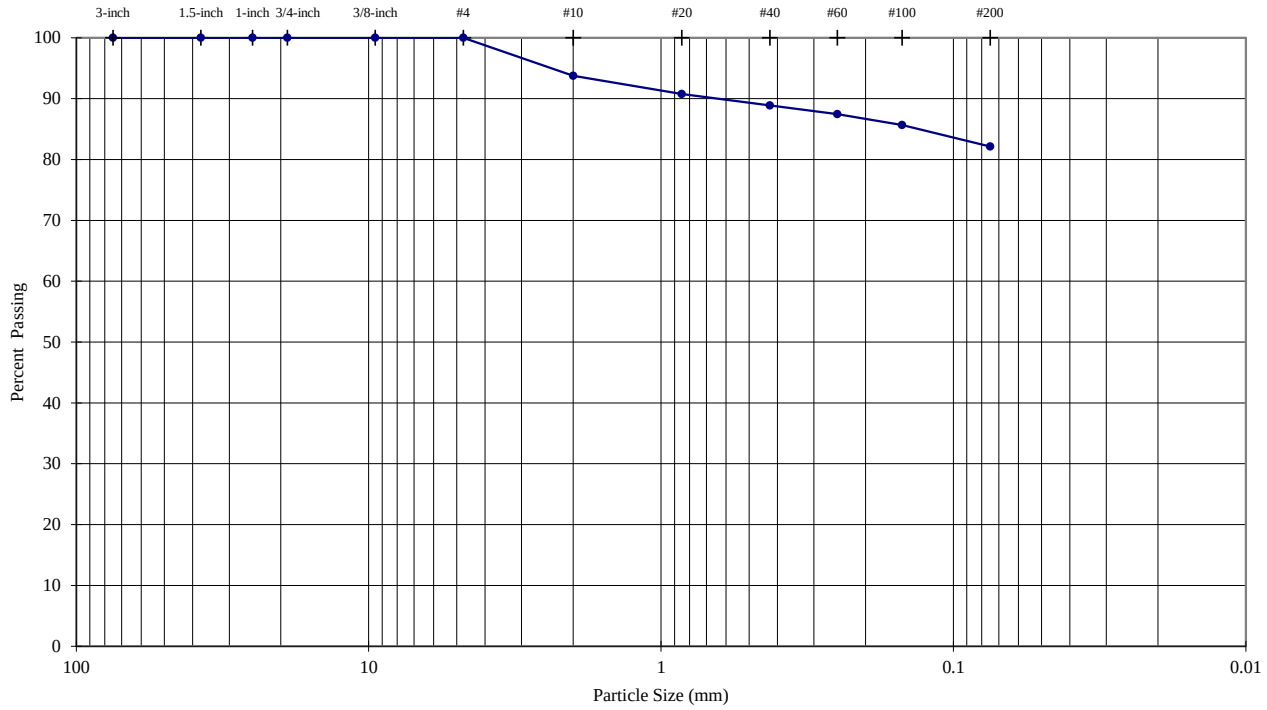
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

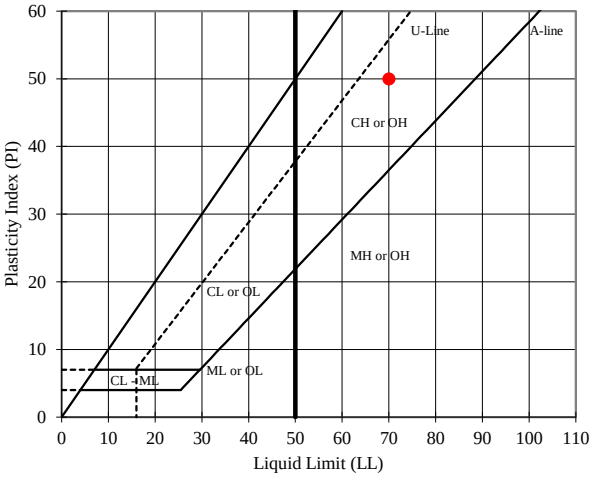
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **50 - 51.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**93.7**
#20	0.850	**90.7**
#40	0.425	**88.9**
#60	0.250	**87.5**
#100	0.150	**85.7**
#200	0.075	**82.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**6.26**
Medium Sand	**4.85**
Fine Sand	**6.76**
Silt or Clay Fines	**82.13**



USCS Description (ASTM D 2487):

Fat clay with sand, dark greenish gray, moist

LL	PL	PI
70	**20**	**50**

As-Received Moisture Content (%): **19.5**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	2-May-2019
REVIEW	MB

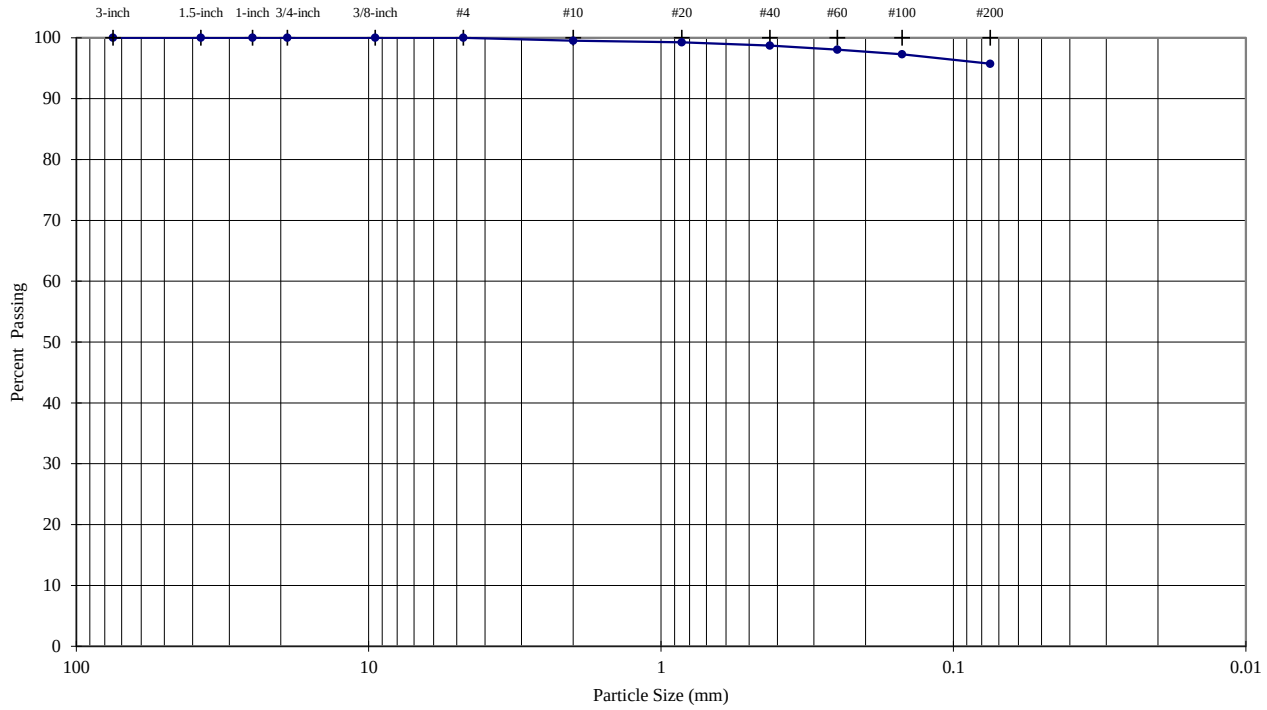
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

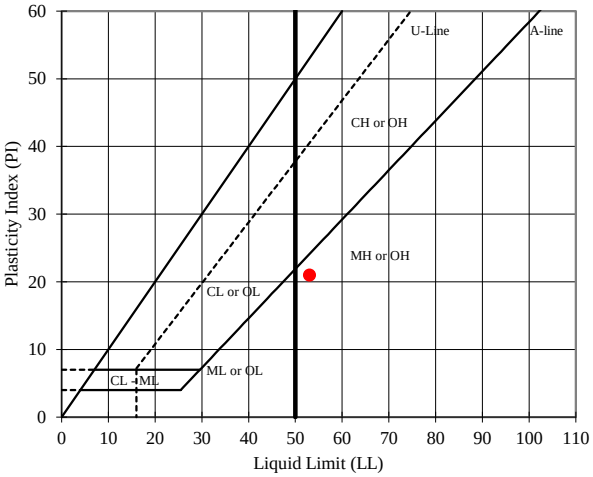
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **60-61.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.5**
#20	0.850	**99.3**
#40	0.425	**98.7**
#60	0.250	**98.1**
#100	0.150	**97.3**
#200	0.075	**95.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.45**
Medium Sand	**0.80**
Fine Sand	**3.00**
Silt or Clay Fines	**95.74**



USCS Description (ASTM D 2487):

Elastic silt, light yellowish brown, moist

LL	PL	PI
53	**32**	**21**

As-Received Moisture Content (%): **26.0**

USCS Group Symbol: MH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	1-May-2019
REVIEW	MB

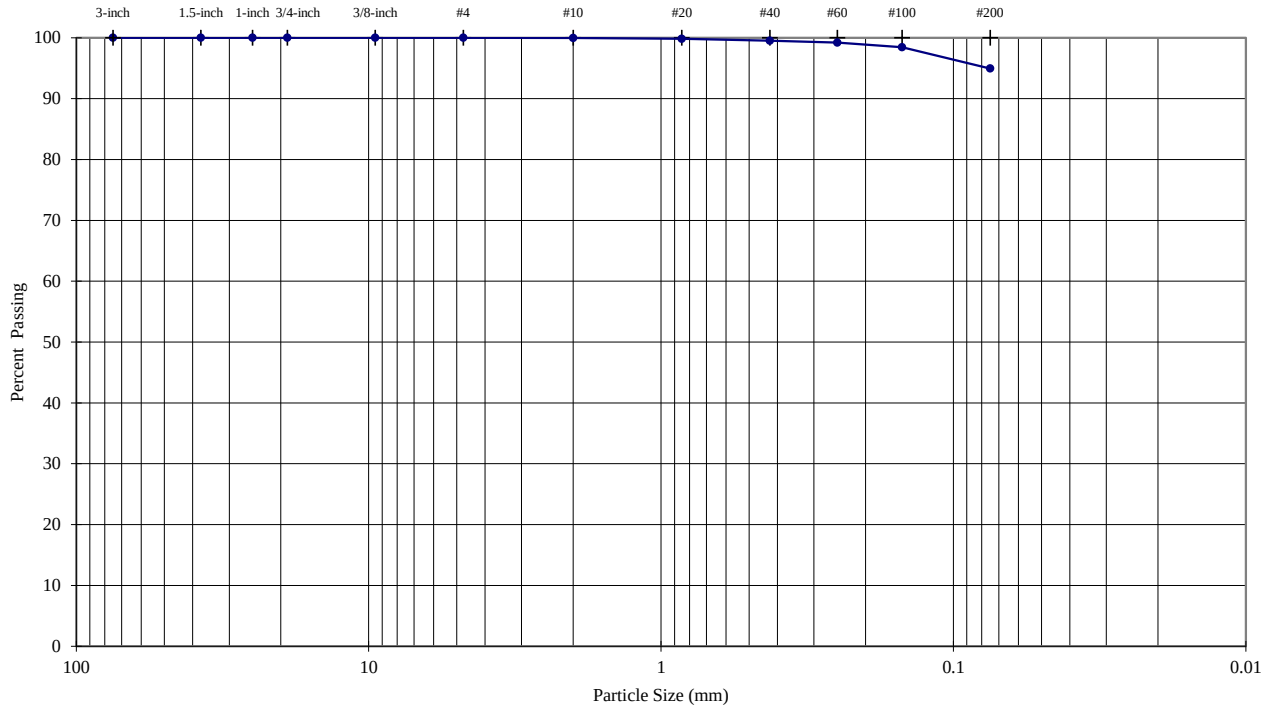
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

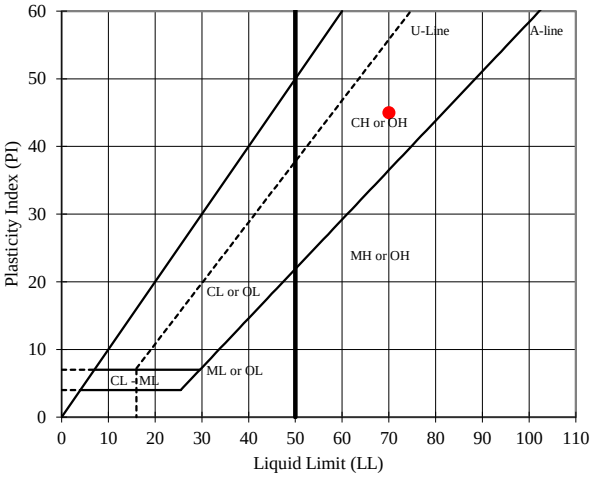
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **100 - 101.5**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.5**
#60	0.250	**99.2**
#100	0.150	**98.4**
#200	0.075	**95.0**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.01**
Medium Sand	**0.45**
Fine Sand	**4.59**
Silt or Clay Fines	**94.95**



USCS Description (ASTM D 2487):

Fat clay, light gray and black, moist

LL	PL	PI
70	**25**	**45**

As-Received Moisture Content (%): **26.1**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	23-May-2019
REVIEW	MB

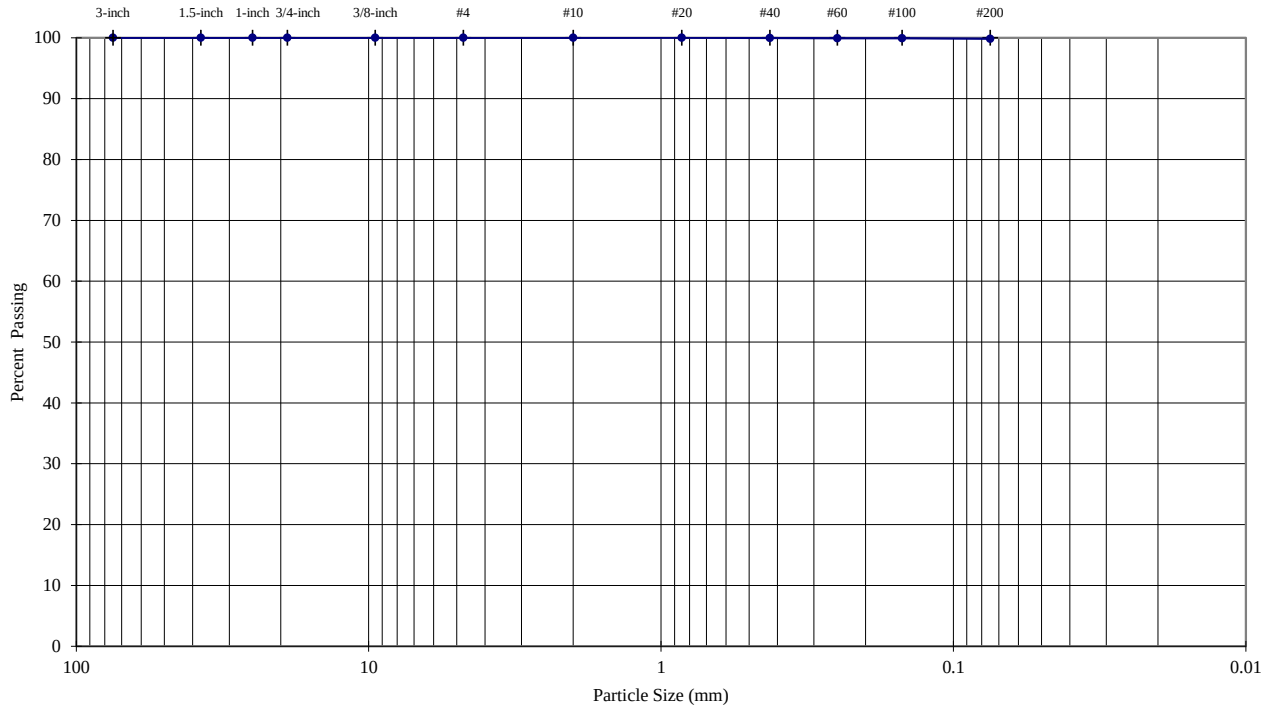
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

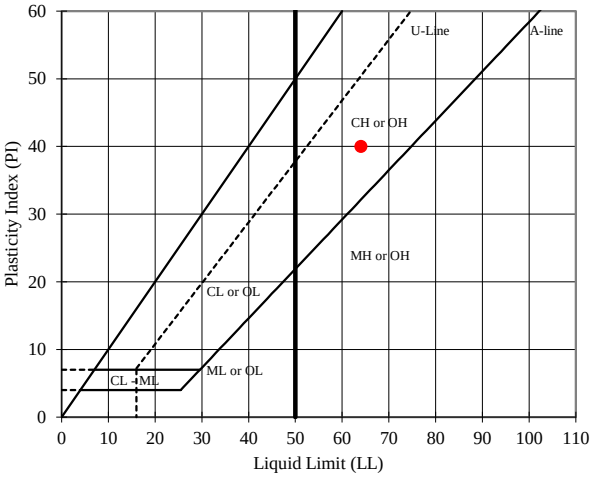
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-23** DEPTH (ft): **120 - 121.3**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**100.0**
#60	0.250	**99.9**
#100	0.150	**99.9**
#200	0.075	**99.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.04**
Fine Sand	**0.12**
Silt or Clay Fines	**99.84**



USCS Description (ASTM D 2487):

Fat clay, gray, moist

LL	PL	PI
64	**24**	**40**

As-Received Moisture Content (%): **25.1**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	17-May-2019
REVIEW	PRH

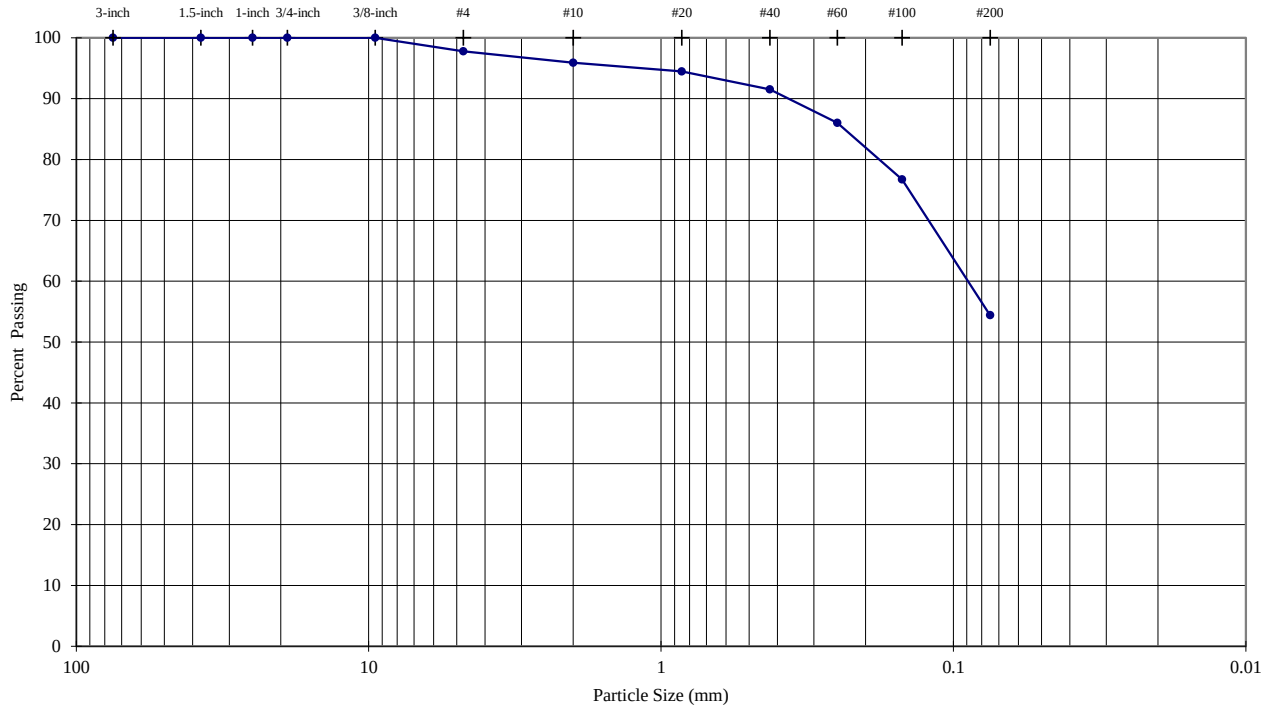
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

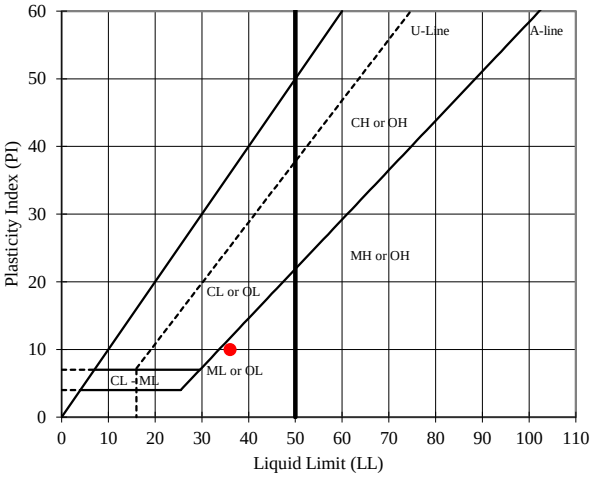
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-39** DEPTH (ft): **10.0-11.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**97.8**
#10	2.0	**95.9**
#20	0.850	**94.5**
#40	0.425	**91.5**
#60	0.250	**86.0**
#100	0.150	**76.7**
#200	0.075	**54.4**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**2.22**
Coarse Sand	**1.87**
Medium Sand	**4.40**
Fine Sand	**37.10**
Silt or Clay Fines	**54.41**



USCS Description (ASTM D 2487):

Sandy silt, light yellowish brown, moist

LL	PL	PI
36	**26**	**10**

As-Received Moisture Content (%): **16.0**

USCS Group Symbol: ML

Notes: 0 g of particles up to 9.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	6-May-2019
REVIEW	MB

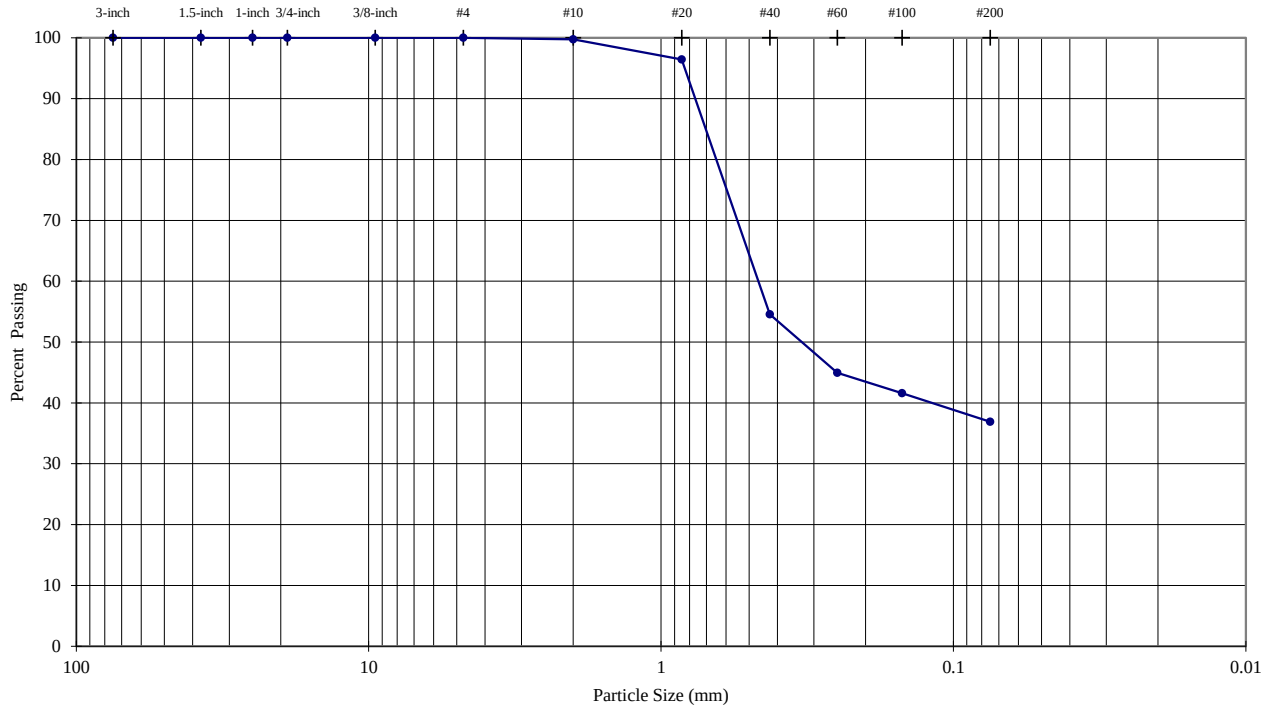
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

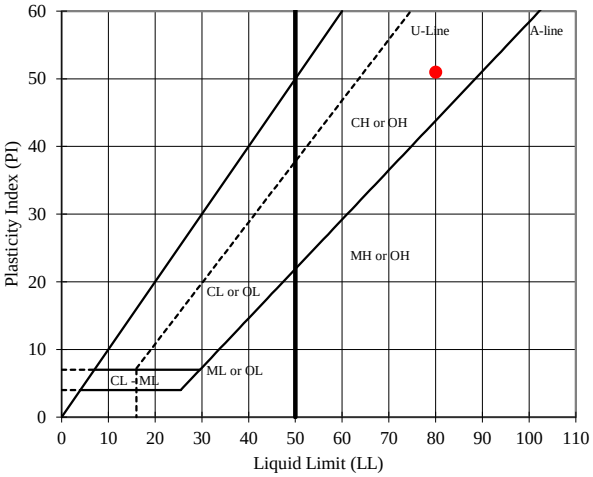
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-39** DEPTH (ft): **15.0-16.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**99.8**
#20	0.850	**96.5**
#40	0.425	**54.6**
#60	0.250	**44.9**
#100	0.150	**41.6**
#200	0.075	**36.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.25**
Medium Sand	**45.19**
Fine Sand	**17.66**
Silt or Clay Fines	**36.90**



USCS Description (ASTM D 2487):

Clayey sand, pale yellow, moist

LL	PL	PI
80	**29**	**51**

As-Received Moisture Content (%): **14.5**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	6-May-2019
REVIEW	MB

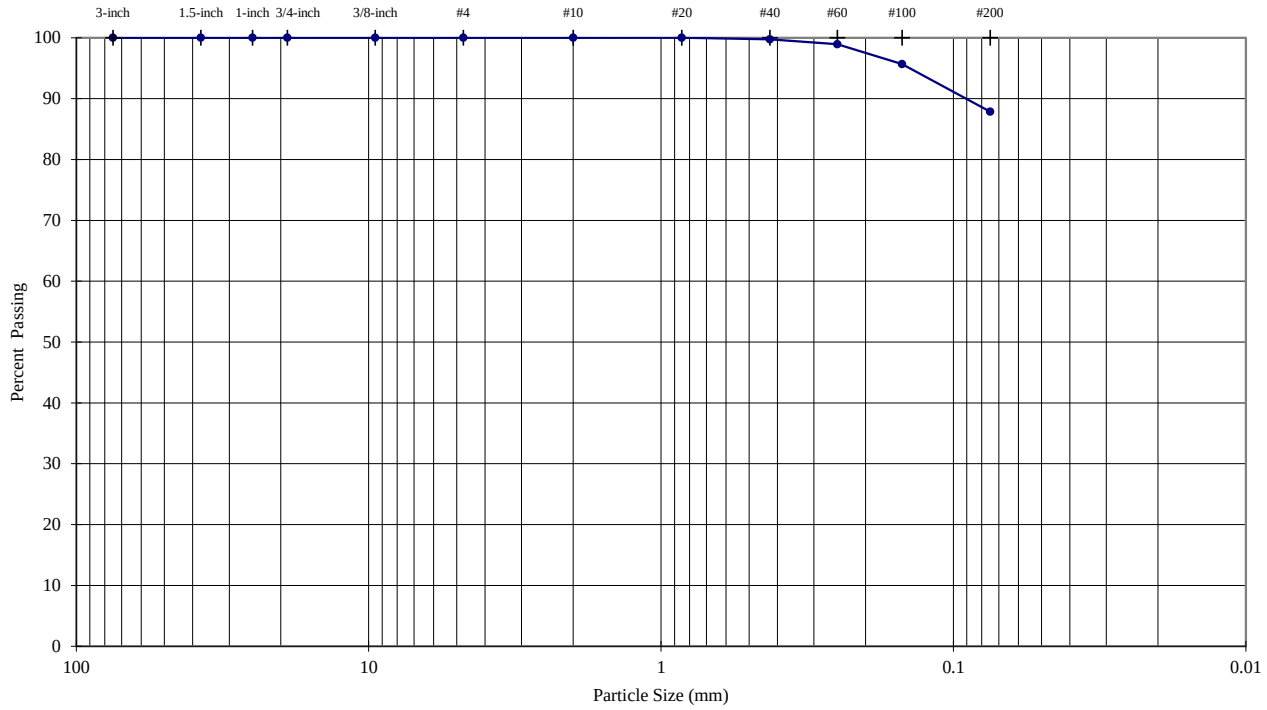
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

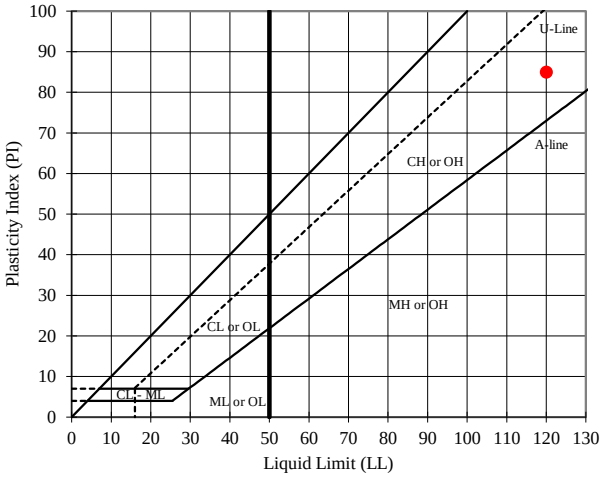
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-39** DEPTH (ft): **25 - 26.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.8**
#60	0.250	**99.0**
#100	0.150	**95.7**
#200	0.075	**87.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.23**
Fine Sand	**11.90**
Silt or Clay Fines	**87.87**



USCS Description (ASTM D 2487):

Fat clay, light greenish gray, moist

LL	PL	PI
120	**35**	**85**

As-Received Moisture Content (%): **39.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	6-May-2019
REVIEW	MB

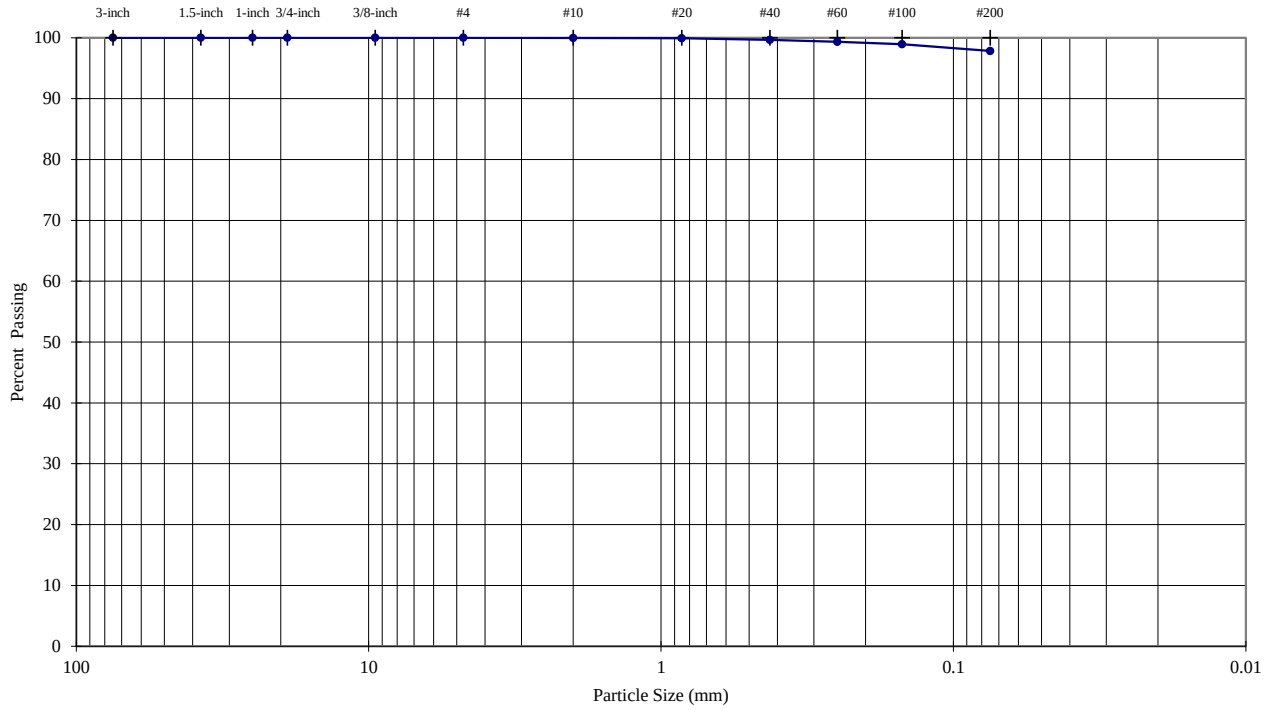
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

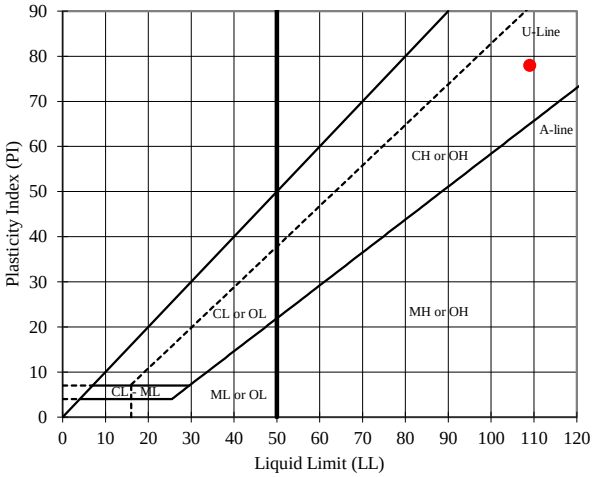
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-39** DEPTH (ft): **35 - 36.5**
TYPE: **Post Triaxial**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.6**
#60	0.250	**99.3**
#100	0.150	**99.0**
#200	0.075	**97.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.03**
Medium Sand	**0.33**
Fine Sand	**1.80**
Silt or Clay Fines	**97.84**



USCS Description (ASTM D 2487):

Fat clay, olive yellow, dry

LL	PL	PI
109	**31**	**78**

As-Received Moisture Content (%): **38.8**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	5-Jun-2019
REVIEW	MB

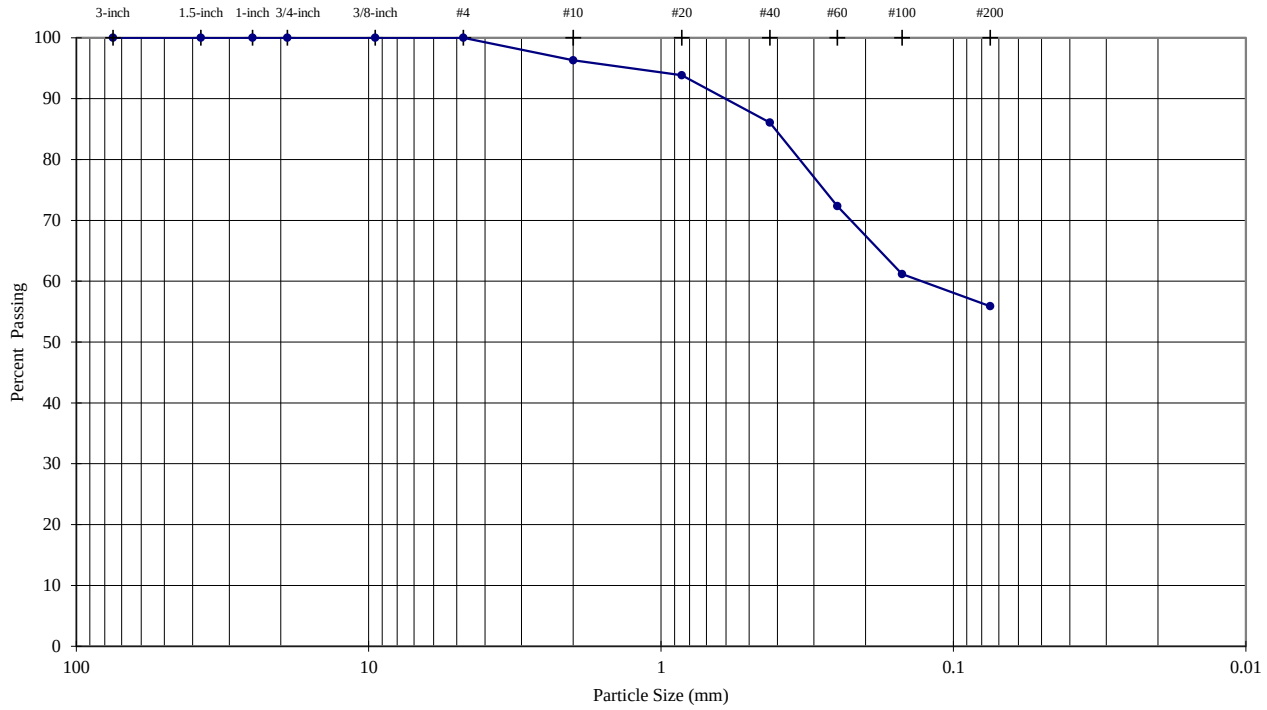
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

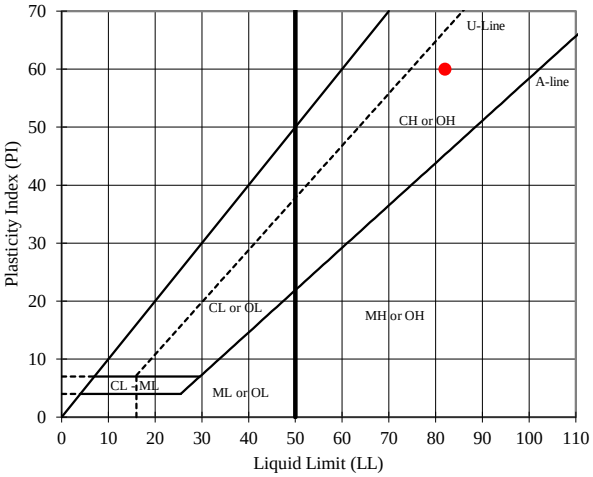
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **10 - 12**
TYPE: **Post Triaxial**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**96.3**
#20	0.850	**93.8**
#40	0.425	**86.1**
#60	0.250	**72.4**
#100	0.150	**61.2**
#200	0.075	**55.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**3.71**
Medium Sand	**10.23**
Fine Sand	**30.17**
Silt or Clay Fines	**55.89**



USCS Description (ASTM D 2487):

Fat clay, olive yellow, dry

LL	PL	PI	SpG
82	**22**	**60**	**2.75**

As-Received Moisture Content (%): **27.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	BC
DATE	5-Jun-2019
REVIEW	MB

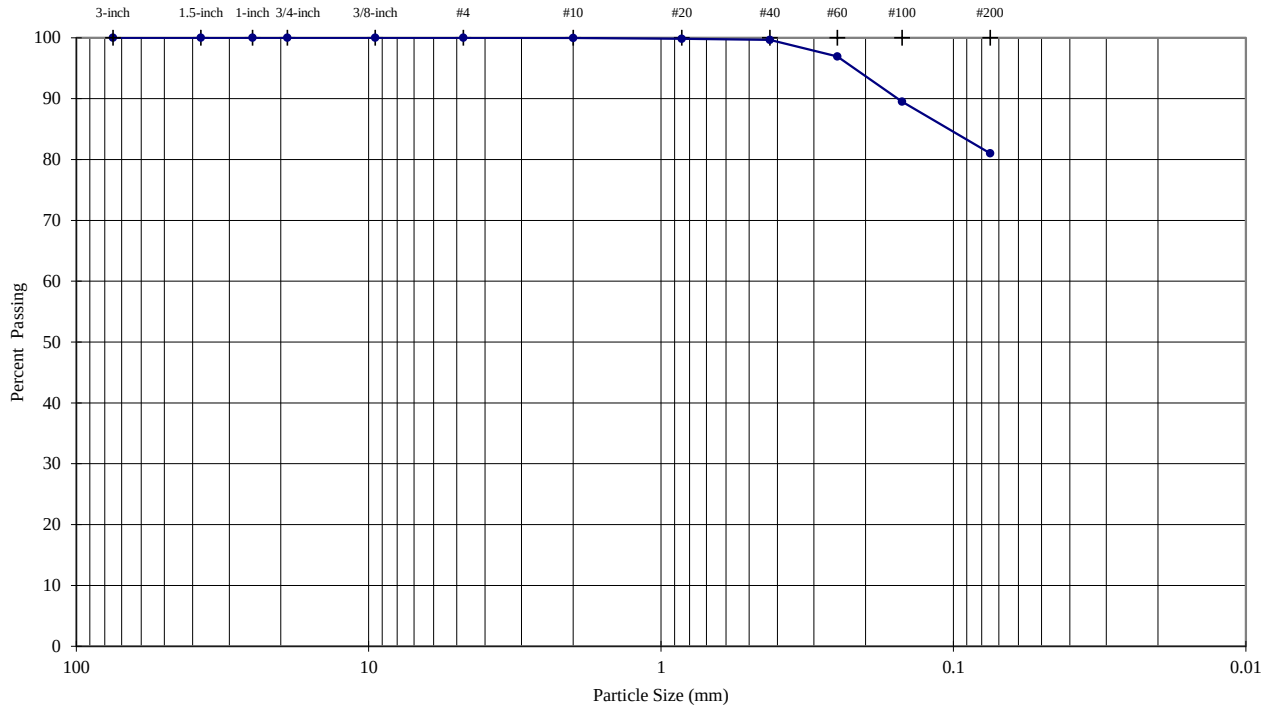
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

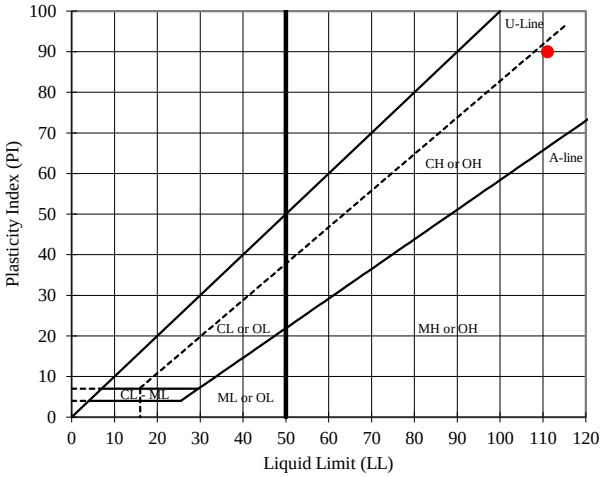
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **22 - 23.5**
TYPE: **Bag**



Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.7**
#60	0.250	**96.9**
#100	0.150	**89.5**
#200	0.075	**81.0**

Sieve Analysis (Initial Separation on No. 4 Sieve)

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.05**
Medium Sand	**0.28**
Fine Sand	**18.65**
Silt or Clay Fines	**81.02**



USCS Description (ASTM D 2487):

Fat clay with sand, light gray, moist

LL	PL	PI
111	**21**	**90**

As-Received Moisture Content (%): **35.5**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	29-May-2019
REVIEW	MB

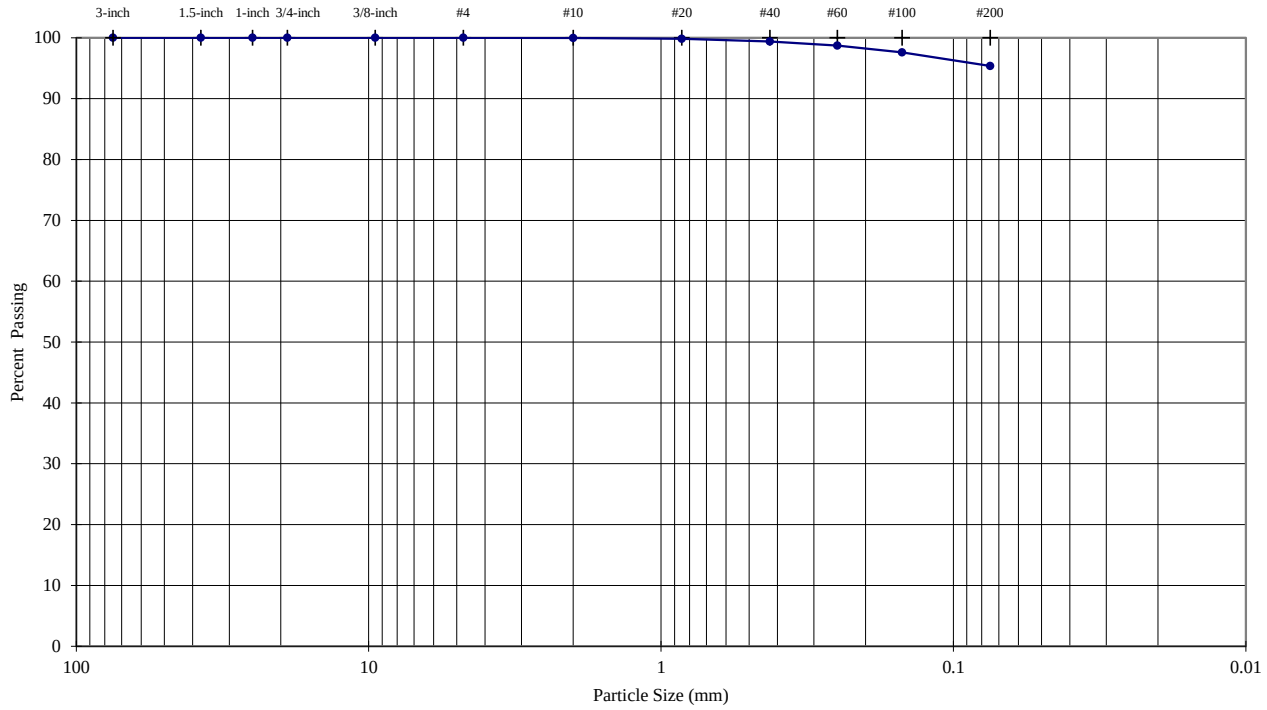
GOLDER

April-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

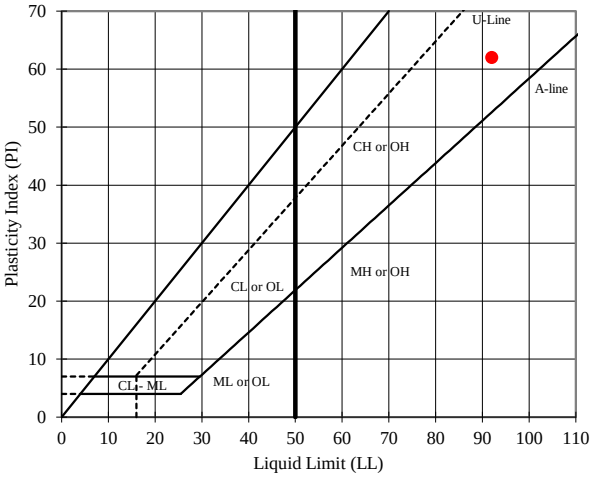
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **25 - 26.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.8**
#40	0.425	**99.4**
#60	0.250	**98.7**
#100	0.150	**97.6**
#200	0.075	**95.4**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.04**
Medium Sand	**0.58**
Fine Sand	**4.01**
Silt or Clay Fines	**95.37**



USCS Description (ASTM D 2487):

Fat clay, bluish gray, moist

LL	PL	PI
92	**30**	**62**

As-Received Moisture Content (%): **36.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	26-Apr-2019
REVIEW	MB

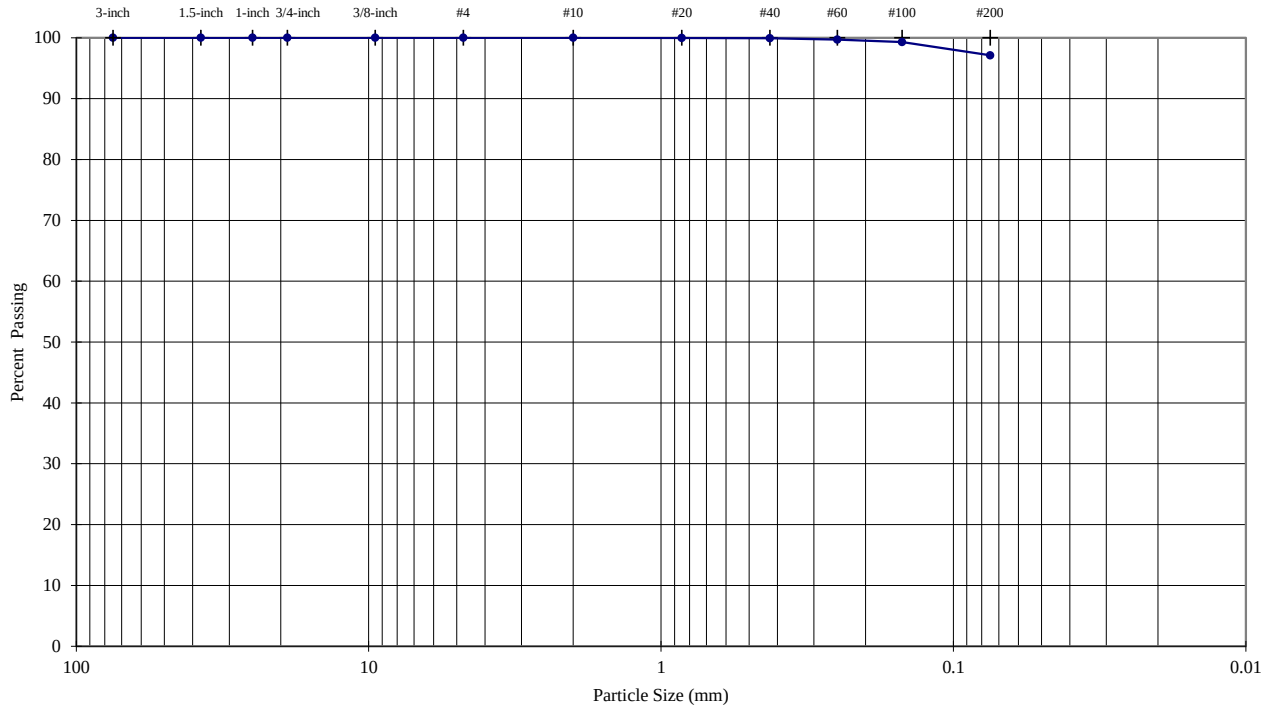
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

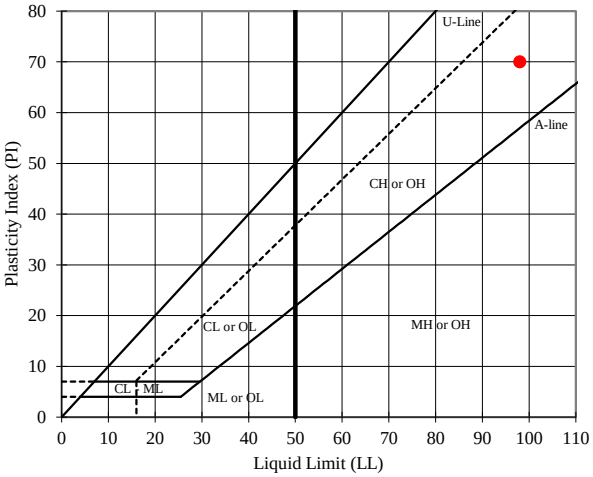
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **32 - 33.5**
TYPE: **Bag**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.7**
#100	0.150	**99.3**
#200	0.075	**97.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.08**
Fine Sand	**2.79**
Silt or Clay Fines	**97.13**



USCS Description (ASTM D 2487):

Fat clay, pale brown, moist

LL	PL	PI
98	**28**	**70**

As-Received Moisture Content (%): **40.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	29-May-2019
REVIEW	MB

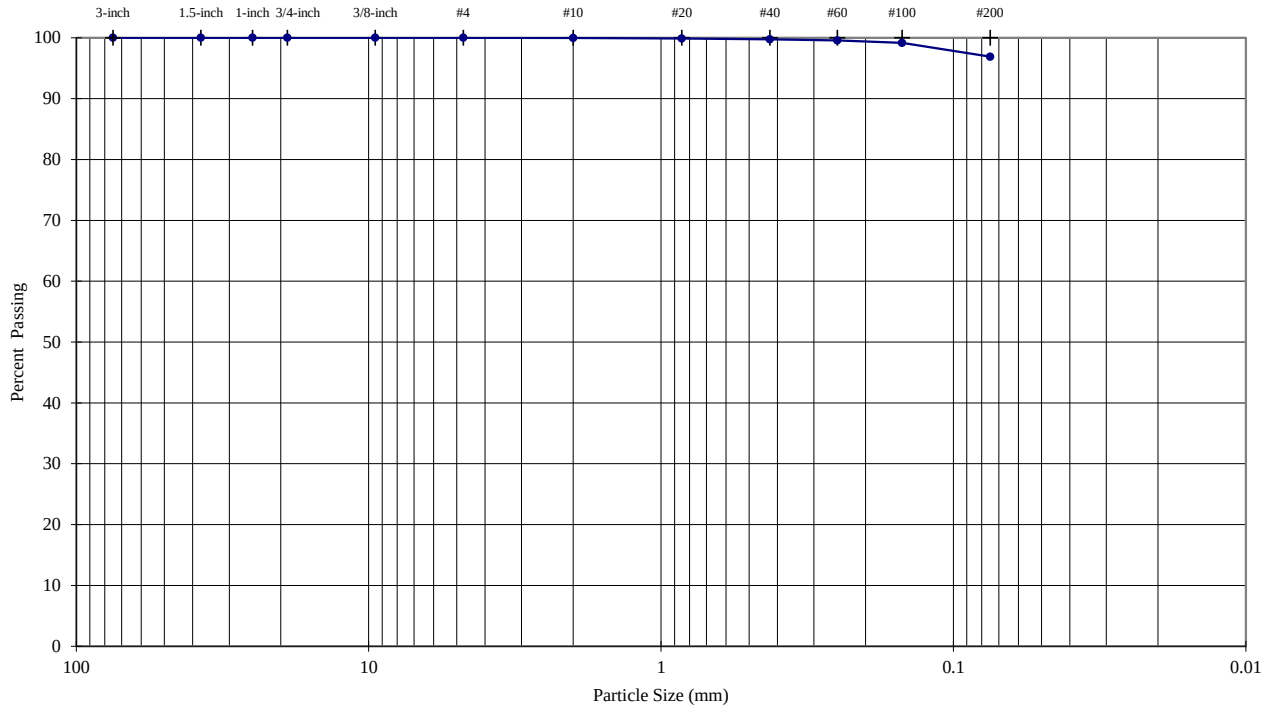
GOLDER

April-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

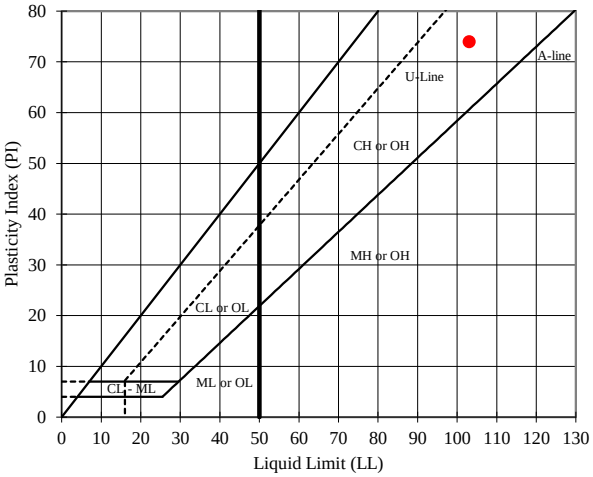
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **35 - 36.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**99.9**
#40	0.425	**99.7**
#60	0.250	**99.6**
#100	0.150	**99.2**
#200	0.075	**96.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.02**
Medium Sand	**0.24**
Fine Sand	**2.84**
Silt or Clay Fines	**96.91**



USCS Description (ASTM D 2487):

Fat clay, bluish gray, moist

LL	PL	PI
103	**29**	**74**

As-Received Moisture Content (%): **39.8**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	26-Apr-2019
REVIEW	MB

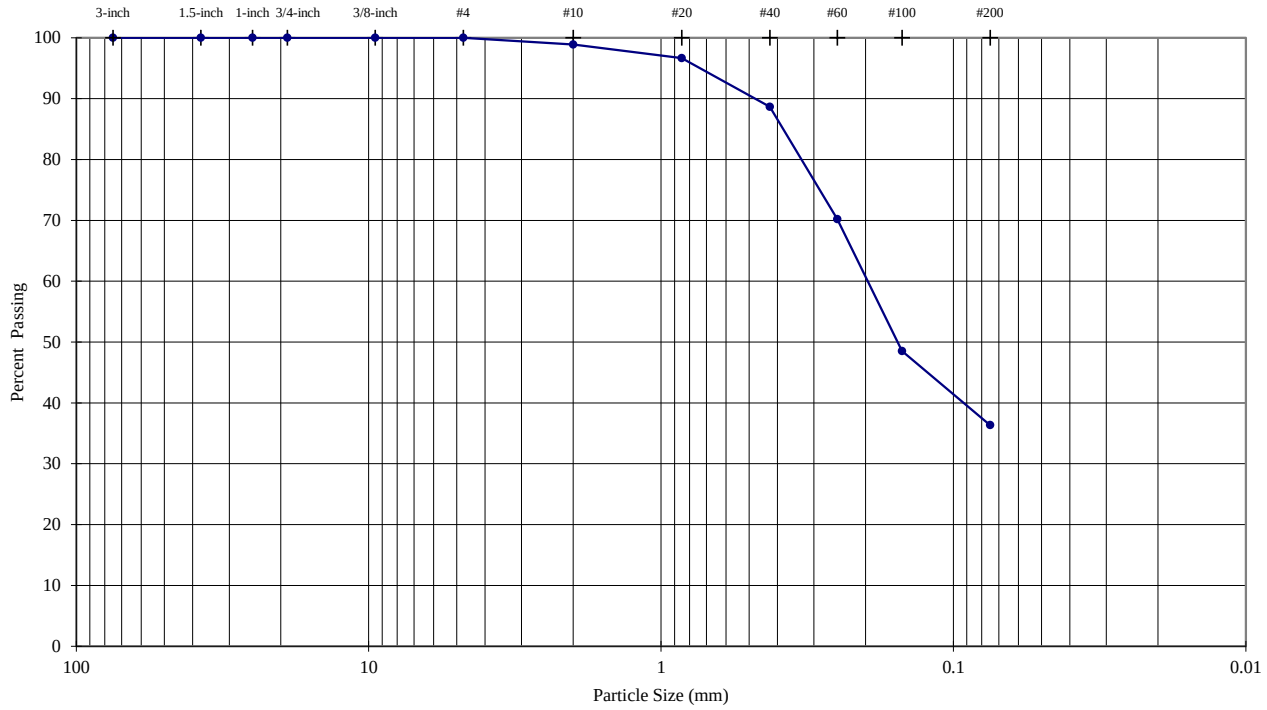
GOLDER

April-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

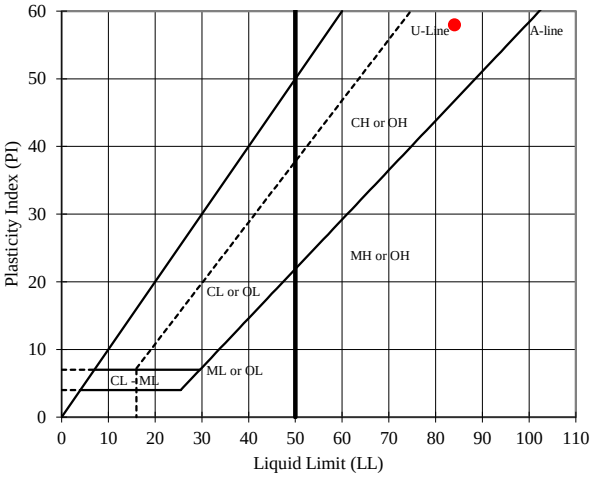
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **40 - 41.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**98.9**
#20	0.850	**96.7**
#40	0.425	**88.6**
#60	0.250	**70.2**
#100	0.150	**48.5**
#200	0.075	**36.3**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**1.08**
Medium Sand	**10.27**
Fine Sand	**52.30**
Silt or Clay Fines	**36.35**



USCS Description (ASTM D 2487):

Clayey sand, pale brown, moist

LL	PL	PI
84	**26**	**58**

As-Received Moisture Content (%): **28.0**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	26-Apr-2019
REVIEW	MB

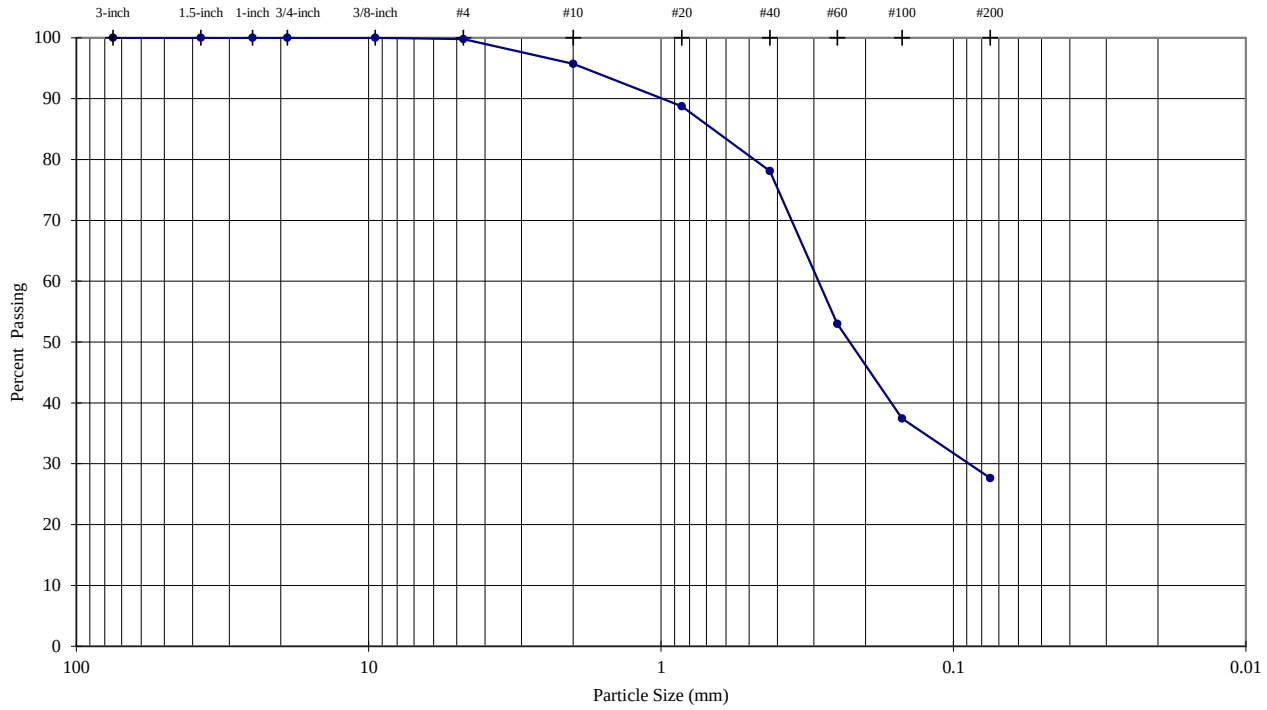
GOLDER

April-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

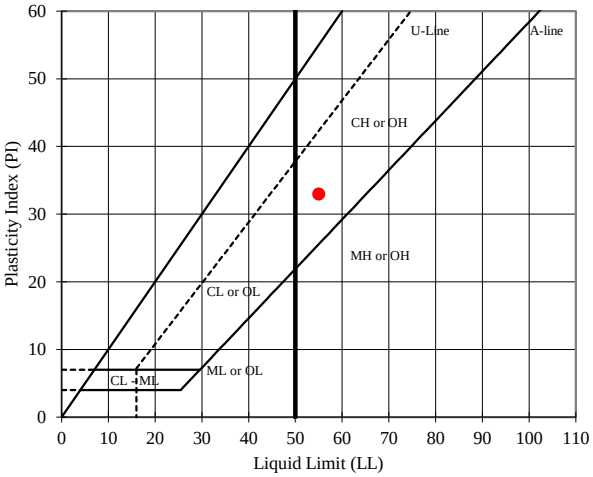
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **45 - 46.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**99.8**
#10	2.0	**95.7**
#20	0.850	**88.7**
#40	0.425	**78.1**
#60	0.250	**53.0**
#100	0.150	**37.4**
#200	0.075	**27.7**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.19**
Coarse Sand	**4.10**
Medium Sand	**17.58**
Fine Sand	**50.47**
Silt or Clay Fines	**27.67**



USCS Description (ASTM D 2487):

Clayey sand, light yellowish brown, moist

LL	PL	PI
55	**22**	**33**

As-Received Moisture Content (%): **17.8**

USCS Group Symbol: SC

Notes: 0 g of particles up to 9.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	26-Apr-2019
REVIEW	MB

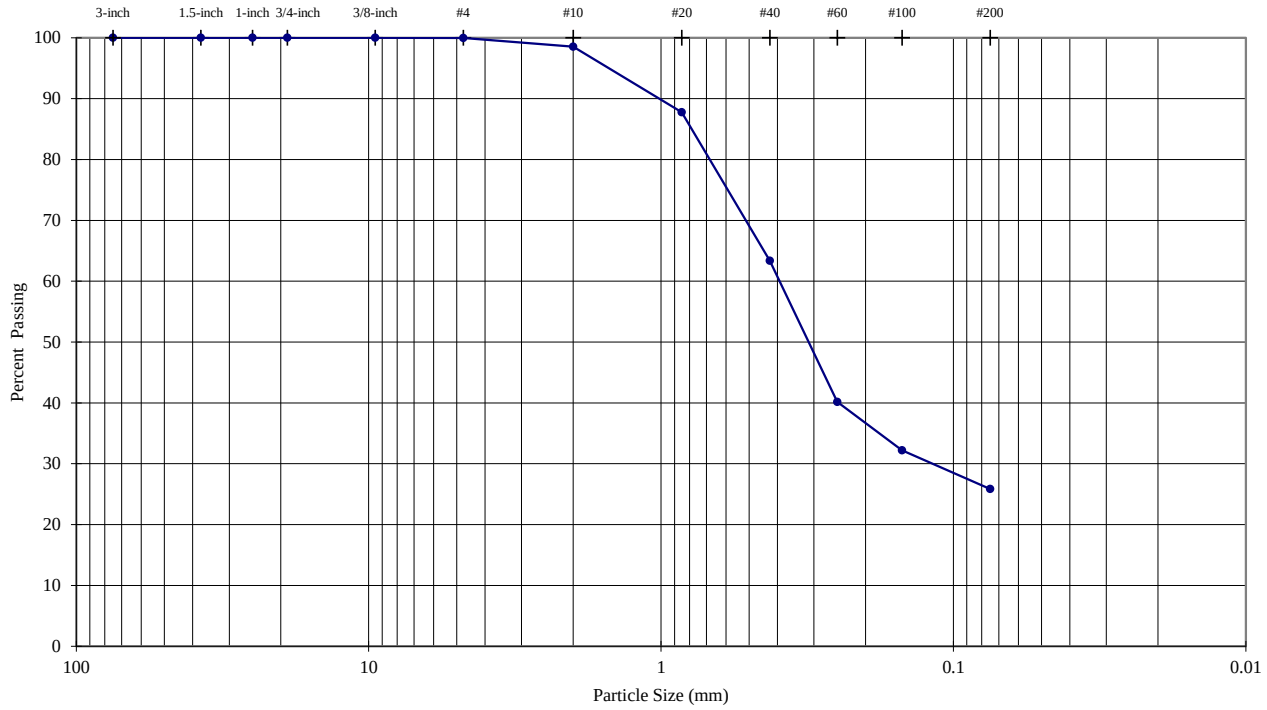
GOLDER

April-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

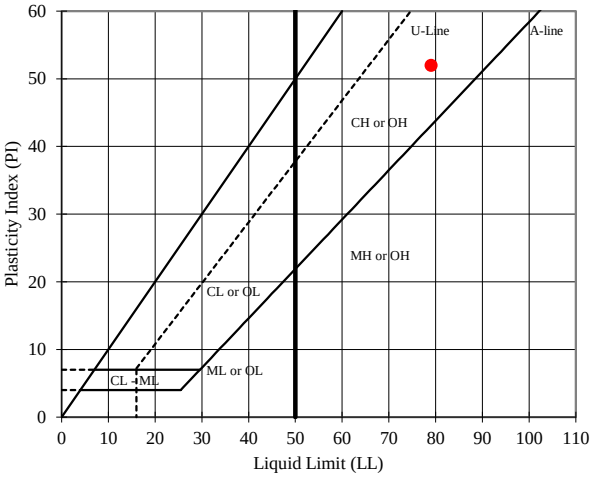
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **50 - 51.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**98.5**
#20	0.850	**87.8**
#40	0.425	**63.4**
#60	0.250	**40.2**
#100	0.150	**32.2**
#200	0.075	**25.9**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.05**
Coarse Sand	**1.40**
Medium Sand	**35.19**
Fine Sand	**37.50**
Silt or Clay Fines	**25.86**



USCS Description (ASTM D 2487):

Clayey sand, light yellowish brown, moist

LL	PL	PI
79	**27**	**52**

As-Received Moisture Content (%): **22.5**

USCS Group Symbol: SC

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	26-Apr-2019
REVIEW	MB

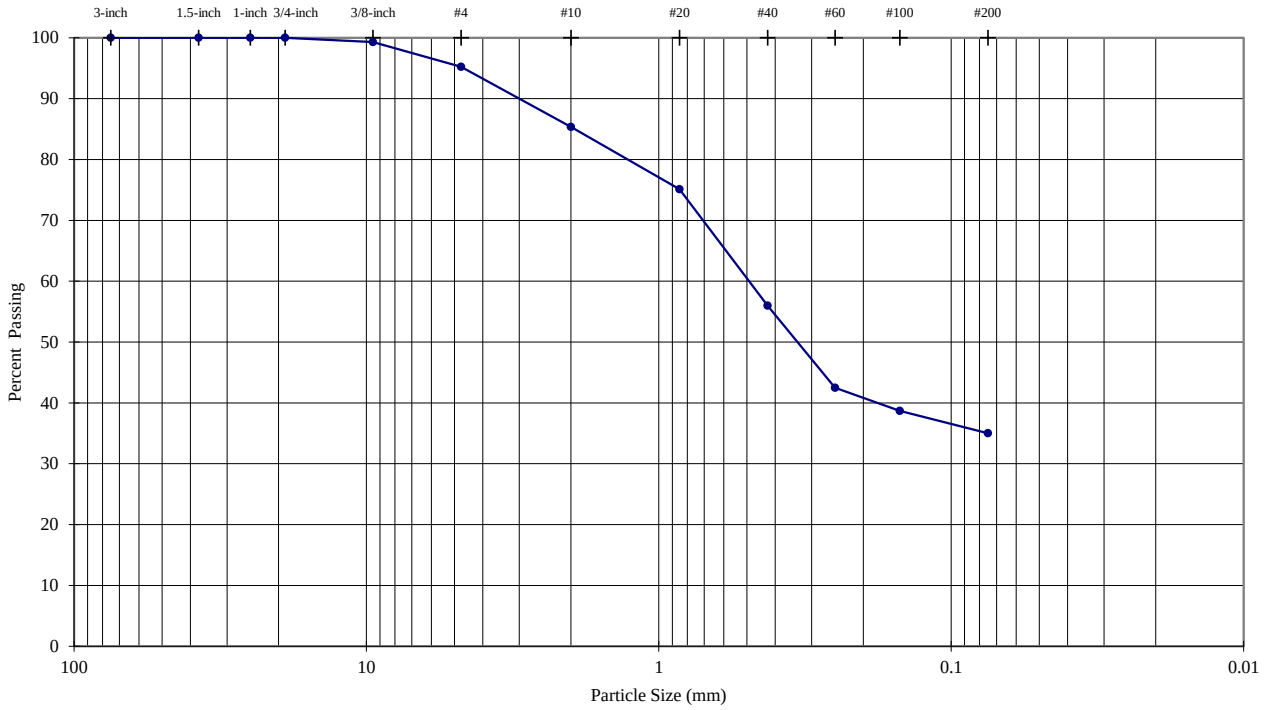
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

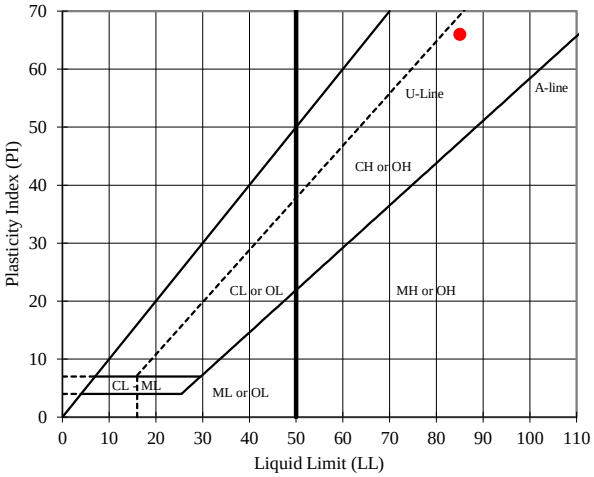
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **60 - 61.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**99.3**
#4	4.75	**95.2**
#10	2.0	**85.4**
#20	0.850	**75.1**
#40	0.425	**56.0**
#60	0.250	**42.5**
#100	0.150	**38.7**
#200	0.075	**35.0**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**4.78**
Coarse Sand	**9.87**
Medium Sand	**29.35**
Fine Sand	**20.99**
Silt or Clay Fines	**35.02**



USCS Description (ASTM D 2487):

Clayey sand, light olive gray, moist

LL	PL	PI
85	**19**	**66**

As-Received Moisture Content (%): **21.0**

USCS Group Symbol: SC

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH
DATE	29-Apr-2019
REVIEW	MB

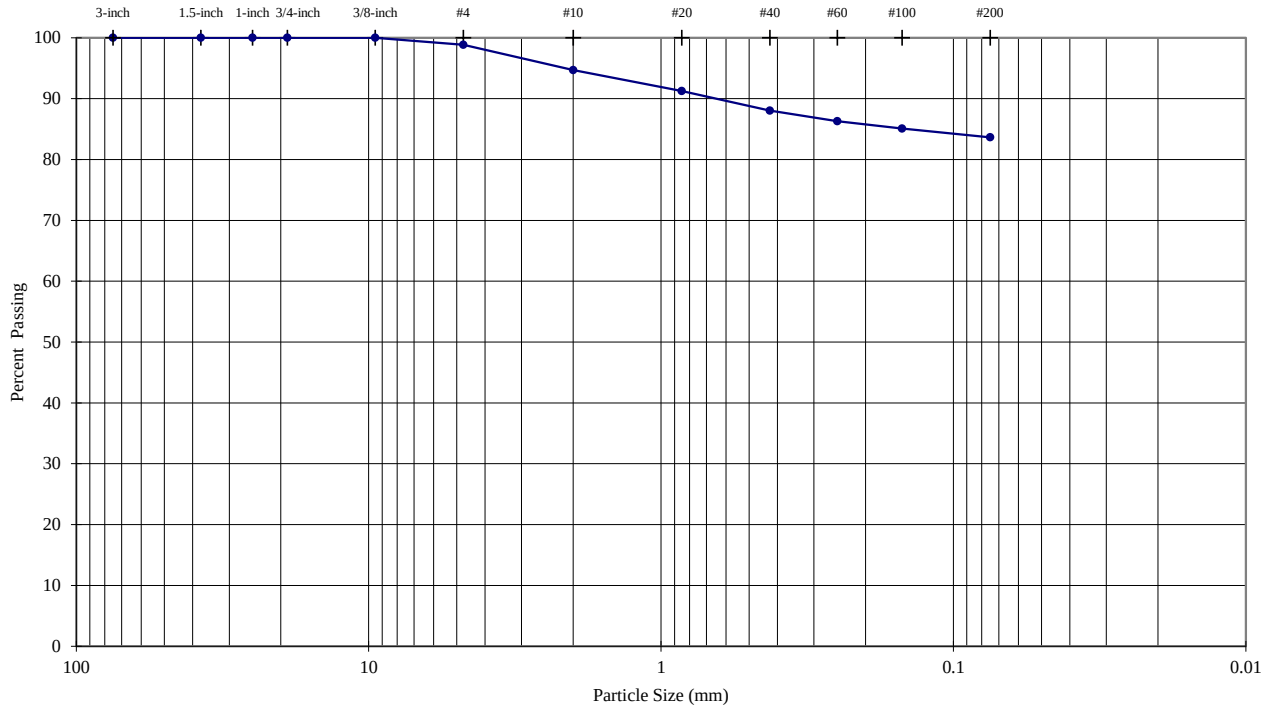
GOLDER

May-19 **1663241.22000**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

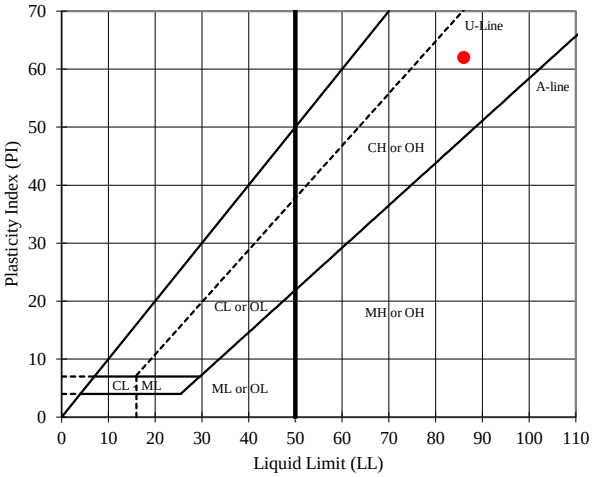
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **70 - 71.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**98.9**
#10	2.0	**94.7**
#20	0.850	**91.3**
#40	0.425	**88.1**
#60	0.250	**86.3**
#100	0.150	**85.1**
#200	0.075	**83.6**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**1.13**
Coarse Sand	**4.16**
Medium Sand	**6.65**
Fine Sand	**4.41**
Silt or Clay Fines	**83.64**



USCS Description (ASTM D 2487):

Fat clay with sand, brownish yellow, moist

LL	PL	PI
86	**24**	**62**

As-Received Moisture Content (%): **30.7**

USCS Group Symbol: CH

Notes: 0 g of particles up to 9.5 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	KWG
DATE	15-May-2019
REVIEW	PRH

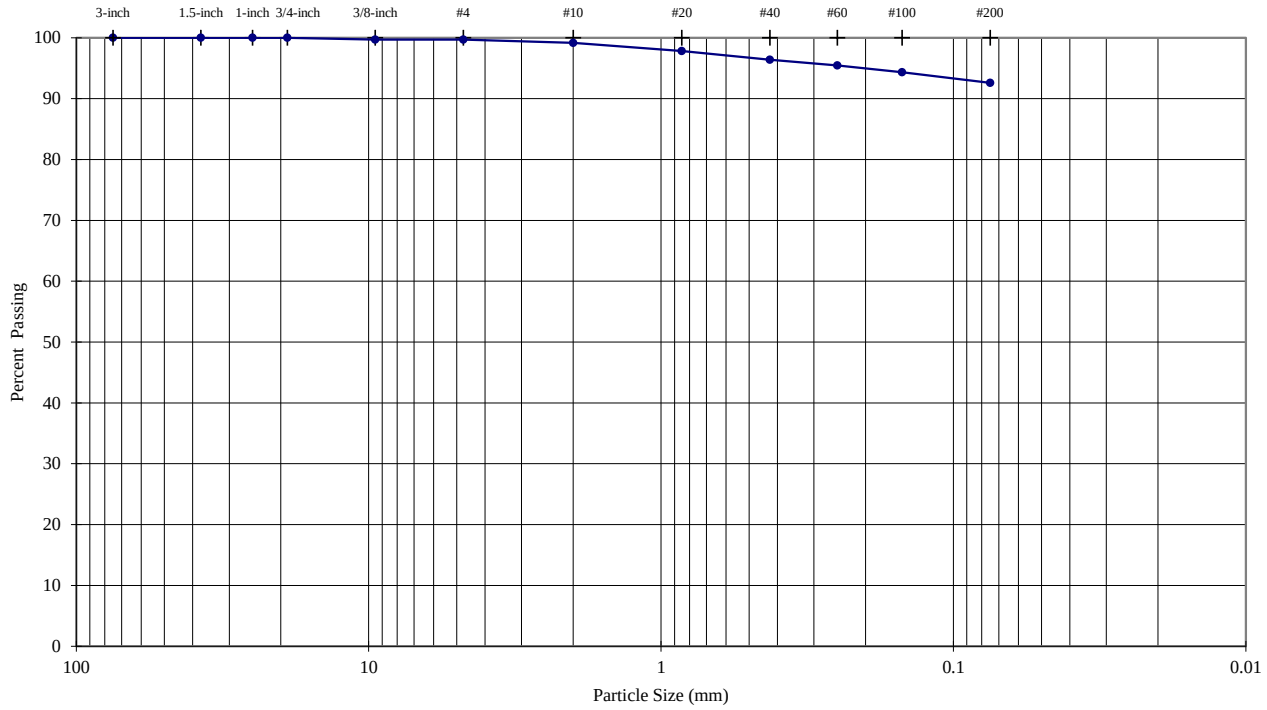
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

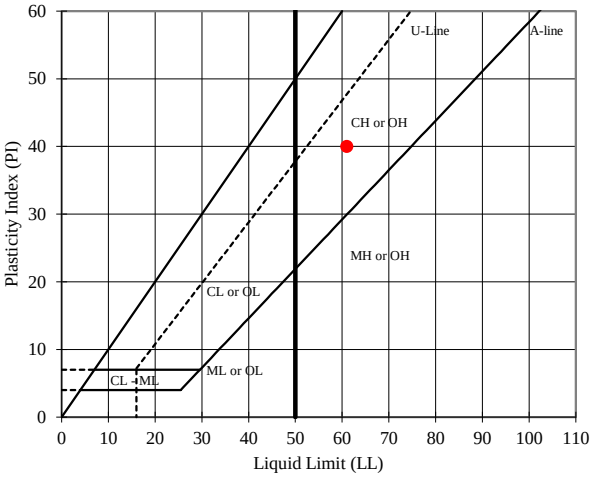
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **80 - 81.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**99.7**
#4	4.75	**99.7**
#10	2.0	**99.2**
#20	0.850	**97.8**
#40	0.425	**96.4**
#60	0.250	**95.4**
#100	0.150	**94.3**
#200	0.075	**92.6**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.28**
Coarse Sand	**0.53**
Medium Sand	**2.79**
Fine Sand	**3.80**
Silt or Clay Fines	**92.60**



USCS Description (ASTM D 2487):

Lean clay, dark gray, moist

LL	PL	PI
61	**21**	**40**

As-Received Moisture Content (%): **24.9**

USCS Group Symbol: CL

Notes: 0 g of particles up to 19.0 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH
DATE	30-Apr-2019
REVIEW	MB

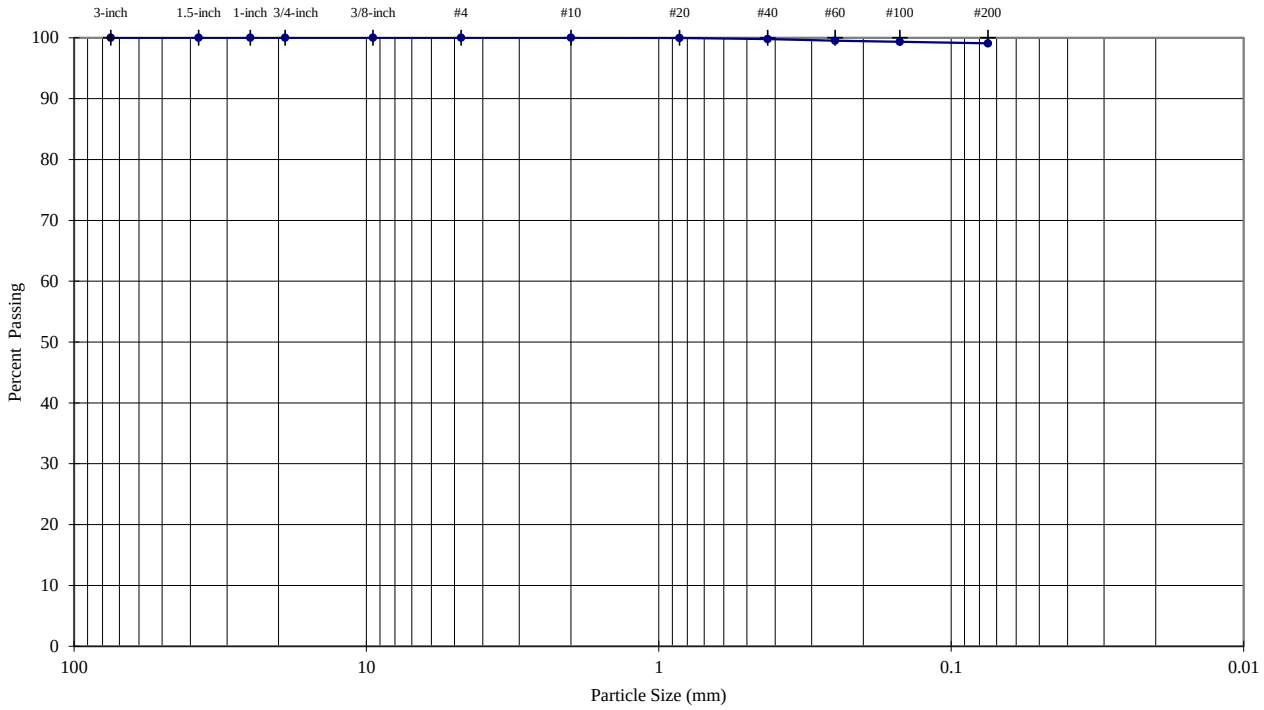
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

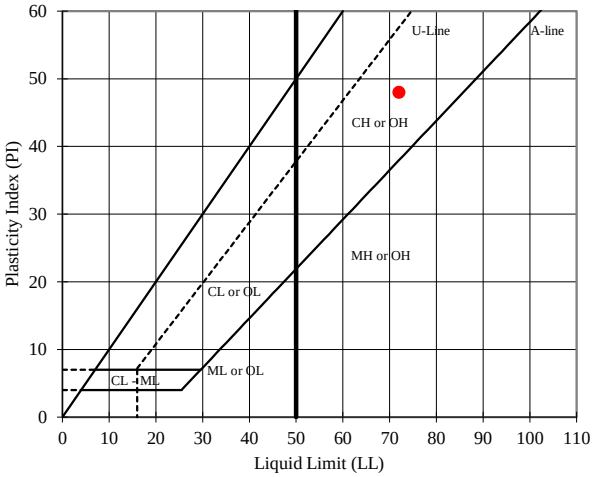
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **90 - 91.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.8**
#60	0.250	**99.5**
#100	0.150	**99.4**
#200	0.075	**99.1**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.00**
Medium Sand	**0.22**
Fine Sand	**0.68**
Silt or Clay Fines	**99.10**



USCS Description (ASTM D 2487):

Fat clay, very dark gray, moist

LL	PL	PI
72	**24**	**48**

As-Received Moisture Content (%): **26.3**

USCS Group Symbol: CH

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH
DATE	29-Apr-2019
REVIEW	MB

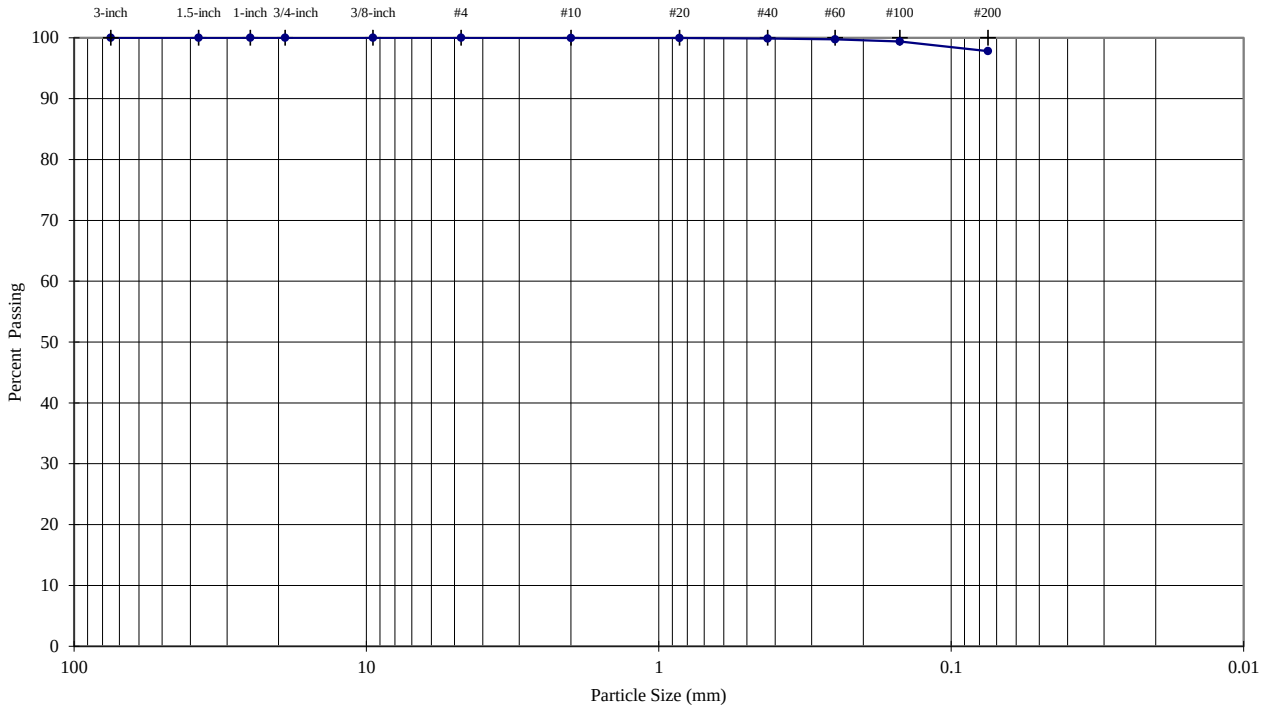
GOLDER

May-19 1663241.22000

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

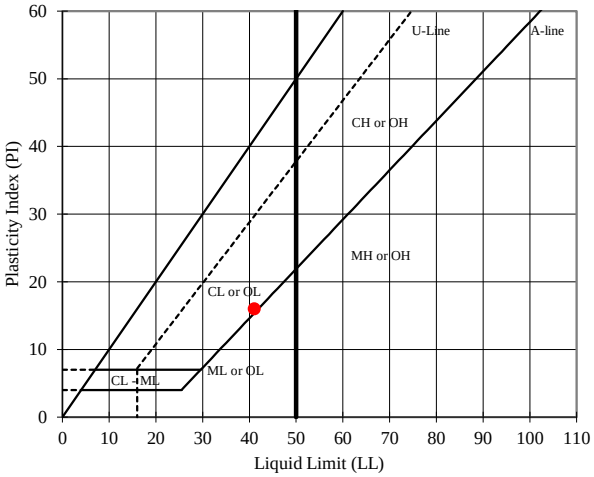
PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **BH19-TP-44** DEPTH (ft): **110.0 - 111.5**
TYPE: **Tube**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing
3-inch	75.0	**100.0**
1.5-inch	37.5	**100.0**
1-inch	25.0	**100.0**
3/4-inch	19.0	**100.0**
3/8-inch	9.5	**100.0**
#4	4.75	**100.0**
#10	2.0	**100.0**
#20	0.850	**100.0**
#40	0.425	**99.9**
#60	0.250	**99.8**
#100	0.150	**99.4**
#200	0.075	**97.8**

Description	Percentage
Coarse Gravel	**0.00**
Fine Gravel	**0.00**
Coarse Sand	**0.01**
Medium Sand	**0.09**
Fine Sand	**2.08**
Silt or Clay Fines	**97.81**



USCS Description (ASTM D 2487):

Lean clay, gray, moist

LL	PL	PI
41	**25**	**16**

As-Received Moisture Content (%): **17.9**

USCS Group Symbol: CL

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample was not mechanically dispersed; hydrometer test was not performed
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

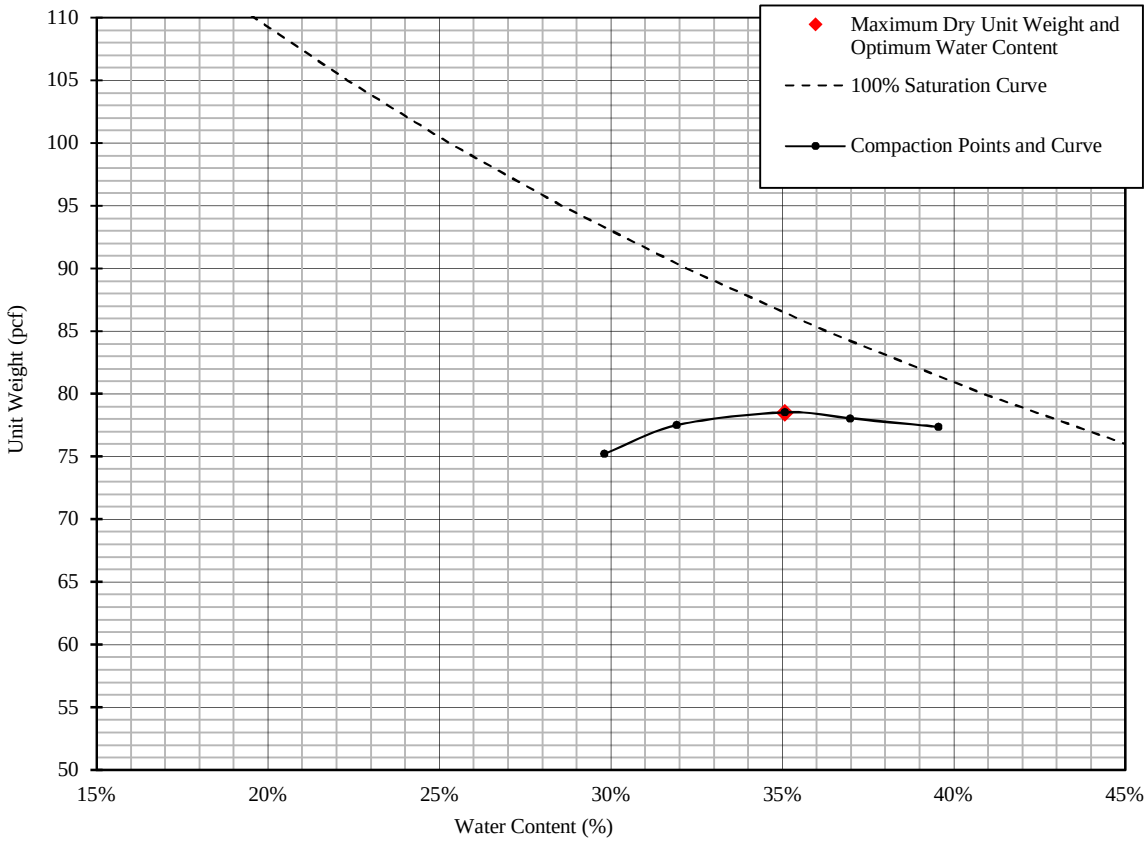
TECH	EH
DATE	29-Apr-2019
REVIEW	MB

March-18 1663241.11000

LABORATORY COMPACTION CHARACTERISTICS OF SOIL
ASTM D698 - Method A

Manual Rammer	Moist Preparation

PROJECT NAME: **MDA/Grassy Mtn PFS/OR**
SAMPLE ID: **TP-9** DEPTH (ft): **2-15**
TYPE: **Pail**



% Test Fraction Passing #4 Sieve	**100%**
As-Received Moisture Content	**NA**
Specific Gravity (estimated)	**2.70**

Maximum Dry Unit Weight (pcf)	**78.5**
Optimum Water Content (%)	**35.1**

USCS Description (ASTM D 2487): Clay, pale olive, moist

USCS 0

TECH	JP
DATE	27-Mar-2018
REVIEW	MB

FLOW PUMP #1

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MEDIA USING A FLEXIBLE WALL PERMEAMETER
ASTM D5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	MDA/Grassy Mtn PFS/OR	BOARD #	7	COMMENTS	1. Specific gravity tested per ASTM D854.
PROJECT NUMBER	1663241.11	CELL #	CC		
SAMPLE ID	BH-6 / S-2 @ 10 - 11.5 ft.	Flow Pump Speed	12		
SAMPLE TYPE	Intact	Technician	BC		

Sample Data

	Initial	Final
Specific Gravity	2.74	
Height, cm	9.011	8.893
Diameter, cm	6.106	6.126
Area, m^2	0.002929	0.002947
Volume, m^3	0.0002639	0.0002621
Mass, g	419.59	421.42
Moisture Content	46.5%	53.0%
Dry Unit Weight, kN/m^3	10.65	10.31
Dry Unit Weight, lbf/ft^3	67.8	65.6
Saturation, %	83.5%	90.4%

Permeant	Water
Back Pressure, kPa	410
Effective Consolidation Stress, kPa	410
Length During Permeation, cm	8.893
Area During Permeation, m^2	0.002947

USCS Description (ASTM D 2487):
Fat clay, olive gray, moist

DATE/TIME		TEMP (°C)	Δh (cm)	Flow (m^3)	Gradient	Uncorrected Hydraulic Conductivity (cm/s)
24-Apr-18	11:25	20.7	101	--	--	--
24-Apr-18	12:05	20.7	98	1.3E-08	11.19	1.67E-08
24-Apr-18	12:20	20.7	99	5.0E-09	11.08	1.68E-08
24-Apr-18	12:35	20.7	98	4.9E-09	11.08	1.68E-08
24-Apr-18	12:50	20.7	100	4.9E-09	11.13	1.68E-08

Average Corrected Hydraulic Conductivity (cm/s) 1.7E-08

DATE 4/30/2018
REVIEW MB

FLOW PUMP #1

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MEDIA USING A FLEXIBLE WALL PERMEAMETER

ASTM D5084

METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	MDA/Grassy Mtn PFS/OR	BOARD #	3	COMMENTS	1. Specific gravity is assumed.
PROJECT NUMBER	1663241.11000	CELL #	AA		2. Specimen was remolded to 90.2% of the Maximum Dry Density and +0.6% of optimum moisture content (per ASTM D698)
SAMPLE ID	TP-9 @ 2 - 15 ft	Flow Pump Speed	12		
SAMPLE TYPE	Remold	Technician	BC		

Sample Data

	Initial	Final
Specific Gravity	2.70	
Height, cm	9.283	8.921
Diameter, cm	7.317	7.192
Area, m^2	0.004205	0.004062
Volume, m^3	0.0003904	0.0003624
Mass, g	600.82	622.13
Moisture Content	35.7%	39.5%
Dry Unit Weight, kN/m^3	11.12	12.07
Dry Unit Weight, lbf/ft^3	70.8	76.9
Saturation, %	69.8%	89.3%

Permeant	Water
Back Pressure, kPa	280
Effective Consolidation Stress, kPa	410
Length During Permeation, cm	8.921
Area During Permeation, m^2	0.004062

USCS Description (ASTM D 2487):

Fat clay, pale olive, moist

DATE/TIME		TEMP (°C)	Δh (cm)	Flow (m^3)	Gradient	Uncorrected Hydraulic Conductivity (cm/s)
26-Apr-18	11:15	20.7	180	--	--	--
26-Apr-18	11:30	20.7	179	4.2E-09	20.12	5.72E-09
26-Apr-18	11:45	20.7	181	4.2E-09	20.18	5.70E-09
26-Apr-18	12:00	20.7	181	4.2E-09	20.29	5.67E-09
26-Apr-18	12:15	20.7	181	4.2E-09	20.29	5.67E-09

Average Corrected Hydraulic Conductivity (cm/s)	5.6E-09

DATE	4/27/2018
REVIEW	MB

GOLDER

FLOW PUMP #1

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MEDIA USING A FLEXIBLE WALL PERMEAMETER

ASTM D5084

METHOD D, CONSTANT RATE OF FLOW

PROJECT NAME	MDA/Grassy Mtn PFS/OR	BOARD #	7	COMMENTS	1. Specific gravity is assumed.
PROJECT NUMBER	1663241.22000	CELL #	No. 5		
SAMPLE ID	BH19-TP-01 @ 45 - 46.5 ft	Flow Pump Speed	10		
SAMPLE TYPE	Intact	Technician	BC		

Sample Data

	Initial	Final
Specific Gravity	2.80	
Height, cm	9.555	9.696
Diameter, cm	6.161	6.253
Area, m^2	0.002982	0.003071
Volume, m^3	0.0002849	0.0002977
Mass, g	534.04	550.91
Moisture Content	32.7%	34.7%
Dry Unit Weight, kN/m^3	13.86	13.48
Dry Unit Weight, lbf/ft^3	88.2	85.8
Saturation, %	93.2%	93.6%

Permeant	Water
Back Pressure, kPa	340
Effective Consolidation Stress, kPa	34
Length During Permeation, cm	9.696
Area During Permeation, m^2	0.003071

USCS Description (ASTM D 2487):

Fat clay with sand, gray, moist

DATE/TIME		TEMP (^oC)	Δh (cm)	Flow (m^3)	Gradient	Uncorrected Hydraulic Conductivity (cm/s)
1-Jun-19	11:30	20.7	155	--	--	--
1-Jun-19	11:45	20.7	153	2.5E-08	15.88	5.74E-08
1-Jun-19	12:00	20.7	153	2.5E-08	15.78	5.78E-08
1-Jun-19	12:15	20.7	154	2.5E-08	15.83	5.76E-08
1-Jun-19	12:30	20.7	153	2.5E-08	15.83	5.76E-08

Average Corrected Hydraulic Conductivity (cm/s): 5.7E-08

DATE: 31-May-2019

REVIEW: MB

GOLDER

FLOW PUMP #2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MEDIA USING A FLEXIBLE WALL PERMEAMETER

ASTM D5084

METHOD D, CONSTANT RATE OF FLOW

PROJECT NAME	MDA/Grassy Mtn PFS/OR	BOARD #	3	COMMENTS	1. Specific gravity is assumed.
PROJECT NUMBER	1663241.22000	CELL #	AA		
SAMPLE ID	BH19-TP-39 @ 25 - 26.5 ft	Flow Pump Speed	11		
SAMPLE TYPE	Intact	Technician	BC		

Sample Data

	Initial	Final
Specific Gravity	2.70	
Height, cm	8.991	9.140
Diameter, cm	6.134	6.273
Area, m^2	0.002955	0.003090
Volume, m^3	0.0002657	0.0002824
Mass, g	469.24	500.21
Moisture Content	22.1%	39.8%
Dry Unit Weight, kN/m^3	14.18	12.43
Dry Unit Weight, lbf/ft^3	90.3	79.1
Saturation, %	68.9%	95.0%

Permeant	Water
Back Pressure, kPa	280
Effective Consolidation Stress, kPa	34
Length During Permeation, cm	9.140
Area During Permeation, m^2	0.003090

USCS Description (ASTM D 2487):

Fat clay, light greenish gray, moist

DATE/TIME		TEMP (^oC)	Δh (cm)	Flow (m^3)	Gradient	Uncorrected Hydraulic Conductivity (cm/s)
29-May-19	10:50	20.7	172	--	--	--
29-May-19	11:05	20.7	170	1.3E-08	18.71	2.42E-08
29-May-19	11:20	20.7	172	1.3E-08	18.71	2.42E-08
29-May-19	11:35	20.7	172	1.3E-08	18.82	2.41E-08
29-May-19	11:50	20.7	172	1.3E-08	18.82	2.41E-08

Average Corrected Hydraulic Conductivity (cm/s): 2.4E-08

DATE	31-May-2019
REVIEW	MB

GOLDER

FLOW PUMP #2

HYDRAULIC CONDUCTIVITY OF SATURATED POROUS MEDIA USING A FLEXIBLE WALL PERMEAMETER

ASTM D5084

METHOD D, CONSTANT RATE OF FLOW

PROJECT NAME	MDA/Grassy Mtn PFS/OR	BOARD #	4	COMMENTS	1. Specific gravity is assumed.
PROJECT NUMBER	1663241.22000	CELL #	AA		
SAMPLE ID	BH19-TP-39 @ 35 - 36.5 ft	Flow Pump Speed	10		
SAMPLE TYPE	Intact	Technician	BC		

Sample Data

	Initial	Final
Specific Gravity	2.80	
Height, cm	9.745	10.060
Diameter, cm	6.131	6.301
Area, m^2	0.002952	0.003119
Volume, m^3	0.0002877	0.0003137
Mass, g	497.45	530.91
Moisture Content	38.8%	46.3%
Dry Unit Weight, kN/m^3	12.22	11.35
Dry Unit Weight, lbf/ft^3	77.8	72.2
Saturation, %	87.1%	91.3%

Permeant	Water
Back Pressure, kPa	280
Effective Consolidation Stress, kPa	34
Length During Permeation, cm	10.060
Area During Permeation, m^2	0.003119

USCS Description (ASTM D 2487):

Fat clay, olive brown, moist

DATE/TIME		TEMP (^oC)	Δh (cm)	Flow (m^3)	Gradient	Uncorrected Hydraulic Conductivity (cm/s)
1-Jun-19	10:45	20.7	165	--	--	--
1-Jun-19	11:00	20.7	163	2.5E-08	16.30	5.51E-08
1-Jun-19	11:15	20.7	163	2.5E-08	16.20	5.54E-08
1-Jun-19	11:30	20.7	163	2.5E-08	16.20	5.54E-08
1-Jun-19	11:45	20.7	163	2.5E-08	16.20	5.54E-08

Average Corrected Hydraulic Conductivity (cm/s): 5.4E-08

DATE: 31-May-2019

REVIEW: MB

Boring or Test Pit:	BH-6		Boring or Test Pit:	BH-6		Boring or Test Pit:	BH-6	
Sample:	S-4		Sample:	S-4		Sample:	S-4	
Depth:	20-21.5	ft	Depth:	20-21.5	ft	Depth:	20-21.5	ft
Point No.:	1		Point No.:	2		Point No.:	3	
	Initial			**Initial**			**Initial**	
Length =	5.196	in	Length =	5.589	in	Length =	5.773	in
Diameter =	2.404	in	Diameter =	2.414	in	Diameter =	2.413	in
Wet Mass =	1.306	lb	Wet Mass =	1.423	lb	Wet Mass =	1.535	lb
Area =	4.539	in^2	Area =	4.577	in^2	Area =	4.573	in^2
Volume =	23.58	in^3	Volume =	25.58	in^3	Volume =	26.40	in^3
Specific Gravity =	2.52	(ASTM D854)	Specific Gravity =	2.52	(ASTM D854)	Specific Gravity =	2.52	(ASTM D854)
Dry Mass of Solids =	1.025	lb	Dry Mass of Solids =	1.079	lb	Dry Mass of Solids =	1.098	lb
Water Content =	27.5%		Water Content =	31.9%		Water Content =	39.8%	
Wet Unit Weight =	95.7	pcf	Wet Unit Weight =	96.1	pcf	Wet Unit Weight =	100.5	pcf
Dry Unit Weight =	75.1	pcf	Dry Unit Weight =	72.9	pcf	Dry Unit Weight =	71.9	pcf
Void Ratio =	1.09		Void Ratio =	1.15		Void Ratio =	1.19	
Percent Saturation =	63%		Percent Saturation =	70%		Percent Saturation =	85%	
	After Consolidation			**After Consolidation**			**After Consolidation**	
Length =	4.980	in	Length =	5.341	in	Length =	5.604	in
Diameter =	2.340	in	Diameter =	2.371	in	Diameter =	2.378	in
Area =	4.301	in^2 (Method B)	Area =	4.414	in^2 (Method B)	Area =	4.443	in^2 (Method B)
Volume =	21.42	in^3	Volume =	23.57	in^3	Volume =	24.90	in^3
Water Content =	35.7%		Water Content =	39.1%		Water Content =	42.1%	
Wet Unit Weight =	112.2	pcf	Wet Unit Weight =	110.0	pcf	Wet Unit Weight =	108.3	pcf
Dry Unit Weight =	82.7	pcf	Dry Unit Weight =	79.1	pcf	Dry Unit Weight =	76.2	pcf
Void Ratio =	0.90		Void Ratio =	0.99		Void Ratio =	1.06	
Percent Saturation =	100%		Percent Saturation =	100%		Percent Saturation =	100%	
B Parameter =	0.98		B Parameter =	0.96		B Parameter =	0.96	
Shear Rate =	0.083%	/min.	Shear Rate =	0.083%	/min.	Shear Rate =	0.083%	/min.
t_{50} =	0.1	min.	t_{50} =	0.2	min.	t_{50} =	2.3	min.
Strain at Failure =	9.4%		Strain at Failure =	13.7%		Strain at Failure =	15.3%	
Cell Pressure =	95	psi	Cell Pressure =	145	psi	Cell Pressure =	200	psi
Back Pressure =	60	psi	Back Pressure =	70	psi	Back Pressure =	50	psi
Confining Pressure =	35	psi	Confining Pressure =	75	psi	Confining Pressure =	150	psi

Notes: USCS description (ASTM D2487): Sandy fat clay, olive yellow, moist

Atterberg limits: LL = 74 PL = 22 PI = 52 (ASTM D4318)

Percent finer: 3/4 in. = 100% No. 4 = 100% No. 200 = 65% (ASTM D422, refer to separate report for gradation curve)

Initial water content specimen obtained from cuttings.

Specimen type:	X	Intact		Reconstituted	
Saturation method:	X	Wet		Dry	
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$	% strain
Membrane effect:	X	Corrected		Not Corrected	

Golder Associates Inc.

Title:

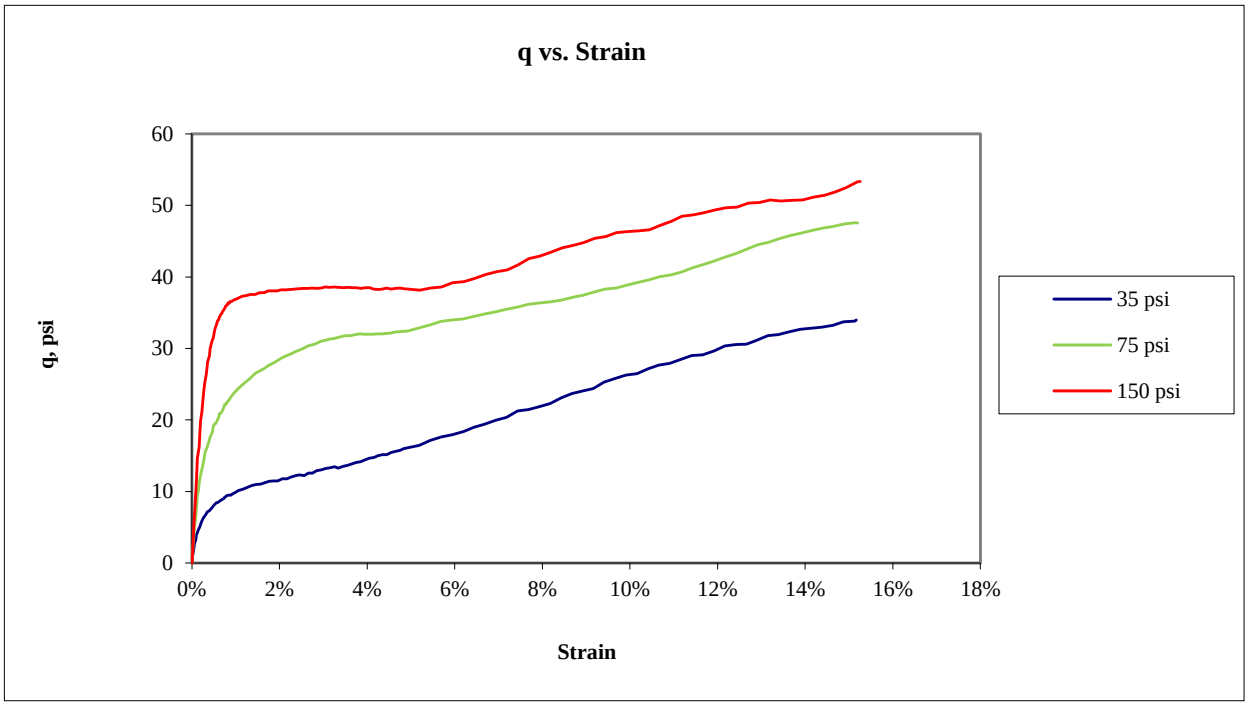
ASTM D4767

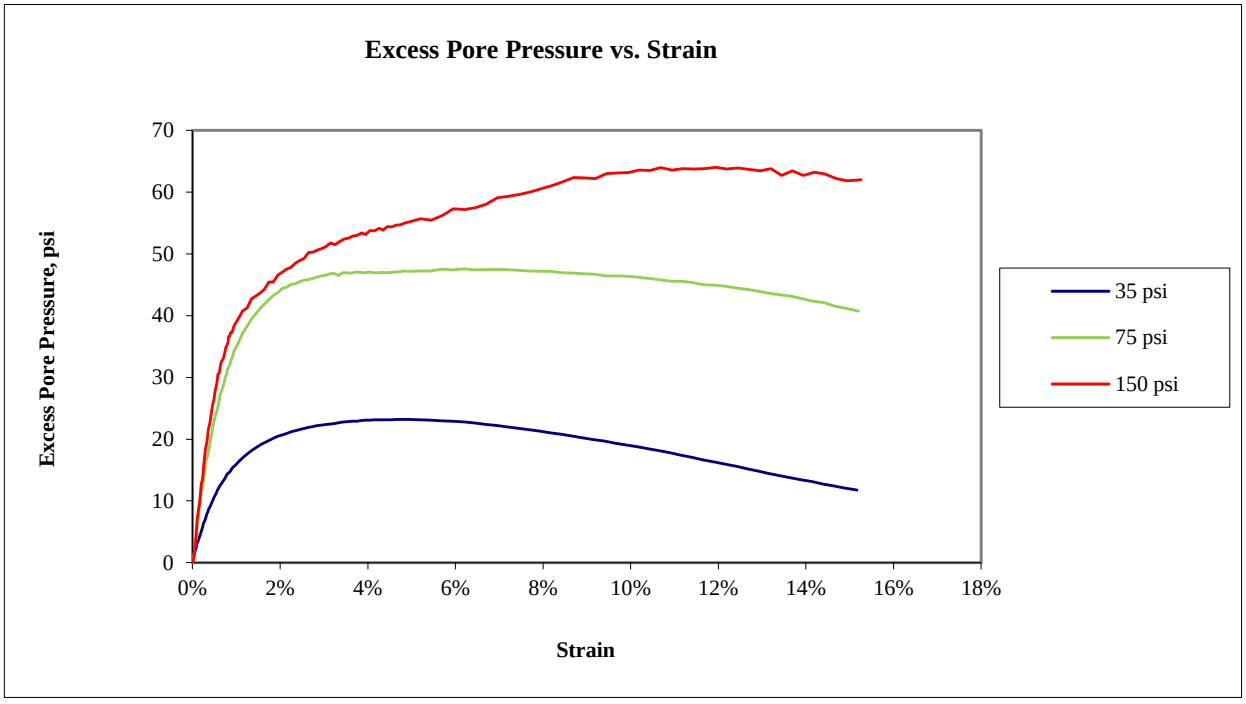
CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT

SAMPLE AND TEST DATA

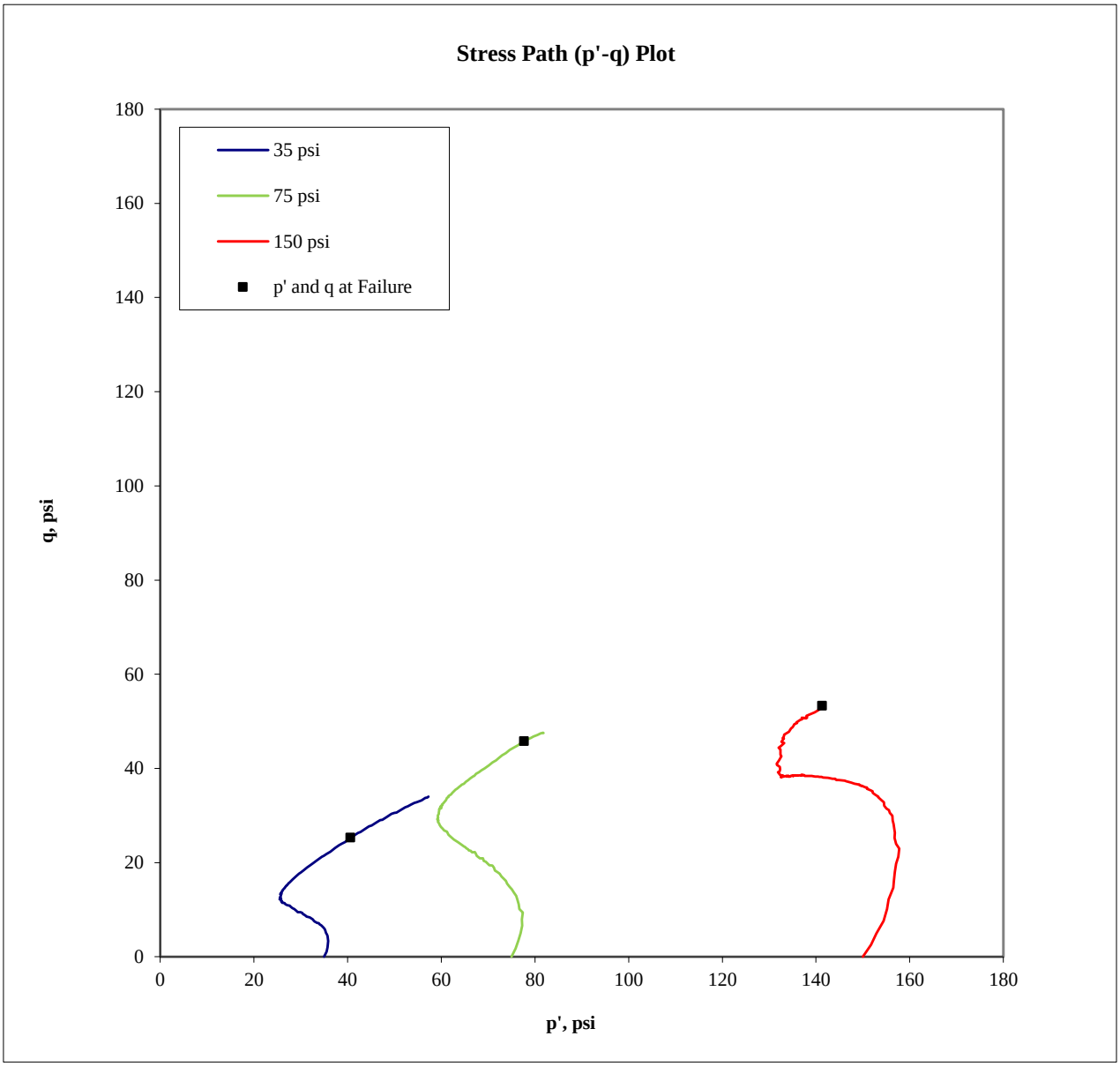
Job Short Title: MDA/Grassy Mtn PFS/OR

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
BH-6 / S4 @ 20 - 21.5 ft.	BC	RFS	1-May-2018	1663241.11000	1



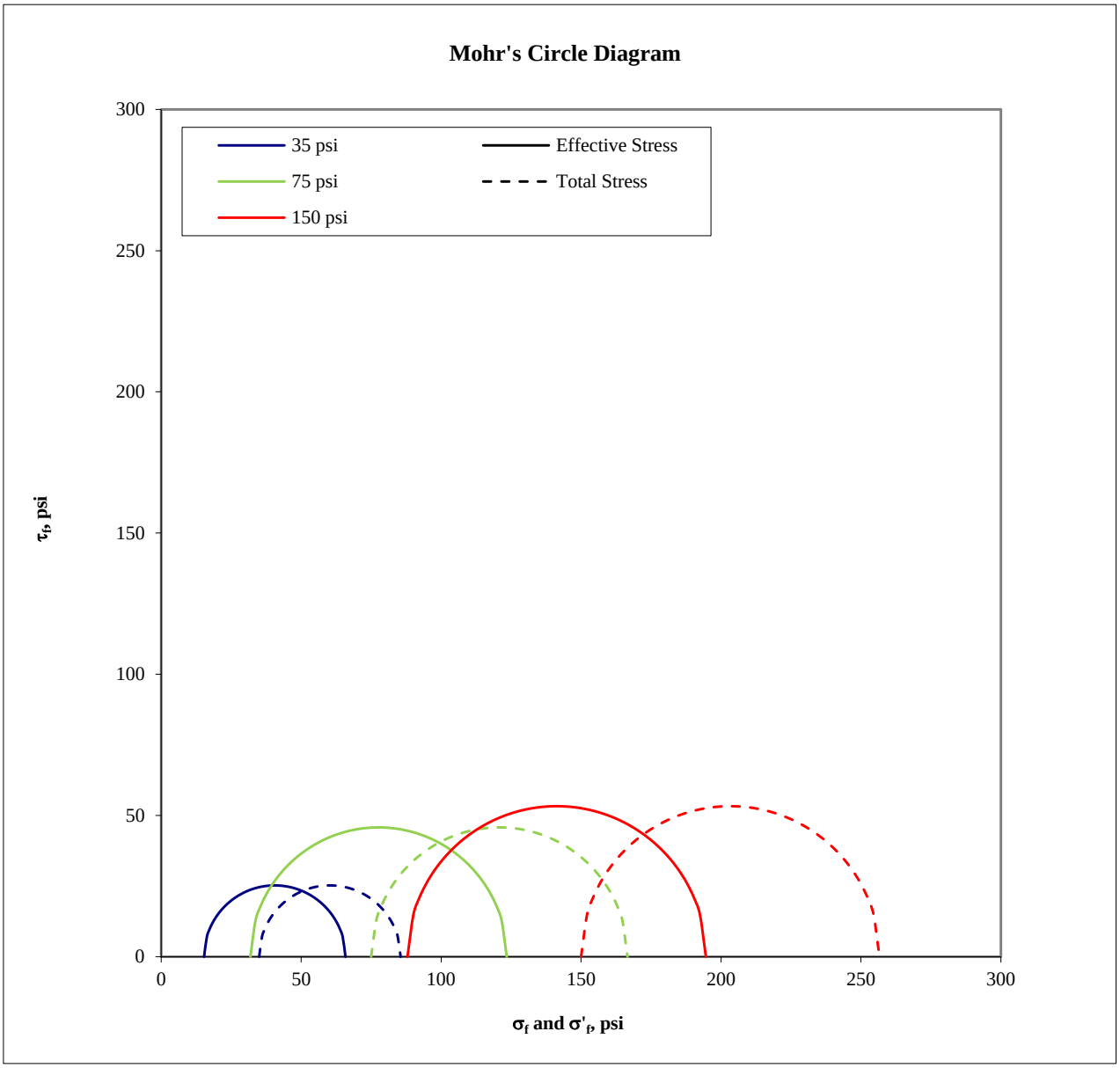


Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS					
Job Short Title: MDA/Grassy Mtn PFS/OR						
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 2	



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35	60.3	40.6	25.3
75	120.8	77.7	45.8
150	203.3	141.3	53.3

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 3



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35	65.8	15.3	85.5	35.0
75	123.5	31.9	166.6	75.0
150	194.6	88.0	256.6	150.0

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 4

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 35 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 5

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 75 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 6

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 150 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S4 @ 20 - 21.5 ft.	**Technician:** BC	**Reviewed:** RFS	**Date:** 1-May-2018	**Job Number:** 1663241.11000	**Figure:** 7

Boring or Test Pit:	BH-13		Boring or Test Pit:	BH-13		Boring or Test Pit:	BH-13	
Sample:	S6		Sample:	S6		Sample:	S6	
Depth:	30	ft	Depth:	30	ft	Depth:	30	ft
Point No.:	1		Point No.:	2		Point No.:	3	
	Initial			**Initial**			**Initial**	
Length =	5.661	in	Length =	5.628	in	Length =	5.663	in
Diameter =	2.407	in	Diameter =	2.414	in	Diameter =	2.411	in
Wet Mass =	1.701	lb	Wet Mass =	1.666	lb	Wet Mass =	1.597	lb
Area =	4.550	in^2	Area =	4.577	in^2	Area =	4.565	in^2
Volume =	25.76	in^3	Volume =	25.76	in^3	Volume =	25.85	in^3
Specific Gravity =	2.72	(ASTM D854)	Specific Gravity =	2.72	(ASTM D854)	Specific Gravity =	2.72	(ASTM D854)
Dry Mass of Solids =	1.278	lb	Dry Mass of Solids =	1.247	lb	Dry Mass of Solids =	1.202	lb
Water Content =	33.1%		Water Content =	33.6%		Water Content =	32.8%	
Wet Unit Weight =	114.1	pcf	Wet Unit Weight =	111.7	pcf	Wet Unit Weight =	106.7	pcf
Dry Unit Weight =	85.7	pcf	Dry Unit Weight =	83.6	pcf	Dry Unit Weight =	80.4	pcf
Void Ratio =	0.98		Void Ratio =	1.03		Void Ratio =	1.11	
Percent Saturation =	92%		Percent Saturation =	89%		Percent Saturation =	80%	
	After Consolidation			**After Consolidation**			**After Consolidation**	
Length =	5.709	in	Length =	5.521	in	Length =	5.359	in
Diameter =	2.444	in	Diameter =	2.438	in	Diameter =	2.374	in
Area =	4.691	in^2 (Method B)	Area =	4.669	in^2 (Method B)	Area =	4.428	in^2 (Method B)
Volume =	26.78	in^3	Volume =	25.78	in^3	Volume =	23.73	in^3
Water Content =	38.8%		Water Content =	37.8%		Water Content =	34.4%	
Wet Unit Weight =	114.5	pcf	Wet Unit Weight =	115.2	pcf	Wet Unit Weight =	117.7	pcf
Dry Unit Weight =	82.5	pcf	Dry Unit Weight =	83.6	pcf	Dry Unit Weight =	87.6	pcf
Void Ratio =	1.06		Void Ratio =	1.03		Void Ratio =	0.94	
Percent Saturation =	100%		Percent Saturation =	100%		Percent Saturation =	100%	
B Parameter =	0.95		B Parameter =	0.95		B Parameter =	0.95	
Shear Rate =	0.003%	/min.	Shear Rate =	0.019%	/min.	Shear Rate =	0.003%	/min.
t_{50} =	128.0	min.	t_{50} =	21.0	min.	t_{50} =	132.0	min.
Strain at Failure =	4.8%		Strain at Failure =	4.5%		Strain at Failure =	4.9%	
Cell Pressure =	85	psi	Cell Pressure =	145	psi	Cell Pressure =	230	psi
Back Pressure =	50	psi	Back Pressure =	70	psi	Back Pressure =	80	psi
Confining Pressure =	35	psi	Confining Pressure =	75	psi	Confining Pressure =	150	psi

Notes: Visual description: Fat clay, olive gray, moist

Atterberg limits: LL = -- PL = -- PI = -- (-- indicates test was not performed)

Percent finer: 3/4 in. = -- No. 4 = -- No. 200 = -- (-- indicates test was not performed)

Initial water content specimen obtained from cuttings.

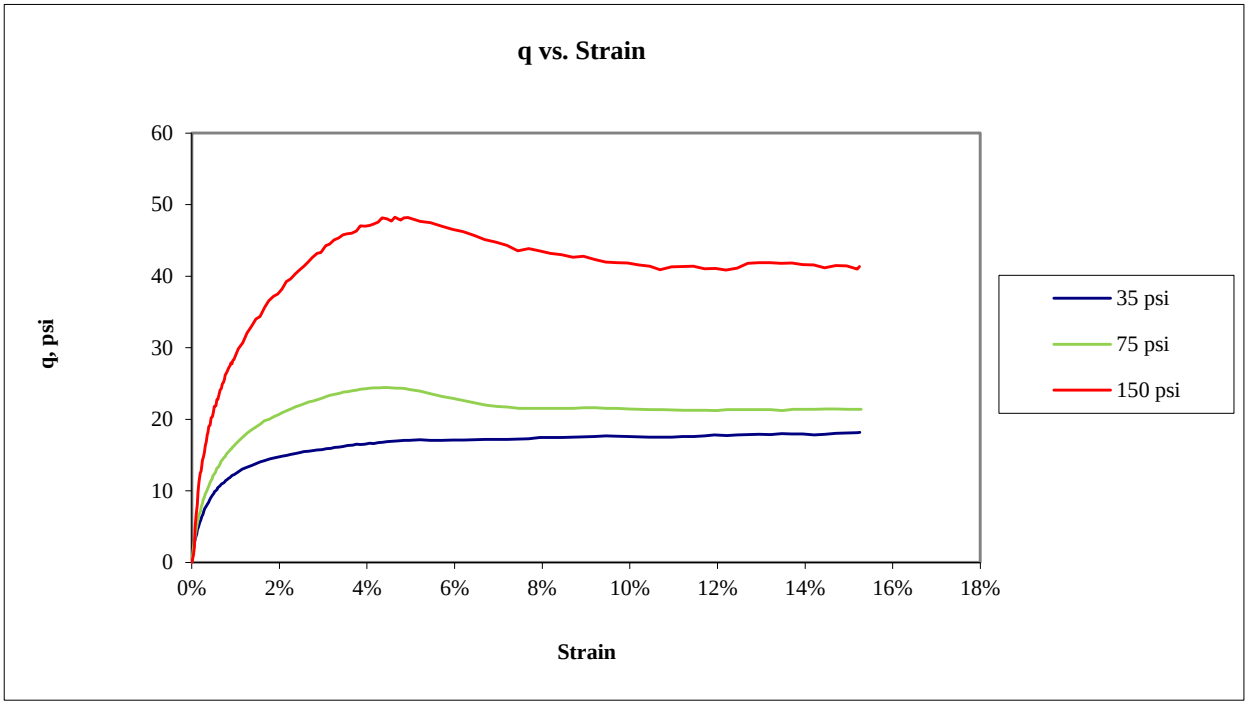
Specimen type:	X	Intact		Reconstituted	
Saturation method:	X	Wet		Dry	
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$	% strain
Membrane effect:	X	Corrected		Not Corrected	

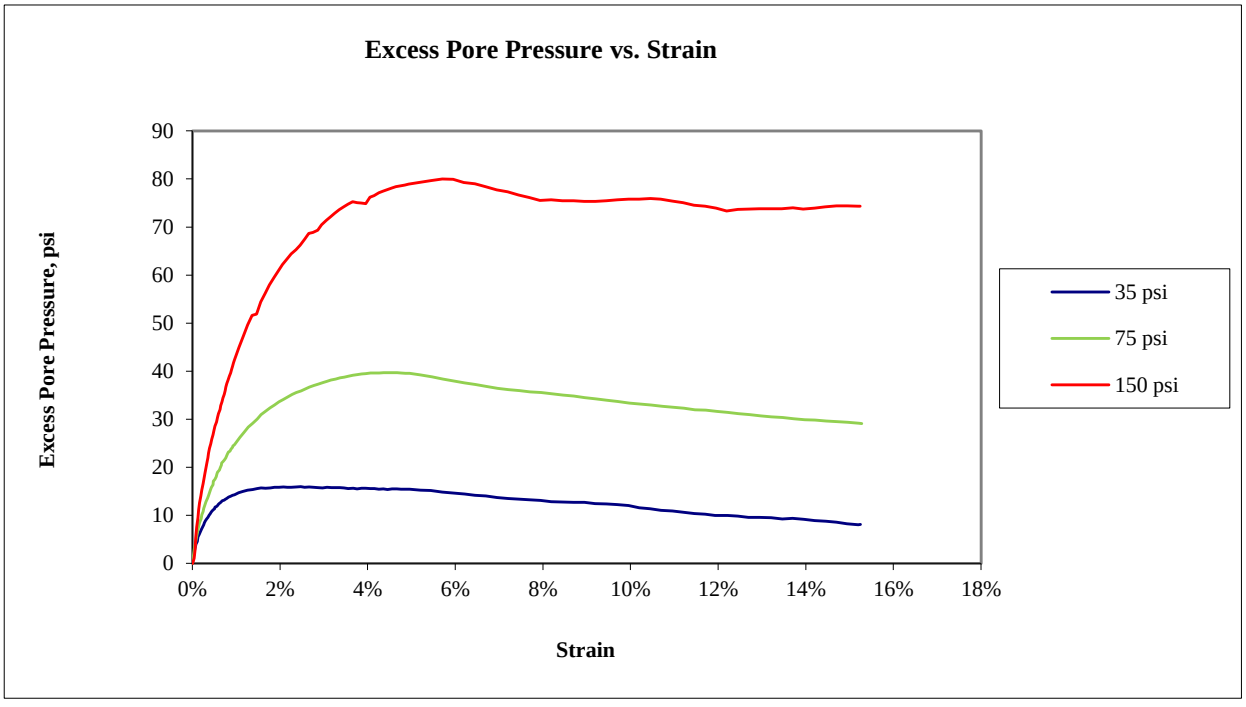
Golder Associates Inc.

Job Short Title: MDA/Grassy Mtn PFS/OR

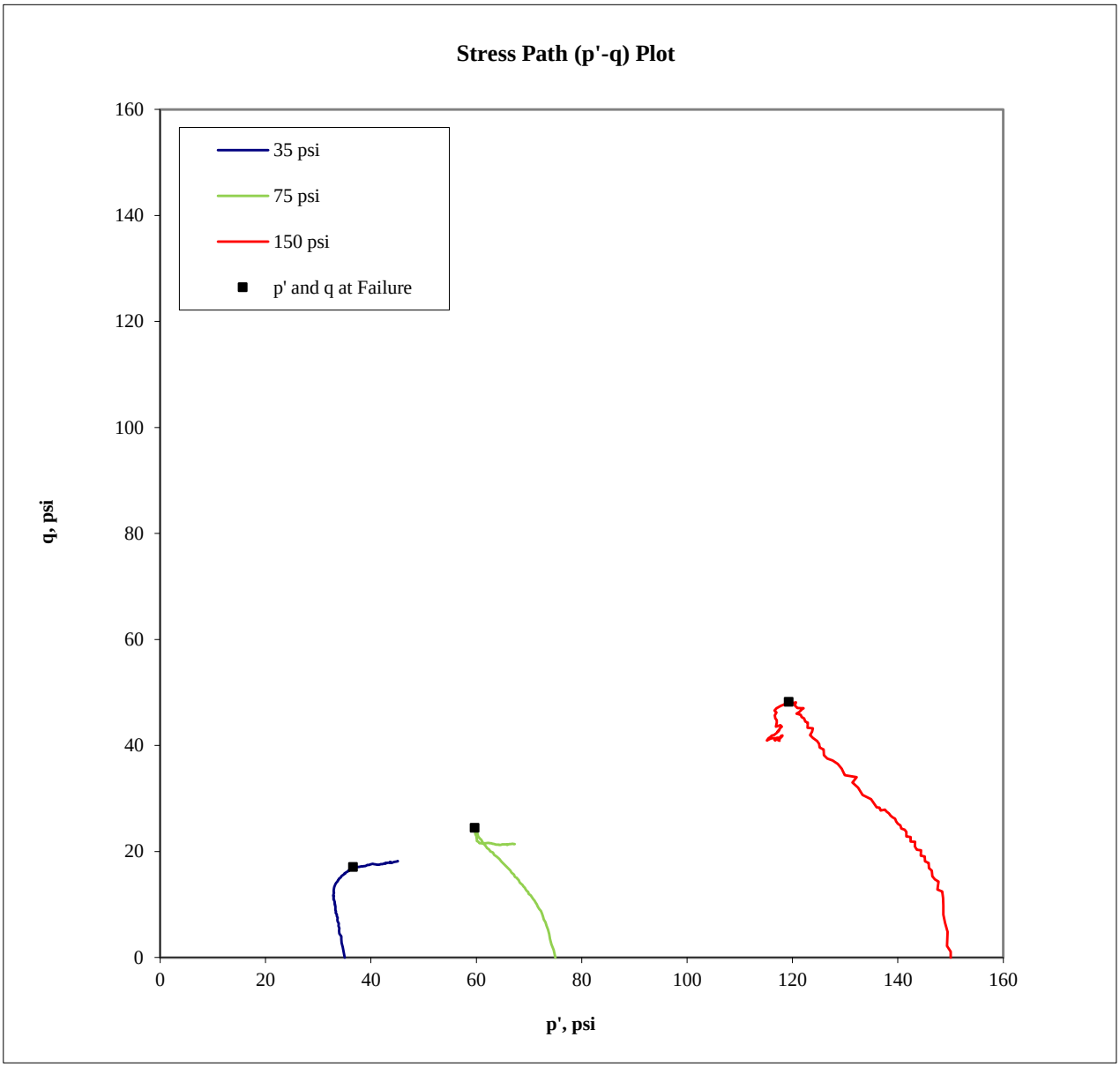
Title: ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SAMPLE AND TEST DATA

Sample:	Technician:	Reviewed:	Date:	Job Number:	Figure:
BH-13 / S6 @ 30 ft	BC	MK	28-Mar-2018	1663241.11000	1



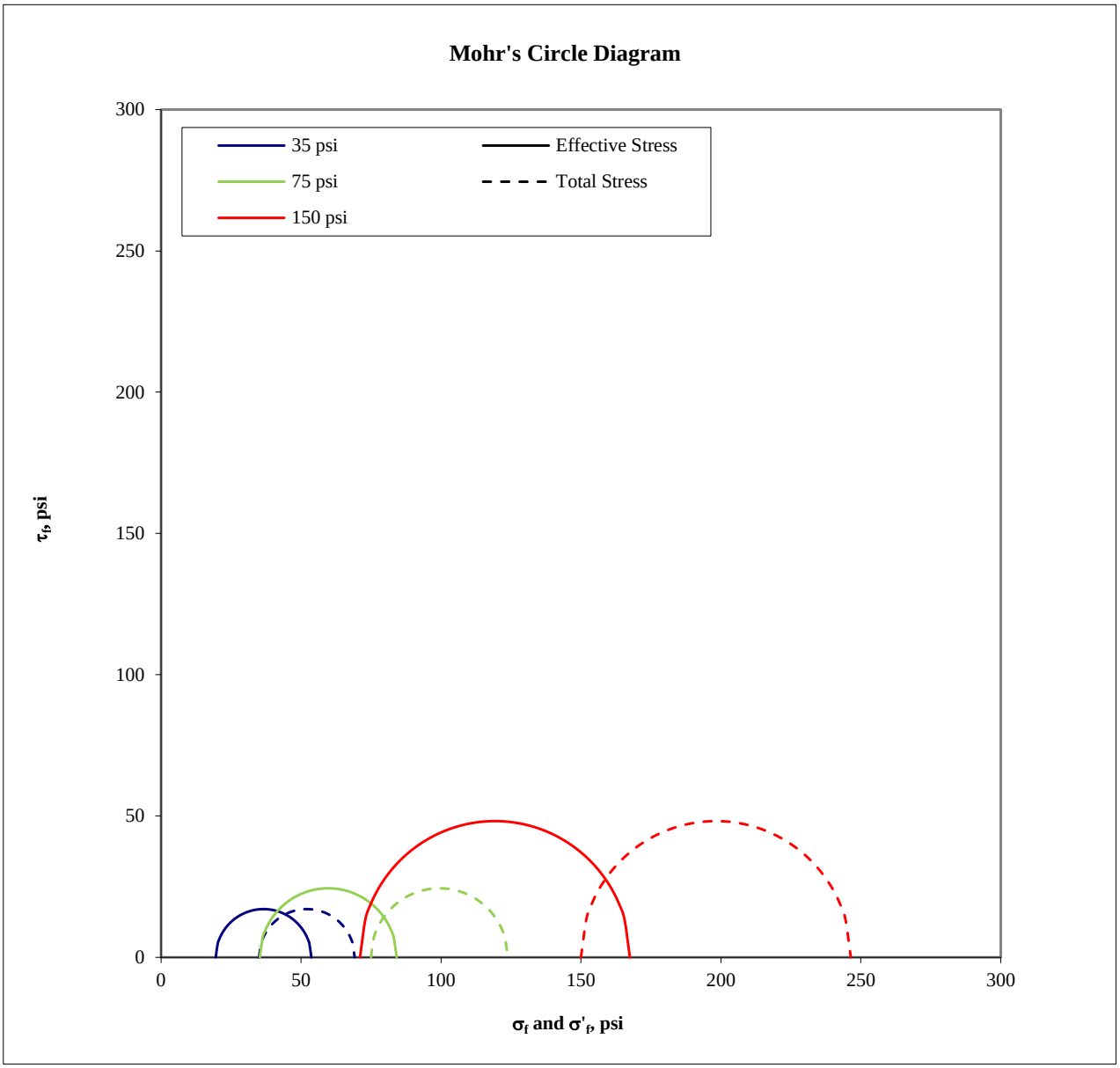


Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	**Technician:** BC	**Reviewed:** MK	**Date:** 28-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 2



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35	52.1	36.6	17.1
75	99.4	59.7	24.4
150	198.2	119.3	48.2

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	**Technician:** BC	**Reviewed:** MK	**Date:** 28-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 3



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35	53.7	19.5	69.1	35.0
75	84.1	35.3	123.9	75.0
150	167.5	71.1	246.4	150.0

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	**Technician:** BC	**Reviewed:** MK	**Date:** 28-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 4

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 35 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	**Technician:** BC	**Reviewed:** MK	**Date:** 28-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 5

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 75 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	**Technician:** BC	**Reviewed:** MK	**Date:** 28-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 6

Golder Associates Inc.	Title: ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 150 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-13 / S6 @ 30 ft	Technician: BC	Reviewed: MK	Date: 28-Mar-2018	Job Number: 1663241.11000	Figure: 7

Boring or Test Pit:	BH-15			Boring or Test Pit:	BH-15	
Sample:	S2			Sample:	S2	
Depth:	25	ft		Depth:	25	ft
Point No.:	1			Point No.:	2	
	Initial				**Initial**	
Length =	5.168	in		Length =	5.699	in
Diameter =	2.427	in		Diameter =	2.382	in
Wet Mass =	1.283	lb		Wet Mass =	1.569	lb
Area =	4.626	in^2		Area =	4.456	in^2
Volume =	23.91	in^3		Volume =	25.40	in^3
Specific Gravity =	2.76	(ASTM D854)		Specific Gravity =	2.76	(ASTM D854)
Dry Mass of Solids =	0.929	lb		Dry Mass of Solids =	1.139	lb
Water Content =	38.2%			Water Content =	37.7%	
Wet Unit Weight =	92.8	pcf		Wet Unit Weight =	106.7	pcf
Dry Unit Weight =	67.1	pcf		Dry Unit Weight =	77.5	pcf
Void Ratio =	1.56			Void Ratio =	1.22	
Percent Saturation =	67%			Percent Saturation =	85%	
	After Consolidation				**After Consolidation**	
Length =	4.694	in		Length =	5.576	in
Diameter =	2.488	in		Diameter =	2.351	in
Area =	4.862	in^2 (Method B)		Area =	4.341	in^2 (Method B)
Volume =	22.82	in^3		Volume =	24.21	in^3
Water Content =	52.4%			Water Content =	40.4%	
Wet Unit Weight =	107.1	pcf		Wet Unit Weight =	114.2	pcf
Dry Unit Weight =	70.3	pcf		Dry Unit Weight =	81.3	pcf
Void Ratio =	1.45			Void Ratio =	1.12	
Percent Saturation =	100%			Percent Saturation =	100%	
B Parameter =	0.96			B Parameter =	0.98	
Shear Rate =	0.003%	/min.		Shear Rate =	0.003%	/min.
t_{50} =	120	min.		t_{50} =	130	min.
Strain at Failure =	6.0%			Strain at Failure =	3.3%	
Cell Pressure =	105	psi		Cell Pressure =	200	psi
Back Pressure =	70	psi		Back Pressure =	50	psi
Confining Pressure =	35	psi		Confining Pressure =	150	psi

Notes: USCS description (ASTM D2487): Fat clay, olive gray, moist

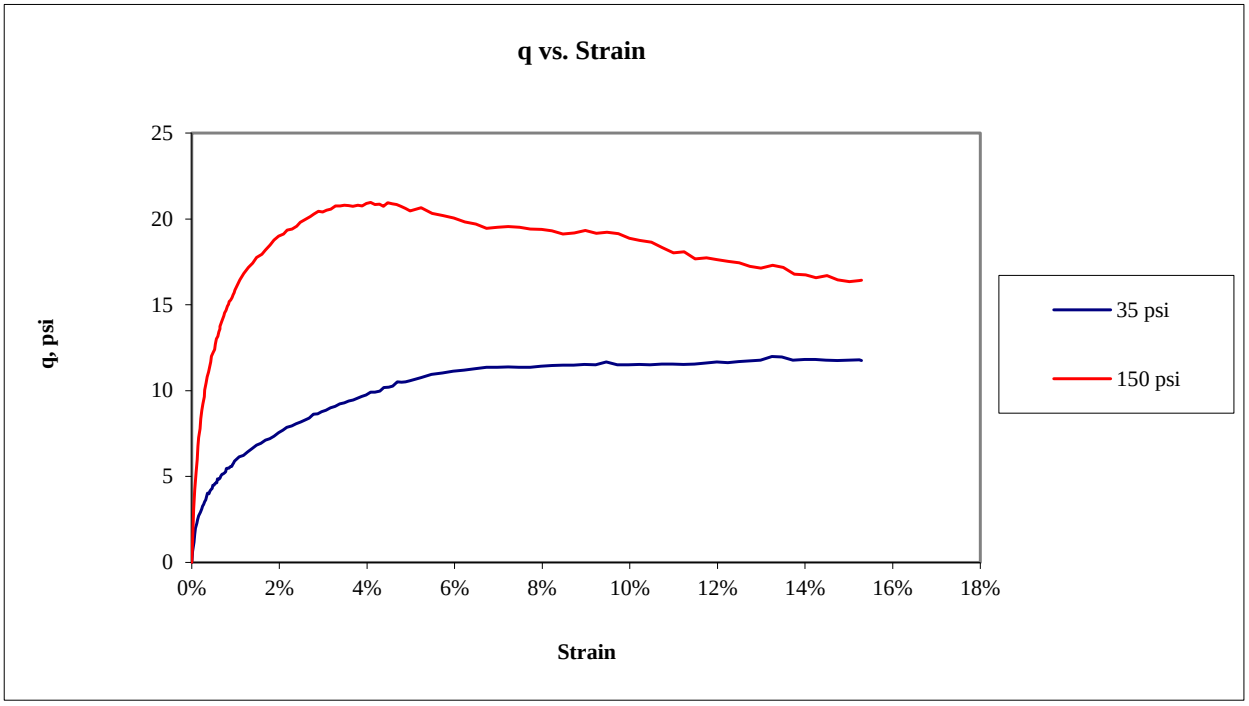
Atterberg limits: LL = 191 PL = 34 PI = 157 (ASTM D4318)

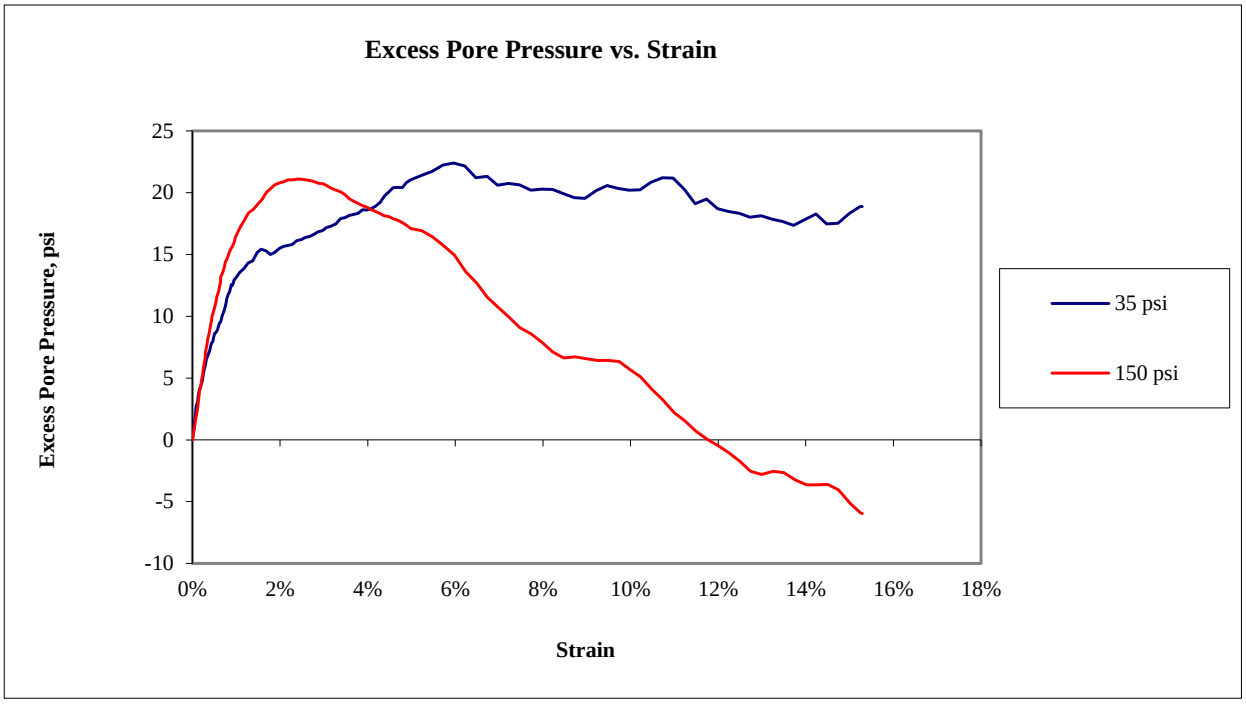
Percent finer: 3/4 in. = 100% No. 4 = 100% No. 200 = 98% (ASTM D422, refer to separate report for gradation curve)

Initial water content specimen obtained from cuttings.

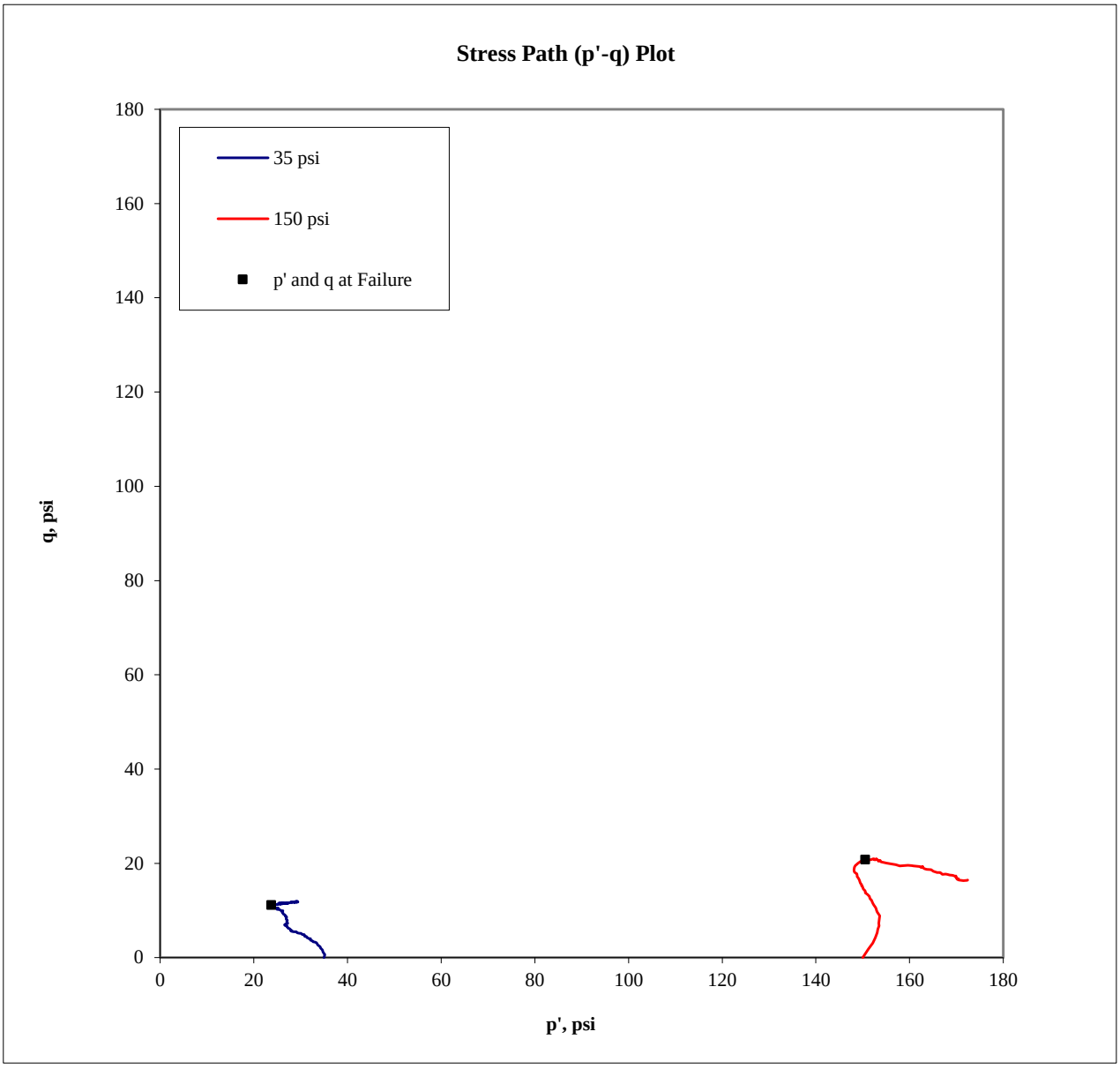
Specimen type:	X	Intact		Reconstituted	
Saturation method:	X	Wet		Dry	
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$	% strain
Membrane effect:	X	Corrected		Not Corrected	

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SAMPLE AND TEST DATA				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 1



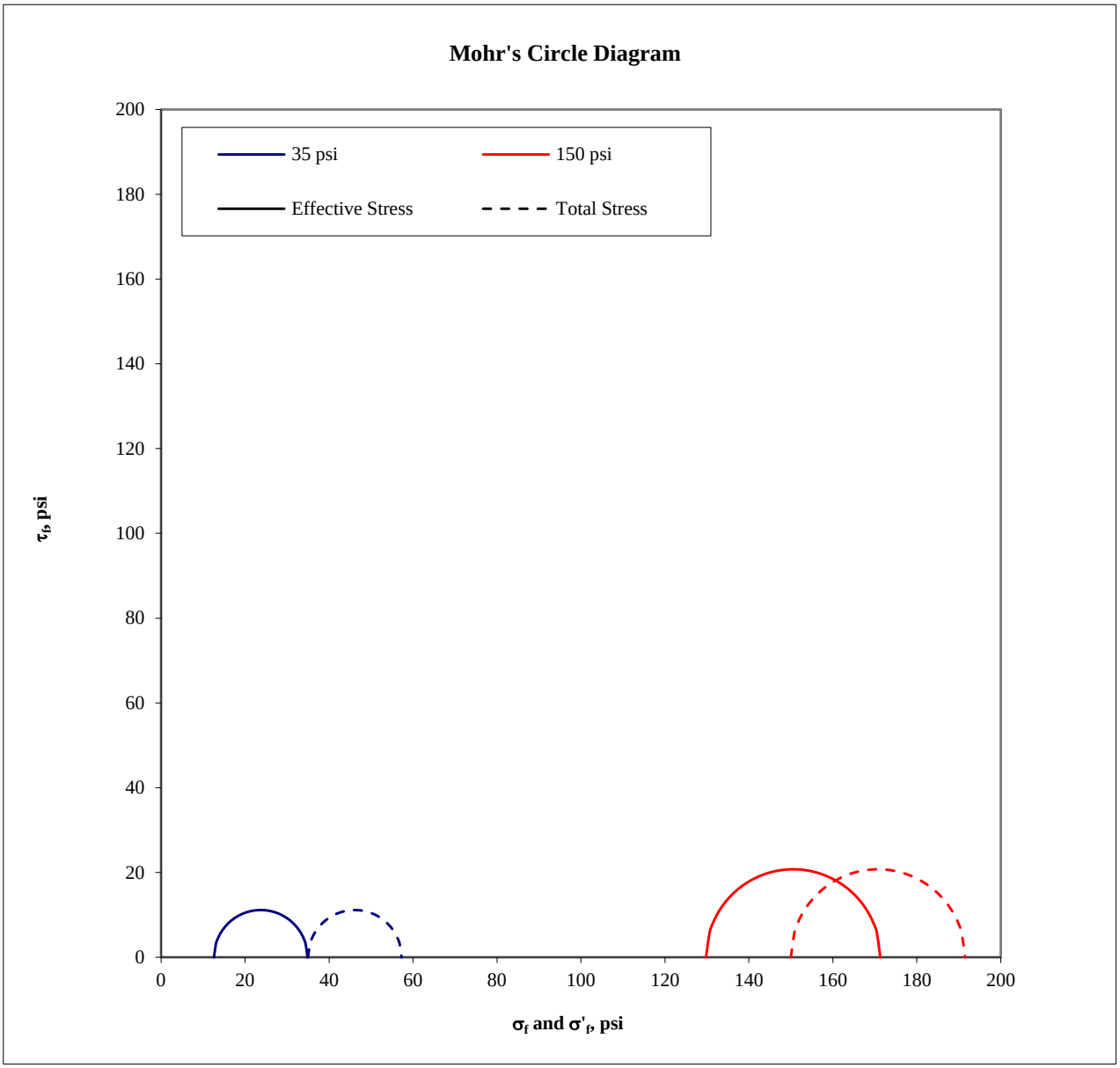


Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 2



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35	46.1	23.7	11.1
150	170.7	150.6	20.7

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 3



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35	34.9	12.6	57.3	35.0
150	171.3	129.8	191.5	150.0

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 4

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 35 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 5

Golder Associates Inc.	**Title:** ASTM D4767 CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 150 psi				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S2 @ 25 ft.	**Technician:** BC	**Reviewed:** MK	**Date:** 16-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 6

GOLDER

Boring or Test Pit:	BH19-TP-23		Boring or Test Pit:	BH19-TP-23		Boring or Test Pit:	BH19-TP-23	
Sample ID:	--		Sample ID:	--		Sample ID:	--	
Depth:	15-17	ft	Depth:	15-17	ft	Depth:	15-17	ft
Point No.:	1		Point No.:	2		Point No.:	3	
	Initial			**Initial**			**Initial**	
Length =	6.021	in	Length =	6.021	in	Length =	5.976	in
Diameter =	2.876	in	Diameter =	2.869	in	Diameter =	2.874	in
Wet Mass =	2.285	lb	Wet Mass =	2.423	lb	Wet Mass =	2.480	lb
Area =	6.496	in^2	Area =	6.465	in^2	Area =	6.487	in^2
Volume =	39.11	in^3	Volume =	38.92	in^3	Volume =	38.77	in^3
Specific Gravity =	2.78	(ASTM D854)	Specific Gravity =	2.78	(ASTM D854)	Specific Gravity =	2.78	(ASTM D854)
Dry Mass of Solids =	1.698	lb	Dry Mass of Solids =	1.871	lb	Dry Mass of Solids =	1.861	lb
Water Content =	34.6%		Water Content =	29.5%		Water Content =	33.3%	
Wet Unit Weight =	100.9	pcf	Wet Unit Weight =	107.6	pcf	Wet Unit Weight =	110.6	pcf
Dry Unit Weight =	75.0	pcf	Dry Unit Weight =	83.0	pcf	Dry Unit Weight =	82.9	pcf
Void Ratio =	1.31		Void Ratio =	1.09		Void Ratio =	1.09	
Percent Saturation =	73%		Percent Saturation =	76%		Percent Saturation =	85%	
	After Consolidation			**After Consolidation**			**After Consolidation**	
Length =	5.898	in	Length =	6.041	in	Length =	5.976	in
Diameter =	2.884	in	Diameter =	2.778	in	Diameter =	2.817	in
Area =	6.534	in^2 (Method B)	Area =	6.060	in^2 (Method B)	Area =	6.231	in^2 (Method B)
Volume =	38.54	in^3	Volume =	36.61	in^3	Volume =	37.23	in^3
Water Content =	45.9%		Water Content =	34.6%		Water Content =	36.2%	
Wet Unit Weight =	111.1	pcf	Wet Unit Weight =	118.9	pcf	Wet Unit Weight =	117.6	pcf
Dry Unit Weight =	76.1	pcf	Dry Unit Weight =	88.3	pcf	Dry Unit Weight =	86.3	pcf
Void Ratio =	1.28		Void Ratio =	0.96		Void Ratio =	1.01	
Percent Saturation =	100%		Percent Saturation =	100%		Percent Saturation =	100%	
B Parameter =	0.99		B Parameter =	0.99		B Parameter =	0.95	
Shear Rate =	0.003%	/min.	Shear Rate =	0.007%	/min.	Shear Rate =	0.007%	/min.
t_{50} =	120	min.	t_{50} =	2,100	min.	t_{50} =	2,300	min.
Strain at Failure =	7.9%		Strain at Failure =	2.9%		Strain at Failure =	3.0%	
Cell Pressure =	85	psi	Cell Pressure =	125	psi	Cell Pressure =	200	psi
Back Pressure =	50	psi	Back Pressure =	50	psi	Back Pressure =	50	psi
Confining Pressure =	35	psi	Confining Pressure =	75	psi	Confining Pressure =	150	psi

Notes: Visual description: Fat clay, olive, moist

Atterberg limits: LL = -- PL = -- PI = -- (-- indicates test wast not performed)

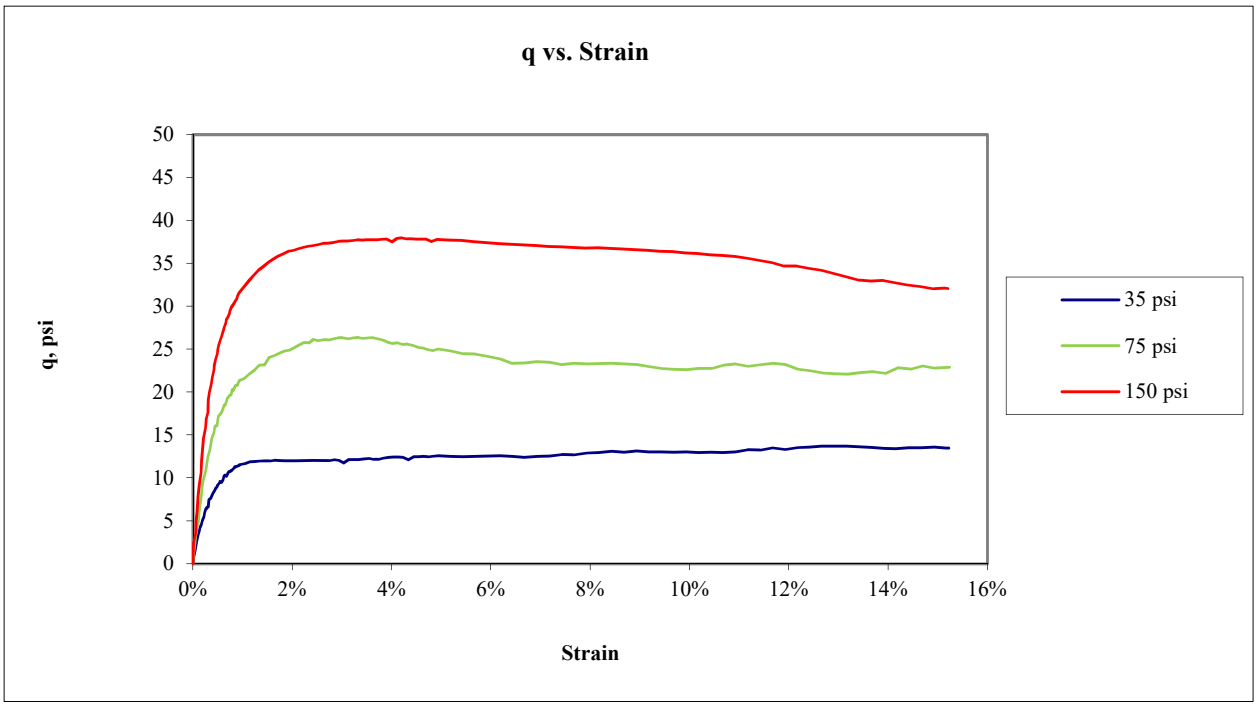
Percent finer: 3/4 in. = -- No. 4 = -- No. 200 = --

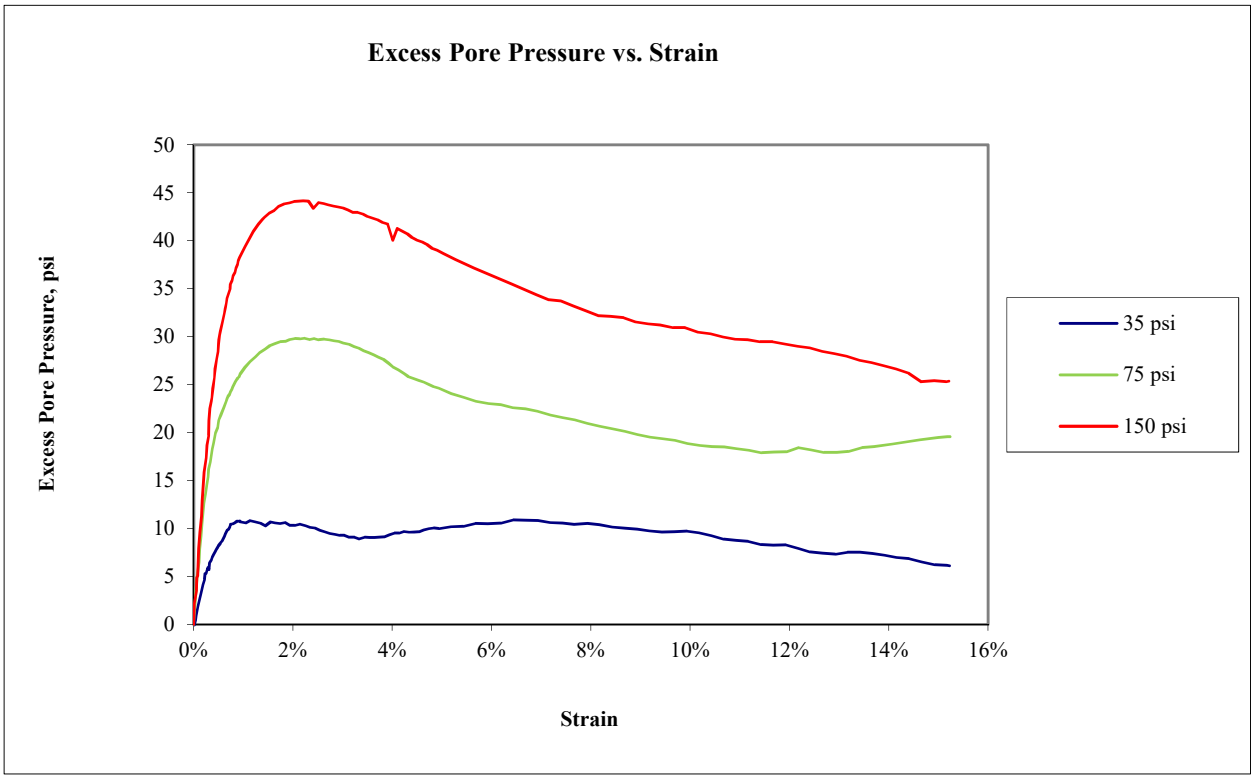
Initial water content obtained from entire sample.

Specimen type:	X	Intact		Reconstituted		
Saturation method:	X	Wet		Dry		
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$		% strain
Membrane effect:	X	Corrected		Not Corrected		

Shear rate for Point 2 and Point 3 assigned by client

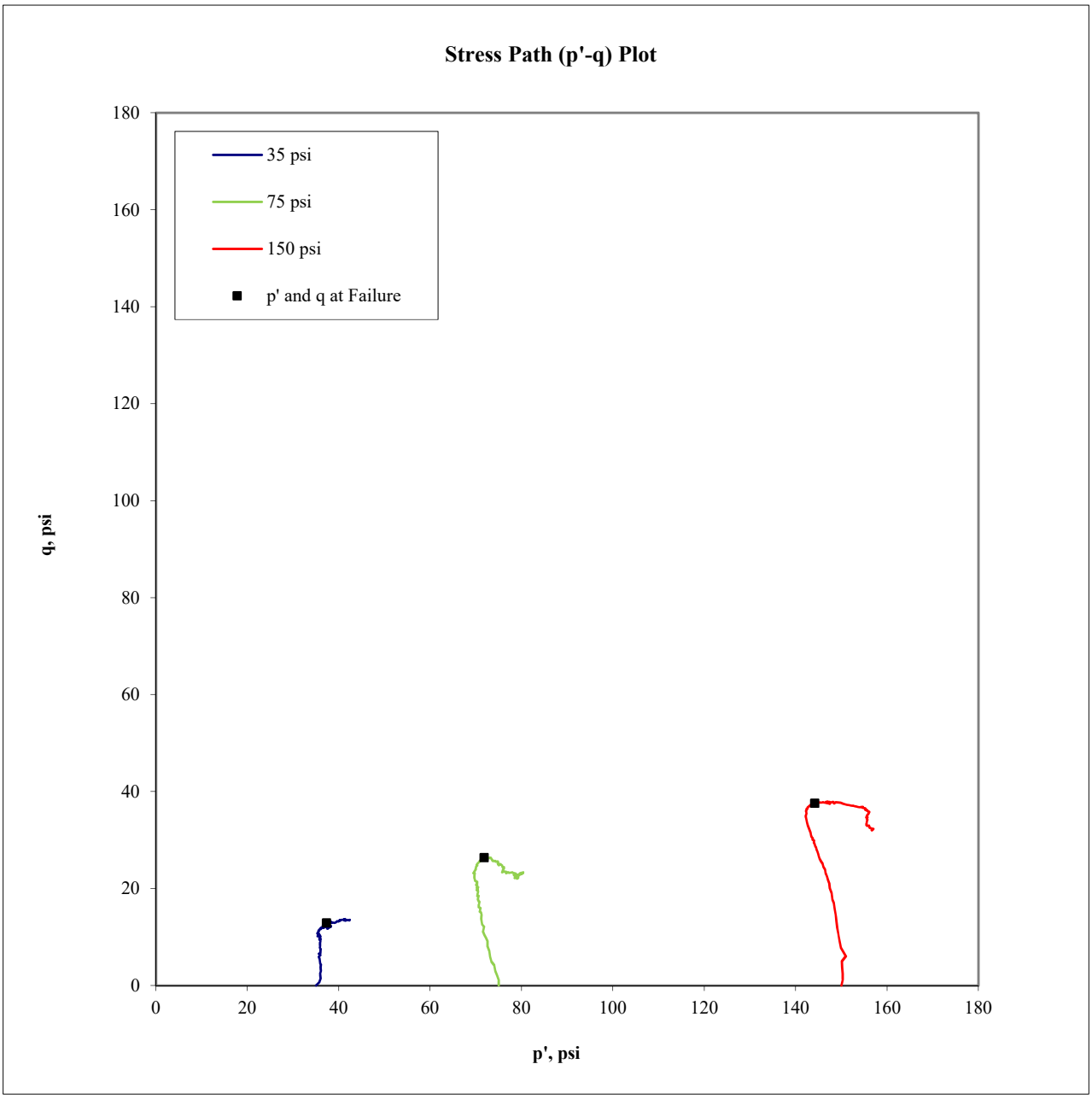
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SAMPLE AND TEST DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 15 - 17 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 1





Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 15 - 17 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 2

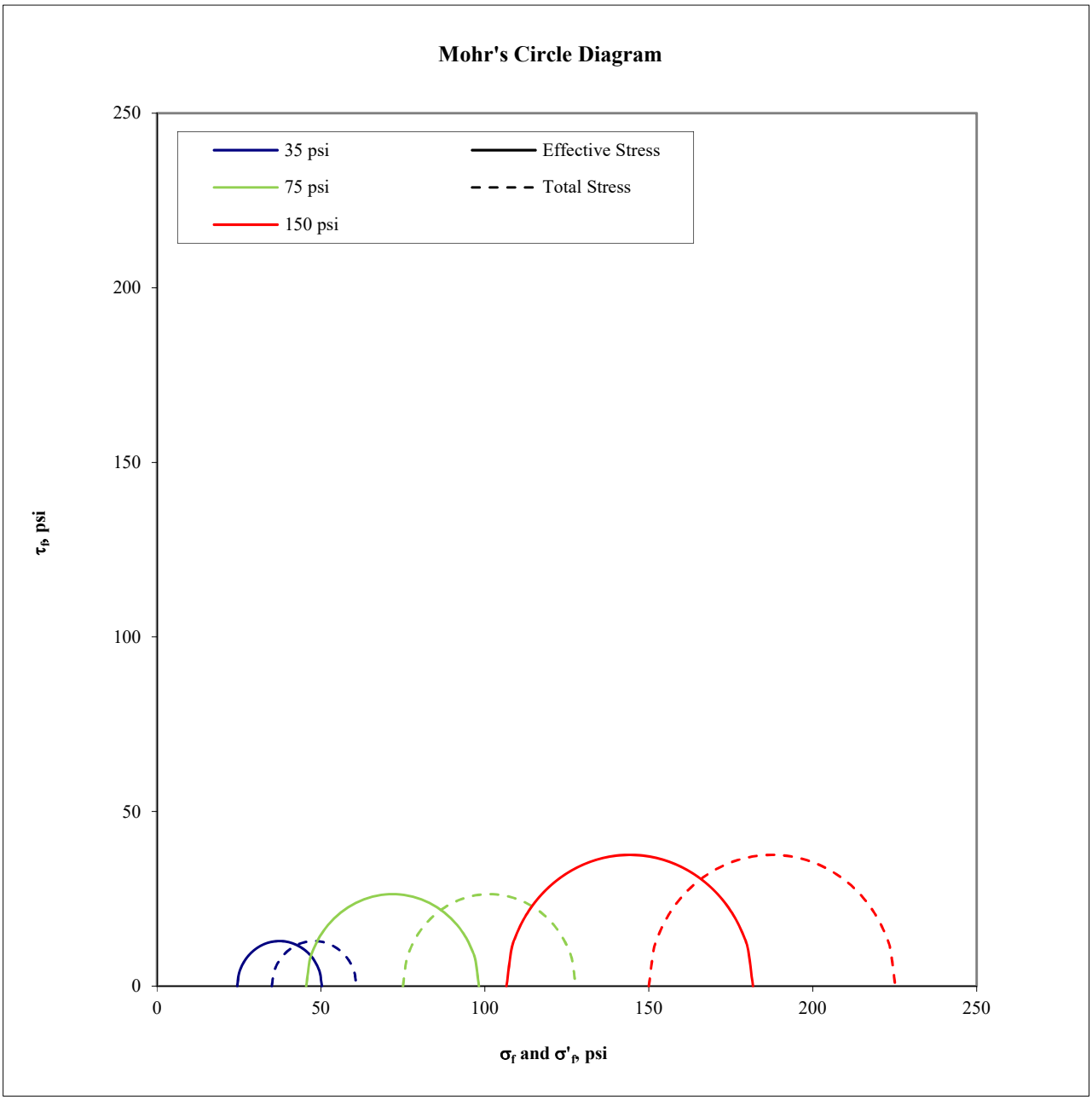
GOLDER



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35.0	47.9	37.4	12.9
75.0	101.3	71.8	26.3
150.0	187.6	144.2	37.6

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 15 - 17 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 3

GOLDER



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35.0	50.3	24.5	60.8	35.0
75.0	98.2	45.5	127.7	75.0
150.0	181.8	106.6	225.2	150.0

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 15 - 17 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 4

GOLDER

Project Name:		ASTM D4767				
MDA/Grassy Mtn PFS/OR		CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 35 psi				
Project Number:						
1663241.22000						
Sample ID:	Technician:	Checked:	Reviewed:	Date:	Figure:	
BH19-TP-23 @ 15 - 17 ft.	BC	PRH	CPA	7-Aug-2019	5	

GOLDER

Project Name:		ASTM D4767				
MDA/Grassy Mtn PFS/OR		CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 75 psi				
Project Number:						
1663241.22000						
Sample ID:	Technician:	Checked:	Reviewed:	Date:	Figure:	
BH19-TP-23 @ 15 - 17 ft.	BC	PRH	CPA	7-Aug-2019	6	

GOLDER

Project Name:	ASTM D4767				
MDA/Grassy Mtn PFS/OR	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 150 psi				
Project Number:					
1663241.22000					
Sample ID:	Technician:	Checked:	Reviewed:	Date:	Figure:
BH19-TP-23 @ 15 - 17 ft.	BC	PRH	CPA	7-Aug-2019	7

GOLDER

Boring or Test Pit:	BH19-TP-23		Boring or Test Pit:	BH19-TP-23	
Sample ID:	--		Sample ID:	--	
Depth:	20-22	ft	Depth:	20 -22	ft
Point No.:	1		Point No.:	3	
	Initial			**Initial**	
Length =	5.971	in	Length =	5.812	in
Diameter =	2.848	in	Diameter =	2.838	in
Wet Mass =	2.255	lb	Wet Mass =	2.235	lb
Area =	6.370	in^2	Area =	6.326	in^2
Volume =	38.04	in^3	Volume =	36.77	in^3
Specific Gravity =	2.73	(ASTM D854)	Specific Gravity =	2.73	(ASTM D854)
Dry Mass of Solids =	1.601	lb	Dry Mass of Solids =	1.609	lb
Water Content =	40.8%		Water Content =	38.9%	
Wet Unit Weight =	102.5	pcf	Wet Unit Weight =	105.0	pcf
Dry Unit Weight =	72.8	pcf	Dry Unit Weight =	75.6	pcf
Void Ratio =	1.34		Void Ratio =	1.25	
Percent Saturation =	83%		Percent Saturation =	85%	
	After Consolidation			**After Consolidation**	
Length =	5.964	in	Length =	5.616	in
Diameter =	2.868	in	Diameter =	2.829	in
Area =	6.458	in^2 (Method B)	Area =	6.287	in^2 (Method B)
Volume =	38.52	in^3	Volume =	35.31	in^3
Water Content =	50.1%		Water Content =	42.5%	
Wet Unit Weight =	107.8	pcf	Wet Unit Weight =	112.2	pcf
Dry Unit Weight =	71.9	pcf	Dry Unit Weight =	78.8	pcf
Void Ratio =	1.37		Void Ratio =	1.16	
Percent Saturation =	100%		Percent Saturation =	100%	
B Parameter =	0.99		B Parameter =	0.98	
Shear Rate =	0.0036%	/min.	Shear Rate =	0.0026%	/min.
t_{50} =	545.0	min.	t_{50} =	4,300.0	min.
Strain at Failure =	2.0%		Strain at Failure =	4.5%	
Cell Pressure =	85	psi	Cell Pressure =	210	psi
Back Pressure =	50	psi	Back Pressure =	60	psi
Confining Pressure =	35	psi	Confining Pressure =	150	psi

Notes: Visual description: Fat clay, olive, moist

Atterberg limits: LL = -- PL = -- PI = -- (-- indicates test wast not performed)

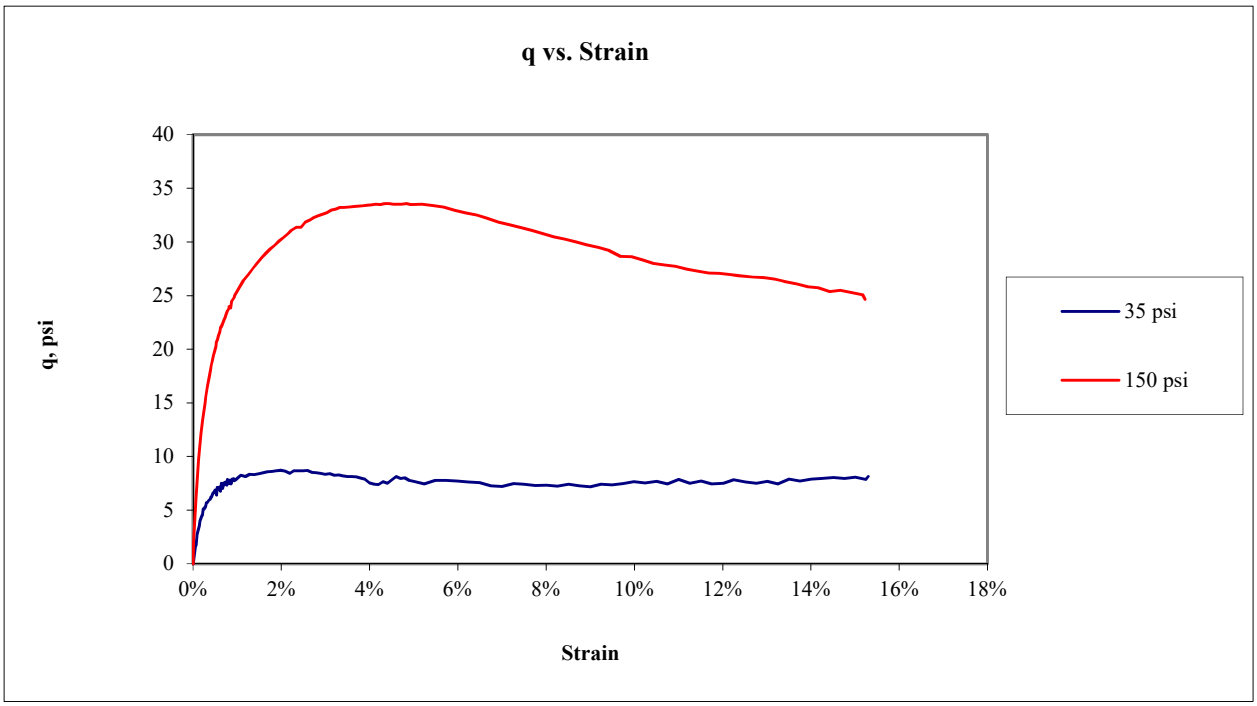
Percent finer: 3/4 in. = -- No. 4 = -- No. 200 = --

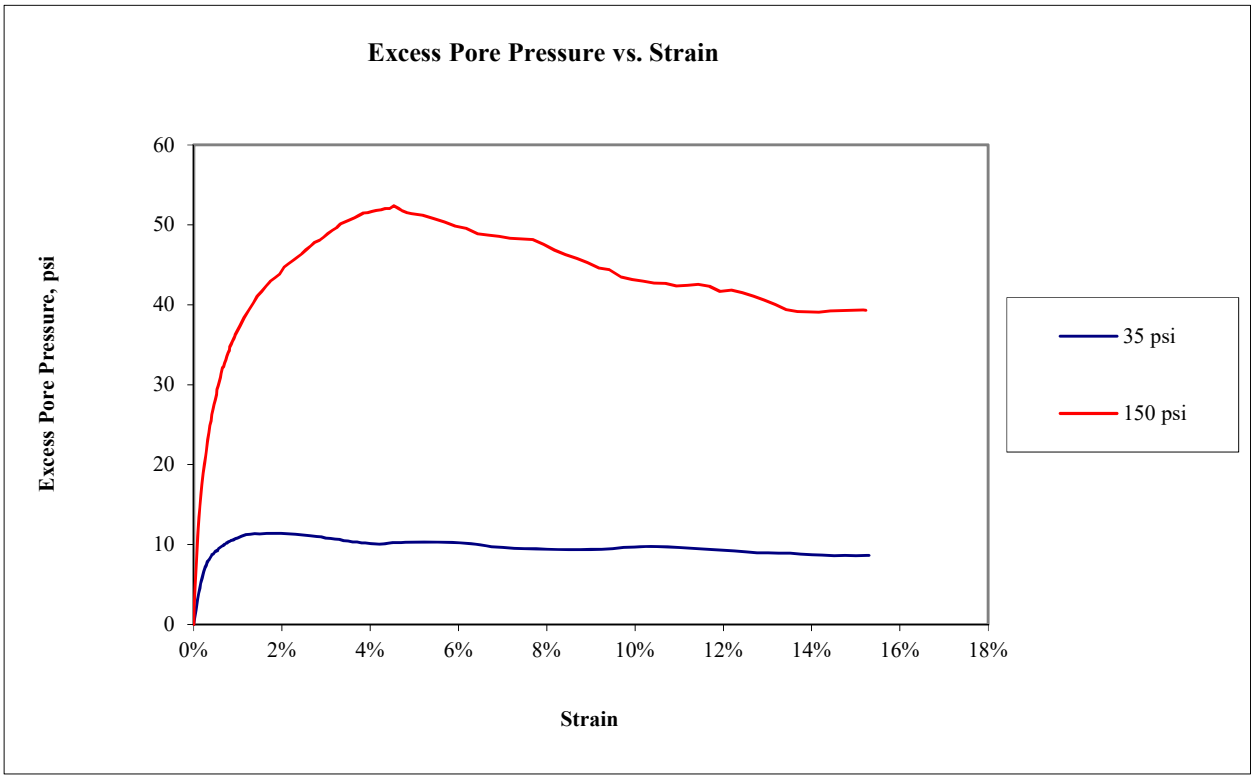
Initial water content obtained from entire sample.

Specimen type:	X	Intact		Reconstituted	
Saturation method:	X	Wet		Dry	
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$	% strain
Membrane effect:	X	Corrected		Not Corrected	

Shear rates assigned by client.

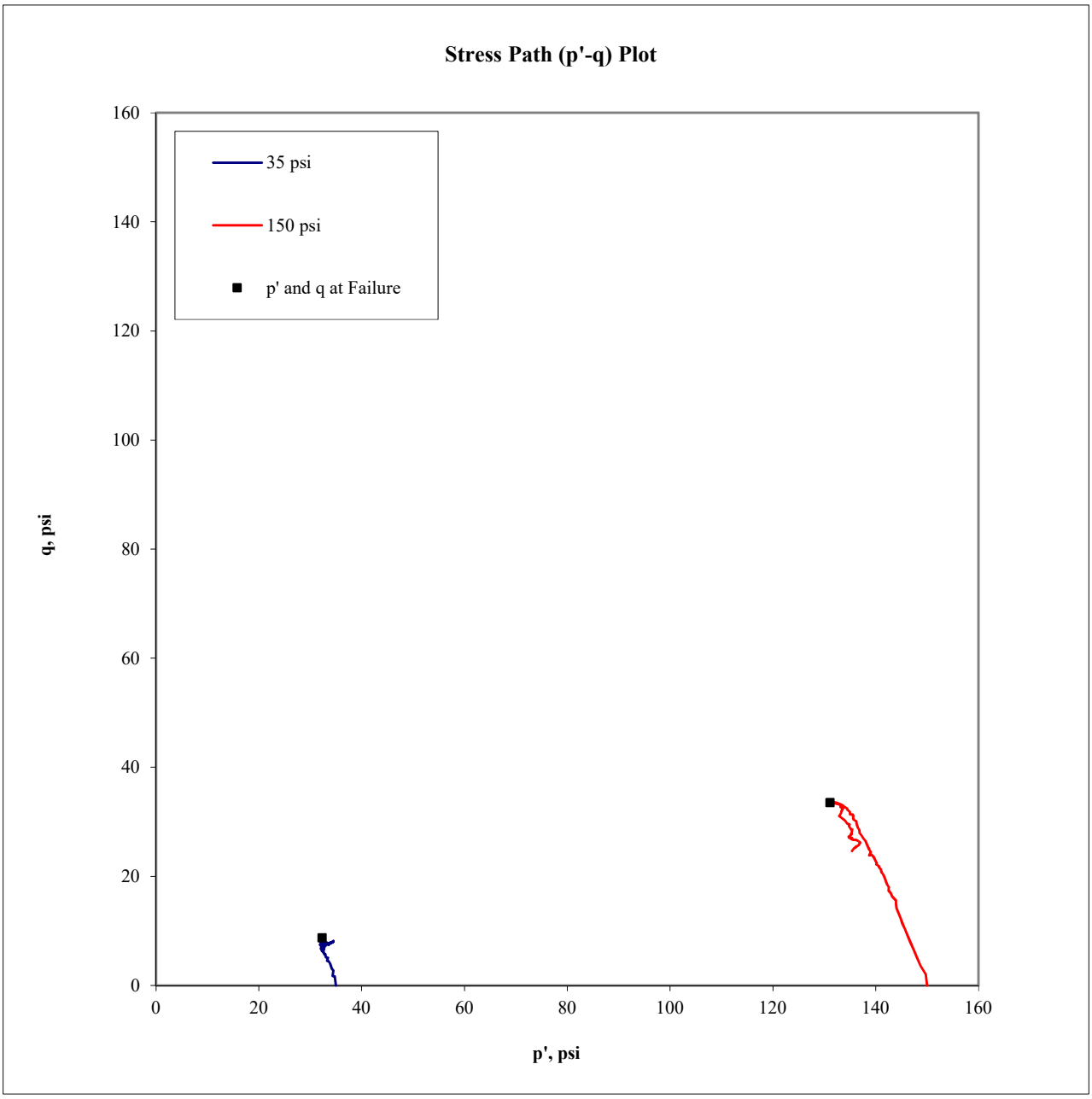
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SAMPLE AND TEST DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 20 - 22 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 1





Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS					
Project Number: 1663241.22000						
Sample ID: BH19-TP-23 @ 20 - 22 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 2	

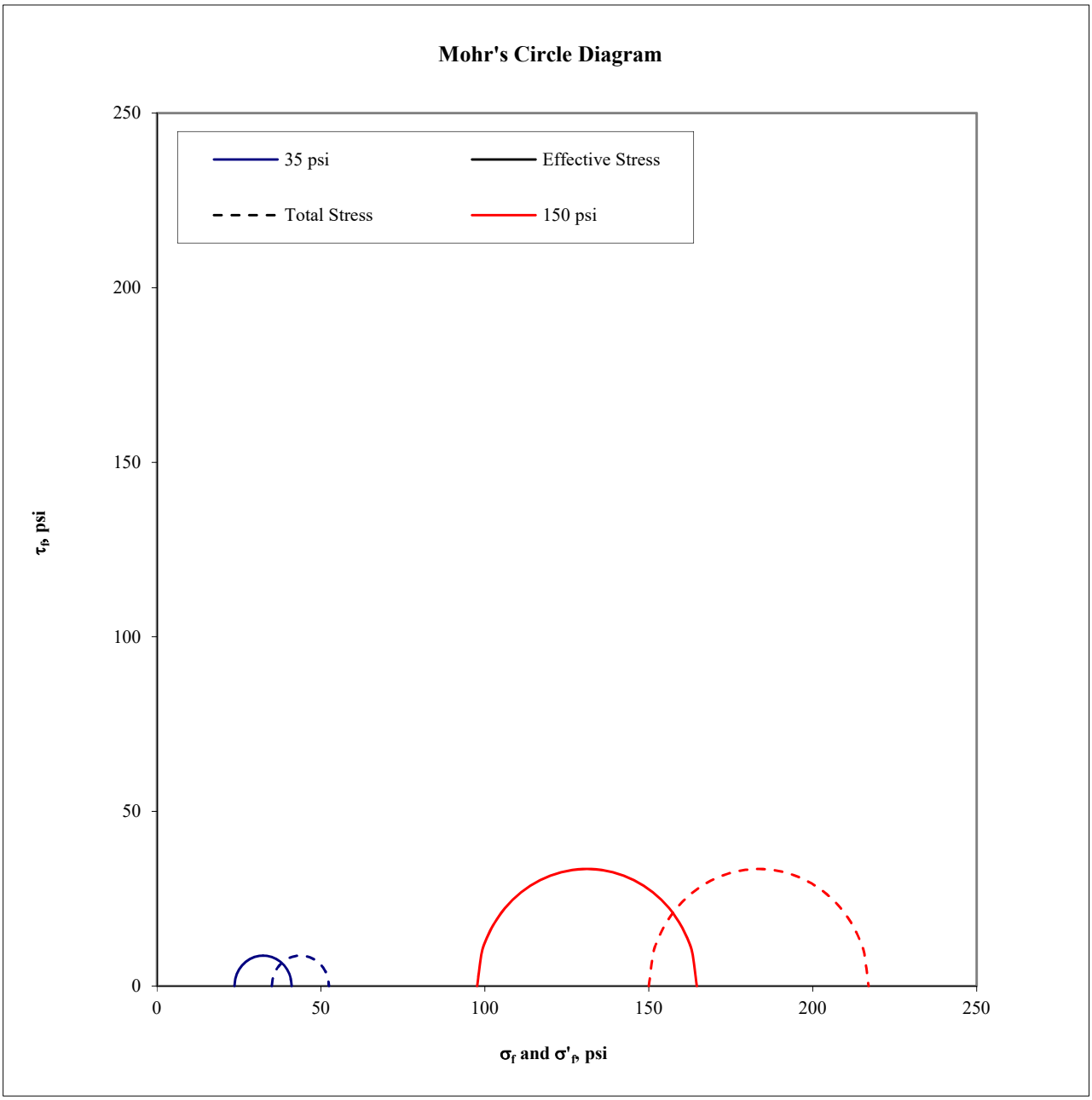
GOLDER



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35.0	43.7	32.3	8.7
150.0	183.5	131.1	33.5

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 20 - 22 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 3

GOLDER



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35.0	41.0	23.6	52.4	35.0
150.0	164.6	97.6	217.0	150.0

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 20 - 22 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 4

GOLDER

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767**					
Project Number: 1663241.22000	**CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT** **SPECIMEN PHOTOGRAPH - 35 psi**					
Sample ID: BH19-TP-23 @ 20 - 22 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 7-Aug-2019	**Figure:** 5	

GOLDER

Project Name: MDA/Grassy Mtn PFS/OR	ASTM D4767				
Project Number: 1663241.22000	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SPECIMEN PHOTOGRAPH - 150 psi				
Sample ID: BH19-TP-23 @ 20 - 22 ft.	Technician: BC	Checked: PRH	Reviewed: CPA	Date: 7-Aug-2019	Figure: 6

GOLDER

Boring or Test Pit:	BH19-TP-44		Boring or Test Pit:	BH19-TP-44	
Sample:	--		Sample:	--	
Depth:	10-12	ft	Depth:	10-12	ft
Point No.:	1		Point No.:	2	
	Initial			**Initial**	
Length =	6.134	in	Length =	--	in
Diameter =	2.878	in	Diameter =	--	in
Wet Mass =	2.374	lb	Wet Mass =	--	lb
Area =	6.505	in^2	Area =	--	in^2
Volume =	39.90	in^3	Volume =	--	in^3
Specific Gravity =	2.75	(ASTM D854)	Specific Gravity =	2.75	(ASTM D854)
Dry Mass of Solids =	1.985	lb	Dry Mass of Solids =	1.985	lb
Water Content =	19.6%		Water Content =	--	
Wet Unit Weight =	102.8	pcf	Wet Unit Weight =	--	pcf
Dry Unit Weight =	86.0	pcf	Dry Unit Weight =	--	pcf
Void Ratio =	0.99		Void Ratio =	--	
Percent Saturation =	54%		Percent Saturation =	100%	
	After Consolidation			**After Consolidation**	
Length =	5.972	in	Length =	5.648	in
Diameter =	--	in	Diameter =	2.815	in
Area =	--	in^2 (Method B)	Area =	6.224	in^2 (Method B)
Volume =	--	in^3	Volume =	35.15	in^3
Water Content =	--		Water Content =	27.5%	
Wet Unit Weight =	--	pcf	Wet Unit Weight =	124.4	pcf
Dry Unit Weight =	--	pcf	Dry Unit Weight =	97.6	pcf
Void Ratio =	--		Void Ratio =	0.76	
Percent Saturation =	100%		Percent Saturation =	100%	
B Parameter =	0.97		B Parameter =	--	
Shear Rate =	0.010%	/min.	Shear Rate =	0.010%	/min.
t_{50} =	38.0	min.	t_{50} =	--	(not computed)
Strain at Failure =	4.7%		Strain at Failure =	5.6%	
Cell Pressure =	85.0	psi	Cell Pressure =	200.7	psi
Back Pressure =	50.0	psi	Back Pressure =	65.7	psi
Confining Pressure =	35.0	psi	Confining Pressure =	135.0	psi

Notes: USCS description (ASTM D2487): Fat clay, olive yellow, moist

Atterberg limits: LL = 82 PL = 22 PI = 60 (ASTM D4318)

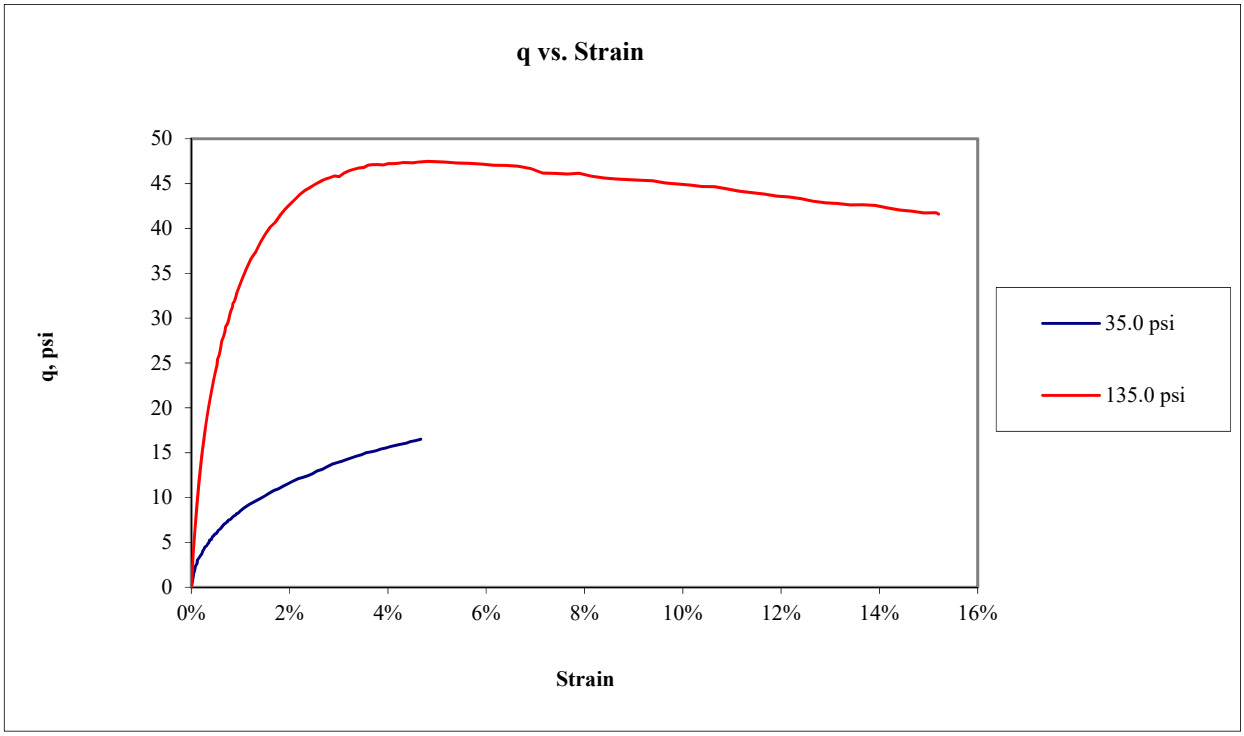
Percent finer: 3/4 in. = 100% No. 4 = 100% No. 200 = 56% (ASTM D422, refer to separate report for gradation curve)

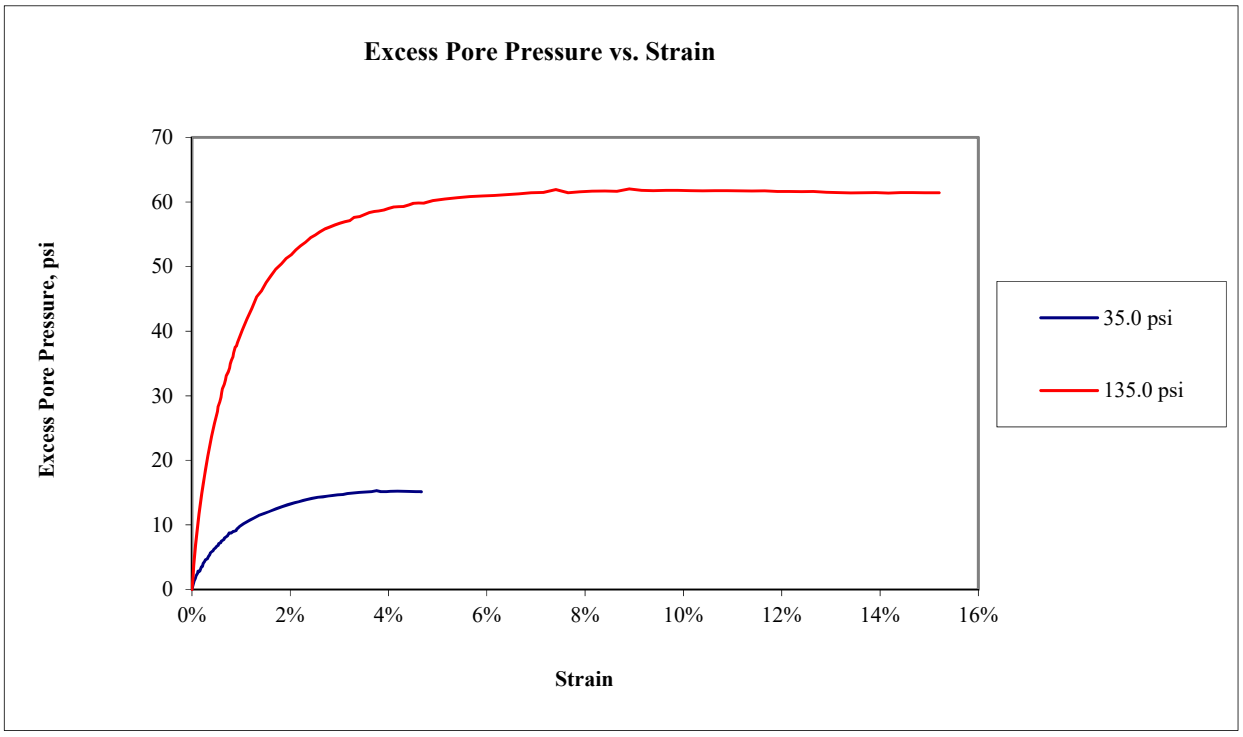
Initial water content obtained from entire sample.

Specimen type:	X	Intact		Reconstituted	
Saturation method:	X	Wet		Dry	
Failure criterion:	X	$(\sigma'_1/\sigma'_3)_{max}$		$(\sigma'_1-\sigma'_3)_{max}$	% strain
Membrane effect:	X	Corrected		Not Corrected	

Test was staged using a single specimen. Specimen was sheared to 5% for the first stage at which failure was defined. Intermediate specimen dimensions were not determined. Calculations are based on initial specimen dimensions and from corrected area calculations based on axial strain (deviation from ASTM D4767).

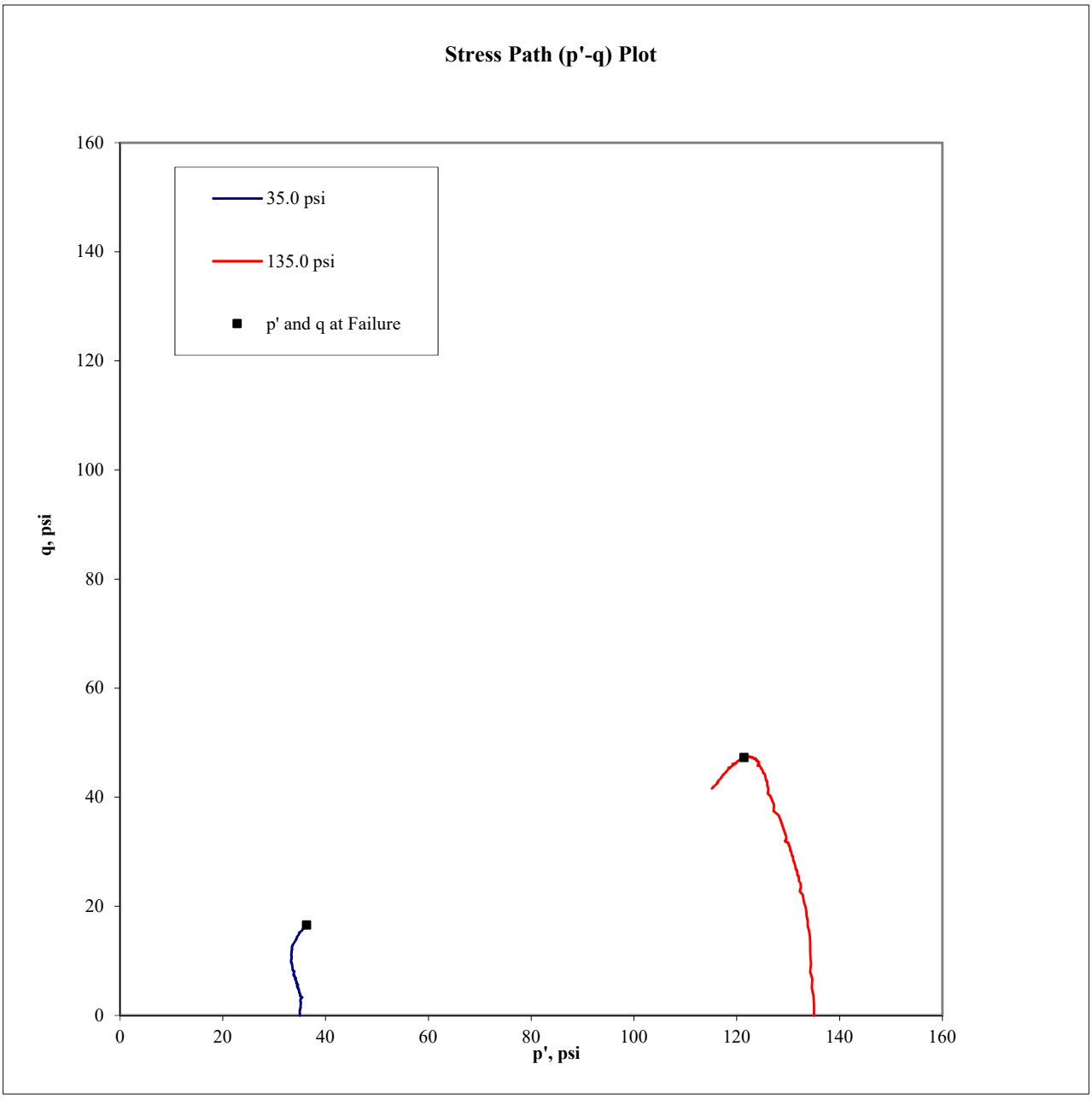
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT SAMPLE AND TEST DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 10 - 12 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Aug-2019	**Figure:** 1





Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT q AND EXCESS PORE PRESSURE PLOTS					
Project Number: 1663241.22000						
Sample ID: BH19-TP-44 @ 10 - 12 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Aug-2019	**Figure:** 2	

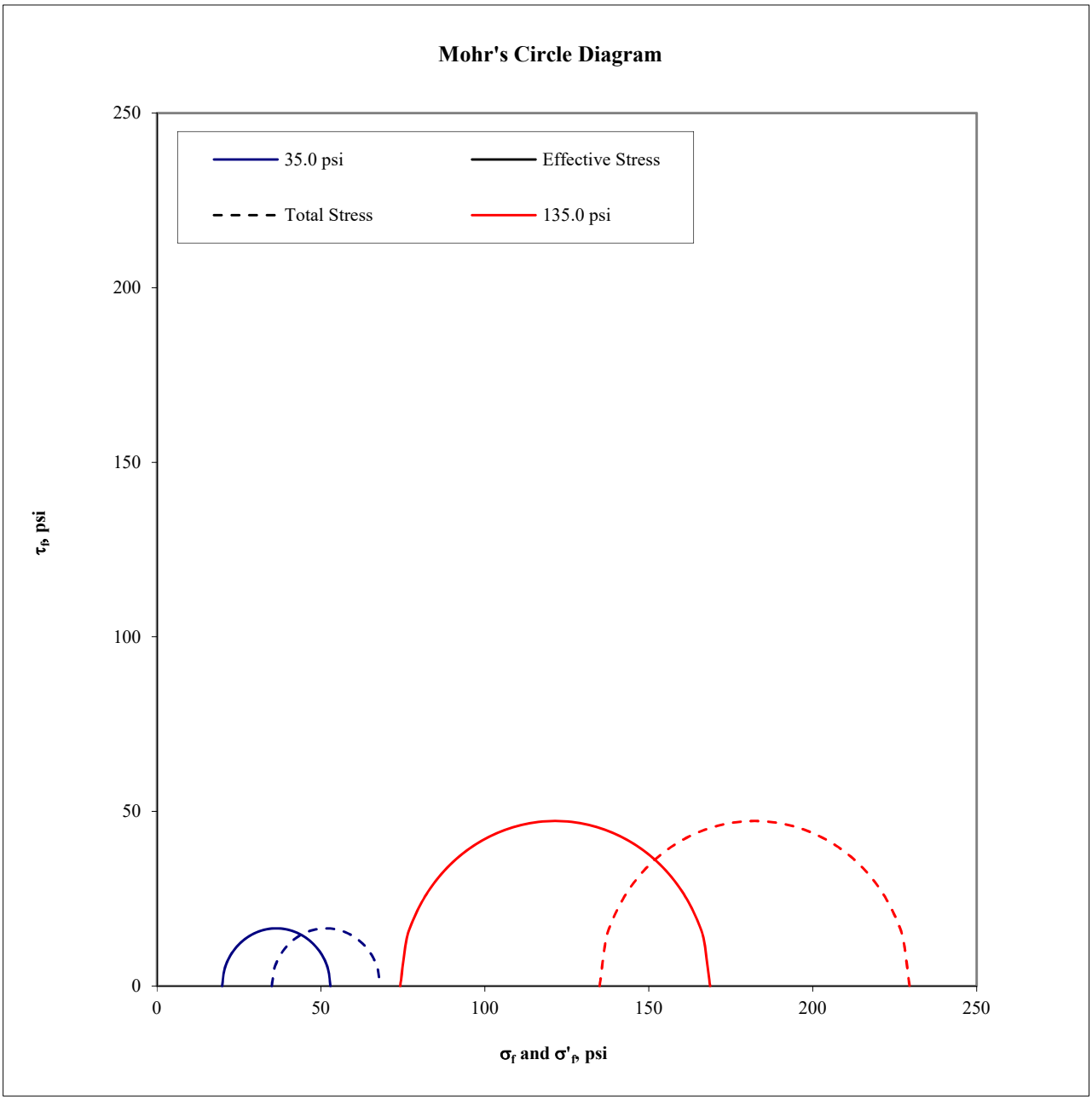
GOLDER



Confining Pressure (psi)	p at failure (psi)	p' at failure (psi)	q at failure (psi)
35.0	51.5	36.4	16.5
135.0	182.3	121.4	47.3

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT STRESS PATH PLOT				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 10 - 12 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Aug-2019	**Figure:** 3

GOLDER



Confining Pressure (psi)	σ'_1 at failure (psi)	σ'_3 at failure (psi)	σ_1 at failure (psi)	σ_3 at failure (psi)
35.0	52.9	19.9	68.0	35.0
135.0	168.7	74.2	229.5	135.0

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D4767** CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT MOHR'S CIRCLE DIAGRAM				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 10 - 12 ft.	**Technician:** BC	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Aug-2019	**Figure:** 4

GOLDER

Project Name: MDA/Grassy Mtn PFS/OR	ASTM D4767				
Project Number: 1663241.22000	CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST REPORT POST-TEST SPECIMEN PHOTOGRAPH				
Sample ID: BH19-TP-44 @ 10 - 12 ft.	Technician: BC	Checked: PRH	Reviewed: CPA	Date: 3-Aug-2019	Figure: 5

	Initial		Final		Notes					
Height =	1.077	in	1.091	in	USCS description (ASTM D2487):	Fat clay, olive gray, moist				
Diameter =	2.00	in	2.00	in	Atterberg Limits (ASTM D4318):	LL = 121	PL = 36		PI = 85	
Area =	3.14	in^2	3.14	in^2	Percent Finer (ASTM D422):	3/4 in. = 100%	No. 4 = 100%		No. 200 = 95%	
Volume =	3.38	in^3	3.43	in^3	Specimen Type:	X	Intact		Reconstituted	
Water Content =	45.4%		49.1%		Remold Targets:	Not applicable				
Specific Gravity =	2.74	(Assumed)	2.74	(Assumed)	Water Content of Trimmings (ASTM D2216):	47.1%				
Height of Solids =	0.4251	in	0.4251	in	Trimming Procedure:	Specimen trimmed using a cylindrical cutting tool				
Void Ratio =	1.533		1.566		Inundation:		Not inundated	X	Inundated at	0.1 ksf
Degree of Saturation =	81.1%		85.9%		Test Method:		A	X	B	
Wet Mass =	0.192	lb	0.197	lb	Apparatus:	GeoTac automated consolidometer				
Dry Mass =	0.132	lb	0.132	lb	Final Water Content Specimen:	X	Entire		Partial	
Wet Unit Weight =	98.0	pcf	99.2	pcf	Final Differential Height:	-0.0082 in				
Dry Unit Weight =	67.4	pcf	66.5	pcf	Estimated Preconsolidation Stress:	--				

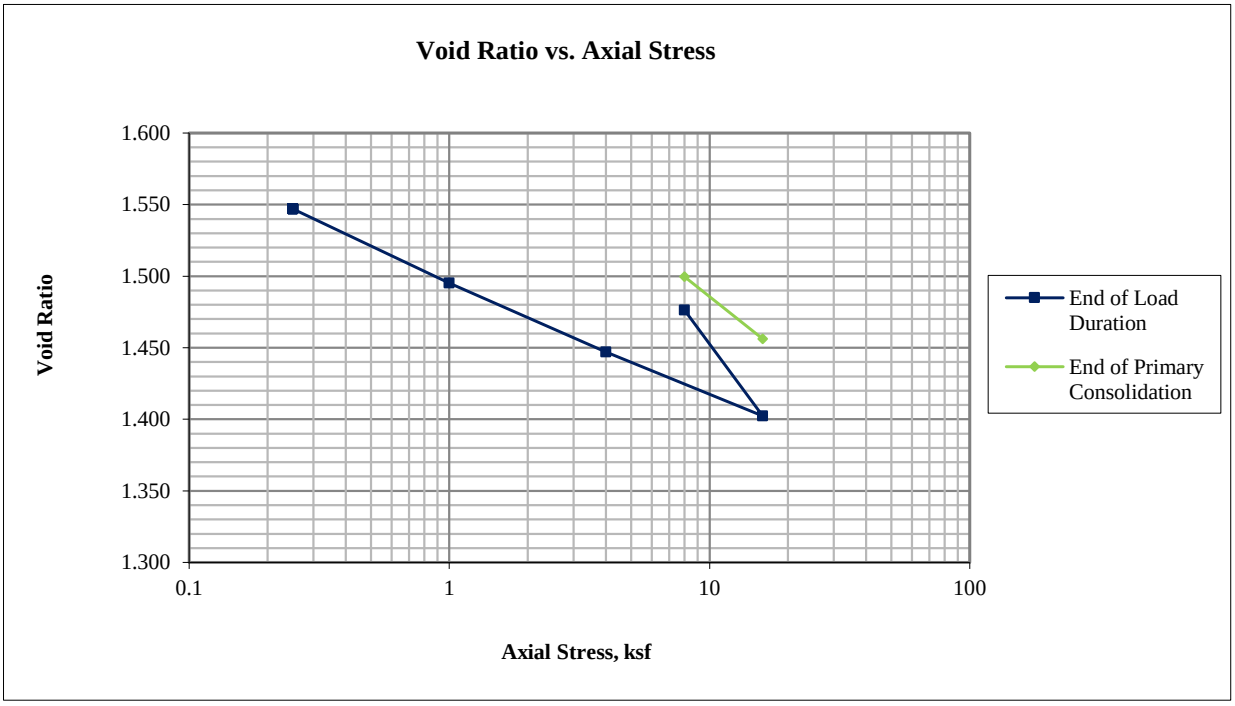
			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	3.05	1482					0.0000	1.0711	0.00	1.519				
1	8.0	1717	0.0084	1.0627	0.78	1.500	0.0183	1.0528	1.70	1.476	2 (Root time)	1.509	4.924	0.1
2	16.0	4320	0.0269	1.0442	2.50	1.456	0.0498	1.0213	4.62	1.402	2 (Root time)	1.460	3.623	0.2
3	4.0	2810					0.0308	1.0403	2.86	1.447				
4	1.0	3198					0.0103	1.0608	0.96	1.495				
5	0.25	10000					-0.0117	1.0828	-1.09	1.547				

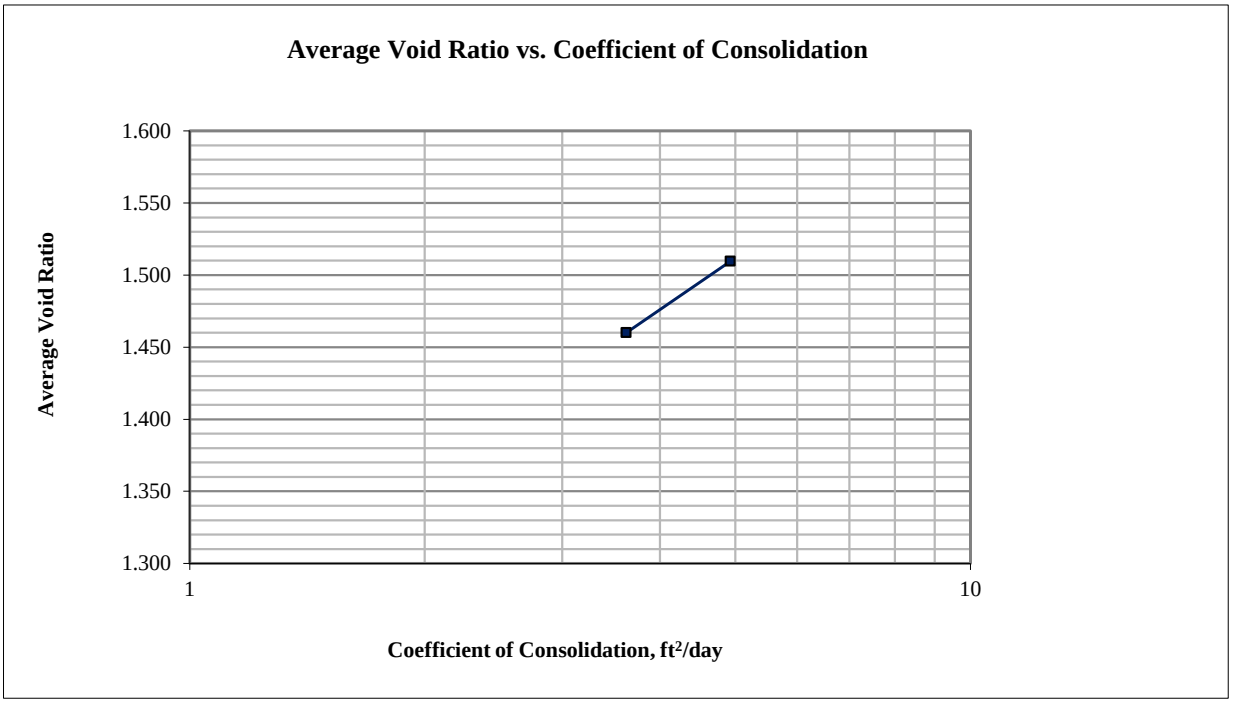
*Axial stress of 3.05 ksf was required to prevent swelling.

Golder Associates Inc.

Title:
ASTM D2435
ONE-DIMENSIONAL CONSOLIDATION TEST REPORT
SPECIMEN AND SUMMARY DATA

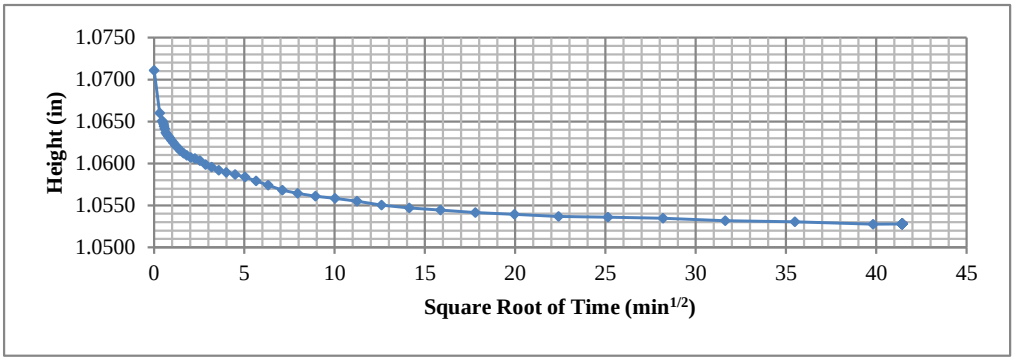
Job Short Title:					
MDA/Grassy Mtn PFS/OR					
Sample:	**Technician:**	**Reviewed:**	**Start Date:**	**Job Number:**	**Figure:**
BH-6 / S2 @ 10.0 - 11.5 ft.	PRH	MK	27-Mar-2018	1663241.11000	1



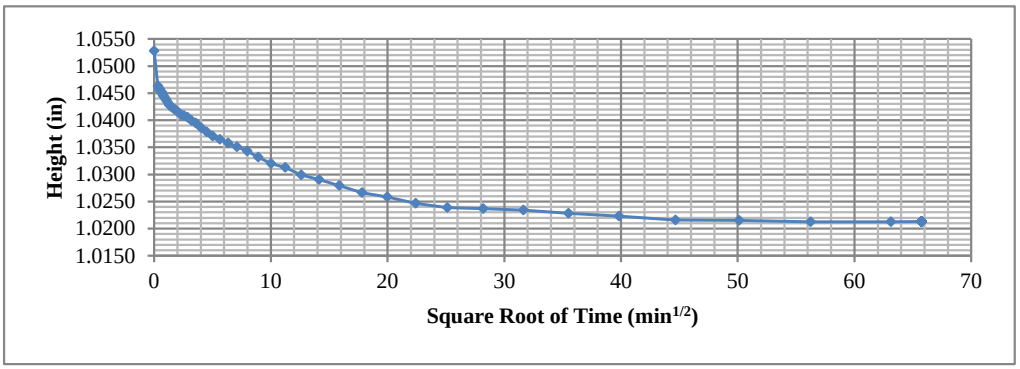


Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S2 @ 10.0 - 11.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 2

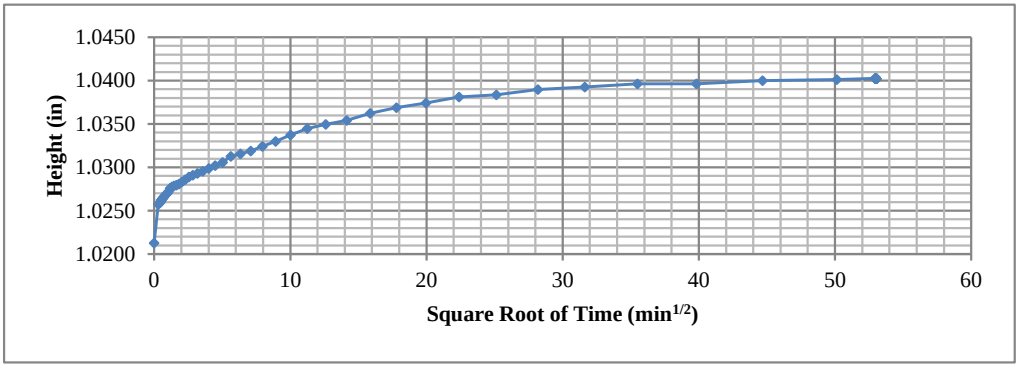
8.0 ksf



16.0 ksf

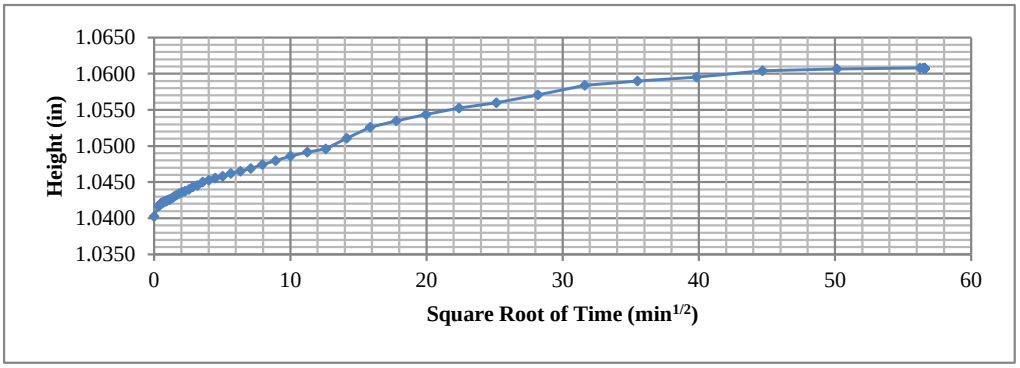


4.0 ksf - Rebound

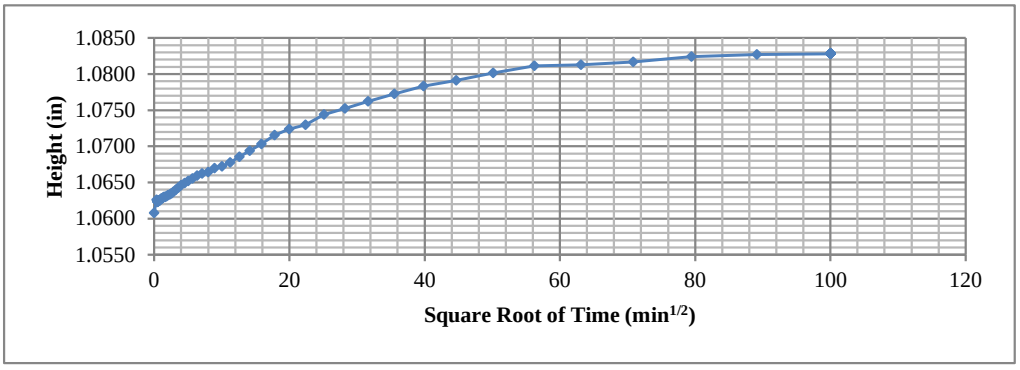


Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT TIME-DEFORMATION PLOTS (1)				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S2 @ 10.0 - 11.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 3

1.0 ksf - Rebound



0.25 ksf - Rebound



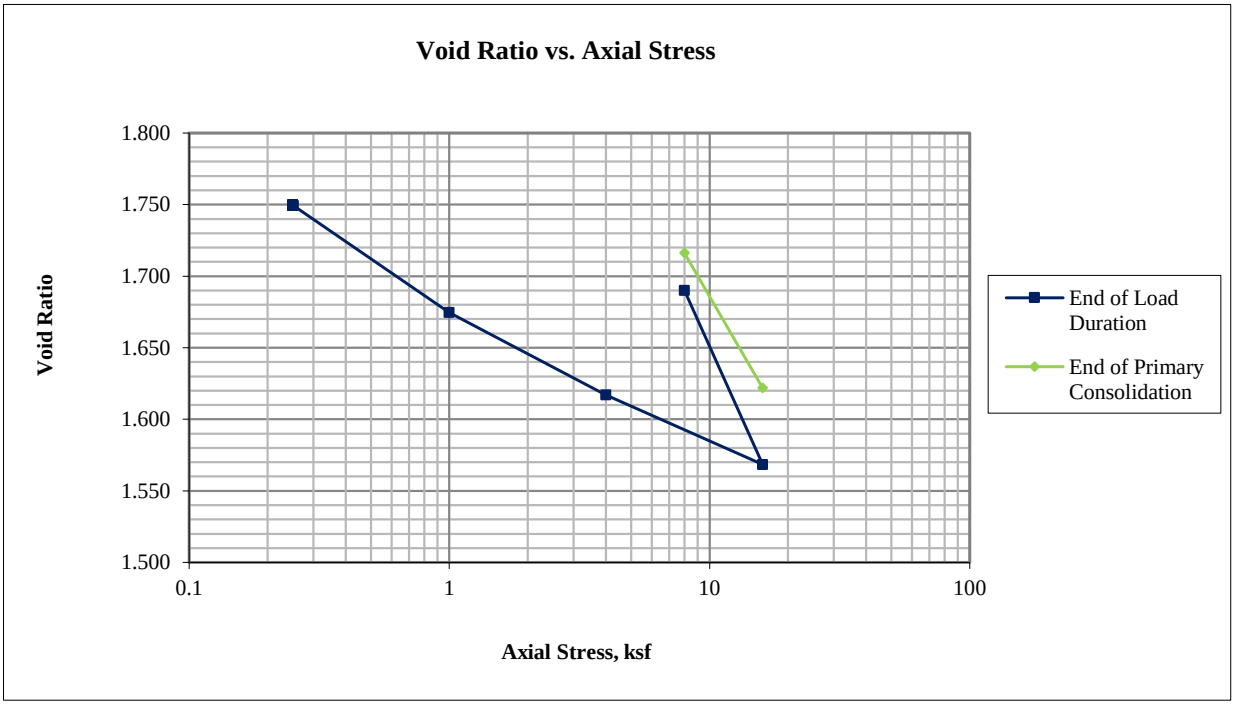
Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT TIME-DEFORMATION PLOTS (2)				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-6 / S2 @ 10.0 - 11.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 4

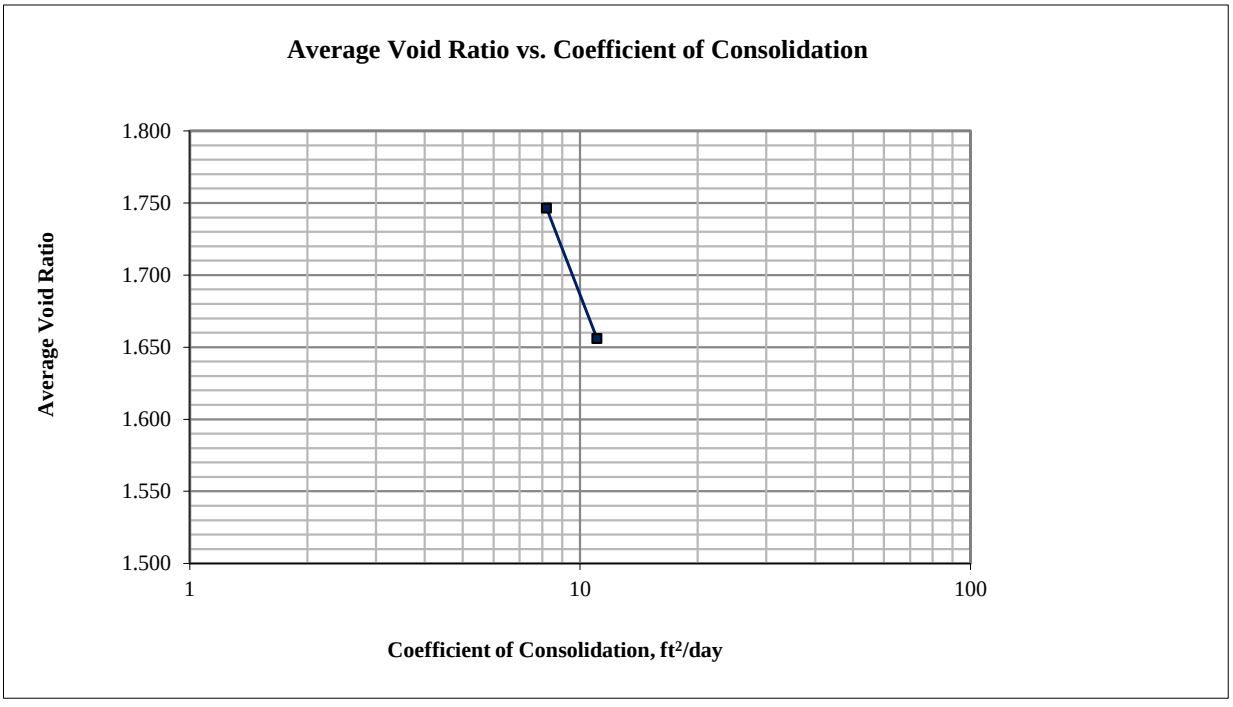
	Initial		Final		Notes					
Height =	1.074	in	1.072	in	USCS description (ASTM D2487):	Lean clay with sand, olive, moist				
Diameter =	2.00	in	2.00	in	Atterberg Limits (ASTM D4318):	LL = 134	PL = 40		PI = 94	
Area =	3.14	in^2	3.14	in^2	Percent Finer (ASTM D422):	3/4 in. = 100%	No. 4 = 100%		No. 200 = 81%	
Volume =	3.37	in^3	3.37	in^3	Specimen Type:	X	Intact		Reconstituted	
Water Content =	38.5%		56.3%		Remold Targets:	Not applicable				
Specific Gravity =	2.74	(Assumed)	2.74	(Assumed)	Water Content of Trimmings (ASTM D2216):	37.4%				
Height of Solids =	0.3868	in	0.3868	in	Trimming Procedure:	Specimen trimmed using a cylindrical cutting tool				
Void Ratio =	1.777		1.771		Inundation:		Not inundated	X	Inundated at	0.1 ksf
Degree of Saturation =	59.4%		87.1%		Test Method:		A	X	B	
Wet Mass =	0.166	lb	0.188	lb	Apparatus:	GeoTac automated consolidometer				
Dry Mass =	0.120	lb	0.120	lb	Final Water Content Specimen:	X	Entire		Partial	
Wet Unit Weight =	85.2	pcf	96.3	pcf	Final Differential Height:	-0.0084 in				
Dry Unit Weight =	61.5	pcf	61.6	pcf	Estimated Preconsolidation Stress:	--				

			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	2.84	1451					0.0000	1.0740	0.00	1.777				
1	8.00	1636	0.0234	1.0507	2.18	1.716	0.0335	1.0405	3.12	1.690	2 (Root time)	1.746	8.205	0.05
2	16.00	2880	0.0599	1.0142	5.58	1.622	0.0805	0.9935	7.50	1.568	2 (Root time)	1.656	11.049	0.04
3	4.00	1440					0.0618	1.0123	5.75	1.617				
4	1.00	2880					0.0395	1.0346	3.67	1.675				
5	0.25	14400					0.0104	1.0636	0.97	1.750				

*Axial stress of 2.84 ksf was required to prevent swelling.

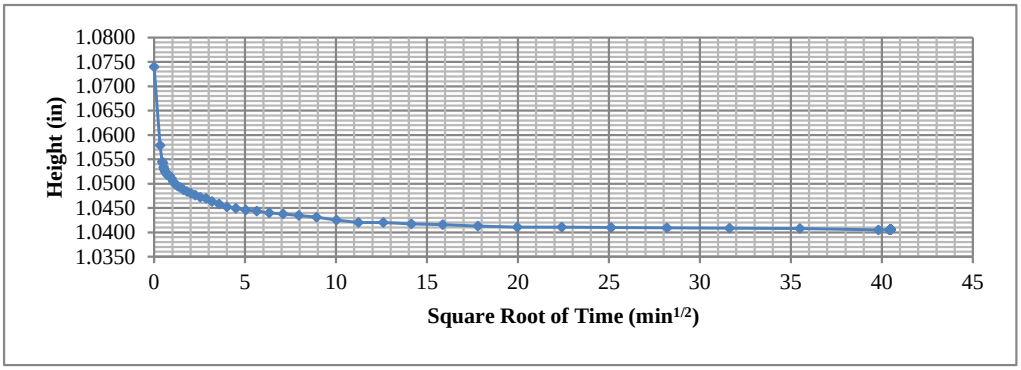
Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT SPECIMEN AND SUMMARY DATA				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S1 @ 15.0 - 16.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 1



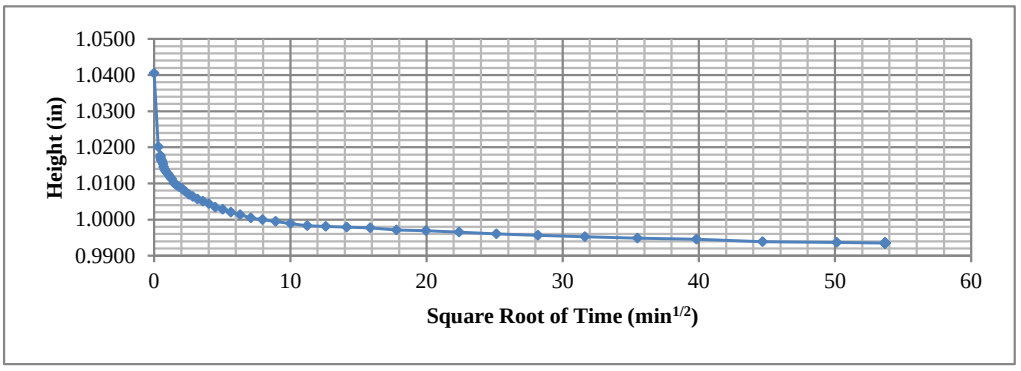


Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S1 @ 15.0 - 16.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 2

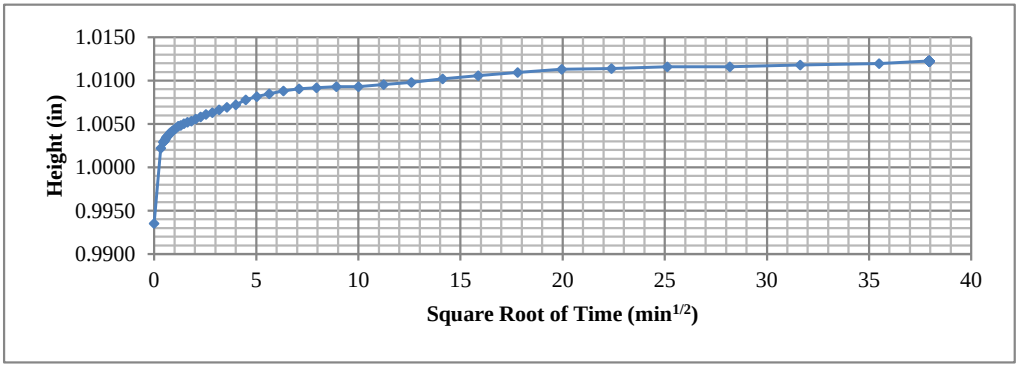
8.0 ksf



16.0 ksf

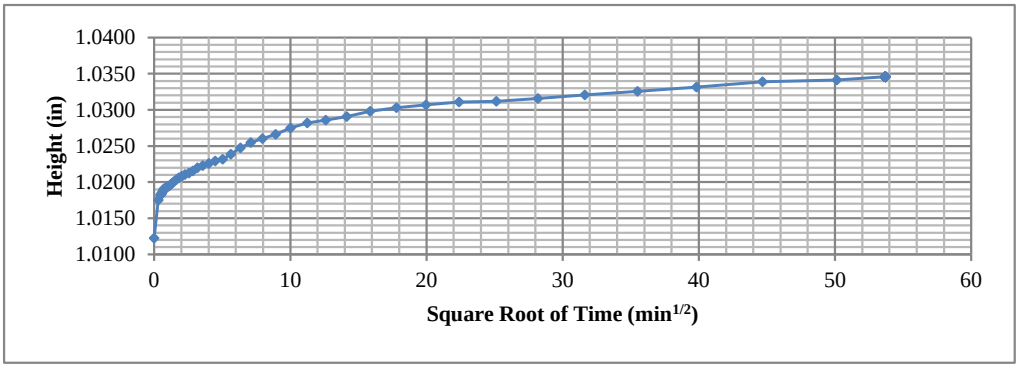


4.0 ksf - Rebound

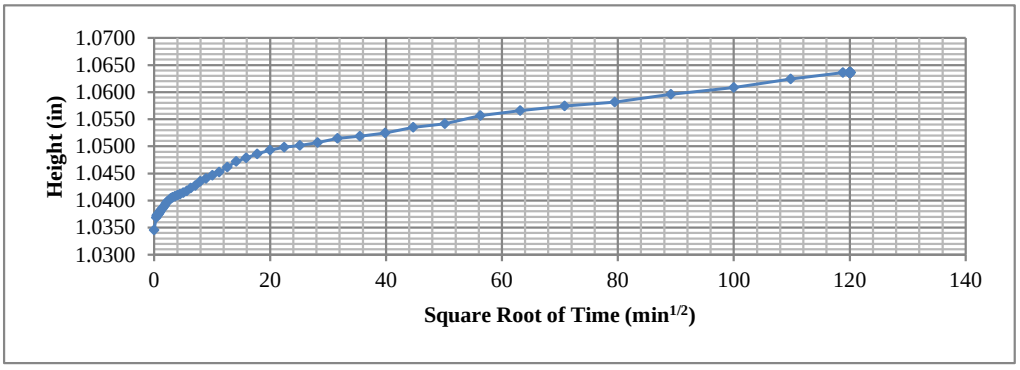


Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT TIME-DEFORMATION PLOTS (1)				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S1 @ 15.0 - 16.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 3

1.0 ksf - Rebound



0.25 ksf - Rebound



Golder Associates Inc.	**Title:** ASTM D2435 ONE-DIMENSIONAL CONSOLIDATION TEST REPORT TIME-DEFORMATION PLOTS (2)				
Job Short Title: MDA/Grassy Mtn PFS/OR					
Sample: BH-15 / S1 @ 15.0 - 16.5 ft.	**Technician:** PRH	**Reviewed:** MK	**Start Date:** 27-Mar-2018	**Job Number:** 1663241.11000	**Figure:** 4

GOLDER

	Initial		Final		Notes
Height =	1.003	in	0.960	in	USCS description (ASTM D2487): Fat clay, olive brown, moist
Diameter =	2.42	in	2.42	in	Atterberg Limits (ASTM D4318): LL = 99 PL = 31 PI = 68
Area =	4.60	in^2	4.60	in^2	Percent Finer (ASTM D422): 3/4 in. = 100% No. 4 = 100% No. 200 = 97%
Volume =	4.61	in^3	4.42	in^3	Specimen Type: [X] Intact [ ] Reconstituted
Water Content =	51.5%		55.3%		Remold Targets: Not applicable
Specific Gravity =	2.69	(ASTM D854)	2.69	(ASTM D854)	Water Content of Trimmings (ASTM D2216): 45.1%
Height of Solids =	0.391	in	0.391	in	Trimming Procedure: Specimen trimmed using cylindrical trimming tool
Void Ratio =	1.567		1.457		Inundation: [ ] Not inundated [X] Inundated at 0.1 ksf
Degree of Saturation =	88.5%		102.1%		Test Method: [ ] A [X] B
Wet Mass =	0.264	lb	0.271	lb	Apparatus: Frame No. 5
Dry Mass =	0.174	lb	0.174	lb	Final Water Content Specimen: [X] Entire [ ] Partial
Wet Unit Weight =	99.0	pcf	106.0	pcf	Final Differential Height: 0.0018 in
Dry Unit Weight =	65.3	pcf	68.2	pcf	Estimated Preconsolidation Stress: -- ksf

			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	2.14	1440					0.0000	1.0055	0.00	1.573				
1	4.0	1440	0.0109	0.9946	1.09	1.545	0.0116	0.9939	1.16	1.543	1 (Log time)	1.555	0.046	10.6
2	8.0	1440	0.0390	0.9665	3.89	1.473	0.0405	0.9650	4.04	1.469	1 (Log time)	1.495	0.054	8.6
3	16.0	1440	0.0750	0.9305	7.48	1.381	0.0760	0.9295	7.58	1.379	1 (Log time)	1.414	0.011	39.0
4	32.0	2880	0.1175	0.8880	11.71	1.272	0.1190	0.8865	11.86	1.268	1 (Log time)	1.318	0.003	160.0
5	64.0	2880	0.1646	0.8409	16.41	1.152	0.1671	0.8384	16.66	1.145	1 (Log time)	1.208	0.002	206.0
6	16.0	2940					0.1315	0.8740	13.11	1.237				
7	4.0	2880					0.0905	0.9150	9.02	1.341				
8	1.0	5400					0.0437	0.9618	4.36	1.461				

*Axial stress of 2.14 ksf was required to prevent swelling.

Project Name: MDA/Grassy Mtn PFS/OR

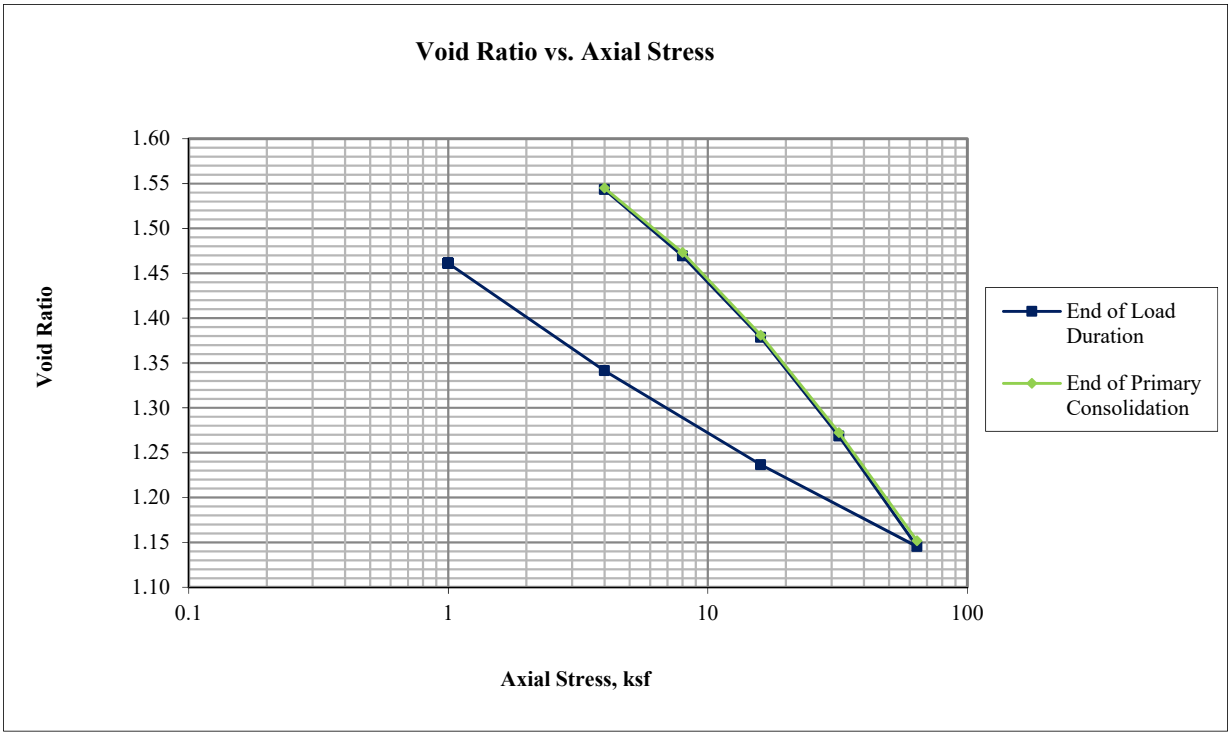
Project Number: 1663241.22000

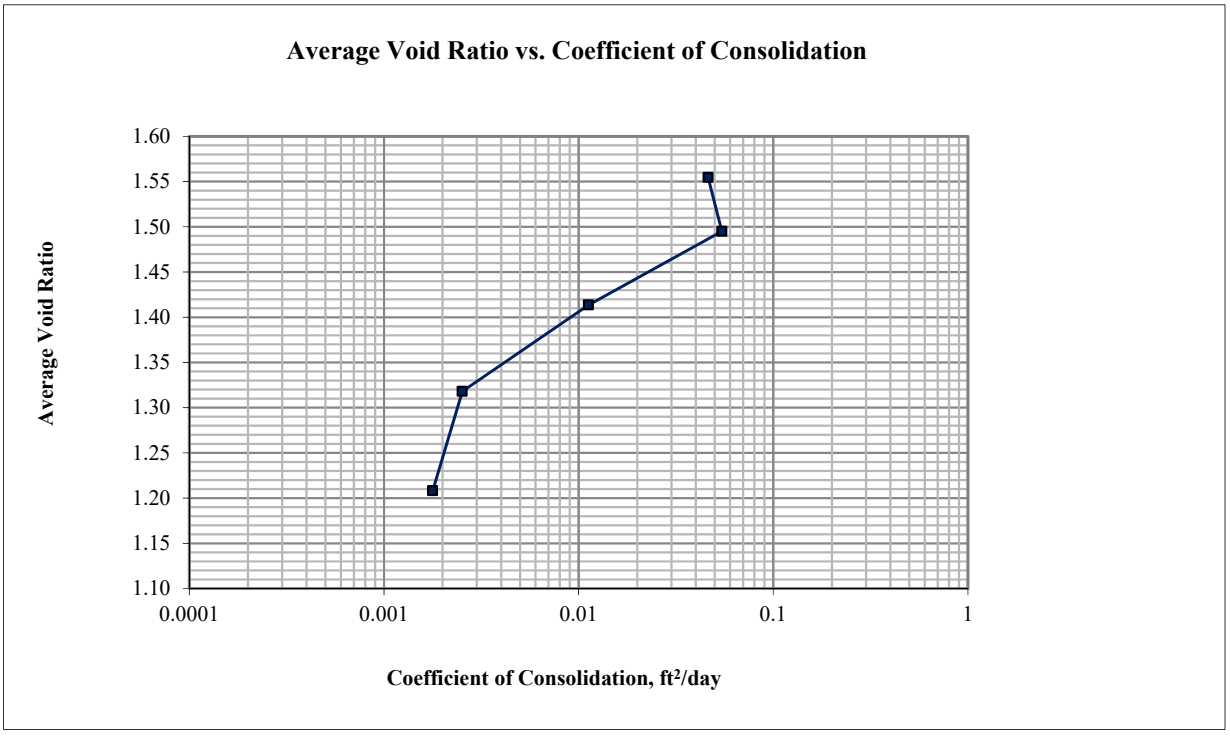
ASTM D2435

ONE-DIMENSIONAL CONSOLIDATION TEST REPORT
SPECIMEN AND SUMMARY DATA

Sample ID:	Technician:	Checked:	Reviewed:	Date:	Figure:
BH19-TP-23 @ 30 - 30.5 ft.	PRH	PRH	CPA	13-Aug-2019	1

GOLDER

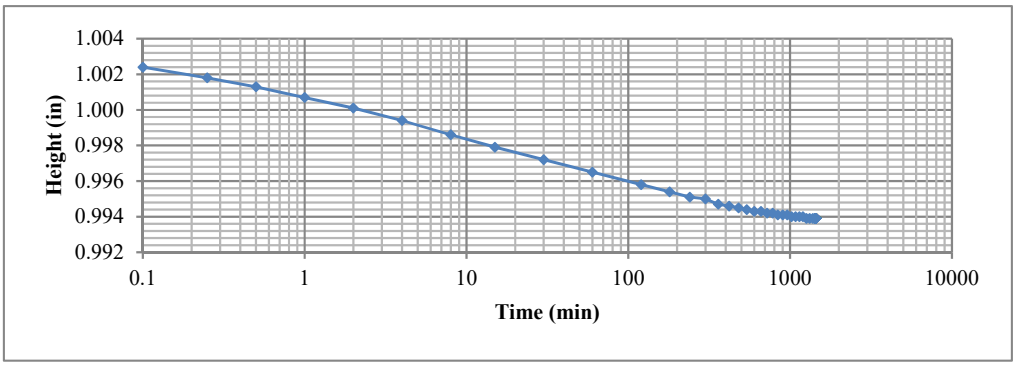




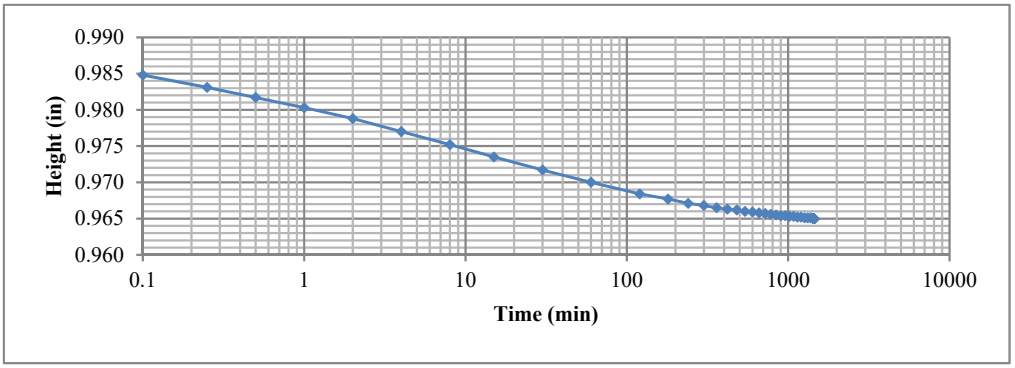
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 30 - 30.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 13-Aug-2019	**Figure:** 2

GOLDER

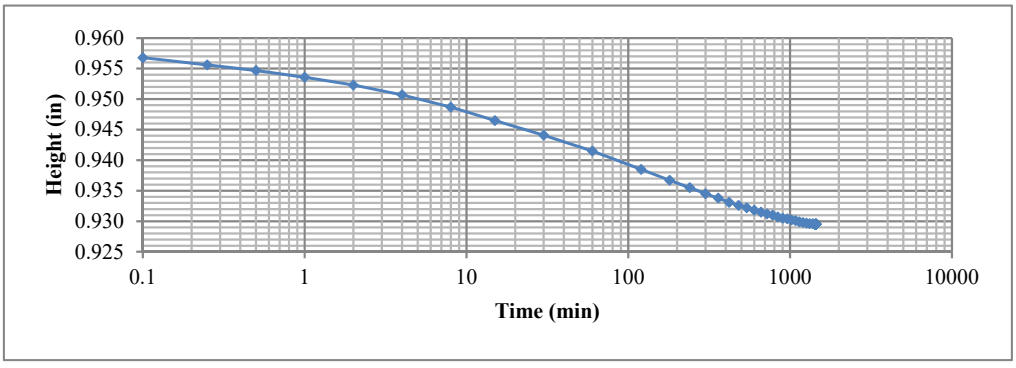
4.0 ksf



8.0 ksf



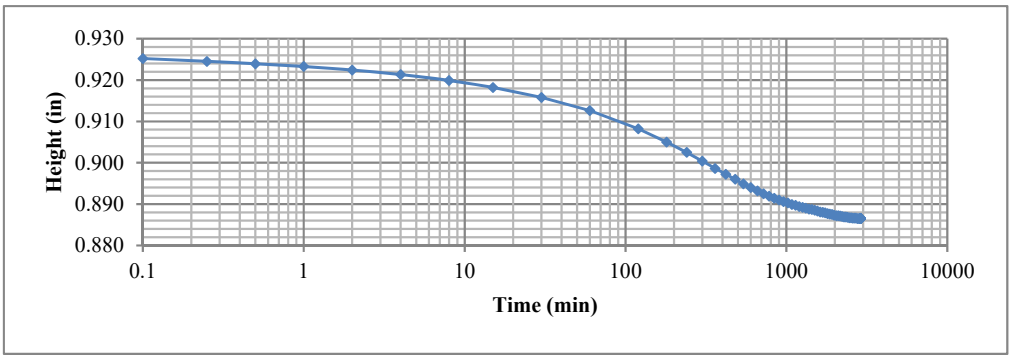
16.0 ksf



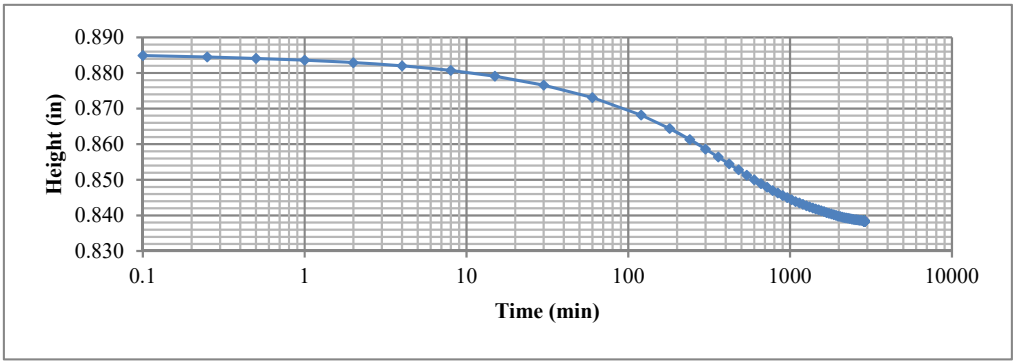
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (1)					
Project Number: 1663241.22000						
Sample ID: BH19-TP-23 @ 30 - 30.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 13-Aug-2019	**Figure:** 3	

GOLDER

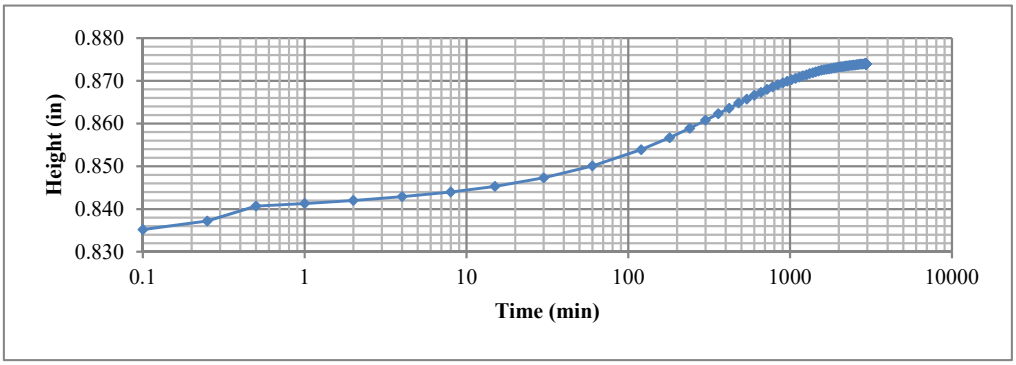
32.0 ksf



64.0 ksf

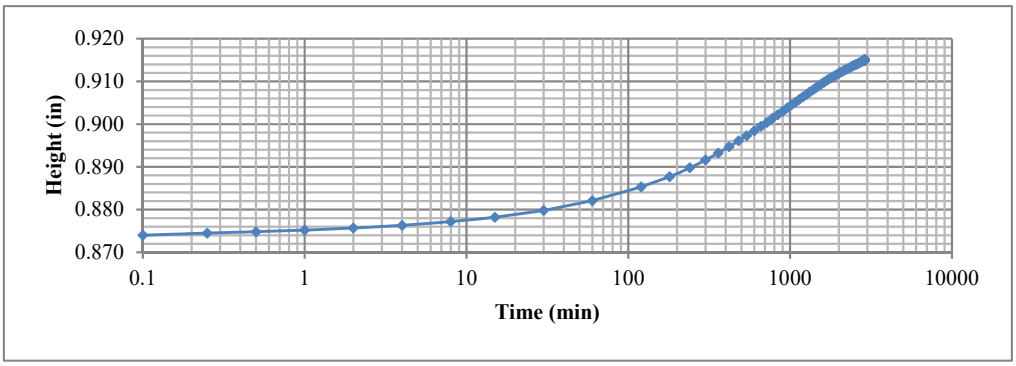


16.0 ksf - Unload

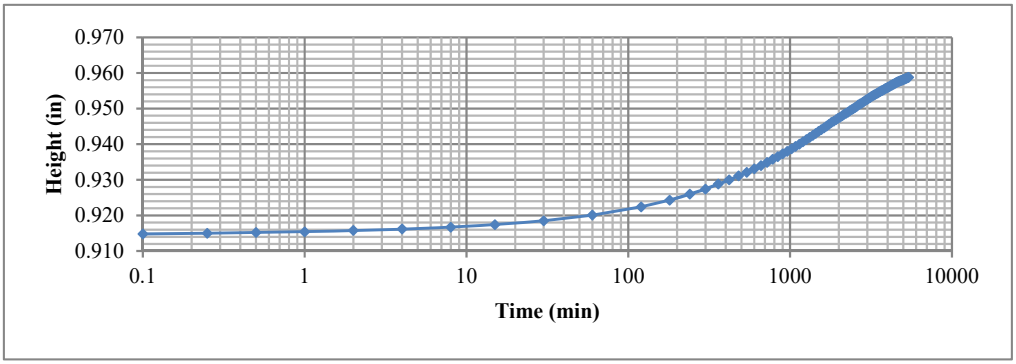


Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (2)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 30 - 30.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 13-Aug-2019	**Figure:** 4

4.0 ksf - Unload



1.0 ksf - Unload



Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (3)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 30 - 30.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 13-Aug-2019	**Figure:** 5

GOLDER

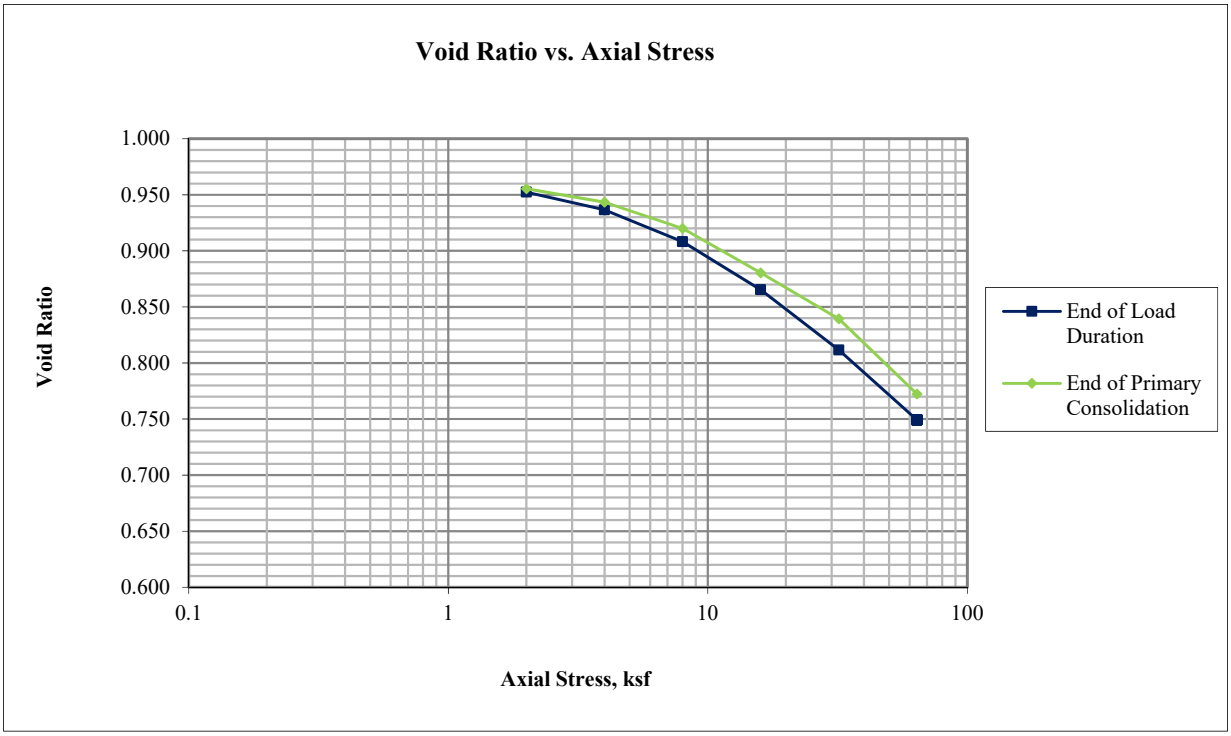
	Initial		Final		Notes
Height =	1.003	in	0.925	in	USCS description (ASTM D2487): Lean clay, pale brown, moist
Diameter =	2.420	in	2.420	in	Atterberg Limits (ASTM D4318): LL = 49 PL = 23 PI = 26
Area =	4.600	in^2	4.600	in^2	Percent Finer (ASTM D422): 3/4 in. = 100% No. 4 = 100% No. 200 = 93%
Volume =	4.613	in^3	4.255	in^3	Specimen Type: [X] Intact [ ] Reconstituted
Water Content =	31.0%		29.5%		Remold Targets: Not applicable
Specific Gravity =	2.66	(ASTM D854)	2.66	(ASTM D854)	Water Content of Trimmings (ASTM D2216): 29.6%
Height of Solids =	0.5133	in	0.5133	in	Trimming Procedure: Specimen trimmed using cylindrical cutting tool
Void Ratio =	0.954		0.802		Inundation: [ ] Not inundated [X] Inundated at 0.1 ksf
Degree of Saturation =	86.5%		97.8%		Test Method: [ ] A [X] B
Wet Mass =	0.297	lb	0.293	lb	Apparatus: Frame No. 5
Dry Mass =	0.226	lb	0.226	lb	Final Water Content Specimen: [X] Entire [ ] Partial
Wet Unit Weight =	111.2	pcf	119.1	pcf	Final Differential Height: -0.0271 in
Dry Unit Weight =	84.8	pcf	92.0	pcf	Estimated Preconsolidation Stress: 10.4 ksf

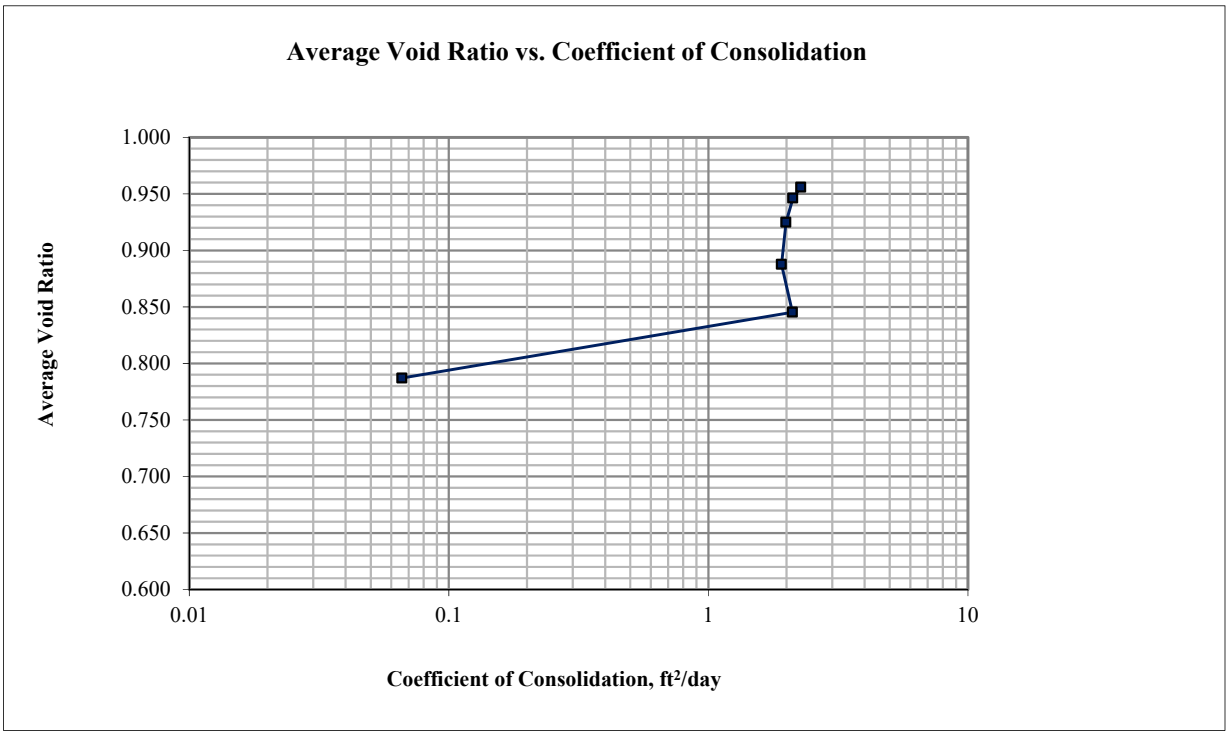
			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	1.47	1380					0.0000	1.0045	0.00	0.957				
1	2.0	1440	0.0007	1.0038	0.07	0.955	0.0023	1.0022	0.23	0.952	2 (Root time)	0.956	2.271	0.2
2	4.0	1430	0.0069	0.9976	0.69	0.943	0.0104	0.9941	1.04	0.937	2 (Root time)	0.946	2.116	0.2
3	8.0	1440	0.0189	0.9856	1.88	0.920	0.0250	0.9795	2.49	0.908	2 (Root time)	0.925	1.989	0.2
4	16.0	1800	0.0392	0.9653	3.91	0.880	0.0470	0.9575	4.69	0.865	2 (Root time)	0.888	1.913	0.2
5	32.0	5400	0.0603	0.9442	6.01	0.839	0.0746	0.9299	7.44	0.812	2 (Root time)	0.845	2.108	0.2
6	64.0	1860	0.0947	0.9098	9.44	0.772	0.1066	0.8979	10.63	0.749	2 (Root time)	0.787	0.066	6.5

*Axial stress of 1.47 ksf was required to prevent swelling.

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT SPECIMEN AND SUMMARY DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 45.0 - 45.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 2-Sep-2019	**Figure:** 1

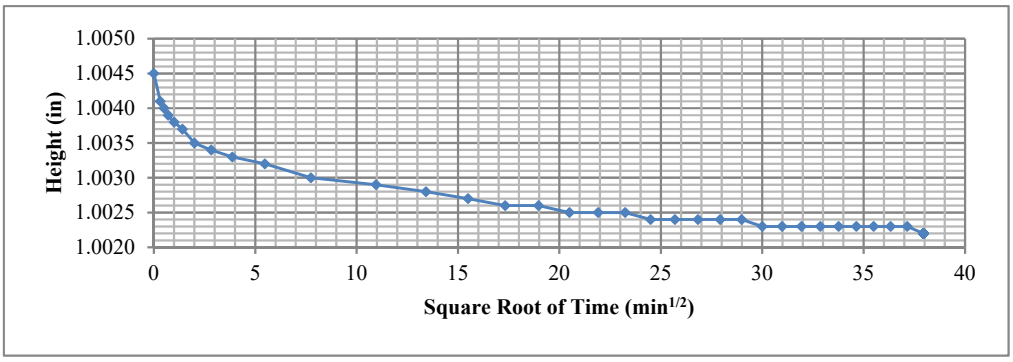
GOLDER



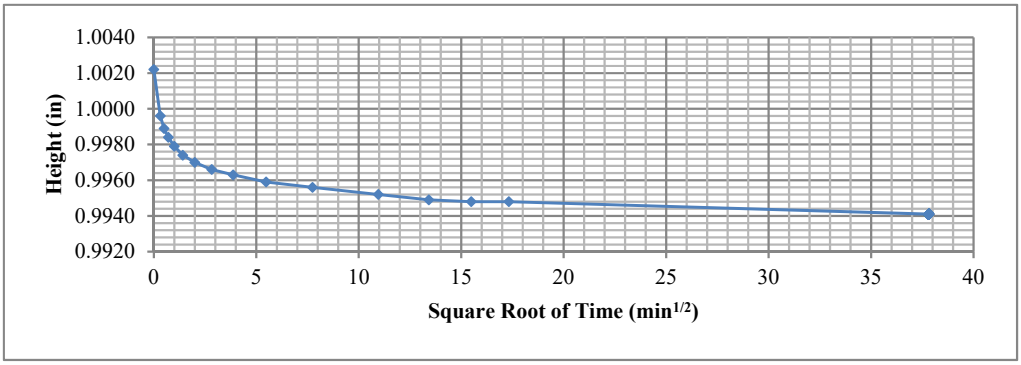


Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 45.0 - 45.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 2-Sep-2019	**Figure:** 2

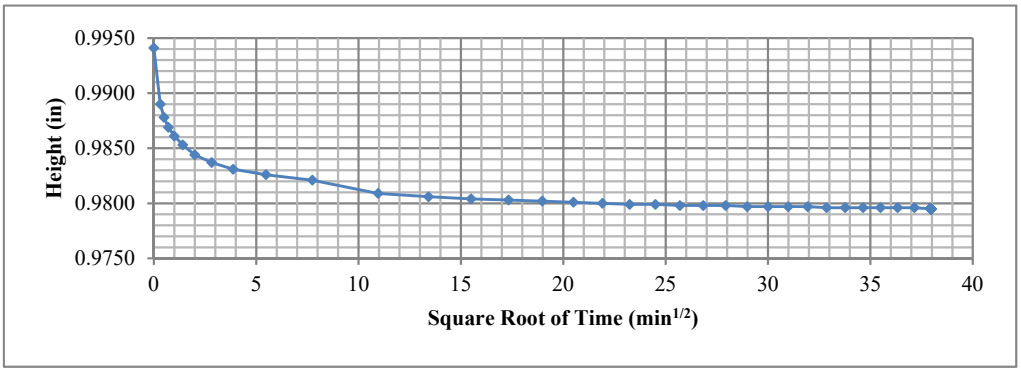
2.0 ksf



4.0 ksf



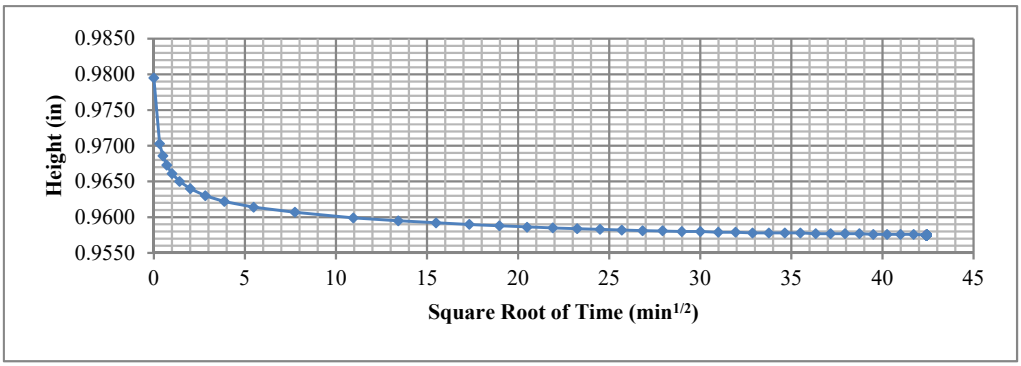
8.0 ksf



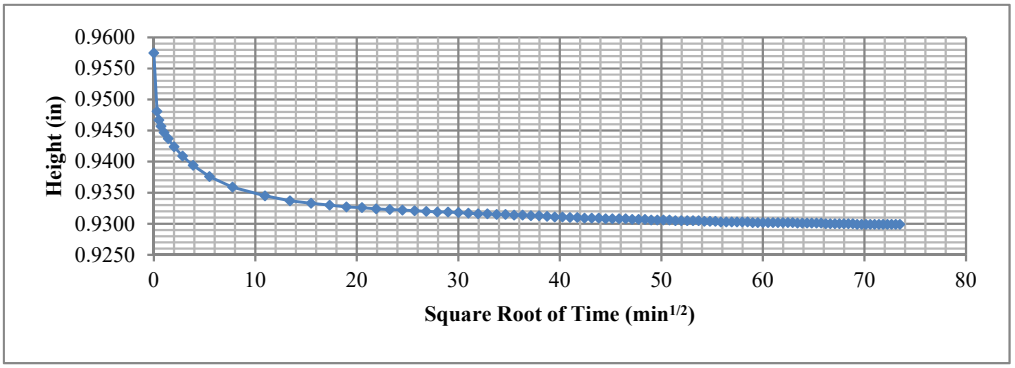
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (1)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 45.0 - 45.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 2-Sep-2019	**Figure:** 3

GOLDER

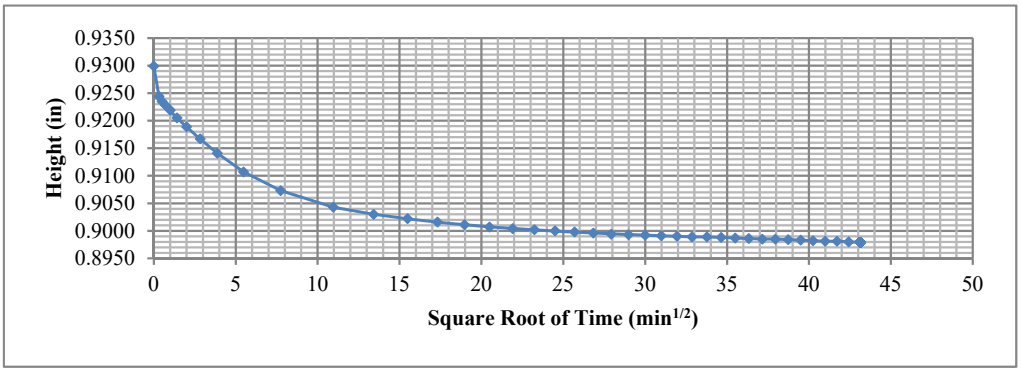
16.0 ksf



32.0 ksf



64.0 ksf



Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (2)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-23 @ 45.0 - 45.5 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 2-Sep-2019	**Figure:** 4

GOLDER

	Initial		Final		Notes
Height =	0.993	in	0.973	in	Visual description: Fat clay, some sand, light gray, moist
Diameter =	2.500	in	2.500	in	Atterberg Limits (ASTM D4318): LL = -- PL = -- PI = --
Area =	4.909	in^2	4.909	in^2	Percent Finer (ASTM D422): 3/4 in. = -- No. 4 = -- No. 200 = --
Volume =	4.874	in^3	4.776	in^3	Specimen Type: [X] Intact [ ] Reconstituted
Water Content =	43.2%		45.7%		Remold Targets: Not applicable
Specific Gravity =	2.81	(ASTM D854)	2.81	(ASTM D854)	Water Content of Trimmings (ASTM D2216): 37.9%
Height of Solids =	0.419	in	0.419	in	Trimming Procedure: Specimen trimmed using cylindrical cutting tool
Void Ratio =	1.368		1.320		Inundation: [ ] Not inundated [X] Inundated at 0.1 ksf
Degree of Saturation =	88.8%		97.3%		Test Method: [ ] A [X] B
Wet Mass =	0.299	lb	0.304	lb	Apparatus: Frame No. 6
Dry Mass =	0.209	lb	0.209	lb	Final Water Content Specimen: [X] Entire [ ] Partial
Wet Unit Weight =	105.9	pcf	110.0	pcf	Final Differential Height: -0.0081 in
Dry Unit Weight =	74.0	pcf	75.5	pcf	Estimated Preconsolidation Stress: -- ksf

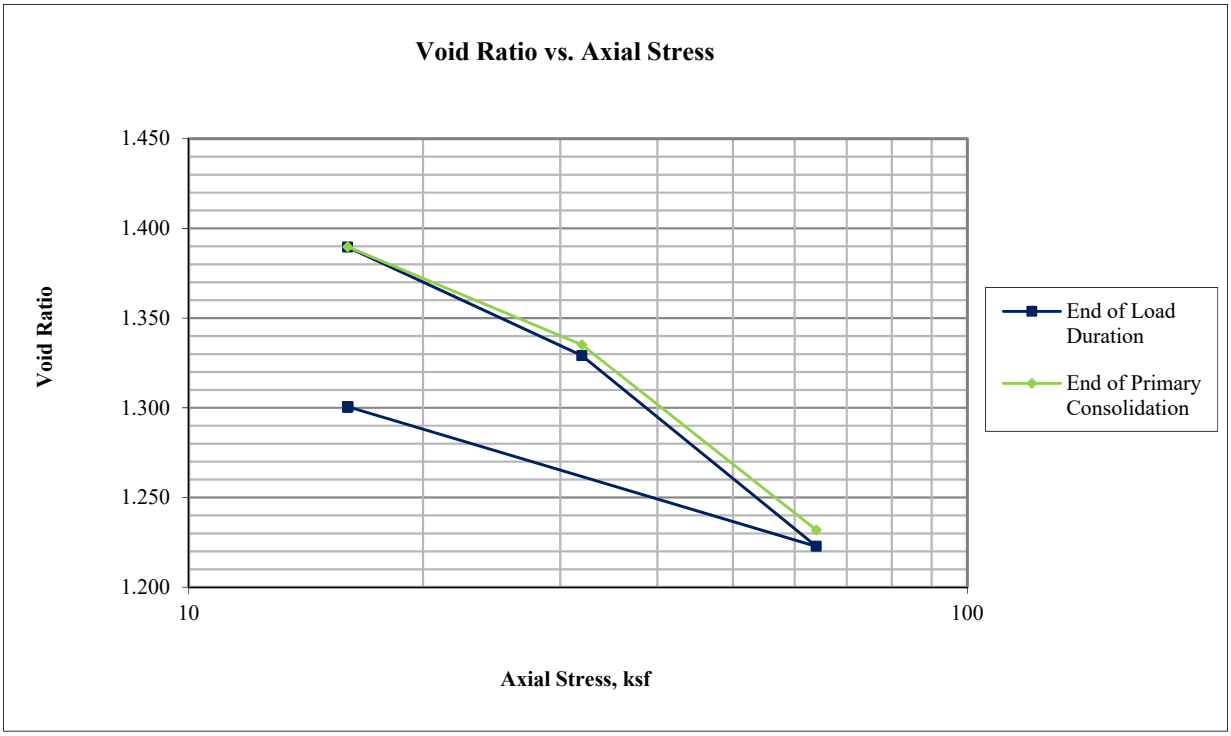
-- indicates test was not performed

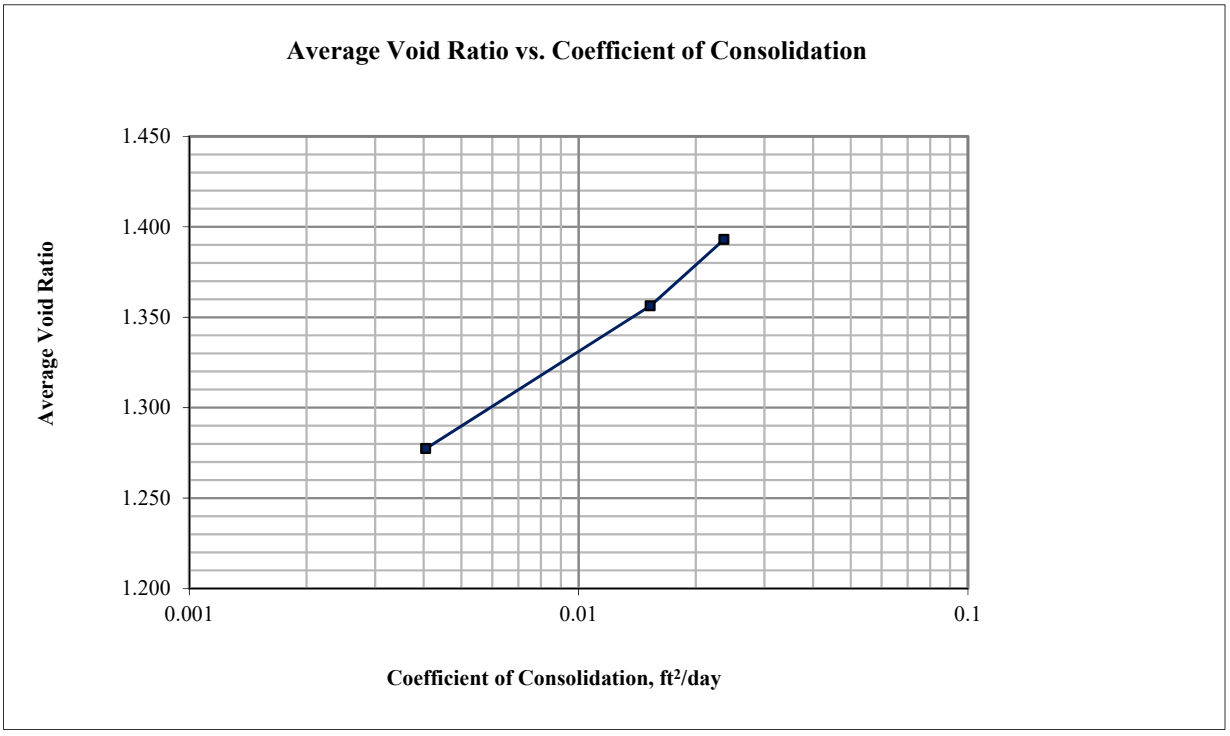
			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	12.3	1425					0.0000	1.0049	0.00	1.396				
1	16.0	1320	0.0026	1.0023	0.26	1.390	0.0027	1.0022	0.27	1.390	1 (Log time)	1.393	0.024	21.0
2	32.0	4260	0.0255	0.9794	2.56	1.335	0.0280	0.9769	2.82	1.329	1 (Log time)	1.356	0.015	31.5
3	64.0	3000	0.0688	0.9361	6.92	1.232	0.0726	0.9323	7.31	1.223	1 (Log time)	1.277	0.004	111.0
4	16.0	1860					0.0400	0.9649	4.02	1.301				

*Axial stress of 12.3 ksf was required to prevent swelling.

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT SPECIMEN AND SUMMARY DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 20 - 22 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Sep-2019	**Figure:** 1

GOLDER

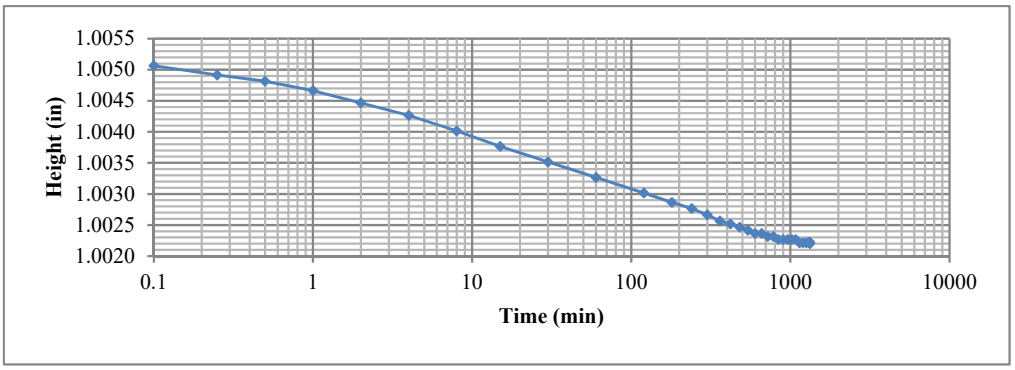




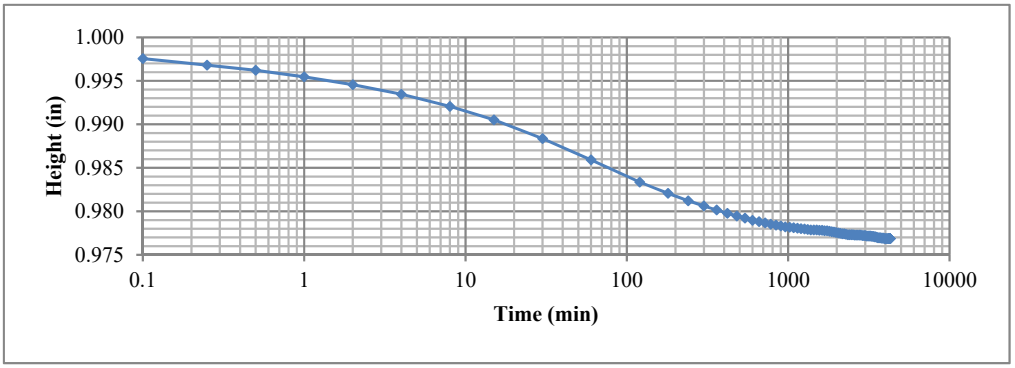
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 20 - 22 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Sep-2019	**Figure:** 2

GOLDER

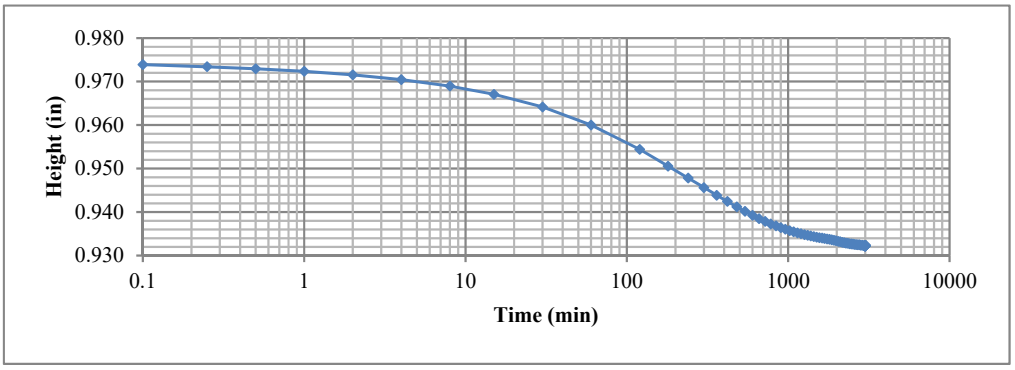
16.0 ksf



32.0 ksf

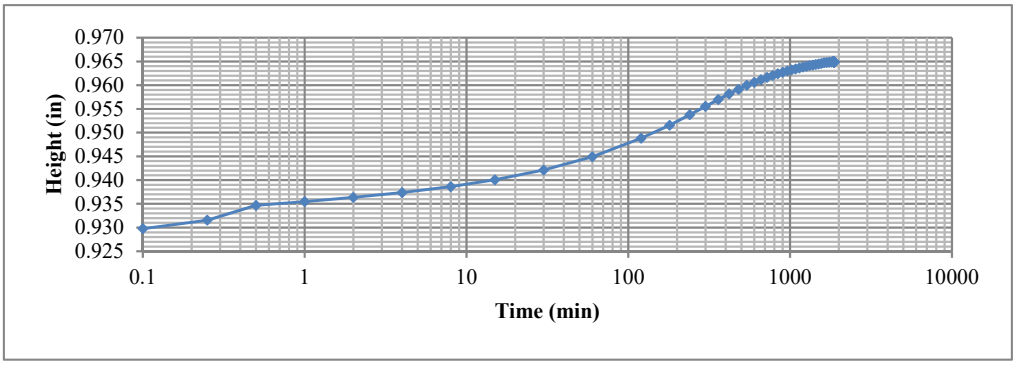


64.0 ksf



Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (1)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 20 - 22 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Sep-2019	**Figure:** 3

16.0 ksf - unload



Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (2)					
Project Number: 1663241.22000						
Sample ID: BH19-TP-44 @ 20 - 22 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 3-Sep-2019	**Figure:** 4	

GOLDER

	Initial		Final		Notes
Height =	0.995	in	0.951	in	Visual description: Fat clay, brown, moist
Diameter =	2.500	in	2.500	in	Atterberg Limits (ASTM D4318): LL = -- PL = -- PI = --
Area =	4.909	in^2	4.909	in^2	Percent Finer (ASTM D422): 3/4 in. = -- No. 4 = -- No. 200 = --
Volume =	4.884	in^3	4.668	in^3	Specimen Type: [X] Intact [ ] Reconstituted
Water Content =	44.6%		43.0%		Remold Targets: Not applicable
Specific Gravity =	2.72	(ASTM D854)	2.72	(ASTM D854)	Water Content of Trimmings (ASTM D2216): 45.1%
Height of Solids =	0.4388	in	0.4388	in	Trimming Procedure: Specimen trimmed using cylindrical cutting tool
Void Ratio =	1.267		1.167		Inundation: [ ] Not inundated [X] Inundated at 0.1 ksf
Degree of Saturation =	95.8%		100%		Test Method: [ ] A [X] B
Wet Mass =	0.306	lb	0.302	lb	Apparatus: Frame No. 6
Dry Mass =	0.211	lb	0.211	lb	Final Water Content Specimen: [X] Entire [ ] Partial
Wet Unit Weight =	108.1	pcf	111.8	pcf	Final Differential Height: -0.0056 in
Dry Unit Weight =	74.8	pcf	78.2	pcf	Estimated Preconsolidation Stress: 20.2 ksf

-- indicates test was not performed

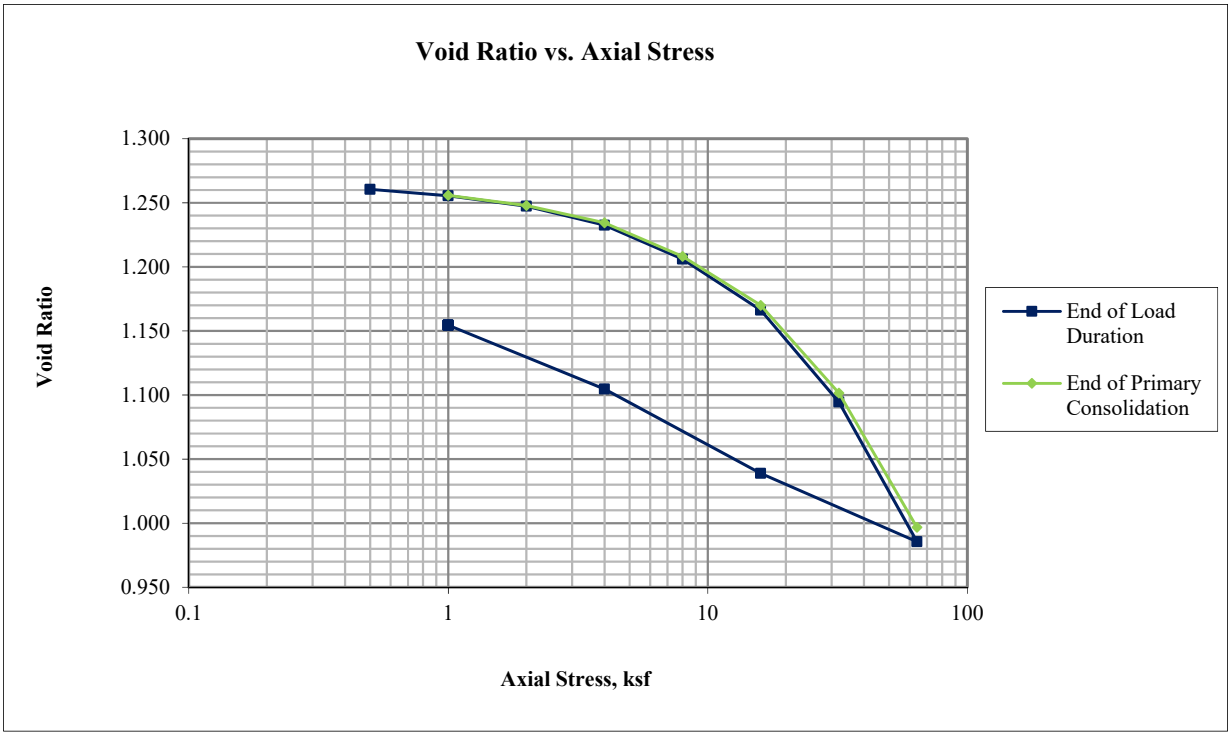
			At End of Primary Consolidation				At End of Load Duration							
	Axial Stress (ksf)	Load Duration (min)	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Deformation (in)	Specimen Height (in)	Axial Strain (%)	Void Ratio	Time Deformation Method	Average Void Ratio	Coefficient of Consolidation (ft^2/day)	Time to 50% Consolidation (min)
Seating*	0.28	1380					0.0000	0.9932	0.00	1.263				
1	0.50	1440					0.0012	0.9920	0.12	1.260				
2	1.00	1440	0.0032	0.9899	0.33	1.256	0.0034	0.9898	0.34	1.255	1 (Log time)	1.258	0.045	10.8
3	2.00	1440	0.0067	0.9864	0.68	1.248	0.0070	0.9862	0.70	1.247	1 (Log time)	1.251	0.038	12.8
4	4.00	1440	0.0127	0.9805	1.27	1.234	0.0135	0.9797	1.36	1.232	1 (Log time)	1.239	0.030	15.7
5	8.00	1440	0.0242	0.9690	2.43	1.208	0.0251	0.9681	2.52	1.206	1 (Log time)	1.218	0.028	16.8
6	16.00	1440	0.0409	0.9522	4.11	1.170	0.0426	0.9506	4.28	1.166	1 (Log time)	1.185	0.032	14.3
7	32.00	2880	0.0710	0.9222	7.13	1.102	0.0740	0.9191	7.44	1.094	1 (Log time)	1.131	0.022	19.7
8	64.00	2940	0.1170	0.8762	11.75	0.997	0.1219	0.8713	12.25	0.986	1 (Log time)	1.043	0.006	63.0
9	16.00	1620					0.0984	0.8947	9.89	1.039				
10	4.00	2520					0.0696	0.9236	6.99	1.105				
11	1.00	2880					0.0478	0.9454	4.80	1.154				

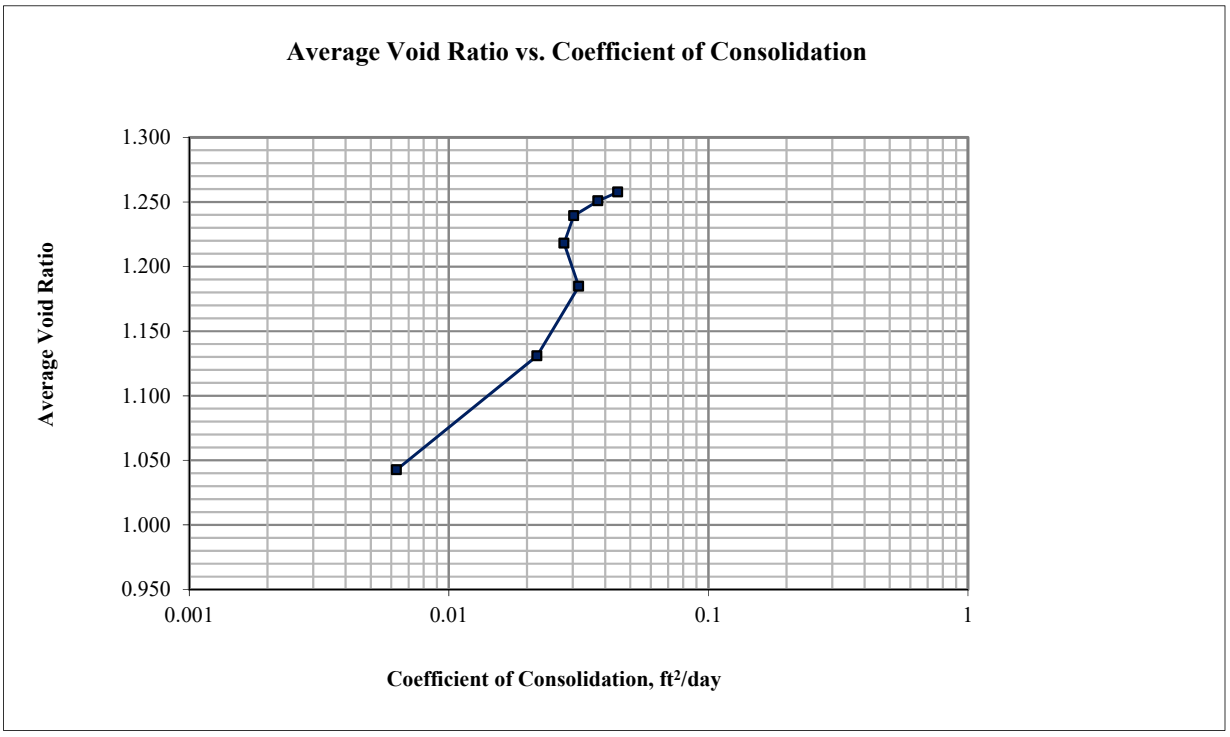
*Axial stress of 0.28 ksf was required to prevent swelling.

Specimen was initially set up for a CU triaxial test and partially saturated prior to being tested for one-dimensional consolidation properties.

Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT SPECIMEN AND SUMMARY DATA				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 1

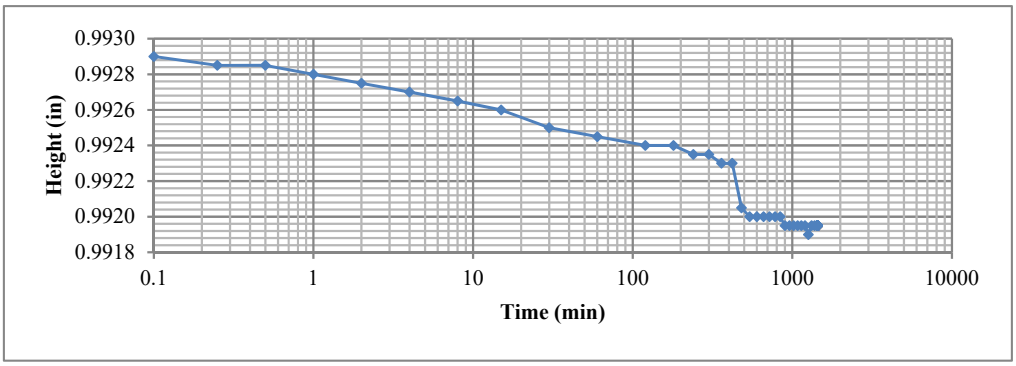
GOLDER



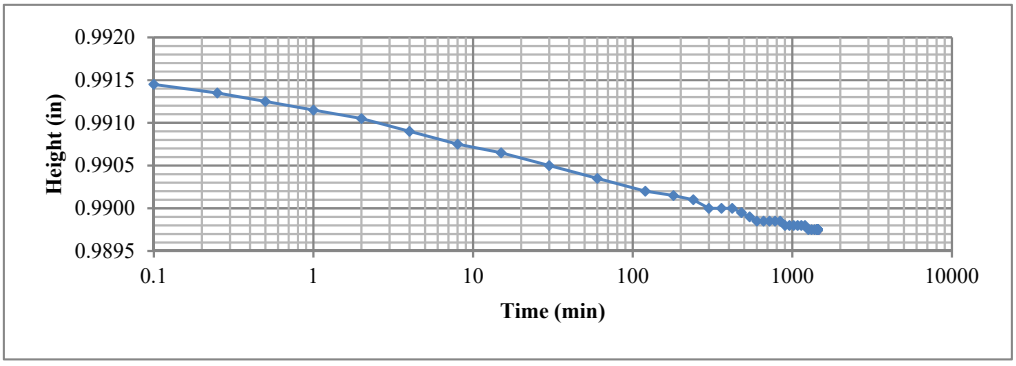


Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION TEST REPORT CONSOLIDATION PLOTS				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 2

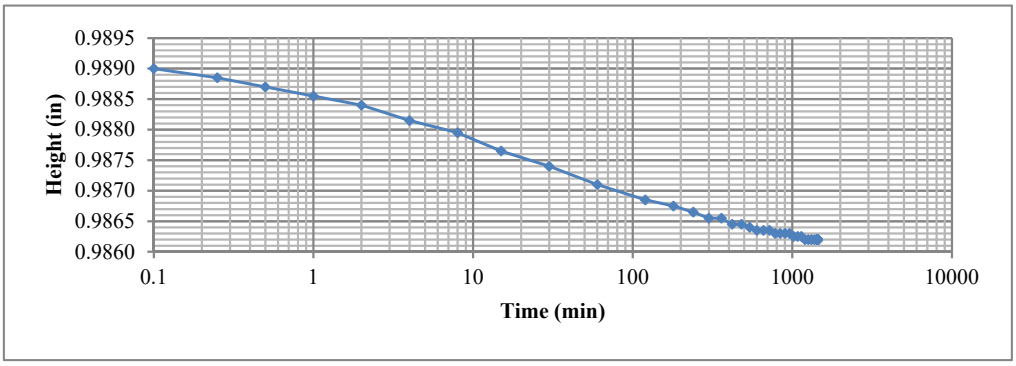
0.5 ksf



1.0 ksf



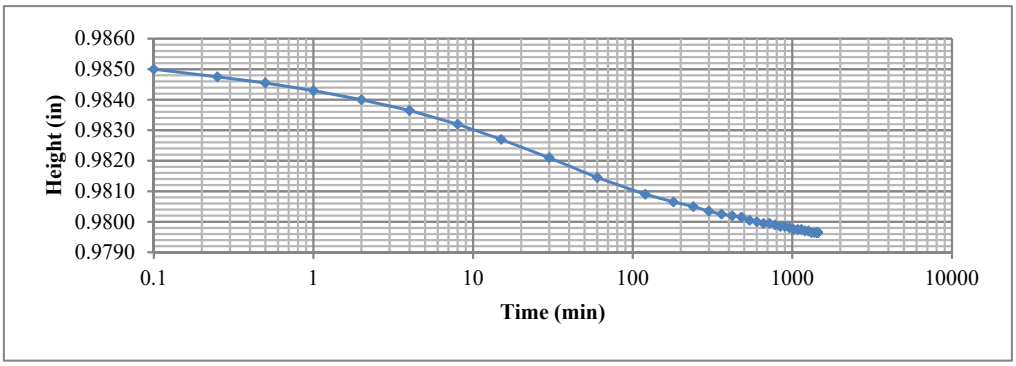
2.0 ksf



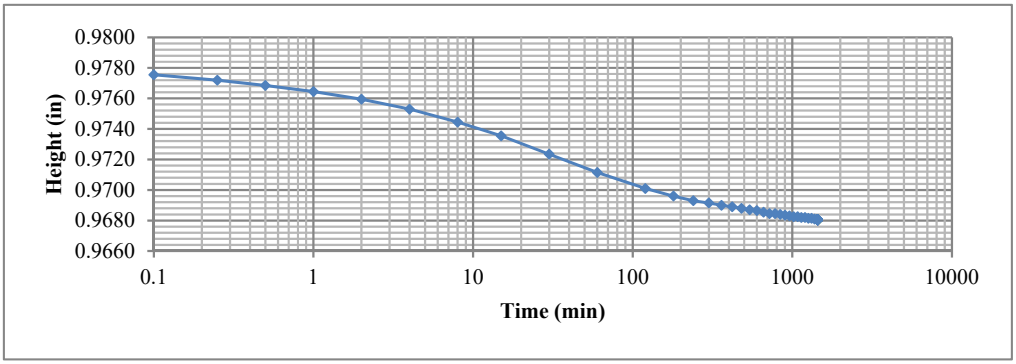
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (1)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 3

GOLDER

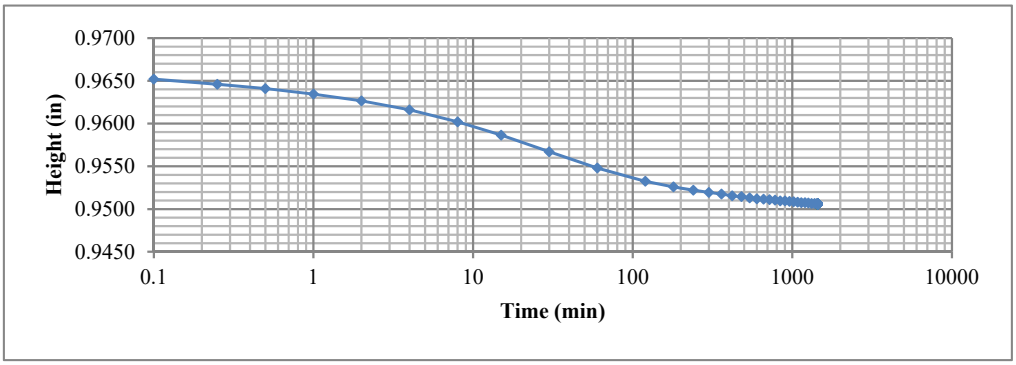
4.0 ksf



8.0 ksf



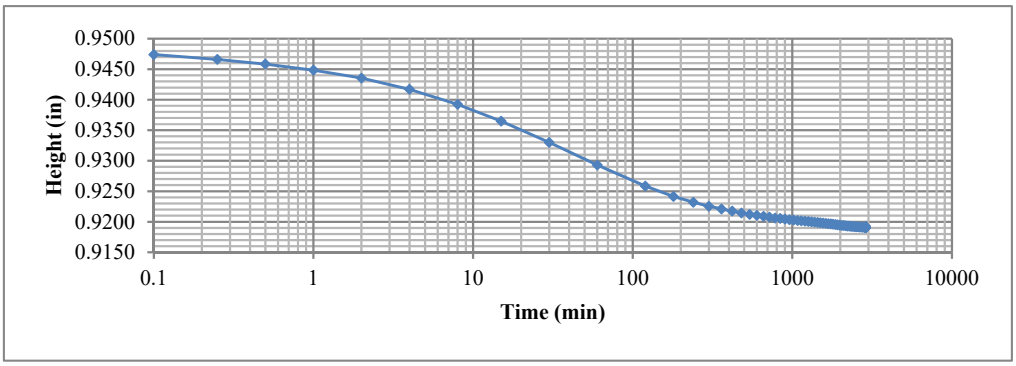
16.0 ksf



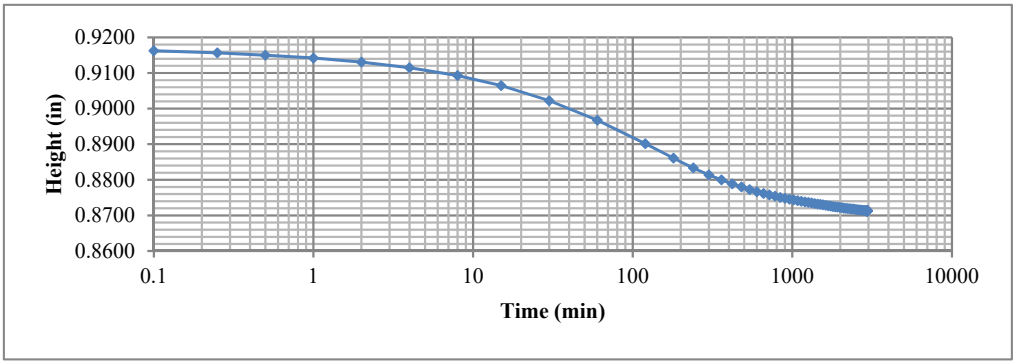
Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (2)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 4

GOLDER

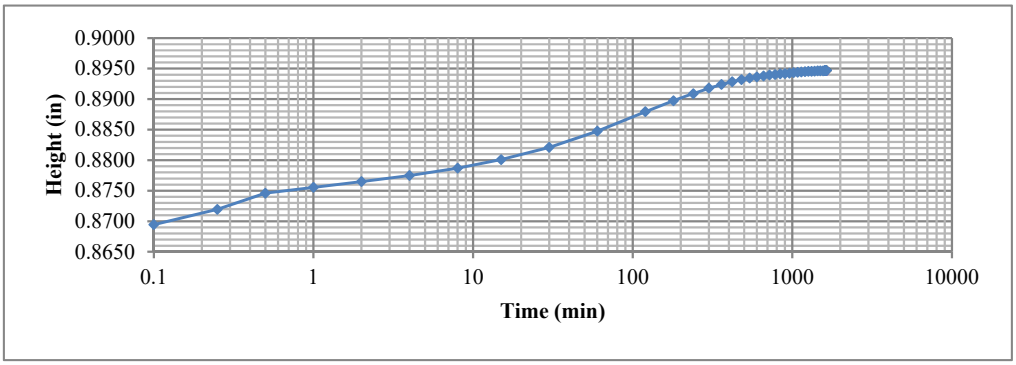
32.0 ksf



64.0 ksf

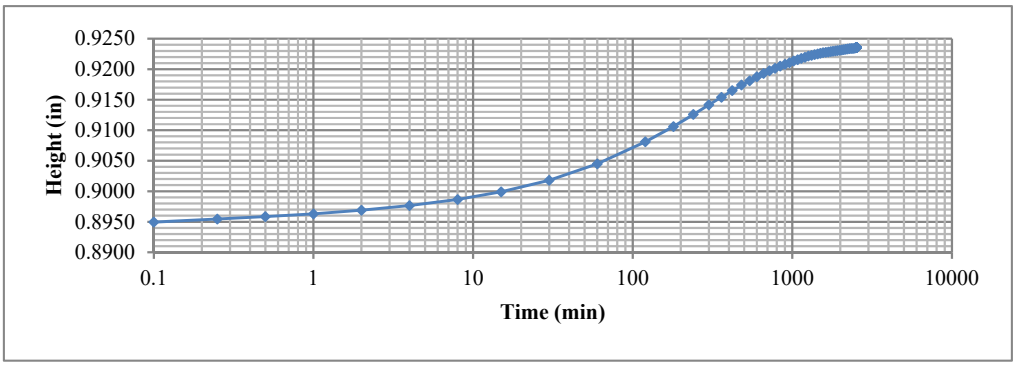


16.0 ksf - Unload

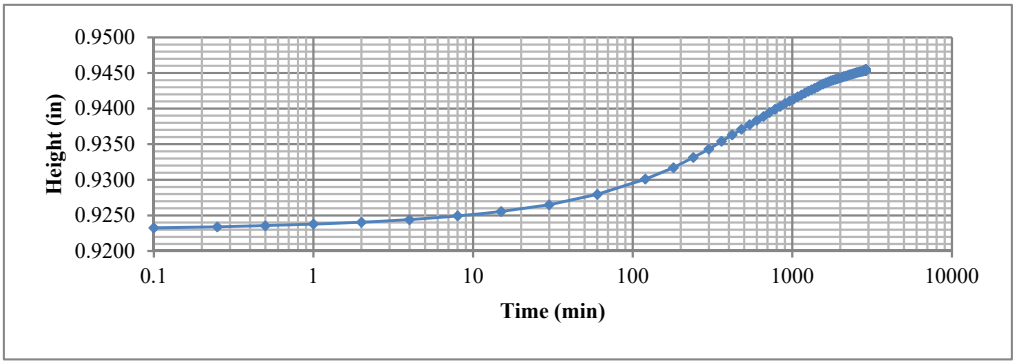


Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (3)					
Project Number: 1663241.22000						
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 5	

4.0 ksf - Unload



1.0 ksf - Unload



Project Name: MDA/Grassy Mtn PFS/OR	**ASTM D2435** ONE-DIMENSIONAL CONSOLIDATION REPORT TIME-DEFORMATION PLOTS (4)				
Project Number: 1663241.22000					
Sample ID: BH19-TP-44 @ 30 - 32 ft.	**Technician:** PRH	**Checked:** PRH	**Reviewed:** CPA	**Date:** 16-Aug-2019	**Figure:** 6

Miles Industrial Mineral Research ("MIMR")
1244 N. Columbine Street
Denver, Colorado 80206
Tel: 303-355-5568 Cell: 303-601-1459
w_miles1@msn.com

April 23, 2018

Ms. Nancy Wolverson, Project Manager
Paramount Gold Nevada Corp.
665 Anderson Street
Winnemucca, NV 89445
Tel: 775-625-3600
Cell: 775-770-4615
nancy@paramountnevada.com
cheryl@paramountnevada.com

Re: X-ray Diffraction Analysis of 15 Grassy Mountain Bentonite Samples

Dear Paramount Gold Nevada Corp. and Ms. Wolverson:

Introduction: Your shipment of fifteen (15) Grassy Mountain Bentonite samples were received by MIMR on April 11, 2018. You requested that each core be evaluated by x-ray diffraction ("XRD") analysis for mineral composition, including montmorillonite. Each sample has been evaluated for montmorillonite and accessory mineral concentrations.

Bentonite characteristics: In the U.S.A., the active ingredient in bentonite is montmorillonite, a swelling smectite clay mineral. There are negative charge defects in the 3 layer structure of montmorillonite platelets that require cations between the platelets for charge neutralization. When monovalent cations such as sodium are dominant, these cations hydrate rapidly with exposure to water, expanding or swelling the bentonite typically 20 or more times its original dry volume. The hydrated sodium montmorillonite disperses to platelets with minimal shear to viscosify/thicken the water phase. When divalent cations such as calcium are dominant, montmorillonite expands to twice its dry volume with exposure to humid air and slightly more when placed in water, but does not expand further or disperse to platelets.

Market characteristics of sodium, and, calcium bentonites: In the U.S.A, sodium bentonite has 20 times greater market share than calcium bentonite does. Some calcium bentonite deposits can be altered to meet some commercial sodium bentonite market requirements. Major markets for sodium bentonite include clumping pet litter, drilling mud for oil and gas, foundry sand binder,

iron ore pelletizing, water proofing & sealing, and few other markets which are not major markets. Sodium bentonite from Wyoming and neighboring states produce the current major source available in the U.S.A. for present sodium bentonite markets. Commercial bentonite markets typically require approximately 70% or more montmorillonite as its active ingredient to meet functional acceptance. Both sodium bentonite, and, calcium bentonite may contain montmorillonite of variant quantity.

In the U.S.A., in 2016, commercial markets for bentonite used about 3.6 million metric tons. However, with changing competition and market demand, the major commercial markets may increase or decrease by up to 300,000 tons per year. In 2016, at the production facility, the average price per ton of processed bentonite was $73.76.

Summary of XRD Analysis of Submitted Samples*:* With regard to further testing of properties for current bentonite markets, only one (1) Grassy Mountain core sample contains sufficient montmorillonite; that is, contains more than approximately 70% active mineral. The remaining 14 core samples have 53% or less montmorillonite. In all 15 cores, divalent cations---such as calcium---are the dominant interlayer cations, further limiting the potential market for such 15 Grassy Mountain bentonite if mined. Calcium bentonite can be reacted with sodium carbonate to result in a quasi-sodium bentonite byproduct, and, a substantial calcium carbonate byproduct. Such conversion is typically not adequate for constituting the desired functional properties. This is because individual calcium montmorillonite platelets do not separate adequately for complete interlayer cation displacement.

X-Ray Diffraction Mineral Composition Analysis:

For XRD analysis, a Philips-Norelco Model 3000 x-ray diffractometer, containing a step-scanning goniometer, was used.

Each of the 15 samples was initially dried to constant weight at 50°C, then pulverized with a ceramic mortar and pestle to less than 200 mesh. In preparation for XRD analysis, the pulverized sample was back-loaded as a randomly oriented powder and compressed into a powder-sample-holder at 10 psi. For powder samples, the XRD range was from 4° to 65° 2theta.

For enhanced smectite detection and identification, a portion of each sample was slurried in distilled water, then the slurry was coated on the surface of a glass slide. As the slurry dried, dispersed smectite platelets oriented parallel to the glass surface, enhancing smectite XRD (0,0,x) layer peaks. After XRD evaluation of an oriented sample, it was exposed to ethylene glycol vapor for a minimum of 4 hours at 50°C, then after cooling to ambient temperature, re-analyzed by XRD.

The following is shown in Excel Table 1: With exposure to ethylene glycol vapor, 14 samples contained a smectite XRD (0,0,1) layer peak that expanded to 17 Angstroms, confirming that swelling smectite was present in each such sample. However, one (1) of the 15 total samples did not contain any smectite. Yet, each of the 14 samples which did contain such swelling smectite were further identified as montmorillonite by its (0,6,0) XRD peak at 1.50 Angstroms. With regard to all 15 samples, the XRD range for oriented samples was 2° to 18° 2theta.

Each mineral has been identified and semi-quantitatively estimated with respect to external standards:

- A refined Wyoming bentonite was prepared by slurrying in water, then centrifuged to less than 2µm to remove accessory minerals. This standard has 98.1% sodium montmorillonite and 1.9% opal-CT (an amorphous silica).
- Silver Bond B quartz was used to estimate quartz in the Grassy Mountain cores.

- Other external standards were used for illite/mica, kaolinite, gypsum, and feldspars, but with less accuracy than montmorillonite and quartz---this is because these minerals have more variable chemistry, particle size distribution, and crystallinity.

The Grassy Mountain cores have variable but significant concentrations of amorphous, or, poorly crystalline materials because the crystalline minerals identified above, by using such XRD standards, do not substantially represent the core samples as a whole.

The mineral compositions by XRD analyses are listed in the separate attachment, Excel Table 1.

Sincerely yours,

W. J. Miles, PhD

Table 1
Paramount Gold Nevada Corporation
XRD Mineral Composition

	Clay Minerals				Feldspars		Carbonate Minerals			Amorphous	
Core Sample	Montmorillonite	Illite	Kaolin	Quartz	Microcline	Albite	Calcite	Dolomite	Gypsum	Material	Total
BH-01 S5 25'	84	~1	2	10	2	0	0	0	0	3	100
BH-01 S9 60'	18	~1	0	23	2	0	0	0	0	58	100
BH-01 S12/13 90&10(	36	0	0	17	0	0	0	0	0	46	100
BH-02 S4 20'	43	~3	11	21	3	0	2	1	0	20	100
BH-02 S7 40'	27	2	0	24	2	0	1	0	0	45	100
BH-03 S6 30'	48	~1	0	13	0	2	0	0	0	36	100
BH-03 S9 60'	24	0	4	13	1	0	0	0	0	59	100
BH-03 S11 80'	7	3	18	32	2	0	0	2	0	36	100
BH-04 S2 10'	14	0	47	25	0	0	0	0	0	15	100
BH-05 S5 25'	23	0	0	1	2	0	0	0		73	100
BH-07 S5/6/7 25-35'	33	3	9	22	6	0	0	0	0	27	100
BH-08 S4 20'	29	0	0	1	0	12	1	0	0	58	100
BH-08 S10 50'	53	0	0	3	0	9	0	0	0	35	100
BH-09 S12 90'	19	0	3	0	0	0	0	0	0	78	100
BH-13 S14 15'	0	0	3	23	0	0	0	0	0	74	100
SCP Refined Bentonit(	98	0	0	0	0	0	0	0	0	2	100

The XRD concentrations of these minerals are estimated at plus or minus 5% by weight.
The detection and quantification limit for smectite clays is 0.3%.

APPENDIX B

Seismic Hazard Assessment

TECHNICAL MEMORANDUM

DATE October 30, 2019 **Project No.** 1663241.058.TM.Rev0

TO Christopher J. MacMahon, PE
Golder Associates Inc.

FROM Don Lowry, PG, CEG & Alan Hull, PG, CEG **EMAIL dlowry@golder.com**

UPDATED SEISMIC HAZARD ASSESSMENT, GRASSY MOUNTAIN TSF SITE, MALHEUR COUNTY, OREGON

Introduction

Golder Associates Inc. (Golder) completed an initial seismic hazard assessment (SHA) in 2017 (Golder 2017) as an appendix in Golder's pre-feasibility report (Golder 2018a) for the proposed Grassy Mountain Tailings Storage Facility (TSF) site (Site) located in Malheur County, Oregon (Figure 1).

At the time of the SHA preparation in 2017, subsurface information, including time-averaged shear wave velocity in the upper 100 feet (ft) (30 m) below the Site (i.e., $V_{S,30}$) was not available. Golder (2017) assumed a weak rock site [i.e., $V_{S,30}$ = 2,500 ft per second (ft/s) (760 meters per second (m/s)] or soil Site Class B/C per ASCE/SEI 7-10 for the initial assessment of earthquake ground motions at the TSF site.

Subsequent to preparation of the 2017 SHA, Golder has acquired new subsurface data that is presented in the main TSF Design Report to which this technical memorandum is appended. This technical memorandum updates the SHA for the proposed Grassy Mountain TSF based on logs from 21 boreholes,11 cone penetration test (CPT) soundings, and 59 seismic CPT tests. This data indicate that bedrock was not encountered in any of the boreholes that extended up to 120 ft beneath the proposed TSF Site.

The boreholes and CPT logs indicate that the proposed TSF Site is underlain by moist, stiff to very stiff clay. Direct measurements of the shear-wave velocity and laboratory testing indicate the presence of at least 100 ft (~30 m) of stiff to very stiff clay indicates that the initial assumption of a $V_{S,30}$ of 2,500 ft/s by Golder (2017) is no longer valid.

The SHA results reported in this technical memorandum update the earthquake ground motions presented in Golder (2017) with a deterministic seismic hazard analysis (DSHA) and probabilistic seismic hazard analysis (PSHA) for the proposed Grassy Mountain TSF site. This SHA provides earthquake ground motion values for a $V_{S,30}$ equivalent to the mid-point of a soil Site Class D sites as defined in ASCE/SEI 7-16. These values are considered appropriate for the seismic analysis and design of the proposed TSF structure given the known subsurface conditions.

Regulatory Framework

In August 2017, Golder presented Calico Resources USA Corp (Calico) with an initial conceptual design for the proposed TSF at the Grassy Mountain TSF site (Golder 2017b). Table 2 of Golder (2017b) notes that the proposed operational and closure design earthquake ground motions have 475- and 2,475-year return periods.

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Golder's current understanding is that the proposed TSF is a low-hazard dam under Oregon Administrative Rule (OAR) 690-020-0038, and the proposed operational and closure design earthquake ground motions exceed the requirements of OAR 690-020-0038.

Although the Oregon regulations do not require the application of deterministic maximum credible earthquake (MCE) ground motions for a low hazard dam classification, it is common practice in tailings dam seismic analysis to identify the MCE ground motions for comparison with the probabilistically derived earthquake ground motions. Accordingly, the minimum seismic criteria for stability analysis of the proposed TSF embankment are the 475-year return period and maximum credible earthquake (MCE) ground motions.

Work Scope

For this update, Golder used the fault location and characteristics information developed during the initial SHA (Golder 2017a) and performed the following additional tasks to define the earthquake ground motion estimates at the proposed TSF site.

- Evaluated the site soil conditions based on logs from 21 boreholes, 11 CPTs, 59 seismic CPTs that extended within the proposed TSF site footprint. Golder's evaluation concentrated on the Standard Penetration Test (SPT) results, soil moisture tests, and thickness of the clay deposits located within the proposed TSF footprint.
- Estimated the soil Site Class based on site classes defined in ASCE/SEI 7-16 Table 20.3-1 and the SPT and seismic CPT test results.
- Re-calculated the deterministic horizontal peak ground acceleration (PGA) for the MCE using a $V_{S,30}$ of 850 ft/s (259 m/s) that correspond to soil Site Class D. PGA values were calculated using 2014 NGA-West2 earthquake ground motion models (GMM) to estimate the source-to-site attenuation of earthquake accelerations.
- Re-calculated mean PGA for 475- and 2,475-year return periods based on the US Geological Survey National Seismic Hazard Maps (NSHM; USGS 2014).
- Estimated the return period of the deterministic MCE ground motions.
- Prepared this technical memorandum that describes of the inputs, results, and recommendations from Golder's SHA update.

The US Geological Survey NSHM was also de-aggregated at PGA to identify the dominant earthquake magnitude-distance pairs at 475 and 2,475-year return periods. This information can be used for any subsequent selection and development of earthquake acceleration time histories, if required.

Physiographic and Tectonic Setting

The proposed TSF Site (and surrounding region) is located within in the Columbia Plateau, a physiographic province of the United States that comprises thick sequences of basalt flows (Columbia River Basalt) erupted from about 17.5 to 6 million years ago (Ma) (e.g., Carson and Pogue 1996, Camp et al. 2003). The Columbia River Basalts are part of the long-lived volcanic activity related to the mantle "hot spot" that is now located below Yellowstone National Park (Madin 2009). The proposed TSF Site area is dissected by a number of rivers and their

tributaries that drain to the Snake River flood plain, including the Payette, Powder, Burnt, Malheur, and Owyhee rivers (Geology.com 2017a and 2017b). The relatively unaltered basalt flows in the Payette section range in elevation from about 3,800 to about 4,500 ft above sea level (asl).

The proposed TSF Site is located about 15 mi (24.5 km) southwest of the Snake River plain near Adrian, Oregon (Figure 1). At this location, some dissection of the basalt flow-dominated landscape has occurred, exposing the underlying sedimentary units of the Grassy Mountain Formation (Ferns and Ramp 1989). The TSF site is located within a north-flowing drainage at an elevation of about 3,700 ft asl northwest of Schweizer Reservoir (Figure 2).

Significant local features nearby include the Owyhee Dam (6.1 mi/9.8 km southeast), Owyhee Reservoir (4.6 mi/7.4 km south-southwest) within the Owyhee River drainage, and Sourdough Basin (1.9 mi/3.0 km west) located within a north–south trending tributary of the Owyhee River (Figure 1).

Site Geology

The geology of the region surrounding the proposed TSF site is a sequence of sedimentary and volcanic deposits within the Oregon-Idaho Graben (Ferns et al. 1993). Contemporaneous deposition of sandstone and conglomerate (Tgs), olivine basalt emplacement (Tbi), and repeated episodes of calc-alkaline lava eruption and flow (Tgb) occurred during middle to upper Miocene time (Figure 2). The volcanoes of west-central to southeastern Oregon range in age from 15 to 2 Ma (Madin 2009). The Payette section of the Columbia Plateau, where the TSF site is located, is a relatively uniform area of basalt flows that overlie and cap the underlying older sedimentary deposits (Fenneman 1946).

Grassy Mountain itself is mapped by Ferns et al. (1993) as underlain by calc-alkaline rich volcanic flow deposits (Tgb) and associated olivine basalt that crops out farther northeast. Ferns et al. (1993) geologic map (Figure 2) indicates that the proposed TSF site is located on a thick sequence of arkosic sandstones containing interbeds of conglomerate separated by the tuff of Kern Basin. Geologically, the site is within the upper arkosic (mid to upper Miocene) and the lower (mid-Miocene) arkosic units. Erosion over about the last 11 Ma has removed some of the volcanic deposits that overlie and cap the sedimentary units to expose the upper arkosic unit at the Site (Tgs, Figure 2).

Bedrock outcrops within the site expose siltstone, sandstone, and conglomerate of the late Miocene Grassy Mountain Formation. These units are also exposed in the northeast–southwest trending drainage that the proposed TSF will partially fill (Figure 2). Olivine-rich basalts are present immediately to the east and south (Figure 2). Igneous intrusions (Tbi) are mapped as isolated bodies surrounded by the sedimentary units (Tgs). The intrusive bodies are in places aligned along the mapped pre-Quaternary faults that may have controlled the locations and extent of these shallow intrusions.

Golder's subsurface investigation (Golder 2018a, 2018b) identified unconsolidated alluvium and colluvium overlying previously unmapped Miocene-aged lacustrine clays underlying most of the proposed TSF Site area. The lacustrine deposits are generally characterized as "fat clay" with variable quantities of dark tan to brown and occasionally blue-gray, fine- to medium-grained sand with lesser amounts of lean clay and poorly graded sand lenses. Moisture content, where measured, varies from 16% within lean clay deposits (BH-01 @ 10 ft) to 30 to 35% within fat clay deposits (BH-03 @ 10 ft, 40 ft and 50 ft). Uncorrected blow count (i.e., N-value) averages within the deep boreholes (BH-01, BH-03, BH-09 and BH-13) varied from 32.2 (BH-3) to 47.6 (BH-13). Laboratory

testing of the lacustrine clays indicates a range of plasticity index (PI) from 10 to 179, with several samples having PI values over 100. Similar deposits were mapped by Ferns et al. (1993) approximately 2 miles

(3 km) northeast of the proposed TSF site. Gray et al. (1989) considers that the clay was deposited during the Upper Miocene Epoch of the Neogene Period within alkaline lakes subjected to regular volcanic ash fall and/or hydrothermal activity.

The proposed mine is located on a 150 ft high, highly resistant, silicified and iron-stained knoll (43.670°N latitude, 117.359°W longitude). Bedding within the sandstone unit appears unaltered at the hilltop, dips at 10° to 25° toward the north-northeast on the northern and eastern flanks of the hill and steepens to 30° to 40° on the west side of the hill due to drag folding in the footwall along a fault striking about N20°W (Paramount 2017). Normal faulting of the Miocene-age units is common, with most faults striking either northwest–southeast or northeast–southwest (most common). Also, a number of mapped older faults strike approximately north–south, but these faults are generally located west of the proposed TSF site. These faults are not considered seismogenic (i.e., capable of generating earthquakes) in the present-day tectonic environment. The proposed TSF Site is located within the valley area to the west and north of the mine. The downstream extent of the TSF embankment is about 0.5 mi (less than 1 km) from the knoll presumed to be the center of the proposed mine workings (Figure 2).

Historical Earthquakes and Quaternary Faults

This section is a summary of information on the occurrence of historical earthquakes surrounding the TSF site. The section also includes descriptions of the activity of mapped Quaternary faults located within about 62 mi (100 km) of the proposed TSF site (Figure 1).

Historical Earthquakes

Figure 1 shows Quaternary-aged faults included in the United States Geological Survey (USGS) Quaternary Fault and Fold Database (USGS 2006) and located within 62 mi (100 km) of the proposed TSF site. Also shown in Figure 1 are historical earthquake epicenters located within a 125 mi (200 km) radius of the proposed TSF site. The earthquake records were obtained from a search within USGS (2016) and International Seismological Centre (2014) online earthquake catalogs. Any duplicate events were manually removed. The area surrounding the site shows a relatively low number of historical earthquakes.

Instrumental and reported historical records from the mid-20th century through April 2017 reveal that 81 earthquakes with magnitudes greater than magnitude 3.0 have been recorded within about 124 mi (200 km) of the proposed TSF site. Of these recorded earthquakes, six have exceeded moment magnitude (**M**)4.0—the most recent in October 1994. The largest earthquake recorded within 125 mi (200 km) of the TSF site in August 1965 had a reported **M**4.4 and was located about 20 mi (33 km) northwest of the site. The closest recorded earthquake with an **M**≥4.0 was an **M**4.0 event in October 1994. The epicenter was located about 81 mi (130 km) northeast of the proposed TSF site (Figure 1).

Quaternary Faults Mapped within 62 mi (100 km) of the Site

General

In the western USA, active faults are typically defined as those that have evidence for one or more displacements of Holocene-age soils and surfaces that range in age from about 10,000 to 11,000 years old or younger. This definition is typically used in seismically active, high average fault slip rate regions close to major tectonic plate

boundaries (e.g., California). Fault studies within regions away from the plate boundaries, such as the Basin and Range and Columbia Plateau of the western United States, however, indicate that recurrence intervals for surface fault rupture can be much longer than 10,000 years, and the use of a Holocene activity criterion may not be appropriate for the identification of potentially seismically active faults. For example, dePolo and Slemmons (1998) suggest that faults be considered as potentially seismically active in Nevada if they demonstrate surface fault rupture in the last 130,000 years (Late Pleistocene). The rationale for the selection of this longer time interval is because about 60% of historical earthquakes within the Basin and Range with magnitudes greater than or equal to **M**6.0 have been located on or near faults without a record of previous Holocene offset. In eastern Oregon, very few earthquakes have been recorded within Malheur County from the late 19th century through to the present day. Of those earthquakes, more than 50% are located more than 12 mi (20 km) from known seismogenic faults (State of Oregon 2003).

The most significant Quaternary faults, with respect to the development of earthquake ground motions, are generally those located closest to, and dip beneath the Site (i.e., the Site experiences more shaking from faults when located on the hanging wall of the fault). These faults are important because future large earthquakes on these faults can be expected to develop earthquake ground motions of engineering significance at the TSF site. Large earthquakes may occur on one or more of the faults further from the Site, but they not expected to generate high levels ground shaking at the Site.

The U.S. Geological Survey defines four classes of geological fault based on the physical evidence of Quaternary (i.e. last 2.6 million years) activity (https://earthquake.usgs.gov/hazards/qfaults/background.php).

- **Class A** faults have geologic evidence that demonstrates the existence of a Quaternary fault of tectonic origin, whether the fault is exposed for mapping or inferred from liquefaction or other deformational features.
- **Class B** faults have geologic evidence that demonstrates the existence of a fault or suggests Quaternary deformation, but either: (1) the fault might not extend deeply enough to be a potential source of significant earthquakes; or (2) the currently available geologic evidence is too strong to confidently assign the feature to Class C but not strong enough to assign it to Class A.
- **Class C** faults have geologic evidence that is insufficient to demonstrate: (1) the existence of tectonic fault; or (2) Quaternary slip or deformation associated with the feature.
- **Class D** faults have geologic evidence that demonstrates that the feature is not a tectonic fault or related feature (i.e., not a fault); this category includes features such as joints or joint zones, landslides, erosional or fluvial scarps, or landforms resembling fault scarps, but of demonstrable non-tectonic origin.

Generally, Class A faults are the only seismogenic sources considered in a SHA, and only Class A faults are considered here. By definition there is insufficient evidence that Class C and D faults are seismogenic sources that need to be considered for seismic analysis of mine facilities. Although there is a known Class B fault group mapped within 3.2 mi (5.2 km) of the site (i.e., Fault No. 808 - Faults near Owyhee Dam), there is insufficient evidence to consider them in the seismic hazard for the proposed Grassy Mountain TSF site. Detailed studies including subsurface investigations would be required to demonstrate Quaternary movement for Fault no. 808 and for its inclusion as a seismogenic source.

Significant Late Quaternary and Holocene Faults

The USGS (2006) and Petersen et al. (2008) recognize at least 11 faults or distinct fault segments with demonstrated Quaternary activity within about a 62 mi (100 km) radius of the proposed TSF site (Figure 1). Of these mapped faults:

- Six have demonstrated surface displacement during the Holocene Epoch (i.e., about the last 11,700 years).
- One has demonstrated surface displacement since the late Pleistocene Epoch (i.e., from about 130,000 to 11,700 years ago).
- Two have surface displacement since the early Pleistocene Epoch (i.e., from about 750,000 to 11,700 years ago).
- Two show surface displacement only in the early Quaternary Period (i.e., at some time in the last 2.6 million years).

The estimated average slip rates on these 11 faults are generally less than 0.2 mm/yr (USGS 2006). Table 1 lists selected fault parameters for each of the faults mapped within 62 mi (100 km) of the Site.

Table 1: Major Pleistocene- and Holocene-age Faults Mapped within about 62 mi (100 km) of the Grassy Mountain TSF Site, Malheur County, Oregon

Fault Number[1]	Fault (F) or Fault Zone (FZ)[2]	Estimated Age of Most Recent Surface Displacement[3]	Approximate Distance from Site (mi/km)[4]	Total Length (km)[5]	Fault Type[6]	Dip Angle, Direction[6]	Estimated Average Slip Rate (mm/yr)[7]	Estimated Recurrence Interval (years)[8]
806	Cottonwood Mountain	Holocene (<15 ka)	17/28	42	N, LLSS	60°±10°NE	<0.2	3,750-25,000[a]
636	Owyhee Mountain	Quaternary (<1.6 Ma)	17/28	206	N	65°-70°NE	<0.2 (0.12-0.18)	3,000-9,000 (5,200 average)[b]
635	Western Snake River Plain	Late Pleistocene (<130 ka) to *Quaternary* (<1.6 Ma)	24/38	74	N	55°-88°NE	<0.2	n/a
856a	Steens FZ, Crowley Section	Middle and late Quaternary (<750 ka)	30/49	43/197	N	60°SE	<0.2	n/a
805	Juniper Mountain	Holocene (<15 ka)	37/60	17	N	60°-70°NE	<0.2	n/a
1801	Warm Springs	Quaternary (<1.6 Ma)	46/74	9	N	*60°E	<0.2	n/a
632	Squaw Creek	Holocene (<15 ka)	50/80	47	N	60°E	<0.2	n/a
807	Faults near Unity Valley	Holocene (<15 ka)	50/80	46	N, RLSS	60°-70°N to E	<0.2	n/a
631	Big Flat	Holocene (<15 ka)	54/87	30	N	60°E	<0.2	n/a
630	Jakes Creek	Holocene (<15 ka)	55/88	16	N	60°W	<0.2	n/a

Fault Number[1]	Fault (F) or Fault Zone (FZ)[2]	Estimated Age of Most Recent Surface Displacement[3]	Approximate Distance from Site (mi/km)[4]	Total Length (km)[5]	Fault Type[6]	Dip Angle, Direction[6]	Estimated Average Slip Rate (mm/yr)[7]	Estimated Recurrence Interval (years)[8]
1802	Harney	Middle and late Quaternary (<750 ka)	61/98	30	N	*60°W	<0.2	n/a

Notes: ka = thousand years; Ma = million years; N = Normal Fault, RLSS = Right-Lateral Strike Slip, LLSS = Left-Lateral Strike Slip; n/a = not applicable; MCE = maximum credible earthquake.

1. Fault numbers from USGS (2006). References include:
   a. Personius (2002), Fault number 806
   b. Personius and Lewis (2003), Fault number 636
   c. Personius (2003), Fault number 635
   d. Personius (2002), Fault number 856a
   e. Personius (2002), Fault number 805
   f. Personius (2002), Fault number 1801
   g. Personius and Neier (2003), Fault number 632
   h. Personius (2002), Fault number 807
   i. Personius and Neier (2010), Fault number 631
   j. Personius and Lewis (2003), Fault number 630
   k. Personius (2002), Fault number 1802
2. Fault names, and zones were taken from Petersen et al. (2008).
3. Age of most recent pre-historic displacement taken from USGS (2006).
4. The distances are the closest approach of the mapped fault traces to the Grassy Mountain TSF site and were measured from the fault traces as plotted on Google Earth™ (from USGS 2006) for a location of 43.6728°N, 117.36437°W.
5. Length is based on the total lengths of the faults and fault segments as indicated in USGS (2006).
6. Fault dip and direction from USGS (2006). Dip determined from reference, where available. *Dip assumed to be 60º for normal faults where no other information is available.
7. Average fault slip rates taken from USGS (2006). Mid-range values assumed (i.e., for 0.2 to 1.0 mm/yr, 0.6 mm/yr) used for MCE calculation.
8. Recurrence interval as reported by:
   a. Knudsen et al. (1994)
   b. Beukelman (1997)

Cottonwood Mountain Fault

The closest mapped Quaternary fault to the proposed TSF site is the Holocene-aged Cottonwood Mountain fault located along the eastern slopes of Cottonwood Mountain (Personius 2002, fault 806) (Figure 1). The Cottonwood Mountain fault is a northwest-trending normal fault with a northeast dip, and with some evidence for left-lateral (sinistral) slip. The fault offsets pre-Quaternary ash-flow tuff and lacustrine deposits. The fault trace has scarps that offset alluvial fan deposits east of Cottonwood Mountain. Small scarps (1.5 to 3 ft [0.5 to 1 m]) on Holocene surfaces and larger scarps (6 to 43 ft [2 to 13 m]) on mid- to late-Pleistocene surfaces indicate repeated late-Quaternary surface rupture. The most recent surface rupture is estimated to have occurred in the late Holocene (Personius 2002, fault 806).

The Cottonwood Mountain fault is mapped by USGS (2006) as two well-defined lineaments about 1.2 to 1.6 mi (2 to 2.5 km) apart. The western lineament is about 11 mi (18 km) long, with the central portion mapped with the last surface displacement occurring in the Holocene. Other mapped portions of the fault show the last movement in middle and late Quaternary time (i.e., <750 ka). The eastern-most lineament is mapped as Holocene-active along its 26 mi (42 km) length. The combined length of mapped fault sections is about 43 mi (69 km), with an average strike at 331º (N29°W). The fault dips northeast at about 60º to 70º (USGS 2006).

Owyhee Mountains Fault System

The Owyhee Mountains Fault System is located about 17 mi (28 km) southeast of the proposed TSF site at its closest approach (Figure 1). This complex zone of faults forms the northwest-trending boundary between the Tertiary volcanic rocks of the Owyhee Mountains and the Neogene to Quaternary basalt flows of the Snake River Plain in southwestern Idaho. Most of the faults mapped in this fault system offset volcanic rocks of probable late Tertiary age, but many of these rock units are poorly dated. Some Quaternary rocks and surfaces may also be offset by these faults. A few faults offset Quaternary surficial deposits in the area between Shoofly Creek and Little Jacks Creek; these deposits are undated but are probably late Quaternary in age. Scarp profiling, trenching, and detailed soils analysis of faults and deposits in the Shoofly/Little Jacks Creek area suggest late Quaternary displacements on some of these faults (Personius and Lewis 2003, fault 636).

Western Snake River Plain Fault System

The Western Snake River Plain fault system is mapped as an east-propagating series of southwest-dipping normal faults that offsets Pliocene-Pleistocene fluvial deposits within the Snake River floodplain (Personius 2003, fault 635). Fault traces are mapped east of the Owyhee Mountains fault exposed within the hills just west of the Snake River floodplain. Tectonic linear and asymmetric ridges up to 100 ft (30 m) high are exposed within the fluvial deposits, including some that deform early Quaternary sediments (Ostenaa 1985; Othberg and Stanford 1992; Wood and Anderson 1981).

The fault system does not appear to extend into the rock units exposed to the southeast of the lower floodplain deposits. The longest fault structure mapped in the fault system extends about 38 mi (61 km) through the valley, about 7 mi (11 km) east of Lake Lowell. USGS (2006) maps the fault with an average strike azimuth of about 307º (N53°W). The fault system has a nominal width of about 23 mi (37 km).

Surface Fault Rupture Hazard

Faults mapped to have had surface rupture within the Quaternary Period (Figure 1) do not cut the footprint of the proposed TSF site. Considering the potential for surface fault rupture hazard, the current understanding of Quaternary faults suggests that the likelihood of surface fault rupture within the proposed TSF site is very low.

The Cottonwood Mountain fault that has a similar trend as the Owyhee Mountains fault system appear to be two independent faults and earthquake sources. Mapped faults are absent for about 29 mi (47 km) between the two fault systems based on current geological assessments. If future studies show there is continuity between these two fault structures, then a seismogenic fault could be located 5 to 10 mi (8 to 16 km) east of the proposed TSF site.

Evaluation of Seismic Hazard

This section presents the results of the DSHA and estimates of earthquake ground shaking from the NSHM (Petersen et al. 2008). Site-specific DSHA was undertaken using fault locations from USGS (2006). Fault-to-site distances and median MCE magnitudes were calculated for this study by measuring the distances to the fault traces as shown on Google Earth™. Probabilistic results are those based on the USGS NSHM and available hazard mapping tools (USGS 2017).

Deterministic Seismic Hazard Analysis

General

Deterministic Seismic Hazard Analysis uses available historical and instrumental seismic records and geologic data to generate discrete, single-valued estimates of earthquake ground motion for a site. These single-valued estimates are commonly used in the seismic analysis and design of major mining structures such as tailings dams and impoundments. Median (50^{th} percentile) values of PGA are sometimes used for analysis and design of low failure consequence structures, while 84^{th} percentile values are often used for high failure consequence structures.

Deterministic Seismic Hazard Analysis uses a concept of the MCE. The MCE is the largest possible earthquake that may reasonably occur along a recognized fault or within a geographically defined tectonic province, under the presently known or presumed tectonic framework. Little regard is given to the earthquake recurrence interval, which may vary from less than a hundred years to more than ten thousand years, depending on the geologic and tectonic environment under consideration.

Typically, in DSHA one or more MCEs are specified by magnitude and location with respect to the site of interest. In areas such as eastern Oregon, major earthquakes are assumed to be generated by movement along mapped active faults that have generated past surface rupture, and on that part of the mapped fault closest to the facility being evaluated. Site ground motions are usually estimated for displacement along a known fault, with a specified MCE magnitude, a source-to-site distance, and site soil conditions.

Review of Subsurface Data from Grassy Mountain TSF Site

For this update, we have reviewed the boring logs included in Golder (2018b) for the proposed TSF site. Boreholes BH-01, BH-03, BH -09 and BH-13 each extended to 100 ft below the ground surface. Average SPT blow counts (N_{avg}), measured shear wave velocity values in the upper 30 meters of soil, ($V_{S,30}$), plasticity index (PI) and moisture content can be used to classify the soil Site Class as defined in ASCE/SEI 7-16 Chapter 20.

$V_{s,30}$ Values (Seismic CPT Tests)

The National Earthquake Hazards Reduction Program (NEHRP 2009) and International Building Code (IBC 2018) define soil Site Class by the time-averages shear wave velocity in the upper 30 meters of the soil profile. Seismic shear wave velocity tests were conducted in twelve (12) CPT bores throughout the site. Shear wave velocities were directly measured at defined depths between 5 to 20 meters at each test and ranged between 200 and 800

meters per second (m/s), or approximately 650 to 2600 ft/s. In the CPT boreholes where direct measurement of shear wave velocities was not available, empirical models were used to estimate the shear wave velocity profiles. The empirical models such as Hegazy and Mayne (1995) for clayey soils, Mayne (2006), Mayne and Rix (1995), and Piratheepan (2002) use CPT tip resistance and sleeve friction measurements to estimate shear wave velocity. These models were used to develop a continuous log of shear wave velocity with depth and averaged over the depth of the hole ($V_{s,D}$).

CPT borings less than 5 ft deep were not considered for the determination of the site-wide shear wave velocity. For each CPT with a depth of hole less than 30 meters in which the $V_{s,30}$ value cannot be directly averaged, the method of Boore's (2004) was used to interpolate the $V_{s,30}$ value from the averaged shear wave velocity over the depth of the hole, $V_{s,D}$. Boore (2004) uses logarithmic regression coefficients based on the total depth of hole to estimate the $V_{s,30}$ value used in NEHRP soil Site Classifications. The calculated $V_{s,30}$ values for each hole ranged between 240 and 920 m/s (790 to 3020 ft/s) and averaged around 470 m/s (1540 ft/s). Golder classifies this site as a soil Site Class D or stiff soil profile based on ASCE/SEI 7-16.

N_{avg}-Values (SPT Blow Counts)

SPT blow counts were used to calculate N_{avg}-value (ASCE/SEI 7-16 20.4-2) for each borehole. N_{avg}-values are 44.9, 32.2, 47.6 and 43.8 for BH-01, BH-03, BH-09 and BH-13, respectively. From ASCE/SEI 7-16 Chapter 20 Table 20.3-1, soil Site Class C has a weighted N_{avg}-value >50 while soil Site Class D has N_{avg} SPT values from 15 to 50, and soil Site Class E weighted N_{avg}-values <15. N_{avg} values indicate that the ground conditions beneath TSF site are near the upper end of a soil Site Class D.

Plasticity Index

Where a soil does not meet the soil Site Class F requirements and there is a total thickness of soft clay greater than 10 ft (3 m) and the soft clay layer has an undrained shear strength (*su*) <500 psf (<25 kPa), moisture content (w) ≥40%, and a plasticity index (PI) >20, it is soil Site Class E. The PI values for all four deep boreholes were all PI >20. BH-01 had one sample tested at a depth of 10 ft with a PI of 25. BH-03 included data from three samples tested at depths of 10 ft (PI=55), 40 ft (PI=99) and 50 ft (PI=198). BH-09 included data from a sample tested at 25 ft (PI=62). BH-13 included data from four samples tested at depths of 5 ft (PI=63), 15 ft (PI=62), 25 ft (PI=35) and 30 ft (PI=62). These results meet some of the criteria for a soil Site Class E in ASCE/SEI 7-16 Chapter 20.

Moisture Content

Lean clay soils within borehole BH-01 had measured moisture content of 16% (BH-01 @ 10 ft). Moisture levels within fat clay soils measured in borehole BH-03 varied from about 30 to 35% (BH-03 @ 10 ft, 40 ft and 50 ft).

Site Soil Classification and Use in Seismic Hazard Analysis

The $V_{s,30}$ measurements calculated from the CPT seismic testing and SPT N_{avg} values from boreholes at the TSF site are generally consistent with a soil Site Class D site. Accordingly, Golder assigned a $V_{S,30}$ of 850 ft/s (259 m/s) for a soil Site Class D to estimate the earthquake ground motions at the site.

Table 2 lists the estimated MCE magnitude for Quaternary faults listed in Table 1. The earthquake magnitudes were calculated using empirical fault rupture versus earthquake magnitude relationships recommended by Stirling et al. (2013) for areas located away from plate boundaries and with low average fault slip rates such as Nevada. The regression developed by Stirling et al. (2008) was used to estimate MCE magnitudes for strike-slip/oblique-

slip faults, while the regression developed by Wesnousky (2008) was used to estimate the earthquake magnitudes for the normal-slip faults.

Individual fault geologic and geometric data were taken from USGS (2006). The MCE magnitude values are, in general, similar to those estimated by Petersen et al. (2008) for those faults included in the 2014 update of the NSHM.

Table 2: Estimated Maximum Credible Earthquake and Median Peak Ground Acceleration values from Faults Mapped within about 62 mi (100 km) of the Grassy Mountain Tailings Storage Facility Site, Malheur County, Oregon

Fault Number [1]	Significant Fault or Fault Zone [1]	Rrup[2]	Rjb[2]	Rx[2]	Ry0[2]	MCE[3]	Median (50th percentile) PGA (g)[4]
806	Cottonwood Mountain	28.78	28.78	17.50	22.85	7.2	**0.15**
636	Owyhee Mountain fault system	29.81	29.81	5.50	29.30	7.2	**0.15**
635	Western Snake River Plain fault system	38.19	38.19	34.37	16.65	7.0	**0.11**
856a	Steens fault zone, Crowley section	50.48	48.20	6.38	48.15	6.9	**0.08**
805	Juniper Mountain	60.31	60.31	41.00	44.23	6.7	**0.06**
1801	Warm Springs	66.53	64.82	73.25	5.47	6.6	**0.05**
632	Squaw Creek	80.46	80.46	63.74	49.10	6.9	**0.05**
807	Faults near Unity Valley	81.05	79.65	8.52	79.64	6.9	**0.05**
631	Big Flat	87.01	87.01	81.45	30.61	6.8	**0.04**
630	Jakes Creek	81.52	80.13	79.17	38.06	6.7	**0.04**
1802	Harney	97.55	97.55	97.55	0.00	6.8	**0.03**

Notes: Rrup = Closest distance to coseismic rupture (km); Rjb = Closest distance to surface projection of coseismic rupture (km); Rx =Horizontal distance from top of rupture measured perpendicular to fault strike (km); Ry0 = Horizontal distance off the end of the rupture measured parallel to strike (km); MCE = maximum credible earthquake

1. Fault numbers and names as defined within Table 1.
2. The distance parameters, in kilometers, are calculated based on the closest approach of the mapped fault traces to the sites, orientation and geometry with respect to the site as measured on Google Earth™ or GIS using the coordinates 43.669687° N, 117.359279° W.
3. MCE magnitudes were calculated based on regressions by Stirling et al. (2008) for strike-slip/oblique-slip and Wesnousky (2008) for normal faults.
4. Median PGA calculated assuming three soil Site Soil Class conditions: 1) Site Class B/C ($V_{S,30}$ = 760 m/s), 2) Middle Site Class D ($V_{S,30}$ = 259 m/s and using the following NGA-West2 GMMs with relative weighting in brackets: Abrahamson and Silva (2013) [0.25], Boore et al. (2013) [0.25], Campbell and Bozorgnia (2013) [0.25], Chiou and Youngs (2013) [0.25].

The median PGA was calculated at the TSF site using the geometric mean of four, equally weighted Next Generation Attenuation (NGA-West2) relations as developed by Abrahamson et al. (2013), Boore et al. (2013), Campbell and Bozorgnia (2013), and Chiou and Youngs (2013). The GMM estimate earthquake accelerations as

a function of earthquake magnitude, fault type, source-to-site distance, and site soil conditions. Table 2 lists the earthquake source-to-site distances (i.e., R_{rup}, R_{jb}, R_X, and R_{Y0}) used in the four NGA-West2 GMMs.

Conclusion from Deterministic Analysis at the Proposed Grassy Mountain TSF Site

Table 2 lists median (50th percentile) PGA values. Median values were calculated because the earthquakes originate on faults with average slip rates less than 0.3 mm/yr as recommended in Idriss et al. (2018). Soil Site Class D values range from 0.03 to 0.15 g based on $V_{S,30}$ of 2,500 ft/s (760 m/s). The soil Site Class D PGA values are about 35% higher than listed in Golder (2017) because the present values are for softer site conditions that generally amplify accelerations on rock conditions at the same site. The largest median PGA values result from an **M**7.2 earthquake occurring along the Cottonwood Mountain fault north of the proposed TSF site (Figure 1). Median PGAs of 0.15 g and 0.16 g indicate a relatively low level for the deterministic hazard at the proposed TSF site.

Probabilistic Seismic Hazard Analysis

General

Probabilistic seismic hazard analysis is commonly used to estimate earthquake ground motions for regions and for sites (e.g., McGuire 2004). The method provides a probabilistically based estimate (annual frequency of exceedance or its inverse of return period) for the specified earthquake ground motions. The earthquake ground motions can be PGA, as is often required for foundation and dam stability analyses, or spectral accelerations (accelerations at a specified frequency), as are commonly used in most modern building codes.

The USGS developed national probabilistic seismic hazard maps (NSHM) in 1996, 2002, 2008, and 2014. Each NSHM update incorporated the latest information on fault locations, fault characteristics, historical earthquakes, and the number and weighting of GMMs developed from earthquake records in the USA and around the world. Online tools based on the NSHM can be used to estimate PGA and spectral accelerations for any site in the conterminous United States (USGS 2017). Table 3 lists PGA and spectral accelerations for various return periods, based on the dynamic model (https://earthquake.usgs.gov/hazards/interactive) of the NSHM (USGS 2014). PGA values listed in Table 3 are for a stiff soil (soil Site Class D with $V_{S,30}$ = 850 ft/s [259 m/s]).

Table 3: PGA, 0.2- and 1.0-second Spectral Accelerations (Sa) for Selected Return Periods at the Grassy Mountain Tailings Storage Facility Site, Malheur County, Oregon

Probability of Exceedance (return period in years)[1]	Mean PGA (g)	0.2 second Sa (g)	1.0 second Sa (g)
10% in 50 years (475)	0.08	0.20	0.10
2% in 50 years (2,475)	0.20	0.50	0.23
1% in 50 years (4,975)	0.27	0.69	0.31

Notes: PGA = peak ground acceleration.

1. Values from the 2014 USGS national probabilistic model (Dynamic; Conterminous v.4.1.1) for a site location of 43.6728°N, 117.36437°W

Conclusion from Probabilistic Analysis for the Proposed Grassy Mountain TSF Site

Interpolation of the 2014 NSHM dynamic model indicates that the 2,475-year return period mean PGA is about 0.20 g for a soil Site Class D site (Table 3). Golder understands that a 2,475-year return period value is being considered for TSF seismic analysis and design. The 2,475-year return period ground motions indicate a low to moderate seismic hazard at the proposed TSF site.

Comparison between probabilistic and deterministic PGA ground motions indicate that the median PGA developed from an **M**7.2 earthquake on the Cottonwood Mountain fault (Table 2) has a return period estimated from the 2014 USGS NSHM at about 1,500 years for a soil Site Class D ground condition.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The Grassy Mountain proposed TSF Site is located in a region of relatively low historical earthquake activity within the Columbia Plateau physiographic province of the western USA. Since 1965, only 81 historical earthquakes with magnitudes greater than **M**3.0 have epicenters located within about a 125 mi (200 km) radius of the TSF site. Only six of the recorded earthquakes have exceeded **M**4.0.

Eleven Quaternary-active faults have been mapped within about 62 mi (100 km) of the proposed TSF site. Of the 11 mapped faults, seven have evidence for surface rupture in Holocene and Late Pleistocene time (i.e., <15 ka and 130 ka, respectively), two faults have had their most recent displacements in the mid- to early Quaternary (<750 ka), and two faults have had their most recent known displacement during the early Quaternary (<2.6 Ma).

The Deterministic Seismic Hazard Analysis indicates that the Cottonwood Mountain fault is the controlling MCE source for the proposed TSF site. The fault strikes at a 331° azimuth (N29°W) and dips 60º to 70º northeast. The trace of the Cottonwood Mountain fault is about 18 mi (28 km) north of the proposed TSF site at its closest approach and has an MCE magnitude estimated at **M**7.2. Using the geometric mean of four equally weighed GMMs, median PGA values for soil Site Class D ($V_{S,30}$ of 850 ft/s [259 m/s]) is 0.15 g. The median deterministic PGA has a return period estimated from the 2014 USGS NSHM at about 1,500 years.

Probabilistic analysis using the USGS 2014 National Seismic Hazard Map indicates that the 475-year and 2,475-year return period mean PGAs for a soil Site Class D site are 0.08 g and 0.20 g, respectively.

CLOSING

This office-based analysis of fault activity and seismic hazard is for use by Calico Resources Corp. The results of the assessment indicate a low to moderate seismic hazard based on the probabilistic analysis and a relatively low seismic hazard based the deterministic analysis. If you have any questions or concerns, please contact the undersigned.

Golder Associates Inc.

Donald Lowry
Senior Engineering Geologist

Alan Hull, PhD
Senior Practice Leader, Principal

DJL/AGH/kt

https://golderassociates.sharepoint.com/sites/17031g/1663241 grassy mountain tsf/500_reporting/520_letters/526_seismic hazard/detailed design/final/1663241.058-tm-rev0-grassy mountain tsf-103019.docx

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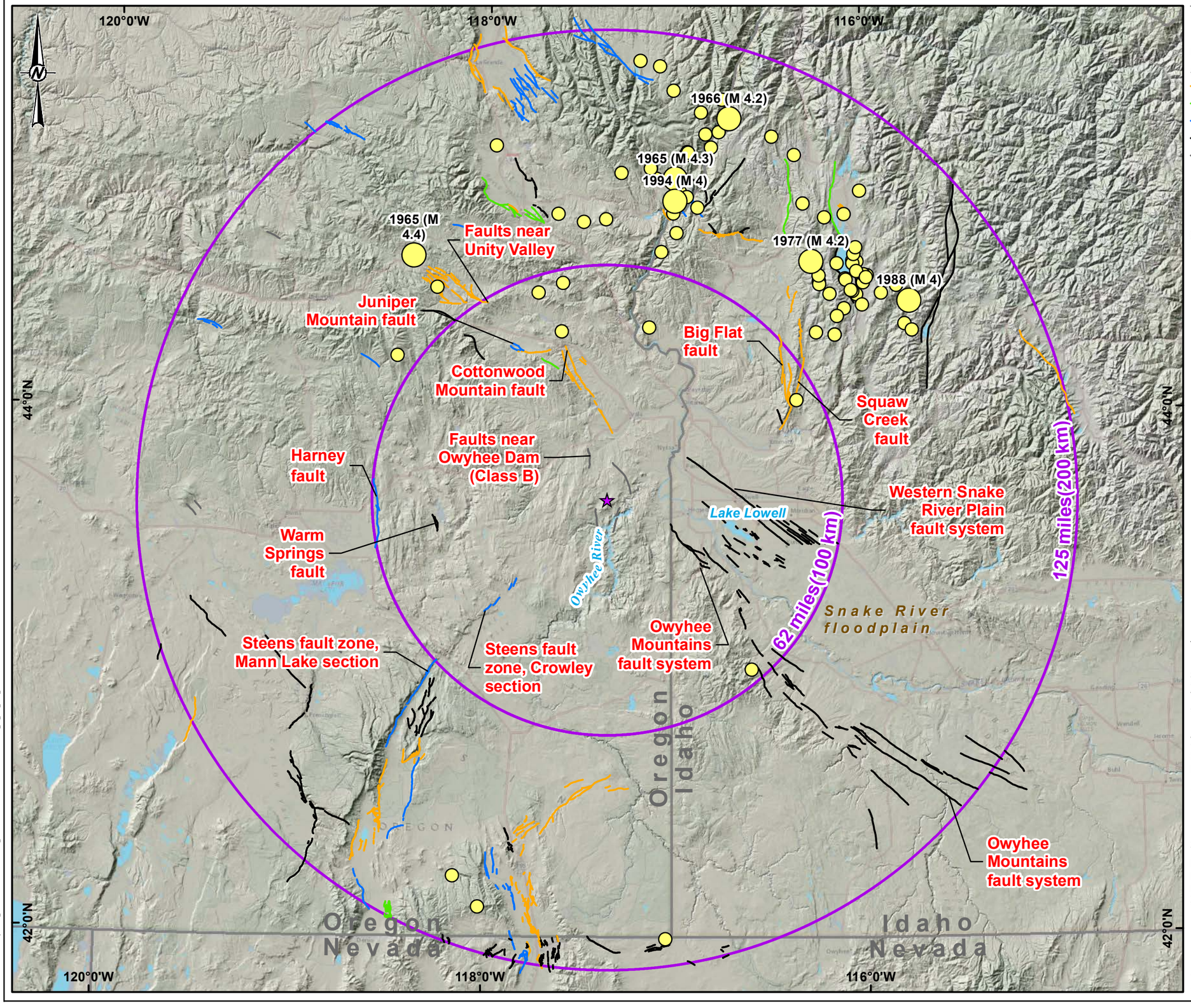
Figure 1



LEGEND

Grassy Mountain TSF Site

Faults

Age of Most Recent Movement

- Latest Quaternary (<15,000 years)
- Late Quaternary (< 130,000 years)
- Middle and Late Quaternary (< 750,000 years)
- Quaternary (< 2.6 million years)
- Class B Faults

Historical Earthquake Epicenters

Magnitude

- 3.0 - 3.9
- ≥ 4.0

0 20 40

MILES

REFERENCE(S)

1. EARTHQUAKE EPICENTERS COMPILED BY GOLDER FROM MULTIPLE SOURCES, SEE REPORT REFERENCES SECTION
2. FAULTS: USGS (2018)
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 11N
4. SERVICE LAYER CREDITS: USGS,NGA,NASA,CGIAR,GEBCO,N ROBINSON,NCEAS,NLS,OS.NMA,GEODATASTYRELSEN AND THE GIS USER COMMUNITY CONTENT MAY NOT REFLECT NATIONAL GEOGRAPHIC'S CURRENT MAP POLICY. SOURCES: NATIONAL GEOGRAPHIC, ESRI, DELORME, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, INCREMENT P CORP.

CLIENT

CALICO RESOURCES USA CORPORATION/
PARAMOUNT GOLD NEVADA CORPORATION

PROJECT

SEISMIC HAZARD ASSESSMENT
GRASSY MOUNTAIN TSF SITE
MALHEUR COUNTY, OREGON

TITLE

HISTORICAL EARTHQUAKES AND POTENTIALLY SEISMOGENIC FAULTS IN REGION SURROUNDING THE PROPOSED GRASSY MOUNTAIN TSF SITE

CONSULTANT

GOLDER

YYYY-MM-DD	2019-06-18
DESIGNED	HJ/DL
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
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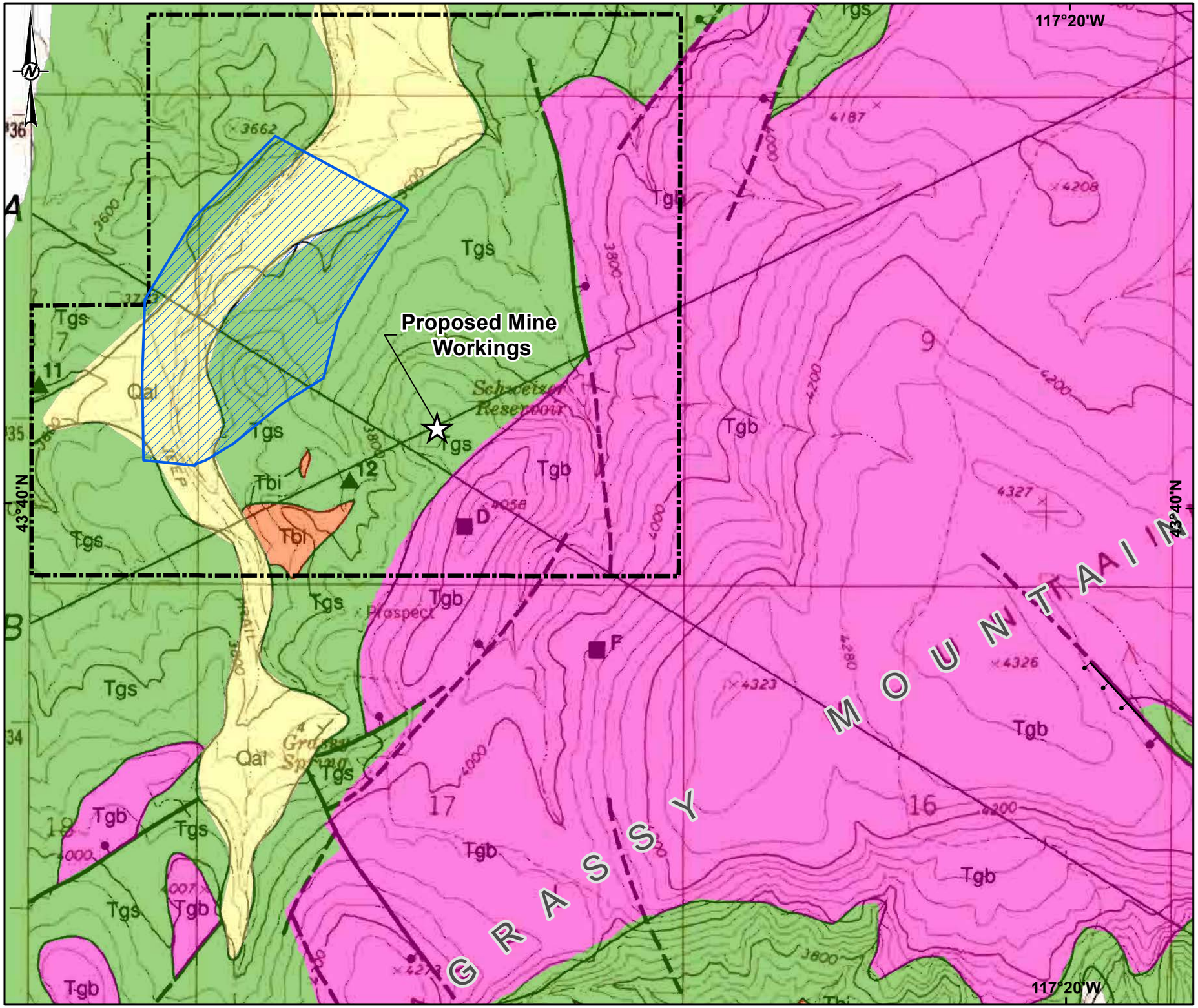
Figure 2



LEGEND

- Grassy Mountain Proposed Tailings Storage Facility (TSF) Footprint
- Project Boundary
- Fault (solid where visible, dashed where inferred, dotted where buried; ball and bar on downthrown side)

Geologic Units

- Qal - Quaternary Alluvium
- Tgb - Upper Miocene Olivine Basalt Flows
- Tbi - Miocene Mafic Dikes and Sills
- Tgs - Mid-upper Miocene Arkosic sandstone and conglomerate (Grassy Mountain Formation)

0 1,000 2,000
FEET

REFERENCE(S)

1. GEOLOGY: FERNS AND RAMP (1989)
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 11N

CLIENT
CALICO RESOURCES USA CORPORATION/
PARAMOUNT GOLD NEVADA CORPORATION

PROJECT
SEISMIC HAZARD ASSESSMENT
GRASSY MOUNTAIN TSF SITE
MALHEUR COUNTY, OREGON

TITLE
MAPPED GEOLOGICAL UNITS SURROUNDING THE GRASSY MOUNTAIN TSF SITE

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-18
DESIGNED	HJ/DL
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1663241	25000	0	2

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APPENDIX C

Geotechnical Stability and Settlement Analyses

November 4, 2019 1663241.061.L.REV0

Mr. Christopher J. MacMahon, PE
Golder Associates Inc
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Reno, Nevada 89521

GEOTECHNICAL STABILITY ANALYSIS AND SETTLEMENT CALCULATIONS
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
GRASSY MOUNTAIN PROJECT, MALHEUR COUNTY, OREGON

Dear Mr. MacMahon,

1.0 INTRODUCTION

This letter presents the geotechnical stability analysis and settlement calculations carried out for the proposed Tailings Storage Facility (TSF) and waste rock dump (WRD) for Calico Resources USA Corp's (Calico's) Grassy Mountain Project (Project) located in Malheur County in southeastern Oregon.

The proposed TSF is designed to be constructed in three stages (Stages1 to 3) using downstream construction methods. The TSF and WRD are designed to be fully geomembrane-lined with a continuous secondary geosynthetic clay liner (GCL) underlayment and leak collection and recovery system (LCRS) between the two primary and secondary containment layers.

Material properties were developed using data obtained during geotechnical investigations performed by Golder Associates Inc. (Golder) presented in Appendix A of the main TSF Design Report that this letter is appended to.

2.0 TSF OVERVIEW

Embankments will be required on the north and west sides of the TSF to impound tailings (Figure 1). The main North embankment will span the width of the valley, with a Stage 3 crest length of about 1,700 feet and maximum height of about 84 feet. The West embankment will be used to bridge saddles along the western ridge, with a Stage 3 crest length of about 1,000 feet and maximum height of about 30 feet. The TSF impoundment and upstream embankment slopes will be continuously-lined using 80 mil high density polyethylene (HDPE) geomembrane primary containment layer and an enhanced GCL secondary containment layer.

3.0 GENERAL GROUND CONDITIONS

3.1 Regional Geology

The proposed TSF and WRD site (and surrounding region) is located within in the Columbia Plateau, a physiographic province of the United States that comprises thick sequences of basalt flows (Columbia River

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Basalt) erupted from about 17.5 to 6 million years ago (Ma). The relatively unaltered basalt flows in the Payette section range in elevation from about 3,800 feet to about 4,500 feet above sea level (asl).

The TSF and WRD site is located about 15 miles southwest of the Snake River plain near Adrian, Oregon. At this location, some dissection of the basalt flow-dominated landscape has occurred, exposing the underlying sedimentary units of the Grassy Mountain Formation. The site is located within a north-flowing drainage area at an elevation of about 3,700 feet asl,

3.2 Site Geology

The geology of the region surrounding the TSF and WRD site is a sequence of sedimentary and volcanic deposits within the Oregon-Idaho Graben. Contemporaneous deposition of sandstone and conglomerate (Tgs), olivine basalt emplacement (Tbi), and repeated episodes of calc-alkaline lava eruption and flow (Tgb) occurred during middle to upper Miocene time. The Payette section of the Columbia Plateau, where the TSF and WRD site is located, is a relatively uniform area of basalt flows that overlie and cap the underlying older sedimentary deposits.

Grassy Mountain itself is mapped as underlain by calc-alkaline rich volcanic flow deposits (Tgb) and associated olivine basalt that crops out farther northeast. The TSF and WRD site is located on a thick sequence of arkosic sandstones containing interbeds of conglomerate separated by the tuff of Kern Basin. Geologically, the site is within the upper arkosic (mid- to upper Miocene) and the lower (mid-Miocene) arkosic units. Erosion over about the last 11 Ma has removed some of the volcanic deposits that overlie and cap the sedimentary units to expose the upper arkosic unit at the Site.

Bedrock outcrops within the site expose siltstone, sandstone, and conglomerate of the late Miocene Grassy Mountain Formation. These units are also exposed in the northeast–southwest trending drainage that the TSF will partially fill. Olivine-rich basalts are present immediately to the east and south. Igneous intrusions (Tbi) are mapped as isolated bodies surrounded by the sedimentary units (Tgs). The intrusive bodies are in places aligned along the mapped pre-Quaternary faults that may have controlled the locations and extent of these shallow intrusions.

The surficial soils at the TSF and WRD site area include unconsolidated alluvium and colluvium overlying previously unmapped Miocene-aged lacustrine clays. The lacustrine deposits are generally characterized as fat (high plastic) clay (with variable quantities of fine- to medium-grained sand, dark tan to brown with some blue-gray deposits) with lesser amounts of lean (low plastic) clay and poorly-graded sand lenses. Similar deposits were mapped by Ferns et al. (1993) approximately 2 miles (3 km) northeast of the proposed TSF site. Gray et al. (1989) considers that the clay was deposited during the Upper Miocene within alkaline lakes subjected to regular volcanic ash fall and/or hydrothermal alteration.

The Grassy Mountain Mine site is located on a 150-foot high, highly resistant, silicified and iron-stained knoll. Bedding within the sandstone unit appears unaltered at the hilltop, dips at 10° to 25° toward the north-northeast on the northern and eastern flanks of the hill and steepens to 30° to 40° on the west side of the hill due to drag folding in the footwall along a fault striking about N20°W (Paramount 2017). Normal faulting of the Miocene-age units is common, with most faults striking either northwest–southeast or northeast–southwest (most common).

Also, a number of mapped older faults strike approximately north–south, but these faults are generally located west of the TSF site and are not considered seismogenic under the current tectonic environment.

3.3 Seismic Hazard Assessment

Golder completed a preliminary seismic hazard analysis (SHA) for the Grassy Mountain Mine in 2017 (Golder, 2017). Subsequent to additional geotechnical field investigations in 2019, the preliminary SHA was updated to support the design of the TSF and WRD.

The SHA developed earthquake ground motions using both a deterministic seismic hazard analysis (DSHA) and probabilistic seismic hazard analysis (PSHA) for the proposed Grassy Mountain TSF and WRD site. The updated SHA is included in the main TSF Design Report this letter is appended to.

The proposed TSF and WRD site is classified as Class D based on the review of shear wave velocity measurements ($V_{S,30}$ of 850 ft/s). A probabilistic analysis using the USGS 2014 National Seismic Hazard Model indicates mean peak ground accelerations (PGA) for Site Soil Class D for return periods of 475 and 2,475 years. The following table presents PGA and spectral accelerations for the referenced return periods:

Table 1: Peak Ground Acceleration, 0.2- and 1.0-second Spectral Accelerations (Sa) for Selected Return Periods at the Grassy Mountain Tailings Storage Facility Site, Malheur County, Oregon

Probability of Exceedance (return period in years)[1]	**Mean PGA (g)**	**0.2 second Sa (g)**	**1.0 second Sa (g)**
Site Soil Class D ($V_{S,30}$[2] of 850 ft/s)			
10% in 50 years (475)	0.08	0.20	0.10
2% in 50 years (2,475)	0.20	0.50	0.23

Notes:

1. Values from the 2014 USGS national probabilistic model (Dynamic; Conterminous v.4.1.1) for a site location of 43.6728°N, 117.36437°W
2. $V_{S,30}$ is the shear wave velocity in the upper 100 feet (30 m) below the site

A deterministic analysis was used to estimate the maximum credible earthquake (MCE) that could be experienced at the Grassy Mountain Mine. The MCE is the largest possible earthquake that may reasonably occur along a recognized fault or within a geographically defined tectonic province, under the presently known or presumed tectonic framework. Little regard is given to the earthquake recurrence interval, which may vary from less than a hundred years to more than ten thousand years, depending on the geologic and tectonic environment under consideration.

Median (50th percentile) values of PGA created by an MCE are sometimes used for analysis and design of low failure consequence structures, while 84th percentile values are often used for high failure consequence structures.

Median (50th percentile) PGA values were calculated because the earthquakes originate on faults with average slip rates less than 0.3 mm/yr as recommended by Idriss et al. (2018). Soil Site Class D PGA values range from 0.03g to 0.15g. The largest median PGA values result from an **M**7.2 earthquake occurring along the Cottonwood Mountain fault north of the TSF site. The median PGA of 0.15g from the MCE indicates a relatively low level for the deterministic hazard at the TSF site. The median MCE was used for stability assessment of the TSF embankments and exceeds the minimum requirements of Oregon Administrative Rues (OAR) 690-020-0038 for Low Hazard dams.

The WRD is considered a temporary facility; therefore, a return period of 475 years with mean PGA of 0.0.08g was used for stability assessment of the WRD facility.

3.4 Geotechnical Investigation Data

The geotechnical investigations and laboratory testing programs pertinent to the development of geotechnical material property characteristics for the Grassy Mountain TSF and WRD site are briefly summarized below. Borehole locations from these investigations are shown on the Design Drawings in the main TSF Design Report this letter is appended to.

3.4.1 2017 Borehole Investigation

This investigation included advancing 14 boreholes to depths ranging between 25 feet to 100 feet below the ground surface (bgs) and excavating 45 test pits to depths of up to 20 feet bgs from November 30 to December 8, 2017. A geotechnical laboratory testing program on selected samples included index testing (grain size analysis, moisture, and Atterberg Limits), permeability (hydraulic conductivity) testing, consolidated undrained (CU) triaxial shear strength testing with porewater pressure measurement, oedometer (one-dimensional consolidation) testing and modified Proctor compaction testing.

3.4.2 2019 Borehole Investigation

This investigation included advancing six boreholes to depths ranging between 50 to 120 feet bgs from March 20 to 26, 2019. The investigation also included laboratory testing on selected samples including index testing (grain size analysis, moisture, and Atterberg Limits), triaxial tests and oedometer tests. Results from this investigation are presented in Appendix A of the main TSF Design Report.

3.4.3 2019 CPT Investigation

This investigation included pushing Cone Penetration Tests (CPTs) from August 16 to 20, 2019. A total of 12 CPTs (8 CPTs and 4 Seismic CPTs) were completed to depths ranging between 11 to 61 feet bgs. Pore water pressures induced during pushing of the cone tip were recorded during all CPTs, with pore pressure dissipation tests performed at selected intervals during the testing program. Results from this investigation are presented in Appendix A of the TSF Design Report. Shear wave velocities were recorded during seismic CPTs at four locations down to the depth of 60 feet bgs.

No groundwater table was detected during the CPT program.

3.5 Stratigraphy

Golder's subsurface 2017 and 2019 geotechnical investigations identified an unconsolidated surficial layer of alluvium (clayey/gravely/silty sand) overlying a thick layer of previously unmapped Miocene-aged lacustrine clays underlying most of the TSF and WRD site area. The lacustrine deposits were generally classified as CL to CH according to the Unified Soil Classification System (USCS), and characterized as high plastic, stiff to hard clay (with variable quantities of fine- to medium-grained sand, dark tan to brown with some blue-gray deposits) with lesser amounts of low plastic clay and poorly graded sand lenses.

The depth of the surficial alluvium and colluvium layer was up to 8 feet under the main North embankment and varied between 10 feet and 20 feet under the west dam embankment. The thickness of the clay layer is estimated to be more than 100 feet. Interbedded layers of sand and silt exist within the clay layer at some locations.

3.6 Groundwater Conditions

No groundwater was encountered during the field exploration with boreholes extending to a maximum depth of approximately 120 feet bgs. In the *Groundwater Resources Baseline Data Report* prepared by SPF Water Engineering, LLC (SPF 2019), it was reported that the groundwater depth beneath the southern portion of the TSF basin ranged between 155 feet at the BLM well located within the TSF footprint and 232 feet at the GW-3 well located just southwest of the TSF (SPF 2019). Inferred groundwater contours presented in the same report indicate groundwater beneath the reclaim pond area may be as shallow as 55 feet; however, no groundwater was encountered in any of the boreholes extending to a maximum depth of approximately 120 feet bgs. Groundwater depths in this area will be refined after the installation of proposed groundwater monitoring wells as presented in SPF (2019)'s report. In addition, no springs were observed in the TSF or mine facility areas during the field investigation.

4.0 MATERIAL PROPERTIES

Geotechnical material properties for use in stability analyses and settlement calculations are summarized in the following sections. Material units were assessed properties developed using information described in the TSF Design Report. Table 2 summarises the material properties selected for the following units:

- Tailings
- Embankment Fill
- Waste Rock
- Lining Interface
- Foundation Alluvium Layer
- Foundation Clay Layer

Table 2: Geotechnical Material Properties for Stability Analysis

Unit	Bulk Unit Weight (pcf)	Strength Model	Shear Strength Parameters					Bbar[1]
			Undrained Shear Strength, s_u (psi)	Effective Stress		Total Stress		
				Friction Angle, Φ' (deg)	Cohesion, c' (psi)	Friction Angle, Φ (deg)	Cohesion, c (psi)	
Tailings	95	Mohr-Coulomb	-	-	-	15	0	0
Lining System	120	Mohr-Coulomb	-	11	0	-	-	0
Embankment Fill	135	Mohr-Coulomb	-	40	0	-	-	0
Waste Rock	135	Mohr-Coulomb	-	35	0	-	-	0

Unit	Bulk Unit Weight (pcf)	Strength Model	Shear Strength Parameters					Bbar[1]
			Undrained Shear Strength, s_u (psi)	Effective Stress		Total Stress		
				Friction Angle, Φ' (deg)	Cohesion, c' (psi)	Friction Angle, Φ (deg)	Cohesion, c (psi)	
Foundation Alluvium	130	Mohr-Coulomb	-	30	0	-	-	0
Foundation Clay	120	Mohr-Coulomb	-	14	2 (315 psf)	-	-	0.15
		Undrained Mohr-Coulomb	20 (2851 psf)		-	-	-	-

Notes:

1. The porewater pressure parameter Bbar is defined as the ratio of load-induced excess porewater pressure to the applied loading expressed in terms of the increment of total vertical stress.

4.1 Tailings

Golder (2018) carried out laboratory testing on tailings samples prepared from bench-scale testing to assess their classification properties, settled density, compressibility and permeability characteristics. A bulk unit weight of 95 pcf was selected for tailings for the stability analyses. The strength parameters for tailings (total stress friction angle, ϕ = 15 degrees and cohesion, c = 0) were selected based on Golder's knowledge and experience with similar tailings facilities. Due to the embankments being constructed using downstream techniques, this unit is not a controlling unit in terms of the stability of the embankments; therefore, no advanced strength tests were carried out to characterize its frictional strength. The strength parameters selected for the tailings are conservatively low and will potentially be higher during operation and closure.

4.2 Embankment Fill

Quarried basalt rock will be used as mass fill material for the TSF embankment and Waste Rock Dump berms. The quarried material is expected to act as a competent and strong rockfill. The suitability of the basalt quarry source to be used as embankment fill material has been assessed by Golder (2019). A bulk unit weight of 135 pcf was selected for quarried basalt fill. The strength parameters for embankment fill material (ϕ'=40 degrees and c'=0) were selected based on review of data provided by Leps (1970) for similar material and range of applied vertical stresses. The maximum applied vertical stress of the embankment fill at the embankment foundation is about 80 psi, based on the maximum Stage 3 height of the embankment (84 feet). Figure 2 presents the supporting data from Leps (1970) and selected friction angle for embankment fill material.

4.3 Waste Rock

During mining, waste rock material will be temporarily stockpiled on the WRD pad. As mining progresses, the stockpiled waste will be rehandled and used as aggregate for cement rock backfill in the underground workings. Based on the current mine plan, the maximum anticipated volume of waste rock to be stockpiled is less than 200,000 tons. The proposed WRD is designed to contain a maximum volume of 200,000 tons of waste.

Generally, materials stockpiled will consist of coarse yet relatively weak run-of-mine waste rock. Waste rock will be placed in relatively thick and uncompacted lifts. However, due to the relatively low rate of dump development, the waste materials are expected to densify over time. A conservative material strength of ϕ'=35 degrees and c'=0 has bee selected.

4.4 Lining System

The proposed geosynthetic lining system to be used for the TSF and WRD consists of (from bottom to top) prepared subgrade, a geosynthetic liner (GCL), an 80-MIL HDPE geomembrane with single-sided texturing (textured side facing down), an 18-inch thick drainage layer, and a 6-inch thick filter fill layer. This lining system will be directly below the tailings in the TSF and the waste rock in the WRD.

Mohr-Coulomb strength parameters for the Lining System were estimated based on Golder's database of past interface direct shear testing between various types of geomembrane liner, soil and other geosynthetics. Golder reviewed strength parameters from this database from over 100 direct shear tests between GCL and soil and over 120 direct shear tests between textured geomembrane and GCL. In our review, Golder found that the interface direct shear tests between the GCL and textured geomembrane generally resulted in the lowest residual strength values. Therefore, average Mohr-Coulomb strength parameters of Φ' = 11° and c' = 0 psi for the GCL-geomembrane interface were conservatively assigned to be the modeled Lining System.

The strength of the lining system does not control the stability of the TSF but is an important factor for stability of WRD. Considering that WRD is a temporary structure which will be removed at closure, the long-term behaviour of the lining system was not assessed for WRD. If waste rock is intended to be stored on the WRD for durations longer than the current life of mine, stability of the WRD should be reconsidered for long-term conditions.

4.5 Alluvium Foundation Layer

These deposits were surficial in the TSF area and were generally characterized as compact to very dense sand to clayey gravelly or silty sand with up to 45% fines content, by weight. The thickness of the alluvium layer is up to 8 feet under the North embankment and varies between 10 feet and 20 feet under the West embankment. The uncorrected field Standard Penetration Testing (SPT) blow counts (N-value) recorded during 2017 and 2019 investigations for the near surface alluvium vary between 12 to 81 blows per foot of penetration.

This unit is not a controlling unit in terms of the stability of the embankments, therefore, no advanced strength tests were carried out to characterize its frictional strength. Considering that the high blow counts might be due to presence of gravel, an average friction angle of 30 degrees and cohesion of zero was conservatively assigned for alluvium layer.

4.6 Clay Foundation Layer

The Miocene-aged clay layer that underlies most of the TSF and WRD site were generally characterized as high plastic, stiff to hard clay (with variable quantities of fine- to medium-grained sand, dark tan to brown with some blue-gray deposits) with lesser amounts of low plastic clay and poorly graded sand lenses. The thickness of the clay layer was estimated to be over 100 feet (at the location of Boreholes TP-01, TP-02, TP-19 and TP-44, clay layer was observed at depth of 120 feet bgs). The measured water content for clay samples ranged between 2% to 73% with an average of 29% and standard deviation of 9%. The measured Plasticity Index for clay samples ranged between 10 to 198 with an average of 63 and standard deviation of 36.

Since this layer is a controlling unit for both stability analysis and settlement estimates, a comprehensive laboratory testing program and CPT program was developed to assist with understanding the geotechnical engineering characteristics of the layer. Figure 1A presents Golder's interpretation of the clay foundation layer's continuity below the North embankment. The following sections describe the material properties interpreted from the available investigations and laboratory testing programs on the foundation clays.

4.6.1 Pre-consolidation pressure

4.6.1.1 CPT Results

The estimated pre-consolidation pressure (using well-established published correlations) versus depth from all CPTs is presented on Figure 3. As shown, the likely pre-consolidation pressure increases with depth at a rate of about 3.3 psi/feet. A pre-consolidation pressure of about 90 psi was estimated for upper clay layers close to the ground surface. Since the anticipated maximum vertical stress caused from construction of the embankment is about 80 psi, it is concluded that the foundation clay will mostly remain over-consolidated (i.e., the stress imposed by the embankment will not make the clay become normally consolidation because the pre-consolidation pressure would not be exceeded).

4.6.1.2 Consolidation Test Results

The average estimated pre-consolidation pressure (p_c) from four laboratory Oedometer (1-dimensional consolidation) tests performed on selected samples of foundation clays is about 70 psi which is slightly lower than the estimated p_c from the CPT data (Section 4.6.1.1) and supports the strongly over-consolidated nature of the clays. The p_c from laboratory oedometer tests is likely to be underestimated due to the tested saturated conditions of the test specimens, while the in-situ condition of the foundation clay as identified by the field CPT tests is unsaturated. The results from the field CPT program are considered more representative of measuring the in-situ undrained shear strength and pre-consolidation pressure of the foundation clay and were therefore relied more heavily on in strength parameter selection. A pre-consolidation pressure p_c of 90 psi was selected for shear strength estimation of the clay layer.

4.6.2 Shear Strength Parameters

According to Mesri (1975), the undrained shear strength of clay (s_u) can be reliably estimated as 0.22 x p_c. This relationship has been demonstrated to be valid for a large number of clays and is commonly used in state-of-practice to estimate undrained shear strength.

A s_u of 19.8 psi (2,850 psf) was estimated for the foundation clay based on the selected p_c of 90 psi (as described on Section 4.6.1).

The measured peak effective friction angle on selected samples of the clay layer from triaxial shear strength tests completed for this study varies between 8 to 38 degrees for low confining (consolidation) stresses of about 35 psi. The effective friction angle of the clay decreases with increasing Plasticity Index. Based on data from Lo (1995) and Bjerrum (1968), the effective-stress friction angle of clay varies between 8° to 35° for PI of 10 to 198.

The failure surface normally passes through the weakest layer(s) (the layer with high plasticity index in clay deposits). Layering of the foundation clay deposit can create discontinuous areas of weaker and stronger materials. Based on laboratory strength and oedometer testing, variability in strength was observed. Due to this variability, clear delineation of these layers during typical geotechnical investigations.

Given these considerations, an average effective friction angle of 14 degrees was selected for the foundation clay. As shown in the geotechnical laboratory test results appended to the main Design Report, this effective friction angle is slightly lower than average strength measured.

Additionally, to account for the in situ unsaturated condition of the foundation clay and additional strength due to suction, an effective cohesion of approximately 2 psi (315 psf) was assigned.

4.6.3 Modulus of Elasticity

Golder estimated embankment settlements resulting from foundation compression using both consolidation theory and elastic settlement theory, the latter of which relies on the elastic moduli of the foundation geology.

The modulus of elasticity for the clay foundations can be estimated based on the large strain shear modulus of the soil, which in-turn is estimated using field data from the geotechnical investigations. The small strain (strain less than 10^{-4} %) shear modulus G_0 for the foundation clay was estimated from the shear wave velocity, V_s, measurements during the 2019 CPT program as:

$$G_0 = \rho V_s^2 \quad (1)$$

Where ρ is the in-situ density of the clay layer. Figure 4 presents the measured shear wave velocities and calculated G_0 versus depth from the four seismic CPTs carried out in Golder's 2019 CPT investigation. Vucetic and Dobry (1991) suggests that the large-scale shear modulus can be estimated using an average 80% reduction from the small-strain shear modulus for strain levels greater than 1% (i.e. $G/G_0=0.2$), as appropriate for strain level commonly experienced in engineering projects dealing with over-consolidated clay (OCR of up to 15) and PI of about 50. It is, therefore, estimated that the shear modulus (G) at engineering strain levels expected for the TSF is about $0.2xG_0$.

The undrained modulus of elasticity was calculated using the following equation of elastic theory:

$$E_{un} = 2(1+\nu)\mathrm{G} \quad (2)$$

where ν is the soil's Poisson's ratio. Figure 4 presents the calculated modulus of elasticity for clay layer versus depth assuming $\nu = 0.4$.

4.6.4 Compressibility Index and Swelling Index

The consolidation parameters: compressibility index, c_c, and swelling index, c_s, can be determined using the void ratio versus vertical stress in semi-log scale plot from oedometer tests. The slope of this plot at vertical stresses less than p_c is the swelling index, c_s, and at vertical stresses higher than p_c is the compressibility index, c_c. An average initial void ratio of 1, c_s of 0.04 and c_c of 0.4 was selected for the foundation clay layer based on the review of four oedometer tests results from the 2019 investigation provided in Appendix A of the main Design Report. These parameters were used for settlement calculations under the embankment due to primary consolidation of the foundation clay layer (Section 7.0).

5.0 MODEL GEOMETRY

Embankments will be constructed on the north and west sides of the TSF to impound tailings. A relatively short containment berm will be constructed around the perimeter of the WRD as shown on the Design Drawings appended to the main Design Report.

5.1 TSF Embankments

Both the North and West embankments will be constructed with an overall upstream slope of 3 horizontal to 1 vertical (3H:1V) or flatter (local slopes of 2.5H:1V separated by benches), and a downstream slope of 2.5H:1V. These slopes are selected during design to satisfy geotechnical stability of the embankment and foundation soils. The maximum height of the North embankment is about 84 feet, while the maximum height of the West embankment is about 30 feet. A minimum freeboard of 2 feet was considered for the embankments.

The phreatic surface was assumed to be at top of the Stage 3 tailings surface along the upstream side of the TSF with no phreatic surface within the embankment due to presence of the geosynthetic lining system.

No groundwater surface was included in the model as groundwater was not encountered in the geotechnical boreholes to depths of 120 feet below ground surface.

However, a pore pressure parameter, Bbar (defined as the ratio of load induced excess porewater pressure to the applied loading) of 0.15 was assumed for clay foundation to account for in-situ water content within foundation clay and excess porewater pressures built up during construction of the embankment. Bbar of 0.1 to 0.2 have been measured in similar foundation material during embankment construction in similar projects (Sherard 1963).

5.2 WRD Pad

Waste rock materials generated during mining will be stockpiled in a waste rock dump (WRD) near the TSF. Waste rock will be stored above a geomembrane lined pad located south of the TSF utilizing the same lining system as the TSF basin as discussed in Section 4.3. Generally, the WRD pad slopes from south to north at an approximate 2.5 percent grade. A perimeter berm with maximum height of about 12 feet, downstream slope of 2.5H:1V and upstream slope of 2H:1V was designed to support the placement of the waste rock material.

An underdrain collection system will be installed above the geomembrane liner for the WRD similar to the TSF underdrain collection system (perforated piping within a drainage layer above the geomembrane liner). Detailed design of the WRD pad, collection system, and cross sections are presented on the Design Drawings appended to the main Design Report.

No groundwater table was assumed in the foundation, however, as discussed in Section 5.1, Bbar of 0.15 was assumed for foundation clay.

6.0 STABILITY ANALYSIS

Golder designed the TSF embankments geometry based on deterministic stability analysis of both upstream and downstream of the of the main north and west TSF embankments and the WRD.

The analyses were performed using the 2-D limit equilibrium methods provided by the software package Slide 2018 (Rocscience 2018). The analyzed cross-sections were evaluated for both static and pseudo-static loading conditions using the Morgenstern-Price Method of slices to calculate the FOS against failure along the critical surface (i.e., the failure surface with the minimum calculated FOS) that was identified through an automated search algorithm.

Cross sections include the maximum embankment and/or dump heights of each facility, with additional sections being developed at the North embankment to refine the need for and/or extent of a downstream buttress. Figure 1 shows the location of the cross sections analysed for geotechnical stability assessment of the TSF and WRD.

Sections A, B and C are within the North embankment, Section D is within the West embankment, and Section E is within the WRD. Section D extends through the highest West embankment height of 30 feet.

As discussed in the main Design Report, no definitive factor of safety design criteria is presented the Oregon Administrative Rules (OAR), Division 20 – *Dam Safety*. The minimum factors of safety selected by Golder for static and pseudo-static loading conditions were selected based on Golder's expertise and industry best practice for tailings facilities in areas with arid climates and moderate seismicity.

Golder selected a minimum factor of safety of 1.5 for stability of the embankments and WRD under static loading and a factor of safety of 1.1 for pseudo-static loading conditions.

Both effective stress analysis (drained conditions) and total stress analysis (undrained conditions) were analysed using the material properties summarised in Table 1 for the foundation clay material**.** Considering the low permeability of the clay foundation and its in situ water content of up to 73 percent, by weight, (Section 4.6), it is likely that the clay foundation will shear in undrained conditions during construction of the embankment. Therefore, a total stress analysis was also conducted for analysed sections.

Pseudo-static analysis is one of the simplified approaches for analysing the seismic response of the embankments. This method is commonly used for facilities with low consequence of failure constructed at sites with low seismicity and for dam embankment and foundation soils that do not liquefy. For pseudo-static stability analysis, state-of-practice uses a horizontal seismic coefficient (k) that is half of the design PGA (Hynes-Griffin, Franklin, 1984) presented in Section 3.3. For the TSF site, the seismic coefficient used is 0.075 g (1/2 of the PGA of 0.15g). For the WRD, the seismic coefficient used is 0.04g (1/2 of the PGA of 0.08g).

6.1 Results

The results from the stability analysis are presented in Figures 5 to 18 for all three stages of the TSF embankment construction and WRD. A summary of the calculated factor of safeties for each section are presented in Table 3 and Table 4.

6.2 TSF Embankments

The foundation failure mode (i.e. failure through the foundation) using both effective stress analysis and total stress analysis were considered for stability analysis of TSF embankments. The internal failure mode (i.e. failure through the tailings and embankment fill material) was found not to be a controlling failure mode for TSF embankments. Stability analysis results for the TSF embankments are presented in Table 3 below.

All minimum calculated factors of safety for the Stage 1 (with downstream slope of 2.5H:1V) were higher than the minimum criterion for both static and pseudo-static analyses. Stages 2 and 3 require 15 feet high by 30 feet wide buttress constructed at the downstream toe to meet the required minimum calculated factor of safety under pseudo-static conditions.

It was found that the tailings' material properties are not controlling the failure surface as the failure surface with minimum factor of safety doesn't pass through the tailings.

It should be also noted that no groundwater was assumed for both effective stress and total stress analysis. If during construction or afterward, a shallow groundwater elevation was observed, the stability of the embankments should be reassessed.

Since the calculated factor of safeties for pseudo-static conditions under both effective stress and total stress analysis are sufficiently above the required factor of safety of 1.1, additional deformation analyses were not considered necessary.

Table 3: Summary of Critical Stability Analysis Results of TSF Embankments

Analysis Method	Stage of Construction	Static FOS (Target design minimum is 1.5)				Pseudo-static FOS (k = 0.075 g) (Target design minimum is 1.1)			
		North Embankment			West Embankment	North Embankment			West Embankment
		Section A	Section B	Section C	Section D	Section A	Section B	Section C	Section D
Effective Stress	1	1.5	1.7	1.6	1.9	1.2	-	-	1.4
	2	1.5	1.6	1.6	1.7	1.2	-	-	1.3
	3	1.5	1.5	1.5	1.5	1.2	-	-	1.2
Total Stress	1	2.1	-	-	-	1.7	-	-	-
	2	1.8	-	-	-	1.3	-	-	-
	3	1.5	-	-	-	1.1	-	-	-

6.3 Waste Rock Dump

The following two failure modes were considered for stability analysis of the WRD:

- Foundation failure mode (i.e. failure through the waste rock and foundation)
- Waste rock block sliding over the liner system

As shown on Figures 18 and 19 and summarised on Table 4 below, the minimum calculated factor of safety for Section E for the WRD was higher than the required minimum calculated factor of safety for both static and pseudo-static analyses.

The waste rock block sliding over the lining system (where the failure surface occurs at the weak interface between the liner and the waste rock) is the controlling mode of failure for WRD design (calculated FOS of 1.6). It was assumed that the drainage system designed for WRD will prevent a build up of pore water pressure within

the waste rock material such that it will not affect stability. It is recommended that the effectiveness of the drainage system in WRD being regularly assessed during waste rock placement in WRD.

It should be noted that the stability analysis for WRD was conducted for maximum stacking height of 35 feet and such that the waste rock is stacked against the geomembrane-lined perimeter containment berm with a maximum vertical separation of 2 feet from the crest of the berm to the toe waste rock dump slope as shown on the Design Drawings appended to the main Design Report. The stability of the WRD should be reassessed if higher waste rock heights are to be constructed.

Table 4: Summary of Critical Stability Analysis Results of Waste Rock Dump

Analysis Method	**Static FOS (Target design minimum is 1.5)**		**Pseudo-static FOS (k = 0.04 g) (Target design minimum is 1.1)**	
Effective Stress	**Circular Failure through Foundation**	**Waste Rock Block Sliding over the Liner System**	**Circular Failure through Foundation**	**Waste Rock Block Sliding over the Liner System**
	1.8	1.6	1.5	1.3

7.0 TSF EMBANKMENT FOUNDATION SETTLEMENT ANALYSIS

The objective of the settlement calculations was to estimate the settlement profile, caused by the weight of the embankment, of the underdrain collection piping system within the North embankment of the TSF for flow capacity evaluation of the pipes after settlement. These estimated settlements were used to determine the profile of the underdrain collection piping system after settlement takes place. Settlement grades along the underdrain collection piping after settlement must allow for positive solution flow from the TSF basin to the reclaim pond. To maintain this flow, underdrain collection pipes were designed to have a minimum post-settlement slope of one percent.

Settlement analysis was performed using Settle3D 4.0 (Rocscience 2019) software for a 150-foot thick clay foundation with material properties summarised in Table 5. The foundation clay has been observed at some boreholes down to the depth of about 120 feet. The actual thickness of the clay is not clear. However, since the induced stresses, and consequently the settlements within the foundation caused by placement of the embankment fill material, tends to decrease with depth and the soil at depth is much stiffer, assigning a clay foundation thickness of 150 feet was considered to be sufficient for settlement estimations. Both elastic compression and primary consolidation of the foundation clay were included in the settlement analysis. Settlements were estimated along the pipe for Section A (with maximum embankment height) of the North embankment of TSF as shown in Figure 1. No groundwater was assumed within analyzed top 150 feet clay layer for settlement calculations.

Table 5: Foundation Material Properties for Settlement Calculations

Unit	Layer Thickness	Bulk Unit Weight	Pre-consolidation Pressure, p_c	Increase in p_c with depth	Undrained Modulus of Elasticity	Consolidation Parameters		
	feet	pcf	psi	psi	psi	c_c	c_r	e_0
Foundation Clay	150	120	90	3.3[1]	10,000	0.4	0.04	1

Notes:

1. The increase in pre-consolidation pressure with depth at a rate of 3.3 psi/feet is assumed based on data from CPT results as shown on Figure 1 and described in Section 4.6.1.1.

A maximum settlement of about 3 feet was estimated in the embankment foundation under the crest of the embankment. Figure 19 presents the section and stationing used to compute the settlement profile along Section A.

As designed, grades of the underdrain pipe will be about 2.5 percent from the downstream crest of Stage 3 to the toe. With a maximum foundation settlement of about 3 feet over 250 feet of pipe length, the underdrain pipes are expected to flatten to about 1.1 percent near the downstream toe of Stage 3.

As presented in the main Design Report, the underdrain outlet pipes are designed to provide redundant capacity and are individually sized for a minimum one percent grade. At a one percent grade, each underdrain pipe can convey approximately 2.5 times the maximum anticipated underdrain flow rate during steady state drainage from the tailings. All calculated post-settlement grades meet the minimum required values for positive flow of the underdrain collection piping.

8.0 TSF EMBANKMENT CREST SETTLEMENT

As staged construction progresses, primary settlements within the foundation and embankment will occur. Placement of subsequent construction fill lifts will be performed up to the final Stage 3 design crest elevation as shown on the Design Drawings appended to the main Design Report. The consolidation of the foundation due to the additional lift at each stage of construction will take place after the immediate settlement and continue at a decreasing rate.

The minimum design freeboard of 2 feet from the maximum tailings surface to the dam crest will be large enough so that long-term settlement of the embankment and foundation after tailings deposition is compete will not reduce the dam crest elevation such that it encroaches on the final tailings surface.

Upon completion of tailings deposition and during the active water management closure period, free water on the tailings surface will be evaporated and settlement of the dam crest as a result of embankment and foundation settlement is expected to be less than settlement due to the foundation and tailings consolidation.

During long-term closure, once the tailings have consolidated and the proposed closure cover installed (discussed in the main Design Report), precipitation falling on the tailings surface will be routed through a closure spillway at the eastern abutment of the North embankment. After installation of the closure cover, the impoundment surface and dam crest will be at the same relative elevation. The final closed TSF will not provide any water retention capacity above the closure cover.

9.0 RECOMMENDATIONS

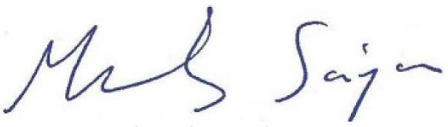
Golder's proposed design of the TSF and WRD have been based on industry-accepted engineering practices, extensive geotechnical investigation and laboratory testing programs, and technical resources. The following are recommended to be monitored during construction and operation. Findings should be compared to those used in this analysis.

- Groundwater conditions below the TSF embankments and WRD pad through installing and monitoring a series of open standpipes at controlling locations along the embankment toe
- Piezometric responses within the dam foundation during construction through installing and monitoring a series of vibrating wire piezometers at controlling locations within the embankment and foundation under the downstream crest and toe of the embankments
- TSF dam crest settlement and lateral movements during staged construction and tailings deposition through installing and monitoring a series of slope inclinometers and monuments at controlling locations within and along the embankment
- Embankment and waste rock drainage conditions
- TSF embankment and waste rock dump construction geometries

10.0 CLOSING

This letter describes the geotechnical stability analysis and settlement calculations for both TSF and WRD, as well as the geotechnical material properties estimated for these analyses. Golder trusts that this document addresses your current requirements. Please do not hesitate to contact the undersigned should you need additional information or clarification.

Golder Associates Ltd.



Masoumeh Saiyar, PhD
Senior Geotechnical Engineer

Dennis E. Becker, PhD
Principal, Senior Geotechnical Specialist

MS/DEB/kg

FIGURES

Figure 1	Stability Analysis, Section Locations
Figure 1A	Stability Analysis, Embankment Foundation Cross Sections
Figure 2	Leps (1970) Rock Fill Strength
Figure 3	Pre-consolidation Pressure Versus Depth
Figure 4	Shear Wave Velocity and Modulus of Elasticity for Clay Layers Versus Depth
Figures 5 to 16	TSF Stability Analysis Results
Figures 17 and 18	WRD Stability Analysis Results
Figure 19	TSF Foundation Settlement Analysis

11.0 REFERENCES

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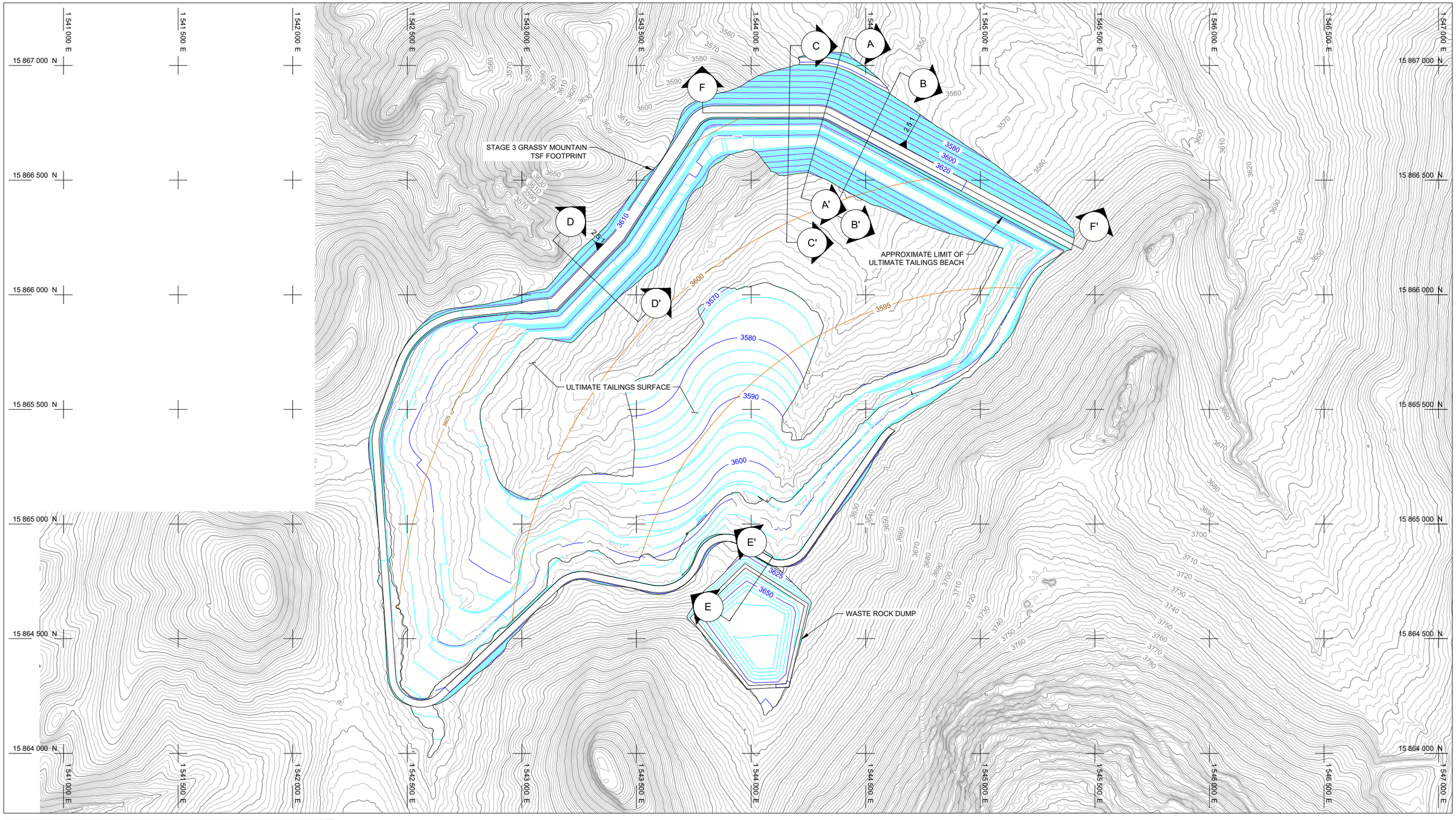
FIGURES



LEGEND

- 3600 — EXISTING GROUND (2 FT CONTOURS)
- 3600 — PROPOSED GRADING (2 FT CONTOURS)
- 3600 — ULTIMATE TAILINGS SURFACE (5 FT CONTOURS)

0 200 400 600
1" = 200' FEET

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GOLDER

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REVIEWED	MS
APPROVED	CJM

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
STABILITY ANALYSIS
SECTION LOCATIONS

PROJECT NO.	REV.	FIGURE
1663241	0	1

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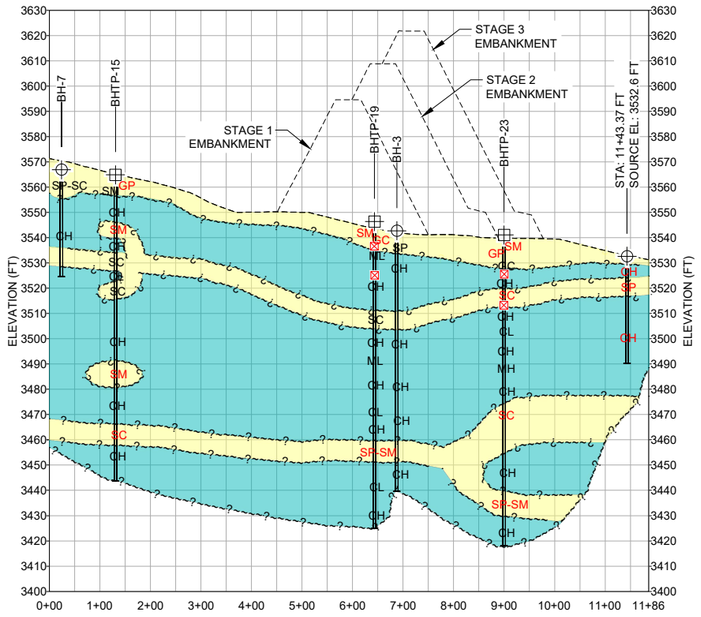

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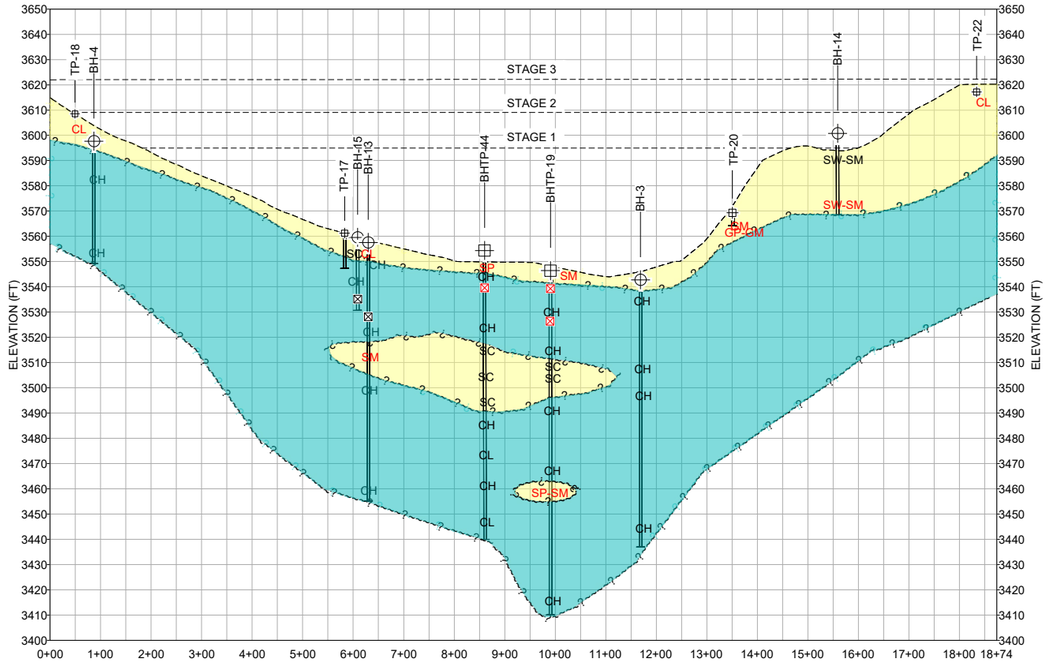
VERT. SCALE 1"=30'

A
1

USCS CLASSIFACTION PROFILE A-A'



SCALE 1"=150'
VERT. SCALE 1"=30'

B
1

USCS CLASSIFACTION PROFILE F-F'

LEGEND

FINE GRAINED SOIL

COARSE GRAINED SOIL

0 150 300 450
1" = 150' FEET

0 30 60 90
1" = 30' FEET

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TITLE
STABILITY ANALYSIS
EMBANKMENT FOUNDATION CROSS SECTIONS

PROJECT NO.	REV.	FIGURE
1663241	0	1A

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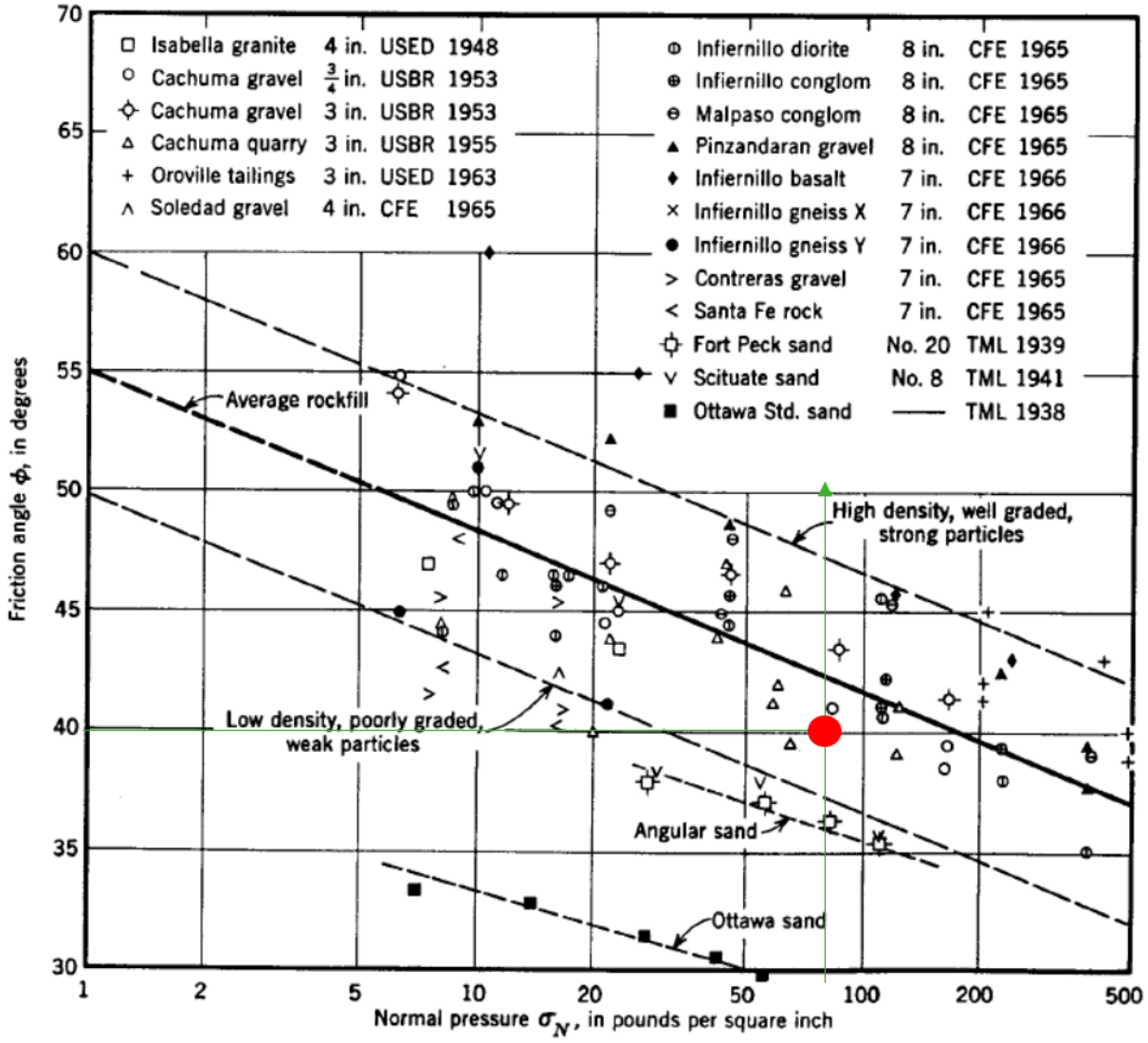

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TITLE
LEPS (1970) ROCK FILL STRENGTH

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1663241

FIGURE
2

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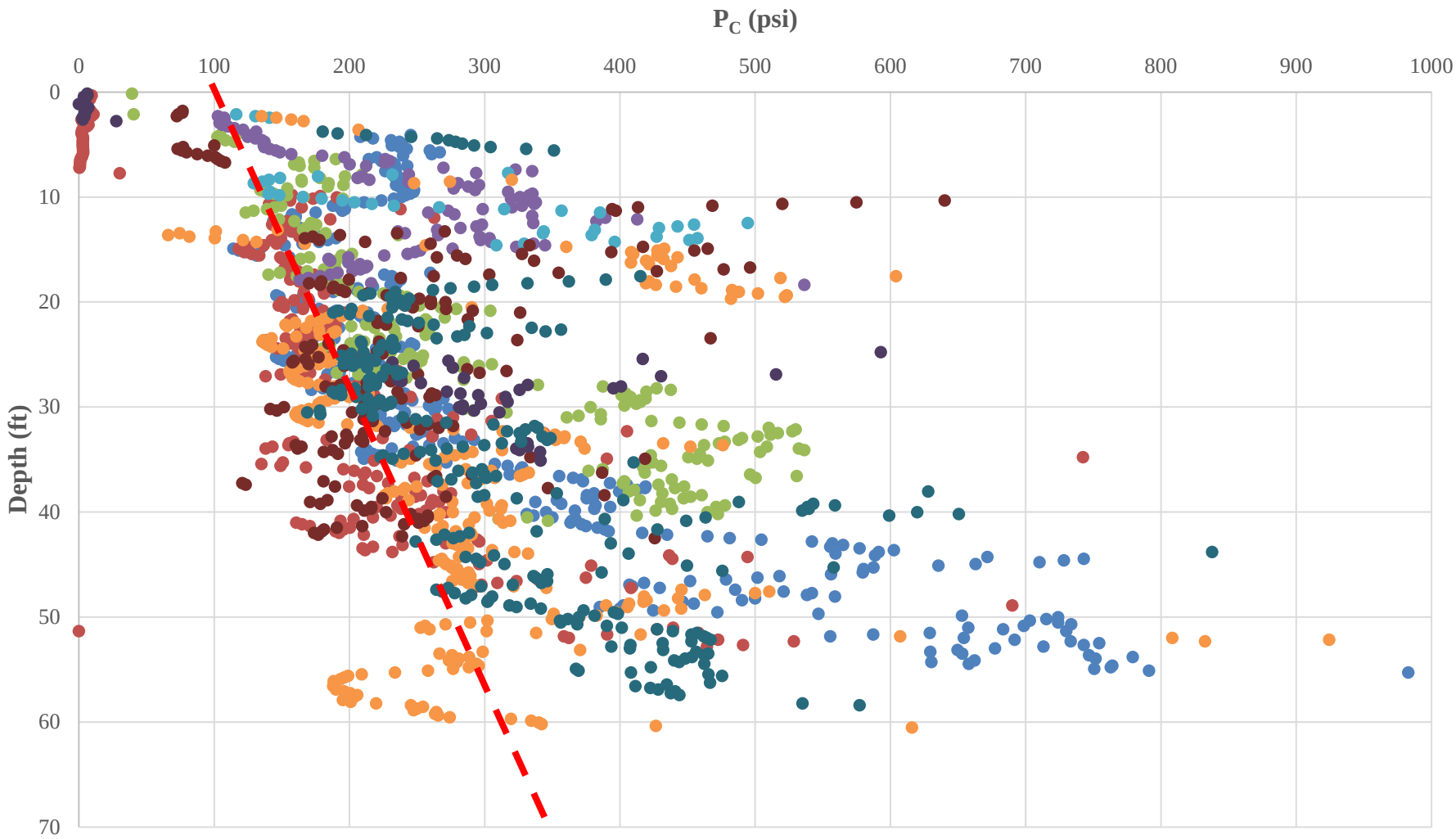

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PRECONSOLIDATION PRESSURE VERSUS DEPTH

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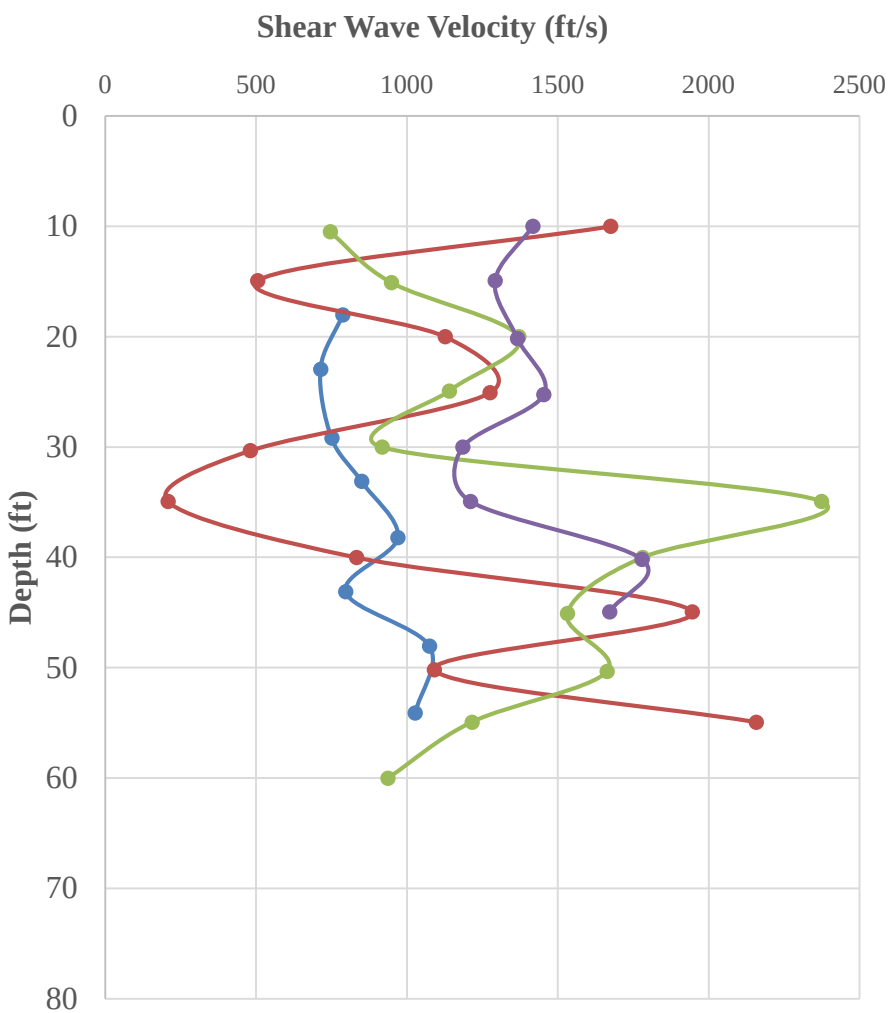
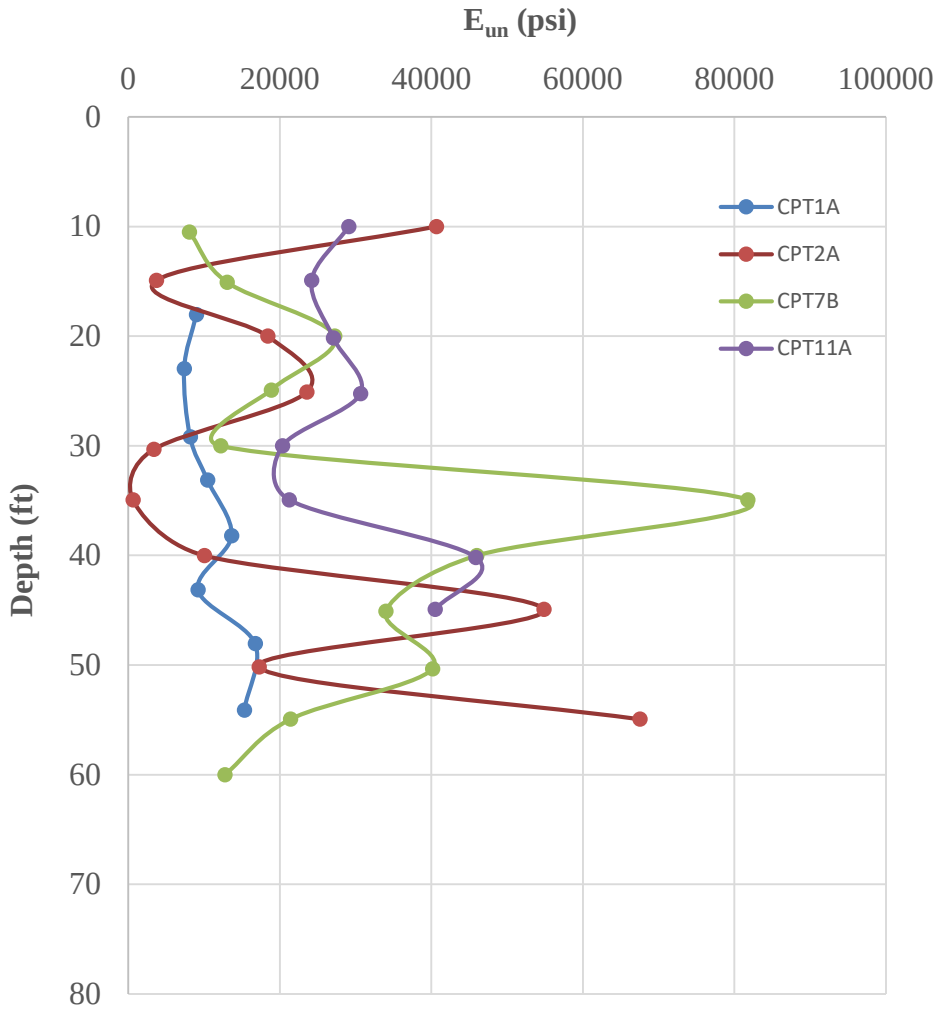
FIGURE
3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0





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SHEAR WAVE VELOCITY AND MODULUS OF ELASTICITY FOR CLAY LAYERS VERSUS DEPTH

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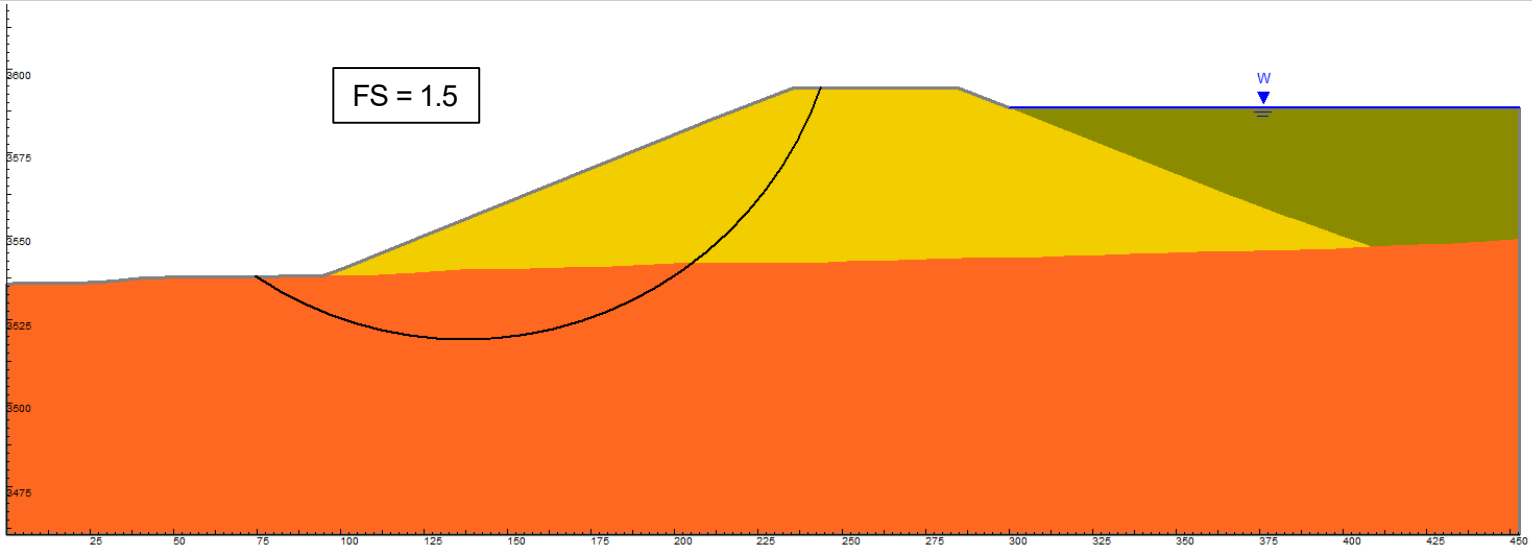
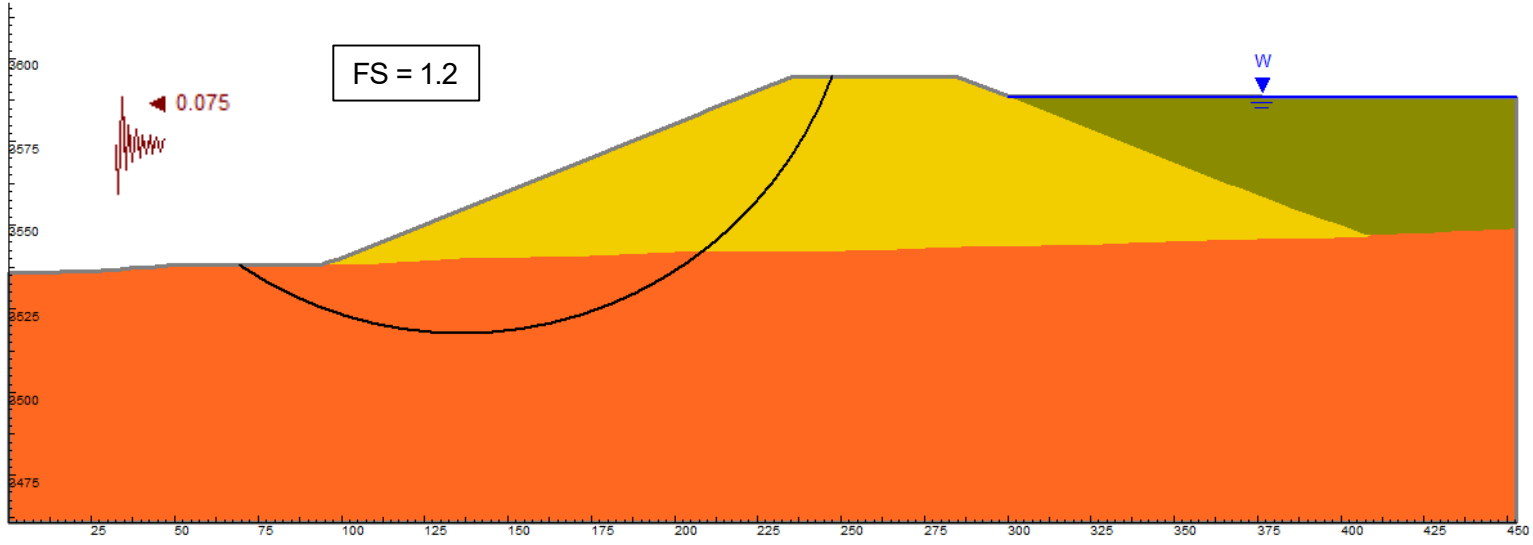
FIGURE
4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 1 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 1 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 1 - SECTION A

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FIGURE
5

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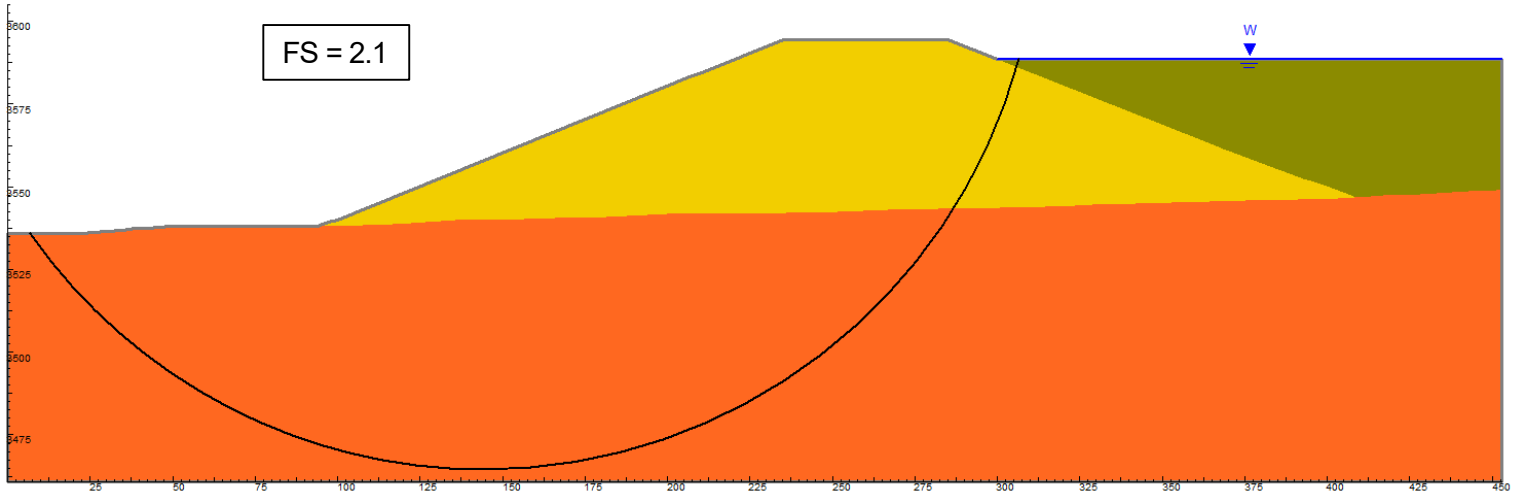
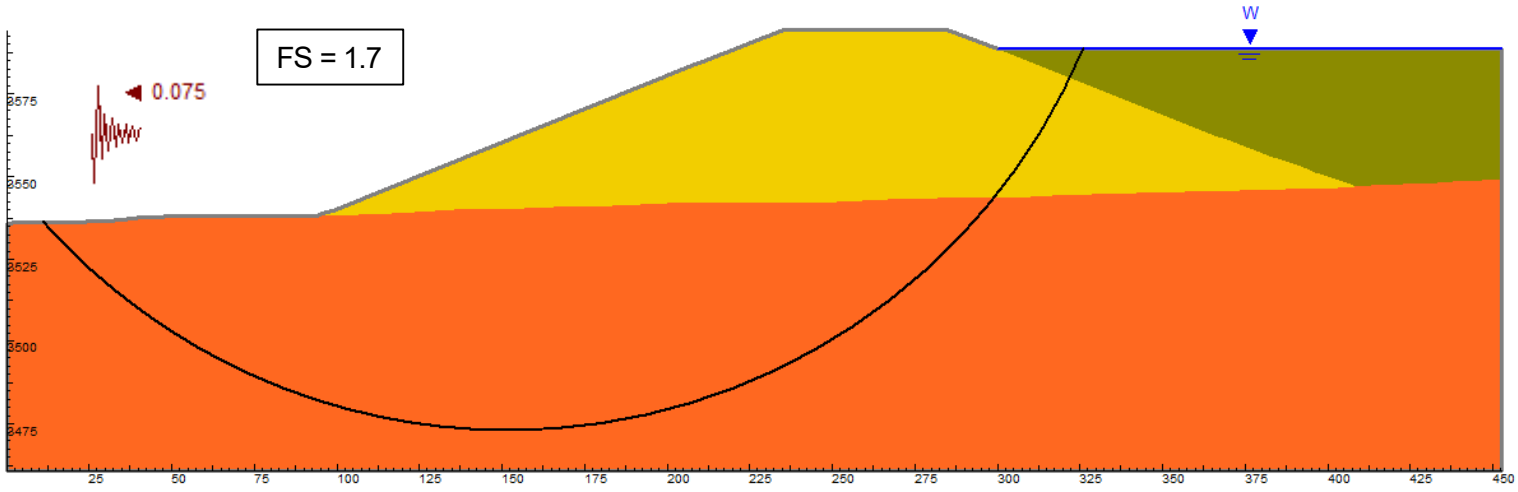


STAGE 1 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 1 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Undrained	2851	
Tailings		95	Mohr-Coulomb	0	15

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TSF STABILITY ANALYSIS RESULTS – TOTAL STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 1 - SECTION A

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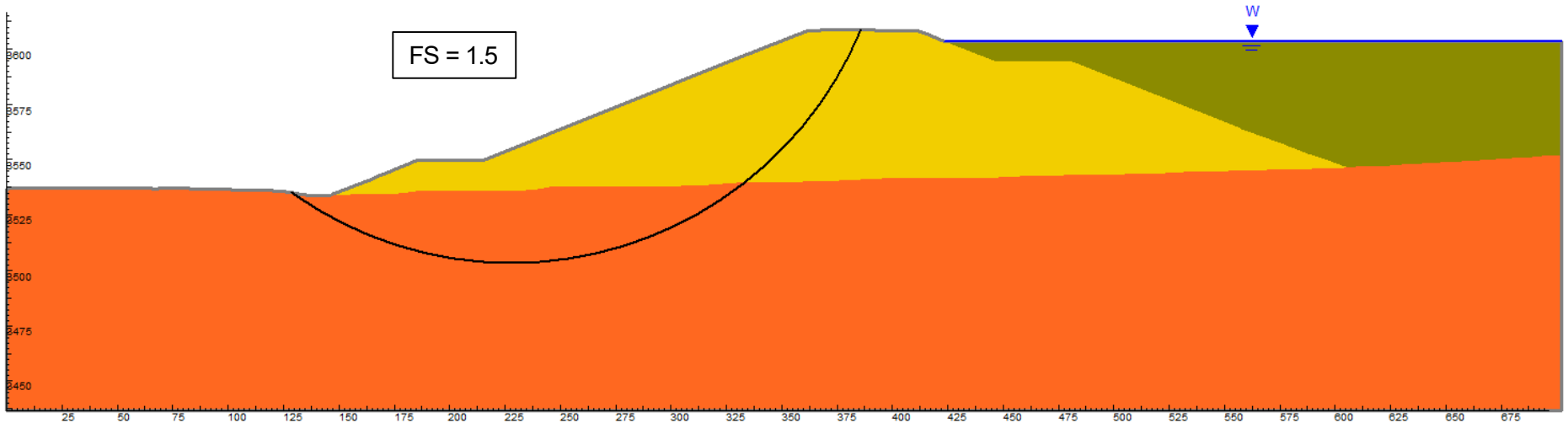
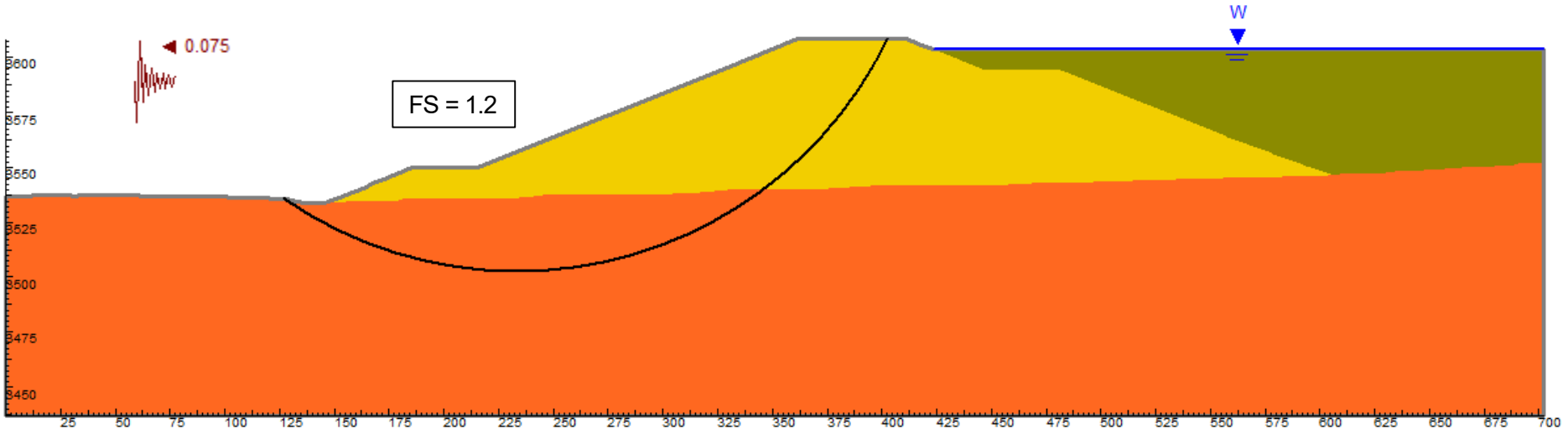
FIGURE
6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 2 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 2 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 2 - SECTION A

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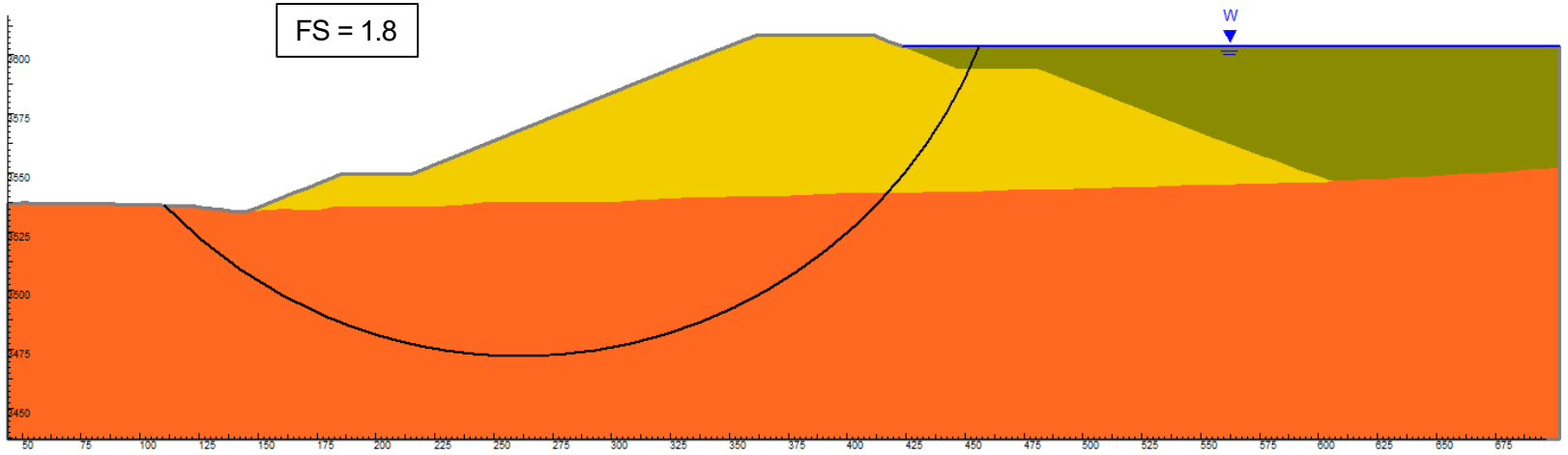
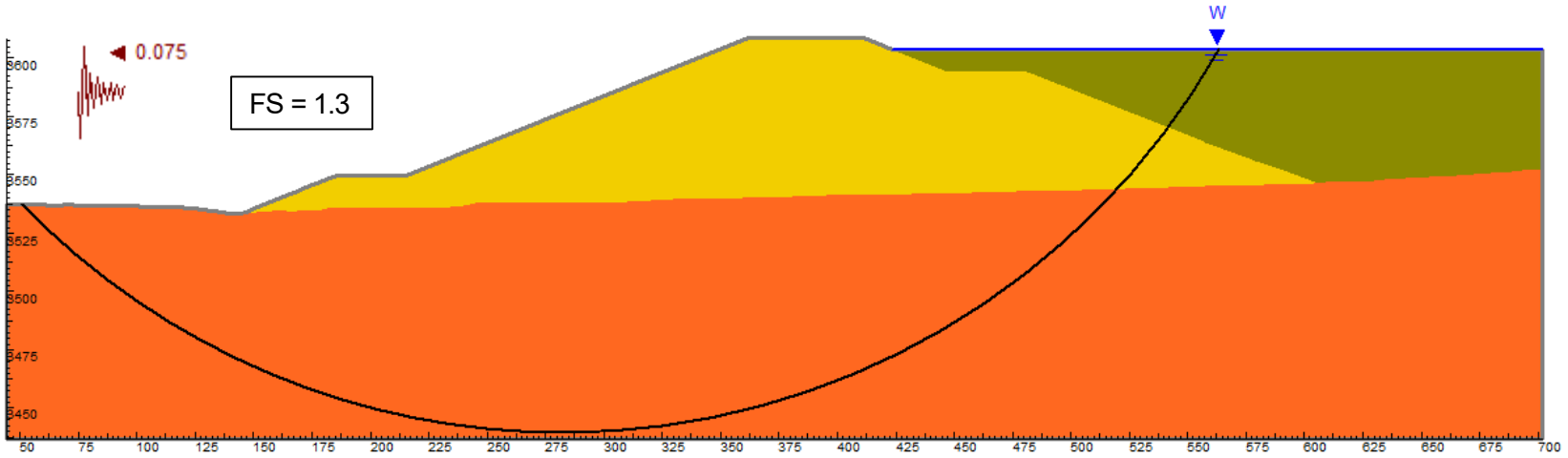
FIGURE
7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 2 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 2 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Undrained	2851	
Tailings		95	Mohr-Coulomb	0	15

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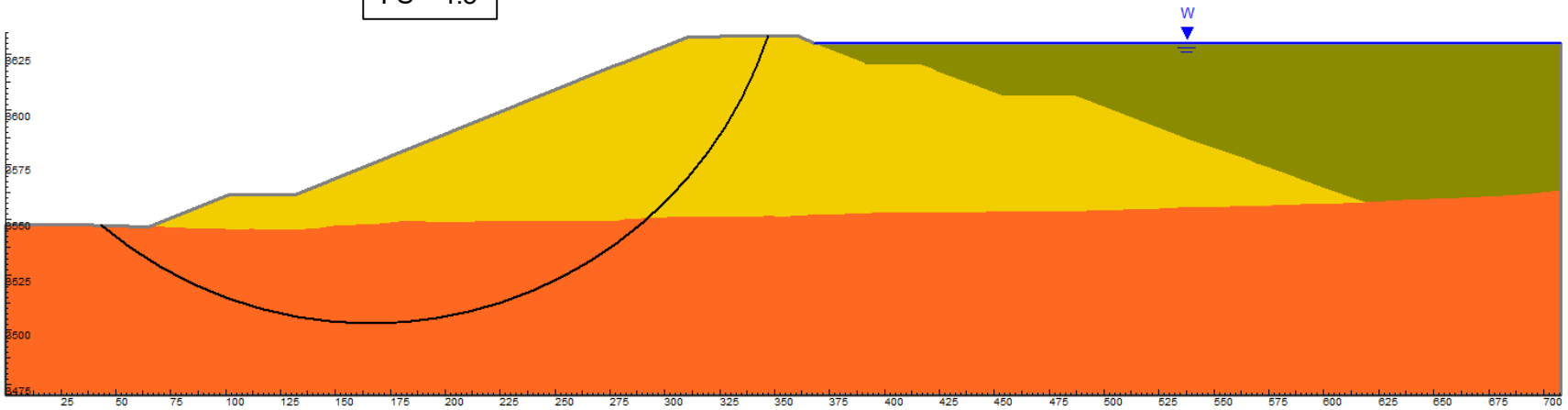
TITLE
TSF STABILITY ANALYSIS RESULTS – TOTAL STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 2 - SECTION A

PROJECT No.
1663241

FIGURE
8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0

FS = 1.5



STAGE 3 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC

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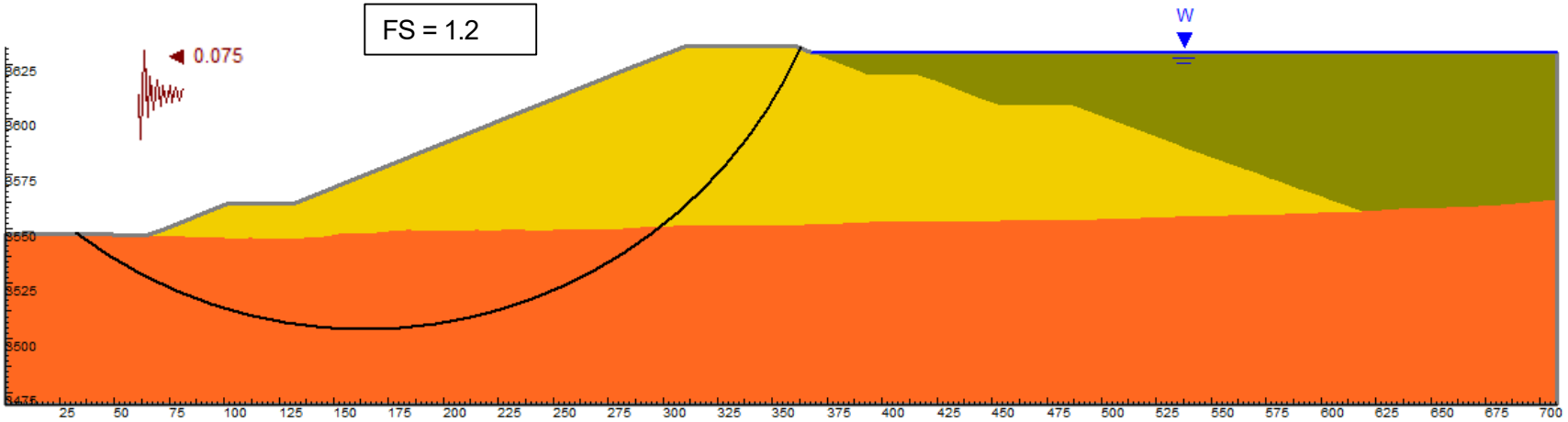

STAGE 3 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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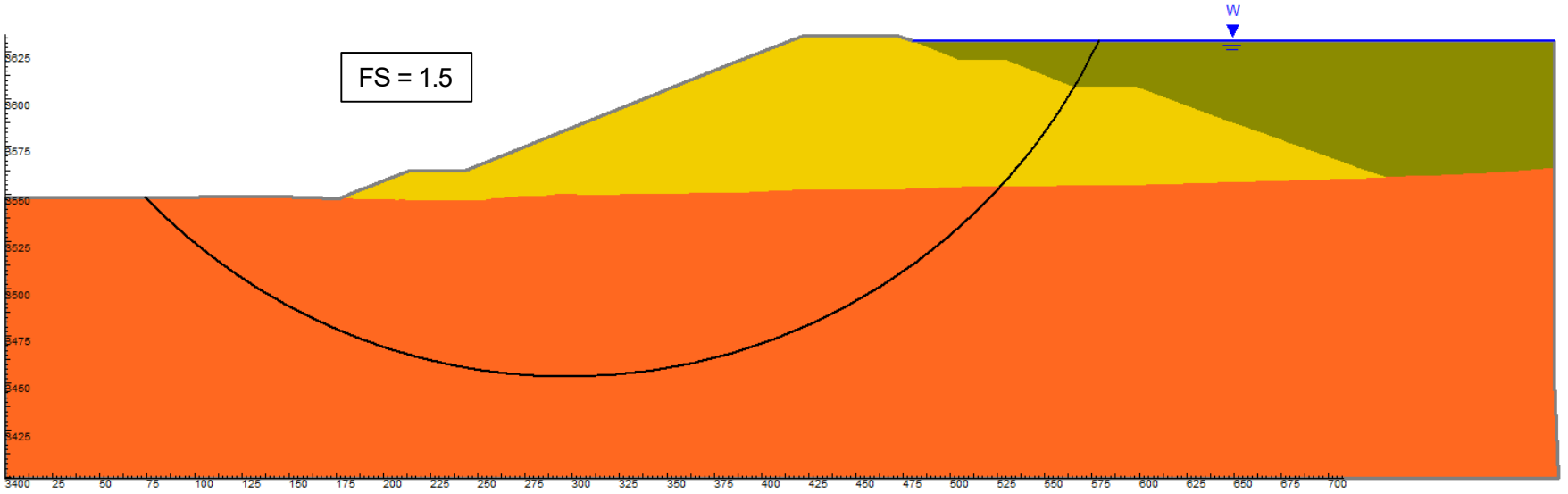
TITLE
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 3 - SECTION A

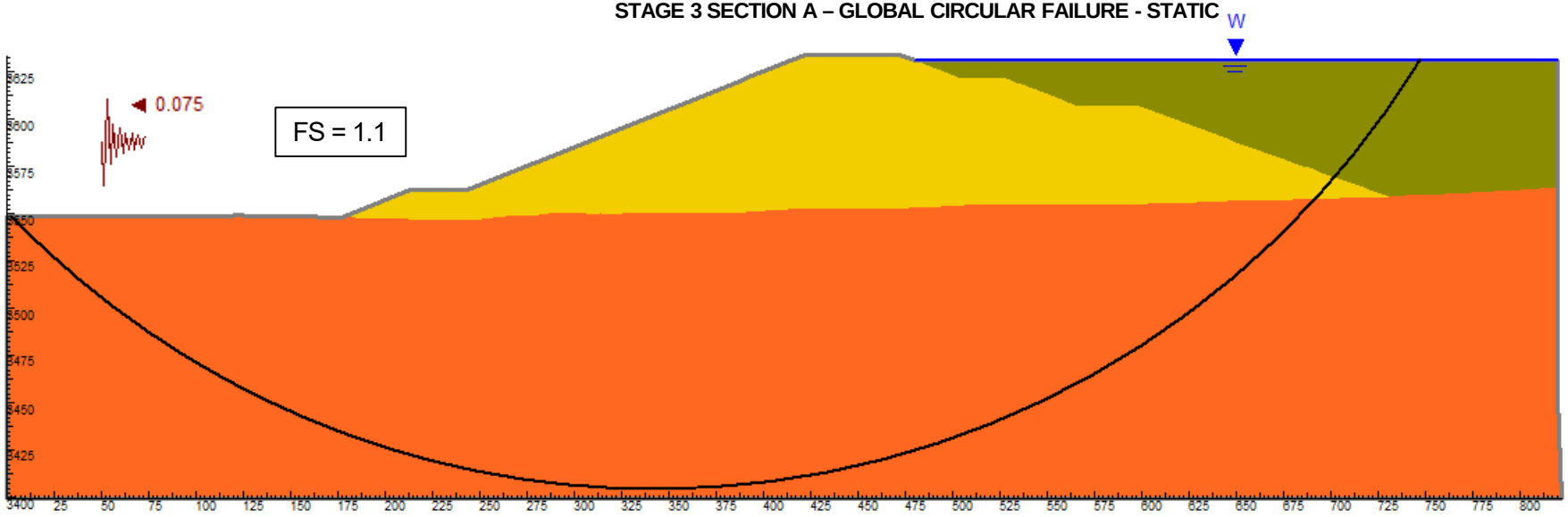
PROJECT No.
1663241

FIGURE
9

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 3 SECTION A – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 3 SECTION A – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Undrained	2851	
Tailings		95	Mohr-Coulomb	0	15

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DETAILED DESIGN

TITLE
TSF STABILITY ANALYSIS RESULTS – TOTAL STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 3 - SECTION A

PROJECT No.
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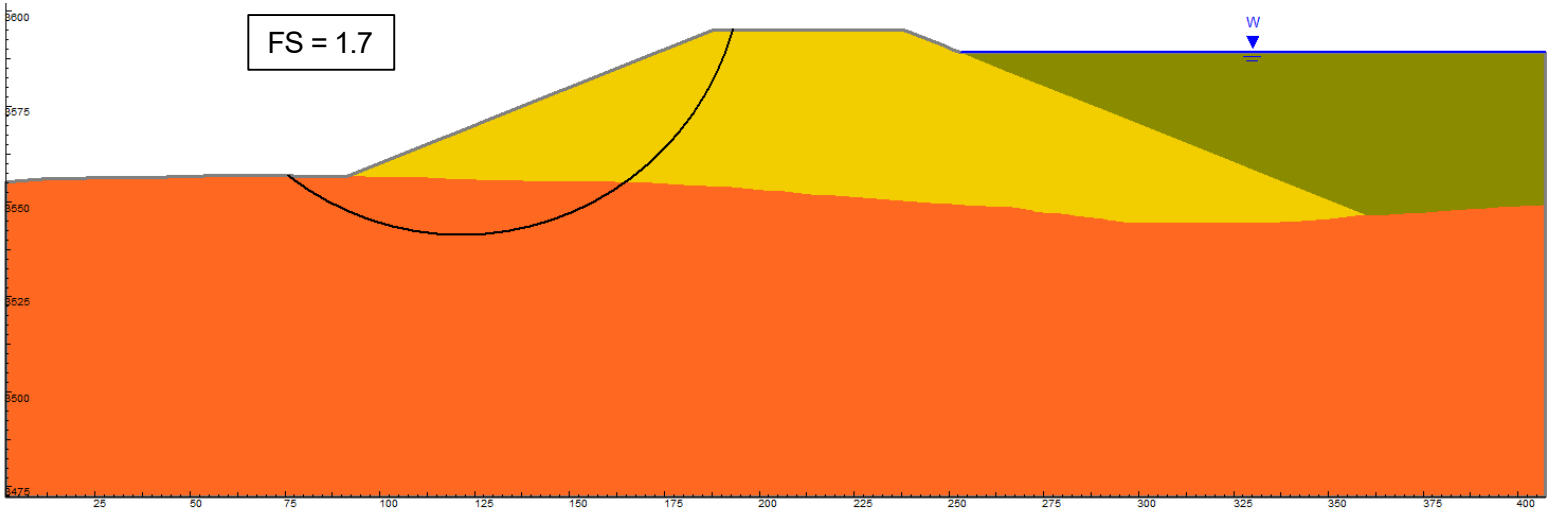
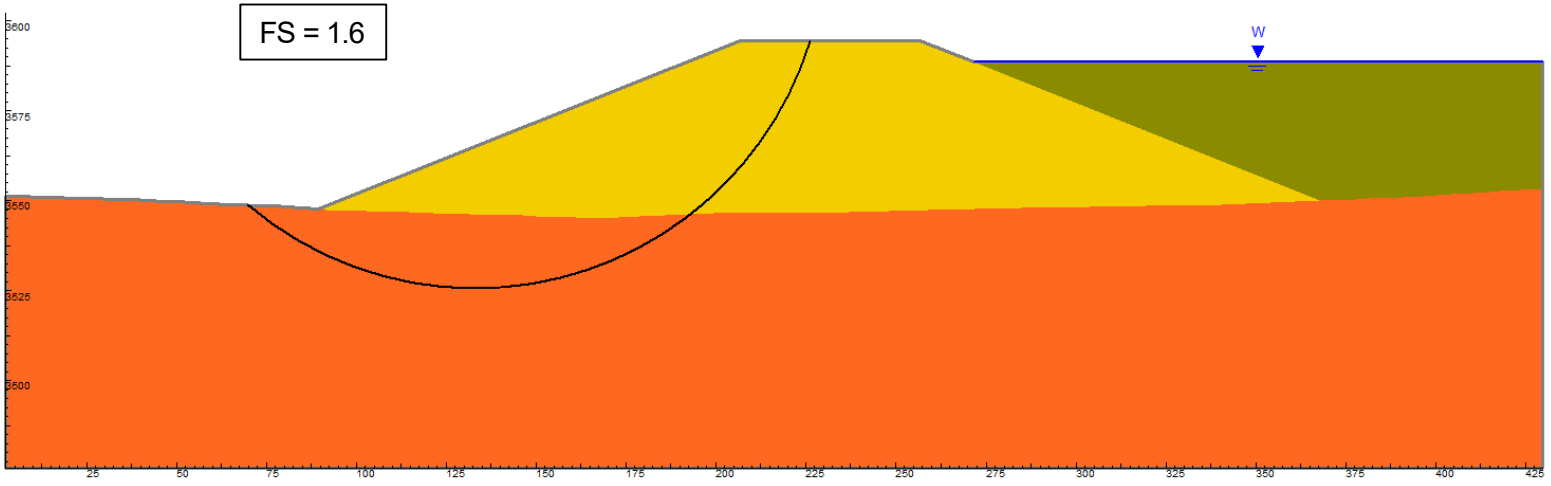
FIGURE
10

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 1 SECTION B – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 1 SECTION C – GLOBAL CIRCULAR FAILURE - STATIC

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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TITLE
TSF STABILITY ANALYSIS RESULTS –EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 1 – SECTIONS B AND C

PROJECT No.
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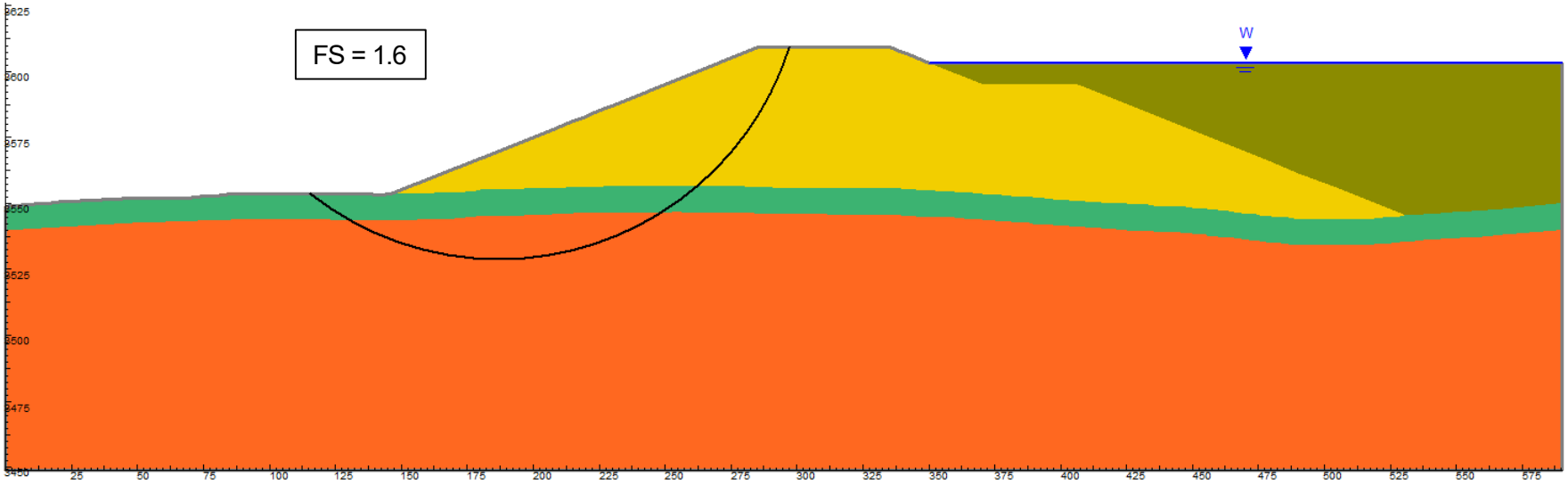
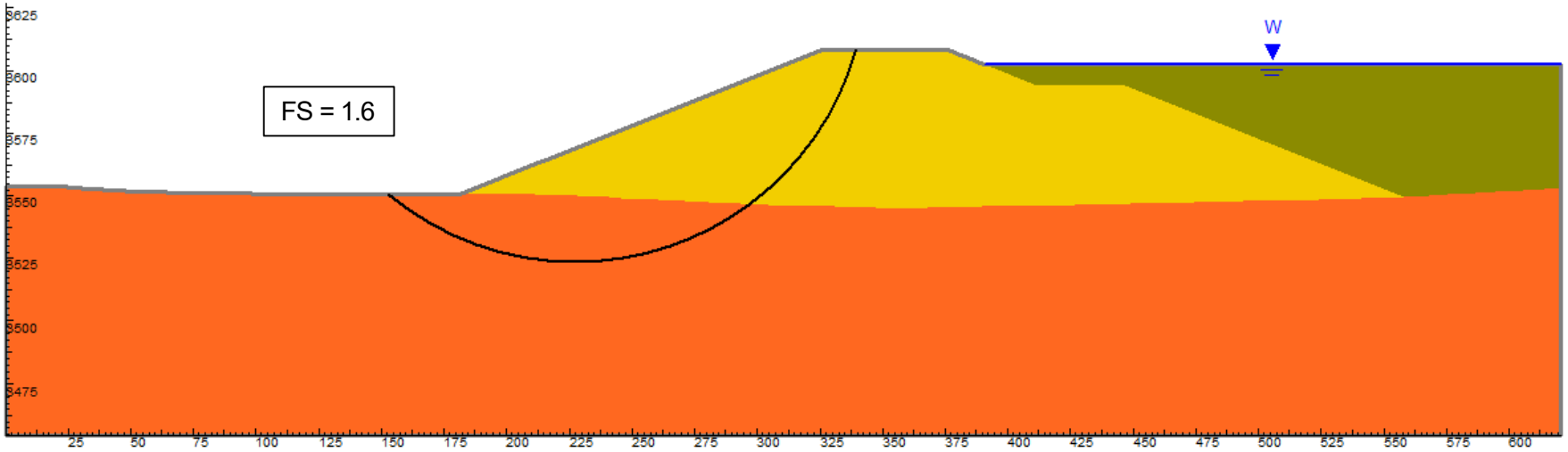
FIGURE
11

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 2 SECTION B – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 2 SECTION C – GLOBAL CIRCULAR FAILURE - STATIC

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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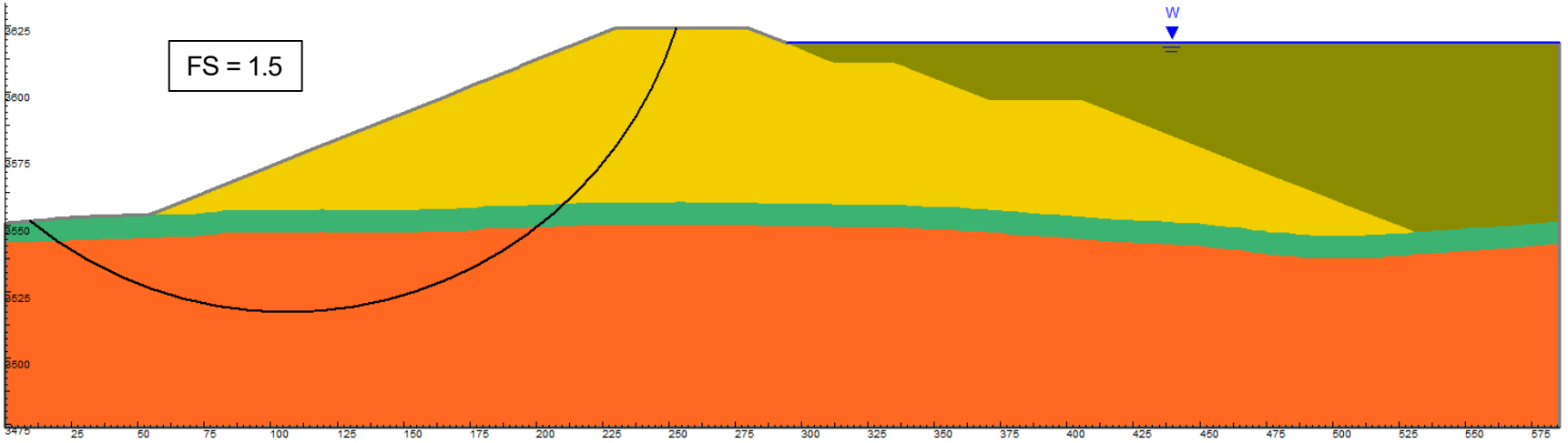
TITLE
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 2 – SECTIONS B AND C

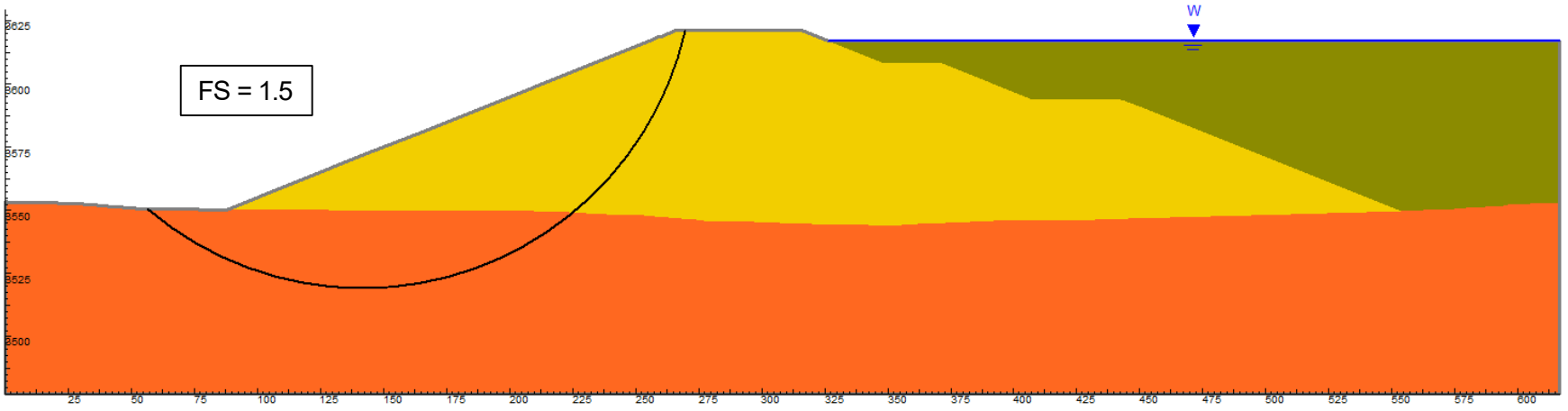
PROJECT No.
1663241

FIGURE
12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 3 SECTION B – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 3 SECTION C – GLOBAL CIRCULAR FAILURE - STATIC

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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TITLE
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 3 – SECTIONS B AND C

PROJECT No.
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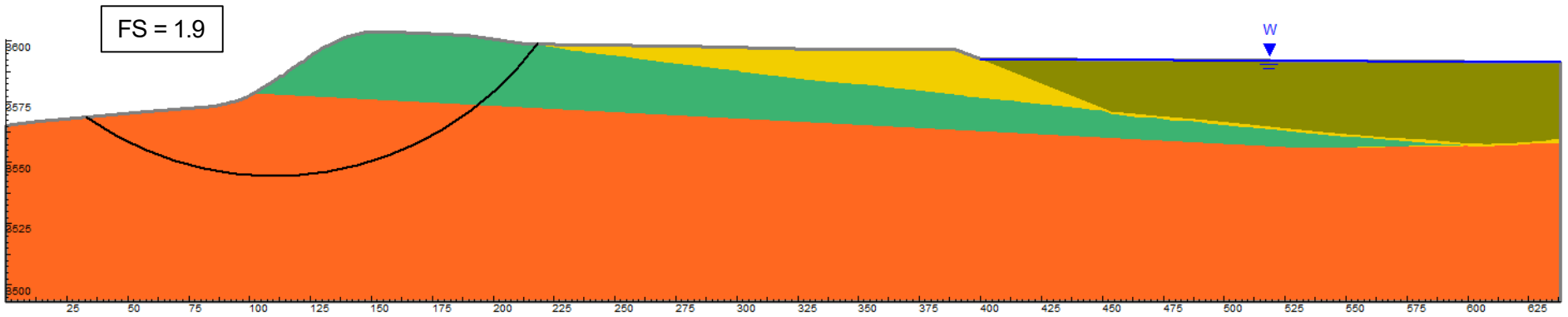
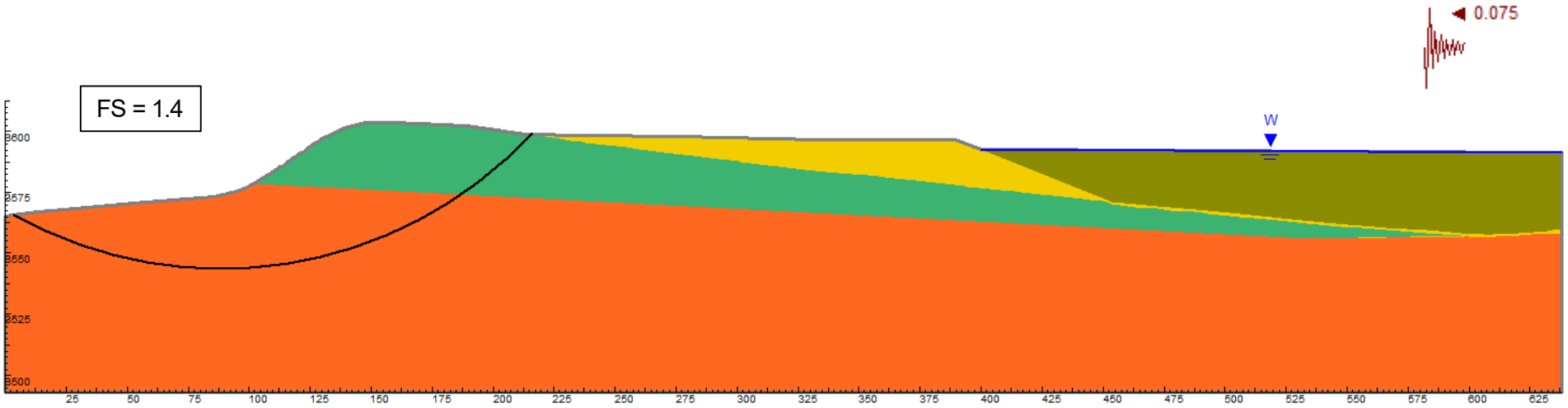
FIGURE
13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 1 SECTION D – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 1 SECTION D – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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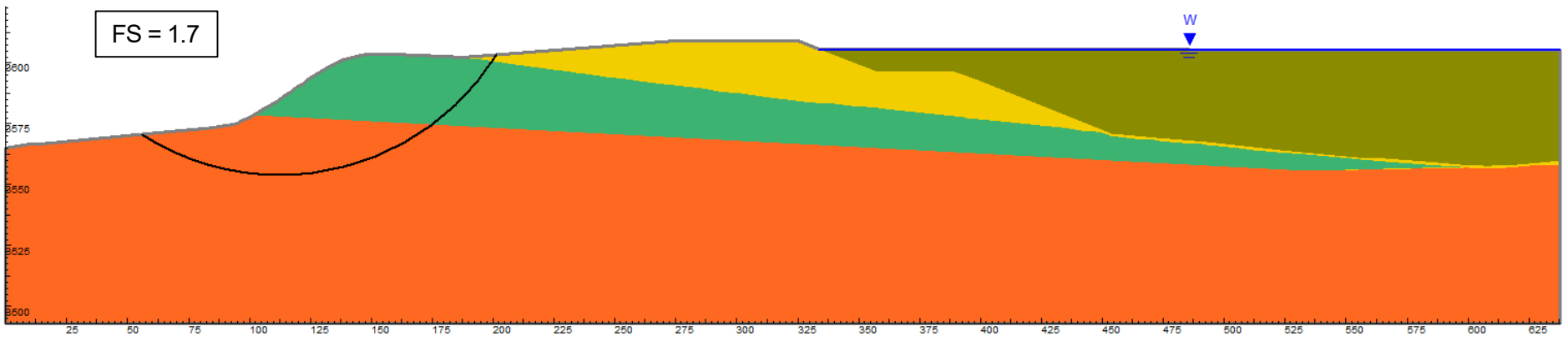
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 1 – SECTION D

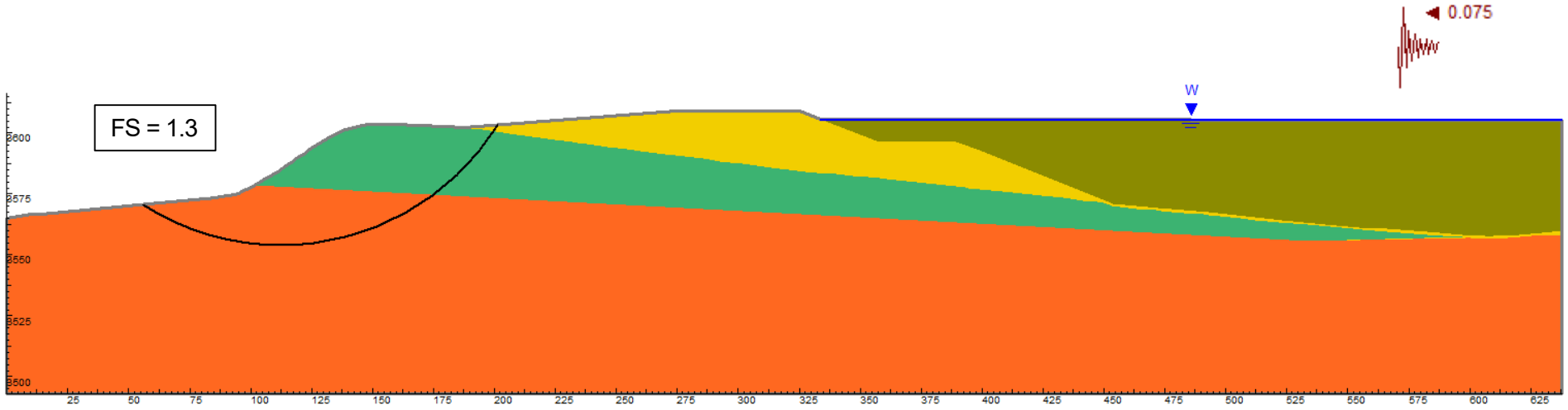
PROJECT No.
1663241

FIGURE
14

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 2 SECTION D – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 2 SECTION D – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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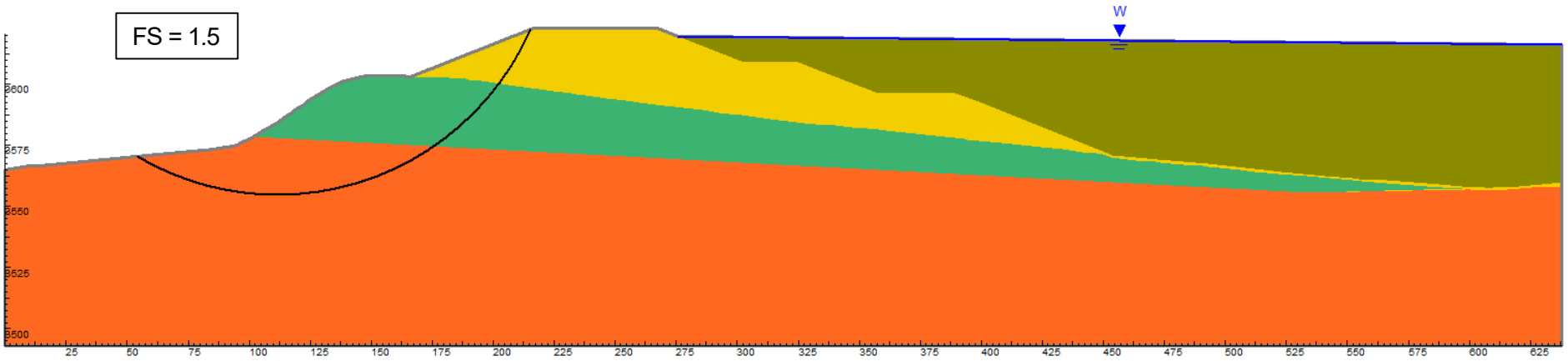
TITLE
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 2 -- SECTION D

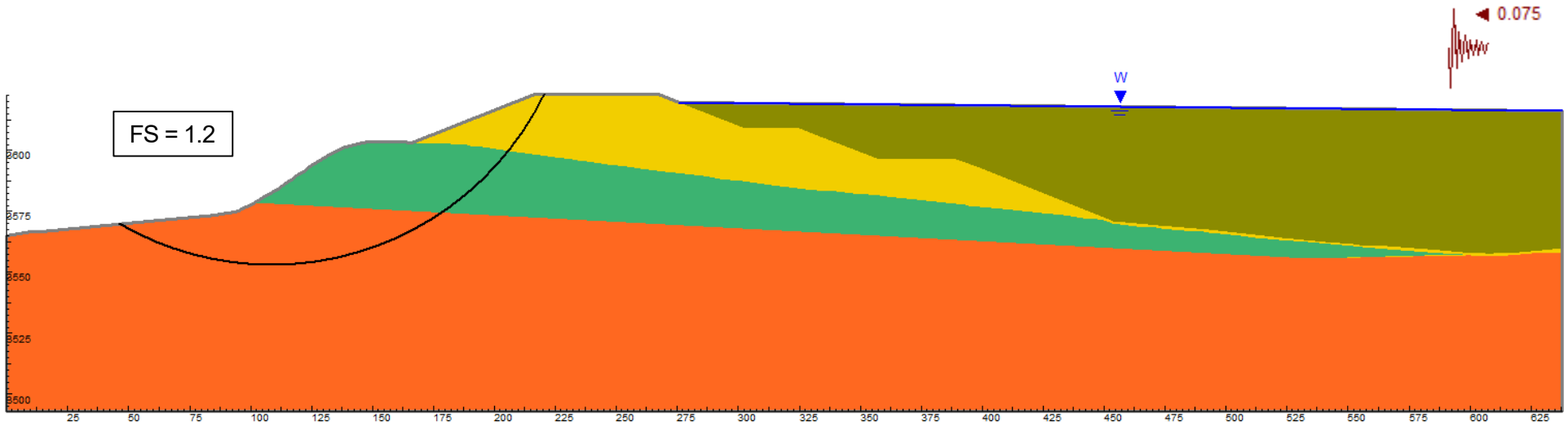
PROJECT No.
1663241

FIGURE
15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



STAGE 2 SECTION D – GLOBAL CIRCULAR FAILURE - STATIC



STAGE 2 SECTION D – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.075 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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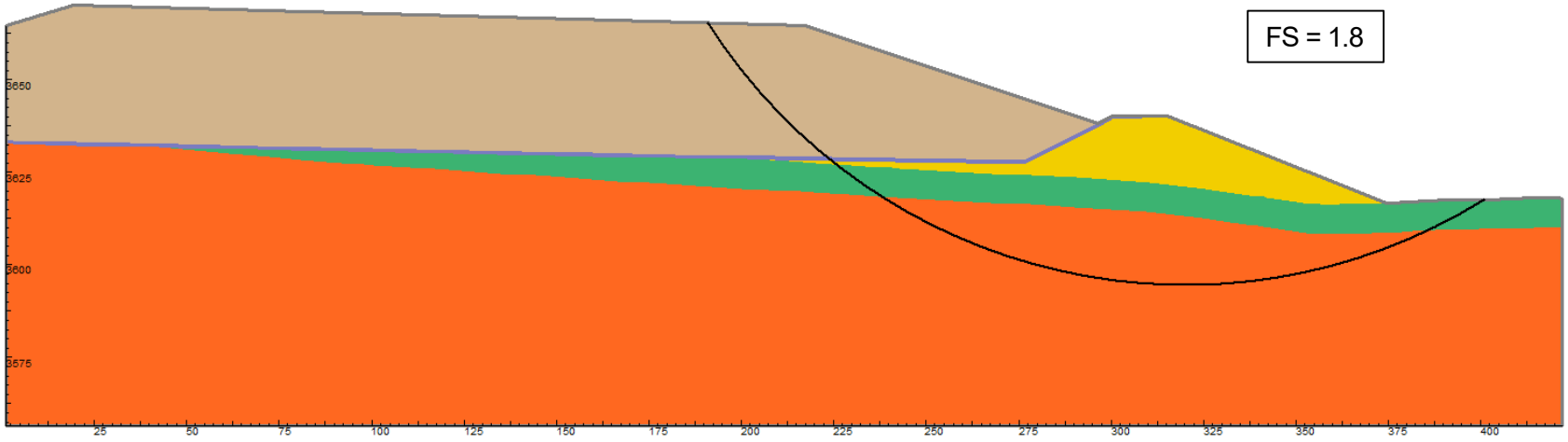
TSF STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – STAGE 2 -- SECTION D

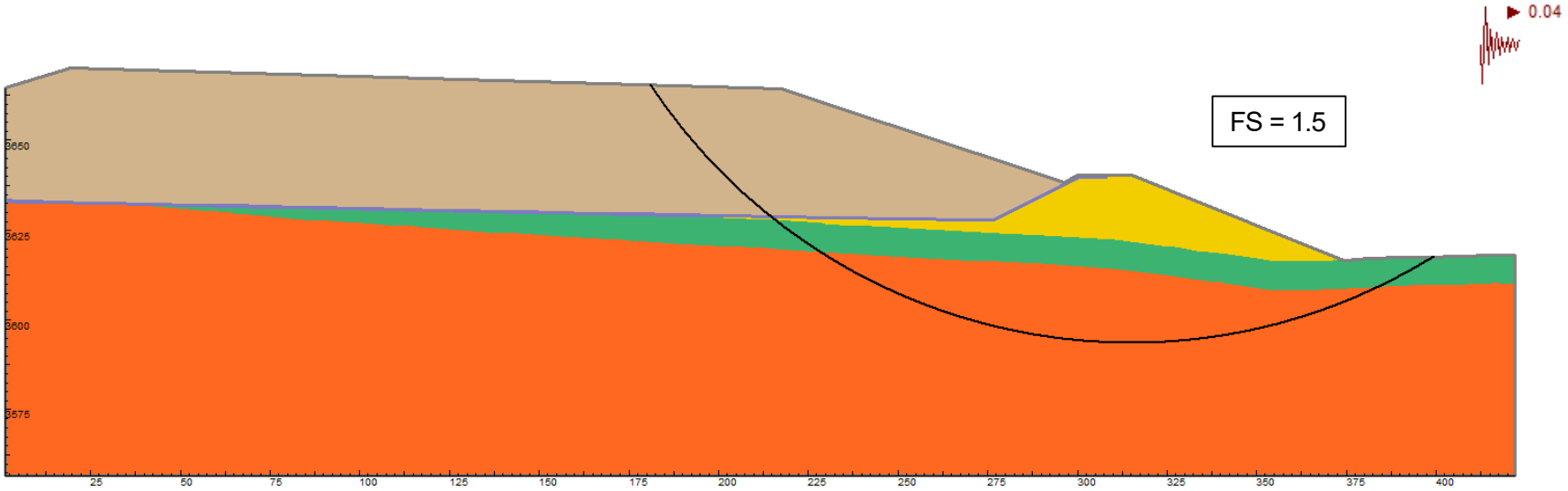
PROJECT No.
1663241

FIGURE
16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



WASTE ROCK DUMP – SECTION E – GLOBAL CIRCULAR FAILURE - STATIC



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Liner Interface		120	Mohr-Coulomb	0	11
Waste Rock		135	Mohr-Coulomb	0	35

WASTE ROCK DUMP – SECTION E – GLOBAL CIRCULAR FAILURE - PSEUDO-STATIC (k = 0.04 g)

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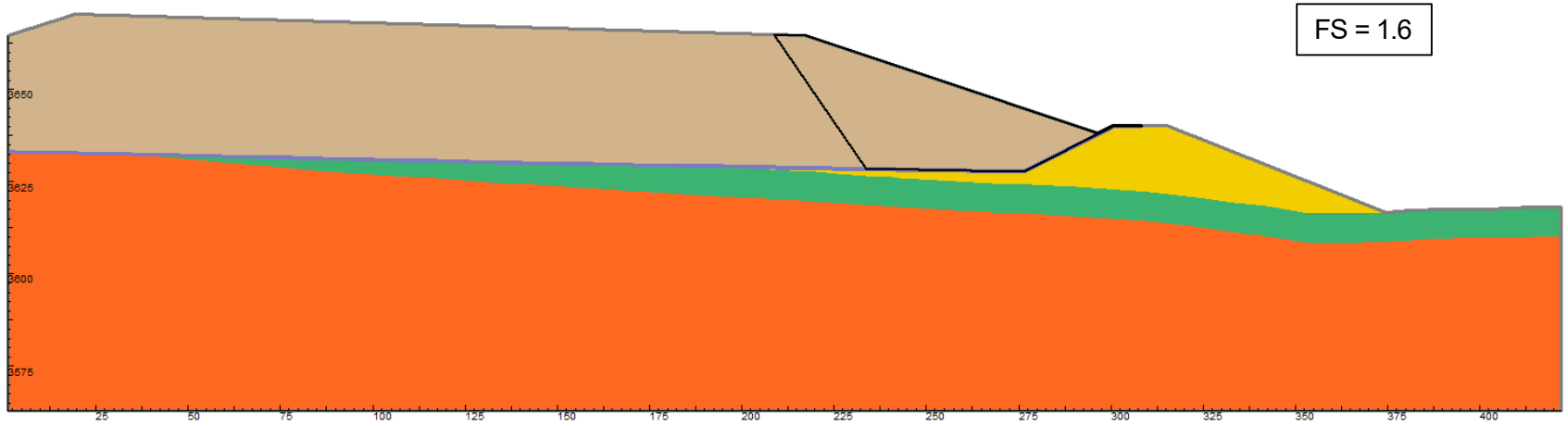
TITLE
WRD STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL CIRCULAR FAILURE – WASTE ROCK DUMP- SECTION E

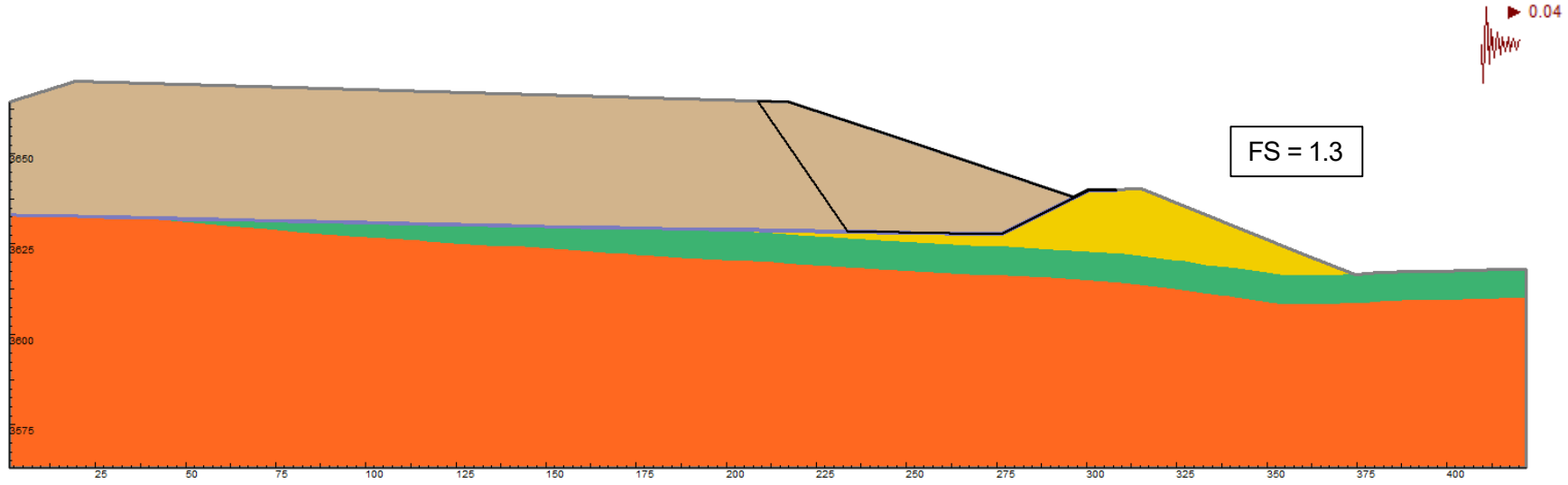
PROJECT No.
1663241

FIGURE
17

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



WASTE ROCK DUMP – SECTION E – BLOCK FAILURE - STATIC



WASTE ROCK DUMP – SECTION E – BLOCK FAILURE- PSEUDO-STATIC (k = 0.04 g)

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		130	Mohr-Coulomb	0	30
Clay		120	Mohr-Coulomb	315	14
Liner Interface		120	Mohr-Coulomb	0	11
Waste Rock		135	Mohr-Coulomb	0	35

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WRD STABILITY ANALYSIS RESULTS – EFFECTIVE STRESS ANALYSIS
GLOBAL BLOCK FAILURE – WASTE ROCK DUMP - SECTION E

PROJECT No.
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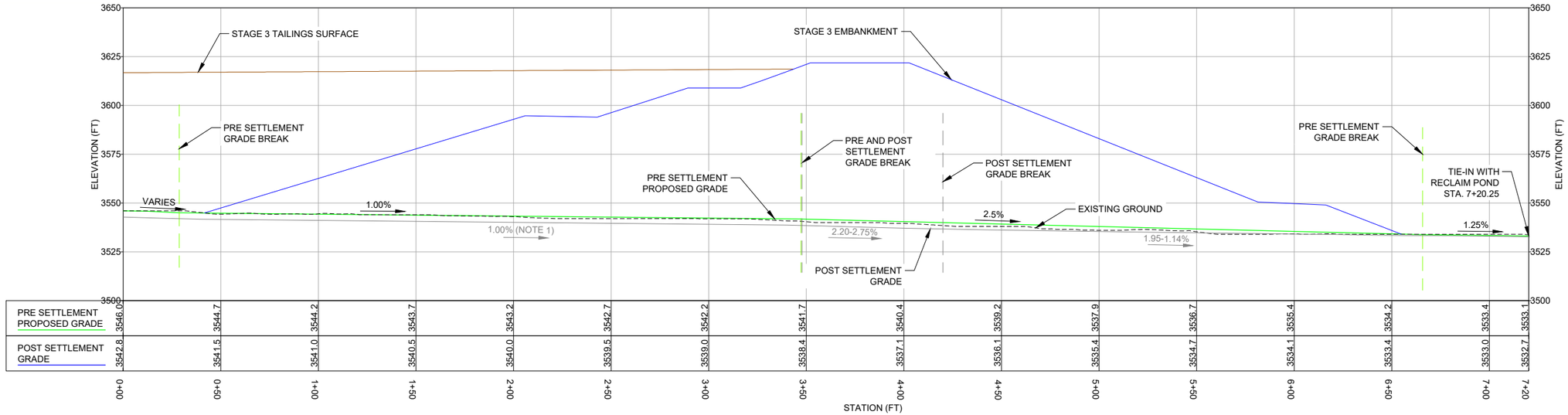
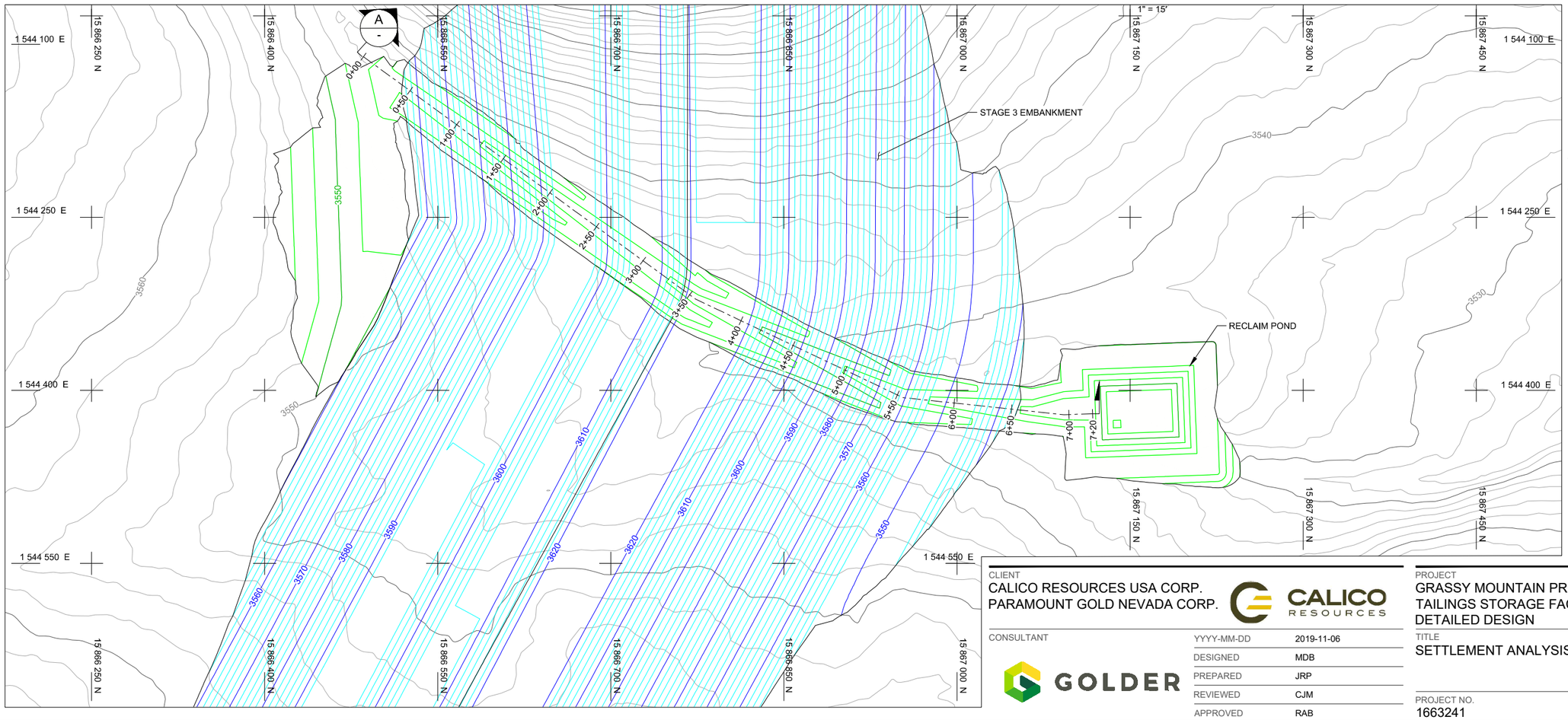
FIGURE
18

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



SCALE 1"=15' A - SETTLEMENT SECTION

0 30 60 90 FEET



LEGEND

- 3600 — EXISTING GROUND CONTOURS (2 FT)
- 3600 — PROPOSED EMBANKMENT CONTOURS (2 FT)
- 0+00 — SETTLEMENT ALIGNMENT (A -)
- 3600 — PROPOSED CHANNEL AND POND GRADING (2 FT)
- 2.5% → PRE SETTLEMENT PROPOSED GRADE
- 1.4% → POST SETTLEMENT GRADE

NOTE

1. POST SETTLEMENT GRADE MAY BE GREATER THAN 1.0% DEPENDING ON TAILINGS ELEVATION.

0 50 100 150
1" = 50' FEET

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TITLE
SETTLEMENT ANALYSIS

PROJECT NO. 1663241 | REV. 0 | FIGURE 19

Path: ---- | File Name: 2019 Settlement Figure.dwg | Last Edited By: jeprice Date: 2019-10-30 Time:10:51:10 AM | Printed By: JePrice Date: 2019-10-30 Time:10:52:16 AM
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

APPENDIX D

Tailings Testing and Consolidation Modeling

TECHNICAL MEMORANDUM

DATE October 18, 2019 **Reference No. 1663241.060.TM.REV0**

TO Chris MacMahon
Golder Associates Inc.

FROM Gordan Gjerapic **EMAIL ggjerapic@golder.com**

GRASSY MOUNTAIN PROJECT – CONSOLIDATION AND THIN-LIFT MODELING

1.0 INTRODUCTION

Golder Associates Inc., (Golder) has prepared this technical memorandum to describe the consolidation and thin-lift modeling results for the Tailings Storage Facility (TSF), proposed to be constructed as a part of the Grassy Mountain Project, Oregon. The main goal of the modeling effort was to evaluate the storage capacity and drainage rates from the tailings impoundment. The consolidation analyses were conducted by using properties for the GMTC-1 and GMTC-2 samples delivered to Golder's Soil Laboratory in Lakewood, Colorado in April 2019. The thin-lift calculations were conducted using parameters for the GMTC-1 and GMTC-2 composite sample. All analyses utilized the tailings production rate of 680 tons per day.

2.0 MODELING APPROACH, INPUTS AND ASSUMPTIONS

2.1 Consolidation Modeling

The TSF consolidation model is commonly used to: 1) predict average dry densities; 2) develop staged settled dry density estimates; and 3) develop predictions for the volume of water extracted from the top and the bottom of the tailings during the consolidation process. Due to uncertainties in boundary conditions associated with the thin-lift deposition process, the consolidation results were compared to results from the thin-lift analyses. Consolidation analyses presented in this memorandum were conducted using the one-dimensional and the simplified three-dimensional column accretion models (see Section 2.1.1). The assumptions and input parameters used to perform consolidation analyses are:

- Production rate of 680 tons per day
- Compressibility and hydraulic conductivity (permeability) parameters for GMTC-1 and GMTC-2 samples (Attachment 1)
- Stage filling curve relationships (see Figure 1) developed from the design drawings (Golder 2019a)
- Perform analyses assuming that water collected by the underdrain system is conveyed from the bottom of the tailings into a reclaim pond
- Assume tailings deposition at 46 percent solids
- Assume tailings solids content between 54 and 56 percent at the end of the sedimentation process based on the available laboratory data (Attachment 1)

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2.1.1 Model Codes

Consolidation modeling was performed using CONDES (Yao and Znidarcic 1997) and FSConsol (GWP 2014) model codes. Model codes are discussed in more detail in Sections 2.1.1.1 and 2.1.1.2.

2.1.1.1 CONDES Model Code

To account for the non-linearity of material properties, the computer program CONDES (Yao and Znidarcic 1997) was used. CONDES is a computer program used to model impoundment filling and one-dimensional consolidation based on the large-strain consolidation theory (Gibson et al. 1967). The program solves a non-linear second order partial differential equation formulated for one-dimensional compression. CONDES results provide time-dependent solutions of void ratio distribution (solid content distribution), and layer thickness. To account for three-dimensional effects, results from multiple CONDES models were combined based on the approach proposed by Gjerapic et al. (2008). The governing equations are listed below:

Velocity function:

$$v_u = \frac{k\cdot(G_s-1)}{1+e} + \frac{k\cdot(1+e_o)}{\gamma_w(1+e)}\frac{d\sigma'}{de}\frac{\partial e}{\partial a} \quad (1)$$

Conservation of mass:

$$\frac{\partial v_u}{\partial a} = \frac{-1}{1+e_0}\frac{\partial e}{\partial t} \quad (2)$$

Where: t = time
a = Lagrangian Coordinate Systems
k = hydraulic conductivity
e_0 = void ratio at zero effective stress
G_s = specific gravity of soil particles
v_u = velocity function
γ_w = unit weight of water

CONDES uses an iterative numerical procedure to solve Equations (1) and (2) and to predict void ratio profiles based on the following constitutive properties (see e.g., Abu-Hejleh and Znidarcic 1994, 1996):

$$e = A(\sigma' + Z)^B \quad (3)$$

and

$$k = Ce^D \quad (4)$$

Where: e denotes the void ratio
σ′ stands for the effective stress and
k is hydraulic conductivity functionally dependent on void ratio.

In the above equations *A, B, Z, C* and *D* are material parameters for the GMTC-1 and GMTC-2 tailings samples.

2.1.1.2 FSConsol Model Code

FSConsol V3.48, is a commercially available software for large strain consolidation modeling based on Gibson et al. (1967) methodology. The program can calculate the pore pressure distribution and the void ratio profile (solids

content distribution) as a function of time. The program inputs include: TSF geometry, tailings production rates, boundary conditions, and tailings consolidation properties.

The following relationships are used in FSConsol to define tailings consolidation properties (GWP 2014):

$$e = A(\sigma')^B + M \quad (5)$$

and

$$k = Ce^D \quad (4 \text{ ibid})$$

Parameters *A, B, M, C* and *D* are determined by fitting constitutive relationships defined by Equations (4) and (5) to laboratory data.

2.2 Thin-Lift Modeling

The thin-lift deposition assumes that the tailings are deposited in a controlled manner allowing for the fresh tailings to desiccate in a climate characterized by relatively high net evaporation losses. As the tailings' densities increase, a large amount of water from the porous matrix is lost to the atmosphere. Consequently, water inflows to the tailings pool are significantly reduced as compared to conventional deposition practices. A successful thin-lift deposition design requires consideration of the water balance needs, tailings' transport and geotechnical properties, climate conditions, TSF geometry, production rates, as well as the management practices throughout the life of the facility. The benefits of the thin-lift deposition considered in the design typically include reduced infiltration, higher tailings densities (lower embankment height, i.e., reduced construction costs), lower permeability (simpler and more efficient water management) and higher strength (increased stability and reduced liquefaction susceptibility). The focus of the modeling effort presented in this memorandum was to evaluate the feasibility of the thin-lift approach and to estimate seepage rates (vertical percolation rates) during the thin-lift deposition process.

The thin-lift deposition is based on the laboratory testing results for the GMTC composite tailings sample (Attachment 1), the proposed TSF geometry (Golder 2019a) and the anticipated climate conditions (Golder 2019b).

2.2.1 Model Approach

To evaluate the feasibility of the thin-lift deposition management, one can apply the simplified model based on the input tailings parameters and the net evaporation potential (see Figure 2). To evaluate impacts of the seasonal effects, however, the thin-lift model needs to account for the continuous deposition (tailings accretion) and the tailings interaction with the atmosphere (see Figure 3). The thin-lift accretion model used in this study allows for the interaction of the deposited tailings with the atmosphere utilizing the numerical approach that was originally implemented by Fayer (2000). The accretion model geometry is updated in daily increments and is accompanied with adjustments of the soil-water characteristic curve (SWCC) determined from laboratory measurements (Attachment 1). The outputs from the accretion model include evaporation and drainage losses reported in daily increments. The simplified and the accretion models were developed for two case scenarios:

- Case 1 – assume that all tailings water entering the TSF is initially contained within the soil matrix.
- Case 2 – assume that a portion of the tailings discharge water is lost during the sedimentation process and reports directly to the tailings pool. Consequently, the initial amount of porous water, at the onset of the thin-

lift modeling process, is reduced by the estimated initial bleed. The initial bleed estimates used for the thin-lift analyses were selected based on the settling column test results (Attachment 1).

2.2.2 Thin-Lift Model Inputs

The following inputs were used in the thin-lift deposition model simulations:

- The annual tailings production rate of 680 tons per day.
- Tailings are deposited over the period of 14 years.
- The stage-storage relationships for thin-lift modeling are based on the design geometry (Golder 2019a) as illustrated in Figure 1.
- The tailings are subjected to semi-arid climate conditions with a relatively low annual precipitation (9.7 inches) and high annual potential evaporation (45.0 inches) resulting in an average net annual evaporation potential of 35.3 inches (Golder 2019b).
- The tailings are discharged at the solids content of 46 percent.
- At the end of the sedimentation process, the average solids content is approximately 56 percent.
- The specific gravity of tailings is 2.63. This value is based on the laboratory results for the GMTC-1 and GMTC-2 composite sample (Attachment 1).
- The tailings shrinkage limit is 38.8% based on desiccation test results (Attachment 1).
- Assume that the tailings are fully saturated from the moment of deposition and throughout the desiccation process until reaching the shrinkage limit.

Results from the settling column tests used to estimate the amount of water released to the tailings pool due to initial bleed and to adjust SWCC parameters (based on the calculated volumetric moisture content/porosity values) are summarized in Table 1.

Table 1: Settling Column Test Results – Summary

Sample ID	Initial Solids Content (%)	Initial Void Ratio (-)	Initial Porosity (%)	Final Void Ratio	Final Porosity (%)
GMTC-1	46%	3.088	75.5%	2.159	68.3%
GMTC-2	46%	3.087	75.5%	1.972	66.4%

Based on the results in Table 1, the initial volumetric moisture content of 67 percent (with the corresponding void ratio of 2.03) was adopted for the Case 2 thin-lift model simulations. I.e., the thin-lift simulations accounting for the initial bleed were conducted assuming the average settled dry density of approximately 54 pcf (solids content of approximately 56 percent) at the end of the sedimentation process.

The SWCC parameters at low suctions (see Attachment 1) were adopted to develop the thin-lift model predictions. The selected van Genuchten model parameters are summarized in Table 2.

Table 2: SWCC Parameters for Thin-Lift Modeling

Sample	θ_{sat} (-)	θ_r (-)	α (1/kPa)	n (cm/sec)
GMTC composite – low suction	0.51 to 0.76	0.00	0.05	1.50

The SWCC relationships used for the thin-lift analyses are shown in Figure 4.

2.3 Staged Filling

The TSF filling process was modeled by starting the tailings deposition from the impoundment bottom and ending at the TSF maximum height according to the stage-storage curve (height-area-volume relationship) developed from the TSF design drawings (Golder 2019a). A simplified stage-storage curve used for both the consolidation and the thin-lift accretion modeling is presented in Table 3:

Table 3: Stage Filling Curve Used for Consolidation and Thin-Lift Analyses

Stage	Top of Tailings Elevation (ft)	Tailings Area (acres)	Cumulative Tailings Storage Volume (MCY)
Initial	3,545	0.0	0.0
1	3,592	37.00	0.93
2	3,605	59.43	1.92
3	3,617	83.43	3.38

The stage-storage curve used for the consolidation and the thin-lift analyses is shown in Figure 1.

3.0 RESULTS

3.1 Consolidation Model Results

The consolidation analyses were conducted assuming flexible TSF side boundaries (FSConsol calculations) and rigid side boundaries (CONDES calculations) for the TSF areas above the impoundment bottom. Dry densities calculated at the end of each stage of the proposed TSF development, for both FSConsol and CONDES calculations, are shown in Table 4.

Table 4: Average Dry Density Estimates

Stage	Top of Tailings Elevation (ft)	Model Column Height (ft)	Average Dry Density (pcf)	
			FSConsol[1]	CONDES[2]
1	3,592	46	80.62	81.0 – 82.2
2	3,605	60	81.98	79.4 – 80.4
3	3,617	>63	>82.26	79.8 – 80.8

Notes:
1) Modeling results for pervious bottom boundary using FSConsol Model.
2) Density range based on GMTC-1 and GMTC-2 parameters.

Average dry densities as a function of the maximum tailings elevation are shown in Figure 5.

3.2 Thin-Lift Model Results

To estimate the minimum TSF area required for the thin-lift deposition approach, one can utilize the simplified model based on the net evaporation requirements illustrated in Figure 2. Based on the assumption that all water (in excess of the amount contained in the pores of a fully saturated tailings deposit) is expelled by evaporation until reaching tailings' shrinkage limit, one can determine the minimum required TSF area using the average annual net evaporation rate of 35.3 inch/year. The simplified thin-lift deposition model results are summarized in Table 5.

Table 5: Minimum TSF Area for Thin-Lift Management

Scenario	Production Rate (t/day)	Solids Volume Rate (yd^3/day)	Evaporation Demand (yd^3/day)	Minimum TSF Management Area (acre)	Dry Density[1] (pcf)
Case 1	680	307	635	49	81.2
Case 2	680	307	322	25	81.2

Note:
1) Dry density corresponding to the shrinkage limit of 38.8% for GMTC-1/GMTC-2 composite sample.

The minimum TSF areas determined from the simplified thin-lift model (see Table 5) are compared to the design TSF area at different stages of development in Figure 6.

The simplified thin-lift model is based on the average annual net evaporation values. In addition, Figure 1 demonstrates that the success of the thin-lift deposition process in Stage 1 is likely to depend on the deposition practices and the associated tailings behavior affecting the desiccation rate. Considering the net evaporation values presented in Table 6, active water management may be required throughout the TSF operation, at least during the winter months. Table 6 demonstrates that the simplified model predictions based on the annual tailings production and the average annual net evaporation may be underpredicting the minimum TSF area requirements for six months out of the year from approximately October through March.

Table 6: Net Evaporation

Month	Precipitation (in/month)	Precipitation (in/year)	Evaporation (inch/month)	Evaporation (inch/yr)	Evaporation (% of Annual Average)	Net Evaporation (inch/yr)	Net Evaporation (% of Annual Average)
1	0.91	10.9	0.85	10.2	22.7%	-0.7	-2.0%
2	0.63	7.6	1.31	15.7	35.0%	8.2	23.1%
3	1.00	12.0	2.69	32.3	71.8%	20.3	57.5%
4	1.14	13.7	3.81	45.7	101.7%	32.0	90.9%
5	1.39	16.7	5.28	63.4	141.0%	46.7	132.4%
6	0.89	10.7	6.37	76.4	170.1%	65.8	186.6%
7	0.51	6.1	8.16	97.9	217.8%	91.8	260.4%
8	0.31	3.7	7.04	84.5	187.9%	80.8	229.1%
9	0.47	5.6	4.39	52.7	117.2%	47.0	133.4%
10	0.83	10.0	2.95	35.4	78.8%	25.4	72.2%
11	0.73	8.8	1.31	15.7	35.0%	7.0	19.7%
12	0.89	10.7	0.79	9.5	21.1%	-1.2	-3.4%

A more detailed assessment of the TSF area with respect to the thin-lift deposition management can be determined by accounting for the accretion process and for the soil-atmosphere interaction at the tailings' boundary. The thin-lift accretion model schematics and assumptions are presented in Figure 3. The accretion model was evaluated using the climate data for the period from 1999 to 2012 (Golder 2019b). The thin-lift accretion model results are summarized in Table 7 in terms of drainage rates.

Table 7: Drainage Rates

Year	Case 1 – Drainage Rate (gpm)			Case 2 – Drainage Rate (gpm)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
1	5.0	122.6	31.7	2.3	99.3	13.5
2	11.1	78.1	34.0	3.3	30.3	12.5
3	8.2	82.8	43.2	5.1	72.1	20.7
4	6.8	82.8	40.0	4.3	52.4	16.6
5	10.3	110.4	45.5	4.9	73.5	19.5
6	12.2	105.4	48.1	5.7	46.3	18.3
7	17.9	115.0	56.1	6.5	57.8	24.6
8	16.6	116.3	52.0	7.9	47.0	20.3
9	16.3	165.3	57.6	8.0	91.4	25.0
10	16.8	133.5	58.2	8.6	58.4	21.7
11	22.6	134.7	64.6	9.1	65.7	26.4
12	21.7	127.4	62.6	10.9	58.8	25.3
13	23.4	122.9	61.3	12.6	64.7	27.0
14	25.1	128.6	64.2	13.7	63.1	28.8

The calculated drainage rates for Case 1 (w/out initial bleed) and Case 2 (with initial bleed) model scenarios are shown in Figures 7 and 8.

4.0 CONCLUSIONS

Presented consolidation analyses demonstrate that the tailings dry densities range from 79 to more than 82 pcf at the end of the staged-filling deposition. Approximately 50 percent or more of the consolidation water is expected to be intercepted by the underdrain system at the beginning of impoundment filling. Within first couple of years, the amount of water conveyed by the underdrain system is expected to decrease to approximately 30 to 40 percent of the total consolidation water with the potential for further reduction as the tailings height in the impoundment increases. The employed consolidation models do not account for the soil-atmosphere interaction during the TSF filling period. Hence, the drainage predictions determined from the thin-lift simulations are likely to be more reliable assuming that the tailings are deposited using the thin-lift management practices.

The settling column tests on GMTC-1 and GMTC-2 samples, using the initial solids content of 46 percent, indicate that the tailings segregation potential is not likely to have a significant impact on settled tailings densities. This finding was confirmed by flume testing.

The thin-lift deposition assessment indicates that the TSF operation may require active water management during the winter months, especially during periods characterized by larger than average precipitation. The TSF is expected to exhibit seasonal variation in drainage rates. The drainage rates ranging from 5.0 to 165 gpm and from 2.3 to 100 gpm were determined for the Case 1 and Case 2 model scenarios, respectively. Median drainage rates of approximately 47 gpm (Case 1) and 19 gpm (Case 2) were determined for the thin-lift simulation period of 14 years. The reported drainage rates are based on the one-dimensional tailings accretion model that does not account for the presence of the tailings pool, i.e., the actual seepage from the TSF will be affected by the employed management practices affecting the extent of the tailings pool area.

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Figures

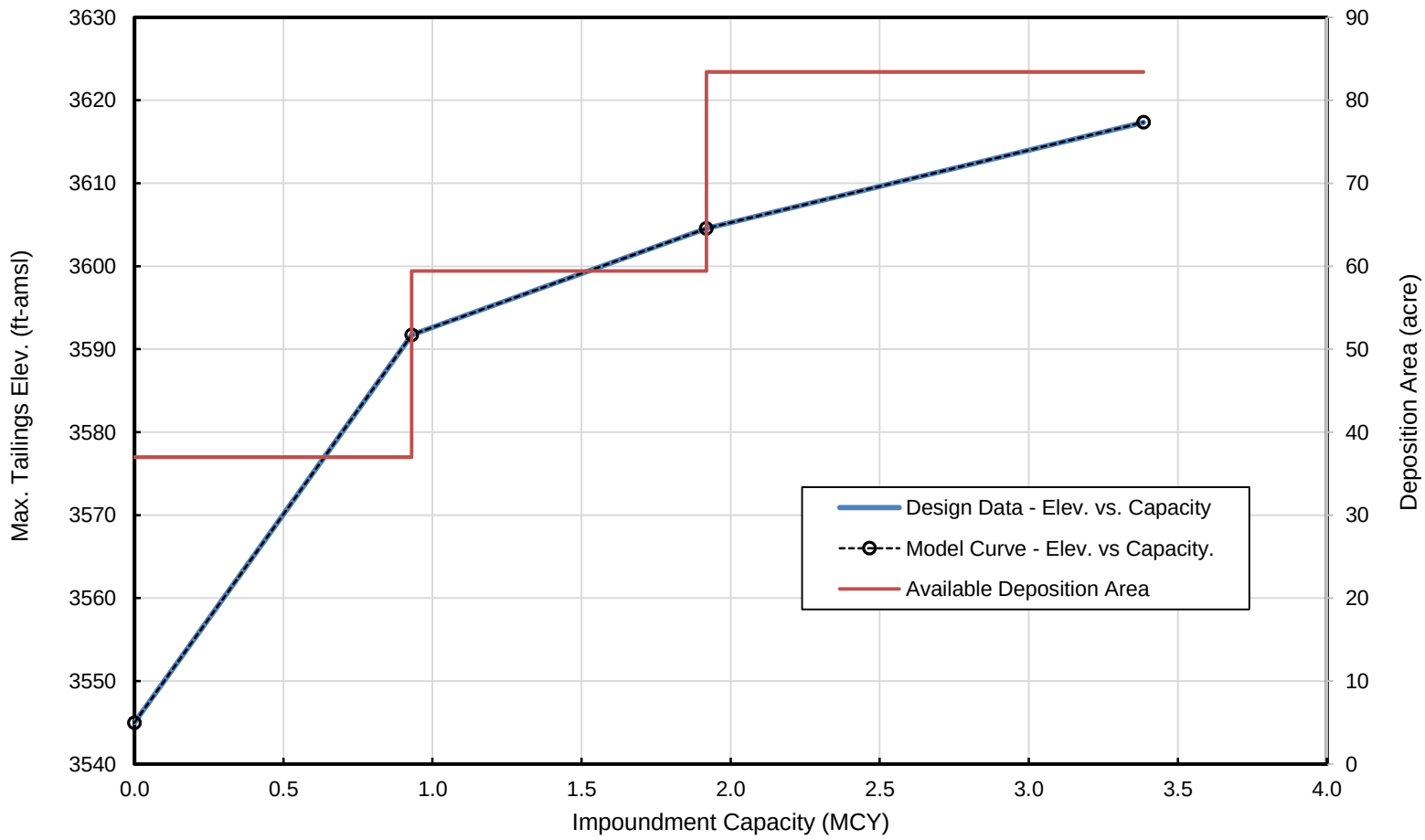


Figure 1

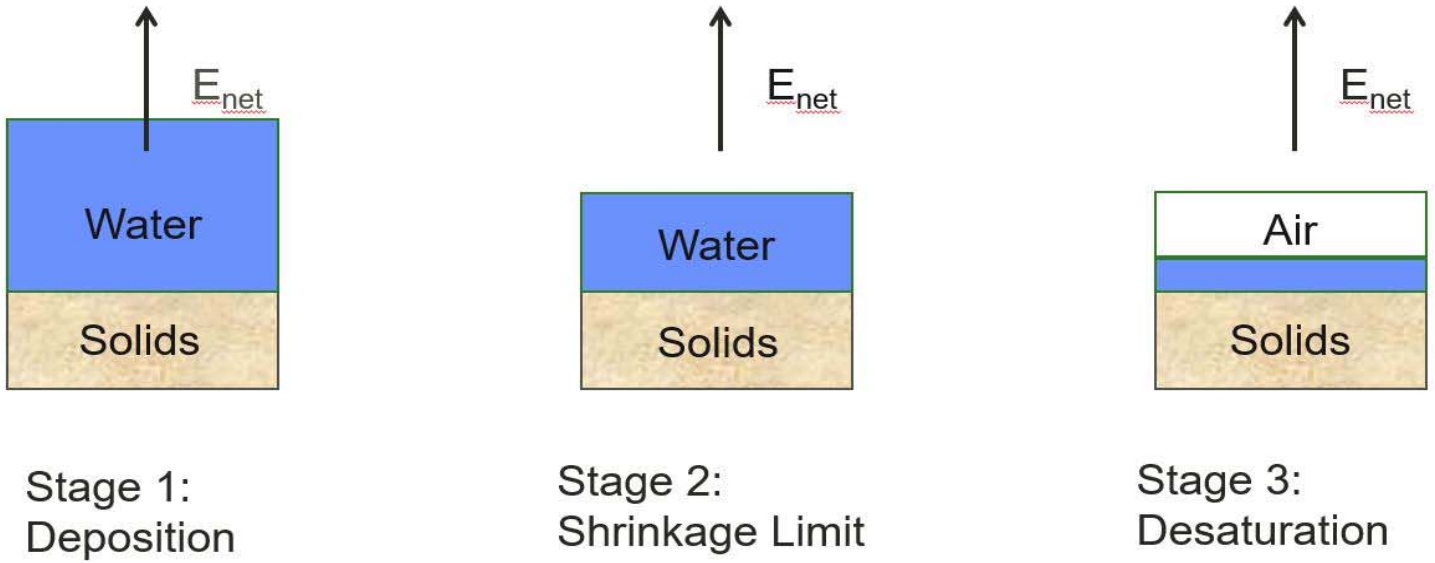
Thin-Lift Model Stage Storage Relationships

Grassy Mountain

Consolidation and Thin Lift Modeling

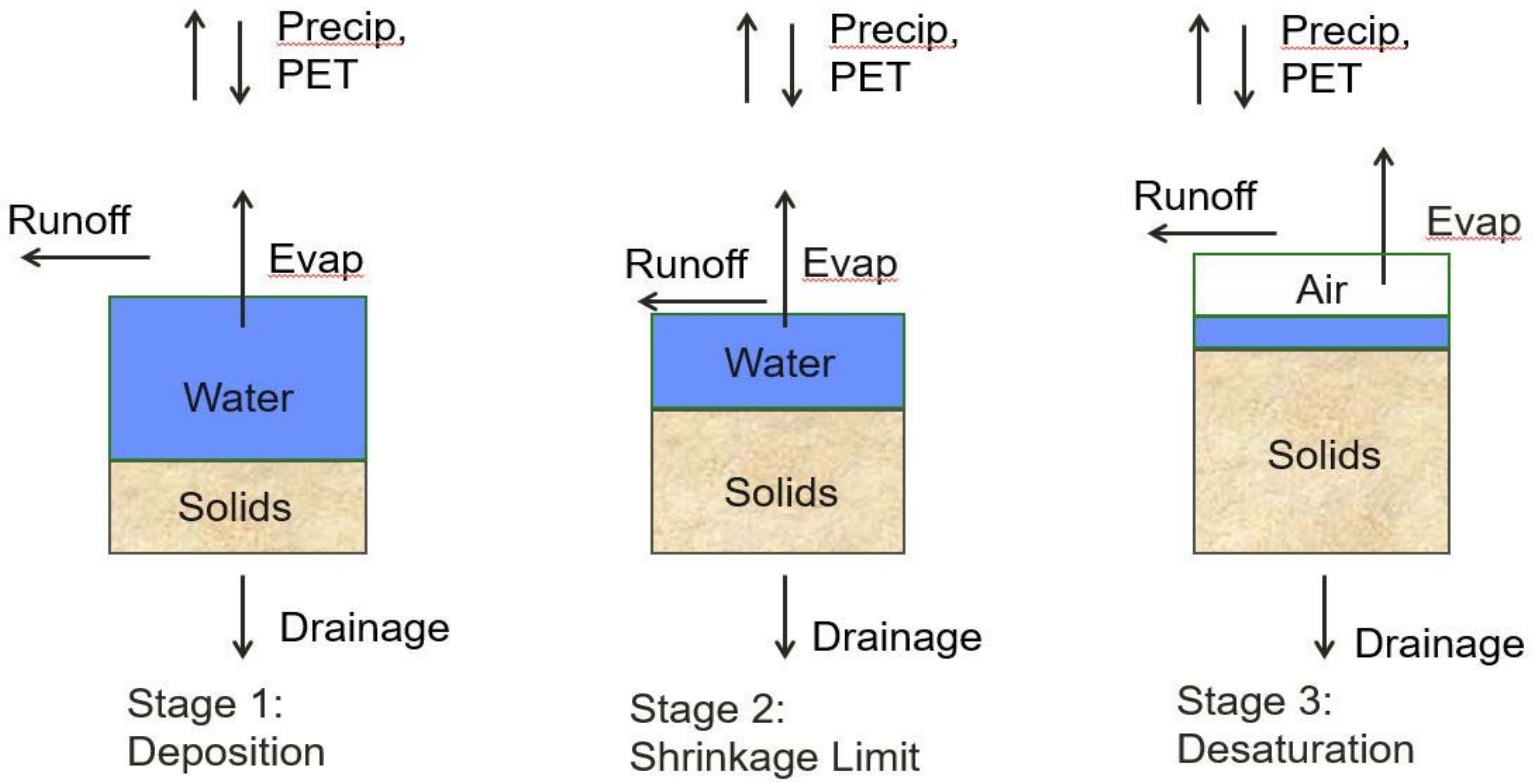
Denver

GOLDER



Simplified Model Assumptions
- No runoff (one-dimensional model)
- No seepage (assume impervious bottom)
- Precipitation is readily absorbed (use net evaporation)
- Fully saturated until shrinkage limit

Figure 2
Thin-Lift Deposition - Simplified Model
Grassy Mountain
Consolidation and Thin Lift Modeling



Accretion Model Assumptions

- Account for runoff (no run-on => one-dimensional model)
- Account for seepage looses (assume unit gradient bottom boundary)
- Calculate evaporation losses based on physical conditions at the soil-atmosphere boundary
- Allow for accretion of tailings and gradual change in height/desaturation (increase in tailings mass)
- Fully saturated until shrinkage limit

Figure 3

Thin-Lift Deposition - Accretion Model

Grassy Mountain

Consolidation and Thin Lift Modeling

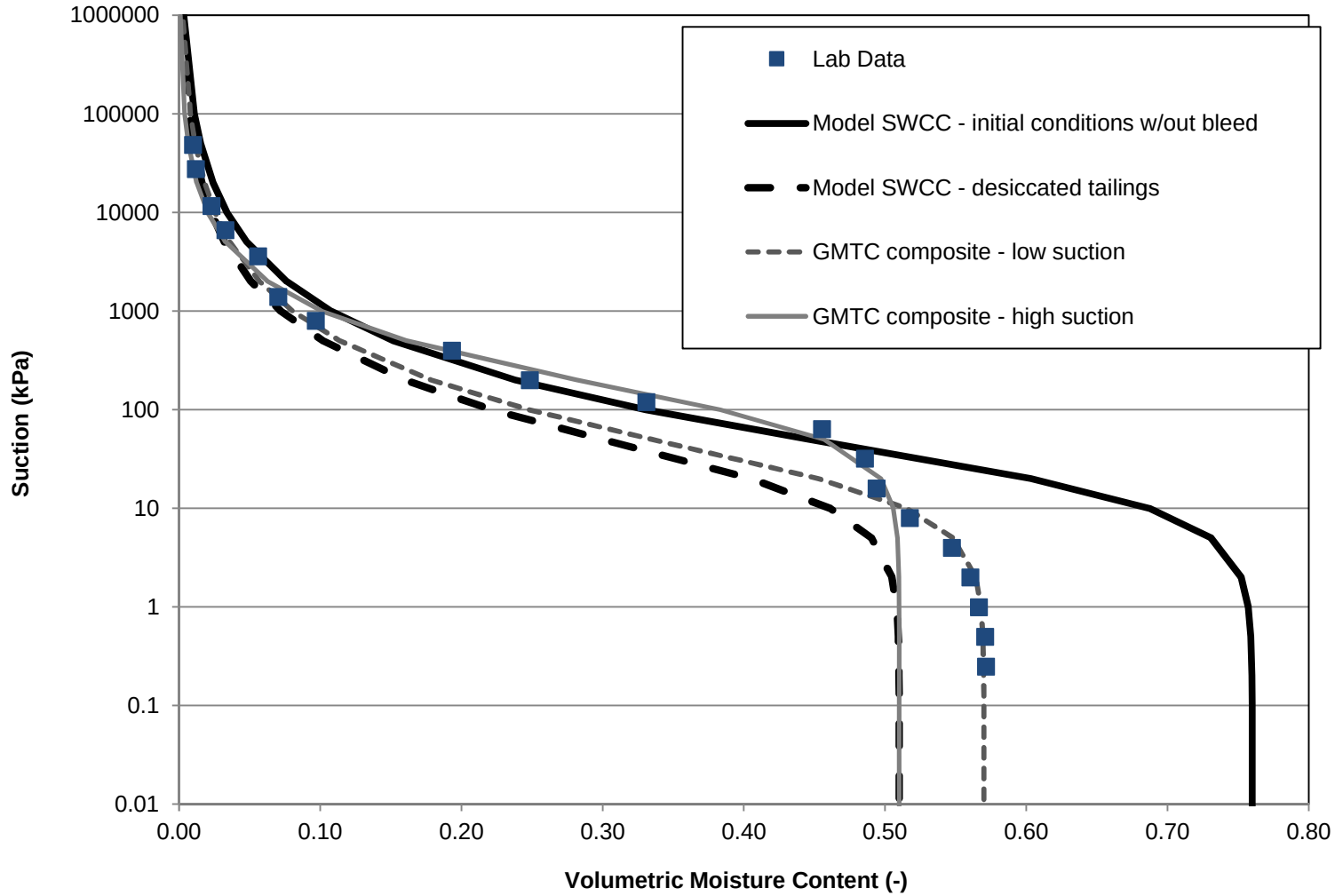


Figure 4

Model SWCCs

Grassy Mountain

Consolidation and Thin Lift Modeling

Denver

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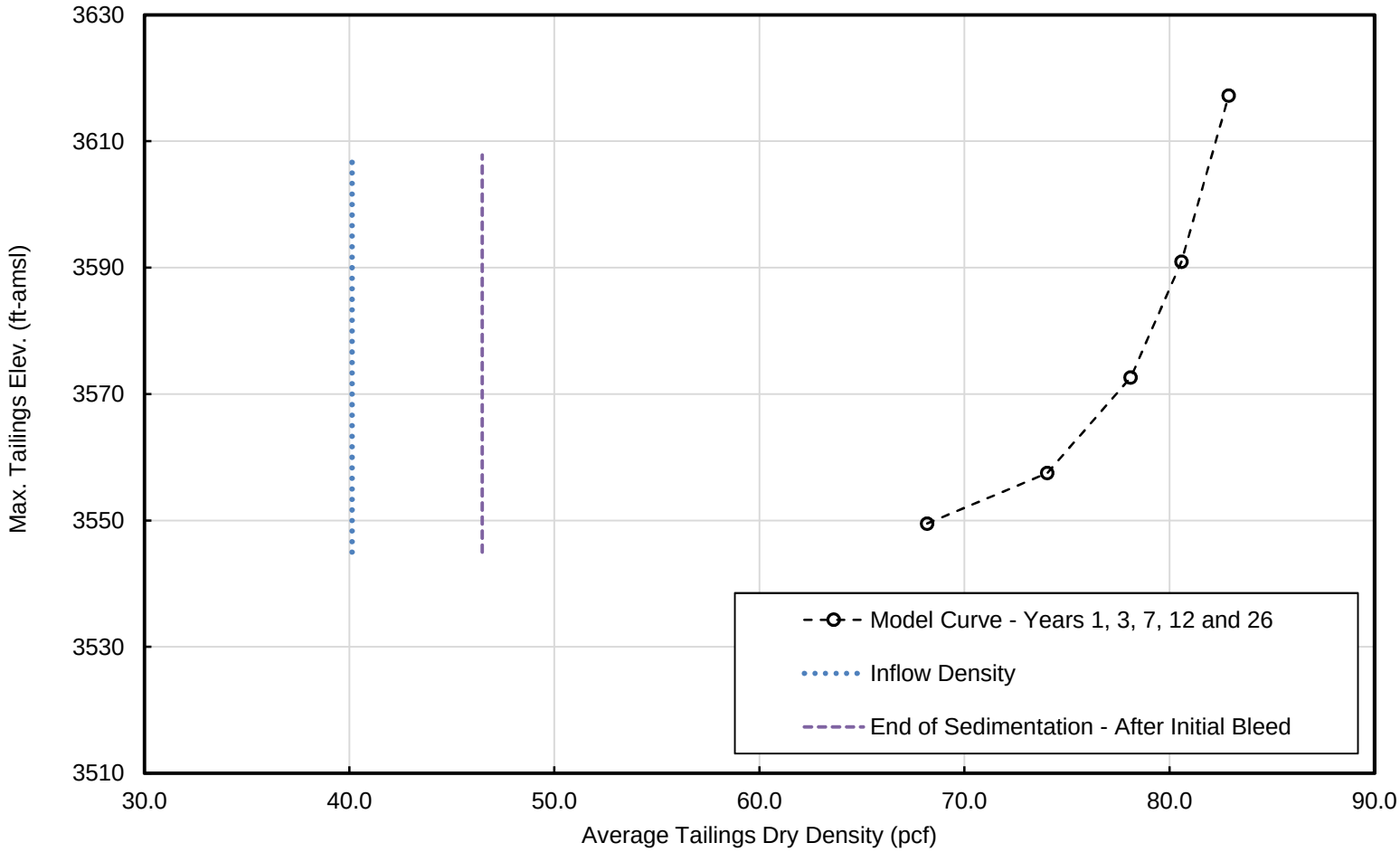

Figure 5

Density Profile - FSConsol Model Results

Grassy Mountain

Consolidation and Thin Lift Modeling

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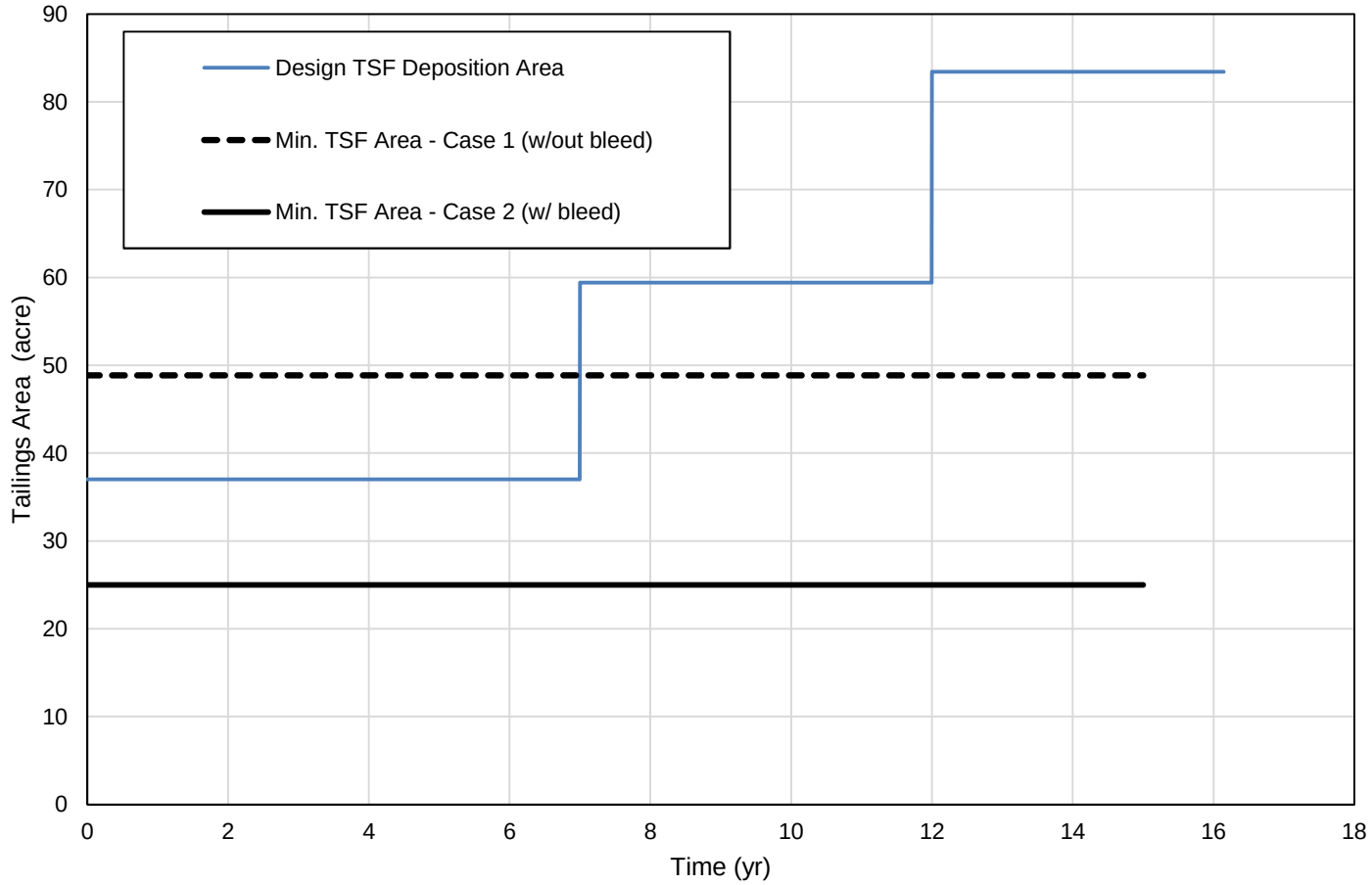

Figure 6

Thin-Lift Simplified Model Results

Grassy Mountain

Consolidation and Thin Lift Modeling

Denver

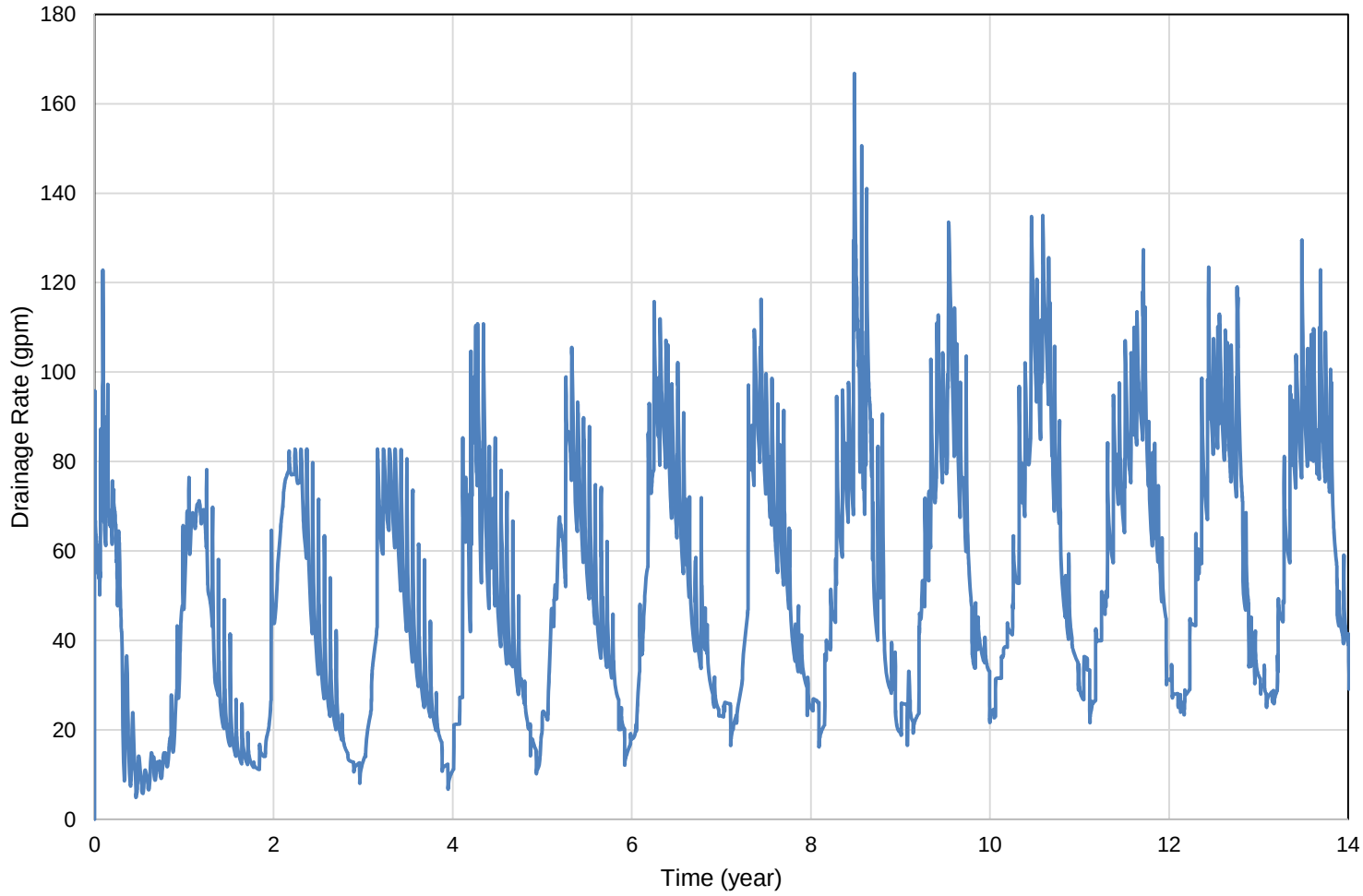

Figure 7

Case 1 - Accretion Model Drainage Rates

Grassy Mountain

Consolidation and Thin Lift Modeling

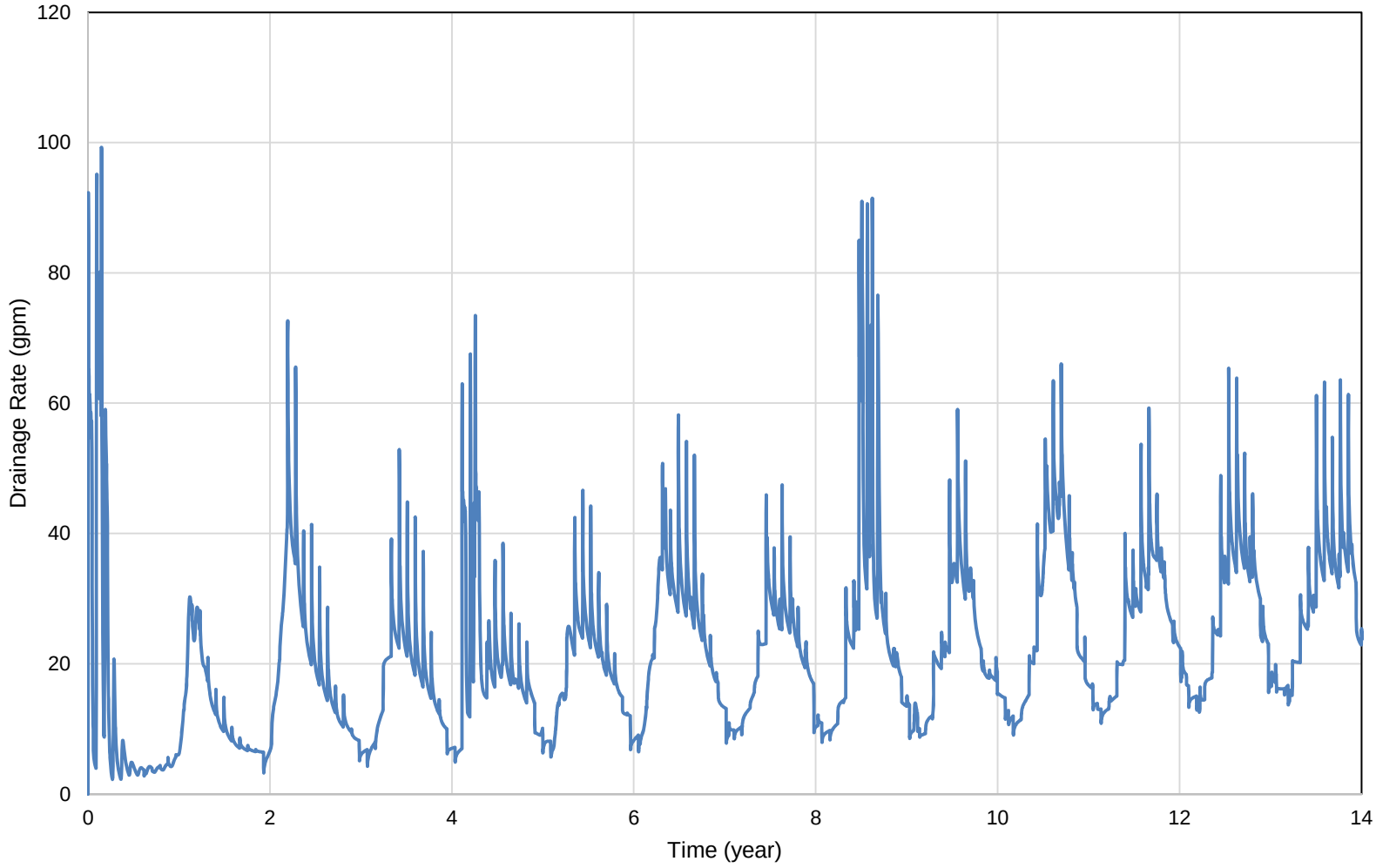

Figure 8

Case 2 - Accretion Model Drainage Rates

Grassy Mountain

Consolidation and Thin Lift Modeling

Denver

GOLDER

ATTACHMENT 1

Laboratory Testing on Tailings Samples

TECHNICAL MEMORANDUM

DATE October 8, 2019 **Reference No.** 1663241-9000-9005-TM-A

TO Chris MacMahon
Golder Associates Inc. – Reno, NV

FROM Gordan Gjerapic, Matt Barrett **EMAIL GGjerapic@Golder.com**

LABORATORY TESTING ON TAILINGS SAMPLES, GRASSY MOUNTAIN PROJECT

1.0 INTRODUCTION

Golder Associates Inc. (Golder) has completed a series of laboratory tests on tailings samples provided to Golder by SGS Canada Inc. (SGS) on behalf of Calico Resources USA Corp. (Calico) to assess the tailings' consolidation properties, settled density, hydraulic conductivity, water retention characteristics, desiccation properties, segregation potential and deposition properties. The laboratory testing was completed in accordance with the ASTM International (ASTM) standards and Golder's internal laboratory procedures for non-standardized tests on tailings slurries. The testing was conducted at Golder's Geotechnical Testing Laboratory at 9197 West 6th Ave, Building C Init 100, Lakewood, Colorado 80215.

This report summarizes results of the laboratory testing program on the GMTC-1 and GMTC-2 samples and the representative mixture of these two samples.

2.0 TAILINGS SAMPLES AND ASSIGNED TESTING

Golder received twelve (12) five-gallon buckets, six buckets of GMTC-1 and six buckets of GMTC-2 tailings, on April 22, 2019. After visual classification, Golder created a composite of the GMTC-1 and GMTC-2 samples. The as-delivered GMTC-1 composite sample had the gravimetric moisture content of 128.9 percent and the solids content of 43.7 percent. The as-delivered GMTC-2 composite sample had the gravimetric moisture content of 148.0 percent and the solids content of 40.3 percent.

The laboratory testing on GMTC-1 and GMTC-2 samples was conducted in two phases. The Phase 1 testing program was conducted to determine classification properties, settled density, compressibility and permeability characteristics and to evaluate the potential for tailings to segregate. The Phase 1 testing included the following:

- Particle size distribution (PSD) – ASTM D422 (hist.)
- Atterberg limits – ASTM D4318
- Specific gravity – ASTM D854
- Settling column testing – Golder procedure
- Slurry consolidation testing – Golder procedure

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The Phase 2 testing was conducted to determine parameters required for the thin-lift deposition modeling, and to determine beach angles and the segregation potential during the deposition process. The Phase 2 testing included the following:

- Soil water characteristic curves (SWCC) determination – ASTM D6836
- Shrinkage curve – Golder procedure
- Flume test – Golder procedure

Conducted laboratory tests are summarized in Table 1.

Table 1: Summary of Laboratory Testing

Test	Procedure	Tailings Sample		
		GMTC-1	GMTC-2	GMTC Composite
Particle Size Distribution	ASTM D422	1 (4)	1 (4)	1
Atterberg Limits	ASTM D4318	1	1	n/a
Specific Gravity	ASTM D854	1	1	n/a
Settling Column	Golder procedure	2	2	n/a
Slurry Consolidation	Golder procedure	1	1	1
SWCC	ASTM D6836	n/a	n/a	1
Shrinkage Curve	Golder procedure	n/a	n/a	1
Flume Test	Golder procedure	n/a	n/a	1

Notes:
1) Numbers in parentheses denote number of PSD tests on settling column samples

3.0 TEST RESULTS

This report summarizes Phase 1 and Phase 2 laboratory data on GMTC-1 and GMTC-2 tailings samples and the GMTC composite. More information is provided in the attachments:

- Attachment 1.1 – Classification Testing on As-Delivered Samples
- Attachment 1.2 – Settling Column Tests
- Attachment 1.3 – Consolidation Tests
- Attachment 1.4 – SWCC Testing
- Attachment 1.5 – Desiccation Tests
- Attachment 1.6 – Flume Testing

3.1 Classification Testing on As-Delivered Samples

Classification testing results for GMTC-1 and GMTC-2 tailings samples are summarized in Table 2.

Table 2: Classification Testing on As-Delivered Samples

Sample	As-Delivered Moisture Content (%)	Solids Content (%)	Specific Gravity (-)	% Fines (< #200)	Liquid Limit	Plastic Limit	Plasticity Index	USCS Symbol
GMTC-1	128.9	43.7	2.62	66.5	NP	NP	NP	ML
GMTC-2	148.0	40.3	2.64	63.3	NP	NP	NP	ML

Particle size distribution (PSD) curves for GMTC-1 and GMTC-2 samples are shown in Figure 1-1. Phase 1 classification testing results are presented in Attachment 1.1.

3.2 Settling Column Tests

The settling column test results are summarized in Table 3.

Table 3: Settling Column Testing Results

Sample/Test[1]	Initial Solids Content (%)	%Fines – Initial Sample	%Fines – Sample Top	%Fines – Sample Bottom	Settled Dry Density (pcf)
GMTC-1/DD	45.9	66.5	65.7	65.5	57.3
GMTC-1/ SD	45.9		66.5	65.7	51.0
GMTC-2/DD	45.8	63.3	63.2	62.9	62.6
GMTC-2/SD	46.1		63.1	62.9	54.2

Notes:
1) DD = double drained settling column tests, SD = single drained settling column test.

The settling column test results are presented in Figure 1-2 in terms of the (final) settled dry density. Settled dry densities of 51 and 54 pcf were recorded for tests conducted with the impervious bottom boundary, i.e., the single drained or SD tests (see Table 3). For tests with the pervious/drained bottom boundary, i.e., the double drained or DD tests, settled dry densities of 57 and 63 pcf were recorded at the end of the test. In both cases, using either SD or DD conditions, lower settled dry density values were recorded for the GMTC-1 sample.

Figures 1-2.1 to 1-2.4 display the PSD for the tailings “feed” material, i.e., tailings poured into the settling column at the initial solids content of 46 percent, and the PSDs for the material sampled at the top and the bottom of the settling column at the end of the test. Results in Figures 1-2.1 to 1-2.4 display very little change in the PSDs recorded for the top and the bottom samples supporting the conclusion that the tailings deposited at 46 percent are not likely to exhibit significant segregation. Similarly, results in Table 3 indicate very low segregation potential based on the difference in the recorded percentage of fines (the difference of less than one percent) between the top and the bottom tailings samples.

Results from the settling column testing are presented in more detail in Attachment 1.2.

3.3 Consolidation Testing

Consolidation parameters for GMTC-1 and GMTC-2 samples were determined from the slurry consolidation test data using the following constitutive relationships (see e.g., Liu and Znidarcic 1991, and Abu-Hejleh and Znidarcic, 1994, 1996):

$$e = A(\sigma' + Z)^B \quad (1)$$

and

$$k = Ce^D \quad (2)$$

Where e denotes the void ratio, σ′ stands for the effective stress, and *k* is the hydraulic conductivity functionally dependent on void ratio. In the above equations *A, B, Z, C* and *D* are material parameters determined by fitting analytical relationships, defined by Equations (1) and (2), to laboratory data. Consolidation parameters determined from the slurry consolidation measurements on GMTC-1 and GMTC-2 tailings samples are summarized in Table 4.

Table 4: Consolidation Parameters Based on Slurry Consolidation Measurements

Sample	A (1/psf)^B	B (-)	Z (psf)	C (cm/sec)	D (-)
GMTC-1	2.1204	-0.1091	1.0097	5.737 x 10^{-6}	10.668
GMTC-2	2.2853	-0.1223	2.0878	8.308 x 10^{-6}	6.2795

Results from the slurry consolidation measurements and the analytical compressibility and permeability relationships for GMTC-1 and GMTC-2 samples are presented graphically in Figures 1-3.1 and 1-3.2. A comparison between the GMTC-1 and GMTC-2 consolidation data is illustrated in Figure 1-3.3. Results in Figure 1-3.3 demonstrate that GMTC-1 and GMTC-2 exhibit similar geomechanical properties.

Detailed consolidation test results on GMTC-1 and GMTC-2 tailings samples are presented in Attachment 1.3.

3.4 SWCC Testing

The SWCC testing was conducted to determine water retention parameters required for the thin-lift deposition modeling, i.e., data to define the tailings' water retention capacity at different values of matric suction. The following suction-saturation relationship was adopted to fit experimental measurements (see van Genuchten 1978, 1980):

$$\theta = \theta_r + (\theta_{sat} - \theta_r)[1 + (\alpha \cdot h_c)^n]^{-m} \quad (3)$$

Where:
- θ = volumetric moisture content
- h_c = matric suction
- θ_r = residual volumetric moisture content
- θ_{sat} = saturated volumetric moisture content (porosity)
- α = van Genuchten "alpha" parameter
- n = van Genuchten "n" parameter
- m = van Genuchten "m" parameter, $m = 1 - 1/n$.

The van Genuchten parameters were determined by fitting the relationship defined by Equation (3) to SWCC laboratory data determined by testing the GMTC composite sample. The adopted SWCC parameters are summarized in Table 5.

Table 5: SWCC Parameters

Sample	θ_{sat} (-)	θ_r (-)	α (1/kPa)	n (cm/sec)
GMTC composite – low suction	0.57	0.00	0.05	1.50
GMTC composite – high suction	0.51	0.00	0.01	1.70

Based on the laboratory SWCC measurements, two closed-form relationships are recommended to describe the GMTC composite retention capacity (see Table 5). For suctions below 10 kPa, the GMTC composite sample exhibits relatively significant changes in volume during the desiccation process. The saturated moisture content of 0.51 is recommended to be applied for capillary pressures in excess of 10 kPa as the soil approaches the shrinkage limit. Laboratory SWCC measurements and the fitted van Genuchten relationships are displayed in Figure 1-4.

Detailed SWCC test results on the GMTC composite sample are provided in Attachment 1.4.

3.5 Desiccation Testing

The purpose of the desiccation test is to determine tailings parameters that are governing soil behavior during the drying/desiccation process. One of the most important parameters describing the desiccation process is the soil's shrinkage limit. The shrinkage limit is defined as a moisture content at which soil ceases to exhibit significant changes in volume when subjected to the continuous increases in suction. I.e., after reaching the shrinkage limit, the soil will continue to desaturate while the pore volume remains approximately the same. Based on the shrinkage limit test results, the following parameters are recommended for the thin-lift deposition analyses:

Table 6: Desiccation Parameters

Sample	Specific Gravity (-)	Shrinkage Limit (%)	Void Ratio at Shrinkage Limit	Dry Density at Shrinkage Limit (pcf)
GMTC composite	2.63	38.8	1.02	81.3

The measured range of dry densities at the end of the shrinkage test is shown in Figure 1-5. The shrinkage test results are presented in more detail in Attachment 1.5.

3.6 Flume Testing

The flume test can be used to determine the following:

- Segregation potential of deposited tailings
- Estimate the range of beach slopes for deposition modeling
- Confirm rheological properties of tailings deposited at relatively low discharge velocities

- Estimate/confirm density, strength and consolidation properties and estimate potential variability of these properties within the impoundment

3.6.1 Segregation Potential

The GMTC composite deposited at the solids content of 46 percent is not likely to exhibit significant segregation during the deposition process. Based on the PSDs on samples collected at the discharge point (beach sample) and at the end of the flume (slimes sample), the difference in the fines content between the beach and the slimes samples is likely to be less than 10 percent. However, results in Figure 1-6.1 demonstrate that a measurable fraction of fines smaller than 10 microns may remain in suspension after the initial settling process is completed. These smaller particles suspended in the bleed water are likely to be transported towards the pool and be responsible for the presence of finer, lower permeability layers in the tailings deposited within the TSF pool area due to the continuous sedimentation process. I.e., flume results indicate that the fines smaller than approximately 10 microns may contribute to reducing the overall hydraulic permeability of tailings within the pool area and affect the turbidity of water returned to the mill.

3.6.2 Beach Slopes

Beach slopes are relatively difficult to predict as they depend on the flow/deposition rate, rate of rise, initial slopes governed by the depositional practices and the TSF geometry, tailings segregation potential, conditions at the deposition surface, etc. Consequently, beach angles are expected to vary as a function of the location of tailings within the impoundment and throughout the life of the facility. To investigate possible range of beach angles under different scenarios, the flume testing program was conducted by depositing tailings in a 12-inch wide and 24-ft long flume. The measured beach angles are summarized in Table 7.

Table 7: Beach Angles

Sample	Average Slope (%)	Slope at Mid-Point (%)	End Slope (%)
GMTC composite	0.63	0.94	1.38

3.6.3 Rheological Properties

Flume results can be used to evaluate rheological properties at relatively low shearing rates associated with the movement of the deposited tailings through the flume and utilizing the recorded tailings profile.

Table 8: Yield Stress

Sample	Minimum Yield Stress (Pa)	Maximum Yield Stress (Pa)	Average Yield Stress (Pa)
GMTC composite	4.4	4.9	4.7

The yield stress estimates in Table 8 were determined using the tailings profile at the end of the flume test. The tailings were discharged at the solids content of 46 percent. At the end of the test, the measured tailings solids content along the flume ranged from 49 to 52 percent.

3.6.4 Density and Consolidation Properties

Samples collected along the flume were used to evaluate the expected range of densities and consolidation properties for the deposited tailings. If required for stability analyses, the variability of tailings strength may be evaluated for the range of densities determined from consolidation analyses using the representative flume samples. The strength testing on tailings samples was not considered in this study. The range of tailings densities at low effective stresses were determined by collecting samples along the flume at the end of the test. Results for the settled dry density, solids content and void ratio, determined for the average flume deposit thickness of less than 2 inches and the initial (discharge) solids content of 46 percent, are summarized in Table 9

Table 9: Flume Test – Settled Dry Density, Solids Content and Void Ratio

	Dry Density (pcf)	Solids Content (%)	Void Ratio (-)
Minimum	43.9	48.8%	2.46
Maximum	47.7	51.7%	2.76
Median	46.7	51.0%	2.53
Average	46.4	50.7%	2.55

Two samples collected at the discharge point (beach sample) and at the end of the flume (slimes sample) were used to evaluate potential variability of the tailings consolidation parameters, i.e., to evaluate the range of consolidation properties in the simulated depositional environment. The consolidation test results on the beach and slimes samples are presented in Figures 1-6.2.1 and 1-6.2.2 with the consolidation parameters summarized in Table 10.

Table 10: Flume Test – Consolidation Parameters on Beach and Slimes Samples

Sample	A $(1/psf)^B$	B (-)	Z (psf)	C (cm/sec)	D (-)
GMTC Composite – Beach	2.4438	-0.1241	0.5637	1.593×10^{-5}	4.1248
GMTC Composite – Slimes	2.2421	-0.1143	0.2505	8.274×10^{-6}	2.9008

Consolidation parameters for the GMTC composite (beach and slimes) samples are compared to GMTC-1 and GTMC-2 samples in Figure 1-6.2.3. The flume test results are presented in Attachment 1.6.

4.0 REFERENCES

Abu-Hejleh, A.N., and D. Znidarcic. 1994. “Estimation of the Consolidation Constitutive Relations,” Computer Methods and Advances in Geomechanics, Siriwardane & Zaman (eds) Balkema, Rotterdam, pp. 499-504.

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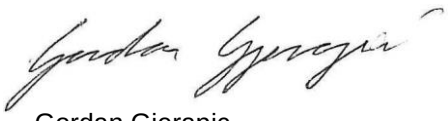
van Genuchten, M.T. 1980. "*A closed-form equation for predicting the hydraulic conductivity of unsaturated soils*," Soil Sci. Soc. Am. J., 44: 892-898.

Golder Associates Inc.



Gordan Gjerapic
Geotechnical Engineer

Matt Barrett
Geotechnical Laboratory Manager

GG/MB/rjg

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Figures

Figure 1-1: PSD – As-Delivered Tailings Samples

Figure 1-2: Settled Dry Density – Settling Column Testing on GMTC-1 and GMTC-2 Samples

Figure 1-2.1: Tailings Gradation and Segregation Potential – GMTC-1 – Double Drained Settling Column Test

Figure 1-2.2: Tailings Gradation and Segregation Potential – GMTC-1 – Single Drained Settling Column Test

Figure 1-2.3: Tailings Gradation and Segregation Potential – GMTC-2 – Double Drained Settling Column Test

Figure 1-2.4: Tailings Gradation and Segregation Potential – GMTC-2 – Single Drained Settling Column Test

Figure 1-3.1: Consolidation Properties – GMTC-1 Sample

Figure 1-3.2: Consolidation Properties – GMTC-2 Sample

Figure 1-3.3: Consolidation Properties – GMTC-1 and GMTC-2 Samples – Comparison

Figure 1-4: SWCC Test – GMTC Composite Sample

Figure 1-5: Shrinkage Curve Test – Dry Density at Shrinkage Limit

Figure 1-6.1: Flume Test – PSD for Beach and Slimes Samples

Figure 1-6.2.1: Consolidation Properties – GMTC Composite – Beach Sample

Figure 1-6.2.2: Consolidation Properties – GMTC Composite – Slimes Sample

Figure 1-6.2.3: Consol. Properties – GMTC Composite vs. GMTC-1/2 Samples – Comparison

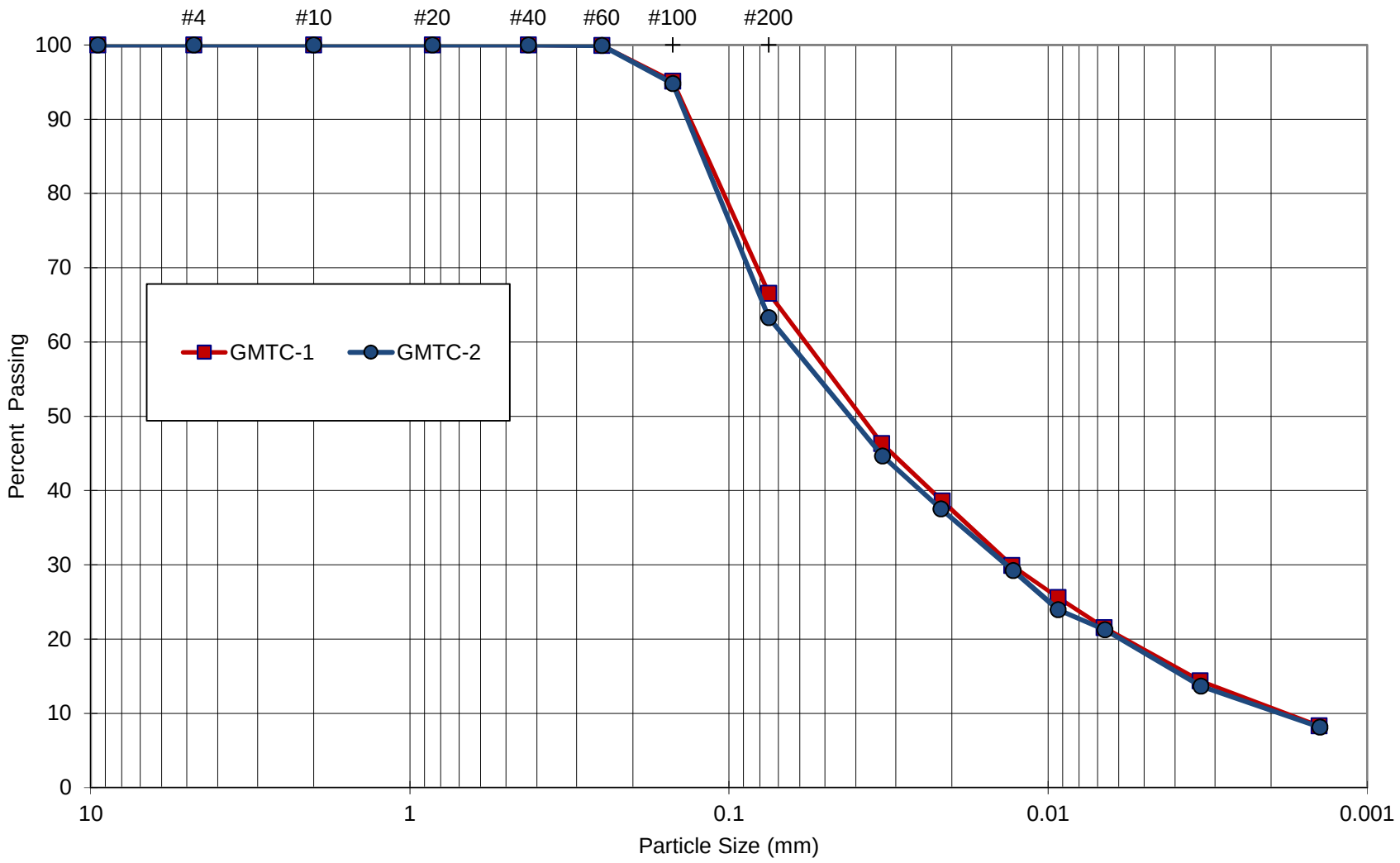


Figure 1-1

PSD - As-Delivered Tailings Samples

Grassy Mountain, OR

Tailings Laboratory Testing

Denver

GOLDER

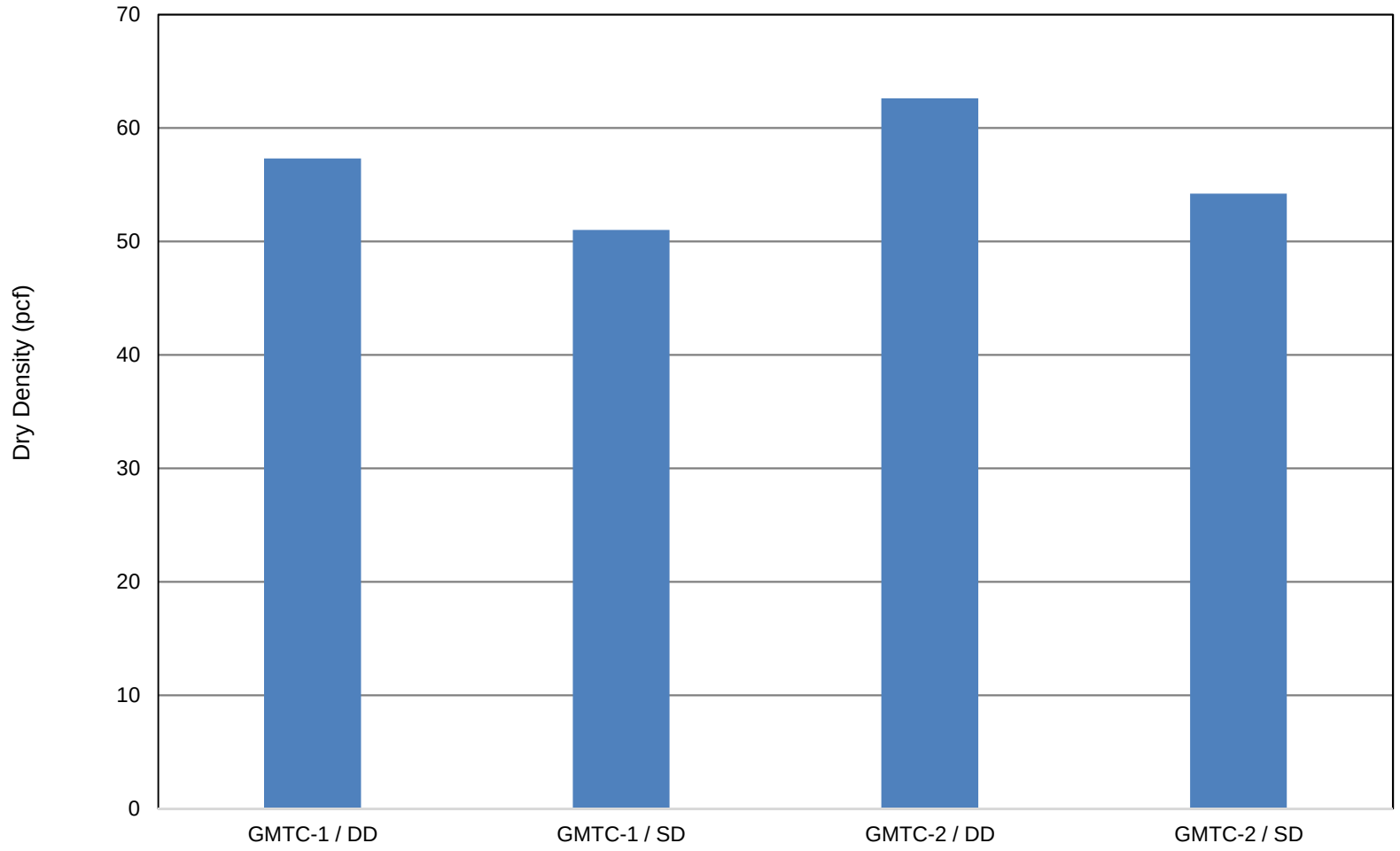


Figure 1-2

Settled Dry Density - Settling Column Testing on GMTC-1 and GMTC-2 Samples

Grassy Mountain, OR

Tailings Laboratory Testing

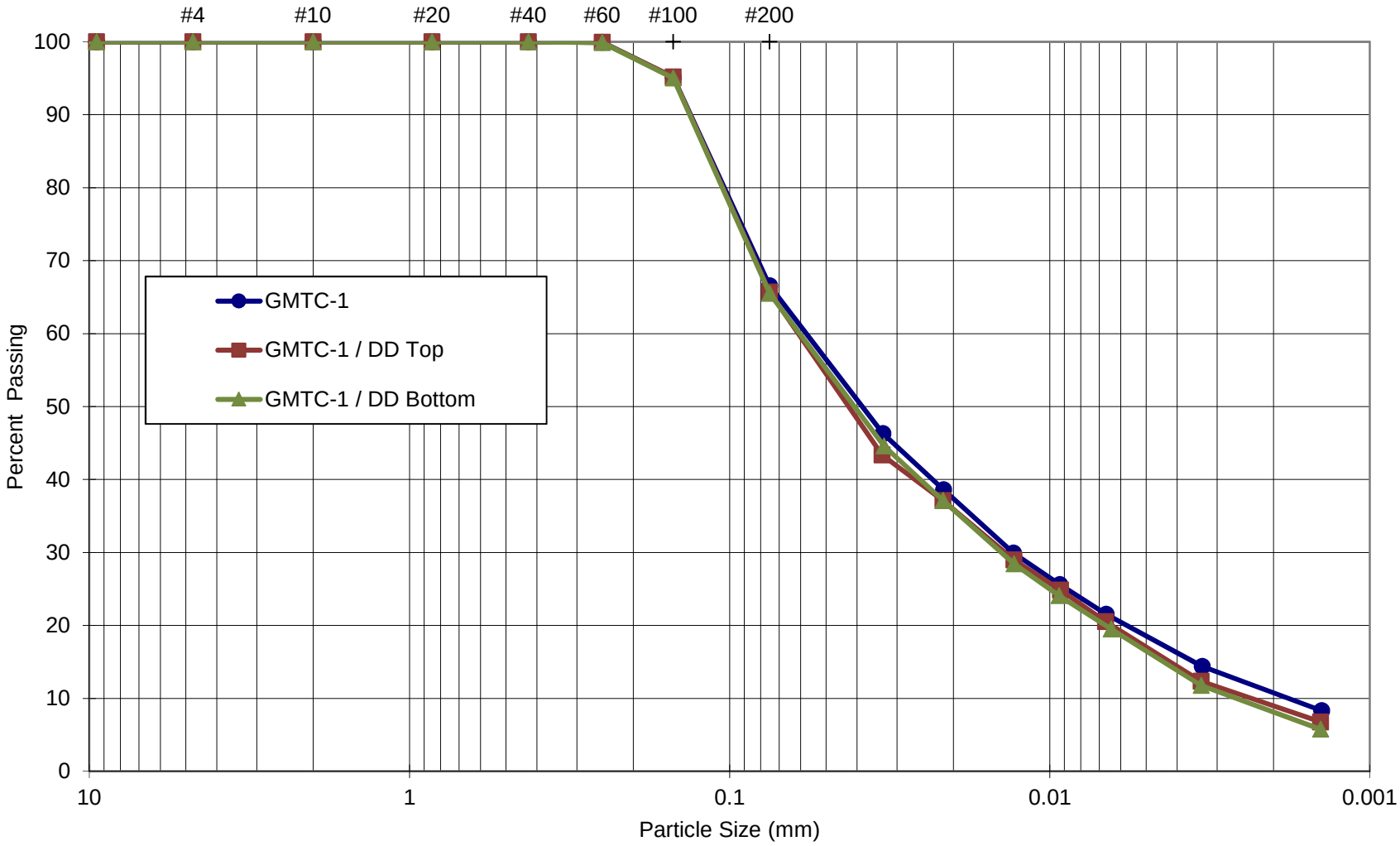


Figure 1-2.1

Tailings Gradation and Segregation Potential - GMTC-1 - Double Drained Settling Column Test

Grassy Mountain, OR

Tailings Laboratory Testing

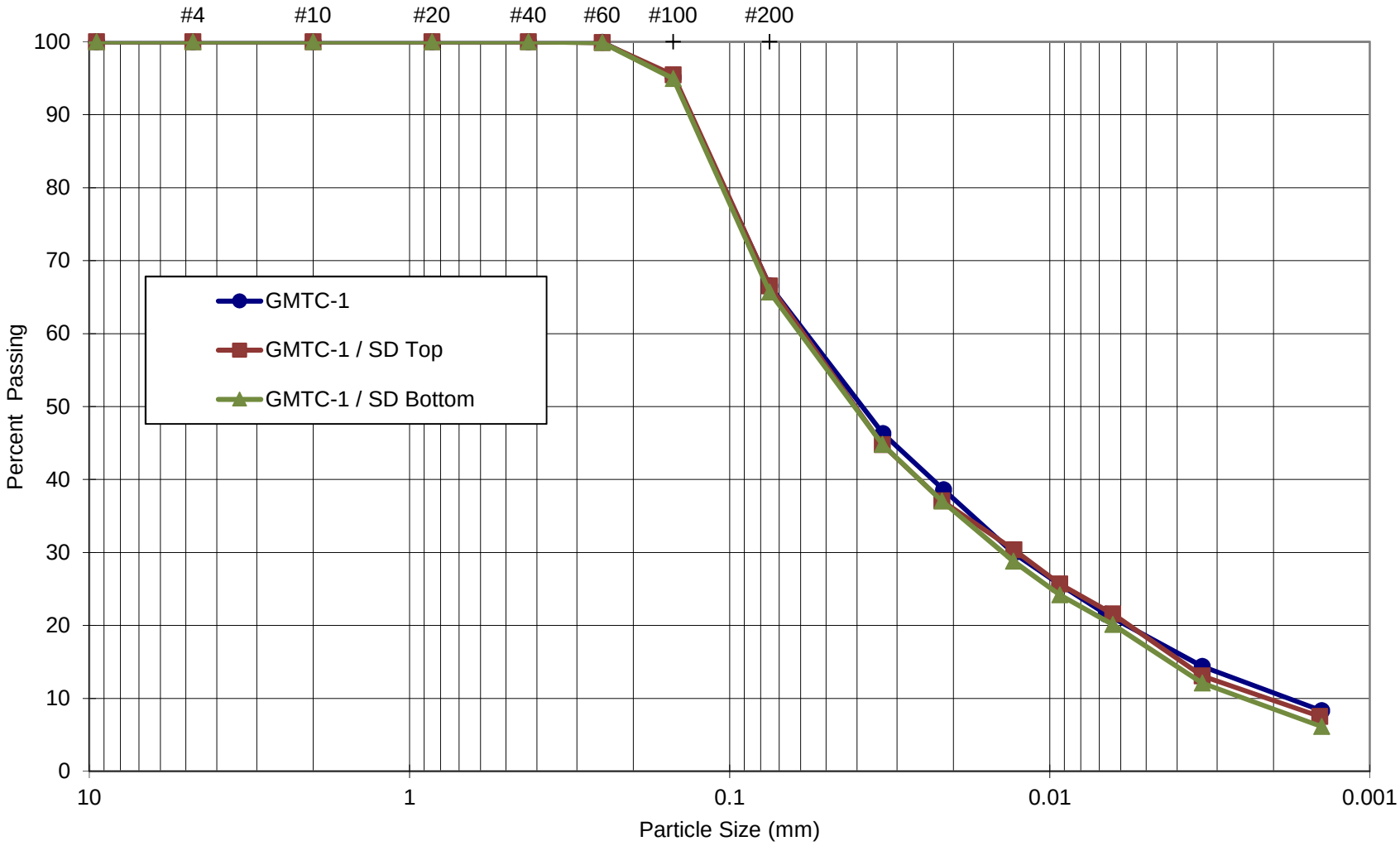


Figure 1-2.2

Tailings Gradation and Segregation Potential - GMTC-1 - Single Drained Settling Column Test

Grassy Mountain, OR

Tailings Laboratory Testing

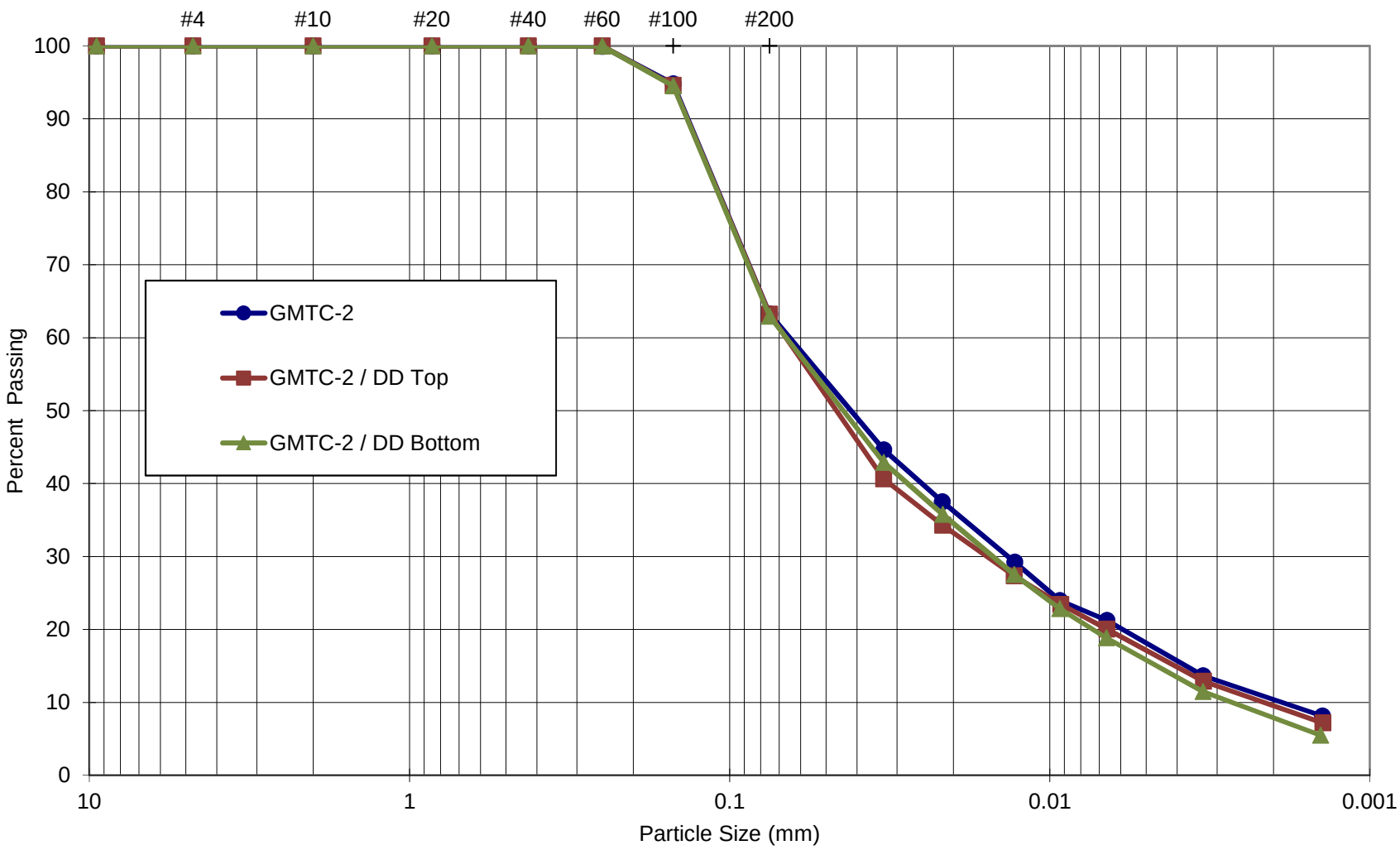


Figure 1-2.3

Tailings Gradation and Segregation Potential - GMTC-2 - Double Drained Settling Column Test

Grassy Mountain, OR

Tailings Laboratory Testing

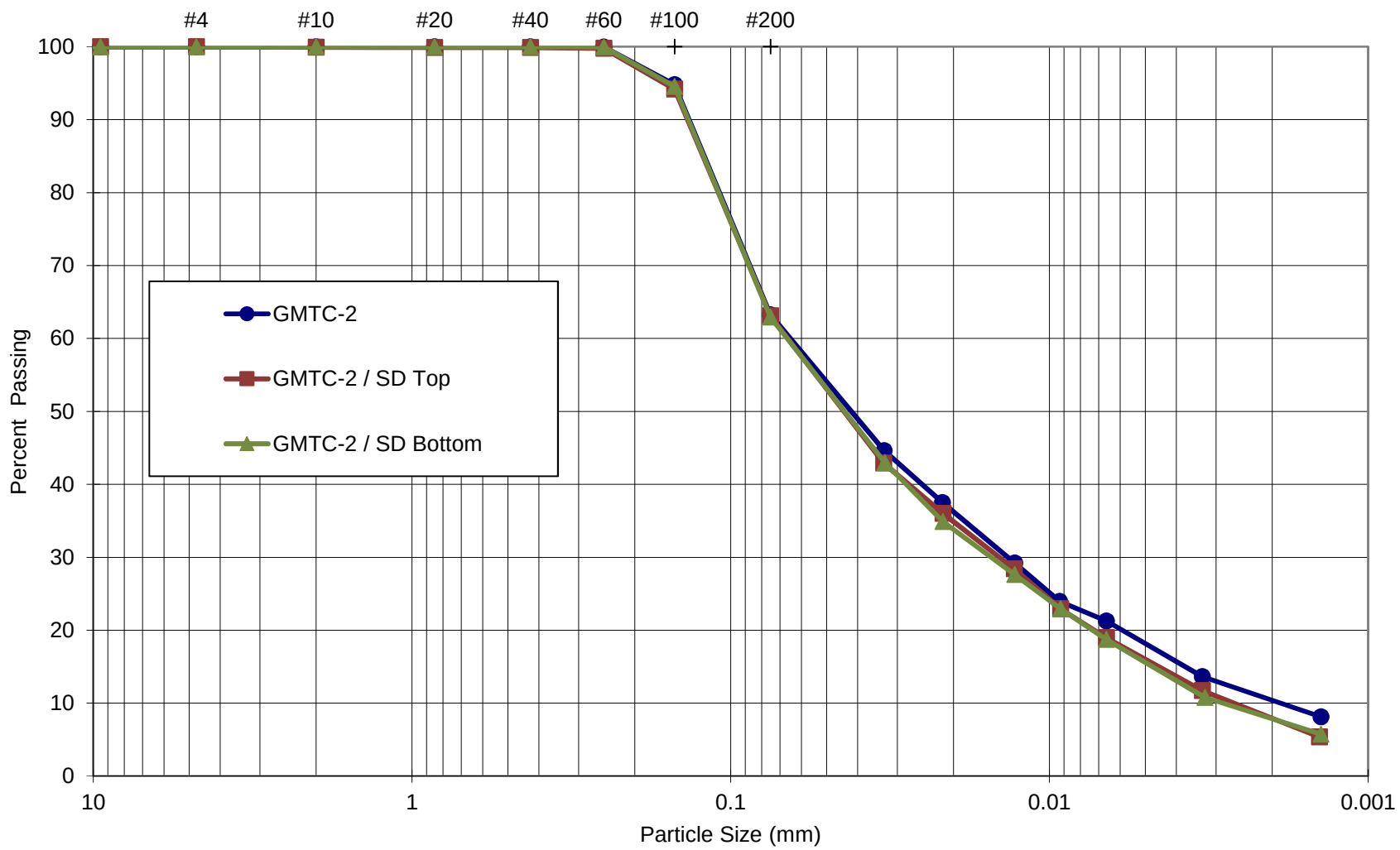
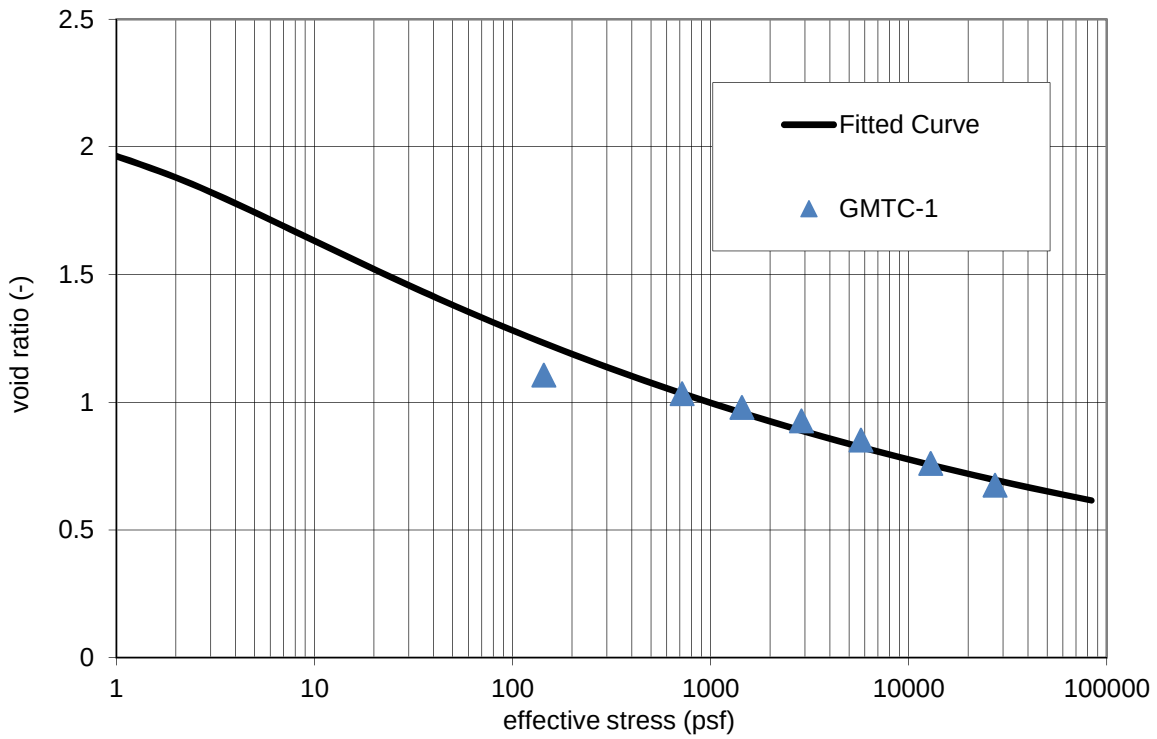


Figure 1-2.4

Tailings Gradation and Segregation Potential - GMTC-2 - Single Drained Settling Column Test

Grassy Mountain, OR

Tailings Laboratory Testing



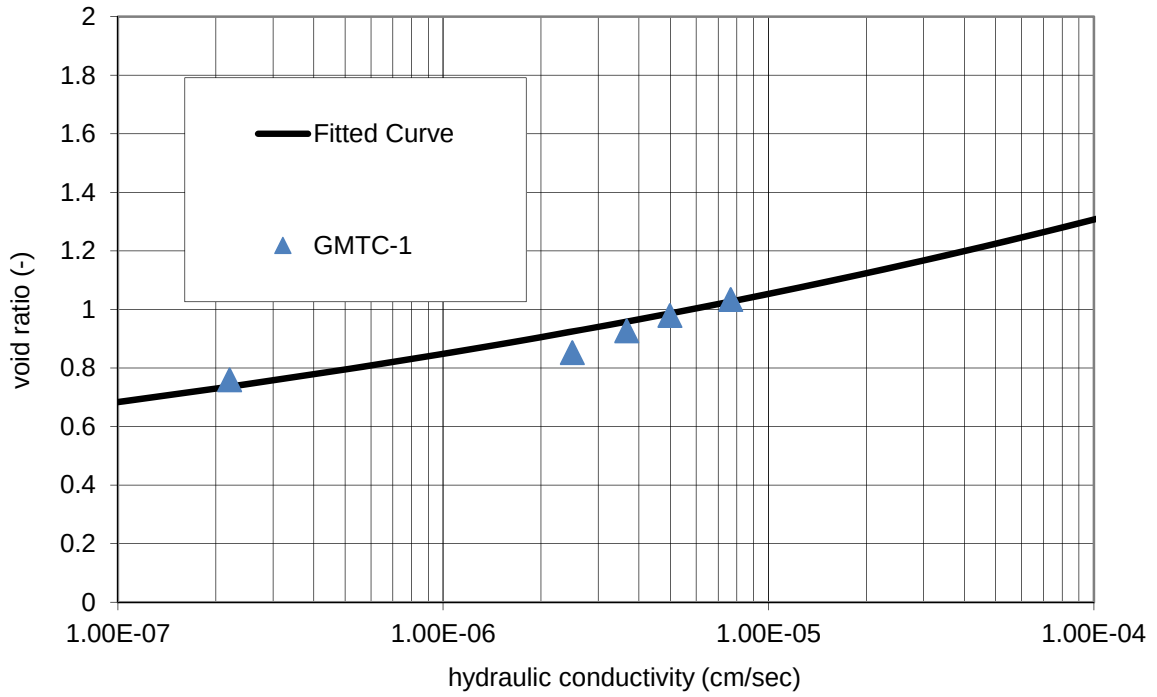
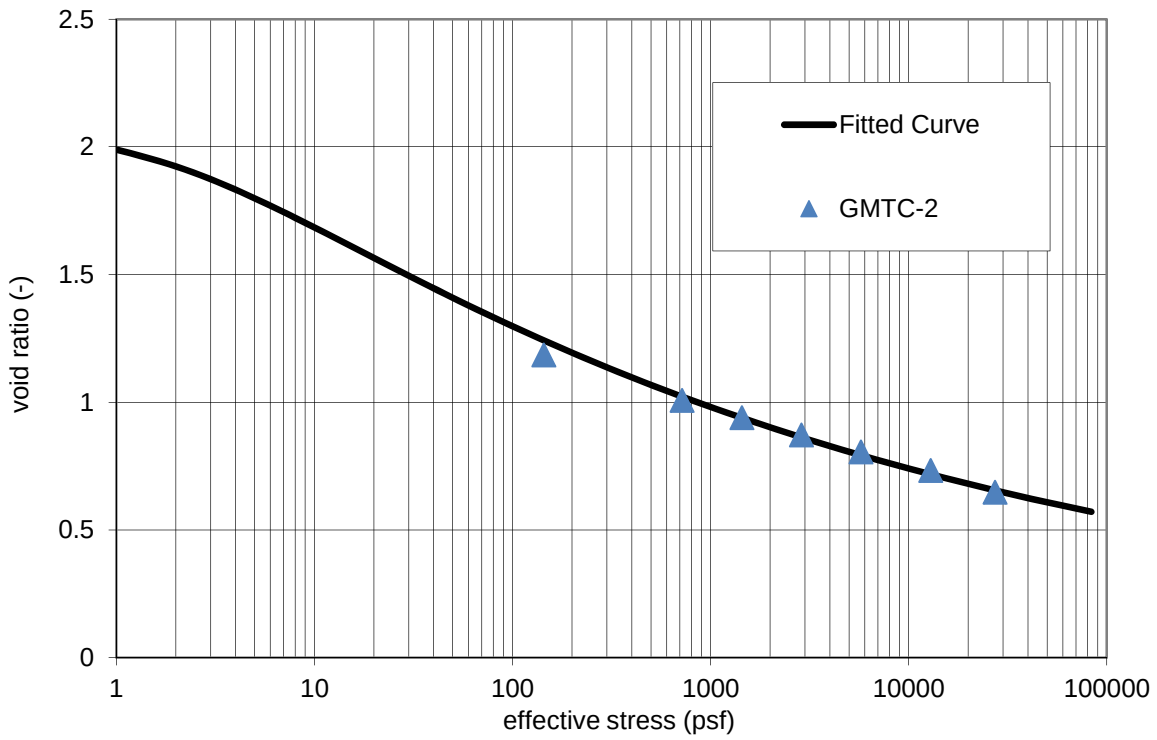


Figure 1-3.1

Consolidation Properties - GMTC-1 Sample

Grassy Mountain, OR

Tailings Laboratory Testing



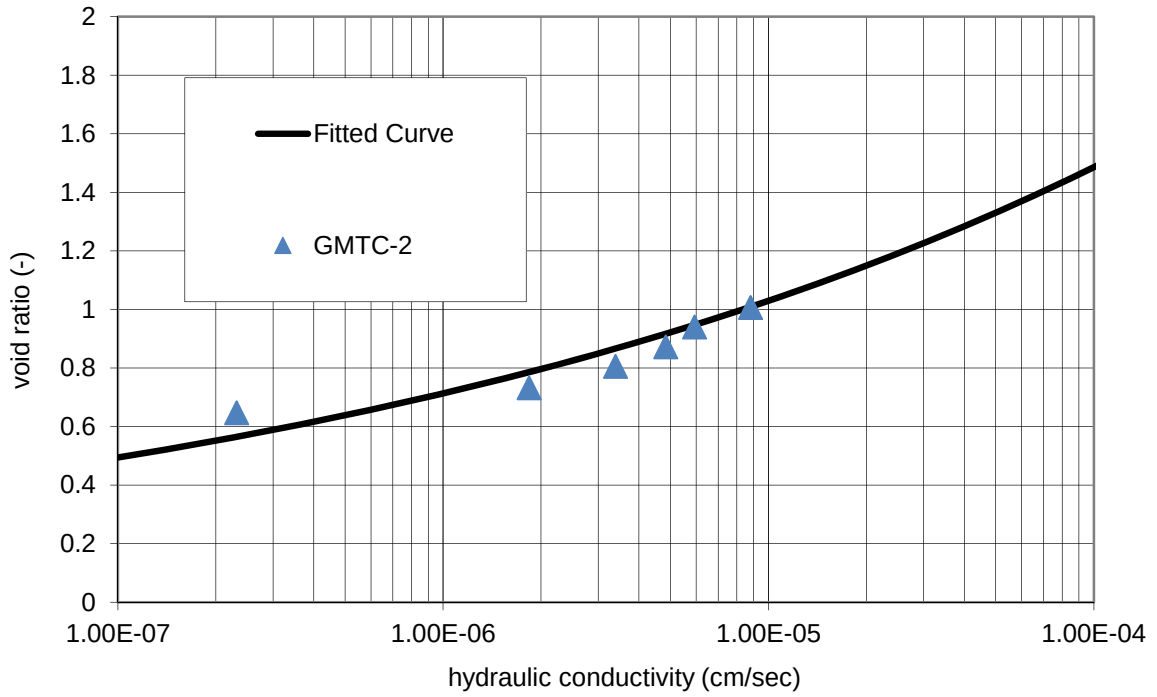
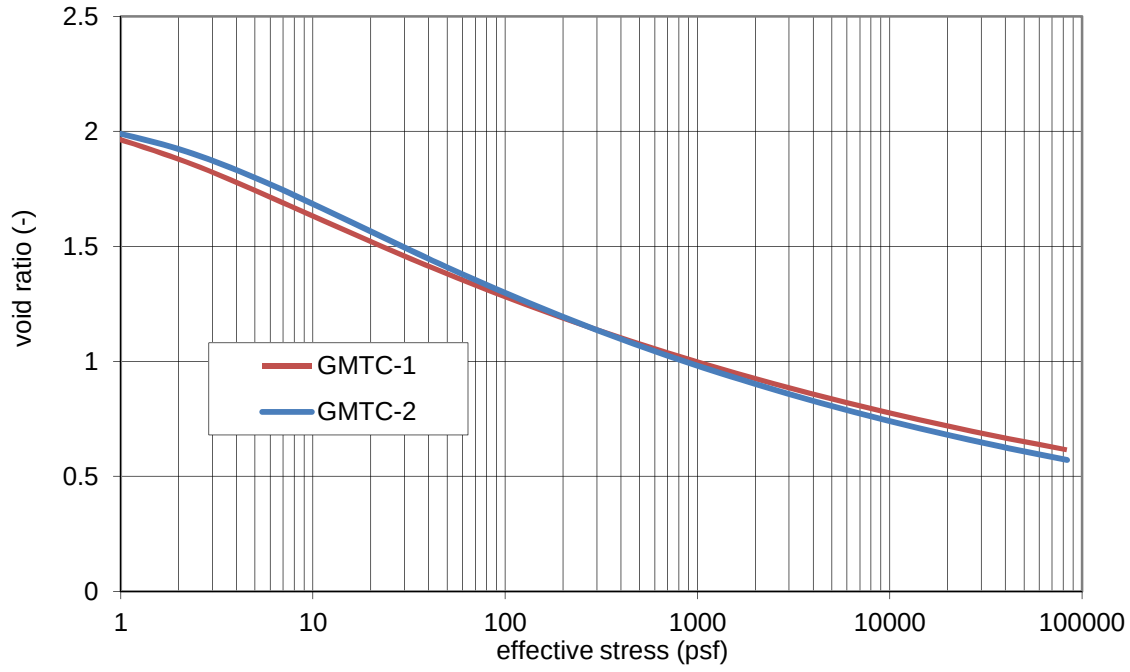


Figure 1-3.2

Consolidation Properties - GMTC-2 Sample

Grassy Mountain, OR

Tailings Laboratory Testing



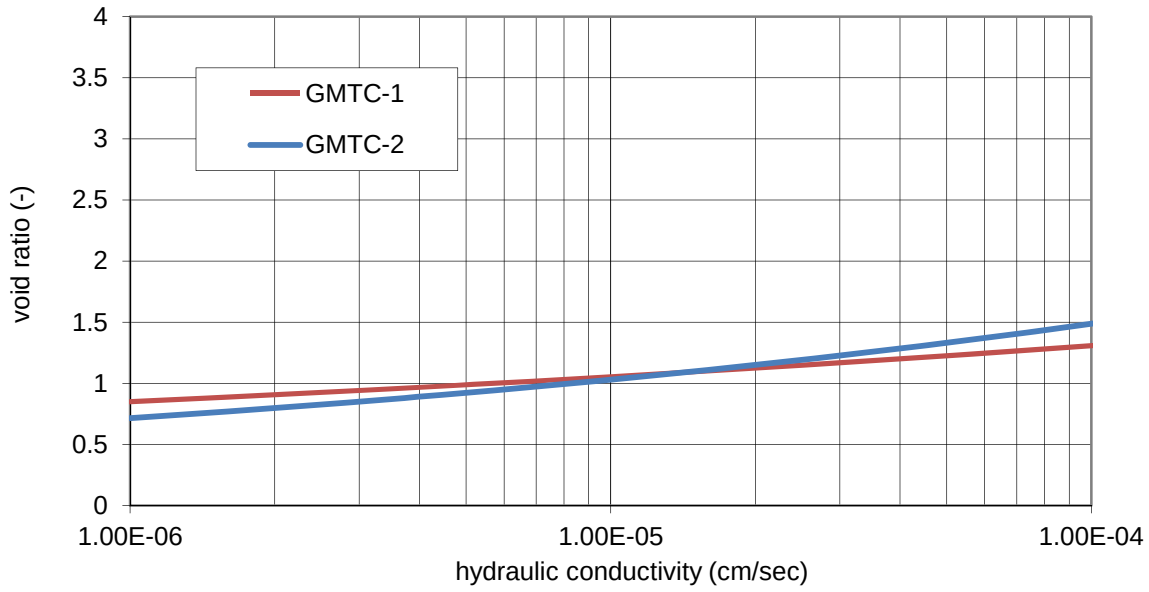


Figure 1-3.3

Consolidation Properties - GMTC-1 and GMTC-2 Samples - Comparison

Grassy Mountain, OR

Tailings Laboratory Testing

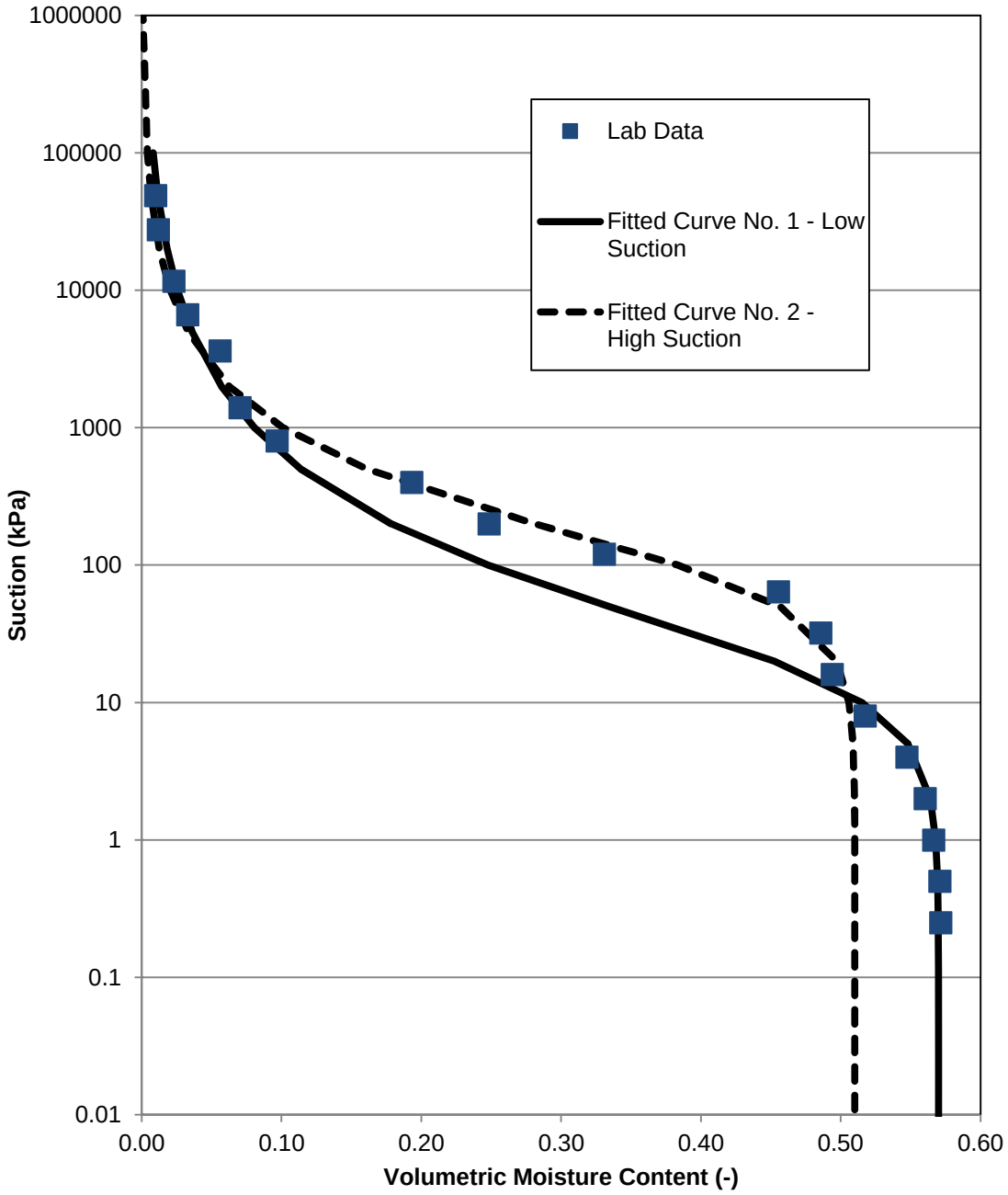


Figure 1-4

SWCC Test - GMTC Composite Sample

Grassy Mountain, OR

Tailings Laboratory Testing

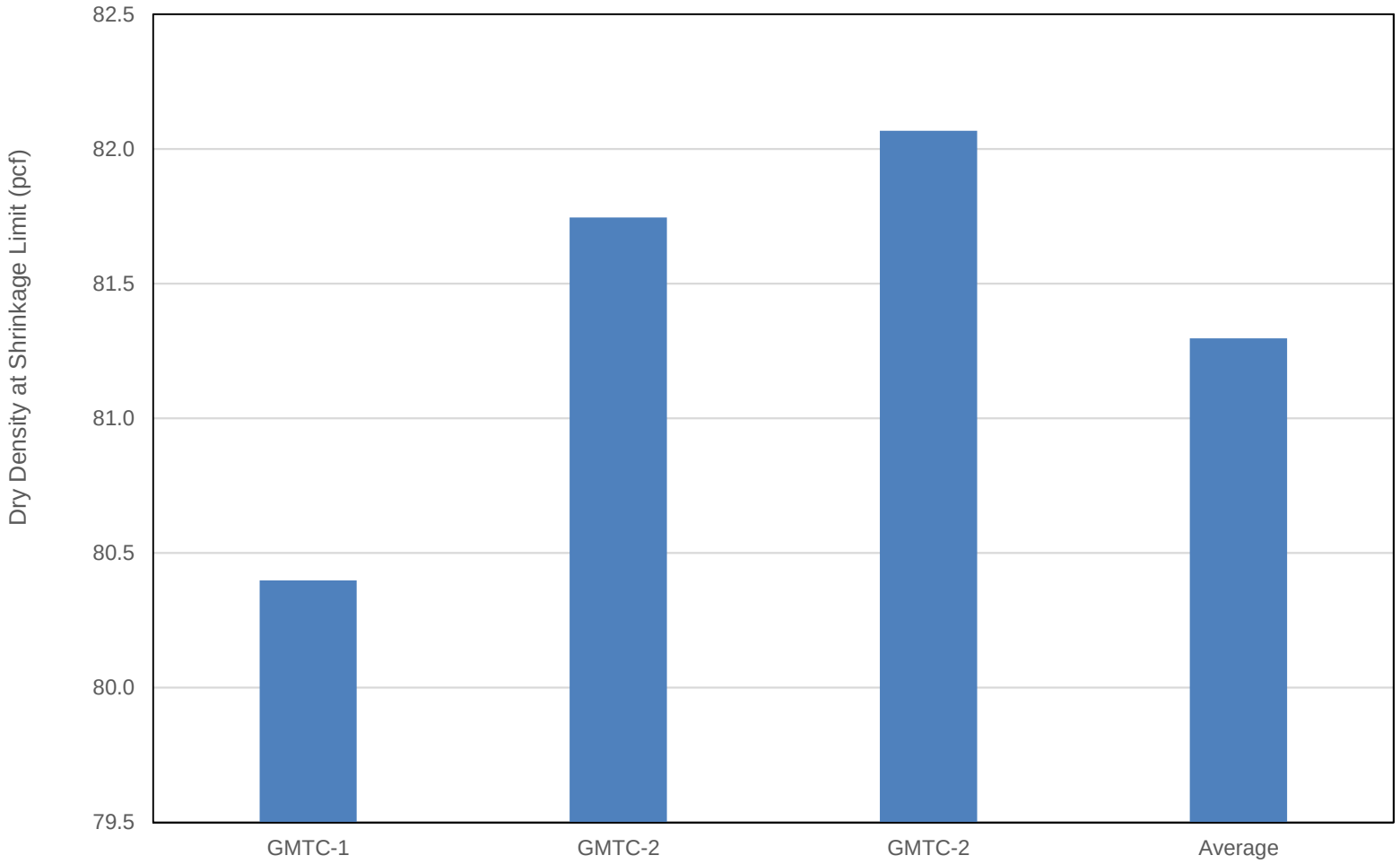


Figure 1-5

Shrinkage Curve Test - Dry Density at Shrinkage Limit

Grassy Mountain, OR

Tailings Laboratory Testing

Denver

GOLDER

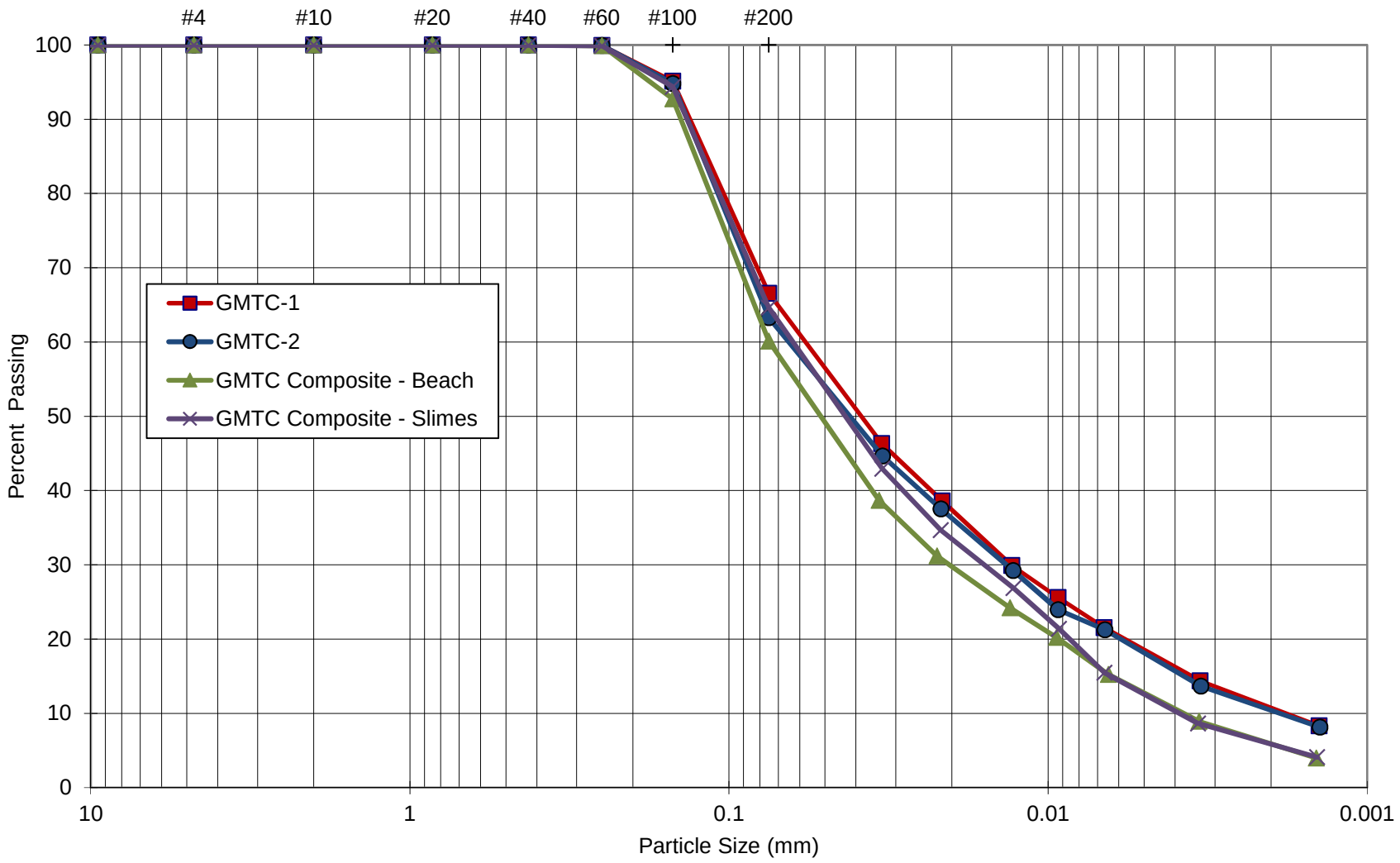
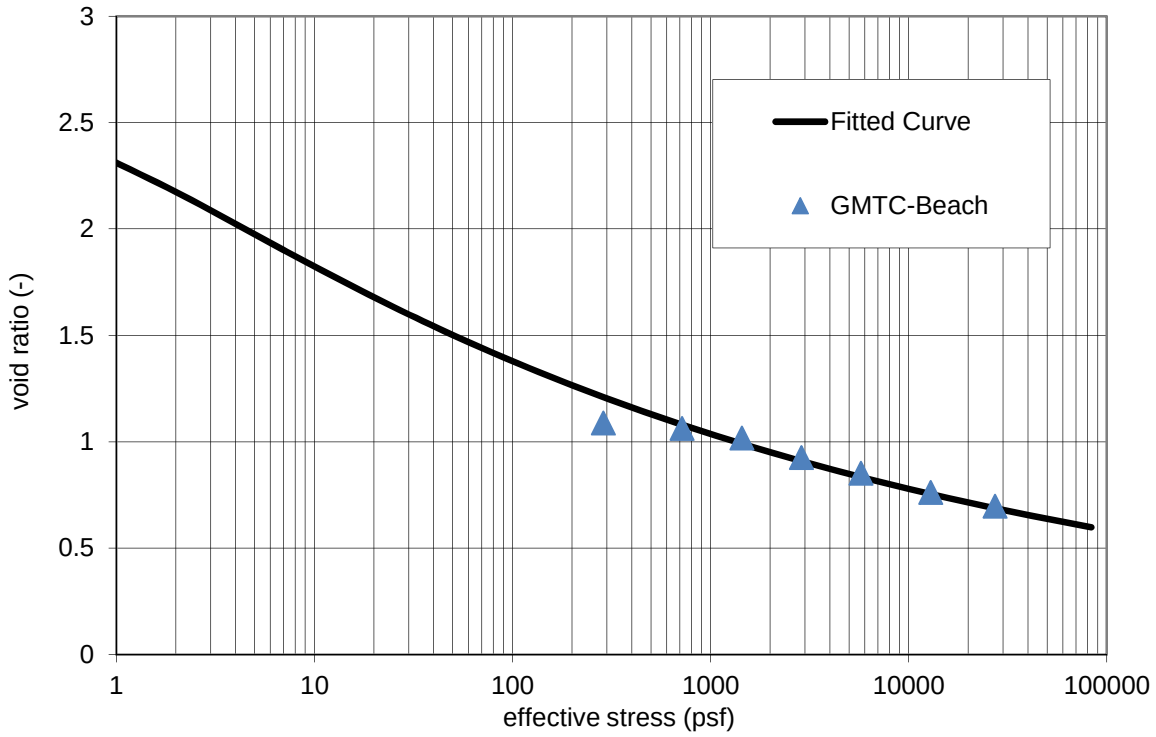


Figure 1-6.1

Flume Test - PSD for Beach and Slimes Samples

Grassy Mountain, OR

Tailings Laboratory Testing



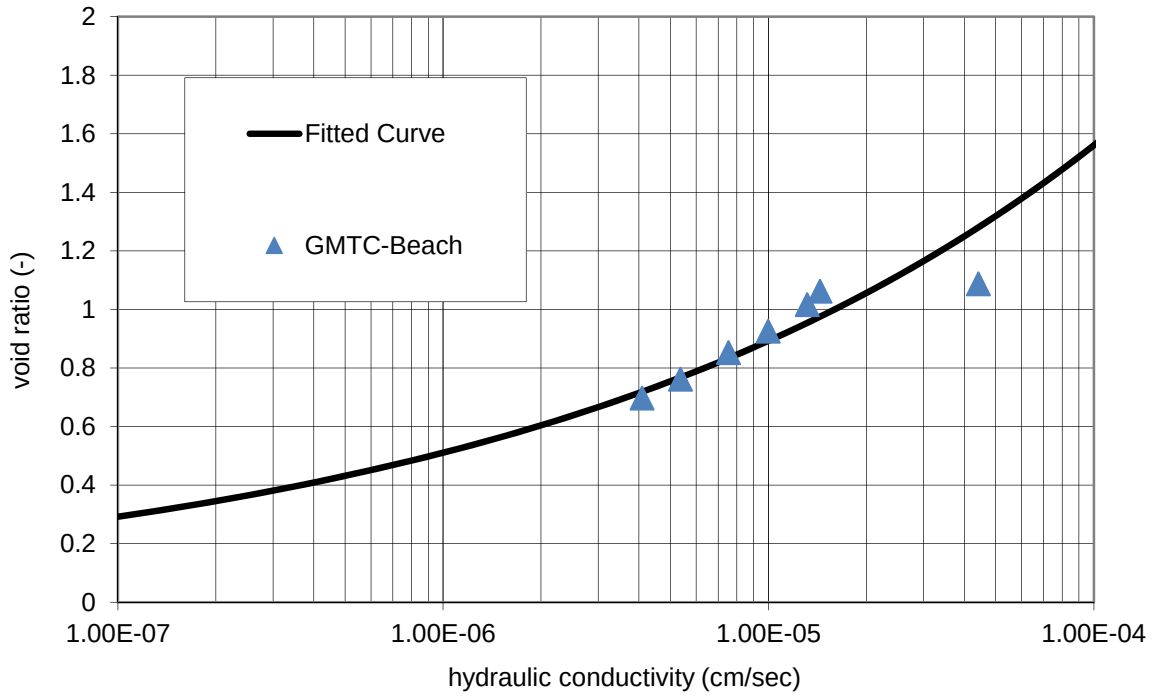
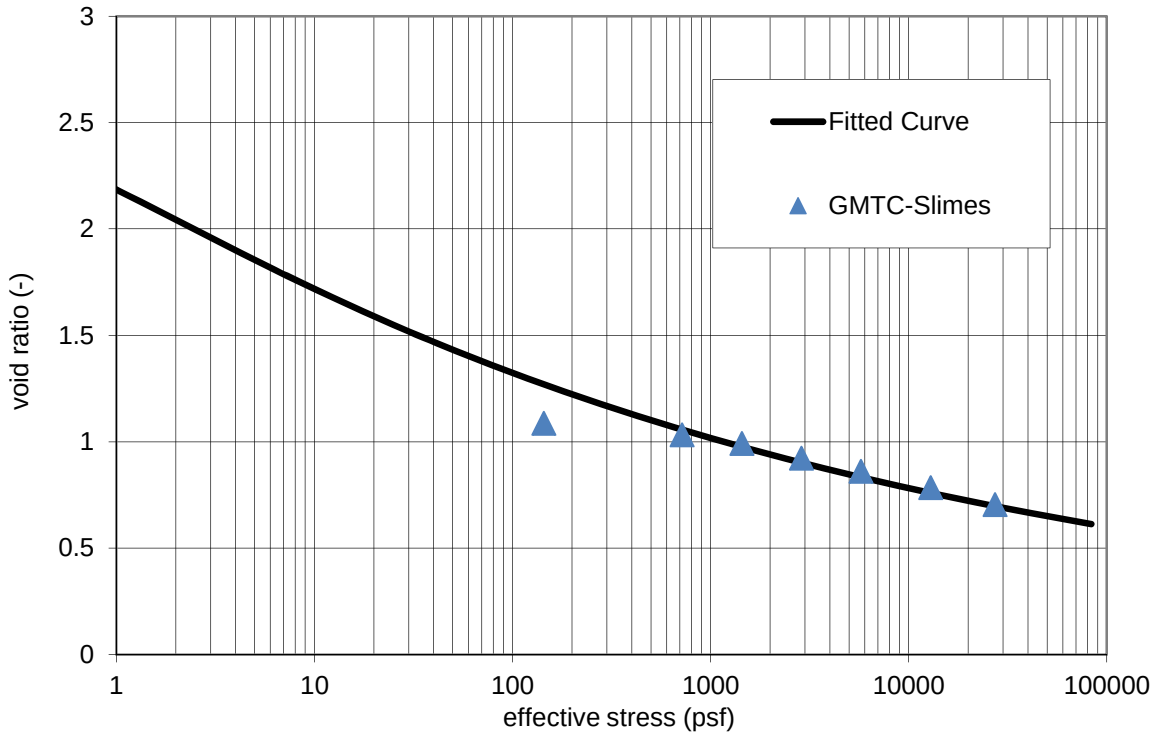


Figure 1-6.2.1

Consolidation Properties - GMTC Composite - Beach Sample

Grassy Mountain, OR

Tailings Laboratory Testing



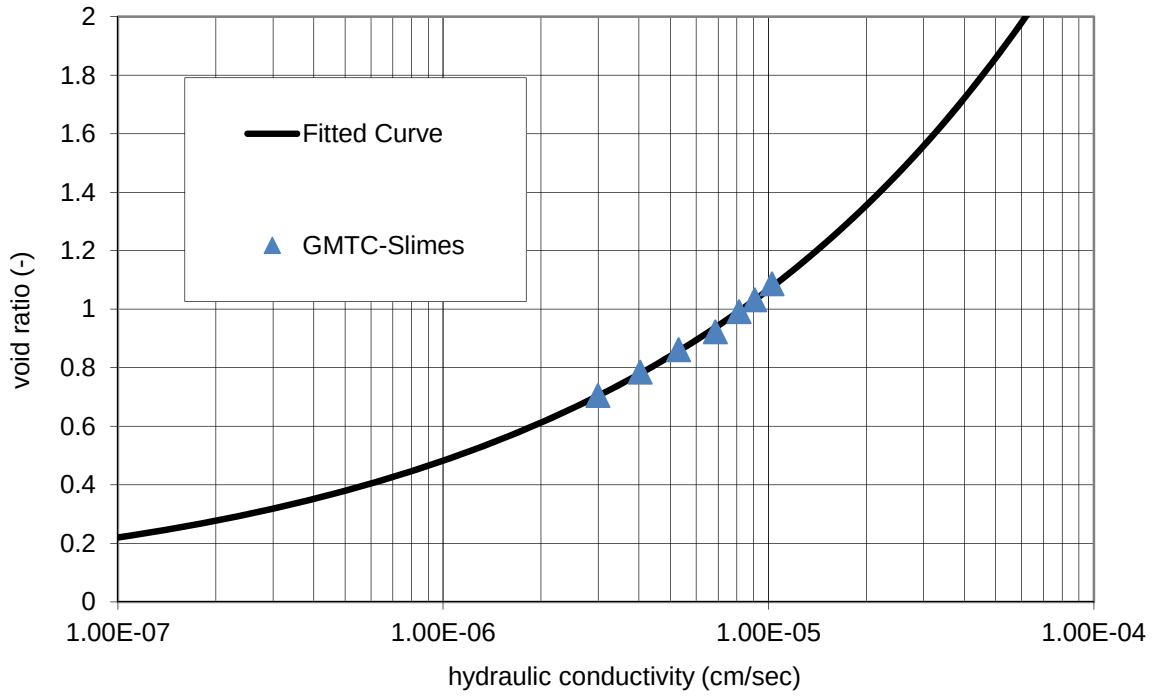
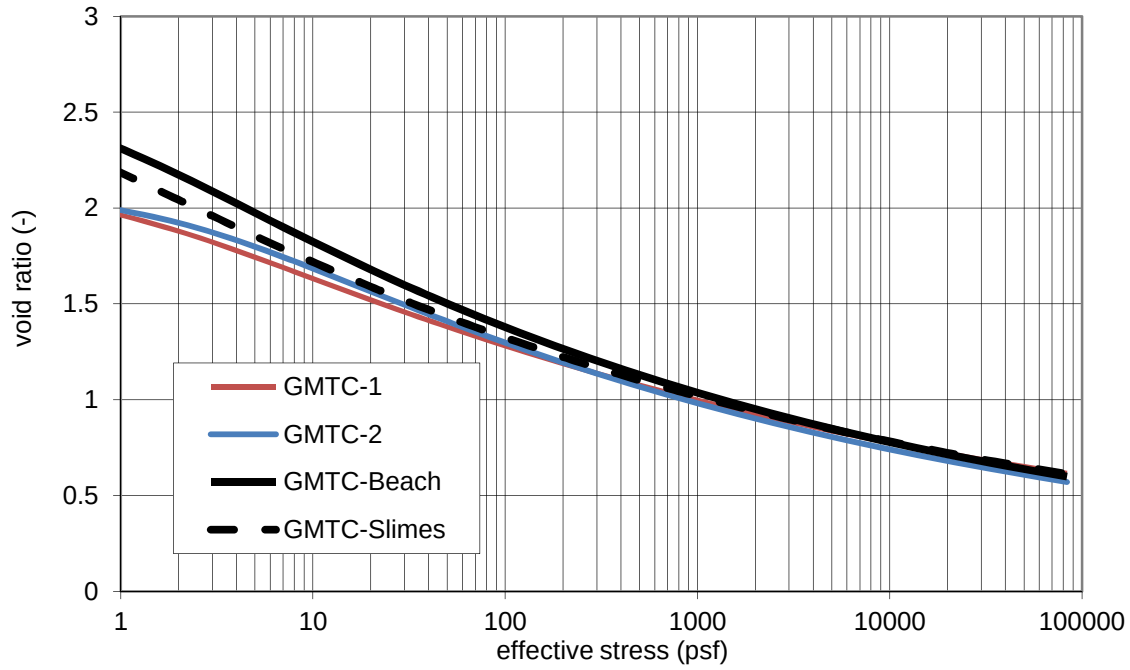


Figure 1-6.2.2

Consolidation Properties - GMTC Composite - Slimes Sample

Grassy Mountain, OR

Tailings Laboratory Testing



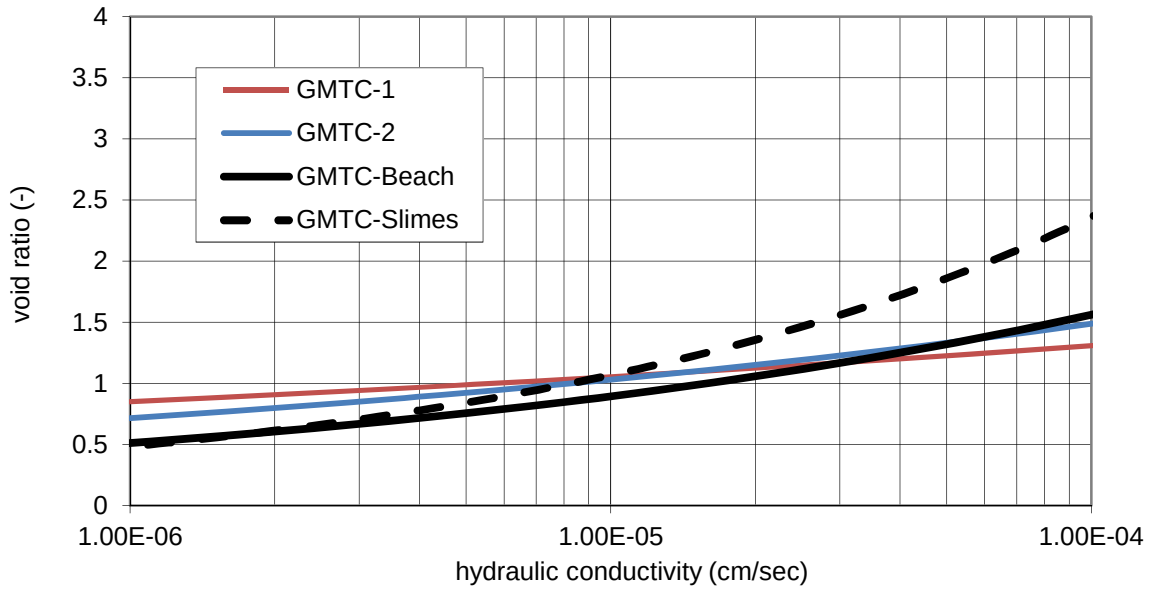


Figure 1-6.2.3

Consol. Properties - GMTC Composite vs. GMTC-1 / 2 Samples - Comparison

Grassy Mountain, OR

Tailings Laboratory Testing

ATTACHMENT 1.1

Classification Testing on As-Delivered Samples

TABLE 1
MDA/GRASSY MTN PFS/OR
SUMMARY OF SOIL DATA

Sample Type	Sample Identification	Sample Depth (ft.)	USCS Soil Classification	Delivered Moisture (%)	Atterberg Limits			Grain Size Distribution			Specific Gravity	Moisture/Density Relationship Standard Proctor		Additional Tests Comments (See Notes)
					LL	PL	PI	% Finer 3/4"	% Finer #4	% Finer #200		Dry Density (pcf)	Moisture (%)	
Bulk	GMTC-1	--	ML	128.9	NP	NP	NP	100	100	67	2.62	--	--	Slurry Consolidation, Column Settling
Bulk	GMTC-1 @ 46% Solids (Single Drain Top 1/3)	--	--	--	--	--	--	100	100	66	--	--	--	
Bulk	GMTC-1 @ 46% Solids (Single Drain Bottom 1/3)	--	--	--	--	--	--	100	100	66	--	--	--	
Bulk	GMTC-1 @ 46% Solids (Double Drain Top 1/3)	--	--	--	--	--	--	100	100	66	--	--	--	
Bulk	GMTC-1 @ 46% Solids (Double Drain Bottom 1/3)	--	--	--	--	--	--	100	100	66	--	--	--	
Bulk	GMTC-2	--	ML	148.1	NP	NP	NP	100	100	63	2.64	--	--	Slurry Consolidation, Column Settling
Bulk	GMTC-2 @ 46% Solids (Single Drain Top 1/3)	--	--	--	--	--	--	100	100	63	--	--	--	
Bulk	GMTC-2 @ 46% Solids (Single Drain Bottom 1/3)	--	--	--	--	--	--	100	100	63	--	--	--	
Bulk	GMTC-2 @ 46% Solids (Double Drain Top 1/3)	--	--	--	--	--	--	100	100	63	--	--	--	
Bulk	GMTC-2 @ 46% Solids (Double Drain Bottom 1/3)	--	--	--	--	--	--	100	100	63	--	--	--	

NOTES:

LL= LIQUID LIMIT
PL= PLASTIC LIMIT
PI= PLASTIC INDEX
SL= SHRINKAGE LIMIT
UW= UNIT WEIGHT
P or Red Indicates Pending test result(s)
* Over size corrected value per ASTM D4718

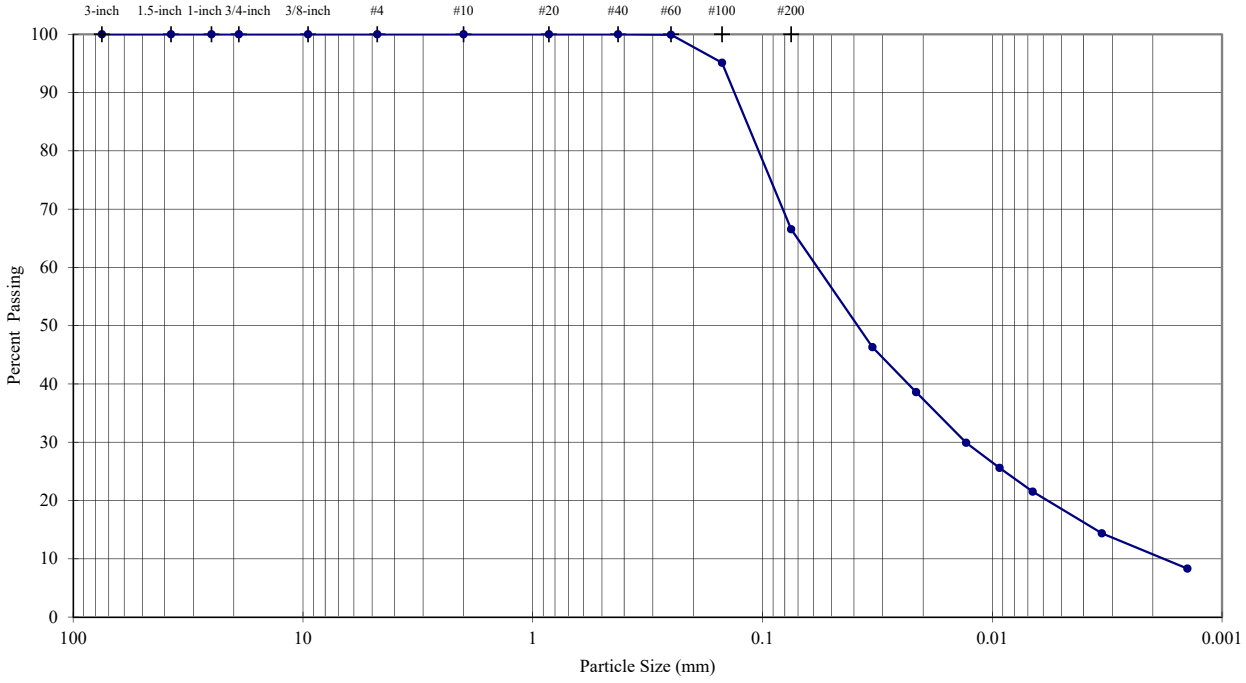
T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
PERM = PERMEABILITY

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

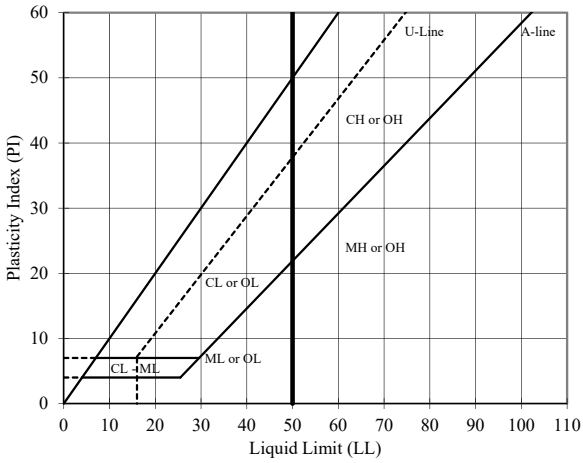
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1** DEPTH (ft): **--**
TYPE: **Bulk**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**99.9**		
#100	0.150	**95.1**	Fine Sand	**33.46**
#200	0.075	**66.5**		
Hydrometer Analysis	0.033	**46.3**		
	0.021	**38.6**		
	0.013	**29.9**		
	0.009	**25.6**	Silt or Clay Fines	**66.54**
	0.007	**21.5**		
	0.003	**14.4**		
	0.001	**8.3**		



USCS Description (ASTM D 2487):

Sandy silt, grayish brown, wet

LL	PL	PI	SpG
NP	**NP**	**NP**	**2.62**

As-Received Moisture Content (%): --

USCS Group Symbol: ML

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH/MGC
DATE	9-May-2019
REVIEW	MB

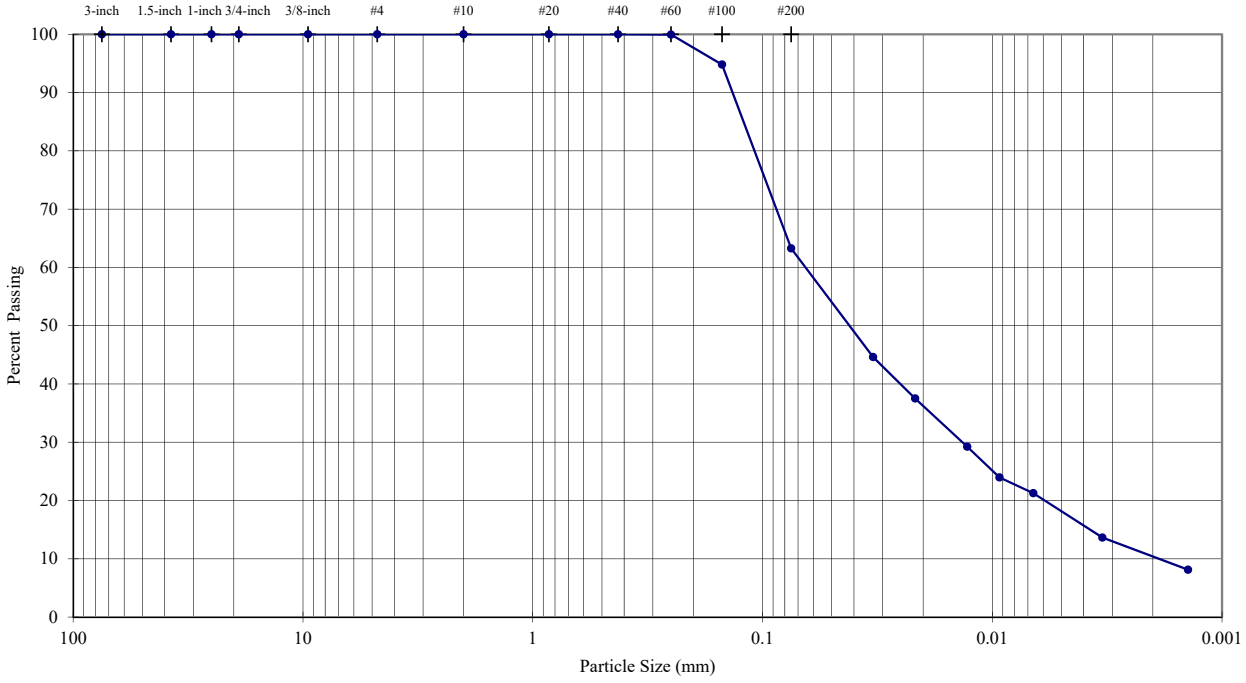
GOLDER

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

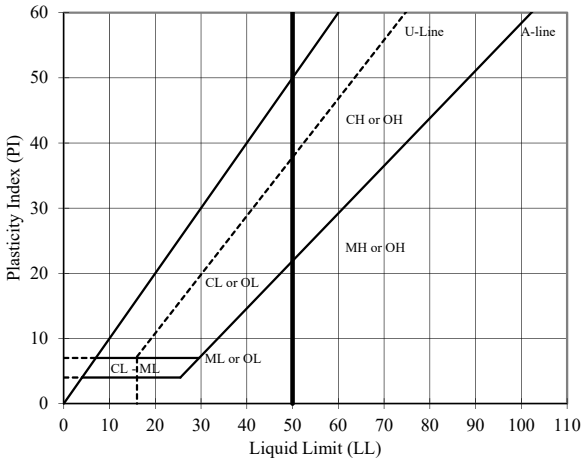
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-2** DEPTH (ft): **--**
TYPE: **Bulk**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**99.9**		
#100	0.150	**94.8**	Fine Sand	**36.74**
#200	0.075	**63.3**		
	0.033	**44.6**		
	0.022	**37.5**		
	0.013	**29.2**		
	0.009	**24.0**	Silt or Clay Fines	**63.26**
	0.007	**21.3**		
	0.003	**13.6**		
	0.001	**8.1**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



USCS Description (ASTM D 2487):

Sandy silt, grayish brown, wet

LL	PL	PI	SpG
NP	**NP**	**NP**	**2.64**

As-Received Moisture Content (%): **148.1**

USCS Group Symbol: ML

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	EH/MGC
DATE	9-May-2019
REVIEW	MB

ATTACHMENT 1.2

Settling Column Tests

Double Drain

GMTC-1 46%	
Initial Moisture Content (%) =	117.9%
Mass of Slurry + Cylinder (g) =	5970
Mass of Cylinder (g) =	5049
Total mass of Slurry (g) =	921.0
Mass of Water Initial (g) =	498.28
Total Mass of Solids (g) =	422.72
Slurry % Solids =	45.9%

Cylinder diameter (cm) =	6.336

INITIAL MOISTURE:	
Wet Weight (g) =	452.7
Dry Weight (g) =	355.37
Tare (g) =	272.8

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
1	5/9/2019 9:26	0.0	21.45	21.45	0.0	498.3	498.3	676.3	117.9%	0.63	39.0	85.0
2	5/9/2019 9:28	2.0	21.25	21.35	3.2	495.1	492.0	670.0	116.4%	0.63	39.4	85.2
3	5/9/2019 9:28	2.5	21.05	21.15	9.5	488.8	485.7	663.7	114.9%	0.64	39.7	85.4
4	5/9/2019 9:30	4.0	20.85	21.00	14.2	484.1	479.4	657.4	113.4%	0.64	40.1	85.6
5	5/9/2019 9:31	5.0	20.70	20.85	18.9	479.4	474.6	652.7	112.3%	0.65	40.4	85.8
6	5/9/2019 9:33	7.0	20.50	20.70	23.6	474.6	468.3	646.4	110.8%	0.65	40.8	86.0
7	5/9/2019 9:35	9.0	20.40	20.60	26.8	471.5	465.2	643.2	110.0%	0.66	41.0	86.1
8	5/9/2019 9:37	11.0	20.20	20.50	30.0	468.3	458.9	636.9	108.6%	0.66	41.4	86.4
9	5/9/2019 9:39	13.5	20.05	20.35	34.7	463.6	454.1	632.2	107.4%	0.67	41.7	86.6
10	5/9/2019 9:43	17.0	19.85	20.20	39.4	458.9	447.8	625.9	105.9%	0.68	42.1	86.8
11	5/9/2019 9:47	21.0	19.65	20.05	44.1	454.1	441.5	619.6	104.4%	0.68	42.6	87.0
12	5/9/2019 9:50	24.0	19.45	19.95	47.3	451.0	435.2	613.3	103.0%	0.69	43.0	87.3
13	5/9/2019 9:53	27.0	19.30	19.80	52.0	446.3	430.5	608.5	101.8%	0.69	43.3	87.5
14	5/9/2019 9:59	33.0	19.10	19.60	58.3	440.0	424.2	602.2	100.3%	0.70	43.8	87.8
15	5/9/2019 10:03	37.0	18.90	19.45	63.1	435.2	417.9	595.9	98.9%	0.71	44.3	88.0
16	5/9/2019 10:07	41.0	18.70	19.40	64.6	433.6	411.6	589.6	97.4%	0.72	44.7	88.3
17	5/9/2019 10:11	45.0	18.55	19.25	69.4	428.9	406.8	584.9	96.2%	0.72	45.1	88.5
18	5/9/2019 10:15	49.0	18.45	19.15	72.5	425.8	403.7	581.7	95.5%	0.73	45.3	88.6
19	5/9/2019 10:23	57.0	18.15	19.00	77.2	421.0	394.2	572.3	93.3%	0.74	46.1	89.1
20	5/9/2019 10:28	62.0	17.95	18.90	80.4	417.9	387.9	566.0	91.8%	0.75	46.6	89.4
21	5/9/2019 10:33	67.0	17.80	18.75	85.1	413.2	383.2	561.2	90.7%	0.75	47.0	89.6
22	5/9/2019 10:38	72.0	17.60	18.65	88.3	410.0	376.9	554.9	89.2%	0.76	47.5	89.9
23	5/9/2019 10:44	78.0	17.40	18.55	91.4	406.8	370.6	548.6	87.7%	0.77	48.1	90.2
24	5/9/2019 10:52	86.0	17.20	18.45	94.6	403.7	364.3	542.3	86.2%	0.78	48.6	90.6
25	5/9/2019 10:58	92.0	17.05	18.35	97.7	400.5	359.6	537.6	85.1%	0.79	49.1	90.8
26	5/9/2019 11:02	96.0	16.85	18.25	100.9	397.4	353.2	531.3	83.6%	0.80	49.6	91.1
27	5/9/2019 11:08	102.0	16.70	18.15	104.0	394.2	348.5	526.5	82.4%	0.80	50.1	91.4
28	5/9/2019 11:27	121.0	16.20	17.85	113.5	384.8	332.8	510.8	78.7%	0.83	51.6	92.3
29	5/9/2019 11:36	130.0	16.00	17.75	116.7	381.6	326.4	504.5	77.2%	0.84	52.3	92.7
30	5/9/2019 11:43	137.0	15.85	17.75	116.7	381.6	321.7	499.7	76.1%	0.85	52.8	93.0
31	5/9/2019 11:52	146.0	15.65	17.55	123.0	375.3	315.4	493.4	74.6%	0.86	53.5	93.3
32	5/9/2019 12:01	155.0	15.50	17.45	126.1	372.2	310.7	488.7	73.5%	0.86	54.0	93.6
33	5/9/2019 12:11	165.0	15.30	17.25	132.4	365.9	304.4	482.4	72.0%	0.88	54.7	94.1
34	5/9/2019 12:22	176.0	15.05	17.25	132.4	365.9	296.5	474.5	70.1%	0.89	55.6	94.6
35	5/9/2019 12:32	186.0	14.80	17.05	138.7	359.6	288.6	466.6	68.3%	0.91	56.5	95.1
36	5/9/2019 12:47	201.0	14.60	16.95	141.9	356.4	282.3	460.3	66.8%	0.92	57.3	95.6

Double Drain

GMTC-1 46%	
Initial Moisture Content (%) =	117.9%
Mass of Slurry + Cylinder (g) =	5970
Mass of Cylinder (g) =	5049
Total mass of Slurry (g) =	921.0
Mass of Water Initial (g) =	498.28
Total Mass of Solids (g) =	422.72
Slurry % Solids =	45.9%

Cylinder diameter (cm) =	6.336

INITIAL MOISTURE:	
Wet Weight (g) =	452.7
Dry Weight (g) =	355.37
Tare (g) =	272.8

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
37	5/9/2019 13:00	214.0	14.45	16.80	146.6	351.7	277.6	455.6	65.7%	0.93	57.9	95.9
38	5/9/2019 13:17	231.0	14.35	16.65	151.3	346.9	274.4	452.5	64.9%	0.93	58.3	96.1

Double Drain

GMTC-1 46%	
Initial Moisture Content (%) =	117.9%
Mass of Slurry + Cylinder (g) =	5970
Mass of Cylinder (g) =	5049
Total mass of Slurry (g) =	921.0
Mass of Water Initial (g) =	498.28
Total Mass of Solids (g) =	422.72
Slurry % Solids =	45.9%

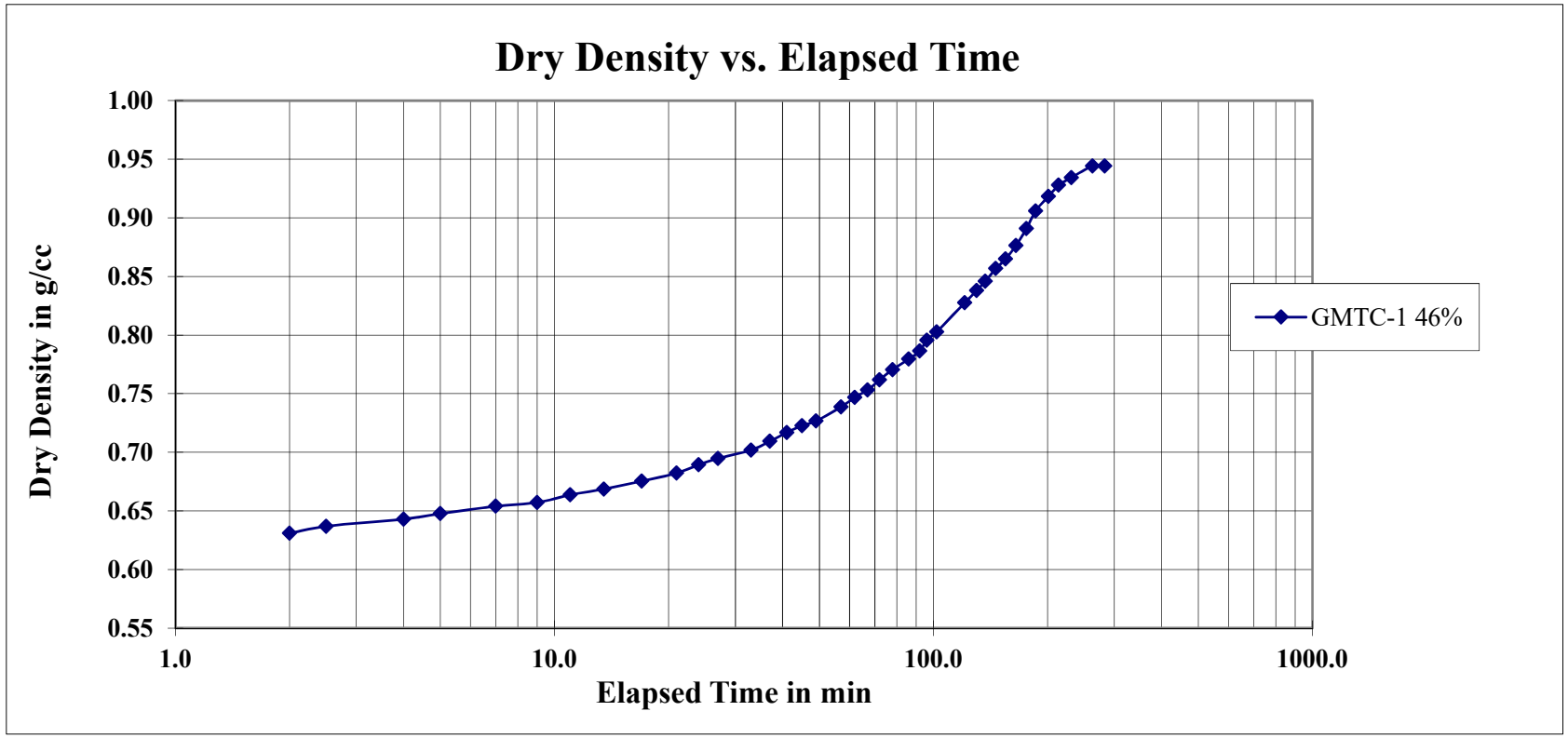
Cylinder diameter (cm) =	6.336

INITIAL MOISTURE:	
Wet Weight (g) =	452.7
Dry Weight (g) =	355.37
Tare (g) =	272.8

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
39	5/9/2019 13:49	263.0	14.20	16.35	160.8	337.5	269.7	447.7	63.8%	0.94	58.9	96.5
40	5/9/2019 14:09	283.0	14.20	16.15	167.1	331.2	269.7	447.7	63.8%	0.94	58.9	96.5

Note: The expected error is +/- 2.5% based on the calcutations of the volume of soil.

Golder Associates, Inc. Denver, Colorado			**Title:** **SEDIMENTATION TESTING SAMPLE DATA AND CALCULATIONS**		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-1 46%	**System:** Double Drain	**Reviewed:** MB	**Date:** 09-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 1



Golder Associates, Inc. Denver, Colorado			Title: SEDIMENTATION TESTING GRAPHICAL DATA		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-1 46%	**System:** Double Drain	**Reviewed:** MB	**Date:** 09-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 2

GOLDER

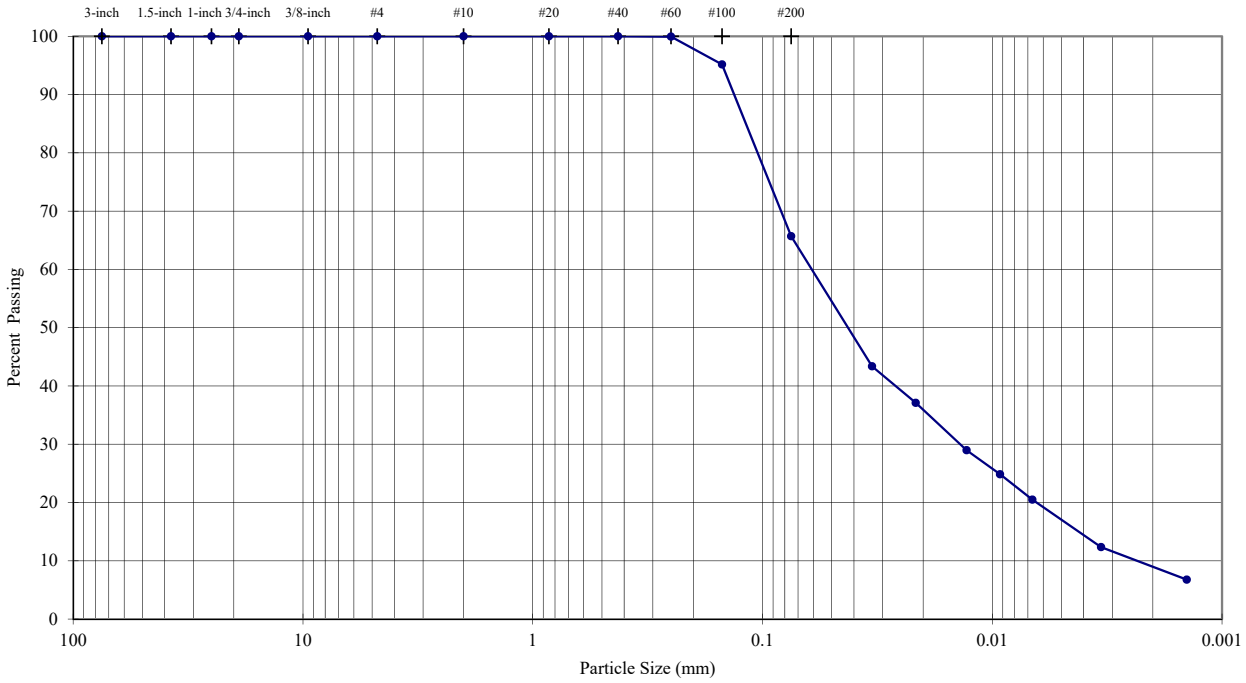
GOLDER

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

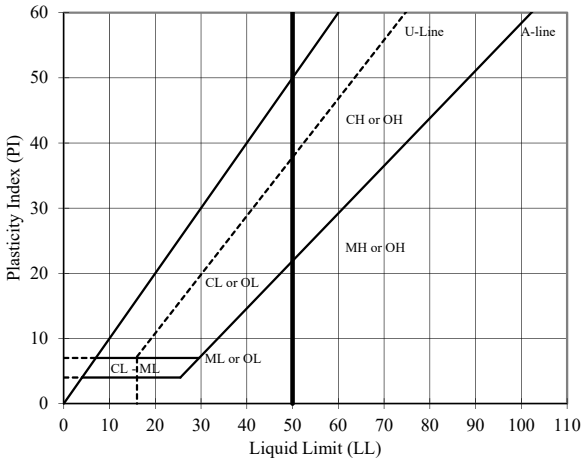
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Double Drain Column Settling Top 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**99.9**		
#100	0.150	**95.2**	Fine Sand	**34.31**
#200	0.075	**65.7**		
	0.033	**43.4**		
	0.022	**37.1**		
	0.013	**29.0**		
	0.009	**24.8**	Silt or Clay Fines	**65.69**
	0.007	**20.5**		
	0.003	**12.3**		
	0.001	**6.8**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



USCS Description (ASTM D 2487):

SILT, white, dry

LL	PL	PI	SpG
--	--	--	**2.62**

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

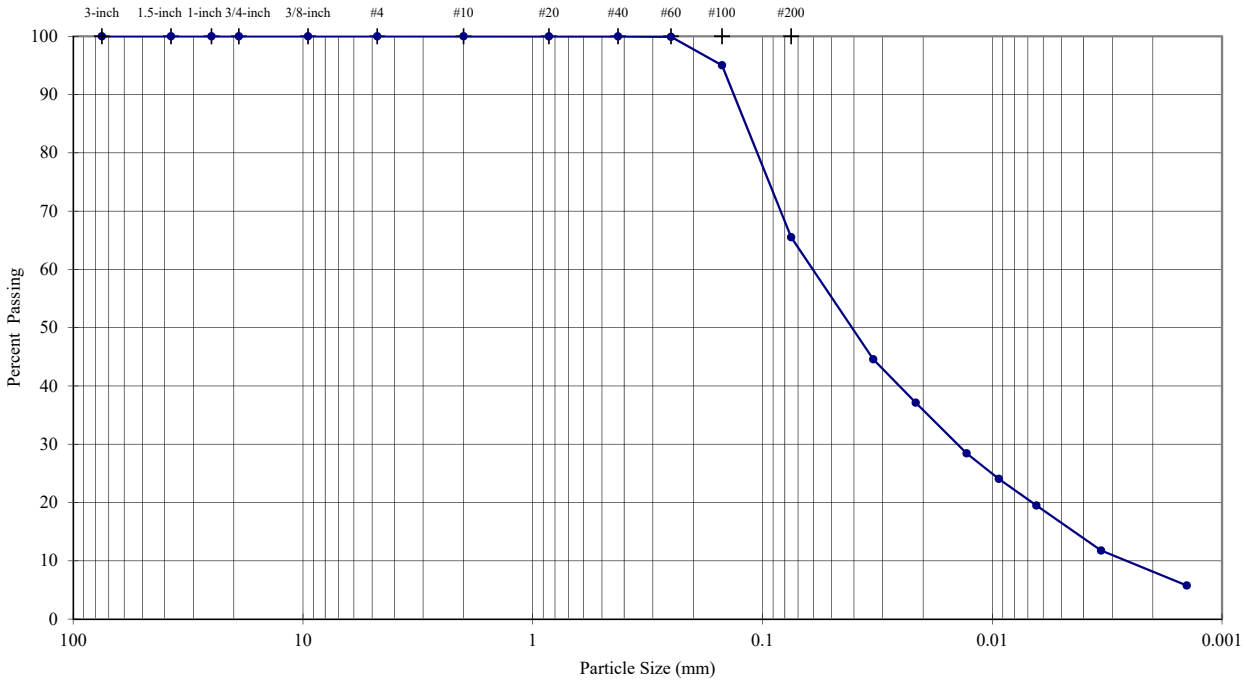
TECH	KWG/MGC
DATE	14-May-2019
REVIEW	MB

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

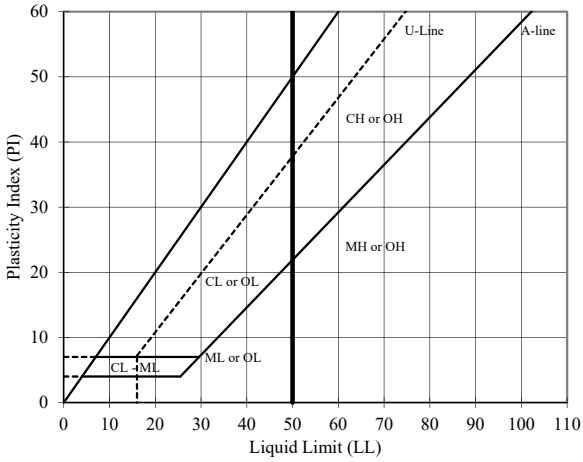
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Double Drain Column Settling Bottom 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.02**
#40	0.425	**100.0**		
#60	0.250	**99.9**		
#100	0.150	**95.0**	Fine Sand	**34.47**
#200	0.075	**65.5**		
	0.033	**44.6**		
	0.022	**37.1**		
	0.013	**28.4**		
	0.009	**24.1**	Silt or Clay Fines	**65.51**
	0.006	**19.5**		
	0.003	**11.8**		
	0.001	**5.8**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



USCS Description (ASTM D 2487):

SILT, white, dry

LL	PL	PI	SpG
--	--	--	**2.62**

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

TECH	KWG/MGC
DATE	14-May-2019
REVIEW	MB

Single Drain

GMTC-1 46%	
Initial Moisture Content (%) =	117.7%
Mass of Slurry + Cylinder (g) =	6100
Mass of Cylinder (g) =	5042
Total mass of Slurry (g) =	1058.0
Mass of Water Initial (g) =	571.94
Total Mass of Solids (g) =	486.06
Slurry % Solids =	45.9%

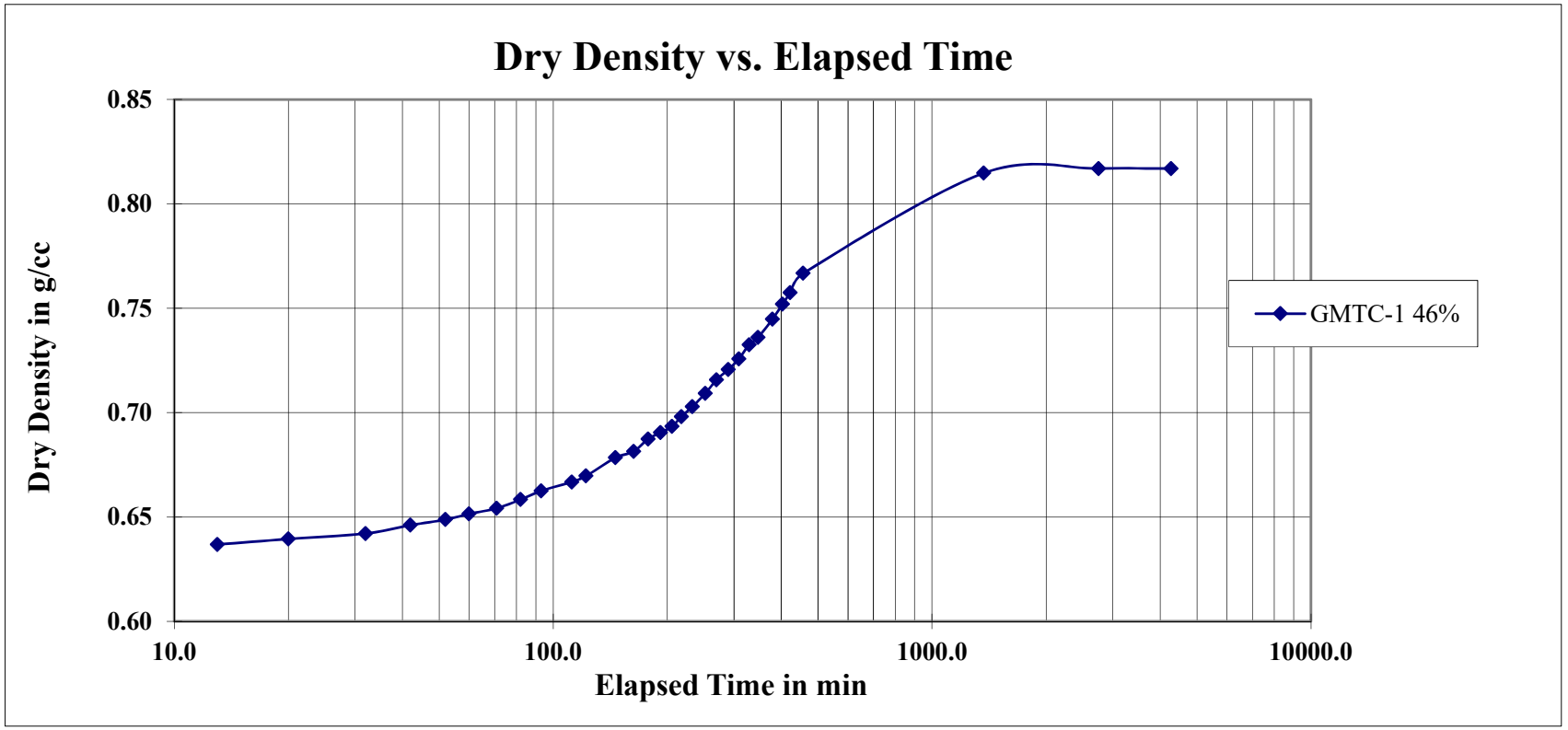
Cylinder diameter (cm) =	6.298

INITIAL MOISTURE:	
Wet Weight (g) =	452.81
Dry Weight (g) =	349.91
Tare (g) =	262.46

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
1	5/9/2019 9:00	0.0	24.60	24.60	0.0	571.9	571.9	766.4	117.7%	0.63	39.6	86.1
2	5/9/2019 9:13	13.0	24.50	24.60	0.0	571.9	568.8	763.2	117.0%	0.64	39.7	86.2
3	5/9/2019 9:20	20.0	24.40	24.60	0.0	571.9	565.7	760.1	116.4%	0.64	39.9	86.3
4	5/9/2019 9:32	32.0	24.30	24.60	0.0	571.9	562.6	757.0	115.7%	0.64	40.1	86.4
5	5/9/2019 9:42	42.0	24.15	24.60	0.0	571.9	557.9	752.3	114.8%	0.65	40.3	86.6
6	5/9/2019 9:52	52.0	24.05	24.60	0.0	571.9	554.8	749.2	114.1%	0.65	40.5	86.7
7	5/9/2019 10:00	60.0	23.95	24.60	0.0	571.9	551.7	746.1	113.5%	0.65	40.7	86.8
8	5/9/2019 10:11	71.0	23.85	24.60	0.0	571.9	548.6	743.0	112.9%	0.65	40.8	86.9
9	5/9/2019 10:22	82.0	23.70	24.60	0.0	571.9	543.9	738.3	111.9%	0.66	41.1	87.0
10	5/9/2019 10:33	93.0	23.55	24.60	0.0	571.9	539.2	733.6	110.9%	0.66	41.3	87.2
11	5/9/2019 10:52	112.0	23.40	24.60	0.0	571.9	534.6	729.0	110.0%	0.67	41.6	87.4
12	5/9/2019 11:02	122.0	23.30	24.60	0.0	571.9	531.4	725.9	109.3%	0.67	41.8	87.5
13	5/9/2019 11:26	146.0	23.00	24.60	0.0	571.9	522.1	716.5	107.4%	0.68	42.3	87.8
14	5/9/2019 11:43	163.0	22.90	24.60	0.0	571.9	519.0	713.4	106.8%	0.68	42.5	87.9
15	5/9/2019 11:58	178.0	22.70	24.60	0.0	571.9	512.7	707.2	105.5%	0.69	42.9	88.1
16	5/9/2019 12:12	192.0	22.60	24.60	0.0	571.9	509.6	704.1	104.8%	0.69	43.1	88.2
17	5/9/2019 12:26	206.0	22.50	24.60	0.0	571.9	506.5	700.9	104.2%	0.69	43.3	88.4
18	5/9/2019 12:38	218.0	22.35	24.60	0.0	571.9	501.8	696.3	103.2%	0.70	43.6	88.5
19	5/9/2019 12:53	233.0	22.20	24.60	0.0	571.9	497.2	691.6	102.3%	0.70	43.9	88.7
20	5/9/2019 13:12	252.0	22.00	24.60	0.0	571.9	490.9	685.4	101.0%	0.71	44.3	89.0
21	5/9/2019 13:30	270.0	21.80	24.60	0.0	571.9	484.7	679.1	99.7%	0.72	44.7	89.2
22	5/9/2019 13:50	290.0	21.65	24.60	0.0	571.9	480.0	674.5	98.8%	0.72	45.0	89.4
23	5/9/2019 14:09	309.0	21.50	24.60	0.0	571.9	475.4	669.8	97.8%	0.73	45.3	89.6
24	5/9/2019 14:29	329.0	21.30	24.60	0.0	571.9	469.1	663.6	96.5%	0.73	45.7	89.8
25	5/9/2019 14:47	347.0	21.20	24.60	0.0	571.9	466.0	660.4	95.9%	0.74	45.9	90.0
26	5/9/2019 15:19	379.0	20.95	24.60	0.0	571.9	458.2	652.6	94.3%	0.74	46.5	90.3
27	5/9/2019 15:43	403.0	20.75	24.60	0.0	571.9	452.0	646.4	93.0%	0.75	46.9	90.6
28	5/9/2019 16:02	422.0	20.60	24.60	0.0	571.9	447.3	641.7	92.0%	0.76	47.3	90.8
29	5/9/2019 16:37	457.0	20.35	24.60	0.0	571.9	439.5	634.0	90.4%	0.77	47.8	91.1
30	5/10/2019 7:49	1369.0	19.15	24.60	0.0	571.9	402.2	596.6	82.7%	0.81	50.8	92.9
31	5/11/2019 6:52	2752.0	19.10	24.60	0.0	571.9	400.6	595.0	82.4%	0.82	51.0	93.0
32	5/12/2019 8:10	4270.0	19.10	24.60	0.0	571.9	400.6	595.0	82.4%	0.82	51.0	93.0

Note: The expected error is +/- 1.5% based on the calcutations of the volume of soil.

Golder Associates, Inc. **Denver, Colorado**			**Title:** **SEDIMENTATION TESTING** **SAMPLE DATA AND CALCULATIONS**		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-1 46%	**System:** Single Drain	**Reviewed:** MB	**Date:** 09-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 1



Golder Associates, Inc. Denver, Colorado			Title: SEDIMENTATION TESTING GRAPHICAL DATA		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-1 46%	**System:** Single Drain	**Reviewed:** MB	**Date:** 09-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 2

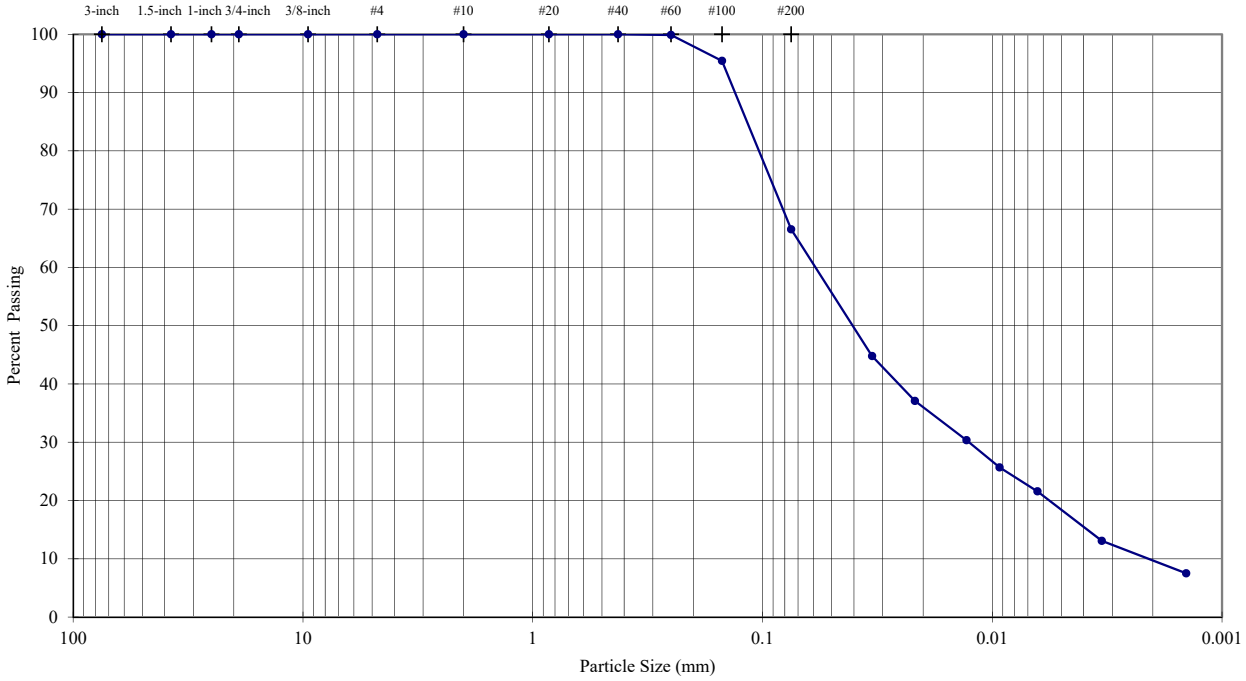
GOLDER

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

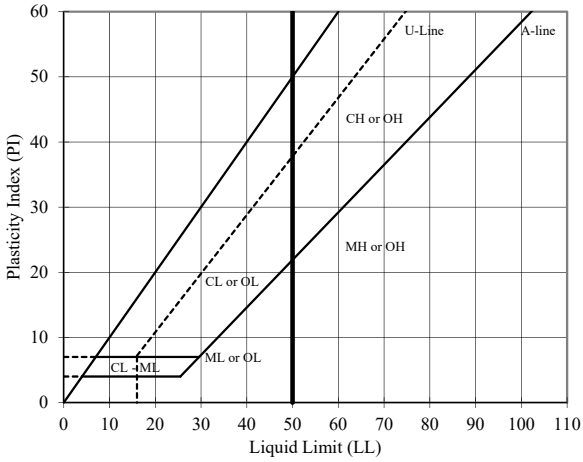
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Single Drain Column Settling Top 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**99.9**	Fine Sand	**33.47**
#100	0.150	**95.4**		
#200	0.075	**66.5**		
	0.033	**44.8**	Silt or Clay Fines	**66.53**
	0.022	**37.1**		
	0.013	**30.3**		
	0.009	**25.7**		
	0.006	**21.6**		
	0.003	**13.1**		
	0.001	**7.5**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



USCS Description (ASTM D 2487):

SILT, light gray, dry

LL	PL	PI	SpG
--	--	--	**2.62**

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

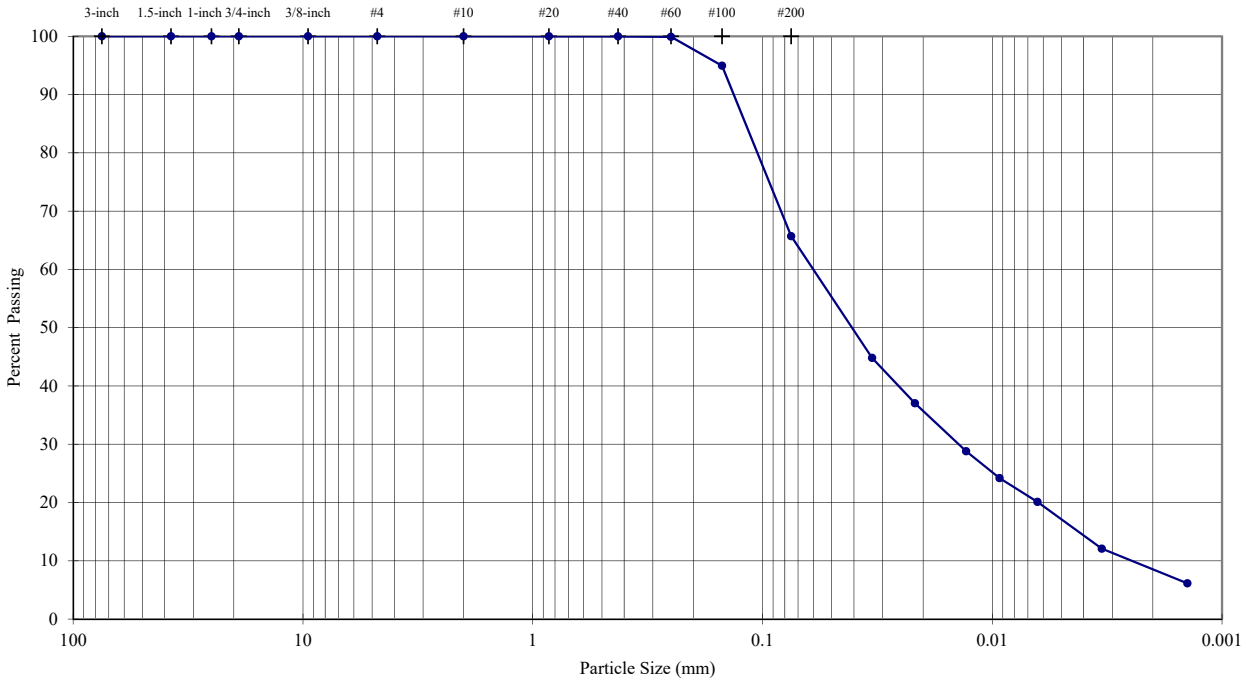
TECH	KWG/MGC
DATE	18-May-2019
REVIEW	MB

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

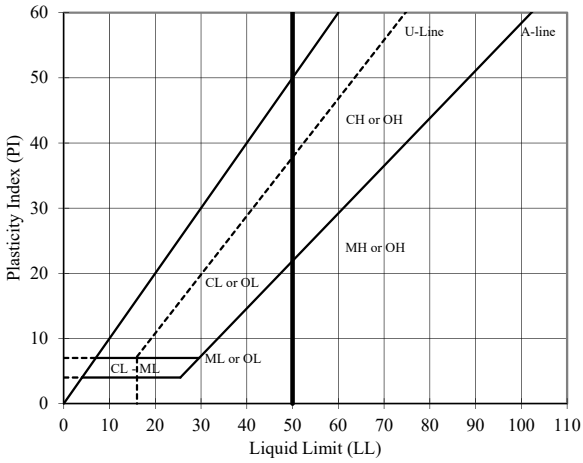
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Single Drain Column Settling Bottom 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.02**
#40	0.425	**100.0**		
#60	0.250	**99.9**	Fine Sand	**34.28**
#100	0.150	**94.9**		
#200	0.075	**65.7**		
Hydrometer Analysis	0.033	**44.8**	Silt or Clay Fines	**65.70**
	0.022	**37.0**		
	0.013	**28.8**		
	0.009	**24.2**		
	0.006	**20.1**		
	0.003	**12.1**		
	0.001	**6.1**		

Sieve Analysis (Initial Separation on No. 4 Sieve)



USCS Description (ASTM D 2487):

SILT, light gray, dry

LL	PL	PI	SpG
--	--	--	**2.62**

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

TECH	KWG/MGC
DATE	18-May-2019
REVIEW	MB

Double Drain

GMTC-2 @ 46% Solids

Initial Moisture Content (%) =	118.3%
Mass of Slurry + Cylinder (g) =	5834
Mass of Cylinder (g) =	4564
Total mass of Slurry (g) =	1270.0
Mass of Water Initial (g) =	688.27
Total Mass of Solids (g) =	581.73
Slurry % Solids =	45.8%

Cylinder diameter (cm) =	6.327

INITIAL MOISTURE:	
Wet Weight (g) =	606.22
Dry Weight (g) =	417.44
Tare (g) =	257.88

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
1	5/17/2019 8:09	0.0	29.35	29.35	0.0	688.3	688.3	922.8	118.3%	0.63	39.3	85.9
2	5/17/2019 8:11	2.5	29.10	29.20	4.7	683.6	680.4	914.9	117.0%	0.64	39.7	86.1
3	5/17/2019 8:12	3.5	28.90	29.10	7.9	680.4	674.1	908.6	115.9%	0.64	40.0	86.2
4	5/17/2019 8:13	4.5	28.70	28.95	12.6	675.7	667.8	902.3	114.8%	0.64	40.2	86.4
5	5/17/2019 8:14	5.5	28.55	28.85	15.7	672.5	663.1	897.6	114.0%	0.65	40.4	86.5
6	5/17/2019 8:16	7.0	28.40	28.70	20.4	667.8	658.4	892.9	113.2%	0.65	40.7	86.7
7	5/17/2019 8:18	9.0	28.25	28.65	22.0	666.3	653.7	888.2	112.4%	0.65	40.9	86.8
8	5/17/2019 8:20	11.0	28.05	28.50	26.7	661.5	647.4	881.9	111.3%	0.66	41.2	87.0
9	5/17/2019 8:22	13.0	27.90	28.40	29.9	658.4	642.7	877.2	110.5%	0.66	41.4	87.1
10	5/17/2019 8:24	15.0	27.75	28.30	33.0	655.3	638.0	872.5	109.7%	0.67	41.6	87.2
11	5/17/2019 8:26	17.0	27.60	28.20	36.2	652.1	633.2	867.8	108.9%	0.67	41.8	87.4
12	5/17/2019 8:29	20.0	27.40	28.10	39.3	649.0	627.0	861.5	107.8%	0.68	42.1	87.6
13	5/17/2019 8:32	23.0	27.20	28.00	42.4	645.8	620.7	855.2	106.7%	0.68	42.4	87.7
14	5/17/2019 8:36	27.0	27.00	27.85	47.2	641.1	614.4	848.9	105.6%	0.69	42.8	87.9
15	5/17/2019 8:39	30.0	26.80	27.75	50.3	638.0	608.1	842.6	104.5%	0.69	43.1	88.1
16	5/17/2019 8:43	34.0	26.60	27.60	55.0	633.2	601.8	836.3	103.5%	0.70	43.4	88.3
17	5/17/2019 8:47	38.0	26.40	27.60	55.0	633.2	595.5	830.0	102.4%	0.70	43.7	88.5
18	5/17/2019 8:52	43.0	26.15	27.45	59.7	628.5	587.7	822.2	101.0%	0.71	44.2	88.8
19	5/17/2019 8:56	47.0	25.95	27.30	64.5	623.8	581.4	815.9	99.9%	0.71	44.5	89.0
20	5/17/2019 9:01	52.0	25.65	27.20	67.6	620.7	571.9	806.4	98.3%	0.72	45.0	89.3
21	5/17/2019 9:07	58.0	25.35	27.20	67.6	620.7	562.5	797.0	96.7%	0.73	45.5	89.6
22	5/17/2019 9:12	63.0	25.05	26.90	77.0	611.2	553.1	787.6	95.1%	0.74	46.1	89.9
23	5/17/2019 9:18	69.0	24.80	26.90	77.0	611.2	545.2	779.7	93.7%	0.75	46.6	90.2
24	5/17/2019 9:24	75.0	24.50	26.75	81.7	606.5	535.8	770.3	92.1%	0.76	47.1	90.5
25	5/17/2019 9:30	81.0	24.25	26.75	81.7	606.5	527.9	762.4	90.7%	0.76	47.6	90.8
26	5/17/2019 9:36	87.0	24.00	26.55	88.0	600.2	520.1	754.6	89.4%	0.77	48.1	91.1
27	5/17/2019 9:46	97.0	23.60	26.40	92.7	595.5	507.5	742.0	87.2%	0.78	48.9	91.6
28	5/17/2019 9:55	106.0	23.25	26.40	92.7	595.5	496.5	731.0	85.3%	0.80	49.7	92.0
29	5/17/2019 10:03	114.0	23.00	26.20	99.0	589.2	488.6	723.1	84.0%	0.80	50.2	92.4
30	5/17/2019 10:08	119.0	22.85	26.20	99.0	589.2	483.9	718.4	83.2%	0.81	50.5	92.6
31	5/17/2019 10:16	127.0	22.55	25.90	108.5	579.8	474.5	709.0	81.6%	0.82	51.2	93.0
32	5/17/2019 10:24	135.0	22.30	25.90	108.5	579.8	466.6	701.1	80.2%	0.83	51.8	93.3
33	5/17/2019 10:31	142.0	22.10	25.85	110.0	578.2	460.3	694.8	79.1%	0.84	52.2	93.6
34	5/17/2019 10:39	150.0	21.90	25.70	114.8	573.5	454.0	688.5	78.0%	0.84	52.7	93.9
35	5/17/2019 10:54	165.0	21.50	25.55	119.5	568.8	441.5	676.0	75.9%	0.86	53.7	94.5
36	5/17/2019 11:01	172.0	21.35	25.55	119.5	568.8	436.7	671.2	75.1%	0.87	54.1	94.7

Double Drain

GMTC-2 @ 46% Solids	
Initial Moisture Content (%) =	118.3%
Mass of Slurry + Cylinder (g) =	5834
Mass of Cylinder (g) =	4564
Total mass of Slurry (g) =	1270.0
Mass of Water Initial (g) =	688.27
Total Mass of Solids (g) =	581.73
Slurry % Solids =	45.8%

Cylinder diameter (cm) =	6.327

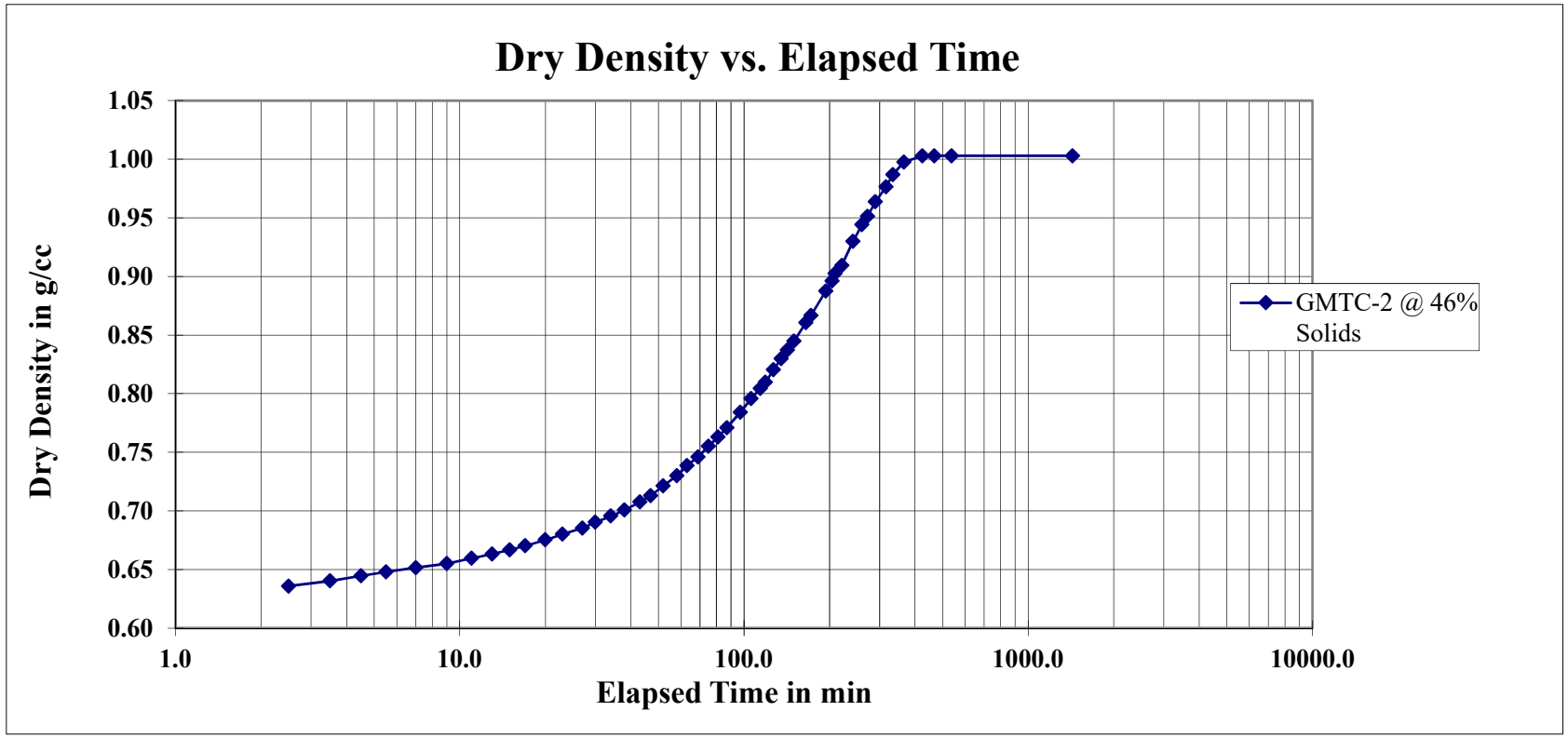
INITIAL MOISTURE:	
Wet Weight (g) =	606.22
Dry Weight (g) =	417.44
Tare (g) =	257.88

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
37	5/17/2019 11:23	194.0	20.85	25.20	130.5	557.8	421.0	655.5	72.4%	0.89	55.4	95.5
38	5/17/2019 11:33	204.0	20.65	25.10	133.6	554.6	414.7	649.2	71.3%	0.90	55.9	95.8
39	5/17/2019 11:38	209.0	20.50	25.10	133.6	554.6	410.0	644.5	70.5%	0.90	56.3	96.0
40	5/17/2019 11:50	221.0	20.35	25.10	133.6	554.6	405.3	639.8	69.7%	0.91	56.7	96.3
41	5/17/2019 12:11	242.0	19.90	24.90	139.9	548.4	391.2	625.7	67.2%	0.93	58.0	97.0
42	5/17/2019 12:29	260.0	19.60	24.75	144.6	543.6	381.7	616.2	65.6%	0.94	58.9	97.6
43	5/17/2019 12:41	272.0	19.45	24.75	144.6	543.6	377.0	611.5	64.8%	0.95	59.4	97.8
44	5/17/2019 12:59	290.0	19.20	24.60	149.3	538.9	369.1	603.7	63.5%	0.96	60.1	98.3
45	5/17/2019 13:25	316.0	18.95	24.40	155.6	532.6	361.3	595.8	62.1%	0.98	60.9	98.8
46	5/17/2019 13:43	334.0	18.75	24.40	155.6	532.6	355.0	589.5	61.0%	0.99	61.6	99.2
47	5/17/2019 14:14	365.0	18.55	24.15	163.5	524.8	348.7	583.2	59.9%	1.00	62.2	99.6
48	5/17/2019 15:13	424.0	18.45	23.90	171.3	516.9	345.6	580.1	59.4%	1.00	62.6	99.8
49	5/17/2019 15:56	467.0	18.45	23.65	179.2	509.1	345.6	580.1	59.4%	1.00	62.6	99.8
50	5/17/2019 17:07	538.0	18.45	23.30	190.2	498.1	345.6	580.1	59.4%	1.00	62.6	99.8
51	5/18/2019 8:00	1431.0	18.45	19.55	308.1	380.2	345.6	580.1	59.4%	1.00	62.6	99.8

Note: The expected error is +/- 1.5% based on the calcutations of the volume of soil.

Golder Associates, Inc. **Denver, Colorado**			**Title:** **SEDIMENTATION TESTING** **SAMPLE DATA AND CALCULATIONS**		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-2 @ 46% Solids	**System:** Double Drain	**Reviewed:** MB	**Date:** 17-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 1

GOLDER



Golder Associates, Inc. **Denver, Colorado**			**Title:** **SEDIMENTATION TESTING GRAPHICAL DATA**		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-2 @ 46% Solids	**System:** Double Drain	**Reviewed:** MB	**Date:** 17-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 2

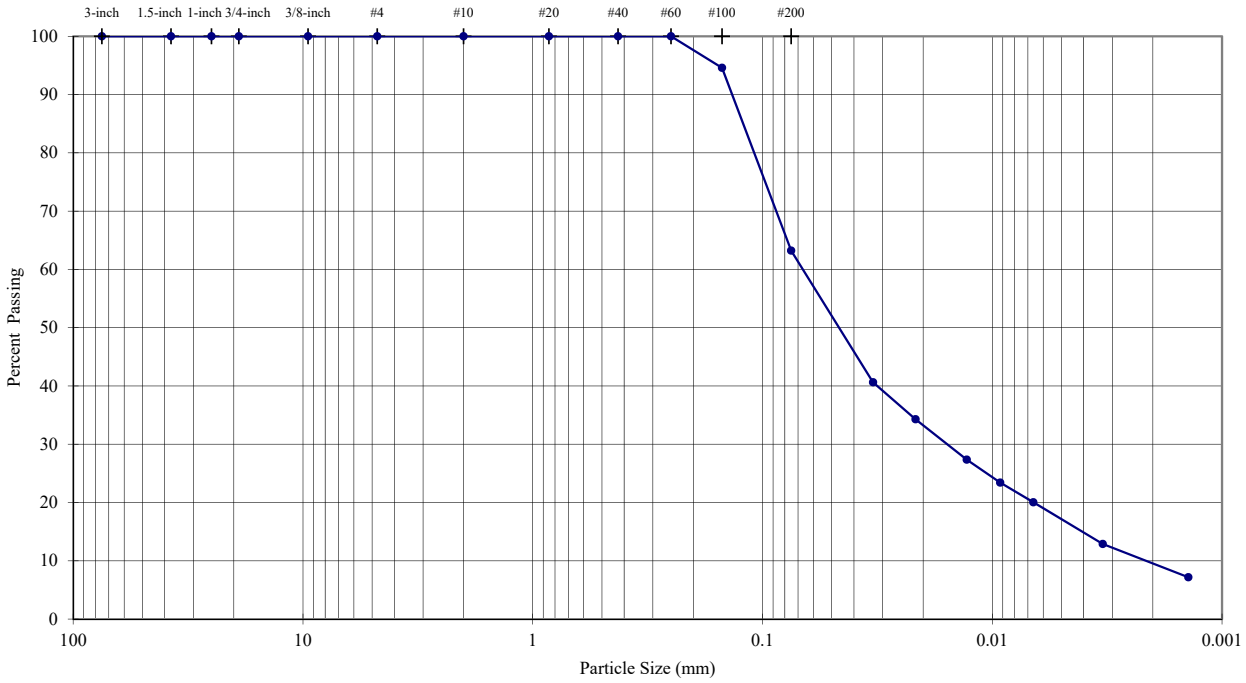
GOLDER

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

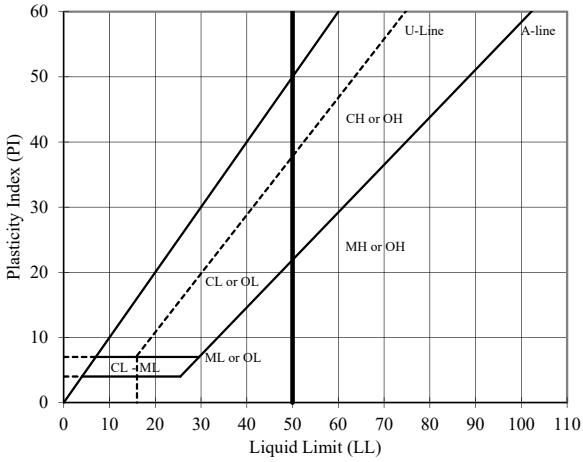
PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-2 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Double Drain Column Settling Top 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**100.0**		
#100	0.150	**94.6**	Fine Sand	**36.78**
#200	0.075	**63.2**		
	0.033	**40.6**		
	0.022	**34.3**		
	0.013	**27.4**		
	0.009	**23.4**	Silt or Clay Fines	**63.22**
	0.007	**20.0**		
	0.003	**12.9**		
	0.001	**7.2**		

Sieve Analysis (Initial Separation on No. 4 Sieve)

Hydrometer Analysis



Visual Description (Golder Procedure):

Sandy silt, white, dry

LL	PL	PI	SpG
--	--	--	--

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

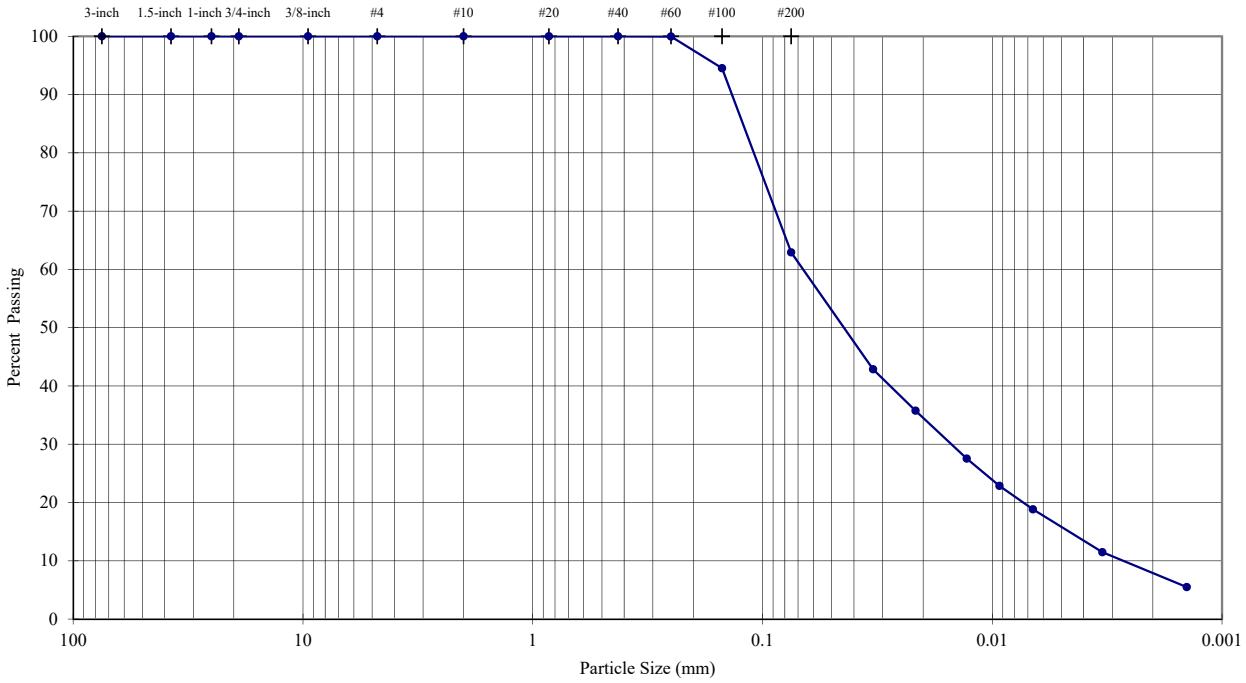
TECH	MGC
DATE	23-May-2019
REVIEW	MB

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-2 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Double Drain Column Settling Bottom 1/3**



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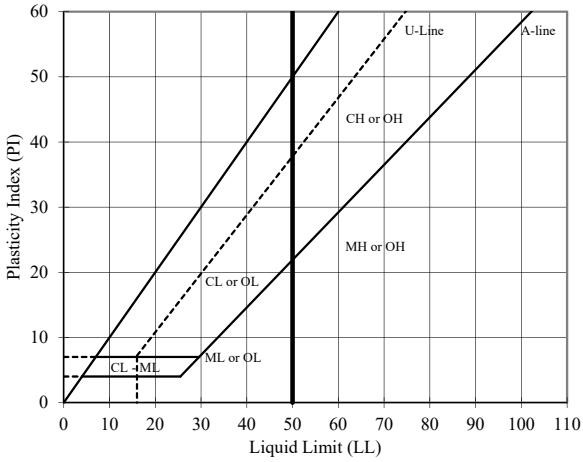
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**100.0**		
#100	0.150	**94.5**	Fine Sand	**37.08**
#200	0.075	**62.9**		
	0.033	**42.9**		
	0.022	**35.7**		
	0.013	**27.5**		
	0.009	**22.9**	Silt or Clay Fines	**62.92**
	0.007	**18.8**		
	0.003	**11.5**		
	0.001	**5.5**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



Visual Description (Golder Procedure):

Sandy silt, white, dry

LL	PL	PI	SpG
--	--	--	--

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

TECH	MGC
DATE	23-May-2019
REVIEW	MB

Single Drain

GMTC-2 @ 46% Solids	
Initial Moisture Content (%) =	117.0%
Mass of Slurry + Cylinder (g) =	5775
Mass of Cylinder (g) =	4547
Total mass of Slurry (g) =	1228.0
Mass of Water Initial (g) =	662.18
Total Mass of Solids (g) =	565.82
Slurry % Solids =	46.1%

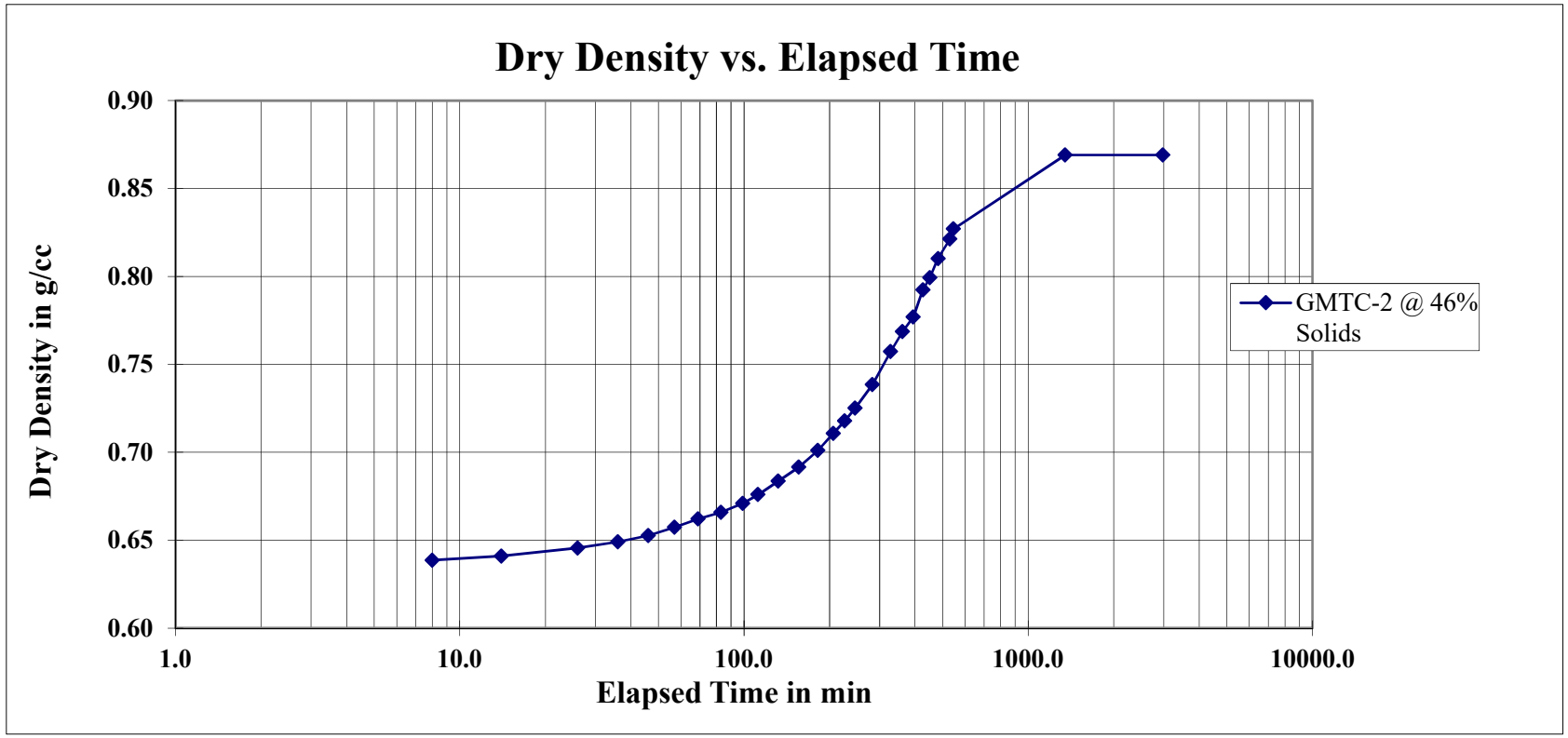
Cylinder diameter (cm) =	6.336

INITIAL MOISTURE:	
Wet Weight (g) =	447.01
Dry Weight (g) =	344.54
Tare (g) =	256.98

Reading Number	Reading Date and Time (mm/dd/yyyy hh:mm)	Elapsed Time (min)	Height of Soil (cm)	Height of Water (cm)	Vol of Water Drained (ml)	Undrained Water (ml)	Pore Water (ml)	Volume of Soil (cm^3)	Moisture Content %	Dry Density of Slurry g/cc	Dry Density of Slurry lbs/ft^3	Wet Density of Slurry lbs/ft^3
1	5/14/2019 8:16	0.0	28.25	28.25	0.0	662.2	662.2	890.7	117.0%	0.64	39.6	86.0
2	5/14/2019 8:24	8.0	28.10	28.25	0.0	662.2	657.4	886.0	116.2%	0.64	39.9	86.2
3	5/14/2019 8:30	14.0	28.00	28.25	0.0	662.2	654.3	882.8	115.6%	0.64	40.0	86.2
4	5/14/2019 8:42	26.0	27.80	28.25	0.0	662.2	648.0	876.5	114.5%	0.65	40.3	86.4
5	5/14/2019 8:52	36.0	27.65	28.25	0.0	662.2	643.3	871.8	113.7%	0.65	40.5	86.5
6	5/14/2019 9:02	46.0	27.50	28.25	0.0	662.2	638.5	867.1	112.8%	0.65	40.7	86.7
7	5/14/2019 9:13	57.0	27.30	28.25	0.0	662.2	632.2	860.8	111.7%	0.66	41.0	86.9
8	5/14/2019 9:25	69.0	27.10	28.25	0.0	662.2	625.9	854.5	110.6%	0.66	41.3	87.0
9	5/14/2019 9:39	83.0	26.95	28.25	0.0	662.2	621.2	849.7	109.8%	0.67	41.6	87.2
10	5/14/2019 9:55	99.0	26.75	28.25	0.0	662.2	614.9	843.4	108.7%	0.67	41.9	87.4
11	5/14/2019 10:08	112.0	26.55	28.25	0.0	662.2	608.6	837.1	107.6%	0.68	42.2	87.5
12	5/14/2019 10:28	132.0	26.25	28.25	0.0	662.2	599.1	827.7	105.9%	0.68	42.7	87.8
13	5/14/2019 10:52	156.0	25.95	28.25	0.0	662.2	589.7	818.2	104.2%	0.69	43.2	88.1
14	5/14/2019 11:18	182.0	25.60	28.25	0.0	662.2	578.6	807.2	102.3%	0.70	43.7	88.5
15	5/14/2019 11:42	206.0	25.25	28.25	0.0	662.2	567.6	796.1	100.3%	0.71	44.3	88.8
16	5/14/2019 12:02	226.0	25.00	28.25	0.0	662.2	559.7	788.2	98.9%	0.72	44.8	89.1
17	5/14/2019 12:22	246.0	24.75	28.25	0.0	662.2	551.8	780.4	97.5%	0.73	45.2	89.4
18	5/14/2019 12:59	283.0	24.30	28.25	0.0	662.2	537.6	766.2	95.0%	0.74	46.1	89.9
19	5/14/2019 13:44	328.0	23.70	28.25	0.0	662.2	518.7	747.3	91.7%	0.76	47.2	90.6
20	5/14/2019 14:17	361.0	23.35	28.25	0.0	662.2	507.7	736.2	89.7%	0.77	48.0	91.0
21	5/14/2019 14:50	394.0	23.10	28.25	0.0	662.2	499.8	728.3	88.3%	0.78	48.5	91.3
22	5/14/2019 15:22	426.0	22.65	28.25	0.0	662.2	485.6	714.1	85.8%	0.79	49.4	91.9
23	5/14/2019 15:47	451.0	22.45	28.25	0.0	662.2	479.3	707.8	84.7%	0.80	49.9	92.1
24	5/14/2019 16:18	482.0	22.15	28.25	0.0	662.2	469.8	698.4	83.0%	0.81	50.6	92.5
25	5/14/2019 17:06	530.0	21.85	28.25	0.0	662.2	460.4	688.9	81.4%	0.82	51.3	92.9
26	5/14/2019 17:22	546.0	21.70	28.25	0.0	662.2	455.7	684.2	80.5%	0.83	51.6	93.2
27	5/15/2019 6:45	1349.0	20.65	28.25	0.0	662.2	422.5	651.1	74.7%	0.87	54.2	94.7
28	5/16/2019 9:51	2975.0	20.65	28.25	0.0	662.2	422.5	651.1	74.7%	0.87	54.2	94.7

Note: The expected error is +/- 3% based on the calcutations of the volume of soil.

Golder Associates, Inc. **Denver, Colorado**			**Title:** **SEDIMENTATION TESTING** **SAMPLE DATA AND CALCULATIONS**		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification: GMTC-2 @ 46% Solids	**System:** Single Drain	**Reviewed:** MB	**Date:** 14-May-19	**Job Number:** 1663241.9000.9005	**Figure:** 1



Golder Associates, Inc. Denver, Colorado			Title: SEDIMENTATION TESTING GRAPHICAL DATA		
Job Short Title: MDA/GRASSY MTN PFS/OR					
Sample Identification:	**System:**	**Reviewed:**	**Date:**	**Job Number:**	**Figure:**
GMTC-2 @ 46% Solids	Single Drain	MB	14-May-19	1663241.9000.9005	2

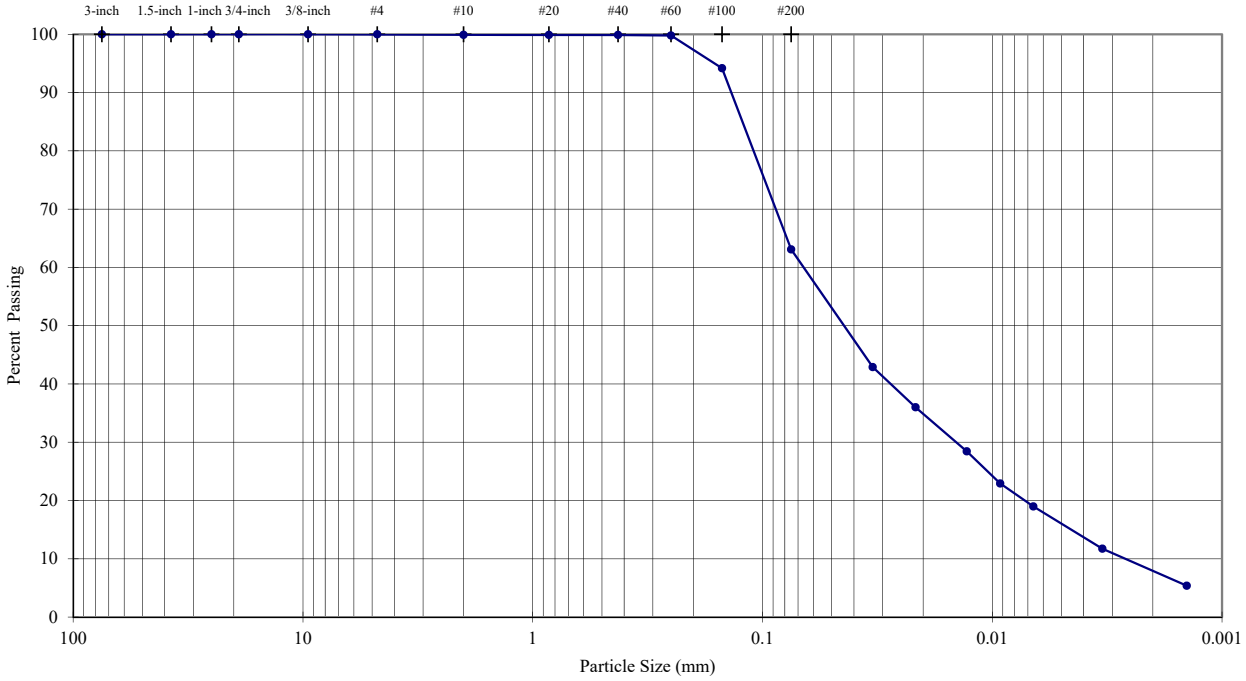
GOLDER

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

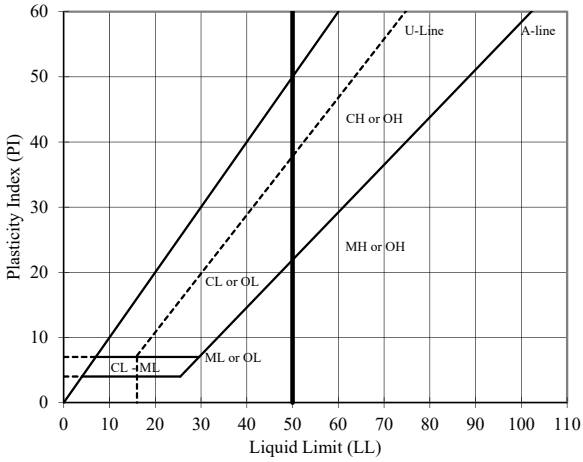
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-2 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Single Drain Column Settling Top 1/3**



Sieve Analysis (Initial Separation on No. 4 Sieve)

Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**99.9**	Coarse Sand	**0.10**
#20	0.850	**99.9**	Medium Sand	**0.02**
#40	0.425	**99.9**		
#60	0.250	**99.8**		
#100	0.150	**94.2**	Fine Sand	**36.80**
#200	0.075	**63.1**		
Hydrometer Analysis	0.033	**42.9**		
	0.022	**36.0**		
	0.013	**28.4**		
	0.009	**22.9**	Silt or Clay Fines	**63.09**
	0.007	**19.0**		
	0.003	**11.7**		
	0.001	**5.4**		



Visual Description (Golder Procedure):

Sandy silt, white, dry

LL	PL	PI	SpG
--	--	--	--

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

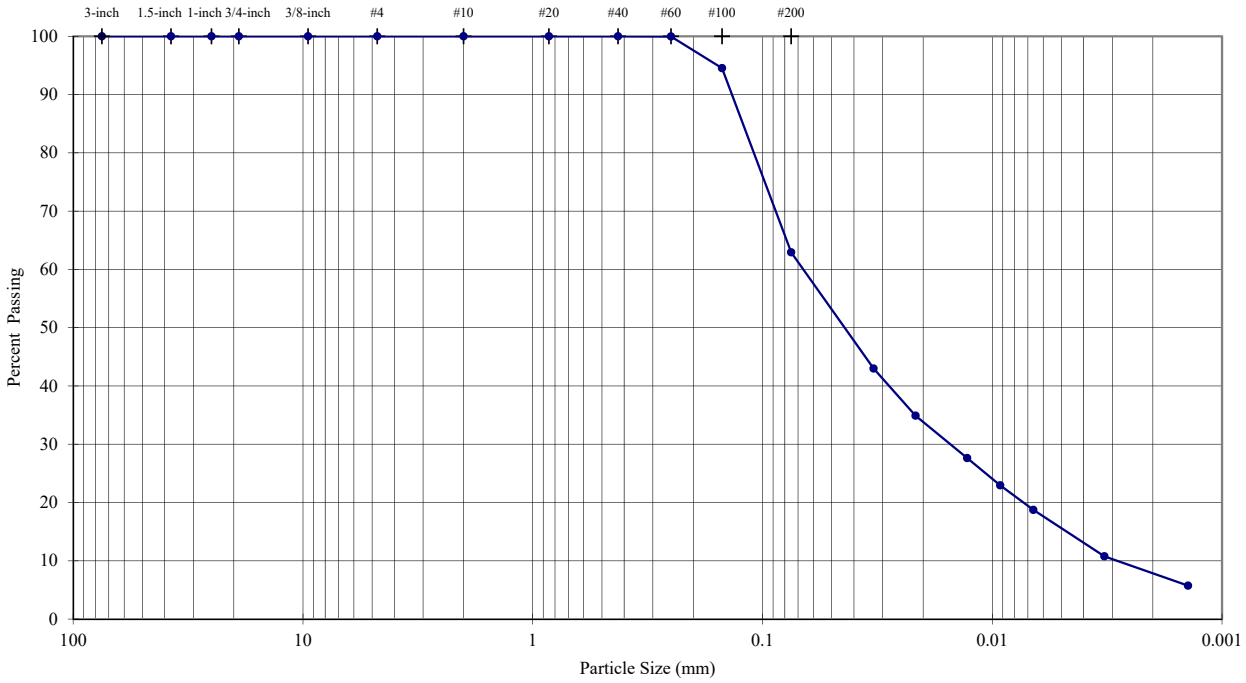
TECH	MGC
DATE	23-May-2019
REVIEW	MB

May-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

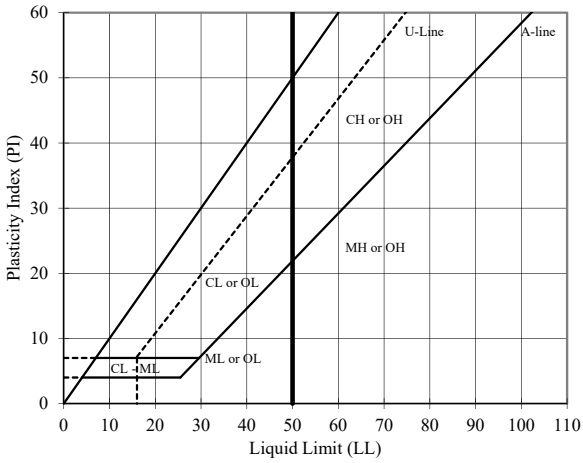
ASTM D421, D422, D4318

PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-2 @ 46% Solids** DEPTH (ft): **--**
TYPE: **Post Single Drain Column Settling Bottom 1/3**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**100.0**		
#100	0.150	**94.5**	Fine Sand	**37.06**
#200	0.075	**62.9**		
	0.033	**43.0**		
	0.022	**34.9**		
	0.013	**27.6**		
	0.009	**23.0**	Silt or Clay Fines	**62.94**
	0.007	**18.7**		
	0.003	**10.8**		
	0.001	**5.7**		

Sieve Analysis (Initial Separation on No. 4 Sieve)
Hydrometer Analysis



Visual Description (Golder Procedure):

Sandy silt, white, dry

LL	PL	PI	SpG
--	--	--	--

As-Received Moisture Content (%): --

USCS Group Symbol: --

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute

TECH	MGC
DATE	23-May-2019
REVIEW	MB

ATTACHMENT 1.3

Consolidation Tests

	Initial	Final	
Length =	4.069	2.194	cm
Diameter =	7.100	7.100	cm
Wet Mass =	263.44	166.44	g
Area =	39.59	39.59	cm^2
Volume =	161.10	86.86	cm^3
Moisture Content =	103.0%	28.5%	
Specific Gravity =	2.62	2.62	(ASTM D854)
Dry Mass of Solids =	129.77	129.53	g
Density =	1.64	1.92	g/cm^3
Dry Density =	0.81	1.49	g/cm^3
Unit Weight =	102.1	119.6	lb/ft^3
Dry Unit Weight =	50.3	93.1	lb/ft^3
Solids Content =	49.3%	77.8%	

Sample initially prepared at approximately 46% solids and allowed to settle. Some supernatant water was then decanted and the sample was mixed and poured into the slurry consolidation device and allowed to settle overnight. Prior to beginning the test, the sample was again decanted.

Piston Pressure:	6.0 psi	421.8 g/cm^2	Piston Pressure:	10.0 psi	703.1 g/cm^2	Piston Pressure:	15.0 psi	1,054.6 g/cm^2	Piston Pressure:	25.0 psi	1,757.7 g/cm^2	Piston Pressure:	50.0 psi	3,515.4 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	10.0 psi	703.1 g/cm^2
Consolidation pressure:	**1.0 psi**	70.3 g/cm^2	Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2	Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2	Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2	Consolidation Pressure:	**40.0 psi**	2,812.3 g/cm^2
Before Consolidation			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**		
Initial Sample Height:	4.069	cm	Initial Sample Height:	2.634	cm	Initial Sample Height:	2.543	cm	Initial Sample Height:	2.475	cm	Initial Sample Height:	2.410	cm
Initial Dry Unit Weight:	0.81	g/cm^3	Initial Dry Unit Weight:	1.24	g/cm^3	Initial Dry Unit Weight:	1.29	g/cm^3	Initial Dry Unit Weight:	1.32	g/cm^3	Initial Dry Unit Weight:	1.36	g/cm^3
Initial Void Ratio:	2.25		Initial Void Ratio:	1.11		Initial Void Ratio:	1.04		Initial Void Ratio:	0.98		Initial Void Ratio:	0.93	
After Consolidation			**After Consolidation**			**After Consolidation**			**After Consolidation**			**After Consolidation**		
Final Sample Height:	2.634	cm	Final Sample Height:	2.543	cm	Final Sample Height:	2.475	cm	Final Sample Height:	2.410	cm	Final Sample Height:	2.316	cm
Final Dry Unit Weight:	1.24	g/cm^3	Final Dry Unit Weight:	1.29	g/cm^3	Final Dry Unit Weight:	1.32	g/cm^3	Final Dry Unit Weight:	1.36	g/cm^3	Final Dry Unit Weight:	1.41	g/cm^3
Final Void Ratio:	1.11		Final Void Ratio:	1.04		Final Void Ratio:	0.98		Final Void Ratio:	0.93		Final Void Ratio:	0.85	
Calculations			**Calculations**			**Calculations**			**Calculations**			**Calculations**		
Coefficient of Compressibility, a_v	1.63E-02	cm^2/g	Coefficient of Compressibility, a_v	2.59E-04	cm^2/g	Coefficient of Compressibility, a_v	1.55E-04	cm^2/g	Coefficient of Compressibility, a_v	7.40E-05	cm^2/g	Coefficient of Compressibility, a_v	5.35E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	5.00E-03	cm^2/g	Coefficient of Volume Compressibility, m_v	1.23E-04	cm^2/g	Coefficient of Volume Compressibility, m_v	7.61E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	3.74E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	2.77E-05	cm^2/g
Compression Index, C_c	-		Compression Index, C_c	0.10		Compression Index, C_c	0.18		Compression Index, C_c	0.17		Compression Index, C_c	0.25	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
3.6	1.3E-05	2.57E-03	4.7	9.5E-06	7.74E-02	7.0	6.2E-06	8.11E-02	8.9	4.8E-06	1.28E-01	12.7	3.2E-06	1.15E-01
6.8	1.1E-05	2.23E-03	8.6	8.5E-06	6.91E-02	12.4	5.7E-06	7.50E-02	15.9	4.4E-06	1.17E-01	22.6	2.9E-06	1.06E-01
10.4	1.1E-05	2.14E-03	13.2	8.2E-06	6.65E-02	19.3	5.4E-06	7.14E-02	24.8	4.1E-06	1.10E-01	35.0	2.8E-06	1.01E-01
15.2	1.0E-05	2.07E-03	19.3	7.9E-06	6.44E-02	28.0	5.3E-06	6.96E-02	36.2	4.0E-06	1.07E-01	51.3	2.7E-06	9.75E-02
22.1	1.0E-05	2.02E-03	27.8	7.8E-06	6.32E-02	33.5	5.2E-06	6.89E-02	43.6	3.9E-06	1.05E-01	62.0	2.7E-06	9.57E-02
27.1	1.0E-05	2.00E-03	42.4	7.6E-06	6.23E-02	40.6	5.2E-06	6.78E-02	53.0	3.9E-06	1.03E-01	75.5	2.6E-06	9.38E-02
34.3	9.8E-06	1.96E-03	49.8	7.7E-06	6.23E-02	49.8	5.1E-06	6.69E-02	65.0	3.8E-06	1.02E-01	93.0	2.6E-06	9.20E-02
41.9	9.4E-06	1.89E-03	56.8	7.7E-06	6.25E-02	62.7	5.0E-06	6.63E-02	82.0	3.8E-06	1.00E-01	117.2	2.5E-06	9.10E-02
49.2	9.2E-06	1.84E-03				74.7	5.0E-06	6.54E-02	98.8	3.7E-06	9.79E-02	140.1	2.5E-06	8.94E-02
						86.4	4.9E-06	6.45E-02	114.9	3.6E-06	9.62E-02	160.4	2.5E-06	8.92E-02
Average (of final 3 values)	9.47E-06	1.89E-03	Average (of final 3 values)	7.66E-06	6.24E-02	Average (of final 3 values)	4.97E-06	6.54E-02	Average (of final 3 values)	3.67E-06	9.82E-02	Average (of final 3 values)	2.49E-06	8.99E-02

Golder Associates Inc.
Denver, Colorado

Project Name:
MDA/Grassy Mtn PFS/OR

Title:
SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Project Number:	Reviewed:	Date:	Sample ID:	Figure:
1663241.9000.9005	GG	8-Jun-2019	GMTC-1	1A

	Initial	Final	
Length =	4.069	2.194	cm
Diameter =	7.100	7.100	cm
Wet Mass =	263.44	166.44	g
Area =	39.59	39.59	cm^2
Volume =	161.10	86.86	cm^3
Moisture Content =	103.0%	28.5%	
Specific Gravity =	2.62	2.62	(ASTM D854)
Dry Mass of Solids =	129.77	129.53	g
Density =	1.64	1.92	g/cm^3
Dry Density =	0.81	1.49	g/cm^3
Unit Weight =	102.1	119.6	lb/ft^3
Dry Unit Weight =	50.3	93.1	lb/ft^3
Solids Content =	49.3%	77.8%	

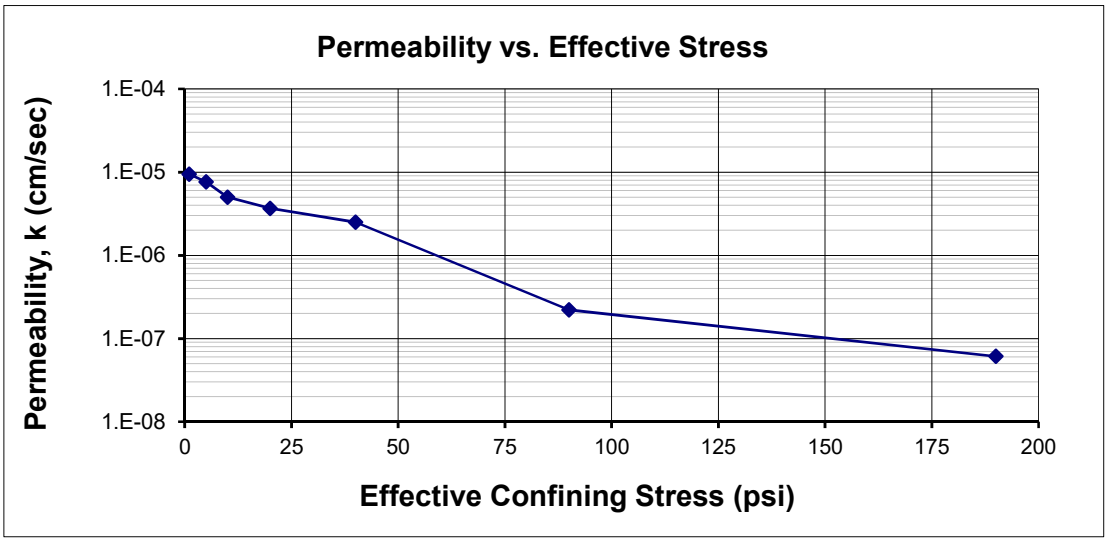
Piston Pressure:	100.0 psi	7,030.8 g/cm^2
Sample Pressure:	10.0 psi	703.1 g/cm^2
Consolidation pressure:	**90.0 psi**	6,327.7 g/cm^2
Before Consolidation		
Initial Sample Height:	2.316	cm
Initial Dry Unit Weight:	1.41	g/cm^3
Initial Void Ratio:	0.85	
After Consolidation		
Final Sample Height:	2.201	cm
Final Dry Unit Weight:	1.49	g/cm^3
Final Void Ratio:	0.76	
Calculations		
Coefficient of Compressibility, a_v	2.62E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.41E-05	cm^2/g
Compression Index, C_c	0.26	

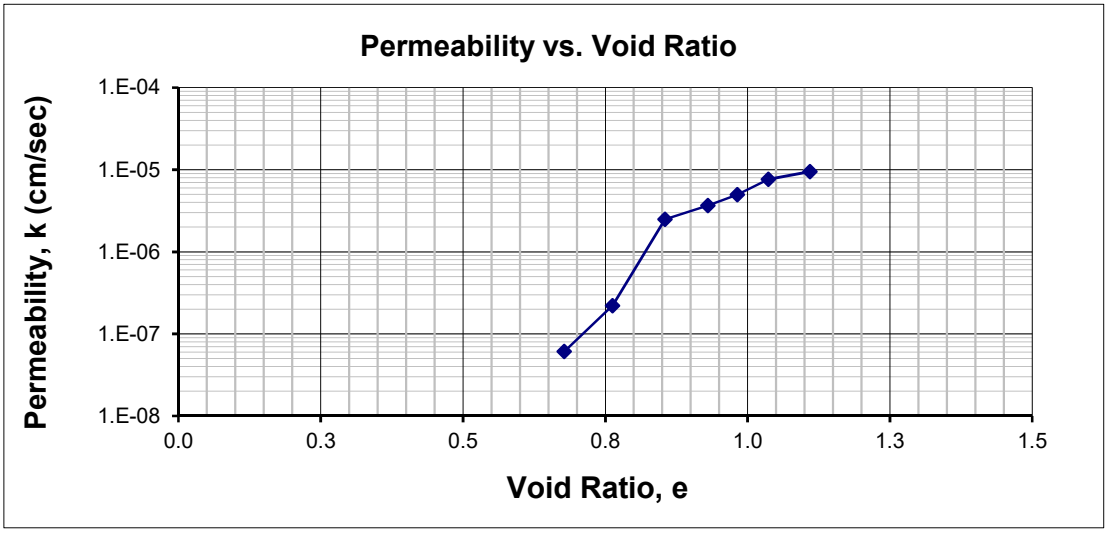
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
46.9	8.2E-07	5.83E-02
99.6	6.3E-07	4.48E-02
170.5	5.5E-07	3.86E-02
308.0	4.3E-07	3.03E-02
418.2	3.7E-07	2.65E-02
583.4	3.2E-07	2.26E-02
844.7	2.7E-07	1.89E-02
1,074.4	2.4E-07	1.69E-02
1,257.8	2.2E-07	1.58E-02
1,648.5	2.0E-07	1.42E-02
Average (of final 3 values)	2.21E-07	1.56E-02

Piston Pressure:	200.0 psi	14,061.5 g/cm^2
Sample Pressure:	10.0 psi	703.1 g/cm^2
Consolidation pressure:	**190.0 psi**	13,358.5 g/cm^2
Before Consolidation		
Initial Sample Height:	2.201	cm
Initial Dry Unit Weight:	1.49	g/cm^3
Initial Void Ratio:	0.76	
After Consolidation		
Final Sample Height:	2.095	cm
Final Dry Unit Weight:	1.56	g/cm^3
Final Void Ratio:	0.68	
Calculations		
Coefficient of Compressibility, a_v	1.21E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	6.85E-06	cm^2/g
Compression Index, C_c	0.26	

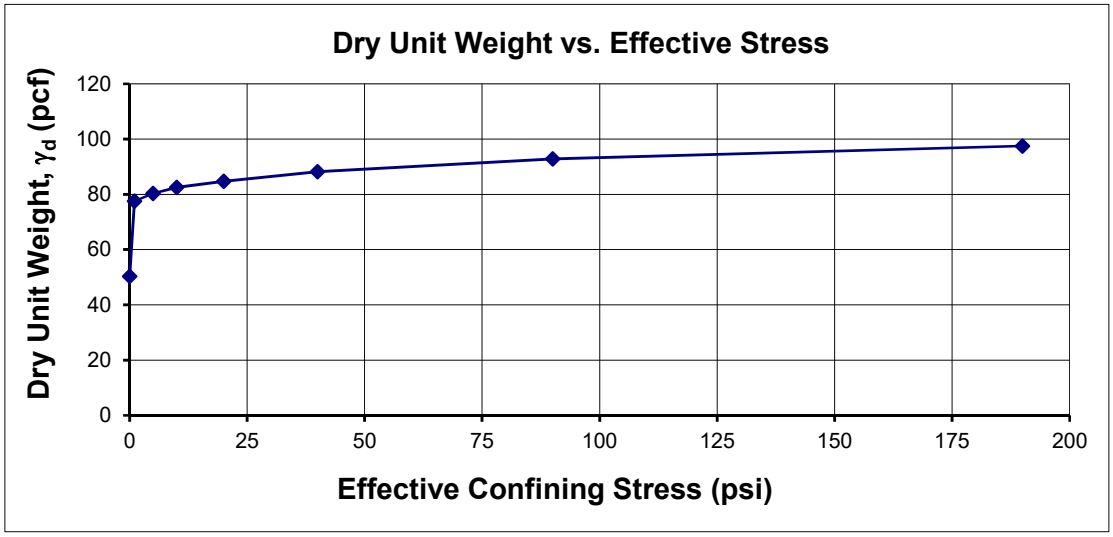
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
239.0	1.5E-07	2.24E-02
610.0	1.0E-07	1.50E-02
903.0	9.1E-08	1.33E-02
1,229.0	8.3E-08	1.21E-02
2,813.0	6.3E-08	9.21E-03
3,248.0	6.1E-08	8.92E-03
3,670.0	6.1E-08	8.90E-03
4,191.0	6.1E-08	8.88E-03
Average (of final 3 values)	6.10E-08	8.90E-03

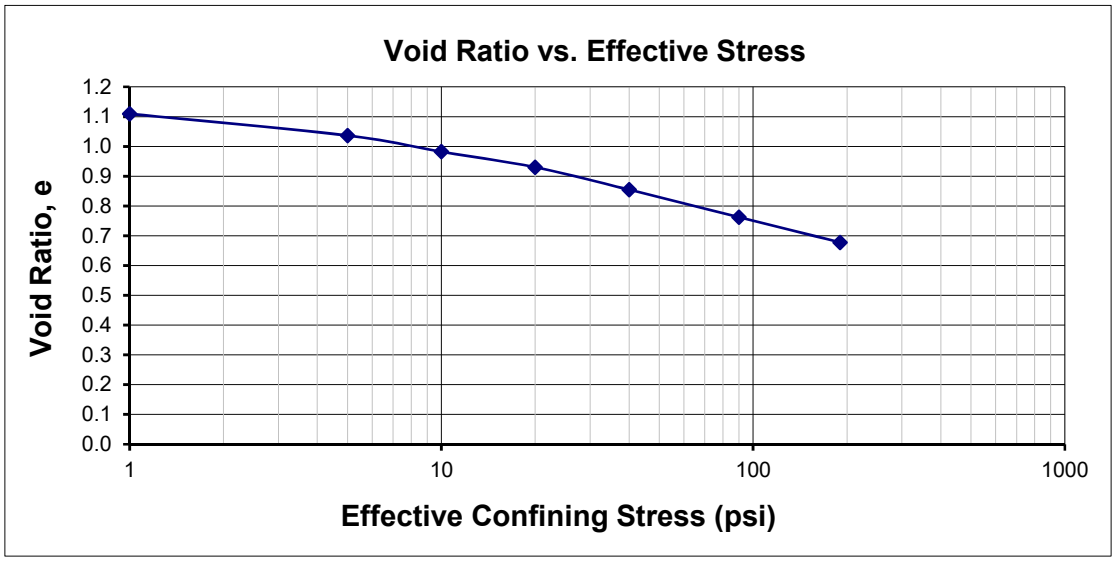
Golder Associates Inc. Denver, Colorado	**Title:** **SLURRY CONSOLIDATION TEST SAMPLE DATA AND CALCULATIONS**			
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-1	**Figure:** 1B



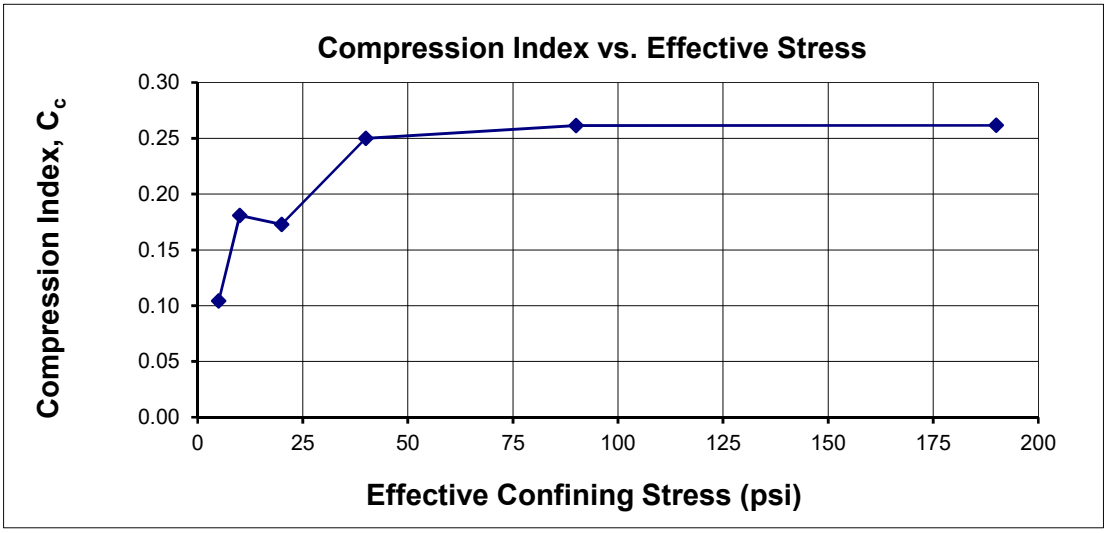


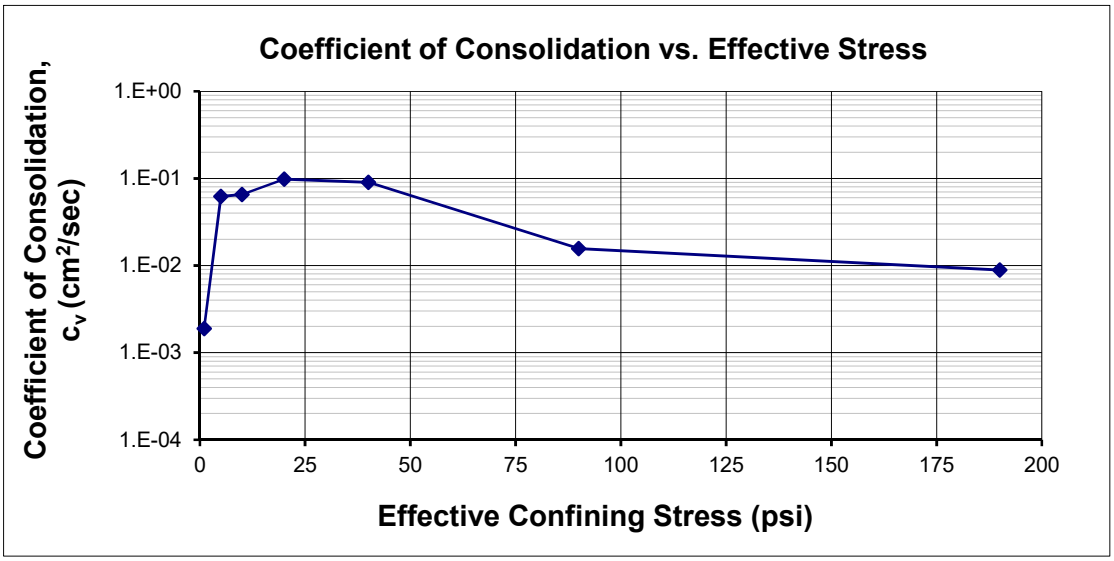
Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **PERMEABILITY DATA**	
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-1	**Figure:** 2





Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**	
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-1	**Figure:** 3





Golder Associates Inc. **Denver, Colorado**	**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **COMPRESSION DATA**			
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-1	**Figure:** 4

	Initial	Final	
Length =	3.961	2.289	cm
Diameter =	7.10	7.10	cm
Wet Mass =	271.57	176.51	g
Area =	39.59	39.59	cm^2
Volume =	156.82	90.63	cm^3
Moisture Content =	94.9%	26.6%	
Specific Gravity =	2.64	2.64	(ASTM D854)
Dry Mass of Solids =	139.34	139.42	g
Density =	1.73	1.95	g/cm^3
Dry Density =	0.89	1.54	g/cm^3
Unit Weight =	108.1	121.6	lb/ft^3
Dry Unit Weight =	55.5	96.0	lb/ft^3
Solids Content =	51.3%	79.0%	

Sample initially prepared at approximately 46% solids and allowed to settle. Some supernatant water was then decanted and the sample was mixed and poured into the slurry consolidation device and allowed to settle overnight. Prior to beginning the test, the sample was again decanted.

Piston Pressure:	6.0 psi	421.8 g/cm^2	Piston Pressure:	10.0 psi	703.1 g/cm^2	Piston Pressure:	15.0 psi	1,054.6 g/cm^2	Piston Pressure:	25.0 psi	1,757.7 g/cm^2	Piston Pressure:	45.0 psi	3,163.8 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**1.0 psi**	70.3 g/cm^2	Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2	Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2	Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2	Consolidation Pressure:	**40.0 psi**	2,812.3 g/cm^2
Before Consolidation			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**		
Initial Sample Height:	3.961	cm	Initial Sample Height:	2.915	cm	Initial Sample Height:	2.677	cm	Initial Sample Height:	2.587	cm	Initial Sample Height:	2.497	cm
Initial Dry Unit Weight:	0.89	g/cm^3	Initial Dry Unit Weight:	1.21	g/cm^3	Initial Dry Unit Weight:	1.32	g/cm^3	Initial Dry Unit Weight:	1.36	g/cm^3	Initial Dry Unit Weight:	1.41	g/cm^3
Initial Void Ratio:	1.97		Initial Void Ratio:	1.19		Initial Void Ratio:	1.01		Initial Void Ratio:	0.94		Initial Void Ratio:	0.87	
After Consolidation			**After Consolidation**			**After Consolidation**			**After Consolidation**			**After Consolidation**		
Final Sample Height:	2.915	cm	Final Sample Height:	2.677	cm	Final Sample Height:	2.587	cm	Final Sample Height:	2.497	cm	Final Sample Height:	2.408	cm
Final Dry Unit Weight:	1.21	g/cm^3	Final Dry Unit Weight:	1.32	g/cm^3	Final Dry Unit Weight:	1.36	g/cm^3	Final Dry Unit Weight:	1.41	g/cm^3	Final Dry Unit Weight:	1.46	g/cm^3
Final Void Ratio:	1.19		Final Void Ratio:	1.01		Final Void Ratio:	0.94		Final Void Ratio:	0.87		Final Void Ratio:	0.81	
Calculations			**Calculations**			**Calculations**			**Calculations**			**Calculations**		
Coefficient of Compressibility, a_v	1.12E-02	cm^2/g	Coefficient of Compressibility, a_v	6.34E-04	cm^2/g	Coefficient of Compressibility, a_v	1.92E-04	cm^2/g	Coefficient of Compressibility, a_v	9.60E-05	cm^2/g	Coefficient of Compressibility, a_v	4.74E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	3.76E-03	cm^2/g	Coefficient of Volume Compressibility, m_v	2.90E-04	cm^2/g	Coefficient of Volume Compressibility, m_v	9.56E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	4.95E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	2.53E-05	cm^2/g
Compression Index, C_c	-		Compression Index, C_c	0.26		Compression Index, C_c	0.22		Compression Index, C_c	0.22		Compression Index, C_c	0.22	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
0.9	5.7E-05	1.51E-02	3.2	1.5E-05	5.00E-02	5.0	9.1E-06	9.46E-02	6.3	6.9E-06	1.40E-01	8.2	5.1E-06	2.03E-01
5.6	2.2E-05	5.88E-03	11.4	9.9E-06	3.41E-02	10.2	7.3E-06	7.60E-02	12.4	5.8E-06	1.17E-01	16.4	4.2E-06	1.66E-01
9.5	1.8E-05	4.88E-03	17.1	9.4E-06	3.22E-02	16.4	6.7E-06	6.98E-02	19.8	5.3E-06	1.08E-01	26.4	3.9E-06	1.52E-01
14.9	1.7E-05	4.42E-03	25.2	9.0E-06	3.10E-02	20.1	6.5E-06	6.79E-02	24.4	5.2E-06	1.04E-01	32.6	3.7E-06	1.47E-01
18.9	1.6E-05	4.21E-03	30.8	8.9E-06	3.06E-02	24.6	6.3E-06	6.59E-02	29.5	5.1E-06	1.02E-01	39.7	3.6E-06	1.43E-01
23.9	1.6E-05	4.13E-03	38.8	8.8E-06	3.03E-02	29.6	6.2E-06	6.49E-02	35.5	5.0E-06	1.01E-01	48.1	3.6E-06	1.40E-01
28.8	1.5E-05	4.04E-03	45.6	8.8E-06	3.04E-02	35.7	6.1E-06	6.42E-02	43.0	4.9E-06	9.96E-02	58.4	3.5E-06	1.38E-01
33.5	1.5E-05	3.96E-03	52.1	8.8E-06	3.03E-02	40.4	6.1E-06	6.34E-02	48.6	4.9E-06	9.84E-02	66.5	3.4E-06	1.35E-01
						43.8	6.1E-06	6.33E-02	52.6	4.9E-06	9.83E-02	72.0	3.4E-06	1.35E-01
						50.5	6.0E-06	6.23E-02	60.1	4.8E-06	9.76E-02	82.7	3.4E-06	1.34E-01
						55.4	6.0E-06	6.23E-02	66.1	4.8E-06	9.75E-02	90.4	3.4E-06	1.34E-01
						66.1	5.9E-06	6.14E-02				106.7	3.4E-06	1.34E-01
Average (of final 3 values)	1.52E-05	4.04E-03	Average (of final 3 values)	8.80E-06	3.03E-02	Average (of final 3 values)	5.93E-06	6.20E-02	Average (of final 3 values)	4.84E-06	9.78E-02	Average (of final 3 values)	3.39E-06	1.34E-01

Golder Associates Inc.
Denver, Colorado

Title:
SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Project Name: MDA/Grassy Mtn PFS/OR

Project Number:	Reviewed:	Date:	Sample ID:	Figure:
1663241.9000.9005	GG	8-Jun-2019	GMTC-2	1A

	Initial	Final	
Length =	3.961	2.289	cm
Diameter =	7.10	7.10	cm
Wet Mass =	271.57	176.51	g
Area =	39.59	39.59	cm^2
Volume =	156.82	90.63	cm^3
Moisture Content =	94.9%	26.6%	
Specific Gravity =	2.64	2.64	(ASTM D854)
Dry Mass of Solids =	139.34	139.42	g
Density =	1.73	1.95	g/cm^3
Dry Density =	0.89	1.54	g/cm^3
Unit Weight =	108.1	121.6	lb/ft^3
Dry Unit Weight =	55.5	96.0	lb/ft^3
Solids Content =	51.3%	79.0%	

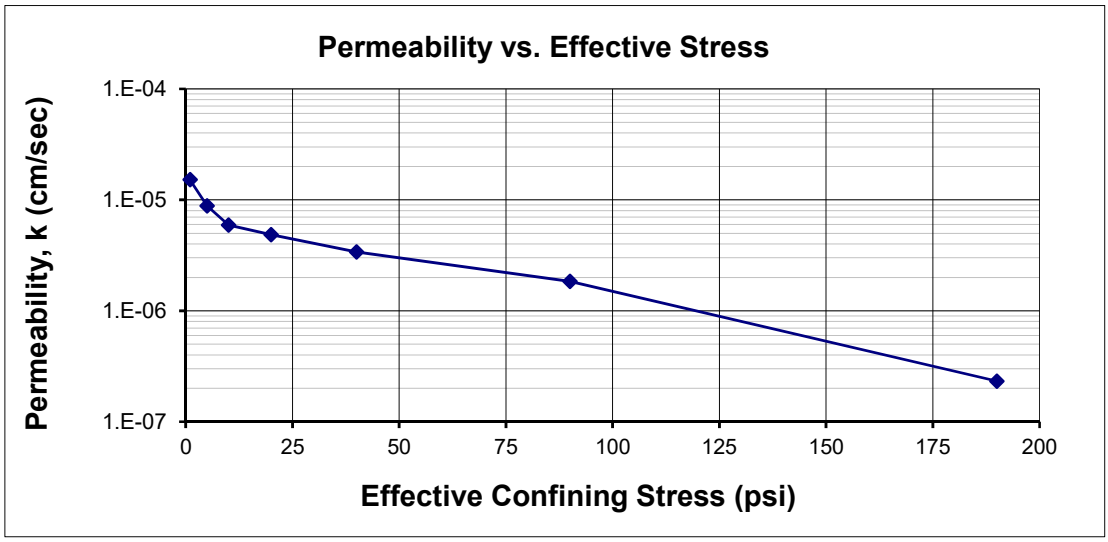
Piston Pressure:	95.0 psi	6,679.2 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**90.0 psi**	6,327.7 g/cm^2
Before Consolidation		
Initial Sample Height:	2.408	cm
Initial Dry Unit Weight:	1.46	g/cm^3
Initial Void Ratio:	0.81	
After Consolidation		
Final Sample Height:	2.310	cm
Final Dry Unit Weight:	1.52	g/cm^3
Final Void Ratio:	0.73	
Calculations		
Coefficient of Compressibility, a_v	2.09E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.16E-05	cm^2/g
Compression Index, C_c	0.21	

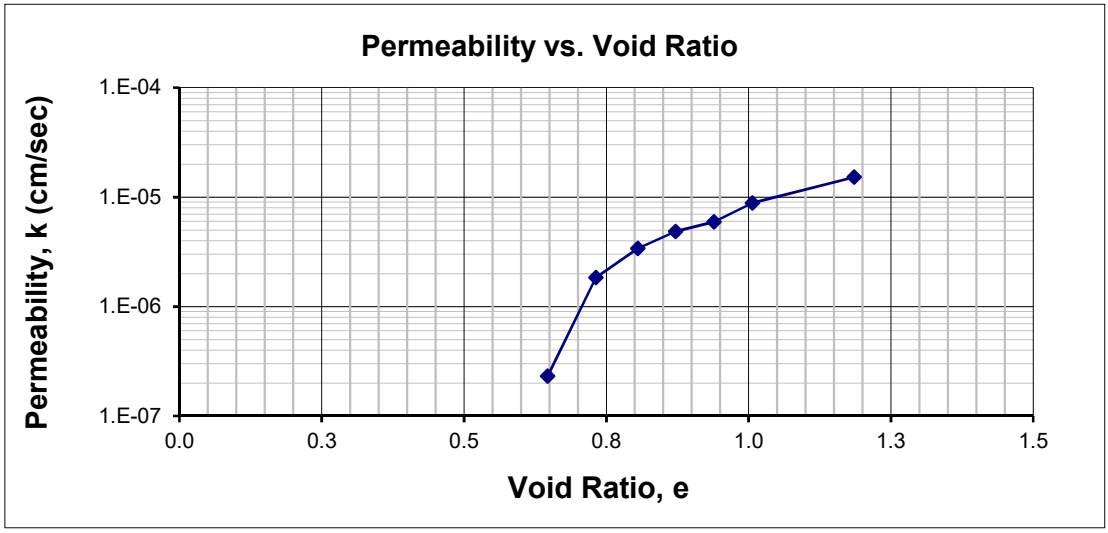
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
15.4	2.6E-06	2.28E-01
30.2	2.2E-06	1.89E-01
48.8	2.0E-06	1.73E-01
60.3	1.9E-06	1.67E-01
73.6	1.9E-06	1.62E-01
88.9	1.8E-06	1.59E-01
106.6	1.8E-06	1.59E-01
119.6	1.8E-06	1.58E-01
128.4	1.8E-06	1.59E-01
Average (of final 3 values)	1.84E-06	1.59E-01

Piston Pressure:	195.0 psi	13,710.0 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**190.0 psi**	13,358.5 g/cm^2
Before Consolidation		
Initial Sample Height:	2.310	cm
Initial Dry Unit Weight:	1.52	g/cm^3
Initial Void Ratio:	0.73	
After Consolidation		
Final Sample Height:	2.197	cm
Final Dry Unit Weight:	1.60	g/cm^3
Final Void Ratio:	0.65	
Calculations		
Coefficient of Compressibility, a_v	1.20E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	6.96E-06	cm^2/g
Compression Index, C_c	0.26	

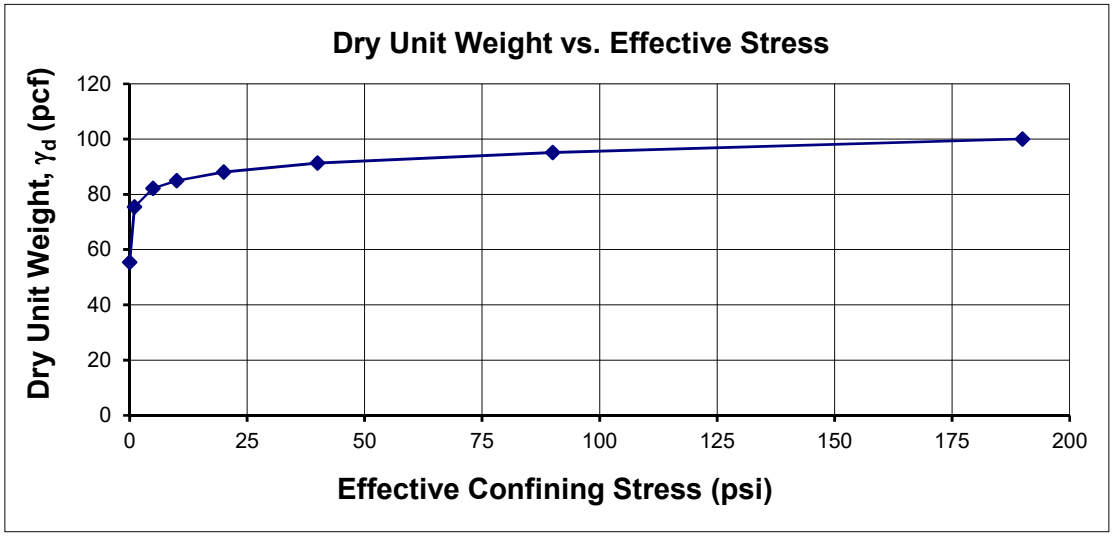
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
	2.3E-07	3.33E-02
	2.32E-07	3.33E-02

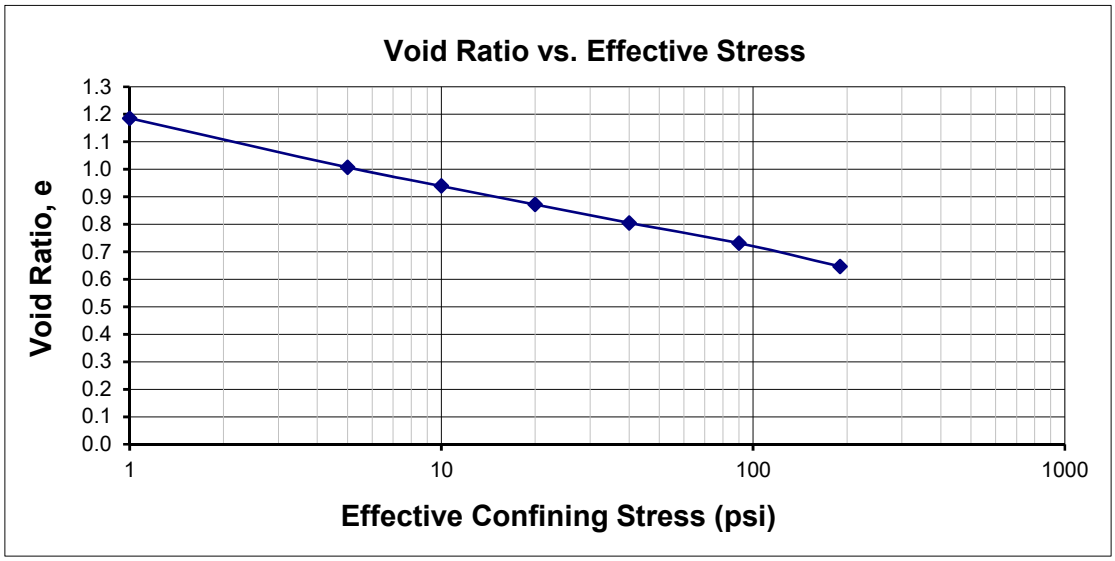
Golder Associates Inc. **Denver, Colorado**	**Title:** **SLURRY CONSOLIDATION TEST** **SAMPLE DATA AND CALCULATIONS**			
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-2	**Figure:** 1B



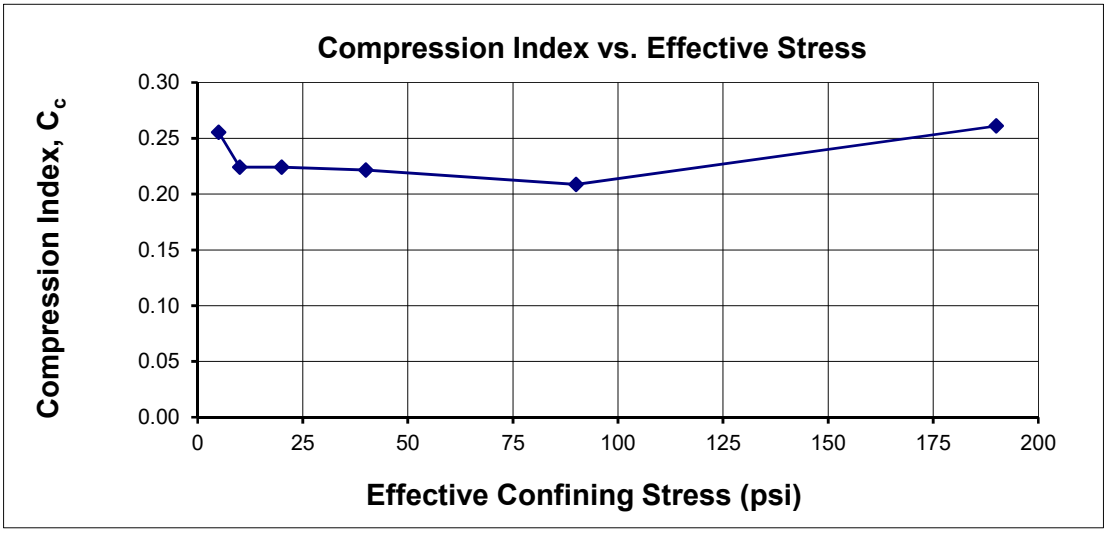


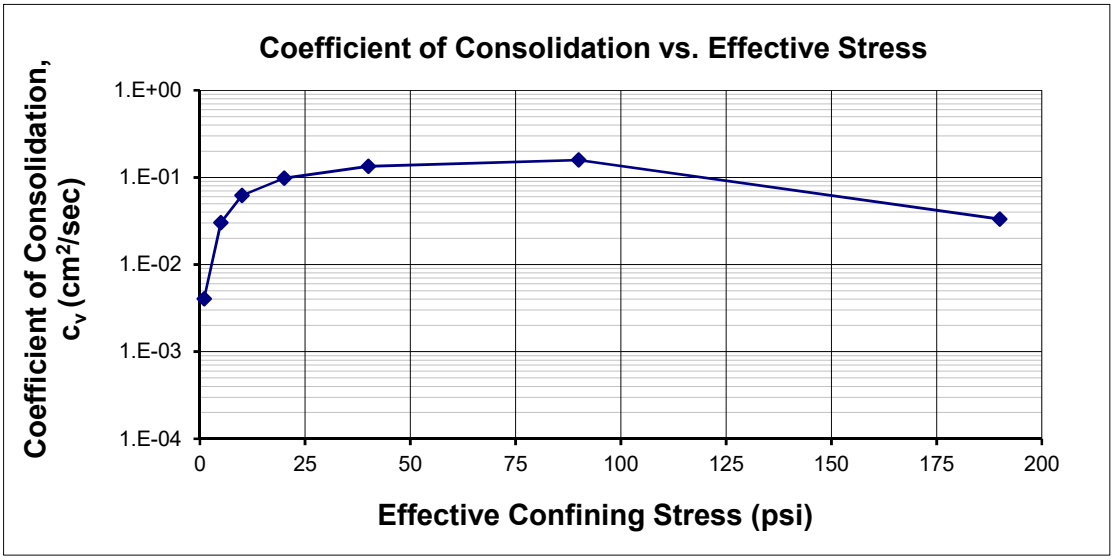
Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **PERMEABILITY DATA**	
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-2	**Figure:** 2





Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**	
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-2	**Figure:** 3





Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **COMPRESSION DATA**	
Project Name: MDA/Grassy Mtn PFS/OR				
Project Number: 1663241.9000.9005	**Reviewed:** GG	**Date:** 8-Jun-2019	**Sample ID:** GMTC-2	**Figure:** 4

ATTACHMENT 1.4

SWCC Testing

SOIL-WATER CHARACTERISTIC CURVE
ASTM D6836

Short Title:	Grassy Mtn PFS/OR			Project #:	1663241.9000.9005
Sample :	GMTC Composite			Reviewed By:	CPA
Tested By:	MGC	Start Date:	8/9/2019	Completion Date:	9/20/2019

Visual Description (Golder Procedure): SILT, olive gray, wet

Test Results:

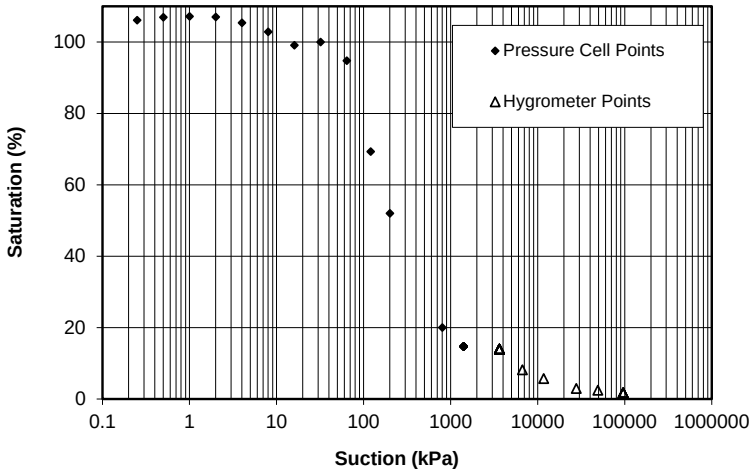
Suction	Water Content (%)	
(kPa)	Gravimetric	Volumetric
0.25	47.1	57.1
0.5	46.6	57.1
1	45.7	56.6
2	44.8	56.0
4	43.3	54.7
8	39.6	51.8
16	37.4	49.4
32	35.9	48.6
64	33.3	45.5
120	24.1	33.1
200	18.1	24.8
800	7.1	9.7
1400	5.1	7.0
3620	3.6	5.6
6650	2.1	3.3
11670	1.5	2.3
27620	0.7	1.2
48770	0.6	1.0
95520	0.4	0.7

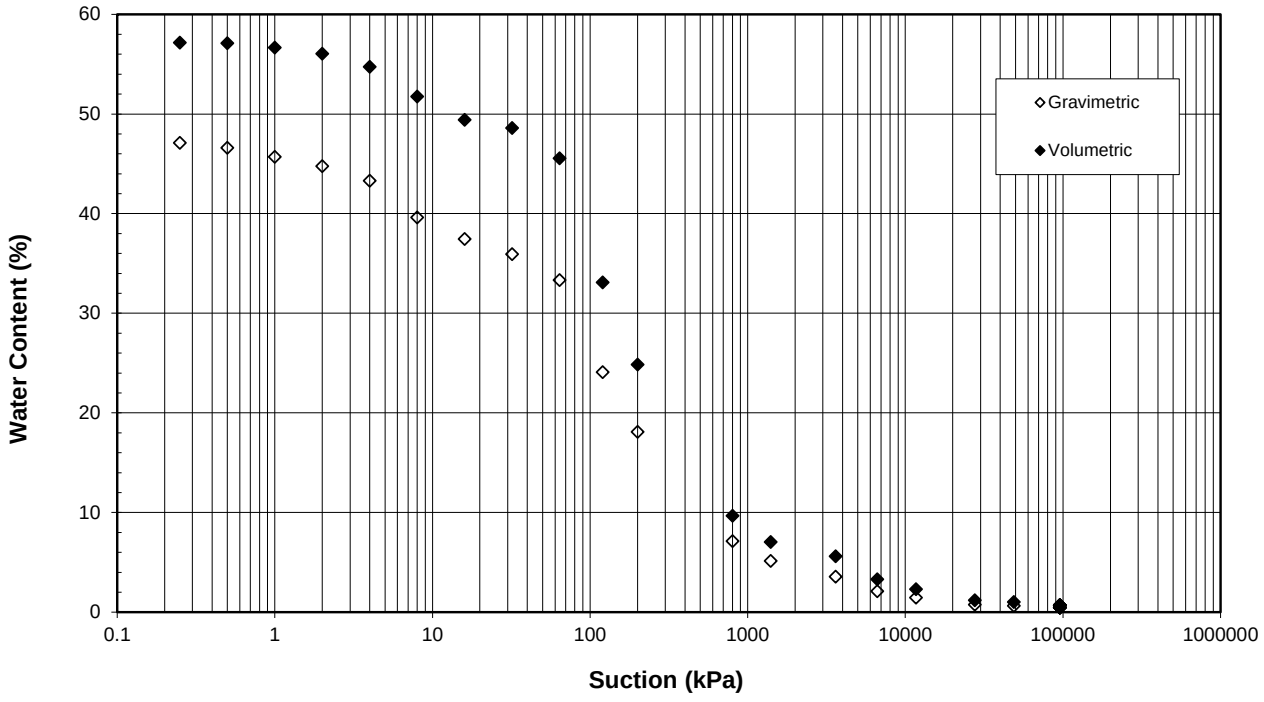
Sample Data:

Diameter:	63.04	mm (initial)	Compactive Method:	
Height:	31.68	mm (initial)	Trimmed from shrinkage curve sample	
Initial Water Content:	47.2	% (gravimetric)	75.1	pcf (initial)
Dry Density:	1203	kg/m^3 (initia	Specific Gravity	
Material used passing:	#4	sieve	(ASTM D854):	2.63

Methods used:
Method A: 5 bar plate
Method C: 5 bar and 15 bar plates
Method D: Decagon WP4C Hygrometer

Type of Water used to Saturate:
De-aired
Method of Saturation:
Sample fully saturated before setup





The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Inc. upon request.

GOLDER

Golder Associates Inc.	Title: ASTM D6836 SOIL WATER CHARACTERISTIC CURVE SPECIMEN PHOTOGRAPH				
Job Short Title: Grassy Mtn PFS/OR					
Sample: GMTC Composite	Technician: MGC	Reviewed: CPA	Date: 9/20/2019	Job Number: 1663241.9000.9005	Figure: 1

ATTACHMENT 1.5

Desiccation Testing

GOLDER

SHRINKAGE CURVE TEST REPORT

PROJECT NAME: MDA/Grassy Mtn PFS/OR
PROJECT NUMBER: 1663241.9000.9005
SAMPLE ID: GMTC-1 **Depth (ft.):** --

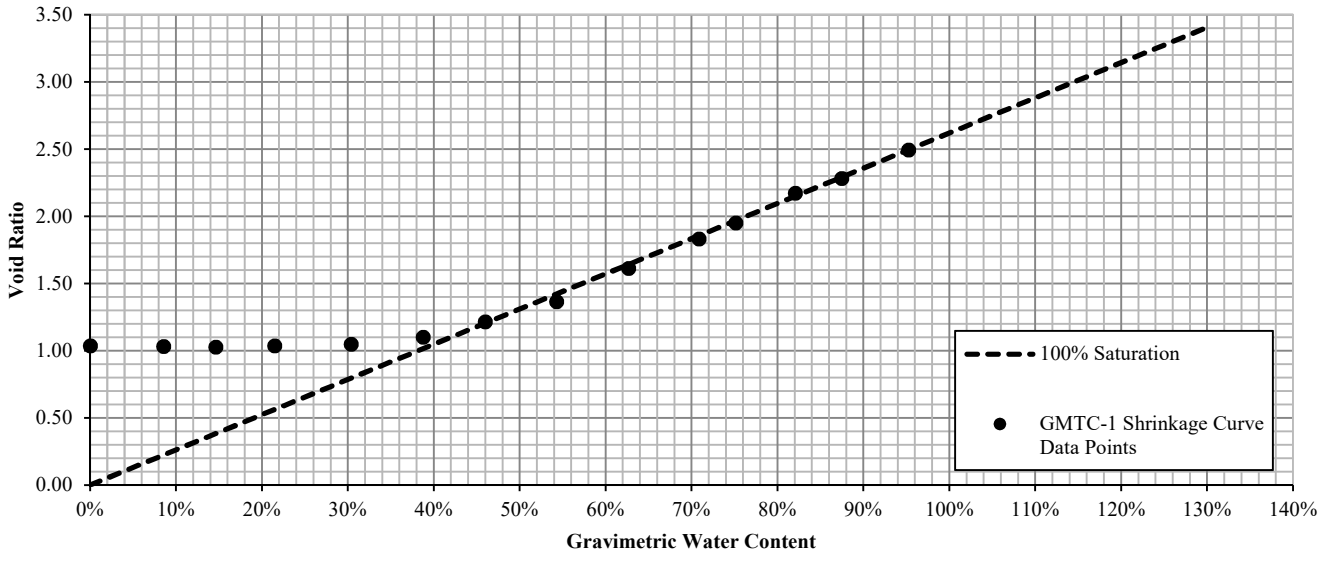
Technician: MGC
Checked: MB
Reviewed: MB
Date: 10-Jul-2019

Description: Sandy silt, grayish brown, wet
Method: USCS Description (ASTM D 2487)

Initial Sample Conditions

Initial Moisture Content: 118.5% Specific Gravity: 2.62 ASTM D854
Initial Dry Density (pcf): 46.8
Initial Saturation %: 124.4%

Date and Time	Temperature °C	Diameter (cm)	Height (cm)	Sample Volume (cc)	Wet Mass Soil (g)	Gravimetric Water Content %	Void Ratio	Saturation %
6/26/2019 16:20	21.4	6.332	2.842	89.485	130.98	95.3%	2.495	100.0%
6/27/2019 7:25	21.4	6.332	2.670	84.054	125.76	87.5%	2.283	100.4%
6/27/2019 16:28	21.4	6.332	2.580	81.225	122.12	82.1%	2.172	99.0%
6/28/2019 7:56	21.4	6.332	2.399	75.542	117.49	75.1%	1.950	100.9%
6/28/2019 16:21	21.4	6.332	2.303	72.519	114.61	70.9%	1.832	101.3%
6/29/2019 10:42	21.4	6.245	2.183	66.875	109.10	62.6%	1.612	101.8%
6/30/2019 9:03	21.4	6.005	2.139	60.581	103.49	54.3%	1.366	104.1%
7/1/2019 10:27	21.4	5.859	2.104	56.733	97.93	46.0%	1.216	99.1%
7/2/2019 8:25	21.4	5.740	2.080	53.809	93.08	38.8%	1.102	92.2%
7/3/2019 9:37	21.4	5.691	2.061	52.425	87.46	30.4%	1.048	76.0%
7/4/2019 9:49	21.4	5.687	2.053	52.136	81.48	21.5%	1.036	54.3%
1/0/1900 0:00	21.4	5.675	2.053	51.933	76.88	14.6%	1.028	37.2%
7/6/2019 8:12	21.4	5.680	2.053	52.019	72.82	8.6%	1.032	21.7%
7/8/2019 8:37	21.4	5.676	2.062	52.179	67.08	0.0%	1.038	0.0%



Notes: The sample was placed in an oven set to approximately 60° C prior to recording the final mass and volume measurements.
The sample began to separate from the ring between the reading on 6/28/2019 at 16:21 and 6/29/2019 at 10:42.

GOLDER

SHRINKAGE CURVE TEST REPORT

PROJECT NAME: MDA/Grassy Mtn PFS/OR
PROJECT NUMBER: 1663241.9000.9005
SAMPLE ID: GMTC-2 **Depth (ft.): --**

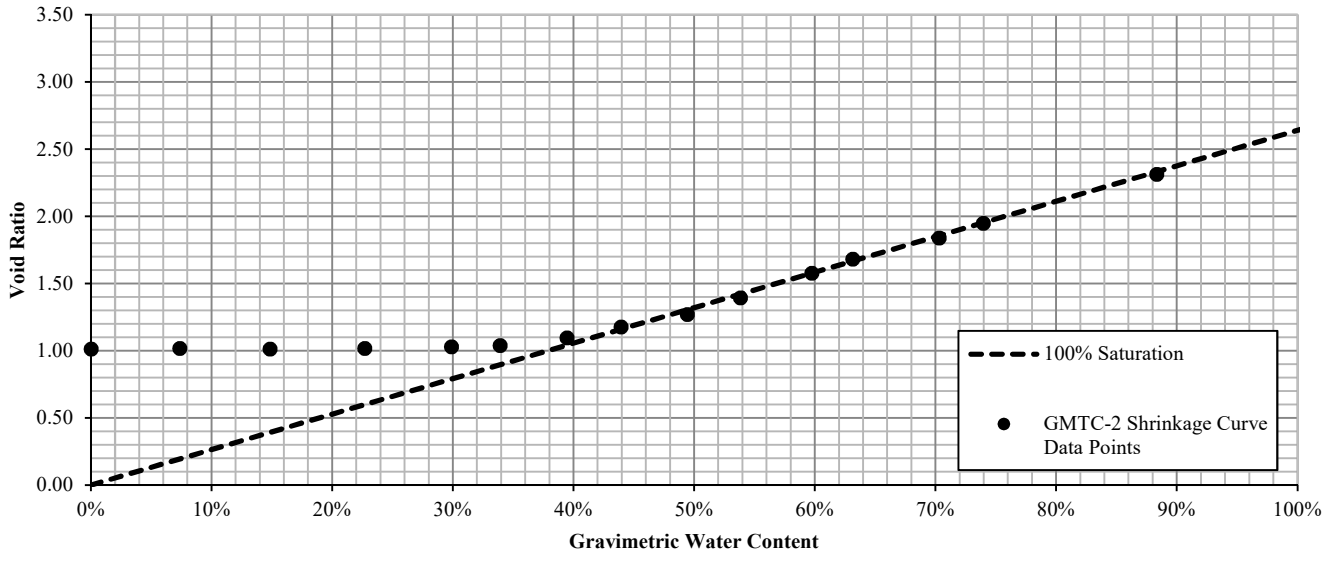
Technician: MGC
Checked: MB
Reviewed: MB
Date: 9-Jul-2019

Description: Sandy silt, grayish brown, wet
Method: USCS Description (ASTM D 2487)

Initial Sample Conditions

Initial Moisture Content: 119.5% Specific Gravity: 2.64 ASTM D854
Initial Dry Density (pcf): 49.7
Initial Saturation %: 136.3%

Date and Time	Temperature °C	Diameter (cm)	Height (cm)	Sample Volume (cc)	Wet Mass Soil (g)	Gravimetric Water Content %	Void Ratio	Saturation %
6/23/2019 9:25	21.4	6.324	2.648	83.181	124.83	88.3%	2.313	100.8%
6/24/2019 9:48	21.4	6.324	2.357	74.041	115.29	73.9%	1.949	100.2%
6/24/2019 16:15	21.4	6.324	2.270	71.282	112.87	70.3%	1.839	100.9%
6/25/2019 9:27	21.4	6.324	2.144	67.335	108.13	63.1%	1.682	99.1%
6/25/2019 16:05	21.4	6.324	2.060	64.686	105.88	59.7%	1.577	100.0%
6/26/2019 7:18	21.4	6.176	2.007	60.110	101.95	53.8%	1.394	101.9%
6/26/2019 16:21	21.4	6.063	1.974	56.979	99.03	49.4%	1.270	102.8%
6/27/2019 7:21	21.4	5.928	1.982	54.683	95.40	43.9%	1.178	98.5%
6/27/2019 16:33	21.4	5.849	1.958	52.625	92.43	39.5%	1.096	95.0%
6/28/2019 7:46	21.4	5.795	1.941	51.191	88.75	33.9%	1.039	86.1%
6/28/2019 16:13	21.4	5.795	1.932	50.964	86.07	29.9%	1.030	76.5%
6/29/2019 10:27	21.4	5.782	1.929	50.662	81.32	22.7%	1.018	58.9%
6/30/2019 8:54	21.4	5.774	1.929	50.513	76.11	14.8%	1.012	38.7%
7/1/2019 10:04	21.4	5.792	1.923	50.650	71.15	7.3%	1.017	19.1%
7/2/2019 7:55	21.4	5.785	1.924	50.559	66.28	0.0%	1.014	0.0%



Notes: The sample was placed in an oven set to approximately 60° C prior to recording the final mass and volume measurements.
The sample began to separate from the ring between the reading on 6/25/2019 at 16:05 and 6/26/2019 at 7:18.

GOLDER

SHRINKAGE CURVE TEST REPORT

PROJECT NAME: MDA/Grassy Mtn PFS/OR
PROJECT NUMBER: 1663241.9000.9005
SAMPLE ID: GMTC-2 **Depth (ft.):** --

Technician: MGC
Checked: MB
Reviewed: MB
Date: 10-Jul-2019

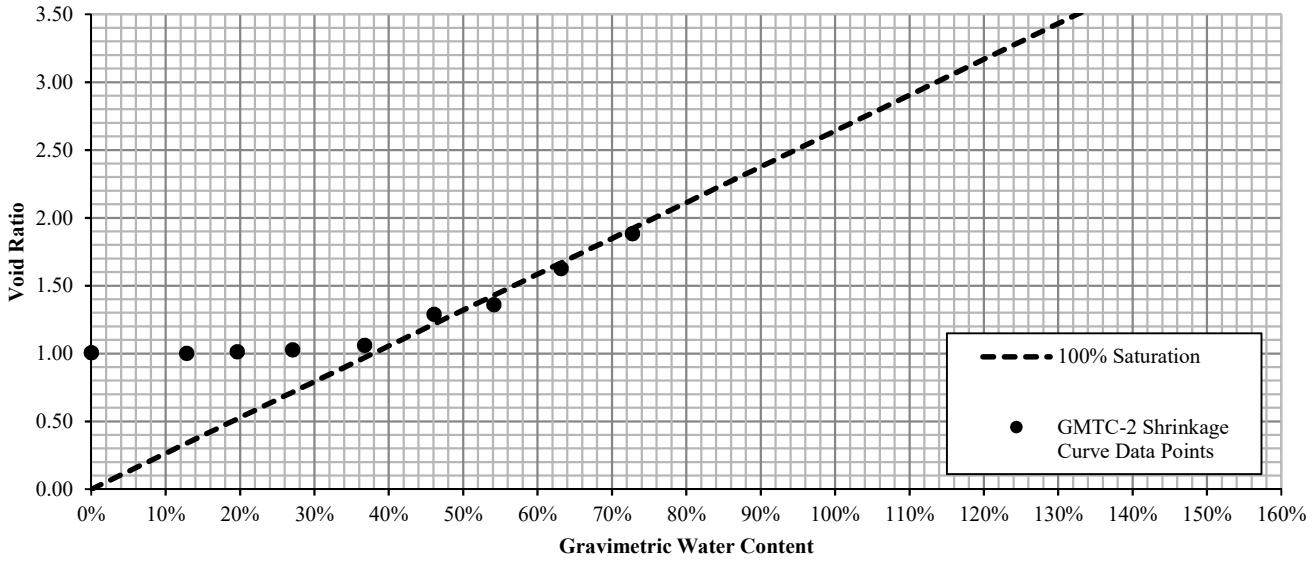
Description: Sandy silt, grayish brown, wet
Method: USCS Description (ASTM D 2487)

Initial Sample Conditions

Initial Moisture Content: 120.7%
Initial Dry Density (pcf): 57.2
Initial Saturation %: 169.3%

Specific Gravity: 2.64 ASTM D854

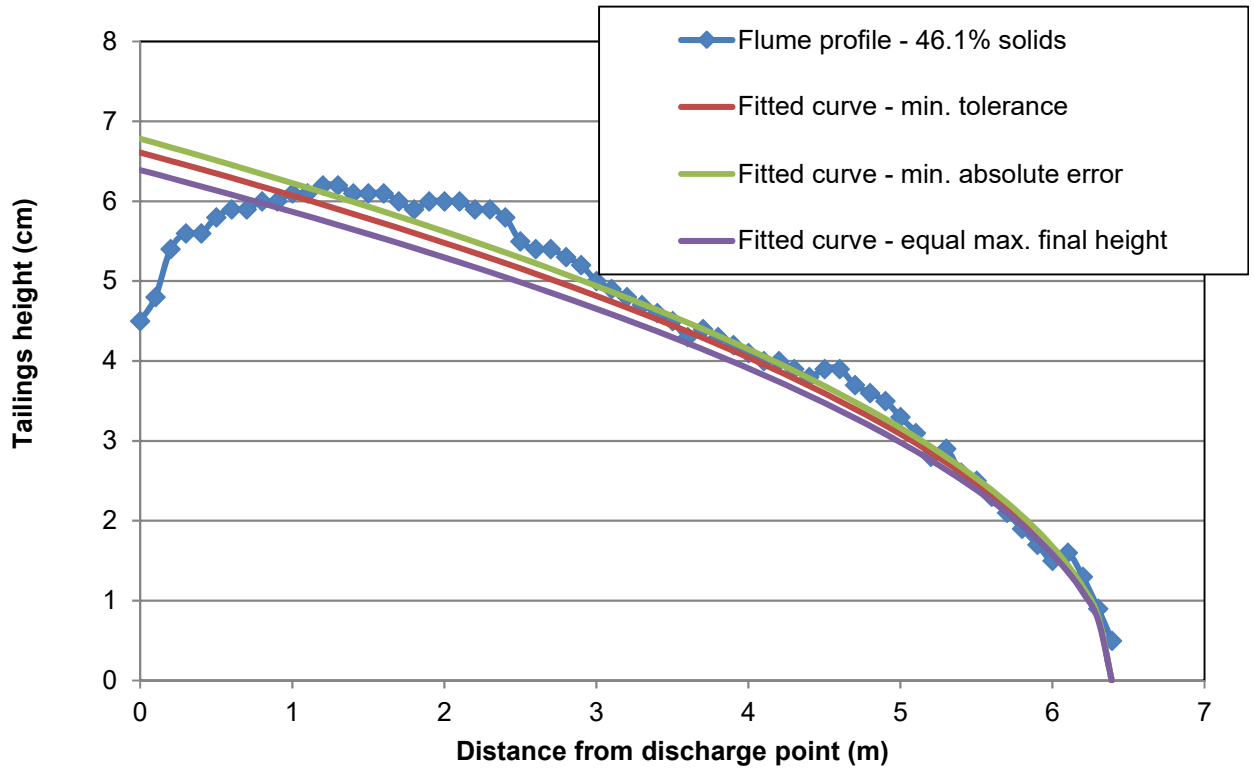
Date and Time	Temperature °C	Diameter (cm)	Height (cm)	Sample Volume (cc)	Wet Mass Soil (g)	Gravimetric Water Content %	Void Ratio	Saturation %
6/29/2019 10:30	21.4	6.280	2.217	68.682	108.68	72.8%	1.883	102.1%
6/30/2019 8:58	21.4	6.280	2.020	62.564	102.64	63.2%	1.626	102.6%
7/1/2019 10:16	21.4	6.139	1.900	56.237	96.96	54.1%	1.360	105.1%
7/2/2019 8:04	21.4	6.007	1.925	54.552	91.90	46.1%	1.290	94.4%
7/3/2019 9:32	21.4	5.798	1.859	49.085	86.02	36.8%	1.060	91.5%
7/4/2019 9:46	21.4	5.772	1.847	48.316	79.93	27.1%	1.028	69.5%
7/5/2019 9:01	21.4	5.755	1.845	47.983	75.26	19.7%	1.014	51.2%
7/6/2019 8:09	21.4	5.738	1.845	47.704	70.96	12.8%	1.002	33.8%
7/8/2019 8:39	21.4	5.743	1.845	47.803	62.90	0.0%	1.006	0.0%



Notes: The sample was placed in an oven set to approximately 60° C prior to recording the final mass and volume measurements.
The sample began to separate from the ring between the reading on 6/30/2019 at 8:58 and 7/1/2019 at 10:16.

ATTACHMENT 1.6

Flume Testing



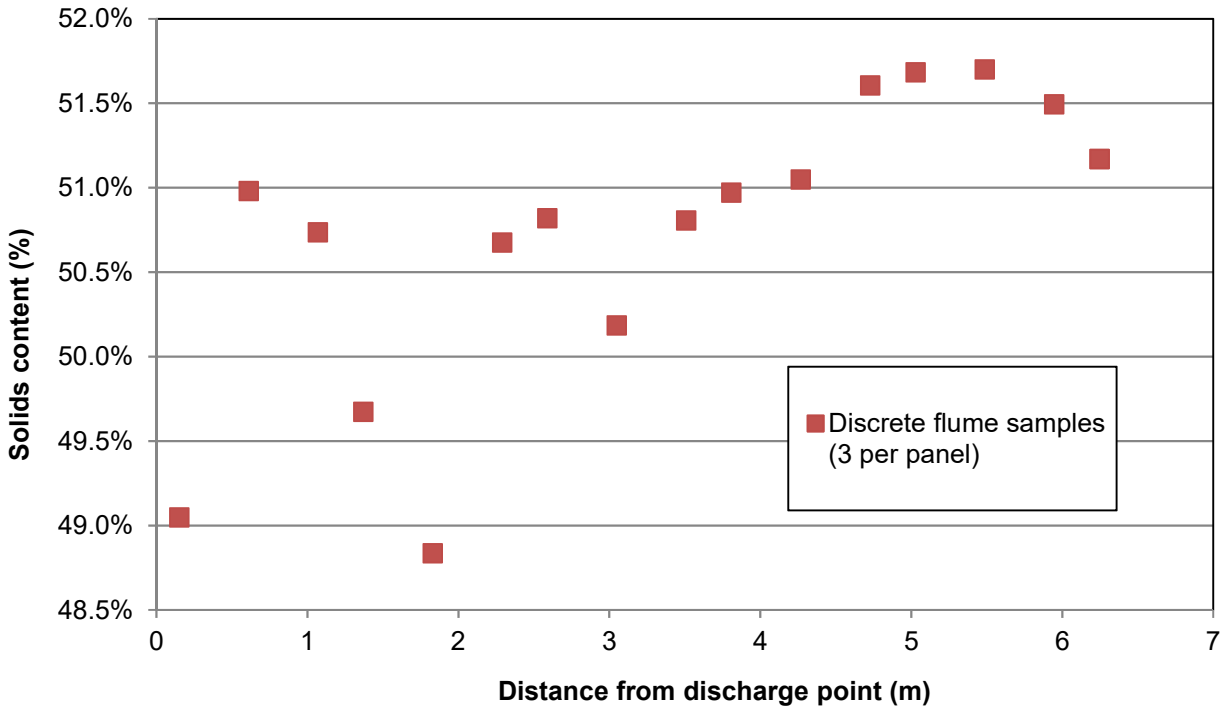


Figure 1-6-1

Flume Test Results

Grassy Mountain, Oregon

Tailings Laboratory Testing

Golder Associates

FINAL

9/17/2019

Denver

166-3241

D:\2019\166-3241-Grassy\Mntl\LAB-DATA-08-30-2019\Flume\[FlumeTestLong-46Percent.xlsm]F-1

Project Number	1663241.9000.9005			Start index	16
Name (flume type - perc. solids)	Flume profile - 46.1% solids			End index	80
Date	23-Aug-2019				
Start time	8:26	Flume Width	12 inch		
End time	8:52	Moisture content	116.92%		
Average flow rate	1 gpm	Void ratio	3.07		
Solids content	46%	Density	1.40 g/cm^3		
Gs	2.63 Assumed				
Yield stress (min. profile error)	4.7 Pa				
Yield stress (min. abs tolerance)	4.9 Pa				
Yield Stress (min. start height)	4.4 Pa				
Max. tails height (end of test)	6.2 cm				
End of flume, L	6.39 m				

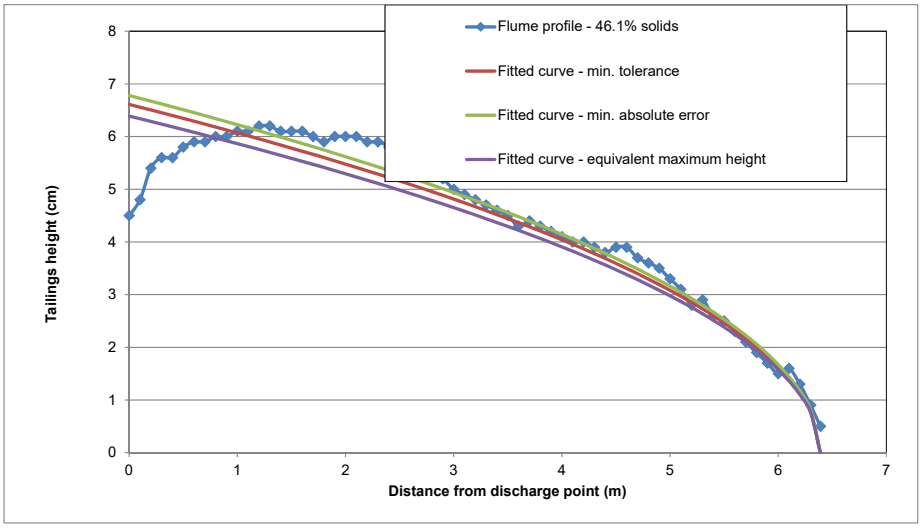
	Slope (%)
Average	0.63
Mid	0.94
Start 1/2	#N/A
End 1/2	1.38

Location	Distance (m)	Index	Height (cm)
x=0	0.00	1	4.50
x=1/3*L	2.13	22	5.97
x=1/2*L	3.20	32	4.90
x=2/3*L	4.26	43	3.97
Hfinal	6.39	65	0.50

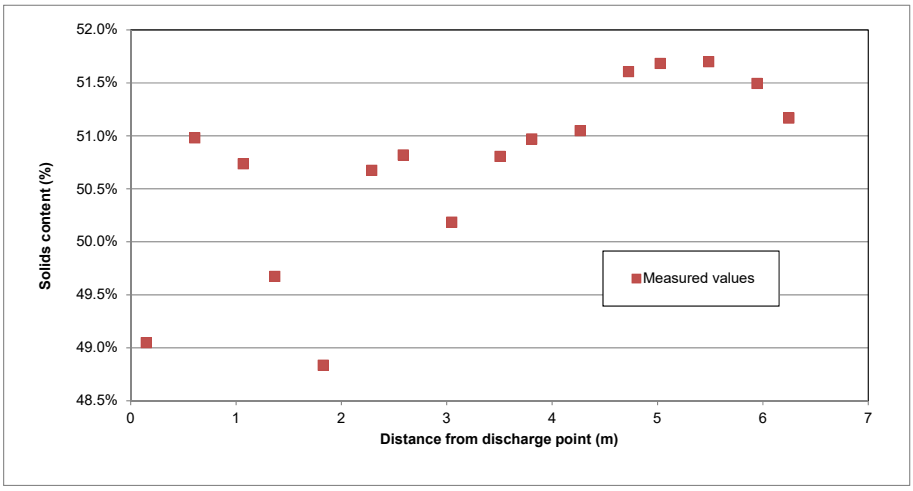
							Cum Error	4.30E-07	1.52E+01
Distance (m)	H (cm)	Volume (cm^3)	x=L-Distance	h1 (cm)	h2 (cm)	h3 (cm)	h-h1	Abs (h-h2)	
0	4.5	0	6.39	6.61	6.78	6.39	-2.11	2.28	
0.1	4.8	1,417	6.29	6.56	6.73	6.34	-1.76	1.93	
0.2	5.4	2,972	6.19	6.51	6.67	6.29	-1.11	1.27	
0.3	5.6	4,648	6.09	6.45	6.62	6.24	-0.85	1.02	
0.4	5.6	6,355	5.99	6.40	6.57	6.19	-0.80	0.97	
0.5	5.8	8,092	5.89	6.35	6.51	6.13	-0.55	0.71	
0.6	5.9	9,876	5.79	6.29	6.46	6.08	-0.39	0.56	
0.7	5.9	11,674	5.69	6.24	6.40	6.03	-0.34	0.50	
0.8	6.0	13,487	5.59	6.18	6.34	5.98	-0.18	0.34	
0.9	6.0	15,316	5.49	6.13	6.29	5.92	-0.13	0.29	
1.0	6.1	17,160	5.39	6.07	6.23	5.87	0.03	0.13	
1.1	6.1	19,020	5.29	6.02	6.17	5.81	0.08	0.07	
1.2	6.2	20,894	5.19	5.96	6.11	5.76	0.24	0.09	
1.3	6.2	22,784	5.09	5.90	6.05	5.70	0.30	0.15	
1.4	6.1	24,658	4.99	5.84	5.99	5.65	0.26	0.11	
1.5	6.1	26,518	4.89	5.78	5.93	5.59	0.32	0.17	
1.6	6.1	28,377	4.79	5.72	5.87	5.53	0.38	0.23	
1.7	6.0	30,221	4.69	5.66	5.81	5.47	0.34	0.19	
1.8	5.9	32,034	4.59	5.60	5.75	5.42	0.30	0.15	
1.9	6.0	33,848	4.49	5.54	5.68	5.36	0.46	0.32	
2.0	6.0	35,677	4.39	5.48	5.62	5.30	0.52	0.38	
2.1	6.0	37,506	4.29	5.42	5.56	5.24	0.58	0.44	
2.2	5.9	39,319	4.19	5.35	5.49	5.17	0.55	0.41	
2.3	5.9	41,118	4.09	5.29	5.43	5.11	0.61	0.47	
2.4	5.8	42,901	3.99	5.22	5.36	5.05	0.58	0.44	
2.5	5.5	44,623	3.89	5.16	5.29	4.99	0.34	0.21	
2.6	5.4	46,284	3.79	5.09	5.22	4.92	0.31	0.18	
2.7	5.4	47,930	3.69	5.02	5.15	4.86	0.38	0.25	
2.8	5.3	49,560	3.59	4.96	5.08	4.79	0.34	0.22	
2.9	5.2	51,161	3.49	4.89	5.01	4.72	0.31	0.19	
3.0	5.0	52,715	3.39	4.82	4.94	4.65	0.18	0.06	
3.1	4.9	54,224	3.29	4.74	4.87	4.59	0.16	0.03	
3.2	4.8	55,702	3.19	4.67	4.79	4.51	0.13	0.01	
3.3	4.7	57,150	3.09	4.60	4.72	4.44	0.10	0.02	
3.4	4.6	58,567	2.99	4.52	4.64	4.37	0.08	0.04	
3.5	4.5	59,954	2.89	4.45	4.56	4.30	0.05	0.06	
3.6	4.3	61,295	2.79	4.37	4.48	4.22	-0.07	0.18	
3.7	4.4	62,621	2.69	4.29	4.40	4.15	0.11	0.00	
3.8	4.3	63,947	2.59	4.21	4.32	4.07	0.09	0.02	
3.9	4.2	65,242	2.49	4.13	4.23	3.99	0.07	0.03	
4.0	4.1	66,507	2.39	4.04	4.15	3.91	0.06	0.05	
4.1	4.0	67,742	2.29	3.96	4.06	3.83	0.04	0.06	
4.2	4.0	68,961	2.19	3.87	3.97	3.74	0.13	0.03	
4.3	3.9	70,165	2.09	3.78	3.88	3.65	0.12	0.02	
4.4	3.8	71,338	1.99	3.69	3.78	3.57	0.11	0.02	
4.5	3.9	72,512	1.89	3.60	3.69	3.48	0.30	0.21	
4.6	3.9	73,701	1.79	3.50	3.59	3.38	0.40	0.31	
4.7	3.7	74,859	1.69	3.40	3.49	3.29	0.30	0.21	
4.8	3.6	75,971	1.59	3.30	3.38	3.19	0.30	0.22	
4.9	3.5	77,053	1.49	3.19	3.27	3.09	0.31	0.23	
5.0	3.3	78,090	1.39	3.08	3.16	2.98	0.22	0.14	
5.1	3.1	79,065	1.29	2.97	3.05	2.87	0.13	0.05	
5.2	2.8	79,964	1.19	2.85	2.93	2.76	-0.05	0.13	
5.3	2.9	80,833	1.09	2.73	2.80	2.64	0.17	0.10	
5.4	2.6	81,671	0.99	2.60	2.67	2.52	0.00	0.07	
5.5	2.5	82,448	0.89	2.47	2.53	2.38	0.03	0.03	
5.6	2.3	83,180	0.79	2.32	2.38	2.25	-0.02	0.08	
5.7	2.1	83,850	0.69	2.17	2.23	2.10	-0.07	0.13	
5.8	1.9	84,460	0.59	2.01	2.06	1.94	-0.11	0.16	
5.9	1.7	85,009	0.49	1.83	1.88	1.77	-0.13	0.18	
6.0	1.5	85,496	0.39	1.63	1.68	1.58	-0.13	0.18	

Flow rate - Check

Duration	0:26	hr:min
Volume	86938.104	cm^3
	5305.28861	inch^3
	22.9650225	gallons
Flow rate	0.88	gallons/min



Panel	Station	Distance (m)	Moisture	Note
1	T	0.15	103.9%	
1	M	0.6096	96.2%	
1	B	1.0692	97.1%	
2	T	1.3692	101.3%	
2	M	1.8288	104.8%	
2	B	2.2884	97.3%	
3	T	2.5884	96.8%	
3	M	3.048	99.3%	
3	B	3.5076	96.8%	
4	T	3.8076	96.2%	
4	M	4.2672	95.9%	
4	B	4.7268	93.8%	
5	T	5.0268	93.5%	
5	M	5.4864	93.4%	
5	B	5.946	94.2%	
6	T	6.246	95.4%	
6	M	6.246	95.4%	



Flume profile - 46.1% solids

Water content and percent solids determination

JOB #	1663241.9000.9005
DATE:	8/23/2019

SAMPLE/MODULE ID	Mod 1			Mod 2			
MODULE STATION (Top -> Mid -> Bot)	Top	Middle	Bottom	Top	Middle	Bottom	
VERT. LOCATION (Up/Center/Low)							
TARE	WU-10	JW-18	CATA	FEE	A7X	ROB-1	
WET WEIGHT + TARE, g	346.35	337.27	305.18	331.81	331.45	319.53	
DRY WEIGHT + TARE, g	235.69	235.29	217.83	225.61	226.35	226.26	
TARE WEIGHT, g	129.17	129.23	127.87	120.79	126.04	130.44	
MOISTURE CONTENT, %	**103.9%**	**96.2%**	**97.1%**	**101.3%**	**104.8%**	**97.3%**	-
WEIGHT OF SOLIDS, g	106.52	106.06	89.96	104.82	100.31	95.82	-
WEIGHT OF WATER, g	110.66	101.98	87.35	106.20	105.10	93.27	-
PERCENT SOLIDS	**49.0%**	**51.0%**	**50.7%**	**49.7%**	**48.8%**	**50.7%**	-

SAMPLE/MODULE ID	Mod 3			Mod 4			
MODULE STATION (Top -> Mid -> Bot)	Top	Middle	Bottom	Top	Middle	Bottom	
VERT. LOCATION (Up/Center/Low)							
TARE	TDM-2	MOE	SCI	STS9	B52	X-25	
WET WEIGHT + TARE, g	340.34	338.39	345.09	323.95	370.38	362.38	
DRY WEIGHT + TARE, g	236.48	231.84	236.67	227.17	259.74	256.76	
TARE WEIGHT, g	129.16	124.50	124.70	126.56	144.36	144.13	
MOISTURE CONTENT, %	**96.8%**	**99.3%**	**96.8%**	**96.2%**	**95.9%**	**93.8%**	-
WEIGHT OF SOLIDS, g	107.32	107.34	111.97	100.61	115.38	112.63	-
WEIGHT OF WATER, g	103.86	106.55	108.42	96.78	110.64	105.62	-
PERCENT SOLIDS	**50.8%**	**50.2%**	**50.8%**	**51.0%**	**51.0%**	**51.6%**	-

SAMPLE/MODULE ID	Mod 5			Mod 6			
MODULE STATION (Top -> Mid -> Bot)	Top	Middle	Bottom	Top	Middle	Bottom	
VERT. LOCATION (Up/Center/Low)							
TARE	S-1	PVD	OX-1	LR-1			
WET WEIGHT + TARE, g	375.40	317.42	236.30	179.01			
DRY WEIGHT + TARE, g	263.52	231.86	175.41	145.18			
TARE WEIGHT, g	143.85	140.28	110.77	109.73			
MOISTURE CONTENT, %	**93.5%**	**93.4%**	**94.2%**	**95.4%**	-	-	-
WEIGHT OF SOLIDS, g	119.67	91.58	64.64	35.45	-	-	-
WEIGHT OF WATER, g	111.88	85.56	60.89	33.83	-	-	-
PERCENT SOLIDS	**51.7%**	**51.7%**	**51.5%**	**51.2%**	-	-	-

SAMPLE/MODULE ID							
MODULE STATION (Top -> Mid -> Bot)							
VERT. LOCATION (Up/Center/Low)							
TARE							
WET WEIGHT + TARE, g							
DRY WEIGHT + TARE, g							
TARE WEIGHT, g							
MOISTURE CONTENT, %	-	-	-	-	-	-	-
WEIGHT OF SOLIDS, g	-	-	-	-	-	-	-
WEIGHT OF WATER, g	-	-	-	-	-	-	-
PERCENT SOLIDS	-	-	-	-	-	-	-

SAMPLE/MODULE ID							
MODULE STATION (Top -> Mid -> Bot)							
VERT. LOCATION (Up/Center/Low)							
TARE							
WET WEIGHT + TARE, g							
DRY WEIGHT + TARE, g							
TARE WEIGHT, g							
MOISTURE CONTENT, %	-	-	-	-	-	-	-
WEIGHT OF SOLIDS, g	-	-	-	-	-	-	-
WEIGHT OF WATER, g	-	-	-	-	-	-	-
PERCENT SOLIDS	-	-	-	-	-	-	-

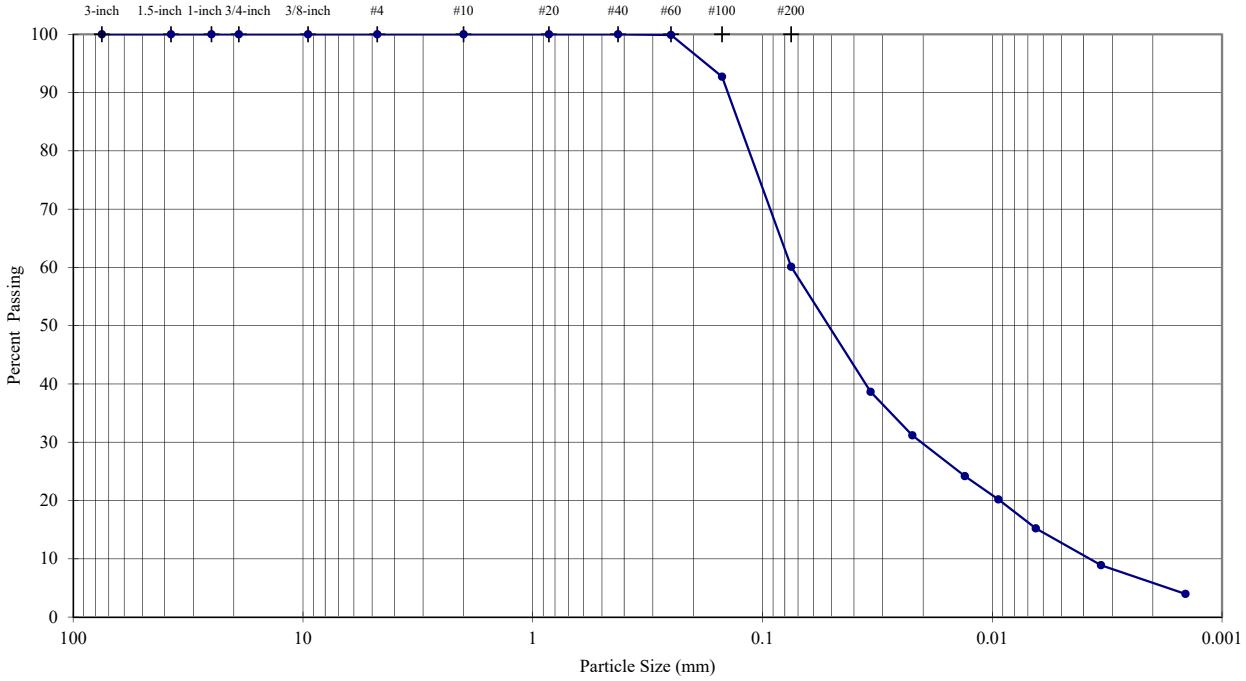
GOLDER

September-19 **1663241.9000.9005**

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

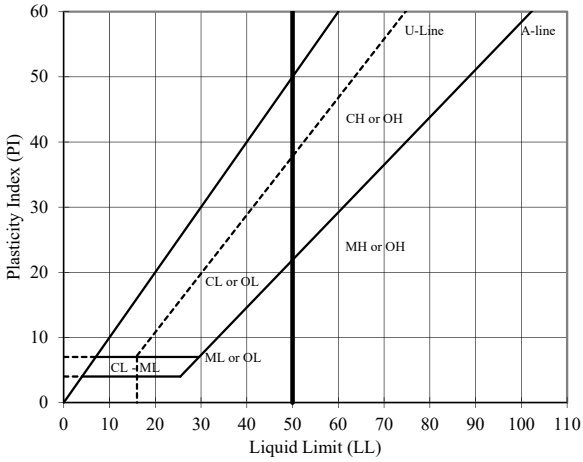
PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 & 2 Composite - "Beach"** DEPTH (ft): **--**
TYPE: **Bulk**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.00**
#40	0.425	**100.0**		
#60	0.250	**99.9**	Fine Sand	**39.90**
#100	0.150	**92.7**		
#200	0.075	**60.1**		
	0.034	**38.6**	Silt or Clay Fines	**60.10**
	0.022	**31.2**		
	0.013	**24.2**		
	0.009	**20.2**		
	0.006	**15.2**		
	0.003	**8.9**		
	0.001	**4.0**		

Sieve Analysis (Initial Separation on No. 4 Sieve)

Hydrometer Analysis



USCS Description (ASTM D 2487):

Sandy silt, light gray, dry

LL	PL	PI	SpG
NP	**NP**	**NP**	**2.64**

As-Received Moisture Content (%): **103.9**

USCS Group Symbol: ML

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	PRH
DATE	11-Sep-2019
REVIEW	MB

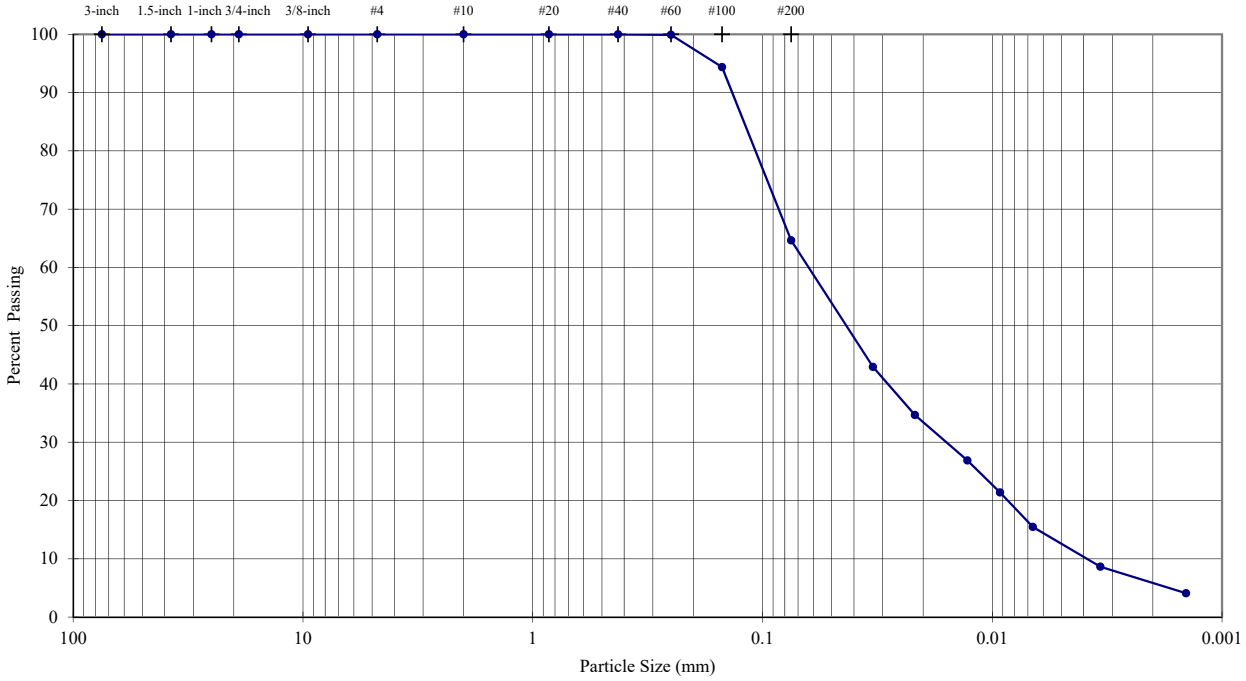
GOLDER

September-19 1663241.9000.9005

PARTICLE SIZE DISTRIBUTION & ATTERBERG LIMITS

ASTM D421, D422, D4318

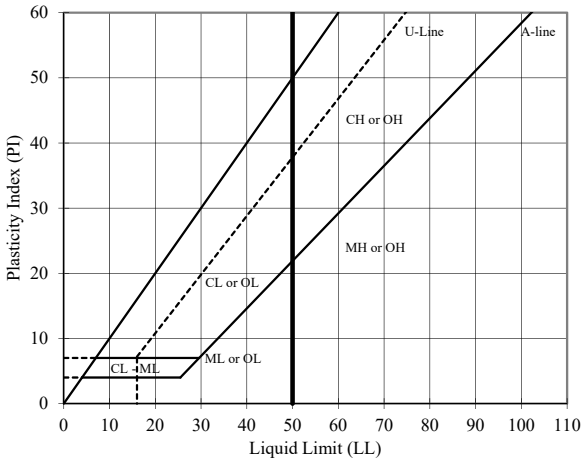
PROJECT NAME: **Grassy Mtn PFS/OR**
SAMPLE ID: **GMTC-1 & 2 Composite - "Slimes"** DEPTH (ft): **--**
TYPE: **Bulk**



Sieve	Particle Size (mm)	% Passing	Description	Percentage
3-inch	75.0	**100.0**		
1.5-inch	37.5	**100.0**	Coarse Gravel	**0.00**
1-inch	25.0	**100.0**		
3/4-inch	19.0	**100.0**		
3/8-inch	9.5	**100.0**	Fine Gravel	**0.00**
#4	4.75	**100.0**		
#10	2.00	**100.0**	Coarse Sand	**0.00**
#20	0.850	**100.0**	Medium Sand	**0.02**
#40	0.425	**100.0**		
#60	0.250	**99.9**		
#100	0.150	**94.4**	Fine Sand	**35.35**
#200	0.075	**64.6**		
	0.033	**42.9**		
	0.022	**34.7**		
	0.013	**26.9**		
	0.009	**21.4**	Silt or Clay Fines	**64.64**
	0.007	**15.5**		
	0.003	**8.6**		
	0.001	**4.1**		

Sieve Analysis (Initial Separation on No. 4 Sieve)

Hydrometer Analysis



USCS Description (ASTM D 2487):

Sandy silt, light gray, dry

LL	PL	PI	SpG
NP	**NP**	**NP**	**2.66**

As-Received Moisture Content (%): **94.6**

USCS Group Symbol: ML

Notes: 0 g of particles up to 4.75 mm maximum size were removed from particle size analysis sample prior to testing
Particle size analysis sample mechanically dispersed using Stirring Apparatus A for about 1 minute
Sample prepared for Atterberg Limits testing by the dry method
Material retained on No. 40 sieve removed from Atterberg Limits sample by sieving
Plastic Limit test performed by hand rolling. Method A Liquid Limit test performed using mechanical device

TECH	PRH
DATE	10-Sep-2019
REVIEW	MB

	Initial	Final		
Length =	5.424	3.243	cm	Approximately
Diameter =	7.100	7.100	cm	
Wet Mass =	400.82	248.55	g	
Area =	39.59	39.59	cm^2	
Volume =	214.75	128.40	cm^3	
Moisture Content =	104.7%	27.6%		
Specific Gravity =	2.64	2.64	(ASTM D854)	
Dry Mass of Solids =	195.81	194.79	g	
Density =	1.87	1.94	g/cm^3	
Dry Density =	0.91	1.52	g/cm^3	
Unit Weight =	116.5	120.8	lb/ft^3	
Dry Unit Weight =	56.9	94.7	lb/ft^3	
Solids Content =	48.9%	78.4%		

Piston Pressure:	7.0 psi	492.2 g/cm^2	Piston Pressure:	10.0 psi	703.1 g/cm^2	Piston Pressure:	15.0 psi	1,054.6 g/cm^2	Piston Pressure:	25.0 psi	1,757.7 g/cm^2	Piston Pressure:	45.0 psi	3,163.8 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**2.0 psi**	140.6 g/cm^2	Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2	Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2	Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2	Consolidation Pressure:	**40.0 psi**	2,812.3 g/cm^2
Before Consolidation			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**		
Initial Sample Height:	5.424	cm	Initial Sample Height:	3.890	cm	Initial Sample Height:	3.843	cm	Initial Sample Height:	3.758	cm	Initial Sample Height:	3.588	cm
Initial Dry Unit Weight:	0.91	g/cm^3	Initial Dry Unit Weight:	1.26	g/cm^3	Initial Dry Unit Weight:	1.28	g/cm^3	Initial Dry Unit Weight:	1.31	g/cm^3	Initial Dry Unit Weight:	1.37	g/cm^3
Initial Void Ratio:	1.90		Initial Void Ratio:	1.09		Initial Void Ratio:	1.06		Initial Void Ratio:	1.02		Initial Void Ratio:	0.93	
After Consolidation			**After Consolidation**			**After Consolidation**			**After Consolidation**			**After Consolidation**		
Final Sample Height:	3.890	cm	Final Sample Height:	3.843	cm	Final Sample Height:	3.758	cm	Final Sample Height:	3.588	cm	Final Sample Height:	3.451	cm
Final Dry Unit Weight:	1.26	g/cm^3	Final Dry Unit Weight:	1.28	g/cm^3	Final Dry Unit Weight:	1.31	g/cm^3	Final Dry Unit Weight:	1.37	g/cm^3	Final Dry Unit Weight:	1.43	g/cm^3
Final Void Ratio:	1.09		Final Void Ratio:	1.06		Final Void Ratio:	1.02		Final Void Ratio:	0.93		Final Void Ratio:	0.85	
Calculations			**Calculations**			**Calculations**			**Calculations**			**Calculations**		
Coefficient of Compressibility, a_v	5.75E-03	cm^2/g	Coefficient of Compressibility, a_v	1.20E-04	cm^2/g	Coefficient of Compressibility, a_v	1.30E-04	cm^2/g	Coefficient of Compressibility, a_v	1.30E-04	cm^2/g	Coefficient of Compressibility, a_v	5.23E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.98E-03	cm^2/g	Coefficient of Volume Compressibility, m_v	5.73E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	6.29E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	6.43E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	2.72E-05	cm^2/g
Compression Index, C_c	-		Compression Index, C_c	0.06		Compression Index, C_c	0.15		Compression Index, C_c	0.30		Compression Index, C_c	0.24	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
2.4	9.4E-05	4.73E-02	5.1	2.1E-05	3.70E-01	2.8	2.4E-05	3.74E-01	4.0	1.5E-05	2.40E-01	5.3	1.1E-05	4.18E-01
4.6	7.0E-05	3.50E-02	9.0	1.8E-05	3.11E-01	6.2	1.7E-05	2.72E-01	8.4	1.2E-05	1.88E-01	10.6	9.1E-06	3.37E-01
8.6	5.5E-05	2.78E-02	13.8	1.6E-05	2.86E-01	10.3	1.5E-05	2.40E-01	13.6	1.1E-05	1.70E-01	17.3	8.3E-06	3.05E-01
11.5	4.8E-05	2.44E-02	16.9	1.6E-05	2.75E-01	15.7	1.4E-05	2.23E-01	20.4	1.0E-05	1.60E-01	25.8	7.8E-06	2.89E-01
14.1	4.4E-05	2.24E-02	20.6	1.5E-05	2.69E-01	19.0	1.4E-05	2.18E-01	24.6	1.0E-05	1.57E-01	31.1	7.7E-06	2.83E-01
18.2	4.0E-05	2.01E-02	25.2	1.5E-05	2.64E-01	22.9	1.4E-05	2.15E-01	29.6	1.0E-05	1.56E-01	37.4	7.6E-06	2.80E-01
			31.6	1.5E-05	2.60E-01	27.9	1.3E-05	2.13E-01	36.3	9.8E-06	1.53E-01	45.3	7.6E-06	2.79E-01
			37.2	1.5E-05	2.57E-01	34.6	1.3E-05	2.12E-01	44.5	9.9E-06	1.54E-01	56.4	7.5E-06	2.77E-01
			42.6	1.5E-05	2.53E-01	40.6	1.3E-05	2.10E-01	51.7	9.9E-06	1.54E-01	64.9	7.6E-06	2.79E-01
			51.4	1.4E-05	2.44E-01	45.9	1.3E-05	2.09E-01	57.9	1.0E-05	1.55E-01	73.1	7.6E-06	2.80E-01
						53.6	1.3E-05	2.09E-01	66.8	1.0E-05	1.56E-01	86.7	7.5E-06	2.74E-01
Average (of final 3 values)	4.43E-05	2.23E-02	Average (of final 3 values)	1.44E-05	2.52E-01	Average (of final 3 values)	1.32E-05	2.09E-01	Average (of final 3 values)	9.98E-06	1.55E-01	Average (of final 3 values)	7.54E-06	2.78E-01

Golder Associates Inc. **Denver, Colorado**	**Title:** **SLURRY CONSOLIDATION TEST** **SAMPLE DATA AND CALCULATIONS**		
Job Short Title: MDA/Grassy Mtn PFS/OR			
Sample No. Comp GMTC 1&2 Flume Beach	**Reviewed:** GG	**Date:** 25-Sep-2019	**Job Number:** 1663241.9000.9005	**Figure:** 1A

	Initial	Final	
Length =	5.424	3.243	cm
Diameter =	7.100	7.100	cm
Wet Mass =	400.82	248.55	g
Area =	39.59	39.59	cm^2
Volume =	214.75	128.40	cm^3
Moisture Content =	104.7%	27.6%	
Specific Gravity =	2.64	2.64	(ASTM D854)
Dry Mass of Solids =	195.81	194.79	g
Density =	1.87	1.94	g/cm^3
Dry Density =	0.91	1.52	g/cm^3
Unit Weight =	116.5	120.8	lb/ft^3
Dry Unit Weight =	56.9	94.7	lb/ft^3
Solids Content =	48.9%	78.4%	

Piston Pressure:	95.0 psi	6,679.2 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**90.0 psi**	6,327.7 g/cm^2
Before Consolidation		
Initial Sample Height:	3.451	cm
Initial Dry Unit Weight:	1.43	g/cm^3
Initial Void Ratio:	0.85	
After Consolidation		
Final Sample Height:	3.283	cm
Final Dry Unit Weight:	1.50	g/cm^3
Final Void Ratio:	0.76	
Calculations		
Coefficient of Compressibility, a_v	2.56E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.38E-05	cm^2/g
Compression Index, C_c	0.26	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
7.2	7.9E-06	5.70E-01
14.3	6.5E-06	4.66E-01
23.3	5.9E-06	4.23E-01
34.7	5.6E-06	4.01E-01
41.9	5.4E-06	3.93E-01
50.3	5.4E-06	3.90E-01
60.9	5.4E-06	3.87E-01
75.3	5.3E-06	3.86E-01
86.9	5.4E-06	3.89E-01
Average (of final 3 values)	5.37E-06	3.87E-01

Piston Pressure:	195.0 psi	13,710.0 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**190.0 psi**	13,358.5 g/cm^2
Before Consolidation		
Initial Sample Height:	3.283	cm
Initial Dry Unit Weight:	1.50	g/cm^3
Initial Void Ratio:	0.76	
After Consolidation		
Final Sample Height:	3.162	cm
Final Dry Unit Weight:	1.56	g/cm^3
Final Void Ratio:	0.70	
Calculations		
Coefficient of Compressibility, a_v	9.23E-06	cm^2/g
Coefficient of Volume Compressibility, m_v	5.24E-06	cm^2/g
Compression Index, C_c	0.20	

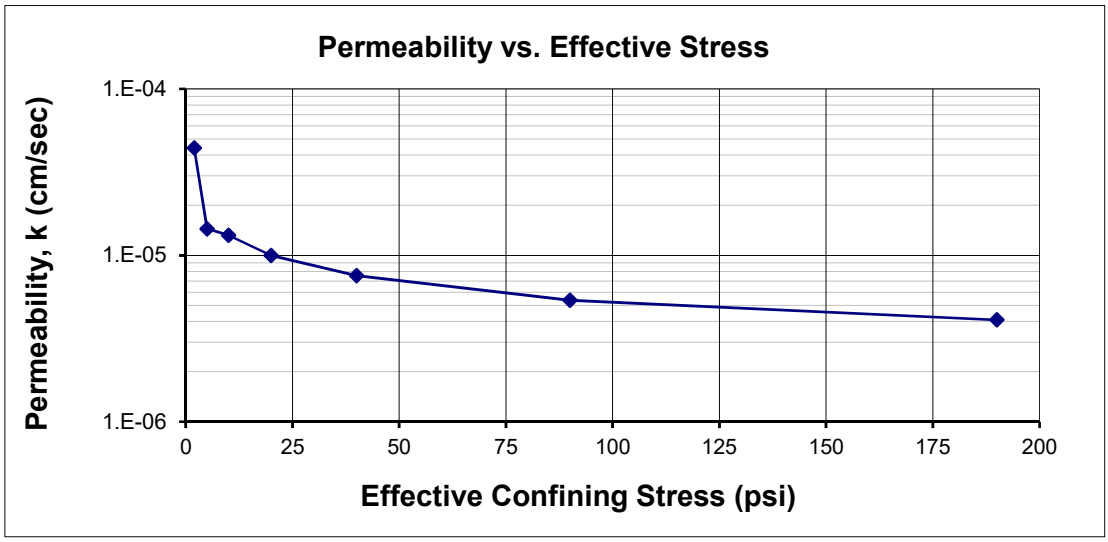
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
10.3	5.3E-06	1.01E+00
19.3	4.6E-06	8.82E-01
30.3	4.3E-06	8.28E-01
36.9	4.2E-06	8.10E-01
44.3	4.2E-06	7.99E-01
53.3	4.1E-06	7.86E-01
63.6	4.1E-06	7.83E-01
71.4	4.1E-06	7.78E-01
77.1	4.1E-06	7.77E-01
86.7	4.1E-06	7.81E-01
94.5	4.1E-06	7.83E-01
Average (of final 3 values)	4.09E-06	7.80E-01

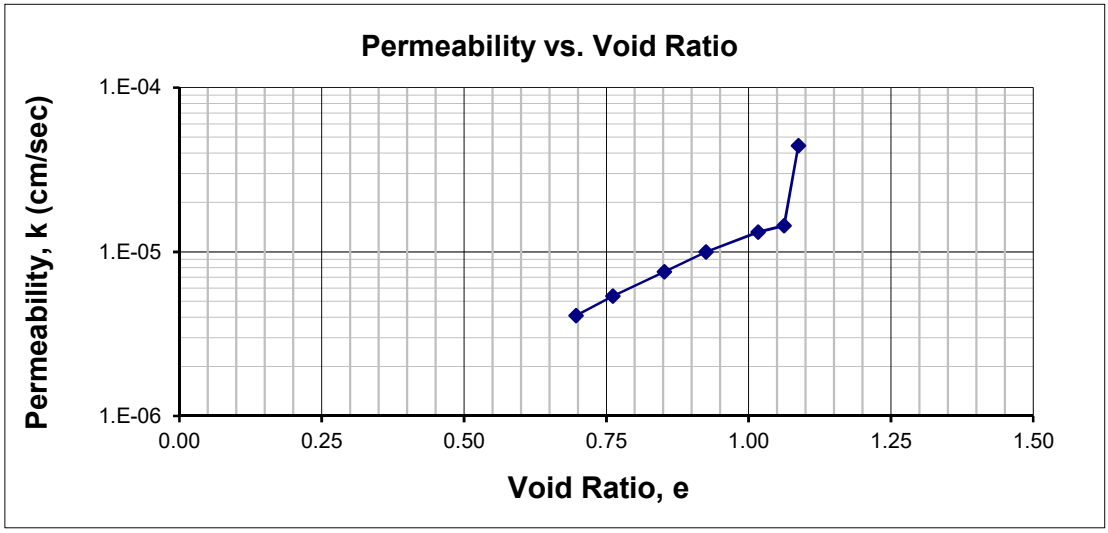
Golder Associates Inc.
Denver, Colorado

Job Short Title:
MDA/Grassy Mtn PFS/OR

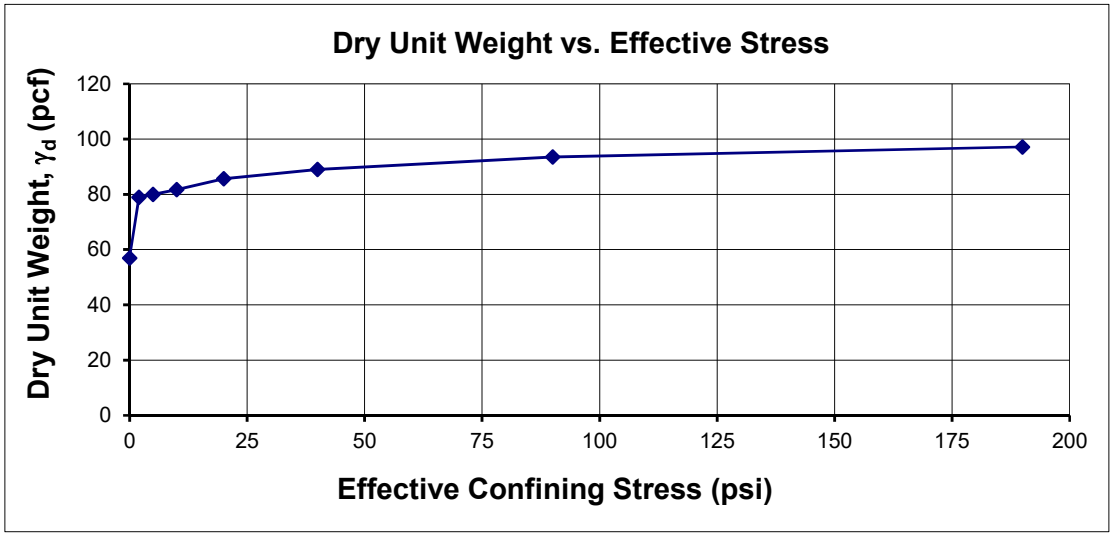
Title:
SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

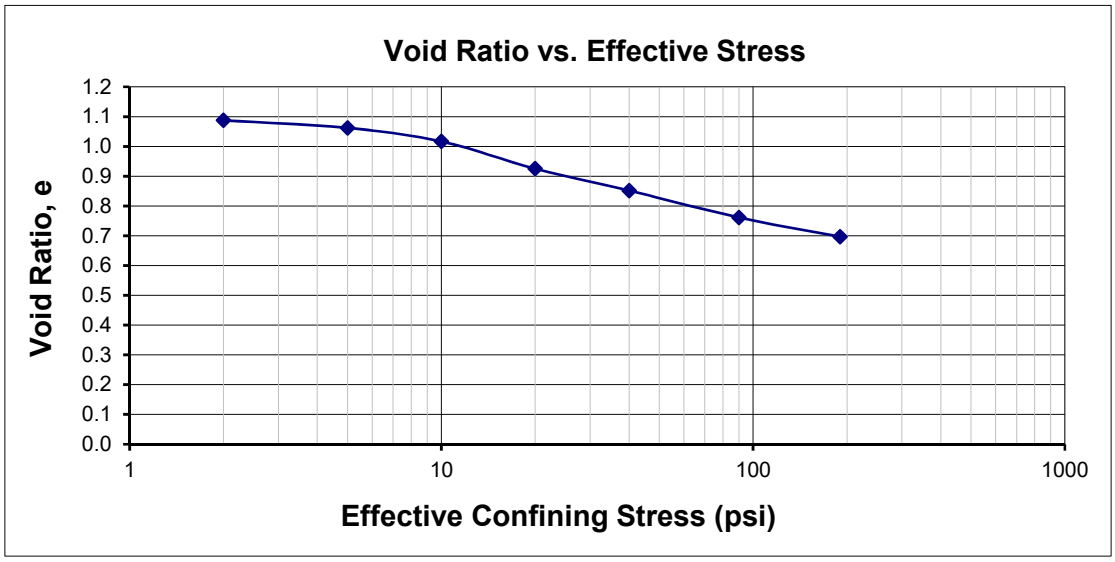
Sample No.	Reviewed:	Date:	Job Number:	Figure:
Comp GMTC 1&2 Flume Beach	GG	25-Sep-2019	1663241.9000.9005	1B



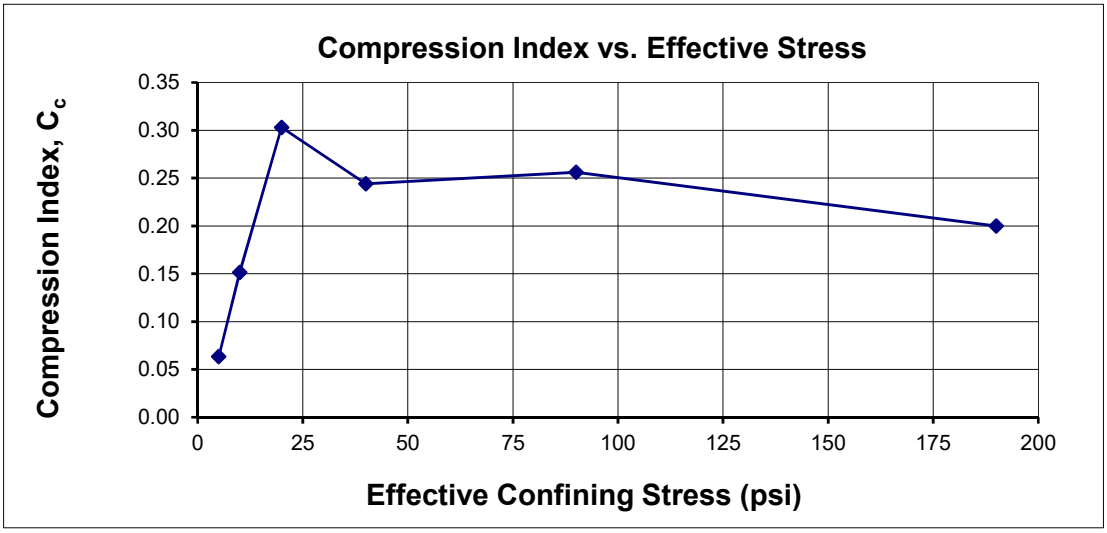


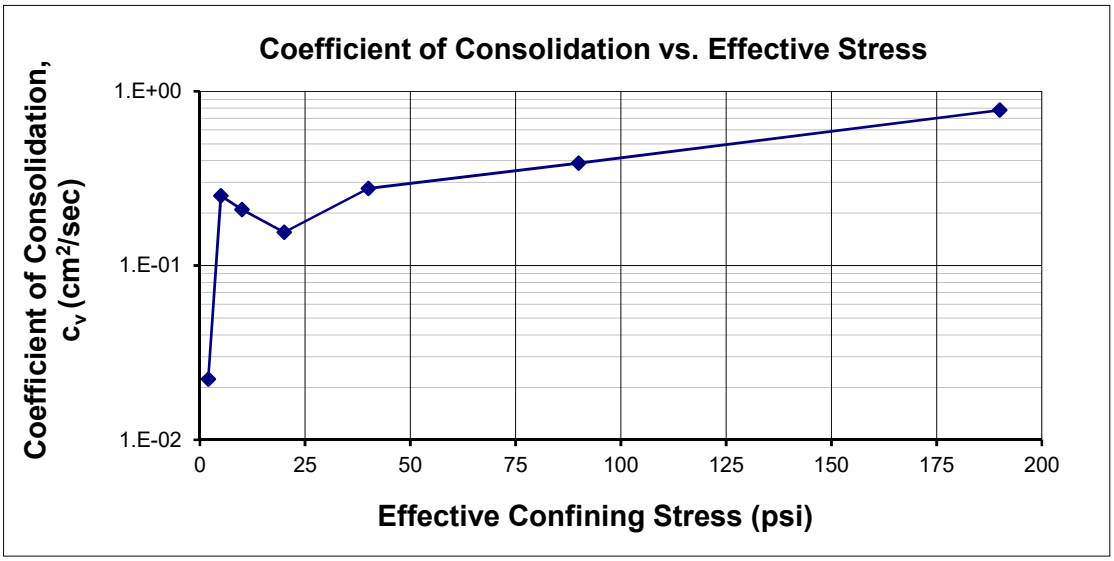
Golder Associates Inc. Denver, Colorado				Title: SLURRY CONSOLIDATION TEST RESULTS PERMEABILITY DATA
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No.	**Reviewed:**	**Date:**	**Job Number:**	**Figure:**
Comp GMTC 1&2 Flume Beach	GG	25-Sep-2019	1663241.9000.9005	2





Golder Associates Inc. **Denver, Colorado**			**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**	
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No. Comp GMTC 1&2 Flume Beach	**Reviewed:** GG	**Date:** 25-Sep-2019	**Job Number:** 1663241.9000.9005	**Figure:** 3





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **COMPRESSION DATA**		
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No. Comp GMTC 1&2 Flume Beach	**Reviewed:** GG	**Date:** 25-Sep-2019	**Job Number:** 1663241.9000.9005	**Figure:** 4

	Initial	Final	
Length =	6.087	3.498	cm
Diameter =	7.100	7.100	cm
Wet Mass =	411.00	269.57	g
Area =	39.59	39.59	cm^2
Volume =	241.00	138.49	cm^3
Moisture Content =	94.7%	27.9%	
Specific Gravity =	2.66	2.66	(ASTM D854)
Dry Mass of Solids =	211.09	210.77	g
Density =	1.71	1.95	g/cm^3
Dry Density =	0.88	1.52	g/cm^3
Unit Weight =	106.5	121.5	lb/ft^3
Dry Unit Weight =	54.7	95.0	lb/ft^3
Solids Content =	51.4%	78.2%	

Approximately 34.9 grams of supernatant water removed from test specimen prior to beginning test.

Piston Pressure:	6.0 psi	421.8 g/cm^2	Piston Pressure:	10.0 psi	703.1 g/cm^2	Piston Pressure:	15.0 psi	1,054.6 g/cm^2	Piston Pressure:	25.0 psi	1,757.7 g/cm^2	Piston Pressure:	45.0 psi	3,163.8 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2	Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**1.0 psi**	70.3 g/cm^2	Consolidation Pressure:	**5.0 psi**	351.5 g/cm^2	Consolidation Pressure:	**10.0 psi**	703.1 g/cm^2	Consolidation Pressure:	**20.0 psi**	1,406.2 g/cm^2	Consolidation Pressure:	**40.0 psi**	2,812.3 g/cm^2
Before Consolidation			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**			**Before Consolidation**		
Initial Sample Height:	6.087	cm	Initial Sample Height:	4.176	cm	Initial Sample Height:	4.067	cm	Initial Sample Height:	3.985	cm	Initial Sample Height:	3.848	cm
Initial Dry Unit Weight:	0.88	g/cm^3	Initial Dry Unit Weight:	1.27	g/cm^3	Initial Dry Unit Weight:	1.31	g/cm^3	Initial Dry Unit Weight:	1.34	g/cm^3	Initial Dry Unit Weight:	1.38	g/cm^3
Initial Void Ratio:	2.04		Initial Void Ratio:	1.09		Initial Void Ratio:	1.03		Initial Void Ratio:	0.99		Initial Void Ratio:	0.92	
After Consolidation			**After Consolidation**			**After Consolidation**			**After Consolidation**			**After Consolidation**		
Final Sample Height:	4.176	cm	Final Sample Height:	4.067	cm	Final Sample Height:	3.985	cm	Final Sample Height:	3.848	cm	Final Sample Height:	3.724	cm
Final Dry Unit Weight:	1.27	g/cm^3	Final Dry Unit Weight:	1.31	g/cm^3	Final Dry Unit Weight:	1.34	g/cm^3	Final Dry Unit Weight:	1.38	g/cm^3	Final Dry Unit Weight:	1.43	g/cm^3
Final Void Ratio:	1.09		Final Void Ratio:	1.03		Final Void Ratio:	0.99		Final Void Ratio:	0.92		Final Void Ratio:	0.86	
Calculations			**Calculations**			**Calculations**			**Calculations**			**Calculations**		
Coefficient of Compressibility, a_v	1.35E-02	cm^2/g	Coefficient of Compressibility, a_v	1.94E-04	cm^2/g	Coefficient of Compressibility, a_v	1.17E-04	cm^2/g	Coefficient of Compressibility, a_v	9.74E-05	cm^2/g	Coefficient of Compressibility, a_v	4.41E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	4.45E-03	cm^2/g	Coefficient of Volume Compressibility, m_v	9.28E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	5.74E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	4.89E-05	cm^2/g	Coefficient of Volume Compressibility, m_v	2.29E-05	cm^2/g
Compression Index, C_c	-		Compression Index, C_c	0.08		Compression Index, C_c	0.14		Compression Index, C_c	0.23		Compression Index, C_c	0.21	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)	Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
3.3	2.7E-05	5.96E-03	6.0	1.4E-05	1.52E-01	7.0	1.2E-05	2.06E-01	8.7	9.2E-06	1.89E-01	11.1	7.0E-06	3.05E-01
9.9	1.5E-05	3.32E-03	13.0	1.1E-05	1.17E-01	14.6	9.5E-06	1.65E-01	17.4	7.7E-06	1.58E-01	21.6	6.0E-06	2.62E-01
13.8	1.3E-05	2.94E-03	17.6	1.0E-05	1.08E-01	19.3	8.9E-06	1.56E-01	22.5	7.4E-06	1.51E-01	28.0	5.8E-06	2.51E-01
18.5	1.2E-05	2.68E-03	22.1	9.7E-06	1.05E-01	24.2	8.7E-06	1.52E-01	28.4	7.2E-06	1.47E-01	34.8	5.7E-06	2.48E-01
24.4	1.1E-05	2.48E-03	27.9	9.4E-06	1.02E-01	30.9	8.3E-06	1.45E-01	35.6	7.0E-06	1.43E-01	43.9	5.5E-06	2.39E-01
30.4	1.1E-05	2.44E-03	34.6	9.3E-06	1.00E-01	38.0	8.3E-06	1.45E-01	43.7	7.0E-06	1.42E-01	54.6	5.4E-06	2.35E-01
39.9	1.0E-05	2.30E-03	43.8	9.1E-06	9.80E-02	48.3	8.1E-06	1.41E-01	55.2	6.8E-06	1.40E-01	69.1	5.3E-06	2.30E-01
54.2	9.7E-06	2.17E-03	57.7	8.8E-06	9.53E-02	62.6	8.0E-06	1.39E-01	70.7	6.8E-06	1.40E-01	89.5	5.2E-06	2.28E-01
Average (of final 3 values)	1.02E-05	2.30E-03	Average (of final 3 values)	9.08E-06	9.78E-02	Average (of final 3 values)	8.12E-06	1.42E-01	Average (of final 3 values)	6.87E-06	1.41E-01	Average (of final 3 values)	5.29E-06	2.31E-01

Golder Associates Inc.
Denver, Colorado

Title:
SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

Job Short Title:
MDA/Grassy Mtn PFS/OR

Sample No.	Reviewed:	Date:	Job Number:	Figure:
Comp GMTC 1&2 Flume Slimes	GG	25-Sep-2019	1663241.9000.9005	1A

	Initial	Final	
Length =	6.087	3.498	cm
Diameter =	7.100	7.100	cm
Wet Mass =	411.00	269.57	g
Area =	39.59	39.59	cm^2
Volume =	241.00	138.49	cm^3
Moisture Content =	94.7%	27.9%	
Specific Gravity =	2.66	2.66	(ASTM D854)
Dry Mass of Solids =	211.09	210.77	g
Density =	1.71	1.95	g/cm^3
Dry Density =	0.88	1.52	g/cm^3
Unit Weight =	106.5	121.5	lb/ft^3
Dry Unit Weight =	54.7	95.0	lb/ft^3
Solids Content =	51.4%	78.2%	

Piston Pressure:	95.0 psi	6,679.2 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**90.0 psi**	6,327.7 g/cm^2
Before Consolidation		
Initial Sample Height:	3.724	cm
Initial Dry Unit Weight:	1.43	g/cm^3
Initial Void Ratio:	0.86	
After Consolidation		
Final Sample Height:	3.571	cm
Final Dry Unit Weight:	1.49	g/cm^3
Final Void Ratio:	0.78	
Calculations		
Coefficient of Compressibility, a_v	2.17E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	1.17E-05	cm^2/g
Compression Index, C_c	0.22	

Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
14.4	5.2E-06	4.42E-01
28.0	4.4E-06	3.80E-01
36.1	4.3E-06	3.66E-01
45.0	4.2E-06	3.60E-01
56.6	4.1E-06	3.49E-01
69.5	4.1E-06	3.48E-01
88.4	4.0E-06	3.38E-01
Average (of final 3 values)	4.03E-06	3.45E-01

Piston Pressure:	195.0 psi	13,710.0 g/cm^2
Sample Pressure:	5.0 psi	351.5 g/cm^2
Consolidation pressure:	**190.0 psi**	13,358.5 g/cm^2
Before Consolidation		
Initial Sample Height:	3.571	cm
Initial Dry Unit Weight:	1.49	g/cm^3
Initial Void Ratio:	0.78	
After Consolidation		
Final Sample Height:	3.412	cm
Final Dry Unit Weight:	1.56	g/cm^3
Final Void Ratio:	0.70	
Calculations		
Coefficient of Compressibility, a_v	1.13E-05	cm^2/g
Coefficient of Volume Compressibility, m_v	6.33E-06	cm^2/g
Compression Index, C_c	0.24	

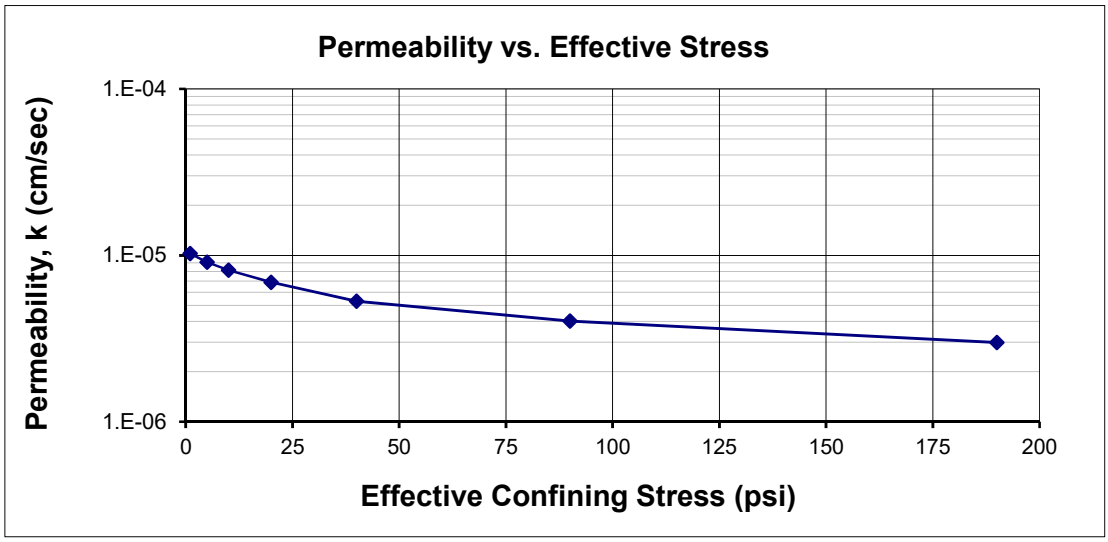
Δ Time (sec)	Permeability k (cm/sec)	Coefficient of Consolidation, c_v (cm^2/sec)
18.5	3.9E-06	6.09E-01
35.6	3.3E-06	5.28E-01
44.9	3.3E-06	5.19E-01
57.4	3.1E-06	4.97E-01
71.8	3.1E-06	4.85E-01
88.5	3.0E-06	4.81E-01
111.9	3.0E-06	4.71E-01
145.4	2.9E-06	4.65E-01
Average (of final 3 values)	2.99E-06	4.73E-01

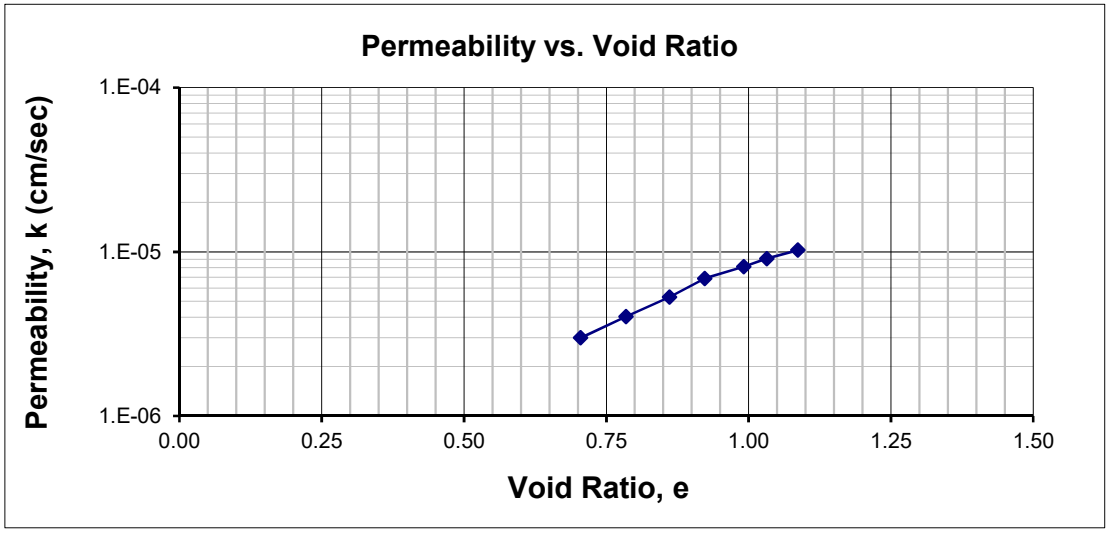
Golder Associates Inc.
Denver, Colorado

Job Short Title: MDA/Grassy Mtn PFS/OR

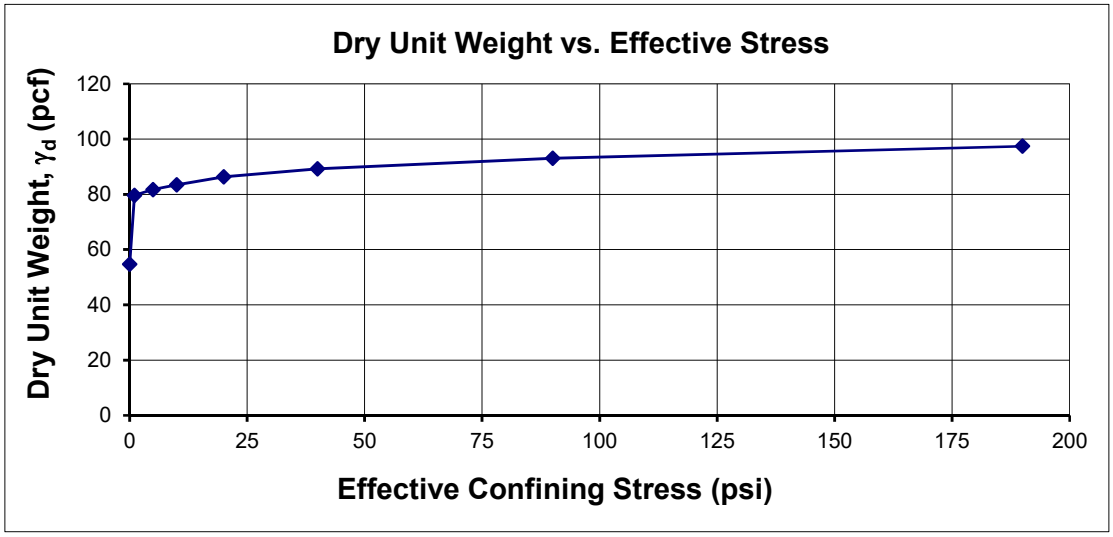
Title:
SLURRY CONSOLIDATION TEST
SAMPLE DATA AND CALCULATIONS

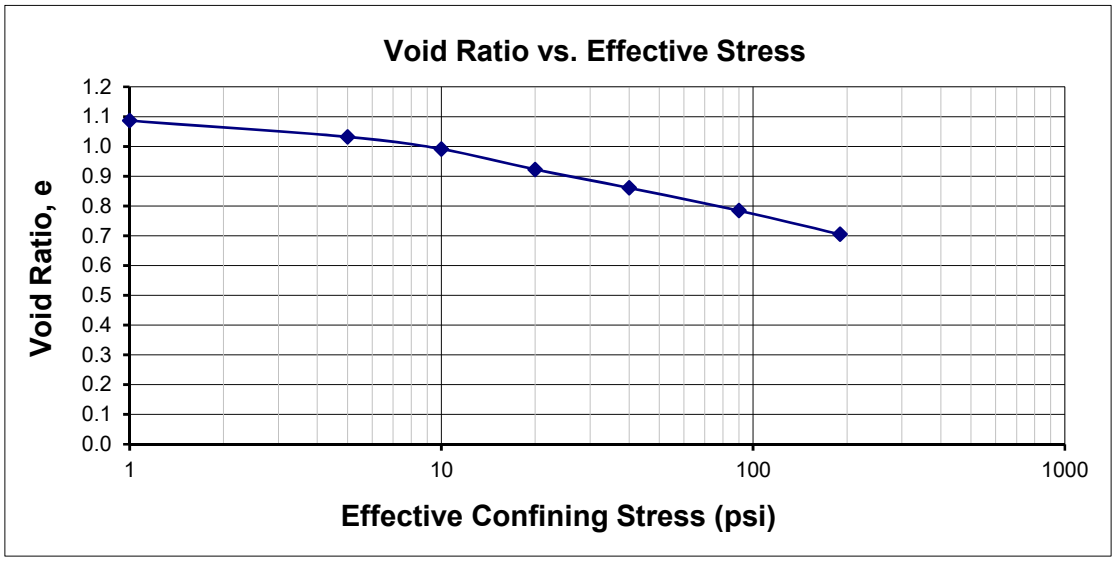
Sample No.	Reviewed:	Date:	Job Number:	Figure:
Comp GMTC 1&2 Flume Slimes	GG	25-Sep-2019	1663241.9000.9005	1B



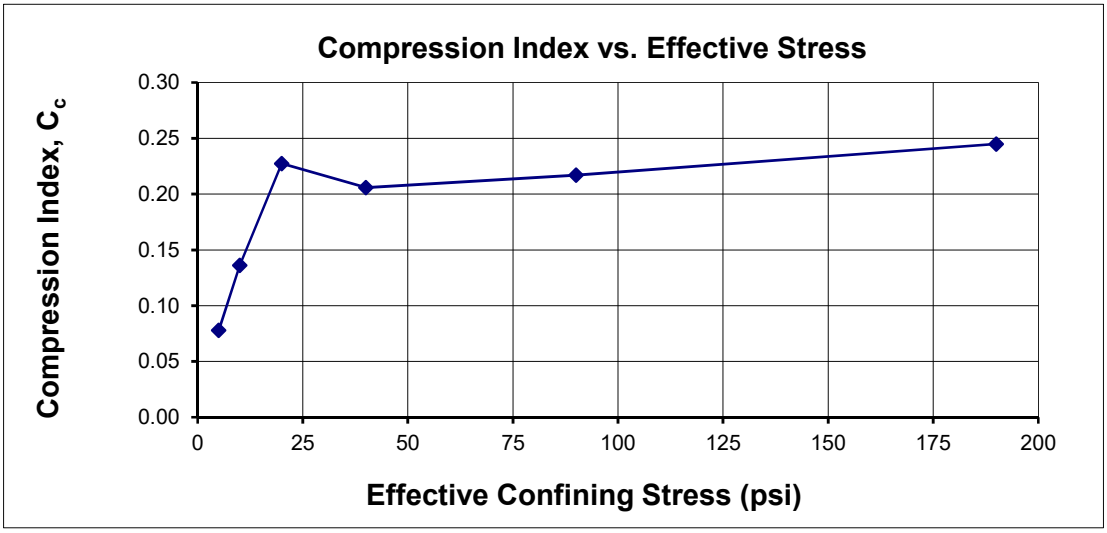


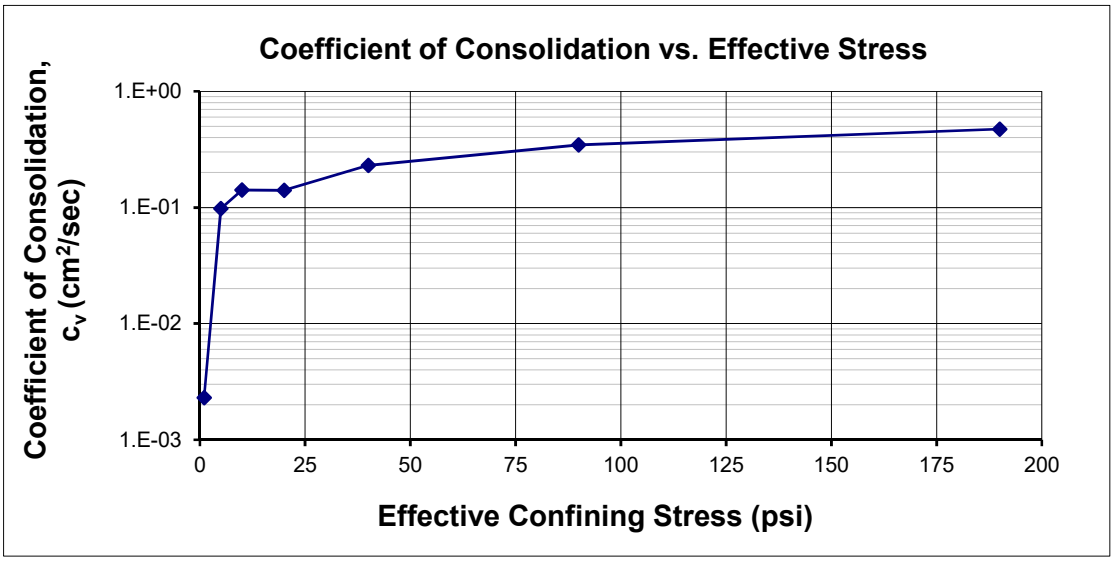
Golder Associates Inc. Denver, Colorado				Title: SLURRY CONSOLIDATION TEST RESULTS PERMEABILITY DATA
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No.	**Reviewed:**	**Date:**	**Job Number:**	**Figure:**
Comp GMTC 1&2 Flume Slimes	GG	25-Sep-2019	1663241.9000.9005	2





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **DENSITY DATA**		
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No. Comp GMTC 1&2 Flume Slimes	**Reviewed:** GG	**Date:** 25-Sep-2019	**Job Number:** 1663241.9000.9005	**Figure:** 3





Golder Associates Inc. **Denver, Colorado**		**Title:** **SLURRY CONSOLIDATION TEST RESULTS** **COMPRESSION DATA**		
Job Short Title: MDA/Grassy Mtn PFS/OR				
Sample No. Comp GMTC 1&2 Flume Slimes	**Reviewed:** GG	**Date:** 25-Sep-2019	**Job Number:** 1663241.9000.9005	**Figure:** 4

APPENDIX E

Lining System Evaluation

GOLDER

CALCULATIONS

DATE: Nov-19
PROJECT NO.: 1663241
SUBJECT: Lining System Comparison
PROJECT TITLE: Grassy Mountain TSF Detailed Design

Made by: CRL
Checked by: MDB
Reviewed by: CJM

1.0 Objectives

Compare performance of OAR 340-043-0130 with equivalent lining systems.

2.0 References

A. GSE BentoLiner NSL Geosynthetic Clay Liner, Product Data Sheet, GSE Environmental.
B. Cetco Bentomat CL, Product Data Sheet, Cetco

3.0 Calculations

3.1 Secondary Containment

The following table summarizes the performance of secondary containment alternative lining systems

Parameter	OAR Requirement	Standard GCL	Enhanced GCL
Secondary Containment Hydraulic Conductivity (cm/s)	1.00E-07	5.00E-09	5.00E-10
Soil Liner Thickness (cm)	91.44	0	0
GCL Thickness (cm)	0	0.6	0.75
Travel Time (sec)	9.16E+08	1.20E+08	1.50E+09
Travel Time (days)	**10,583**	**1,389**	**17,361**

3.2 Lining System Comparison (60 mil Liner)

The following table summarizes performance of equivalent lining systems with 60-mil liner (OAR Requirement).

Parameter	OAR Requirement	Standard GCL	Enhanced GCL
60-mil Geomembrane Liner Hydraulic Conductivity (cm/s)	1.00 E - 11		
Geomembrane Liner Thickness (cm)	0.15		
Secondary containment Hydraulic Conductivity (cm/s)	1.00E-07	5.00E-09	5.00E-10
Soil Liner Thickness	91.6	0	0
GCL Thickness (cm)	0	0.6	0.75
Travel Time (sec)	1.59E+10	1.51E+10	1.65E+10
Travel Time (Days)	**184,194**	**175,000**	**190,972**

3.3 Lining System Comparison (80 mil Liner)

The following table summarizes the performance of equivalent lining systems with 80 mil liner (exceeding the OAR requirement)

Parameter	OAR Requirement	Standard GCL	Enhanced GCL
80-mil Geomembrane Liner Hydraulic Conductivity (cm/s)	1.00E-11		
Geomembrane Liner Thickness (cm)	0.2		
Hydraulic Conductivity (cm/s)	1.00E-07	5.00E-09	5.00E-10
Soil Liner Thickness	91.6	0	0
GCL Thickness (cm)	0	0.6	0.75
Travel Time (sec)	2.09E+10	2.01E+10	2.15E+10
Travel Time (Days)	**242,065**	**232,870**	**248,843**

APPENDIX F

Water Balance

TECHNICAL MEMORANDUM

DATE November 6, 2019 **Project No.** 1663241-052-TM-Rev0

TO Christopher J. MacMahon, PE
Golder Associates Inc.

CC Russell A. Browne, PE (NV)

FROM Andrew Schaper, PE (NV) **EMAIL Aschaper@golder.com**

GRASSY MOUNTAIN TSF WATER BALANCE

1.0 INTRODUCTION

The purpose of the deterministic water balance model is to evaluate water management of the proposed Grassy Mountain Tailings Storage Facility (TSF) including:

- Predicting the volume of the supernatant pool located at the south boundary of the facility
- Sizing the Reclaim Pond at the base of the facility
- Estimating makeup water requirements
- Estimating return water flow rates from the supernatant pool to the mill
- Estimating return water flow rates from the underdrain pond to the mill

The water balance accounts for inflows and outflows to the process and tailings disposal system. Inflows include precipitation falling on lined facilities, runoff from an upstream basin reporting to the TSF, and fresh make-up water. Outflows include evaporation from the tailings surface and supernatant pool, and underdrain reclaim pond, and water lost in the void spaces of the stored tailings. For this analysis, only the process fluids within the TSF circuit were evaluated.

2.0 METHOD

Golder prepared the water balance model using Microsoft Excel spreadsheet software. The model approximates the circulation of fluids within the impoundment, underdrain reclaim pond, and mill, as well as the introduction of precipitation and evaporation as a function of time. The tailings impoundment and processing facilities are designed as zero discharge facilities to either surface water or ground water, so the impoundment liner was modeled as a no flow boundary. Golder evaluated the model for three climate scenarios which vary average monthly precipitation and evaporation: average year, 1:100 wet year, and 1:100 dry year. Each model was run from June 1, 2018 to April 30, 2031, which constitutes one realization and includes operations during Stage 1, 2, and 3.

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3.0 CLIMATE

For the climate portion of the model, Golder used regression analysis methods to predict average monthly precipitation using daily data from three nearby weather stations obtained from the Western Regional Climate Center (WRCC). Lake evaporation using the Combination Method of Penman was calculated using daily temperature, humidity, and wind speed from the Owyhee Ridge RAWS weather station. A detailed discussion and climate model development calculations are presented in Attachment A.

To obtain the one in one hundred (1:100) wet and dry year average monthly precipitation and lake evaporation values, a frequency analysis was performed on the annual precipitation and lake evaporation data from 1999 through 2017 and from 1999 through 2018, respectively. A three-parameter log-normal distribution was used to generate the extreme annual rates.

Table 1: Grassy Mountain Project Site Precipitation and Lake Evaporation Data

	Average Year Precipitation (in)	Average Year Lake Evaporation (in)	1:100 Wet Year Precipitation (in)	1:100 Wet Year Lake Evaporation (in)	1:100 Dry Year Precipitation (in)	1:100 Dry Year Lake Evaporation (in)
January	0.93	0.85	1.50	0.79	0.27	1.07
February	0.62	1.31	1.00	1.21	0.18	1.65
March	0.97	2.69	1.56	2.49	0.29	3.39
April	1.14	3.81	1.83	3.52	0.34	4.80
May	1.49	5.28	2.40	4.88	0.44	6.65
June	0.89	6.37	1.43	5.89	0.26	8.02
July	0.51	8.16	0.82	7.54	0.15	10.27
August	0.31	7.04	0.50	6.51	0.09	8.86
September	0.46	4.39	0.74	4.06	0.14	5.53
October	0.83	2.95	1.33	2.73	0.24	3.71
November	0.73	1.31	1.17	1.21	0.22	1.65
December	0.89	0.79	1.43	0.73	0.26	0.99
Total	9.77	44.97	15.71	41.55	2.88	56.59

4.0 VARIABLES USED IN WATER BALANCE

Golder obtained the following tailings, underdrain, and miscellaneous data from (1) tailings testing results provided by Golder's Denver, Colorado Geotechnical Laboratory; (2) Ausenco-provided data in Grassy Mountain

Prefeasibility Study Mass Balance report updated on March 29, 2018 (Doc. No. 101768-MB-0001); and (3) assumptions based on climatically and operationally similar mine sites in Nevada.

4.1 Given

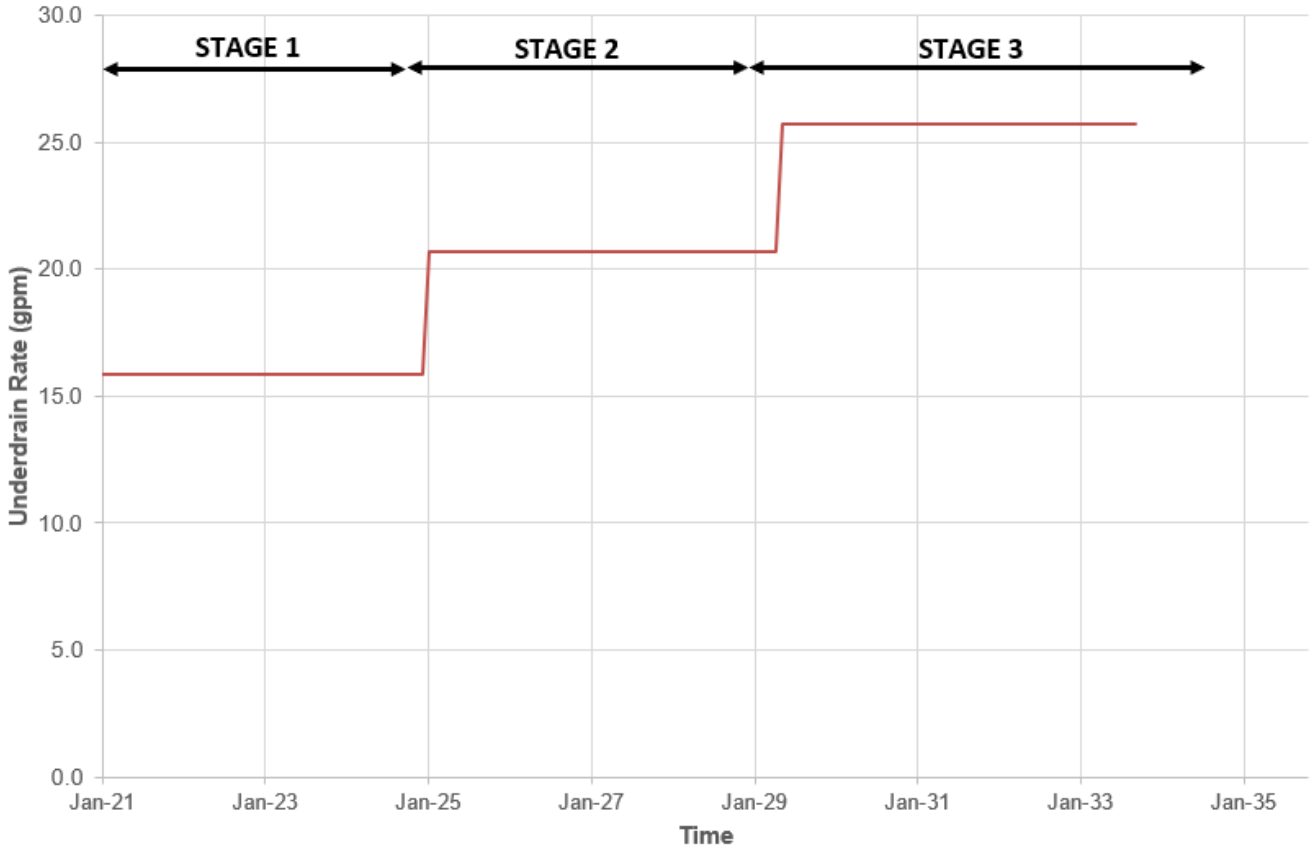
- Tailings are deposited in the TSF at a rate of 680 tons per day
- Tailings settled dry density of 80 lb/ft^3 at a saturation of 90 percent
- Tailings have a specific gravity of 2.65
- Tailings slurry contains 46 percent solids
- The dry beach area will make up 84% of the total exposed tailings area
- The wet beach area will make up 16% of the total exposed tailings area
- Evaporation rates from wet and dry tailings beach areas were developed using the tailings testing data performed in the Denver, Colorado Golder geotechnical laboratory and are presented in Table 2

Table 2: Tailings Beach Evaporation Rates

Stage	Wet Beach Evaporation Coefficient (% of ET)	Dry Beach Evaporation Coefficient (% of ET)
1	92	48
2	93	38
3	94	33

- Underdrain rates are constant and vary by stage. Tailings consolidation testing indicated the tailings underdrain rates shown in Figure 1.

Figure 1: Tailings Underdrain Rates by Stage



- Water discharge in tailings slurry at rate of 132.9 gpm

4.2 Assumptions

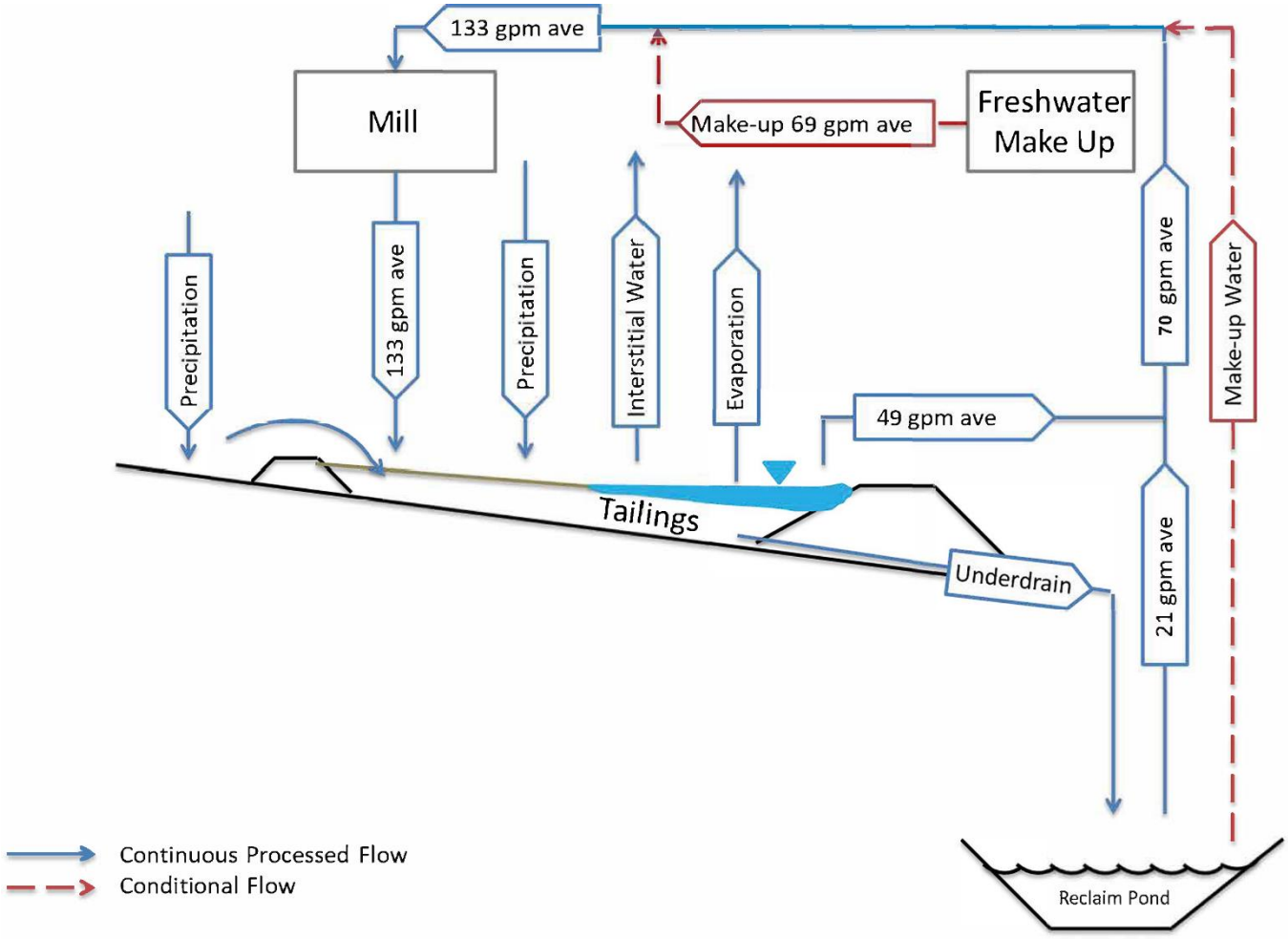
- Pool evaporation is 75 percent of the evapotranspiration rate
- Tailings have a runoff coefficient of 100 percent
- Upstream basins reporting to the TSF have a runoff coefficient of 40 percent
- No seepage through the underlying geomembrane liner
- The surface area of the supernatant pool corresponds to a minimum pool depth of 5-feet required for normal reclaim pump operations
- The area of the supernatant pool for each stage was held constant assuming that all solution above the 5-foot operating pool would be removed monthly
- Water losses in the mill are negligible and are not considered in this analysis

Total lined areas and tailings capacities of Stages 1 through 3 are presented in Table 3.

Table 3: Lined Areas and Tailings Capacities by Stage

Stage	Lined Area (ft^2)	Minimum Tailings Capacity (Million Tons)
1	1,949,200	1.01
2	2,983,900	2.07
3	4,011,100	3.67

Figure 2: Process Flow Diagram



5.0 METHOD

The reclaim rate to the mill from the supernatant pool was calculated as the rate required to:

- Maintain the supernatant pool at a minimum operating depth of 5-feet
- Maintain a minimum freeboard of 3-feet below the dam crest

The reclaim rate was determined after calculating the losses and gains to the impoundment. If in a given month there was excess water in the supernatant pool then the reclaim rate to the mill is equal to the rate water is reporting to the TSF in the tailings slurry. Conversely, if there is a monthly deficit of water in the TSF, only the minimum amount of water to maintain the 5-ft minimum supernatant pool depth would be removed from the supernatant pool, requiring the remaining water demand of the mill to be satisfied by make-up water.

Given the unknown water demands of the Grassy Mountain TSF Mill, make-up water required was defined as the rate of evaporation from the tailings beach and supernatant pool plus interstitial water loss minus precipitation. The make-up water rate is less than or equal to rate that water is reporting to the TSF in the tailings slurry.

6.0 RESULTS OF WATER BALANCE

6.1 Reclaim Rate to the Mill

The average reclaim rate from the supernatant pool is 49 gpm for Stages 1 through 3. Results for the average, 1:100 wet year, and 1:100 dry year are presented in Table 4 below. Calculations are included as an attachment to this memorandum.

Table 4: Reclaim Rates to Mill (gpm)

	Stage 1			Stage 2			Stage 3		
	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year
January	71	106	117	63	105	112	56	106	107
February	55	84	117	43	78	112	30	73	107
March	32	77	117	13	67	112	0	59	107
April	8	66	114	0	52	112	0	39	107
May	0	58	110	0	40	112	0	24	107
June	0	8	44	0	0	31	0	0	54
July	0	0	0	0	0	0	0	0	0
August	0	0	0	0	0	0	0	0	0
September	0	22	41	0	0	23	0	0	4
October	25	66	94	4	54	87	0	36	74
November	58	89	113	46	84	112	35	81	107
December	72	105	117	64	104	112	57	105	107
Minimum	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Maximum	**72**	**106**	**117**	**64**	**105**	**112**	**57**	**106**	**107**
Average	**27**	**57**	**82**	**20**	**51**	**80**	**14**	**41**	**71**

6.2 Make-up Water

The average make-up water rate is 69 gpm for Stages 1 through 3. Results for the average, 1:100 wet year, and 1:100 dry year are presented in Table 5 below. Calculations are included as an attachment to this memorandum.

Table 5: Make-up Water Requirements (gpm)

	Stage 1			Stage 2			Stage 3		
	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year	Dry Year	Average Year	Wet Year
January	46	11	0	49	7	0	52	1	0
February	62	33	0	70	34	0	77	34	0
March	85	40	0	99	45	0	114	48	0
April	109	51	0	130	61	0	133	68	0
May	133	59	7	133	72	0	133	84	0
June	133	109	73	133	133	79	133	133	47
July	133	133	130	133	133	133	133	133	133
August	133	133	128	133	133	133	133	133	133
September	131	95	76	133	113	90	133	132	103
October	92	51	23	109	59	25	126	65	24
November	59	28	4	66	28	0	72	27	0
December	45	12	0	48	8	0	50	2	0
Minimum	**45**	**11**	**0**	**48**	**7**	**0**	**50**	**1**	**0**
Maximum	**133**	**133**	**130**	**133**	**133**	**133**	**133**	**133**	**133**
Average	**97**	**63**	**37**	**102**	**66**	**36**	**108**	**74**	**40**

6.3 Maximum Accumulation of Fluid in the Supernatant Pool

During average climate conditions, the supernatant pool will not accumulate any excess solution from precipitation. During the 1 in 100 wet year climate, the supernatant pool will accumulate a maximum of approximately 498,600 ft^3 of a water above its minimum operating level during January of Stage 3 operations. The accumulation will increase the pool maximum depth from 5.0 ft to 5.5 ft. The increase in the depth of the supernatant pool will not infringe on the TSF freeboard.

Golder also evaluated the available surge capacity of the supernatant pool to store the 500-year, 24-hour peak design storm event plus wave run-up due to wind action. Golder assumed that the 500-year, 24-hour storm would occur on the 5-foot deep operating pool and be subjected to the average annual wind in the prevailing direction of west to east.

Based on these calculations, the Stage 3 supernatant pool (most critical) would rise 1.8 feet above the 5-foot deep operating pool. Wave action due to the annual average wind would result in an additional rise of about ¼ foot. This results in a maximum storm and wind surge depth of about 2 feet. The design freeboard within the supernatant pool area is 3 feet above the normal operating pool, which is adequate to contain the 500-year, 24-hour peak design storm plus wave action resulting from the annual average wind speed.

Detailed calculations for storm surge and wave action are presented in Attachment E.

6.4 Reclaim Pond Sizing

The Reclaim Pond at the eastern base of the eastern TSF embankment will collect all the underdrain flows from the TSF. The Reclaim Pond has been sized to contain the sum of the following:

- Drain down of the average underdrain flow for a duration of 48-hours
- Drain down of the water in the reclaim return pipe due to power outage
- Runoff from the Reclaim Pond liner resulting from the 1 in 100-year, 24-hour storm event

Detailed calculations are included in Attachment F.

7.0 LIMITATIONS

The results of Golder's analysis are based on limited data or information. The accuracy and reliability of the data used in the analyses will have direct correlation to the accuracy and reliability of the results. Calico Resources Corporation (Calico) should be aware that values based on a limited data set, such as climate, and geotechnical properties does not guarantee that actual conditions will be accurately represented. Golder has not quantified the risk associated with recommendations that are based on the limited data available.

In addition to site conditions, operational variables can have a large impact on water consumption and accumulation. Golder's analyses and recommendations are based on design parameters such as; rate/volume of tailings placement, percent solids, beach evaporation rates, and reclaim and supernatant pond volume management. Calico should contact a qualified engineer prior to deviating from the basis of design parameters (including temporary shut downs), to evaluate what affect the changes could have on the facility.

Golder's water balance analysis uses monthly time steps, thus provides monthly flow rates and volumes, and not peak daily, or peak instantaneous pumping rates from makeup water wells or reclaim pumps. This approach may attenuate the peak rate as it averages the volumes over a month period.

8.0 CONCLUSIONS/RECOMMENDATIONS

As discussed in Section 7.0 (Limitations); this water balance has limitations and we recommend that the water balance be re-evaluated prior to changes in operations, ore rinsing, or closure.

As discuss in Section 6.3 (Maximum Accumulation of Fluid in the Supernatant Pool); under the 1 in 100 wet year climate conditions, the depth of the supernatant pool will increase by approximately 0.5 ft. This increase is not expected to infringe on the freeboard level of the TSF.

The 500-year, 24-hour peak design storm event and wave action resulting from the annual average wind will increase the supernatant pool depth approximately 2 feet. This increase is not expected to infringe on the freeboard level of TSF.

ATTACHMENTS

Attachment A Climate Data Development Memorandum
Attachment B Average Year Water Balance Calculations
Attachment C Wet Year Water Balance Calculations
Attachment D Dry Year Water Balance Calculations
Attachment E Supernatant Pool Storm Surge Capacity Calculations
Attachment F TSF Reclaim Pond Sizing

ATTACHMENT A

Climate Data Development Memorandum

MEMORANDUM

DATE October 18, 2019 **Project No.** 1663241.053.TM.REV0

TO Christopher J. MacMahon, PE

CC Russell A. Browne, PE (NV)

FROM Matthew Barton and Erin Chichlowski **EMAIL** Erin_Chichlowski@golder.com

GRASSY MOUNTAIN CLIMATE DATA – DETAILED DESIGN REVISION

There is no on-site weather station recording site specific data, therefore climate data for the Grassy Mountain project site was developed using nearby weather station data and regression analysis based on elevation of the proposed Grassy Mountain tailings storage facility (TSF) dam. For this project, climate data and station metadata of the closest Remote Automated Weather Stations (RAWS) and Cooperative Observer Network (COOP) stations to Grassy Mountain project site were identified and compared, along with the PRISM Climate Group (PRISM) spatial data, using statistical and regression analyses.

The goal was to establish quantifiable relationships which would assist in development of a representative climate data set for the Grassy Mountain project site to support the detailed design of the proposed TSF.

1.0 SUMMARY OF DATA SOURCES

The data used to develop a climate data set for the Grassy Mountain project site were selected based on proximity to the project site, period of record, and data available at the time of the analysis.

RAWS collect hourly data including air temperature, wind speed and direction, precipitation, solar radiation, and evapotranspiration. RAWS are typically stationed in remote locations and use solar and battery power to collect, store, and forward climate data. Data is forwarded to repositories such as the Western Regional Climate Center (WRCC) and available for free public download. The WRCC applied quality checks to daily and monthly time series by establishing thresholds and designating any data which falls outside these thresholds as “missing”.

The PRISM Climate Group from Oregon State University gathers climate data and observations from a range of monitoring networks and data repositories (including the WRCC) and develops spatial climate datasets based on short- or long- term climate patters. PRISM data set uses user-input coordinates, to factor in location, elevation, and coastal proximity to produce time series datasets for precipitation, air temperature, dewpoint temperature, and vapor pressure deficit values.

Data sets from five RAWS, one COOP station, and PRISM were considered based on orientation to the Grassy Mountain project site. Table 1 presents a summary of the stations used in the climate data analysis along with the station orientation to Grassy Mountain project site, the station elevation, and periods of record.

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Table 1: Summary of Climate Data Sources

	Owyhee Ridge Oregon COOP (356405)	**Red Butte Oregon RAWS (NWS ID 353616)**	**Kelsay Butte Oregon RAWS (NWS ID 353613)**	**Owyhee Dam, Oregon RAWS (NWS ID 353614)**	**PRISM**
Orientation to Grassy Mountain Project Site	Approximately 9 miles southeast	Approximately 25 miles southwest	Approximately 36 miles northwest	Approximately 6 miles southeast	Long: 43.6728°N, Lat: 117.36437°W
Elevation	4400 ft.	4460 ft.	5187 ft.	2400 ft.	3707 ft.
Earliest Period of Record	January 1985	September 1986	January 1985	February 1935	January 1895
Latest Period of Record	February 2018	February 2018	February 2018	February 2018	January 2018

2.0 PRECIPITATION

Daily values from the time period January 1, 1987 through December 31, 2017 were used to obtain average monthly precipitation and average annual precipitation. This period of record represents overlapping periods of records between all five data sets.

Table 2: Average Monthly and Annual Precipitation (in) for the Period 1987-2017

	Owhyee Ridge RAWS	**Kelsay Butte RAWS**	**Red Butte RAWS**	**PRISM**	**Owhyee Dam COOP**
JANUARY	0.92	0.90	0.68	1.20	0.98
FEBRUARY	0.61	0.71	0.52	0.79	0.60
MARCH	0.96	1.26	0.76	0.93	0.82
APRIL	1.13	1.18	0.65	0.99	0.87
MAY	1.48	1.53	1.07	1.22	1.13
JUNE	0.88	0.89	0.74	0.89	0.79
JULY	0.50	0.35	0.33	0.43	0.40
AUGUST	0.31	0.48	0.30	0.37	0.30
SEPTEMBER	0.46	0.53	0.39	0.39	0.39
OCTOBER	0.82	0.97	0.65	0.68	0.64
NOVEMBER	0.72	1.04	0.65	0.99	0.78
DECEMBER	0.88	1.18	0.79	1.25	1.04
AVERAGE ANNUAL	**9.68**	**11.03**	**7.52**	**10.13**	**8.72**
STATION ELEVATION (ft amsl)	4400	4460	5187	3707	2400

Given that elevation has a significant effect on temperature and precipitation, especially in mountainous regions, a relationship between precipitation and elevation was assumed in order to develop a climate set for the Grassy Mountain project site. Thus, regression analyses focused on developing a relationship between average annual precipitation and elevation for each station. The best-fit equation developed from this analysis and the resulting R-squared value was used to develop a factor (or multiplier) that could be used to predict average annual precipitation values for the Grassy Mountain project site. Given that regression analyses can sometimes result in false relationships between data variables, a variety of data set combinations and exclusions were considered.

The following data sets were excluded from the final analysis:

1. Red Butte RAWS: outlier in average monthly precipitation data that if included would only predict a lower annual average precipitation (i.e. a less conservative data set for the design)
2. PRISM data set: over-predicts average monthly precipitation data when compared to actual nearby station data. This spatial dataset has a resolution of 4 km which establishes a “best estimate” time series based on the long-term average patterns developed from station data (regardless of periods of record) from over 20 sources and consequently does not support observed data.

Based on the results of Golder’s analysis, a regression function estimated from the average annual precipitation and elevations of the Owhyee Ridge RAWS, Kelsay Butte RAWS, and Owhyee Dam COOP was used to develop the average annual precipitation values for the Grassy Mountain project site (see Figure 1). The power-based trendline provided the best-fit (largest R-squared value) and the resulting equation was used to calculate the average annual precipitation for Grassy Mountain:

$y=0.9851\ x^{0.2799}$

Where:

y = average annual precipitation (in)

x = elevation (ft)

An elevation of 3622 feet corresponds to the maximum embankment height of the proposed TSF main embankament and resulted in an average annual precipitation of 9.77 inches for the Grassy Mountain project site.

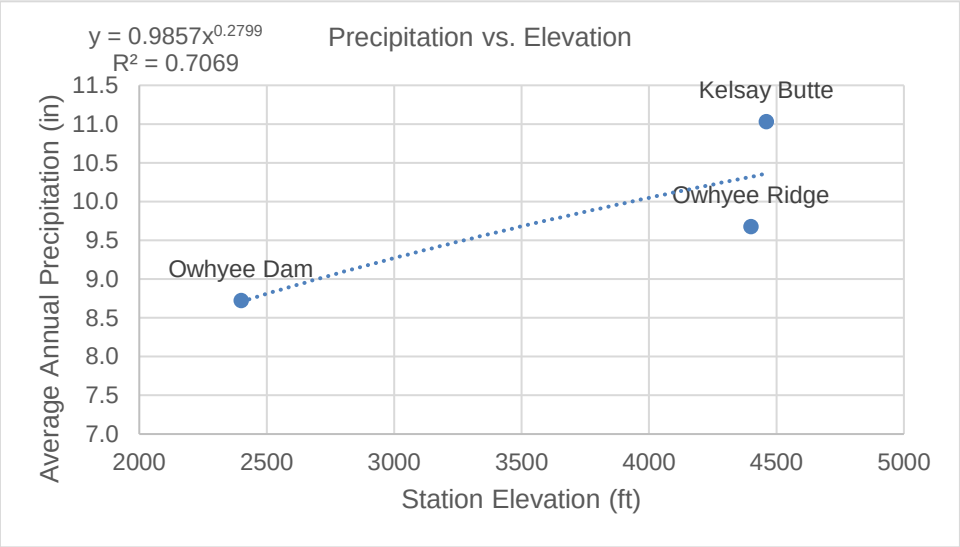

Figure 1: Precipitation vs. Elevation regression power relationship

The resulting average annual precipitation value for the Grassy Mountain project site was divided by the average annual precipitation for each of the three stations to develop a station-by-station "factor" presented in Table 3. This factor could then be multiplied by the respective stations average monthly precipitation to calculate the predicted average monthly precipitation for Grassy Mountain. A factor of 1.0 indicates no change or zero divergance between the actual value and the predicticed value.

It should be noted that only monthly average precipitation varies depending on which station and factor is chosen (i.e. total annual average precipitation is the same). The factors for each station were as follows: Owhyee Ridge RAWS = 1.01, Kelsay Butte RAWS = 0.89, and Owhyee Dam COOP = 1.12; and are presented in Table 3.

Since the Owyhee Ridge RAWS had monthly average precipitation data that best correlated with the results of the regression analysis, only the precipitation data from this station was used to develop the climate data for the Grassy Mountain project site. The Owhyee Ridge average monthly precipitation values were multipilied by 1.01 to obtain the predicted average monthly precipitation values for the Grassy Mountain project site.

Table 3: Average Annual Precipitation and Regression Factors

	Owhyee Ridge	**Kelsay Butte**	**Owhyee Dam**	**Grassy Mountain**
Average Annual Precipitation (in)	9.67	11.03	8.72	9.77
Factor	1.01	0.89	1.12	1.0

Prior to the factor adjustment, monthly precipitation values totalled from daily recorded values at the Owhyee Ridge RAWS for the period of record (1999-2017) were checked for any outliers.

Three monthly precipitation values were identified as outliers and replaced with the overall monthly average: (1) March 2003 reported 60.61 inches was replaced with 0.99 inches; (2) May 1988 reported 10.01 inches was replaced with 1.38 inches; and (3) May 1998 reported 6.02 inches was replaced with 1.38 inches.

Table 4: Factor Predicted Monthly Average Precipitation

Month	Factored Average Precipitation Depth (in)
January	0.93
February	0.62
March	0.97
April	1.14
May	1.49
June	0.89
July	0.51
August	0.31
September	0.46
October	0.83
November	0.73
December	0.89
Annual	9.77

2.1 1:100 Wet and Dry Monthly Precipitation Rates

Average monthly precipitation rates for the 1:100 wet-year and 1:100 dry-year climate scenarios were calculated using the factor predicted monthly average precipitation rates recorded at the Owhyee Ridge RAWS between the years 1999 and 2017 (summarized in Table 5).

A statistical analysis of the precipitation data was performed using an Excel workbook that performs wet year and dry year frequency analyses for specified return years using four different distribution methods. The Log Pearson III method, determined to be the best-fit for the data set, was used to calculate the average annual precipitation rates for both climate scenarios for the 100-year return period.

The 1:100 wet-year and 1:00 dry-year annual precipitation at the Grassy Mountain TSF project site is estimated to be 2.88 inches and 15.71 inches, respectively. To generate monthly average precipitation rates for each climate scenario, a multiplication factor equal to the annual average precipitation depth of each climate scenario was divided by the average annual Grassy Mountain project site precipitation depth of 9.77 inches was used.

The results of the frequency analysis, multiplication factor, and average monthly precipitation rates are presented in Table 5.

Table 5: Average Monthly Precipitation Rates for Extreme Climate Scenarios

	1:100 Dry Year Average Precipitation (in)	1:100 Wet Year Average Precipitation (in)
Multiplication Factor (dimensionless)	0.29	1.61
January	0.23	1.26
February	0.19	1.05
March	0.33	1.79
April	0.31	1.67
May	0.40	2.18
June	0.23	1.27
July	0.09	0.50
August	0.13	0.68
September	0.14	0.76
October	0.25	1.38
November	0.27	1.49
December	0.31	1.67
Annual	2.88	15.71

3.0 EVAPORATION

To develop monthly average pan evaporation data, climate data from the Owhyee Ridge RAWS was used to calculate evaporation rates using the Penman-Montieth equation. The Penman-Monteith equation combines energy-balance and mass-balance methods using available sunshine, temperature, humidity, and wind speed data to estimate evaporation from an open water surface. Penman-Monteith evaporation rates were calculated in an Excel workbook for the date range April 1998 through May 2019, beginning when solar radiation data was available from the Owhyee Ridge RAWS.

The Penman-Montieth equation used to calculate evaporation from an open water source at the Owhyee Ridge RAWS is shown below:

$$E = \frac{\Delta}{\Delta + \gamma} E_r + \frac{\gamma}{\Delta + \gamma} E_a$$

Where:

E=lake evaporation

Δ =gradient of saturated vapor pressure

γ =psychrometric constant

E_r=lake evaporation (Energy-balance Method)

E_a=lake evaporation (Aerodynamic Method)

A breakdown of the energy-balance and mass-balance (referred to as Aerodynamic Method) is shown in the following formulas:

Aerodynamic Method:

$$E_a = M(e_s - e_z)u_Z \qquad M = 0.622 \frac{p_a C_E}{p_w P}$$

Where:

E_a=lake evaporation

M=mass-transfer coefficient, the dimension is the inverse of pressure

e_s=saturation vapor pressure at water temperature

e_z=vapor pressure of the air at level Z, e_z=RH(e_z^0)

e_z^0=saturation vapor pressure at air temperature at level Z

RH=relative humidity (fraction)

u_Z=wind velocity at level Z

p_a=density of air

p_w=density of water

C_E=bulk evaporation coefficient, dimensionless

P=atmosphere pressure at level Z

Energy Balance Method:

$$E_r = \frac{R_n - G}{p_w \lambda (1+\beta)} \qquad \beta = \gamma \frac{T_2 - T_1}{e_2 - e_1}$$

Where:

E_r=lake evaporation
R_n=net radiation flux at the surface, $Jm^{-2}s^{-1}$
p_w=density of water
λ =latent heat of vaporization
G=sensible heat flux to soil or water (+ if soil or water is warming)
β =Bowen ratio
γ =psychrometric constant
T_1,T_2=temperatures of the air at different elevations above the water surface
e_1,e_2=saturation vapor pressures of the air at different elevations above the water surface (function of air temperature)

Given the Owhyee Ridge RAWS only records one temperature, the second temperature that is required to calculate the Bowen ratio, β, was assumed to be recorded at the lake surface itself. To correlate air temperature to lake temperature, the following assumptions shown in Table 6 were made by Golder.

Table 6: Lake Temperature to Air Temperature Correlation

Air Temperature (C°)	Lake Temperature at the Surface (C°)
-50	1
-10	1
0	1
10	10
20	10
30	20
40	30
50	40

Table 7 presents the average monthly open water evaporation rates calculated for the Owhyee Ridge RAWS which were used to simulate pan evaporation at the Sage TSF project site.

Table 7: Average Monthly Open Water Evaporation Rates

Month	Calculated Average Evaporation Rate (in)
January	0.85
February	1.31
March	2.69
April	3.81
May	5.28
June	6.37
July	8.16
August	7.04
September	4.39
October	2.95
November	1.31
December	0.79
Annual	44.97

3.1 1:100 Wet and Dry Monthly Evaporation Rates

Average monthly evaporation rates for the 1:100 wet-year and 1:100 dry-year climate scenarios were calculated using the evaporation rates calculated from the Owhyee Ridge RAWS data between the years 1999 and 2018 (summarized in Table 7). 1998 and 2019 values were not included due to missing monthly measurements.

A statistical analysis of the precipitation data was performed using an Excel workbook that performs wet year and dry year frequency analyses for specified return years using four different distribution methods. The Log Pearson III method, determined to be the best-fit, was used to calculate the average annual evaporation rate for both climate scenarios for the 100-year return period.

The 1:100 wet-year and 1:00 dry-year annual evaporation at the Grassy Mountain TSF project site is estimated to be 41.55 inches and 56.59 inches, respectively. To generate monthly average evaporation rates for each climate scenario, a multiplication factor equal to the respective climate scenario value divided by the average mine site

value of 44.97 inches was used. The results of the frequency analyses, multiplication factor, and climate scenario average monthly evaporation rates are presented in Table 8.

Table 8: Average Monthly Evaporation Rates for Extreme Climate Scenarios

	1:100 Wet Year Average Evaporation (in)	1:100 Dry Year Average Evaporation (in)
Multiplication Factor (dimensionless)	0.92	1.26
January	0.79	1.07
February	1.21	1.64
March	2.49	3.39
April	3.52	4.80
May	4.88	6.64
June	5.89	8.03
July	7.54	10.27
August	6.51	8.86
September	4.05	5.52
October	2.73	3.71
November	1.21	1.65
December	0.73	1.00
Annual	41.55	56.59

EMC/CJM/kg

https://golderassociates.sharepoint.com/sites/17031g/1663241 grassy mountain tsf/500_reporting/520_letters/532_climate data/final/1663241.053.tm.rev0.docx

ATTACHMENT B

Average Year Water Balance Calculations

Average Year Model Simulation Results
WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

VARIABLES USED IN WATER BALANCE:

Variables by Month	Precip (in)	Evapotranspiration (in)	1-100 Wet Year Precip (in)	1-100 Wet Year ET (in)	1-100 Dry Year Precip (in)	1-100 Dry Year ET (in)
Jan	0.93	0.85	1.50	0.79	0.27	1.07
Feb	0.62	1.31	1.00	1.21	0.18	1.65
Mar	0.97	2.69	1.56	2.49	0.29	3.39
Apr	1.14	3.81	1.83	3.52	0.34	4.80
May	1.49	5.28	2.40	4.88	0.44	6.65
Jun	0.89	6.37	1.43	5.89	0.26	8.02
Jul	0.51	8.16	0.82	7.54	0.15	10.27
Aug	0.31	7.04	0.50	6.51	0.09	8.86
Sep	0.46	4.39	0.74	4.06	0.14	5.53
Oct	0.83	2.95	1.33	2.73	0.24	3.71
Nov	0.73	1.31	1.17	1.21	0.22	1.65
Dec	0.89	0.79	1.43	0.73	0.26	0.99
Totals	9.77	44.95	15.71	41.55	2.88	56.59
Monthly Avg.	0.81	3.7	1.31	3.46	0.24	4.72

Variables by Year	Tails Loading (tpd)
1	680
2	680
3	680
4	680
5	680
6	680
7	680
8	680
9	680
10	680
11	680
12	680
13	680
14	680
15	680
16	680
17	680

Variables by Stage	Lined Area (sq.ft.)	Maximum Tails Storage Vol. (tons)	Upstream Basin Area (sq.ft.)	Lined Reclaim and WRD Area (sq.ft.)	Pan Evaporation Coeff. For Dry Beach % of ET	Pan Evaporation Coeff. For Wet Beach % of ET
1	1,949,200	1,010,000	3,287,100	168,600	48	92
2	2,983,900	2,070,000	2,258,800	168,600	38	93
3	4,011,100	3,670,000	1,766,600	168,600	33	94

Unlined Areas Runoff Coefficient	0.4			
Tailings Runoff Coefficient	100	Percent of Precipitation		
Percent Wet Beach	16	Percent of Total Exposed Tailings Area		
Percent Dry Beach	84	Percent of Total Exposed Tailings Area		
Pan to Lake Evaporation Factor	75	Percent of ET		
Tailings Specific Gravity	2.65	From Prefeas Test Results		
Slurry Water Specific Gravity	1			
Tailings Percent Solids	46	Percent		
Tailings Void Ratio	1.07			
Tailings Saturation	90	Percent		
Settled Tailings Dry Density	80	pcf		
Minimum Supernatant Pool Depth	5	ft		
Minimum Supernatant Pool Area Stage 1	715,700	sq. ft.		
Minimum Supernatant Pool Volume	1,394,100	cu. ft.	10,428,592.21	US gallons
Minimum Supernatant Pool Area Stage 2	609,800	sq. ft.		
Minimum Supernatant Pool Volume	1,042,000	cu. ft.	7,794,701.30	US gallons
Minimum Supernatant Pool Area Stage 3	743,100	sq. ft.		
Minimum Supernatant Pool Volume	1,416,700	cu. ft.	10,597,651.95	US gallons

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
Production Year	1	1	1	1	1	1	1	1	1	1	1	1
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	21,080	40,120	61,200	81,600	102,680	123,080	144,160	165,240	185,640	206,720	227,120	248,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
	132.9											
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	164,130	109,420	171,189	201,191	262,960	157,070	90,007	54,710	81,182	146,481	128,833	157,070
Precipitation Volume on Non-lined Areas (cu.ft.)	101,900	67,933	106,283	124,910	163,259	97,517	55,881	33,967	50,402	90,943	79,986	97,517
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	12,861	19,822	40,702	57,649	79,891	96,384	123,468	106,522	66,425	44,636	19,822	11,953
Evaporation from Dry Tailings Beach (cu.ft.)	35,229	54,294	111,489	157,908	218,833	264,008	338,196	291,777	181,946	122,265	54,294	32,742
Evaporation from Supernatant Pool (cu.ft.)	38,022	58,598	120,327	170,426	236,181	284,938	232,071	238,226	196,370	131,957	58,598	35,338
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	65,022	176,596	239,986	296,920	353,625	627,782	792,788	792,788	550,195	306,374	160,933	70,386
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	633,331	454,174	458,367	378,905	344,727	48,043	0	0	125,630	391,979	514,892	627,967
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	11	33	40	51	59	109	133	133	95	51	28	12
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	84	77	66	58	8	0	0	22	66	89	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Production Year	2	2	2	2	2	2	2	2	2	2	2	2
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	269,280	288,320	309,400	329,800	350,880	371,280	392,360	413,440	433,840	454,920	475,320	496,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	164,130	109,420	171,189	201,191	262,960	157,070	90,007	54,710	81,182	146,481	128,833	157,070
Precipitation Volume on Non-lined Areas (cu.ft.)	101,900	67,933	106,283	124,910	163,259	97,517	55,881	33,967	50,402	90,943	79,986	97,517
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	12,861	19,822	40,702	57,649	79,891	96,384	123,468	106,522	66,425	44,636	19,822	11,953
Evaporation from Dry Tailings Beach (cu.ft.)	35,229	54,294	111,489	157,908	218,833	264,008	338,196	291,777	181,946	122,265	54,294	32,742
Evaporation from Supernatant Pool (cu.ft.)	38,022	58,598	120,327	170,426	236,181	284,938	232,071	238,226	196,370	131,957	58,598	35,338
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	65,022	176,596	239,986	296,920	353,625	627,782	792,788	792,788	550,195	306,374	160,933	70,386
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	633,331	454,174	458,367	378,905	344,727	48,043	0	0	125,630	391,979	514,892	627,967
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	11	33	40	51	59	109	133	133	95	51	28	12
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	84	77	66	58	8	0	0	22	66	89	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Production Year	3	3	3	3	3	3	3	3	3	3	3	3
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	517,480	536,520	557,600	578,000	599,080	619,480	640,560	661,640	682,040	703,120	723,520	744,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	164,130	109,420	171,189	201,191	262,960	157,070	90,007	54,710	81,182	146,481	128,833	157,070
Precipitation Volume on Non-lined Areas (cu.ft.)	101,900	67,933	106,283	124,910	163,259	97,517	55,881	33,967	50,402	90,943	79,986	97,517
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	12,861	19,822	40,702	57,649	79,891	96,384	123,468	106,522	66,425	44,636	19,822	11,953
Evaporation from Dry Tailings Beach (cu.ft.)	35,229	54,294	111,489	157,908	218,833	264,008	338,196	291,777	181,946	122,265	54,294	32,742
Evaporation from Supernatant Pool (cu.ft.)	38,022	58,598	120,327	170,426	236,181	284,938	232,071	238,226	196,370	131,957	58,598	35,338
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	65,022	176,596	239,986	296,920	353,625	627,782	792,788	792,788	550,195	306,374	160,933	70,386
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	633,331	454,174	458,367	378,905	344,727	48,043	0	0	125,630	391,979	514,892	627,967
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	11	33	40	51	59	109	133	133	95	51	28	12
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	84	77	66	58	8	0	0	22	66	89	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Production Year	4	4	4	4	4	4	4	4	4	4	4	4
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	765,680	784,720	805,800	826,200	847,280	867,680	888,760	909,840	930,240	951,320	971,720	992,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	164,130	109,420	171,189	201,191	262,960	157,070	90,007	54,710	81,182	146,481	128,833	157,070
Precipitation Volume on Non-lined Areas (cu.ft.)	101,900	67,933	106,283	124,910	163,259	97,517	55,881	33,967	50,402	90,943	79,986	97,517
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	12,861	19,822	40,702	57,649	79,891	96,384	123,468	106,522	66,425	44,636	19,822	11,953
Evaporation from Dry Tailings Beach (cu.ft.)	35,229	54,294	111,489	157,908	218,833	264,008	338,196	291,777	181,946	122,265	54,294	32,742
Evaporation from Supernatant Pool (cu.ft.)	38,022	58,598	120,327	170,426	236,181	284,938	232,071	238,226	196,370	131,957	58,598	35,338
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	65,022	176,596	239,986	296,920	353,625	627,782	792,788	792,788	550,195	306,374	160,933	70,386
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	633,331	454,174	458,367	378,905	344,727	48,043	0	0	125,630	391,979	514,892	627,967
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	11	33	40	51	59	109	133	133	95	51	28	12
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	84	77	66	58	8	0	0	22	66	89	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Production Year	5	5	5	5	5	5	5	5	5	5	5	5
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,013,880	1,032,920	1,054,000	1,074,400	1,095,480	1,115,880	1,136,960	1,158,040	1,178,440	1,199,520	1,219,920	1,241,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	244,319	162,879	254,827	299,488	391,435	233,810	133,981	81,440	120,846	218,048	191,777	233,810
Precipitation Volume on Non-lined Areas (cu.ft.)	70,023	46,682	73,035	85,834	112,187	67,011	38,400	23,341	34,635	62,493	54,964	67,011
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	25,023	38,565	79,190	112,162	155,437	187,525	240,221	207,249	129,237	86,845	38,565	23,257
Evaporation from Dry Tailings Beach (cu.ft.)	53,678	82,728	169,876	240,606	333,438	402,272	480,009	444,583	277,233	186,296	82,728	49,889
Evaporation from Supernatant Pool (cu.ft.)	32,396	49,927	102,523	145,209	201,234	241,200	0	796	167,314	112,432	49,927	30,109
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	41,695	182,895	268,668	349,693	431,426	767,215	792,788	792,788	655,341	349,971	161,517	47,373
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	627,715	421,733	400,742	298,123	237,984	0	0	0	0	319,440	486,299	622,037
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	7	34	45	61	72	133	133	133	113	59	28	8
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	105	78	67	52	40	0	0	0	0	54	84	104

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26	Oct-26	Nov-26	Dec-26
Production Year	6	6	6	6	6	6	6	6	6	6	6	6
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,262,080	1,281,120	1,302,200	1,322,600	1,343,680	1,364,080	1,385,160	1,406,240	1,426,640	1,447,720	1,468,120	1,489,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	244,319	162,879	254,827	299,488	391,435	233,810	133,981	81,440	120,846	218,048	191,777	233,810
Precipitation Volume on Non-lined Areas (cu.ft.)	70,023	46,682	73,035	85,834	112,187	67,011	38,400	23,341	34,635	62,493	54,964	67,011
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	25,023	38,565	79,190	112,162	155,437	187,525	240,221	207,249	129,237	86,845	38,565	23,257
Evaporation from Dry Tailings Beach (cu.ft.)	53,678	82,728	169,876	240,606	333,438	402,272	480,009	444,583	277,233	186,296	82,728	49,889
Evaporation from Supernatant Pool (cu.ft.)	32,396	49,927	102,523	145,209	201,234	241,200	0	796	167,314	112,432	49,927	30,109
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	41,695	182,895	268,668	349,693	431,426	767,215	792,788	792,788	655,341	349,971	161,517	47,373
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	627,715	421,733	400,742	298,123	237,984	0	0	0	0	319,440	486,299	622,037
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	7	34	45	61	72	133	133	133	113	59	28	8
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	105	78	67	52	40	0	0	0	0	54	84	104

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-27	Feb-27	Mar-27	Apr-27	May-27	Jun-27	Jul-27	Aug-27	Sep-27	Oct-27	Nov-27	Dec-27
Production Year	7	7	7	7	7	7	7	7	7	7	7	7
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,510,280	1,529,320	1,550,400	1,570,800	1,591,880	1,612,280	1,633,360	1,654,440	1,674,840	1,695,920	1,716,320	1,737,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	244,319	162,879	254,827	299,488	391,435	233,810	133,981	81,440	120,846	218,048	191,777	233,810
Precipitation Volume on Non-lined Areas (cu.ft.)	70,023	46,682	73,035	85,834	112,187	67,011	38,400	23,341	34,635	62,493	54,964	67,011
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	25,023	38,565	79,190	112,162	155,437	187,525	240,221	207,249	129,237	86,845	38,565	23,257
Evaporation from Dry Tailings Beach (cu.ft.)	53,678	82,728	169,876	240,606	333,438	402,272	480,009	444,583	277,233	186,296	82,728	49,889
Evaporation from Supernatant Pool (cu.ft.)	32,396	49,927	102,523	145,209	201,234	241,200	0	796	167,314	112,432	49,927	30,109
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	41,695	182,895	268,668	349,693	431,426	767,215	792,788	792,788	655,341	349,971	161,517	47,373
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	627,715	421,733	400,742	298,123	237,984	0	0	0	0	319,440	486,299	622,037
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	7	34	45	61	72	133	133	133	113	59	28	8
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	105	78	67	52	40	0	0	0	0	54	84	104

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-28	Feb-28	Mar-28	Apr-28	May-28	Jun-28	Jul-28	Aug-28	Sep-28	Oct-28	Nov-28	Dec-28
Production Year	8	8	8	8	8	8	8	8	8	8	8	8
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,758,480	1,777,520	1,798,600	1,819,000	1,840,080	1,860,480	1,881,560	1,902,640	1,923,040	1,944,120	1,964,520	1,985,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	244,319	162,879	254,827	299,488	391,435	233,810	133,981	81,440	120,846	218,048	191,777	233,810
Precipitation Volume on Non-lined Areas (cu.ft.)	70,023	46,682	73,035	85,834	112,187	67,011	38,400	23,341	34,635	62,493	54,964	67,011
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	25,023	38,565	79,190	112,162	155,437	187,525	240,221	207,249	129,237	86,845	38,565	23,257
Evaporation from Dry Tailings Beach (cu.ft.)	53,678	82,728	169,876	240,606	333,438	402,272	480,009	444,583	277,233	186,296	82,728	49,889
Evaporation from Supernatant Pool (cu.ft.)	32,396	49,927	102,523	145,209	201,234	241,200	0	796	167,314	112,432	49,927	30,109
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	41,695	182,895	268,668	349,693	431,426	767,215	792,788	792,788	655,341	349,971	161,517	47,373
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	627,715	421,733	400,742	298,123	237,984	0	0	0	0	319,440	486,299	622,037
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	7	34	45	61	72	133	133	133	113	59	28	8
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	105	78	67	52	40	0	0	0	0	54	84	104

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-29	Feb-29	Mar-29	Apr-29	May-29	Jun-29	Jul-29	Aug-29	Sep-29	Oct-29	Nov-29	Dec-29
Production Year	9	9	9	9	9	9	9	9	9	9	9	9
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	2	2	2	2	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,006,680	2,025,720	2,046,800	2,067,200	2,088,280	2,108,680	2,129,760	2,150,840	2,171,240	2,192,320	2,212,720	2,233,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	244,319	162,879	254,827	299,488	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	70,023	46,682	73,035	85,834	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	25,023	38,565	79,190	112,162	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	53,678	82,728	169,876	240,606	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	32,396	49,927	102,523	145,209	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	41,695	182,895	268,668	349,693	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	627,715	421,733	400,742	298,123	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	7	34	45	61	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	105	78	67	52	24	0	0	0	0	42	81	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-30	Feb-30	Mar-30	Apr-30	May-30	Jun-30	Jul-30	Aug-30	Sep-30	Oct-30	Nov-30	Dec-30
Production Year	10	10	10	10	10	10	10	10	10	10	10	10
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA						-743,100	-743,100					
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,254,880	2,273,920	2,295,000	2,315,400	2,336,480	2,356,880	2,377,960	2,399,040	2,419,440	2,440,520	2,460,920	2,482,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	42	81	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-31	Feb-31	Mar-31	Apr-31	May-31	Jun-31	Jul-31	Aug-31	Sep-31	Oct-31	Nov-31	Dec-31
Production Year	11	11	11	11	11	11	11	11	11	11	11	11
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,503,080	2,522,120	2,543,200	2,563,600	2,584,680	2,605,080	2,626,160	2,647,240	2,667,640	2,688,720	2,709,120	2,730,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	42	81	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-32	Feb-32	Mar-32	Apr-32	May-32	Jun-32	Jul-32	Aug-32	Sep-32	Oct-32	Nov-32	Dec-32
Production Year	12	12	12	12	12	12	12	12	12	12	12	12
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA						743,100	743,100					
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,751,280	2,770,320	2,791,400	2,811,800	2,832,880	2,853,280	2,874,360	2,895,440	2,915,840	2,936,920	2,957,320	2,978,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	42	81	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-33	Feb-33	Mar-33	Apr-33	May-33	Jun-33	Jul-33	Aug-33	Sep-33	Oct-33	Nov-33	Dec-33
Production Year	13	13	13	13	13	13	13	13	13	13	13	13
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,999,480	3,018,520	3,039,600	3,060,000	3,081,080	3,101,480	3,122,560	3,143,640	3,164,040	3,185,120	3,205,520	3,226,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	42	81	105

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-34	Feb-34	Mar-34	Apr-34	May-34	Jun-34	Jul-34	Aug-34	Sep-34	Oct-34	Nov-34	Dec-34
Production Year	14	14	14	14	14	14	14	14	14	14	14	14
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83	0.73	0.89
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95	1.31	0.79
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	3,247,680	3,266,720	3,287,800	3,308,200	3,329,280	3,349,680	3,370,760	3,391,840	3,412,240	3,433,320	3,453,720	3,474,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096	254,265	309,994
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876	42,987	52,409
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829	53,656	32,358
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698	98,893	59,638
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009	60,841	36,691
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	387,504	153,177	11,222
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	251,920	465,620	628,201
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	65	27	2
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	42	81	105

Average Year Model Simulation Results
WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: AVERAGE YEAR
AVERAGE YEAR PRECIPITATION + AVERAGE EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10
Days in Month	31	28	31	30	31	30	31	31	30	31
Month-Yr	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35
Production Year	15	15	15	15	15	15	15	15	15	15
Annual Precipitation	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE	AVERAGE
Active Stage	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA										
Mean Monthly Precipitation (in.)	0.93	0.62	0.97	1.14	1.49	0.89	0.51	0.31	0.46	0.83
Site Lake Evaporation (in.)	0.85	1.31	2.69	3.81	5.28	6.37	8.16	7.04	4.39	2.95
AREAS AND TAILINGS DEPOSITED INPUT DATA										
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA										
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	7,520
Total Tailings Deposited (Tons)	3,495,880	3,514,920	3,536,000	3,556,400	3,577,480	3,597,880	3,618,960	3,640,040	3,660,440	3,667,960
WATER IN DEPOSITED TAILINGS										
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	282,816
INFLOW VOLUME CALCULATION DATA										
Precipitation Volume on Lined Areas (cu.ft.)	323,927	215,951	337,859	397,072	518,979	309,994	177,637	107,976	160,222	289,096
Precipitation Volume on Non-lined Areas (cu.ft.)	54,765	36,510	57,120	67,131	87,741	52,409	30,032	18,255	27,088	48,876
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA										
Evaporation from Wet Tailings Beach (cu.ft.)	34,815	53,656	110,180	156,054	216,263	260,908	334,225	288,351	179,810	120,829
Evaporation from Dry Tailings Beach (cu.ft.)	64,167	98,893	203,070	287,620	398,591	480,876	421,293	385,728	331,405	222,698
Evaporation from Supernatant Pool (cu.ft.)	39,477	60,841	124,934	176,951	245,223	150,795	0	0	203,888	137,009
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	87,379
UNDERDRAIN DATA										
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
NET SOLUTION BALANCE										
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	4,708	182,166	288,144	393,460	498,297	767,215	792,788	792,788	764,831	229,943
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	634,715	395,378	351,279	225,336	141,126	0	0	0	0	0
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	1	34	48	68	84	133	133	133	132	39
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	106	73	59	39	24	0	0	0	0	0

ATTACHMENT C

Wet Year Water Balance Calculations

Wet Year Model Simulation Results
WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

VARIABLES USED IN WATER BALANCE:

Variables by Month	Precip (in)	Lake Evap (in)	1-100 Wet Year Precip (in)	1-100 Wet Year Lake Evap (in)	1-100 Dry Year Precip (in)	1-100 Dry Year Lake Evap (in)
Jan	0.93	0.85	1.50	0.79	0.27	1.07
Feb	0.62	1.31	1.00	1.21	0.18	1.65
Mar	0.97	2.69	1.56	2.49	0.29	3.39
Apr	1.14	3.81	1.83	3.52	0.34	4.80
May	1.49	5.28	2.40	4.88	0.44	6.65
Jun	0.89	6.37	1.43	5.89	0.26	8.02
Jul	0.51	8.16	0.82	7.54	0.15	10.27
Aug	0.31	7.04	0.50	6.51	0.09	8.86
Sep	0.46	4.39	0.74	4.06	0.14	5.53
Oct	0.83	2.95	1.33	2.73	0.24	3.71
Nov	0.73	1.31	1.17	1.21	0.22	1.65
Dec	0.89	0.79	1.43	0.73	0.26	0.99
Totals	9.77	44.95	15.71	41.55	2.88	56.59
Monthly Avg.	0.81	3.7	1.31	3.46	0.24	4.72

Variables by Year	Tails Loading (tpd)
1	680
2	680
3	680
4	680
5	680
6	680
7	680
8	680
9	680
10	680
11	680
12	680
13	680
14	680
15	680

Variables by Stage	Lined Area (sq.ft.)	Maximum Tails Storage Vol. (tons)	Upstream Basin Area (sq.ft.)	Lined Reclaim and WRD Area (sq.ft.)	Pan Evaporation Coeff. For Dry Beach % of Lake E	Pan Evaporation Coeff. For Wet Beach % of Lake E
1	1,949,200	1,010,000	3,287,100	168,600	48	92
2	2,983,900	2,070,000	2,258,800	168,600	38	93
3	4,011,100	3,670,000	1,766,600	168,600	33	94

Unlined Areas Runoff Coefficient	0.4			
Tailings Runoff Coefficient	100	Percent of Precipitation		
Percent Wet Beach	16	Percent of Total Exposed Tailings Area		
Percent Dry Beach	84	Percent of Total Exposed Tailings Area		
Pan to Lake Evaporation Factor	75	Percent of Lake Evaporation		
Tailings Specific Gravity	2.65	From Prefeas Test Results		
Slurry Water Specific Gravity	1.00			
Tailings Percent Solids	46	Percent		
Tailings Void Ratio	1.07			
Tailings Saturation	90	Percent		
Settled Tailings Dry Density	80	pcf		
Minimum Supernatant Pool Depth	5.0	ft		
Minimum Supernatant Pool Area Stage 1	715,700	sq. ft.		
Minimum Supernatant Pool Volume	1,394,100	cu. ft.	10,428,592.21	US gallons
Minimum Supernatant Pool Area Stage 2	609,800	sq. ft.		
Minimum Supernatant Pool Volume	1,042,000	cu. ft.	7,794,701.30	US gallons
Minimum Supernatant Pool Area Stage 3	743,100	sq. ft.		
Minimum Supernatant Pool Volume	1,416,700	cu. ft.	10,597,651.95	US gallons

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
Production Year	1	1	1	1	1	1	1	1	1	1	1	1
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	21,080	40,120	61,200	81,600	102,680	123,080	144,160	165,240	185,640	206,720	227,120	248,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
	5,930,454											
INFLOW VOLUME CALCULATION DATA	132.9											
Precipitation Volume on Lined Areas (cu.ft.)	263,918	175,945	275,269	323,512	422,836	252,566	144,729	87,973	130,540	235,539	207,161	252,566
Precipitation Volume on Non-lined Areas (cu.ft.)	163,854	109,236	170,901	200,853	262,518	156,806	89,855	54,618	81,046	146,235	128,616	156,806
Volume of Water Carried Over from Previous Month (cu.ft.)	0	103,233	44,503	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	11,888	18,322	37,624	53,288	73,848	89,094	114,129	98,465	61,400	41,260	18,322	11,049
Evaporation from Dry Tailings Beach (cu.ft.)	32,564	50,187	103,056	145,964	202,280	244,039	312,615	269,707	168,184	113,016	50,187	30,265
Evaporation from Supernatant Pool (cu.ft.)	35,146	54,166	111,226	157,535	218,316	263,385	337,398	291,088	181,517	121,976	54,166	32,665
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	103,233	44,503	0	0	0	0	0	0	0	0	0	90,453
Volume of Solution in Supernatant Pool (cu.ft)	1,497,333	1,438,603	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,484,553
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	0	0	6,171	69,461	54,031	424,184	774,498	761,610	436,554	139,418	23,936	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	698,353	630,770	692,181	606,364	644,322	251,641	0	0	239,271	558,935	651,889	698,353
Reclaim Rate from Underdrain to the Mill (gpm)	15.8	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	0	0	1	12	9	73	130	128	76	23	4	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	117	117	116	105	108	44	0	0	41	94	113	117

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Production Year	2	2	2	2	2	2	2	2	2	2	2	2
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	269,280	288,320	309,400	329,800	350,880	371,280	392,360	413,440	433,840	454,920	475,320	496,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	263,918	175,945	275,269	323,512	422,836	252,566	144,729	87,973	130,540	235,539	207,161	252,566
Precipitation Volume on Non-lined Areas (cu.ft.)	163,854	109,236	170,901	200,853	262,518	156,806	89,855	54,618	81,046	146,235	128,616	156,806
Volume of Water Carried Over from Previous Month (cu.ft.)	90,453	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	11,888	18,322	37,624	53,288	73,848	89,094	114,129	98,465	61,400	41,260	18,322	11,049
Evaporation from Dry Tailings Beach (cu.ft.)	32,564	50,187	103,056	145,964	202,280	244,039	312,615	269,707	168,184	113,016	50,187	30,265
Evaporation from Supernatant Pool (cu.ft.)	35,146	54,166	111,226	157,535	218,316	263,385	337,398	291,088	181,517	121,976	54,166	32,665
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0	90,453
Volume of Solution in Supernatant Pool (cu.ft)	1,587,786	1,529,056	1,478,382	1,408,921	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,484,553
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	0	0	0	0	39,210	424,184	774,498	761,610	436,554	139,418	23,936	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	698,353	630,770	698,353	675,825	659,143	251,641	0	0	239,271	558,935	651,889	698,353
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	0	0	0	0	7	73	130	128	76	23	4	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	117	117	117	117	110	44	0	0	41	94	113	117

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Production Year	3	3	3	3	3	3	3	3	3	3	3	3
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	517,480	536,520	557,600	578,000	599,080	619,480	640,560	661,640	682,040	703,120	723,520	744,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	263,918	175,945	275,269	323,512	422,836	252,566	144,729	87,973	130,540	235,539	207,161	252,566
Precipitation Volume on Non-lined Areas (cu.ft.)	163,854	109,236	170,901	200,853	262,518	156,806	89,855	54,618	81,046	146,235	128,616	156,806
Volume of Water Carried Over from Previous Month (cu.ft.)	90,453	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	11,888	18,322	37,624	53,288	73,848	89,094	114,129	98,465	61,400	41,260	18,322	11,049
Evaporation from Dry Tailings Beach (cu.ft.)	32,564	50,187	103,056	145,964	202,280	244,039	312,615	269,707	168,184	113,016	50,187	30,265
Evaporation from Supernatant Pool (cu.ft.)	35,146	54,166	111,226	157,535	218,316	263,385	337,398	291,088	181,517	121,976	54,166	32,665
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0	90,453
Volume of Solution in Supernatant Pool (cu.ft)	1,587,786	1,529,056	1,478,382	1,408,921	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,484,553
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	0	0	0	0	39,210	424,184	774,498	761,610	436,554	139,418	23,936	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	698,353	630,770	698,353	675,825	659,143	251,641	0	0	239,271	558,935	651,889	698,353
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	0	0	0	0	7	73	130	128	76	23	4	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	117	117	117	117	110	44	0	0	41	94	113	117

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Production Year	4	4	4	4	4	4	4	4	4	4	4	4
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	765,680	784,720	805,800	826,200	847,280	867,680	888,760	909,840	930,240	951,320	971,720	992,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	263,918	175,945	275,269	323,512	422,836	252,566	144,729	87,973	130,540	235,539	207,161	252,566
Precipitation Volume on Non-lined Areas (cu.ft.)	163,854	109,236	170,901	200,853	262,518	156,806	89,855	54,618	81,046	146,235	128,616	156,806
Volume of Water Carried Over from Previous Month (cu.ft.)	90,453	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	11,888	18,322	37,624	53,288	73,848	89,094	114,129	98,465	61,400	41,260	18,322	11,049
Evaporation from Dry Tailings Beach (cu.ft.)	32,564	50,187	103,056	145,964	202,280	244,039	312,615	269,707	168,184	113,016	50,187	30,265
Evaporation from Supernatant Pool (cu.ft.)	35,146	54,166	111,226	157,535	218,316	263,385	337,398	291,088	181,517	121,976	54,166	32,665
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	193,686	134,956	84,282	14,821	0	0	0	0	0	0	0	90,453
Volume of Solution in Supernatant Pool (cu.ft)	1,587,786	1,529,056	1,478,382	1,408,921	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,484,553
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	0	0	0	0	39,210	424,184	774,498	761,610	436,554	139,418	23,936	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	698,353	630,770	698,353	675,825	659,143	251,641	0	0	239,271	558,935	651,889	698,353
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	0	0	0	0	7	73	130	128	76	23	4	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	117	117	117	117	110	44	0	0	41	94	113	117

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Production Year	5	5	5	5	5	5	5	5	5	5	5	5
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,013,880	1,032,920	1,054,000	1,074,400	1,095,480	1,115,880	1,136,960	1,158,040	1,178,440	1,199,520	1,219,920	1,241,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	392,861	261,907	409,758	481,571	629,422	375,963	215,440	130,954	194,318	350,617	308,374	375,963
Precipitation Volume on Non-lined Areas (cu.ft.)	112,596	75,064	117,438	138,020	180,395	107,753	61,746	37,532	55,692	100,488	88,381	107,753
Volume of Water Carried Over from Previous Month (cu.ft.)	90,453	248,276	205,741	163,002	85,246	12,213	0	0	0	0	0	1,448
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	23,130	35,648	73,201	103,678	143,680	173,341	222,051	191,573	119,461	80,276	35,648	21,498
Evaporation from Dry Tailings Beach (cu.ft.)	49,618	76,470	157,027	222,406	308,217	371,845	476,335	410,955	256,263	172,204	76,470	46,116
Evaporation from Supernatant Pool (cu.ft.)	29,945	46,151	94,768	134,225	186,013	224,413	126,649	113,805	154,658	103,928	46,151	27,831
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	248,276	205,741	163,002	85,246	12,213	0	0	0	0	0	1,448	144,780
Volume of Solution in Supernatant Pool (cu.ft)	1,290,276	1,247,741	1,205,002	1,127,246	1,054,213	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,043,448	1,186,780
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	0	0	0	0	0	510,708	792,788	792,788	517,411	150,241	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	669,410	604,628	669,410	647,816	669,410	137,108	0	0	130,405	519,169	647,816	669,410
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	0	0	0	0	0	88	133	133	90	25	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	112	112	112	112	112	24	0	0	23	87	112	112

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26	Oct-26	Nov-26	Dec-26
Production Year	6	6	6	6	6	6	6	6	6	6	6	6
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,262,080	1,281,120	1,302,200	1,322,600	1,343,680	1,364,080	1,385,160	1,406,240	1,426,640	1,447,720	1,468,120	1,489,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	392,861	261,907	409,758	481,571	629,422	375,963	215,440	130,954	194,318	350,617	308,374	375,963
Precipitation Volume on Non-lined Areas (cu.ft.)	112,596	75,064	117,438	138,020	180,395	107,753	61,746	37,532	55,692	100,488	88,381	107,753
Volume of Water Carried Over from Previous Month (cu.ft.)	144,780	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	23,130	35,648	73,201	103,678	143,680	173,341	222,051	191,573	119,461	80,276	35,648	21,498
Evaporation from Dry Tailings Beach (cu.ft.)	49,618	76,470	157,027	222,406	308,217	371,845	476,335	410,955	256,263	172,204	76,470	46,116
Evaporation from Supernatant Pool (cu.ft.)	29,945	46,151	94,768	134,225	186,013	224,413	126,649	113,805	154,658	103,928	46,151	27,831
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448	144,780
Volume of Solution in Supernatant Pool (cu.ft)	1,344,602	1,302,068	1,259,329	1,181,572	1,108,540	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,043,448	1,186,780
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	0	0	0	0	0	456,381	792,788	792,788	517,411	150,241	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	669,410	604,628	669,410	647,816	669,410	191,435	0	0	130,405	519,169	647,816	669,410
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	0	0	0	0	0	79	133	133	90	25	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	112	112	112	112	112	33	0	0	23	87	112	112

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-27	Feb-27	Mar-27	Apr-27	May-27	Jun-27	Jul-27	Aug-27	Sep-27	Oct-27	Nov-27	Dec-27
Production Year	7	7	7	7	7	7	7	7	7	7	7	7
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,510,280	1,529,320	1,550,400	1,570,800	1,591,880	1,612,280	1,633,360	1,654,440	1,674,840	1,695,920	1,716,320	1,737,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	392,861	261,907	409,758	481,571	629,422	375,963	215,440	130,954	194,318	350,617	308,374	375,963
Precipitation Volume on Non-lined Areas (cu.ft.)	112,596	75,064	117,438	138,020	180,395	107,753	61,746	37,532	55,692	100,488	88,381	107,753
Volume of Water Carried Over from Previous Month (cu.ft.)	144,780	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	23,130	35,648	73,201	103,678	143,680	173,341	222,051	191,573	119,461	80,276	35,648	21,498
Evaporation from Dry Tailings Beach (cu.ft.)	49,618	76,470	157,027	222,406	308,217	371,845	476,335	410,955	256,263	172,204	76,470	46,116
Evaporation from Supernatant Pool (cu.ft.)	29,945	46,151	94,768	134,225	186,013	224,413	126,649	113,805	154,658	103,928	46,151	27,831
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448	144,780
Volume of Solution in Supernatant Pool (cu.ft)	1,344,602	1,302,068	1,259,329	1,181,572	1,108,540	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,043,448	1,186,780
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	0	0	0	0	0	456,381	792,788	792,788	517,411	150,241	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	669,410	604,628	669,410	647,816	669,410	191,435	0	0	130,405	519,169	647,816	669,410
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	0	0	0	0	0	79	133	133	90	25	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	112	112	112	112	112	33	0	0	23	87	112	112

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-28	Feb-28	Mar-28	Apr-28	May-28	Jun-28	Jul-28	Aug-28	Sep-28	Oct-28	Nov-28	Dec-28
Production Year	8	8	8	8	8	8	8	8	8	8	8	8
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,758,480	1,777,520	1,798,600	1,819,000	1,840,080	1,860,480	1,881,560	1,902,640	1,923,040	1,944,120	1,964,520	1,985,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	392,861	261,907	409,758	481,571	629,422	375,963	215,440	130,954	194,318	350,617	308,374	375,963
Precipitation Volume on Non-lined Areas (cu.ft.)	112,596	75,064	117,438	138,020	180,395	107,753	61,746	37,532	55,692	100,488	88,381	107,753
Volume of Water Carried Over from Previous Month (cu.ft.)	144,780	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	23,130	35,648	73,201	103,678	143,680	173,341	222,051	191,573	119,461	80,276	35,648	21,498
Evaporation from Dry Tailings Beach (cu.ft.)	49,618	76,470	157,027	222,406	308,217	371,845	476,335	410,955	256,263	172,204	76,470	46,116
Evaporation from Supernatant Pool (cu.ft.)	29,945	46,151	94,768	134,225	186,013	224,413	126,649	113,805	154,658	103,928	46,151	27,831
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	302,602	260,068	217,329	139,572	66,540	0	0	0	0	0	1,448	144,780
Volume of Solution in Supernatant Pool (cu.ft)	1,344,602	1,302,068	1,259,329	1,181,572	1,108,540	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,043,448	1,186,780
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	0	0	0	0	0	456,381	792,788	792,788	517,411	150,241	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	669,410	604,628	669,410	647,816	669,410	191,435	0	0	130,405	519,169	647,816	669,410
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	0	0	0	0	0	79	133	133	90	25	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	112	112	112	112	112	33	0	0	23	87	112	112

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-29	Feb-29	Mar-29	Apr-29	May-29	Jun-29	Jul-29	Aug-29	Sep-29	Oct-29	Nov-29	Dec-29
Production Year	9	9	9	9	9	9	9	9	9	9	9	9
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	2	2	2	2	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,006,680	2,025,720	2,046,800	2,067,200	2,088,280	2,108,680	2,129,760	2,150,840	2,171,240	2,192,320	2,212,720	2,233,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	392,861	261,907	409,758	481,571	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	112,596	75,064	117,438	138,020	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	144,780	302,602	260,068	217,329	139,572	75,207	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	23,130	35,648	73,201	103,678	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	49,618	76,470	157,027	222,406	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	29,945	46,151	94,768	134,225	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	302,602	260,068	217,329	139,572	75,207	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,344,602	1,302,068	1,259,329	1,181,572	1,491,907	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	538,238	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	669,410	604,628	669,410	647,816	639,423	80,559	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	93	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	112	112	112	112	107	14	0	0	4	83	107	107

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-30	Feb-30	Mar-30	Apr-30	May-30	Jun-30	Jul-30	Aug-30	Sep-30	Oct-30	Nov-30	Dec-30
Production Year	10	10	10	10	10	10	10	10	10	10	10	10
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,254,880	2,273,920	2,295,000	2,315,400	2,336,480	2,356,880	2,377,960	2,399,040	2,419,440	2,440,520	2,460,920	2,482,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	83	107	107

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-31	Feb-31	Mar-31	Apr-31	May-31	Jun-31	Jul-31	Aug-31	Sep-31	Oct-31	Nov-31	Dec-31
Production Year	11	11	11	11	11	11	11	11	11	11	11	11
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,503,080	2,522,120	2,543,200	2,563,600	2,584,680	2,605,080	2,626,160	2,647,240	2,667,640	2,688,720	2,709,120	2,730,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	83	107	107

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-32	Feb-32	Mar-32	Apr-32	May-32	Jun-32	Jul-32	Aug-32	Sep-32	Oct-32	Nov-32	Dec-32
Production Year	12	12	12	12	12	12	12	12	12	12	12	12
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA						743,100	743,100					
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,751,280	2,770,320	2,791,400	2,811,800	2,832,880	2,853,280	2,874,360	2,895,440	2,915,840	2,936,920	2,957,320	2,978,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	83	107	107

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-33	Feb-33	Mar-33	Apr-33	May-33	Jun-33	Jul-33	Aug-33	Sep-33	Oct-33	Nov-33	Dec-33
Production Year	13	13	13	13	13	13	13	13	13	13	13	13
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,999,480	3,018,520	3,039,600	3,060,000	3,081,080	3,101,480	3,122,560	3,143,640	3,164,040	3,185,120	3,205,520	3,226,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	83	107	107

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-34	Feb-34	Mar-34	Apr-34	May-34	Jun-34	Jul-34	Aug-34	Sep-34	Oct-34	Nov-34	Dec-34
Production Year	14	14	14	14	14	14	14	14	14	14	14	14
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33	1.17	1.43
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73	1.21	0.73
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	3,247,680	3,266,720	3,287,800	3,308,200	3,329,280	3,349,680	3,370,760	3,391,840	3,412,240	3,433,320	3,453,720	3,474,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861	408,854	498,466
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592	69,123	84,273
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689	49,598	29,910
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853	91,413	55,127
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646	56,239	33,915
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	0	43,689	262,536
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,460,389	1,679,236
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	145,675	0	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	493,748	618,797	639,423
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	24	0	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	83	107	107

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: WET YEAR
WET YEAR PRECIPITATION + WET EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10
Days in Month	31	28	31	30	31	30	31	31	30	31
Month-Yr	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35
Production Year	15	15	15	15	15	15	15	15	15	15
Annual Precipitation	WET	WET	WET	WET	WET	WET	WET	WET	WET	WET
Active Stage	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA										
Mean Monthly Precipitation (in.)	1.50	1.00	1.56	1.83	2.40	1.43	0.82	0.50	0.74	1.33
Site Lake Evaporation (in.)	0.79	1.21	2.49	3.52	4.88	5.89	7.54	6.51	4.06	2.73
AREAS AND TAILINGS DEPOSITED INPUT DATA										
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA										
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	7,520
Total Tailings Deposited (Tons)	3,495,880	3,514,920	3,536,000	3,556,400	3,577,480	3,597,880	3,618,960	3,640,040	3,660,440	3,667,960
WATER IN DEPOSITED TAILINGS										
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	282,816
INFLOW VOLUME CALCULATION DATA										
Precipitation Volume on Lined Areas (cu.ft.)	520,869	347,246	543,272	638,484	834,510	498,466	285,638	173,623	257,634	464,861
Precipitation Volume on Non-lined Areas (cu.ft.)	88,061	58,707	91,848	107,945	141,086	84,273	48,291	29,354	43,557	78,592
Volume of Water Carried Over from Previous Month (cu.ft.)	262,536	498,539	486,006	471,147	406,858	342,493	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA										
Evaporation from Wet Tailings Beach (cu.ft.)	32,182	49,598	101,846	144,250	199,905	241,173	308,944	266,540	166,209	111,689
Evaporation from Dry Tailings Beach (cu.ft.)	59,314	91,413	187,710	265,864	368,442	444,503	569,411	484,285	306,337	205,853
Evaporation from Supernatant Pool (cu.ft.)	36,491	56,239	115,484	163,566	226,674	273,469	3,423	0	188,466	126,646
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	87,379
UNDERDRAIN DATA										
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
NET SOLUTION BALANCE										
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	498,539	486,006	471,147	406,858	342,493	0	0	0	0	11,886
Volume of Solution in Supernatant Pool (cu.ft)	1,915,239	1,902,706	1,887,847	1,823,558	1,759,193	1,416,700	1,416,700	1,416,700	1,416,700	1,428,586
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	0	0	0	0	0	270,952	792,788	792,788	596,860	0
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	639,423	577,544	639,423	618,797	639,423	347,845	0	0	21,937	129,451
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	0	0	0	0	0	47	133	133	103	0
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	107	107	107	107	107	60	0	0	4	22

ATTACHMENT D

Dry Year Water Balance Calculations

Dry Year Model Simulation Results
WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

VARIABLES USED IN WATER BALANCE:

Variables by Month	Precip (in)	Lake Evap (in)	1-100 Wet Year Precip (in)	1-100 Wet Year Lake Evap (in)	1-100 Dry Year Precip (in)	1-100 Dry Year Lake Evap (in)
Jan	0.93	0.85	1.50	0.79	0.27	1.07
Feb	0.62	1.31	1.00	1.21	0.18	1.65
Mar	0.97	2.69	1.56	2.49	0.29	3.39
Apr	1.14	3.81	1.83	3.52	0.34	4.80
May	1.49	5.28	2.40	4.88	0.44	6.65
Jun	0.89	6.37	1.43	5.89	0.26	8.02
Jul	0.51	8.16	0.82	7.54	0.15	10.27
Aug	0.31	7.04	0.50	6.51	0.09	8.86
Sep	0.46	4.39	0.74	4.06	0.14	5.53
Oct	0.83	2.95	1.33	2.73	0.24	3.71
Nov	0.73	1.31	1.17	1.21	0.22	1.65
Dec	0.89	0.79	1.43	0.73	0.26	0.99
Totals	9.77	44.95	15.71	41.55	2.88	56.59
Monthly Avg.	0.81	3.7	1.31	3.46	0.24	4.72

Variables by Year	Tails Loading (tpd)
1	680
2	680
3	680
4	680
5	680
6	680
7	680
8	680
9	680
10	680
11	680
12	680
13	680
14	680
15	680

Variables by Stage	Lined Area (sq.ft.)	Maximum Tails Storage Vol. (ton)	Unlined Upstream Basin Area (sq.ft.)	Lined Reclaim and WRD Area (sq.ft.)	Pan Evaporation Coeff. For Dry Beach % of Lake E	Pan Evaporation Coeff. For Wet Beach % of Lake E
1	1,949,200	1,010,000	3,287,100	168,600	48	92
2	2,983,900	2,070,000	2,258,800	168,600	38	93
3	4,011,100	3,670,000	1,766,600	168,600	33	94

Unlined Areas Runoff Coefficient	0.4			
Tailings Runoff Coefficient	100	Percent of Precipitation		
Percent Wet Beach	16	Percent of Total Exposed Tailings Area		
Percent Dry Beach	84	Percent of Total Exposed Tailings Area		
Pan to Lake Evaporation Factor	75	Percent of Lake Evaporation		
Tailings Specific Gravity	2.65000	From Prefeas Test Results		
Slurry Water Specific Gravity	1.0			
Tailings Percent Solids	46.000	Percent		
Tailings Void Ratio	1.07			
Tailings Saturation	90	Percent		
Settled Tailings Dry Density	80.0	pcf		
Minimum Supernatant Pool Depth	5.0	ft		
Minimum Supernatant Pool Area Stage 1	715,700	sq. ft.		
Minimum Supernatant Pool Volume	1,394,100	cu. ft.	10,428,592.21	US gallons
Minimum Supernatant Pool Area Stage 2	609,800	sq. ft.		
Minimum Supernatant Pool Volume	1,042,000	cu. ft.	7,794,701.30	US gallons
Minimum Supernatant Pool Area Stage 3	743,100	sq. ft.		
Minimum Supernatant Pool Volume	1,416,700	cu. ft.	10,597,651.95	US gallons

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21
Production Year	1	1	1	1	1	1	1	1	1	1	1	1
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	21,080	40,120	61,200	81,600	102,680	123,080	144,160	165,240	185,640	206,720	227,120	248,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	48,382	32,255	50,463	59,307	77,515	46,301	26,532	16,127	23,931	43,180	37,977	46,301
Precipitation Volume on Non-lined Areas (cu.ft.)	30,038	20,025	31,330	36,821	48,126	28,746	16,473	10,013	14,858	26,808	23,578	28,746
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	16,192	24,954	51,242	72,577	100,580	121,343	155,441	134,106	83,626	56,195	24,954	15,049
Evaporation from Dry Tailings Beach (cu.ft.)	44,351	68,353	140,359	198,799	275,500	332,375	425,773	367,334	229,062	153,925	68,353	41,221
Evaporation from Supernatant Pool (cu.ft.)	47,867	73,772	151,486	214,559	297,341	151,506	9,639	72,549	247,221	166,128	73,772	44,489
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	274,930	336,036	506,234	626,845	792,720	767,215	792,788	792,788	758,159	551,200	342,563	270,651
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	423,422	294,734	192,118	48,980	0	0	0	0	0	147,152	333,262	427,702
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	46	62	85	109	133	133	133	133	131	92	59	45
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	71	55	32	8	0	0	0	0	0	25	58	72

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22
Production Year	2	2	2	2	2	2	2	2	2	2	2	2
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	269,280	288,320	309,400	329,800	350,880	371,280	392,360	413,440	433,840	454,920	475,320	496,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	48,382	32,255	50,463	59,307	77,515	46,301	26,532	16,127	23,931	43,180	37,977	46,301
Precipitation Volume on Non-lined Areas (cu.ft.)	30,038	20,025	31,330	36,821	48,126	28,746	16,473	10,013	14,858	26,808	23,578	28,746
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	16,192	24,954	51,242	72,577	100,580	121,343	155,441	134,106	83,626	56,195	24,954	15,049
Evaporation from Dry Tailings Beach (cu.ft.)	44,351	68,353	140,359	198,799	275,500	332,375	425,773	367,334	229,062	153,925	68,353	41,221
Evaporation from Supernatant Pool (cu.ft.)	47,867	73,772	151,486	214,559	297,341	151,506	9,639	72,549	247,221	166,128	73,772	44,489
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	274,930	336,036	506,234	626,845	792,720	767,215	792,788	792,788	758,159	551,200	342,563	270,651
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	423,422	294,734	192,118	48,980	0	0	0	0	0	147,152	333,262	427,702
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	46	62	85	109	133	133	133	133	131	92	59	45
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	71	55	32	8	0	0	0	0	0	25	58	72

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
Production Year	3	3	3	3	3	3	3	3	3	3	3	3
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	517,480	536,520	557,600	578,000	599,080	619,480	640,560	661,640	682,040	703,120	723,520	744,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	48,382	32,255	50,463	59,307	77,515	46,301	26,532	16,127	23,931	43,180	37,977	46,301
Precipitation Volume on Non-lined Areas (cu.ft.)	30,038	20,025	31,330	36,821	48,126	28,746	16,473	10,013	14,858	26,808	23,578	28,746
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	16,192	24,954	51,242	72,577	100,580	121,343	155,441	134,106	83,626	56,195	24,954	15,049
Evaporation from Dry Tailings Beach (cu.ft.)	44,351	68,353	140,359	198,799	275,500	332,375	425,773	367,334	229,062	153,925	68,353	41,221
Evaporation from Supernatant Pool (cu.ft.)	47,867	73,772	151,486	214,559	297,341	151,506	9,639	72,549	247,221	166,128	73,772	44,489
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	274,930	336,036	506,234	626,845	792,720	767,215	792,788	792,788	758,159	551,200	342,563	270,651
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	423,422	294,734	192,118	48,980	0	0	0	0	0	147,152	333,262	427,702
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	46	62	85	109	133	133	133	133	131	92	59	45
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	71	55	32	8	0	0	0	0	0	25	58	72

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24
Production Year	4	4	4	4	4	4	4	4	4	4	4	4
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	1	1	1	1	1	1	1	1	1	1	1	1
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200	1,949,200
Supernatant Pool Area (sq.ft.)	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700	715,700
Tailings Beach Area (sq.ft.)	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500	1,233,500
Wet Tailings Beach Area (sq.ft.)	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360	197,360
Dry Tailings Beach Area (sq.ft.)	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140	1,036,140
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100	3,287,100
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	765,680	784,720	805,800	826,200	847,280	867,680	888,760	909,840	930,240	951,320	971,720	992,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	48,382	32,255	50,463	59,307	77,515	46,301	26,532	16,127	23,931	43,180	37,977	46,301
Precipitation Volume on Non-lined Areas (cu.ft.)	30,038	20,025	31,330	36,821	48,126	28,746	16,473	10,013	14,858	26,808	23,578	28,746
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	16,192	24,954	51,242	72,577	100,580	121,343	155,441	134,106	83,626	56,195	24,954	15,049
Evaporation from Dry Tailings Beach (cu.ft.)	44,351	68,353	140,359	198,799	275,500	332,375	425,773	367,334	229,062	153,925	68,353	41,221
Evaporation from Supernatant Pool (cu.ft.)	47,867	73,772	151,486	214,559	297,341	151,506	9,639	72,549	247,221	166,128	73,772	44,489
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100	1,394,100
Reclaim Rate from Underdrain to the Mill (gpm)	94,436	85,297	94,436	91,390	94,436	91,390	94,436	94,436	91,390	94,436	91,390	94,436
Make Up Water Required (cu.ft.)	274,930	336,036	506,234	626,845	792,720	767,215	792,788	792,788	758,159	551,200	342,563	270,651
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	423,422	294,734	192,118	48,980	0	0	0	0	0	147,152	333,262	427,702
Reclaim Rate from Underdrain to the Mill (gpm)	16	16	16	16	16	16	16	16	16	16	16	16
Make Up Water Required (gpm)	46	62	85	109	133	133	133	133	131	92	59	45
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	71	55	32	8	0	0	0	0	0	25	58	72

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Production Year	5	5	5	5	5	5	5	5	5	5	5	5
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,013,880	1,032,920	1,054,000	1,074,400	1,095,480	1,115,880	1,136,960	1,158,040	1,178,440	1,199,520	1,219,920	1,241,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	72,020	48,014	75,118	88,283	115,387	68,923	39,495	24,007	35,623	64,276	56,532	68,923
Precipitation Volume on Non-lined Areas (cu.ft.)	20,641	13,761	21,529	25,302	33,070	19,754	11,319	6,880	10,210	18,422	16,202	19,754
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	31,503	48,551	99,697	141,207	195,688	236,086	302,427	260,918	162,703	109,333	48,551	29,279
Evaporation from Dry Tailings Beach (cu.ft.)	67,579	104,151	213,867	302,911	419,783	382,766	296,236	317,818	349,024	234,538	104,151	62,808
Evaporation from Supernatant Pool (cu.ft.)	40,785	62,856	129,071	182,811	80,836	0	0	0	64,282	141,547	62,856	37,906
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	292,144	375,020	590,928	750,383	792,788	767,215	792,788	792,788	767,215	647,660	379,863	286,257
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	377,266	229,609	78,482	0	0	0	0	0	0	21,751	267,954	383,153
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	49	70	99	130	133	133	133	133	133	109	66	48
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	63	43	13	0	0	0	0	0	0	4	46	64

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26	Jul-26	Aug-26	Sep-26	Oct-26	Nov-26	Dec-26
Production Year	6	6	6	6	6	6	6	6	6	6	6	6
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,262,080	1,281,120	1,302,200	1,322,600	1,343,680	1,364,080	1,385,160	1,406,240	1,426,640	1,447,720	1,468,120	1,489,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	72,020	48,014	75,118	88,283	115,387	68,923	39,495	24,007	35,623	64,276	56,532	68,923
Precipitation Volume on Non-lined Areas (cu.ft.)	20,641	13,761	21,529	25,302	33,070	19,754	11,319	6,880	10,210	18,422	16,202	19,754
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	31,503	48,551	99,697	141,207	195,688	236,086	302,427	260,918	162,703	109,333	48,551	29,279
Evaporation from Dry Tailings Beach (cu.ft.)	67,579	104,151	213,867	302,911	419,783	382,766	296,236	317,818	349,024	234,538	104,151	62,808
Evaporation from Supernatant Pool (cu.ft.)	40,785	62,856	129,071	182,811	80,836	0	0	0	64,282	141,547	62,856	37,906
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	292,144	375,020	590,928	750,383	792,788	767,215	792,788	792,788	767,215	647,660	379,863	286,257
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	377,266	229,609	78,482	0	0	0	0	0	0	21,751	267,954	383,153
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	49	70	99	130	133	133	133	133	133	109	66	48
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	63	43	13	0	0	0	0	0	0	4	46	64

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-27	Feb-27	Mar-27	Apr-27	May-27	Jun-27	Jul-27	Aug-27	Sep-27	Oct-27	Nov-27	Dec-27
Production Year	7	7	7	7	7	7	7	7	7	7	7	7
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,510,280	1,529,320	1,550,400	1,570,800	1,591,880	1,612,280	1,633,360	1,654,440	1,674,840	1,695,920	1,716,320	1,737,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	72,020	48,014	75,118	88,283	115,387	68,923	39,495	24,007	35,623	64,276	56,532	68,923
Precipitation Volume on Non-lined Areas (cu.ft.)	20,641	13,761	21,529	25,302	33,070	19,754	11,319	6,880	10,210	18,422	16,202	19,754
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	31,503	48,551	99,697	141,207	195,688	236,086	302,427	260,918	162,703	109,333	48,551	29,279
Evaporation from Dry Tailings Beach (cu.ft.)	67,579	104,151	213,867	302,911	419,783	382,766	296,236	317,818	349,024	234,538	104,151	62,808
Evaporation from Supernatant Pool (cu.ft.)	40,785	62,856	129,071	182,811	80,836	0	0	0	64,282	141,547	62,856	37,906
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	292,144	375,020	590,928	750,383	792,788	767,215	792,788	792,788	767,215	647,660	379,863	286,257
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	377,266	229,609	78,482	0	0	0	0	0	0	21,751	267,954	383,153
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	49	70	99	130	133	133	133	133	133	109	66	48
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	63	43	13	0	0	0	0	0	0	4	46	64

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-28	Feb-28	Mar-28	Apr-28	May-28	Jun-28	Jul-28	Aug-28	Sep-28	Oct-28	Nov-28	Dec-28
Production Year	8	8	8	8	8	8	8	8	8	8	8	8
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	2	2	2	2	2	2	2	2	2	2	2	2
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900	2,983,900
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800	609,800
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100	2,374,100
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856	379,856
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244	1,994,244
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800	2,258,800
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	1,758,480	1,777,520	1,798,600	1,819,000	1,840,080	1,860,480	1,881,560	1,902,640	1,923,040	1,944,120	1,964,520	1,985,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	72,020	48,014	75,118	88,283	115,387	68,923	39,495	24,007	35,623	64,276	56,532	68,923
Precipitation Volume on Non-lined Areas (cu.ft.)	20,641	13,761	21,529	25,302	33,070	19,754	11,319	6,880	10,210	18,422	16,202	19,754
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	31,503	48,551	99,697	141,207	195,688	236,086	302,427	260,918	162,703	109,333	48,551	29,279
Evaporation from Dry Tailings Beach (cu.ft.)	67,579	104,151	213,867	302,911	419,783	382,766	296,236	317,818	349,024	234,538	104,151	62,808
Evaporation from Supernatant Pool (cu.ft.)	40,785	62,856	129,071	182,811	80,836	0	0	0	64,282	141,547	62,856	37,906
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000	1,042,000
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	123,378	119,398	123,378	123,378	119,398	123,378	119,398	123,378
Make Up Water Required (cu.ft.)	292,144	375,020	590,928	750,383	792,788	767,215	792,788	792,788	767,215	647,660	379,863	286,257
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	377,266	229,609	78,482	0	0	0	0	0	0	21,751	267,954	383,153
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	21	21	21	21	21	21	21	21
Make Up Water Required (gpm)	49	70	99	130	133	133	133	133	133	109	66	48
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	63	43	13	0	0	0	0	0	0	4	46	64

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-29	Feb-29	Mar-29	Apr-29	May-29	Jun-29	Jul-29	Aug-29	Sep-29	Oct-29	Nov-29	Dec-29
Production Year	9	9	9	9	9	9	9	9	9	9	9	9
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	2	2	2	2	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	2,983,900	2,983,900	2,983,900	2,983,900	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	609,800	609,800	609,800	609,800	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	2,374,100	2,374,100	2,374,100	2,374,100	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	379,856	379,856	379,856	379,856	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	1,994,244	1,994,244	1,994,244	1,994,244	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	2,258,800	2,258,800	2,258,800	2,258,800	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,006,680	2,025,720	2,046,800	2,067,200	2,088,280	2,108,680	2,129,760	2,150,840	2,171,240	2,192,320	2,212,720	2,233,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	72,020	48,014	75,118	88,283	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	20,641	13,761	21,529	25,302	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	31,503	48,551	99,697	141,207	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	67,579	104,151	213,867	302,911	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	40,785	62,856	129,071	182,811	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,042,000	1,042,000	1,042,000	1,042,000	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	123,378	111,439	123,378	119,398	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	292,144	375,020	590,928	750,383	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	377,266	229,609	78,482	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	21	21	21	21	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	49	70	99	130	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	63	43	13	0	0	0	0	0	0	0	35	57

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-30	Feb-30	Mar-30	Apr-30	May-30	Jun-30	Jul-30	Aug-30	Sep-30	Oct-30	Nov-30	Dec-30
Production Year	10	10	10	10	10	10	10	10	10	10	10	10
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,254,880	2,273,920	2,295,000	2,315,400	2,336,480	2,356,880	2,377,960	2,399,040	2,419,440	2,440,520	2,460,920	2,482,000
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0	35	57

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-31	Feb-31	Mar-31	Apr-31	May-31	Jun-31	Jul-31	Aug-31	Sep-31	Oct-31	Nov-31	Dec-31
Production Year	11	11	11	11	11	11	11	11	11	11	11	11
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,503,080	2,522,120	2,543,200	2,563,600	2,584,680	2,605,080	2,626,160	2,647,240	2,667,640	2,688,720	2,709,120	2,730,200
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0	35	57

WATER BALANCE ESTIMATE FOR GRASSY MOUNTAIN TSF

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-32	Feb-32	Mar-32	Apr-32	May-32	Jun-32	Jul-32	Aug-32	Sep-32	Oct-32	Nov-32	Dec-32
Production Year	12	12	12	12	12	12	12	12	12	12	12	12
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA						743,100	743,100					
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,751,280	2,770,320	2,791,400	2,811,800	2,832,880	2,853,280	2,874,360	2,895,440	2,915,840	2,936,920	2,957,320	2,978,400
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
											5	
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0	35	57

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-33	Feb-33	Mar-33	Apr-33	May-33	Jun-33	Jul-33	Aug-33	Sep-33	Oct-33	Nov-33	Dec-33
Production Year	13	13	13	13	13	13	13	13	13	13	13	13
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	2,999,480	3,018,520	3,039,600	3,060,000	3,081,080	3,101,480	3,122,560	3,143,640	3,164,040	3,185,120	3,205,520	3,226,600
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0	35	57

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10	11	12
Days in Month	31	28	31	30	31	30	31	31	30	31	30	31
Month-Yr	Jan-34	Feb-34	Mar-34	Apr-34	May-34	Jun-34	Jul-34	Aug-34	Sep-34	Oct-34	Nov-34	Dec-34
Production Year	14	14	14	14	14	14	14	14	14	14	14	14
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA												
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24	0.22	0.26
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71	1.65	0.99
AREAS AND TAILINGS DEPOSITED INPUT DATA												
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA												
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	21,080	20,400	21,080
Total Tailings Deposited (Tons)	3,247,680	3,266,720	3,287,800	3,308,200	3,329,280	3,349,680	3,370,760	3,391,840	3,412,240	3,433,320	3,453,720	3,474,800
WATER IN DEPOSITED TAILINGS												
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	792,788	767,215	792,788
INFLOW VOLUME CALCULATION DATA												
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220	74,952	91,380
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408	12,672	15,449
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA												
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118	67,551	40,737
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	280,366	124,502	75,081
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	172,488	76,596	46,192
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	244,940	237,039	244,940
UNDERDRAIN DATA												
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
NET SOLUTION BALANCE												
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	750,285	418,063	300,120
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0	200,733	339,303
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	126	72	50
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0	35	57

PROJECT: GRASSY MOUNTAIN TSF PREFEASBILITY STUDY
SIMULATION SCENARIO: DRY YEAR
DRY YEAR PRECIPITATION + DRY EVAPORATION FROM SITE DATA

month	1	2	3	4	5	6	7	8	9	10
Days in Month	31	28	31	30	31	30	31	31	30	31
Month-Yr	Jan-35	Feb-35	Mar-35	Apr-35	May-35	Jun-35	Jul-35	Aug-35	Sep-35	Oct-35
Production Year	15	15	15	15	15	15	15	15	15	15
Annual Precipitation	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY	DRY
Active Stage	3	3	3	3	3	3	3	3	3	3
PRECIPITATION AND EVAPORATION INPUT DATA										
Mean Monthly Precipitation (in.)	0.27	0.18	0.29	0.34	0.44	0.26	0.15	0.09	0.14	0.24
Site Lake Evaporation (in.)	1.07	1.65	3.39	4.80	6.65	8.02	10.27	8.86	5.53	3.71
AREAS AND TAILINGS DEPOSITED INPUT DATA										
Total Lined Area (sq.ft.)	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100	4,011,100
Supernatant Pool Area (sq.ft.)	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100	743,100
Tailings Beach Area (sq.ft.)	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000	3,268,000
Wet Tailings Beach Area (sq.ft.)	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880	522,880
Dry Tailings Beach Area (sq.ft.)	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120	2,745,120
Lined Reclaim Channel and Waste Rock Dump (sq.ft.)	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600	168,600
Upstream Unlined Basin Area (sq.ft.)	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600	1,766,600
AREA AND DISTRIBUTED TAILINGS DATA										
Tailings Deposited (Tons)	21,080	19,040	21,080	20,400	21,080	20,400	21,080	21,080	20,400	7,520
Total Tailings Deposited (Tons)	3,495,880	3,514,920	3,536,000	3,556,400	3,577,480	3,597,880	3,618,960	3,640,040	3,660,440	3,667,960
WATER IN DEPOSITED TAILINGS										
Water Volume (cu.ft.)	792,788	716,067	792,788	767,215	792,788	767,215	792,788	792,788	767,215	282,816
INFLOW VOLUME CALCULATION DATA										
Precipitation Volume on Lined Areas (cu.ft.)	95,487	63,658	99,594	117,049	152,985	91,380	52,364	31,829	47,230	85,220
Precipitation Volume on Non-lined Areas (cu.ft.)	16,144	10,762	16,838	19,789	25,864	15,449	8,853	5,381	7,985	14,408
Volume of Water Carried Over from Previous Month (cu.ft.)	0	0	0	0	0	0	0	0	0	0
OUTFLOW VOLUME CALCULATION DATA										
Evaporation from Wet Tailings Beach (cu.ft.)	43,831	67,551	138,711	196,464	272,265	328,472	420,774	363,021	226,372	152,118
Evaporation from Dry Tailings Beach (cu.ft.)	80,784	124,502	255,656	362,100	454,432	308,534	188,292	222,038	359,019	142,947
Evaporation from Supernatant Pool (cu.ft.)	49,700	76,596	157,286	108,449	0	0	0	0	0	0
Interstitial Water Lost (cu.ft.)	244,940	221,236	244,940	237,039	244,940	237,039	244,940	244,940	237,039	87,379
UNDERDRAIN DATA										
Tailings Underdrain (cu.ft.)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
NET SOLUTION BALANCE										
Volume of Solution in the Supernatant Pool Above its Min Operational Level (cu.ft.)	0	0	0	0	0	0	0	0	0	0
Volume of Solution in Supernatant Pool (cu.ft)	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700	1,416,700
Reclaim Rate from Underdrain to the Mill (gpm)	153,365	138,523	153,365	148,418	153,365	148,418	153,365	153,365	148,418	153,365
Make Up Water Required (cu.ft.)	307,623	415,464	680,161	767,215	792,788	767,215	792,788	792,788	767,215	282,816
Reclaim Rate to the Mill from the Supernatant Pool (cu.ft.)	331,800	162,079	0	0	0	0	0	0	0	0
Reclaim Rate from Underdrain to the Mill (gpm)	26	26	26	26	26	26	26	26	26	26
Make Up Water Required (gpm)	52	77	114	133	133	133	133	133	133	47
Reclaim Rate to the Mill from the Supernatant Pool (gpm)	56	30	0	0	0	0	0	0	0	0

ATTACHMENT E

Supernatant Pool Storm Surge Capacity Calculations

GOLDER

CALCULATIONS

DATE:	Oct-19	**Made by:**	JRP
PROJECT NO.:	1663241	**Checked by:**	MDB
SUBJECT:	Wave Run-up Calcuation for 500-year, 24-hour Storm Event	**Reviewed by:**	CJM
PROJECT SHORT TITLE:	Grassy Mountain TSF Detailed Design		

1.0 Objectives

The following objectives were completed for each stage at the maximum design tailings capacity with a 5-ft deep supernatant pool:
- Calculate the maximum wave run-up generated from the average recorded wind speed in the prevailing wind direction across the surface of the supernatant pool after the 500-year, 24-hour storm event.

2.0 References

A - US Army Corps of Engineers, Shoreline Protection Manual, Volumes I and II, Chapters 3 and 7
B - US Army Corps of Engineers, Water Levels and Wave Heights for Coastal Engineering Design, EM-1110-2-1414, Chapter 5, p 5-28
C - Owyhee Ridge Oregon Weather Station wind speed and direction data, 1985 to 2018

3.0 Project Description

See the design report for detailed description of the project and the proposed design modifications.

4.0 Wave Run-up Calculations

Reference A:

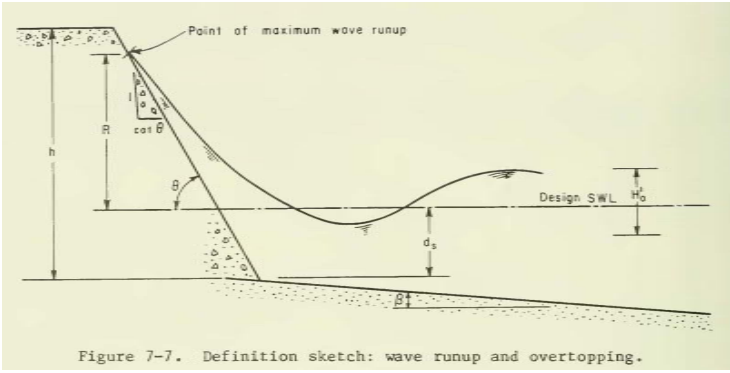

Figure 7-7: Definition Sketch: Wave Run-up and Overtopping (Reference A)

Equations:

Wave Forecasting Equations (Reference B, Table 5-3, p5-46)
Fetch Length Limited
Wave Height: $H'_0 = 1.77 \cdot 10^{-2} \cdot U_c^{1.23} \cdot F^{0.5}$
Wave Peak Period: $T_p = 46.86 \cdot 10^{-2} \cdot U_c^{0.41} \cdot F^{0.33}$
Fetch Duration Limited
Wave Height: $H'_0 = 90.79 \cdot 10^{-4} \cdot U_c^{1.58} \cdot t^{0.714}$
Wave Peak Period: $T_p = 24.16 \cdot 10^{-2} \cdot U_c^{0.724} \cdot t^{0.411}$

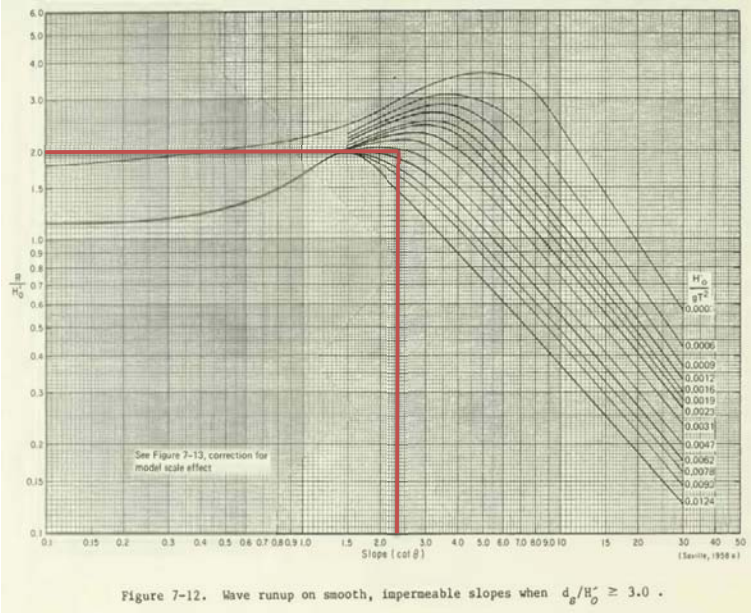

Figure 7-12: Wave Run-up on Smooth, Impermeable Slopes when $d_s/H'_0 \geq 3$ (Reference A)

Wave Height to Pool Depth Relationship: $\frac{d_s}{H'_0}$

Run-up to Wave Height Relationship: $\frac{R}{H'_0}$ (Figure 7-12)

Adjusted Overwater Wind Speed: $U_c = 1.2 \cdot U_L$ (Ref. B)

Adjusted Fetch Duration: $t = \frac{3600}{U_c}$

Fetch Limited Wind Duration: $t_f = 1.91 \cdot F^{0.67} \cdot U_c^{-0.41}$

Where:
- **U_L** = Wind Speed at 10m Above Ground, mph
- **U_c** = Adjusted Wind Speed Over Water, mph
- **t** = Adjusted Fetch Duration, hr
- **F** = Effective Fetch Length, mi
- **d_s** = Depth of Reservoir, ft
- **T_p** = Wave Peak Period, s
- **H'_0** = Wave Height, ft
- **t_f** = fetch limited wind duration, hr

DATE:	Oct-19	**Made by:**	JRP
PROJECT NO.:	1663241	**Checked by:**	MDB
SUBJECT:	Wave Run-up Calcuation for 500-year, 24-hour Storm Event	**Reviewed by:**	CJM
PROJECT SHORT TITLE:	Grassy Mountain TSF Detailed Design		

4.1 Wind Speed Normal to the Embankment Face at the Supernatant Pool

Wind data from Reference C suggests that the majority of recorded wind gusts are from the West. In order to appropriately estimate the wind speed associated with a rolling wave, the average of the wind speeds recorded in the West-East direction were used in the wave run-up analysis. Wind speeds in the prevailing wind direction averaged 7.79 mph.

Recorded Wind Speeds		**Reference**
Average Wind Speed	7.79 mph	(Reference C)

4.2 Effective Fetch Length and Pool Depth

The effective fetch length for the supernatant pool is the longest length of the water surface in the wind direction normal to the embankment slope. The prevailing wind direction is from the West so the fetch length generally trended West-East. This fetch length coincides with the average supernatant pool depth of 5 feet and the additional volume collected during the 500-year, 24-hour storm event.

Stage	Wind Source Direction	Effective Fetch Length (ft)	Pool Depth (ft) (5-ft Operating Depth + 500-yr, 24-hr Storm Event)
1	West	1,314 ft	6.65
2	West	1,200 ft	6.80
3	West	1,160 ft	6.60

4.3 Wave Forecastings

Deep water wave height can vary depending on the fetch length, wind velocity, and fetch duration. Depending on these variables, the wave height may be limited by either the fetch length or the fetch duration. Overland wind speeds should be adjusted for overwater. For fetch lengths less than 10 miles, the wind has not fully adjusted to the frictional characteristics of the waves, in such cases, the adjusted overwater wind speed is estimated to be 120 percent of the overland wind speed (Reference B).

Inputs	**Stage 1**	**Stage 2**	**Stage 3**
Effective Fetch, F	0.25 mi	0.23 mi	0.22 mi
Adjusted Wind Speed, U_c	9.3 mph		
Adjusted Fetch Duration, *t*	0.107 hr		

Fetch Length Limited			
Forecasting Parameter	**Stage 1**	**Stage 2**	**Stage 3**
Wave height, H'_0	0.14 ft	0.13 ft	0.13 ft
Wave Peak Period, T_p	0.7 s	0.7 s	0.7 s
Required Wind Duration, t_f (Note 1)	0.301 hr	0.283 hr	0.277 hr

Note 1: The required wind duration for the fetch limited condition was not met, however the wave height calculated for the fetch limited condition was greater that the fetch duration limited condition and therefore used in calculating wave run-up to provide additional conservatism.

Fetch Duration Limited			
Forecasting Parameter	**Stage 1**	**Stage 2**	**Stage 3**
Wave height, H'_0	0.06 ft	0.06 ft	0.06 ft
Wave Peak Period, T_p	0.5 s	0.5 s	0.5 s

4.4 Wave Run-up

Wave Run-up is dependent on tailings pond shape, roughness of the slope, water depth, and incident wave characteristics. For smooth, impermeable slopes, a ratio of wave run-up to wave height can be determined using Figures in Reference A. The depth of water to wave height must first be determined.

Parameter	**Stage 1**	**Stage 2**	**Stage 3**
Wave Height to Pool Depth Relationship, d_s/H'_0	48.2	51.6	50.9
Embankment Slope 2.5H: 1V (21.8°)	2.50		
Ave. H'_0/gT_p^2 (Use on Figure 7-12)	0.0078	0.0079	0.0080
Run-up to Wave Height Relationship, R/H'_0, (Figure 7-12)	2.00	1.95	1.90
Wave Run-up Height, R	**0.28 ft**	**0.26 ft**	**0.25 ft**

Freeboard Summary			
Parameter	**Stage 1**	**Stage 2**	**Stage 3**
Depth of Operating Pool, ft	5 ft	5 ft	5 ft
Depth Increase (500-yr, 24-hr storm), ft	1.65 ft	1.80 ft	1.60 ft
Wave Run-up Height, R	0.28 ft	0.26 ft	0.25 ft
Total of Depth Increase (500-yr, 24-hr storm) and Wave Run-up, ft	1.93 ft	2.06 ft	1.85 ft
Minimum Freeboard in Pool Area, ft	**2.0 ft**	**3.0 ft**	**2.0 ft**
Design Freeboard in Pool Area, ft	**3.0 ft**	**3.0 ft**	**3.0 ft**

ATTACHMENT F

TSF Reclaim Pond Sizing

GOLDER

CALCULATIONS

DATE:	Oct-19	**Made by:**	MDB
PROJECT NO.:	18111356	**Checked by:**	CJM
SUBJECT:	TSF Reclaim Pond Sizing	**Reviewed by:**	RAB
PROJECT SHORT TITLE:	Grassy Mountain TSF Pre-Feasibility Design		

1.0 Pond Storage Capacity Criteria

- 48 hours of underdrain flows due to power outage
- Draindown of 4-inch diameter DR17 Return Water Pipeline
- 100-yr, 24-hr storm event falling on the pond surface
- Freeboard of 2-feet below the crest of the pond

Pond Length (ft)	65
Pond Width (ft)	85
Pond Depth (ft)	7

1.1 Design Storm Event Volumes

Storm Event	Precipitation Depth (in)	Volume (gallons)
100-yr, 24-hr	2.28	7,853

1.2 Aggregate Volumes

Underdrain Flow		Draindown of Return Water Pipe		
Average Underdrain Flow (gpm)[1]	48 hr Power Outage Volume (gal)	Pipe Flow Area (ft^2) (4-IN HDPE DR17 Pipe)	Pipe Length (ft)	Drain Down (gal)
21.4	61,632	0.086	3,150	2,026

Notes: 1. Average underdrain flow rate represents the peak average rate during Stage 1 operations.

1.3 Total Required and Design Volumes

Pond	Required Storage Volume (gal)	Design Storage Volume (gal)
Event Pond	69,485	100,900
Freeboard	-	71,900
Total Pond Volume (gal) =		**172,800**

APPENDIX G

Hydrologic and Hydraulic Assessment

TECHNICAL MEMORANDUM

DATE October 18, 2019 **Project No.** 1663241-062-TM-Rev0

TO Nancy Wolverson
Calico Resources USA Corp.

CC

FROM Christopher J. MacMahon, PE **EMAIL Chris_MacMahon@Golder.com**

HYDROLOGIC AND HYDRAULIC DESIGN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
GRASSY MOUNTAIN MINE
MALHEUR COUNTY, NEVADA

1.0 OBJECTIVE

This report presents the detailed design of stormwater diversion channels around the tailings storage facility (TSF) at Calico Resources USA Corp.'s (Calico's) Grassy Mountain Mine in Malheur County, Oregon. These stormwater diversion channels are designed to meet the minimum design criteria defined by Oregon Administrative Rules (OAR), Division 43 – Chemical Mining requirements.

Golder's scope included the following tasks:

- Develop peak flow rates from stormwater run-off during the 25-year, 24-hour storm event for temporary stormwater diversion channel sizing
- Develop peak flow rates from stormwater run-off during the 100-year, 24-hour storm event for temporary and permanent stormwater diversion channel sizing
- Develop peak flow rates from stormwater run-off during the 500-year, 24-hour storm event for permanent stormwater diversion channel sizing
- Hydraulic design of temporary stormwater diversion channels in the TSF area
- Hydraulic design of permanent stormwater diversion channels in the TSF area
- Stormwater erosion protection design

2.0 SYNTHETIC STORM EVENTS

The National Oceanic and Atmospheric Administration (NOAA) Atlas 2 was used to develop the probabilistic-based synthetic storm events for the calculation of the peak flows. Atlas 2, Volume 10 (Oregon) contains precipitation frequency estimates for the western United States (NOAA, 1973). Atlas 2 generates the precipitation frequency estimates based on analysis of previously recorded weather patterns. The precipitation frequency estimates for Grassy Mountain were obtained using the latitudinal/longitudinal coordinates of N43.669819° and W117.35926°.

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A frequency analysis was conducted to determine annual extreme daily rainfall depths for the 1 in 25-year, 24-hour and 1 in 500-year, 24-hour storm events that were not presented in the NOAA Atlas 2. Thirty-three years of maximum daily annual precipitation data from 1986 through 2018 was obtained from the Owyhee Ridge Oregon RAWS weather stations that is located approximately 8 miles southeast of the project site. Table 1 presents the precipitation data for the storms used in this analysis.

Table 1: 24-Hour Storm Event Precipitation Depths

Recurrence Interval (years)	Precipitation Depth (in)	
	NOAA Atlas 2	Lognormal Analysis
2	0.99	-
25	Not Available	1.87
100	2.28	-
500	Not Available	3.03

Peak stormwater runoff flows generated from the 25-year, 100-year, and 500-year, 24-hour storm events, presented in Table 1, were calculated using methodologies published in Technical Release 55 (TR-55) by the USDA NRCS (USDA, 2011) and HEC-HMS Version 4.1, utilizing the SCS Rainfall Distribution Method (Type II), by the USACE (HEC, 2015). Malheur County, Oregon is located in the western United States where there are distinct dry and wet seasons and the Type II SCS Rainfall Distribution Method is most applicable. Type II rainfall distribution was used for the hydrologic models presented in this report.

Soil characteristic curve numbers (CNs) used to predict stormwater run-off potential were determined using the WIN TR-55 software for each hydrologic basin using a weighted average of natural soil, vegetation, and proposed ground conditions. Using the NRCS TR-55 Method and Golder's knowledge of the site conditions, CNs were assigned for the revegetated closure cover (placed above the TSF during closure), undisturbed existing ground, and newly graded areas.

Times of Concentration (Tc) were calculated for each hydrologic catchment area using WIN TR-55 by inputting the longest flow path in each basin and the calculated composite CNs discussed in Section 3.2 (USDA, 2011).

Temporary and permanent stormwater diversion channels were designed using the Manning's Equation via Bentley's hydraulic modeling software FlowMaster (Flowmaster, 2009). Manning's roughness coefficients were selected for multiple channel lining systems based on Golder's experience and review of various technical publications.

3.0 HYDROLOGIC ANALYSIS

Golder developed two hydrologic basin models for the Grassy Mountain TSF:

- Permanent Stormwater Diversion: The permanent stormwater diversion channels will collect stormwater runoff generated up-gradient of the TSF and divert the collected water around the TSF to existing natural drainages. This scenario includes all channels that will remain in place during closure along with the drainage swale that will be constructed across the top of the reclaimed surface of the TSF during closure.

- Temporary Stormwater Diversion: During staged construction of the TSF, temporary diversion channels will be constructed to divert stormwater falling downgradient of the permanent diversion channels around the TSF impoundment perimeter road, reclaim pond, underdrain channel, and WRD pad. These channels will be in effect during the stages presented in Table 3.

The stormwater models were prepared using the U.S. Army Corp of Engineers (USACE) Hydrologic Modelling System (HEC-HMS) (HEC, 2015). The models incorporate characteristics of the hydrologic sub-basins, existing drainages and proposed stormwater diversions to calculate peak storm water runoff flow rates from each sub-basin and at critical design locations. The models were developed and run using the following model parameters:

- Rain Distribution
  - SCS Storm Precipitation Meteorological Model
  - Type II Storm Distribution
- Sub-Basin Routing
  - SCS Curve Number Loss Method
  - SCS Unit Hydrograph Transform Method
- Reach Routing
  - Kinematic Wave Routing Method

Figures 1 and 2 schematically present the hydrologic models for the two scenarios.

3.1 Hydrologic Basin Models

Sub-basins were developed based on existing site topography, the overall project layout, the proposed TSF grading plan and identifying features where calculated peak flows would be required for hydraulic design of stormwater diversion improvements. Hydrologic catchment areas were delineated in AutoCAD and 2D surface areas for each sub-basin were extracted for use in the model.

3.1.1 Permanent Stormwater Diversion Condition

The total upgradient hydrologic catchment area for the permanent stormwater diversion channels is 785 acres. To calculate channel geometries for specific areas of each diversion channel, the total catchment area was divided into 10 smaller catchment areas ranging from under 3 acres to 480 acres. A hydrologic basin map depicting the catchment area with respective flow paths is presented in Figures 1 and 2.

The HEC-HMS model presented in Attachment A includes only non-contact water catchment areas, Catchment Areas W-1 through W-3 and E-1 through E-7. During operations and closure, all water generated from Catchment Areas W-1 through W-3, E-1 through E-3, and E-5 through E-7 will be collected and conveyed around the TSF and reclaim pond the natural drainages shown on Figures 1 and 2.

Stormwater falling onto Catchment Area E-4 (TSF impoundment surface) during operations will be is accounted for, and will be managed, in the TSF water balance. Stormwater falling on Catchment Area E-4 will not discharged into the environment. Stormwater falling on Catchment Area E-4 during closure will be conveyed by a drainage swale constructed over top of the TSF's closure cover toward the northeast corner of the TSF where it will

discharge into the east permanent diversion channel at the TSF Swale Outlet shown on Figures 1 and 2. The permanent east and west diversion channels, V-Ditch R-2 and Stage 3 Toe V-Ditch, will remain in place during TSF closure.

Table 2: Permanent Stormwater Diversion Condition Catchment Areas

Catchment Area	Catchment Area (acres)	Channel Name
W-1	17.99	Diversion Channel W-1
W-2	479.61	Diversion Channel W-2
W-3	3.62	Diversion Channel W-3
E-1	7.04	Diversion Channel E-1
E-2	91.28	Diversion Channel E-1
E-3	39.4	Diversion Channel E-1
E-4	136.5	Diversion Channel E-2
E-5	3.03	Diversion Channel E-3
E-6	5.06	Stage 3 Toe V-Ditch
E-7	1.73	Diversion V-Ditch R-1
Total	785.26	

3.1.2 Temporary Stormwater Diversion Condition

During staged construction of the TSF, areas between the TSF impoundment limits and the permanent diversion channels will be managed in temporary diversion channels that convey stormwater falling down gradient of the permanent diversion channels around the staged TSF impoundment. These temporary diversion channels will convey collected stormwater down to permanent diversion channels constructed during Stage 1.

As shown in Figure 3, the temporary stormwater diversion condition will require two temporary diversion channels to be constructed at various points in time throughout the mine staging process, as shown in Figure 3.Table 3 presents the catchment areas for each temporary diversion channel.

Table 3: Temporary Stormwater Diversion Condition Catchment Areas

Catchment Area	Catchment Area (acres)	Channel Name	Phases in Effect
T-1	7.44	Stage 1 Temporary Diversion Channel	1
T-2	7.51	Diversion V-Ditch R-2	1, 2, 3

3.1.3 SCS Curve Numbers

The SCS curve number (CN) is an empirical value accounting for soil type, infiltration characteristics, land use and vegetative cover characteristics that are used to predict stormwater runoff potential; developed by the Soil Conservation Service (SCS) now known as the Natural Resource Conservation Service (NRCS). The NRCS divides soils into four Hydrologic Soil Groups A through D, based on runoff potential of the soils. A Hydrologic Soil Group C was chosen for this area. Soils belonging to the Hydrologic Soil Group C have a slow infiltration rate when thoroughly wet and are generally fine in texture as observed during geotechnical investigation of the Project site.

Weighted average CN values were developed for each hydrologic catchment area for each of the ground conditions listed below:

- Natural soils and vegetation, CN = 80 (classified as Sagebrush with Grass Understory)
- TSF closure cover with vegetation, CN = 85 (classified as Natural Desert (pervious areas only))
- Unlined TSF embankment slopes, CN = 91 (classified as Newly Graded Area (pervious areas only))

Table 4 presents composite CN values for the Permanent Stormwater Diversion Channel contributing areas.

Table 4: Permanent Stormwater Diversion Condition Curve Numbers

Catchment Area	Composite CN
W-1	80
W-2	80
W-3	80
E-1	80
E-2	80
E-3	80
E-4	85
E-5	80
E-6	88
E-7	80

Table 5 presents the composite CN values for the Temporary Stormwater Diversion Channel contributing areas.

Table 5: Temporary Stormwater Diversion Condition Curve Numbers

Catchment Area	Composite CN
T-1	80
T-2	83

3.2 Times of Concentration and Lag Time

Times of concentration (Tc) for each catchment area was calculated by determining the flow path, gradient, and approximate drainage geometry along longest hydraulic flow path of each catchment area.

Tc calculations use flow lengths, gradients of sheet flow, shallow concentrated flow, and channelized flow conditions, where applicable. A maximum sheet flow length of 100 feet was used (USDA, 2011). Tc's are calculated using the WIN TR-55 method (USDA, 2011).

The Tc is then used to calculate the travel time (lag time, L) it takes for storm water to travel downstream from the most hydraulically distant point in the sub-basin to its outlet point. Tc is reduced by 40 percent to account for the delay between the time a storm event begins and when the run-off reaches its maximum peak flow. Table 6 and Table 7 present a summary of the Tc and L for the permanent and temporary stormwater hydrologic catchment areas, respectively. Attachment A presents the detailed calculations for developing the Tc and L for each contributing area.

Table 6: Permanent Stormwater Diversion Channel Catchment Areas Tc and L

Catchment Area	Time of Concentration, Tc (min)	Lag Time, L (min)
W-1	0.207	0.124
W-2	0.367	0.220
W-3	0.266	0.159
E-1	0.145	0.087
E-2	0.340	0.204
E-3	0.382	0.229
E-4	0.299	0.179
E-5	0.192	0.115
E-6	0.222	0.133
E-7	0.100	0.060

Table 7: Temporary Stormwater Diversion Channels Catchment Areas Tc and L

Catchment Area	Time of Concentration, Tc (min)	Lag Time, L (min)
T-1	0.325	0.195
T-2	0.286	0.172

3.3 Hydrologic Model Outputs

Using the data presented in the previous sections, Golder calculated the peak discharge flow rates from each of the contributing area using HEC-HMS 4.1 (HEC, 2015). The following section presents the model output estimate for peak stormwater flows reporting from the delineated catchment areas presented on Figures 1 and 3 for permanent and temporary stormwater diversion channels, respectively.

Calculated peak discharge flow rates for the 25-year, 24-hour storm event under the Permanent Stormwater Diversion Channels are presented in Table 8.

Table 8: Permanent Stormwater Diversion Channel, 25-year, 24-hour Peak Discharge Flow Rates

Catchment Area	25-year, 24-hour Peak Discharge (ft^3/s)
W-1	13.2
W-2	228.7
W-3	2.1
E-1	4.9
E-2	45.5
E-3	18.4
E-4	113.1
E-5	2.0
E-6	5.9
E-7	1.9

Calculated peak discharge flow rates for the 100-year, 24-hour storm event under the Permanent Stormwater Diversion Channels are presented in Table 9.

Table 9: Permanent Stormwater Diversion Channel, 100-year, 24-hour Peak Discharge Flow Rates

Catchment Area	100-year, 24-hour Peak Discharge (ft^3/s)
W-1	20.8
W-2	368.7
W-3	3.3
E-1	7.1
E-2	73.2
E-3	29.6
E-4	164.7
E-5	3.1
E-6	8.2
E-7	2.0

Table 10 presents the calculated peak discharge flow rates for the 500-year, 24-hour storm event under the Permanent Stormwater Diversion Condition.

Table 10: Permanent Stormwater Diversion Channels, 500-year, 24-hour Peak Discharge Flow Rates

Catchment Area	500-year, 24-hour Peak Discharge (ft^3/s)
W-1	36.5
W-2	657.7
W-3	5.9
E-1	13.6
E-2	130.4
E-3	52.9
E-4	266.2
E-5	5.5
E-6	12.6
E-7	3.6

Table 11 presents the calculated peak discharge flow rates for the 25-year, 24-hour storm event under the Temporary Stormwater Diversion Condition.

Table 11: Temporary Stormwater Diversion Condition, 25-year, 24-hour Peak Discharge Flow Rates

Catchment Area	25-year, 24-hour Peak Discharge (ft^3/s)
T-1	3.8
T-2	5.4

Table 12 presents the calculated peak discharge flow rates for the 100-year, 24-hour storm event under the Temporary Stormwater Diversion Condition.

Table 12: Temporary Stormwater Diversion Condition, 100-year, 24-hour Peak Discharge Flow Rates

Catchment Area	100-year, 24-hour Peak Discharge (ft^3/s)
T-1	6.1
T-2	8.1

Due to their temporary nature, the peak discharges resulting from the 500-year, 24-hour were not calculated for the Temporary Stormwater Diversion Channels. All Temporary Stormwater Diversion Channels will be removed during staged construction of the TSF.

4.0 CHANNEL HYDRAULIC CALCULATIONS

4.1 Stormwater Diversion Channels

Using the peak discharge flow rates presented in Section 3.3, Golder performed a hydraulic analysis of each Permanent and Temporary Stormwater Diversion Channel. Detailed design of each channel is presented on the Design Drawings , appended to the Tailings Storage Facility and Waste Rock Dump Final Design Report. The Permanent Stormwater Diversion Channels were sized under the for the greater of the following scenarios:

- 100-year, 24-hour storm event, 9-inches freeboard
- 500-year, 24-hour storm event, no freeboard

The Temporary Stormwater Diversion Channels were sized for the greater of the following scenarios:

- 25-year, 24-hour storm event, 9-inches freeboard
- 100-year, 24-hour storm event, no freeboard

To estimate the open channel flow characteristic of diversion channels, Golder used the Manning's formula and the Bentley software FlowMaster (Flowmaster, 2009). Detailed channel hydraulic characteristics are presented in Attachment B.

Golder assigned the following Manning's roughness coefficients each type of channel lining expected:

- Earth lined channels, n = 0.035
- Riprap lined channels, n = 0.045

4.1.1 Permanent Stormwater Diversion Channels

The Permanent diversion channels around the TSF each have unique geometries, lining systems, with a minimum design grade of 1.4%.

The West Permanent Diversion Channel utilizes two different geometries along its flow path, Diversion Channels W-1 and W-2. Diversion Channel W-1 is a triangular channel (V-ditch) and transitions to trapezoidal Diversion Channel W-2 as the channel collects more flow. The West Permanent Diversion Channel is approximately 0.5-miles long and is designed to flow towards the natural saddle west of the TSF.

The East Permanent Diversion Channel is approximately 1.0-mile long and contains three different geometries along its flow path, Diversion Channels E-1, E-2, and E-3, adjusting geometry as necessary for the increase of contributing flow. Each section of the East Permanent Diversion Channel is trapezoidal with different dimensions. The East Permanent Diversion Channel is designed to flow around the southeast to northeast side of the TSF and discharge into the natural drainage north (down gradient) of the reclaim pond.

Upon closure of the TSF, a drainage swale will be constructed above the impoundment closure cover to convey stormwater to the East Permanent Diversion Channel as shown on Figure 2.

Golder has also designed two permanent triangular (V-ditch) shaped channels, V-Ditch R-1 and Stage 3 Toe V-Ditch. V-Ditch R-1 is located on the northwest side of the reclaim pond that discharges into the same natural drainage as the East Permanent Diversion Channel described above. V-Ditch R-1 is designed to minimize runoff into the reclaim pond. Stage 3 Toe V-Ditch is located at the downstream toe of the Stage 3 north embankment and is designed to minimize runoff onto the access road along the East Diversion Channel.

Culverts installed along the East Permanent Diversion Channel are designed as temporary facilities and will remain during operation for light vehicle access and haul road crossings as shown on Figure 2.Culverts have been sized to convey the 25-year, 24-hour storm event.

. Upon closure, culverts will be removed from the permanent diversion channels as roads are reclaimed.

Locations, cross sections, dimensions, design grade, and lining system for each channel and culvert are presented on construction-level Design Drawings for the Grassy Mountain Tailings Storage Facility and Waste Rock Dump Facility.

4.1.2 Temporary Stormwater Diversion Channels

The following temporary diversion channels have been designed around the TSF:

- Temporary Diversion Channel R-2: to be constructed at the beginning of stage 1 operations and in effect through stage 3 operation
- Stage 1 Temporary Diversion Channel: to be constructed at the beginning of stage 1 operations and in effect through stage 1 operation

Locations, Cross sections, dimensions, design grade, and lining system for each channel are presented on construction-level Design Drawings for the Grassy Mountain Tailings Storage Facility and Waste Rock Dump Facility.

5.0 EROSION PROTECTION DESIGN

5.1 Channel Outlet Aprons

, Riprap energy dissipation aprons have been designed to reduce the velocities to a maximum velocity of 5 feet per second at the downstream end of the apron. Riprap aprons have been designed at the following locations:

- Apron 1 – East Permanent Diversion Discharge into the Natural Drainage
- Apron 2 – West Permanent Diversion Discharge into the Natural Drainage
- Apron 3 – Concentrated flows from Catchment Area W-2 prior to entering the West Permanent Diversion Channel

Apron geometry is based on the flow characteristics of the up-gradient channel or drainage and the downstream conditions of the natural drainage or diversion channel. The outlet aprons were designed using the American Society of Agricultural Engineer's Design of Rock Chutes methods. The lengths of the aprons were calculated as 15 time the D_{50} riprap stone size (Robinson, 1998). The transition length from the channel or drainage outlet to the full width of the apron was calculated as 5 times the D_{50} riprap stone size.

Table 13 presents the minimum outlet apron dimensions. Detailed calculations for selection of outlet apron riprap stone size are presented in Attachment C. Detailed design of the aprons is presented on the construction-level Design Drawings for the Grassy Mountain Tailings Storage Facility and Waste Rock Dump Facility.

Table 13: Diversion Channel Outlet Apron Geometry

Apron	Apron Width (ft)	Recommended Apron Length (ft)
Apron 1	30	13.5
Apron 2	30	13.5
Apron 3	40	13.5

5.2 Riprap Stone Sizing

At the conclusion of designing the diversion channel geometries, the velocities and critical flow states were reviewed for erosion potential. Diversion channels that are expected to have flows with velocities greater than 5 ft/s, as well as supercritical flows, have been designed with riprap lining systems.

FHWA HEC-11 was used to calculate the required D_{50} riprap stone size to resist shear forces resulting from the maximum calculated flow velocity (FWHA, 1989). The resulting D_{50} for all channels and outlet aprons varies between D_{50} = 12 and 28 in. The D_{max} of the riprap was selected as 1.5 times the D_{50} size and a total thickness of the riprap layer was selected as 1.5 times the D_{50} size. Calculations for riprap stone sizing and outlet aprons are presented in Attachment C.

6.0 REFERENCES

Flowmaster, 2009. Bentley® FlowMaster® V8i (SELECTseries 1) [software], build 08.11.01.03. Bentley Systems, Inc. November 4, 2009.

FHWA, 1989. Design of Riprap Revetment, Hydraulic Engineering Circular No. 11 (HEC-11). Report No. FHWA-IP-89-016 HEC-11, Metric Version, U.S. Federal Highway Administration.

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NOAA 1973. *Precipitation-Frequency Atlas of the Western United States, Volume X – Oregon. Prepared for the US Department of Agriculture, Soil Conservation Service, Engineering Division*. 1973.

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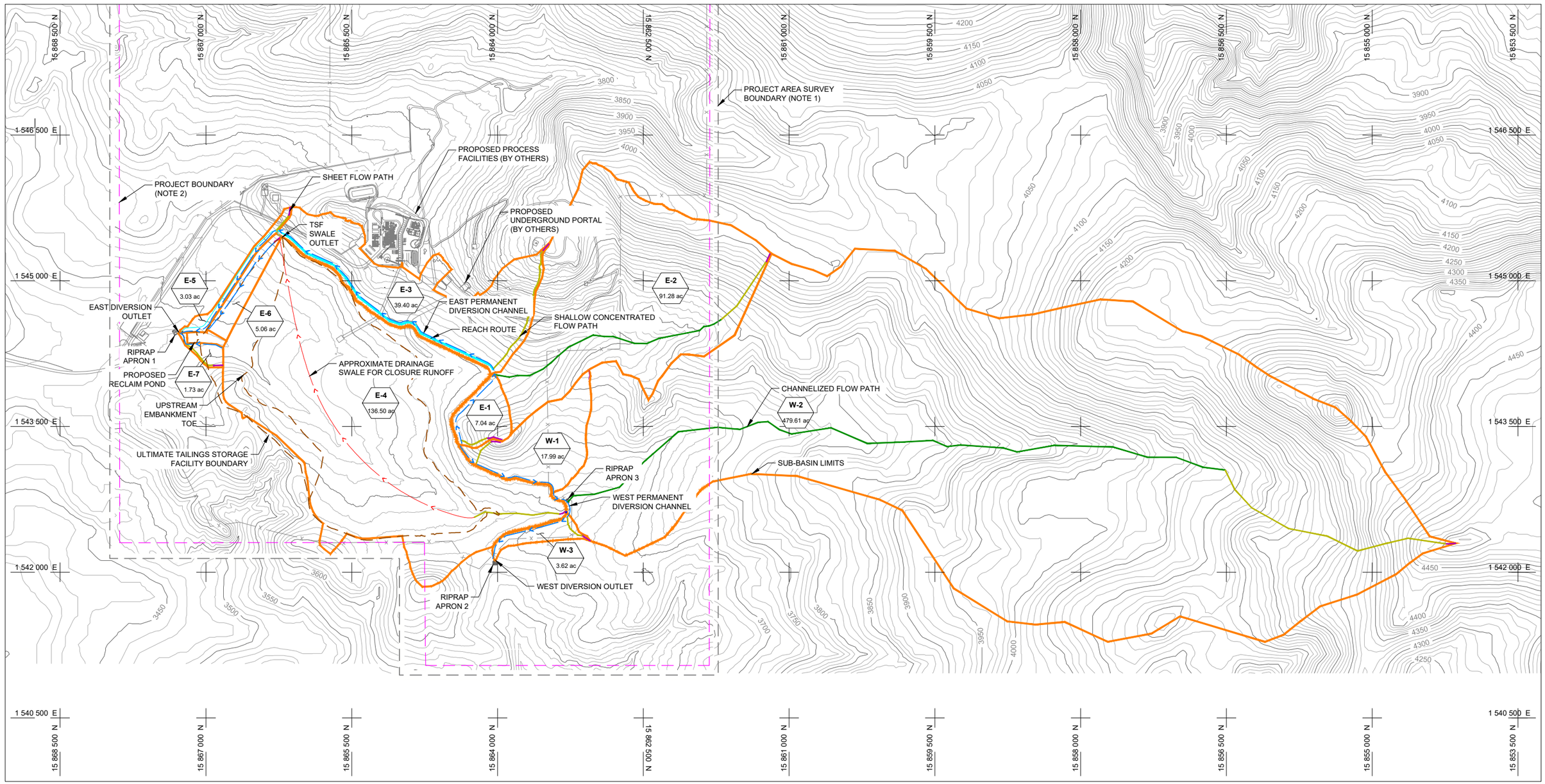
FIGURES

Figure 1 Permanent Stormwater Condition (1 of 2)
Figure 2 Permanent Stormwater Condition (2 of 2)
Figure 3 Temporary Stormwater Condition

ATTACHMENTS

Attachment A Times of Concentration and Lag Time Calculations
Attachment B Diversion Channel Hydraulic Design Calculations
Attachment C Erosion Protection Design Calculation

FIGURES



0 500 1000
1" = 500' FEET

LEGEND

- 3600 EXISTING GROUND CONTOURS (10 FT) (NOTE 1)
- PROJECT BOUNDARY (NOTE 2)
- REACH ROUTE
- PERMANENT STORMWATER DIVERSION CHANNEL
- SHALLOW CONCENTRATED FLOW PATH
- SHEET FLOW PATH
- SUB-BASIN LIMITS
- ULTIMATE TAILINGS STORAGE FACILITY BOUNDARY
- PROJECT AREA SURVEY BOUNDARY (NOTE 1)

NOTES

1. EXISTING GROUND TOPOGRAPHY WITHIN THE PROJECT AREA SURVEY BOUNDARY WAS PROVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf". TOPOGRAPHY OUTSIDE THE PROJECT AREA SURVEY BOUNDARY WAS AVAILABLE FROM WEBGIS DIGITAL ELEVATION MODELS WITH 30 m RESOLUTION.
2. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
PERMANENT STORMWATER CONDITION (1 OF 2)

PROJECT NO.	REV.	FIGURE
1663241	0	1

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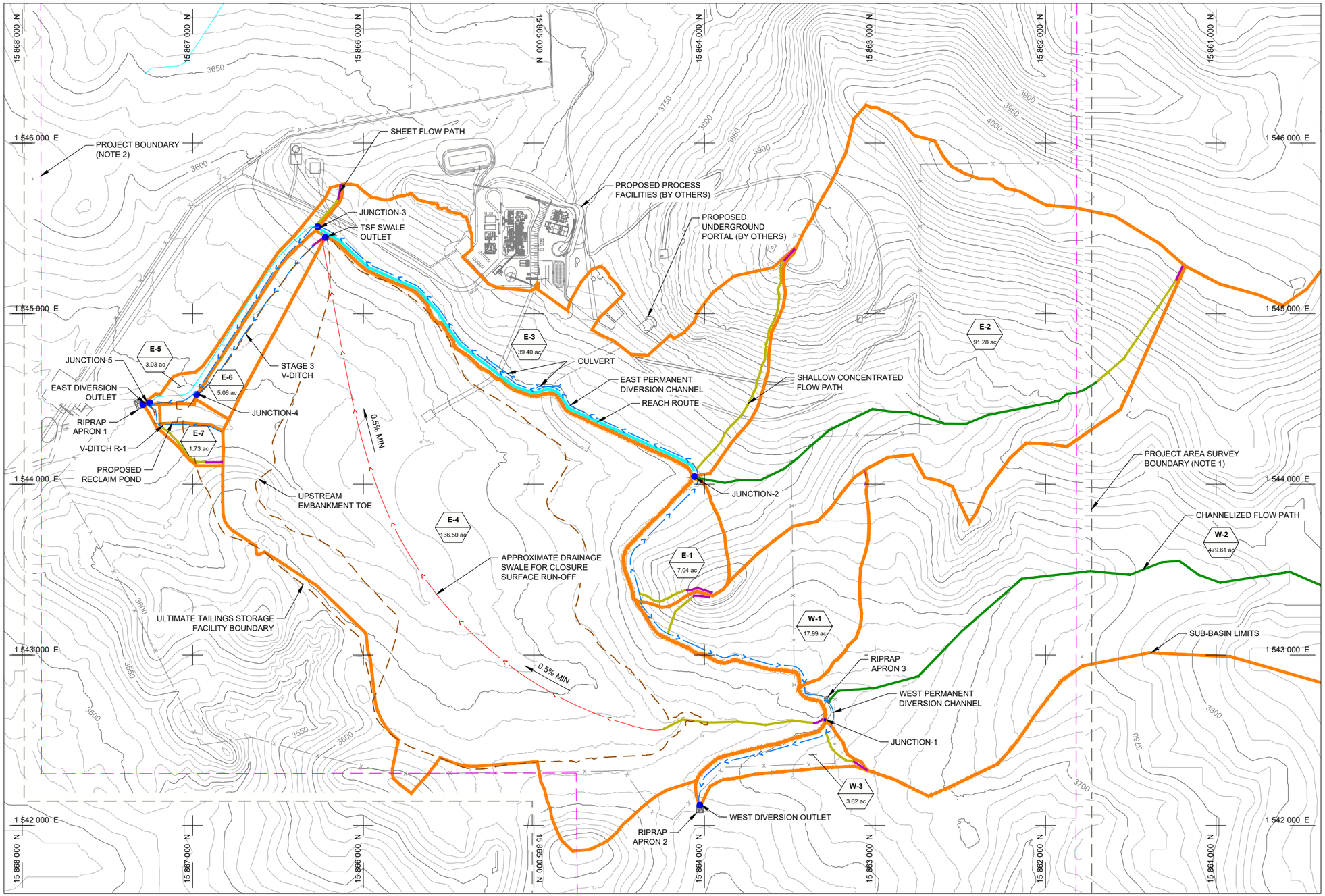

NOTES

1. EXISTING GROUND TOPOGRAPHY WITHIN THE PROJECT AREA SURVEY BOUNDARY WAS PROVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf". TOPOGRAPHY OUTSIDE THE PROJECT AREA SURVEY BOUNDARY WAS AVAILABLE FROM WEBGIS DIGITAL ELEVATION MODELS WITH 30 m RESOLUTION.
2. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".

LEGEND

- 3600 — EXISTING GROUND CONTOURS (10 FT) (NOTE 1)
- PROJECT BOUNDARY (NOTE 2)
- ULTIMATE TAILINGS STORAGE FACILITY BOUNDARY
- APPROXIMATE DRAINAGE SWALE FOR CLOSURE SURFACE RUN-OFF
- CULVERT
- PROJECT AREA SURVEY BOUNDARY (NOTE 1)
- REACH ROUTE
- PERMANENT STORMWATER DIVERSION CHANNEL
- SHEET FLOW PATH
- SHALLOW CONCENTRATED FLOW PATH
- SUB-BASIN LIMITS

0 300 600
1" = 300' FEET

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
PERMANENT STORMWATER CONDITION (2 OF 2)

PROJECT NO. 1663241 | REV. 0 | FIGURE 2

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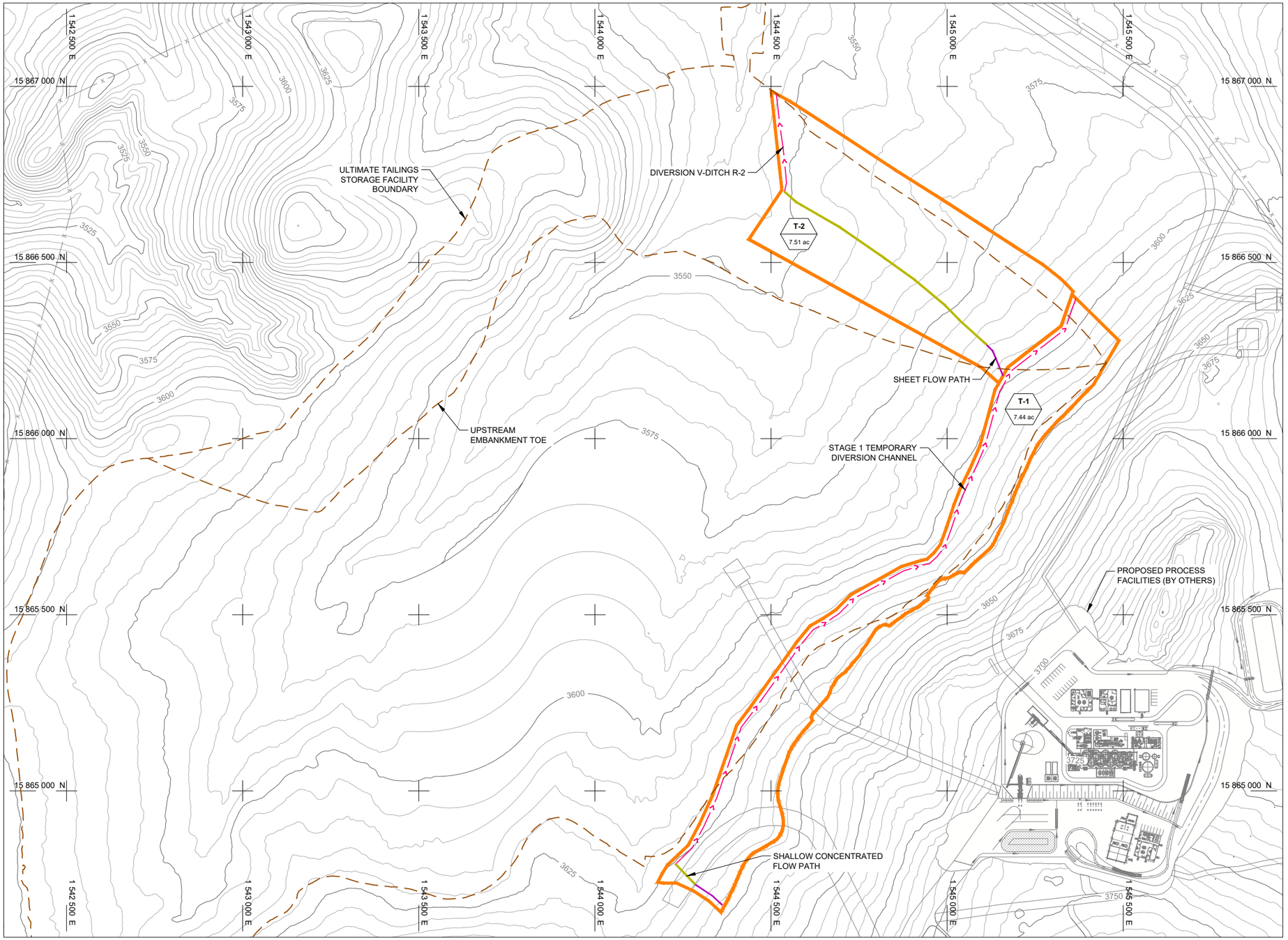

NOTES

1. EXISTING GROUND TOPOGRAPHY PROVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf".

LEGEND

- 3600 — EXISTING GROUND CONTOURS (5 FT) (NOTE 1)
- ULTIMATE TAILINGS STORAGE FACILITY BOUNDARY
- TEMPORARY STORMWATER DIVERSION CHANNEL
- SHEET FLOW PATH
- SHALLOW CONCENTRATED FLOW PATH
- SUB-BASIN LIMITS

0 150 300
1" = 150' FEET

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-01
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
TEMPORARY STORMWATER CONDITION

PROJECT NO.	REV.	FIGURE
1663241	0	3

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

0 1 in

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ATTACHMENT A

Times of Concentration and Lag Time Calculations

WinTR-55 Current Data Description

--- Identification Data ---

User: J.Price
Project: Grassy Mountain
SubTitle: Permanent Stormwater Condition - East
State: Nevada
County:
Filename: C:\Users\JePrice\Golder Associates\18111356, Calico Grassy Mountain Civil Design Support Oregon

Date: 10/31/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
E3		Outlet	39.4	80	.382
E4		Outlet	136.5	85	0.299
E6		Outlet	5.06	88	.222
E5		Outlet	3.03	80	0.192
E7		Outlet	1.73	80	0.1
E2		Outlet	91.28	80	.34
E1		Outlet	7.04	80	0.145

Total area: 284.04 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	500-Yr (in)
.99	1.27	1.53	1.87	2.13	2.28	3.03

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

WinTR-55 Current Data Description

--- Identification Data ---

User: J.Price
Project: Grassy Mountain TSF
SubTitle: Permanent Stormwater Condition - West
State: Nevada
County:
Filename: C:\Users\JePrice\Golder Associates\18111356, Calico Grassy Mountain Civil Design Support Oregon

Date: 10/31/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
W-2			479.61	80	.367
W-3			3.62	80	.255
W-1			17.99	80	.114

Total area: 501.22 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	500-Yr (in)
.99	1.27	1.53	1.87	2.13	2.28	3.03

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

WinTR-55 Current Data Description

--- Identification Data ---

User: J.Price
Project: Grassy Mountain TSF
SubTitle: Temporary Stormwater Condition
State: Nevada
County:
Filename: C:\Users\JePrice\Golder Associates\18111356, Calico Grassy Mountain Civil Design Support Oregon

Date: 10/31/2019
Units: English
Areal Units: Acres

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
T-1			7.43	80	.325
T-2			7.51	83	.286

Total area: 14.94 (ac)

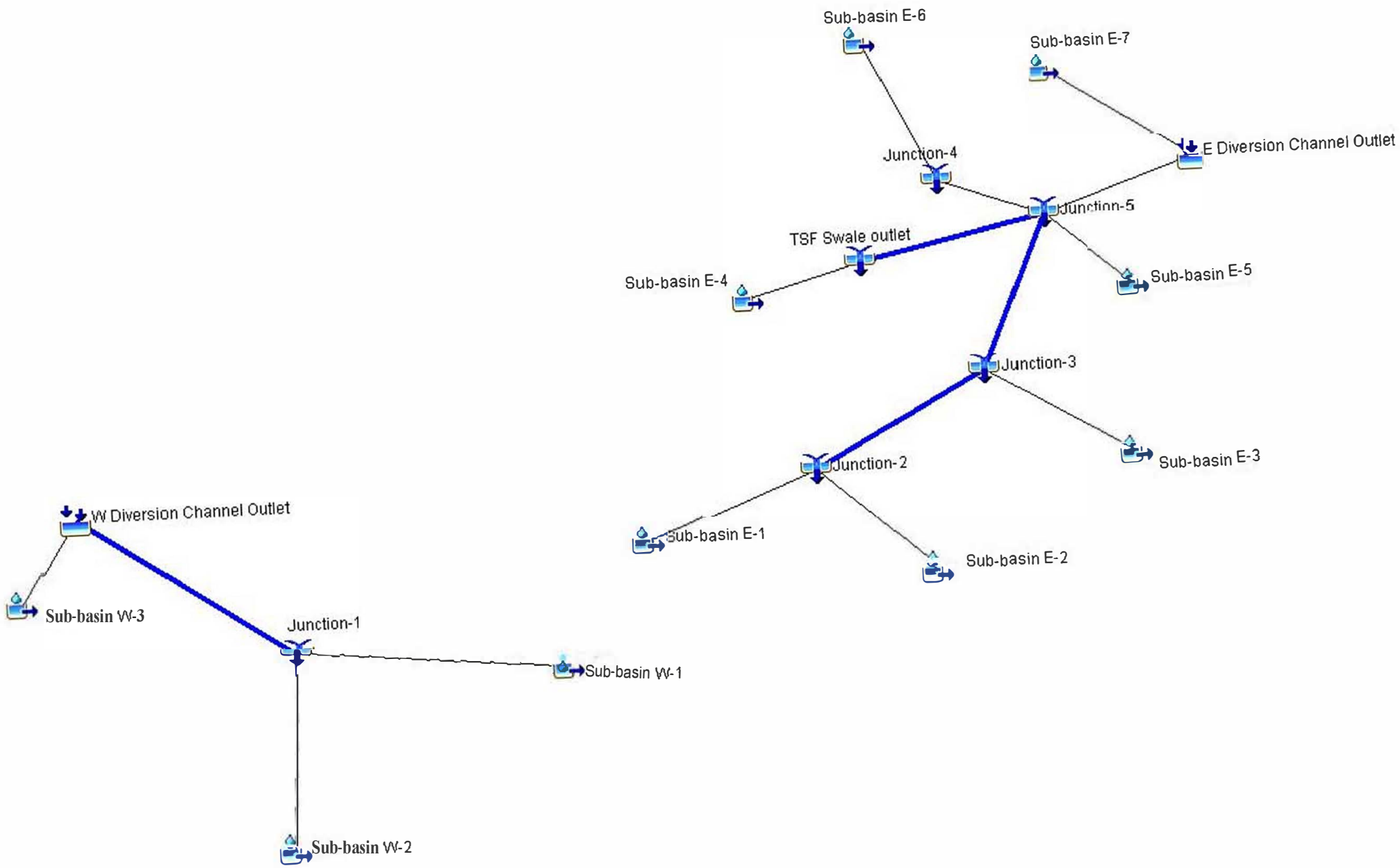
--- Storm Data --

Rainfall Depth by Rainfall Return Period

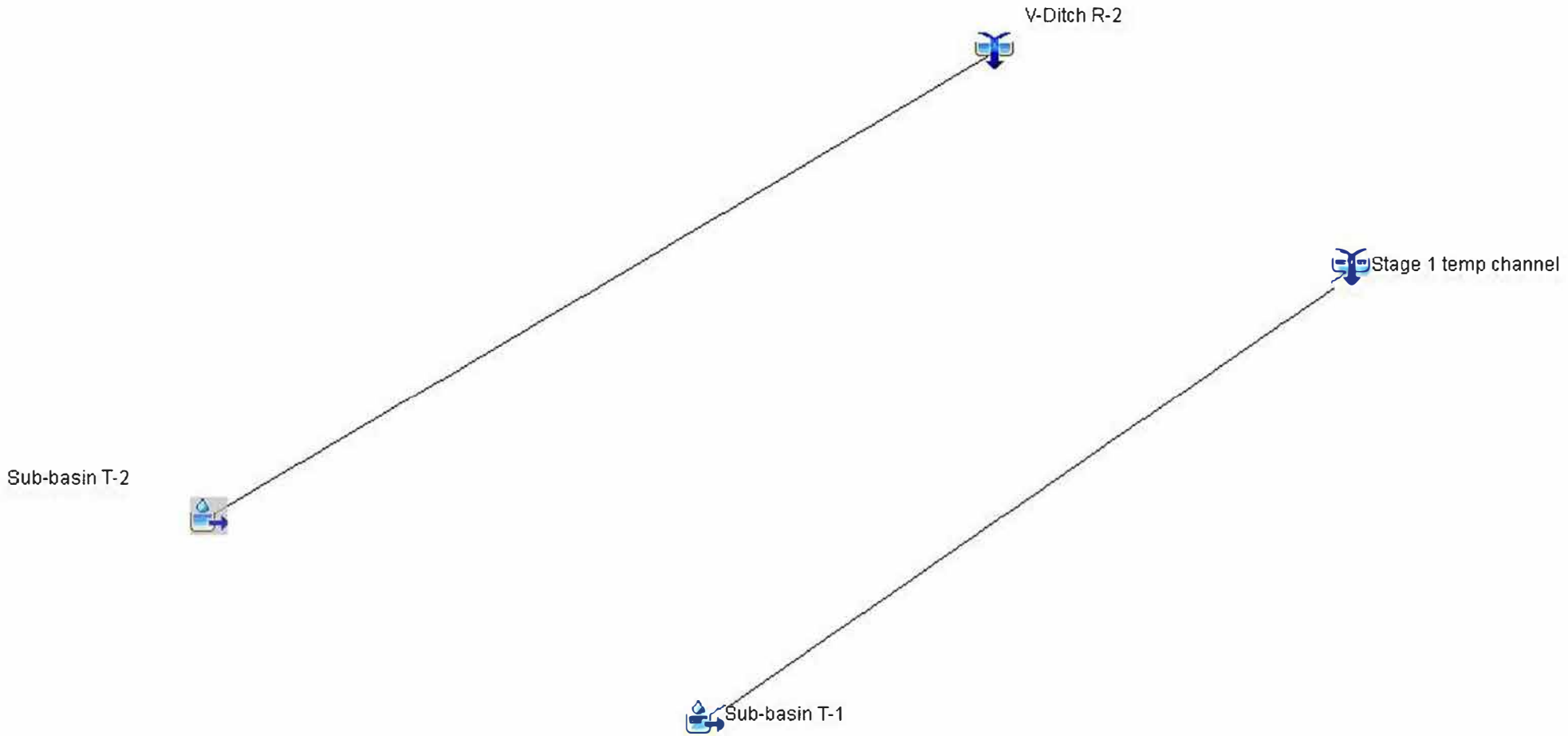
2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	500-Yr (in)
.99	1.27	1.53	1.87	2.13	2.28	3.03

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

Grassy Mountain Project
HEC-HMS Permanent Stormwater Conditions Basin Layout
Projcet Number: 1663241



Grassy Mountain Project
HEC-HMS Temporary Stormwater Conditions Basin Layout
Projcet Number: 1663241



ATTACHMENT B

Diversion Channel Hydraulic Design Calculations

Permanent Channel Hydraulics - Diversion Channel E-1 - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01400	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	106.90	ft³/s

Results

Normal Depth	1.31	ft
Flow Area	20.87	ft²
Wetted Perimeter	20.29	ft
Hydraulic Radius	1.03	ft
Top Width	19.86	ft
Critical Depth	1.21	ft
Critical Slope	0.01843	ft/ft
Velocity	5.12	ft/s
Velocity Head	0.41	ft
Specific Energy	1.72	ft
Froude Number	0.88	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.31	ft
Critical Depth	1.21	ft
Channel Slope	0.01400	ft/ft
Critical Slope	0.01843	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel E-1 - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01400	ft/ft
Left Side Slope	3.00	ft/ft (H:V)
Right Side Slope	3.00	ft/ft (H:V)
Bottom Width	12.00	ft
Discharge	191.10	ft³/s

Results

Normal Depth	1.80	ft
Flow Area	31.31	ft²
Wetted Perimeter	23.38	ft
Hydraulic Radius	1.34	ft
Top Width	22.80	ft
Critical Depth	1.71	ft
Critical Slope	0.01683	ft/ft
Velocity	6.10	ft/s
Velocity Head	0.58	ft
Specific Energy	2.38	ft
Froude Number	0.92	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.80	ft
Critical Depth	1.71	ft
Channel Slope	0.01400	ft/ft
Critical Slope	0.01683	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel E-**2** - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.04000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	270.00	ft³/s

Results

Normal Depth	2.07	ft
Flow Area	31.41	ft²
Wetted Perimeter	21.15	ft
Hydraulic Radius	1.49	ft
Top Width	20.35	ft
Critical Depth	2.32	ft
Critical Slope	0.02612	ft/ft
Velocity	8.60	ft/s
Velocity Head	1.15	ft
Specific Energy	3.22	ft
Froude Number	1.22	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.07	ft
Critical Depth	2.32	ft
Channel Slope	0.04000	ft/ft
Critical Slope	0.02612	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel E-**2** - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.04000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	458.60	ft³/s

Results

Normal Depth	2.73	ft
Flow Area	45.92	ft²
Wetted Perimeter	24.70	ft
Hydraulic Radius	1.86	ft
Top Width	23.65	ft
Critical Depth	3.10	ft
Critical Slope	0.02427	ft/ft
Velocity	9.99	ft/s
Velocity Head	1.55	ft
Specific Energy	4.28	ft
Froude Number	1.26	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.73	ft
Critical Depth	3.10	ft
Channel Slope	0.04000	ft/ft
Critical Slope	0.02427	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel E-**3** - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.03000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	270.00	ft³/s

Results

Normal Depth	2.23	ft
Flow Area	34.80	ft²
Wetted Perimeter	22.03	ft
Hydraulic Radius	1.58	ft
Top Width	21.17	ft
Critical Depth	2.32	ft
Critical Slope	0.02612	ft/ft
Velocity	7.76	ft/s
Velocity Head	0.94	ft
Specific Energy	3.17	ft
Froude Number	1.07	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.23	ft
Critical Depth	2.32	ft
Channel Slope	0.03000	ft/ft
Critical Slope	0.02612	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel E-**3** - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.03000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	458.60	ft³/s

Results

Normal Depth	2.94	ft
Flow Area	50.96	ft²
Wetted Perimeter	25.82	ft
Hydraulic Radius	1.97	ft
Top Width	24.69	ft
Critical Depth	3.10	ft
Critical Slope	0.02427	ft/ft
Velocity	9.00	ft/s
Velocity Head	1.26	ft
Specific Energy	4.20	ft
Froude Number	1.10	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	2.94	ft
Critical Depth	3.10	ft
Channel Slope	0.03000	ft/ft
Critical Slope	0.02427	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **W-1** - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	20.80	ft³/s

Results

Normal Depth	1.44	ft
Flow Area	5.22	ft²
Wetted Perimeter	7.78	ft
Hydraulic Radius	0.67	ft
Top Width	7.22	ft
Critical Depth	1.34	ft
Critical Slope	0.02253	ft/ft
Velocity	3.98	ft/s
Velocity Head	0.25	ft
Specific Energy	1.69	ft
Froude Number	0.83	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.44	ft
Critical Depth	1.34	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02253	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **W-1** - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	35.60	ft³/s

Results

Normal Depth	1.77	ft
Flow Area	7.81	ft²
Wetted Perimeter	9.52	ft
Hydraulic Radius	0.82	ft
Top Width	8.84	ft
Critical Depth	1.66	ft
Critical Slope	0.02097	ft/ft
Velocity	4.56	ft/s
Velocity Head	0.32	ft
Specific Energy	2.09	ft
Froude Number	0.85	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.77	ft
Critical Depth	1.66	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02097	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **W-2** - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.01400	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	377.90	ft³/s

Results

Normal Depth	3.23	ft
Flow Area	58.39	ft²
Wetted Perimeter	27.40	ft
Hydraulic Radius	2.13	ft
Top Width	26.15	ft
Critical Depth	2.79	ft
Critical Slope	0.02492	ft/ft
Velocity	6.47	ft/s
Velocity Head	0.65	ft
Specific Energy	3.88	ft
Froude Number	0.76	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.23	ft
Critical Depth	2.79	ft
Channel Slope	0.01400	ft/ft
Critical Slope	0.02492	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **W-2** - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.045	
Channel Slope	0.01400	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Bottom Width	10.00	ft
Discharge	657.70	ft³/s

Results

Normal Depth	4.25	ft
Flow Area	87.59	ft²
Wetted Perimeter	32.88	ft
Hydraulic Radius	2.66	ft
Top Width	31.24	ft
Critical Depth	3.76	ft
Critical Slope	0.02311	ft/ft
Velocity	7.51	ft/s
Velocity Head	0.88	ft
Specific Energy	5.12	ft
Froude Number	0.79	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	4.25	ft
Critical Depth	3.76	ft
Channel Slope	0.01400	ft/ft
Critical Slope	0.02311	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **R-1** - 100 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	2.00	ft³/s

Results

Normal Depth	0.57	ft
Flow Area	0.81	ft²
Wetted Perimeter	3.06	ft
Hydraulic Radius	0.26	ft
Top Width	2.84	ft
Critical Depth	0.52	ft
Critical Slope	0.03078	ft/ft
Velocity	2.47	ft/s
Velocity Head	0.09	ft
Specific Energy	0.66	ft
Froude Number	0.82	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.57	ft
Critical Depth	0.52	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.03078	ft/ft

Permanent Channel Hydraulics **-** Diversion Channel **R-1** - **5**00 Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.02000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	3.60	ft³/s

Results

Normal Depth	0.71	ft
Flow Area	1.26	ft²
Wetted Perimeter	3.82	ft
Hydraulic Radius	0.33	ft
Top Width	3.55	ft
Critical Depth	0.66	ft
Critical Slope	0.02846	ft/ft
Velocity	2.86	ft/s
Velocity Head	0.13	ft
Specific Energy	0.84	ft
Froude Number	0.85	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.71	ft
Critical Depth	0.66	ft
Channel Slope	0.02000	ft/ft
Critical Slope	0.02846	ft/ft

Permanent Channel Hydraulics **- Stage 3 Toe V-Ditch - 100** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.07000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	8.20	ft³/s

Results

Normal Depth	0.76	ft
Flow Area	1.46	ft²
Wetted Perimeter	4.11	ft
Hydraulic Radius	0.35	ft
Top Width	3.82	ft
Critical Depth	0.92	ft
Critical Slope	0.02550	ft/ft
Velocity	5.63	ft/s
Velocity Head	0.49	ft
Specific Energy	1.26	ft
Froude Number	1.61	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.76	ft
Critical Depth	0.92	ft
Channel Slope	0.07000	ft/ft
Critical Slope	0.02550	ft/ft

Permamemt Channel Hydraulics **- Stage 3 Toe V-Ditch - 500** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.07000	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	12.60	ft³/s

Results

Normal Depth	0.90	ft
Flow Area	2.01	ft²
Wetted Perimeter	4.83	ft
Hydraulic Radius	0.42	ft
Top Width	4.48	ft
Critical Depth	1.10	ft
Critical Slope	0.02408	ft/ft
Velocity	6.27	ft/s
Velocity Head	0.61	ft
Specific Energy	1.51	ft
Froude Number	1.65	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.90	ft
Critical Depth	1.10	ft
Channel Slope	0.07000	ft/ft
Critical Slope	0.02408	ft/ft

Temporary Channel Hydraulics **- Stage 1 Temp Channel - 25** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	3.80	ft³/s

Results

Normal Depth	0.76	ft
Flow Area	1.46	ft²
Wetted Perimeter	4.11	ft
Hydraulic Radius	0.35	ft
Top Width	3.82	ft
Critical Depth	0.68	ft
Critical Slope	0.02826	ft/ft
Velocity	2.61	ft/s
Velocity Head	0.11	ft
Specific Energy	0.87	ft
Froude Number	0.74	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.76	ft
Critical Depth	0.68	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02826	ft/ft

Temporary Channel Hydraulics **- Stage 1 Temp Channel - 100** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	6.10	ft³/s

Results

Normal Depth	0.91	ft
Flow Area	2.08	ft²
Wetted Perimeter	4.91	ft
Hydraulic Radius	0.42	ft
Top Width	4.56	ft
Critical Depth	0.82	ft
Critical Slope	0.02653	ft/ft
Velocity	2.93	ft/s
Velocity Head	0.13	ft
Specific Energy	1.05	ft
Froude Number	0.77	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.91	ft
Critical Depth	0.82	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02653	ft/ft

Temporary Channel Hydraulics **- V-Ditch R-2 - 25** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	5.40	ft^3/s

Results

Normal Depth	0.87	ft
Flow Area	1.90	ft^2
Wetted Perimeter	4.69	ft
Hydraulic Radius	0.40	ft
Top Width	4.36	ft
Critical Depth	0.78	ft
Critical Slope	0.02697	ft/ft
Velocity	2.84	ft/s
Velocity Head	0.13	ft
Specific Energy	1.00	ft
Froude Number	0.76	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	0.87	ft
Critical Depth	0.78	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02697	ft/ft

Temporary Channel Hydraulics **- V-Ditch R-2 - 100** Year Storm

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.035	
Channel Slope	0.01500	ft/ft
Left Side Slope	2.50	ft/ft (H:V)
Right Side Slope	2.50	ft/ft (H:V)
Discharge	8.10	ft^3/s

Results

Normal Depth	1.01	ft
Flow Area	2.57	ft^2
Wetted Perimeter	5.46	ft
Hydraulic Radius	0.47	ft
Top Width	5.07	ft
Critical Depth	0.92	ft
Critical Slope	0.02555	ft/ft
Velocity	3.15	ft/s
Velocity Head	0.15	ft
Specific Energy	1.17	ft
Froude Number	0.78	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.01	ft
Critical Depth	0.92	ft
Channel Slope	0.01500	ft/ft
Critical Slope	0.02555	ft/ft

ATTACHMENT C

Erosion Protection Design Calculations

Grassy Mountain Project
Channel Riprap Calculations
Project Number: 1663241

Date:	11/1/19
By:	JRP
Chkd:	MDB
Aprvd:	CJM

Rip Rap Sizing

Channel	Design Grade	Maximum Velocity (mps)	Average Flow Depth (m)	Safety Factor	Specific Gravity of Rip Rap	Angle of Repose of Rip Rap (°)	Channel Side Slope Angle (°)	C_s	C_{sf}	K_1	Required Rip Rap D_{50} (m)	Rip Rap D_{15} (m)	Recommended Rip Rap D_{50} (m)	Recommended Rip Rap Thickness (m) ($1.5xD_{50}$)	Rip Rap Filter Fill Thickness (m)
E-1	2-6%	3.0	0.57	1.2	2.75	40	21.8	0.92	1.00	0.82	0.27	0.11	0.305	0.46	0.30
E-1	6-8.5%	3.3	0.52	1.2	2.75	40	21.8	0.92	1.00	0.82	0.38	0.16	0.406	0.61	0.30
E-1	>8.5%	3.9	0.46	1.2	2.75	40	21.8	0.92	1.00	0.82	0.65	0.27	0.711	1.07	0.30
W-2	1.40%	2.0	0.98	1.2	2.75	40	21.8	0.92	1.00	0.82	0.06	0.02	0.102	0.15	0.30

Apron	Design Grade	Maximum Velocity (mps)	Average Flow Depth (m)	Safety Factor	Specific Gravity of Rip Rap	Angle of Repose of Rip Rap (°)	Channel Side Slope Angle (°)	C_s	C_{sf}	K_1	Required Rip Rap D_{50} (m)	Rip Rap D_{15} (m)	Recommended Rip Rap D_{50} (m)	Recommended Rip Rap Thickness (m) ($1.5xD_{50}$)	Rip Rap Filter Fill Thickness (m)
Apron 1	6%	2.5	0.30	1.2	2.75	40	18.4	0.92	1.00	0.87	0.19	0.08	0.203	0.30	0.30
Apron 2	5%	2.7	0.4	1.2	2.75	40	18.4	0.92	1.00	0.87	0.21	0.09	0.203	0.30	0.30
Apron 3	5%	2.4	0.3	1.2	2.75	40	18.4	0.92	1.00	0.87	0.17	0.07	0.203	0.30	0.30

$$D_{50} = C_S C_{SF} \frac{0.00594\, V_a^{\ 3}}{\sqrt{d}\, K_1^{1.5}}$$

$$C_S = \frac{2.12}{(G_S - 1)^{1.5}}$$

$$C_{SF} = \left(\frac{SF}{1.2}\right)^{1.5}$$

$$K_1 = \left(1 - \frac{\left(\sin^2\theta\right)}{\left(\sin^2\Phi\right)}\right)^{1/2}$$

APPENDIX H

Underdrain Collection Piping Design

GOLDER

CALCULATIONS

DATE:	Oct-19	**Made by:**	MDB
PROJECT NO.:	1663241 - Grassy Mountain TSF Detailed Design	**Checked by:**	CJM
SUBJECT:	TSF Underdrain Pipe Sizing	**Reviewed by:**	RAB

Assumptions:

- Solid wall underdrain pipes will maintain a minimum slope of 1.0%, after settlement, beneath the embankment.
- Underdrain pipes will be DR17 HDPE.
- Underdrain pipes will be sized to convey the maximum flow estimated by Golder in the Consolidation and Thin-Lift Modeling Technical Memorandum.
- Full flow capacity of the underdrain pipes was calculated using Bentley Flowmaster Version 8i.
- Manning's Roughness Coefficient of 0.012 (smooth wall HDPE).

areas of the tailings however for redundancy each underdrain pipe will be sized to convey the entire drainage rate.

Given:

- Golder developed drainage rates through the tailings for two scenarios in the *Consolidation and Thin-Lift Modeling* Technical Memorandum.
- The drainage rates developed for Case 2, which assumes water lost at the surface of the tailings during the sedimentation process reports to the supernatant pool, were used to size the solid wall underdrain pipes used to convey solution collected at the base of the TSF to the reclaim pond
- The volume of water reporting to the supernatant pool was estimated by based on the results of the settling column tests.

Year	Case 2 – Drainage Rate (gpm)		
	Min	Max	Average
1	2.3	99.3	13.5
2	3.3	30.3	12.5
3	5.1	72.1	20.7
4	4.3	52.4	16.6
5	4.9	73.5	19.5
6	5.7	46.3	18.3
7	6.5	57.8	24.6
8	7.9	47.0	20.3
9	8.0	91.4	25.0
10	8.6	58.4	21.7
11	9.1	65.7	26.4
12	10.9	58.8	25.3
13	12.6	64.7	27.0
14	13.7	63.1	28.8

Calculations:

Full flow capacity of 6-inch DR17 HDPE (5.8" I.D.):	**249.3**	gpm	*(Calculation attached)*
Maximum drainage rate:	99.3	gpm	*(Case 2 above)*
Average drainage rate:	21.4	gpm	*(Case 2 above)*

In the event that any of the underdrains were to become plugged, a single 6-inch solid wall DR17 HDPE pipe will convey the maximum estimated drainage rate at 40% capacity and the average drainage rate at 18% capacity. This additional capacity will accommodate long term pipe scaling and roughening of the inner wall of the pipe.

Attachment A

Underdrain Flow Capacity Calculations

6" DR17 HDpE Underdrain Pipe - Full Flow

Project Description

Friction Method	Manning Formula
Solve For	Full Flow Capacity

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.01000	ft/ft
Normal Depth	5.80	in
Diameter	5.80	in
Discharge	249.23	gpm

Results

Discharge	249.23	gpm
Normal Depth	5.80	in
Flow Area	0.18	ft²
Wetted Perimeter	1.52	ft
Hydraulic Radius	1.45	in
Top Width	0.00	ft
Critical Depth	0.38	ft
Percent Full	100.0	%
Critical Slope	0.01071	ft/ft
Velocity	3.03	ft/s
Velocity Head	0.14	ft
Specific Energy	0.63	ft
Froude Number	0.00	
Maximum Discharge	0.60	ft³/s
Discharge Full	0.56	ft³/s
Slope Full	0.01000	ft/ft
Flow Type	SubCritical	

GVF Input Data

Downstream Depth	0.00	in
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%

6" DR17 HDpE Underdrain Pipe - Full Flow

GVF Output Data

Normal Depth Over Rise	100.00	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	5.80	in
Critical Depth	0.38	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.01071	ft/ft

Worksheet for 6" DR17 HDPE Underdrain Pipe - Max Drainage Rate

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.01000	ft/ft
Diameter	5.80	in
Discharge	99.30	gpm

Results

Normal Depth	2.54	in
Flow Area	0.08	ft²
Wetted Perimeter	0.70	ft
Hydraulic Radius	1.33	in
Top Width	0.48	ft
Critical Depth	0.24	ft
Percent Full	43.9	%
Critical Slope	0.00663	ft/ft
Velocity	2.86	ft/s
Velocity Head	0.13	ft
Specific Energy	0.34	ft
Froude Number	1.25	
Maximum Discharge	0.60	ft³/s
Discharge Full	0.56	ft³/s
Slope Full	0.00159	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	in
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	43.86	%
Downstream Velocity	Infinity	ft/s

Worksheet for 6" DR17 HDPE Underdrain Pipe - Max Drainage Rate

GVF Output Data

Upstream Velocity	Infinity	ft/s
Normal Depth	2.54	in
Critical Depth	0.24	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.00663	ft/ft

Worksheet for 6" DR17 HDPE Underdrain Pipe - Avg. Drainage Rate

Project Description

Friction Method	Manning Formula
Solve For	Normal Depth

Input Data

Roughness Coefficient	0.012	
Channel Slope	0.01000	ft/ft
Diameter	5.80	in
Discharge	21.40	gpm

Results

Normal Depth	1.15	in
Flow Area	0.03	ft²
Wetted Perimeter	0.45	ft
Hydraulic Radius	0.69	in
Top Width	0.39	ft
Critical Depth	0.11	ft
Percent Full	19.8	%
Critical Slope	0.00626	ft/ft
Velocity	1.85	ft/s
Velocity Head	0.05	ft
Specific Energy	0.15	ft
Froude Number	1.26	
Maximum Discharge	0.60	ft³/s
Discharge Full	0.56	ft³/s
Slope Full	0.00007	ft/ft
Flow Type	SuperCritical	

GVF Input Data

Downstream Depth	0.00	in
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	in
Profile Description		
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.00	%
Normal Depth Over Rise	19.83	%
Downstream Velocity	Infinity	ft/s

Worksheet for 6" DR17 HDPE Underdrain Pipe - Avg. Drainage Rate

GVF Output Data

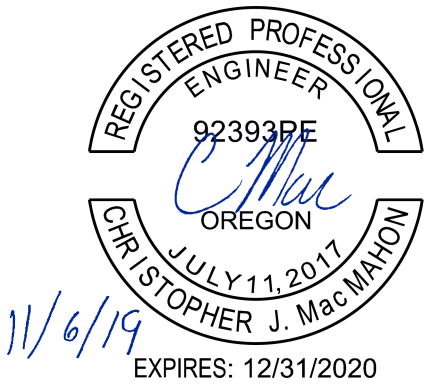
Upstream Velocity	Infinity	ft/s
Normal Depth	1.15	in
Critical Depth	0.11	ft
Channel Slope	0.01000	ft/ft
Critical Slope	0.00626	ft/ft

APPENDIX I

Technical Specifications

Technical Specifications
Tailings Storage Facility and Waste Rock Dump
Grassy Mountain Mine

Malheur County, Oregon



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1662341-056-SP-Rev0

November 6, 2019

Table of Contents

Specification Number	Specification Title	Revision	Date
01010	Summary of Work	0	November 6, 2019
01041	Project Coordination	0	November 6, 2019
01042	Mobilization	0	November 6, 2019
01050	Field Engineering	0	November 6, 2019
01051	Geotechnical Exploration	0	November 6, 2019
01090	Reference Standards and Regulations	0	November 6, 2019
01300	Submittals	0	November 6, 2019
01400	Quality Control Assurance	0	November 6, 2019
01410	Testing Laboratory Services	0	November 6, 2019
01500	Construction Facilities and Temporary Controls	0	November 6, 2019
01600	Materials and Equipment	0	November 6, 2019
01700	Demobilization	0	November 6, 2019
02110	Site Clearing and Stripping	0	November 6, 2019
02205	Fill Materials	0	November 6, 2019
02211	Rough Grading	0	November 6, 2019
02222	Excavating	0	November 6, 2019
02223	Filling	0	November 6, 2019
02272	Geotextile	0	November 6, 2019
02273	Geonet	0	November 6, 2019
02350	Geosynthetic Clay Liner	0	November 6, 2019
02710	Gravity Piping	0	November 6, 2019
02775	Geomembranes	0	November 6, 2019
03110	Concrete Formwork	0	November 6, 2019
03220	Reinforcing Steel	0	November 6, 2019
03300	Cast-in-Place Concrete	0	November 6, 2019
11207	Parshall Flumes	0	November 6, 2019
17150	Meters and Instrumentation	0	November 6, 2019

SECTION 01010
SUMMARY OF WORK

1.0 GENERAL

1.1 Section Includes

A. Work Scope

B. Definitions

C. Contradictions

D. Contractor's Responsibilities

1.2 Work Scope

A. The scope of work for this project shall consist of construction of Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) at the Grassy Mountain Mine as shown on the Drawings. The Work under this contract will include, but is not limited to:

1. Mobilization of all equipment and material required for the Work including: mobilization of temporary power facilities, sanitation facilities, and communication facilities.
1. Installation of temporary and permanent surface water control.
2. Furnishing and placement of construction water for both fill moisture control and dust control on roads and fills associated with construction of the Work in coordination with the Owner.
3. Backfilling and compaction of exploration test pits and boreholes, as required by the Owner, within the TSF and WRD footprints.
4. Clearing, grubbing, and stripping as required for the Work.
5. Construction of temporary access and haul roads.
6. Excavation, hauling, placement, of fill materials for the embankment, including Embankment Fill, Grading Fill, and Prepared Subgrade including moisture-conditioning and compaction.
7. Excavation, hauling, processing, and placement of fill materials Drainage Layer, Filter Fill, Anchor Trench Backfill, Drain Gravel, Leak Detection Fill, Pipe Bedding Fill, and Cable Bedding Fill including moisture-conditioning and compaction.
8. Subgrade preparation for geosynthetic clay liner (GCL) and high-density polyethylene (HDPE) geomembrane liner and embankment foundations.
9. Furnishing and installing 60 and 80 mil HDPE Geomembrane liner in the areas shown on the Drawings.
10. Furnishing and installing GCL.
11. Furnishing and installing Non-woven Geotextile in areas shown on the Drawings.
12. Furnishing and installing geonet in areas shown on the Drawings.
13. Furnishing, welding, and installing corrugated polyethylene (CPE) and HDPE piping and filling.
14. Demobilization, which includes: removal of temporary structures, shaping, contouring, and grading of final surfaces in preparation of reclamation seeding.

1.3 DEFINITIONS

B. The following definitions apply to these Technical Specifications:

1. "Owner" is defined as an authorized representative of Calico Resources USA Corp. (Calico).

2. “Engineer” is defined as a representative appointed and authorized by the Owner (Golder Associates, Inc.). The Engineer shall be a registered Professional Engineer in the State of Oregon, or a designated site representative under his supervision during construction.
3. “Resident Engineer” is defined as the Engineer’s on-site representative to oversee the completion of Quality Assurance of the Work.
4. “Quality Control Team” is defined as the individuals working under the direction of Engineer to perform on-site Quality Control tasks at the frequencies listed in these Specifications. The Quality Control Team shall be approved by the Owner. All field and laboratory testing shall be supervised by a registered Professional Engineer licensed in the State of Oregon.
5. “Quality Assurance Team” is defined as the individuals working under the direction of Engineer to perform on-site quality assurance tasks for the Owner during earthwork placement, pipe installation, and geomembrane installation.
6. “Contractor” is defined as the party which has executed a contract agreement for the specified work with the Owner.
7. “Geomembrane Installation Contractor: is defined as the Subcontractor retained by the Contractor or the Owner to install the geomembrane, geotextile, geonet and related appurtenances.
8. “Vendor” is defined as the supply or manufacturer of fabricated materials retained by the Contractor or Owner required to complete the Work.
9. “Subcontractor” is defined as a party retained by the Contractor to provide services or materials required to complete the Work. The Subcontractor shall be under direct supervision and report directly to the Contractor.
10. “Quality Control” is defined as inspection and testing performed prior to manufactured material being placed as well as inspection and testing performed on earthwork materials placed during construction of the Work. Performed by the Contractor, Manufacturer, or facility retained by the Contractor or Manufacturer.
11. “Quality Assurance” is defined as inspection and testing performed by the Quality Assurance Team and third-party laboratories retained by the owner.
12. “Specifications” are defined as this document of Technical Specifications prepared by Golder Associates Inc. (Golder) for the Owner.
13. “Report” is defined as the Construction-level Design Report presented as Appendix C in the Grassy Mountain Consolidated Permit Application and titled *Detailed Design, Tailings Storage Facility and Waste Rock Dump, Grassy Mountain Mine, Malheur County, Oregon,* Revision 0, dated November 6, 2019 prepared by Golder in conjunction with these Specifications and Drawings.
14. “Drawings” are defined as the construction-level design drawings prepared by Golder in conjunction with these Specifications titled *Grassy Mountain Mine, Tailings Storage Facility and Waste Rock Dump,* Revision 0, dated November 6, 2019.
15. “Modifications” are defined as changes made to the Specifications or the Drawings that are approved by the Owner and Engineer in writing after the Specifications or the Drawings have been finalized.
16. “On-Site Material” is defined as borrow soils obtained from within required facility excavations.
17. “Off-Site Materials” is defined as material obtained from sources other than on-site.
18. “Record Documents” are defined as the documents prepared by the contractor documenting the progress, location, type and quantity of materials placed to complete the Work.
19. “Products” are defined as new material, machines, components, equipment, fixtures, and systems forming the Work. This does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing material or components required for reuse.

20. “Work is defined as the entire complete construction, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents. Work is the result of performing services, furnishing labor, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.
21. “Contract Documents” are defined as the Agreement, Addenda (which pertain to the Contract Documents), Contractor’s Bid (including documentation accompanying the Bid and any post-Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Bonds, the General Conditions, the Supplementary Conditions, the Specifications, the Drawings, the CQA Plan, together with all Modifications issued after the execution of the Agreement.
22. All slopes are described in terms of horizontal distance to vertical distance (H:V).

1.4 CONTRADICTIONS

A. Should any contradiction, either implied or real, exist between the Specifications and the Drawings, the Contractor shall:

1. Notify the Owner and Engineer.
2. Stop all work that concerns the contradiction until the contradiction is remedied or clarified by the Engineer.

B. The decision of the Engineer is final.

1.5 CONTRACTOR’S RESPONSIBILITIES

A. The Contractor Shall:

1. Maintain Oregon Workman’s Compensation Insurance and provide evidence of such to the Owner.
2. Familiarize himself/herself with the relevant regional and site-specific conditions which may have an impact upon the work.
3. Be responsible for making his own measurements and installing his work to fit the conditions encountered.
4. Before proceeding with the Work, examine all Drawings, Specifications, CQA Plan, and Reports and notify the Engineer and Owner in writing of any apparent discrepancies or interferences. The Engineer, in consultation with the Owner, shall make minor alterations to the Drawings as needed. All alterations shall be issued under a covering work order signed by the Owner prior to the start of alteration, if the alteration will affect the terms of Contract.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01041
PROJECT COORDINATION

1.0 GENERAL

1.1 Section Includes

A. Contractor's Responsibilities

B. Submittals

1.2 Related Sections

A. Section 01010 – Summary of Work

B. Section 01300 – Submittals

C. Section 01500 – Reference Standards

1.3 Contractor's Responsibilities

A. Cooperate with the Owner in allocation of mobilization areas, areas for field offices, access, traffic, and parking facilities.

B. During construction, coordinate use of site and facilities through the Owner.

C. Comply with Owner's and Engineer's procedures for intra-project communications

D. Comply with instructions from the Owner for use of temporary utilities and construction facilities.

E. Submit request for interpretation of the Contract Documents to the Owner, and obtain instructions through the Owner.

F. All Contractor's personnel may be required to take site specific hazard training session, conducted by the Owner, and must have updated MSHA training in order to work at the site.

1.4 Submittals

A. Submit Contractor's MSHA number to Owner.

B. Submit MSHA health and safety certification of each employee that will work on site to the Owner prior to working at the site.

C. Submit preliminary deployment drawings, show drawings, product data, and samples in accordance with Section 01300 for review and compliance with Contract Documents. Revise and resubmit as required.

D. Maintain a record of man-hours worked on site and lost time accident hours. Submit the record weekly to the Owner.

E. Submit copies of air quality permits, if such permits are required to construct the Work.

F. Submit Material Safety Data Sheets (MSDS) to Owner for all chemicals or hazardous materials used on site, or stored on site, in support of performance of the Work. Submit weekly quantity use of TRI chemicals to the Owner, as requested by the Owner.

G. Submit a disposal plan for all waste r contaminated materials developed on site during performance of the Work. Submit plan prior to mobilization.

H. Submit statement at the end of the project stating that all waste and contaminated materials were disposed of in accordance with the approved plan.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01042
MOBILIZATION

1.0 GENERAL

1.1 Section Includes

A. General

1.2 Work Scope

A. Section 01010 – Summary of Work

B. Section 01500 – Construction Facilities and Temporary Controls

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 General

A. Upon receipt of notice to proceed, the Contractor shall furnish, mobilize and install such temporary works, materials, equipment, and construction plants as necessary for the successful completion of the Work. The Contractor shall also operate and maintain such temporary works, equipment and construction plants throughout the period of construction. All applicable temporary works, such as sanitation facilities, shall fully comply with the rules and regulations of the government agency having jurisdiction. Portable screening or crushing facilities used on-site shall have applicable air emissions permits. Clearing, grading, earthwork and construction of access roads necessary for the temporary works, if any, shall be included as mobilization.

B. The Contractor shall obtain any permits necessary to complete the Work at Contractor's expense.

*****END OF SECTION*****

SECTION 01050
FIELD ENGINEERING

1.0 GENERAL

1.1 Section Includes

A. Project Record Documents

B. Examination

C. Survey

D. Alterations to Drawings and Specifications

1.2 Related Sections

A. Section 01010 – Summary of Work

B. Section 01090 – Reference Standards

C. Section 01300 – Submittals

1.3 Project Record Documents

A. The Contractor shall:

1. Maintain a complete and accurate log of survey control and survey work.
2. Make the log available for review to the Owner and Engineer without limitation.

B. After project completion, submit record documents per Section 01300 – Submittals: As-built Documentation.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 General

A. The Contractor shall notify the Owner and Engineer of any discrepancies discovered in the surveying or Drawings.

3.2 Survey

A. The Owner shall provide a minimum of three (3) survey control points to layout and control the Work.

B. The Contractor shall:

1. Retain the services of a surveyor licensed in the State of Oregon.
2. Use the survey control points provided by the Owner to lay out the Work.
3. Triangulate between the three control-points to verify accuracy prior to using the points for control work.
4. Perform a survey of the site in its original form on a minimum 100-foot grid. The survey will be submitted to the Engineer for review prior to initiation of growth media stripping. The survey will be used as a basis for quantity verification for site grading. If earthworks are performed prior to survey verification, Contract shall remedy at Contractor's expense.
5. Survey the grid after completion of the following tasks and submit the topographic survey to the Owner and Engineer.
    a. Growth Media Stripping.

b. Excavation and placement of Embankment Fill.

c. Placement of Liner Bedding Fill (survey will be used to determine finish geomembrane liner limits and elevations).

d. Placement of Drainage Layer.

e. Placement of Filter Layer.

f. All permanent cut slopes or water diversion/control areas affected during construction.

6. Submit each survey to the Engineer within two (2) weeks of completion of each task.

7. Provide additional surveying necessary to accurately maintain slopes and grades for control of the Work.

8. The Contractor shall make every effort to preserve Owner-provided control and points. If, in the opinion of the Owner, any survey control points have been carelessly or willfully disturbed or destroyed by the Contractor or his employees, the cost of replacement shall be incurred by the Contractor.

3.3 Alterations To Drawings and Specifications

A. Alterations made by the Contractor to either the Specifications or Drawings shall be subject to the Owner's and Engineer's approval and, where applicable, to the approval of regulatory agencies. All alterations shall be issued under a covering work order signed by the Owner prior to the start of alteration.

*****END OF SECTION*****

SECTION 01051
GEOTECHNICAL EXPLORATION

1.0 GENERAL

1.1 Section Includes

A. Summary

B. Verification

C. Warranty

1.2 Summary

A. Geotechnical explorations in the Tailings Storage Facility and Waste Rock Dump footprints were conducted during the following:

1. December 2017 – 15 Borings, 44 Test Pits and six (6) field falling head permeability tests conducted in boreholes
2. March 2019 – Six geotechnical boreholes at previously completed Test Pits
3. July 2019 – 11 cone penetration test soundings at previously completed Borings and Test Pits

B. The design for the Grassy Mountain TSF and WRD, written by Golder in November 2019 titled D*etailed Design, Tailings Storage Facility and Waste Rock Dump, Grassy Mountain Mine, Malheur County, Oregon,* Revision 0, dated November 2019 references the geotechnical investigation findings.

C. Test Pit, Boring, and CPT exploration locations located within the TSF embankment, TSF basin, and WRD footprint will require over-excavation and backfill in accordance with Section 02222 and Section 02223.

1.3 Verification

A. Field verify the location of all exploration boreholes and test pits with the Engineer and Owner.

B. Contractor shall supply certification that all test pits have been filled in accordance with these Specifications. The Contractor will supply a list of the boreholes/pits backfilled with the certification, including the depth of each borehole/test pit.

1.4 Warranty

A. The conclusions and recommendations described in the Golder Report cited above were based on Golder's understandings of the project, as described in the Report, and the site conditions as documented during Golder's geotechnical investigation. Unanticipated soil and subsurface conditions are commonly encountered and cannot be fully determined by reviewing soil logs from the borings or test pits. The report prepared by Golder should not be construed as a warranty of actual subsurface conditions.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Verification

A. Bidders shall visit the site and familiarize themselves with all existing surface and subsurface conditions, whether covered in the reports or not, and shall understand all recommendations associated with the earthwork.

*****END OF SECTION*****

SECTION 01090
REFERENCE STANDARDS AND REGULATIONS

1.0 GENERAL

1.1 Section Includes

A. Codes and Regulations

B. Schedule of References

1.2 Related Sections

A. Section 01400 – Quality Control/Assurance

B. Section 01600 – Materials and Equipment

C. Section 02110 – Site Clearing and Stripping

D. Section 02205 – Fill Materials

E. Section 02211 – Rough Grading

F. Section 02223 – Filling

G. Section 02273 – Geonet

H. Section 02350 – Geosynthetic Clay Liner

I. Section 02710 – Gravity Piping

J. Section 02775 – Geomembrane

K. Section 03300 – Cast-in-Place Concrete

1.3 Codes and Regulations

A. The work shall conform to applicable federal, state, county, and local regulations.

B. The following publications current at the date of Contract Documents, unless specified otherwise, are a part of this specification, except where modified or replaced by local codes or ordinances having jurisdiction, in which case such local codes or ordinances shall govern:

1. Occupational Safety and Health Administration, General Industry and Health Standards – OSHA 2206.
2. Mine Safety and Health Administration - Code of Federal Regulations - Title 30 (Mineral Resources)
3. Oregon Department of Transportation.
4. U.S. Department of Transportation.
5. Clean Water Act – Oregon Department Environmental Quality.
6. Environmental Impact Statement and the Plan of Operations at the site, if applicable.
7. Water Resources Department (WRD), Dam Safety Regulations, OAR 690, Division 20.
8. Department of Geology and Minerals Industries (DOGAMI), Chemical Process Mine Regulations, OAR 632, Division 37.
9. Department of Fish and Wildlife (ODFW), Chemical Process Mining Consolidated Application and Permit Review Standards, OAR 635, Division 420.

10. Department of Environmental Quality (DEQ), Chemical Mining, OAR Chapter 340, Division 43.

1.4 Schedule of References

A. For products of workmanship specified by association, trade, or Federal Standards, all shall comply with the requirements of the standard, except when more rigid requirements are specified or are required by applicable codes. Conform to reference standard that is current at the date of Contract Documents. As a minimum the following reference standards shall be used for this project:

1. AASHTO — American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W.
Washington, DC 20001

2. ACI — American Concrete Institute
Box 19150
Redford Station
Detroit, MI 48219

3. ANSI — American National Standards Institute
1430 Broadway
New York, NY 10018

4. ASTM — American Society for Testing and Materials
1916 Race Street
Philadelphia, PA 19103

5. AWWA — American Water Work Association
6666 West Quincy Avenue
Denver, CO 80235

6. CRSI — Concrete Reinforcing Steel Institute
933 Plum Grove Road
Schaumburg, IL 60195

7. NSF — National Sanitation Foundation
Box 1468
Ann Arbor, MI 48106

8. GRI — Geosynthetics Research Institute
Drexel University
West Wing – Rush Building, #10
Philadelphia, PA 19104

9. NSF — National Sanitation Foundation
Box 1468
Ann Arbor, MI 48106

10. PPI — Plastic Pipe Institute
105 Decker Court, Suite 825
Irvine, TX 75062

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01300
SUBMITTALS

1.0 GENERAL

1.1 Section Includes

A. Technical Data

B. Progress Schedules

C. As-Built Documentation

1.2 Related Sections

A. Section 01400 – Quality Control/Assurance

B. Section 01600 – Materials and Equipment

C. Section 02205 – Fill Materials

D. Section 02223 – Filling

E. Section 02273 – Geonet

F. Section 02350 – Geosynthetic Clay Liner

G. Section 02710 – Gravity Piping

H. Section 02775 – Geomembrane

I. Section 03220 – Reinforcing Steel

J. Section 03300 – Cast in Place Concrete

1.3 Technical Data

A. Engineering data covering all equipment and fabricated materials to be furnished under this contract shall be submitted to the Engineer for review. This data shall include drawings and descriptive information in sufficient detail to show the kind, size, arrangement, and operation of component material and devices: the external connections, anchorages, and supports required: performance characteristics; and dimensions needed for installations and correlation with other materials and equipment. Data submitted shall include drawings showing essential details of any changes proposed by Contractor.

B. No work shall be performed in connection with the fabrication or manufacture of material and equipment, nor shall any accessory or appurtenance be purchased until the drawings and data have been reviewed and approved by the Engineer, except at the Contractor's own risk and responsibility.

C. Three (3) copies of each submittal, drawing, and necessary data shall be submitted to the Engineer. Each drawing or data sheet shall be clearly marked with the name of the project, the Contractor's name, references to applicable Specification paragraphs, and Drawing sheets. When catalog pages are submitted, the applicable items shall be identified. The Engineer shall return one (1) copy of the submittal to the Contractor with comments.

D. When the drawings and data are returned marked REVISE AND RESUBMIT the corrections shall be made as noted thereon and as instructed the Engineer and not less than three (3) corrected copies resubmitted.

E. When the drawings and data are returned marked REJECTED, the Contractor shall take necessary corrective actions to comply with contract documents. All items marked REJECTED will not be accepted and a substitute must be submitted for approval from the Engineer.

F. Unless otherwise directed by the Engineer, when drawings and data are returned marked APPROVED AS NOTED, the changes shall be made as noted thereon and not less than three (3) corrected copies shall be furnished to the Engineer.

G. When the drawings and data are returned marked APPROVED, one (1) copy, shall be returned to the Contractor, one (1) copy shall be retained for the Owner, and one (1) copy shall be retained by the Engineer.

H. The Engineer's review of drawings and data submitted by the Contractor shall cover only general conformity to the Drawings and Specifications, external connections, and dimensions which affect the layout. The Engineer's review of drawings and data returned marked APPROVED or APPROVED AS NOTED does not indicate a thorough review of all dimensions, quantities, and details of the material, equipment, devices, or items shown, and does not relieve the Contractor from any responsibility for errors or deviations from the contract requirements.

I. All drawings and data, after the final processing by the Engineer, shall become a part of the Contract Documents and the Work shown or described thereby shall be performed in conformity therewith unless authorized by the Owner or the Engineer.

1.4 Progress Schedules

A. Procedure

1. Submit a preliminary progress schedule to the Owner.
2. After Owner's review, revise and resubmit schedule to comply with Owners review.
3. Submit revised progress schedule every two weeks or according to a scheduled agreed upon by the Owner.

B. Show complete sequence of construction by activity, with dates for beginning and completion of each element of construction.

C. Provide subcontractors activity schedules.

D. Provide separate schedule of submittal dates for shop drawings, product data, and samples, including Owner furnished products, and dates that reviewed submittals shall be required from the Owner and Engineer. Indicate delivery data for products.

E. Schedules shall be in a form that is acceptable to the Owner.

F. Distribute copies of reviewed schedules to the project file, Subcontractors, suppliers, and the Engineer.

G. Instruct recipients to promptly report in writing problems anticipated by projections indicated in schedules.

1.5 Quality Control Test Results and Daily Field Reports

A. The Contractor shall be responsible for material property testing of soil, rock, and aggregate material in accordance with the testing frequencies in Section 02223.

B. Quality Control testing shall be performed by qualified personnel under direct supervision of a Professional Engineer licensed in the State of Oregon.

C. Complete Quality Control Test results shall be submitted to the Owner and Engineer within twenty-four (24) hours of collecting sample for testing, or upon request, for review and approval.

D. All Quality Control test results shall be stored in hard copy in the Contractor's or Quality Control's on-site facility and shall be available for review from the Owner and Engineer at all times.

E. The Quality Control Team shall be responsible for accurately testing and reporting results of all Quality Control test results and observations in a timely manner to the Owner and Contractor throughout the project in the form of a Daily Field Report.

1. Daily Field Reports shall be typed and submitted to the Engineer and/or Owner within one (1) working day.
2. Minimum information required, and example Daily Field Report are presented in the CQA Plan

1.6 As-Built Documentation

A. As-built Survey Documentation

1. The Contractor shall be responsible for accurately surveying the locations and elevations and, where applicable, the type, thickness and geometry of any and all pipes and fittings, ditches, geosynthetic materials, breaks in fill or cut slopes, general grading, change in fill or synthetic material type and any other aspect of the work required by the Engineer.
2. The Contractor shall submit as-built documentation surveys as described in Section 01050.
3. Submittal: Completed as-built documentation will be submitted within two (2) weeks of project acceptance in the following manner:
    a. Submit one (1) digital reproducible copy each to the Owner and Engineer.
    b. Submit one (1) paper copy each to the Owner and Engineer.
        i. As-built documentation survey shall be sealed by a registered Professional Land Surveyor licensed in the State of Oregon.

B. Quality Control Documentation

1. Submittal: Within two (2) weeks of project acceptance, the Quality Control Team shall submit a Quality Control Summary Report sealed by a Professional Engineer licensed in the State of Oregon documenting all manufacturer, field, and laboratory quality control test result and data sheets that include the following:
    a. One (1) digital reproducible copy and one (1) paper copy of each of the following Quality Control Report(s):
        i. Earthwork Quality Control Documentation in accordance with Section 02223.
        ii. Geonet Quality Control Documentation in accordance with Section 02273.
        iii. Geosynthetic Clay Liner Quality Control Documentation in accordance with Section 02350.
        iv. Piping Quality Control Documentation in accordance with Section 02710
        v. Geomembrane Quality Control Documentation in accordance with Section 02275.
        vi. Reinforcing Steel Quality Control Documentation in accordance with Section 03220.
        vii. Cast in Place Concrete Quality Control Documentation in accordance with Section 03300.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01400
QUALITY CONTROL AND ASSURANCE

1.0 GENERAL

1.1 Section Includes

A. References

B. General Quality Control Requirements

C. Manufacturer's Quality Control Inspection, Sampling, and Testing

D. Quality Control Sampling and Testing Frequency

E. Quality Assurance and Referee Inspection and Testing

1.2 Related Sections

A. Section 01090 – Reference Standards

B. Section 01300 – Submittals

C. Section 01410 – Testing Laboratory Services

D. Section 01600 – Materials and Equipment

E. Section 02205 – Fill Materials

F. Section 02211 – Rough Grading

G. Section 02223 – Filling

H. Section 02273 – Geonet

I. Section 02350 – Geosynthetic Clay Liner

J. Section 02710 – Gravity Piping

K. Section 02775 – Geomembrane

L. Section 03300 – Cast-in-Place Concrete

1.3 References

A. Conform to reference standard by date of issue current on date of Contract Documents unless specified otherwise in the specific section.

B. Should specified reference standards conflict with Contract Documents, the Contractor shall request clarification from Engineer before proceeding.

C. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by mention or inference otherwise in any reference document.

1.4 General Quality Control Requirements

A. The Quality Control Team as defined in Section 01010 shall perform the Quality Control testing and inspection required by these Specifications for all earthworks, geosynthetics, and piping installation.

B. The Quality Control Team shall be under the direct supervision of a Professional Engineer licensed in the State of Oregon. All Quality Control test results shall be used as the record tests documented in the Quality Control As-built Report in accordance with Section 01300.

C. Results of Quality test results are subject to verification by the Engineer. Should a discrepancy between results of the Quality Control Team and the Engineer, the Engineer's, results and conclusions shall prevail.

D. Quality Control test results are not a basis of acceptance of Work. Results of inspection and testing on in-place material approved the Engineer or performed by the Quality Assurance Team shall prevail.

E. The Contractor shall be responsible to monitor Quality Control over Vendors, Manufacturers, products, services, site conditions and workmanship to produce Work of specified quality.

F. Comply fully with Manufacturers' instructions. Should Manufacturers' instructions conflict with the Contract Documents, the Contractor shall request clarification from the Engineer prior to proceeding.

G. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes or specified requirements indicate higher standard or more precise workmanship.

H. The Quality Control Team's inspections will not relieve the Contractor of responsibility for the acceptance of the finished Work or portions thereof.

I. Work performed by the Quality Control Team personnel shall be qualified to perform specified testing in accordance with specified test methods and procedures as required by these Specifications.

J. A summary report of the Quality Control Work performed shall be submitted to the Engineer in accordance with Section 01300 and be sealed by a Professional Engineer licensed in the State of Oregon.

K. Re-testing required due to the Contractor's non-conformance to specified requirements of these Specifications shall be performed by the same Quality Control Team, Quality Assurance Team, or independent third party, as instructed by the Engineer. The cost of re-resting shall be borne by the Contractor if re-testing requires the testing agency to work extra hours or overtime.

1.5 Manufacturer's Quality Control Inspection, Sampling, and Testing

A. The Manufacturer shall sample and perform Quality Control testing at the frequencies specified in these Specifications. Test results shall be submitted by the Contractor and/or the Manufacturer to the Engineer in accordance with Section 01300.

B. The Manufacturer and/or Contractor will cooperate with the Quality Control Team; furnish samples of materials, design mixes, equipment, tools, storage, and assistance as required and:

1. Notify the Engineer and Quality Control Team twenty-four (24) hours prior to expected time for operations requiring services.
2. Make arrangements with Quality Control Team and pay for additional samples and tests required for Contractor's use.

C. The Quality Control Team will submit to the Engineer one (1) copy of reports indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents in accordance with Section 01300.

1. If observations, inspections, or Manufacture Quality Control test results identify any materials or methods used to complete the Work that do not meet these Specifications, the Engineer shall be notified immediately.

2. In the event that a test failed to meet these Specifications and a retest is performed, the Engineer shall be notified regardless of the retest results.
3. Removal of materials, repairs, or retests shall be determined by the Engineer. Costs associated with the Contractor's actions to remediate deficiencies shall be borne by the Contractor.

1.6 Quality Control Sampling and Testing Frequency

A. The frequency of Contractor and Manufacturer Quality Control testing of materials is specified in the following sections:

Table 01400-1: Testing Frequency Reference Sections

MATERIAL	REFERENCE SECTION
Fill Materials	02205
Rough Grading	02211
Filling	02223
Geonet	02273
Geosynthetic Clay Liner	02350
Gravity Piping	02710
Geomembrane	02775
Cast-in-Place Concrete	03300

1.7 Quality Assurance and Referee Inspection and Testing

A. The Quality Assurance Team as defined in Section 01010 shall perform the Quality Assurance testing and inspection required by these Specifications.

B. At any time during the project Work, the Engineer may collect a sample split from the Quality Control sample and perform a referee test for Quality Assurance.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Quality Control

A. Maintain access at all times for the Engineer and/or Quality Assurance Team to perform inspection, sampling, and testing. At no time deny the Quality Assurance Team personnel, Engineer, or Owner access to any Work area, fabrication area, staging area, or any other area associated with the Work.

B. Make allowance for the Quality Assurance or referee sampling and testing to be performed and divert equipment elsewhere during the required sampling and testing.

C. Quality Control test results shall be provided to the Owner and/or Engineer within 24 hours of collecting sample for testing, or upon request, for review and approval in accordance with Section 01300.

D. Daily Field Reports shall be completed and submitted to the Engineer and/or Owner within one (1) working day in accordance with Section 01300. The minimum information required for each Daily Field Report as well as an example is provided in the CQA Plan.

E. There is no provision for claims of delays due to Quality Assurance inspection, testing, or sampling. Should Contractor feel that delays are being incurred due to Quality Assurance inspection, testing, sampling, or other activities, notify Owner and Engineer in writing documenting in detail the date, time, and quality assurance activity of each occurrence. Should Owner and/or Engineer determine that excessive time is being spent at quality assurance activities causing delay to Work, corrective action will be taken.

F. If any Work should be covered up without prior approval or consent of the Engineer, it must, if required by the Engineer, be uncovered for examination. After the uncovered Work has been observed and authorization given by the Engineer, the Work shall be recovered in accordance with the Specifications. The cost of uncovering and recovering the Work and any consequential costs shall be the responsibility of the Contractor regardless of the condition of the Work uncovered. If the Work is found to be deficient, the Contractor shall expose all Work that was covered prior to approval, correct any Work that is deficient, and proceed according to the Specifications. The cost of uncovering deficient Work, correcting deficient Work and any consequential costs shall be borne entirely by the Contractor.

G. All Work performed by the Contractor shall meet the approval of the Engineer. The method and manner of doing the Work will be under the control of the Contractor. The Engineer may review the Contractor's work practices and make adjustments as necessary to minimize the risk of damage to critical components of the Work.

3.2 Submittals

A. The Contractor shall submit all Quality Control test results to the Engineer for review and approval on a regular basis, or at the request of the Engineer.

B. Fill materials proposed by the Contractor for use to complete the Work shall be tested by the Quality Control Team prior to placement to verify that the materials meets these Specifications.

C. Initial Quality Control test results of proposed materials shall be submitted to the Engineer for the approval at least 24 hours prior to material placement.

D. At the completion of the Work, a sealed Quality Control Report shall be submitted to the Owner and Engineer in accordance with Section 01300 and include at a minimum:

1. Cover letter summarizing the quantities of materials placed, required testing frequency, and actual testing frequency achieved. The Quality Control Report shall be sealed by a Professional Engineer licensed in the State of Oregon.
2. Typed field documentation including daily field reports, field and laboratory test results summary tables and individuals test results forms for all tests performed for each construction material for tests specified in the Specifications.
3. Summary tables shall be suitable for report presentation and regulatory agency review. One (1) digital reproducible copy of the summary tables shall be provided to the Engineer.

*****END OF SECTION*****

SECTION 01410
TESTING LABORATORY SERVICES

1.0 GENERAL

1.1 Section Includes

A. Selection and Payment

B. Laboratory Reports

C. Limits on Testing Laboratory Authority

D. Contractor Responsibilities

1.2 Related Sections

A. Section 01300 – Submittals

B. Section 01400 – Quality Control/Assurance

C. Section 01600 – Materials and Equipment

D. Section 02205 – Fill Materials

E. Section 02211 – Rough Grading

F. Section 02223 – Filling

G. Section 02273 – Geonet

H. Section 02350 – Geosynthetic Clay Liner

I. Section 02775 – Geomembrane

J. Section 03300 – Cast-in-Place Concrete

1.3 Selection and Payment

A. The Contractor shall perform, or will employ and pay for services of an independent testing laboratory to perform specified inspection and testing.

B. All laboratory testing shall be performed under the direct supervision of a registered Professional Engineer licensed in the State of Oregon.

C. Employment of testing laboratory shall in no way relieve the Contractor of obligation to perform work in accordance with requirements of Contract Documents.

1.4 Laboratory Reports

A. After each inspection and test, promptly submit a copy of laboratory report to the Engineer, and a copy to the Owner.

B. Include in Report:

1. Date issued
2. Project title and number
3. Name of inspector
4. Date and time of sampling or inspection
5. Identification of product and Specifications Section

6. Location in the Project
7. Type of inspection or test
8. Date of test
9. Results of test
10. Conformance with Contract Documents
11. When requested by Engineer, provide interpretation of test results

1.5 Limits On Testing Laboratory Authority

A. Laboratory may not release, revoke, alter, or enlarge on requirements of Contract Documents.

B. Laboratory may not approve or accept any portion of the Work.

C. Laboratory many assume any duties of Contractor.

D. Laboratory has no authority to stop Work.

1.6 Contractor Responsibilities

A. The Contractor shall notify the laboratory and Engineer at least five (5) working days in advance of intended use of materials that require laboratory testing to allow sufficient time for laboratory to retrieve samples and perform testing.

B. Provide proposed mix designs at least five (5) working days in advance of intended use.

C. Cooperate with laboratory personnel, and provide access to the Work.

D. Provide incidental labor and facilities to provide access to Work to be tested, to obtain and handle samples at the site or at source of products to be tested, to facilitate tests and inspections, storage and curing of test samples.

E. When requested by the Engineer prior to sampling, the Contractor shall provide Engineer a split sample for Quality Assurance testing. The sample shall be split in accordance with ASTM C702-*Standard Practice for Reducing Samples of Aggregate to Testing Size,* and shall be of sufficient quantity to meet minimum testing requirements.

F. Notify the laboratory and Engineer 24 hours prior to expected time for operations requiring field inspection and field testing services.

G. Arrange with the laboratory and pay for additional testing and inspection services required by Contractor beyond specified requirements.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01500

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

1.0 GENERAL

1.1 Section Includes

A. Access

B. Power

C. Construction Water

D. Fugitive Dust Control

E. Surface Water Control

F. Work Limits

G. Traffic Control/Road Use

1.2 Related Sections

A. Section 01010 – Summary of Work

1.3 Access

A. Access to the site shall be provided by the Owner.

B. The Contractor shall not construct any staging areas, temporary facilities, haul roads, or access roads without the approval of the Owner.

1.4 Power

A. Contractor shall provide his own temporary power needs, unless provided by the Owner.

1.5 Construction Water

A. Water for dust control on haul roads, moisture conditioning of borrow material to be placed as fill, and for maintaining in place fill soils shall be obtained by the Contractor. The Contractor shall supply all the pumps and tanks necessary to provide an adequate supply of water fulfill the conditions of the contract. Water will be available in a pond and/or truck standpipe at a location designated by the Owner.

1.6 Fugitive Dust Control

A. During the performance of the Work defined by these Specifications or any operations appurtenant thereto, whether on right-of-way provided by the Owner or elsewhere, the Contractor shall:

1. Furnish all labor, equipment, materials, and means required to perform proper and efficient measures to reduce the dust nuisance.
2. Prevent dust which has originated from the Work from damaging land, vegetation, and dwellings or causing a nuisance to persons.
3. Control dust to a degree acceptable to the appropriate State and Federal Agencies, and to the Owner.
4. Notify Owner in writing, and obtain Owner's approval, to use chemical additives to control fugitive dust. Provide Material Safety Data Sheets (MSDA) for such chemicals to Owner.

1.7 Surface Water Control

A. Install permanent ditches and/or channels shown on the drawings and construct facilities to control surface water resulting from precipitation.

B. Provide temporary erosion protection for prepared surfaces and all potential erosion areas associated with the Work, or as directed by the Engineer, until all such portions of the Work have been accepted by the Owner. Erosion control shall consist of silt fences, fiber rolls, and sediment traps in accordance with best management practices.

C. If precipitation or runoff damage occurs to the Work prior to acceptance of the Owner, repair the damaged Work in accordance to these Specifications at the Contractor's expense.

D. All temporary and final design storm water diversion ditches, sedimentation basins, and/or channels shall be installed prior to site grading.

1.8 Work Limits

A. Confine apparatus, equipment, the storage of Materials, and the operation of workmen to the limits indicated by law, ordinances, permits, or as directed by the Owner.

B. Avoid unreasonable encumbering the premises with materials or equipment.

C. Do not block plant or other access roads or traveled ways.

D. Avoid interfering with the Owners operations.

E. Do not present a hazard to the Owner's personnel and equipment or to the public.

F. Use existing roads whenever possible.

G. Minimize construction of new roads.

H. Keep the site neat, tidy and free of waste materials or rubbish.

I. Store and dispense fuel, lubricating oils, and chemicals in such a manner as to prevent or contain spills and prevent said materials from reaching local streams or groundwater according to regulatory requirements.

J. Dispose of waste in accordance with state and local regulations.

K. Keep MSDS on file at the site and provide copies of such sheets to the Owner for all hazardous materials.

L. Avoid damage to monitoring wells, piezometers, survey monuments, or any other instrumentation used at the site.

M. Notify Owner if monitoring wells, piezometers, or instrumentation is in conflict with the Work prior to construction.

1.9 Traffic Control/Road Use

A. Owner's mine haulage traffic has the right-of-way at all times. The Contractor shall conduct his haul operations in a safe manner yielding to Owner's haulage equipment and providing flagmen, if necessary, to stop Contractor's equipment at haul road crossings, public road crossings, or other

traffic areas. Flag persons will not be required at haul road crossings during water truck hauling. A stop sign will be installed at crossings to give the Owner's haulage equipment right-of-way.

B. Any Public or private roads that become damaged as a result of the Contractor's hauling operations shall be repaired at the Contractor's expense.

C. Contractor's personnel will park personal vehicles in areas designated by the Owner. The quantity and routes of normal construction or supervisory vehicles through the mine site will agreed on by the Owner and Contractor.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01600
MATERIALS AND EQUIPMENT

1.0 GENERAL

1.1 Section Includes

A. Transportation and Handling

B. Storage and Protection

C. Product Options

D. Substitutions

1.2 Related Sections

A. Section 01400 – Quality Assurance/Control

1.3 Transportation and Handling

A. Transport and handle products in accordance with manufacturer's instructions.

B. Promptly inspect shipments to assure that products comply with requirements, quantities are correct, and products are undamaged.

C. Provide equipment and personnel to handle products by methods to prevent soiling, disfigurement, or damage.

1.4 Storage and Protection

A. Store and protect products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store sensitive products in weather-tight, climate controlled enclosures.

B. For exterior storage or fabricated products, place on sloped supports, above ground.

C. Cover products subject to deterioration from ultraviolet light or weather with impervious sheet covering.

D. Provide ventilation to avoid condensation.

E. Store loose granular materials on solid flat surface in a well-drained area.

F. Prohibit mixing with foreign matter.

G. Arrange storage of products to permit access for inspection.

H. Contractor shall inspect products to assure products are undamaged and maintained under specified conditions.

I. At the end of construction, catalog all remaining unused permanent materials and provide catalog list to Owner, including description, quantity, and location. Store unused permanent materials in the location directed by the Owner. Except for soil and rock products, all permanent materials shall be stored on pallets or other methods to prevent ground contact. Containers holding permanent materials shall be protected against deterioration from rain and water.

1.5 Product Options

A. Products Specified by Reference Standard or by Description Only: Any product meeting those standards or descriptions.

B. Products Specified by Naming One or More Manufacturers. Products of manufacturers named and meeting Specifications, no options or substitutions allowed.

C. Products Specified by Naming One or More Manufacturers with a provision for Substitutions: Submit a request for substitution for any manufacturer not named.

1.6 Substitutions

A. Engineer will consider request for Substitutions only within 15 days after date established in Notice to Proceed.

B. Substitutions may be considered when a products becomes unavailable through no fault of the Contractor.

C. Substitution Submittal Procedure:

1. Submit three (3) copies of Request for Substitution for Consideration. Limit each request to one proposed substitution.
2. Submit shop drawings, product data, and certified test results attesting to the proposed product equivalence.
3. The Engineer shall notify the Contractor, in writing, of decision to accept or reject request.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

NOT USED

*****END OF SECTION*****

SECTION 01700
DEMBOLIZATION

1.0 GENERAL

1.1 Section Includes

A. General

B. Warranty

C. Summary

1.2 Related Sections

A. Section 01010 – Summary of Work

B. Section 01600 – Materials and Equipment

1.3 General

A. The demobilization work consists of repairing all slopes disturbed during construction, the removal of all construction debris, and returning the site to a suitable condition for permanent stabilization and reclamation of disturbed surfaces as required by the Owner.

1.4 Warranty

A. All materials and workmanship furnished by the Contractor under this specification shall be guaranteed by the Contractor against failure due to defective materials or improper installation for a period of one year from the date of final acceptance, or as noted otherwise in these Specifications. Upon receipt of written notice of failure of guaranteed workmanship or materials during the guarantee period, the Contractor shall promptly furnish and install new materials and/or furnish the labor necessary to correct the failure at the expense of the Contractor.

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Summary

A. Permanent cut slopes outside of the Work area that have been affected by the Work shall not have a slope steeper than 2.5H:1V unless otherwise shown in the Drawings or otherwise approved by the Owner and Engineer.

B. The Contractor shall remove all trash, debris, hazardous and dangerous chemicals or waste, and waste material from the site that was brought on site by the contractor and properly dispose of all said materials. The Owner will have the right to determine what is waste or rubbish and the manner and place of disposal. All materials furnished for the execution of the Work and thereby purchased by the Owner shall remain the property of the Owner.

C. The Contractor shall clean out all installations and tear down and remove all temporary structures built by the Contractor. Any existing structures or installations that were in place prior to construction shall be left in a condition at least as good as the condition prior to construction. All trash and remnants of the Contractor's work shall be removed by the Contractor prior to final inspection and acceptance by the Owner.

D. Unused permanent materials shall be cataloged and stored in accordance with specification Section 01600.

E. The final condition of the site is subject to approval by the Owner.

*****END OF SECTION*****

SECTION 02110
SITE CLEARING AND STRIPPING

1.0 GENERAL

1.1 Section Includes

A. Clearing

B. Stripping

1.2 Related Sections

A. Section 02205 – Fill Materials

B. Section 02211 – Rough Grading

C. Section 02222 – Excavating

D. Section 02223 – Filling

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Summary

A. Clearing area required for access to site and execution of Work as shown on the Drawings.

B. Remove shrubs and other vegetative growth within the required areas. Remove stumps and roots great than ½ inch in diameter to a minimum depth of 6 inches.

C. Remove man-made structures, debris, or waste material as directed by the Owner/Engineer.

D. All clearing shall be completed prior to the start of any grading operations.

E. Clearing shall extend laterally beyond excavation, liner systems, and fill slopes a minimum of 10 feet but shall not extend past the Plan of Operations Boundary as designated by the Owner.

F. Clearing shall not be performed until all exploration test pits and boreholes within the limits of the proposed site grading have been excavated and re-compacted in accordance with Sections 02222 and 02223 as approved by the Owner. The location of the test pits and boreholes are shown on the Drawings.

3.2 Stripping

A. Growth media (the surficial soils often referred to as Topsoil) shall be stripped from cleared areas to a depth approved by the Engineer. In undisturbed areas, the typical stripping depth is anticipated to be 6-inches. The actual depth will be determined in the field by the Engineer during the stripping operation.

B. Growth media shall be stockpiled in areas designated by the Owner. Construct stockpiles with maximum 3H:1V slopes and in a manner that the soil receive the maximum amount of compactive effort from the haulage equipment.

C. Growth media stripping shall include removal of all organic sod, grass, topsoil and roots greater than ½ inch in diameter.

D. Stripping shall be performed in the footprint of the TSF embankments and basin, reclaim pond, waste rock dump facility, containment channels, temporary and permanent access roads, haul roads, construction and staging areas, on-site borrow areas, and temporary and permanent diversion facilities.

E. Stripping shall extend laterally beyond excavations, liner systems, and fill slopes a minimum of 10 feet but shall not extend past the Plan of Operations Boundary as designated by the Owner.

F. Stripping shall not be performed until all exploration test pits and boreholes within the limits of the proposed site grading have been excavated and re-compacted in accordance with Sections 02222 and 02223 as approved by the Owner. The location of the test pits and boreholes are shown on the Drawings.

G. All stripping shall be completed prior to the start of any grading.

H. Excess stripping without the prior approval of the Owner will be at the expense of the Contractor.

*****END OF SECTION*****

SECTION 02205
FILL MATERIALS

1.0 GENERAL

1.1 Section Includes

A. Definitions
B. References
C. General
D. Embankment Fill
E. Grading Fill
F. Prepared Subgrade
G. Drainage Layer
H. Filter Fill
I. Anchor Trench Backfill
J. Drain Gravel
K. Leak Detection Fill
L. Pipe Bedding Fill
M. Cable Bedding Fill
N. Riprap
O. Safety Berm Material

1.2 Related Sections

A. Section 01051 –Geotechnical Exploration
B. Section 01400 – Quality Control/Assurance
C. Section 02110 – Site Clearing and Stripping
D. Section 02211 – Rough Grading
E. Section 02222 – Excavating
F. Section 02223 – Filling

1.3 Definitions

A. Embankment Fill: Fill material that is non-gold-bearing blasted run-of-mine rock or native alluvial overburden soils borrowed from on-site grading and quarry operations. Embankment Fill will be placed and compacted in controlled lifts and used as the primary fill material for TSF embankment construction in accordance with Section 02223.

B. Grading Fill: Native alluvial soils excavated to be placed and compacted in controlled lifts below the geomembrane liner within the TSF basin and WRD pad.

C. Drainage Layer: Crushed rock or screened native alluvium material placed above the geomembrane liner within the TSF basin to promote drainage into the perforated underdrain collection pipes.

D. Filter Fill: Alluvial fill material placed above the Drainage Layer within the TSF basin to act as a filter between the Drainage Layer and the tailings and promote drainage into the perforated underdrain collection pipes.

E. Anchor Trench Backfill: Soil or rock material placed and compacted in the geomembrane anchor trenches and placed as ballast on the above ground process conveyance pipes.

F. Drain Gravel: Crushed rock material installed around the primary perforated CPE and HDPE underdrain collection pipes and in the reclaim pond leak detection sump.

G. Leak Detection Fill: Crushed rock material placed around the PVC leak detection pipes below the TSF geomembrane liner to promote drainage into the perforated leak detection pipes.

H. Riprap: Crushed and screened rock material placed in permanent diversion channels and outlet aprons for erosion protection.

I. Safety Berm Material: native or processed material placed along travel to protect proposed structures from vehicle traffic.

1.4 References

A. American Society for Testing and Materials (ASTM)

B. ASTM C 702 – Standard Practice for Reducing Samples of Aggregate to Testing Size

C. ASTM D 422 – Stand Test Method for Particle-Size Analysis of Soils

D. ASTM D 1140 – Standard Test Method for Amount of Materials in Soils Finer than the No.200 (75 Micrometers)

E. ASTM D 1556 – Test Method for Density of Soils in Place by the Sand-Cone Method

F. ASTM D 1557 – Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer ad 18-in. (457-mm) Drop

G. ASTM D 2216 – Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures

H. ASTM D 4318 – Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

I. ASTM D 4643 – Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

JJ. ASTM D 5519 - Standard Test Methods for Particle Size Analysis of Natural and Man-made Riprap Materials

J. ASTM D 5856 – Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-wall, Compaction-mold Permeameter.

K. ASTM D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

2.1 General

A. All fill materials shall be obtained from required excavations, designated borrow areas, and stockpiles as directed by the Owner. The selection, blending, routing, and disposition of materials in the various fills shall be subject to approval by the Engineer.

B. Fill materials shall contain no sod, brush, roots or other perishable, unsuitable materials, debris, and the type of materials used as earth fill shall be as described in the Specifications and Drawings. The suitability of all fill materials intended for use in the Work shall be subject to approval by the Engineer.

2.2 Embankment Fill

A. Embankment Fill shall be material that is non-gold-bearing blasted run-of-mine rock from on-going mining operations or the basalt borrow.

B. If Embankment Fill contains greater than 30% of particles in excess of three-quarter inch (3/4") nominal grain size it shall be considered a rock fill and placed accordingly as described in Specification 02223.

C. Embankment Fill shall meet the following gradational and plasticity requirement and shall be placed and compacted in accordance with Section 02223:

Table 1: 02205-1 Embankment Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
16 inch*	100
12 inch*	50-100
8 inch*	30-100
¾ inch	0-80
No. 4	0-40
No. 200	0-20

Plastic Limit: N/A

D. A maximum of any one (1) sieve size is allowed to be out of the specified range list above for any individual test.

E. * Maximum particle size shall be limited to 2/3 the allowable loose lift height based on the Embankment Fill being classified as a Soil or Rock Fill material. Allowable loose lift thickness shall determined in accordance with Section 02223.

2.3 Grading Fill

A. Native alluvial materials excavated during on-site grading operation within the TSF basin and WRD pad or imported native alluvial materials.

B. Native foundation clay materials, as defined by the Engineer, shall not be used as Grading Fill.

C. If Grading Fill contains greater than 30% of particles in excess of three-quarter inch (3/4") nominal grain size it shall be considered a rock fill and placed accordingly as described in Specification 02223.

Table 2: 02205-2 Grading Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
6 inch	100
¾ inch	20-100
No. 4	10-70
No. 40	0-40
No. 200	0-30

Plastic Limit: Less than or equal to 15

2.4 Prepared Subgrade

A. Native material generated from on-site grading operations or developed from on-site borrow area to be place immediately below the geosynthetic clay liner within the TSF basin, WRD Pad, on the TSF upstream embankment slopes, and below the reclaim pond.

B. Prepared Subgrade shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

2. Table 3: 02205-3 Prepared Subgrade Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
3 inch	100
¾ inch	70-100
No. 4	20-100
No. 40	0-60
No. 200	0-50

Plastic Limit: Less than or equal to 20

2.5 Drainage Layer

A. Crushed rock material or processed native alluvium placed above the geomembrane liner within the TSF basin and WRD Pad to promote drainage into the perforated underdrain collection pipes.

B. Drainage Layer shall have a maximum hydraulic conductivity of 5×10^{-3} cm/sec (ASTM D5856).

C. The Drainage Layer shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 4: 02205-4 Drainage Layer Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
3 inch	100
¾ inch	50-100
No. 4	20-50
No. 40	0-25
No. 200	0-15

Plastic Limit: Less than or equal to 10

2.6 Filter Fill

A. Crushed rock material, processed or native alluvium placed above the Drainage Layer within the TSF basin to act as a filter between the Drainage Layer and the tailings and promote drainage into the perforated underdrain collection pipes.

B. Filter Fill shall have a maximum hydraulic conductivity of 5×10^{-4} cm/sec (ASTM D5856).

C. Filter Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 5: 02205-5 Filter Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
1.5 inch	100
¾ inch	30-90
No. 4	55-85
No. 40	25-50
No. 200	10-30

Plastic Limit: Less than or equal to 10

2.7 Anchor Trench Backfill

A. Anchor Trench Backfill shall be on-site native alluvium placed in geomembrane anchor trenches and placed as ballast on the Tailings Distribution and Decant Return pipes in accordance with the Drawings.

B. Anchor Trench Backfill shall be placed in accordance with Section 02223.

C. Anchor Trench Backfill has no gradational or plasticity requirements.

2.8 Drain Gravel

A. Drain Gravel shall be a manufactured, crushed rock installed around the primary underdrain collection pipes, within the underdrain outlet channel, and the reclaim pond leak detection sump.

B. Drain Gravel shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 6: 02205-6 Drain Gravel Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
2 inch	100
¾ inch	50-80
No. 4	15-50
No. 200	0-5

Plastic Limit: Less than or equal to 10

2.9 Leak Detection Fill

A. Crushed rock material installed around the leak detection pipes in accordance with the drawings to promoted drainage into the perforated leak detection pipes.

B. The Leak Detection Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 7: 02205-7 Leak Detection Fill Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
1 inch	100
¾ inch	75-100
⅜ inch	20-55
No. 200	0-10

Plastic Limit: Less than or equal to 5

2.10 Pipe Bedding Fill

A. Pipe Bedding Fill shall be on-site native alluvium placed as backfill around culverts and buried HDPE Piping in locations as shown on the Drawings.

B. Pipe Bedding Fill shall be placed in accordance with Section 02223 and shall meet the following gradational and plasticity requirements:

Table 8: 02205-8 Drainage Layer Gradation

U.S. Standard Sieve Size	Percent Passing by Dry Weight
2 inch	100
¾ inch	70-100
No. 4	20-70
No. 40	0-35
No. 200	0-25

Plastic Limit: Less than or equal to 20

2.11 Cable Bedding Fill

A. Cable Bedding Sand shall be placed as backfill around instrumentation signal cables in locations as shown on the Drawings.

B. Cable Bedding Fill shall the finer fraction of on-site native alluvium or Drainage Layer processed over the ⅜-inch screen and placed in accordance with Section 02223.

2.12 Riprap

A. Riprap shall be a process rock material placed as erosion protection as the finish surface layer on the side slope and toe diversion channel as shown on the Drawings.

B. Riprap shall consist of a competent rock material with a specific gravity greater than 2.65 and a rock strength of R4 or greater in accordance with ISRM and from an on-site borrow area or raveling from exposed rock cut slopes near the Work area.

C. Riprap shall meet the following gradational and plasticity requirements and be placed in accordance with Section 02223.

Table 9: 02205-8 Drainage Layer Gradation

Rip Rap D_{50}	Rock Gradation	Rock Size (in.)
8”	D_{100}	12
	D_{85}	10
	D_{50}	8
	D_{15}	3
12”	D_{100}	18
	D_{85}	14
	D_{50}	12
	D_{15}	4
16”	D_{100}	24
	D_{85}	20
	D_{50}	16
	D_{15}	6
28”	D_{100}	42
	D_{85}	36
	D_{50}	28
	D_{15}	12

2.13 Safety Berm Material

A. Safety Berm Material shall be on-site native alluvium placed along the edges of access and haul roads as needed for vehicle and structure protection.

B. Safety Berm Material has no gradational or plasticity requirements.

2.14 Source Quality Control

A. Quality Control inspection and testing will be performed under provisions of Sections 01010, 01400, and 01410 under the supervision of a professional engineer licensed in the State of Oregon.

B. Frequency of testing will be in accordance with Section 02223.

C. Quality Control tests and analysis of soil materials will be in accordance with ASTM D 422, ASTM D 1557, ASTM D 4318 and ASTM D 2167, and D 6938.

D. If tests indicate materials do not meet specified requirements, changes in material or placement conditions, retests shall be performed by the Quality Control Team at no cost to Owner.

3.0 EXECUTION

3.1 Stockpiling

A. If stockpiling is performed, materials shall be stockpiled at locations designated by the Owner. Stockpile sufficient material to meet project schedule and requirements. Separate different materials to prevent mixing. Direct Surface water away from stockpile to prevent erosion or deterioration of material.

B. Leave unused stockpile material in a neat, compact stockpile.

C. Prevent mixing of native subgrade soils with stockpile material.

D. Refer to Section 02223 for fill placement requirements.

3.2 Borrow Area Cleanup

E. Leave area in a clean and neat condition. Grade site surface to prevent free standing surface water. Grade slopes to a maximum 2.5H:1V slope.

*****END OF SECTION*****

SECTION 02211
ROUGH GRADING

1.0 GENERAL

1.1 Section Includes

A. References

B. Lines and Grades

C. Subgrade Preparation

D. Site Grading

E. Field Quality Assurance

1.2 Related Sections

A. Section 01051 – Geotechnical Exploration

B. Section 01400 – Quality Control/Assurance

C. Section 01410 – Testing Laboratory Services

D. Section 02110 – Site Clearing and Stripping

E. Section 02205 – Fill Materials

F. Section 02222 – Excavating

G. Section 02223 – Filling

1.3 References

A. American Society for Testing and Materials (ASTM)

1. ASTM D 422 – Stand Test Method for Particle-Size Analysis of Soils
2. ASTM D 1556 – Test Method for Density of Soils in Place by the Sand-Cone Method
3. ASTM D 1557 – Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer ad 18-in. (457-mm) Drop
4. ASTM D 2216 – Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
5. ASTM D 4318 – Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
6. ASTM D 4643 – Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
7. ASTM D 6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Lines and Grades

A. Locate control points and verify that the vertical and horizontal positioning are as indicated on the Drawings.

B. Stake required lines, levels, contours, and datum.

C. Protect Owner-supplied control points from excavation equipment and vehicular traffic.

D. Replacement of destroyed or lost Owner-supplied control points shall be at the expense of the Contractor.

E. As required in Section 01050, prior to commencement of grading within Work area, and after completion of site stripping activities, the Contractor shall provide a detailed survey of the stripped ground surface of the Owner. The survey shall have an accuracy of plus or minus 0.2 feet with a 2 foot contour interval. The survey will be used by the Owner and Engineer to confirm that the general grading requirement provided in these Specifications are met and to detail areas where additional site grading may be required.

3.2 Subgrade Preparation

A. Remove all stockpiles, roadway fills, and any other undocumented fills prior to subgrade preparation.

B. *Under Embankment Foundation and Grading Fill:* Proof-roll subgrade under the footprint of the dam embankment with a loaded scrapper, a loaded water truck, or a loaded haul truck to identify soft spots in the presence of the Engineer. Remove soft or yielding subgrade soils identified by the proof-roll to the depth determined by the Engineer. Fill these areas in accordance with Section 02223. Prior to placement of the Embankment Fill material, scarify the subgrade to a minimum depth of 12 inches, moisture condition to near optimum moisture content, and compact the subgrade to a minimum of 90 percent of the soils maximum dry density as determined by ASTM D 1557, or as approved by the Engineer. Roughen the final surface with at least two (2) passes of sheepsfoot compactor, wedge foot compactor, or other equipment approved by the Engineer.

C. *In Areas within the TSF Basin to Receive Geomembrane where Grading Fill is Required:* Proof-roll subgrade under the Grading Fill with a loaded scrapper, a loaded water truck, or a loaded haul truck to identify soft spots in the presence of the Engineer. Remove soft or yielding subgrade soils identified by the proof-roll to the depth determined by the Engineer. Fill these areas in accordance with Section 02223. Prior to placement of the Grading Fill material, scarify the subgrade to a minimum depth of 12 inches, moisture condition to near optimum moisture content, and compact the subgrade to a minimum of 90 percent of the soils maximum dry density as determined by ASTM D 1557, or as approved by the Engineer. Roughen the final surface with at least two (2) passes of sheepsfoot compactor, wedge foot compactor, or other equipment approved by the Engineer.

D. *In Areas within the TSF Basin to Receive Geomembrane on Native or Excavated Ground:* Following compaction, the upper surface of Prepared Subgrade shall be graded and oversized rock greater than 1-inch diameter, and projections shall be removed from the exposed surface. Prior to geosynthetics placement, the final surface of the Prepared Subgrade shall be proof-rolled with a minimum of 4 passes with vibratory smooth drum roller with a 10-ton static and 25 ton dynamic drum weight. The final surface shall be free draining, compact, free of protrusions, and suitable for geosynthetics placement

E. If prior placed or prepared, tested, and accepted Prepared Subgrade or fills become loosened, softened, or disturbed by construction equipment traffic, during dry or wet weather, these materials shall be moisture-conditioned or dried, and recompacted. If weather or soil conditions prevent soils

from being properly compacted, the unsuitable soils shall be removed and replaced with properly compacted fill at no expense to the Owner.

3.3 Site Grading

A. Grading Fill may be required to fill depressions or other areas identified by the Engineer. This material shall be placed according to Specifications 02223.

B. Where fill is required in areas that are inaccessible using conventional compaction equipment, these area shall be compacted using hand-held equipment or backfilled using Lean Mix Concrete with the approval of the Engineer.

3.4 Field Quality Control

A. Field Quality Control inspections and testing shall be performed in accordance with Sections 01010, 01400 and 01410. The Quality Control Team shall be under the supervision of a Professional Engineer licensed in the State of Oregon.

B. In place density testing shall be performed in accordance with ASTM D 1556 or D 6938.

C. Laboratory compaction testing to determine the soils maximum dry density shall be performed in accordance with ASTM D 1557.

D. Frequency of tests: Field and laboratory testing of the Prepared Subgrade shall be performed in accordance with Section 02223.

*****END OF SECTION*****

SECTION 02222
EXCAVATING

1.0 GENERAL

1.1 Section Includes

A. Lines and Grades

B. Excavation

C. Tolerances

D. Quality Assurance

1.2 Related Sections

A. Section 01051 – Geotechnical Explorations

B. Section 01400 – Quality Control/Assurance

C. Section 01500 – Construction Facilities and Temporary Controls

D. Section 02110 – Site Clearing and Stripping

E. Section 02211 – Rough Grading

F. Section 02205 – Fill Materials

G. Section 02223 – Filling

2.0 PRODUCTS

NOT USED

3.0 EXECUTION

3.1 Lines and Grades

A. Locate control points and verify that the vertical and horizontal positioning are as indicated on the Drawings.

B. Stake required lines, levels, contours, and datum.

C. Protect Owner-supplied control points from excavation equipment and vehicular traffic.

D. Replacement of destroyed or lost Owner-supplied control points shall be at the expense of the Contractor.

E. As required in Section 01050, prior to commencement of grading within Work area, and after completion of site stripping activities, the Contractor shall provide a detailed survey of the stripped ground surface of the Owner. The survey shall have an accuracy of plus or minus 0.2 feet with a 2-foot contour interval. The survey will be used by the Owner and Engineer to confirm that the general grading requirement provided in these Specifications are met and to detail areas where additional site grading may be required.

3.2 Excavation

A. Contractor shall excavate all loose and disturbed soil from exploration borings and test pits within the TSF, WRD, and reclaim pond footprints, as shown on the Drawings and presented in Section 01051 and backfill in accordance with Section 02223. Excavation and backfill borings and test pits shall be performed prior to site clearing and stripping.

B. Excavate soils and rock to the lines and slopes shown on the Drawings.

C. On-site materials encountered in excavations are anticipated to be alluvial soils, residual soils, and waste material.

D. Grade the top perimeter of excavations to prevent surface water from draining into the excavation.

E. Alluvial soils excavated on-site may be used for fill in the dam, subject to the specifications described in Section 02205 and Section 02223.

F. All final cut surfaces will be moisture-conditioned and compacted in accordance with Section 02211 prior to subsequent fill placement.

G. Remove loose, soft, and yielding material from the bottom and sides of excavations at the direction of the Engineer.

H. During excavating operations, underlying foundation clays materials may be exposed. Contractor shall protect excavations from surface water run-on. In the event that foundation clay materials become saturated, or deemed unacceptable by the engineer, the Contractor shall overexcavate unsuitable materials and backfill the excavation with General Fill in accordance with Section 02223.

I. Excavation extending beyond the lines, grades, and dimensions shown on the Drawings shall be backfilled with Grading Fill in accordance with Section 02223 at no expense to the Owner.

J. Excavations shall be graded and properly maintained to provide adequate drainage at all times. Ponding shall not be allowed to develop. In excavation that cannot be properly graded to drain, such as ponds, the Contractor will provide equipment and labor to keep the excavation free of standing water.

K. Excavation shall be suspended when the site is wet, muddy or in any other condition where the area cannot be properly maintained.

L. Correct areas over-excavated in accordance with Section 02223.

M. Stockpiles excess excavated material as directed by the Owner.

N. The Contractor shall lay out diversion ditches and channels, so channels are excavated in original site soils and not fill. Ditches shall be laid out to provide minimum grades of 1 percent, unless shown flatter on the Drawings. Channel grade breaks shall not exceed 2 percent, unless otherwise shown on the Drawings.

3.3 Tolerances

A. Local slopes shall be within 5 percent of those shown on the Drawings. Overall slopes will be within 0.1 percent of those shown on the Drawings.

B. Finished grades shown on the Drawings are given in feet and tenths or hundredths of feet and shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

C. All excavations shall not exceed 0.3 feet in variation from dimensions and elevations shown on the Drawings, unless authorized by the Engineer.

D. Minimum grades and slopes shown on the Drawings to provide drainage control shall be maintained.

E. Correction of over-excavated and backfilling past the tolerances identified above shall be to the Contractor's account, at no expense to the Owner.

3.4 Quality Control

A. Field Quality Control inspection and testing will be performed in accordance with Sections 01400 and 01410.

B. Visual inspection of the excavated surface will be made to verify that all loose material has been removed or compacted and that there are no soft and yielding areas.

C. In place density testing will be performed in accordance with Sections 02211 and 02223.

*****END OF SECTION*****

SECTION 02223
FILLING

1.0 GENERAL

1.1 Section Includes

JJ. Related Sections
KK. References
LL. Fill Materials
MM. Verification
NN. Subgrade Preparation
OO. Fill Placement
PP. Tolerances
QQ. Protection of Finished Work
RR. Quality Control
SS. Submittals
TT. Quality Assurance

1.2 Related Sections

A. Section 01051 – Geotechnical Explorations
B. Section 01300 – Submittals
C. Section 01400 – Quality Control/Assurance
D. Section 01500 – Construction Facilities and Temporary Controls
E. Section 02205 – Fill Materials
F. Section 02222 – Excavating
G. Section 02273 – Geonet
H. Section 02350 – Geosynthetic Clay Liner
I. Section 02775 – Geomembranes
J. Section 02710 – Gravity Piping
K. Section 03300 – Cast-in-Place Concrete

1.3 References

A. ASTM D 136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate.
B. ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils
C. ASTM D 1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method
D. ASTM D 1557 - Standard Test Method for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop
E. ASTM D 2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
F. ASTM D 2216 - Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures
G. ASTM D 4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

H. ASTM D 4643 – Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

I. ASTM D 5519 – Standard Test Methods for Particle Size Analysis of Natural and Man-made Riprap Materials

J. ASTM D 5856 – Standard Test Method for Measurement of Hydraulic Conductivity of Porous Material Using a Rigid-Wall, Compaction-Mold Permeameter

K. ASTM D 6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

2.0 PRODUCTS

A. Embankment Fill

B. Grading Fill

C. Drainage Layer

D. Filter Fill

E. Anchor Trench Backfill

F. Drain Gravel

G. Leak Detection Fill

H. Riprap

I. Safety Berm Material

3.0 EXECUTION

3.1 VERIFICATION

A. Verify that lines and grades of fill limits and slopes have been established as required.

B. Field verify location of all exploration boreholes and test pits with Engineer and Owner prior to site clearing and stripping.

C. Contractor shall supply certification that all boreholes and test pits have been filled in accordance with these Specifications. The Contractor will supply a list of the boreholes/pits backfilled with the certification, including the depth of each borehole/pit.

3.2 SUBGRADE PREPARATION

A. Prepare subgrade according to Section 02211 and Section 02222.

B. Do not place fill until subgrade has been tested and approved by the Engineer.

3.3 FILL PLACEMENT

A. Do not place frozen material as fill.

B. Do not place fill on frozen ground. EXCEPTION: Fill may be placed on frozen subgrade provided that the depth of freezing is no more than 2 inches AND the subgrade has been previously tested and proof-rolled and approved by the Engineer. Engineer shall be consulted prior to fill placement when freezing depths are greater than 2 inches. Fill placement on frozen subgrade shall only be performed with the approval of the Engineer.

C. Prior to topsoil stripping, boreholes and test pits within the TSF, WRD, and reclaim pond footprints shall be re-excavated to their original depths in accordance with Section 02222. All loose soils and debris shall be removed. The re-excavated explorations shall be backfilled with General Fill, placed in 12-inch maximum loose lifts, moisture-conditioned, compacted with tampers, vibratory compactors, hoe-packs, or other suitable approved compaction methods, to achieve a stable, non-yielding surface. Open boreholes shall be backfilled with bentonite seal in accordance with regulatory requirements.

D. Fill materials shall be obtained from designated borrow areas or areas designated by the Engineer and Owner. For fill materials that are proposed to be imported by the Contractor from areas other than those designated by the Engineer, the Contractor shall give the Owner at least five (5) working days' notice prior to using the imported material to enable the Owner's representative to sample and test the material. Imported material must be tested for compliance with the Specifications and the results approved by the Engineer prior to the material being delivered to the site.

E. Placement of fill shall be made only in areas approved by the Engineer for fill placement. Fill shall be placed to the lines and grades shown on the Drawings and according with these Specifications.

F. Fill placement shall be temporarily stopped due to inclement weather conditions at the direction of the Engineer. Under marginal weather conditions, the Contractor may place fill, provided the fill, when tested, meets these Specifications.

G. The distribution of materials shall be such that the fill is free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The combined borrow excavation and fill placement operation shall be such that the materials, when compacted in the fill, will be blended sufficiently to provide the best practicable distribution of the material, subject to the approval of the Engineer.

H. If, in the opinion of the Engineer, the surface of the subgrade or the surface of any layer of the fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be scarified to a depth of 6 inches, or as directed by the Engineer, then moisture-conditioned to provide a satisfactory bonding surface before the next layer of fill material is placed.

I. If, in the opinion of the Engineer, the surface of the subgrade or the rolled surface of any layer of the fill in place is too wet for proper compaction of the layer of fill material to be placed thereon, it shall be removed and allowed to dry or shall be worked with discs, scarifier, or other equipment to reduce the moisture content to the required amount, and then compacted before the next layer of fill material is placed.

J. The Contractor shall place fill only after the subgrade below fills has been adequately compacted and approved by the Engineer. Should any of the work be covered before it has been approved, the Contractor shall uncover all such work at no cost to the Owner. After the work has been examined, tested and approved by the Engineer, the Contractor shall make all repairs and replacements necessary to restore the work to the contract specifications at no additional cost to the Owner.

K. All fill materials shall be moisture-conditioned prior to applying compactive effort. Moisture-conditioning may be performed to fill material either in the borrow area or at the fill site or in both areas as directed by the Engineer. The Owner may also require additional moisture conditioning in the cut or fill to limit fugitive dust.

L. During compaction operations, the borrow and reworked in-place materials requiring moisture conditioning shall be maintained within the range of moisture content required in these Specifications to achieve, with the equipment being used, adequate compaction to the specified density. The moisture content of the fill material prior to and during compaction shall be uniform throughout the material.

M. When material is too dry for proper compaction and/or is below the minimum moisture content specified, the Contractor shall spray water on the fill and work the moisture into the fill by discing or scarifying, or other means approved by the Engineer, until a uniform distribution of moisture is obtained.

N. Material that is too wet for proper compaction and/or is above the maximum moisture content specified, shall be removed from the fill or the material may be spread and permitted to dry, assisted by discing or scarifying until the moisture content is reduced to an amount suitable for obtaining the specified degree of compaction. The Contractor shall not mix underlying fill materials with fill materials being moisture conditioned.

O. The upper 1-foot of final travel way surfaces shall not contain oversize materials greater than 3 inches.

P. For purposes of these Specifications, soil fills are defined as a material where greater than 70% (by weight) passes the ¾-inch screen and rock fills are defined as materials where greater than 30% (by weight) is retained on the ¾-inch screen.

Q. The relative compaction of fill materials shall be tested in-place to check compliance with the Specifications. Rock fills shall be compacted using compactive efforts and performance-based specifications as herein specified, or by an Engineer's approved method based on test fills with specific roller equipment. For the purposes of these specifications, relative compaction of soil fill is the ratio of the in-place dry density of the constructed fill to the maximum laboratory dry density determined by ASTM D 1557 (Modified Proctor).

R. The Engineer shall continuously evaluate the Contractor's equipment and methods. If such equipment or methods are found unsatisfactory for the intended use, the Engineer will require the Contractor to replace the unsatisfactory equipment with other types or adjust methods until proper compaction is achieved.

S. The Contractor shall maintain and protect fills in a condition satisfactory to the Engineer at all times until the final completion and acceptance of the work. Any approved fill material which becomes unsuitable for any reason whatsoever, after being placed in the fill and before final acceptance of the Work, shall be removed and replaced by the Contractor in a manner satisfactory to the Engineer.

T. The Contractor shall route equipment and take all actions necessary to prevent material of one type from being deposited inadvertently, either by dumping or through travel of equipment, in or on material of another type. Such improperly deposited material shall be removed from the fill areas, as directed by the Engineer. If in-place material becomes contaminated, it shall also be removed. All removed material shall be wasted in locations designated by the Engineer. Removal of all such material shall be at no cost to the Owner.

U. At no time shall the native foundation clay be used as General Fill or Embankment Fill. Any foundation clay that becomes exposed during rough grading operations, it shall be over excavated and backfilled, or capped with a minimum 12 inches of General Fill to the lines and grades shown on the Drawings at the direction of the owner.

V. If prior placed, tested and accepted in-place fills become loosened, softened, or disturbed by construction equipment traffic, during dry or wet weather, these materials shall be moisture-conditioned or dried as previously described and recompacted. If weather or soil conditions prevent soils from being properly compacted, the unsuitable soils shall be removed and replaced with properly compacted fill. Such replacement and/or re-compaction shall be at no expense to the Owner.

W. Berms and fills placed for diversion ditches shall be placed, compacted, and tested in accordance with these Specifications. When backfilling staged diversion ditches, fill shall be placed, compacted, and tested in accordance with these Specifications.

X. Embankment Fill:

1. Areas to receive Embankment Fill shall include, but are not limited to: embankment, diversion ditches, access and perimeter roads, and diversion berms.
2. Condition to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
3. Prior to subsequent staged Embankment Fill placement, the dam crest shall be scarified to a depth of 6 inches, or as directed by the Engineer, then moisture-conditioned prior to placement of the first lift of new Embankment Fill. The first lift placed over the scarified dam crest shall be placed to a maximum loose lift thickness of 12 inches to 18 inches, or less as required by these Specifications.
4. Embankment Fill with less than 30 percent rock materials above 3/4-inch size and 8-inch maximum rock size (Embankment Soil Fill) shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D1557).
5. Embankment Fill containing more than 30 percent rock materials above 3/4-inch size (Compacted Rockfill) shall be placed as a rock fill and compacted according to the following method. However, in all cases vibratory drum compactors, if used as the primary means of compaction, must have a minimum 10-ton static and 25-ton dynamic drum weight.

6. For Rock Fills, a test fill shall be conducted to determine the maximum lift thickness and compactive effort for the material. The test fill may be located so that it is incorporated within the limits of the compacted fill area. The test fill shall be constructed and monitored as per U.S. Army Corps of Engineers' guidelines for test fill construction. The Contractor shall outline his proposed procedures for moisture conditioning and fill placement of Compacted Rock Fill and submit them to the Engineer for review and approval prior to placing the test fill.
7. Loose lift thicknesses of 12, 18, and 24 inches or as determined by the Engineer shall be used for the Test Fill; (three test fills to determine optimum lift thickness)
8. The data to be collected during construction of the test fill shall include:
    a. Amount of settlement after every two passes of the proposed compaction equipment to a maximum of ten (10) passes;
    b. Gradation and moisture content of in-place material; and
    c. In-place fill density at completion of the test by bulk density or Nuclear Gauge methods.
    d. A curve showing change in settlement versus number of passes shall be produced from the data. This curve will be used to determine the number of passes for acceptable compaction. In general, the minimum number of passes will be that number required to achieve 80 percent of the total settlement obtained after ten complete passes of the compaction equipment. Final determination by the Engineer of the lift thickness and minimum required passes will be based on a review of the test data.
    e. Maximum rock size for rock fills shall be two-thirds of the compacted lift thickness, unless otherwise approved by the Engineer. Provisions shall be made by the Contractor for removal of oversize materials from fills for use as riprap or exterior slope protection. No additional payment will be made to remove oversize materials.

Y. Grading Fill

1. Areas to receive General Fill shall include, but are not limited to: TSF basin, perimeter access roads, reclaim pond, underdrain channel, WRD pad, and permanent diversion channels.
2. It is the intent of the design to use excavated materials within the TSF basin footprint as much as possible for General Fill.
3. Condition the fill to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
4. Soil General Fill:
    a. General Fill with less than 30 percent rock materials above 3/4-inch in size and 8-inch maximum rock size shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D 1557).
5. Rock General Fill:
    a. General Fill containing more than 30 percent rock materials above 3/4-inch size (Compacted Rockfill) shall be placed as a rockfill based on the results of a Test Fill as described in the Embankment Fill Section below. The type of compaction equipment, number of passes, lift thickness, and maximum rock size shall be approved by the Engineer in writing based on the acceptable Test Fill performance.
    b. Maximum rock size for rock fills shall be two-thirds of the compacted lift thickness, unless otherwise approved by the Engineer. Provisions shall be made by the Contractor for removal of oversize materials from fills for use as riprap or exterior slope protection. No additional payment will be made to remove oversize materials.
6. The Contractor shall adopt methods to remove all oversize rock from the fill. Oversize rock will be stockpiled in a location designated by the Owner. No additional payment shall be made to the Contractor for oversize rock removal.

7. Where bedrock is encountered within 12 inches of the bottom of Prepared Subgrade, the Contractor shall place a 12-inch thick lift of soil General Fill as a “Rock Cap”.

Z. Prepared Subgrade

1. Condition Prepared Subgrade to a moisture content which allows compaction to the required density without an excessive amount of effort and that results in a stable non-yielding surface.
2. Prepared Subgrade shall be placed in 12-inch maximum loose lifts and compacted to 92 percent of maximum dry density (ASTM D1557).
3. Following compaction, the upper surface of the Prepared Subgrade shall be treated as described in Section 02211 of these Specifications in preparation of geomembrane liner placement.
4. On slopes steeper than 20 percent, Prepared Subgrade shall be placed in 18-inch lifts be as measured perpendicular to the slope. Prepared Subgrade may be placed in a single 6-inch lift if the underlying Embankment Fill material is free from excessive coarse material, cobbles, and boulders. Reduction of the total lift thickness shall be approved by the Engineer.

AA. Drainage Layer

1. Drainage Layer shall not be placed until final inspection and approval of the geosynthetics has been made by the Engineer
2. Drainage Layer shall be placed over the geomembrane liner in one lift to result in a minimum eighteen (18)-inch-thick layer after construction is complete.
3. Drainage Layer shall not be compacted.
4. Drainage Later shall have an in-place hydraulic conductivity of 5×10^{-3} cm/sec when tested in accordance with ASTM D 5856.
5. Drainage Layer shall be placed by dumping with trucks or loaders at the edge of geomembrane cover and spreading over the geomembrane with a dozer equipped with Low Ground Pressure (LGP) tracks that exert a pressure of seven (7.0) psi or less, or similar equipment, as approved by the Engineer, that will prevent heavy loads on the liner. Equipment shall not be allowed to come in direct contact with the plastic liner. Rubber-tire equipment shall not be allowed to cross over collection and distribution pipe at any time unless it can be proved by a field test that the subject equipment will not crush the pipe. It may be necessary to place a thicker lift of Drainage Fill over piping if an alternate method of placement is used. Alternative methods of placement proposed by the Contractor will be considered. However, such methods shall be proposed to and approved by the Engineer prior to mobilization of equipment to the site. The Engineer reserves the right to accept or reject any such alternative placement proposal.
6. Thickness of the Drainage Layer will be monitored by the Contractor with twenty-four (24)-inch-high highway cones, or an alternative method proposed by the Contractor and approved by the Engineer.
7. Hauling equipment shall operate on a minimum thickness of Drainage Layer Material above any geosynthetic layer as determined by the Engineer. Prior to commencing Work, Contractor shall provide a list of proposed equipment to operate on the Drainage Layer for approval and minimum roadway thickness determination.
8. In locations with the TSF basin and WRD pad where heat seaming has been used to join geomembrane sections, the protective cover material shall be spread in the same direction as the seam overlap to avoid placing additional stress on the seam.
9. The finished surface of the Drainage Layer shall be bladed with the LGP dozer to provide a surface free of ridges, mounds, and ponding areas.
10. The Contractor shall protect underlying geosynthetics from mechanical damage at all times during placement of Drainage Layer.

11. The geomembrane Installation Contractor shall take steps to minimize wrinkle generation in underlying geosynthetic materials during placement of the Drainage Layer. The measures may include placing protective layer material in the early morning hours when the geosynthetic materials are cool and monitoring and walking out wrinkles in the geosynthetic materials that appear at the edge of the placement area.
12. Placement of Drainage Layer shall not be performed when the ambient air temperature exceeds 100°F or if excessive wrinkles developed in the geomembrane as determined by the Engineer.

BB. The Contractor shall survey to control overall protective cover and drainage layer thickness as specified in Section 01050. Results shall be provided to the Engineer.

CC. Filter Fill

1. Filter Fill shall be placed in a single 6-inch loose lift above the Drainage Layer and under riprap in the permanent diversion channels.
2. Filter Fill shall not be compacted above the drainage layer.
3. Filter Fill shall be compacted to a smooth and non-yielding surface where used as bedding below riprap.
4. Filter Fill shall be placed by dumping with trucks or loaders and spreading over the Drainage Layer with a dozer equipped with Low Ground Pressure (LGP) tracks that exert a pressure of seven (7.0) psi or less, or similar equipment, as approved by the Engineer, that will prevent heavy loads on the liner. Rubber-tire equipment shall not be allowed to cross over collection and distribution pipe at any time unless it can be proved by a field test that the subject equipment will not crush the pipe. Alternative methods of placement proposed by the Contractor will be considered. However, such methods shall be proposed to and approved by the Engineer prior to mobilization of equipment to the site. The Engineer reserves the right to accept or reject any such alternative placement proposal.
5. Thickness of the Filter Fill will be monitored by the Contractor with twenty-four (24)-inch-high highway cones, or an alternative method proposed by the Contractor and approved by the Engineer.
6. Hauling equipment shall operate on a minimum thickness of Drainage Layer Material above any geosynthetic layer as determined by the Engineer. Prior to commencing Work, Contractor shall provide a list of proposed equipment to operate on the Drainage Layer for approval and minimum roadway thickness determination.
7. The finished surface of the Filter Fill shall be bladed with the LGP dozer to provide a surface free of ridges, mounds, and ponding areas.

DD. The Contractor shall survey to control overall protective cover and Filter Fill thickness as specified in Section 01050. Results shall be provided to the Engineer

EE. Anchor Trench Backfill

1. Anchor Trench Backfill shall be placed in geomembrane anchor trenches.
2. Fill placed in geomembrane anchor trenches shall be placed in maximum 12-inch thick compacted horizontal lifts and compacted by tamping with a minimum of two passes with a mechanical “whacker” type tamper or bucket compacted.
3. Anchor Trench Backfill may be used as pipe ballast as directed by the Owner.

FF. Drain Gravel

1. Drain Gravel shall be placed around the primary perforated CPE and HDPE underdrain collection pipes.
2. Drain Gravel shall be placed around the pipe with a minimum clearance of 6-inches on all sides then wrapped with a non-woven geotextile.

3. No equipment other than track-mounted vehicle shall be allowed on the Drain Gravel.

GG. Leak Detection Fill

1. Leak Detection Fill shall be placed around the perforated PVC leak detection pipes.
2. Leak Detection Fill shall be around the pipe with a minimum clearance of 8-inches above and on the sides of the pipe.
3. Leak Detection Fill and leak detection pipe shall be placed directly above the GCL within the leak detection channel as shown on the Drawings.
4. No equipment other than track-mounted vehicle shall be allowed on the Leak Detection Fill.

HH. Pipe Bedding Fill

1. Pipe bedding fill shall be placed around leak detection risers, culverts and buried HDPE piping as shown on the Drawings.
2. Pipe Bedding Fill shall be brought up in horizontal lifts to prevent unbalanced pressure on structures or pipes.
3. Pipe Bedding Fill shall be placed a minimum of 6 inches below the pipe and shall be compacted and approved by the Engineer prior to pipe placement.
4. Pipe Bedding Fill shall be worked under pipe haunches by hand to provide uniform support of the pipe.
5. Pipe Bedding Fill shall be placed in maximum 6-inch loose lift, moisture-conditioned, and compacted to 92 percent of maximum dry density (ASTM D1557).
6. Only hand-guided mechanical tampers or hand-guided vibratory rollers shall be used for compaction around, over, near, or adjacent to pipes.

II. Cable Bedding Fill

1. Cable Bedding Fill shall be placed below and around instrumentation signal cables as shown on the Drawings.
2. Cable Bedding Fill shall be placed in a minimum 6 inches compacted lift below the signal cables and compacted to a smooth and non-yielding surface using hand-guided compaction equipment.
3. Cable Bedding Fill shall be placed in a single 12-inch loose above the signal cables and compacted with hand-guided compaction equipment to achieve a smooth and non-yielding surface.
4. Cable Bedding Fill shall extend a minimum of 12 inches on either side of the maximum extents of the signal cable layout.

JJ. Riprap

1. Riprap shall be placed above Filter Fill in permanent diversion channel and outlet aprons to the lines and grades shown on the Drawings.
2. Riprap shall be placed in a single lift equivalent to 1.5 times D_{50}.
3. Riprap shall be track walked or bucket compacted.

KK. Safety Berm Material

1. Safety Berm Material shall be placed along light vehicle and haul roads.
2. Safety Berm Material shall be uncompacted and placed by either front end loader, dozer, or motor grader.
3. Safety Berm Material shall be placed to such a height as to be equal to the middle of the axel of the largest vehicle assigned to the Work Area.

3.4 TOLERANCES

A. Local slopes shall be within 5 percent of those shown on the Drawings, and overall slopes shall be within 0.1 percent of those shown on the Drawings.

B. Finished grades shown on the Drawings are given in feet and tenths or hundredths of feet, and shall slope uniformly between given spot and contour elevations. All grades shall provide for natural runoff of water without low spots or pockets.

C. Fill and backfill shall be placed within a tolerance of plus or minus 0.2 feet, unless otherwise approved by the Engineer. Where the thickness of fill or backfill is specified as a minimum thickness on the Drawings and/or in the Specifications, place fill to the minimum thickness shown. Layer thicknesses shown on the drawings are compacted thicknesses.

D. Minimum grades and slopes shown on the Drawings provide drainage control and shall be maintained.

E. Correction of over-excavation and backfilling beyond the tolerances identified above shall be to the Contractor's account, at no expense to the Owner.

3.5 PROTECTION OF FINISHED WORK

A. Protect finished Work and Work in progress in accordance with of Section 01500.

3.6 QUALITY CONTROL

A. Quality Control inspection and testing will be performed under provisions of Sections 01010, 01300, 01400, and 01410 under the supervision of a Professional Engineer licensed in the State of Oregon.

B. In place density testing shall be performed in accordance with ASTM D 1556 or D 6938.

C. Laboratory compaction testing to determine the soils maximum dry density shall be performed in accordance with ASTM D 1557.

D. Laboratory permeability testing to determine hydraulic conductivity of the Drainage Layer shall be performed in accordance with ASTM D 5856.

E. Field particle size analyses of riprap materials shall be performed in accordance with ASTM D 5519.

F. If Quality Control test results indicate Work does not meet specified requirements, perform remedial action as described below.

1. Immediately notify the Engineer.
2. Compaction below specified minimum density:
    a. Apply additional effort, or scarify, moisture condition, recompact, and retest.
3. Moisture content outside of specified limits during compaction:
    a. Moisture content below specified minimum: Scarify the depth of the lift, moisture condition, mix to achieve uniform moisture content, recompact, and retest.
    b. Moisture content above specified maximum: Scarify the depth of the lift, allow to air dry, mix to achieve uniform moisture content, recompact, and retest or remove the wet material. Mixing of dry material to lower the moisture content will not be allowed without the prior approval of the Engineer and on a case by case basis.
4. Moisture content outside of specified limits after compaction and approved prior to covering: Determine depth of material outside of specified limits and correct as specified above.
5. Material not in accordance with material specification requirements of Section 02205: Remove material in its entirety as determined by the Engineer.

G. Frequency of tests:

The following table shows the minimum frequency of Quality Control testing of soil, rock, and aggregate materials placed, unless otherwise approved by the Engineer:

Table 1: 02233-1 QUALITY CONTROL - MINIMUM TESTING FREQUENCIES

Materia Type		**Number of Units Per Test**					
	Test	Field Density and Moisture	Field Particle Size Analysis	Laboratory Sieve Analysis	Laboratory Atterberg Limits	Laboratory Moisture Density Relationship	Laboratory Permeability
	ASTM	**D 6938**	**D 5519**	**D 422**	**D 4318**	**D 1557**	**D 5856**
Subgrade	sq.ft	50,000	N/A	200,000	200,000	500,000	
Embankment Fill	cu.yds	2,000	N/A	5,000	5,000	20,000 per material type	
Grading Fill	cu.yds	1,000	N/A	5,000	5,000	20,000	
Prepared Subgrade	cu.yds	1,000	N/A	5,000	5,000	15,000	
Drainage Layer	cu.yds	N/A	N/A	5,000	5,000	N/A	2 per material type
Filter Fill	cu.yds	N/A	N/A	3,000	3,000	N/A	2 per material type
Anchor Trench Backfill	cu.yds	N/A	N/A	500	N/A	N/A	
Drain Gravel	cu.yds	N/A	N/A	200 (or 3 per material type)	200 (or 3 per material type)	N/A	
Leak Detection Fill	Each	N/A	N/A	2 per material type	2 per material type	N/A	
Pipe Bedding Fill	LF	100	N/A	100 (2 per material type)	100 (2 per material type)	200 (1 per material type)	
Cable Bedding Fill	cu.yds	N/A	N/A	2 per material type	2 per material type	N/A	
Riprap	cy.yds	N/A	2 per material type	N/A	N/A	N/A	
Safety Berm Material	cu.yds	N/A	N/A	N/A	N/A	N/A	

6. Tests may be conducted more or less frequently at the direction of the Engineer. More frequent testing shall be performed, where indicated by the following guidelines:
    a. Areas where special compaction equipment or methods are used.
    b. Areas where the height of fill rises quickly versus the quantity of fill placed.
    c. Areas where doubtful construction procedures are being used.
    d. Areas where the required compaction may not have been achieved based upon visual observations.
    e. Areas where unacceptable material may have been placed.
7. If additional Quality Control testing is required by the Engineer, costs for additional testing shall be borne by the Contractor.

H. Quality Control test results shall be made available to the Owner and Engineer within twenty-four (24) hours after completion of test.

I. Quality Control test results shall be stored in hard copy in the Quality Control Team's on-site facility for from the Owner or Engineer at all times. If no hard copies are stored on-site, the Quality Control Team shall provide the electronic test results to the Engineer within twenty-four (24) hours after completion of the test.

3.7 Submittals

A. The Quality Control test results shall be submitted to the Engineer for review and approval on a regular basis, or at the request of the Engineer.

B. The Quality Control Team shall be responsible for accurately testing and reporting results of all Quality Control test results and observations in a timely manner to the Owner and Contractor throughout the project in the form of a Daily Field Report.

1. Daily Field Reports shall be typed and submitted to the Engineer and/or Owner within one (1) working day.

C. Fill materials proposed by the Contractor for use to complete the Work shall be tested by the Quality Control Team prior to placement to verify that the material meets these Specifications.

D. Initial Quality Control test results of proposed materials shall be submitted to the Engineer for approval at least twenty-four (24) hours prior to material placement.

E. At the completion of the Work, a sealed Quality Control Report shall be submitted to the Owner and Engineer in accordance with Section 01300 and include at a minimum:

1. Cover letter summarizing the quantities of materials placed, required testing frequency, and actual testing frequency achieved. The Quality Control Report shall be sealed by a professional engineer licensed in the State of Oregon.
2. Typed field documentation including daily field reports, field and laboratory test results summary tables and individual test results forms for all tests performed for each construction material for the tests specified in these Specifications.
3. Summary tables shall be suitable for report presentation and regulatory agency review. One (1) digital reproducible copy of the summary tables shall be provided to the Engineer.

3.8 Quality Assurance

A. The Quality Assurance Team shall perform Quality Assurance or Referee testing at the direction of the Engineer.

B. The Engineer has the final decision regarding the use of a proposed material for completion of the Work.

C. At any time, the Engineer or Quality Assurance Team may collect a sample split from the Quality Control Team's sample and perform a referee test for Quality Assurance.

1. Quantity of tests and frequencies shall be at the discretion of the Engineer. Costs for Quality Assurance testing where test results do not meet these Specifications shall borne by the Contractor.

*****END OF SECTION*****

SECTION 02272
GEOTEXTILE

1.0 GENERAL

1.1 Section Includes

A. References
B. Performance Requirements
C. Submittals
D. Delivery, Storage, and Handling
E. Material
F. Deployment
G. Seaming
H. Quality Control
I. Quality Assurance

1.2 Related Sections

A. Section 01300 – Submittals
B. Section 01400 – Quality Control/Assurance
C. Section 01410 – Testing Laboratory Services
D. Section 02205 – Fill Materials
E. Section 02223 – Filling

1.3 References

A. American Society for Testing and Materials (ASTM)
   1. ASTM D 4354 – Practice for Sampling of Geosynthetics for Testing
   2. ASTM D 4355 – Test Method for Deterioration of Geotextile from Exposure to Ultraviolet Light and Water
   3. ASTM D 4533 -Test Method for Trapezoidal Tearing Strength of Geotextiles
   4. ASTM D 4632 – Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
   5. ASTM D 4751 – Test Method for Determining Apparent Opening Size of a Geotextile
   6. ASTM D 4759 – Practice for Determining the Specification Conformance of Geosynthetics
   7. ASTM D 4873 – Guide for Identification, Storage and Handling of Geotextiles
   8. ASTM D 5035 – Test Method for Break Strength and Elongation of Textile Fabrics (2” Strip Method)
   9. ASTM D 5261 – Test Method for Determining Mass Per Unit Area
   10. ASTM D 6241 – Test Method for Static Puncture Strength of Geotextiles and Geotextile Related Products Using a 50-mm Probe
   11. ASTM D 7238 – Test Method for Effect of Exposure of Unreinforced Polyfin Geomembrane Using Fluorescent Condensation Apparatus
B. Geosynthetic Research Institute (GRI)
   1. GT12a – Test Method and Properties for Nonwoven Geotextile Used as Protection (or cushioning) Materials

1.4 Performance Requirements

A. Contractor shall furnish and install the geotextile and all materials incidental to the installation in accordance with these Specifications.

B. Alignment, lengths, and areas for geotextile placement are shown on the Drawings. Exact locations and lengths may be varied to suit conditions encountered in the field only as approved by the Engineer.

A. Contractor shall furnish sufficient material to provide the finished geotextile shown on the Drawings; including material for all seams and laps. Contractor shall balance the actual project geotextile requirements, as determined by their quantity take-offs, against those shown on the Drawings.

1.5 Submittals

A. Submittals detailed below shall be in accordance with Section 01300.

B. After the Contract Award:

1. Product Data: Provide manufacturer's data regarding filtration, permeability, and mechanical properties.

2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.

C. During Installation:

1. Manufacturer Quality Control certificates

1.6 Delivery, Storage, and Handling

D. Transportation: The geotextile shall be packaged and shipped in such a manner that the material is not damaged or exposed to damaging substances. Transportation shall be the responsibility of the Geomembrane Installation Contractor unless agreed to by the Manufacturer and the Owner, in writing, prior to the initiation of shipment of geotextile to the site.

E. Off-Loading: Off-loading of the geotextile is the responsibility of the Geomembrane Installation Contractor. No off-loading of geotextile shall be performed unless the Owner's representative is present. Any damage to the rolls during off-loading shall be documented by the Owner's representative and the Geomembrane Installation Contractor. All damaged rolls must be stored separate from the undamaged rolls until. The rolls shall be unrolled to determine the extent of the damage. The use of the roll or portions of the roll shall be only at the approval of the Engineer. The cost of evaluating, replacing or repairing rolls damaged during off-loading shall be the sole responsibility of the Installation Contractor.

F. Storage: The geotextile shall be stored according to manufacturer's recommendations, ASTM D 4873, and such that it is protected from puncture, dirt, grease, gasoline, diesel fuel, water, moisture, mud, mechanical abrasion, excessive heat and other causes of damage to the geotextile material.

A. Rolls without the proper documentation shall be stored separately until all the required documentation is received and approved by the Engineer.

2.0 PRODUCTS

2.1 Material

A. The geotextile as referenced in the Drawings and these Specifications shall be Non-woven Needle Punched Geotextile.

1. Composition: Geotextile shall be of polypropylene or polyethylene fibers.

2. Rolls shall be free of holes, contamination, and foreign matter.

B. The geotextile supplied to the project shall meet or exceed the minimum (unless noted otherwise) roll values shown in the table below:

Table 02272-1: Minimum Average Roll Values For Geotextile Material (per GRI-GT12a)

Property[1]	ASTM Test Method	Value
Weight	D 5261	12 oz/sq.yd.
Grab Tensile	D 4632	300 lb
Grab Tensile Elongation	D 4632	50%
Trapezoidal Tear Strength	D 4533	115 lb
Puncture (CBR) Strength	D 6241	800 lb
UV Resistance (at 500 hrs)	D 7238	70% strength retained
Apparent Opening Size	D 4751	No. 100 Sieve (0.15 mm)

Notes:
1. Evaluation to be on a 2.0 inch strip tensile specimens per ASTM D 5035 after 500 light hour exposure.

C. Rolls shall be manufactured a minimum of 15 feet wide and 300 feet long.

D. The geotextile will be warranted by the Manufacturer to be free from defects in materials and workmanship and to have a useful life of 5 years from the date of purchase under normal weathering and normal use.

3.0 EXECUTION AND DEPLOYMENT

3.1 Deployment

A. Procedure and methods shall not damage the geotextile. Manufacturer's recommended deployment techniques shall be followed by the Contractor to the greatest extent possible.

B. Do not deploy frozen geotextile.

C. Do not deploy geotextile over frozen ground.

D. Deploy only in areas approved by the Engineer.

E. Placement of drainage aggregate should proceed immediately following placement of the geotextile. If a perforated collection pipe is to be installed, a bedding layer of drainage aggregate should be placed below the pipe, with the remainder of the aggregate placed to the minimum required construction depth.

3.2 Seaming

A. Seams can be sewn or overlapped a minimum of 12 inches.

3.3 Quality Assurance

A. Quality Assurance shall consist of:

1. Review of required documentation.
2. Approval of geotextile rolls for deployment.
3. Observation of unrolled material for damage.
4. Observation of seaming procedure and completed seams.

B. Engineer has final authority in the Quality Assurance for the project.

C. Compliance Testing:

1. At the option of the Engineer, compliance testing may be performed at any time prior to, during, or after the installation.

2. The cost of the compliance testing shall be negotiated between the Owner and Contractor.
3. The tests performed for the compliance testing shall be directed by the Engineer.
4. Compliance testing shall not include any tests that are not listed in these Specifications as a basis for evaluating compliance of the geotextile to the Specifications.
5. Sampling for Compliance Testing:
    a. Samples shall be obtained by the Engineer.
    b. The sample shall be taken as close to the middle of the roll as practical but shall, at a minimum, be sampled no closer than three (3) feet from the end of a roll.
6. The sample shall be labeled by the Engineer, using a permanent marker, with the roll number, machine direction, date sampled, and name of individual that sampled the material.

D. Seams:

1. Will be observed for required overlap and seaming procedures.
2. Seams that do not have the required overlap will be marked for adjustment.

*****END OF SECTION*****

SECTION 02273
GEONET

1.0 GENERAL

1.1 Section Includes

A. Definitions
B. Performance Requirements
C. Submittals
D. Delivery, Storage, and Handling
E. Material
F. Deployment
G. Seaming
H. Quality Assurance

1.2 Related Sections

A. Section 02775 – Geomembrane

1.3 References

A. American Society for Testing and Materials (ASTM)

1. ASTM D 792 – Standard Test Method for Density and Specific Gravity (Relative Density) of Plastics by Displacement
2. ASTM D 1505 – Standard Test Method for Density of Plastic by the Density-Gradient Technique
3. ASTM D 1603 – Test Method for Carbon Black in Olefin Plastics
4. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds By the Muffle-Furnace Technique
5. ASTM D 4354 – Practice for Sampling of Geosynthetics and Rolled Erosion Control (RECPs)
6. ASTM D 4355 – Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
7. ASTM D 4491 – Test Methods for Water Permeability of Geotextiles by Permittivity D 4533 Test Method for Trapezoidal Tearing Strength of Geotextiles
8. ASTM D 4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles
9. ASTM D 4716 – Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthectic using a Constant Head
10. ASTM D 4716 – Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
11. ASTM D 4751 – Test Method for Determining Apparent Opening Size of a Geotextile
12. ASTM D 4873 – Guide for Identification, Storage and Handling of Geosynthetic Rolls and Samples
13. ASTM D 5035 – Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)
14. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geotextile and Geomembranes
15. D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles

16. ASTM D 6241 – Standard Test Method for Static Puncture Strengths of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
17. ASTM D 6364 – Standard Test Method for Determining Short-Term Compression Behavior of Geosynthetics
18. ASTM D 7005 – Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposite
19. ASTM D7179 – Standard Test Method for Determining Geonet Breaking Force
20. ASTM D7238 – Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembranes Using Fluorescent UV Condensation Apparatus

B. Geosynthetic Research Institute (GRI)

1. GRI-GN2 and GC13 – Joining and Attaching Geonets and Drainage Composites
2. GRI-GN4 – Test Methods, Required Properties and Testing Frequencies for Biplaner Geonets and Biplaner Geonet Composites

1.4 Definitions

A. Installation Contractor: Subcontractor retained by the General Contractor to install the geonet or General Contractor, if General Contractor elects to install the geonet.

1.5 Performance Requirements

A. Installation Contractor shall furnish and install the geonet and all materials incidental to the installation in accordance with these Specifications.

B. Alignment, lengths, and areas for geonet placement are shown on the Drawings. Exact locations and lengths may be varied to suit conditions encountered in the field only as approved by the Engineer.

C. Installation Contractor shall furnish sufficient material to provide the finished geonet shown on the Drawings; including material for all seams and laps. Installation Contractor shall balance the actual project geonet requirements, as determined by his quantity take-offs, against those shown on the Drawings.

1.6 Submittals

A. Submittals detailed below shall be in accordance with Section 01300.

B. After the Contract Award:

1. Product Data: Provide manufacturer's data sheet.
2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.

1.7 Delivery, Storage, and Handling

A. Transportation: The geonet shall be packaged and shipped in such a manner that the material is not damaged or exposed to damaging substances. Transportation shall be the responsibility of the Geonet Installation Contractor unless agreed to by the Manufacturer and the Owner, in writing, prior to the initiation of shipment of geonet to the site.

B. Off-Loading: Off-loading of the geonet is the responsibility of the Geonet Installation Contractor. No off-loading of geonet shall be performed unless the Owner's representative is present. Any damage to the rolls during off-loading shall be documented by the Owner's representative and Geonet Installation Contractor. All damaged rolls must be stored separate from the undamaged rolls until. The rolls shall be unrolled to determine the extent of the damage. The use of the roll or portions of the roll shall be only at the approval of the Engineer. The cost of evaluating, replacing or repairing rolls damaged during off-loading shall be the sole responsibility of the Installation Contractor.

C. Storage: The geonet shall be stored according to manufacturer's recommendations and such that it is protected from puncture, dirt, grease, gasoline, diesel fuel, water, moisture, mud, mechanical abrasion, excessive head and other causes of damage to the geotextile material.

D. Rolls without the proper documentation shall be stored separately until all the required documentation is received and approved by the Engineer.

2.0 PRODUCTS

2.1 Material

Table 02273-1: Minimum Average Roll Values for Geonet Material (per GRI-GN4)

Property	ASTM Test Method	Minimum Average Roll Value
Thickness[1] (min. ave.)	D 5199	200 mil
Density[2] (min. ave.)	D 1505/D 792	0.950 g/cm^3
Carbon Black Content (%)	D 1603/D 4218	1.5-3.0%
Tensile Strength[3] (MD)	D 7179	180 lb/in
Compressive Strength[4] (min. ave.)	D 6364	120
Transmissivity[5]	D 4716	5.0 gal/min-ft

Notes:

1. The diameter of the presser foot shall be 2.22 in. and the pressure shall be 2.9 lb./in^2.
2. Density is of the formulated material; the base resin will be slightly lower.
3. This is the average peak value for five equally spaced machine direction tests across the roll width.
4. Test to be conducted using Section 6.3, the movable plate method.
5. Geonets shall be tested between rigid end platens at a hydraulic gradient of 1.0; a pressure of 10,000 lb/ft^2, and a seating dwell time of 15 min. Test values are for machine direction only.

3.0 EXECUTION AND DEPLOYMENT

3.1 Installation

A. Do not deploy frozen geonet.

B. Do not deploy geonet over frozen ground.

C. Deploy only in areas approved by the Engineer.

D. Deploy the geonet in a downhill manner, when applicable, with the long dimensions of the panel sloping downhill.

E. Install the overlying geomembrane liner without damaging the geonet layer or underlying geomembrane.

3.2 Seaming

A. Use plastic wire ties of a color contrasting to the color of the geonet.

B. Tie Spacing: According to manufacturer's recommendations but at a minimum of 5 feet on seam perpendicular to slopes, 2 feet on seams parallel to slopes, 5 feet on seams on grades of less than 5percent, and 6 inches on seams in anchor trenches.

C. Do not overlap.

3.3 Construction Quality Assurance

A. Construction Quality Assurance (CQA) shall consist of:

1. Observation of geonet prior to and during deployment for dirt and debris that may clog the leak detection system.
2. Observation of tie spacing.
3. Observation of procedures for damage to secondary liner.

*****END OF SECTION*****

SECTION 02350
GEOSYNTHETIC CLAY LINER

1.0 GENERAL

1.1 Section Includes

A. References
B. Performance Requirements
C. Submittals
D. Delivery, Storage, and Handling
E. Material
F. Deployment
G. Seaming
H. Quality Assurance

1.2 Related Sections

A. Section 01300 – Submittals
B. Section 01400 – Quality Control/Assurance
C. Section 02205 – Fill Materials
D. Section 02223 – Filling

1.3 References

A. American Society for Testing and Materials (ASTM)
   1. ASTM D 4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
   2. ASTM D 5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
   3. ASTM D 5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles
   4. ASTM D 5887 – Standard Test Method for Measuring the Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
   5. ASTM D 5993 – Standard Test Method for Measuring Mass per Unit Area of Geosynthetic Clay Liners
   6. ASTM D 5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembranes
   7. ASTM D 6243 – Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punch Geosynthetic Clay Liners
   8. ASTM D 6496 – Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
   9. ASTM D 6768 – Standard Test Method for Tensile Strength of Geosynthetic Clay Liners
B. Geosynthetic Research Institute (GRI)
   1. GCL3 – Geosynthetic Research Institute Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)

1.4 Performance Requirements

A. This Work shall include the furnishing of all labor, tools, equipment, and other items necessary for the installation of geosynthetic clay liner (GCL) as shown on the Drawings. All Work shall be performed in accordance with the lines, grades, sections, and dimensions shown on the Drawings, or as directed by the Engineer

1.5 Submittals

A. Submittals detailed below shall be in accordance with Section 01300.

B. After the Contract Award:

1. Product Data: Provide manufacturer's data regarding filtration, permeability, and mechanical properties.

2. Sample: Submit one (5 feet by 5 feet) sample with the machine direction marked.

C. During Installation:

1. Manufacturer Quality Control certificates

D. After Installation:

1. At the completion of the Work, the GCL Installation Contractor shall submit the Quality Control Documentation outlined in Section 01300 and shall include at a minimum:

   a. Typed summary tables of the field documentation including summaries of on-site field personnel, GCL panel deployment, heat-bonded test seams, samples and test results recorded during installation, if any.

   b. A GCL record drawing showing panels and heat-bonded test locations. The record drawing shall be drawn on a 22 –inch by 34-inch sheet.

   c. The summary tables and record drawings shall be suitable for report presentation and agency review. One (1) digital reproducible copy of the summary tables and record drawings shall be provided to the Engineer.

1.6 Delivery, Storage, and Handling

A. Rolls shall be stored following all Manufacturer's recommendations and the requirements of ASTM D 4873.

B. Rolls shall be stored on a flat dry surface. Store to protect the GCL from dust, dirt, and debris. All rolls shall be labeled and bagged in packaging that is resistant to photodegradation by ultraviolet (UV) light.

C. Rolls shall be handled utilizing a solid steel bar inserted through the core bar and slings or chains attached to the ends of the bar. The core bar shall be suspended from a spreader bar so that the edges of the liner are not damaged by the suspending straps or chains.

2.0 PRODUCTS

2.1 Material

A. The GCL as referenced in the Drawings and these Specifications shall be reinforced geofilm-related GCL similar to ContainMAT manufactured by GSE Environmental of Houston, Texas, or similar which has a maximum allowable composite hydraulic conductivity of 5×10^{-10} cm/sec.

B. The GCL shall be formulated and manufactured from polypropylene geotextiles and high swelling, containment resistant sodium bentonite.

C. The GCL shall be manufactured reinforced by the mechanical bonding of the needle punch process to enhance the friction characteristics of the GCL and to maintain the integrity of the GCL under hydration. No glues or adhesives shall be used in lieu of the needle punch process so as to retain these characteristics.

D. Needle-punched GCL's are those which, by the process of a needling board (similar to that used in the manufacture of standard non-woven geotextiles) have fibers of a non-woven geotextile pushed through the bentonite clay core and integrated into a woven or non-woven geotextile without the use of any chemical binders or adhesives.

E. No disassociation of geotextile components from the bentonite core shall occur. A sample of the GCL placed in 70º F tap water for 1 hour shall not delaminate.

F. The GCL supplied to the project shall meet or exceed the minimum (unless noted otherwise) roll values shown in the table below:

Table 02350-1: Minimum Average Roll Values For Reinforced Geofilm Related GCL Material (per GRI-GCL3)

PROPERTY	ASTM TEST METHOD	VALUE
Geotextile/Geofilm Properties		
Cap Geosynthetic		
Type	-	Non-woven
Weight	ASTM D 5261	6.0 oz/sq.yd.
Carrier Geosynthetic		
Type	-	Woven
Weight	ASTM D 5261	3.0 oz/sq.yd.
Geofilm		
Thickness	ASTM D 5199/ D 5994	4 mil
Break Tensile Strength (MD & XMD)	ASTM D 882	12 lb/in
Clay Properties		
Clay Type	-	80% or more montmorillonite
Bentonite Mass at 0% Moisture[2]	ASTM D 5993	0.75 psf
Maximum Allowable Moisture Content	ASTM D 5993	35%, by weight
Swell Index	ASTM D 5890	24 ml/2g min
Fluid Loss	ASTM D 5891	18 ml max
GCL Composite Properties		
GCL Permeability[1]	ASTM D 5887	5 x 10^{-10} cm/sec max at 5.0 psi
Tensile Strength in Machine Direction	ASTM D 6768	23 lb/in
Peel Strength	ASTM D 6496	2.1 lb/in
Geofilm Durability[4]	ASTM D 5721	80% strength
Internal Shear Strength	ASTM D 6243	150 psf typical

Notes:
1. Maximum allowable permeability per Golder.
2. For both cap and carrier fabrics for non-woven reinforced GCLs; one, or the other, must contain a scrim component of mass > 2.9 oz/sq.yd. for dimensional stability. This only applies to GM/GCL composites which are exposed to the atmosphere for several months or longer so as to mitigate panel separation.
3. If the GCL is manufactured at a higher moisture content, it shall have a minimum of 1 psf of bentonite when adjusted to a 12% moisture level.
4. Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60° C for 50 days.

G. Rolls shall be manufactured a minimum of 15.5 feet wide and 150 feet long. A minimum 6-inch lap line and a 9-inch match line shall be printed on both edges of the woven geotextile of the GCL (the upper surface as installed) to assist in overlap quality control.

H. The GCL will be warranted by the Manufacturer to be free from defects in materials and workmanship and to have a useful life of 5 years from the date of purchase under normal weathering and normal use.

3.0 EXECUTION AND DEPLOYMENT

3.1 Deployment

A. Procedure and methods shall not damage the GCL. Manufacturer's recommended deployment techniques shall be followed by the Contractor to the greatest extent possible.

B. Prior to deployment of the GCL, the subgrade shall be final graded and rolled to provide a smooth surface free of any soft areas, rocks protruding greater than 1/2 inches above the subgrade, or ruts in accordance with Section 02223. Subgrade shall also be free from any chemicals which could damage the GCL. The subgrade shall be approved by the Engineer prior to GCL deployment.

C. Panels shall be placed with the non-woven side against the subgrade and the woven polypropylene coated side oriented upwards. The GCL shall be smoothed to be free of wrinkles and creases.

D. The Contractor shall only Work on an area that can be completed in one working day. Completion shall be defined as the full installation of the liner and placement of the geomembrane liner. The GCL shall be covered immediately to protect it from any precipitation that may occur during construction.

E. Whenever possible, direct contact to the GCL will be avoided. If access requires travel over the GCL, the Contractor shall use low ground pressure (LGP) that exerts 7.0 psi or less to the contact area of GCL. Equipment tracks shall be made of rubber. Care shall be taken to avoid sharp turns and any quick stops or starts so as to avoid pinching or moving the GCL. Any damage caused by direct contact to the GCL will be repaired at the Contractor's expense.

F. The Contractor shall keep the GCL dry during installation. Installation shall not take place during high humidity, rain, or other types of precipitation. Any GCL which becomes hydrated prior to covering with drainage layer material or protective soil shall be removed and replaced at the Contractor's expense.

3.2 Seaming

A. Seams shall be flat without wrinkles and shall be overlapped a minimum of 18-inches on all sides.

B. Granular bentonite shall be placed between the upper and lower panels for a minimum width of 12-inches at a rate of the-quarter (1/4) pound per lineal foot of seam.

C. All seams shall be continuously heat-bonded together. Heat bonding techniques shall be approved by the Engineer. Care shall be taken to not place granular bentonite where it may interfere with heat-bonding of the seam.

D. Repair Procedures:

1. Rips, tears, or holes in the GCL shall be repaired by completely exposing the affected area, removing all foreign objects or soil, and then placing a patch over the defect, with a minimum overlap of 18-inches on all edges.

2. All seams shall be continuously heat-bonded to the underlying GCL panel.

3. Granular bentonite shall be placed between the patch and the repaired material at a rate of one-quarter (1/4) pound per lineal foot of edge.

    a. Defective seams, tears, and holes, shall be repaired as described above.

    b. Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches.

3.3 Quality Assurance

A. Quality Assurance shall consist of:

1. Review of required documentation.
2. Approval of GCL rolls for deployment.
3. Observation of unrolled material for damage.
4. Observation of seaming procedure and completed seams.

B. Engineer has final authority in the Quality Assurance for the project.

C. Compliance Testing:

1. At the option of the Engineer, compliance testing may be performed at any time prior to, during, or after the installation.
2. The cost of the compliance testing shall be negotiated between the Owner and Contractor.
3. The tests performed for the compliance testing shall be directed by the Engineer.
4. Compliance testing shall not include any tests that are not listed in these Specifications as a basis for evaluating compliance of the GCL to the Specifications.
5. Sampling for Compliance Testing:
    a. Samples shall be obtained by the Engineer.
    b. The sample shall be taken as close to the middle of the roll as practical but shall, at a minimum, be sampled no closer than three (3) feet from the end of a roll.
6. The sample shall be labeled by the Engineer, using a permanent marker, with the roll number, machine direction, date sampled, and name of individual that sampled the material.

D. Seams:

1. Will be observed for required overlap and seaming procedures.
2. Seams that do not have the required overlap will be marked for adjustment.

*****END OF SECTION*****

SECTION 02710
GRAVITY PIPING

1.0 GENERAL

1.1 Section Includes

A. Related Sections
B. References
C. Submittals
D. Piping
E. High Density Polyethylene Pipe and Fittings
F. Fabrication
G. Handling and Storage
H. Installation
I. Pipe Connections
J. Bedding and Backfill

1.2 Related Sections

A. Section 02205 – Fill Materials
B. Section 02222 – Excavating
C. Section 02223 – Filling
D. Section 11207 – Parshall Flumes
E. Section 03300 – Cast-in-place Concrete

1.3 References

A. AASHTO M252 - Standard Specification for Corrugated Polyethylene Drainage Pipe
B. ASTM D1693 – Standard Test Method for Environmental Stress Cracking Ethylene Plastics
C. ASTM 2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity Flow Applications
D. ASTM D3350 – Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.
E. ASTM D3261 – Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

1.4 Submittals

A. Submit the following under provisions of Section 01300:
   1. The Contractor shall provide detailed information to the Owner and Engineer for: pipe, valves, fittings, and joining manufacturer's data, including type/class, method of joining, specifications, manufacturer's name, and manufacturer’s certificate of compliance.
   2. If an equivalent product is proposed, submit samples, technical data, test data, and specifications sufficient to allow evaluation by Engineer.

2.0 PRODUCTS

2.1 Pipe

A. Tailings Storage Facility Underdrain Collection Piping
   1. 6-inch diameter perforated Underdrain Outlet Pipe (HDPE DR17)
   2. 6-inch diameter solid wall Underdrain Outlet Pipe (HDPE DR17)

3. 6-inch diameter, 20-foot long with 3-inch wide water stop Underdrain Outlet Pipe (HDPE DR17)
4. 6-inch diameter perforated CPE Underdrain Collection Pipe
5. 4-inch diameter perforated CPE Underdrain Collection Pipe

B. Waste Rock Dump Underdrain Collection Piping

1. 6-inch by 10-inch diameter dual containment Underdrain Outlet Pipe (HDPE DR17)
2. 6-inch diameter perforated Underdrain Outlet Pipe (HDPE DR17)
3. 6-inch diameter perforated CPE Underdrain Collection Pipe
4. 4-inch diameter perforated CPE Underdrain Collection Pipe

C. Reclaim Pond

1. 10-inch diameter solid wall Leak Detection Riser Pipe (HDPE DR17)

2.2 High Density Polyethylene Pipe and Fittings

A. The polyethylene pipe and fittings shall meet or surpass the physical property values. Pipe and fittings shall be made of polyethylene compounds which meet or exceed the requirements of Type III, Category 4 or 5, Grade P33 or P24, Class C per ASTM D 1248. Pipe fittings shall be manufactured from the same resin and by the same pipe Manufacturer.

B. HDPE pipe material shall be PE4710. The PE4710 material shall conform to ASTM D 3350 with the cell classification of 445574C.

C. All pipe shall comply with ASTM F 714.

D. The polyethylene compound shall contain a minimum of 2 percent carbon black to withstand outdoor exposure without loss of properties. The polyethylene compound shall have a minimum resistance of 5,000 hours when tested for environmental stress crack in accordance with requirements of ASTM D 1693.

E. Minimum parallel plate pipe stiffness values at 5% deflection shall be 50 psi per test method ASTM D 2412.

F. Pipes and fittings shall be homogenous throughout and free of visible cracks, holes (other than intentional manufactured perforations), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.

G. Fittings at the ends of pipes shall consist of polyethylene unless indicated otherwise on the Drawings. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the Engineer. HDPE fittings shall be in accordance with ASTM D 3261.

H. Segments of pipe having cuts or gouges in excess of 10% of the wall thickness of the pipe shall be cut out, removed, and replaced.

I. The standard dimension ratio (DR) for the piping shall be as shown on the Drawings.

J. Where polyethylene pipe is to be slotted, slots shall be completed at the manufacturing plant or by the Contractor prior to installation of the Work.

K. Polyethylene pipe shall be supplied in standard laying lengths not exceeding 50 feet.

L. Underdrain water stop segments shall be cast-in-place to the lines and grades shown on the Drawings for the underdrain outlet pipes at the upstream toe of the Stage 1 embankment. Underdrain Pipe water stops shall be constructed of 20-foot long pipe segments with continuous 3-inch wide by ½-inch thick rig factory-fabricated at the midpoint of the segment length.

2.3 Valves

A. Butterfly Valve:

1. 6-inch gear operated butterfly valve, Class 150 manufactured by a company whose products are approved by the Engineer. Valve bodies shall be cast iron, ductile iron, or other approved material mounted with approved non-corrosive metals. All wearing surfaces shall be bronze or other approved non-corrosive materials compatible with the sodium cyanide solution used for the Project. There shall be no moving, bearing, or contact surfaces of iron in contact with iron. Contact surfaces shall be machined and finished in the best workmanlike manner, and all wearing surfaces shall be easily renewable or replaceable.

B. The valves shall be standard pattern of the Manufacturer whose products are approved by the Engineer. The valves shall have the name or mark of the Manufacturer, year valve casting was made, size, and working pressure plainly cast in raised letters on the valve body.

2.4 Fabrication

A. Finished pipe lengths shall have beveled ends for field welding.

B. Pipe shall be fabricated in accordance with manufacturer's recommendations and ASTM F 2620.

C. Underdrain water stop segments shall be prefabricated in the manufacturing facility. Pipe segment shall be a minimum of 20 feet long and suitable for field butt fusion welding.

3.0 EXECUTION

3.1 Handling and Storage

A. Transportation of pipe, valves, and fittings shall be the responsibility of the Contractor. The Contractor shall be liable for all damage to the pipe, valves, and fittings incurred prior to and during transportation to the site.

B. Handling, storage and care of the pipe, valves, and fittings prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance by the Engineer.

C. The Contractor shall be responsible for storage of pipe, valves, and fittings at the site. Pipe, valves, and fittings shall be stored on clean level ground, which is free of sharp objects which could damage these materials. Stacking shall be limited to a height that shall not cause excessive deformation of the bottom layers of pipe under anticipated temperature conditions. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

3.2 Installation

A. There is no guarantee that existing utilities are properly located or that other utilities are not present. It shall be the Contractor's responsibility to request locates, confirm locates, expose, and protect all nearby utilities or other potential subsurface facilities that may interfere with the work.

3.3 Work Staging Area

A. Installation of piping, fittings, and valves shall be done to replace existing damaged or malfunctioning parts, as directed by the Engineer.

B. Install all piping, fittings, and valves according to manufacturer's recommendations.

3.4 Pipe Connections

A. All connections for the piping system shall be watertight under maximum anticipated pressure head.

B. The ends of all pipe shall be capped with a manufactured pipe cap unless otherwise noted on the Drawings.

C. TSF underdrain outlet pipe cast-in-place water stops shall be prefabricated.

D. HDPE pipe shall be butt-heat-fusion welded in accordance with the manufacturer's guidelines and ASTM D3261 unless otherwise noted on the Drawings.

E. Perforated to solid wall HDPE pipe connections at the upstream toe of the Stage 1 embankment within the basin shall be electrofusion couplings.

3.5 Bedding and Backfill

A. Pipe Bedding Fill shall be placed only in the locations shown on the Drawings.

A. Backfill and compact Pipe Bedding Fill in accordance with Section 02223.

B. Pipe Bedding Fill shall be hand-worked under the haunches of the pipe to uniformly bed and support the pipe.

3.6 Tolerances

A. Grade surface in a manner so that piping can be laid straight at a uniform grade, without sags or humps.

3.7 Quality Control

A. A short description of the Quality Control program shall be submitted by the Contractor with the bid to the Engineer and Owner. This description shall state the Quality Control standard to be used and as a minimum containing the following:

1. An organization chart with a brief job description of Quality Control function
2. A list of applicable procedures for implementation of the Quality Control program
3. A general description of how each Quality Control requirement is to be fulfilled during the design, procurement, manufacture, assembly and testing

B. During award phase, the Quality Control documentation shall be forwarded to the Engineer as specified in Section 01300. Pertinent Quality Control documentation including Quality Control manuals shall be approved by the Engineer prior to any production work commencing. A minimum of five working days shall be allowed for the Engineer's review.

C. Upon delivery of the pipe, the Contractor shall forward the following documentation:

1. All Vendor certificates and tests performed per these Specifications
2. All Vendor documents verifying that inspection, control, and tests performed are in accordance with these Specifications
3. Identification lists with cross references between documents and hardware/materials for traceability purposes

D. The Engineer or Owner shall have the right to carry out audits at the Contractor’s, Vendor’s, and their subcontractor’s facilities, to verify compliance with all aspects of the documentation included in the purchase order. For the purpose of evaluating and auditing, the Contractor, Vendor, and their subcontractors shall give free access to all facilities concerned and to all the Quality Control documents and records

E. Applicable records may be requested by the Engineer or Owner at any time during production, these shall be forwarded to the Engineer or Owner upon request within five working days. The Contractor or Vendor shall give a written response to the Engineer or Owner for any corrective action requests and if requested, take the necessary corrective action in a timely manner

3.8 Mechanical Properties Testing

A. All mechanical properties shall be tested and records submitted per applicable codes and Vendor standards.

3.9 Non-Destructive Examination Requirements

A. All non-destructive examinations and records shall be submitted per applicable code and Vendor standards

3.10 Hydrostatic Pressure Tests

A. All piping must be hydrostatically tested per ASME B31.11 and the pipe class sheets. Test records shall be submitted by the Contractor as part of the turnover package

B. The Contractor shall continuously monitor the hydrostatic pressure throughout the test, from the start of pressurization to the completion of depressurization. Suitable equipment shall be used to provide a continuous record of test pressure, time and the ambient temperature.

C. Hydrostatic test gauges shall be calibrated prior to the commencement of production and shall be recalibrated weekly. Certified dead weight testers shall be used for calibration. The Engineer shall witness the calibration of the gauges.

D. The hydrostatic pressure test shall show no variation in pressure which is not directly related to a change in recorded temperature. The test medium shall be clean, filtered non-saline potable water with added corrosion inhibitors. The inhibited water shall be free from sand, dirt and organic materiaI. The hydrostatic testing records and certificates shall be identified to the individual pipe section numbers.

E. No welding shall be allowed after hydrostatic testing has been completed.

3.11 Supplemental Requirements

A. The Contractor shall submit the Vendor’s schedule showing the complete plan for drawing submittal, manufacturing, testing and delivery to site. This schedule shall include hold points pertaining to the entire Work.

B. The Engineer reserves the right to enter the Contractor’s, Vendor's, or any Subcontractor's facility, at any time, with 48 hours prior written notice, for verification of Work. The Engineer shall have the right to reject any and all materials or order the rework of any and all parts and components not meeting these Specifications at no additional cost to the Owner.

C. The Contractor shall provide the Engineer with all Vendor inspection records, laboratory certificates and any other documentation deemed by the Engineer to be required for verification of materials used or work done. The Contractor shall keep Vendor’s records of chemical and physical mill certifications for all materials. These records shall be made available to the Engineer and Owner, upon request.

D. The Contractor or Vendor shall be responsible for the inspection, Quality Assurance and Quality Control of the all the Vendor’s work. The Engineer reserves the right to supplement and amend the Contractor’s or Vendor's Quality Control program if determined necessary at any time.

E. Certification of all levels of personnel is the responsibility of the Vendor. A Vendor who purchases outside services is responsible for assuring that training and examination services are in accordance with the Vendor’s written practices and these Specifications.

3.12 Repair of Defects

A. All defect repair procedures require written approval by the Engineer.

B. Defects are to be reported to Engineer as soon as they are identified.

C. HDPE pipe repairs and defects:

1. Items that contain defects shall be rejected or repaired. Such injurious defects include defects that reduce the mechanical properties, such as internal or external surface gouges, scars, scratches, blisters, or discontinuities that produce a notch effect or reduce the specified pipe wall thickness by 10% or more.

2. The Contractor shall mark all bonds that have been examined and accepted inspected per the pipe manufacturer’s recommended inspection method. All bonds requiring repair shall be marked as defective. When a repaired bond is subsequently accepted, it shall be marked over with green paint signifying its acceptance. The marking shall be done in such a manner so as to enable the Quality Assurance Team, Engineer, and Contractor to determine the status of the bonds on the pipeline.

3. All repairs made to defects shall be re-inspected using the same inspection methods recommended by the pipe manufacturer.

4. Butt-heat-fusion welds that do not meet the acceptance criteria as noted in these Specification, Manufacturer's recommendations, or any Code shall be completely removed. All butt-heat-fusion welds are subject to visual inspection.

*****END OF SECTION*****

SECTION 02775
GEOMEMBRANES

1.0 GENERAL

1.1 Summary

A. This Section describes requirements for the manufacture and installation of geomembrane liner materials for the tailings storage facility.

B. The Work includes furnishing all labor, tools, equipment, and supervision required to install the geomembrane in accordance with the Drawings and these Specifications.

1.2 Related Sections

A. Section 01300 – Submittals

B. Section 01400 – Quality Control/Assurance

C. Section 01500 – Testing Laboratory Services

D. Section 02205 – Fill Materials

E. Section 02211 – Rough Grading

F. Section 02223 – Filling

G. Section 02273 – Geonet

H. Section 02350 – Geosynthetic Clay Liner

1.3 References

A. The publications listed below form a part of this Section to the extent referenced. The publications are referred to in the text by basic designation only.

1. American Society for Testing and Materials (ASTM)

a. ASTM D 792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

b. ASTM D 882 – Standard Test Method for Tensile Properties of Thin Plastic Sheeting

c. ASTM D 1004 – Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting

d. ASTM D 1505 – Standard Test Method for Density of Plastics by the Density-Gradient Technique

e. ASTM D 1603 – Standard Test Method for Carbon Black in Olefin Plastics

f. ASTM D 1790 – Standard Test Method for Brittleness Temperature of Plastic Sheeting by Impact

g. ASTM D 3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

h. ASTM D 4218 – Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

i. ASTM D 4833 – Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

j. ASTM D 5199 – Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

k. ASTM D 5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

l. ASTM D 5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembrane Using Notched Constant Tension Load Test

m. ASTM D 5596 – Standard Test Method Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

n. ASTM D 5721 – Standard Practice for Air-Oven Aging of Polyolefin Geomembranes

o. ASTM D 5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Colorimetry

p. ASTM D 5994 – Standard Test Method for Measuring Core Thickness of Textured Geomembrane

q. ASTM D 6392 – Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

r. ASTM D 6693 – Standard Test Method Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes

s. ASTM 7003 - Standard Test Method for Strip Tensile Properties of Reinforced Geomembranes

2. Geosynthetic Research Institute (GRI):

a. GM10 – Specification for Stress Crack Resistance of Geomembrane Sheet

b. GM13 – Test Properties, Testing Frequency, and Recommended Warranty for HDPE Smooth and Textured Geomembranes

c. GM19a – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.4 Submittals Prior To Construction

A. The Geomembrane Installation Contractor shall provide the following information to the Owner prior to mobilization:

1. Manufacturer information including; company name, address, telephone number, the names of the company president and quality control manager, and narrative of the company history. Additional information required includes factory size and production capability.

2. Quality Control Manuals from the Manufacturer and Geomembrane Installation Contractor for the installation and testing of the geomembrane, including trial seams, seaming, nondestructive testing, destructive testing procedures, repair procedures and in-field quality control forms. Upon review of the Quality Control Manuals, the Owner may request additional testing during the manufacturing process at no additional cost to the Owner.

3. A list of at least five completed facilities from the Manufacturer totaling a minimum of 5,000,000 square feet of the type of geomembrane that is being installed for this project. Each entry in this list should specify the name and purpose of the facility, its location and date of installation, the name of the Owner, the project manager, designer, fabricator (if any), and Geomembrane Installation Contractor and the name and telephone number of the contact at the facility who can discuss the project. In addition, the geomembrane thickness and total square footage of the installation surface should be included.

4. A list of at least five completed facilities, totaling 5,000,000 square feet for which the Geomembrane Installation Contractor has installed the type of geomembrane that is being installed for this project. For each installation, the following information shall be provided:

a. Name and purpose of facility, its location, and date of installation

b. Name of Owner, design engineer, manufacturer, fabricator, if applicable, and name and telephone number of the contact at the facility who can discuss the project

c. Geomembrane type and surface area of the installed geomembrane

d. Type of seaming, patching, and tacking equipment

e. A copy of the Manufacturer’s and/or fabricator's approval letter(s) and/or license(s), if applicable

f. applicable

B. The Geomembrane Installation Contractor shall provide the following information 14 days prior to geomembrane arrival on-site and prior to commencement of the Work:

1. A copy of each of the Quality Control Certificates on each lot of resin issued by the resin Supplier for the specific material at this project including certification of the resin for extrusion welding.
2. The results of Quality Control testing conducted by the Manufacturer on the resin used in manufacturing the specific material for this project.
3. A listing that correlates the resin to the individual geomembrane rolls and welding rods.
4. A copy of the geomembrane roll Quality Control Certificates. These certificates shall be supplied at a minimum frequency of one per every 50,000 square feet of geomembrane material produced. These certificates shall be issued only for the individual geomembrane rolls sampled and tested by the Manufacturer or its representative. The certificates shall contain test results of properties outlined in Article 2.1 of this Section. The Engineer reserves the right to refuse use of any geomembrane supplied without the proper quality control documentation at no cost to the Owner.
5. A detailed list of performance criteria for the geomembrane material being produced for this project. (Note: Performance criteria are sometimes referred to as "minimum property values". Refer to Articles 2.1 of this Section for geomembrane properties and Test Methods).
6. Resumes from the Geomembrane Installation Contractor of the Installation Superintendent, Master Seamer, and Quality Control Inspector to be assigned to the work, including dates and duration of employment.
7. Certification from the Geomembrane Installation Contractor that Installation Supervisor, Quality Control Inspector, and Master Seamer have reviewed the Specifications, Construction Quality Assurance Plan, and the Drawings.
8. A panel layout drawing showing the proposed installation layout identifying field seams and including areas such as sumps, trenches and pipe penetrations as well as any variance or additional details that deviate from the Drawings. The layout shall be adequate for use as a construction plan and shall include dimensions, details, etc. Any proposed variance or deviation from these documents shall be submitted to the Engineer in writing a minimum of seven working days prior to the scheduled start of geomembrane installation and shall be accepted/rejected by the Engineer prior to start of installation.
9. A list of personnel performing field seaming operations along with pertinent experience information.
10. Certification that extrudate to be used is comprised of the same resin as the geomembrane to be used.

C. The Geomembrane Installation Contractor shall provide the following information daily to the Engineer during the course of the work:

1. Summaries of geomembrane panel deployment, field test seams, fusion and extrusion seams, extrusion seam repairs, nondestructive seam tests, seam pressure tests, defects and repairs, and seam destructive samples and test results recorded during installation.
2. Daily reports detailing arrival and departure times, the personnel present on-site, the progress of the Work, the arrival of materials, and any problems encountered.
3. Geomembrane record drawings identifying the panels, seams, and test locations. The Quality Control Inspector’s geomembrane record drawing shall be made available for review by the Engineer at any time during the day.
4. Subgrade surface acceptance certificates for each area to be covered by the lining system, signed by the Geomembrane Installation Contractor.
5. It is the Quality Control Inspector’s responsibility to ensure that the documentation is checked for errors and conflicts prior to submitting the documentation to the Engineer. The daily field documentation and record drawings shall be completed in a neat and professional manner.

1.5 Submittals After Construction

A. At the completion of the Work, the Geomembrane Installation Contractor shall submit the Quality Control Documentation outlined in Section 01300 and shall include at a minimum:

1. Typed summary tables of the field documentation including summaries of on-site field personnel, geomembrane panel deployment, field test seams, fusion and extrusion seams, extrusion seam repairs, nondestructive seam tests, seam pressure tests, defects and repairs, and seam destructive samples and test results recorded during installation.
2. A geomembrane record drawing showing panels and destructive test locations. The record drawing shall be drawn on a 22-inch by 34-inch sheet and in AutoCAD .dwg electronic format.
3. The summary tables and record drawings shall be suitable for report presentation and agency review. One (1) digital reproducible copy of the summary tables and record drawings shall be provided to the Engineer.

1.6 Quality Control

A. The geomembrane Manufacturer shall have the following qualifications:

1. Experience in the manufacture of the type of geomembrane that is being installed for this project totaling at least five completed facilities totaling a minimum of 5,000,000 square feet.
2. Sufficient production and qualified personnel to meet the demands of the work and shall have an internal quality control program for its product.
3. Shall permit the Quality Assurance Team, Engineer, or their authorized representatives to visit the manufacturing plant.

B. The Geomembrane Installation Contractor shall have the following qualifications:

1. The Manufacturer or an approved Geomembrane Installation Contractor trained and certified to install the Manufacturer's geomembrane.
2. Installation shall be performed under the constant direction of a single Installation Superintendent who shall remain on-site and be responsible, throughout the geomembrane installation, for geomembrane layout, seaming, patching, testing, repairs, and all other installation activities related to geomembrane installation.
3. The Installation Superintendent shall have installed or supervised, at a minimum three installation projects that entailed the installation of at least a total of 1,000,000 square feet of the type of geomembrane that is being installed for this project.
4. Actual seaming shall be performed under the direction of a Master Seamer who has seamed a minimum of 1,000,000 square feet of the type of geomembrane that is being installed for this project, using the same type of seaming equipment specified for the Work.
5. The Installation Superintendent and/or Master Seamer shall be present whenever seaming is performed.

C. All Work shall be constructed, monitored, and tested in compliance with the requirements of these Specifications. The Geomembrane Installation Contractor and Manufacturer shall participate in and comply with all items in these Specifications.

D. The Geomembrane Installation Contractor shall ensure that geomembrane material supplied to this project has an internal product quality control program that meets Specifications.

E. During manufacturing of the geomembrane, samples of geomembrane shall be removed for laboratory conformance testing to ensure compliance with these Specifications. Conformance sampling and testing shall be performed by the Quality Assurance Team in accordance with Article 3.11 of this Section.

F. The Contractor shall assure that the geomembrane is delivered to the site at least 14 calendar days prior to installation. The Contractor shall provide required Quality Control information to the Quality Assurance Team and the Engineer 14 calendar days prior to geosynthetics being delivered to this project and on delivery of geosynthetics to the project site.

G. Geomembrane rolls that do not meet the requirements of this Specification shall be rejected. The Contractor shall replace the rejected material with new material that conforms to the Specification requirements, at no additional cost to the Owner.

H. The Geomembrane Installation Contractor shall ensure that all personnel performing geomembrane seaming operations are qualified by experience or by successfully passing seaming tests in accordance with Article 3.7 of this Section. The Engineer reserves the right to reject any welding technician whose performance is unsatisfactory.

I. The Geomembrane Installation Contractor's Installation Superintendent and QC Inspector shall attend the pre-construction meeting.

J. The Geomembrane Installation Contractor shall perform Quality Control during geomembrane installation in accordance with the Quality Control Manual.

K. Field Samples

1. Geomembrane sampling and testing shall be conducted in accordance with the project Specifications for the following:
    a. Trial seam testing (Article 3.7 of this Section)
    b. Non-destructive seam testing (Article 3.8 of the Section)
    c. Destructive seam testing (Article 3.9 of this Section)
2. The Geomembrane Installation Contractor shall maintain on-site a minimum of one spare operable tensiometer and provide documentation indicating that all tensiometers used at the project were calibrated within 60 days prior to the tensiometer arriving on-site for testing field samples.

L. In order to prevent wind damaged geomembrane from being placed, the following Quality Control procedures shall be followed:

1. The Geomembrane Installation Contractor shall utilize sufficient ballast as necessary to prevent wind uplift of the geomembrane panels.
2. If wind damage should occur, the Engineer shall determine if the geomembrane shall be repaired or replaced. Wind damage to the geomembrane shall include wrinkles, creases, and tears, as determined by Engineer.
3. Repair or replacement of the wind-damaged geomembrane shall be completed by the Geomembrane Installation Contractor at no additional cost to the Owner.
4. As determined by the Engineer, the geomembrane panel may be rejected at no cost to the Owner.

M. In order to prevent thermal stress damage to installed geomembrane, the following Quality Control procedures shall be followed:

1. The Geomembrane Installation Contractor shall perform its Work and utilize sufficient slack as necessary for temperature compensation to prevent bridging or trampolining of the installed geomembrane.
2. If bridging or trampolining should occur, the Engineer shall determine if the geomembrane shall be repaired or replaced.
3. Repair or replacement of the bridging or trampolining geomembrane shall be completed by the Geomembrane Installation Contractor at no additional cost to the Owner.

1.7 Delivery, Storage, and Handling

A. Packing and Shipping

1. Labels on each roll delivered to site shall identify the following:
    a. Manufacturer’s Name
    b. Product Identification

c. Thickness

d. Roll number

e. Batch or resin lot number

f. Panel number (when applicable)

g. Roll dimensions

h. Roll weight

2. The Geomembrane Installation Contractor shall ensure that geomembrane rolls are properly loaded and secured to prevent damage during transit in accordance with the Manufacturer's recommendations.

3. The Geomembrane Installation Contractor shall protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions in accordance with Manufacturer's recommendations.

4. The Geomembrane Installation Contractor shall ensure personnel responsible for loading, transport, and unloading of geomembrane are fully aware of the consequences of damage to geomembrane and are familiar with handling and transport constraints in accordance with the Manufacturer's recommendations.

5. Geomembrane shall be supplied in rolls with straps for unloading.

B. Acceptance at Site

1. The Quality Assurance Team or Engineer shall perform inventory and surface inspection for defects and damage of all geomembrane rolls upon delivery.

2. The Geomembrane Installation Contractor shall unroll and inspect any geomembrane roll that may be damaged below the outer surface of the roll.

3. The Geomembrane Installation Contractor shall repair damage resulting from handling and transport of geomembrane at no additional cost to the Owner. If irreparable, in the opinion of the Quality Assurance Team or the Engineer, damaged materials shall be replaced at no additional cost to the Owner.

C. Storage and Protection

1. The Owner shall provide area for on-site storage of the geomembrane rolls from time of delivery until installation.

2. The storage and handling of the materials is the responsibility of the Geomembrane Installation Contractor from the time the materials are manufactured until the time the completed installation is accepted by the Engineer. The Geomembrane Installation Contractor is responsible for preparing the storage location and for the protection of the materials from the elements (e.g. ultraviolet light, moisture, temperature, etc.).

3. The rolls shall be stored on a prepared continuous surface free of large protrusions (e.g. not wooden pallets) and should not be stacked more than two rolls high. Proper blocking shall be used to prevent rolls from moving (e.g. tire chocks).

4. After the Geomembrane Installation Contractor has removed material from storage, the Geomembrane Installation Contractor shall protect geomembrane from puncture, dirt, grease, water, moisture, mud, mechanical abrasion, excessive heat and other sources of damage.

5. The Geomembrane Installation Contractor shall preserve integrity and readability of the geomembrane roll labels and store the rolls such that the Engineer has access to the package slips or roll labels for each roll to verify roll acceptance.

1.8 Site Conditions

A. Geomembrane Deployment

1. Do not proceed with deployment at an ambient temperature below 14ºF or above 100ºF unless otherwise authorized, in writing, by the Engineer.
2. Do not deploy during precipitation, in the presence of excessive moisture (e.g. fog, dew, frost, rain, snow, sleet, hail), in an area of ponded water, or in the presence of excessive winds.
3. Do not undertake deployment if weather conditions shall preclude material seaming on same day as deployment.

B. Seaming

1. Normal Weather Conditions. Normal seaming procedures may take place if the following weather conditions exist:

a. Ambient temperature between 35ºF and 100ºF

b. Dry conditions, i.e., no precipitation or other excessive moisture, such as fog, dew, rain, snow, sleet, or hail

c. No excessive winds

2. Adverse Weather Conditions

a. Do not seam if ambient temperature is below 14ºF or above 102ºF

b. Do not seam during precipitation, in the presence of excessive moisture (e.g. fog, dew, frost, rain, snow, sleet, hail), in an area of ponded water, in the presence of excessive winds

c. If the ambient air temperature is between 14ºF and 35ºF for the entire shift, the following Cold Weather Seaming provisions shall govern:

i. In accordance with these Specifications, trial seaming shall be conducted under the same ambient temperature and condition as the production seams. A minimum of four trial seams for each welding apparatus shall be required during the shift, at approximately the same time interval throughout the scheduled work day; additional trial seams may be required, at the discretion of the Quality Assurance Team or Engineer.

ii. If the subgrade is frozen, geomembrane rub-sheets will be placed between the liner and the subgrade during fusion welding of the seams.

iii. It may be necessary for the Geomembrane Installation Contractor to pre-heat the liner using a hand-held leister type device during field seaming. If this procedure is used, a trial seam for each welding apparatus shall be performed using the same technique.

iv. Destructive testing for peel adhesion shall be conducted at the beginning and end of each extrusion welded seam in excess of 25 feet. The coupon sample shall exhibit a film tear bond (FTB) type of failure and may be pulled by hand by the welding technician using vice grip pliers. The testing shall be witnessed by the Quality Assurance Team.

v. Destructive testing frequencies may be increased at the discretion of the Quality Assurance Team and/or the Engineer.

vi. Air testing/vacuum testing of the seams/patches shall be performed on the same day as the welding, to ensure any potential problems are identified as early as possible.

vii. All patches shall be completed by the end of shift.

2.0 PRODUCTS

2.1 Materials

A. The geomembrane shall be 60-mil smooth and 80-mil double sided textured high-density polyethylene (HDPE) as shown in the Drawings. The geomembranes shall be manufactured of new, first-quality resin produced in the United States and shall meet or exceed all manufacturing requirements and recommendations for HDPE geomembranes specified by the American Society for Testing and Material (ASTM) and the Geosynthetics Research Institute (GRI).

B. All geomembrane shall be manufactured by the same manufacturer using the same resin compound or mixture. Geomembrane from more than one manufacture for each phase of Work shall not be permitted unless approved by the Engineer. If geomembrane between phases is of different manufacturing origin, prior to installation, documentation shall be provided to the Engineer showing that welds between both manufacturers' geomembrane meet the minimum requirements of these Specifications for seaming.

C. The geomembrane sheet shall be comprised of a minimum 96 percent pure polyethylene. The remaining portion shall be made up of materials necessary for the performance of the liner (such as carbon black, anti-oxidants, etc.) The geomembrane rolls shall meet the following Specifications:

1. The surface of the geomembrane shall not have striations, roughness (except texture as specified), pinholes, or bubbles and shall be free of holes, blisters, undispersed raw materials, or any contamination by foreign matter. The Engineer may request additional testing in order to support such acceptance. All such testing shall be done at the sole expense of the Geomembrane Installation Contractor.

2. The geomembrane supplied for the project shall meet or exceed the minimum values and testing requirements:

Table 02775-1: Required Minimum Geomembrane Properties for Textured HDPE Geomembrane (per GRI-GM13)

Property	Test Value		Test Method	MQC Testing Frequency
	60 mil	**80 mil**		
Thickness mils (min avg.)	57 mil	76 mil	ASTM D 5994	Per Roll
Thickness (Minimum 8 of 10)	-10% (54 mil)	-10% (72mil)		
Lowest individual for any of the 10 values	-15% (51 mil)	-15% (68 mil)		
Asperity Height	16 mil	18 mil	ASTM D 7466	Every 2nd Roll(1)
Density (g/cc) min.	0.940	0.940	ASTM D 1505/ D 792	200,000 lb
Tensile Properties (min. avg.)(2)				
Yield Strength (lb/in)	126	168	D 6993 Type IV	20,000 lb
Break strength (lb/in)	90	120		
Yield Elongation (%)	12%	12%		
Break Elongation (%)	100%	710%		
Tear Resistance (lbs) (min. ave)	42	56	D 1004	45,000 lb
Puncture Resistance (lbs) (min. ave)	90	120	D 4833	45,000 lb
Stress Crack Resistance (3)	500 hr	500 hr	D 5397	Per GRI GM-10
Carbon Black Content (%)	2.0-3.0	2.0-3.0	D 4218	20,000 lb
Carbon Black Dispersion (5)	*Note 5*	*Note 5*	D 5596	45,000 lb
Oxidative Induction Time (OIT)				
a. Std OIT, or	100 min	100 min	D 3895	200,000 lb
b. High Pressure (HP) OIT	400 min	400 min	D 5885	
Oven Aging at 85°C (min. avg.)(6),(7)			D 5721	Per Each Formulation
a. Std OIT (% ret. after 90 days) min. avg. or;	55%	55%	D 3895	
b. HP OIT (% ret. after 90 days) min. avg.	80%	80%	D 5885	
UV Resistance (min avg.)(8)			D 7238	Per Each Formulation
a. Std. OIT (min. avg.), or	N.R.	N.R.	D 3895	
b. HP OIT (min. avg.) (% ret. after 1600 hrs) (9)	50%	50%	D 5885	

*MQC = Manufacturing Quality Control

Notes:

1. Alternate measurement side for double sided textured sheet.
2. Machine direction and cross machine direction average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gage length of 33 mm. Break elongation is calculated using a gage length of 50 mm.
3. The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the Manufacturers mean value via MQC testing.
4. Other methods such as D 1603 (tube furnace) or D6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
5. Carbon Black Dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3.
6. The manufacturer has the option to select either one of the OIT methods to evaluate the antioxidant content.
7. Evaluate samples at thirty (30) and sixty (60) days and compare with the ninety (90) day response.
8. The condition of the test shall be a twenty (20) hour UV cycle at 75 degrees C followed by a four (4) hour condensation cycle at 60 degrees C.
9. UV Resistance is based on percent retained values regardless of the original HP-OIT value.

D. Seam Properties: The finished seams shall meet or exceed the values specified in the following table.

Table 02775-2: HDPE Geomembrane Seam Properties Wedge and Extrusion Welds (per GRI-GM19a)

Property	Test Value for 60 mil HDPE	Test Value for 80 mil HDPE	Test Method	MQC Testing Frequency
Seam Shear Strength lb/in	120	160	ASTM D6392	500 LF
Shear elongation at break %	50	50		500 LF
Seam Peel Strength (lb/in)	91 for hot wedge 78 for extrusion	121 for hot wedge 104 for extrusion		500 LF
Peel separation %	25	25		500 LF

Notes:

1. Seam tests for peel and shear must fail in the Film Tear Bond mode. This is a failure in the ductile mode of one of the bonded sheets by tearing or breaking prior to complete separation of the bonded area. Failures in Non-FTB mode are allowed if the failure is classified as “AD-BRK” and the strength at failure exceeds the listed value.
2. Where applicable, both tracks of a double hot wedge seam shall be tested for peel adhesion.
3. Value listed for shear and peel strengths are for 4 out of 5 test specimens, the 5th specimen can be as low as 80 percent of the listed value.

E. Stainless steel clamps shall be used to fasten pipe to the polyethylene pipe boot (if any) as shown on the Drawings. The stainless steel clamps shall be approved by the Engineer prior to their installation.

2.2 Seaming and Test Equipment

A. Seaming:

1. Approved field seaming processes are hot shoe double fusion welding and extrusion welding, when approved by the Engineer. Use double fusion welding as primary method of seaming adjacent field panels.
2. The Geomembrane Installation Contractor shall maintain on-site a minimum of two spare operable seaming apparatuses.
3. Seaming equipment shall not damage the geomembrane.
4. The Geomembrane Installation Contractor may use a hot air device ("Leister") to temporarily bond geomembrane panels that are to be extrusion welded.
5. The Geomembrane Installation Contractor shall use extrusion welding apparatus equipped with gauges giving temperature of preheat and extrudate at nozzle of apparatus.

6. Welding rods or beads used for extrusion welding shall have the same physical properties as that used for the resin used in the manufacture of the type of geomembrane that is being installed for this project.
7. The Geomembrane Installation Contractor shall use fusion welding apparatus which are self-propelled devices equipped with a gauge indicating temperature of heating element, and a gauge indicating the speed of the welding apparatus.

B. Vacuum Testing (for extrusion seam only)

1. The equipment shall consist of the following:

a. Vacuum box assembly consisting of a rigid housing, transparent viewing window, soft neoprene gasket attached to bottom of housing or port hole and valve assembly, and vacuum gauge.

b. Pump assembly equipped with pressure controller and pipe connections.

c. Rubber pressure/vacuum hose with fittings and connections.

d. Bucket of soapy solution.

e. Wide paint brush, or other means of applying soapy solution.

C. Air Pressure Testing (for double fusion seam only)

a. The equipment shall consist of the following:

b. Air pump (manual or motor driven), equipped with a pressure gauge, capable of generating, sustaining, and measuring pressure between 25 and 30 pounds per square inch (psi) and mounted on a cushion to protect geomembrane.

c. Rubber hose with fittings and connections.

d. Sharp hollow needle, or other approved pressure feed device.

e. An air pressure monitoring device.

3.0 EXECUTION

3.1 Subgrade

A. The Geomembrane Installation Contractor, on a daily basis, shall certify in writing that the surface on which the geomembrane shall be installed is acceptable. It shall be the Geomembrane Installation Contractor's responsibility to maintain and protect the subgrade in the condition that was originally accepted, prior to geosynthetic deployment until accepted by the Owner and Engineer.

3.2 Acceptance

A. The Geomembrane Installation Contractor shall retain all Ownership and responsibility for the geomembrane until final acceptance.

B. The geomembrane shall be accepted by the Owner and Engineer when all of the following conditions are met:

1. Installation is finished.
2. Verification of the adequacy of all seams and repairs, including associated testing, is complete.
3. Certification, including QC documentation is provided by the Geomembrane Installation Contractor to the Engineer.
4. Recommended acceptance by the Engineer.

3.3 Anchor Trench

A. The anchor trenches shall be excavated to the lines, grade, and width shown on the Drawings, prior to geosynthetic placement. The Engineer shall verify that the anchor trench has been constructed according to the Drawings.

B. Slightly rounded corners shall be provided in the trench where the geomembrane adjoins the trench so as to avoid sharp bends in the geomembrane.

C. The anchor trench shall be backfilled and compacted in accordance with Section 02223 and as approved by the Engineer. Anchor Trench Backfill material shall be placed in 12-inch thick loose lifts and compacted by wheel rolling with light, rubber-tired or other light compaction equipment, as approved by the Engineer.

D. Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane. At no time shall construction equipment come into direct contact with the geomembrane. If damage occurs, it shall be repaired by the Geomembrane Installation Contractor prior to the completion of backfilling, at no additional cost to the Owner.

E. Extend geomembrane into the anchor trench as shown in the Drawings. The geomembrane shall be seamed along its entire length within the anchor trench.

3.4 Protection

A. The Geomembrane Installation Contractor shall be responsible for the following:

1. Do not use equipment or tools which may damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
2. Ensure prepared surface underlying geomembrane has not deteriorated since previous acceptance, and remains acceptable until acceptance by the Owner, as detailed in Article 3.2 of this Section.
3. Keep any geotextile elements immediately underlying the geomembrane clean and free of debris.
4. Personnel shall not be permitted to smoke or wear damaging shoes while working on geomembrane.
5. Unroll panels in a manner which prevents scratches or crimps in geomembrane and does not damage supporting soil.
6. Place panels in a manner that prevents wrinkles (especially differential wrinkles between adjacent panels).
7. Prevent wind uplift and damage to geomembrane subgrade by providing temporary and permanent loading and/or anchoring that shall not damage geomembrane.
8. Prevent bridging of installed geomembrane by providing adequate slack.
9. Minimize direct contact of equipment and personnel with geomembrane.
10. Protect geomembrane in areas where excessive traffic is expected with geotextile, extra geomembrane, or other materials acceptable to the Engineer.

3.5 Field Panel Development

A. The Geomembrane Installation Contractor shall install field panels at locations indicated on the Geomembrane Installation Contractor's layout plan, as approved by the Engineer.

B. The Geomembrane Installation Contractor shall replace damaged (i.e., torn, twisted, or crimped) field panels, or portions thereof, at no cost to the Owner. The Geomembrane Installation Contractor shall repair less serious damage according to Article 3.10 of this Section, at no cost to the Owner. The Engineer shall determine if material is to be repaired or replaced.

C. The Geomembrane Installation Contractor shall remove damaged panels, portions of damaged panels, and other geomembrane scrap.

D. Geomembrane Installation Contractor shall not deploy more geomembrane field panels in one day than can be seamed during the day of deployment.

E. Geomembrane deployment shall proceed between ambient temperatures of 14º F to 102º F. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, rain, dew) or in the presence of excessive winds, as determined by the Engineer.

F. Following the installation of the geomembrane, an examination of the entire surface shall be conducted to detect potentially harmful objects. Any such objects shall be removed and the geomembrane repaired by the Geomembrane Installation Contractor, at no cost to the Owner.

3.6 Factory Seams

A. The Engineer may require the Geomembrane Installation Contractor to test up to as much as 20 percent of factory fusion welds (non-destructive air pressure test) in the field to verify factory test results. Additional testing at Geomembrane Installation Contractor's expense shall be required if failed tests are obtained in the field.

3.7 Field Seams

A. Seam Layout

1. Seams shall be oriented parallel to the line of maximum slope, i.e., oriented down, not across the slope. In corners and odd-shaped geometric locations, the number of field seams shall be minimized.

2. No horizontal or base T-seam or tie-in seams shall be closer than 5 feet from the toe or crest of the slope. Seams shall be aligned to prevent wrinkles and "fish mouths". If a fish mouth or wrinkle is found, it shall be relieved and capped.

3. The previous phase geomembrane shall be cut adjacent to the existing anchor trench and double fusion welded to the new geomembrane in accordance with the Design Drawings.

4. Panels of geomembrane shall have sufficient overlap provided to allow peel tests to be performed on the seam.

B. Seaming Method

1. The procedure used to temporarily bond adjacent panels together shall not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus shall be controlled such that the geomembrane is not damaged.

2. The Geomembrane Installation Contractor shall use double fusion welding as primary method of seaming adjacent field panels.

a. For cross seam tees associated with fusion welding, the Geomembrane Installation Contractor shall patch panel intersections consisting of three or more panels and extrusion weld to a minimum distance of 4 inches on each side of patch. The edge of the sheet shall be ground to a 45º angle prior to welding.

b. Place a protective layer, e.g., insulting plate or fabric, beneath hot welding apparatus after usage.

c. When subgrade conditions dictate, use a moveable protective layer directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between sheets and prevent debris from collecting around pressure rollers.

d. Remove seaming sheets and excess geomembrane trimmed to provide required overlap.

3. Use conventional extrusion welding as a secondary method for seaming between adjacent panels and as a primary method of welding for detail and repair work.

a. Purge heat-degraded extrudate from barrel of extruder under the following conditions:

i. Prior to beginning a seam.

ii. Whenever extruder has been inactive.

b. Place a smooth insulating plate or fabric beneath hot welding apparatus after usage

i. Use clean and dry welding rods or extrudate pellets.

ii. Complete grinding process without damaging geomembrane according to Manufacturer's instructions no more than one hour prior to seaming operations.

iii. Prevent exposed grinding marks adjacent to an extrusion weld. Do not extend exposed grinding marks more than 1/4 inch from seam area. The Engineer may request that any and all abraded areas be covered with extrudate.

iv. Extrusion weld all cross seam tees to a minimum distance of 4 inches on each side of the tee.

v. For extrusion welds, the edge of the top sheet shall be beveled by grinding the edge of the sheet to approximately a 45 degree angle. Extrusion welds cannot be placed on previous extrusion welds.

C. Seaming Procedures

1. General Seaming Procedures

a. Areas to be seamed shall be cleaned and free of moisture, debris, or any marking on the geomembrane.

b. Use a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support if required.

c. Cut fish mouths or wrinkles at the seam overlap along the ridge of the wrinkle in order to achieve a flat overlap. The cut fish mouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 6 inches beyond the cut in all directions.

d. Extend seaming to the outside edge of panels placed in the anchor trench.

e. Do not field seam without the Seaming Supervisor present.

D. Field Trial Seams

1. Trial seams shall be conducted at the beginning of each seaming period and within 30 minutes of commencement of seaming, at the Engineer's discretion, and immediately following any work stoppage (i.e., lunch, weather conditions, etc.) of 30 minutes or more for each seaming apparatus used that day. Each Seamer shall make at least one trial seam each day.

2. Testing shall include visual observation of a trial seam on the geomembrane material. The Geomembrane Installation Contractor shall mark the trial seam with date, ambient air temperature, welding machine number, welding technician identification, and machine temperature and speed. For extrusion welding, the Geomembrane Installation Contractor shall include the nozzle and extrusion settings and welding technician identification. The remainder of trial seam should be cut in two pieces; one to be retained in the Owner's archive; and one to be retained by the Geomembrane Installation Contractor.

3. All trial seams shall be made at a location selected by the Engineer in the area of the seaming and in contact with the subgrade. The trial seam samples shall be a minimum of 5 feet long for fusion seaming and a minimum of 5 feet long for extrusion seaming, with the seam centered lengthwise. Specimens one inch wide shall be cut from opposite ends of the test seam by the Geomembrane Installation Contractor. The Geomembrane Installation Contractor shall use a tensiometer to test these specimens for shear and peel. Both inside and outside tracks of fusion welds shall be tested for peel. For both fusion and extrusion welds, two coupons shall be tested for peel and one coupon for shear. The tensiometer shall have a grip separation of 4 inches plus the width of the seam. The seam is to be centered between the clamps. These tests shall not fail according to the criteria in Article 2.1 of this Section. A break through the weld or at the weld/sheet interface shall be considered a failure in both shear and peel strength tests unless the weld strength exceeds the minimum strength, as discussed in Article 3.9 of this Section. If a trial seam fails to meet field seam

Specifications, the seaming apparatus and/or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

4. The Geomembrane Installation Contractor shall mark the test weld with date, ambient temperature, welding machine number, welding technician identification, machine temperature and speed. For extrusion welding, the Geomembrane Installation Contractor shall record the nozzle and extrusion settings.
5. The Geomembrane Installation Contractor shall cut remainder of successful trial seams into two pieces, one to be retained in the Owner's archives and one to be retained by Geomembrane Installation Contractor

3.8 Non-Destructive Testing

A. The Geomembrane Installation Contractor shall non-destructively test all field seams over their full length. All test equipment shall be furnished by the Geomembrane Installation Contractor.

B. The following vacuum box procedures are applicable to extrusion seaming and shall be followed by the Geomembrane Installation Contractor:

1. Clean the vacuum box window, gasket surfaces and check for leaks.
2. Energize the vacuum pump and reduce the tank pressure to approximately 5 psi.
3. Wet a strip of geomembrane the approximate dimensions of the vacuum box with the soapy solution.
4. Place the box over the wetted area and compress.
5. Close the bleed valve and open the vacuum valve.
6. Ensure that a leak-tight seal is created.
7. For a period of not less than 10 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.
8. If no bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches overlap and repeat the process.
9. All areas where soap bubbles appear shall be marked and repaired and then retested.
10. Test locations, documentation number, date and tester shall be indicated with an indelible marker on the geomembrane for each repair or seam section. The color code for indelible markers is to be determined at the pre-construction meetings, and strictly adhered to.

C. The following nondestructive test procedures are applicable to fusion seaming and shall be followed by the Geomembrane Installation Contractor:

1. Seal one end of the seam to be tested.
2. Insert needle or other approved pressure feed device through the sealed end of the channel created by the double wedge fusion weld.
3. Energize the air pump to verify the unobstructed passage of air through the channel.
4. Seal the other end of the channel.
5. Energize the air pump to the pressure of approximately 30 psi, close valve, and sustain pressure for approximately 5 minutes.
6. If loss of pressure exceeds 3 psi, or pressure does not stabilize, locate faulty area, repair and retest.
7. Remove needle or other approved pressure feed device.
8. Repair pressure test locations as described in Article 3.10 of this Section.

9. Beginning and ending pressures and times, test locations, documentation number, date and tester shall be indicated with an indelible marker on the liner at each test interval location.

D. The following procedures shall apply to locations where seams cannot be non-destructively tested, as determined by the Engineer:

1. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.

2. If the seam cannot be tested prior to final installation, the seaming operations shall be observed by the Engineer for uniformity and completeness.

E. In the event that seam continuity cannot be demonstrated for a non-destructive test of a fusion seam as outlined above, the Geomembrane Installation Contractor shall perform the non-destructive testing over smaller areas as a means of defining the questionable area, and shall:

1. Extrusion weld the outside edge of the questionable seam area and vacuum box test the extrusion weld, or

2. Cap the questionable area and vacuum test the cap.

3.9 Destructive Testing

A. The Geomembrane Installation Contractor shall test a minimum of one destructive test sample per 500 feet of seam length per welding machine from a location specified by the Engineer. The Geomembrane Installation Contractor shall not be informed in advance of the sample location. The samples shall be taken centered over the seam and prioritized as follows:

1. All areas identified as suspect during seaming, non-destructive testing/monitoring, and in unusual working conditions.

2. A minimum of one sample for each geomembrane seamer.

3. A minimum of one sample every 500 feet of seaming.

B. Samples shall be cut by the Geomembrane Installation Contractor as the seaming progresses. Sampling locations shall be determined by the Engineer. The Engineer must witness the obtainment of all destructive test samples by the Geomembrane Installation Contractor. All samples shall be marked with their seam number, date, welding machine number, welding technician identification, extruder and nozzle/wedge temperature, and ambient air temperature. The Geomembrane Installation Contractor shall document the date, time, roll and seam number, ambient temperature, and pass or fail description. All holes in the geomembrane resulting from obtaining the seam samples shall be immediately repaired. All patches shall be vacuum tested.

C. The samples shall be a minimum 12 inches wide by 24 inches long with the seam centered lengthwise. The sample shall be cut into two equal length pieces, half to be given to the Owner for archiving and the other kept by the Geomembrane Installation Contractor for testing.

D. Geomembrane Installation Contractor shall cut and test ten (10) one-inch (1”) wide specimens from his sample. All testing shall be conducted at room temperature (60ºF to 80ºF). The Geomembrane Installation Contractor shall test five (5) specimens for seam shear strength and five (5) for peel strength. Both inside and outside tracks of fusion seams shall be tested for peel strength. To be acceptable, four (4) out of the five (5) specimens must pass according to criteria established in Article 2.1 of this Section. Any specimen that fails through the weld or at the weld/sheet interface shall be considered a failure, unless the weld strength exceeds the minimum strength specified in Table 02775-2, as discussed Article 2.1. The tensiometer shall have a grip separation of 4 inches plus the width of the seam. The seam is to be centered between the clamps.

E. The Engineer must witness the testing of all destructive samples. Destructive tests shall be performed within two (2) days of the samples being obtained.

F. Failing tests shall be subjected to additional testing until a passing area is found. A passing area is defined as a seam(s) bounded at each end by a passing destructive test. Seams shall be tracked in each direction until a passing destructive test is found or until a previous passing destructive test is

reached. Seams shall be tracked according to the welding apparatus and the machine operator. The following procedures shall apply whenever a sample fails the field destructive test:

1. The Geomembrane Installation Contractor can retrace the welding path to an intermediate location (at a minimum of 10 feet from the location of the failed test), at the Engineer's discretion, and take a small sample for an additional field test. If this test passes, then the seam shall be cap stripped between that location and the original failed location. If the test fails, the process shall be repeated.
2. Over the length of seam failure, the Geomembrane Installation Contractor shall either cut out the old seam, reposition the panel and reseam, or add a cap strip, as required by the Engineer.
3. After reseaming or placement of the cap strip, additional destructive field test(s) shall be taken within the reseamed area. The reseamed sample shall be found acceptable if test results are approved by the Engineer. If test results are not acceptable, this process shall be repeated until the reseamed length is judged satisfactory by Engineer.
4. Samples taken as the result of failed tests do not count toward the total number of destructive tests required.

G. The Geomembrane Installation Contractor shall document all actions taken in conjunction with destructive test failures, with the Engineer providing Quality Assurance documentation.

H. Cap strips shall be non-destructively tested as described in Article 3.8 of this Section.

3.10 Defects and Repairs

A. All seams and non-seam areas of the geomembrane shall be observed by the Engineer for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of observation. The geomembrane surface shall be brushed, blown, or washed by the Geomembrane Installation Contractor if the amount of dust or mud inhibits inspection. The Engineer shall determine if cleaning of the geomembrane is needed to facilitate observation.

B. Each suspect location in seam and non-seam areas shall be non-destructively tested as determined appropriate by the Engineer, in the presence of the Engineer. Each location that fails the non-destructive testing shall be marked by the Geomembrane Installation Contractor, and repaired accordingly.

C. Repair Procedures

1. Defective seams shall be reconstructed as described in these Specifications.
2. Small holes shall be repaired by abrading the sheet surface and welding an extrusion bead. If the hole is larger than ¼-inch in diameter it shall be patched.
3. Tears shall be repaired by patching. Where the tear is on a slope or an area of stress and has a sharp end it must be rounded prior to patching.
4. Blisters, large holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches.
5. Surface of geomembrane that are to be patched shall be abraded and cleaned no more than 15 minutes prior to the repair. No more than 10 percent of the thickness shall be removed.

D. Patches shall be round or oval in shape, and extend a minimum of 6 inches beyond the edge of defects. All patches shall be of the same compound and thickness as the geomembrane specified. All patches shall have their top edge beveled to an approximately 45º angle with an angle grinder prior to placement of the patch. Patches shall be applied using approved methods only.

E. The extrusion welding process shall restart by grinding the existing seam and rewelding a new seam. Welding shall commence where the grinding started and must overlap the previous seam by at least 2 inches. Reseaming over an existing seam without regrinding shall not be permitted.

F. Each repair shall be non-destructively tested, except when the Engineer requires a destructive seam sample obtained from a repaired seam. Repairs that pass the destructive test shall be taken as an

indication of an adequate repair. Failed tests indicate that the repair shall be repeated and retested until passing test results are achieved.

G. Recording the Results: Daily documentation of all non-destructive and destructive testing shall be provided to the Engineer. This documentation shall identify all seams that initially failed the test and include evidence that these seams were repaired and successfully retested.

3.11 Conformance Testing

A. During manufacturing of the geomembrane, the Engineer shall be present to observe manufacturing of geomembrane and shall ensure that samples are obtained and forwarded to the Geomembrane Quality Assurance Testing Laboratory for testing to ensure conformance with the Specifications.

B. Samples shall be taken across the entire width of the roll and shall not include the first 3 feet. Unless otherwise stated, samples shall be 3 feet long by the width of the roll. The Engineer shall mark the machine direction on the samples with an arrow. Unless otherwise stated, samples shall be taken at a frequency of no less than one per 2,000,000 square feet or one per lot, whichever is less. As a minimum, the following tests shall be performed to verify conformance to the design Specifications with minimum values specified in Article 2.1 of this Section:

Table 02775-3: Minimum Conformance Testing

PROPERTY	TEST METHOD	FREQUENCY
Thickness (mils)	ASTM D 5199	2,000,000 sq. ft or Minimum 1 test per resin lot, whichever is greater (each test)
Compound Density (g/cc)	ASTM D 1505	
Tensile Strength (Both yield and ultimate strength and elongation, as specified)	ASTM D 6693	
Carbon Black Content (%)	ASTM D 1603	

C. Manufacturer shall provide current certification for Oxidation Induction Time (OIT) for each formulation and shall meet the minimum test values presented in Article 2.1 of this Section.

3.12 Placement of Soil or Granular Materials

A. All soil materials located on top of a geomembrane shall be placed in such a manner as to ensure:

1. The geomembrane and any underlying geotextile is not damaged.
2. Minimal slippage of the geomembrane on underlying layers occurs.
3. Minimal movement and wrinkling or folding of the underlying geosynthetics layer(s) occurs.

No excess tensile stresses shall occur in the geomembrane, such as by earth moving equipment making sudden starts, stops, turns. The allowable ground pressure for equipment shall be prescribed by the Engineer for the material type and layer thickness.

3.13 Warranty

A. Without limiting the provisions of the Contract, the Geomembrane Installation Contractor shall warrant the Work to the Owner in accordance with the following:

B. The geomembrane supplied is suitable for the environmental conditions at the site and the service conditions as described in this Specification.

C. The geomembrane supplied meets or exceeds all published Specifications as referenced by the Specification.

D. The geomembrane is free of defects in materials and workmanship.

E. The Geomembrane Installation Contractor shall repair or replace all defects in the material detected on-site, including uncovering and recovering the work, in compliance with the Specifications.

F. The Geomembrane Installation Contractor shall repair any detected leaks in any seams (Manufactured or field joined), including uncovering and recovering the work, in compliance with the Specifications.

G. All workmanship furnished by the Geomembrane Installation Contractor under this Specification shall be guaranteed by the Geomembrane Installation Contractor against failure due to improper installation for a period of not less than two (2) years. All permanent materials furnished by the Geomembrane Installation Contractor under this Specification shall be guaranteed by the Geomembrane Installation Contractor and the geomembrane manufacturer for a period of not less than twenty (20) years.

H. Upon written notice that the material fails to meet the original intent of the design, or of failure of guaranteed materials or workmanship during the guarantee period, the Geomembrane Installation Contractor shall promptly furnish and install new materials and/or furnish the workmanship necessary to correct the failure at the expense of the Geomembrane Installation Contractor. The Geomembrane Installation Contractor shall bear all costs for labor and materials associated with repair of guaranteed work.

*****END OF SECTION*****

SECTION 03110
CONCRETE FORMWORK

1.0 GENERAL

1.1 Section Includes

A. Related Sections

B. Products

C. Execution

1.2 Related Sections

A. Section 03300 – Cast-in-place Concrete

1.3 Products

1.3.1 Materials

A. Forms shall be 5-ply, ¾-inch, waterproof, exterior type plywood, free of loose knots, splinters, or other defects. The face adjacent to concrete shall be Grade B or better. Forms may be fiberboard, Fed. Spec. LLL-B-810, Type II, tempered, waterproof, screenback, concrete form hardboard.

B. Form ties shall be of the removable end, permanently embedded body type. Cones shall be provided on the outer ends of each tie and the permanently embedded portion shall be at least one inch back from the concrete face. Form ties for water bearing walls, shall be provided with water seal washers located on the permanently embedded portions of the tie at the approximate center of the wall. The cone ends of the form ties shall have a diameter of 1 inch and shall be constructed so that they are easily removed or broken off without damage to the concrete. Form ties may be Burke BA Penta-Tie with a water seal washer, or an equivalent approved by the Engineer.

C. Form release or coating shall be nontoxic after 30 days and non-staining, such as Nox-Crete "Form Coating" or Protex "Pro-Cote", or Richmond "Rich-Cote".

2.0 EXECUTION

2.1 Installation

A. The Contractor shall be responsible for the location and placement of all sleeves, pipe fittings, anchors, ties, and inserts, and shall make certain that offsets, recesses, openings, and block-outs are in place in the forms before concrete is placed.

B. Form release agents shall be applied at no more than the manufacturer's recommended application rates.

C. Where forms are placed above geomembrane liner, no anchoring of the forms will be allowed that damage the geomembrane liner. Use of sandbags, earth forms, or other form of anchoring/bracing maybe employed and approved by the Engineer prior to construction of formwork.

D. Horizontal joints shall be level and continuous. Vertical joints shall be plumb.

E. Forms shall be sufficiently tight and rigid to prevent leakage of concrete.

F. Forms shall be properly tied, braced, shored, and supported to insure stability against pressure from any source and without deflection or failure of any component or part.

G. Forms shall be removed without damage to the concrete, chamfers, inserts, anchors, geomembrane liners, and piping.

H. Forms shall not be removed until concrete has sufficiently hardened. Unless otherwise approved by the Engineer, forms shall not be removed within five (5) days of placement.

*****END OF SECTION*****

SECTION 03220
REINFORCING STEEL

1.0 GENERAL

1.1 Section Includes

A. Related Sections
B. References
C. Submittals
D. Quality Control
E. Delivery, Storage, and Handling
F. Products
G. Execution

1.2 Related Sections

A. Section 03110 – Concrete Formwork
B. Section 03300 – Cast-in-place Concrete

1.3 References

A. ACI 301 - Specifications for Structural Concrete
B. ACI 315 - Details and Detailing of Concrete Reinforcement
C. ACI 318 – Building Code Requirements for Structural Concrete
D. ASTM A 82/A82M- Steel Wire, Plain, for Concrete Reinforcement
E. ASTM A 184/A 184M - Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
F. ASTM A 416/A 416M - Steel Strand, Uncoated Seven-Wire for Pre-stressed Concrete
G. ASTM A 496/A 496M - Steel Wire, Deformed, for Concrete Reinforcement
H. ASTM A 497/A 497M - Steel Welded Wire Reinforcement, Deformed, for Concrete
I. ASTM A 615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
J. ASTM A 704/A 704M-06 (R2011) - Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
K. ASTM A 775/A 775M-07B - Epoxy-Coated Reinforcing Steel Bars
L. ASTM A 1064/A 1064M-14 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
M. AWS D1.4 - Structural Welding Code - Reinforcing Steel
N. IBC 2018 - International Building Code 2018

1.4 Submittals

A. Detail reinforcement in accordance with ACI 301, ACI 315 and ACI 318.
B. Provide complete bar lists together with location and setting drawings with sufficient plans, elevations, sections and details to clearly show the positioning and number of bars. Identify bar lists with drawings. Identify by mark number of each bar. Show relationship of reinforcement with construction joints, control joints, expansion joints and embedded parts.
C. Ensure that embedded parts not shown on the Drawings, but required for the Work, are shown on the reinforcing setting drawings when submitted to the Owner or His Representative for review.

D. Do not prepare work until the bar lists and drawings covering that work have been reviewed and approved by the Owner or his Representative. Submit bar list well in advance of required fabrication to avoid construction delay.

E. Improperly prepared bar lists and drawings are subject to rejection on that basis alone without further review. Redraw and resubmit.

1.5 Quality Control

A. Personnel Qualifications

1. Contractor shall employ personnel skilled and experienced in the fabrication and installation of reinforcement.

B. Tolerances

1. Fabricate and install concrete reinforcement in accordance with ACI 301 except as required by the Drawings.

1.6 Delivery, Storage, and Handling

A. In addition to the requirements of ACI 301:

1. Store and handle reinforcing steel so as not to alter the shape and dimensions.
2. Prevent contamination of the reinforcing steel.
3. Do not dump materials when unloading or handling.

2.0 PRODUCTS

2.1 Materials

A. Reinforcing steel and rock dowels

1. In accordance with ASTM A615 GRADE 60.

B. Welded wire fabric:

1. In accordance with ASTM A1064.

C. Headed Studs:

1. Headed studs shall be mild streel studs from Nelson Stud Welding conforming to the requirement of ASTM A108.

D. Support of reinforcement

1. Supports, spacers and chairs:
   a. Precast concrete blocks, for bottom bars in ground supported slabs and foundations only.
   b. Plastic of approved design and manufacture.
   c. Steel of approved design and manufacture with rust-proof finish where any part extends to the surface of the concrete.

2.2 Fabrication

A. Reinforcing steel

1. Fabricate reinforcing steel in accordance with ACI 301 to the dimensions shown on the bar lists and shop drawings.
2. Do not bend or straighten reinforcing bars in a manner, which might damage the bars or reduce the cross-section. Do not use bars with kinks or sharp bends.
3. Identify each bar, with the same code used for it in the bar lists and shop drawings.
4. Verify foundation elevations at the Site before cutting and bending reinforcing steel.

3.0 EXECUTION

3.1 Examination

A. Prior to commencing installation, thoroughly examine other work upon which the Work of this Section is dependent. Report any deficiencies discovered and propose adjustments to the Owner or His Representative and obtain written authorization before proceeding.

B. Check that forms are in satisfactory condition for the Work of this Section to proceed.

3.2 Installation

A. Install reinforcement in accordance with ACI 301, ACI 315, ACI 318 and the following:

B. Secure crossing bars at every intersection (unless otherwise noted on the Drawing) by using black tie-wire of not less than No. 16 gage.

C. Ensure concrete cover, placing and maintaining position of reinforcement is in accordance with ACI 301, ACI 315, ACI 318 and as shown on the Drawings.

D. Install tension and compression splices for reinforcing steel in accordance with ACI 318 and as shown on the Drawings.

E. At running joints, place starter bars or dowels equivalent in size and spacing to the continuing reinforcing of the member.

F. At wall corners, provide embedment and splice all horizontal bars according to code requirements.

G. Welding of Reinforcing Steel:

1. Obtain approval of the Owner or His Representative before welding or tack welding reinforcement. Rebar may only be welded along the longitudinal axis only with the approval of the Owner or His Representative.
2. Perform welding in accordance with AWS D1.4.
3. Weld structural reinforcement in accordance with the requirements of ACI 301.
4. Do not weld reinforcing steel closer than 2 inches from the beginning of a bend and within a bend.

H. Openings in Concrete

1. Provide additional reinforcing bars around opening as shown on the Drawings.
2. Where opening of 18 inches diameter or square and larger occur and interrupt more than two reinforcing bars, add reinforcing bars equivalent to the interrupted reinforcing bars at each side of the opening.

*****END OF SECTION*****

SECTION 03300
CAST-IN-PLACE CONCRETE

1.0 GENERAL

1.1 Section Includes

A. Submittals
B. Materials
C. Mixes
D. Curing Compounds
E. Installation
F. Quality Control

1.2 Relation Sections

A. Section 01010 – Summary of Work
B. Section 01300 – Submittals
C. Section 02710 – Gravity Piping
D. Section 11207 – Parshall Flumes

1.3 References

A. American Concrete Institute (ACI)

1. ACI 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete
2. ACI 305R - Hot Weather Concreting
3. ACI 306R - Cold Weather Concreting
4. ACI 318 - Building Code Requirements for Structural Concrete

B. American Society of Testing and Materials (ASTM)

1. ASTM C 33 – Standard Specification for Concrete Aggregates
2. ASTM C 39 – Standard Specification for Compressive Strength of Cylindrical Concrete Specimens
3. ASTM C 94 – Standard Specification for Ready-Mix Concrete
4. ASTM C 143 – Standard Test Method for Slump of Hydraulic-Cement Concrete
5. ASTM C 150 – Standard Specification for Portland Cement
6. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete
8. ASTM C 309 – Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
9. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete
10. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for use in Concrete

C. International Building Code

1. IBC 2018 – International Building Code 2018

1.4 Submittals

A. Submit mix designs to the Engineer under provisions of Section 01300 and this section.

B. Product Data: Mix design for each tentative mix for Lean Mix Concrete:

1. Slump on which design is based
2. Total gallons of water per cubic yard
3. Brand, type, composition, and quantity of cement
4. Specific gravity and gradation of each aggregate
5. Ration of fine to total aggregates
6. Weight (surface dry) of each aggregate per cubic yard
7. Brand, type, ASTM designation, active chemical ingredients, and quantity of each admixture
8. Air content
9. Compressive strength based on 7 day and 28-day compression tests
10. Time of initial set

2.0 PRODUCTS

2.1 Materials

A. Portland cement, ASTM C 150, Type II.

B. Coarse aggregate, ASTM C 33, except that clay and shale particles shall not exceed on percent.

C. Fine aggregate, ASTM C 33, washed natural sand.

2.2 Mixes

A. Mix Designs

1. Concrete mix design shall be designed by an independent testing laboratory.

B. Cast-in-Place Concrete, reinforced

1. Cast-in-Place Concrete shall have a minimum 28-day compressive strength of 4,000 psi.
2. Maximum aggregate size of ¾-inch.
3. Placement slump of 4 inches, with tolerances of plus 1-inch or minus 1-inch.
4. Design mix shall assure 4 to 6 percent air entrainment.

C. Lean Mix Concrete, unreinforced

1. Lean Concrete shall have a minimum 28-day compressive strength of 2,000 psi.
2. Maximum aggregate size of 1-½ inches.
3. Placement slump of 4 inches, with tolerances of plus 1-inch or minus 1-inch.

2.3 Curing Compounds

A. Concrete curing compounds shall be a clear compound conforming to ASTM C 309, Type 1-D, Class A and B, such as “RES-X” by Burke, or an equivalent approved by the Engineer.

3.0 EXECUTION

3.1 Installation

A. Ready-mix concrete shall be batched, transported, and placed in accordance with ASTM C94. Each batch delivered to the site shall be accompanied by a certified weightmaster's delivery ticket.

B. All mixed concrete delivered to the site shall be placed within 90 minutes from the time of introduction of cement and water into the mix.

C. No water shall be added after leaving the batch plant without the approval of the Engineer.

D. Placement of concrete, once started, shall be performed as a continuous operation until the scheduled pour is completed.

E. Concrete placed under water will be placed using tremie methods. Concrete will not be allowed to free fall through water.

F. Concrete shall not be placed during freezing weather conditions.

3.2 Schedules

A. The Contractor shall notify the Engineer at least 48-hours before each concrete placement.

3.3 Quality Control

A. Concrete testing will be performed by the Quality Assurance Team. Such testing shall not relieve the Contractor from providing quality control to make sure concrete is in compliance with specification.

B. Four standard 6-inch diameter by 12-inches long test cylinders shall be prepared for every 50 cubic yards of concrete poured or for each pour, whichever is greater.

C. Standard compression tests shall be performed to determine the compressive strength: one at 7 days, one at 14 days, and one at 28 days. The fourth cylinder shall be kept in reserve for additional testing, if necessary.

D. Slump and air entrainment testing shall be performed at the time the cylinders are prepared.

*****END OF SECTION*****

SECTION 11207
PARSHALL FLUMES

1.0 GENERAL

1.1 Section Includes

A. References
B. Submittals
C. Parshall Flumes
D. Fabrication
E. Handling and Storage
F. Installation
G. Pipe Connections
H. Cast-in-place Concrete

1.2 Related Sections

A. Section 02205 – Fill Materials
B. Section 02222 – Excavating
C. Section 02223 – Filling
D. Section 03110 – Concrete Formwork
E. Section 03220 – Reinforcing Steel
F. Section 03300 – Cast-in-place Concrete

1.3 References

A. ASTM D 638 – Standard Test Method for Tensile Properties of Plastics.
B. ASTM D 790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulation Materials.
C. ASTM D 1941-91(2001) – Standard Test Method for Open Channel Flow Measurement of Water with Parshall Flume
D. ASTM D 2583 – Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol impressor.
E. ISO 982-92 – Measurement of Liquid Flow in Open Channel – Parshall and SANIIRI Flumes.
F. United States Department of the Interior, Bureau of Reclamation, Water Measurement Manual.

1.4 Submittals

A. Submit the following under provisions of Section 01300.
B. The Contractor shall provide detailed information to the Owner and Engineer for: flume, fittings, measurement attachments, and joining manufacturer's data, including type/class, method of joining, specifications, manufacturer's name, and manufacturer’s certificate of compliance.
C. Shop Drawings:
    1. Critical dimensions, jointing and connections, fasteners, and anchors.
    2. Materials of construction.
    3. Sizes, spacing, location of structural members, connections, attachments, openings, and fasteners.
D. Contractor to follow Manufacturer’s recommended installation instructions. Deviations from Manufacturer’s installation instructions shall be approved by the Engineer.

E. If an equivalent product is proposed, submit samples, technical data, test data, and specifications sufficient to allow evaluation by Engineer.

2.0 PRODUCTS

2.1 Parshall Flumes

A. Flumes shall be manufactured by TRACOM, Inc. of Alpharetta, Georgia, USA, or an equivalent approved by the Engineer.

B. Flumes shall be 2-inch Parshall type and shall be of one-piece construction

C. Materials:

1. Fiberglass reinforced plastic.
2. Gloss inside surfaces, free of irregularities.
3. Minimum 3/16-inch wall thickness.
4. Minimum 30% glass, by weight.
5. Isophthalic polyester resin.
6. Removable pultruded fiberglass bracing at top of flume with T-304 stainless steel hardware.
7. 2-inch (minimum) top and end stiffening flanges.
8. Molded-in stiffening ribs, maximum 12-inch center-to-center spacing.
9. 15 mil Isophthalic UV resistant gel coat on all surfaces, white interior, grey exterior.
10. Anchor clips, pre-drilled with ¾-inch hole, pultruded fiberglass construction
11. Tensile strength (ASTM D 638) – 14,000 psi.
12. Flexural strength (ASTM D 790) – 27,000 psi.
13. Flexural modulus (ASTM D 790) – 1.0 million psi.
14. Barcol hardness (ASTM D 2583) – 50.

2.2 Flume Attachments

A. Ultrasonic Mounting Bracket:

1. Fixed Position stainless steel.
2. Horizontally and vertically adjustable stainless steel.
3. 2-inch diameter NPT coupling for third-party mounting bracket, if required.

2.3 End Connections

A. Inlet and outlet end adaptors

1. 6-inch inlet and outlet pipe stubs shall be fitted with a bolt pattern to allow bolting to a 6-inch IPS flange adaptor and ANSI 150 lb. flat-faced flange.

3.0 EXECUTION

3.1 Handling and Storage

A. Transportation of Parshall Flumes and fittings shall be the responsibility of the Contractor. The Contractor shall be liable for all damage incurred prior to and during transportation to the site.

B. Handling, storage and care of the pipe, valves, and fittings prior to and following installation at the site, is the responsibility of the Contractor. The Contractor shall be liable for all damage to the material incurred prior to final acceptance by the Engineer.

C. The Contractor shall be responsible for storage of Parshall Flumes and fittings at the site. Pipe, valves, and fittings shall be stored on clean level ground, which is free of sharp objects which could damage these materials. Stacking shall be limited to a height that shall not cause excessive deformation of the bottom flumes under anticipated temperature conditions. Where necessary, due to ground conditions, the pipe shall be stored on wooden sleepers, spaced suitable and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

3.2 Installation

A. Parshall Flumes shall be installed above an 80-mil HDPE geomembrane rubsheet within the Underdrain Collection Channel in accordance with the Design Drawings.

B. Parshall Flumes shall be installed to the lines and grades shown on the Design Drawings.

C. Parshall Flumes shall be installed plumb and the upstream floor of the Flume is level.

D. Parshall Flumes shall be embedded in concrete. Pour concrete in maximum 6-inch lifts. Internally line and brace the flume as necessary to prevent bowing or distortion of the of the flume until concrete in cured. Concrete shall meet the specifications of Section 03300 – Cast-in-place Concrete.

3.3 Tolerances

A. Parshall Flumes shall be installed to the lines and grades in the Design Drawings.

B. Parshall Flumes shall be installed plump and the upstream floor level.

3.4 Quality Control

A. A short description of the Quality Control program shall be submitted by the Contractor with the bid to the Engineer and Owner. This description shall state the Quality Control standard to be used and as a minimum containing the following:

1. An organization chart with a brief job description of Quality Control function
2. A list of applicable procedures for implementation of the Quality Control program
3. A general description of how each Quality Control requirement is to be fulfilled during the design, procurement, manufacture, assembly and testing

B. During award phase, the Quality Control documentation shall be forwarded to the Engineer as specified in Section 01300. Pertinent Quality Control documentation including Quality Control manuals shall be approved by the Engineer prior to any production work commencing. A minimum of five working days shall be allowed for the Engineer's review.

C. Upon delivery of the pipe, the Contractor shall forward the following documentation:

1. All Vendor certificates and tests performed per these Specifications
2. All Vendor documents verifying that inspection, control, and tests performed are in accordance with these Specifications
3. Identification lists with cross references between documents and hardware/materials for traceability purposes

D. The Engineer or Owner shall have the right to carry out audits at the Contractor’s, Vendor’s, and their subcontractor’s facilities, to verify compliance with all aspects of the documentation included in the purchase order. For the purpose of evaluating and auditing, the Contractor, Vendor, and their subcontractors shall give free access to all facilities concerned and to all the Quality Control documents and records

E. Applicable records may be requested by the Engineer or Owner at any time during production, these shall be forwarded to the Engineer or Owner upon request within five working days. The Contractor or Vendor shall give a written response to the Engineer or Owner for any corrective action requests and if requested, take the necessary corrective action in a timely manner.

*****END OF SECTION*****

SECTION 17150
METERS AND INSTRUMENTATION

1.0 GENERAL

1.1 Section Includes

A. Prequalification
B. Performance Requirements
C. Design Requirements
D. Submittals
E. Delivery, Storage, and Handling
F. Products
G. Execution

1.2 Performance Requirements

A. This Work shall include the furnishing of all labor, tools, equipment, and other items necessary for the installation meters and instrumentation as shown on the Drawings. All Work shall be performed in accordance with the lines, grades, sections, and dimensions shown on the Drawings, or as directed by the Engineer.

1.3 Design Requirements

A. All instrumentation materials, installation methods and materials, and data collection prior to, during, and after installation shall meet the minimum requirements of Manufacturer's recommendation and the **Geotechnical Monitoring Plan for the Grassy Mountain TSF and WRD, Revision 0 prepared by Golder Associates Inc.**

B. All instrumentation installation shall be performed by, or at the direction of, the Engineer.

1.4 Submittals

A. Submittals detailed below shall be in accordance with Section 01300.

B. After the Contract Award:

1. Submit equipment models, operation, installation, and maintenance manuals for vibrating wire piezometers, settlement cells and gauges, readout equipment, and inclinometers. Obtain Engineer approval for all instrumentation prior to shipping to the site.
2. Submit shop drawings of prefabricated instruments and materials for approval by the Engineer.
3. Submit proof of qualification for installation of any instrumentation.

C. After Installation:

1. Submit installation details for all instrumentation, including boring logs, location and elevation of the piezometers, piezometer cables, riser pipes, readout stations, surface monuments, inclinometers, and underdrain flow meters.
2. Submit the installation-specific operation manual developed for the vibrating wire piezometers, inclinometers, underdrain flow meters, and readout stations including calibration data for conversion of gauge readings to pressure.

2.0 PRODUCTS

2.1 Product Handling

A. Shipping Precautions: After completion of shop assembly, factory test, and approval, instruments shall be packed and secured to provide complete protections from damage, dust and moisture.

A. Special Instructions: Special instructions for proper field handling, storage, and installation required by the manufacturer shall be securely attached to each piece of instrument prior to packaging and shipment.

B. Tagging: Each component shall be tagged to identify its location, instrument tag number, and function in the system. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as given in the tabulation, shall be provided on each piece of equipment. Identification shall be prominently displayed on the outside of the package.

C. Storage: Instruments shall not be stored outdoors. Instruments shall be stored in dry permanent shelters and shall be adequately protected against mechanical injury. If any apparatus has been damaged, such damage shall be repaired by the Contractor.

2.2 Manufacturer's Services

A. Contractor may need to furnish some or all of the manufacturer's services for the instrumentation listed in this specification:

1. Perform factory bench calibration
2. Oversee installation
3. Verify installation of installed instrument
4. Site verification of calibration

2.3 Material

A. Vibrating Wire (VW) Piezometers

1. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU, PZ-WU Series)
   a. Impoundment and Underliner VW piezometers shall have a pressure range of 0 to 100 psi with a resolution of 0.03 psi at 100 psi (Model Number VW2100-XXXX).
   b. Signal output shall be a frequency output in the millivolt range or digits.
   c. The filter shall be Standard: 50 micron sintered stainless steel.
   d. VW piezometers shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia, or other manufacturer approved by the Engineer.
2. Embankment Foundation VW Piezometers (PZ-TF Series)
   a. Embankment Foundation VW piezometers shall be of standard VW piezometers prefabricated in nested construction (Multi-point Piezometer Strings).
   b. Embankment Foundation VW piezometers shall have a pressure range of 0 to 150 psi with a resolution of 0.04 psi at 150 psi (Model Number VW2100MP).
   c. Nesting of the Embankment Foundation VW piezometers will be at the vertical intervals described in the Geotechnical Monitoring Plan, or at the direction of the Engineer.
   d. Signal output shall be a frequency output in the millivolt range or digits.
   e. The filter shall be Standard: 50 micron sintered stainless steel.
   f. VW piezometers shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia, or other manufacturer approved by the Engineer

B. VW Piezometer Signal Cables

1. Impoundment VW Piezometer (PZ-TI, PZ-WI Series) and Underliner (PZ-TU, PZ-WU Series) Signal Cable
   a. Shall be standard vibrating wire signal cable (Model EL380004) manufactured by RST Instruments, based in Maple Ridge, British Columbia.

b. Shall be with 22-gauge tinned-copper conductors and polyurethane jacket.

c. Signal cable shall be prefabricated to the VW piezometer during manufacturing to the specific cable length required for each instrument as shown on the Drawings and Geotechnical Monitoring Plan.

d. Cable conduit shall be 2-inch diameter Schedule 80 PVC pipe with flush interior glue joints.

2. Embankment Foundation VW Piezometers (PZ-TF Series)

a. Shall be 12 conductor, Kevlar® wire with water-blocked polyurethane jacket signal cable (Model EL380012) manufactured by RST Instruments, based in Maple Ridge, British Columbia.

b. Shall be with 22-gauge tinned-copper conductors and polyurethane jacket.

c. Signal cable shall be prefabricated to the VW piezometer during manufacturing to the specific cable length required for each instrument as shown on the Drawings and Geotechnical Monitoring Plan.

3. Cable splicing shall be limited to areas where vertical overburden pressures are limited to less than 25 psi and as directed by the Engineer. Cable splicing kits shall be manufactured by RST Instruments, based in Maple Ridge, British Columbia and shall be compatible with the specific VW piezometer signal cables.

4. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU, PZ-WU Series) shall be placed in canvas bags supplied by the manufacturer and surrounded by No. 30 concrete sand.

C. Readout Stations

1. Single Channel VW portable readout (model number VW2106), shall be used for all VW piezometers for instantaneous field measurements during and after installation. The readout will measure a frequency range of 400 Hz to 6000 Hz, a temperature readout range between -50 and 80 °C, with a frequency resolution of 0.01 µs and temperature resolution of 0.1 °C.

2. After initial installation, Data loggers and multiplexers shall be installed within each Readout Station to collect real-time measurements of all WV piezometers.

3. Data Loggers shall be the RST FlexDAQ system and include the following:

a. CR6 Data Logger manufactured by Campbell Scientific, Inc. of Logan, Utah

b. RST Flexi-Mux Multiplexer(s) manufactured by RST Instruments.

c. AC or DC (solar) power supply with battery backup module

d. Electrical grounding if DC-powered

e. Lightning protection

f. Communication module (if required by, and at the direction of, the Owner)

g. Weatherproof NEMA-rated enclosure

h. Mounting post and hardware

4. Each Readout Station shall be constructed such that it has the capability to read and record in real-time the following quantity of instruments:

a. RS-1 – Twenty-two (22) VW piezometer signal cables

b. RS-2 – Four (4) VW piezometer signal cables

c. RS-3 – Four (4) Ultrasonic transducer signal cables and dataloggers

d. RS-4 – Eight (8) VW piezometer signal cables

e. RS-5 – Six (6) VW piezometer signal cables

D. Inclinometers

1. Inclinometer casing shall be installed along the downstream dam crest of the Stages 1 through 3 main north embankments as shown on the Drawings and in accordance with the Geotechnical Monitoring Plan.
2. Inclinometer casings shall be 70-mm (2.75-inch) diameter Snap Seal type (Model ICS205 or ICS210) manufactured by RST Instruments, based in Maple Ridge, British Columbia.
3. Inclinometer casings shall be either 5-foot or 10-foot segments and constructed of non-recycled virgin ABS resin.
4. Associated attachments such as bottom cap, top cap, casing anchor, alignment tool, and grout cap shall be manufactured by RST Instrumentation and approved by the Engineer.
5. Inclinometers shall be measured during and after installation with an RST MEMS Digital Inclinometer System or other suitable device approved by the Engineer.
6. Inclinometer signal cable shall have a minimum length of 200 feet.

E. Dam Crest Survey Monuments

1. Survey monuments shall be imbedded into the embankment at least 18 inches and constructed 12-inch diameter corrugated CPE pipe backfilled with grout.
2. Grout shall have a minimum 2,000 psi compressive strength at 28 days.
3. The survey marker shall be 2½-inch diameter cast-in-place brass survey cap (Model M/M-BCS-2 1/2FS) as manufactured by Surv-Kap, or an equivalent approved by the Owner.

F. Underdrain Flow Meters

1. Underdrain Flow Meters shall be installed above the Underdrain Parshall Monitoring Flumes as shown on the Drawings.
2. Underdrain Flow Meters shall be of Open Channel Flow Meter type (Model Dynasonics iSonic 4000) as manufactured by Badger Meter, Inc., of Milwaukee, Wisconsin.
3. Ultrasonic transducer shall be the EchoPod DL-10 mafactured by Badger Meter.
4. Underdrain Flow Meters shall be capable of measuring flume water levels in standard Parshall Flumes with an accuracy 0.125 inches (3 mm).

3.0 EXECUTION

3.1 Vibrating Wire Piezometer Installation

A. Impoundment (PZ-TI and PZ-WI Series) and Underliner VW Piezometers (PZ-TU and PZ-WU Series)

1. Installation of the Impoundment and Underdrain VW piezometers shall be installed at the locations identified on the Drawings and Geotechnical Monitoring Plan.
2. Installation methods, materials, and data collection procedures shall be in accordance with manufacturer's recommendations and at the direction of the Engineer.
3. VW Piezometers shall be placed in canvas sand filter bags provided by the piezometer manufacturer. Bags will be filled with No. 30 concrete sand with the piezometer centered in the bag.

B. Embankment Foundation VW Piezometers (PZ-TF Series)

1. Installation of the Impoundment and Underdrain VW piezometers shall be installed at the locations identified on the Drawings and Geotechnical Monitoring Plan.
2. Installation methods, materials, and data collection procedures shall be in accordance with manufacturer's recommendations and at the direction of the Engineer.

3. Boreholes shall be advanced below the TSF embankment foundation to the depths required for down-hole installation of the nested multi-point VW piezometers.
    a. Boreholes shall be advanced to a minimum of 1 foot (12 inches) below the deepest VW piezometer.
4. Downhole VW piezometers shall be installed using the Fully Grouted Method per RST Instruments recommendations.
    a. A bentonite-Type I/II cement mix shall be used to backfill the boreholes after nested VW piezometer installation.
    b. Viscosity of bentonite-cement backfill mix may be adjusted by the cutting short or additional bentonite to allow mixture to remain flowable for downhole pumping.
    c. Care shall be taken to prevent air entrapment in the VW piezometer filter stone. The VW piezometers shall be installed upside down and secured to either the signal cable or PVC guide pipe.
    d. If a PVC guide pipe is used during installation, it shall remain in place and be backfilled with bentonite-cement backfill mix.
    e. The PVC guide pipe shall be terminated no shallower than 2 feet below the native ground surface.

C. Calibrate piezometers to site-specific factors.

D. All cable shall be placed to loosely meander in the trench and the riser casing to allow for settlement and avoid development of tension in cable. Minimum cable meander shall be between 12 inches and 18 inches of amplitude for every 36 inches of pitch.

E. All cables shall be surrounded with Cable Bedding Fill as shown in the Drawings. Cable Bedding Fill will be compacted using hand-guided compaction equipment to form a smooth and non-yielding surface. Where placed as backfill in cable risers, Cable Bedding Fill shall be placed in lifts of 4 inches and tamped to a dense condition using a wood pole or rod.

F. Survey the precise location and elevation of each of the piezometers to an accuracy of 0.1 feet in all directions. Survey the location of wiring and conduits leading to the piezometers to an accuracy of 0.5 feet. Provide the surveyed locations with the as-built documentation. Permanently label piezometers in the readout stations and protect the stations from damage due to traffic and construction operations.

3.2 Readout Station Installation

A. Instrumentation Readout Stations shall be installed at the general locations shown on the Drawings.

B. Installation Criteria and Validation: Field-mounted components and assemblies shall be installed and connected according to the requirements below:

1. Installation personnel have been instructed on manufacturers' installation requirements.
2. Technical assistance from the Engineer is available to installation personnel at least by telephone.
3. Installation personnel have one copy of the approved Drawings, Geotechnical Monitoring Plan and pertinent data.
4. Power and signal wires shall be terminated with crimp type lugs, where the terminal block requires this.
5. Connectors shall be, as a minimum, water tight.
6. Wires shall be mounted clearly with an identification tag that is of a permanent and reusable nature.
7. Wire and cable shall be arranged in a neat manner and securely supported in cable groups and connected without splices unless specifically approved by the Engineer. Wiring shall be protected from sharp edges and corners.

8. Lightning protection shall be installed on the Readout Stations.

C. Verify the correctness of each installation, including polarity of electric power and signal connections, and make sure process connections are free of leaks.

3.3 Inclinometer Installation

A. Boreholes shall be advanced from the TSF embankment dam crest and into the clay foundation at the locations shown on the Drawings.

B. Boreholes shall be advanced to a minimum of 1 foot (12 inches) below the deepest VW piezometer.

C. Inclinometers shall be installed using the per RST Instruments recommendations.

D. The “A” axis of the inclinometer shall be installed perpendicular to the dam alignment. Proper alignment of the casing shall be maintained at all times during installation. Casing shall not be twisted or pushed from top during installation.

E. A bentonite-Type I/II cement mix shall be used to backfill the boreholes after nested VW piezometer installation.

A. Viscosity of bentonite-cement backfill mix may be adjusted by the cutting short or additional bentonite to allow mixture to remain flowable for downhole pumping.

3.4 Dam Crest Survey Monument Installation

A. Embankment Crest Survey Monuments shall be made an 18” diameter CPE pipe with smooth interior and backfilled with Lean Mix Concrete in accordance with Section 03300.

B. A minimum 6-inch wide base of concrete shall be pours around the outside of the vertical CPE pipe to for a minimum depth of 6 inches from the base of the pipe.

C. A 12-inch long ⅝ inch diameter “All Thread” rod with coarse thread shall be cast plumb into the concrete with a minimum 2½ inch extending above the top of the concrete.

D. 1-inch diameter weep holes shall be drilled through the CPE pipe immediately above the top of the concrete to provide drainage of surface water. A minimum of six weep holes shall be installed equally spaced around the circumference of the CPE pipe.

E. The annular space between the edges of the excavation and the CPE pipe shall be backfilled with Pipe Bedding Fill and placed in accordance with Section 02223.

F. The CPE pipe shall be capped with a removable lid to protect concrete and survey monument.

3.5 Underdrain Flow Meter Installation

G. Ultrasonic transducers shall be installed in accordance with the manufacturer’s recommendation.

H. Ultrasonic transducers shall be mounted to the Parshall Flumes using manufacturer-supplied mounting brackets.

I. Signal cables shall be routed to Readout Station RS-3 shown on the Drawings.

J. Signal cables shall be secured and protected from damage.

K. Transducer readouts shall be installed in a weatherproof NEMA enclosure adjacent to the reclaim pond as shown on the Drawings.

L. Weatherproof enclosure shall be mounted to fence post installed below grade and founded in Lean Mix Concrete meeting the requirements of Section 03300.

M. Power shall be supplied to the transducers in either AC (275V max, 50-60 Hz) or DC (9 to 36 V, max 9W).

3.6 Calibration

A. General: Devices provided shall be calibrated according to the manufacturer's recommended procedures to verify operation readiness and ability to meet the indicated functional and tolerance requirements.

B. Calibration Points: When possible each instrument shall be calibrated at 5, 50, and 90 percent of span using test instruments to simulate inputs. The test instruments shall have accuracies traceable to National Institute of Standards and Testing.

C. Bench Calibration: Instruments that have been bench-calibrated shall be examined in the field to determine whether any of the calibrations are in need of adjustment.

D. Field Calibration: Instruments which were not bench-calibrated shall be calibrated in the field to ensure proper operation in accordance with the instrument data sheets.

3.7 Performance Test

A. All instruments shall operate for 30 days without failure.

B. The Contractor shall furnish support staff as required to satisfy the repair or replacement requirements at no cost to the Owner.

C. If any component fails during the performance test, it shall be repaired or replaced at no Cost to the Owner.

3.8 Acceptance

A. The following conditions shall be fulfilled before the WORK is considered substantially complete:

1. Submittals have been completed and approved.
2. The instruments have been calibrated.
3. Any necessary training has been performed.
4. Spare parts and expendable supplies and test equipment have been delivered.
5. The performance test has been successfully completed.
6. Record drawings have been submitted.
7. Revisions to the Technical Manuals that may have resulted from the field tests have been made and reviewed.
8. Debris associated with installation of instrumentation has been removed.

*****END OF SECTION*****

APPENDIX J

Construction Quality Assurance Plan

Construction Quality Assurance Plan
Tailings Storage Facility and Waste Rock Dump
Grassy Mountain Mine

Malheur County, Oregon

Submitted to:

Calico Resources USA Corp.
665 Anderson St.
Winnemucca, NV 98445

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1663241-055-R-REV0

November 6, 2019

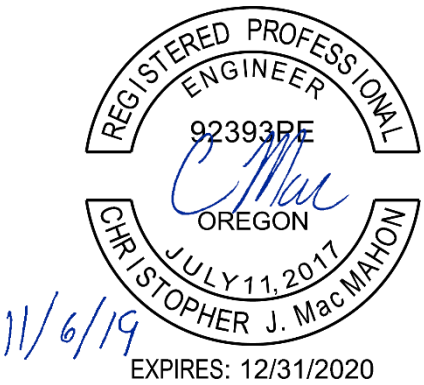
Construction Quality Assurance Plan
Tailings Storage Facility and Waste Rock Dump
Grassy Mountain Mine

Malheur County, Oregon

The following Construction Quality Assurance Plan has been prepared by the staff of Golder Associates Inc. under the professional supervision of the engineers whose signatures appear herein.

This Plan is presented to Calico Resources USA Corp. and has been prepared in accordance with generally accepted profession engineering principles and practices.

Golder Associates Inc.



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Document Revisions

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APPENDIX

Appendix A Example of CQA Daily Field Report

1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan has been prepared by Golder Associates Inc. (Golder) on behalf of Calico Resources USA Corp. (Calico). This CQA Plan describes the program used to verify and document that earthwork construction, geomembrane installation, gravity pipe installation, and structural concrete installation for the Grassy Mountain Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) are conducted in accordance with the Technical Specifications and the Drawings included in the Contract Documents for the Project.

This Plan is intended as summary of the Technical Specifications prepared as part of the Grassy Mountain TSF and WRD construction-level design presented as Appendix C in the Grassy Mountain Mine consolidated Permit Application.

Quality Control (QC) is a planned system of activities, or the use of such a system, whose purpose is to provide a level of quality that meets the requirements of the Technical Specifications and the Owner's needs. The objective of QC is to provide a work product that is safe, adequate, dependable, and economical. The overall system involves integrating the quality factors of several related steps including: the proper specification to meet the Owner's needs, production to meet the full intent of the Technical Specifications, inspection to determine whether the resulting material, product, service, etc. is in accordance with the Technical Specifications. In practice, QC refers to those procedures, criteria, and tests employed by the Quality Control Team to confirm the Work meets industry standards of practice and complies with the approved Design Drawings, Technical Specifications, and the CQA Plan. This plan does not address quality control procedures, criteria and/or tests employed by the Contractor.

Quality Assurance (QA) is a planned system of activities whose purpose is to provide assurance that the overall quality control program is in fact being effectively implemented. The system involves evaluating the adequacy and effectiveness of the overall Quality Control program and implementing corrective measures where necessary. For a specific material, product, service, etc., this involves verifications, audits, and the evaluation of the quality factors that affect the specification, production, inspection, and use of the product, service, system, or environment. In practice, QA refers to those procedures, criteria, and tests required by the Owner or Engineer to confirm the Work performed by the Contractor is in compliance with the approved Design Drawings and Technical Specifications and any additional requirements of this Plan.

The inspection and testing activities addressed under this CQA Plan include the following:

- Excavation
  - Embankment Fill Borrow Areas
  - Reclaim Pond
  - Waste Rock Dump
  - Stormwater Diversion Channels
  - Geotechnical Explorations
- Fill Materials
  - Subgrade

  - Embankment Fill
  - Grading Fill
  - Prepared Subgrade
  - Drainage Layer
  - Filter Fill
  - Anchor Trench Backfill
  - Drain Gravel
  - Leak Detection Fill
  - Pipe Bedding Fill
  - Cable Bedding Fill
  - Riprap
  - Safety Berm Material
- Geosynthetic Materials
  - Geomembrane
  - Geotextile
  - Geosynthetic Clay Liner
  - Geonet
- Monitoring Systems
  - Vibrating Wire Piezometers
  - Underdrain Flow Rate Monitoring and Flumes
  - Survey Monuments
  - Inclinometers
  - Leak Detection
- Cast-in-place Concrete
- Gravity Piping and Valves

2.0 ORGANIZATION

This section of the CQA Plan describes the parties involved during construction.

Owner: The Owner is the individual, corporation, entity, public body, or authority with whom the Contractor has entered into the Agreement and for whom the Work is performed. For this Project, the Owner is Calico Resources USA Corp. (Calico).

Engineer of Record (EOR): Engineer, or EOR, is the representative appointed and authorized by the Owner. The Engineer is responsible for preparation of the Design Drawings and Technical Specifications and this CQA Plan for the Project. The Engineer is also responsible for the interpretation of those documents and for resolution of technical matters that arise during construction. For this Project, the Engineer is Golder Associates Inc. (Golder). The Engineer-of-Record for this project is Christopher J. MacMahon, PE from Golder's Reno, Nevada Office.

Resident Engineer (RE): The RE is the on-site representative of the Engineer and oversees the Quality Assurance Team. The RE is responsible for overseeing the completion of the Work in accordance with the Drawings, Technical Specifications, and this CQA Plan. Other responsibilities include documenting daily construction activities, review of material submittals, review of the Quality Control program, and acceptance of completed Work. The RE will work directly with the Engineer and oversee the Quality Assurance Team. For this project, the RE will be a senior field technician provided by Golder.

Earthworks Contractor: Party, independent of the Owner, whose primary responsibility is to ensure the TSF is constructed in accordance with the Drawings, Technical Specifications, and this CQA Plan developed by the Engineer and approved by the permitting agency. Other responsibilities include the performance of all construction activities (including Subcontractors) at the site including site facilities, administration, material purchasing (other than materials procured by the Owner and Geomembrane Contractor), material handling and storage, safety, supervision, construction Quality Control program, installation, and subcontracting. The Contractor is also responsible for informing the Owner, Engineer, and Quality Assurance Team of the scheduling and occurrence of all construction activities and shall be fully responsible for scheduling and coordinating the work of the Quality Control Team and Subcontractor(s). The Contractor is responsible for the protection of completed work until it is accepted by the Owner.

Geosynthetics Contractor: Party, independent of the Owner, contracted through the Owner or Earthworks Contractor, responsible for field handling, sorting, placing, seaming, ballasting (against wind), and other aspects of the geosynthetics installation, including geomembranes, geotextiles, geonet, and Geosynthetic clay liners. The Geosynthetics Contractor is also responsible for transportation of these materials to the site, unless otherwise directed by the Owner. In addition, the Geosynthetics Contractor is responsible for the protection of the materials once they arrive on site, until the Work is accepted by the Owner.

Quality Control Team (QCT): Party, independent from the Owner, contracted through the Owner or Earthworks Contractor, responsible for performing the earthwork and geomembrane Quality Control field and laboratory testing, observations, and inspections required by the Technical Specifications. The QCT shall be approved by the Owner and Engineer. The QCT shall have experience in testing earth fills, aggregates, concrete, and geosynthetics and be familiar with the test methods and standards as required in the Technical Specifications.

At a minimum, the QCT shall consist of the following personnel:

- QC Manager – Registered Professional Engineer licensed in the State of Oregon responsible for all QC material testing, observation, and reporting of all QC activities required by the Technical Specifications

- QC Field Technician(s) – Qualified field technicians responsible for performing all earthwork, geomembrane and concrete field sampling, testing, and observations required by the Technical Specifications
- QC Earthwork Testing Laboratory – Qualified geotechnical testing laboratory responsible for performing all geotechnical laboratory testing required by the Technical Specifications
- QC Geomembrane Testing Laboratory – Qualified geomembrane testing laboratory responsible for performing all geomembrane laboratory testing during manufacturing required by the Technical Specifications

At a minimum, the QCT shall be responsible for the following:

- Performing all QC geotechnical testing required by the Technical Specifications
- Performing all QC geomembrane testing as required by the Technical Specifications
- Performing all QC concrete testing as required by the Technical Specifications
- Procuring all material data sheets and certifications of manufactured materials used to complete the Work and submitting to the Engineer for approval as required by the Technical Specifications
- Formally submitting test results, observations, manufacturer certifications, and QC daily field reports to the Engineer as required by the Technical Specification
- Preparation of the Quality Control Report and shall be approved and sealed by the QC Manager

At a minimum, the QC Manager shall have the following responsibilities:

- Oversee the QC Technicians and review of testing and analytical procedures employed to perform the QC testing, observation, and reporting of all QC activities as required by the Technical Specifications
- Review of all QC test results, observations, and QC daily field reports for all QC activities as required by the Technical Specifications
- Reporting of all QC tests and daily field reports to the Engineer as required by the Technical Specifications
- Report identified deficiencies and proposed corrective action to the QAT

Quality Assurance Team (QAT): Party, independent from the Contractor and QCT, responsible for QA field and laboratory testing, observations, documenting activities required by the Technical Specifications. The QAT shall be contracted through the Owner and perform assigned duties at the direction of the RE and Engineer. The QCT shall have experience in testing earth fills, aggregates, concrete, and geosynthetics and be familiar with the test methods and standards as required in the Technical Specifications.

At a minimum the QAT shall consist of the following personnel:

- RE – On-site representative of the Engineer overseeing the QAT

- QA Field Technician(s) – Qualified field technicians responsible for performing all geotechnical and geomembrane QA sampling, testing, and observations required by the Technical Specifications and at the direction of the Engineer
- QA Geotechnical Laboratory - Qualified geotechnical testing laboratory responsible for performing geotechnical laboratory at the direction of the Engineer
- QA Geomembrane Laboratory – Qualified geomembrane testing laboratory responsible for performing all geomembrane laboratory conformance testing during manufacturing required by the Technical Specifications

At a minimum, the QAT shall be responsible for the following:

- Review and approval of manufacturer QC certificates and test results as required by the Technical Specifications
- Review and approval of QC test results, observations, and QC daily field reports
- Review and approval of compaction procedures for materials placed and compacted as required by the Technical Specifications
- Sampling and performing geomembrane conformance tests as required by the Technical Specifications
- Initiation of design changes or clarifications required by the Engineer or Contractor
- Verify that the Work is constructed in accordance with industry standards of practice, Technical Specifications, and the Owner's needs
- Prepare the Record of Construction Report and shall be approved and sealed by the Engineer

Geosynthetic Manufacturer (Manufacturer): The party responsible for manufacturing the geomembrane, geosynthetic clay liner, geotextile, and appurtenances.

Subcontractor: The Subcontractor is an entity or individual who has a direct contract with the Contractor for the performance of a part of the Work. The Subcontractor shall communicate with the Owner or Engineer through the Contractor. The Subcontractor shall adhere to the requirements of the Drawings, Technical Specifications, and this CQA Plan as it relates to the Subcontractor's part of the Work.

3.0 MEETINGS

3.1 General Preconstruction Activities

Prior to the start of construction, a preconstruction meeting shall be held among the Owner, the Engineer, RE, QCT, QAT, and the Contractor(s) responsible for completing the Work. If necessary, a separate preconstruction meeting shall be held upon mobilization of the Geosynthetics Contractor if they cannot attend the first preconstruction meeting. The topics covered at this meeting shall include, but not be limited to:

- Providing each party with all relevant Construction Documents and supporting information
- Familiarizing each Party with this site-specific CQA Plan, its role relative to accomplishing the intent of the design, as well as review of the Design Drawings and Technical Specifications

- Reviewing the responsibilities of each Party
- Reviewing lines of authority and communication for each Party
- Discussing the established procedures or protocols for construction, deficiencies, repairs, and retesting
- Reviewing methods of documenting and reporting inspection data
- Reviewing work area security and safety protocols
- Discussing procedures for the location and protection of construction materials, and for the prevention of damage of the materials from inclement weather or other adverse events
- Conducting a site walk to review site conditions as well as material staging and storage locations
- Discussing the construction plan, schedule, and procedures
- Clarifying installation, testing, and acceptance criteria and procedures

3.2 Progress Meetings

Progress meetings will be held throughout progress of the Work at least once per week unless more frequent meetings are required. The RE and/or the Contractor will make arrangements for meetings, prepare agenda with copies for participants, preside at meetings, record the minutes, and distribute copies of the minutes within three days to the participants and those affected by decisions made. At a minimum, progress meetings shall be attended by the RE, the Contractor, and major Subcontractors. The purpose of a progress meeting is to address the following items:

- Review minutes of previous meetings
- Review Work progress and schedule
- Field observations, problems, and decisions
- Identify problems that impede planned progress
- Review submittals schedule and status of submittals
- Review material availability and quality
- Plan Work activities and progress during succeeding work period
- Coordinate projected progress
- Discuss construction quality and work standards
- Discuss other issues relating to the work

3.3 Problem or Work Deficiency Meeting

A special meeting shall be held when, and if, a problem or deficiency is present or is anticipated. At a minimum, the meeting shall be attended by the RE and the Contractor. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency

- Review alternative solutions
- Implement an action plan to resolve the problem or deficiency

The meeting shall be documented by the RE. Copies of the meeting minutes shall be distributed within three days to participants and those affected by decisions made.

4.0 CONSTRUCTION QUALITY ASSURANCE REQUIREMENTS

4.1 General

This section of the CQA Plan describes the observations and testing activities that will be performed during construction. The scope of this section addresses the construction method, including material installation and the manufacture/fabrication as specified in the following Technical Specification sections:

- Section 01041 – Project Coordination
- Section 01050 – Field Engineering
- Section 01051 – Geotechnical Exploration
- Section 01400 – Quality Control and Assurance
- Section 02110 – Site Clearing and Stripping
- Section 02205 – Fill Materials
- Section 02211 – Rough Grading
- Section 02222 – Excavating
- Section 02223 – Filling
- Section 02272 - Geotextile
- Section 02272 – Geonet
- Section 02350 – Geosynthetic Clay Liner
- Section 02710 – Gravity Piping
- Section 02775 – Geomembranes
- Section 03110 – Concrete Formwork
- Section 03220 – Reinforcing Steel
- Section 03300 – Cast-in-Place Concrete
- Section 11207 – Parshall Flumes
- Section 17150 – Meters and Instrumentation

Acceptance criteria for construction work shall be as identified in the Technical Specifications. The RE will be on-site at all times while construction is ongoing, observing and documenting all relevant activities. QA shall consist of observing the work as construction proceeds and review of laboratory and field testing

performed by the QCT to ensure that the materials conform to the Specifications and construction performance specifications are achieved. The RE will also review the required Contractor/Subcontractor submittals as specified in the Technical Specifications.

The Engineer shall visit the site periodically as construction progress warrants. Such visits will be frequent enough to allow the Engineer to be fully knowledgeable of the construction methods and performance. The Engineer may then determine if QC/QA observation and testing activities are adequate to meet the requirements of this CQA Plan.

4.2 List of Applicable Methods

List of applicable methods (references) are provided in the Technical Specifications.

4.3 Sampling and Testing Requirements

The QC\QA sampling and testing requirements for the construction activities are summarized in the tables in Section 6.0.

5.0 GENERAL QUALITY CONTROL/ASSURANCE PROCEDURES

5.1 General Description

The QCT shall be responsible for implementing a QC program that satisfies the requirements of the Technical Specifications and this CQA Plan. The QAT shall be responsible for reviewing all QC field and laboratory test results, observations, and QC daily field reports and document that the project construction has been completed in conformance with the Technical Specifications, Design Drawings, and the CQA Plan.

For this Project, QA testing performed by the QAT will satisfy the QC testing requirements of the Project. If selected by the Contractor and approved by the Owner, the Contractor may elect to not perform field QC testing in solely rely on the QAT to document contractor QC. This does not eliminate the requirements of the Contractor from performing assigned Work in accordance with the Technical Specifications and Design Drawings.

5.2 Visual Observations

5.2.1 Quality Control Team

Visual observations shall be performed by the QCT that include, but not be limited to, the following:

- Compaction method for materials placed (placement, moisture conditioning, equipment type, number of passes) as required by the Technical Specifications
  - Adherence to the procedures established during the test fills (if any)
- Consistency of materials during processing and/or placement
- Deleterious material that may hinder proper construction
- Attention to areas where damage due to excess moisture, insufficient moisture, or freezing may have occurred
- Safe working procedures and construction methods

5.2.2 Quality Assurance Team

Visual observations shall be performed by the QAT that include, but no be limited to, the following:

- Compaction method for materials placed (placement, moisture conditioning, equipment type, number of passes)
  - Adherence to the procedures established during the test fills (if any)
- Proper material usage
- Reviewing QCT procedures for sampling, testing, observations, and documentation
- Approval of areas where Work has been completed
- Safe working procedures and construction methods

5.3 Defects and Repairs

5.3.1 Identification

If a defect is identified, the QCT shall determine the extent and the nature of the defect and notify the QAT immediately. If the defect is indicated by an unsatisfactory test result, the QAT shall determine the extent of the deficient area by additional QC tests, observations, review of records, or other means that the QAT deems appropriate.

5.3.2 Notification

After determining the extent and nature of the defect, the QAT shall promptly notify the Contractor. The QAT shall review the QCT's determination regarding the extent of the defect. If the QAT agrees with the QCT's determination, the Contractor shall be notified of the defect. If in the opinion of the QAT, disagrees with the QCT's determination, additional observations and testing may be required prior to notifying the Contractor.

5.3.3 Repairs and Retesting

Upon notification from the QAT, the Contractor shall correct all deficiencies to meet the Contract Documents. The QAT and QCT shall schedule appropriate retests when the Work deficiencies have been corrected. All retests by the QCT or QAT must verify that the deficiencies have been corrected before additional Work may be performed by the Contractor in the deficient area. The QAT shall observe any repair and report any noncompliance with the above requirements in writing to the Engineer.

5.4 Documentation

5.4.1 General

Proper documentation shall be maintained throughout the duration of the construction activities. The QCT will be responsible for ensuring that applicable forms and written records are completed daily. Originals of applicable forms and written documentation will be stored on-site and shall be made available for the QAT's review upon request. Copies of written documentation will be made each week and shall be sent to the QAT. Further details of typical documentation are presented below.

5.4.2 Daily Records

5.4.2.1 Quality Control Daily Reports

The QCT shall issue a typed daily report of activities. QC daily reports shall include the following:

- Date and shift
- List of organizations and their responsibilities
- List of equipment used for construction of Work
- Health and safety issues
- Summary of QC activities
  - Materials used for construction
  - Summary of samples taken, sample locations and elevations as appropriate, and test results
  - Test equipment calibrations
  - List of materials received
- Issues and problems encountered, and resolutions reached
- Summary of meetings and discussions (if any)
- QCT personnel hours, gear, and vehicles
- Photographs taken with a description

A template for daily reports is provided in Appendix A.

5.4.2.2 Quality Assurance Daily Reports

The QAT shall issue a typed daily report of activities. QA daily reports shall include the following:

- Date and shift
- Weather conditions
- List of organizations and their responsibilities
- List of equipment operating on-site
- Health and safety issues
- Summary of QC documentation review
- Summary of QC activities
- Issues and problems encountered, and resolutions reached
- Summary of meetings and discussions
- QAT personnel hours, personal protective equipment used, and vehicles
- Photographs taken with a description

A template for daily reports is provided in Appendix A.

5.4.3 Construction Reporting

5.4.3.1 Construction Quality Control Report

Following completion of construction, the QCT shall provide a Construction Quality Control Report by that will include the following:

- Description of Quality Control activities
- Summary of test results
- Copies of QC daily reports
- As-Built Survey documentation
- Color photographs of major project features

The Construction Quality Control Report shall be submitted to the Engineer within 14 days upon acceptance of the completed Work. The Construction Quality Control Report shall be sealed by a registered Professional Engineer, licensed in the State of Oregon certifying that the activities performed by the QCT have been performed in accordance with the Contract Documents.

5.4.3.2 As-built Survey Documentation

Following completion of construction, the Contractor shall provide As-built Survey Documentation of all Work performed by the Contractor that will include the following:

- Survey of all areas disturbed by the Contractor that pertain to the completion of the Work
- Survey of all structures, pipes, utilities, and other facilities that pertain to the completion of the Work

The As-built Survey Documentation shall be submitted to the Engineer within 14 days upon acceptance of the completed Work. The As-built Survey Documentation shall be sealed by a registered Professional Land Surveyor, licensed in the State of Oregon certifying that the surveys are in accordance with the Contract Documents.

5.4.3.3 Record of Construction Report

Following completion of Construction and receipt of the Construction Quality Control Report and As-built Survey Documentation, the Engineer shall prepare the Record of Construction report documenting the following:

- Description of construction activities
- Summary of test results
- Copies of QCT and Resident Engineer Daily Reports
- As-built Survey documentation
- As-built Drawings
- Critical correspondence pertaining to the Work including changes and clarifications to the Drawings

- Description of deviations from the Technical Specifications and justification for such changes
- Color photographs of major project features

The Record of Construction Report will be sealed by the Engineer, certifying that the facility has been constructed in accordance with the Contract Documents.

6.0 QUALITY CONTROL REQUIREMENTS

Table 1: Subgrade

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Subgrade Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	N/A	
	Sieve Analysis	N/A	ASTM D 6913	200,000 sq.ft of prepared surface	
	Atterberg Limits	N/A	ASTM D 4318	200,000 sq.ft of prepared surface	
	Moisture-Density Relationship	Modified Proctor	ASTM D 1557	500,000 sq.ft of prepared surface	
Subgrade Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Scarification Depth	6 inches below	N/A	Continuous Monitoring	
	Field Density	90% of Max Dry Density as determined by ASTM D 1557	ASTM D 6938	50,000 sq.ft of prepared surface	
	Field Moisture Content	N/A	ASTM D 6938	50,000 sq.ft of prepared surface	May be collected during field density test
	Sand Cone Referee Density	N/A	ASTM D 1556	1 test per 10 field density tests	As required by the Engineer
	Laboratory Moisture Content	N/A	ASTM D 4643	1 test per 10 field moisture tests	As required by the Engineer

Table 2: Embankment Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Embankment Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	N/A		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	- A maximum of any 1 sieve is allowed to be out of spec for an individual test - Maximum particle size shall be less than 2/3 loose lift thickness
		16 inch	100			
		12 inch	50 – 100			
		8 inch	30 – 100			
		¾ inch	0 – 80			
		No. 4	0 – 40			
		No. 200	0 – 15			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	20,000 cu.yds	Per material type
Embankment Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	12, 18, and 24-inch test fill		USACOE	Continuous Monitoring	Per test fill procedures described in Section 02223
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	2,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 3: Grading Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Grading Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 15		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		6 inch	100			
		¾ inch	20 – 100			
		No. 4	10 – 70			
		No. 40	0 – 40			
		No. 200	0 – 30			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	20,000 cu.yds	Per material type
Grading Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Soil Fill: Maximum 12-inch thick loose lift Rock Fill: 12, 18, and 24-inch test fill		USACOE	Continuous Monitoring	Per test fill procedures described in Section 02223
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	1,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 4: Prepared Subgrade

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Prepared Subgrade Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		3 inch	100			
		¾ inch	70 – 100			
		No. 4	20 – 100			
		No. 40	0 – 60			
		No. 200	0 – 50			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	15,000 cu.yds	Per material type
Prepared Subgrade Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Maximum 12-inch thick loose lift On slopes steeper than 20% maximum 18-inch lifts measured perpendicular to slope		N/A	Continuous Monitoring	May be placed in a single 6-inch lift if the underlying Embankment Fill is free of coarse material. Lift thickness shall be approved by Engineer.
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	1,000 cu.yds	
	Field Moisture Content	N/A		ASTM D 6938	Continuous Visual Monitoring	
	Sand Cone Referee Density	N/A		ASTM D 1556	N/A	
	Laboratory Moisture Content	N/A		ASTM D 2216 or D 4643	N/A	

Table 5: Drainage Layer

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Drainage Layer Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	5,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	5,000 cu.yds	
		3 inch	100			
		¾ inch	50 – 100			
		No. 4	20 – 50			
		No. 40	0 – 25			
		No. 200	0 – 15			
	Moisture-Density Relationship	N/A		N/A	N/A	
	Hydraulic Conductivity	5 x 10^{-3} cm/sec or faster		ASTM D 5856	2 per material type	
Drainage Layer Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only Low Ground Pressure (LGP) tracks allowed for material spreading
	Lift Thickness	Single 18-inch thick loose layer		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 6: Filter Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Filter Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	3,000 cu.yds	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	3,000 cu.yds	
		8 inch	100			
		3 inch	70 – 100			
		¾ inch	30 – 90			
		No. 40	0 – 25			
		No. 200	0 – 15			
	Moisture-Density Relationship	N/A		N/A	N/A	
	Hydraulic Conductivity	5×10^{-4} cm/sec or faster		ASTM D 5856	2 per material type	
Filter Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only Low Ground Pressure (LGP) tracks allowed for material spreading.
	Lift Thickness	Single 6-inch thick loose lift		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 7: Anchor Trench Fill

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Anchor Trench Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Atterberg Limits	N/A	ASTM D 4318	N/A	
	Sieve Analysis	N/A	ASTM D 6913	500 cu.yds	
	Moisture-Density Relationship	N/A	N/A	N/A	
Anchor Trench Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Lift Thickness	Maximum 12-inch-thick loose lifts	N/A	Continuous Monitoring	
	Field Density	N/A	N/A	Continuous Monitoring	Hand guided or bucket compacted
	Field Moisture Content	N/A	N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A	N/A	N/A	
	Laboratory Moisture Content	N/A	N/A	N/A	

Table 8: Drain Gravel

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Drain Gravel Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 10		ASTM D 4318	200 cu.yds or 3 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	200 cu.yds or 3 per material type	
		2 inch	100			
		¾ inch	50 – 80			
		No. 4	15 – 50			
		No. 200	0 – 5			
	Moisture-Density Relationship	N/A		N/A	N/A	
Drain Gravel Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only LGP track-mounted equipment allowed on Drain Gravel
	Lift Thickness	6-inch above and laterally around perforated pipe		N/A	Continuous Monitoring	Not Compacted
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 9: Leak Detection Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Leak Detection Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Native borrow material or process Waste Overburden
	Atterberg Limits	PI ≤ 15		ASTM D 4318	2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	2 per material type	
		1 inch	100			
		¾ inch	75 – 100			
		⅜ inch	20 – 55			
		No. 200	0 – 10			
	Moisture-Density Relationship	N/A		N/A	N/A	
Leak Detection Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Only track-mounted equipment allowed on Leak Detection Fill
	Lift Thickness	8 inch above and laterally around perforated pipe		N/A	Continuous Monitoring	Hand placed below spring line of pipe
	Field Density	N/A		N/A	N/A	
	Field Moisture Content	N/A		N/A	N/A	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 10: Pipe Bedding Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Pipe Bedding Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20		ASTM D 4318	200 lineal feet or 2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	200 lineal feet or 2 per material type	
		2 inch	100			
		¾ inch	70 – 100			
		No. 4	20 – 70			
		No. 40	0 – 35			
		No. 200	0 – 25			
	Moisture-Density Relationship	Modified Proctor		ASTM D 1557	200 lineal feet or 3 per material type	Per material type
Pipe Bedding Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	Maximum 6-inch thick loose lift		N/A	Continuous Monitoring	
	Field Density	92% of Max Dry Density as determined by ASTM D 1557		ASTM D 6938	100 lineal feet	Only hand-guided, mechanical tampers, or hand-guided vibratory rollers shall be used around pipes
	Field Moisture Content	N/A		N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 11: Cable Bedding Fill

Type	Parameter	Standard		Test Method	Frequency (units per test)	Comments
Cable Bedding Fill Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Atterberg Limits	N/A		ASTM D 4318	2 per material type	
	Sieve Analysis	Sieve Size	% Passing	ASTM D 6913	2 per material type	Screened Drainage Layer or Native Alluvium
		⅜ inch	100			
	Moisture-Density Relationship	smooth and non-yielding		ASTM D 1557	N/A	
Cable Bedding Fill Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials		N/A	Continuous Monitoring	
	Lift Thickness	6-inch loose lift below cables 12-inch loose lift above cables		N/A	Continuous Monitoring	Hand guided-compaction equipment only
	Field Density	Visually documentation of a smooth and non-yielding surface		N/A	Continuous Monitoring	
	Field Moisture Content	N/A		N/A	Continuous Monitoring	
	Sand Cone Referee Density	N/A		N/A	N/A	
	Laboratory Moisture Content	N/A		N/A	N/A	

Table 12: Riprap

Type	Parameter	Standard					Test Method	Frequency (units per test)	Comments
Riprap Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials					N/A	Continuous Monitoring	
	Atterberg Limits	PI ≤ 20					N/A	N/A	
	Sieve Analysis	**Riprap D50**	**8”**	**12”**	**16”**	**28”**	ASTM D 5519	2 per material type	
			Rock Size (in.)						
		D_{100}	12	18	24	42			
		D_{85}	10	14	20	36			
		D_{50}	8	12	16	28			
		D_{15}	3	4	6	12			
	Moisture-Density Relationship	N/A					N/A	N/A	
Riprap Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials					N/A	Continuous Monitoring	Shall be placed in horizontal lifts
	Lift Thickness	1.5 x D_{50}					N/A	Continuous Monitoring	
	Field Density	N/A					N/A	Continuous Monitoring	Track-walked or bucket compacted
	Field Moisture Content	N/A					N/A	N/A	
	Sand Cone Referee Density	N/A					N/A	N/A	
	Laboratory Moisture Content	N/A					N/A	N/A	

Table 13: Safety Berm Material

Type	Parameter	Standard	Test Method	Frequency (units per test)	Comments
Safety Berm Material Physical Properties	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Atterberg Limits	N/A	N/A	N/A	
	Sieve Analysis	N/A	N/A	N/A	
	Moisture-Density Relationship	N/A	N/A	N/A	
Safety Berm Material Compaction	Visual Inspection	Free of sod, brush, roots or other perishable and unsuitable materials	N/A	Continuous Monitoring	
	Lift Thickness	N/A	N/A	N/A	Shall be placed by loader, dozer or grader
	Field Density	N/A	N/A	N/A	Uncompacted
	Field Moisture Content	N/A	N/A	N/A	
	Sand Cone Referee Density	N/A	N/A	N/A	
	Laboratory Moisture Content	N/A	N/A	N/A	

Table 14: Textured Geomembrane Required Minimum Properties (Per GRI-GM13)

Parameter	Test Value		Test Method (ASTM)	Manufacturer Quality Control Frequency (units per test)
	60 mil	80 mil		
Thickness mils (min avg.)	57 mil	76 mil	D 5994	Per roll
Thickness (Minimum 8 of 10)	-10% (54 mil)	-10% (72mil)		
Lowest individual for any of the 10 values	-15% (51 mil)	-15% (68 mil)		
Asperity Height	16 mil	18 mil	D 7466	Every 2nd roll*
Density (g/cc) min.	0.940	0.940	D 1505/D 792	200,000 lb
Tensile Properties (min. avg.)*				
Yield Strength (lb/in)	126	168	D 6693 Type IV	20,000 lb
Break strength (lb/in)	90	120		
Yield Elongation (%)	12	12		
Break Elongation (%)	100	710		
Tear Resistance (lbs) (min. ave)	42	56	D 1004	45,000 lb
Puncture Resistance (lbs) (min. ave)	90	120	D 4833	45,000 lb
Stress Crack Resistance (hr)*	500 hr	500 hr	D 5397	Per GRI GM-10
Carbon Black Content (%)	2.0-3.0	2.0-3.0	D 4218*	20,000 lb
Carbon Black Dispersion*	See Notes*	See Notes*	D 5596	45,000 lb
Oxidative Induction Time (OIT)				
Standard OIT (minutes), or	100	100	D 3895	200,000 lbs
High Pressure OIT (HP OIT) (minutes)	400	400	D 5885	
Oven Aging at 85°C (min. avg.)*)			D5721	Per each formulation
a. Std OIT (% retained after 90 days) min. avg. or;	55	55	D 3895	
b. HP OIT (% retained after 90 days) min avg.	80	80	D 5885	
UV Resistance (min ave)*			D5721	Per each formulation
a. Std. OIT (min. avg.), or	N.R.	N.R.	D 3895	
b. HP OIT (min. avg.) (% ret. after 1600 hrs)*	50%	50%	D 5885	

*Refer to Notes presented in Table 02775-1 of Section 02775 in the Technical Specifications

Table 15: HDPE Geomembrane Seam Properties Wedge and Extrusion Welds (per GRI GM-19a)

Parameter	Textured HDPE Test Values		Test Method (ASTM)	Testing Frequency (units per Test)	Comments
	60 mil	80 mil			
Seam Shear Strength (lbs/in) minimum*	120	160	D 6392	500 LF per machine	Peel and Shear seams must fail in the Film Tear Bond mode*
Lowest Individual Seam Shear Strength of 5 tests (lbs/in)*	96	128			
Shear elongation at break (%)	50	50			
Seam Peel Strength (lbs/in) minimum*	91 for hot wedge 78 for extrusion	121 for hot wedge 104 for extrusion			
Lowest Individual Seam Peel Strength of 5 tests (lbs/in)*	73 for hot wedge 62 for extrusion	97 for hot wedge 83 for extrusion			
Peel separation (%)	25	25			

*Refer to Notes presented in Table 02775-2 of Section 02775 in the Technical Specifications

Table 16: Geomembrane Conformance Testing

Property	Test Value	Test Method (ASTM)	Testing Frequency (units per Test)
Thickness (mils)	See Table 13	D 5199	2,000,000 sq. ft. per liner type, or per resin lot, whichever is greater (each test)
Compound Density (g/cc)	See Table 13	D 1505	
Tensile Strength (Both yield and ultimate strength and elongation, as specified)	See Table 13	D 6693	
Carbon Black Content (%)	See Table 13	D 4218	

Table 17: Minimum Average Roll Values For Reinforced Geofilm Related GCL Material (per GRI-GCL3)

Property	ASTM Test Method	Value	Comments
Cap Geosynthetic			Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Type	-	Non-woven	
Weight	ASTM D 5261	6.0 oz/sq.yd.	
Carrier Geosynthetic			
Type	-	Woven	
Weight	ASTM D 5261	3.0 oz/sq.yd.	
Geofilm			
Thickness	ASTM D 5199/ D 5994	4 mil	
Break Tensile Strength (MD & XMD)	ASTM D 882	12 lb/in	
Clay Properties			
Clay Type	-	80% or more montmorillonite	
Bentonite Mass at 0% Moisture*	ASTM D 5993	0.75 psf	
Maximum Allowable Moisture Content	ASTM D 5993	35%, by weight	
Swell Index	ASTM D 5890	24 ml/2g min	
Fluid Loss	ASTM D 5891	18 ml max	
GCL Composite Properties			
GCL Permeability*	ASTM D 6766	5×10^{-10} cm/sec max at 5.0 psi	
Tensile Strength in Machine Direction	ASTM D 6768	23 lb/in	
Peel Strength	ASTM D 6496	2.1 lb/in	
Geofilm Durability*	ASTM D 5721	80% strength	
Internal Shear Strength	ASTM D 6243	150 psf typical	

*Refer to Notes presented in Table 02350-2 of Section 02350 in the Technical Specifications

Table 18: Minimum Average Roll Values For Geotextile Material (per GRI-GT12a)

Parameter	ASTM Test Method	Value	Testing Frequency	Comments
Weight	D 5261	12 oz/sq.yd.	1 per material type, or as requested by the Engineer	Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Grab Tensile	D 4632	300 lb		
Grab Tensile Elongation	D 4632	50%		
Trapezoidal Tear Strength	D 4533	115 lb		
Puncture (CBR) Strength	D 6241	800 lb		
UV Resistance (at 500 hrs)	D 7238	70% strength retained		
Apparent Opening Size	D 4751	No. 100 Sieve (0.15 mm)		

*Refer to Notes presented in Table 02272-1 of Section 02272 in the Technical Specifications.

Table 19: Minimum Average Roll Values for Geonet Material (per GRI-GN4)

Parameter	ASTM Test Method	Value	Testing Frequency	Comments
Thickness* (min. ave.)	D 5199	200 mil	1 per material type, or as requested by the Engineer	Material Data Sheets shall be provided to the Engineer per Section 01300 of the Technical Specifications
Density* (min. ave.)	D 1505/D 792	0.950 g/cm*		
Carbon Black Content (%)	D 1603/D 4218	1.5-3.0%		
Tensile Strength* (MD)	D 7179	180 lb/in		
Compressive Strength* (min. ave.)	D 6364	120		
Transmissivity*	D 4716	5.0 gal/min-ft		

*Refer to Notes presented in Table 02273-1 of Section 02273 in the Technical Specifications.

Table 20: Cast-In-Place Concrete

Type	Parameter	Test Value	Test Method (ASTM)	Testing Frequency	Comments
Cast-In-Place Concrete (Reinforced)	Compressive strength	4,000 psi at 28 days	C 39	4 Standard 6-inch diameter by 12-inches long test cylinders for every 50 yards of concrete poured or for each pour, whichever is greater	One at 7 days, one at 14 days, and one at 28 days, one reserve
	Maximum aggregate size	3/4-inch	C 136		
	Slump	3 to 5 inches	C 143	Every 50 yards of concrete poured or for each pour, whichever is greater	
	Air Entrainment (%)	4 to 6%	C 233	Every 50 yards of concrete poured or for each pour, whichever is greater	
Lean Mix Concrete (unreinforced)	Compressive strength	2,000 psi at 28 days	C 39	4 Standard 6-inch diameter by 12-inches long test cylinders for every 50 yards of concrete poured or for each pour, whichever is greater	One at 7 days, one at 14 days, and one at 28 days, one reserve
	Maximum aggregate size	1.5-inch	C 136		
	Slump	3 to 5 inches	C 143	Every 50 yards of concrete poured or for each pour, whichever is greater	

APPENDIX A

Example of CQA Daily Field Report

DAILY FIELD REPORT

DATE: **PROJECT NO.**

REPORT NO.
FILE TO:

GRASSY MOUNTAIN TSF CONSTRUCTION

Table 1: Present at Site

Organization	Responsibility

Table 2: Equipment Present at Site

Qty	Type	Make/Model	Notes

Health and Safety

■

Construction Activity Summary

■

QA/QC Activity Summary

■

Issues and Resolution

■

Meetings and Discussions Summary

■

Signature
First and Last Name
Title

Total Hours On-site:
Field Equipment:
Vehicle:

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Photographs

Description

APPENDIX K

Geotechnical Monitoring Plan

REPORT

Geotechnical Monitoring Plan
Tailings and Waste Rock Dump Facilities
Grassy Mountain Mine

Malheur County, Oregon

Submitted to:

Calico Resources USA Corp.
665 Anderson St.
Winnemucca, Nevada 89445

Submitted by:

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Reno, Nevada, USA 89521

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1663241-057-R-Rev0

November 6, 2019

Geotechnical Monitoring Plan
Tailings and Waste Rock Dump Facilities
Grassy Mountain Mine

Malheur County, Oregon

The following geotechnical monitoring plan has been prepared by the staff of Golder Associates Inc. under the professional supervision of the engineers whose signatures appear herein.

The monitoring plan and recommendations presented to Calico Resources USA Corp. have been prepared in accordance with generally accepted profession engineering principles and practices.

Golder Associates Inc.

11/6/19

EXPIRES: 12/31/2020

Christopher J. MacMahon, PE
Associate, Engineer of Record

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Lead Civil Design Engineer

Document Revisions

Date	Revision	Comment
November 6, 2019	0	Final Plan Prior to Construction

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1.0 INTRODUCTION

This Geotechnical Monitoring Plan (Plan) was prepared by Golder Associates Inc. (Golder) for Calico Resources USA Corp. (Calico) to monitor the geotechnical performance and stability of the planned Tailings Storage Facility (TSF) and Waste Rock Dump (WRD) at the Grassy Mountain Mine in Malheur County, Oregon.

This Plan was prepared in accordance with the design as presented in the Detailed Design Tailings Storage Facility and Waste Rock Dump Facility Report (Golder, 2019).

Monitoring instrumentation described in this Plan includes vibrating wire (VW) piezometers, flow meters, survey monuments, and inclinometers. At the time of this report, construction has not started on either the TSF and WRD. Upon completion of Stage 1 TSF and WRD construction, this Plan shall be updated to reflect the as-built instrumentation.

The goals of monitoring the Grassy Mountain TSF and WRD are to:

- Monitor pore pressure in the foundation clay to detect development of excess pore pressures during the construction of the Stages 1 through 3 North Embankment to confirm short-term construction stability and to monitor pore pressures throughout the operating life of the facility.
- Monitor the pore pressure at the base of the impounded tailings above the toe drain pipe and primary underdrain collection pipes in the TSF and WRD to confirm that the drainage system continues to operate within design parameters.
- Monitor pore pressures in the foundation below the TSF basin and WRD pad lining systems to confirm the proper containment performance.
- Monitor leakage flow rates between the primary and secondary containment layers in the TSF and WRD liner systems.
- Monitor flow rates from the Primary TSF collection pipes, and the TSF toe drain pipe, prior to discharge into the reclaim pond to verify proper functioning of the pipes and to support water balance estimates.
- Monitor displacements of the TSF dam embankment crest that could indicate instability and/or excessive settlement.
- Monitor potential subsurface displacements within the TSF dam embankment and in the underlying foundation soils to provide early indication of potential instability prior to development of evidence that can be measured or recognized at the surface.
- Visually inspect the operation and general condition of the TSF and WRD during operation and construction to monitor the overall performance of the facilities.

Monitoring is through both measurements of Monitoring Points and visual observations of surface conditions. For the purposes of this Plan, a Monitoring Point is defined as any geotechnical instrument or Dam Crest Survey Monument installed to monitor the geotechnical field conditions at the TSF and WRD. The parties that will be responsible for the data collection, instrument maintenance, reporting, and data review, are defined as follows:

Owner/Operator – As the owner and operator of the TSF and WRD, Calico will be responsible for implementation of this Plan, data collection, instrument maintenance, summarizing data, reporting internally and to regulatory agencies, identifying trends in the data that could be of concern as outlined in this plan, assuring the involvement

of an Engineer of Record throughout construction, operation, and closure of the TSF and WRD, and notifying the EOR when needed as required by the Plan. Calico staff are responsible for data collection will be referred to as the Monitor.

Monitor – Calico will directly employ or subcontract qualified personnel to collect readings of the instrumentation presented in this Plan. The Monitor will be responsible for collecting and managing data obtained from the vibrating wire piezometers, inclinometers, leak detection ports, and regular visual inspections. The Monitor will be responsible for completing internal quality control checks before the data is submitted to the Operator and/or the EOR for review.

Surveyor – Calico will use their own surveyor or a subcontracted professionally-licensed surveyor to monitor Survey Monuments. The Surveyor will be responsible for routine and as-needed data collection, and for completing internal quality control checks before the data is submitted to the Operator and/or the EOR for review.

Engineer of Record (EOR) – Engineer, or EOR, refers to a geotechnical engineering firm that is experienced in monitoring and assessing stability and performance of mining facilities, and who is familiar with the Grassy Mountain TSF and WRD designs, construction, and operation. The EOR should be a Professional Engineer licensed in the State of Oregon. The EOR will assist Calico with installation of the monitoring points, review and interpret monitoring data, and provide engineering recommendations in their role as EOR or when requested by Calico. For this project, the EOR is Christopher J. MacMahon, PE of Golder Associates in our Reno, Nevada office.

This Plan describes the geotechnical monitoring and reporting for the TSF and WRD with the intent of developing consistent and accurate data for use in geotechnical interpretation. Specifically, this Plan:

- Summarizes the location and installation information of planned monitoring points;
- Outlines monitoring requirements, including frequency, responsible parties, calibration, monitoring protocol, and monitoring quality control methods;
- Defines routine reporting requirements, including frequency, responsible parties, and reporting format; and
- Summarizes notification and reporting requirements for unusual data readings or data trends.

This Plan will be used by the Operator and their consultants or subcontractors assigned to tasks associated with monitoring and reporting. The Plan is dynamic, and modifications may be appropriate based on changes to staged construction, operation, readings, and embankment performance. It will be updated by the Operator as details of the monitoring program change, which could include addition, replacement, or abandonment of monitoring points, changes in the frequency of monitoring, changes in site conditions, refinement or revisions in monitoring protocol, and changes in reporting requirements.

2.0 MONITORING POINT TYPE, LOCATIONS, AND INSTALLATION

Figure 1 shows the types and locations of planned monitoring points for the Stage 1 construction. Table 1 summarizes the type, location, depth/elevation, and installation date of each of the monitor points. A description of installation details follows. The following systems will be installed to monitor the performance of the TSF and WRD:

- Vibrating wire (VW) Foundation Piezometers

- VW Impoundment Piezometers
- VW Underliner Piezometers
- Underdrain Flow Monitoring System
- Dam Crest Survey Monuments
- Inclinometers
- Leak Detection Piping System

2.1 Vibrating Wire Piezometers

This Plan presents the VW piezometers to be installed at strategic locations throughout the TSF and WRD. Each VW piezometer identification ID referenced in this Plan is considered a Monitoring Point. At each Monitoring Point, either a matching pair or nested VW piezometers will be installed. Paired/nested piezometer systems provide redundancy and confirmation on measured readings.

As construction and operations progress, instruments are sometimes abandoned due to malfunction, failure, damage from construction equipment, and blinding or plugging. Redundant pairs are often installed in an attempt to maintain adequate monitoring points throughout construction and operation when monitoring is most critical.

As presented in the Plan Tables, each VW ID includes an “a,” “b,” or “c” providing a unique identifier for each instrument at each Monitoring Point.

Figure 1 presented in this Plan is intended as a schematic showing the relative location of each Monitoring Point. Construction-level installation details for the Monitoring Points are presented in the *Grassy Mountain Mine, Tailings Storage Facility and Waste Rock Dump,* Revision 0, dated November 2019 prepared by Golder and should be reviewed parallel with this Plan.

2.1.1 Vibrating Wire Foundation Piezometers

A total of eight nested groups of VW Foundation Piezometer (PZ-TF series) will be installed in the foundation clay below the North and West embankment footprints to monitor the pore pressures in the foundation soils during embankment placement and throughout operations. The locations of the piezometers are shown on Figure 1 and Table 1. Each nested group will contain three VW piezometers as shown on Figure 2.

Three nested Foundation Piezometers will be installed in vertical boreholes drilled into the foundation clay below the following locations:

- Stage 1
  - Four boreholes below the North embankment (PZ-TF-1, 2, 4 and 5)
  - One borehole below the West embankment (PZ-TF-7)
- Stage 2
  - Two borehole below the North embankment (PZ-TF-3 and 6)
  - One borehole below the West embankment (PZ-TF-8)

- Stage 3
  - None

All Foundation Piezometers will be installed prior to each planned expansion stage embankment construction as described above. The Foundation Piezometers will be installed at variable depths as determine by the trigger level stability modeling discussed in Section 5.2.2. Sensor depth below the native ground surface and nesting intervals for each Foundation Piezometer are presented on Table 1. Foundation Piezometers will be grouted in-place using manufacturer recommended bentonite-Type II cement grout mix.

The piezometer signal cables will be directly buried in trenches excavated through the native foundation soils and routed toward the TSF reclaim pond. Cables will be bedded and backfilled with cable bedding sand to prevent damage to the cables due to embankment construction.

The cables will be routed to a readout station installed along the access road adjacent to the reclaim pond and underdrain channel.

Readout Stations will be installed near the Stage 3 downstream toe of the North and West Embankments where the Foundation Piezometer signal cables will be routed to. The following Readout Stations will be installed for the instrumentation listed:

- RS-1: PZ-TF-1 through PZ-TF-6
- RS-5: PZ-TF-7 and PZ-TF-8

Location of the embankment Foundation Piezometers and sensor depths are presented on Table 1 and readout station locations are presented on Table 2.

2.1.2 Vibrating Wire Impoundment Piezometers

PZ-TI Series – Drainage Layer above TSF Lining System

A total of five VW piezometer pairs (PZ-TI series) will be installed at the base of the impoundment to monitor hydraulic head within the Drainage Later above the TSF lining system:

- Two Impoundment Piezometer pairs (PZ-TI-1 and PZ-TI-2) adjacent to the primary underdrain collection pipes at the inlet to the underdrain channel (Stage 1 upstream toe)
- One Impoundment Piezometer pair in the northern portion of the basin (PZ-TI-3)
- One Impoundment Piezometer pair below the supernatant pool (PZ-TI-4)

The Impoundment Piezometers will be installed directly in the drainage layer, within the geotextile which surrounds the primary underdrain collection pipes and the toe drain pipe. The piezometer cables will run through the drainage layer to the upstream embankment slope. The cables will be routed up the upstream slope to a temporary readout station on the embankment crest. The cables will be secured to the upstream geomembrane liner by placing a strip of HDPE geonet above the cables on the primary layer that is spot extrusion welded.

Locations of the Impoundment Piezometer pairs are presented on Table 1 and readout station locations are presented on Table 2.

PZ-WI Series – Drainage Layer Above WRD Lining System

A VW piezometer (PZ-WI series) will be placed in the Drainage Layer adjacent to the primary collection pipe at the outlet from the WRD pad. The cables will be routed to a Readout Station RS-2 installed along the access road adjacent WRD Pad berm at the haul road as shown on Figure 1 and Table 2. Locations of the WRD Impoundment Piezometer pair and Readout Station RS-2 are presented in Table 1.

2.1.3 Vibrating Wire Underliner Piezometers

PZ-TU Series – Below TSF Lining System

Two VW piezometer pairs (PZ-TU series) will be installed below the GCL of the TSF lining system within the subgrade and at the general locations as the PZ-TI series located at the upstream toe of the Stage 1 embankment, immediately below the underdrain outlet channel to monitor development of pore pressures below the TSF lining system.

The signal cables will be bedded and routed in a cable trench in the subgrade embankments. The signal cable will route adjacent to the underdrain channel to Readout Station RS-1 on the east side of the underdrain channel adjacent to the reclaim pond and access road as shown on Figure 1 and Table 2. Locations of each TSF basin Underliner Piezometer pair are presented in Table 1.

PZ-WU Series – Below WRD Lining System

An Underliner Piezometer pair (PZ-WU series) will be installed below the GCL of the WRD lining system and within the subgrade. The signal cables will be bedded in a cable trench in the subgrade below the containment berm and be routed to Readout Station RS-2 as shown on Figure 1 and Table 2. Location of the WRD Underliner Piezometer pair is presented in Table 1.

2.2 Underdrain Flow Monitoring

Parshall Flumes will be installed along the TSF and WRD underdrain outlet pipes in the underdrain channel prior to discharge to the reclaim pond (Figure 1). The Parshall Flumes will be permanent installations, capable of measurement of open channel flow (i.e. not pipe full) flow rates. The Parshall Flumes will allow independent assessment of the performance of the underdrain pipes and provide flow rate data for use in calibration of the water balance model. Three Parshall Flumes (TUF-1 through 3) will monitor underdrain flow rates from the TSF Basin. One Parshall Flume (WUF-1) will monitor underdrain flow rates from the WRD Pad.

Ultrasonic Transducers will be mounted to each Parshall Flume to monitor flow rates. Signal cables from the ultrasonic transducers will be routed overland to Readout Station RS-3 located adjacent to the TSF reclaim pond as shown on Figure 1 and Table 2. Locations of each underdrain monitoring flume are presented in Table 1.

2.3 Survey Monuments

Dam crest survey monuments will be installed along the North and West Embankment crests for each construction stage. The crest survey monuments monitor vertical and horizontal displacements of the embankment after construction to assess settlement and horizontal movement of the embankment.

Survey monuments will be imbedded into the embankment at least 18 inches and constructed of corrugated CPE pipe backfilled with Lean Mix Concrete and a 2.5-inch diameter flush-mounted brass survey cap cast into top surface. For each stage of construction, two survey monuments will be installed along the downstream crest of the North Embankment and two monuments along the West Embankment. The locations of the survey monuments are shown on Figure 1. Locations of dam crest survey monument are presented in Table 1.

2.4 Inclinometers

Three sets of inclinometers (INC1, INC2, and INC3 series) will be installed through the North and West embankments at the locations shown in Figure 1 to monitor stability of the embankment. For each construction stage, two inclinometers will be installed in North Embankment. One inclinometer will be installed in the West Embankment for Stages 2 and 3, each. No inclinometer will be installed in the West Embankment during Stage 1.

Prior to construction of subsequent stages, existing inclinometers will be abandoned by backfilling with bentonite-Type II cement grout mix or flowable concrete backfill. At the completion of each subsequent stage of embankment expansion, three new inclinometers will be installed for Stage 2 (INC2-1, INC2-2, and INC2-3) and Stage 3 (INC3-1, INC3-2, and INC3-3).

The bottom of each inclinometer casing was set below the deepest anticipated potential critical failure surface below the embankment. The inclinometer alignment grooves on the casings are to be designated as “A” axis and “B” axis. The “A” axis is to be installed perpendicular to the dam alignment to monitor inclinations in the direction of potential movement. Location and total depth of each inclinometer is presented on Table 1. The top of the inclinometer will be protected using a steel surface completion and traffic bollards on the staged dam crest.

2.5 Leak Detection

The TSF and WRD are equipped with leak detection systems to monitor the performance of the containment systems. Although leak detection systems do not directly indicate geotechnical performance of the TSF and WRD, they can be used as an early warning system for instrumentation that may experience elevated pore pressure that would relate to geotechnical stability. Therefore, leak detection of the TSF and WRD is included in this Plan.

Leak detection system will be installed during all stages of construction and will consist of:

- Perforated 2-inch diameter Schedule 80 PVC pipes installed below the primary geomembrane liner in areas where concentrated underdrain flows are expected in the TSF and WRD basins for all stages of construction
- Secondary containment geomembrane liner, geonet leakage collection recover system (LCRS) with HDPE evacuation riser pipe at TSF reclaim pond
- Secondary containment pipe (dual containment HDPE piping) for the Reclaim Pipe from the reclaim pond to the Mill
- Secondary containment pipe (dual containment HDPE piping) for the Tailings Delivery Pipe from the Mill to the TSF
- Secondary containment pipe (dual containment HDPE piping) for the Supernatant Return Water Pipe from the TSF to the Mill
- Secondary containment pipe (dual containment HDPE piping) for the WRD Underdrain Pipe from the WRD to the TSF basin
- Visual monitoring of the underdrain channel from the TSF basin to the reclaim pond

The leak detection pipes report to independent risers for monitoring and fluid evacuation. Locations of the leak detection piping and monitoring risers are shown on Figure 1.

Dual containment piping will be monitored visually during dry climate conditions as discussed in Section 5.2.9. All outlet points for dual containment piping are located above either the TSF basin, underdrain channel, or reclaim pond lining systems.

3.0 ACTIONS FOR DAMAGED OR LOST MONITORING POINTS

Over the course of monitoring or data collection, it may be discovered that one or more monitoring points has become damaged or lost. Inclinometer and survey monitoring points installed on the Stage 1 and Stage 2 embankments will require abandonment or relocation during the subsequent dam raises.

For all other instrumentation, if damaged or disturbed, readings will still be taken, if possible, and the damage reported. If lost or inaccessible, reasonable attempts will be made to access the point and the reason for inaccessibility will be reported. Damaged or lost monitoring points will be noted on the data collection sheets and remitted to those responsible for review and interpretation. These notes should include comments regarding the condition of the monitoring point and the feasibility of repairing a damaged monitoring point.

The Operator staff reviewing the data and preparing the monitoring report will be responsible for recommending actions regarding these lost or damaged monitoring points. The recommendations will also consider input from the EOR. Actions may include replacement, abandonment, or continued use, and such actions will be based on trends observed in the point or other points in its vicinity prior to the occurrence of damage.

4.0 MONITORING METHODS

4.1 Monitoring Frequency

Monitoring frequencies will generally be quarterly but will be increased during staged embankment construction and may also be triggered by visual observations, earthquake, intense rain or flood events, above-average seasonal precipitation, or Trigger Level readings from monitoring points. The monitoring frequencies are provided in Table 4 through Table 10.

4.2 VW Piezometers

4.2.1 Description and Specifications

The recommended VW piezometers and data loggers are manufactured by RST Instruments, based in Maple Ridge, British Columbia. The piezometers are pluck-type vibrating wire sensors with built-in thermistors.

Underliner and Impoundment VW piezometers (PZ-TI, PZ-WI, PZ-TU, and PZ-WU series) will have a pressure range of 0 to 100 psi with a resolution of 0.03 psi at 100 psi (Model Number VW2100).

Embankment Foundation VW piezometers (PZ-TF series) will be standard VW piezometers prefabricated for nested construction (Mutli-point Piezometer Strings) and will have a pressure range of 0 to 150 psi with a resolution of 0.04 psi at 150 psi (Model Number VW2100MP). Nesting of the Embankment Foundation VW piezometers will be at the vertical intervals described in Section 2.1.1.

A single channel VW portable readout (model number VW2106), will be provided for all VW piezometers for instantaneous field measurements during and after installation. The readout will measure a frequency range of 400 Hz to 6000 Hz, a temperature readout range between -50 and 80 °C, with a frequency resolution of 0.01 µs and temperature resolution of 0.1 °C.

After initial installation, Data loggers and multiplexers will be installed within each Readout Station to collect real-time measurements of all VW piezometers. The RST FLexDAQ system is recommended. The RST FlexDAQ system includes a CR6 data logger, manufactured by Campbell Scientific, Inc. of Logan, Utah, and an RST Flexi-Mux multiplexer system capable to managing the quantity VW piezometer signal cables at each Readout Station presented in Table 2. Each Readout Station stall will be equipped with an internal or solar power supply, lightning protection, and weatherproof enclosure.

If required by Calico, each Readout Station can be equipped with cellular, satellite, ethernet, or radio transmission capabilities to connect to the Mine's wired or wireless communication network for remote and real time monitoring.

Specifications, installation instructions, and detailed operation instruction sheets for VW piezometers, single channel portable readout, and data loggers and multiplexers, are presented in Appendix A.

4.2.2 Accuracy

The Impoundment and Underliner PZ-TI, PZ-WI, PZ-TU, and PZ-WU series VW piezometers will have a pressure range of 0 to 100 psi with a resolution of 0.03 psi at 100 psi (Model Number VW2100).

VW piezometers (PZ-TF series) will be of standard VW piezometers prefabricated in nested construction (Multi-point Piezometer Strings) and will have a pressure range of 0 to 150 psi with a resolution of 0.04 psi at 150 psi (Model Number VW2100MP).

For optimum accuracy, water level measurements should be taken using the same VW data recorder or datalogger and should be measured and recorded to the nearest 0.1 Hz.

4.2.3 Installation Protocol and Quality Control

During installation of the VW piezometers, recommended manufacture installation procedures are to be followed. The EOR shall oversee or directly perform the installation of VW piezometers. During installation, an RST VW2016 portable readout device, manufactured by RST Instruments, will be used to record initial and baseline readings. Upon acceptance by the EOR, the VW piezometers may continue to be monitored by the Operator using the RST VW2106 readout device approved by the EOR or install a remotely operated data logger.

If a remotely operated data logger is installed, an RST FlexDAQ Data Logger and Flexi-Mux Multiplexer, manufactured by RST Instruments can be installed at each Readout Station where VW piezometer signal cables are terminated. Each Readout Station should be equipped with a suitable quantity of Flexi-Mux Multiplexers to allow concurrent connection of all VW piezometers at each Station.

4.2.4 Monitoring Protocol and Quality Control

Locations and identification of the piezometers are summarized in Figure 1 and Table 1. The Monitor will refer to the checklist/table of active piezometers during monitoring to ensure that all piezometers have been measured.

The VW piezometers will be measured using RST VW2016 portable readout device or RST FlexDAQ data logger. Initial calibration and continuity testing of the VW piezometers should be performed with the RST VW2016 portable readout device during installation to ensure all Impoundment Piezometers are functioning properly.

Portable Data Recorder

When taking readings with the VW2016 portable readout device, the following protocol, field calibration, and measurement procedures will be followed:

- Bring the water pressure readings from the previous survey and check current water head against the previous survey to identify in the field any unusual piezometric readings.
- Turn on the VW data recorder; check the battery and replace if necessary.
- The connection wires should be cleaned prior to use as necessary.
- Take the readings, including both temperatures and frequencies, and examine the accuracy by comparison of the new readings and previous readings.
- If a significant discrepancy is observed, check wire connections and take another reading. Repeat the above two steps until the difference between two consecutive readings is within ±0.2 Hz.
- Measure water level readings to the nearest 0.1 Hz. The readings should be recorded only after piezometric readings are stable.
- In the event of an unusual reading, the piezometric level will be measured again to confirm or revise the original measurement.
- The Monitor will also enter on the form the loss or damage of a piezometer with a description of any damage and whether the piezometer remains usable.

After the data is collected, the measured frequencies and temperatures will be converted into water pressure (fluid head in feet) using the spreadsheet attached in Appendix B. Depending on the selected instrumentation manufacturer, the final spreadsheet implemented may vary based on specific requirements of the manufacturer.

Data Logger

When taking readings with the RST FlexDAQ data logger, the following protocol, field calibration, and measurement procedures will be followed:

- Data collection frequency should be set to a minimum one reading per day per instrument.
- Bring the water pressure readings from the previous survey and check current water head against the previous survey to identify in the field any unusual piezometric readings.
- Download recorded data from data logger using either the remote communication system or hardwire connection to the data logger.
    - Downloaded readings should include the following data:
        - Channel Number
        - Instrument ID as defined in this Plan
        - Instrument serial number
        - Raw data reading (Hz, or digits and temperature) to the nearest 0.1

  - Calculated pressure (if programmed) to the nearest 0.1 feet

- Examine the accuracy by comparison of the new readings and previous readings.
- If a significant discrepancy is observed, check wire connections and take another reading. Repeat the above two steps until the difference between two consecutive readings is within ±0.2 Hz.
- In the event of an unusual reading, the piezometric level will be measured again to confirm or revise the original measurement.
- The Monitor will also enter on the form the loss or damage of a piezometer with a description of any damage and whether the piezometer remains usable. The Monitor will also record the date and time when readings were lost.

After the data is collected, the measured frequencies and temperatures will be recorded in a separate database file and provided to the EOR on a monthly basis. If the data logger is not configured to calculate pore pressures, the spreadsheet attached in Appendix B will be used. Depending on the selected instrumentation manufacturer, the final spreadsheet implemented may vary based on specific requirements of the manufacturer.

Manufacturer's calibration factors are applied in the spreadsheet and can be applied to the data logger configuration files. According to manufacturer's specifications in Appendix A, elevation and barometric calibration will not be required since the piezometers are unvented and buried at depths are not influenced by ambient barometric pressure.

4.3 Flow Monitoring

4.3.1 Underdrain Flumes

Recommended underdrain flow monitoring will be performed by installing open channel flumes adjacent to the reclaim pond within the underdrain channel as shown on Figure 1. A total of four flumes will be installed to monitor independent underdrain flow rates from the TSF basin (TUF Series) and from the WRD pad (WUF Series). The flumes will each be a 2-inch fiberglass reinforced Parshall Flume manufactured by TRACOM, Inc. of Alpharetta, Georgia.

The flumes will be located adjacent to the reclaim pond and within the lined underdrain channel. Flumes will be installed such that the flume crest is level in all directions. The flumes will be placed in pairs such that two flume pairs are separated by a minimum 3 feet of clear span for access. Flumes will be cast in concrete to prevent movement.

Mounting brackets will be prefabricated on each flume above the throat for mounting of the ultrasonic flow meter.

Manufacturer shop drawings, specifications, installation instructions, and detailed operation instruction sheets for VW piezometers, single channel portable readout, and data loggers and multiplexers, are presented in Appendix A.

4.3.2 Water Level Measurements

Recommended flow meters for the underdrain monitoring flumes will be the Dynasonics iSonic 4000 Open Channel Flow Meter by Badger Meter, Inc. of Milwaukee, Wisconsin for fixed-installation open channel flow meter type applications. The iSonic 4000 flow meter measures the open channel water surface level using the EchoPod

DL-10 sensor manufactured by Flowline of Los Alamitos, California. Flow rates are calculated in the iSonic 4000 by programing the data logger with the Parshall Flume geometry provided by the Flume manufacture.

Flow rates are measured by using ultrasonic waves and rely on fluid level, and average velocity measurements using acoustic doppler profiling technology. The electronics are DC powered (12V) but can be equipped with an AC power source if selected by the Owner. The electronics incorporate a datalogger that can store flow rate data in memory for later retrieval either through modem or via a USB link to a computer. The data logger can store up to 130,000 distinct readings of flow rate at pre-defined intervals. However, measurement intervals are adjustable from 1 second to 24 hours. The integral LCD display provides instantaneous flow rate reading as well as date, time, and water level.

Specifications, installation instructions, and detailed operation instruction sheets for VW piezometers, single channel portable readout, and data loggers and multiplexers, are presented in Appendix A.

4.3.3 Accuracy

The ultrasonic transducers installed on the Parshall Flumes can measure flow rates ranging from a minimum of 3 gallons per minute (gpm) to 194 gpm. The EchoPod DL-10 sensor has a measurement accuracy of 0.125 inches. This accuracy equates to an error of between 0.8 gpm and 4 gpm depending on the water level within the flume.

4.3.4 Monitoring Protocol and Quality Control

The underdrain pipe flow monitoring will be used to confirm the TSF and WRD underdrain system are functioning properly and flows are not obstructed, limiting drainage of the tailings and WRD that could raise the hydraulic head on the liner, and possible reduction of predicted tailings consolidation.

The underdrain flow rates will vary depending on tailings thickness above the drainage layer. During initial tailings deposition of each stage of construction, a high percentage of the process flow will be collected by the underdrain and report to the reclaim pond through the flumes.

The pipe flow rate data will also be used to calibrate the process water balance. Flow rate and totalized volume data at 15-minute increments should be collected at least quarterly.

4.4 Dam Crest Survey Monuments

4.4.1 Description and Specifications

Recommended dam crest survey monuments are 2½-inch diameter cast-in-place brass survey cap (Model M/M-BCS-2 1/2FS) manufactured by Surv-Kap LLC of Tucson, Arizona. The survey cap will be installed in a 12-inch diameter CPE pipe that is backfilled with grout. The monument will be embedded into the dam crest a minimum of 18-inches.

The northing, easting, and elevation of the top of the survey monuments will be monitored using GPS surveying equipment equipped with a high-accuracy receiver. The position of the monuments will be measured using the Post-Process Mode on the GPS receiver.

If elected to do so by Calico, remote GPS monitoring stations can be installed in lieu of survey monuments. The remote GPS monitoring stations will collect real-time location information and store the reading in a data logger that can be retrieve either by direct download or remote communication equipment.

4.4.2 Accuracy

Accuracy of survey monitoring point readings is a function of the equipment used. The Surveyor will use methods and equipment to achieve an accuracy in each of the northing, easting, and elevation readings of about 0.04 feet.

Crest Monument surveys will be completed and reported to the nearest 0.01 feet for northing, easting, and elevation.

Real-time data recording through remote GPS monitoring stations would provide a daily average of all collected GPS data and account for variability in GPS satellite communication. Whereas instantaneous GPS readings using conventional survey equipment will include a level of inaccuracy due to variability in GPS satellite communications.

4.4.3 Calibration and Maintenance

The Surveyor will be responsible for regular equipment maintenance and reading corrections for atmospheric conditions, such as temperature and pressure. The Operator will be responsible for maintaining the survey monuments and making sure the survey monuments are clear of fill materials, are accessible, and remain properly marked or flagged to reduce the risk of damage.

4.4.4 Monitoring Protocol and Quality Control

The locations and designations of crest survey monuments are summarized in Figure 1, and Table 1. The Surveyor will review the figure and table during monitoring to ensure that all points have been surveyed. Prior to mobilizing to the site, the Surveyor will enter the coordinates and elevations of each point from the most recent previous survey. This data will be used as a quality control check against current readings to allow additional surveying in the event of unusual readings.

The position of all survey monuments will be shot at the top and center of the monument or survey cap. When surveying, if any monument appears to be disturbed, a note will be made using the example visual observation sheet attached in Appendix B. The Surveyor will also enter on the monitoring form the loss or damage of a monitoring point, with a description of any damage and whether the monitoring point remains usable.

4.5 Inclinometers

4.5.1 Description and Specifications

Recommended inclinometer instruments are RST Digital MEMS Inclinometer System manufactured by RST Instruments. The system includes the 2.75-inch diameter Snap Seal inclinometer casing, Digital MEMS Inclinometer digital probe, 200-foot long Kevlar® reinforced polyurethane cable, the Ultra-Rugged Field PC, and Inclinalysis software.

Tilt is positive on one side of the vertical and negative on the other side. Tilt is converted to a lateral displacement and the incremental lateral distances are summed to give a cumulative displacement. The probe measures tilt in two perpendicular directions; parallel to the probe wheels (A-orientation) and perpendicular to the wheels (B-orientation). The A-orientation should be in the direction of the expected slope movement.

The specifications for the casing, probe, data recorder, and software system are provided in Appendix A. The inclinometer probe does not measure displacement directly. Instead, it measures the tilt of the casing.

4.5.2 Accuracy

As documented in the specifications, the accuracy of the recommended inclinometer probe is ±0.02 inches over 100 ft, which is well within the accuracy requirements of the project.

4.5.3 Monitoring Protocol and Quality Control

Using proper care of the inclinometer probe and recommended sampling measurement protocol will result in little error in inclinometer readings and little need for calibration. However, the inclinometer probe should be field checked for calibration before each round of monitoring and, if needed, be calibrated by a qualified person such as the manufacturer.

The survey is performed by lowering the probe in the grooved casing to the bottom of the bottom of the hole. The survey is started in the same groove for each survey (referred to as the 0-direction) with the wheels parallel to the expected direction of slope movement. As the probe is raised it is stopped at typically 2 feet intervals and allowed to stabilize. Pressing a button on the datalogger records a reading. Readings are taken at 2 feet intervals to the top of the hole.

The probe is then rotated 180 degrees (referred to as the 180-direction) and the survey repeated. Ideally the sum of the two readings at each interval (referred to as checksums) should be zero since the readings have opposite signs. In practice, variations in casing grooves, the positioning of the probe and offset within the probe itself contribute to non-zero check sums. A check sum is the sum of the 0- and 180-direction reading at the same depth. The average of the 0- and 180-degree readings are applied to compute the lateral displacements.

Locations and identifications of planned inclinometer casings are shown on Figure 1, and Table 1. The Monitor will refer to Table 10 of this report during monitoring to ensure that all inclinometers have been measured. The Monitor will also enter on the field form the loss or damage of an inclinometer casing, any blockage in the inclinometer casing that prevents a full sounding, a description of any damage to the inclinometer casing, and whether the casing remains usable.

The inclinometer readings will be taken using the Ultra-Rugged Field PC, manufactured by RST Instruments. With this system, readings are taken at depth intervals of 2 feet. The following procedures will be used for collecting inclinometer readings:

- Make sure that the battery is charged prior to mobilizing to the site.
- For the highest accuracy, always use the same probe and control cable. If a different probe is used, be sure to note the serial number of the probe being used for each data set so corrections can be made during data processing.
- Always use the same reference for the depth marks on the control cable. If one technician uses the cleat on the pulley assembly as reference and another technician uses the top of the casing as reference, there will be a one-foot variation in the probe position from survey to survey. Accurate results require placement repeatability of ¼ inch or less.
- Mark the “A“ axis groove in the casing with paint or with a notch in the casing. Always start the survey by placing the top wheels of the probe in that groove.

- Two sets of readings will be taken in each set of two slots. For each set of slots, the first reading will be taken on the “A” axis position (top wheels of probe in the 0-direction). The second reading will be taken by rotating the instrument 180 degrees (top wheels in the 180-direction, “B” axis).
- For future new casing installation, survey the casing two to three times and compare the “checksum.” Choose a representative set as the initial reading set. All other data sets will be compared with this set.
- It is preferable to use the same software and same user for data input and presentation. See Appendix B for the example sheet that shows the format used for data reporting.

Before submitting the data to the Operator personnel and the EOR for review and interpretation, the Monitor taking the readings will perform a quick quality control check by completing the following:

- Plot the results and compare with the historic readings. If movement distribution or magnitude does not roughly follow or match the historic data, a new reading will be taken to validate the reading. The magnitude of the largest movement readings between consecutive probing should be within the accuracy of the inclinometer probe.
- Compare the movements of the inclinometer at the ground surface with that of nearby surface monuments. If the difference of recent surface movements is found to be greater than ½ inch, a new reading should be taken to validate the reading of the inclinometer. The magnitude of the largest movement readings between consecutive probing should be within the accuracy of the inclinometer probe.

4.6 Leak Detection

The Monitor will perform inspection of leak detection systems defined in Section 2.5 and findings recorded on facility-specific checklists (to be prepared prior to operation). Leak detection monitoring will be performed a minimum of once per week.

Leak detection monitoring will be performed using both visual and mechanical detection methods. For leak detection risers installed to monitoring the TSF basin, reclaim pond, and WRD pad, leak detection will be performed using a field mirror to observer the riser sumps.

For dual containment piping and secondary containment channels, visual observations during dry weather will be recorded.

If convict water is observed in any of the leak detection risers or dual containment monitoring points, the following will be performed by the Monitor:

- Record the date and item leakage is observed
- Record the location where leakage is observed
- Evacuate the convict fluid into an area where primary containment exists
- Record total volume of convict water evacuated
- Turn off submersible pump (if used for fluid evacuation) and observe if leak detection riser continues to fill with water. Record observations.

If convict water continues to report to leak detection monitoring point, immediately notify the Operator. The Operator should notify the EOR to assist with determination in the source of the leak and develop a mitigation or corrective action plan.

Prior to operation, the EOR and Operator will prepare facility-specific checklists to be used by the Monitor or EOR for visual inspections. The documentation checklist, as well as any supporting documentation, will be submitted to the Operator staff responsible for reporting and coordinating with the EOR.

4.7 Visual Monitoring

Visual observations will typically be made quarterly coinciding with the measurement of Monitoring Points. Additional inspections may be completed during construction, following large storm events, earthquakes, and operational abnormality, or may be triggered by a Monitoring Point Reading. The visual observations will be completed by the Operator's staff or its Surveyor but should be completed at least annually by the EOR.

Visual monitoring will include:

- Walking the crest and toe of the embankment and observing surface conditions
- Checking the conditions of exposed Monitoring Points, readout stations, and wirings (where exposed)
- Observing upstream and downstream slope conditions of the embankment and ground conditions near the downstream toe of the embankment
- Inspection of all leak detection monitoring points

Visual monitoring is intended to identify new development or changes in surface cracks, surface displacements, bulges in slopes, slumps, sag ponds (depressions), and seepage and/or wet areas.

Observations of any changes will be documented by:

- Recording the locations observed on a drawing
- Recording an estimate of the observed change in writing, including the magnitude of the change (seepage flow, wet area, width or length of crack, etc.
- Photographing the change

An example visual inspection checklist is presented in Appendix B. Prior to operation, the EOR and Operator will prepare facility-specific checklists to be used by the Monitor or EOR for visual inspections. The documentation checklist, as well as any supporting documentation, will be submitted to the Operator staff responsible for reporting and coordinating with the EOR.

5.0 MONITORING AND ACTION PLAN

This section provides guidance on expected trends in both short-term construction monitoring and long-term monitoring so that unusual readings can be identified, and appropriate actions be taken in response to those readings. Readings from the monitoring points that are above normal trends will activate Trigger Levels that increase in severity from Trigger Level 1 to Trigger Level 3 with associated changes in the monitoring frequency and notifications.

5.1 Normal Trends

The following normal trends are anticipated during and after staged embankment construction:

VW Foundation Piezometers (PZ-TF Series): These piezometers monitor pore pressures in the foundation clay soils beneath the North and West Embankments. During staged construction, some short-term increases in pore pressure in the Foundation Piezometers can be expected. After staged construction, pore pressures are expected to dissipate, and piezometric readings should decrease over time. During embankment fill placement, pore pressure readings should be reviewed regularly by the EOR to identify any concerns of lowered stability.

VW Impoundment Piezometers (PZ-TI and PZ-WI Series): These piezometers monitor water pressure development in the TSF and WRD underdrain systems prior to water leaving the TSF impoundment or WRD pad. The piezometers monitor fluid head in feet. Under normal conditions, these piezometers should be monitoring fluid heads of less than 3 feet. Higher heads could be caused by closed valves where underdrain outlets enter the reclaim pond, an obstruction in the underdrain outlet pipe, or construction activity.

VW Underliner Piezometers (PZ-TU and PZ-WU Series): These piezometers monitor water pressure development in the native soils or prepared subgrade below the TSF and WRD lining systems at the upstream toe of each facility adjacent to, and below, the VW Impoundment Piezometers. The piezometers monitor fluid head in feet. Under normal conditions, these piezometers should be monitoring fluid heads of negative or zero feet. Higher heads could be caused construction related pore pressures or leakage in the impoundment lining system.

Underdrain Flumes (TUF and WUF Series): These flumes and associated flow meters measure flow rates of each underdrain pipe prior to release in the reclaim pond. Flow rates are expected to fluctuate throughout operation depending on the stage of deposition and the area of exposed TSF basin and WRD pad. As tailings deposition and waste rock stacking progress, the exposed basin and pad areas will reduce, and the underdrain flow rates are expected to drop to a lower and steady-state condition.

Dam Crest Survey Monuments (SM Series): Crest survey monuments will measure both vertical and horizontal movement during and after staged construction. Only minor movements can be expected with movements expected to diminish after staged construction has been completed. If dam crest survey monuments are monitored during construction, movements are expected to be larger.

Inclinometers (INC Series): Inclinometers will monitor vertical and lateral stress relaxation in the embankment fill and foundation clay, in addition to monitoring for the presence of shear displacements which could be indicators of lowered stability. The normal condition is some slow lateral deformation without signs of shear deformations.

Leak Detection Systems: Leak detection systems will monitor for convict water between primary and secondary containment systems within the TSF impoundment, underdrain channel, reclaim pond, WRD, and process pipelines. The normal condition is no convict water detected.

5.2 Trigger Levels

The following section presents measurable or quantifiable values and observations for determination if a reading or event activates a Trigger Level. If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

Trigger Levels listed below are specific to seismic activity and geotechnical monitoring of instruments. Additionally, increased monitoring frequency of the process solution containment systems should be performed in the event of extreme weather conditions such as prolonged heavy rainfall, prolonged freezing or intense snowfall..

5.2.1 Seismic Activity

During operation of the TSF, there is a potential for seismic activity. In the event that seismic activity is recorded or observed at the Site, the following Trigger Levels will be used to determine the level of response required:

Trigger Level 1: A seismic event of a Magnitude IV (Light) earthquake on the Modified Mercalli scale. A Magnitude IV is characterized as being felt by most people; windows and doors are rattled; creaking walls and/or a sensation like a heavy truck striking a building are felt; and vehicles are noticeably rocked. No injuries, severe property damage or disruption to operations.

Trigger Level 2: A seismic event of a Magnitude V to VII (Moderate to Very Strong) earthquake on the Modified Mercalli scale. A Magnitude V to VII is characterized as being felt by all people; many people are frightened and run outdoors; some windows broken; cracked plaster on building walls; unstable objects overturned; sloughing of embankment; sliding or rockfalls outside of construction activity; and disturbance of poles and other tall objects is noted. Injury or severe property damage occurs, disruption to operations.

Trigger Level 3: A significant earthquake (M ≥ 7.2) within 17 miles of the TSF regardless of observable damage at the Site or a seismic event of an earthquake of Magnitude VIII or larger (Severe or greater) on the Modified Mercali scale. A Magnitude VIII or greater is characterized as being felt by all people; some people are knocked off balance; changes are noted in the water depths of wells; considerable damage occurs in buildings; panel walls are thrown out of frames in buildings; heavy furniture is overturned; the ground cracks conspicuously; waves can be seen on the ground surface; and underground pipes are broken. Severe injuries or fatality, widespread property damage, operations severely affected or shut down.

For up-to-date earthquake activity, the Monitor should regularly monitor the United States Geologic Survey's website for Earthquake Hazards, Latest Earthquakes map for earthquakes in the near vicinity (within 60 miles) of the Grassy Mountain Mine site (USGS 2019, https://earthquake.usgs.gov/earthquakes/map/).

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.2 TSF Foundation Piezometers

These piezometers monitor pore pressure in the clayey foundation soils that underly the TSF. The regional groundwater is below the depth of the Foundation Piezometers and under normal circumstances, these piezometers are expected to record unsaturated conditions (zero or negative pore pressures) or possibly fluid heads of less than 2 to 3 feet reflecting local perched zones of groundwater or immediate pore pressure increases due to construction loading.

During staged embankment construction, the embankment will impose loads on the foundation of up to approximately 75 psi. Foundation soils with high degrees of saturation may develop excess pore pressures that may not dissipate at the rates of construction loading, resulting in a reduction of the effective stresses and the potential for instability.

Pore pressure readings in Foundation Piezometers in the TSF embankment foundation clay (PZ-TF Series) will be used as indicators of reduced confidence of stability during periods of staged construction and long-term

operation. The following discussion provides the Monitor with information on the impact of high piezometric pore pressure readings and helps set trigger levels for stability-related piezometers.

5.2.3 Pore Pressure Measurement in Foundation Piezometers

The piezometers installed in the dam foundations (PZ-TF Series) are used to monitor pore pressure development in the clay foundation and its impact on the static stability of the North and West Embankments.

As indicated during the 2017 and 2019 geotechnical field investigations, and as modeled in the stability analyses that supported the construction-level design, groundwater is sufficiently deep such that existing groundwater conditions will not influence overall long-term stability of the tailings dam. However, the geotechnical investigations in the foundation clay soils identified zones that are close to saturation and interbedded with less saturated sandy zones, although no static water level or piezometric surface was encountered. There is a risk that staged construction could temporarily create pore pressures in the foundation clay soils, which could lead to a short-term reduction in the strength of the foundation, potentially influencing short-term stability of the dam.

Personnel responsible for monitoring and evaluating the pore pressures in the Foundation Piezometers need guidelines for what piezometric levels constitute a concern so that notifications and evaluations can be made during staged construction. Accordingly, Golder has established Trigger Levels by using stability models to compare stability response to creation and/or changes in a piezometric surface within the foundation clay soils below the embankments.

The following stability case scenarios were evaluated to develop Trigger Levels using the most critical dam sections for the North and West Embankments. For assignment of these Trigger Levels, Golder assumed that pore pressure under the embankment would be developed uniformly at the levels recorded in the Foundation Piezometers. The following stability cases were evaluated:

- Dry conditions with no pore pressure development in foundation clay soils
- Geotechnical material properties used in the construction-level design are presented on Table 3.
- Foundation piezometric elevation in the foundation clay soils required to reduce the overall static factor of safety:
  - Trigger Level 1: Below the design criteria of 1.5
  - Trigger Level 2: To about 1.3
  - Trigger Level 3: To about 1.05

For each of the above cases, the critical failure mode is a deep rotational failure through the dam and foundation clay soils under static conditions. Results of the trigger level stability analyses are presented in Appendix C.

The stability analysis results indicate that significant development and/or changes in pore pressures in the foundation clay soils will affect the stability of the embankment.

It should be noted that short-term development and fluctuation of piezometric levels within the foundation clay soils would only be expected during staged construction or in the event of a significant leak in the TSF impounding lining system. Any detection of pore pressure should be confirmed with a minimum of two consecutive readings.

If significant changes of pore pressures are measured during construction, the EOR should review the readings to determine whether the pore pressure response is expected or not, and to evaluate its potential influence on the stability and performance of the embankment. If the EOR's review identifies a potential stability risk during active embankment fill placement, a solution may be to slow fill placement to allow sufficient pore pressure dissipation.

Build-up of pore pressures in the embankment foundations when embankment loading is not ongoing could signal high leakage rates through the impoundment liner or a rise in the regional water table.

Trigger Level criteria and TARPs are the same during construction and outside of construction with only the frequency of monitoring reduced when construction is not on-going. Based on the above stability analyses, Table 4 presents the Monitoring Plan and Trigger Levels for the Foundation Piezometers.

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.4 Impoundment Piezometers

The piezometers installed at the base of the TSF impoundment and WRD pad, within the Drainage Layer above the lining system, and adjacent to the primary underdrain collection pipes (PZ-TI and PZ-WI Series).

These piezometers monitor pore pressure development in the underdrain system prior to water exiting the impoundment or pad. The underdrain spacing design was developed based on estimates on the hydraulic conductivity of the tailings and the gradient of the lined surface and was intended to limit pore pressure on the lining system to reduce the potential leakage through the liner if there were a hole. Under normal conditions, these piezometers are predicted to record fluid heads less than approximately 3 feet.

High fluid head levels at the base of the tailings may signal an impeded collection system and Drainage Layer potentially resulting from crushed pipes, clogged Drainage Layer or Filter Fill, or an obstruction of the underdrain outlet pipes.

Trigger Levels for the Impoundment Piezometers are separated into three groups of instruments:

- Impoundment Piezometers PZ-TI-1 and PZ-TI-2 are located immediately adjacent to the Stage 1 upstream toe and monitor the performance of the underdrain pipes as it exits the lined TSF impoundment.
- Impoundment Piezometers PZ-TI- 3 and PZ-TI-4 are located within the TSF basin and monitor performance of the drainage layer and underdrain collection pipe network. Elevated pore pressures within the TSF Basin do not pose a risk to geotechnical stability, therefore, higher pore pressures Trigger Levels are assigned.
- Impoundment Piezometer PZ-WI-1 is located at the upstream toe of the WRD perimeter containment berm and monitors the performance of the underdrain pipe as it exits the lined WRD pad.

Table 5 and Table 6 provide the Monitoring Plan for the TSF and WRD Impoundment Piezometers, respectively.

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.5 Underliner Piezometers

These piezometers monitor water pressures below the TSF lining system at the upstream toe of the Stage 1 embankment and the WRD containment berm. These piezometers should indicate dry (zero or negative pore pressures) conditions. Development of saturated conditions or significant head pressures would indicate leakage

through the liner system. Table 7 and Table 8 present the Monitoring Plans and Trigger Levels for the TSF and WRD Underliner Piezometers, respectively.

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.6 Underdrain Flow Monitoring

The underdrain flow rates will vary depending on the depth of burial of the underdrain piping. During the early stage of tailings construction, a high percentage of the process flow will be collected by the underdrain system. During tailings deposition directly onto the TSF basin, combined underdrain flows are predicted to be as high 100 gpm. As tailings cover the TSF basin, combined underdrain flow rates are expected to drop to between about 15 gpm and 30 gpm.

No Trigger Levels are required for the underdrain flows. If Trigger Levels are activated for the VW Impoundment or Underliner piezometers (PZ-TI, PZ-WI, PZ-TI, and PZ-WU Series), the underdrain flow rates will be used in determining if a reduction in underdrain flows reporting to the reclaim pond is an indicator for adverse performance within the TSF basin.

5.2.7 Survey Monuments

Settlement of the embankment crests is anticipated in response to the consolidation settlement of the foundation clay soil and within the embankment fill due to long term settlement and consolidation. Up to 3.5 feet of foundation settlement is predicted below the maximum embankment height. Dam crest settlements are expected to be less than foundation settlements due to staged constructions and reestablishment of design dam crest elevations.

The dam crest survey monuments measure the movement of the embankment crest, including horizontal movement and vertical settlements. Movement of these monuments is expected to occur for a period of time during, and following, embankment construction and tailings deposition.

The dam crest survey monuments will be installed upon completion of each stage of embankment construction. Locations are shown on Figure 1 and the coordinates for all survey monuments are provided in Table 1 .

Trigger Levels have been assigned for dam crest survey monuments during construction and during operation (no active construction). Table 9 presents the Monitoring Plan and Trigger Levels for the dam crest survey monuments.

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.8 Inclinometers

The inclinometer measures the horizontal deformation of the embankment over the height of the embankment and into the foundation to a depth where no movement is predicted. Under normal conditions, some horizontal movement can be expected from settlements, but there should be no evidence of shear movement at a discrete depth. Shear movement is characterized as a significant differential displacement over a relatively short vertical distance. Table 10 presents the Monitoring Plan and Trigger Levels for the inclinometers.

If a Trigger Level is activated, the Trigger Action Response Plans presented in Section 5.3 will be executed.

5.2.9 Leak Detection

Leak detection systems will collect any water between primary and secondary containment layers for the TSF and WRD. In the event that fluid is detected in the leak detection risers, portable submersible pumps will be used to evacuate the monitoring risers of the convict water and reduce fluid head on the secondary containment layer.

Fluid level monitoring in the leak detection risers will be performed visually the Monitor using a field mirror or water level indicator. Any flows observed in the leak detection piping system are considered abnormal and activate Trigger Level 1. Flows observed in the underdrain channel during dry weather are considered to activate Trigger Level 1.

5.2.10 Visual Monitoring

The Monitor should watch for any signs of distress in the dam crest, upstream and downstream slopes, and foundation near the downstream toe. Distress would include vertical offsets, cracks, heaves, seepage, or wet spots during dry periods. The triggering conditions are discussed below:

- **Trigger Level 1**: Localized cracking on the crest or slopes with crack openings or vertical offsets up to ½-inch for any length of crack; any wet spots (during dry weather) or intermittent seepage from the embankment slopes or foundation near the downstream toe of the dam.
- **Trigger Level 2:** Fracture zones forming a cone-shape on the dam crest or downstream slope; any cracks or vertical offsets wider than ½ inch wide traceable for up to 20 feet in the dam crest or slopes; visible bulging or deformation at the toe area any continued or significant seepage from the embankment slopes or from the foundation near the downstream toe of the dam.
- **Trigger Level 3:** Continued propagation of cracks and slope deformation; and increase in seepage or leakage rates from visible seeps.

5.3 Trigger Action Response Plans

5.3.1 Seismic TARPS

In the event that seismic activity is recorded that is considered to meet the conditions of the seismic Trigger Levels presented in Section 5.2.1, the corresponding Seismic TARP will be implemented:

Trigger Level 1:

- Record the date and time of the earthquake and provide a description of the earthquake, such as the duration, the indicators, and the consequences.
- Inspect the fluid management systems for signs of leaks or releases and implement response measures as appropriate.
- Continue to monitor leak detection systems twice daily for two days for the presence of leaks; implement response measures as appropriate.
- Continue to monitor the VW piezometer and inclinometers twice daily for two days for presence of pore pressure increases or displacement.

Trigger Level 2:

- Record the date and time of the earthquake and provide a description of the earthquake, such as the duration, the indicators, and the consequences.
- Inspect the fluid management systems for evidence of damage and signs of leaks or releases and implement response measures as appropriate. Record all damage noted. Inspection should include all piping and vessels in the mill and process facilities. Solution and collection ponds and the tailings impoundment should be inspected for embankment movement, sudden changes in water levels, or seepage flowing from the ground in the vicinity of the pond.
- In the event of damage such that process fluid may escape, implement measures to prevent a release as soon as possible.
- Continue to monitor the VW piezometer and inclinometers twice daily for seven days for presence of pore pressure increases or displacement.
- Perform a survey of the dam crest survey monuments to detect deformation at least twice daily for seven days.
- If differential displacement has occurred in the tailings impoundment, in the tailings dam, or in solution ponds, processing will be stopped until the EOR (or at their direction) has evaluated the damage and determined that the integrity of the lining systems has not been impaired. If damage is observed in reclaim pond, solution from the pond should be recirculated to the TSF impoundment.
- If no leakage is noted in leak detection systems, continue to monitor leak detection systems twice daily for seven days.

Trigger Level 3:

- Record the date and time of the earthquake and provide a description of the earthquake, such as the duration, the indicators, and the consequences.
- Immediately notify the Process Operations Superintendent. Notification will be escalated from the Process Operations Superintendent to the Process, Environmental, Projects Managers, and the EOR.
- Cease operations until the structural integrity of the fluid management systems including the tailings impoundment and solution ponds can be inspected by the EOR (or at their direction).
- Immediately inspect the embankment and top of the impoundment for obvious deformation, cracks, raveling, or any other noticeable movements.
- Inspect the fluid management systems for evidence of damage and signs of leaks, releases or obstruction and implement response measures as appropriate.
- In the event of damage such that process fluid may escape, implement measures to prevent a release as soon as possible.
- If it is determined that the structural integrity of the facilities has not been diminished by the earthquake and there is no evidence of leaks or releases from the fluid management system, continue to monitor the leak detection system twice daily for 14 days.

- If facility is safely accessible, collect VW piezometer and inclinometers data leading up to and after the seismic event.
- If facility is safely accessible, continue monitoring the VW piezometer and inclinometers once daily for 14 days for presence of pore pressure increases and displacement.
- If facility is safely accessible, perform a survey of the dam crest survey monuments to detect deformation at least once daily for 14 days.
- Review underdrain flow-rates against previous or historic flow-rates, and immediately report any variance or anomalies to the Process Operations Superintendent.
- Check water level switches in drainage collection sump for possible malfunctions caused by line breaks or shorts. If switched off, activate immediately.
- Restart tailings deposition only after all inspections have provided satisfactory results, and release for service has been granted by Process, Environmental, Projects Managers, and the EOR.
- If facilities have been damaged beyond repair and require closure, continue to monitor the leak detection systems for those facilities through the closure period.

For a lesser earthquake (M < 7.2 and closer than 17 miles), **the same inspections will be carried out**, but deposition of tailings may continue unless the inspections indicate that continued operations may be detrimental to any component of the facility.

5.3.2 Instrumentation, Leak Detection, and Visual Monitoring TARPs

In the event that monitoring instrumentation measurement recordings, leak detection recordings, or visual observations are considered to meet the conditions of Trigger Levels presented in Section 5.2, the corresponding TARPs will be implemented:

Trigger Level 1: Not of immediate geotechnical concern to the integrity and performance of the dam. Trigger Level 1 readings or observations should be reviewed by the Monitor. If, through review, Level 1 readings are verified as accurate, the Operator shall be notified, and the Monitor shall increase the monitoring frequency to see whether they could develop to the conditions of Trigger Level 2.

Trigger Level 1 events requires notification of a reading outside of the range of anticipated values to the Operator (Tailings Supervisor) AND EOR. All or some of the following actions should be considered in response to a Trigger Level 1 event:

- Record the date and time of the trigger event and provide a description of the event and subsequent follow-up action taken by Monitor.
- One to two additional readings of the Monitoring Point(s) that exceeded the trigger level to confirm the reading(s), taken within one week of the initial reading.
- A review of the triggering readings, adjacent readings, and spreadsheet calculations to make sure the instruments are functioning properly to confirm that the problem is not associated with input or data reduction.

- Increasing the monitoring frequency of the Monitoring Point(s) with the high reading(s) and surrounding Monitoring Points.
- If not a data error, the Monitor will notify the Process Operations Superintendent. Notification will be escalated from the Process Operations Superintendent to the Process, Environmental, Projects Managers, and the EOR.
- If recommended by the EOR and/or Operator, an engineering analysis to check the implication of the conditions.
- A close out memorandum prepared to document the trigger event, investigation, engineering analyses (if any), recommendations, and follow-up action items.

Trigger Level 2: A concern for the integrity and performance of the dam. Readings or observations that exceed Level 2 will require immediate team attention and response. Trigger Level 2 may require additional monitoring, heightened monitoring, and/or initiation of remedial measures.

Trigger Level 2 events require notification and attention by the Operator and the EOR. The following actions should be implemented by the team, which should consist of Operator project management and engineers, and the EOR:

- Record the date and time of the trigger event and provide a description of the event and subsequent follow-up action taken by Monitor.
- One to two additional readings of the Monitoring Point(s) that exceeded the trigger level to confirm the reading(s), taken as soon as possible after the triggering data has been reduced.
- If not a data error, the Monitor will notify the Process Operations Superintendent. Notification will be escalated from the Process Operations Superintendent to the Process, Environmental, Projects Managers, and the EOR.
- A review of the triggering readings, adjacent readings, and spreadsheet calculations to make sure the instruments are functioning properly to confirm that the problem is not associated with input or data reduction.
- If recommended by the Operator or EOR, a site inspection by the EOR, or designee, should be performed.
- Inspection of pertinent leak detection monitoring points.
- A meeting or a conference call to discuss reading history, trends, likely causes and actions to be taken.
- Increasing the monitoring frequency of the Monitoring Point(s) with the high reading(s) and surrounding Monitoring Points.
- If not data error, a review of the site data by the EOR to assess the potential cause of the readings and to provide recommendations for additional data collection.
- If recommended by the EOR and/or Operator, an engineering analysis to check the implication of the conditions.
- If recommended by the EOR and/or Operator, a remediation plan prepared by the team.

- A review of the conditions to see whether they exceed the Environmental permitting limits.
- An individual report documenting the conditions, actions and remediation actions.
- A close out memorandum prepared to document the trigger event, investigation, engineering analyses (if any), recommendations, and follow-up action items.

Trigger Level 3: A condition of imminent concern that could lead to a failure of the dam embankment and trigger the implementation of the Emergency Action Plan (EAP) for the TSF. The EAP will be prepared and issued prior to construction.

Trigger Level 3 events require notification and attention by the Operator and the EOR. The following actions should be implemented by the team, which should consist of Operator project management and engineers, and the EOR:

- Record the date and time of the trigger event and provide a description of the event and subsequent follow-up action taken by Monitor.
- One to two additional readings of the Monitoring Point(s) that exceeded the trigger level to confirm the reading(s), taken as soon as possible after the triggering data has been reduced.
- If not a data error, the Monitor will notify the Process Operations Superintendent. Notification will be escalated from the Process Operations Superintendent to the Process, Environmental, Projects Managers, and the EOR.
- A review of the triggering readings, adjacent readings, and spreadsheet calculations to make sure the instruments are functioning properly to confirm that the problem is not associated with input or data reduction.
- Site visit by the EOR to inspect the instrumentation or monitoring point and to meet with the Operator and Monitor and review.
- Increasing the monitoring frequency of the Monitoring Point(s) with the high reading(s) and surrounding Monitoring Points.
- If not a data error, a site visit and a visual observation by the EOR as soon as possible to observe site conditions and monitoring conditions.
- If recommended by the EOR and/or Operator, an engineering analysis to check the implication of the conditions.
- If recommended by the EOR and/or Operator, a remediation plan prepared by the team.
- A review of the conditions to see whether they exceed the Environmental permitting limits.
- A review of the EAP to see whether it meets the conditions listed in the EAP and requires corresponding actions.
- An individual report documenting the conditions, actions and remediation actions.

6.0 MONITORING NOTIFICATIONS AND REPORTING

Monitoring data will be collected from all available monitoring points at the frequencies discussed in the previous Sections and summarized in Table 4 through Table 10. Any triggering events or unusual conditions, such as intense storm events, earthquakes, or operational abnormality may prompt more frequent monitoring.

If unusual conditions are observed during visual inspection, or if Trigger Levels are activated, the Monitor will immediately notify the Process Operations Superintendent in charge of monitoring and the EOR and implement the corresponding TARP presented in Section 5.3.

- Trigger Level 1 requires the Process Operations Superintendent to be informed and the Monitor will follow the steps outlined in Section 5.0 and inform the Process Operations Superintendent of their findings.
- Trigger Level 2 requires notification to the Process Operations Superintendent and the Mine Superintendent and review of the data by the EOR.
- Trigger Level 3 requires a site visit by the EOR and meetings with the Process Operations Superintendent, Mine Superintendent and EOR. Engineering analyses would be completed to determine the causes of the abnormal readings and develop mitigating strategies.

The monitoring data will be collected, recorded, reduced, and presented using the spreadsheets and reporting templates provided in Appendix B, so similarly prepared by the Operator. Use of these templates may promote the need for minor changes in the format for simplicity or accuracy. Upon operation, such changes to monitoring and reporting templates will be incorporated into future revisions of this Plan.

Monitoring data will be measured and reported to the following tolerances:

- VW piezometers – to the nearest 0.1 feet in fluid head
- Underdrain Flow Monitoring – to the nearest 0.1 gpm
- Survey Monuments – to the nearest 0.01 feet in northing, easting, and elevation
- Inclinometers – as presented using the equipment and applicable software
- Leak Detection – total volume in gallons to the nearest 1 gallon and flow rate to the nearest to 0.1 gpm.

Unless monitoring is driven by Trigger Level 3, the Operator will provide the EOR with all geotechnical monitoring data for review and interpretation on a quarterly basis, or more frequent. Annually, the geotechnical monitoring data will be presented in either the Engineer of Record's Annual Inspection Report or a Geotechnical Monitoring Report. The Report will be used to summarize the data collected, provide a geotechnical evaluation of the data, and document the data, conclusions, and recommendations.

If readings or observations activate Trigger Level 3, a geotechnical evaluation will be conducted as soon as possible, and the results and recommendations will be provided in a Geotechnical Monitoring Report.

In preparation of developing the Engineer or Record's Annual Inspection Report or annual Geotechnical Monitoring Report, all monitoring data will be remitted by the Monitor and Surveyor to the Process Operations Superintendent and the EOR, who will review the data, draw conclusions from data trends observed, and provide recommendations as appropriate. The Geotechnical Monitoring Report will be prepared by the EOR with input from the Monitor and Process Operations Superintendent.

The annual Geotechnical Monitoring Report will include the following:

- Summary of the monitoring data collected since submittal of the previous Report.
- Summary of any additional monitoring points installed or monitoring points abandoned since submittal of the previous Report.
- Interpretation of monitoring data and identification of data showing unusual movements or variation in past trends of movements, including data which exceeded Trigger Levels.
- Conclusions and/or confirmations for facilities, or portions of facilities, that show little to no data trends outside of the normal trends defined in this Plan.
- Explanation of possible cause(s) of unusual trends in the recent Monitoring Point data.
- Recommendations for additional monitoring, response, or remediation (if needed), for portions of facilities where recent monitoring data indicates unusual trends.

In addition, the Report should identify the need for updating this Plan as the details of the monitoring program or the site conditions change.

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Tables

Table 1: Summary of Monitoring Point Installation Locations

Monitoring Point Series	Monitoring Point ID	Easting (ft)	Northing (ft)	Elevation (ft)	Sensor Depth Below Ground Surface (ft)	Comment
Foundation Piezometers	PZ-TF-1a	1,544,584	15,866,622	3545	4	
	PZ-TF-1b	1,544,584	15,866,622	3521	28	
	PZ-TF-1c	1,544,584	15,866,622	3505	44	
	PZ-TF-2a	1,544,613	15,866,672	3545	8	
	PZ-TF-2b	1,544,613	15,866,672	3521	32	
	PZ-TF-2c	1,544,613	15,866,672	3505	48	
	PZ-TF-3a	1,544,680	15,866,766	3545	10	
	PZ-TF-3b	1,544,680	15,866,766	3521	34	
	PZ-TF-3c	1,544,680	15,866,766	3505	50	
	PZ-TF-4a	1,544,336	15,866,678	3524	18	
	PZ-TF-4b	1,544,336	15,866,678	3500	42	
	PZ-TF-4c	1,544,336	15,866,678	3484	58	
	PZ-TF-5a	1,544,378	15,866,798	3524	16	
	PZ-TF-5b	1,544,378	15,866,798	3500	40	
	PZ-TF-5c	1,544,378	15,866,798	3484	56	
	PZ-TF-6a	1,544,434	15,866,928	3524	13	
	PZ-TF-6b	1,544,434	15,866,928	3500	37	

Monitoring Point Series	Monitoring Point ID	Easting (ft)	Northing (ft)	Elevation (ft)	Sensor Depth Below Ground Surface (ft)	Comment
	PZ-TF-6c	1,544,434	15,866,928	3484	53	
	PZ-TF-7a	1,543,274	15,866,086	3583	9	
	PZ-TF-7b	1,543,274	15,866,086	3552	40	
	PZ-TF-7c	1,543,274	15,866,086	3540	52	
	PZ-TF-8a	1,543,232	15,866,153	3583	17	
	PZ-TF-8b	1,543,232	15,866,153	3552	48	
	PZ-TF-8c	1,543,232	15,866,153	3540	60	
TSF Impoundment Piezometers	PZ-TI-1a	1,543,530	15,865,808	3564	N/A	
	PZ-TI-1b	1,543,530	15,865,808	3564	N/A	
	PZ-TI-2a	1,544,354	15,865,777	3572	N/A	
	PZ-TI-2b	1,544,354	15,865,777	3572	N/A	
	PZ-TI-3a	1,544,130	15,866,515	3545	N/A	
	PZ-TI-3b	1,544,130	15,866,515	3545	N/A	
	PZ-TI-4a	1,544,138	15,866,514	3545	N/A	
	PZ-TI-4b	1,544,138	15,866,514	3545	N/A	
WRD Pad Piezometers	PZ-WI-1a	1,543,979	15,864,769	3624	N/A	
	PZ-WI-1b	1,543,979	15,864,769	3624	N/A	

Monitoring Point Series	Monitoring Point ID	Easting (ft)	Northing (ft)	Elevation (ft)	Sensor Depth Below Ground Surface (ft)	Comment
TSF Underliner Piezometers	PZ-TU-1a	1,544,142	15,866,511	3544		
	PZ-TU-1b	1,544,142	15,866,511	3544	N/A	
	PZ-TU-2a	1,544,127	15,866,511	3544	N/A	
	PZ-TU-2b	1,544,127	15,866,511	3544	N/A	
WRD Underliner Piezometers	PZ-WU-1a	1,543,979	15,864,765	3624	N/A	
	PZ-WU-1b	1,543,979	15,864,765	3624	N/A	
TSF Underdrain Flow Meters	TUF-1	1,544,411	15,867,107	3533.7	N/A	Upstream Flume Invert
	TUF-2	1,544,413	15,867,107	3533.7	N/A	Upstream Flume Invert
	TUF-3	1,544,420	15,867,107	3533.7	N/A	Upstream Flume Invert
WRD Underdrain Flow Meter	WTUF-3	1,544,418	15,867,107	3533.7	N/A	Upstream Flume Invert
Survey Monuments	SM1-1	1,544,596	15,866,537	3593.4	N/A	Dam Crest
	SM1-2	1,544,287	15,866,699	3594.6	N/A	Dam Crest
	SM1-3	1,543,507	15,866,204	3595.0	N/A	Dam Crest
	SM1-4	1,543,346	15,866,036	3595.1	N/A	Dam Crest
	SM2-1	1,544,627	15,866,600	3608.0	N/A	Dam Crest
	SM2-2	1,544,347	15,866,751	3608.7	N/A	Dam Crest
	SM2-3	1,543,448	15,866,236	3607.9	N/A	Dam Crest

Monitoring Point Series	Monitoring Point ID	Easting (ft)	Northing (ft)	Elevation (ft)	Sensor Depth Below Ground Surface (ft)	Comment
	SM2-4	1,543,308	15,866,088	3608.1	N/A	Dam Crest
	SM3-1	1,544,655	15,866,649	3620.9	N/A	Dam Crest
	SM3-2	1,544,351	15,866,811	3621.8	N/A	Dam Crest
	SM3-3	1,543,402	15,866,269	3622.0	N/A	Dam Crest
	SM3-4	1,543,255	15,866,116	3622.0	N/A	Dam Crest
Inclinometers	INC1-1	1,544,572	15,866,549	3596.7	105	Total depth from crest
	INC-1-2	1,544,315	15,866,690	3597.5	110	Total depth from crest
	INC2-1	1,544,606	15,866,612	3611.0	135	Total depth from crest
	INC2-2	1,544,416	15,866,876	3554.7	95	Total depth from crest
	INC2-3	1,543,289	15,866,070	3611.1	110	Total depth from crest
	INC3-1	1,544,632	15,866,662	3623.9	150	Total depth from crest
	INC3-2	1,544,444	15,866,965	3553.5	100	Total depth from crest
	INC3-3	1,543,208	15,866,142	3604.5	95	Total depth from crest

Table 2: Summary of Readout Station Installation Locations

Readout Station ID	Assigned Instrumentation	Easting (ft)	Northing (ft)	Ground Elevation (ft)	Comment
RS-1	PZ-TF-1a, 1b, 1c PZ-TF-2a, 2b, 2c PZ-TF- 3a, 3b, 3c PZ-TF-4a, 4b, 4c PZ-TF-5a, 5b, 5c PZ-TF-6a, 6b, 6c PZ-TU-1a, 1b PZ-TU-2a, 2b	1,544,436	15,867,069	3536.8	
RS-2	PZ-WI-1a, 1b PZ-WU-1a, 1b	1,544,186	15,864,680	3642.2	
RS-3	TUF-1 TUF-2 TUF-3 WUF-1	1,544,439	15,867,104	3536.7	
RS-4	PZ-TI-1a, 1b PZ-TI-2a, 2b PZ-TI-3a, 3b PZ-TI-4a, 4b	1,544,116	15,866,643	3595.0	
RS-5	PZ-TF-7a, 7b, 7c PZ-TF-8a, 8b, 8c	1,543,296	15,866,237	3601.8	

Table 3: Material Properties Used in Action Level Stability Analyses

Unit	Unit Weight (pcf)	Strength Type	Stress Shear Strength		
			s_u (psf)	Φ' (deg)	c' (psf)
Tailings	95	Mohr-Coulomb	-	15	0
Lining System	120	Mohr-Coulomb	-	11	0
Embankment Fill	135	Mohr-Coulomb	-	40	0
Alluvium	125	Mohr-Coulomb	-	30	
Clay	120	Mohr-Coulomb	-	14	315

Table 4: Foundation (PZ-TF-Series) Piezometer Monitoring Plan During Normal Operations

Trigger Level	Monitoring Point ID	Trigger Level Criteria (PE=Piezometric Elevation)	Monitoring Schedule		Comment
			During Construction	Outside of Construction	
No Trigger	PZ-TF-Series	Head ≤ 3 feet	Weekly	Monthly	NA
Trigger Level 1	PZ-TF-1a, 1b, 1c PZ-TF-2a, 2b, 2c PZ-TF-3a, 3b, 3c	PE ≥ 3515 feet	Weekly	Weekly	**Corresponds to a Static FOS ≤ 1.5**
	PZ-TF-4a, 4b, 4c PZ-TF-5a, 5b, 5c PZ-TF-6a, 6b, 6c	PE ≥ 3494 feet			
	PZ-TF-7a, 7b, 7c PZ-TF-8a, 8b, 8c	PE ≥ 3550 feet			
Trigger Level 2	PZ-TF-1a, 1b, 1c PZ-TF-2a, 2b, 2c PZ-TF- 3a, 3b, 3c	PE ≥ 3531 feet	2x Daily	2x Daily	**Corresponds to a Static FOS ≤ 1.3** .
	PZ-TF-4a, 4b, 4c PZ-TF-5a, 5b, 5c PZ-TF-6a, 6b, 6c	PE ≥ 3510 feet			
	PZ-TF-7a, 7b, 7c PZ-TF-8a, 8b, 8c	PE ≥ 3562 feet			
Trigger Level 3	PZ-TF-1a, 1b, 1c PZ-TF-2a, 2b, 2c PZ-TF- 3a, 3b, 3c	PE ≥ 3570 feet	2x Daily	2x Daily	**Corresponds to a Static FOS ≤ 1.05**
	PZ-TF-4a, 4b, 4c PZ-TF-5a, 5b, 5c PZ-TF-6a, 6b, 6c	PE ≥ 3549 feet			
	PZ-TF-7a, 7b, 7c PZ-TF-8a, 8b, 8c	PE ≥ 3593 feet			

Table 5: TSF Impoundment (PZ-TI-Series) Piezometer Monitoring Plan

Trigger Level	Monitoring Point ID	Trigger Level Criteria	Monitoring Schedule		Comment
			During Construction	Outside of Construction	
No Trigger	PZ-TI-Series	Head ≤ 3 feet	Weekly	Monthly	
Trigger Level 1	PZ-TI-1a, 1b PZ-TI-2a, 2b	3 feet ≤ Head ≤ 6 feet	Weekly	Weekly	
	PZ-TI-3a, 3b PZ-TI-4a, 4b	5 feet ≤ Head ≤ 8 feet	Weekly	Weekly	
Trigger Level 2	PZ-TI-1a, 1b PZ-TI-2a, 2b	5 feet ≤ Head ≤ 10 feet	Weekly	Daily	
	PZ-TI-3a, 3b PZ-TI-4a, 4b	8 feet ≤ Head ≤ 15 feet	Weekly	Daily	
Trigger Level 3	PZ-TI-1a, 1b PZ-TI-2a, 2b	Head ≥ 10 feet	Daily	Daily	
	PZ-TI-3a, 3b PZ-TI-4a, 4b	Head ≥ 15 feet	Daily	Daily	

Table 6: WRD Impoundment (PZ-WI-Series) Piezometer Monitoring Plan

Trigger Level	Monitoring Point ID	Trigger Level Criteria	Monitoring Schedule		Comment
			During Construction	Outside of Construction	
No Trigger	PZ-WI-Series	Negative or zero	Weekly	Monthly	
Trigger Level 1	PZ-WI-1a, 1b	0 feet ≤ Head ≤ 2 feet	Weekly	Weekly	
Trigger Level 2	PZ-WI-1a, 1b	2 feet ≤ Head ≤ 5 feet	Weekly	Daily	
Trigger Level 3	PZ-WI-1a, 1b	Head ≥ 5 feet	Daily	Daily	

Table 7: TSF Underliner (PZ-TU-Series) Piezometer Monitoring Plan

Trigger Level	Monitoring Point ID	Trigger Level Criteria	Monitoring Schedule	Comment
No Trigger	PZ-TU-Series	Negative or zero	Quarterly	
Trigger Level 1	PZ-TU-1a, 1b PZ-TU-2a, 2b	0 feet ≤ Head ≤ 2 feet	Monthly	
Trigger Level 2	PZ-TU-1a, 1b PZ-TU-2a, 2b	2 feet ≤ Head ≤ 5 feet	Weekly	
Trigger Level 3	PZ-TU-1a, 1b PZ-TU-2a, 2b	Head ≥ 5 feet	Daily	

Table 8: WRD Underliner (PZ-WU-Series) Piezometer Monitoring Plan

Trigger Level	Monitoring Point ID	Trigger Level Criteria	Monitoring Schedule	Comment
No Trigger	PZ-TU-Series	Negative or zero	Quarterly	
Trigger Level 1	PZ-TU-1a, 1b, 2a, 2b	0 feet ≤ Head ≤ 2 feet	Monthly	
Trigger Level 2	PZ-TU-1a, 1b, 2a, 2b	2 feet ≤ Head ≤ 5 feet	Weekly	
Trigger Level 3	PZ-TU-1a, 1b, 2a, 2b	Head ≥ 5 feet	Daily	

Table 9: Survey Monument Monitoring Plan

Trigger Level	Trigger Level Criteria		Monitoring Schedule		Comment
	During Construction	Outside of Construction	During Construction	Outside of Construction	
No Trigger	Horizontal and vertical movements rates less than ½ inch per month	Horizontal and vertical movements rates less than ¼ inch per month	Weekly	Quarterly	All Monuments
Trigger Level 1	Horizontal and vertical movements rates between ½ inch and 1 inch per month, or total movement between 2 and 3 inches	Horizontal and vertical movements rates between ¼ inch and ½ inch per month, or a total movement between 1 and 2 inches	Weekly	Monthly	All Monuments
Trigger Level 2	Horizontal and vertical movement rates between 1 inch and 2 inches per month, or total movement of 3 and 6 inches	Horizontal and vertical movement rates between ½ inch and 1 inch per month, or a total movement between 2 and 3 inches	Weekly	Weekly	All Monuments
Trigger Level 3	Horizontal and vertical movement rates greater than 2 inches per month, or total movement greater than 6 inches	Horizontal and vertical movement rates greater than 1 inch per month, or a total movement greater than 3 inches	Daily	Daily	All Monuments

Table 10: Inclinometer Monitoring Plan

Trigger Level	Monitoring Point ID	Trigger Level Criteria	Monitoring Schedule	Comment
No Trigger	INC1-Series INC2-Series INC3-Series	Total displacement rate less than ½ inch per month or total differential displacement less than ½ inch in 2 feet	Quarterly	
Trigger Level 1	INC1-Series INC2-Series INC3-Series	Total displacement rate of ½ inch per month or total differential displacement of ½ inch in 2 feet	Weekly	
Trigger Level 2	INC1-Series INC2-Series INC3-Series	Total displacement rate of 1 inch per month or a total shear strain of 1 inches in 2 feet	Weekly	
Trigger Level 3	INC1-Series INC2-Series INC3-Series	Total displacement rate of 1 inch per month or a total shear strain of 2 inches in 2 feet	Daily	

Figures

INCLINOMETERS CONTROL POINT TABLE

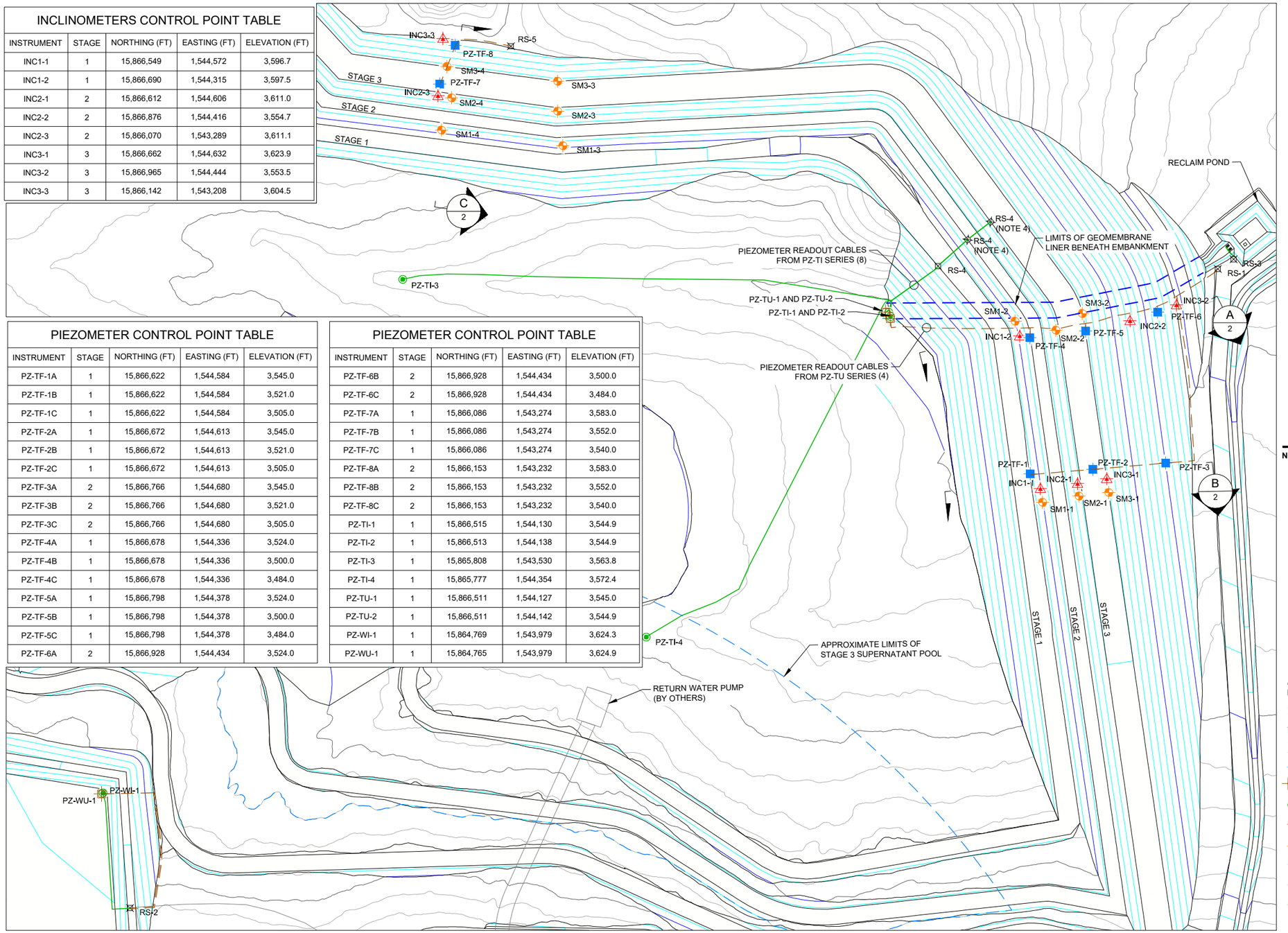
INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
INC1-1	1	15,866,549	1,544,572	3,596.7
INC1-2	1	15,866,690	1,544,315	3,597.5
INC2-1	2	15,866,612	1,544,606	3,611.0
INC2-2	2	15,866,876	1,544,416	3,554.7
INC2-3	2	15,866,070	1,543,289	3,611.1
INC3-1	3	15,866,662	1,544,632	3,623.9
INC3-2	3	15,866,965	1,544,444	3,553.5
INC3-3	3	15,866,142	1,543,208	3,604.5

PIEZOMETER CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
PZ-TF-1A	1	15,866,622	1,544,584	3,545.0
PZ-TF-1B	1	15,866,622	1,544,584	3,521.0
PZ-TF-1C	1	15,866,622	1,544,584	3,505.0
PZ-TF-2A	1	15,866,672	1,544,613	3,545.0
PZ-TF-2B	1	15,866,672	1,544,613	3,521.0
PZ-TF-2C	1	15,866,672	1,544,613	3,505.0
PZ-TF-3A	2	15,866,766	1,544,680	3,545.0
PZ-TF-3B	2	15,866,766	1,544,680	3,521.0
PZ-TF-3C	2	15,866,766	1,544,680	3,505.0
PZ-TF-4A	1	15,866,678	1,544,336	3,524.0
PZ-TF-4B	1	15,866,678	1,544,336	3,500.0
PZ-TF-4C	1	15,866,678	1,544,336	3,484.0
PZ-TF-5A	1	15,866,798	1,544,378	3,524.0
PZ-TF-5B	1	15,866,798	1,544,378	3,500.0
PZ-TF-5C	1	15,866,798	1,544,378	3,484.0
PZ-TF-6A	2	15,866,928	1,544,434	3,524.0

PIEZOMETER CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
PZ-TF-6B	2	15,866,928	1,544,434	3,500.0
PZ-TF-6C	2	15,866,928	1,544,434	3,484.0
PZ-TF-7A	1	15,866,086	1,543,274	3,583.0
PZ-TF-7B	1	15,866,086	1,543,274	3,552.0
PZ-TF-7C	1	15,866,086	1,543,274	3,540.0
PZ-TF-8A	2	15,866,153	1,543,232	3,583.0
PZ-TF-8B	2	15,866,153	1,543,232	3,552.0
PZ-TF-8C	2	15,866,153	1,543,232	3,540.0
PZ-TI-1	1	15,866,515	1,544,130	3,544.9
PZ-TI-2	1	15,866,513	1,544,138	3,544.9
PZ-TI-3	1	15,865,808	1,543,530	3,563.8
PZ-TI-4	1	15,865,777	1,544,354	3,572.4
PZ-TU-1	1	15,866,511	1,544,127	3,545.0
PZ-TU-2	1	15,866,511	1,544,142	3,544.9
PZ-WI-1	1	15,864,769	1,543,979	3,624.3
PZ-WU-1	1	15,864,765	1,543,979	3,624.9



READOUT STATION CONTROL POINT TABLE

READOUT STATION	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
RS-1	1	15,867,069	1,544,436	3,536.8
RS-2	1	15,864,680	1,544,186	3,642.2
RS-3	1	15,867,104	1,544,439	3,536.7
RS-4	1	15,866,643	1,544,116	3,595.0
RS-5	1	15,866,237	1,543,296	3,601.8

SURVEY MONUMENT CONTROL POINT TABLE

INSTRUMENT	STAGE	NORTHING (FT)	EASTING (FT)	ELEVATION (FT)
SM1-1	1	15,866,537	1,544,596	3,593.4
SM1-2	1	15,866,699	1,544,287	3,594.6
SM1-3	1	15,866,204	1,543,507	3,595.0
SM1-4	1	15,866,036	1,543,346	3,595.1
SM2-1	2	15,866,600	1,544,627	3,608.0
SM2-2	2	15,866,751	1,544,347	3,608.7
SM2-3	2	15,866,236	1,543,448	3,607.9
SM2-4	2	15,866,088	1,543,308	3,608.1
SM3-1	3	15,866,649	1,544,655	3,620.9
SM3-2	3	15,866,811	1,544,351	3,621.8
SM3-3	3	15,866,269	1,543,402	3,622.0
SM3-4	3	15,866,116	1,543,255	3,622.0

NOTE

1. AT EACH DESIGNATED MONITORING POINT FOR PZ-TI, PZ-TU, PZ-WI, PZ-WU SERIES PLACE 2 PIEZOMETERS APPROXIMATELY 1 ft APART.
2. SEE DRAWING C15 FOR DETAILS AND UNDERDRAIN PIPING SYSTEM.
3. INCLINOMETER ELEVATIONS REPRESENT COLLAR ELEVATION 3 FT ABOVE PROPOSED GROUND.
4. READOUT STATION RS-4 AND REQUIRED CABLES TO BE RELOCATED TO NEW UPSTREAM DAM CREST WITH EACH DAM RAISE.
5. SURVEY MONUMENTS LOCATED ALONG DOWNSTREAM CREST OF EACH STAGE.
6. EXISTING GROUND TOPOGRAPHY PORVIDED BY CALICO RESOURCES USA CORP. ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf".

LEGEND

- 3600 — EXISTING GROUND (5 FT CONTOURS) (NOTE 6)
- 3600 — PROPOSED GRADING (5 FT CONTOURS)
- RS-1 READOUT STATION
- PZ-TF1 FOUNDATION PIEZOMETER
- PZ-TU-1 UNDERLINER PIEZOMETER
- PZ-TI-1 IMPOUNDMENT PIEZOMETER
- INC1-1 INCLINOMETER (NOTE 3)
- SM1-1 SURVEY MONUMENT
- LIMITS OF SUPERNATANT POOL
- CABLE ROUTES BELOW LINER
- CABLE ROUTES ABOVE LINER

0 100 200
1" = 100' FEET

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

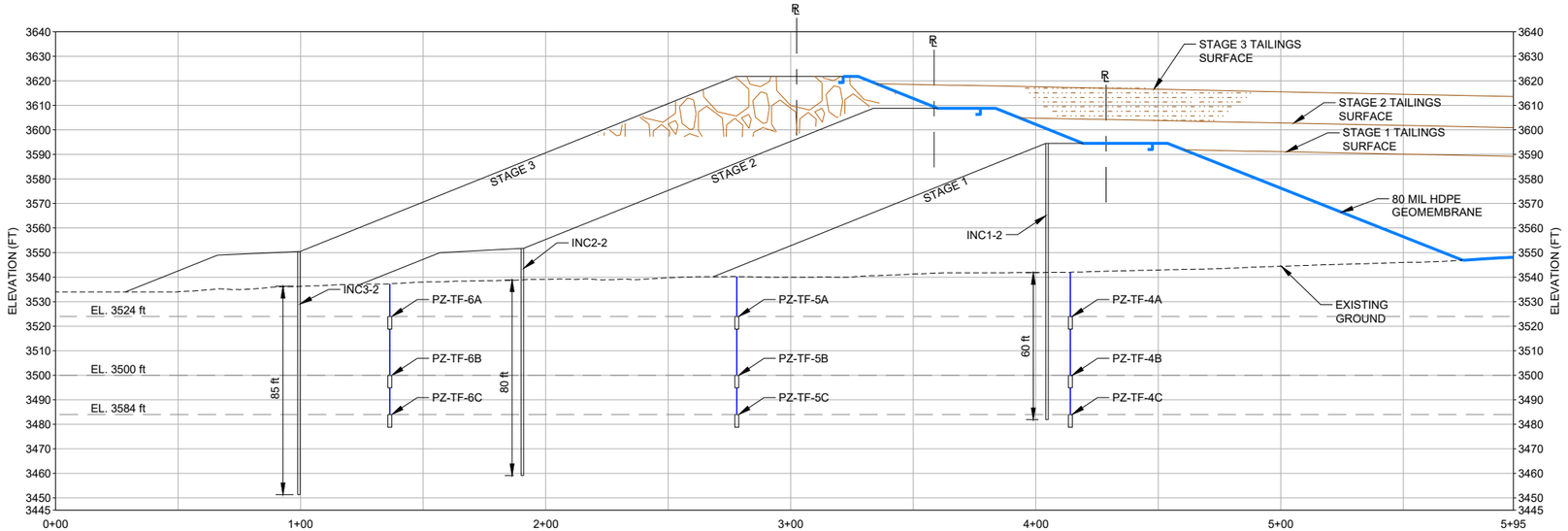
PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL MONITORING PLAN
GEOTECHNICAL INSTRUMENTATION LAYOUT

PROJECT NO.	REV.	FIGURE
1663241	0	1

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

Path: \\reno\data\MDA\1663241 Grassy Mountain PFS\900_Drawings\PRODUCTION\FIGURES\Geotechnical Monitoring Plan\ | File Name: Figure 1 - Geotechnical Instrumentation Layout.dwg | Last Edited By: jeprice Date: 2019-11-06 Time:2:41:56 PM | Printed By: JePrice Date: 2019-11-06 Time:2:42:33 PM

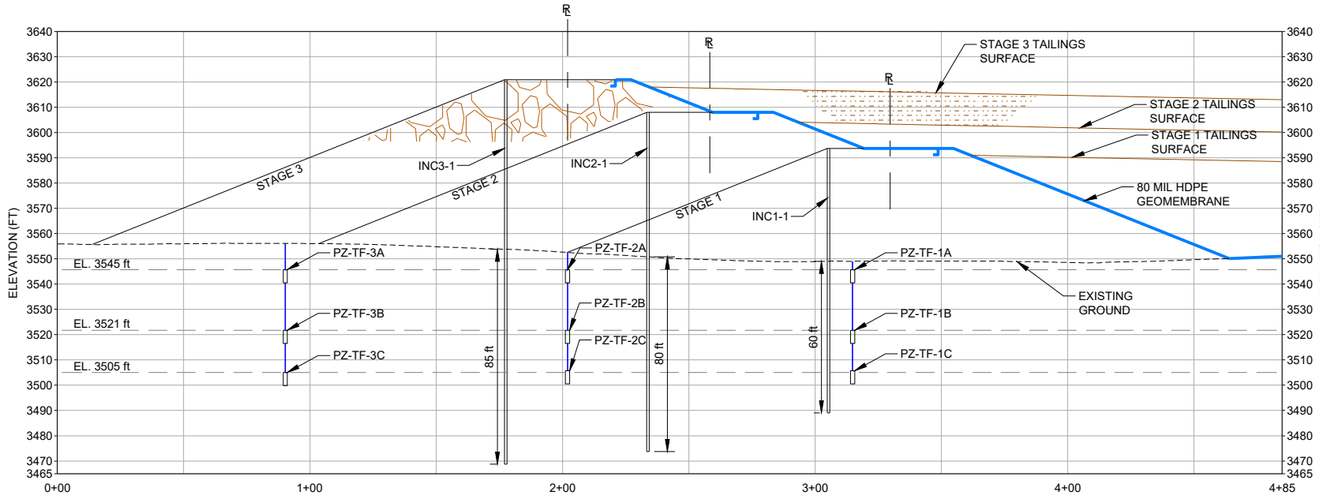


SCALE 1" = 30' (A, 1) NORTH EMBANKMENT PIEZOMETER LOCATIONS (1 OF 2)

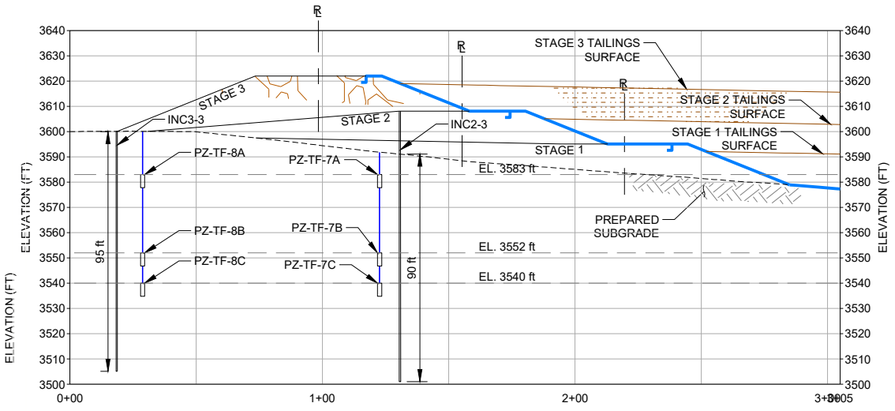
LEGEND

- EMBANKMENT LINING SYSTEM
- EXISTING GROUND
- TAILINGS SURFACE
- FOUNDATION PIEZOMETER (PZ-TF SERIES)
- INCLINOMETER

0 30 60 90
1" = 30' FEET



SCALE 1" = 30' (B, 1) NORTH EMBANKMENT PIEZOMETER LOCATIONS (2 OF 2)



SCALE 1" = 30' (C, 1) WEST EMBANKMENT PIEZOMETER LOCATIONS

CLIENT
CALICO RESOURCES USA CORP.
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-06
DESIGNED	MDB
PREPARED	JRP
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL MONITORING PLAN
GEOTECHNICAL INSTRUMENTATION SECTIONS

PROJECT NO.	REV.	FIGURE
1663241	0	2

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

0 1in

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APPENDIX A

Instrumentation Specifications

Underliner and Impoundment Vibrating Wire Piezometers

Monitor with Confidence

TEL 604 540 1100
info@rstinstruments.com
www.rstinstruments.com

RST Instruments Ltd.
11545 Kingston St.,
Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

PRODUCT CATEGORY:
PIEZOMETERS + TRANSDUCERS

Vibrating Wire Piezometer

The RST Vibrating Wire Piezometer provides excellent long-term accuracy, stability of readings, and reliability under demanding geotechnical conditions. Vibrating Wire Piezometers are the electrical piezometers of choice as the frequency output of VW devices is immune to external electrical noise and able to tolerate wet wiring common in geotechnical applications.

Vibrating Wire Piezometers contain a high tensile steel wire with a fixed anchor at one end and are attached to a diaphragm in contact with water pressure at the other end. The wire is electrically plucked, with the resonant frequency of vibration proportional to the tension in the wire. This frequency induces an alternating current in a coil which is detected by the readout unit, such as the VW2106 Vibrating Wire Readout (see separate brochure), and can then be converted to a pressure. The frequency output is immune to external electrical noise.

The frequency signal is exceptionally immune from cable effects, including length (to several kilometers), splicing, resistance, noise pickup, and moisture. The vibrating wire coil circuit contains no semiconductor devices and has built-in ionized gas discharge device protection against transient damage. As a result, the vibrating wire piezometer provides excellent reliability in typical geotechnical situations – i.e. long outdoor cables buried in saturated soil.

The piezometer is equipped with a standard sintered stainless steel porous filter to prevent soil particles from contacting the diaphragm. A thermistor is built into the piezometer body to permit temperature measurement and temperature compensation of the piezometer. Standard construction is all stainless steel. RST vibrating wire piezometers are shipped with extremely tough polyurethane-jacketed foil-shielded cable for maximum endurance in field conditions.

VW2100
Standard
Vibrating Wire
Piezometer

VW2100-HD
Heavy Duty
Vibrating Wire
Piezometer

VW2100-DPC
Drive Point
Vibrating Wire
Piezometer

> APPLICATIONS

Slope stability investigations.	Monitoring well and standpipe water levels.
Assessing performance and investigating stability of earth fill dams and embankments.	
Monitoring pressures behind retaining walls and diaphragm walls.	
Monitoring pore pressures during fill or excavation.	
Monitoring pore pressure in land reclamation applications.	

> FEATURES

Field proven reliability and accuracy.	Integral lightning protection.
Signal transmission of several kilometer.	Data logger compatible.
High Accuracy - IE a low pressure vented model will measure water level changes as small as 0.5 mm (0.02 in.).	
Will tolerate wet wiring common in geotechnical applications.	
Thermistor for temperature measurement is standard.	Hermetically sealed, stainless steel construction.
Negligible displacement of pore water during the measurement process.	
Heavy case to minimize reading errors caused by overburden pressure.	
Cable lengths may be changed without affecting the calibration.	

Available for **QUICK DELIVERY** Info on reverse.

> BENEFITS

✓ **Increase Safety**	✓ **High Accuracy**

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Vibrating Wire Piezometer

PRODUCT CATEGORY:
PIEZOMETERS + TRANSDUCERS

SPECIFICATIONS + ORDERING

SPECIFICATIONS

DESCRIPTION	SPECIFICATION
Over range	2 X F.S.
Resolution	0.025% F.S. minimum
Accuracy	0.1% F.S.
Linearity	<0.5% F.S.
Operating Temperature	-20 to 80°C (-4 to 176°F)
Diaphragm Displacement	<0.001 cc at F.S.
Thermal Zero Shift	<0.05% F.S./°C
Materials	Hermetically sealed stainless steel housing
Thermistor Type	NTC 3K Ohms @ 25°C
Thermistor Interchangeability	±0.2°C
Thermistor Resolution	0.1°C
Filter	50 micron sintered filter. (High air entry alumina filter 1 Bar available)

VW2100-DPC
Drive point model

ELECTRICAL CABLE SPECS

PART #	DESCRIPTION
EL380004	Two twisted pairs cable with polyurethane jacket
EL380004HDL	Two twisted pairs heavy duty cable with a thick polyurethane jacket mold for added protection
EL380004K	Two twisted pairs Kevlar® reinforced, non-stretch polyurethane jacketed cable for rigorous installations where the stretching of cable is a concern

Other types of cables, depending on site conditions and atmospheric reference requirements, are available upon request. These include vented, FEP, PVC, polyurethane, and armored varieties.

OPTIONAL EQUIPMENT

VW2106 Vibrating Wire Readout
Data loggers
Cable splice kits

ORDERING

Available for QUICK DELIVERY

PART #	DESCRIPTION	PRESSURE RANGE	DIMENSION
VW2100	Standard model for general applications Contact RST for Details	0.35, 0.7, 1.0, 2.0, 3.0 MPa	19 mm Ø X 130 mm
VW2100-HD	Heavy duty piezometer for direct burial in fills and large dam embankments or for high pressure borehole installations	0.35, 0.7, 1.0, 2.0 3.0, 5.0, 7.5, 10, 20 MPa	25.4 mm Ø X 146 mm
VW2100-DPC	Drive point model with CPT thread	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	33.4 mm Ø X 508 mm
VW2100-DPEW	Drive point model with EW thread	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	34.6 mm Ø (body) X 304.8 mm
VW2100-L	Low Pressure, unvented	70, 175 kPa	25 mm Ø X 133 mm
VW2100-LV	Low Pressure vented	70, 175 kPa	25 mm Ø X 133 mm
VW2100-M	Miniature version – 17.5 mm diameter	0.35, 0.7, 1.0, 2.0, 3.0 MPa	17.5 mm Ø X 133 mm
VW2100-MM	Micro-miniature version – 11.1 mm diameter	0.35, 0.7 MPa	11.1 mm Ø X 165 mm
VW2190	Heavy duty piezometer with bladder for brine environment	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	42 mm Ø X 319 mm
VW2191	Heavy duty piezometer with bladder for acidic environment with secondary corrosion protection	0.07, 0.175, 0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.5 MPa	42 mm Ø X 319 mm

VW2190 - Heavy Duty Piezometer with Bladder

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Foundation
Vibrating Wire Piezometers

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ISO 9001

PRODUCT CATEGORY:
PIEZOMETERS + TRANSDUCERS

Fully Grouted Multi-Point Piezometer String

Fully grouted installation permits multiple piezometers to be simply and reliably installed in a single borehole. The piezometer string and grout pipe are placed in the borehole and cement-bentonite grout is pumped until the borehole is filled.

Multi-point Piezometer Strings allow for multiple Vibrating Wire Piezometers to be connected on a single cable. This facilitates the installation of fully grouted multiple piezometers. The single cable prevents vertical void channels. Tough polyurethane-jacketed, Kevlar® reinforced, non-stretch cable is employed to withstand the rigors of installation and is entirely water-blocked to minimize any leakage. No conductors are shared to maximize independent reliability of each sensor.

RST Vibrating Wire Piezometers provide excellent long-term accuracy, stability of readings, and reliability under demanding geotechnical conditions. Vibrating Wire Piezometers are the electrical piezometers of choice as the frequency output of vibrating wire devices is immune to external electrical noise and able to tolerate wet wiring common in geotechnical applications.

> APPLICATIONS

Ideal when more than one piezometer reading is needed at various depths at the same location.

Assessing performance and investigating stability of:

Earth fill dams & embankments.	Slope stability.

Monitoring of:

Pressures behind retaining walls and diaphragm walls.	Pore pressure in land reclamation applications.
Pore pressures during fill or excavation.	

> FEATURES

No inter-zone leakage.	Straightforward installation.
Field proven reliability and accuracy.	Immune from external electrical noise.
Will tolerate wet wiring common in geotechnical applications.	Cable lengths may be changed without affecting the calibration.
Thermistor for temperature measurement is standard.	Hermetically sealed, stainless steel construction.
Heavy case to minimize reading errors caused by overburden pressure.	Negligible displacement of pore water during the measurement process.
Signal transmission of several kilometers.	Data logger compatible.
Integral lightning protection.	

> BENEFITS

✓ **Increase Safety**	✓ **High Accuracy**
✓ **Increase Productivity**	✓ **High Reliability**
✓ **Custom Options**	

Traditionally, multiple piezometer installations in a borehole was slow, complex, and subject to unintended communication between piezometers. Grouted piezometers are quick and easy to install, have excellent zone isolation, and have rapid response to pore pressure changes. The fully grouted method is increasingly the preferred standard approach for installing piezometers in boreholes. For more information see:

McKenna, G.T. (1995),"Grouted-in Installation of Piezometers in Boreholes," Canadian Geotechnical Journal, Volume 32, pp 355-363.

Contreras, I.A. Grosser, A.T., VerStrate, R.H. (2007), "The Use of the Fully-grouted Method for Piezometer Installation". Proceedings of the Seventh International Symposium on Field Measurements in Geomechanics. FMGM, 2007. Boston, MA. ASCE Geotechnical Special Publication 175.

Also published in: Geotechnical News, June 2008, Vol. 26, No.2, http://www.bitech.ca/pdf/GeoTechNews/2008/GIN_June08.pdf

Contreras, I.A. Grosser, A.T., VerStrate, R.H. (2011), "Practical Aspects of the Fully-Grouted Method for Piezometer Installation", Proceedings of the Eigth International Symposium on Field Measurements in Geomechanics. FMGM, 2011. Berlin, Germany, September 12-16, 2001

For further references and information regarding grout mixes, contact RST Instruments Ltd.

WORKS WITH flexDAQ DATALOGGERS

READY TO RUN
pre-assembled
pre-wired
pre-tested
pre-programmed

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Monitor with Confidence

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www.rstinstruments.com

RST Instruments Ltd.
11545 Kingston St.,
Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

Fully Grouted Multi-Point Piezometer String

PRODUCT CATEGORY:
PIEZOMETERS + TRANSDUCERS

SPECIFICATIONS + ORDERING

VIBRATING WIRE PIEZOMETER SPECIFICATIONS

The following specifications are for an individual vibrating wire piezometer.

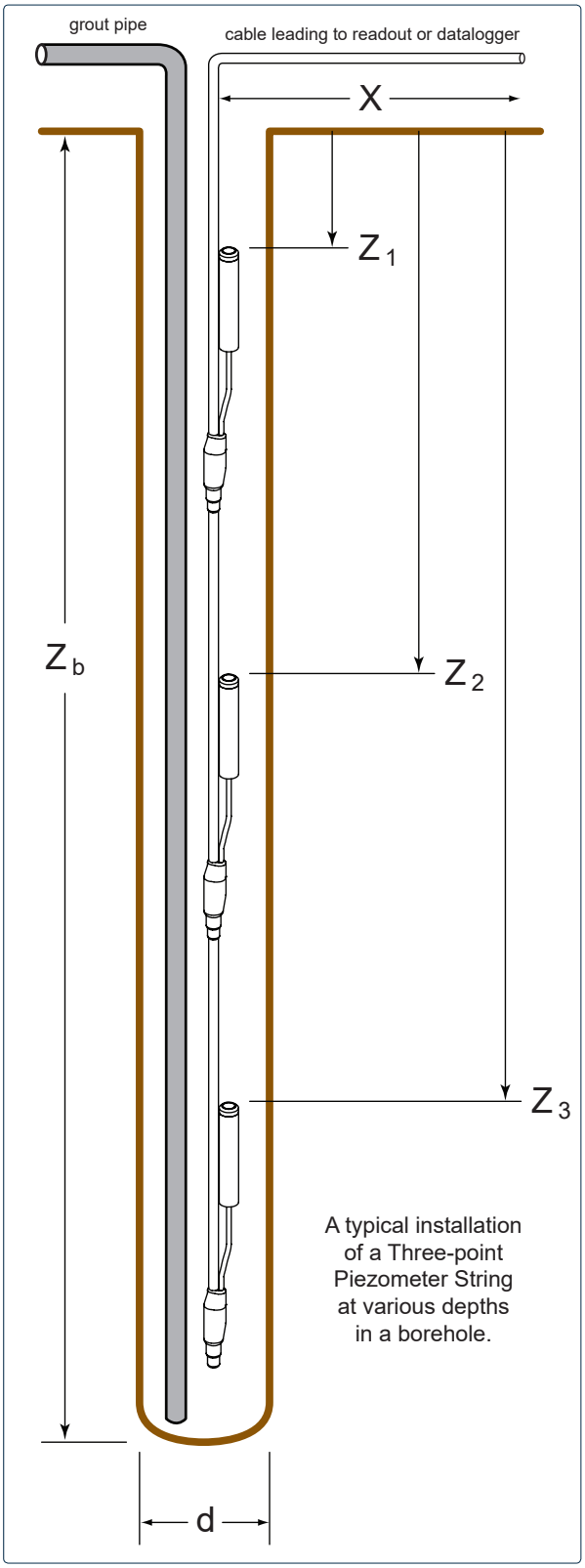
DESCRIPTION	SPECIFICATION
Over range	2 X F.S.
Resolution	0.025% F.S. minimum
Accuracy	0.1% F.S.
Operating Temperature	-20 to 80°C (-4 to 176°F)
Diaphragm Displacement	<0.001 cc at F.S.
Thermal Zero Shift	<0.05% F.S./°C
Materials	Hermetically sealed stainless steel housing
Thermistor Type	NTC 3K Ohms @ 25°C
Thermistor Interchangeability	±0.2°C (optional ±0.1°C)
Thermistor Resolution	0.1°C
Filter	50 micron sintered filter.

ELECTRICAL CABLE SPECIFICATIONS

PART #	DESCRIPTION
2-3 Piezometers	
EL380012	12 conductor, Kevlar® wire with water-blocked polyurethane jacket
4-6 Piezometers	
EL380013P	13 pair, Kevlar® wire with water-blocked polyurethane jacket

ORDERING INFO

PART #	DESCRIPTION	PRESSURE RANGES	DIMENSION
Due to the semi-custom nature of Multi-Point Piezometer Strings, please contact RST Instruments for complete ordering info. Ordering info will be dependent on required cable depth, number of piezometers per string and measurement parameters regarding pressure and/or temperature.			
VW2100MP-XXXX	Multi-Point Piezometer String	0.35, 0.7, 1.0, 2.0, 3.0, 5.0, 7.0, and 10.0 MPa (Standard model vibrating wire piezometer ranges shown).	Dimensions dependent on cable and pressure ranges chosen.



A typical installation of a Three-point Piezometer String at various depths in a borehole.

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Vibrating Wire Piezometer Signal Cables

Monitor with Confidence

TEL 604 540 1100
info@rstinstruments.com
www.rstinstruments.com

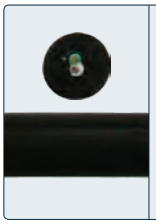
RST Instruments Ltd.
11545 Kingston St.,
Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

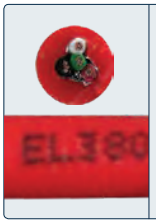
PRODUCT CATEGORY:
READOUTS + DATA LOGGERS

Cables

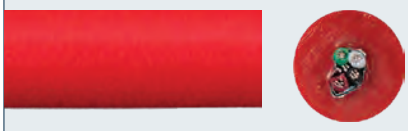
RST Instruments Ltd. offers a variety of cables that can be effectively matched to any instrument that requires a signal cable. RST uses Meter Marked Cable for a majority of our instruments that require a signal cable such as those used in Vibrating Wire Piezometers, Load/Pressure Cells, Crack Meters, Joint Meters, etc. In the unfortunate event of the cable being accidentally severed, the meter cable markings can be cross-referenced with the calibration record.



EL380002	USED FOR	CONDUCTORS	DIAM. O.D.
Abrasion-resistant polyurethane jacket.	· Single Point Thermistors	2 (1 twisted pair), 24 AWG (0.20 mm²)	5.33 mm (0.210 in.)



EL380004	USED FOR	CONDUCTORS	DIAM. O.D.
Standard vibrating wire cable, abrasion-resistant polyurethane jacket.	· Vibrating Wire Piezometers and most other VW instruments · Strain Gauge Load Cells · MEMS In-place Inclinometers · MEMS Tilt Meters & Beams	4 (2 twisted pairs), 22 AWG (0.33 mm²)	6.35 mm (0.250 in.)



EL380004HDL	USED FOR	CONDUCTORS	DIAM. O.D.
Heavy Duty Cable with a thick polyurethane jacket mold for added protection.	Direct burial of surface cable for: · Vibrating Wire Piezometers and most other VW instruments · MEMS In-place Inclinometers · MEMS Tilt Meters & Beams	4 (2 twisted pairs), 22 AWG (0.33 mm²)	9.52 mm (0.375 in.)

EL380004K	USED FOR	CONDUCTORS	DIAM. O.D.
Kevlar® reinforced, non-stretch polyurethane jacketed cable for rigorous installations where the stretching of the cable is a concern.	· VW Piezometers	4 (2 twisted pairs), 22 AWG (0.33 mm²)	6.35 mm (0.250 in.)

EL370004	USED FOR	CONDUCTORS	DIAM. O.D.
Thin polyurethane jacket mold.	· VW Rebar Strain Meters · VW Embedment Strain Gauges · VW Arc Weldable Strain Gauges	4 (2 twisted pairs), 24 AWG (0.20 mm²)	4.76 mm (0.1875 in.)

EL342202	USED FOR	CONDUCTORS	DIAM. O.D.
HDPE jacket.	· Used in acidic applications (leachate) and land fills · Saltwater	4 (2 twisted pairs), 22 AWG (0.33 mm²)	6.35 mm (0.250 in.)

*NOTE: IMAGES ARE NOT SHOWN TO SIZE; VIEW SPECIFICATIONS FOR ACTUAL DIAMETERS. Contact RST for complete details on exact specifications and suitable applications.

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Cables

PRODUCT CATEGORY:
READOUTS + DATA LOGGERS

EL35VT04	USED FOR	CONDUCTORS	DIAM. O.D.
Vented polyurethane cable for barometric compensation; Kevlar® reinforced.	· Low-Pressure Vented Transducers	4 (2 twisted pairs), 22 AWG (0.33 mm²)	7.92 mm (0.312 in.) (jacket) 3.17 mm (0.125 in.) OD (vent tube)

EL380006	USED FOR	CONDUCTORS	DIAM. O.D.
Water blocked, polyurethane jacket. Grease blocked.	· In-Place Tiltmeters (analog biaxial) · Strain Gauge Analog Piezometer with Thermistor · Push-In Pressure Cells · Thermistor Strings	6 (3 twisted pairs), 22 AWG (0.33 mm²)	6.35 mm (0.250 in.)

EL360008	USED FOR	CONDUCTORS	DIAM. O.D.
Polyurethane jacket.	· MPBX Heads · VW Load Cells · Remote multiplexer connection cable to logger · Thermistor Strings	8 (4 twisted pairs), 20 AWG (0.52 mm²)	8.13 mm (0.320 in.)

EL380012	USED FOR	CONDUCTORS	DIAM. O.D.
Kevlar® reinforced, polyurethane jacket. Grease blocked.	· Thermistor Strings and VW Piezometer Strings · VW Load Cells · MPBX Heads	12 (6 twisted pairs), 24 AWG (0.20 mm²)	10.54 mm (0.415 in.)

EL380007P	USED FOR	CONDUCTORS	DIAM. O.D.
Polyurethane jacket.	· Thermistor Strings and VW Piezometer Strings · VW Load Cells · MPBX Heads	14 conductors (7 pairs), 22 AWG (0.33 mm²)	9.84 mm (0.3875 in.)

EL380013P	USED FOR	CONDUCTORS	DIAM. O.D.
Kevlar® reinforced, polyurethane jacket. Grease blocked.	· Thermistor Strings and VW Piezometer Strings · VW Load Cells · MPBX Heads	26 (13 twisted pairs), 24 AWG (0.20 mm²)	10.88 mm (0.425 in.)

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Vibrating Wire Piezometer Manual

Monitor with Confidence

VW2100 Vibrating Wire Piezometer

Instruction Manual

All efforts have been made to ensure the accuracy and completeness of the information contained in this document. RST Instruments Ltd reserves the right to change the information at any time and assumes no liability for its accuracy.

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Q	Added instructions for installation of heavy-duty piezometer with bladder (5.6). Expanded instructions for removing the cap from the pre-saturated HAE filter (5.3.2).	2019-Aug-28	MP	AP, TW
R	Removed Appendix B: Casagrande Style Filter Assembly and reference to Appendix B on p. 8; updated reference to Appendix C in 5.7.1.	2019-Sep-17	MP	CJ

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1 INTRODUCTION

The RST Vibrating Wire Piezometer is a stable, robust pressure transducer designed to allow very accurate remote measurements of piezometric levels and borehole pressures over extended periods of time and through all conditions. The vibrating wire pressure transducer output is a frequency signal which is unaffected by line impedance and/or contact resistance of the conductor. This allows for the accurate transmission of the frequency signal over very long distances. These types of vibrating wire sensors can be installed in boreholes or driven into soft ground.

A standard integral thermistor is included within each transducer, which measures the temperature of the transducer and its surroundings. This temperature information is used to provide temperature correction to the output pressure readings. A gauge calibration factor and temperature correction factor are supplied with each manufactured gauge based on the factory calibrations which are carried out for each sensor, immediately following manufacture.

A portable vibrating wire readout unit, such as the RST VW2106 Readout Unit, is used to display the frequency of the vibrating wire which is proportional to the pressure being applied to the vibrating wire transducer diaphragm. Additionally, the VW2106 readout unit will display the transducer temperature directly in degrees Celsius.

Complete data logging systems are available from RST to provide automated data collection from vibrating wire transducers. Consult RST for more information, if required.

FIGURE 1-1 VIBRATING WIRE PIEZOMETER (0.7 MPA)

The RST VW piezometer is a Vibrating Wire diaphragm pressure sensor. Pressure applied to the transducer diaphragm will cause a change in the Vibrating Wire tension, resulting in a change to the resonant frequency, which is directly proportional to the pressure change.

The Vibrating Wire sensors are made of two small diameter cylindrical parts joined by a length of steel tubing. The diaphragm is welded to the front cylinder. A high strength steel wire (the Vibrating Wire) is clamped to the center of the diaphragm, then is run through the first cylinder, and then clamped to the base of the second cylinder which is the end block. The Vibrating Wire is clamped to the diaphragm and end block by low temperature hydraulic swaging which virtually welds the parts together without affecting the elastic properties of the wire. All parts of the sensor, other than the actual Vibrating Wire are machined from a high-grade stainless steel, selected for its low yield and high corrosion resistance.

The Vibrating Wire is set to a pre-determined tension during the manufacture. The instrument housing is evacuated and sealed using electron beam welding to ensure a perfect seal and a long working life. An O-ring placed behind the diaphragm seals the back of the assembly within the housing. A coil/magnet assembly is built into every VW transducer which is used in conjunction with the RST readout box, to pluck the Vibrating Wire and measure the VW's vibration period.

1.1 MODEL VW2100

The RST VW2100 Vibrating Wire Piezometer is designed to be embedded in earth fills and concrete or inserted into boreholes and pipes as small as 19 mm (3/4 inch) in diameter. The VW2100 piezometer consists of a small diameter cylindrical housing containing a pressure transducer and thermistor. One end is fitted with an insert that holds a micrometric high air or low air entry filter. The opposite end contains the cable entry sealed with an epoxy compound. All parts are made of stainless steel.

The entry filter is set in the front end of the housing and sealed with an O-ring. With the filter in place, the diaphragm is protected from solid particles, and senses only the fluid pressure to be measured. The filter housing is easily removable for calibration of the transducer. The filter assembly can also be replaced with a pipe thread adapter to use the gauge as a pressure transducer (Model VW2100-PT).

1.2 MODEL VW2100-DP

The RST VW2100-DP Vibrating Wire Piezometer is designed to be driven into unconsolidated fine grain material such as sand, silt, or clay. The external housing is a thick-walled cylinder fitted with a pointed shoe at one end. The opposite end is fitted with a male thread adapter at the cable entry, which fits standard "EX" drill rods. Three port holes above the point are equipped with micrometric filters. The data cable passes through the threaded end and can be fed up through the drill rods to the surface. The cable entry is sealed with an epoxy compound. Both high and low air entry filters are available.

2 VIBRATING WIRE PRINCIPLE

The sensing element of the Vibrating Wire piezometer is a high strength steel wire attached to the diaphragm. The vibrating wire is excited by two coil/magnets set around the connecting over tube. In operation, external pressure on the diaphragm will move the diaphragm a very small amount, which changes the tension on the vibrating wire. This tension change is directly proportional to the resonant, or natural, frequency at which the vibrating wire will vibrate.

The VW2106 Readout Unit generates plucking voltages to the coil/magnet in a spectrum of frequencies, spanning the natural frequency of the vibrating wire. This plucking allows the vibrating wire to find its current natural frequency related to the pressure it is currently experiencing. In turn, the oscillation of the vibrating wire generates AC voltage in the coil. This output signal is amplified by the VW2106 Readout Unit, which also discriminates against harmonic frequencies, to determine the resonant frequency of the wire.

The VW2106 Readout Unit measures 100 cycles of vibration with a precise quartz oscillator and displays a value proportional to the frequency squared, which is called B-Units (Frequency^2 x 10^{-3}). The relationship between B-Unit readings and the pressure being exerted on the diaphragm is expressed by the following equation:

$$\mathbf{P = CF\ (L_0 - L)}$$

where:

P = Corrected Pressure Reading

CF = Linear Calibration Factor in kPa\B-Unit digit. The CF is a unique value for each manufactured VW sensor, as determined by the initial laboratory calibration

L_0 = Initial B-Unit Reading at zero applied pressure on the diaphragm. The L_0 is a unique value for each manufactured VW sensor and is determined by initial laboratory calibration

L = B-Unit Reading under the currently applied pressure on the diaphragm

The Vibrating Wire technology offers the unique advantage of frequency output signal virtually unaffected by line impedance or contact resistance. Up to 1.5 km of cable length can be used without signal deterioration.

3 CALIBRATION

All RST vibrating wire piezometers are individually calibrated in the laboratory before shipment. Each vibrating wire piezometer is calibrated over its full working pressure range. A Linear Calibration Factor (CF) is established by using the calibration data points to do a linear regression. In addition, the calibration data is also fitted to a polynomial regression which provides slightly more accurate data output over the full reading range. Both formulas are provided on the instrument Calibration Record sheet for use as appropriate. It is also noted that RST data loggers are set up to use either formula to calculate the instrument output in engineering units.

As part of the calibration procedure, all vibrating wire piezometers are tested to 150% of the standard working range to prove their function at overpressure. The sensor calibration is carried out over a temperature range of -20º C to +80º C which proves their function at a wide temperature range and provides the input data for the Temperature Correction Factor for each sensor.

A Calibration Record sheet is provided with each vibrating wire sensor for use in calculating the applied loads on the vibrating wire sensors. The following general information is contained in the Calibration Record sheet:

- Model, Serial, and Manufacturing Numbers;
- Pressure Range;
- Temperature and Barometric Pressure at time of Calibration;

- Work Order Number;
- Cable Information (Length, Meter Markings, Color Code, and Type);
- Thermistor Type;
- Linear Calibration Factor (CF);
- Temperature Correction Factor (Tk);
- Polynomial Gauge Factors (A, B, and C);
- Calibration Data Table;
- Linear and Polynomial Formulas;
- Zero Reading, Temperature, and Barometric Pressure at time of Shipment;
- Calibration Certification.

Refer to Appendix A for an example of a Calibration Record sheet.

3.1 FIELD CALIBRATION CHECK

The following procedure can be used in the field to verify the validity of a vibrating wire piezometer calibration as supplied on the Calibration Record sheet.

Note that VW2100 piezometers will require the filter stone to be saturated prior to calibration. Place the VW2100 piezometer in water to saturate the filter stone. Ensure the entire space between the instrument diaphragm and the filter stone is filled with water.

1. Lower the piezometer to depth in a vertical, water filled borehole using the cable markings to accurately control and set the depth. A minimum emersion depth of 10 m is recommended to ensure adequate accuracy of the field calibration check.

2. Allow 20 to 30 minutes for the piezometer to come to complete thermal equilibrium in the borehole. Record the B-unit and temperature readings at that depth using an RST VW2106 readout unit.

3. Raise the piezometer a known amount while keeping it fully submerged. If the temperature reading is changing, allow the instrument to come to the new thermal equilibrium. This may take another 20 to 30 minutes.

4. Record the new B-Unit and temperature readings at the higher elevation. Calculate the instrument Calibration Factor (CF) (kPa per B-Unit) from this information, given the change in pressure head and B-Unit readings.

5. Compare this field calibration to the calibration factor value provided on the Calibration Record sheet. The two values should agree within ± 0.5%. Repeat this calibration check as required to confirm the sensor is in proper working condition.

It is not recommended to install the piezometer if the calibration record sheet CF value cannot be confirmed by the field calibration test. The instrument will need to be inspected and undergo a full shop function test and re-calibrated before being returned to service. Contact RST for further information.

If the diameter of the water filled borehole is too small, the volume of water that the vibrating wire piezometer cable displaces, when raised or lowered into position, could potentially raise, or lower the borehole water level. This effect may seriously impact the accuracy of the above detailed Field Calibration Check. Note that this potential effect will be further dependent on the available permeability of the borehole to absorb small amounts of volume change.

To avoid this potential problem, it is recommended that the water filled borehole used for Field Calibration Checks be large enough in diameter so that the potential error caused by cable volume displacement will be insignificant in the calculation of the pressure change. It is recommended to use a borehole diameter that is a minimum of 10 times greater than the wire diameter. A borehole with a moderate degree of permeability would be preferred to a “tight” borehole.

4 READING PROCEDURES

4.1 VW INSTRUMENT READINGS

It is strongly recommended that the instruction manual for the RST VW2106 Readout Unit be read thoroughly before proceeding. Failure to become familiar with the function and operation of the VW2106 Readout could potentially result in damage to the VW2106 Readout unit and/or the vibrating wire sensors that are connected to it.

4.2 INITIAL INSPECTION AND CHECK READINGS

A full inspection of all received vibrating wire instrumentation equipment is required immediately upon receipt at site to ensure that the vibrating wire instruments have not been damaged in any way during shipment and are fully functional/ready for use.

Test readings should be taken of each vibrating wire instrument and compared to the vibrating wire instrument reading information provided on the Calibration Record sheet. Any discrepancies should fully investigated and satisfactorily resolved before the vibrating wire instrument is released for field installation and service.

The individual performing the inspection and initial test readings must be familiar with the vibrating wire instrument operation and contents of this instruction manual.

4.3 INITIAL READINGS

Vibrating wire piezometers differ from other types of pressure sensors as the core of the vibrating wire sensor is manufactured with an initial tension. The piezometers have a positive B-Unit reading without any external pressure being applied. Vibrating wire piezometers are acutely sensitive to pressure changes at zero point as there is no zero-point hysteresis to overcome. The determination of vibrating wire instrument

initial readings at the “zero point” is extremely important for the accuracy of the subsequent readings.

Before installing the vibrating wire piezometer, it is necessary to take the initial zero reading with no applied load. The initial zero reading can be taken in one of the following ways:

- With the filter stone removed, or
- With the stone completely saturated and installed.

More information can be found in Section 5.

If the filter stone is saturated, initial zero readings should be taken with the piezometer exposed to the open air.

CAUTION: DO NOT SUBMERGE THE INSTRUMENT IN WATER TO TAKE THE INITIAL READINGS. ONLY ATMOSPHERIC PRESSURE SHOULD BE APPLIED TO THE PIEZOMETER AT THIS TIME. FAILURE TO DO SO MAY IMPACT THE ACCURACY OF THE SUBSEQUENT READINGS.

The temperature reading from the internal thermistor must also be recorded. The barometric pressure for piezometers with a total range lower than 2 MPa must also be recorded. These values are needed to apply the correct correction factors for changes in temperature and/or barometric pressure, which will impact the reading accuracy of the vibrating wire piezometers through their intended range.

Initial zero readings are generally obtained immediately prior to installation with no external pressure and a constant ambient temperature and barometric pressure.

NOTE: BE SURE TO RECORD THE VIBRATING WIRE PIEZOMETER TEMPERATURE AND BAROMETRIC PRESSURE AT THE SAME TIME THE B-UNIT ZERO READINGS ARE TAKEN.

The following checks are required to obtain accurate initial zero readings:

- Has the temperature of the vibrating wire piezometer body reached full thermal equilibrium?
  - Variations in temperature across the mass of the piezometer body may result in a temperature reading which is not consistent with the entire vibrating wire instrument. This inconsistency will result in an error to the calculated pressure being read by the vibrating wire sensor. Allow 20 to 30 minutes for the temperature of the vibrating wire piezometer to equilibrate. Sources of temperature fluctuation, such as water flow, may have to be eliminated.
- Is the filter stone saturated?
  - Surface tension effects within the pore spaces of the filter could affect the zero readings if the filter stone is only partially saturated. This can be a problem particularly at low pressures (less than 350 kPa). Remove the filter

stone to allow direct atmospheric connection with the transducer diaphragm if there is any question regarding the adequate saturation of the filter stone.

4.4 PRESSURE EQUATION (USING THE VW2106 READOUT)

The VW2106 Readout Unit displays vibrating wire piezometer readings in frequency units called B-Units, which equal Frequency^2 x 10^{-3}, where frequency is in Hertz.

The B-Unit values represent absolute pressure and must be corrected for changes in temperature and barometric pressure. B-Unit changes from the initial zero reading are converted to the actual pressure changes using equations in Sections 4.4.1 and 4.4.2, which include corrections for temperature and barometric pressure changes.

4.4.1 Linear Equation

$$P = CF(L_0 - L) - T_K(T_0 - T) + F(S_0 - S)$$

EQUATION 1 LINEAR EQUATION

Where:

P = Corrected Pressure in kPa

CF = Calibration Factor in kPa/B-Unit (From the VW Piezometer Calibration Record sheet for each individual sensor)

L_0 , L = Initial and Current B-Unit reading (Frequency^2 x 10^{-3})

T_K = Temperature Correction Factor in kPa/ºC (From the VW Piezometer Calibration Record sheet in each individual sensor)

T_0 , T = Initial and current temperature readings in (ºC)

F = Barometric Pressure Constant = 0.1 kPa/mbar

S_0 , S = Initial and Current Barometric pressure readings in mbar

4.4.1.1 Example for a 350 kPa Range Piezometer

CF = 0.11594 kPa/B-Unit

L_i = 8776 B-Unit

L = 7200 B-Unit

T_K = - 0.03413 kPa/ºC

T_i = 22.9 ºC

T = 5.0 ºC

F = 0.1 kPa/mbar

S_i = 1003.1 mbar

S = 995 mbar

P = [(0.11594) x (8776 - 7200)] - [(-0.03413) x (22.9 - 5.0)] + [0.1 x (1003.1 - 995)]

= [182.72] - [-0.61] + [0.81]

= 184.14 kPa

NOTE: BAROMETRIC COMPENSATION IS NOT REQUIRED WITH VENTED AND DIFFERENTIAL PRESSURE TRANSDUCERS.

4.4.2 Second Order Polynomial Equation

$$P = A(L)^2 + B(L) + C - T_K(T_0 - T) + F(S_0 - S)$$

EQUATION 2 SECOND ORDER POLYNOMIAL EQUATION

Where:

P = Corrected Pressure in kPa

A = Polynomial Gauge Factor A in kPa/B-Unit^2 (Second Order Polynomial Expression derived from the VW Piezometer Calibration data, for each individual sensor)

B = Polynomial Gauge Factor B in kPa/B-Unit (Second Order Polynomial Expression derived from the VW Piezometer Calibration data, for each individual sensor)

C = Polynomial Gauge Factor C kPa (Second Order Polynomial Expression derived from the VW Piezometer Calibration data, for each individual sensor)

NOTE: POLYNOMIAL GAUGE FACTOR C MUST BE CALCULATED USING THE SITE ZERO READINGS, AS PER THE EQUATION BELOW.

$$C = -[A(L_0)^2 + B(L_0)]$$

L_0 , L = Initial and Current B-Unit reading (Frequency^2 x 10^{-3})

T_K = Temperature Correction Factor in kPa/ºC (From the VW Piezometer Calibration Record sheet in each individual sensor)

T_0, T = Initial and current temperature readings in (ºC)

F = Barometric Pressure Constant = 0.1 kPa/mbar

S_0, S = Initial and Current Barometric pressure readings in mbar

4.4.2.1 Example for a 350 kPa Range Piezometer

A = - 4.1484E-07 kPa/(B-Unit^2)

B = - 0.10991 kPa/B-Unit

C = 996.58 kPa

L = 7200 B-Unit

$\mathbf{T_K}$ = -0.03413 kPa/ºC

$\mathbf{T_0}$ = 22.9 ºC

T = 5.0 ºC

F = 0.1 kPa/mbar

$\mathbf{S_0}$ = 1003.1 mbar

S = 995 mbar

P = [(-4.1484 E-07) x (7200)^2] + [-0.10991 x 7200] + [996.58]

+ [-0.03413 x (5.0 - 22.9)] - [0.1 x (995 - 1003.1)]

= [-21.51] + [-791.35] + [996.58] + [0.61] - [-0.81]

= 185.14 kPa

5 INSTALLATION

Vibrating wire piezometers can be installed in various ways to suit the individual application. Specific guidelines for piezometer installation have been developed by various agencies and technical specialists. Appendix E provides a list of references.

The following instructions summarize the generally accepted practice for:

- Filter saturation;
- Cable identification;
- Piezometers installed in clay fill, granular material, or boreholes;
- Cable routing.

It is not recommended that vibrating wire piezometers be installed in wells or standpipes where an electrical pump and/or a power supply cable is present or nearby. Electrical interference from these sources can cause unstable readings. Ground fault currents from this type of equipment can easily damage the sensitive low voltage vibrating wire piezometers. Additional steps must be performed on site to ensure complete isolation and adequate grounding of the instrumentation circuits if

installation under these conditions is unavoidable. The instrument shield wire should be well grounded, but isolated from sources of external electrical interference.

In situations where vibrating wire piezometers and packers are used at the same time in standpipes or wells, special care must be taken to avoid damaging or cutting the cable jacket with the packer equipment or tools. Any cuts in the cable jacket will allow water entry, which can potentially result in damage or failure of the vibrating wire sensor.

5.1 FILTER SATURATION

High air entry ceramic or low air entry sintered stainless steel filters are available. The filters are intended to protect the delicate diaphragm area of the vibrating wire piezometer while allowing the transmission of external pressures. The filters and bottom cavity of the piezometer body must be saturated to allow the accurate transmission of hydraulic pressures to the vibrating wire diaphragm. Filter saturation provides the following reading advantages:

- There is no fluid movement in a saturated environment - only pressure transmission. This reduces the possibility of the filter becoming clogged with debris due to oscillating water movement;
- Decreased response times due to pressure changes, which means increased sensor sensitivity;
- Ensure hydraulic continuity between the pore water and the piezometer diaphragm in unsaturated soils, which will provide the highest accuracy of pressure measurement.

5.2 LOW AIR ENTRY SINTERED STAINLESS-STEEL FILTERS

Total saturation of the filter is necessary for accurate reading results. For the standard filter supplied, the low air entry filter, saturation will start to occur as the piezometer is lowered into the water. Water will be forced into the filter, compressing the air in the space between the filter stone and the pressure sensitive diaphragm. Given enough time, this air will dissolve into the water until the space below the diaphragm and within the filter is entirely saturated. This could take multiple days, which could mean slightly inaccurate reading results the first few days.

The following procedure will speed up the filter saturation process and allow accurate readings to be taken immediately:

- Turn the vibrating wire piezometer upside down. Remove the end filter assembly, which is held in place with an internal O-ring.
- Submerge the inverted piezometer in a bucket of flat water (water which has been sitting for 24 hours). This will fill the space above the piezometer diaphragm with water.
- While keeping the piezometer submerged, slowly replace the filter housing onto the inverted piezometer end, allowing the water to be forced out through the filter sinter.

- Note that with a low-pressure range piezometer (less than 350 kPa), it is recommended that vibrating wire readings be taken with a VW2106 Readout Unit while the filter housing is being pushed slowly into place, to ensure that the sensor does not over-range due to this operation.

- The vibrating wire piezometer should be stored in the bucket of water until ready to install downhole to maintain the filter saturation prior to installation.

- During the installation, the vibrating wire piezometers should be handled as gently as possible to keep the water in the filter sinter and the bottom chamber until submerging in the borehole.

CAUTION: VIBRATING WIRE PIEZOMETERS CANNOT BE ALLOWED TO FREEZE WHEN FULLY SATURATED, OTHERWISE DAMAGE WILL OCCUR TO THE TRANSDUCER DIAPHRAGM, WHICH WILL INVALIDATE THE TRANSDUCER FUNCTION AND CALIBRATION.

The O-ring providing the friction fit may become worn and the filter housing may become loose if the vibrating wire piezometer must undergo multiple removals and reinstallations of the filter housing. Replace the O-ring immediately if the filter housing is loose.

Coarser screen housings are available for use on vibrating wire piezometers if salts or other precipitates are clogging the stainless sinter filter. Screens are less likely to become clogged by precipitates and other debris found in some water sources.

Note that salts and other dissolved solids can be deposited within a stainless sintered filter if the filter is allowed to dry out completely. Thoroughly rinse out the filter with clean distilled water prior to drying to prevent filter clogging.

5.3 HIGH AIR ENTRY CERAMIC FILTERS

The ceramic filter on high air entry piezometers is also removable for de-airing. Because of the high air entry characteristics of the filter, proper de-airing is particularly important for this type of filter assembly in order to ensure that accurate readings can be taken. High air entry filters are available with different air entry values, which will require different procedures. It is therefore very important to know which type of high air entry filter is installed.

5.3.1 One Bar High Air Entry Filters

1. Remove the filter housing from the piezometer body by carefully twisting and pulling on the filter housing assembly. Remove the filter housing slowly to avoid causing a vacuum pressure on the piezometer diaphragm.

2. Boil the filter assembly in de-aired water for 30 minutes to force all air out of the filter and to saturate the filter material. Place the filter into de-aired water when boiling is completed.

3 Re-assemble the filter housing into the piezometer body under the surface of de-aired water, while keeping the piezometer oriented with the diaphragm pointing upward. Take care to ensure that no air is trapped in the transducer cavity.

4 Vibrating wire readings must be taken with a VW2106 readout unit while the filter housing is being pushed slowly into place. Allow any over-range pressures to fully dissipate before pushing the filter on any further.

5 The vibrating wire piezometer with a high air entry filter installed must be stored in de-aired water until the unit is installed.

CAUTION: VIBRATING WIRE PIEZOMETERS CANNOT BE ALLOWED TO FREEZE WHEN FULLY SATURATED, OTHERWISE DAMAGE WILL OCCUR TO THE TRANSDUCER DIAPHRAGM, WHICH WILL INVALIDATE THE TRANSDUCER FUNCTION AND CALIBRATION.

5.3.2 Two Bar (or Higher) High Air Entry Filters

The proper procedure for de-airing and saturating two bar (or higher) high air entry filters is complex and difficult to complete properly. It is recommended that it be performed either at the factory or by carefully following the instructions below:

1 Place the assembled piezometer, with the filter housing facing downward, at the bottom of a vacuum chamber. The vacuum chamber is to have an inlet port at the bottom to later allow introduction of de-aired water into the chamber.

2 Close the valve for the de-aired water inlet and evacuate the chamber. The piezometer should be monitored with a VW2106 readout unit while the chamber is being evacuated.

3 When the maximum vacuum has been achieved in the vacuum chamber, use the VW2106 readout unit to read the piezometer until it has also reached the same maximum vacuum pressure.

4 Open the de-aired water inlet valve to allow de-aired water to enter the bottom of the chamber and reach an elevation of approximately 50 mm above the top of the piezometer high air entry filter.

5 Close the de-aired water inlet valve when the de-aired water has reached the required height.

6 Release the vacuum, allowing the chamber to return to atmospheric pressure.

7 Observe the transducer output on the VW2106 readout unit. Up to 24 hours may be required for the (5 bar high entry) filter to completely saturate and for the piezometer pressure to return to zero. The saturation of the high entry filter is considered to be completed at this point.

8 After saturation, the transducer must be kept in a sealed container of de-aired water until ready for installation.

9 If de-aired at the factory, a special plastic cap is applied to the piezometer tip to maintain the saturation level. The plastic cap must be removed immediately before installation. When removing the cap, there will always be an unavoidable amount of movement of the filter when the O-ring drags past the filter adapter. The instructions below will help to minimize the movement:

a Remove the sealing screw from the top of saturation cap before trying to remove the cap from the sensor (Figure 5-1). This will eliminate the vacuum effect created when the cap is pulled off.

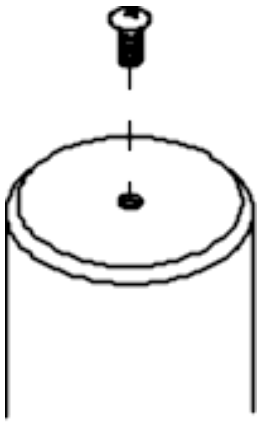


FIGURE 5-1 REMOVING THE SEALING SCREW

b Gently twist the saturation cap slightly to loosen the O-ring inside of the cap, and then pull to remove the cap from the piezometer tip.

If the filter becomes loose when the cap is removed, follow the steps outlined in Sections 5.3.1 to replace it.

CAUTION: VIBRATING WIRE PIEZOMETERS CANNOT BE ALLOWED TO FREEZE WHEN FULLY SATURATED, OTHERWISE DAMAGE WILL OCCUR TO THE TRANSDUCER DIAPHRAGM, WHICH WILL INVALIDATE THE TRANSDUCER FUNCTION AND CALIBRATION.

5.4 INSTALLATION IN FULL

5.4.1 Compacted Clay

1 Excavate a vertical trench or recess approximately 50 cm deep in the clay material. Form a horizontal cylindrical hole in the sidewall of the excavated trench near the bottom. The hole diameter should be slightly smaller than the piezometer body to ensure a snug fit when the piezometer is inserted in the hole.

2 Push the piezometer into the hole in the trench side, and into the host clay material. Smear the filter ceramic with a thin paste of the saturated clay material if necessary, to ensure continuity of the saturated air entry filter and pore water.

3 Place the cable with the utmost care to avoid any damage due to kinking or stretching. Look the cable and route it out of the trench. Make sure it rests on a bed of hand placed and lightly compacted screened clay. Ensure that the cable does not come into direct contact with itself or other cables in the area. Always maintain a few centimeters of compacted clay material between any two cables.

4 Backfill the trench with screened clay containing no particles larger than 3 mm in dimension. The backfill should have a water content and density equal to that of the surrounding material.

5 Ensure that the cable is well protected from any potential damage caused by any angular fill material, compacting equipment, and any settlement that might occur due to construction work or subsequent fill placement.

5.4.2 Granular Materials

1 Excavate a vertical trench or recess about 50 cm deep in the granular material.

2 Place the piezometer horizontally in the center of the trench or recess.

3 Loop the cable and backfill the bottom 10 cm of the trench around the piezometer with screened granular material not exceeding 3 mm in dimension.

4 Above that level, the trench can be backfilled in 10 cm lift with the same granular material that was excavated. The granular backfill should contain the same moisture content and be compacted to the same density as the surrounding fill. Care must be exercised to not subject the piezometer instrument to damage during compaction work.

5 In rock fill (particle sizes greater than 10mm), the large interstitial voids will not allow fine backfill materials around the piezometer to stay in place. The fine filter materials will migrate into the rock fill, eventually leaving the piezometer body in direct contact with the angular rock fill material. It will be necessary to place a graded filter zone around the piezometer to ensure that the filter materials will not be moved. Fine grained clean sand, grading to pea gravel or larger, will be required around the piezometer instrument. The particle size of the backfill will have to increase in size outwards toward the rock fill. The sand placed around the piezometer instrument and cable should range in size from 0.5 to 3mm in diameter and should not be angular.

- Note that it may be necessary or advisable to use geotextile filter fabric layers and/or envelopes to provide hard boundaries when attempting to place a fine grained zoned backfill around a piezometer within courser fill materials. This practice will ensure that fine grained backfill materials used within a graded filter will not become mobilized and wash away.

5.5 INSTALLATION IN BOREHOLES

5.5.1 Sand/Bentonite Method

The method used to install a piezometer in a borehole depends on the technical requirements for the instrument, the drilling method that was employed, the particular downhole conditions, and the materials which the installation must be carried out in. The general method described below will have general applicability to most installations. However, the Field Engineer must be aware of the unique conditions that may be present in the subject borehole, which could make downhole installations a major challenge. Conditions such as artesian pressures, squeezing ground, shear zones, and borehole wall instabilities will impact the piezometric instrumentation method chosen and installation techniques required. Refer to Appendix E for references of descriptions of other potential instrumentation methods.

5.5.1.1 General Installation Methodology

The drill casing is drilled 30 cm below the required piezometer installation elevation. If the piezometer is intended to measure the pore water pressure at a specific horizon, it may be necessary to drill hole to 90 cm below the required piezometer elevation to provide room for the placement of a bentonite bottom seal.

After the drilling is completed to the required depth, the drill cuttings and other downhole debris must be removed from inside the drill casing. The borehole is washed to bottom, inside the drill casing, until the water emerging runs clear.

If the borehole walls are stable enough to remain open, the drill casing can be withdrawn a certain distance above the hole bottom to allow the piezometer installation to proceed in the open length of the borehole. This is the desired method because the work will able to proceed in much easier fashion.

The piezometer installation will have to proceed with multiple small withdrawals of the drill casing to minimize the risk of losing the installation if the borehole walls are considered to be unstable or likely to cave or collapse. This method is described below and it will be obvious why longer drill rod or casing pulls will be more desirable if possible.

In general, boreholes in bedrock are more stable than boreholes in soil. Boreholes in cohesive soils are also more stable than boreholes in less cohesive, granular soils.

5.5.1.2 Bentonite Plug Method

Bentonite chips are recommended for downhole backfill work because they are a made from solid bentonite which will not hydrate as quickly when exposed to water compared to bentonite pellets, which are a manufactured product. Bentonite pellets will become sticky very quickly when exposed to water and can easily clump together, bridging inside the casing well above the target zone. Use of either bentonite products for downhole seals should be limited to holes which are less that 20 meters, due to the difficulty involved with this method.

CAUTION: DO NOT ROTATE THE DRILL CASING. THE DRILL CASING CANNOT BE ROTATED WHEN BEING PULLED. ROTATING THE DRILL CASING WILL LIKELY RESULT IN DAMAGE TO THE INSTALLED PIEZOMETERS.

1. Place a 60 cm bentonite seal at the bottom of the borehole to seal (if required).

2. Raise the drill casing 15 cm and start placing the bentonite chips until the bentonite level is 30 cm below the required piezometer elevation.

3. Pull the drill casing as the bentonite is set in place. Be very careful not to bridge or plug the drill casing with the bentonite.

   - This is accomplished by ensuring the bentonite level is at all times below the casing bottom and by slowly dropping the bentonite chips one at a time down the hole. Feeding the bentonite chips in too rapidly will result in bridging of the chips in the drill casing or borehole. Bridging will make completing downhole installations extremely difficult.

   - Tamping is not required because the natural swelling of the chips will provide an adequate seal to the borehole walls once the bentonite chips are in place.

4. Lower a cylindrical weight down the drill casing to the top of the bentonite plug to ensure the hole is clear of any obstructions prior to setting filter sand in place for the piezometer zone.

5. Rinse the borehole with clean water to remove any obstructions or debris.

6. Place 30 cm of fine, clean sand in 15 cm increments by dropping from surface. The drill casing will also have to be pulled as the sand back-filling proceeds.

7. Lower the piezometer into the hole and take the initial readings, as described in Section 4.3.

8. Raise the drill casing 15 cm and backfill the hole around the piezometer with fine, clean sand. Repeat until the sand is 30 cm above the top of the piezometer.

9. Take a second reading on the piezometer.

10. Lift the casing in 15 cm increments and backfill with bentonite chips until a minimum four-foot seal has been placed. Keep the piezometer cable taut to prevent the bentonite chips from adhering to the wall of the drill casing during the bentonite chip placement. Drop the bentonite chips into the hole one at a time to avoid bridging.

    - If more than one piezometer is to be installed in the drill hole, the intervening distance between the top of the first piezometer zone and the bottom of the next piezometer zone can be backfilled with either cement grout or cement/bentonite grout delivered by tremie method. The second piezometer can then be constructed in the same general manner as described above.

11. Top off the borehole collar with grout and a protective steel collar casing once all the drill casing has been removed from the hole.

5.5.2 Fully Grouted Method

The fully grouted method of piezometer installation involves the installation of the vibrating wire piezometers directly within a cement-bentonite grout mixture. This method has now become widely accepted based on the technical theory and on extensive field testing and application. It provides a simple and accurate method to obtain precision piezometric monitoring results. Refer to Mikkelson & Green (2003) and Contreras et al. (2008) in Appendix E for more details on this method.

The general method described below was taken from the two above technical papers and outlines the basic concepts and methodology of the Fully Grouted Method:

When using the fully grouted method, it is very important that proper filter saturation is performed. This ensures that there are no air-filled voids in the filter and that cement-bentonite grout will not be able to plug the filter stone. The best practice is to install the piezometers upside down with the filter tips facing upwards which will ensure that the water stays inside the filter stone. The piezometer can be inverted and tied off to its own cable or it can be inverted and taped onto a PVC pipe which can be used as either a downhole carrier pipe or as a tremie pipe for grout delivery.

The design of a bentonite-cement mixture is intended to approximate the strength and deformation characteristics of the surrounding soil or rock (rather than the surrounding permeability). The strength of the grout can be controlled by adjusting the Water-Cement ratio which is easy to control in the field. The water and cement are mixed first prior to adding any bentonite. This ensures that the water-cement ratio stays fixed and the strength/modulus of the mix is more predictable. Any type of bentonite drilling mud can be combined with Type I or II Portland Cement to make the mix. The quantity of bentonite powder will vary depending on the grade of the bentonite, the mixing agitation, the water pH, and the water temperature. As the bentonite solids content increases, the mix density increases and the permeability decreases.

The final mix point has to be carefully monitored to ensure that the completed grout remains pumpable. Although the grout mix has a target bentonite content, it may be cut short or extra bentonite may be added to attain the required pumping viscosity. In the end, the low permeability cement bentonite grout will provide adequate permeability for the vibrating wire piezometer diaphragm to react to any pressure changes occurring at the location. A number of installation methods have been identified using the fully grouted method:

- Install piezometers one by one from the borehole bottom to the collar over multiple days. Use a single PVC plastic tremie pipe, which is reduced in length, as each successive installation is competed to the hole collar.

- Attach the multiple piezometers to a PVC plastic tremie pipe and install to depth in the borehole. Use the PVC plastic tremie pipe to grout the entire hole in one stage and leave it in place. Note that you need to ensure that the piezometers being grouted into the borehole will not be over ranged by the grout column being placed. Vibrating wire piezometers can be over pressured to 200% of the full-scale range. However, in practice, it is recommended that 150% of FS not be exceeded to ensure an adequate safety buffer.

- For deep holes with lower range piezometers, multiple grouted in PVC plastic tremie pipes may be required. If multiple PVC tremie pipes are used, they should have their annulus fully grouted to ensure that no internal to external pressure communication can occur, if one or both PCV pipes should break.
- Install piezometers attached to a PVC plastic tremie pipe inside a casing or hollow stem auger. Leave in place while casing or auger stem is pulled out. Downhole grouting may be carried out before the casing or auger stem is pulled or following. This method is well suited to boreholes with wall stability issues.
- Complete drilling and then grout the hole with casing or hollow stem auger still in hole. Next, pull the casing or auger stem and top up the hole collar with grout. Install piezometers in the borehole, from the bottom to the top. Add weights to each piezometer as required, to overcome viscous resistance of the grout while lowering the piezometer.
- Attach piezometers directly to the outside of the inclinometer casing and grout in place. Piezometers should be placed midway between the casing couplings.
- Attach directly to the outside of corrugated polyethylene settlement pipe (Sondex) or similarly attach to magnet/reed switch casing between the magnet sensors so that pore water pressure and settlement can be measured along the same borehole.
- Install a series of vibrating wire piezometers inside a length of perforated 2-inch PVC plastic pipe. The piezometer filter housings will be located in close proximity to one or more of the perforation holes and will therefore be able to monitor the external pressures when fully grouted in-place. This technique is useful in deep installations inside of drill casing or hollow stem augers to prevent cable and/or sensor damage when rotation is required during casing extraction. Later tremie grouting outside the PVC pipe will result in the piezometers being fully grouted in-place.

5.6 INSTALLATION OF HEAVY-DUTY PIEZOMETERS WITH BLADDERS

The method used to install a heavy-duty piezometer in a borehole depends on the particular site conditions. Artesian conditions, borehole stability, available drilling equipment, and sealing materials are among the factors that will influence the most appropriate method. The method described below will cover most applications.

1 Drive the casing one foot below the required piezometer elevation. If the piezometer is to measure the pore water pressure in a specific horizon, drive the casing three feet below the piezometer elevation to allow for the placement of a bentonite seal at the bottom of the hole.

2 Remove the cuttings. Wash the borehole until the water emerging runs clear.

3 If required, place a two-foot bentonite seal at the bottom of the borehole. Raise the casing six inches and place the bentonite in six-inch increments until the bentonite level is one foot below the piezometer elevation. Pull the casing as the bentonite is set in place. Be very careful not to plug or allow bentonite to stick to the inside walls of the casing. This is accomplished by making sure the

bentonite level is below the casing at all times and by **slowly** dropping the bentonite chips down the hole in single file. Feeding the bentonite chips too rapidly will result in bridging of the chips in the casing or borehole. This will make it extremely difficult to complete the seal. Tamping of compressed bentonite chips is not required.

4 Lower a cylindrical weight down the borehole to ensure that it is clear from any obstructions. Rinse the borehole until clear water emerges, if necessary.

5 Place twelve inches of fine, clean sand in six-inch increments below the level of the piezometer tip, following the same procedure as Step 3. Pull the casing back as the sand back-filling proceeds. Lower the piezometer into the hole.

6 Pull the casing up six inches and backfill with fine clean sand. Repeat until the sand and casing are one foot above the top of the piezometer. Take another reading on the piezometer.

7 Lift the casing up in six-inch increments and backfill with bentonite until a seal of at least four feet has been formed. Keep the cable taut to prevent the bentonite from hooking up in the casing. Pour the bentonite in the hole one chip at a time to avoid bridging.

8 If more than one piezometer will be installed in the hole, backfill the casing with a cement/bentonite grout, host material, or sand/bentonite mixture to an elevation of 4 feet below the second piezometer, then use 3 feet of bentonite, 1 foot of sand, then the piezometer. Follow the procedure outlined in Steps 3 – 10.

9 Pull the casing out of the borehole. Take care when pulling the casing to not twist or damage the cable.

10 Once the entire casing has been removed, top off the borehole with grout. The profile of the borehole should resemble Figure 5-2.

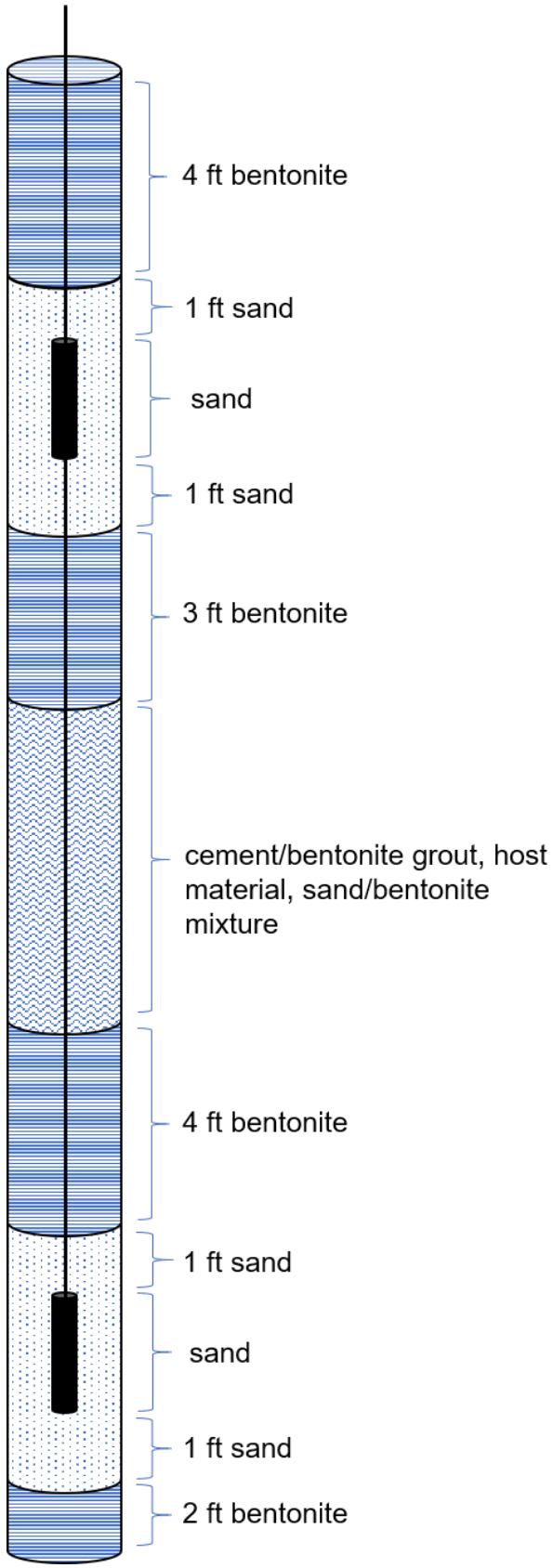


FIGURE 5-2 HEAVY-DUTY PIEZOMETER WITH BLADDER INSTALLATION

5.7 PIEZOMETERS DRIVE IN SOFT GROUND

RST Model VW2100-DP is designed to be pushed into place from the surface in soft soil. For deeper installations where driving from the surface would not be possible, the piezometer may be pushed into place from the bottom of a pre-drilled borehole.

The model VW2100-DP piezometer comes with an adapter fitting which can be connected to AW, CPT, 1" NPT, or 1-1/4" NPT threaded pipe or drill rod for pushing.

The drive rods are larger in diameter than the VW2100-DP and form an effective seal above the piezometer. The drive rods are left in the ground with the piezometers and can only be retrieved when and if the piezometer is recovered. Should other rods need to be adapted to push the VW2100-DP piezometer in place, it is important to ensure that the first 1.5 meters of these rod have a diameter which is larger than the outside diameter of the VW2100 piezometer housing.

5.7.1 Installation

1. Total saturation of the VW2100-DP filter is necessary for accurate results. Refer to Appendix B which outlines the steps required to saturate a drive point piezometer filter.

2. Prepare the rods to be used downhole. Lay a sufficient number of rods for the push side by side, alternating between male threaded and female threaded ends.

3. Thread the piezometer cable through the rods leaving a 0.5 m loop of extra cable laying flat on the ground at each rod end.

4. Leave an 8-meter length of free cable extending beyond the lower extremity of the first rod (assuming 3-meter rod lengths). This should provide sufficient slack to allow easy manipulation of the rods as they are screwed together and pushed into the drill hole.

5. Pull back the spare cable. Screw the lower rod onto the piezometer body. Use a pipe sealing compound or Teflon tape on the threads to form a permanent seal preventing pore-water from flowing into the rod string, thus causing delay response.

6. Add on the required number of rods in sequence to reach the push point.

7. Connect the VW2106 readout unit to the VW2100-DP and start monitoring the readings prior to pushing.

8. Push the piezometer into place while monitoring any pressure build-up at the tip. Stop the driving and wait until the pressure dissipates should the pressure exceed the working pressure range.

9. Complete the installation and ensure the cable leads are protected.

5.8 CABLE IDENTIFICATION

The vibrating wire cables are identified with a serial number tag that is attached to the cable jacket at the readout end. If the cable must be cut, this VW serial number tag must be removed and reattached at the new cable end. As an added identification feature, the large cable rolls used in the manufacture of all RST vibrating wire sensors have meterage numbers marked on the cable at every meter. The start and end point of the numbering sequence is unique to each sensor and is recorded on the instrument calibration sheet for later reference. Inspection of the cable meterage numbers can therefore be easily used to verify the ID of an installed vibrating wire sensor.

If the vibrating wire cable is cut and needs to be repaired, or the cable must be lengthened with a cable splice, RST recommends the use of an RST ELSPLICE4 Electrical Cable Splice Kit for Vibrating Wire Cable. Any cable splice that will be exposed to any moisture should be protected in this manner to eliminate the potential of water egress, short circuiting, and conductor corrosion.

5.9 CABLE ROUTING

5.9.1 Transition from Vertical Borehole to Horizontal Trench

The vibrating wire cable should be routed along a curved path as it goes from a vertical to a horizontal position. At the collar of the borehole, prepare a large radius circular transition path within a cushion of screened sand/5% bentonite mix, hand compacted to the surrounding fill density. Embed the cable along this transition pathway and bury it in place to ensure the cable will not be stretched or kinked by uneven loading.

5.9.2 Horizontal Cable Runs

Two methods are currently used to protect horizontal cable runs from damage. The first method is embedment within selected materials on the surface of the fill. The second method is embedment in an excavated trench in the fill. The second method is the most commonly used because once the trench is backfilled and compacted, the surface can be used for access. The trench method is discussed below. Refer to Clements (1982) in Appendix E for a description of this method.

All surface cable installations require continuous surveillance and protection from traffic and earth moving equipment which must move around on the fill surface.

Note that the trench dimensions should be 300 mm wider than the width required for the cable layout and a minimum 600 mm deep. A 100-150 mm bedding layer of 1 mm minus sand is then placed along the trench bottom. Bentonite can be added to the sand to form an impervious section or plug if required.

1. Cover cable completely with a 150 mm lift of 10 mm minus select material.

2. Completely backfill the trench with selected material. Compact it with light hand operated equipment.

3 Avoid traversing transition zones in the fill where large differential settlements could occur and create excessive strain in the cable. If cables must traverse these zones, install them with additional length for cable snaking which will allow slack for settlement to occur, rather than creating excessive cable strain.

4 Avoid cable splices. Only use an RST ELSPLICE4 Electrical Cable Splice Kit for Vibrating Wire Cables if splicing is required. The kit will ensure a strong and waterproof splice.

5 Spend time on the design of the cable layout in the trench. Avoid overlaying or crossing the cable runs on top of each other. If overlaying and crossing cannot be avoided, the cables must be separated by a 50 mm blanket of compacted fine-grained soil.

6 Use horizontal or vertical snaking of the cable within trenches to provide a certain amount of potential slack to avoid overstressing the cables during backfilling and the subsequent fill placement.

   - For most materials, a pitch of 1.8 m with an amplitude of 0.4 m will be suitable.
   - In very wet clays, which could be subject to settlement, increase the amplitude from 0.4 m to between 0.6 m and 1.0 m.

7 During cable routing, read the instruments at regular intervals to ensure their continued function. This is especially important prior to backfilling any trenches.

5.10 LIGHTNING PROTECTION

All RST Model 2100 Vibrating Wire Piezometers have highly reliable surge/lightning protection incorporated into the sensor circuitry. This surge protection is adequate for most applications. The entire instrumentation system needs to be considered to be effectively isolated in all situations, especially when multiple instruments are connected by wires into a large area network. The network could be subject to transient and/or induced currents which could damage sensors and/or data acquisition equipment.

In cases where there may be additional risks of surge damage to the network and/or data loss, the following suggestions for additional surge protection are provided:

- If a vibrating wire piezometer is connected to a terminal box or multiplexer on surface, components such as plasma surge arrestors (spark gaps) could be installed in the terminal box/multiplexer to provide an increased measure of transient protection. Terminal boxes and multiplexers available from RST provide built-in locations for the installation of these surge protection devices.
- Lightning arrestor boards and enclosures are available from RST that install at the exit point of an instrument cable from a drill hole or structure. The enclosure can be easily accessed and opened so that in the event that the protection board (Surge 4C) is damaged by a surge event, the user may easily service the components or replace the board. A connection is made between this enclosure

and ground to facilitate the passing of transients away from the vibrating wire instrument.

Additional information on surge protection alternatives is available from RST. Additional sources of information on protecting instruments, junction boxes, and data logging systems against power surges, transients, and electromagnetic pulses are listed in available in Appendix E.

6 TROUBLESHOOTING

Maintenance and troubleshooting of Vibrating Wire Piezometers is confined to periodic checks of cable connections and maintenance of terminals. The transducers themselves are sealed and are not user serviceable. The following are typical problems with suggested remedial actions.

6.1 VW PIEZOMETER FAILS TO GIVE A READING

1. Check the resistance of the vibrating wire coils by connecting an ohmmeter across the gauge terminals (red and black wires). Nominal resistance is approximately 180Ω (±5%), plus cable resistance at approximately 15Ω per 300 m of 22 AWG wire. Ensure to account for the two lengths of 22 AWG wire (i.e. red wire AND black wire) in this calculation. If the resistance is very high or infinite, the cable is possibly broken or cut. If the resistance is very low, the gauge conductors may be shorted.

2. Check the VW2106 Readout Unit with another vibrating wire piezometer to confirm that the VW2106 Readout Unit is working.

3. The vibrating wire piezometer may have been over-ranged or physically damaged. Inspect the diaphragm and housing for any obvious damage. Contact RST Instruments if necessary.

6.2 VW PIEZOMETER READING UNSTABLE

1. Connect the blue shield drain wire on the vibrating wire readout to the shield wire of the vibrating wire instrument. In the absence of a shield wire on the vibrating wire instrument, the blue shield drain wire can be connected to the black or green wires from the vibrating wire instrument. If this does not result in more stable readings, proceed to step 2 below.

2. Isolate the vibrating wire readout from ground sources by placing it on a piece of wood or similar non-conductive material. If this does not result in more stable readings, proceed to step 3 below.

3. Check for sources of nearby electrical noise such as motors, generators, antennas, or electrical cables. Move the vibrating wire piezometer cables as far as possible away from any sources of electrical noise. Filtering and shielding equipment is likely required if the noise cannot be eliminated. Contact RST for technical advice.

4 The vibrating wire piezometer housing may be shorted to the shield. Check the resistance between the shield drain wire and piezometer housing. The resistance should very high.

5 The vibrating wire piezometer may have been over-ranged or physically damaged. Inspect the diaphragm and housing for any obvious damage. Contact RST Instruments if necessary.

6.3 THERMISTOR READING IS TOO LOW

1 If the calculated temperature from the thermistor resistance reading is unrealistically low, it is very likely that there is an open circuit or poor connection in the thermistor wiring which is resulting in excessive resistance.

2 Check all connections, terminals, and plugs for any damage or corrosion that could cause excessive in-line resistance.

3 If cable damage or a cut is located, a splice must be performed to return the function of the wire connection to normal. It is recommended that an RST ELSPLICE4 Electrical Cable Splice Kit for Vibrating Wire Cables be used to ensure a strong and waterproof splice.

6.4 THERMISTOR READING IS TOO HIGH

1 If the calculated temperature from the thermistor resistance reading is unrealistically high, it is very likely that there is a short circuit in the thermistor wiring which is resulting in a lower resistance reading.

2 Check all connections, terminals and plugs for any damage or current leakage that could explain a partial short that could result in a reduced circuit resistance. If a short or partial short is located in the cable, the cable must be repaired with a splice. It is recommended that an RST ELSPLICE4 Electrical Cable Splice Kit for Vibrating Wire Cables be used to ensure a strong and waterproof splice.

3 If no obvious sources of shorting are found, it is possible that water may have penetrated into the interior of the piezometer. There are no remedial actions available if this is concluded to be the case

7 SPECIFICATIONS

TABLE 7-1 GENERAL SPECIFICATIONS FOR ALL MODELS

Specification	Value
Range	0.07, 0.175, 0.35, 0.7, 1, 2, 3, 5, 7.5, 10 MPa
Over-range	1.5 x FS
Temperature Range	-20°C to 80°C
Resolution	<0.025% FS
Accuracy	±0.1% FS
Non-Linearity	<0.5% FS
Zero Stability	0.02% FS/year
Thermal Zero Shift	< 0.05% FS/°C
Frequency Range	1200-3550 Hz
Coil Resistance	180 Ω ± 5%
Diaphragm Displacement	<0.001 cc @ FS
Thermistor Type	NTC 3k Ω @ 25°C
Filter	50 micron sintered stainless steel (High air entry alumina ceramic filter available for 1, 3 and 5 MPa versions)

TABLE 7-2 SPECIFICATIONS FOR INDIVIDUAL MODELS

Model	Description	Pressure Range	Dimensions
VW2100	Standard model for general applications	0.35, 0.7, 1, 2, 3 MPa	19mm ϕ x 130mm
VW2100-HD	Heavy-duty piezometer for direct burial in fills and large dam embankments	0.35, 0.7, 1, 2, 3, 5, 7.5, 10 MPa	25.4mm ϕ x 130mm
VW2100-XHD	Extra heavy-duty piezometer for direct burial in fills and large dam embankments	1, 2, 3, 5, 7.5 ,10 MPa	38.1mm ϕ x 130mm
VW2100-DPC	Drive point with CPT thread	0.07, 0.175, 0.35, 0.7, 1, 2, 3, 5, 7.5 MPa	33mm ϕ x 130mm
VW2100-DPC-CT	Drive point model with drop-off shoe	0.07, 0.175, 0.35, 0.7, 1, 2, 3 MPa	50.8mm ϕ (tip) 33.4 ϕ (body) x 130mm
VW2100-DPE	Drive point model with extension rod (31.8mm ϕ x 127mm)		
VW2100-L	Low pressure, unvented	70, 175 kPa	25mm ϕ x 133mm
VW2100-LV	Low pressure, vented	70, 175 kPa	25mm ϕ x 133mm
VW2100-M	Miniature version	0.35, 0.7, 1, 2, 3 MPa	17.5mm ϕ x 133mm
VW2100-MM	Micro-miniature version	0.35, 0.7 MPa	11.1mm ϕ x 165mm
VW2190	Heavy duty piezometer with bladder for brine environment	0.07, 0.175, 0.35, 0.7, 1, 2, 3, 5, 7.5 MPa	42mm ϕ x 319mm
VW2191	Heavy duty piezometer with bladder for acidic environment and secondary corrosive protection	0.07, 0.175, 0.35, 0.7, 1, 2, 3, 5, 7.5 MPa	42mm ϕ x 319mm

8 SERVICE AND REPAIR

The product contains no user-serviceable parts. Contact RST for product service or repair not covered in this manual.

Appendix A : VW2100 CALIBRATION SHEET

Vibrating Wire Piezometer

Customer:		RST Instruments Ltd.
Model:		VW2100-0.35
Serial Number:		**VW21345**
Mfg Number:		P101940
Range:		350.0 kPa
Temperature:		23.0 °C
Barometric Pressure:		1024.4 millibars
Work Order Number:		54049
Cable Length:		50 meters
Cable Markings:		802296 m - 802345 m
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:		EL380004
Thermistor Type:		3 kΩ

Applied Pressure (kPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (kPa)	Linearity Error (% FS)	Calculated Polynomial (kPa)	Polynomial Error (% FS)
0.000	8507	8508	8507	-0.004	0.00	0.006	0.00
70.000	7718	7719	7718	70.057	0.02	70.055	0.02
140.000	6932	6933	6932	139.851	-0.04	139.843	-0.04
210.000	6141	6142	6141	210.090	0.03	210.081	0.02
280.000	5353	5354	5353	280.062	0.02	280.060	0.02
350.000	4566	4567	4566	349.945	-0.02	349.956	-0.01
			Max. Error (%):		0.04		0.04

Linear Calibration Factor: **CF = 8.8797E-02 kPa/B unit**
Temperature Correction Factor: **Tk = -9.4569E-02 kPa/°C rise**

Polynomial Gage Factors:

A = 5.1074E-09 kPa/(B unit)² **B = -8.8864E-02 kPa/B unit** **C = _____ kPa**

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

Users must establish site zero readings for calculation purposes
Polynomial C = - $[A(L_0^2) + B(L_0)]$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in kPa
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = $Hz^2/1000$ ie: 1700 Hz = 2890 B units

	Date (dd/mm/yy)	VW Reading (B units)	Temperature (°C)	Baro (mbar)
Shipped Zero Readings:	25-Apr-18	8505	21.8	1008.8

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: E. Gilboe Date: 25-Apr-18

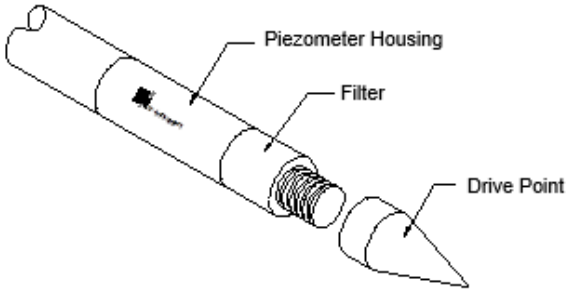
Appendix B : VW2100-DP (DRIVE POINT) PIEZOMETER

Pre-Operation Instructions:

1 Remove the protective plastic bag from the piezometer. Avoid touching the ceramic filter element, as oil from fingers may affect the permeability of the filter material.

2 Fill a bucket with water.

3 Unscrew the drive point of the piezometer, so that water can flow freely into the piezometer housing.



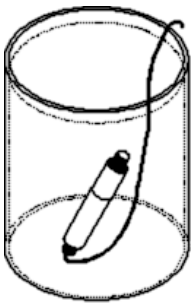
4 Immerse the piezometer upside-down in the bucket of water and ensure that all air is removed from the inside of the piezometer housing.

5 While the piezometer is still immersed in the water, thread the drive point back on. The drive point should be hand tightened. The filter should be slightly compressed by this process.

6 Note that with low pressure range piezometers (<70 kPa), readings must be taken with a readout box while carefully pushing the filter housing on so as not to over-range the sensor.

7 Remove the piezometer from the water and slide the wires through the adapter pipe. The unit should be kept under water to maintain saturation if the piezometer is not being installed immediately.

8 Thread the adapter pipe onto the VW2100-DP piezometer. Install the piezometer.



Appendix C : USING THE SECOND ORDER POLYNOMIAL TO IMPROVE THE ACCURACY OF THE CALCULATED PRESSURE

Most Vibrating Wire Pressure Transducers are sufficiently linear (<0.2% FS) that the use of a Linear Equation and a Linear Calibration Factor will satisfy most normal output requirements. However, it must be noted that the accuracy of the calibration data used to establish the Linear Calibration Factor is dictated by the accuracy of the calibration procedure and apparatus, which is always <0.1% FS.

The level of accuracy for a Vibrating Wire Pressure Transducer can be improved, especially when the transducer output is non-linear, by using the Second Order Polynomial Expression, which is better suited to the real pressures than the Linear Equation.

The Second Order Polynomial Expression has the following form:

$$\mathbf{P\ (pressure) = A(L)^2 + B(L) + C}$$

Where, L is the current Vibrating Wire reading (in B-Units) and A, B, and C are the polynomial coefficients determined by the individual instrument calibration procedure.

Appendix A shows a sample calibration sheet for a Vibrating Wire pressure transducer which has a comparatively low non-linearity. In this case, there will only be a very small difference between the pressure value calculated by the Linear Equation and by the Second Order Polynomial Expression.

In contrast, it is noted that the Second Order Polynomial Expression method will provide more accurate pressure values for VW transducers which have a high non-linearity (greater than 0.2% FS). The vibrating wire calibration sheet contains a column labeled “Linearity Error (% Full Scale)”. This column displays the calculated linear error percentage for the calibration steps. If the average of these percentage values (usually 6) exceeds 0.2%, it would be advisable to carry out all pressure calculations using the Second Order Polynomial Expression.

The Linearity Error (% Full Scale) is calculated as follows:

LE = [(Calculated Pressure – Applied Pressure) / Full Scale Pressure] * 100%

The Second Order Polynomial Expression will provide a calculated pressure which is more accurate to the actual pressure monitored and will contain less error. However, it should be noted that where the accuracy of absolute pressure measurement is not required, such as monitoring relative water level changes, it makes little difference whether the Linear Equation or the Second Order Polynomial Expression is used.

Appendix D : THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale 41C3001 B3, Alpha #13A3001 B3
Resistance to Temperature Equation:

$$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

EQUATION D-1 CONVERT THERMISTOR RESISTANCE TO TEMPERATURE

where:
- T = Temperature in °C
- Ln(R) = Natural Log of Thermistor Resistance
- A = 1.4051×10^{-3} (coefficient calculated over the -50 to +150°C span)
- B = 2.369×10^{-4}
- C = 1.019×10^{-7}

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.11	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342..2	83	107.9	123
77.99K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-35	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	282.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	56.92	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.	53	250.9	93	83.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

FIGURE 8-1 THERMISTOR RESISTANCE VERSUS TEMPERATURE

Appendix E : REFERENCES

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Vibrating Wire Piezometer
Portable Readout

Monitor with Confidence

TEL 604 540 1100
info@rstinstruments.com
www.rstinstruments.com

RST Instruments Ltd.
11545 Kingston St.,
Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

The VW2106 Vibrating Wire Readout shown connected to a Vibrating Wire Piezometer.

PRODUCT CATEGORY:
READOUTS + DATA LOGGERS

VW2106
Vibrating Wire Readout

The portable VW2106 Vibrating Wire Readout reads, displays, and logs both vibrating wire sensors and thermistors. Vibrating wire load cells can be read without any additional accessories.

Available for IMMEDIATE DELIVERY
Contact RST for Details

Unprecedented accuracy, flexible memory options, and ease of use make the VW2106 invaluable for projects requiring vibrating wire sensor monitoring. Maximum download time is only 15 seconds.

Complementing its high level of accuracy, the VW2106 is also designed for maximum efficiency with the user in mind. In addition to the simple power requirements of only 3 "AA" batteries, the VW2106 comes well-equipped with standard features such as a large graphics display with backlight, a built-in multiplexer, "no-tools" vibrating wire transducer inputs and a convenient on-board speaker for sensor diagnostics.

> APPLICATIONS

Reads, displays, and logs both vibrating wire sensors and thermistors.

> FEATURES

- Durable, compact design for excellent portability and field use.
- Large graphics display with a convenient backlight.
- Readings in raw or engineering units.
- Built-in multiplexer for load cells up to 6 vibrating wire gauges.
- "No-tools" vibrating wire transducer inputs.
- Field-replaceable "AA" alkaline batteries eliminate the need for a large, bulky 12 V battery and charger.
- On-board speaker for sensor diagnostics.
- Stores up to 254 instrument locations per route, each with a text label, calibration constants, previous data, and up to 11,400 time/date stamped data points.
- Data transfer to a host computer via USB in a compatible file format for Microsoft Excel® and other spreadsheets. User friendly host software for Microsoft Windows® included.

> BENEFITS

- ✓ **High Reliability**
- ✓ **High Accuracy**

SPECIFICATIONS

DESCRIPTION	SPECIFICATION
Vibrating Wire Readout Excitation Range	400 Hz to 6000 Hz, 5 V Square Wave
Vibrating Wire Readout Resolution	0.01 μs
Vibrating Wire Readout Timebase Accuracy	±50 ppm
Supported Temperature Readout Sensors	NTC3000 (standard), NTC2252, NTC10K, RTD
Temperature Readout Accuracy	±0.1°C
Temperature Readout Range	-50°C to 80°C
Display	Graphic 128 x 64 pixels large character display
Display Backlight	High efficiency LCD with auto off
Max Instrument Locations	254
Memory Capacity	11,400 custom labelled points
Location Identification String	Up to 20 characters
Download Speed	15 seconds (full memory)
Battery	3 "AA" alkaline
Battery Indicator	On-screen, low battery indicator
Operating Temperature	-20°C to 60°C
Dimensions	W 22 cm x D 19 cm x H 9.5 cm (8.75 x 7.5 x 3.75in.)
Weight	1.1 kg (2.4 lbs)

ORDERING INFO

ITEM	PART #
Vibrating Wire Readout	VW2106
Fly Lead	VW2106-AG

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VW2106 Vibrating Wire Readout Manual

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REVISION TABLE

Rev.	Revision History	Date	Prepared By	Approved By
J	Added revision table, section 4.6 instruction 4 “thermistor” changed to “sensor”, updated column heading in Table 4-2 from “Thermistor Type” to “Sensor Type”.	2019-09-03	MP	JW

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1 INTRODUCTION

The RST VW2106 Readout is a lightweight device used to read and display vibrating wire sensor and thermistor data. It is suitable for harsh environments and the user interface is simple to use.

The VW2106 readout is powered by 3 standard "AA" alkaline batteries to facilitate replacement in the field. Data can be reviewed either on-board or downloaded to the computer using RST-provided software.

FIGURE 1-1 VW 2106 READOUT

1. USB Connector
2. Large character LCD display
3. Backlight (hold down to display Engineering Units)
4. ESC (navigates back one menu)
5. Scroll Up
6. Scroll Down
7. Enter
8. Terminal Strip (for sensor connection)
9. Expansion port (VW Load Cells and external Multiplexers)

2 SAFETY

This product is battery operated. There are no major safety concerns associated with use.

It is important to keep the unit clean during use in the field. Ensure there is no dirt or dust in the wire terminals, battery compartment, and weather seal along the edge of the lid of the enclosure. Make sure that weather caps for the USB port and expansion port are properly secured when not in use.

3 GETTING STARTED

3.1 POWERING ON

The VW2106 Readout unit can be powered on any time by pressing any key.

3.2 POWERING OFF

The VW2106 unit can be powered off either manually or automatically.

The following instructions illustrate how to power off the unit manually:

1. Use the up/down arrows to scroll to the **Power Off** screen (Figure 3-1).

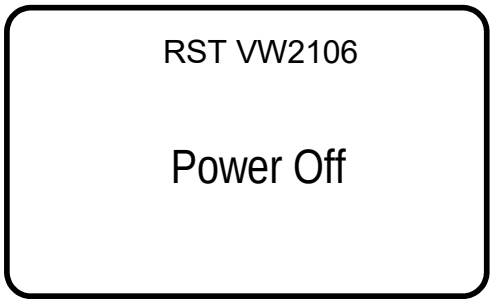

FIGURE 3-1 POWER OFF SCREEN

2. Press **Enter** and the unit will turn off.

The following instructions detail how to configure the unit to power off automatically.

1. Navigate to the **Auto Off** screen (Figure 3-2).

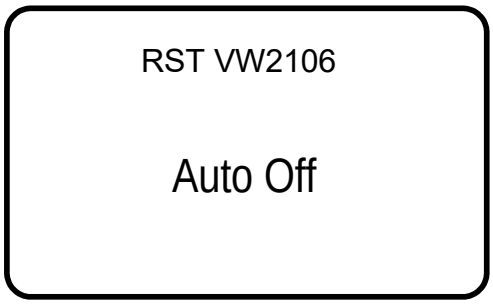

FIGURE 3-2 AUTO OFF SCREEN

2. Press **Enter**. The following screen will appear (Figure 3-3):

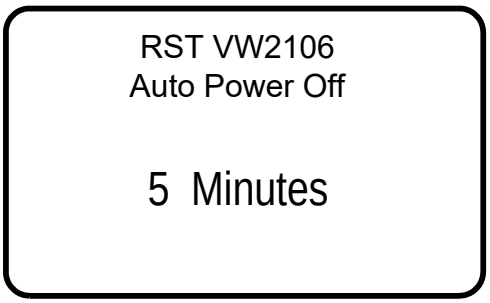

FIGURE 3-3 AUTO POWER OFF TIME

3. Use the up/down arrows to scroll to the desired auto power off time. Press **Enter** to select the time. The default time is five minutes.

NOTE: THE AUTO POWER OFF FEATURE IS ALWAYS ACTIVE AND CANNOT BE DISABLED TO CONSERVE BATTERY LIFE.

4. The next screen prompts the user to select the Auto Backlight Off (Figure 3-4). Use the up/down arrows to adjust the desired time and press **Enter**.

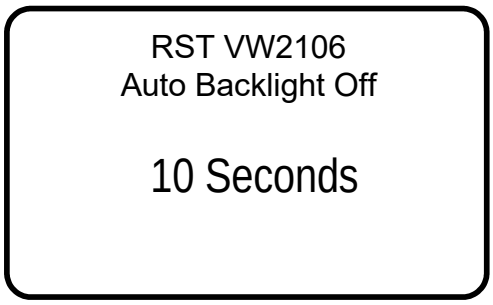

FIGURE 3-4 AUTO BACKLIGHT OFF

5. The next screen prompts the user to select the Speaker On time. Use the up/down arrows to select the desired time and press **Enter**. The unit will return to the previous menu.

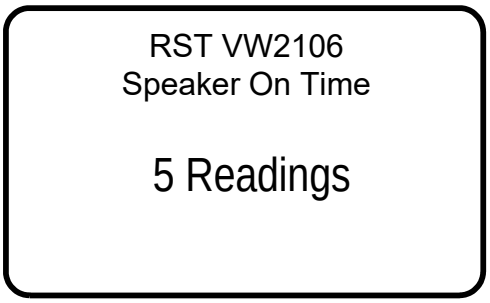

FIGURE 3-5 SPEAKER ON TIME

NOTE: IT IS RECOMMENDED TO KEEP THE UNIT OFF UNLESS IN USE TO PRESERVE BATTERY LIFE

4 CONFIGURATION

The VW2106 may be connected to **either** single field instruments **or** multi-channel instruments.

4.1 SINGLE FIELD INSTRUMENT CONNECTION

The following instructions outline the steps to connect single field instruments:

1. Using hands or a screw driver, lift the gates on the terminal strip.
2. Insert the stripped ends of the instrument cable to the matching wire transducer. Refer to Table 4-1 for matching colours and wire transducers.

TABLE 4-1 STANDARD WIRING COLOUR CODES

Colour	Wire Transducer
Red	Coil +
Black	Coil -
Green	Therm +
White	Therm -
Bare	Shield

CAUTION: MAKE SURE THAT THE WIRES ARE CLEAN AND FREE OF DIRT BEFORE INSERTING THEM INTO THE TERMINALS.

CAUTION: ENSURE THAT THE TERMINALS ARE FREE FROM DIRT AND DEBRIS BEFORE INSERTING THE WIRES. TERMINALS CAN BE BLOWN OUT WITH COMPRESSED AIR IF NECESSARY.

3. Close each gate to secure the wire.

CAUTION: ENSURE THAT THE GATES ARE SECURED BEFORE CLOSING THE LID TO THE UNIT TO AVOID DAMAGING THE GATES.

NOTE: APPLYING SOLDER TO THE BARE ENDS OF THE CABLE REDUCES FRAYING OVER TIME. ALL RST SENSORS ARE PRE-TINNED IN THE FACTORY.

4.2 MULTI-CHANNEL CONNECTION

The VW 2106 may be connected to multi-channel instruments through its expansion connection (Figure 1-1, 9).

Mating halves of the connectors are available through RST if your current sensors are not equipped with the appropriate connector.

The most common instrument with multiple channels is a Load Cell. Typical load cells have either 3 or 6 Vibrating Wire sensors with a common thermistor. During location setup, the number of sensors can be specified. Please refer to section 4.6 for detailed instructions.

The expansion connection is also able to control external multiplexers, which can facilitate connecting multiple single-channel instruments simultaneously.

For specific applications and configurations, please contact RST Instruments.

4.3 SETTING DATE AND TIME

Each reading includes a date and time stamp and it is stored in the unit's memory. To ensure accurate historical records of the readout data, keep the date and time current.

The following outlines the steps to set the date and time on the readout.

1. Turn on the readout by pressing any key.

2. Scroll to the **Set Time** screen (Figure 4-1) using the up/down arrows and press 'Enter'.

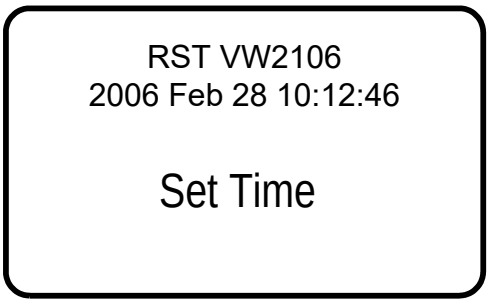

FIGURE 4-1 SET TIME SCREEN

4.4 CREATING LOCATIONS

The VW2106 Readout may be pre-configured either using the software on a host computer or directly on the device.

It is recommended that the VW2106 be pre-configured with the software prior to use in the field, as the site location names can be defined ahead of time.

If taken directly to the field prior to defining locations, each location will be assigned a generic name which can be edited once the VW2106 is connected to a host computer.

NOTE: THE MAXIMUM NUMBER OF PRE-DEFINED LOCATIONS IS 254.

The following instructions outline the steps to define new locations and location parameters on the device.

1. Turn on the readout by pressing any key.

2. Scroll to the **Memory** screen (Figure 4-2) using the up/down arrows and press **Enter.**

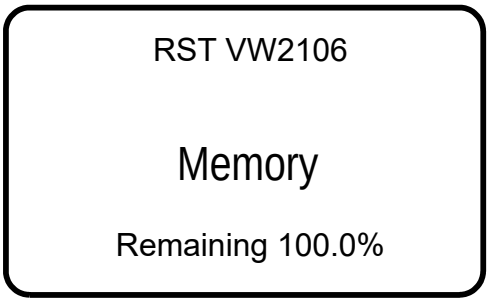

FIGURE 4-2 MEMORY SCREEN

3. Scroll to the **Create Location** screen (Figure 4-3) using the up/down arrows and press **Enter**.

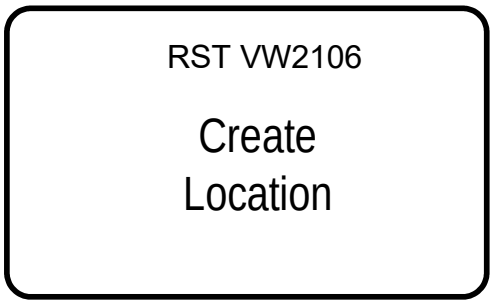

FIGURE 4-3 CREATE LOCATION SCREEN

4. The VW2106 will automatically create a site called Location X, where 'X' is the next storage location available in the unit's memory. Make note of the real location name in your field notebook and its relation to the location number. When connected to the Host Software back in the office, a custom name can be entered, which replaced the site name assigned by the readout.

NOTE: NEW SITES CREATED IN THE FIELD ARE ASSIGNED THE NAME 'LOCATION X' BY DEFAULT. THE READOUT AUTOMATICALLY INCREMENTS THE 'X' TO THE NEXT NUMBER AVAILABLE IN THE UNIT'S MEMORY. LOCATION NAMES CAN ONLY BE CHANGED WHEN THE VW2106 IS CONNECTED TO HOST SOFTWARE.

5. Use the up/down arrows to select between 1 and 6 sensors to read and press **Enter**.

NOTE: IN MOST CASES, THE SENSOR NUMBER WILL BE EQUAL TO 1. CASES WHERE MORE THAN ONE SENSOR IS USED ON THE LOAD CELLS REQUIRE THE EXPANSION CONNECTOR WHICH WILL BE AUTOMATICALLY ENABLED.

6. When connecting a single sensor, you will be given a choice between reading from the terminal strip or the expansion connector when connecting a single sensor. Select the appropriate connection and press **Enter**.

7. Use the up/down arrows to select the appropriate 'Sweep Frequency' for the gauge being measured at that location (Figure 4-4) and press **Enter**. The default is the "B" sweep (1200-3550Hz), which is the standard range for the RST model VW2100 series piezometers. Additional Sweep Frequencies are summarized in

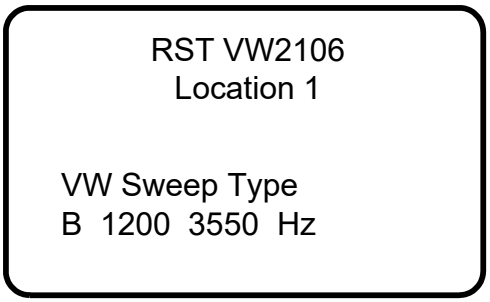

FIGURE 4-4 SELECTING THE SWEEP FREQUENCY

8. Use the up/down arrows to select the type of thermistor (Figure 4-5) and press **Enter**. The default is 3K, which is the standard thermistor in all RST Vibrating Wire sensors.

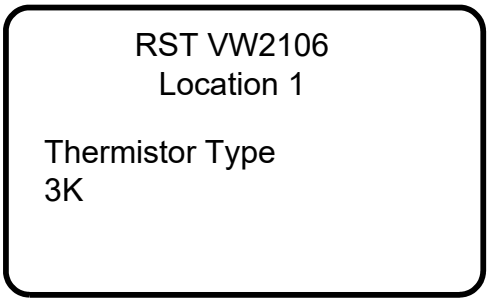

FIGURE 4-5 THERMISTOR TYPE

You may now use the newly created location to store readings. For instructions on how to store readings, refer to section 5.2.

4.5 IMPORTING PARAMETERS

If at least one location has previously been defined, the following instructions outline the steps to import parameters.

1. Scroll to the **Monitor Settings** screen using the up/down arrows and press **Enter**.

2. Select the **Import from Loc.** option and scroll to the desired location using the up/down arrows and press **Enter** when complete.

The location label will appear at the top of the screen to indicate the current location in use.

NOTE: THE DEVICE WILL DISPLAY THE MESSAGE "NO LOCATIONS" IF NO LOCATIONS EXIST IN THE READOUT'S MEMORY.

4.6 CREATING CUSTOM PARAMETERS

The following instructions outline the steps to set up custom parameters.

1. Scroll to the **Monitor Settings** screen using the up/down arrows and press **Enter**.

2. Select the **Custom Setup** option and press **Enter.**

3. Select the number of sensors connected and press **Enter**. Most devices will be set to connect to one sensor per terminal strip (Figure 4-6). The expansion connector is automatically enabled when more than one sensor is selected.

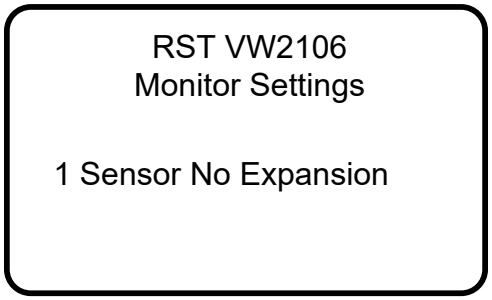

FIGURE 4-6 ONE SENSOR CONNECTED

4. Select the appropriate sweep frequency and press **Enter**. Refer to Table 4-2 for sweep frequencies corresponding to sensor type.

TABLE 4-2 SWEEP FREQUENCIES

Sweep	Frequency	Sensor Type
A	450-6000Hz	Wide Sweep
B (Default)	1200-3550Hz	Piezometer, Strain Gauge, Borehole Stressmeter, Jointmeter, Crackmeter, Displacement, Settlement, Temperature, Load Cells
C	450-1200Hz	Arc Weldable Strain Gauge
D	450-1200Hz	Embedment Strain Gauge
E	1000-3600Hz	Spot Weldable Strain Gauge
F	2500-6000Hz	Borehole Stressmeter
U (Custom)	1200-3550Hz	Custom user specified sweep frequency. May only be set within the readout software.

5. Select the Thermistor Type and press **Enter.** Options include 2252, 3K (default), 10K, and RTD.

6. Select the desired display units and press **Enter.**

7. The unit will return to the previous menu.

5 OPERATION

This section describes the operation of the VW2106 Readout once the unit has been powered on (see Section 3.1).

5.1 STARTUP

Once powered on, an opening screen will appear with the RST Instruments logo. If the user wishes to view the details of the readout, **press any key** immediately. Details of the unit (Figure 5-1) including the model, version number, serial number and current date and time settings are displayed.

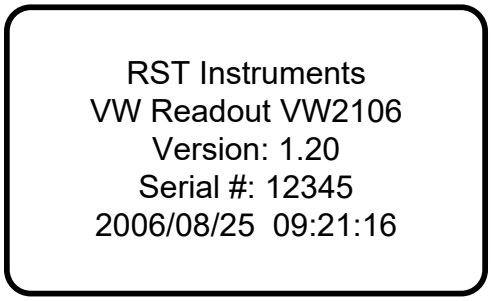

FIGURE 5-1 VW2106 READOUT DETAILS

NOTE: CHECK THAT THE DATE AND TIME SETTINGS ARE CORRECT, AS THIS MAY AFFECT ANY READINGS STORED IN THE UNIT'S MEMORY.

If no keys are pressed after powering on, the unit will default to the readings screen (Figure 5-2).

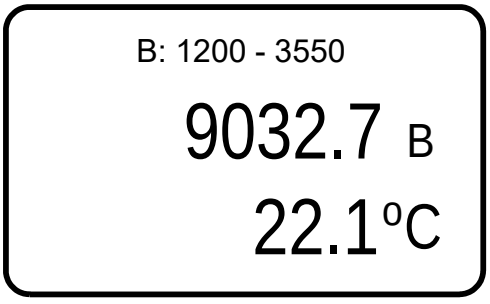

FIGURE 5-2 READINGS SCREEN

If a unit is connected, the readings screen will display the current sweep settings and a reading from the VW instrument and its internal thermistor. The default units are B units ($f^2 \times 10^{-3}$) and degrees Celsius. Units can be changed if desired (see section 4.6).

5.2 STORING READINGS IN MEMORY

The VW2106 readout has 128k of internal memory, allowing it to store over 11,000 time-stamped readings.

The following instructions outline the steps required to store readings in the unit's memory.

1. Using the up/down arrows, scroll to the **Store Data** screen and press **Enter**.
2. Using the up/down arrows, scroll to the desired location and press **Enter**.
3. Press **Enter** when prompted to store the reading (Figure 5-3).

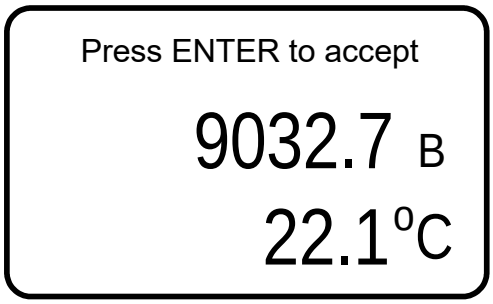

FIGURE 5-3 STORING A READING

4. If the unit has more than once sensor, the unit will display both average readings (in bold) and individual readings (Figure 5-4).

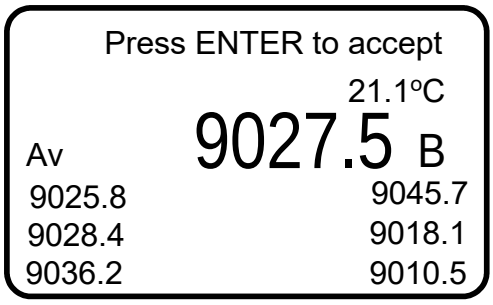

FIGURE 5-4 STORING A READING WITH 6 SENSORS

NOTE: AVERAGE READINGS WILL NOT BE STORED IN THE UNIT'S MEMORY.

5.3 REVIEWING DATA

The following instructions outline the steps to review readings on the VW2106.

1. Press any key to turn the readout on.

2. Using the up/down arrows, scroll to the **Memory** screen and press **Enter.**

3. Using the up/down arrows, scroll to **Review Data** and press **Enter.**

4. Scroll to the desired location using the up/down arrows and press **Enter**.

5. If a location contains more than one reading, the readings can be scrolled through using the up/down arrow.

5.4 DATA LOGGING

The VW2106 has a basic datalogging function where the user can set the datalogging interval and the number of iterations.

The following instructions detail the steps to log data at a given location.

1. Use the up/down arrows to scroll to the **Memory** screen and press **Enter**.

2. Use the up/down arrows to scroll to the **Data Logging** screen and press **Enter.**

3. Use the up/down arrows to select the location to record the data. If no locations are currently defined, the readout with respond with “No Locations.” See section 4.4 for detail about how to define locations.

4. Use the up/down arrows to set the reading interval and press **Enter**. For example, if 4 is selected, the data will log every 4 seconds (Figure 5-5).

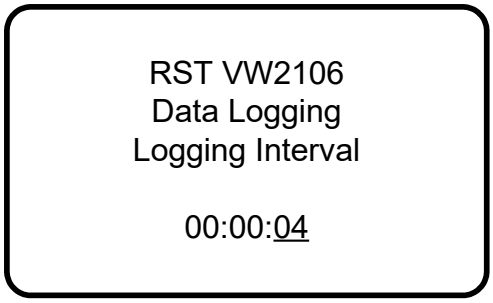

FIGURE 5-5 DATA LOGGING INTERVAL

5. Using the up/down arrows, select the data logging number and press **Enter**. For example, if the number 4 is selected, the data will log 4 times every interval, as illustrated in Figure 5-6. To continuously log data until the memory is full, set the data logging number to 0.

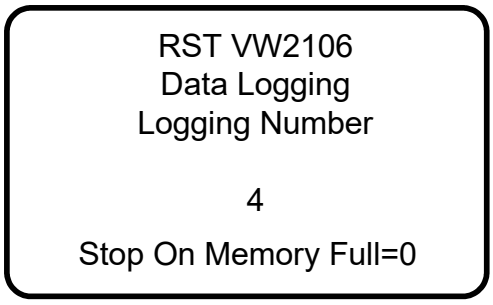

FIGURE 5-6 DATA LOGGING NUMBER

6. The readout will start the data logging process and will end with a message stating “Logging completed”. **ESC** can be pressed any time to abort the data logging process.

5.5 DATA LOGGING THROUGH STORE DATA

Once the intervals and iteration preferences have been defined (see section 5.4 step 4), data logging can also be accessed through the **Store Data** screen.

1. Using the up/down arrows, scroll to the **Store Data** screen and press **Enter**.
2. Select the location where the data will be stored. Press **Enter**.
3. Press and HOLD the **Enter** button to commence data logging. The logging screen will appear (Figure 5-7).

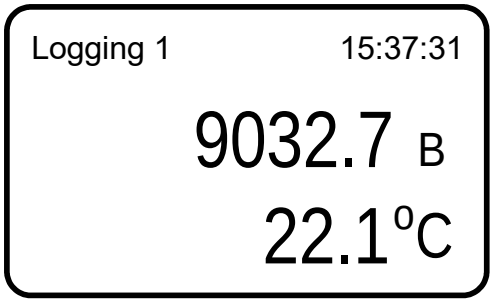

FIGURE 5-7 LOGGING SCREEN

During the logging process, the logging number and the corresponding time stamp will increase in the upper right-hand corner of the screen.

A message will appear indicating the logging process has been completed. The readout will automatically turn off.

5.6 ZEROING READOUT

The readout can be zeroed once the calibration factors are set for a specific location and the correct sensor engineering units are selected and uploaded from the

Multireadout Host Software to the VW2106 unit. Please refer to the Multi Readout Software Manual to set up sensor engineering units.

The following instructions detail the procedure for zeroing the sensor:

1. Using the up/down arrows, scroll to the **Memory** screen and press **Enter**.
2. Scroll to the **Zero Readout** screen and press **Enter**.
3. Scroll to the desired location and press **Enter**.
4. Select **Zero Readout** and press **Enter**.
5. Press **Enter** to accept the value displayed or press **ESC** for more options (Figure 5-8).

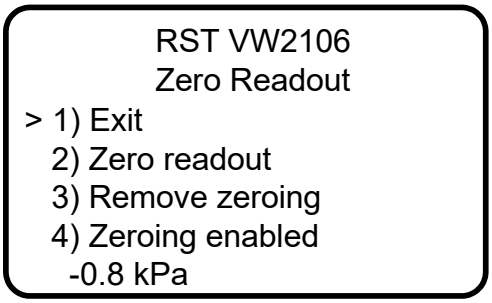

FIGURE 5-8 ZEROING OPTIONS

6. Using the up/down arrows, scroll to the desired option and press **Enter**.
   - **Selection 1** will exit the current screen.
   - **Selection 2** will zero the readout.
   - **Selection 3** will delete the current zeroing value.
   - **Selection 4** will toggle between zeroing enabled/disabled.

NOTE: "ENABLE/DISABLE" WILL SAVE THE ZERO OFFSET, SO IT CAN BE RE-APPLIED AT A LATER TIME. WHEN ZEROING IS ENABLED FOR A GIVEN LOCATION, 'TARE' WILL APPEAR IN THE READINGS SCREEN TO CONFIRM A READING IS BEING TAKEN WITH AN APPLIED ZERO OFFSET.

5.7 DELETING DATA

All location information can be deleted from the readout or through the Multi Readout Host Software. The following instructions detail the process for deleting data in the readout.

1. Press **any key** to power on the display.

2. Scroll to the **Memory** screen using the up/down arrows and press **Enter**.

3. Scroll to **Delete** using the up/down arrows and press **Enter**.

4. Scroll to the desired delete option (Figure 5-9) using the up/down arrows and press **Enter**.

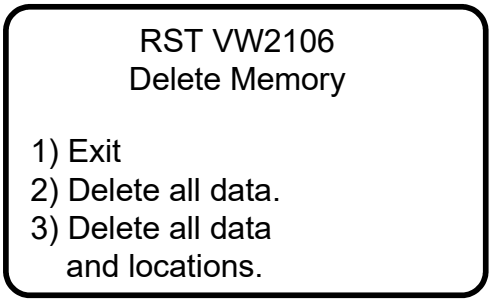

FIGURE 5-9 DELETE OPTIONS

NOTE: ESC CAN BE PRESSED AT ANY TIME TO ABORT THE DATA DELETION PROCESS.

6 MAINTENANCE

6.1 DEVICE HEALTH

The VW2106 Readout contains a built-in speaker. The following procedure outlines the steps to determine the health of the device by listening to the ring of the wire.

1. Simultaneously press the **Up** and **Down** arrows for several seconds to enable the audio feature. Once enabled, a small speaker graphic will appear on the screen.

2. Listen to the ring emitted from the device, If the instrument is functioning correctly, a steady ping without distortion will be audible.

3. This feature can be disabled by either waiting for it to time out or by simultaneously pressing both the **Up** and **Down arrows.**

6.2 BATTERY

The VW2106 operates on 3 standard “AA” batteries. The battery terminal can be found the left side of the readout unit (Figure 6-1).

FIGURE 6-1 BATTERY COMPARTMENT

The following instructions detail the process for accessing the battery compartment:

1. Using a flat-head screwdriver, turn the cap on the battery cover one quarter turn counter clockwise.
2. Remove the cap.
3. To replace the cap, ensure the notched on the cap align with the notches on the compartment. Firmly press the cap into place and turn the cap one quarter turn to the right.

CAUTION: ENSURE THE NOTCHES OF THE BATTERY COMPARTMENT COVER AND THE BATTERY COMPARTMENT ITSELF ARE ALIGNED BEFORE REPLACING AND TIGHTENING THE COMPARTMENT COVER TO PREVENT DAMAGING THE COVER.

Battery polarity is described in Figure 6-2:

FIGURE 6-2 BATTERY POLARITY DIAGRAM

The status of the battery can be checked using the following steps:

1. Turn on the readout by pressing **any key**.
2. Using the up/down arrow keys, scroll to the **Battery Voltage** screen.
3. The readout will display the current battery status, as illustrated in Figure 6-3.

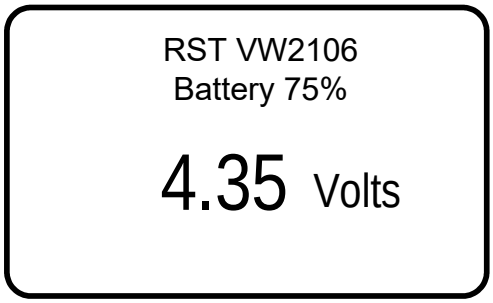

FIGURE 6-3 BATTERY VOLTAGE SCREEN

When the battery level is low (i.e. the battery voltage drops below 3.5 volts), "BATT" will appear on the upper right corner of every screen. All 3 batteries should be changed once this warning appears.

NOTE: REPLACE ALL 3 BATTERIES WHEN THE "BATT" WARNING APPEARS.

CAUTION: DO NOT REPLACE BATTERIES IN WET CONDITIONS TO PREVENT WATER INGRESS.

6.3 PROTECTING THE DEVICE

There are a number of steps that can be taken to protect the integrity of the unit:

- Ensure wires and terminals are free from dirt before inserting wires into the terminals.
- Check that the latch on the terminal block is in the closed position prior to closing the lid of the enclosure.
- It is important to keep the weather seal free from dust and dirt to maintain the water ingress protection.
- Make sure the weather caps are secured before closing the lid of the enclosure.
- Ensure the unit is dry before storing it to avoid damage from standing water.

7 SOFTWARE AND FIRMWARE UPDATES

The VW2106 Readout is designed so that the unit's software and firmware can be easily updated by the customer by connecting a host computer to the unit via the USB port. Please visit http://www.rstinstruments.com for product updates.

8 SERVICE AND REPAIR

The product contains no user-serviceable parts. Contact RST for product service or repair not covered in this manual.

Vibrating Wire Piezometer
Data Logger System

Vibrating Wire Piezometer
FlexDAQ Data Logger

Monitor with Confidence

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Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

CR6 FlexDAQ Data Logger (with optional wi-fi) in a weatherproof enclosure with RST Flexi-Mux Multiplexers.

CR300 FlexDAQ Data Logger shown with optional cellular modem for data communication.

PRODUCT CATEGORY:
READOUTS + DATA LOGGERS

FlexDAQ Data Loggers

Ideal for remote monitoring in both common and demanding geotechnical conditions, RST FlexDAQ Data Loggers offer precise measurement and reliable data acquisition from various sensor types and gauges including vibrating wire, thermistor, MEMS (analog and digital), Tensmeg, linear potentiometer, strain gauge, LVDT, TDR, etc.

The 4 main FlexDAQ models are the CR6, CR300, CR800, and CR1000X. All offer extreme flexibility in their design configurations and are custom made to accommodate a variety of sensor types as they pertain to the parameters of your project. The framework for building a FlexDAQ Data logger is dependent on the type, number, precision, and speed of measurements required. Best of all, FlexDAQ Data Loggers arrive to you completely pre-assembled, pre-wired, pre-tested, and pre-programmed; ready to be put to work straight out of the box with minimal set-up.

All FlexDAQ Data Loggers bear similarities in measurement and programming capabilities and can easily incorporate additional sensor and telecommunication options.

> APPLICATIONS

Remote data logging of various types of geotechnical instrumentation used in dams, tunnels, bridges, mines, and natural slopes.	Alarm triggering when movement reaches a preset critical rate or levels reach a present value.
Real time data logging and analysis.	

> FEATURES

Immediate functionality straight out of the box - “Ready to Run”.	Weatherproof housing available.
Pre-assembled, pre-wired, pre-programmed and pre-tested.	
Flexible data logger configurations made to exact customer specifications.	
Multiplexers, such as the RST Flexi-Mux (see reverse) may be added to augment measurement and control capabilities that include:	
Adding extra sensors that can be monitored by the data logger (RST Flexi-Mux).	Providing non-volatile data storage and on-board battery-backed clock.
On-board data processing.	Initiating measurement and control functions based on time or event.
Controlling external devices such as pumps, motors, alarms, freezers, valves, etc.	Using PC support software or keyboard/display to program.
Operating independently of AC power, computers, and human interaction.	Consuming minimal power from a 12 Vdc source.
Interfacing with on-site and telecommunication devices such as cellular modems, radio transceivers, Wi-Fi routers, satellite transmitters, and ethernet interfaces. See diagram on reverse.	

ORDERING INFO

ITEM	PART #
CR6	ELGL1206
CR300	ELGL1430
CR800	ELGL1300
CR1000X	ELGL1200
Flexi-Mux Multiplexer	ELGL2042

NOTE: Due to the customizable nature of each FlexDAQ Data Logger model, specifications can vary greatly in accordance to customer specifications and optional additions. Please contact RST Instruments Ltd. for complete information.

> BENEFITS

- ✓ **Increase Productivity**
- ✓ **High Reliability**
- ✓ **Custom Options**
- ✓ **High Accuracy**
- ✓ **Technical Support**
- ✓ **Increase Safety**

RST Instruments Ltd. reserves the right to change specifications without notice. ELB0030I

Monitor with Confidence

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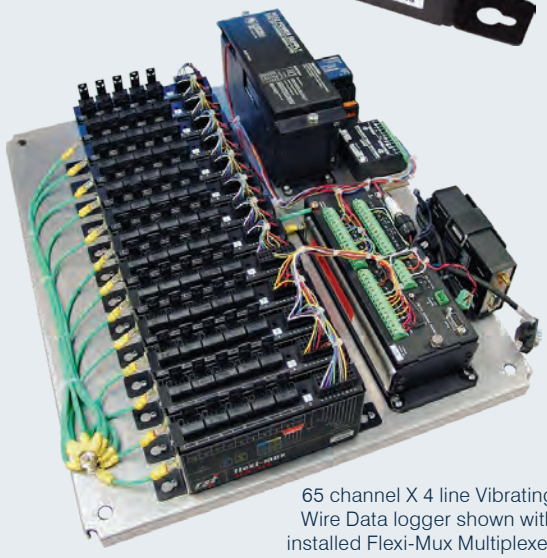
ISO 9001

FlexDAQ Data Loggers

PRODUCT CATEGORY:
READOUTS + DATA LOGGERS

SPECIFICATIONS + ORDERING

RST Flexi-Mux Multiplexer



65 channel X 4 line Vibrating Wire Data logger shown with installed Flexi-Mux Multiplexers.

Flexi-Mux

The RST Instruments Flexi-Mux allows a single channel of data loggers, such as the Campbell CR1000X, to be sequentially connected to numerous sensors. Each Flexi-Mux can sequentially multiplex 5 groups of 4 lines for a total of 20 lines. Alternatively, internal DIP switch settings permits the multiplexing of 10 groups of 2 lines.

The extremely slim and compact (8.15"H x 1.05"W x 3.17"D) vertical design permits the Flexi-Mux to occupy minimal space in the control box which allows for more Flexi-Mux units to be installed. By utilizing a unique cascade feature, there is theoretically no limit to the number of channels which can be connected to the data logger.

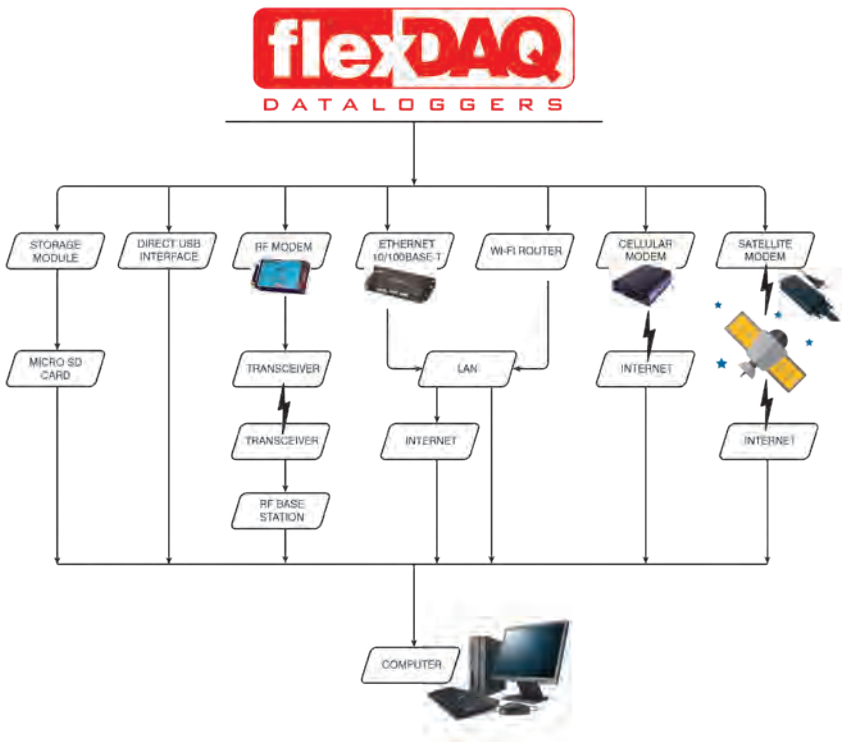
Conveniently designed detachable screw terminals allow rapid wiring of large systems, with straightforward testing and substitution of both sensors and multiplexers. Built-in transient protection on every line safeguards against damage which can be caused by occurrences such as nearby lightning.

The Flexi-Mux requires only 2 data logger control ports; one for "enable" (Reset terminal), and a second for channel stepping (Clock terminal). The Flexi-Mux is compatible with most sensors including load cells, pressure transducers, vibrating wire sensors, thermistors, potentiometers, and numerous other specialty sensors.

FLEXI-MUX SPECIFICATIONS

ITEM	DESCRIPTION
Power	12 Vdc (under load), unregulated
Current Drain	10μ quiescent; 8 mA active
Reset Active Levels, max.	2.0 V
Clock Active Levels, max.	2.0 V
Min. Clock Pulse Width	1 ms
Max. Actuation Relay Time	20 ms
Relay Operation	Break before make
Initial Relay Resistance, max.	0.1 Ohm
Max. Switching Current	1 A
Min. Contact Life	10^7 closures
Operating Temp.	-40°C to 70°C (-40°F to 158°F) - extended
Size	8.15"H x 1.05"W x 3.17"D
Weight	0.24 kg (0.53 lbs.)

COMMUNICATION METHODS



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FlexDAQ Setup and Installation Manual

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REVISION TABLE

Rev.	Revision History	Date	Prepared By	Approved By
A	Initial Release	01-Feb-2019	MP	CB

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1 INTRODUCTION

FlexDAQ data loggers are versatile, custom-made systems that provide precise and reliable data acquisition from various sensor types and gauges. They are all contained in a durable, rugged enclosures that are dust-tight and water-resistant (IP-66) (Figure 1-2). The enclosures can be exposed to the elements, such as rain, snow and splashes of water, but are not suitable for submersion.

FIGURE 1-1 AN EXAMPLE FLEXDAQ CONFIGURATION FEATURING THE CR6

FIGURE 1-2 RUGGED FLEXDAQ ENCLOSURE

Due to the high customizable and unique nature of each FlexDAQ system, the information provided in this document is general and is intended to be used as a guide only. Information that is specific to your individual system, including schematic diagrams and set up instructions, has been provided on a USB drive included with your shipment. Please refer to those documents when setting up the FlexDAQ. Contact RST Instruments with any questions or concerns that may arise.

CAUTION: **PLEASE USE THE DOCUMENTS SUPPLIED ON THE USB DRIVE INCLUDED WITH YOUR SHIPMENT AS THE PRIMARY RESOURCE WHEN SETTING UP THE FLEXDAQ. IT CONTAINS CUSTOM INFORMATION THAT IS HIGHLY SPECIFIC TO YOUR INDIVIDUAL SYSTEM. THE INFORMATION IN THIS DOCUMENT IS GENERAL AND WILL PROVIDE AN OVERVIEW ONLY.**

2 SAFETY

Normal safety precautions should be followed and proper personal protective equipment (PPE) should be worn when working in the field with this equipment, including safety glasses and high-visibility clothing.

Care should be taken to ensure the inside of the enclosure and the seal remain dry and free from dust and dirt. Should the FlexDAQ unit need to be opened, protect the electronics from the elements as much as possible and ensure the seal is clean before closing the cover and securing the latches.

3 COMMON COMPONENTS

The FlexDAQ components described below are some of the most typical components included in a single FlexDAQ enclosure. The type of datalogger included in a given enclosure depends on the required communication method, sensor type, and the required number of ports, switches and charging ports, among other considerations. Keep in mind that each enclosure in your system may contain different hardware. Consult the schematic drawings on the supplied USB drive (Section 5.1) to confirm the details of your specific system and each individual FlexDAQ unit.

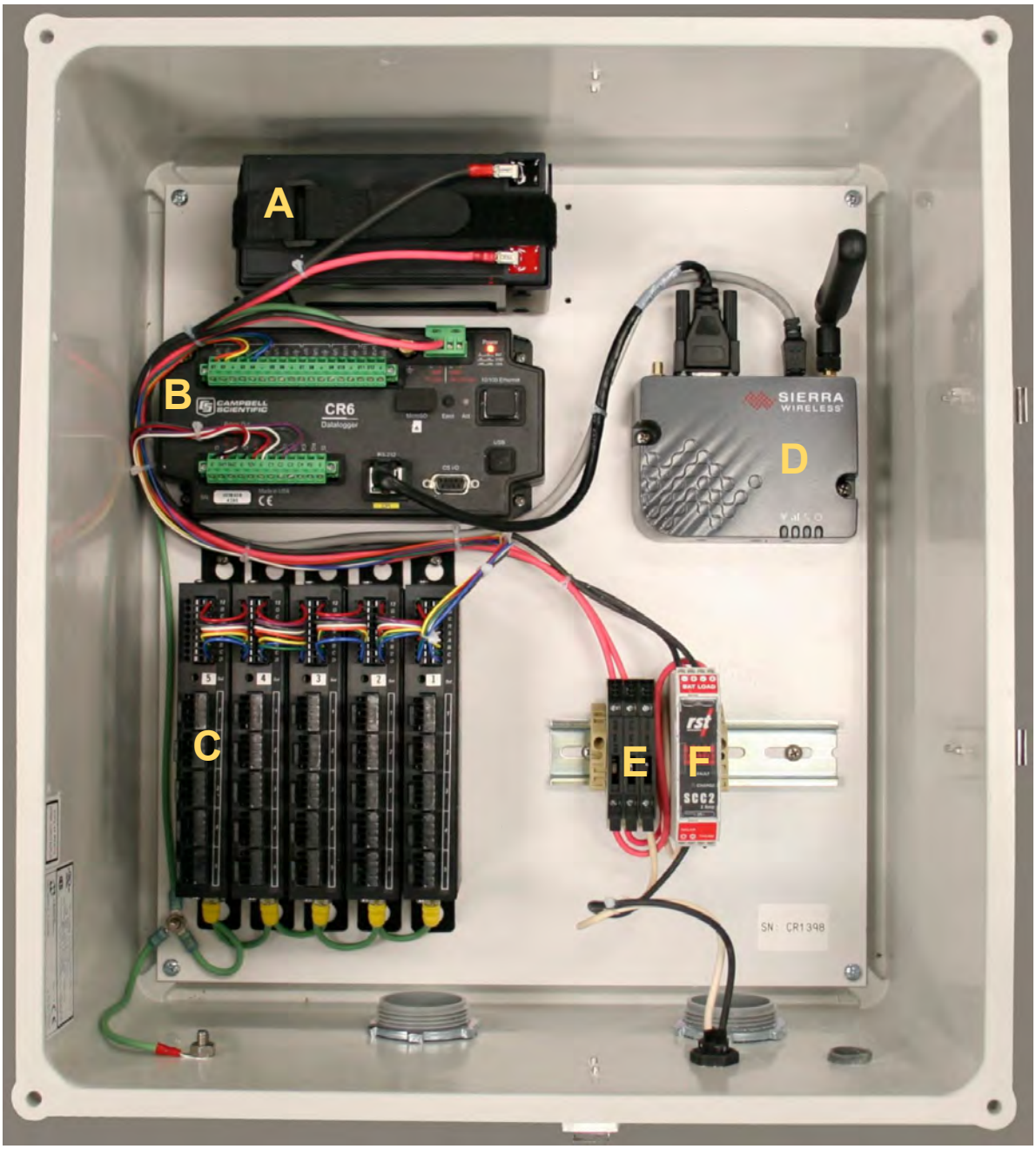

FIGURE 3-1 COMMON COMPONENTS OF THE FLEXDAQ SYSTEM

A Battery (see sections 3.1)

B Data logger (see section 3.2)

C Flexi-Mux (see section 3.3)

D Communications module (see section 3.4)

E Fuses (not covered in this document)

F Charger controller (not covered in this document)

3.1 POWER AND BATTERY

The FlexDAQ system is generally powered by 12V DC battery. The battery is charged by one of two methods:

- Solar power
- AC

The size and type of battery depends on many factors including the unit's consumptions and charger power source. Further information regarding the battery contained in your unit can be located on the USB drive included with your shipment.

3.2 DATALOGGER

The core of any FlexDAQ unit is its datalogger. It is pre-programmed in the factory, thus requiring minimal setup and configuration in the field. There are four commonly used models, each of which is briefly described in the sections below. The model in a particular unit is determined based on its application.

3.2.1 CR6

The CR6 datalogger (Figure 3-2) is a multi-purpose and low power datalogger that provides high accuracy and fast communication options such as Wi-Fi, cellular modem, ethernet, satellite, radio or USB connection to a PC. It features many different types of communication ports and its memory can be expanded with a microSD card.

FIGURE 3-2 THE CR6 DATALOGGER

3.2.2 CR300

The CR300 datalogger (Figure 3-3) is a compact, low-cost logger that features low power requirements and fast communications. This logger comes equipped with communication options such as Wi-Fi, cellular modem, radio or USB connection to a PC. With additional hardware, communication capabilities can be expanded to include ethernet and satellite.

FIGURE 3-3 THE CR300 DATALOGGER

3.2.3 CR800

The CR800 datalogger (Figure 3-4) is a simple logger ideal for situations where fewer sensors need to be monitored over long periods. It can communicate via radio or cellular modem, direct serial connection to a PC, and, with additional hardware, ethernet and satellite.

FIGURE 3-4 THE CR800 DATALOGGER

3.2.4 CR1000X

The CR1000X (Figure 3-5) is a versatile and robust datalogger. It is used in many diverse applications, can handle complex configurations and has communication options such as Wi-Fi, cellular modem, ethernet, satellite, radio or USB connection to a PC. It features many different types of communication ports and its memory can be expanded with a microSD card.

FIGURE 3-5 THE CR1000X DATALOGGER

3.3 FLEXI-MUX MULTIPLEXER

The Flexi-Mux Multiplexer (Figure 3-6) is included in many FlexDAQ systems to increase the number of sensors that can be measured by a single datalogger. It is a versatile unit that is compatible with many kinds of dataloggers and sensors. Multiple Flexi-Mux units may be used to dramatically increase the number of sensors measured by a FlexDAQ unit.

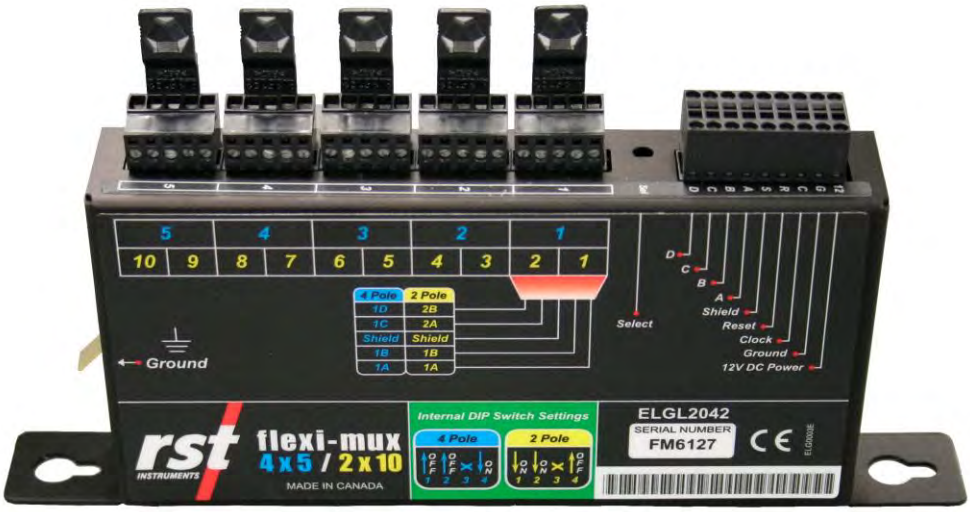

FIGURE 3-6 FLEXI-MUX MULTIPLEXER

3.4 COMMUNICATION

There are two main methods to communicate with your datalogger: wired connections and wireless. The communication method particular to your FlexDAQ will be defined upon purchase. Each method is described in the sections below.

3.4.1 Wireless

Wireless communication methods include Wi-Fi, radio, cellular modem and satellite modem. The type of communication module appropriate for a given system depends on a number of variables, including the intended location of the FlexDAQ, the type of datalogger used and customer preference. The communication method will be defined upon purchase. For generic setup instructions, see Section 4.2. For setup instructions specific to your individual system, please see the USB drive included in your shipment.

3.4.2 Wired Connections

The datalogger and any data stored in its memory can also be accessed through a wired connection. This is usually either ethernet or USB cable connected directly to the datalogger. Refer to the schematic diagram on the USB drive included in your shipment for exact configurations.

CAUTION: ENSURE THAT THE ELECTRONICS INSIDE THE RUGGED ENCLOSURE REMAIN PROTECTED FROM RAIN, SNOW, ICE, DIRT AND DUST. TO MAINTAIN THE INTEGRITY OF THE WEATHER PROTECTION OF THE ENCLOSURE AFTER OPENING, ENSURE THE SEAL REMAINS FREE FROM DUST AND DIRT BEFORE CLOSING THE COVER AND SECURING THE LATCHES.

4 INSTALLATION

The following section describes two common installation scenarios: mounting the FlexDAQ on a wall or pole. The location of the installation and relevant sizing information should be defined when ordering, and the appropriate hardware will be included with the shipment. Installation procedures may need to be adjusted based on the particular needs of a given site. Please read the following section and contact RST Instruments with any site-specific questions or concerns that may arise.

CAUTION: **INSTALLATION SHOULD BE HANDLED BY AT LEAST 2 PEOPLE. IF THE FLEXDAQ IS VERY LARGE, ADDITIONAL TECHNICIANS MAY BE USEFUL TO SUCCESSFULLY COMPLETE THE INSTALLATION.**

4.1 WALL MOUNT

The FlexDAQ can be mounted on a wall or any flat, secure, vertical surface. The tools and hardware required will depend on the type of wall selected. The FlexDAQ comes equipped with four steel feet (Figure 4-1) on the back of the unit to facilitate installation.

FIGURE 4-1 MOUNTING FOOT

4.1.1 Installation Tools and Materials

The following tools will be needed for installing the FlexDAQ on a wall:

- 4 bolts appropriate for the material of the wall.
- Drill.
- Drill bits appropriate for the material of the wall.
- Appropriate grounding stake and cable, if required.
- Flat-head screwdriver.

4.1.2 Installation Procedure

The following steps outline a general procedure for installing the FlexDAQ on a wall. Characteristics of individual site may require changes to the procedure. Please contact RST Instruments with any questions or concerns.

4.1.2.1 Preparation

1. Ensure the wall or vertical surface is sturdy and secure and capable of supporting the weight of the FlexDAQ.
2. Select the installation location. Ensure that the back of the wall is unobstructed, and installation of the unit will not interfere with important utilities.
3. Measure the spacing between the feet on the back of the FlexDAQ in both the vertical and horizontal direction.
4. Mark the spacing on the wall.

4.1.2.2 Installation

5. Drill guide holes into the wall, if necessary.
6. With one person holding the FlexDAQ unit in place, install the bolts through the holes in each foot into the wall.

4.1.2.3 Grounding (if required)

The unit should always be grounded. If the unit is charged using AC power, a grounding stake is not required so long as the AC power is properly grounded.

7. A grounding lug (Figure 4-2) is located on the lower side of each FlexDAQ enclosure.

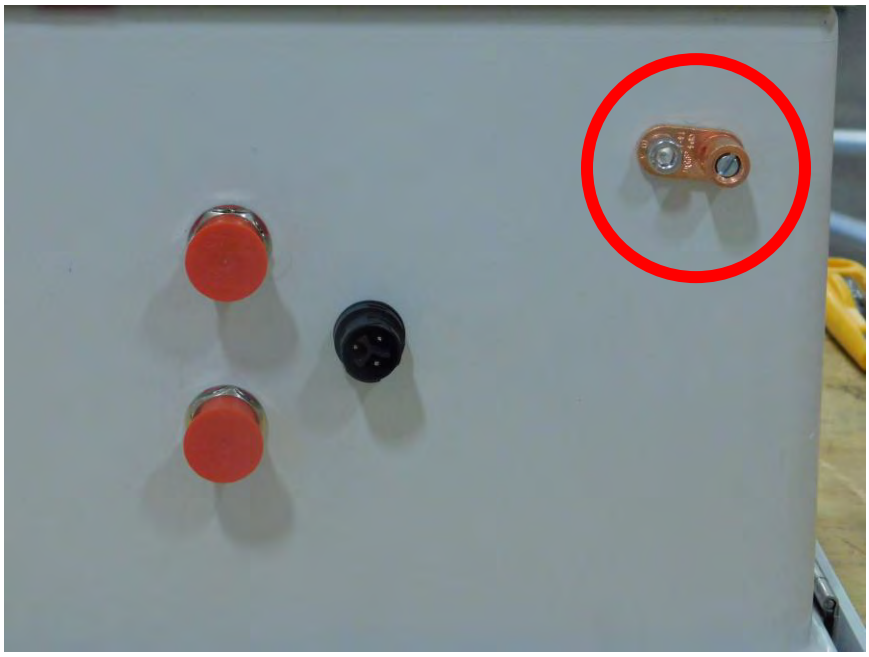

FIGURE 4-2 GROUNDING LUG (HIGHLIGHTED IN RED)

8 Attach an appropriate grounding cable to the grounding lug.

9 Run the cable from the FlexDAQ to a grounding stake. Ensure the grounding stake is firmly in the ground.

4.2 POLE MOUNT

The FlexDAQ unit may also be mounted on a pole or post. If this installation method is selected, two Unistrut channels will be added to the back of the enclosure to facilitate installation.

4.2.1 Installation Tools and Materials

- Cush-A-Clamps (supplied by RST Instruments).
- Wrench.
- An appropriate grounding stake and cable, if required.
- Flat-head screwdriver.

4.2.2 Installation Procedure

The following steps outline a general procedure for installing a FlexDAQ unit on a pole or post. Individual site requirements may necessitate changes to the procedure. Please contact RST Instruments with any questions or concerns.

4.2.2.1 Preparation

1 Ensure the pole or post is firmly and securely in the ground.

2 Ensure that the Cush-A-Clamp (Figure 4-3 and Figure 4-4) fits snugly around the pole.

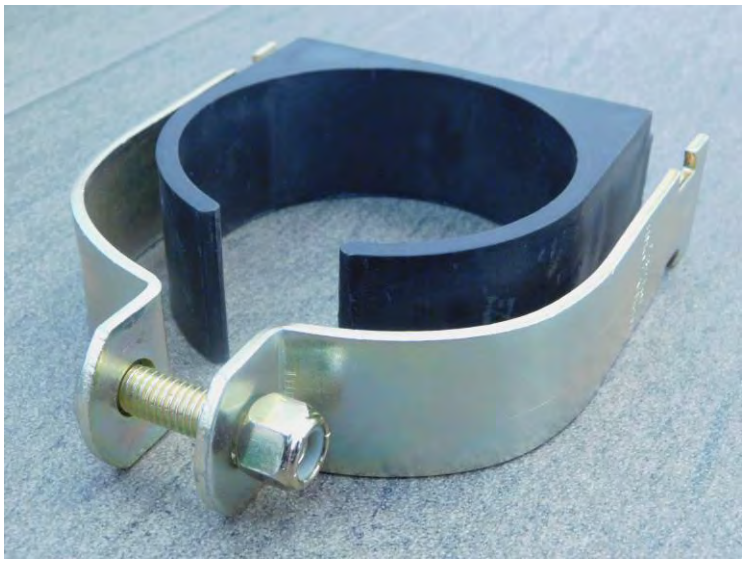

FIGURE 4-3 CUSH-A-CLAMP FOR SECURING FLEXDAQ TO POLE

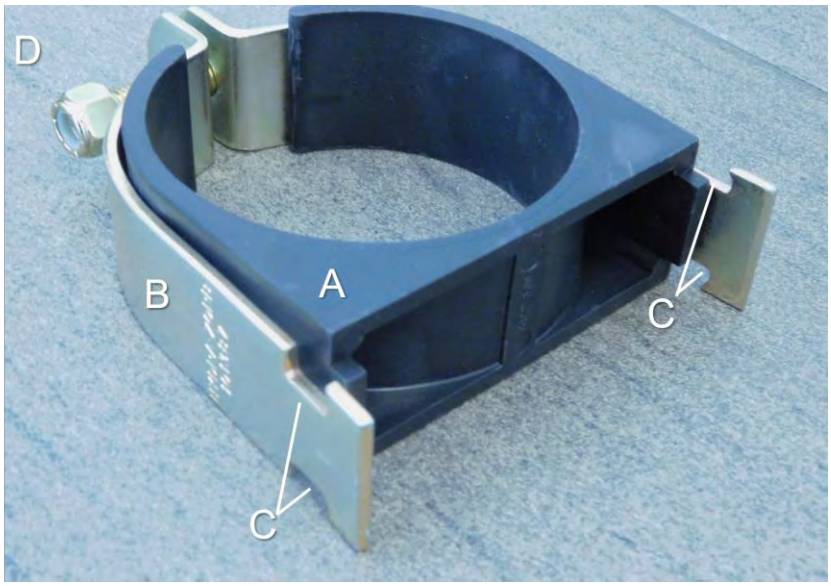

FIGURE 4-4 THE CUSH-A-CLAMP

A Thermoplastic cushion **B** Clamp

C Unistrut guide **D** Nut and bolt

NOTE: IF THE CUSH-A-CLAMP DOES NOT FIT SECURELY AROUND THE POLE, PLEASE CONTACT RST INSTRUMENTS.

3 Measure the vertical distance between the Unistrut bars on the back of the FlexDAQ.

4 Mark the distance on the pole, with the top mark corresponding to the approximate height of the FlexDAQ unit.

5 Place the black thermoplastic cushion around the pole at the markings. The flat side of the cushion should face the FlexDAQ.

6 Lift the FlexDAQ unit to the desired height.

7 Place the clamp around the thermoplastic cushion, with the bolt directly opposite from the flat edge of the cushion.

8 Thread the Unistrut guides through the Unistrut bars, as illustrated in Figure 4-5.

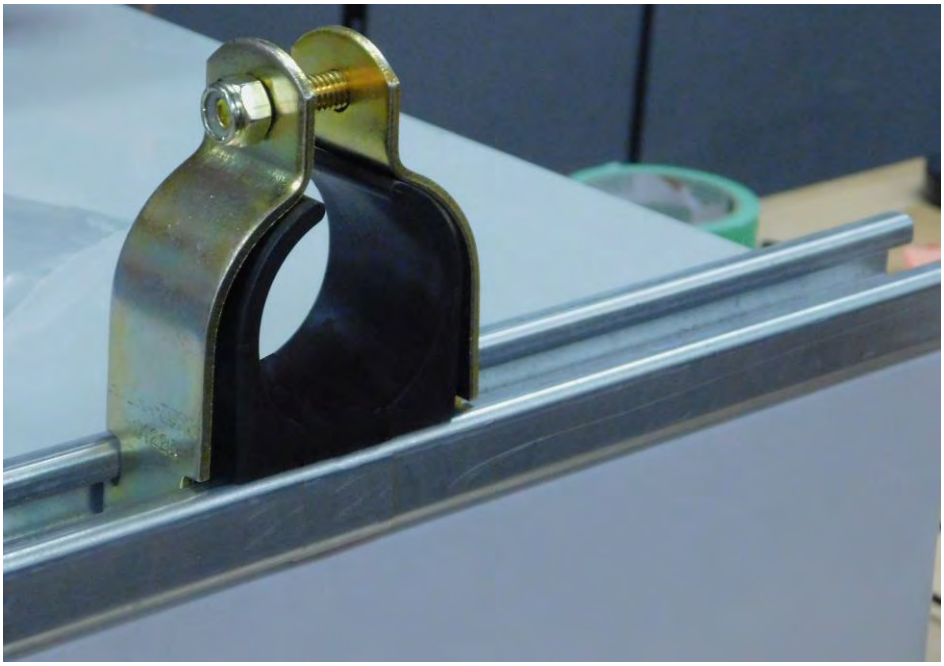

FIGURE 4-5 UNISTRUT AND CUSH-A-CLAMP ON BACK OF FLEXDAQ

9 Tighten the bolt. Final installation should resemble the example in Figure 4-6 and Figure 4-7.

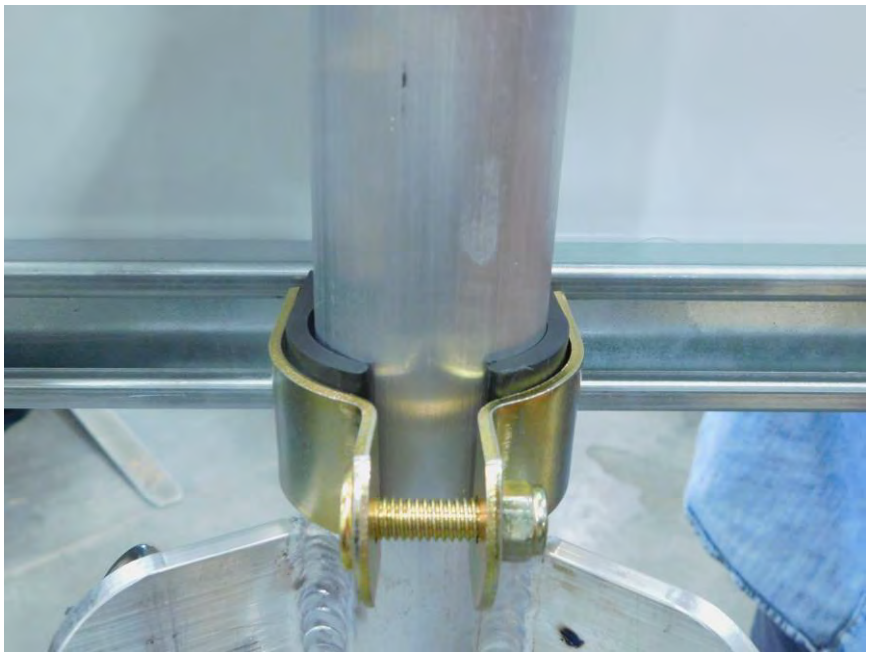

FIGURE 4-6 POLE MOUNT EXAMPLE, VIEW 1

FIGURE 4-7 POLE MOUNT EXAMPLE, VIEW 2

4.2.2.2 Grounding (if required)

The unit should always be grounded. If the unit is charged using AC power, a grounding stake is not required so long as the AC power is properly grounded.

10 A grounding lug (Figure 4-8) is located on the lower side of each FlexDAQ enclosure.

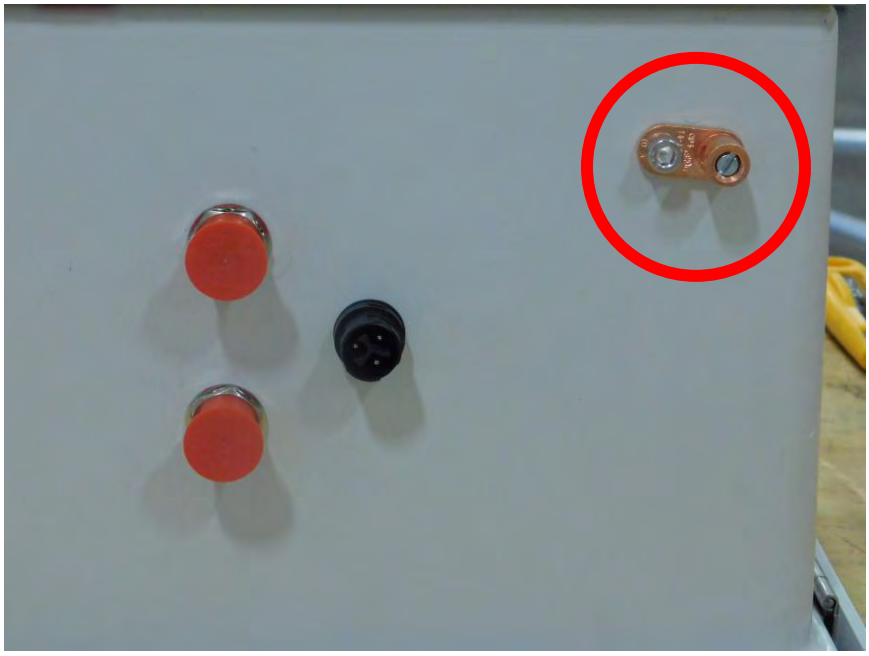

FIGURE 4-8 GROUNDING LUG (CIRCLED IN RED)

11 Attach the grounding cable to the grounding lug.

12 Run the cable from the FlexDAQ to a grounding stake. Plant the grounding stake firmly into the ground.

4.3 AUXILIARY COMPONENTS

Depending on the design specifications of a FlexDAQ unit, it may require the assembly and installation of some auxiliary components. The following section outlines two of the most common: the solar panel and the antenna.

4.3.1 Solar Panel (90W)

If the 12V DC battery is charged by solar power, a solar panel will need to be erected. The following instructions detail the best method for setting up a 90W solar panel.

4.3.1.1 Installation Tools and Materials

The solar panel comes with the hardware seen in Figure 4-9.

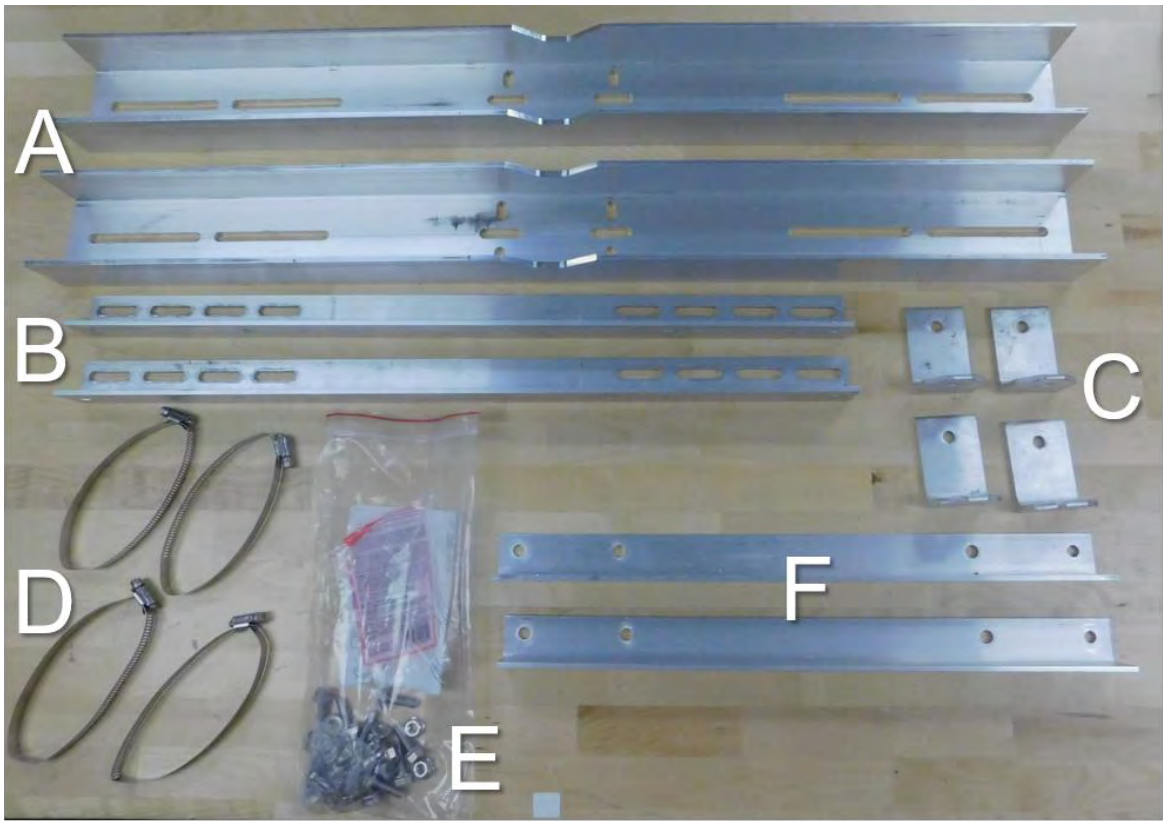

FIGURE 4-9 COMPONENTS TO MOUNT SOLAR PANEL

A Post brackets

B Panel brackets

C Foot brackets

D Pipe clamps

E Bolts, nuts, washers, Loctite

F Adjustment brackets

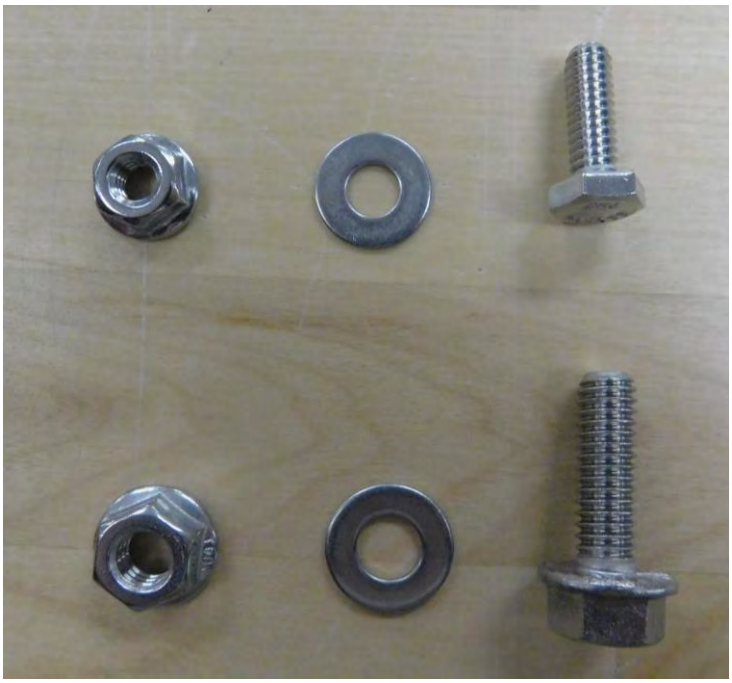

FIGURE 4-10 NUTS, WASHERS AND BOLTS
(TOP ROW: SMALL BOLT. BOTTOM ROW: LARGE BOLT)

4.3.1.2 Instructions

The following instructions detail the steps needed to correctly set up a solar power.

1 Place the panel brackets across the back of the solar panel, aligning the slots on the bracket with the inner holes on the back of the solar panel (Figure 4-11 and Figure 4-12, highlighted in red).

CAUTION: **ENSURE THAT THE SLOTTED SIDES OF THE PANEL BRACKET ARE POINTING AWAY FROM THE EDGES OF THE PANEL (FIGURE 4-11).**

FIGURE 4-11 PLACING THE PANEL BRACKETS ON THE BACK OF THE SOLAR PANEL

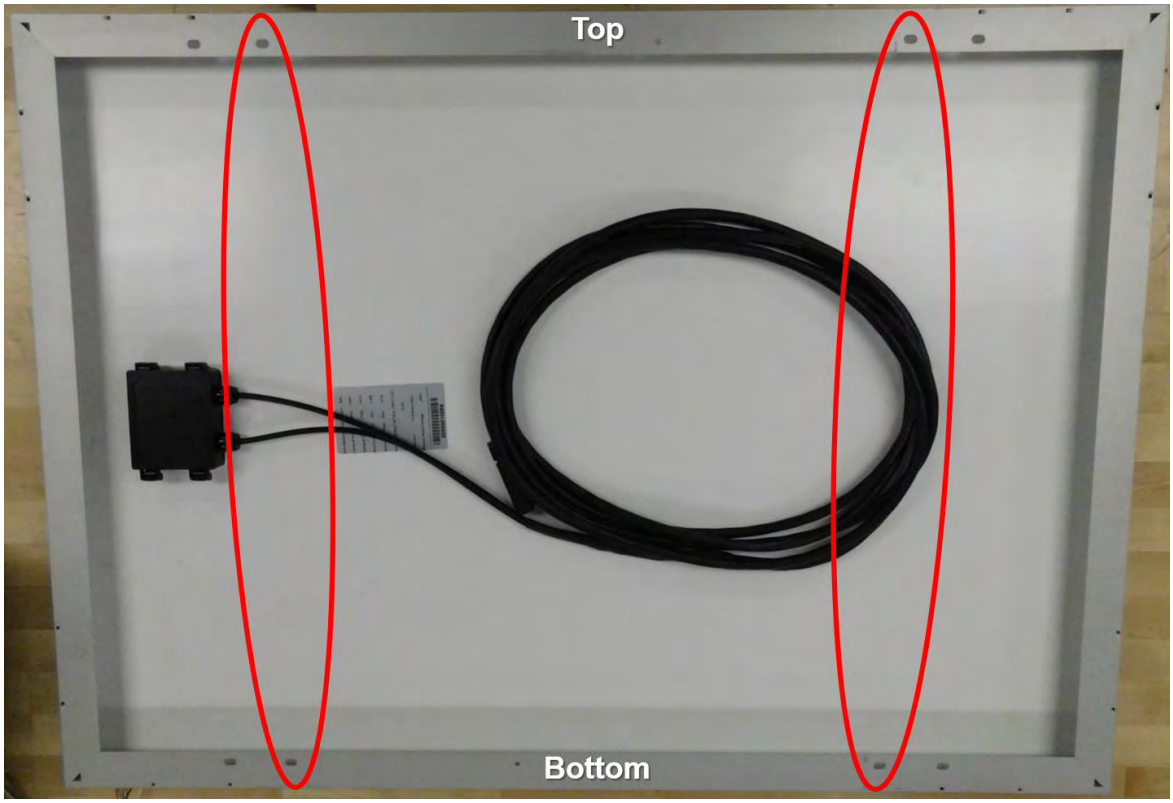

FIGURE 4-12 BACK OF THE SOLAR PANEL

2 Secure the panel bracket to the solar panel using the small bolt, washer and nut (Figure 4-13).

FIGURE 4-13 FASTENING THE NUT AND BOLT

3 Attach the foot brackets to panel bracket on the top side of the solar panel using the large bolt, washer and nut.

4 Attach the adjustment brackets to the bottom side of each panel bracket, as illustrated in Figure 4-14.

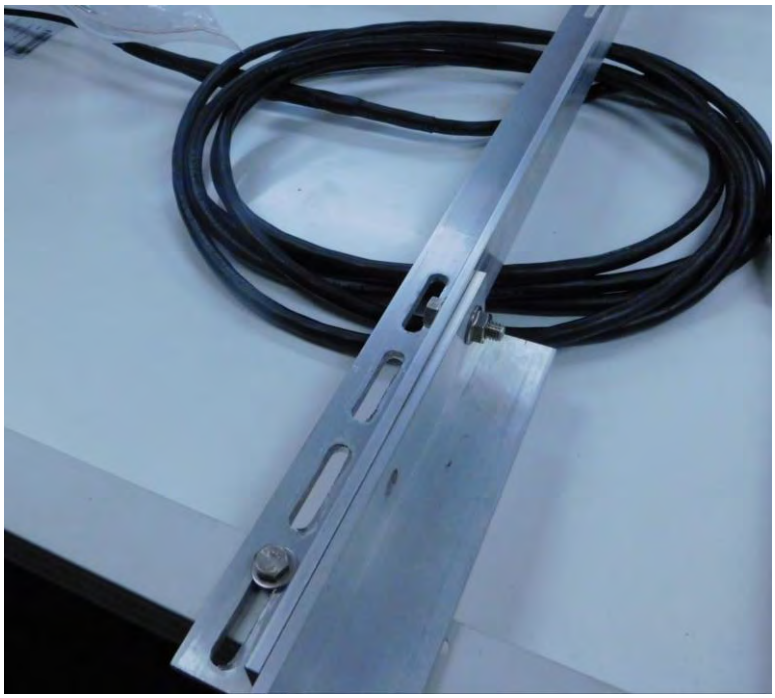

FIGURE 4-14 ADJUSTMENT BRACKETS ATTACHED TO BOTTOM SIDE OF THE PANEL BRACKETS

5 Secure a foot bracket to the free end of each adjustment bracket towards the top of the solar panel, as illustrated in Figure 4-15.

FIGURE 4-15 ATTACHING THE FOOT BRACKET TO THE END OF THE ADJUSTMENT BRACKET

6 Place a post bracket atop the foot brackets at both the top and bottom of the solar panel. Secure the post bracket with the small bolt, washer and nut (Figure 4-16).

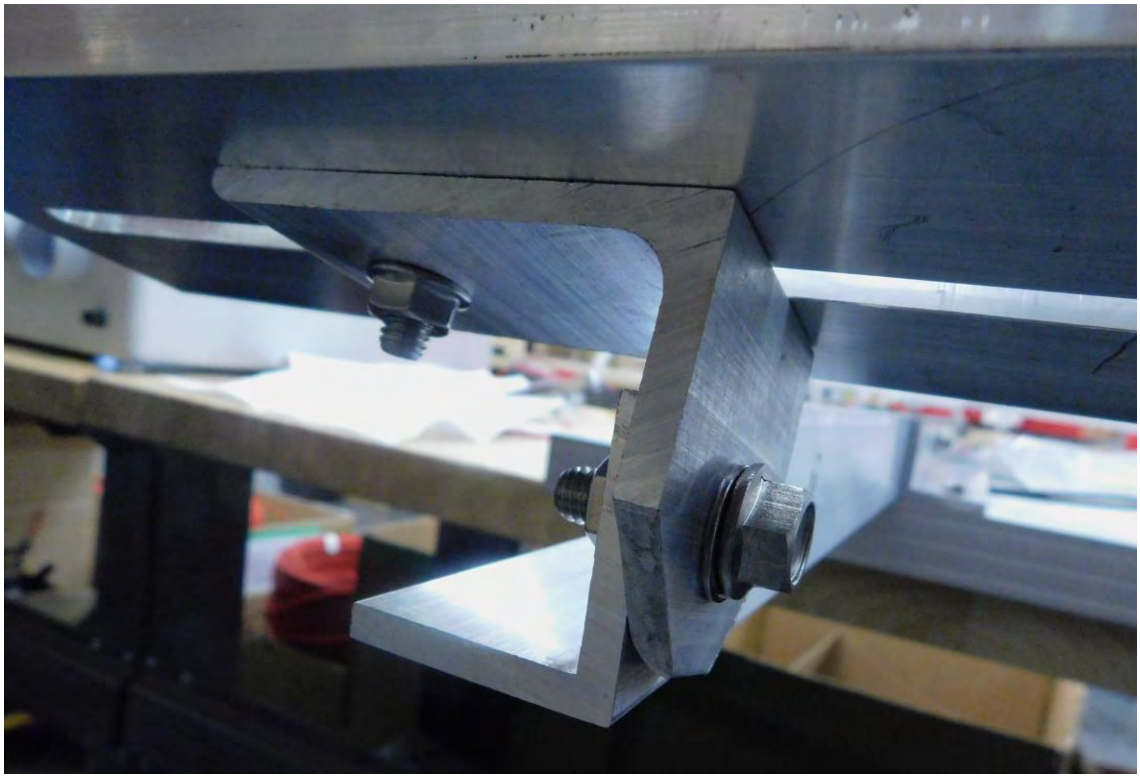

FIGURE 4-16 ATTACHING A POST BRACKET THE FOOT BRACKET AT THE END OF THE ADJUSTMENT BRACKET

7 The final solar panel assembly will resemble Figure 4-17.

FIGURE 4-17 FINAL ASSEMBLY

8 Select the correct orientation for the solar panel.

NOTE: ORIENT THE PANEL SO THAT IT RECEIVES DIRECT SUNLIGHT DURING DAYLIGHT HOURS. IF A LARGE VOLUME OF SNOW IS ANTICIPATED AT THE INSTALLATION SITE, ENSURE THE PANEL FACE IS MORE VERTICAL TO PREVENT ACCUMULATION OF SNOW. SNOW AND ICE WILL NEED TO BE REMOVED FROM THE PANEL FACE AS SOON AS POSSIBLE.

9 Open the pipe clamps and thread them through the vertical slots in the middle of each post bracket (on either side of the notches) (Figure 4-18).

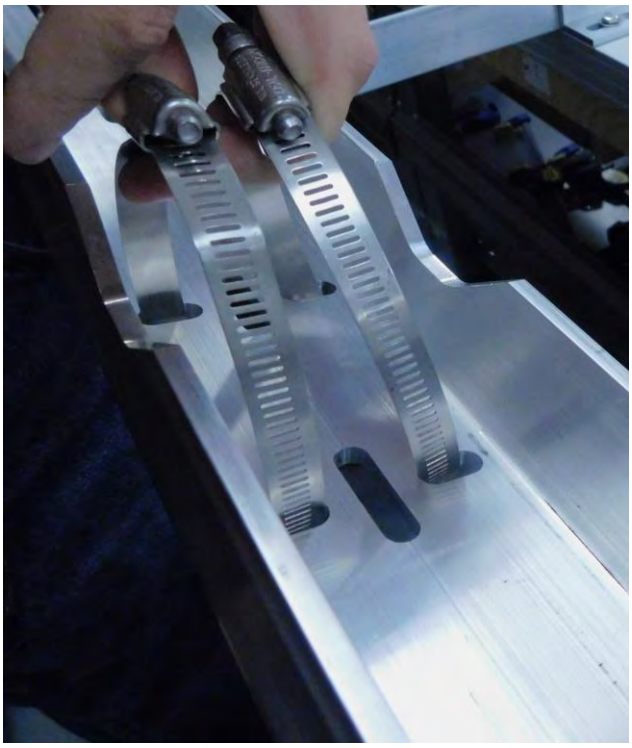

FIGURE 4-18 ATTACHING THE PIPE CLAMPS TO THE POST BRACKET

10 Wrap the pipe clamps around the pipe or post and secure. Tighten the bolt using a flathead screwdriver or a 5/16” socket.

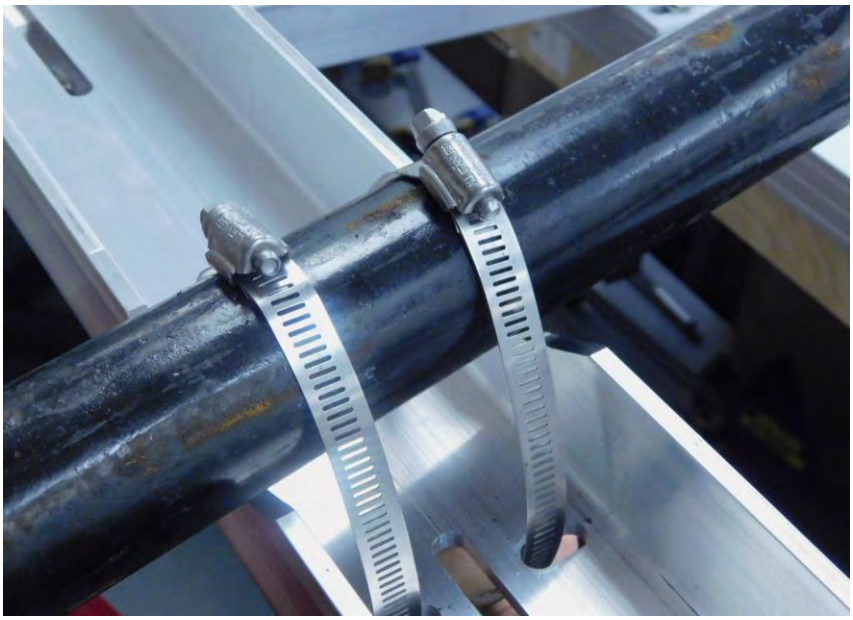

FIGURE 4-19 PIPE CLAMPS SECURED AROUND PIPE

11 Once the solar panel has been properly and securely mounted, connect it to the FlexDAQ.

4.3.2 Solar Panel (20 – 40W)

If the 12V DC battery will be charged by solar power, a solar panel will need to be erected. The following instructions detail the best method for setting up a 20 – 40W solar panel.

4.3.2.1 Components

The following components are required for the successful assembly of a 20 – 40W solar panel. Ensure that all components are present before proceeding with the assembly.

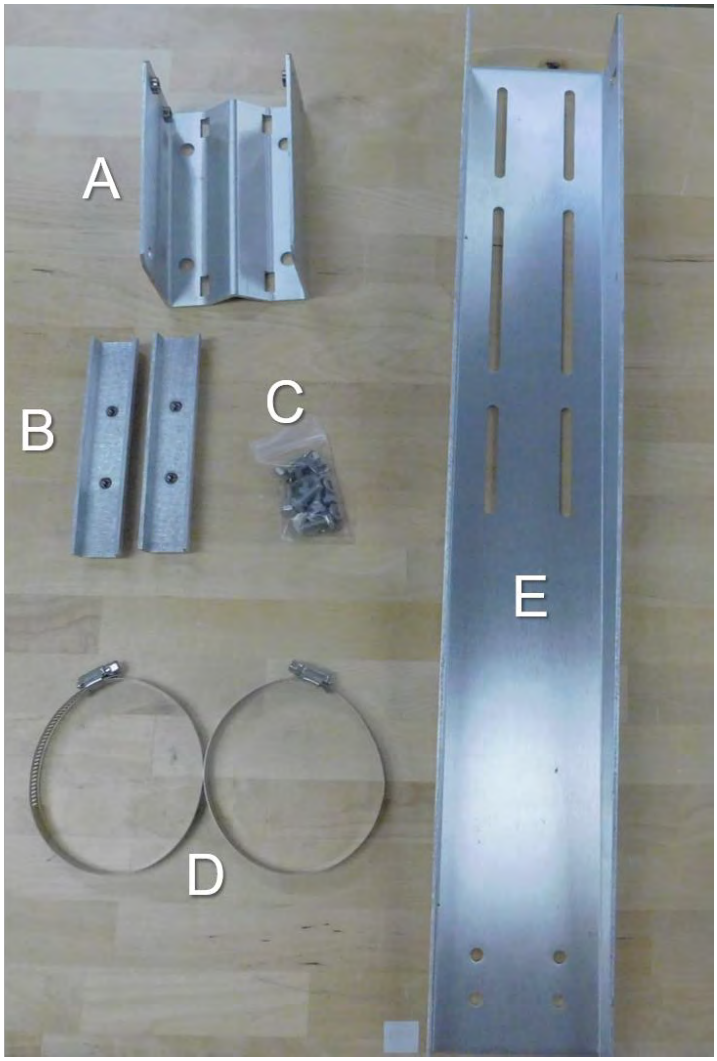

FIGURE 4-20 MOUNTING COMPONENTS

A Post bracket

B Clamping brackets

C Bolts, lock washers and washers

D Pipe clamps

E Panel bracket

4.3.2.2 Instructions

The following steps detail how to assemble the solar panel.

12 Loosely attach the clamping brackets to the back of the panel bracket (see Figure 4-21).

NOTE: DO NOT TIGHTEN THE BOLTS AT THIS TIME.

FIGURE 4-21 CLAMPING BRACKETS ON BACK OF PANEL BRACKET

13 Place the panel bracket across the short side of the back of the solar panel and slide the clamping brackets under the panel's lips (see Figure 4-22).

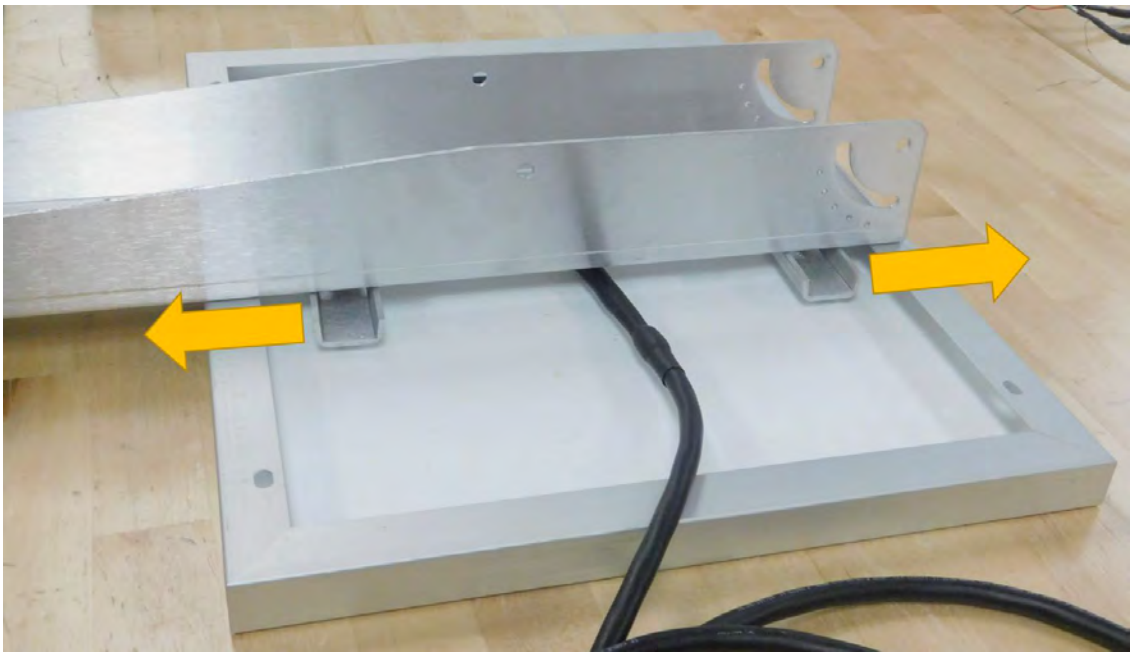

FIGURE 4-22 SECURING PANEL BRACKET TO PANEL WITH CLAMPING BRACKETS

14 Tighten the bolts on the panel bracket to secure (Figure 4-23).

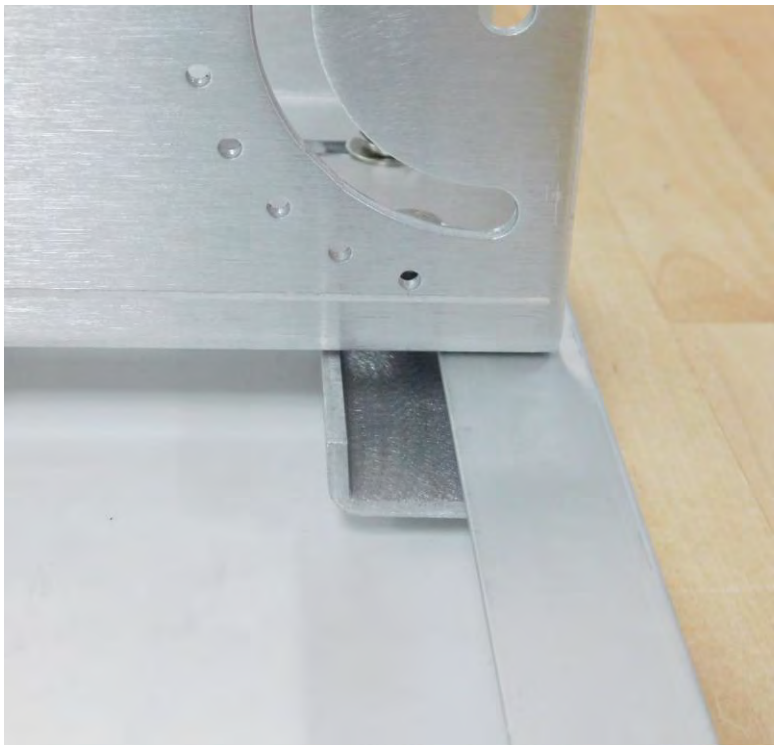

FIGURE 4-23 PANEL BRACKET ATTACHED

15 Place the post bracket in the top of the panel bracket and loosely bolt it into place, as illustrated in Figure 4-24.

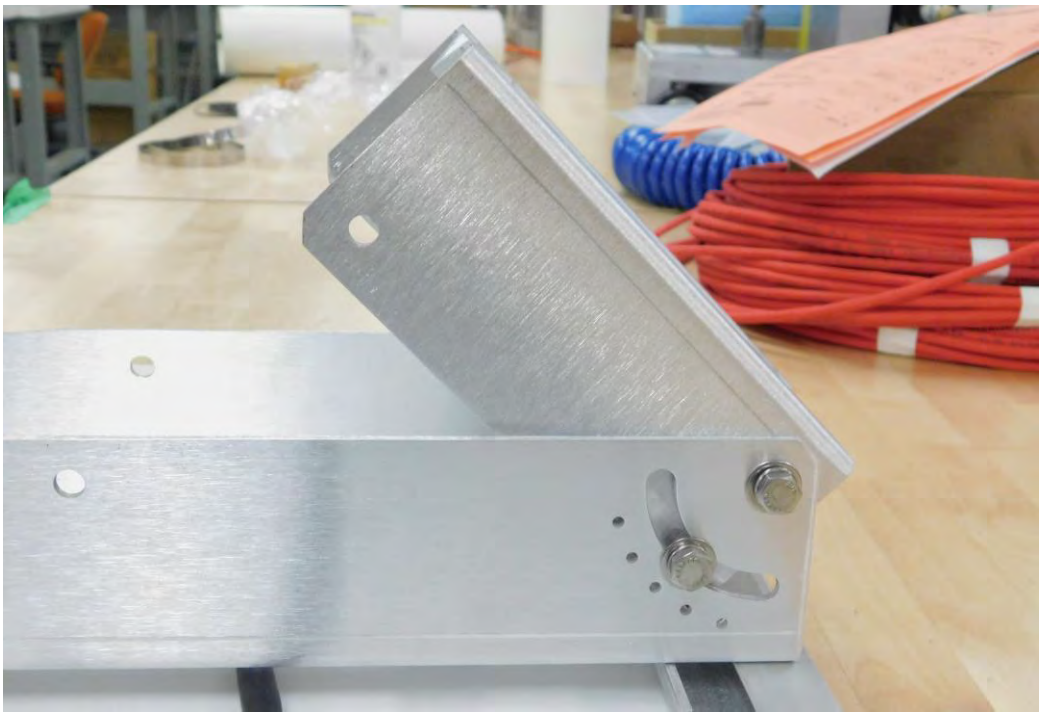

FIGURE 4-24 POST BRACKET IN PANEL BRACKET

16 Thread the pipe clamps through the slots on the post bracket (Figure 4-25).

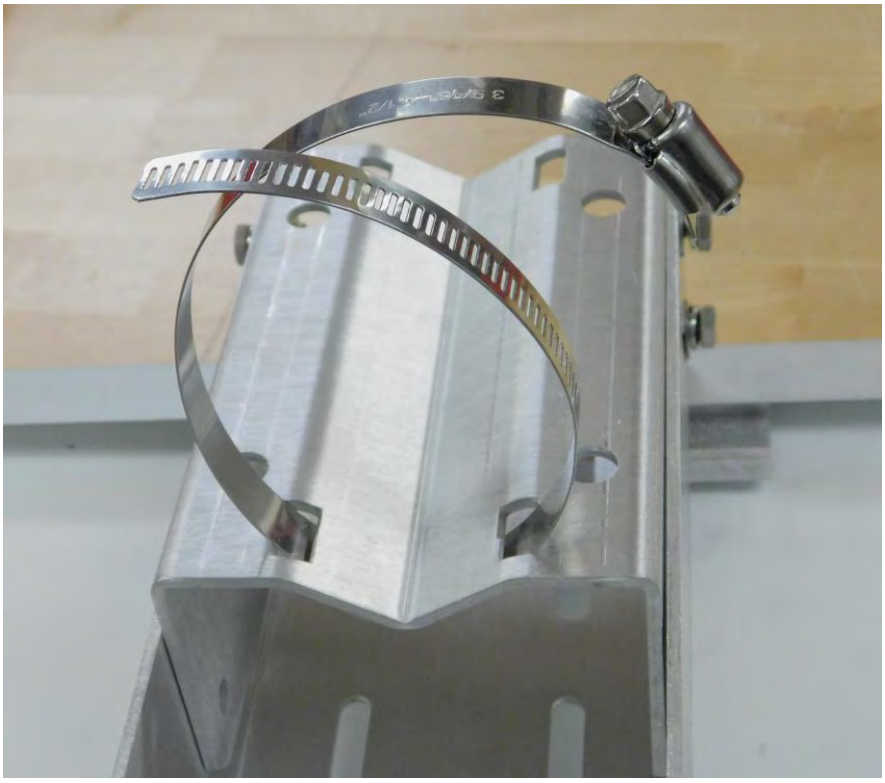

FIGURE 4-25 THREAD PIPE CLAMP THROUGH SLOTS ON POST BRACKET

17 Select the correct angle of orientation for the solar panel and tighten the bolts on the post bracket to lock it into place.

NOTE: ORIENT THE PANEL SO THAT IT RECEIVES DIRECT SUNLIGHT DURING DAYLIGHT HOURS. IF A LARGE VOLUME OF SNOW IS ANTICIPATED AT THE INSTALLATION SITE, ENSURE THE PANEL FACE IS MORE VERTICAL TO PREVENT ACCUMULATION OF SNOW. SNOW AND ICE WILL NEED TO BE REMOVED FROM THE PANEL FACE AS SOON AS POSSIBLE.

18 Wrap the pipe clamps around the pipe or post and tighten, as illustrated in Figure 4-26.

FIGURE 4-26 TIGHTEN PIPE CLAMP AROUND THE PIPE

19 Once the solar panel has been properly and securely mounted, connect it to the FlexDAQ.

4.3.3 Antennas

FlexDAQ systems may come equipped with two types of antennas. Though the Yagi and Omni antennas differ in appearance and function, the method for mounting each is similar. Please contact RST Instruments with any questions or concerns.

4.3.3.1 Components for a Yagi Antenna

The following hardware is needed to complete installation of a Yagi antenna:

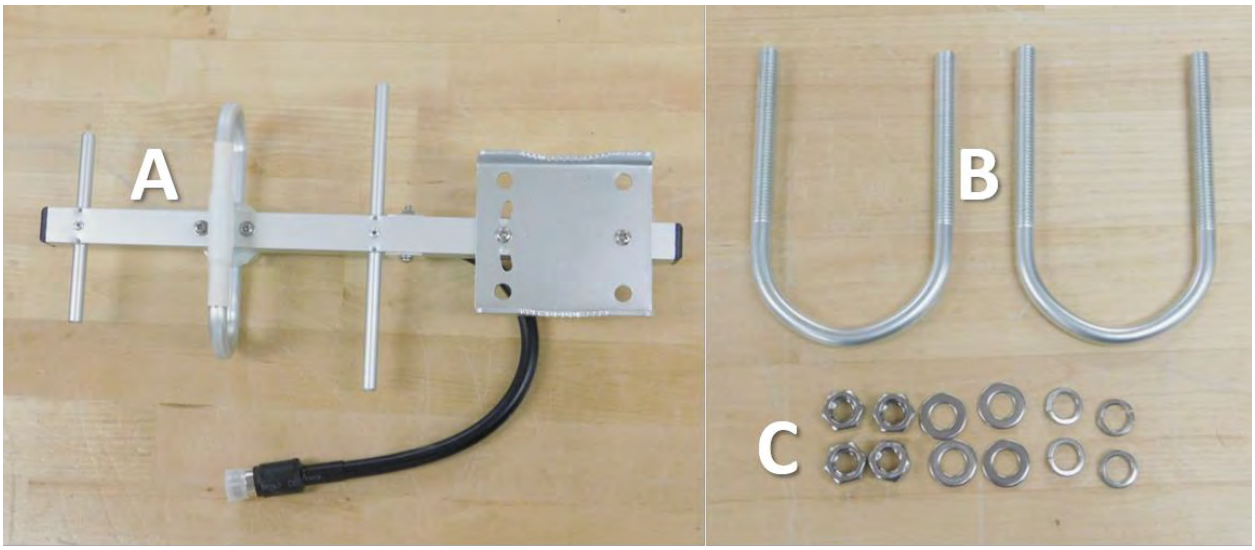

FIGURE 4-27 YAGI ANTENNA COMPONENTS AND HARDWARE

A Yagi antenna with pole bracket

B U-bolts

C Nuts, washers and lock washers

4.3.3.2 Mounting Instructions for a Yagi Antenna

The following instructions outline the steps requires for successfully mounting a Yagi antenna. One U-bolt has been installed for illustration purposes. Please be aware that both U-bolts will be needed to secure the antenna to the post.

1 Place the bracket of the antenna on the post or pole, with the post or pole resting in the serrated groove.

2 A Yagi antenna is directional, and direction of the antenna may need to be adjusted in order to receive the strongest signal. Referring to the screw highlighted in Figure 4-28, to adjust the direction of the antenna,

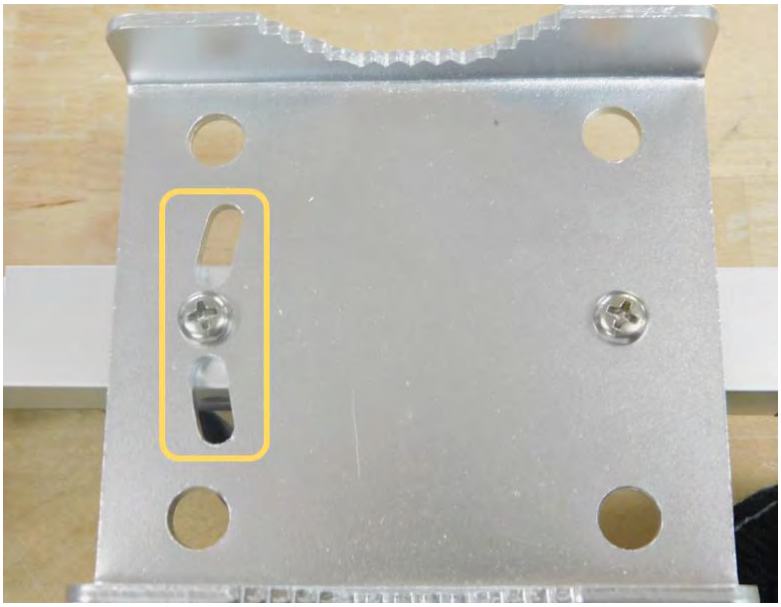

FIGURE 4-28 ADJUSTING THE DIRECTION

a. Hold the nut.

b. Remove the screw.

c. Adjust the angle of the antenna so it is oriented correctly.

d. Once the desired direction has been achieved, replace the screw to secure.

3 Place the U-bolt around the pole and feed the ends of the U-bolt through the holes in the bracket (highlighted in red in Figure 4-29).

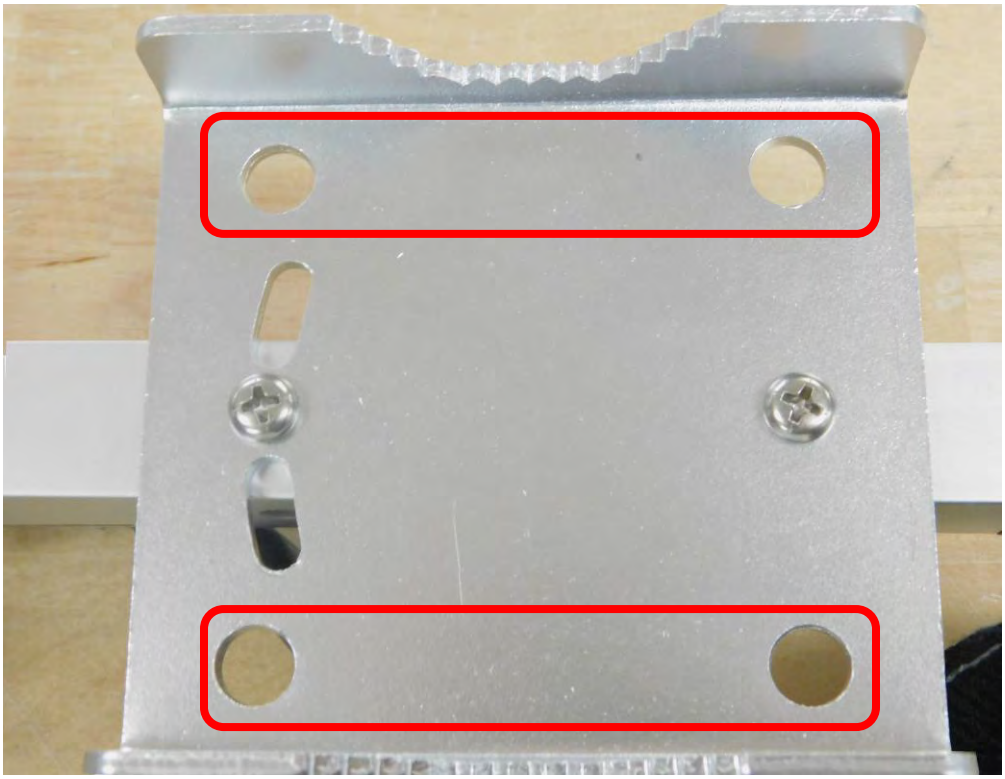

FIGURE 4-29 POST BRACKET

4 Once the U-bolt is in place, secure by placing a washer, lock washer and nut on the back of the bracket (Figure 4-30). Once both U-bolts have been secured, the installation is complete (Figure 4-31).

FIGURE 4-30 WASHER, LOCK WASHER AND NUT

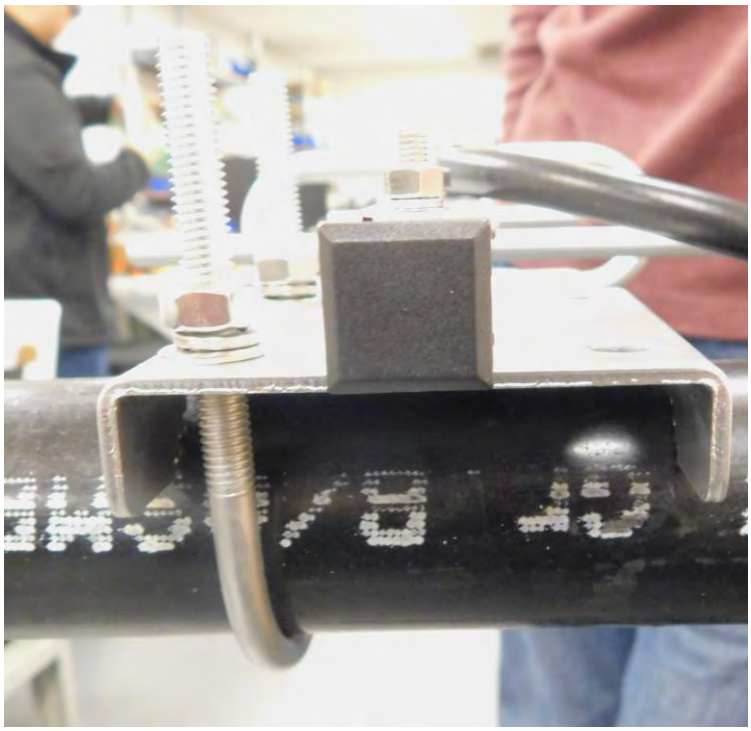

FIGURE 4-31 U-BOLT INSTALLED ON POST

5 Once the antenna has been properly and securely mounted, connect it to the FlexDAQ.

4.3.3.3 Components of an Omni Antenna

The following components are needed for the successful installation of an omni antenna:

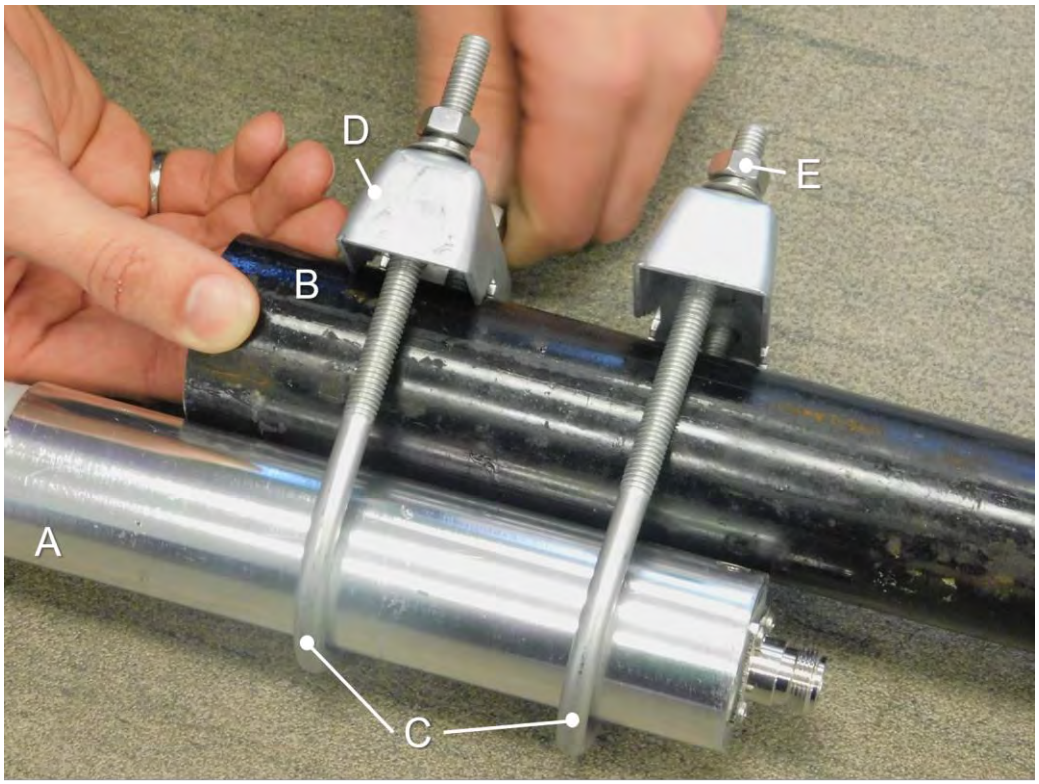

FIGURE 4-32 OMNI ANTENNA COMPONENTS

A Antenna

B Post

C U-bolts

D Post clamps

E Nut, washer and lock washer

4.3.3.4 Mounting Instructions for an Omni Antenna

The following instructions detail the steps required for successful installation of an Omni antenna:

1 Ensure that the post to which the antenna will be mounted is secured in the ground and is vertical.

CHECK: THE OMNI ANTENNA MUST BE VERTICAL AND MOUNTED ON A VERTICAL POST.

2 Place the antenna against the post, as illustrated in Figure 4-32.

3 Place the U-bolts around the metal base of the antenna, leaving 3 – 5 inches of space between them.

4 Place the post clamps on the U-bolts, as illustrated in Figure 4-33. Ensure that the serrated grooves (highlighted in yellow in Figure 4-33) on the clamps face the post.

FIGURE 4-33 OMNI ANTENNA CLAMPED TO POST

CAUTION: **ENSURE THAT THE SERRATED GROOVES ON THE POST CLAMPS ARE FACING THE POST TO PREVENT DAMAGE TO THE ANTENNA OR ITS BASE.**

5 Place a washer, lock washer and nut on the end of each side of each bolt to secure.

6 Once the antenna has been properly and securely mounted, connect it to the FlexDAQ.

4.3.3.5 Waterproofing the Connector

Both the Omni and Yagi antennas are connected to the FlexDAQ with an NxN cable. An O-ring inside the connection ensures that moisture does not enter the connection. If additional waterproofing to the connection of the antenna is desired, the connector may be wrapped in two layer of vulcanized rubber splicing tape, followed by two layers of electrical tape. The following instructions detail the steps to successfully apply these tapes.

1 Ensure the connection between the antenna and the FlexDAQ (Figure 4-34) is hand-tight.

FIGURE 4-34 THE CONNECTION BETWEEN THE ANTENNA AND THE FLEXDAQ

2 Beginning on one end of the connection, wrap the vulcanized rubber splicing tape around the connector, keeping it somewhat taut with a light pull (Figure 4-35). The tape is activated by stretching it during application.

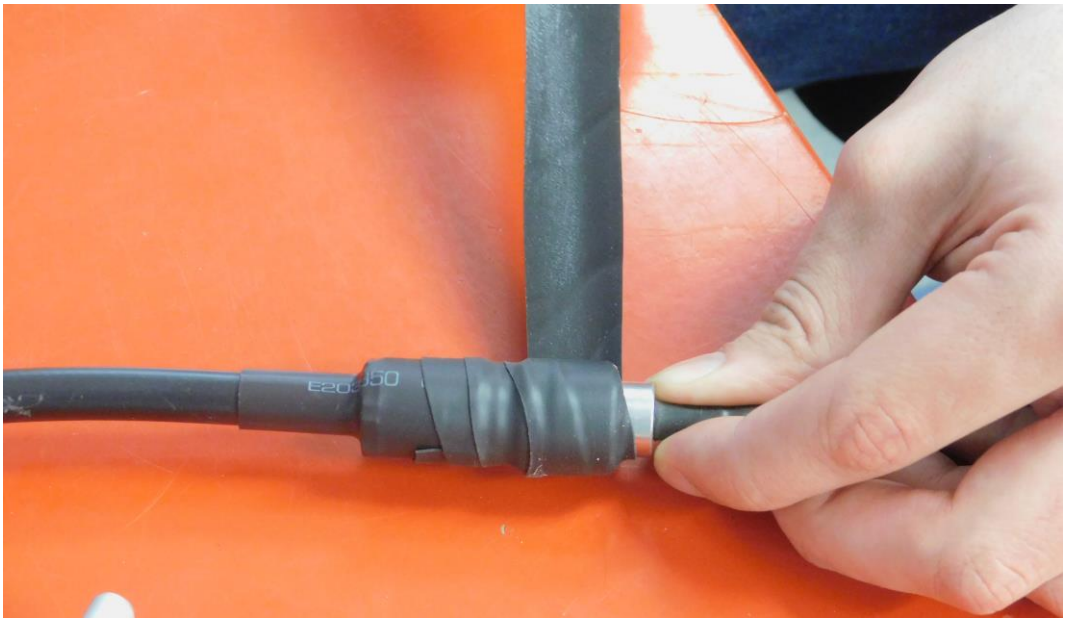

FIGURE 4-35 WRAPPING THE SPLICING TAPE AROUND THE CONNECTOR

3 Continue wrapping until two layers of tape have been applied to the connector and both ends of the connector have been sealed (Figure 4-36).

FIGURE 4-36 THE CONNECTOR WRAPPED IN TWO LAYERS OF SPLICING TAPE

4 Wrap electrical tape around the connector in the same manner. Ensure that the ends of the splice tape wrap are secured under the electrical tape.

FIGURE 4-37 WRAPPING ELECTRICAL TAPE AROUND THE SPLICE WRAP

5 The connection from the cable to the antenna should now be waterproof (Figure 4-38). The connector to the FlexDAQ does not need to be waterproofed but can be if required.

FIGURE 4-38 THE WATERPROOFED CONNECTION

5 SET UP

Due to the highly customizable nature of the FlexDAQ system, individual set up instructions have been included on a USB drive along with important information about the system. The following sections below contain generic information that may or may not be applicable to your system. Please read the information below and the information on the USB drive and contact RST Instruments with any questions or concerns that may arise.

CAUTION: **PLEASE USE THE DOCUMENTS SUPPLIED ON THE USB DRIVE INCLUDED WITH YOUR SHIPMENT AS THE PRIMARY RESOURCE WHEN SETTING UP THE FLEXDAQ. IT CONTAINS CUSTOM INFORMATION THAT IS HIGHLY SPECIFIC TO YOUR INDIVIDUAL SYSTEM.**

5.1 USB DRIVE

A USB drive with relevant information and files is included with your shipment. It contains schematic drawings, certificates, custom logger program files, setup and backup files. Please review these documents carefully.

5.2 DAQ SOFTWARE

RST Instruments recommends using the LoggerNet program to connect to the unit and access data. The program is supplied by RST and can be located on a CD included with your shipment. The software will need to be installed on a PC or laptop in order to complete the configuration of the FlexDAQ unit and access data in the future. Detailed instructions have been provided on the USB drive. For additional support, please contact RST Instruments.

6 MAINTENANCE

The FlexDAQ system will generally not require maintenance. However, a small desiccant packet has been included in the unit to assist in keeping the electrical components inside

the FlexDAQ enclosure dry. Upon receiving the unit, open the enclosure and locate the desiccant packets. Remove them from the plastic bag and place them inside the unit. The desiccant packets will need to be replaced periodically (approximately every 6 months to 1 year, depending on the humidity of the site).

CHECK: THE DESICCANT PACKET WILL NEED TO BE REPLACED EVERY 6 MONTHS TO 1 YEAR.

If the unit has a solar panel, the panel will need to be inspected for buildup of dirt, debris, ice and snow periodically and cleaned. The frequency of inspection will depend on the installation location and site weather conditions.

7 TROUBLESHOOTING

Due to the unique features and capabilities of each FlexDAQ system, please contact RST Instruments for any questions or concerns that arise.

8 SERVICE AND REPAIR

The product contains no user-serviceable parts. Please contact RST Instruments for product service or repair not covered in this manual.

Vibrating Wire Piezometer
Flexi-MUX Multiplexer

RST INSTRUMENTS LTD.

RST Flexi-Mux
Instruction Manual

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RST Flexi-Mux Instruction Manual

Although all efforts have been made to ensure the accuracy and completeness of the information contained in this document, RST Instruments reserves the right to change the information at any time and assumes no liability for its accuracy.

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Instruction Manual

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1 OVERVIEW

The RST Flexi-Mux is designed to increase the number of sensors that can be measured with a datalogger. The Flexi-Mux is located between the datalogger and the sensors and allows a single channel of a datalogger to be sequentially connected to numerous sensors. Each Flexi-Mux can sequentially multiplex 5 groups of 4 wire inputs or 10 groups of 2 wire inputs. Internal DIP switch settings permit the changing of these settings. The system can be expanded by chaining together multiple Flexi-Mux's allowing the signals to cascade through the system. This allows a virtually unlimited number of sensors to be connected to a single channel.

The datalogger program and control ports advance the Flexi-Mux through each sensor. An added feature of the RST Flexi-Mux is that it contains internal transient protection on each individual line. Unlike traditional multiplexers, this negates the need for external transient protection devices to be installed saving cost, wiring and time deploying the system.

2 FUNCTION

The RST Flexi-Mux allows a single channel of a datalogger such as a Campbell Scientific CR10x to be sequentially connected to numerous sensors. Each Flexi-Mux can sequentially multiplex 5 groups of 4 wire for a total of 20 wires. Alternatively, internal DIP switch settings permit the multiplexing of 10 groups of 2 wires.

The extremely slim and compact (8.15"H x 1.05"W x 3.07"D) vertical design permits the Flexi-Mux to occupy minimal space in the control box which allows for more Flexi-Mux units to be installed. By utilizing a unique cascade feature, there is theoretically no limit to the number of channels which can be connected to the datalogger.

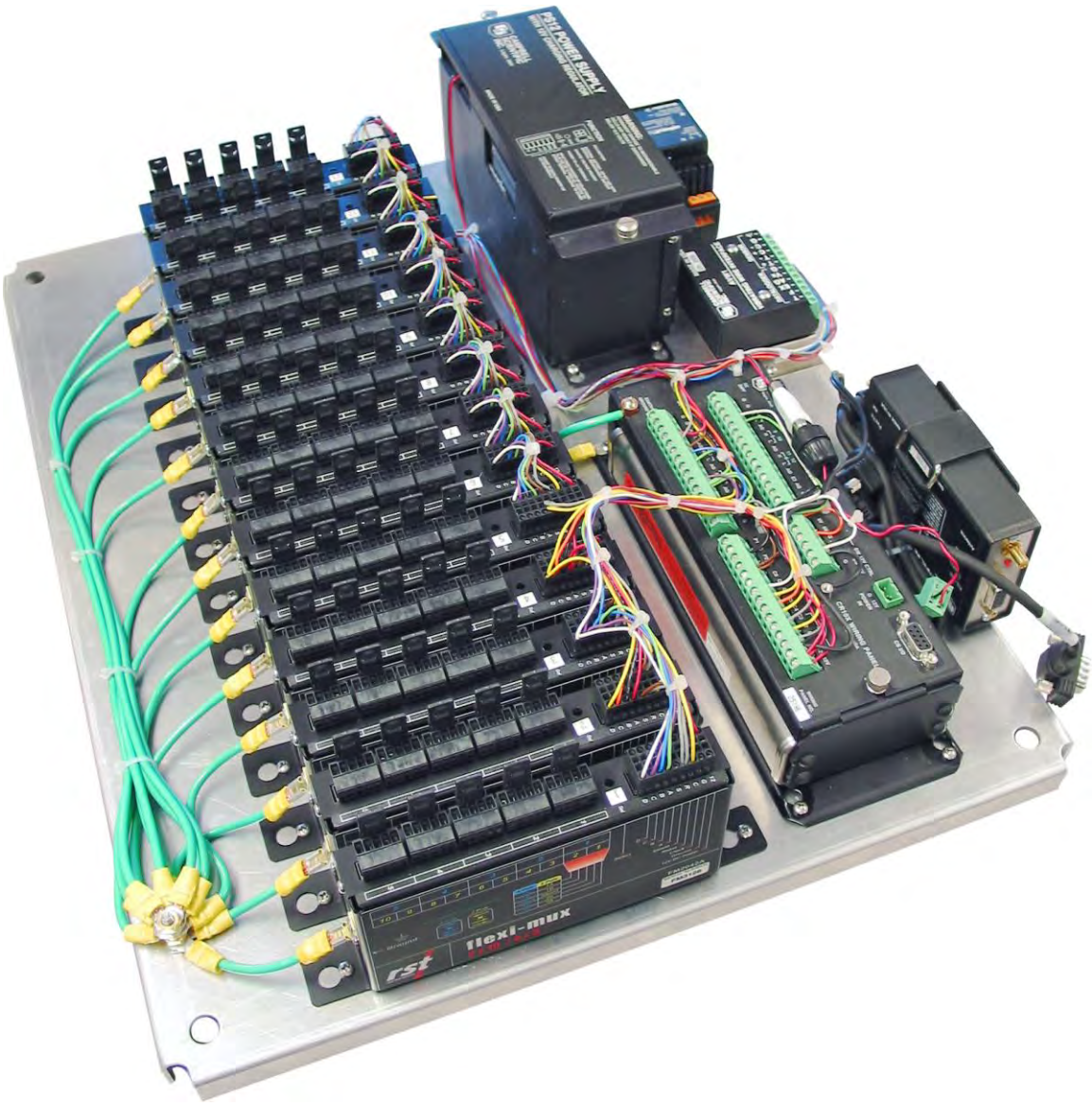


Figure 1 – Flexi-Mux Cascading Feature

Conveniently designed detachable screw terminals allow rapid wiring of large systems, with straightforward testing and substitution of both sensors and multiplexers. Built-in transient protection on every line safeguards against damaging power surges which can be caused by occurrences such as nearby lightning.

The Flexi-Mux requires only two datalogger control ports: One for “enable” (Reset Terminal), and a second for channel stepping (Clock Terminal). The Flexi-Mux is compatible with most sensors including load cells, pressure transducers, vibrating wire sensors, thermistors, potentiometers, tiltmeters, strain gauges, in-place inclinometers and tilt beams.

3 COMPATIBILITY

The Flexi-Mux is compatible with, but not limited to, Campbell's CR200, CR510, CR10(X), CR23X, CR5000 series dataloggers.

A wide variety of commercially available sensors are supported provided the current maximums are not exceeded on the relay contacts (section 6).

Using a single Flexi-Mux in combination with a Campbell AVW-1 Vibrating Wire Interface, up to 5 RST vibrating wire piezometers can be multiplexed. Cascading each Flexi-Mux permits a theoretically unlimited number of muxes to be chained together. Thus many vibrating wire sensors can be connected to a single vibrating wire interface.

4 PHYSICAL DESCRIPTION

4.1 LAYOUT

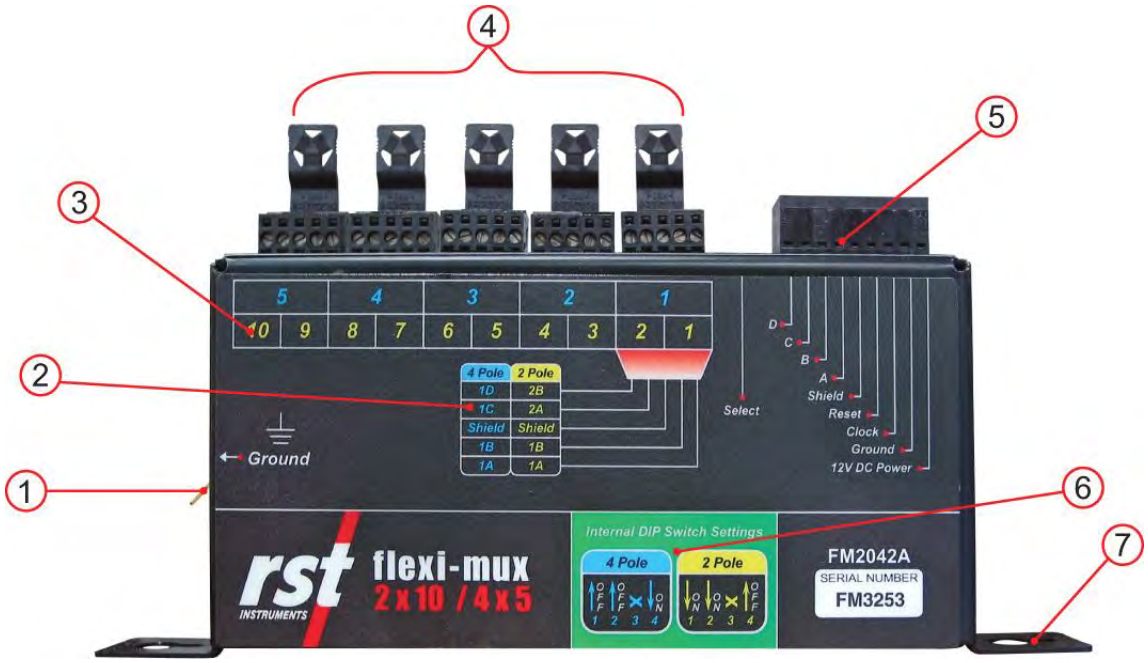


Figure 2 – Flexi-Mux Layout

1. Grounding spade terminal.
2. Channel Assignments
3. Multiplexed terminal channel assignments.
4. Modular 5-pole terminal blocks for multiplexed sensors.
5. Modular 18-pole Mux control terminal.
6. Graphical representation for internal DIP switch settings.
7. Mounting tabs.

4.2 DIMENSIONS

The Flexi-Mux is housed in a slim 15.6cm x 8.1cm x 2.7cm (6.15" x 3.17" x 1.05") aluminum case (Figure 3). Convenient mounting tabs extend 2.5cm (1") from each end and provide simple means of mounting the unit on any flat surface or base plate. The finished length including the mounting tabs is 20.7cm (8.15"). Mounting holes are 17.9cm (7.07") apart.

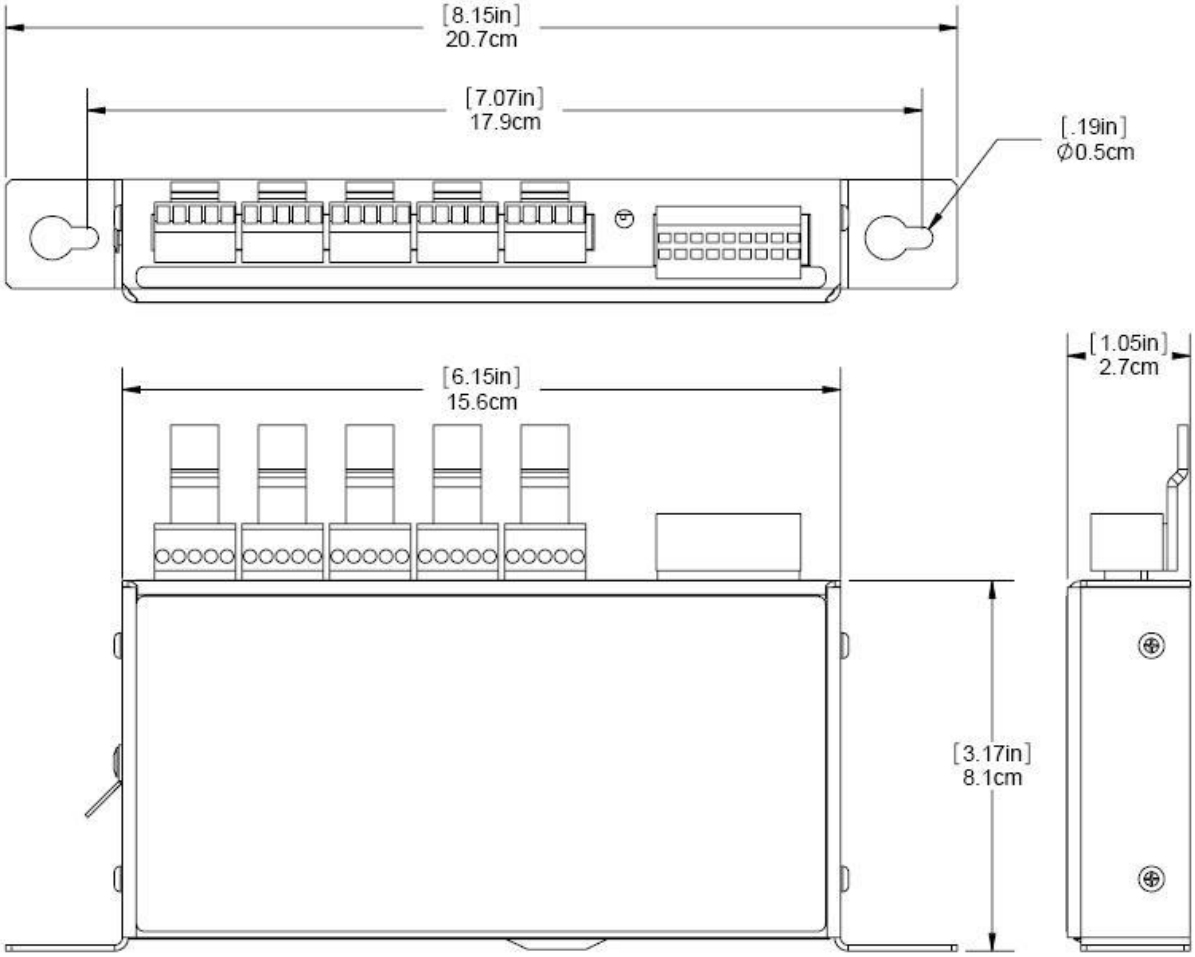


Figure 3 – Flexi-Mux Dimension

4.3 CONNECTION DETAILS

Connections to the Flexi-Mux are made on the top mounted modular terminal blocks. The removable 18-pin connector block is dedicated for connecting the datalogger power and control lines (section 5.1). This connector has a tension clamp which is rated to accept 14-28 AWG wire as shown below:

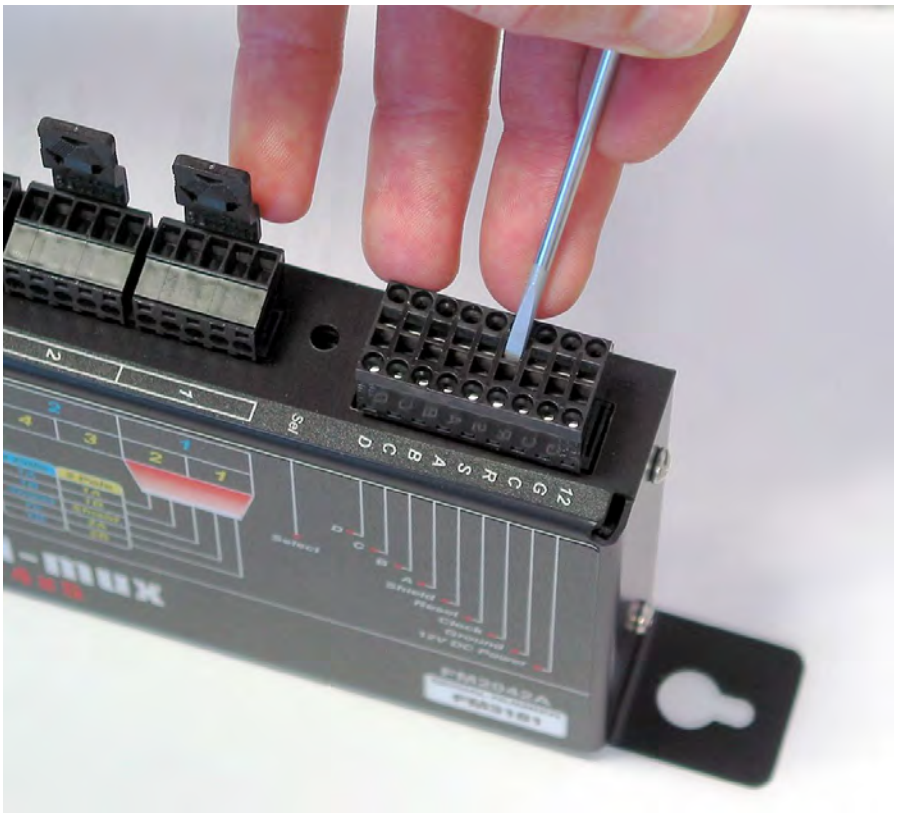


Figure 4 – Connector Detail

The cable grips are spring loaded, and require a small screwdriver to be inserted into the centre to retract the spring. Once retracted, insert the wire into the round hole and remove the screwdriver. The spring will grasp the wire.

The five, 5-pole terminal blocks are connection points for the shielded multiplexed sensor signals destined for the datalogger analog inputs (section 5.3). The 5-pole blocks have screw clamps and are rated to accept 14-28 AWG wire. Each sensor line is connected to a quick-connect terminal block with an integrated stress release system. The tab is designed to accommodate a tie-wrap which holds the lead wires. The connectors are designed to be easily disconnected, giving the flexibility to switch or move sensors. Lead wires are attached using a standard screw terminal on each block. Pin locations are numbered from the top down, with the shield being located in the centre. Ensure that connections are made in this order.

All terminal blocks are modular and socketed, allowing them to be unplugged. This provides the flexibility of being able to switch out and entire mux or switch the locations of instruments without having to rewire.

5 OPERATION

Section 5.1 describes the terminals that control the operation of the multiplexer. These terminals are located in the 18-pin terminal block labelled “5” in Figure 2. Section 5.2 discusses the use of the DIP switch settings which control the behaviour of the measurement terminals.

5.1 CONTROL TERMINALS

The CR10X datalogger (or other Campbell Scientific Datalogger) connects to the Flexi-Mux as shown in Figure 5. The power, ground, reset, and clock connections remain essentially the same unless the Flexi-Mux is being used with a CR510 Basic Datalogger (see note below).

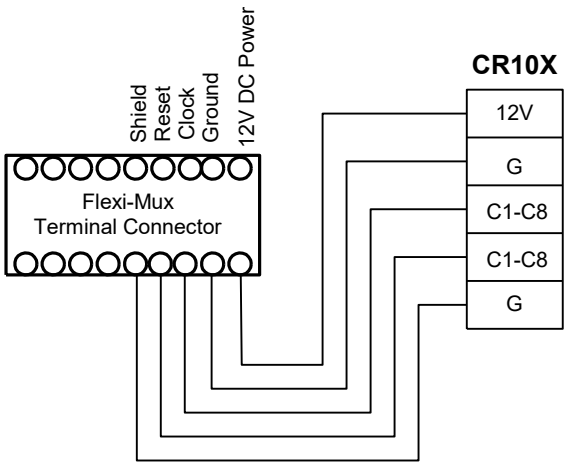


Figure 5 – Flexi-Mux to CR10x Datalogger Power/Control Hookup

With the CR10x, the Flexi-Mux connects to an available 12V port and a Ground terminal for power. One control port is used for *Reset* and another is used for *Clock*. If two control ports are not available (depending on the datalogger) a switched excitation channel can be used. The Flexi-Mux only requires 2 volts in order to be clocked.

Note

A control port is not always necessary to "clock" the Flexi-Mux. On basic dataloggers such as the Campbell Scientific CR510 which does not have a spare control port, a switched excitation channel can be used. This gives the RST Flexi-Mux more flexibility as compared to standard multiplexers.

5.1.1 RESET

The reset line is used to activate the Flexi-Mux. A signal in the range of +2.0V to +10VDC applied to the reset terminal activates the multiplexer. When this line drops lower than 0.9VDC, the multiplexer enters a quiescent, low current drain state. In the quiescent state the common terminals (A, B, C, D) are electrically disconnected from all the sensor input channels. Reset should always connect to a datalogger control port.

5.1.2 CLOCK

Pulsing the Flexi-Mux “clock” line high (with “reset” set high) advances the channel. Whether or not the Flexi-Mux advances 2 positions or 4 positions depends on the internal DIP switch settings (section 5.2). When the reset first goes high, the common terminals A, B, C and D are disconnected from all sensor input terminals. With the Flexi-Mux set in the 4-Pole mode, when the first clock pulse arrives the common terminals are switched to connect with the sensor input channel 1 (consists of 5 wires: A, B, C, D and shield). When a second clock pulse arrives the common lines are switched to connect to channel 2. The multiplexer advances along the leading edge of the positive going clock pulse. The voltage level must fall below 1.5VDC and then rise about 2.0VDC to clock the multiplexer. The clock pulse should be at least 1 ms long. A delay (typically 10 to 20 ms) is inserted in the datalogger program between the beginning of the clock pulse and the measurement instruction to ensure sufficient settling time for the relay contacts.

In general, a control port is used to clock the multiplexer. However, switched excitation for the sensors can also be used (as stated in section 5.1). See section 5.3 for more details on datalogger connections with the Flexi-Mux.

If several multiplexers are required, the Flexi-Mux allows a virtually unlimited number of units (limited by cable losses) to be connected in series because the Flexi-Mux boosts the clock and reset signals through its circuitry. Thus no control voltage is lost through the ports. An adequate 12VDC power source must be maintained through each multiplexer for this to function correctly.

5.1.3 GROUND

The Flexi-Mux “ground” terminal is connected to the datalogger power ground.

5.2 DIP SWITCH SETTINGS

Internal DIP switches on the Flexi-Mux control whether it switches 2 or 4 wires each time it is clocked. To change the DIP switch settings, remove the dust cover located on the base of the unit. The piano-key style DIP switches are accessed through this hole as shown in Figure 6. Adjust the DIP switches as outlined below. There is also a diagram on the Flexi-Mux itself which reflects these settings (item 6, Figure 2).

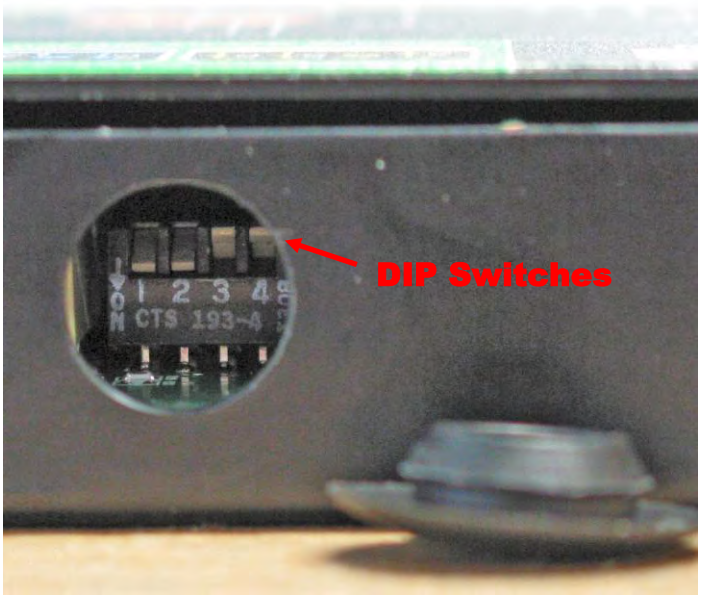


Figure 6 – DIP Switch Location

Switch No.	4-Pole	2-Pole
1	↑ (off)	↓ (on)
2	↑ (off)	↓ (on)
3	**X** (not used)	**X** (not used)
4	↓ (on)	↑ (off)

Figure 7 – DIP Switch Positions

5.3 CONNECTION EXAMPLES

The following illustrations depict some connection examples for using the RST Flexi-Mux in conjunction with Campbell Scientific CR10x dataloggers. Please note that the following sections are simply meant as an overview of the many ways an RST Flexi-Mux can be used. Many custom applications can be created. Contact RST Instruments Ltd. for more details.

5.3.1 2-WIRE SERIAL SWITCHING

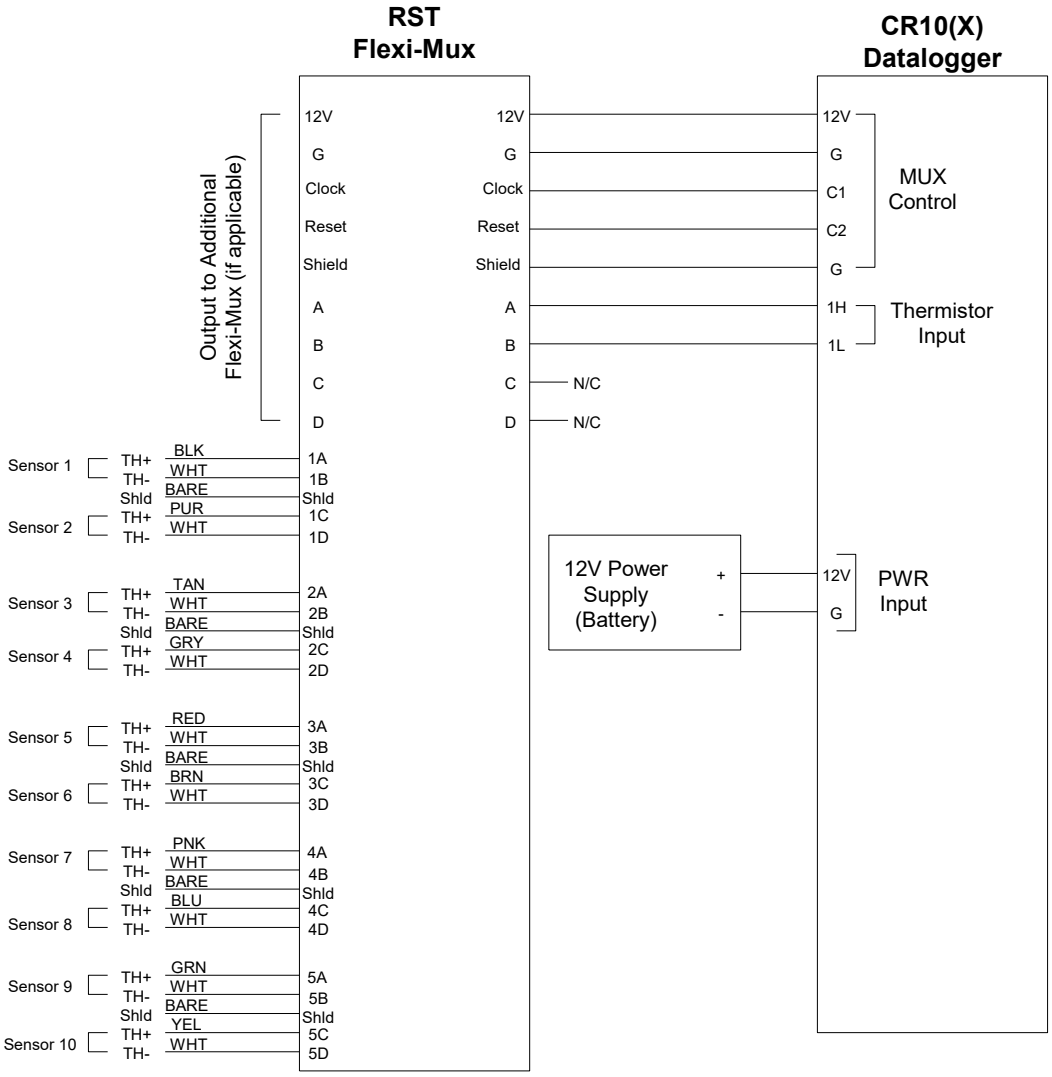


Figure 8 – Flexi-Mux Connected to a Thermistor String

5.3.2 4-WIRE SERIAL SWITCHING

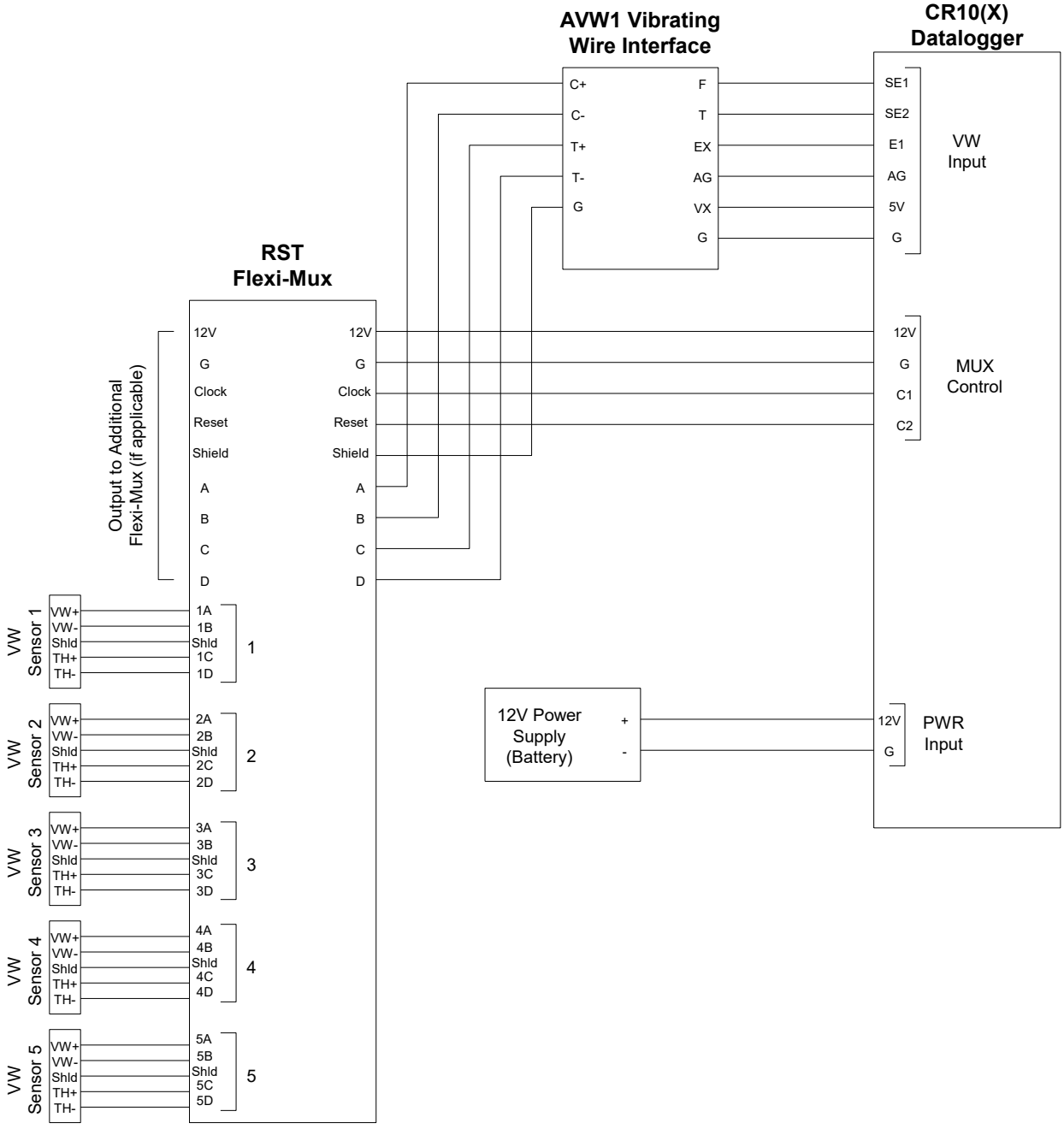


Figure 9 – Flexi-Mux with VW Instruments

5.3.3 4-WIRE SWITCHING WITH SEPARATE EXCITATION

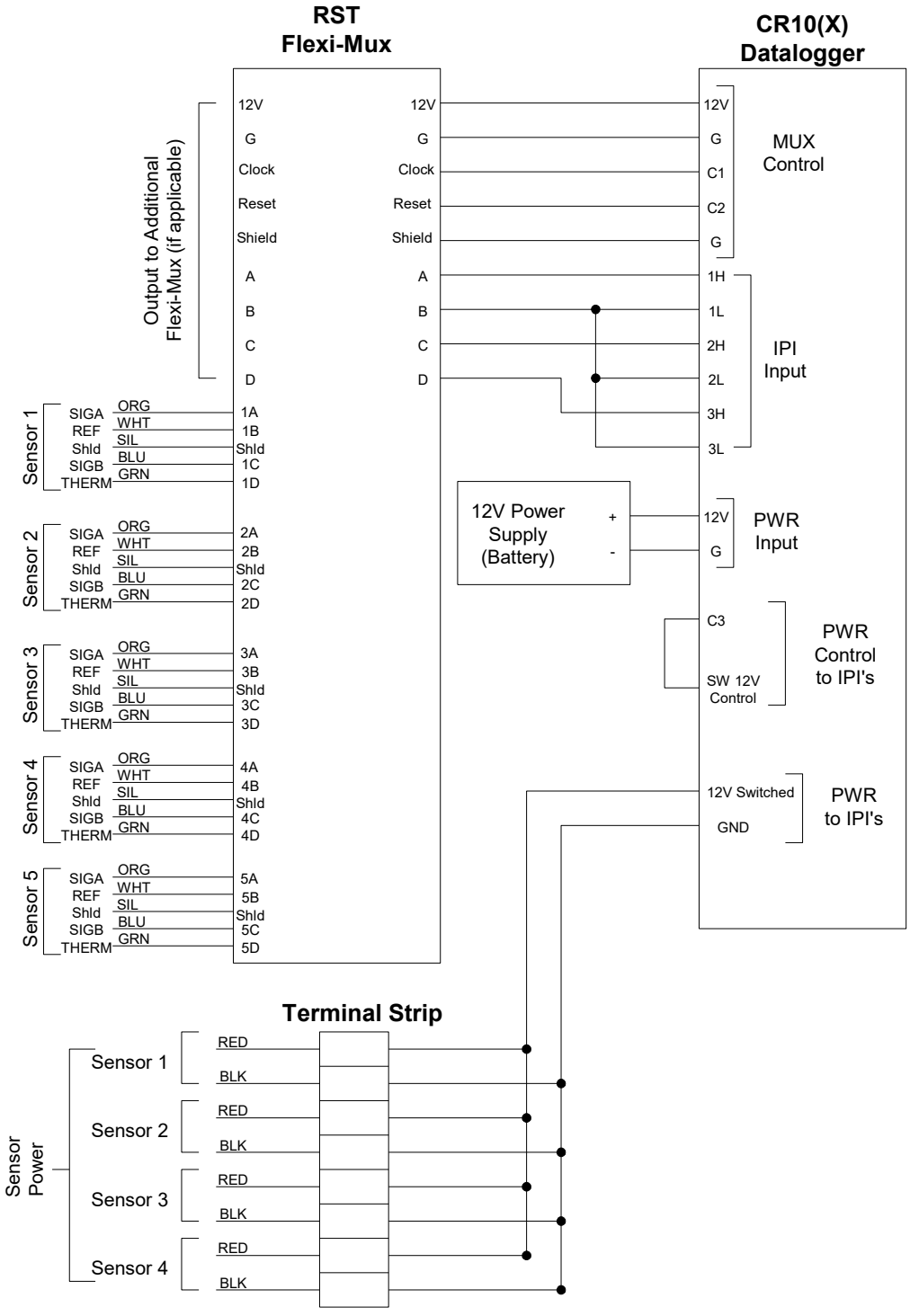


Figure 10 – Flexi-Mux with Biaxial In-Place Inclinometers

5.3.4 8-WIRE SERIES/PARALLEL SWITCHING

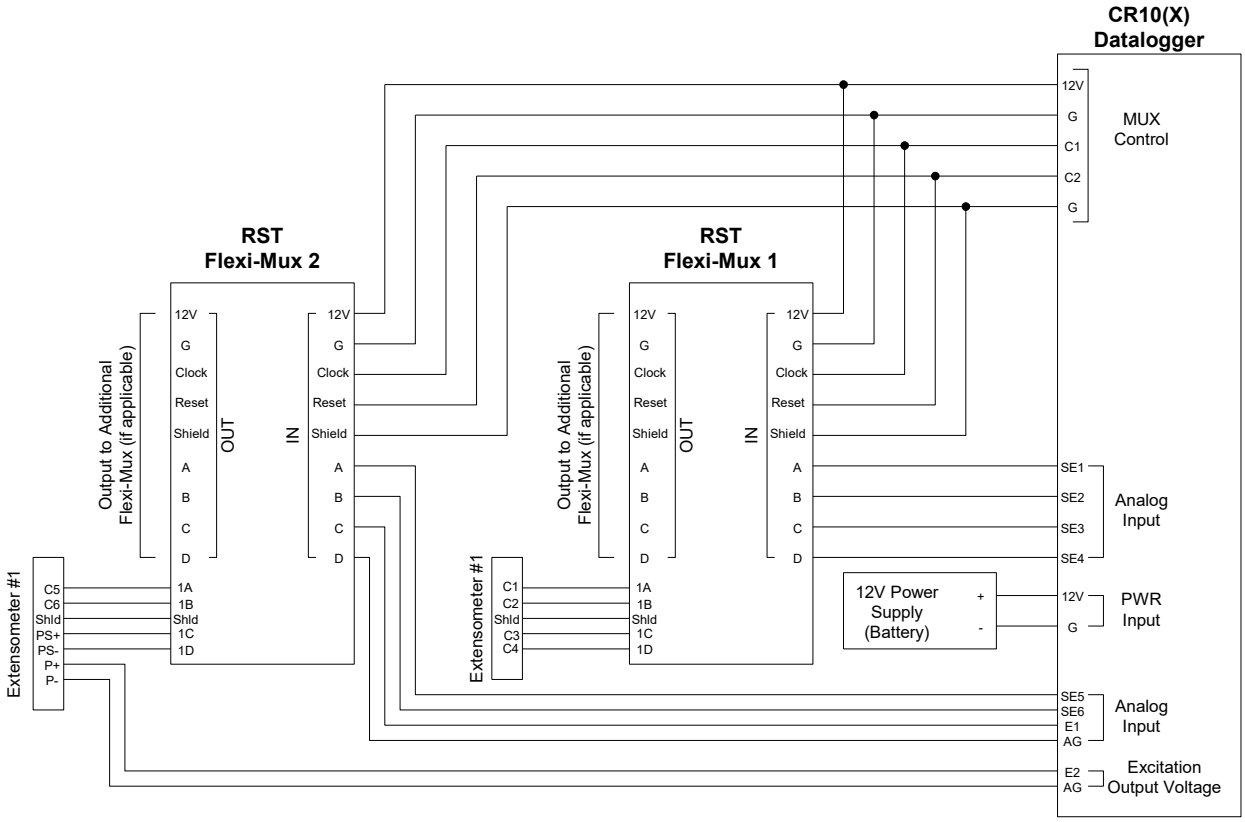


Figure 11 – Flexi-Mux wired in Parallel to Switch 8-wires

5.4 DATALOGGER PROGRAMMING

The following table outlines the basic program instructions which can be used to activate the RST Flexi-Mux and measure RST Vibrating Wire Piezometers with Campbell Scientific Dataloggers. Please note that this is a very basic example only, there are many options available.

```
 1:  Do (P86)
  1: 41       Set Port 1 High
;Turn on Multiplexer (reset)

 2:  Excitation with Delay (P22)
  1: 3        Ex Channel
  2: 5        Delay W/Ex (units = 0.01 sec)
  3: 0000     Delay After Ex (units = 0.01 sec)
  4: 0000     mV Excitation
;Delay

 3:  Beginning of Loop (P87)
  1: 0000     Delay
  2: 2        Loop Count

     4:  Do (P86)
      1: 72       Pulse Port 2
;1st Mux clock

     5:  Excitation with Delay (P22)
      1: 3        Ex Channel
      2: 0000     Delay W/Ex (units = 0.01 sec)
      3: 1        Delay After Ex (units = 0.01 sec)
      4: 0    0   mV Excitation
;delay for Mux

     6:  Vibrating Wire (SE) (P28)
      1: 1        Reps
      2: 1        SE Channel
      3: 1        Excite all reps w/Exchan 1
      4: 20       Starting Freq. (units = 100 Hz)
      5: 32       End Freq. (units = 100 Hz)
      6: 200      No. of Cycles
      7: 0        Rep Delay (units = 0.01 sec)
      8: 1     -- Loc [ VW_1      ]
      9: 1.0      Mult
     10: 0.0      Offset
;Read Vibrating Wire Model VW2100

     7:  Excite-Delay (SE) (P4)
      1: 1        Reps
      2: 15       ñ 2500 mV Fast Range
      3: 2        SE Channel
      4: 1        Excite all reps w/Exchan 1
      5: 1        Delay (units 0.01 sec)
      6: 2500     mV Excitation
      7: 17    -- Loc [ Therm_1   ]
      8: .001     Mult
      9: 0.0000   Offset
;Read 3K thermistors

     8:  Polynomial (P55)
      1: 1        Reps
      2: 17    -- X Loc [ Therm_1   ]
      3: 17    -- F(X) Loc [ Therm_1   ]
      4: -104.78  C0
      5: 378.11   C1
      6: -611.59  C2
      7: 544.27   C3
      8: -240.91  C4
      9: 43.089   C5
;Linearize 3K thermistors

 9:  End (P95)
;of loop

 10:  Do (P86)
  1: 51       Set Port 1 Low
;turn off multiplexer
```

Figure 12 – Flexi-Mux Program Example

The above program example assumes that the Flexi-Mux DIP switches are set to 4-wire switching, therefore a pulse for the *reset* and *clock* lines will switch 4 wires (VW sensor and thermistor).

6 SPECIFICATIONS

Power	12 Vdc (under load), unregulated
Current Drain	10µA quiescent; 8mA active
Reset Active Levels, max.	2.0V
Clock Active Levels, max.	2.0V
Min. Clock Pulse Width	1 ms
Max. Actuation Relay Time	20 ms
Relay Operation	Break before make
Initial Relay Resistance, closed	0.1 Ohm
Max. Switching Current	1A
Min. Contact Life	10^7 closures
Operating Temp.	-40°C to 70°C (-40°F to 158°F) - extended
Size	20.7cm(8.15”H) x 8.5cm (3.17”W) x 2.7cm (1.05”D)
Weight	0.24kg (0.53lbs.)

Underdrain Flow Monitoring
Ultrasonic Transducers

Dynasonics®
Ultrasonic Flow Meters

iSonic 4000

Open-Channel Flow Meter

DESCRIPTION

An economical open-channel flow meter, iSonic 4000 measures level, flow rate and total volume of water flowing through weirs and flumes. The meter includes a non-contact ultrasonic level sensor to detect the water level and then calculates the flow rate and total volume using the Gauckler-Manning or other equations based on characteristics of the channel. All the measurements are available over Modbus RTU and can be logged for historical records.

BENEFITS

- Measure level, flow rate and total volume with a single device
- Simple setup for flumes and weirs
- Retain a historical log of all measurements
- Easily connect up to SCADA systems with Modbus RTU
- Rugged IP67 powder coated aluminum enclosure

OPERATION

Based on empirical formulas, the iSonic 4000 calculates the flow rate based on the geometry of the channel or primary element and water depth. The level sensor measures the depth of the water used in the calculation.

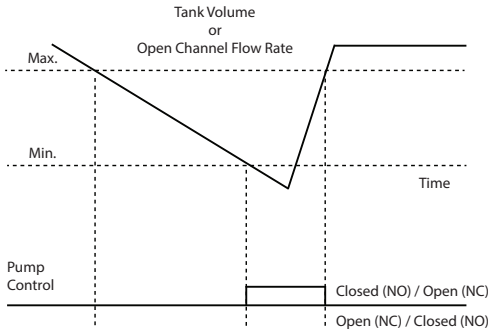
The iSonic 4000 includes a selection of primary elements with preprogrammed tables to simplify the setup, including:

- Parshall flumes
- Manhole flumes
- V-notch weirs

Additionally, you can enter custom tables using the Flow Meter Tool software.

PUMP CONTROL OPTION

The Pump Control option automatically starts and stops the pump based on water level.



PART NUMBER

- DK-1S-S
  - ◊ iSonic 4000 transmitter
  - ◊ Level sensor with 32 ft (10 m) cable
  - ◊ USB cable
  - ◊ Flow Meter Tool configuration software
- Optional bracket for level sensor

APPLICATIONS

Open channels with a primary element are a cost effective solution for managing varying flow rates in unpressurized systems. The iSonic 4000 flow meter performs best when used with a primary element, such as a flume or weir, and where the sediment does not build up.

- Flow into water treatment plants from reservoirs
- Storm and sanitary sewer systems
- Effluent from water resource recovery or wastewater treatment
- Industrial discharge
- Agriculture irrigation channels

Badger Meter®

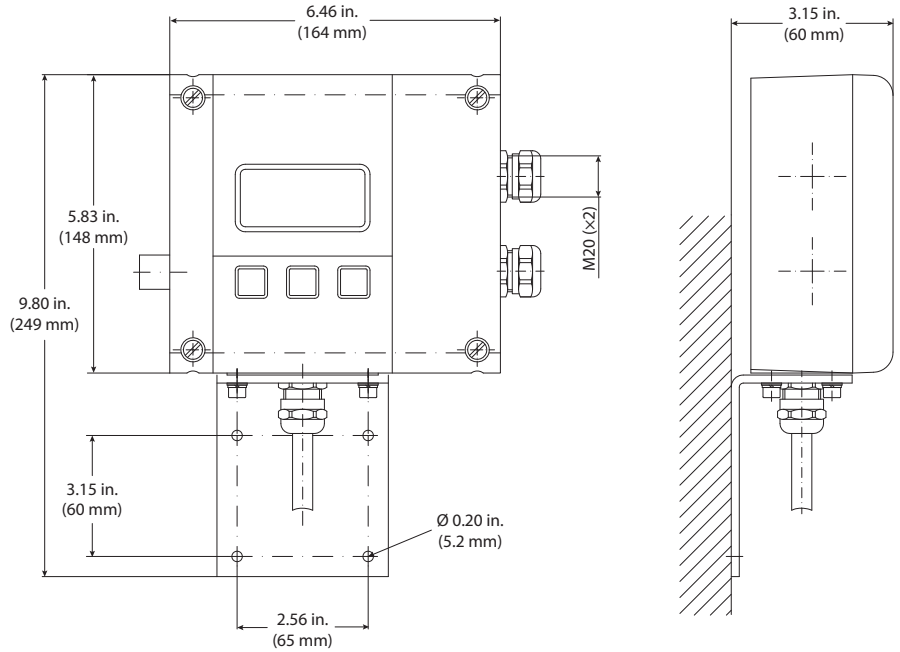
HYB-DS-02510-EN-03 (September 2019)

Product Data Sheet

SPECIFICATIONS

Type	iSonic 4000					
Auxiliary power	92…275V AC (50/60 Hz), < 14 VA					
Analog output	4…20 mA, 0…20 mA, 0…10 mA ≤ 800 Ohm, active or passive; Assigned parameter depends on flow meter mode					
Level sensor input	4…20 mA from level sensor					
Digital outputs	2 open collectors; passive: max. 32V DC, 0…100 Hz 100 mA, 100…10.000 Hz 20 mA; active: 24V DC, max. 20 mA; Select active pulse, min/max. alarm, error messages or pump control					
	Solid-state relay (n.o./n.c.) max. 230V AC, 500 mA, 1 Hz; Function is linked with open collector output 2					
Digital input	5…30V DC; totalizer reset, positive return zero, BEACON/AquaCUE connectivity					
Programming port	Mini USB, IP67					
Configuration	3 front-panel mounted push-buttons					
Communication	RS485 Modbus RTU, Modbus TCP/IP Ethernet, BEACON/AquaCUE connectivity					
Pulse length	Configurable up to 2000 msec					
Datalogger	2 MB capacity with 130,000 logged lines: date, level, flow rate, tank volume					
Display	Graphical LCD 64 × 128, backlight, actual flow rate, totalizers, status display					
Body	Die cast powder-coated aluminium, protection class IP67					
Cable inlet	Supply and signal cables 2 × M20; cable glands included					
Signal cable	From meter M20; cable gland included					
Ambient temperature	-20…60° C					
Sensors	**Measuring range**	**Offset**	**Beam width**	**Material**	**Accuracy**	**Deadband**
	0…49.21 in. (0…1250 mm)	2 in. (50 mm)	2 in. (50 mm)	PVDF	0.125 in. (3 mm)	2 in. (50 mm)
Security	Three level password					
Languages	English, Spanish, French, German, Italian, Czech, Russian					
Channel selection	Contracted rectangular weir, suppressed rectangular weir, Cipoletti weir; V-notch weir (30°, 45°, 60°, 90°); Parshall flume (1, 2, 3, 6, 9, 12, 18, 24, 36, 48 and 60 in.); Manhole flume (4, 6, 8, 10 and 12 in.); table entry, exponential equation, Manning rectangle flume, Manning pipe					

DIMENSIONS



Control. Manage. Optimize.

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EchoPod® DL10

Ultrasonic Liquid Level Transmitter

FLOWLINE™ LEVEL BEST

Application

The general purpose ultrasonic transmitter provides continuous level measurement up to 49.2” (1.25m) with a 4-20 mA signal output, and is configured via our free WebCal® software. This non-contact liquid level sensor is ideally suited for corrosive, sticky or waste liquids, and is selected for chemical feed, IBC or drum, skid or machine and cooling tower applications.

Features

- Continuous non-contact level measurement up to 49.2” (1.25m)
- 4-20 mA output for longer signal distances up to 1000’ (300m)
- Configuration is fast and easy via WebCal software and USB adapter
- Narrow 2” beam width and short 2” dead band optimized for small tanks
- PVDF transducer and 6P polycarbonate enclosure for corrosive liquids
- Automatic temperature compensation for accurate measurement

Success

Stormwater run-off from highways is a major source of pollution that degrades our clean water resources, negatively impacting both wildlife and people. This run-off carries high levels of lead, fuel, oil and chemicals which are commonly found on highways. State and federal agencies monitor run-off to determine its volume, content and risk to the local environment. Here, an EchoPod ultrasonic level sensor is installed over a V-Notch weir on the side of the highway. The continuous level sensor measures the volume of stormwater passing through the weir, and provides a 4-20 mA signal to the wireless telemetry system for remote data collection.

Compatible Products

LI23

DATALOOP™

Level Indicator

LI55

DATAVIEW™

Level Controller

LI40

PODVIEW™

Level Indicator

© 2019 Flowline | 10500 Humbolt Street, Los Alamitos, CA 90720 USA **p** 562.598.3015 **f** 562.431.8507 **w** flowline.com **DS300230 REV C2**

EchoPod® DL10

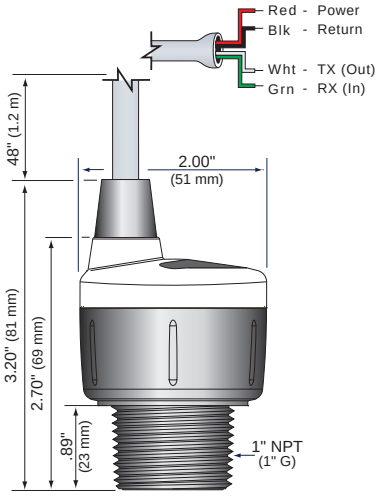
Ultrasonic Liquid Level Transmitter

FLOWLINE™ LEVEL BEST

Specifications

Range:	49.2” (1.25m)
Accuracy:	0.125” (3mm)
Resolution:	0.019” (0.5mm)
Dead band:	2” (5cm)
Beam width:	2” (5cm)
Configuration:	WebCal® PC Windows® USB 2.0
Memory:	Non-volatile
Supply voltage:	24 VDC (loop)
Consumption:	0.5W
Loop resist.:	400Ω max @ 24 VDC
Signal output:	4-20 mA, two-wire
Signal invert:	4-20 mA or 20-4 mA
Loop fail-safe:	4 mA, 20 mA, 21 mA, 22 mA or hold last
Process temp.:	F: 20° to 140° C: -7° to 60°
Temp. comp.:	Automatic
Ambient temp.:	F: -31° to 140° C: -35° to 60°
Pressure:	MWP = 30 PSI (2 bar)
Enclosure rating:	Type 6P, encapsulated, corrosion resistant & submersible
Encl. material:	Polycarbonate
Strain relief mat.:	Santoprene
Trans. material:	PVDF
Cable jacket mat:	Polyurethane
Cable type:	4-conductor, shielded
Cable length:	48” (1.2m)
Process mount:	1” NPT (1” G)
Mount gasket:	Viton®
Classification:	General purpose
Compliance:	CE, RoHS
Approvals:	cFMus

Dimensions



Configuration

LI99-1001

The level sensor is configurable via our free WebCal PC software and Fob USB adapter. The sensors are offered with and without Fobs. Fobs are universal and can be used to configure any WebCal compatible product. Download your free copy of WebCal in English or Chinese.

Fittings

For optimum performance, install the level sensor using the below recommended or direct equivalent fittings.

	P/N	DESCRIPTION
	LM52-1400	2” NPT x 1” NPT, PVC, schedule 40
	LM52-1800	2” NPT x 1” NPT, PVC, schedule 80
	LM52-1410	2” socket x 1” NPT, PVC, schedule 40
	LM52-1810	2” socket x 1” NPT, PVC, schedule 80
	LM52-1850	1” ANSI x 1” NPT, CPVC, schedule 80
	LM50-1001-1	1” NPT side mount bracket, PP

Ordering

DL10 - ☐ ☐

PROCESS MOUNT (1)

- **0** NPT (US)
- **1** G (Metric)

FOB USB ADAPTER (2)

- **0** Without Fob
- **1** With Fob

NOTES

1) Install the level sensor using Flowline installation fittings or equivalents.
2) The level sensor is configured via our WebCal software and one LI99-1001 Fob USB adapter. The level sensor is offered with and without a Fob. Fobs are universal and can be used to configure any WebCal compatible product. WebCal is a free download from our website.

Badger Meter

iSonic 4000

Open-Channel Flow Meter

HYB-UM-02509-EN-04 (November 2018)

User Manual

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SCOPE OF THIS MANUAL

This manual contains instructions for installing, operating and programming the iSonic 4000 flow meter.

IMPORTANT

Read this manual carefully before attempting any installation or operation. Keep the manual accessible for future reference.

SAFETY PRECAUTIONS AND INSTRUCTIONS

Some procedures in this manual require special safety considerations. In such cases, the text is emphasized with the following symbols:

Symbol	Explanation
⚠WARNING	Warning indicates the potential for severe personal injury, death or substantial property damage. Comply with the instructions and proceed with care.
⚠CAUTION	Caution indicates the potential for minor personal injury or property damage. Comply with the instructions and proceed with care.

Before installing or using this product, please read this instruction manual thoroughly. Only qualified personnel should install and/or repair this product. If a fault appears, contact your distributor.

Installation

- Do not place any unit on an unstable surface that may allow it to fall.
- Never place the units above a radiator or heating unit.
- Route all cabling away from potential hazards.
- Isolate from the mains before removing any covers.

Power Connection

- Use only the type of power source suitable for electronic equipment. If in doubt, contact your distributor. Ensure that any power cables are of a sufficiently high current rating.
- All units must be earthed to eliminate risk of electric shock. Failure to properly earth a unit may cause damage to that unit or data stored within it.

Protection Class

The device has protection class IP 67 and needs to be protected against dripping water, water, oils, etc.

Setup and Operation

Adjust only those controls that are covered by the operating instructions. Improper adjustment of other controls may result in damage, incorrect operation or loss of data.

Cleaning

Switch off all units and isolate from mains before cleaning. Clean using a damp cloth. Do not use liquid or aerosol cleaners.

Repairing Faults

Disconnect all units from power supply and have it repaired by a qualified service person if any of the following occurs:

- If any power cord or plug is damaged or frayed
- If a unit does not operate normally when operating instructions are followed
- If a unit exposed to rain/water or if any liquid has been spilled into it
- If a unit has been dropped or damaged
- If a unit shows a change in performance, indicating a need for service.

⚠ WARNING

FAILURE TO ADHERE TO THESE SAFETY INSTRUCTIONS MAY RESULT IN DAMAGE TO THE PRODUCT OR SERIOUS BODILY INJURY.

RoHs

Our products are RoHs compliant.

Battery Disposal

The batteries contained in our products need to be disposed of as per your local legislation, according to EU directive 2006/66/EG.

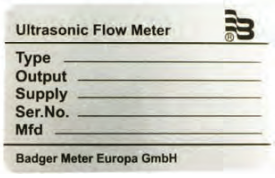
SYSTEM DESCRIPTION

The iSonic 4000 Ultrasonic flow meter is designated for flow measurements in open channels and partially filled pipes and volume measurements of liquids in tanks. You can connect one ultrasonic level sensor with 4…20 mA output to the unit. Flows are consequently calculated from measured levels using pre-programmed formulas for various primary flow elements (flumes, weirs) or from the Q/h table. The unit can also calculate flow rates in partially filled pipes and angular open channels using the Manning equation.

- The iSonic 4000 flow meter is an IP67 device in a robust wall-mounted metal case, with a large graphic display.
- The flow meter menu is operated with three front panel high endurance buttons.
- The flow meter is powered externally by 92…275V AC / 50…60 Hz. The DC version is powered externally by 9…36V DC (maximum 9 W).
- You can operate the flow meter via connection to a USB or Ethernet interface with Flow Meter Tool software, which can be used for parameter setup and datalogger download.
- The flow meter has an internal datalogger with 2 MB capacity for approximately 130,000 logged lines. You can download the logged data with the Flow Meter Tool software and save it in .csv format to a PC.
- USB, Ethernet, ADE, RS232, Modbus RS485/RS422 galvanic isolated interfaces are mounted on the board.
- The flow meter has one analog output (0…20 mA or 4…20 mA) and two galvanic isolated pulse outputs.

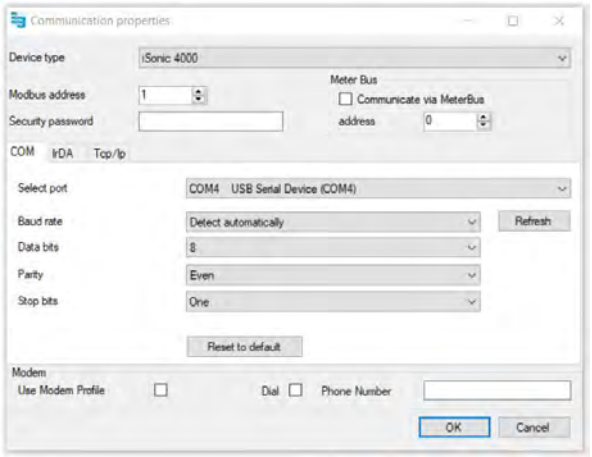
Nameplate

Look at the device nameplate to make sure the device is delivered according to your order. Check for the correct supply voltage printed on the nameplate.



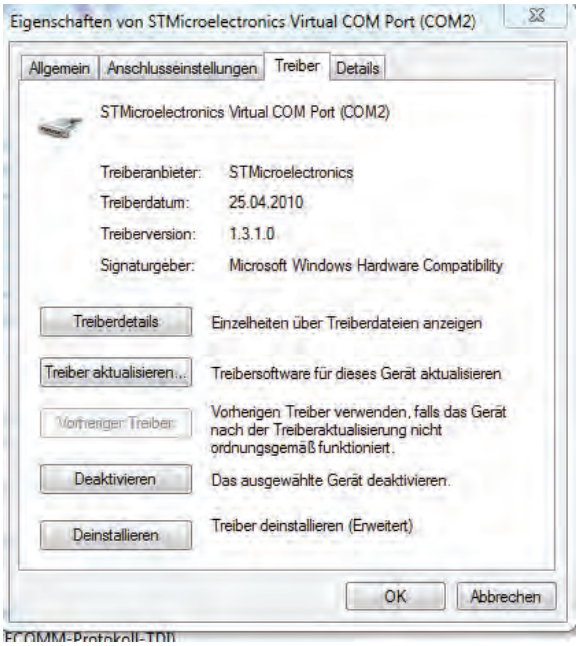
System Settings

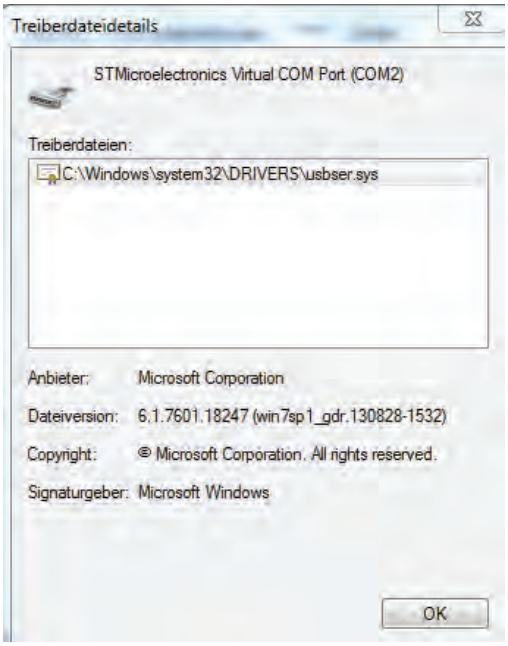
Flow Meter Tool Settings



Settings Control Panel

Driver Details



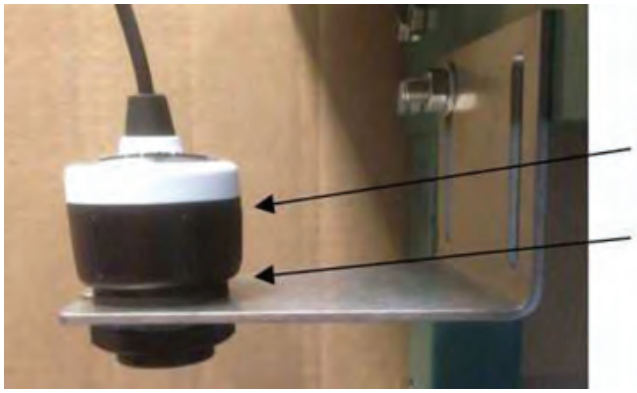


INSTALLATION

⚠ WARNING

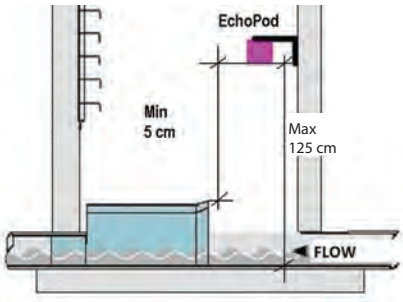
INSTALLATION INSTRUCTIONS GIVEN IN THE FOLLOWING ARE TO BE OBSERVED IN ORDER TO PROVIDE FUNCTIONALITY AND SAFE OPERATION OF THE METER.

Installation the EchoPod DL-10 Sensor

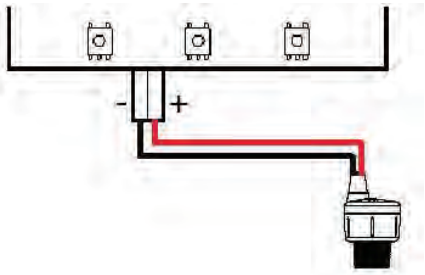


1. Insert the gasket onto the threaded end of the sensor.
2. Screw the sensor into the stainless steel mounting bracket.

NOTE: Install the sensor at a maximum of 49.21 in. (125 cm) above the flume bottom (minimal measured level) with a minimum of 1.97 in. (5 cm) distance above the maximal measured level.



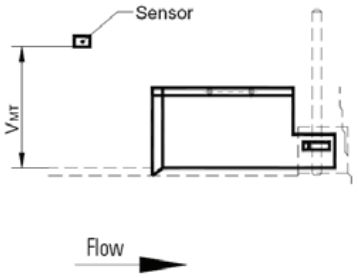
3. Connect the sensor to the 4…20 mA input terminal on the bottom side of display board.



Mounting Positions

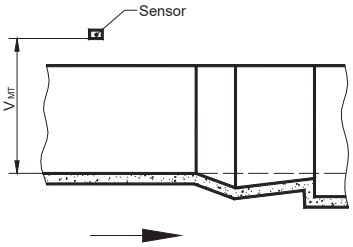
Manhole Flume

Size	Max. Flow	Max. Water Level	V-Mt	H-Mt
in. (DN)	g/sec (l/sec)	in. (mm)	in. (mm)	in. (mm)
4 (100)	1.32 (5)	5.83 (148)	23.62 (600)	5.75 (146)
6 (150)	4.23 (16)	8.94 (227)	23.62 (600)	7.75 (197)
8 (200)	9.25 (35)	12.28 (312)	23.62 (600)	9.76 (248)
10 (250)	16.64 (63)	15.55 (395)	27.56 (700)	11.73 (298)
12 (300)	24.83 (94)	18.00 (457)	27.56 (700)	13.74 (349)



Parshall Flume

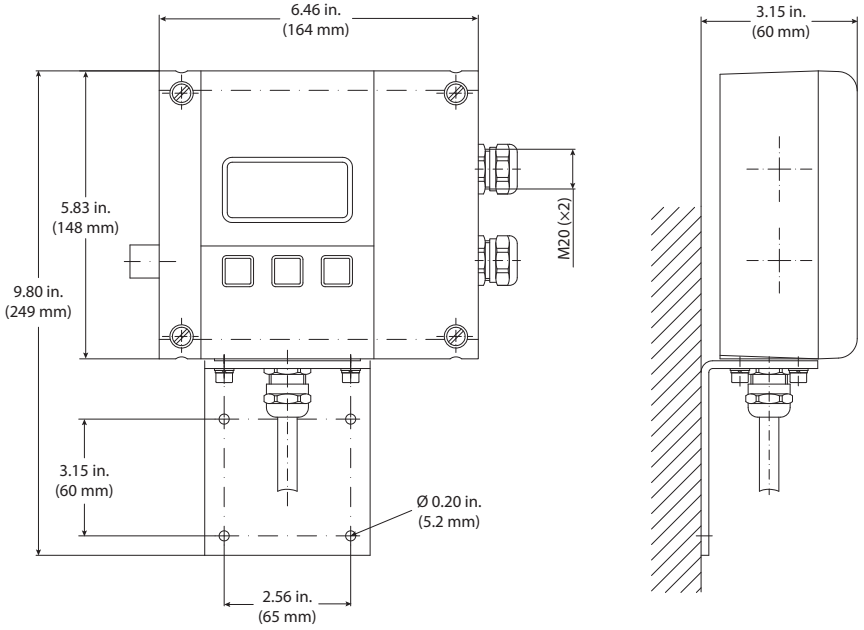
Size	Max. Flow	V-Mt	H-Mt
in. (DN)	g/sec (l/sec)	in. (mm)	in. (mm)
3 (75)	14.26 (54)	30.71 (780)	12.00 (305)
6 (150)	30.12 (114)	30.71 (780)	15.98 (406)
9 (230)	77.67 (284)	38.19 (970)	22.52 (572)
12 (305)	157.98 (598)	contact factory	contact factory
18 (455)	24.83 (94)	contact factory	contact factory



POWER CONNECTIONS

⚠CAUTION

FOR THE 2 × M20 CABLE INLETS, USE ONLY FLEXIBLE ELECTRIC CABLES. USE SEPARATE CABLE INLETS FOR AUXILIARY POWER, SIGNAL AND INPUT/OUTPUT CABLES.



Auxiliary Power

⚠ WARNING

- ***DO NOT CONNECT METER TO POWER SOURCE UNDER CONDITIONS THAT COULD CAUSE PERSONAL INJURY OR DAMAGE TO THE EQUIPMENT.***
- ***WIRING OF THIS EQUIPMENT MUST COMPLY WITH LOCAL AND NATIONAL CODES AND BE WITHIN THE VOLTAGE AND FREQUENCY RATING LISTED ON THE METER.***
- ***INSTALL EQUIPMENT WITH AN EXTERNAL MEANS FOR DISCONNECTING IT FROM POWER, SUCH AS A SWITCH OR A CIRCUIT BREAKER.***

1. Slightly loosen the lower cover screws.
2. Completely loosen both upper cover screws.
3. Open the cover to the lower side.
4. Push the auxiliary power cable through the upper cable inlet.
5. Connect the power as shown in *Figure 1* or *Figure 2*, depending on the version (AC or DC) of meter you have.
6. Close the cover and tighten the four screws.

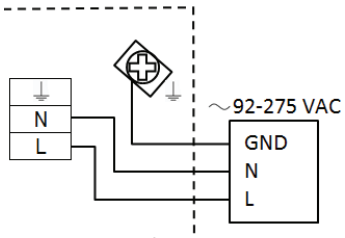


Figure 1: Power supply 92…275V AC (50/60 Hz); recommended cable size min. 0.3 sq. in. (0.75 mm²)

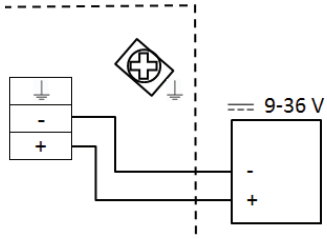
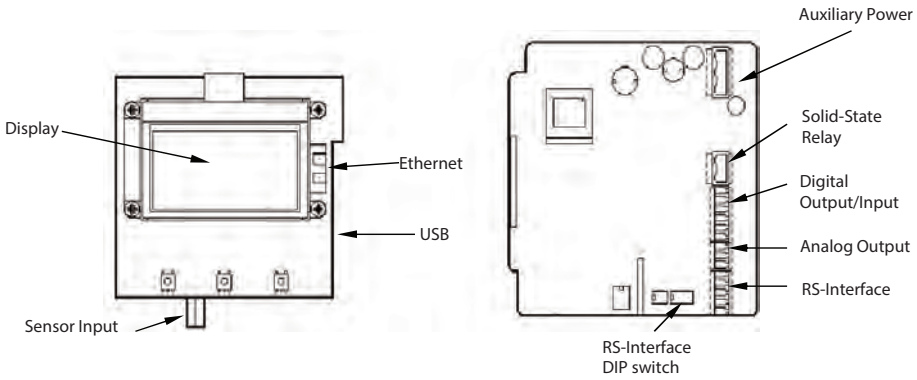
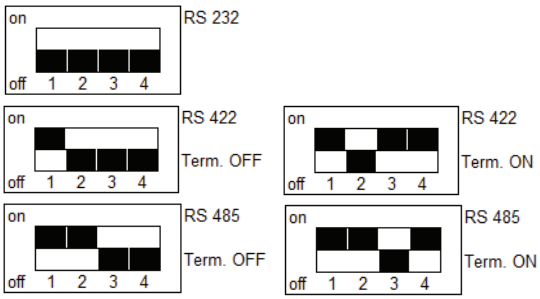


Figure 2: Power supply 9…36V DC (max. 9 W); recommended cable size min. 0.3 sq. in. (0.75 mm²)

Configuring Input/Outputs (I/O)



Input/Output		Description	Terminal
Analog output*		0…20 mA, 4…0 mA, RL < 800 Ohm, 0…10 mA	7 (+), 8 (-), 9 (GND)
Digital output	1*	Open collector max. 10 kHz, Passive max. 32V DC, <100 Hz 100 mA, >100 Hz 20 mA, Active 24V DC, 20 mA, (can be powered by analog output if not used)	3 (-),4 (+)
	2*	Open collector max. 10 kHz, Passive max. 32V DC, <100 Hz 100 mA, >100 Hz 20 mA, Active 24V DC, 20 mA, (can be powered by analog output if not used)	1 (-) 2 (+)
	3	Solid-state relays max. 230V AC, 500 mA, max. 1 Hz (function is linked to Output 2)	S1 and S2
Digital input*		5…30V DC	5 (-) and 6 (+)
RS interfaces*		RS232, RS485 and RS422 with Modbus RTU. Mode can be configured by DIP switches also termination ON or OFF. For the RS485, connect the A wire to the Y terminal and the B wire to the Z terminal. 	422 / 232 / 485 A / RxD / B / / Z / TxD / B Y / / A G (GND)
USB		USB Device CDC (Host Mass Storage)	Micro USB
Ethernet*		Ethernet Interface connection	RJ45 socket

* All marked inputs and outputs are according to safety data TNV-1 IEC 60950-1.

Input and Output Cable Connections

For the normal I/Os, use shielded cables. Connect the shield of the cable to one of the grounding screws. Recommended cable is LiYCY size min. 0.06 sq. in. (0.14 mm^2).

Solid-State Output
If using a second cable gland for the normal I/Os, use one cable and cable gland for the power supply and solid-state relay. Recommended cable size is min. 0.3 sq. in. (0.75 mm^2).

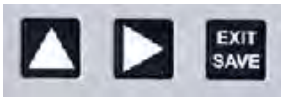
⚠CAUTION

- ***USE SEPARATE CABLE INLETS FOR CABLES CONNECTED TO THE SOLID-STATE RELAY OUTPUT AND CABLES CONNECTED TO THE OTHER INPUT/OUTPUTS.***
- ***WITH MULTIPHASE POWER, SOLID-STATE RELAY SHOULD HANDLE ONLY THE SAME PHASE THAT IS USED FOR POWERING THE METER.***

OPERATION

Function Buttons

All programming is accomplished using the three function buttons on the front of the unit. Screen navigation and digit and parameter selection is performed by a combination of these buttons.



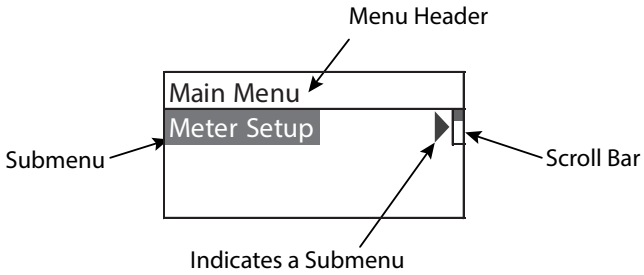
Use the **up-arrow** to scroll through the menu screens or to advance numerical digits to change values.

Use the **right-arrow** to select digits from left to right and allows or to enter a submenu.

Use **EXIT SAVE** to save changed values, return to a previous menu or toggle between *Measuring* mode and *Programing* mode.

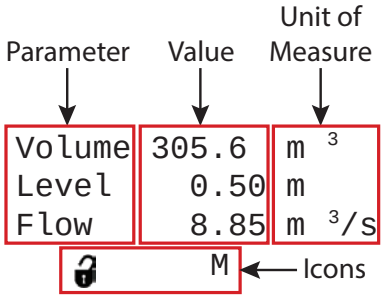
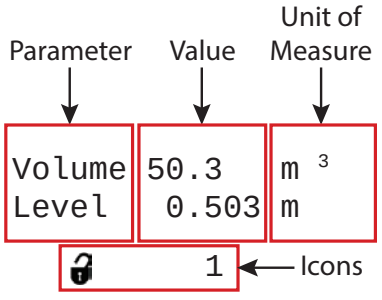
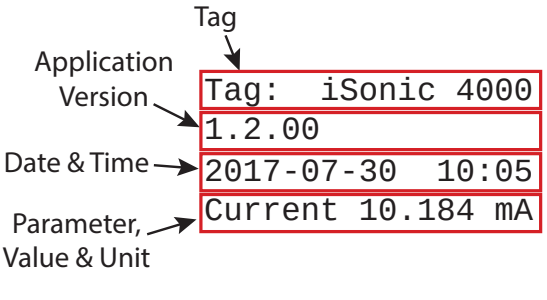
Display Icons

Minor battery power (Realtime clock)	**W**	Sensor warming
Device error	**0**	Sensor not connected
No keyword active	**M**	Sensor measuring
USB active	**S**	Simulation active



Initial Screens

From the *Main Menu*, press **EXIT SAVE** to display the current values and system information. The first screen to display depends on the application type (open channel or tank).

First screen for open channel applications:	First screen for tank applications:	Second screen for both applications.
		

Setting a PIN

The iSonic 4000 flow meter security feature allows the option to restrict access to the meter by way of a 6-digit Personal Identification Number (PIN). The system administrator can set up a single PIN for each of the three different levels of access:

- **Administration** – allows access to all iSonic 4000 flow meter menu configuration screens.
- **Service** – allows access to service-level and user-level menu configuration screens.
- **User** – allows access only to user-level menu configuration screens.

NOTE: For a lost PIN, Contact Badger Meter Technical Support at 800-456-5023 for a replacement PIN.

Not all levels of access need to be set. If no PINs are set up, any user will have access to all functions.

1. From the *Main Menu*, press the **right-arrow**.
2. From the *Meter Setup* menu, press the **up-arrow** until the *Pin* menu is displayed.
3. Press the **right-arrow** to display the PINS *Control* menu.
4. Press the **right-arrow** to highlight ON or OFF.
5. With either ON or OFF highlighted, press the **up-arrow** to display ON.
6. Press **EXIT SAVE** to save the ON setting.
7. With the *Control* menu highlighted, press the **up-arrow** to display the required security level (user, service, or admin).
8. With the required security level highlighted, press **EXIT SAVE** to display the first of six zeros (digits).
9. Press the **up-arrow** to change the first digit, followed by pressing the **right-arrow** to select the next digit.
10. Press the **EXIT SAVE** button to save the PIN number for that security level.

Logging In

To change any parameter, the PIN entered must provide the proper security privilege required by the parameter.

To enter a PIN, go to the *Login* menu and enter the PIN for the required security level.

Once you are properly logged in, the unlocked icon appears on the meter display.

NOTE: A ***PIN Error*** message displays if the incorrect PIN is entered.

Logging Out

To log out, follow steps 1 through 8 under *"Setting a PIN"*. At step 9, enter an invalid PIN, then press **EXIT SAVE**.

PROGRAMMING

Main Menu

From the *Main Menu*, you can access these submenus, each of which is described on the following pages:

- Meter Setup
- Measurements
- Input and Outputs
- Totalizer Reset
- Communication
- Miscellaneous
- Information
- Pin

The security levels are:

Administrative

Service

User

Parameters indicated by the battery icon, if changed, will affect battery performance.

To program the security levels, see *"Setting a PIN" on page 13*. No passwords were set at the factory.

Meter Setup Menu

Application	***Tank***	Select for a tank application.
	Open Channel	Select for an open channel application.
Sensor	***Interval***	Setup of time measurement interval(s); default value is 1 second; larger interval (for instance, 300 seconds) is set when unit is powered from battery
	WarmUpTime	Powering time of sensor(s) before measurement; larger interval is set when unit is powered from battery
	LowerRangeValue	The minimum level value of used sensor = 4 mA in selected level units
	UpperRangeValue	The maximum level value of used sensor = 20 mA in selected level units
	Offset	Level offset in selected level units, depends of sensor mounting position

Measurement Menu

Length

Establishes the unit of measure for the length

Display	*Length Unit*
ft	Feet
m	Meter
in.	Inch
cm	Centimeter
mm	Millimeter

DecimalPlaces – set of the decimal places of the Length values

Flow Rate

Establishes the unit of measure for the flow rate

Display	*Flow Unit*	*Display*	*Flow Unit*
L/s	Liters/Second	gal/s	Gallons/Sec.
L/min	Liters/Minute	gal/min	Gallons/Min.
L/h	Liters/Hour	gal/h	Gallons/Hour
m^3/s	Cubic Meters/Sec.	MG/d	MillionGallons/Day
m^3/min	Cubic Meters/Min.	IG/s	ImperialGallons/Sec.
m^3/h	Cubic Meters/Hour	IG/min	ImperialGallons/Min.
ft^3/s	Cubic Feet/Sec.	IG/h	ImperialGallons/Hour
ft^3/min	Cubic Feet/Min.	Bbl/min	Barrel/Min
ft^3/h	Cubic Feet/Hour.		

DecimalPlaces – set of the decimal places of the Flow Rate values

Volume

Display	*Volume Unit*	*Display*	*Volume Unit*
L	Liters	MG	MegaGallons
hL	HectoLiter	IG	Imperial Gallons
m^3	Cubic Meters	bbl	Barrel
Ft^3	Cubic Feet	Aft	Acre Feet
gal	US Gallons		

DecimalPlaces – set of the decimal places of the Volume values

Equation Selection

Q/h Table selection is possible only from the Flow Meter Tool software

Display	***Description***
Exponential Eq	Exponential Function Q = K h ^{exp}
Contract.Weir	Contracted Weir
Suppress.Weir	Suppressed Weir
CipolettiWeir	Cipoletti Weir
VNotchWeir30°	V Notch Weir 30°
VNotchWeir45°	V Notch Weir 45°
VNotchWeir60°	V Notch Weir 60°
VNotchWeir90°	V NotchWeir 90°
ManningRect.	Manning Rectangle Flume
ManningPipe	Manning Pipe
Pars.Flume1"	Parschall Flume 1"
Pars.Flume2"	Parschall Flume 2"
Pars.Flume3"	Parschall Flume 3"
Pars.Flume6"	Parschall Flume 6"
Pars.Flume9"	Parschall Flume 9"
Par.Flume12"	Parschall Flume 12"
Par.Flume18"	Parschall Flume 18"
Par.Flume24"	Parschall Flume 24"
Par.Flume36"	Parschall Flume 36"
Par.Flume48"	Parschall Flume 48"
Par.Flume60"	Parschall Flume 60"
Manh.Flume4"	Manhole Flume 4"
Manh.Flume6"	Manhole Flume 6"
Manh.Flume8"	Manhole Flume 8"
Manh.Flume10"	Manhole Flume 10"
Manh.Flume12"	Manhole Flume 12"

Equation Params

Exponent value in for equation (Q= K h exp)	Exponent
Coefficient value in for equation (Q= K h exp)	Coefficient
Measured profile width (Weirs, Manning equation)	Width
Rectangular profile slopes angle (Manning equation)	Angle
Measured pipe Radius (Manning equation)	Radius
Water Surface Slope (Manning equation)	WaterSurfaceSlope
Surface Roughness coefficient (Manning equation)	SurfaceRoughness
Maximum Water Level	MaximumWaterLevel
Flow Rate Upper Range Value	UpperRangeValue

Maximum Water Level /SetDefaultVal.
Set of the Maximum Water Level for the selected primary element – the value is possible to edit further.

Upper Range Value /Calculate
Is calculating the maximal Flow Rate value for Maximal Water Level - the value is possible to edit further – this parameter is used also for outputs (Upper Range Value=100% - full range)

Open Channel Calculation

Volumetric flow is calculated from actual water level. Actual water level is limited by the maximum water level.

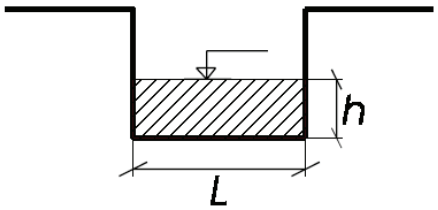
The Exponential Equation for general Parshall or Manhole flume: **$Q=K.Q^{exp}$**

Q – Volumetric flow [m^3/s]
K – Coefficient [$m^{(3-n)}/s$]
h – Water level [m]
exp – Exponent [-]

Predefined Flume	Equation [m^3/s, m]	Max. Water Level [m]
Parshall flume 1 in.	$Q = 0.0604 \cdot h^{1.55}$	0.230
Parshall flume 2 in.	$Q = 0.1207 \cdot h^{1.55}$	0.260
Parshall flume 3 in.	$Q = 0.1771 \cdot h^{1.55}$	0.667
Parshall flume 6 in.	$Q = 0.3810 \cdot h^{1.55}$	0.724
Parshall flume 9 in.	$Q = 0.5350 \cdot h^{1.55}$	0.876
Parshall flume 12 in.	$Q = 0.7050 \cdot h^{1.55}$	0.925
Parshall flume 18 in.	$Q = 1.0670 \cdot h^{1.55}$	0.925
Parshall flume 24 in.	$Q = 1.4290 \cdot h^{1.55}$	0.925
Parshall flume 36 in.	$Q = 2.1900 \cdot h^{1.57}$	0.925
Parshall flume 48 in.	$Q = 2.9600 \cdot h^{1.58}$	0.925
Parshall flume 60 in.	$Q = 3.7500 \cdot h^{1.59}$	0.925
Manhole flume 4 in.	$Q = 0.2343 \cdot h^{1.95}$	0.149
Manhole flume 6 in.	$Q = 0.3026 \cdot h^{1.95}$	0.227
Manhole flume 8 in.	$Q = 0.3424 \cdot h^{1.95}$	0.313
Manhole flume 10 in.	$Q = 0.3868 \cdot h^{1.95}$	0.396
Manhole flume 12 in.	$Q = 0.4345 \cdot h^{1.95}$	0.457

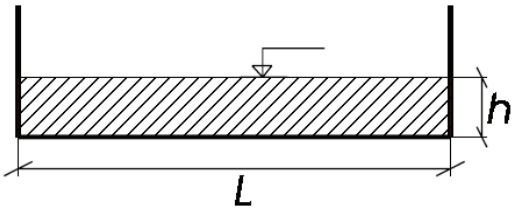
Contracted rectangular weir

Equation $Q = 1.84 \cdot (L - 0.2 \cdot h) \cdot h^{1.5}$
Q – Volumetric flow [m^3/s]
1.84 – Coefficient [$\sqrt{m}/s$]
L – Width [m]
h – Water level [m]



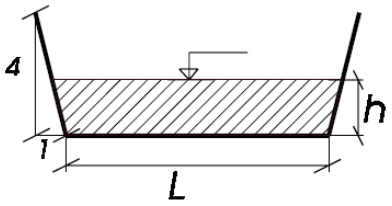
Suppressed rectangular weir

Equation $Q = 1.84 \cdot L \cdot h^{1.5}$
Q – Volumetric flow [m^3/s]
1.84 – Coefficient [$\sqrt{m}/s$]
L – Width [m]
h – Water level [m]



Cipoletti rectangular weir

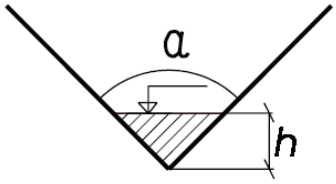
Equation $Q = 1.84 \cdot L \cdot h^{1.5}$
Q – Volumetric flow [m^3/s]
1.84 – Coefficient [$\sqrt{m}/s$]
L – Width [m]
h – Water level [m]



V-notch weir 30°

Equation $Q=\frac{8}{12}\sqrt{2 \cdot g} \cdot \tan\left(\frac{30^2}{2}\right) \cdot 0.586 \cdot (h + 0.0021)^{2.5}$

Q – Volumetric flow [m^3/s]
g – Standard gravity 9.80665 [m/s^2]
h – Water level [m]



V-notch weir 45°

Equation $Q=\frac{8}{12}\sqrt{2 \cdot g} \cdot \tan\left(\frac{45^2}{2}\right) \cdot 0.580 \cdot (h + 0.0015)^{2.5}$

Q – Volumetric flow [m^3/s]
g – Standard gavity 9.80665 [m/s^2]
h – Water level [m]

V-notch weir 60°

Equation $Q=\frac{8}{12}\sqrt{2 \cdot g} \cdot \tan\left(\frac{60^2}{2}\right) \cdot 0.577 \cdot (h + 0.0012)^{2.5}$

Q – Volumetric flow [m^3/s]
g – Standard gavity 9.80665 [m/s^2]
h – Water level [m]

V-notch weir 90°

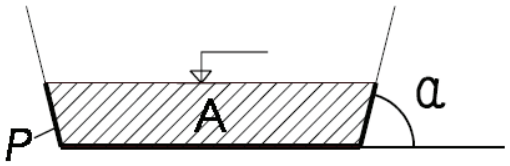
Equation $Q=\frac{8}{12}\sqrt{2 \cdot g} \cdot \tan\left(\frac{90^2}{2}\right) \cdot 0.578 \cdot (h + 0.0008)^{2.5}$

Q – Volumetric flow [m^3/s]
g – Standard gavity 9.80665 [m/s^2]
h – Water level [m]

Manning equation: $Q = 1/n\ R_h^{2/3}\ I^{1/2}\ A \qquad R_h = A/P$

Manning rectangular

Equation $Q = \frac{1}{n}\left(\frac{h \cdot L + \frac{h^2}{tg\alpha}}{\frac{2 \cdot h}{\sin\alpha} + L}\right)^{2/3} \cdot \sqrt{I} \cdot h \cdot L + \left(\frac{h^2}{tg\alpha}\right)$

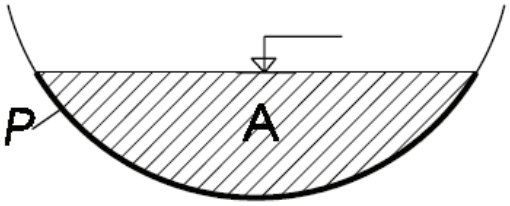


Q – Volumetric flow [m^3/s]
n – Gauckler-Manning coefficient [$s/\sqrt[3]{m}$]
L – Width [m]
h – Water level [m]
α – Angle [°]
I – Water surface slope [m/m]

Manning pipe

Equation $Q = \frac{1}{n}\left(\frac{(a - \sin\alpha) \cdot r}{2\alpha}\right)^{2/3} \cdot \sqrt{I} \cdot \left(\frac{(a - \sin\alpha) \cdot r^2}{2}\right)$ where

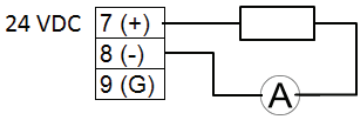
$$\alpha = \begin{cases} 2 \cdot \pi - 2 \cdot \arcsin\left(\sqrt{\frac{2 \cdot h \cdot r - h^2}{r}}\right) \mid h > r \\ 2 \cdot \arcsin\left(\sqrt{\frac{2 \cdot h \cdot r - h^2}{r}}\right) \mid h \le r \end{cases}$$

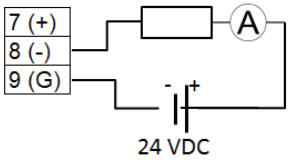


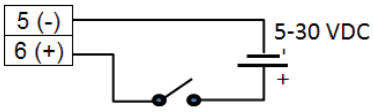
Q – Volumetric flow [m^3/s]
n – Gauckler-Manning coefficient [$s/\sqrt[3]{m}$]
L – Width [m]
h – Water level [m]
I – Water surface slope [m/m]

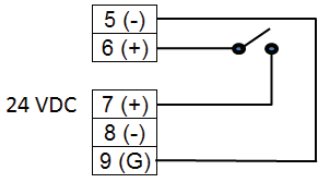
Material	n = $s/\sqrt[3]{m}$	**Material**	n = $s/\sqrt[3]{m}$	**Material**	n = $s/\sqrt[3]{m}$
Glass , PVC	0.010	Gravel, firm	0.023	Natural channels, poor	0.060
Cement, concrete, steel	0.011	Earth channel, gravelly	0.025	Floodplains, heavy brush	0.075
Brick	0.015	Earth channel, weedy	0.030	Floodplains, trees	0.150
Earth, smooth	0.018	Natural streams, clean	0.035		
Earth channel, clean	0.022	Floodplains, light brush	0.050		

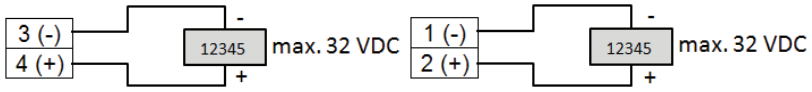
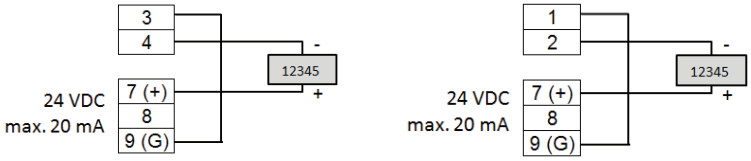
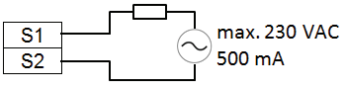
Input/Outputs Menu

<table>
<tr><td>Analog Output</td><td>Range
 </td><td>Establishes the range of the analog output signal: 0…100% (= full scale). The following current output ranges are available:
• 0…20 mA
• 4…20 mA
• 0…10 mA
Analog output active
 

Analog output passive
 

NOTE: If an error message displays, set the current according the programing of the Alarm Mode below. When you select bidirectional operation, you can signal the flow direction via digital outputs.</td></tr>
<tr><td></td><td>Alarm Mode
 </td><td>This parameter configures the behavior of the analog output during alarm conditions. The options are OFF, 3.5 mA and 23 mA.
• OFF: Analog signal is based on flow rate and always within the configured range.
• 3.5 mA: During alarm conditions, the analog signal is 3.5.
• 23 mA: During alarm conditions, the analog signal is 23 mA.
For example, if the analog range is 4…20 mA and the alarm mode is set to 23 mA, then during a full scale flow alarm condition, the analog output current will be 23 mA.</td></tr>
<tr><td></td><td>Compensation
 </td><td>Correction of the current value output.</td></tr>
<tr><td>Digital Input
 </td><td colspan="2">Digital input lets you reset totalizers (remote reset), interrupt flow measurement (PosZeroReturn) or ADE. Input switching is provided by applying an external potential of 5…30V DC
 

or by an internal voltage source of 24V DC (analog output if not used).
 
</td></tr>
</table>

Digital Outputs	You can configure functional operation of the 2 digital outputs. For example, you can select *Forward Pulse* for the digital output and define the pulses per totalizer unit via pulse scale.	
	Digital Outputs 1 and 2	The two outputs can be operated as open collector passively or actively. Passive output  Active output (if analog output is not used) 
	Solid-State Relay	The solid-state relay is functionally linked with *Output 2*. See *"Out 1 / 2 Function"* below. 

<table>
<tr><td rowspan="8">Digital Outputs</td><td>Pulse Width</td><td>This parameter establishes the ON duration of the transmitted pulse. The configurable range is from 0…2000 ms. If 0 ms is configured, pulse width is automatically adapted depending on pulse frequency (pulse/pause ratio 1:1).
During the configuration the program checks if pulses/unit and pulse width are in accordance with full scale defined. If not, an error alarm displays and scale, pulse width or full scale need to be adapted.</td></tr>
<tr><td>Pulse/Unit</td><td>The Pulses/Unit parameter lets you set how many pulses per unit of measure to transmit. The maximum output frequency of 10,000 pulses/sec. (10 kHZ) must not be exceeded.</td></tr>
<tr><td>Out 1 /2 Function</td><td>The following functions can be selected for the Output 1, Output 2 and the Solid-State Relay. The Solid-State Relay function is linked functionally with Output 2.
<table>
<tr><th>Function</th><th>Out1</th><th>Out2 / Solid-State Relay</th></tr>
<tr><td>Off</td><td>X</td><td>X</td></tr>
<tr><td>Forward pulse</td><td>X</td><td>X</td></tr>
<tr><td>Min/Max Alarm</td><td>X</td><td>X</td></tr>
<tr><td>Error alarm</td><td>X</td><td>X</td></tr>
<tr><td>Pump Control</td><td>X</td><td>X</td></tr>
<tr><td>Test</td><td>X</td><td>X</td></tr>
<tr><td>ADE</td><td>X</td><td></td></tr>
</table>
• OFF: Digital output is switched off.
• Forward pulse: Generates pulses during forward flow conditions.
• Min/Max Alarm: Indicates when flow rate exceeds thresholds defined by Set Min. or Set Max. in % of full scale. See *“Figure 3: Tank volume or open-channel flow rate” on page 23*.
• Error alarm: Indicates when the meter has error an condition.
• Pump Control: Starts or stops the pump. See *“Figure 3: Tank volume or open-channel flow rate” on page 23*.
• Test: Used only for the Verification Device.
• ADE: Used for BEACON and AquaCUE connectivity.</td></tr>
<tr><td>Output 1 /2 Type</td><td>The output type parameter lets you set the output switch to “normally closed“ or “normally open“.</td></tr>
<tr><td>Output 1 /2 Set Min</td><td>The flow Min Set Point establishes, as a percentage of full scale flow, the minimum threshold at which the output alarm activates. Select thresholds in 1% steps. Flow rates below or above the threshold activate the output alarm.</td></tr>
<tr><td>Output 1 /2 Set Max</td><td>The Flow Max Set Point establishes, as a percentage of full scale flow, the maximum threshold at which the output alarm activates. Select thresholds in 1% steps. Flow rates below or above the threshold activate the output alarm.</td></tr>
<tr><td>Flow Simulation</td><td colspan="2">Flow Simulation provides analog and digital output simulation based on a percentage of the full scale flow in cases where no real flow is occurring. The range of simulation includes 0…100% in steps of 10% of the full scale flow. This function remains active when you exit the menu. You must set it to Off to deactivate it. If the simulation is still active, a character “S” displays in the Measuring mode.</td></tr>
</table>

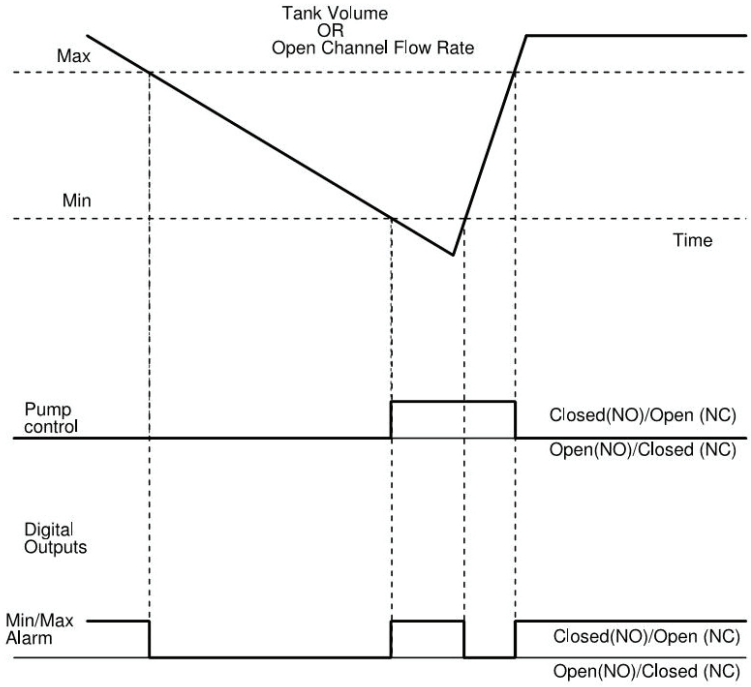
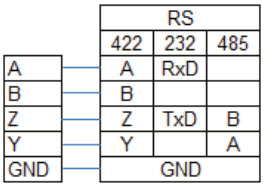
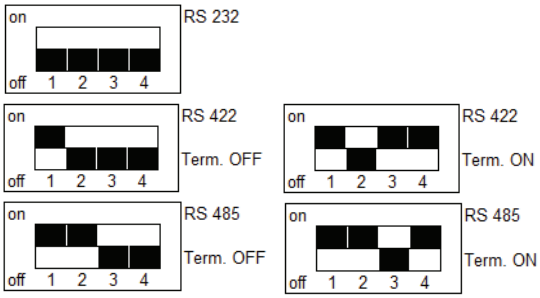


Figure 3: Tank volume or open-channel flow rate

Clear Total

Total	Resets the totalizer within the *ClearTot* item on the Flow Meter Tool software.

Communications Menu

Interfaces	Modbus® RTU	RS232, RS485 and RS422 with Modbus RTU.  Mode can be configured by DIP switches also if termination ON or OFF. 
Modbus	Address	Address available from 1…247
	RS232, RS422, RS485	Baudrate: 1200, 2400, 4800, 9600, 19200, 38400 Bd Parity: Even, Odd, Mark, Received Packets, Sent Packets
Ethernet	Modbus TCP/IP with MEAP-Header	
	IP Address	IPv4 address default 192.168.1.60
	IP Mask	IPv4 subnetting reference default 255.255.255.0
	IP Gateway	Gateway address default 192.168.1.1
	MAC Address	Media-Access-Control-Address
ADE	Control	ON or OFF
	Protocol	1 or 2
	Dial	4…9
	Resolution	0.001 / 0.01 / 0.1 / 1 / 10 / 100 / 1000 / 10,000

Miscellaneous

Power up	The number of times that the unit has been powered on.
Language	The unit supports these languages: English, German, Czech, Spanish, French, Russian
Date	Set the system date in the format [DD.MM.YY]; used for data logging.
Time	Set the system time in the format [HH.MM.SS]; used for data logging.
Contrast	The contrast of the display can be adjusted between 14 (low) and 49 (high).
Datalog Period	The data logging period can be adjusted to every 10 min / 20 min / 30 min / 1 h / 24 h. There is a 2 MB memory with about 130,000 data records for data logging available. The logging capacities (uni-directional mode) and durations are: 10 min up to 2.50 years 20 min up to 5 years 30 min up to 7.5 years 1 h up to 15 years 24 h up to 260 years The logging information can be downloaded by a PC program Flow Meter Tool.

Info Menu

Serial Number	Serial number of the electronic board.
Version	Software version of the device.
Compilation Date	Date of the software version.
Otp CRC	Checksum of software update
Application CRC	Checksum of application

PIN Menu

The menus and parameters can be secured via three password levels. See *"Setting a PIN" on page 13*.

- Administrator PIN
- Service PIN
- User PIN

The password protection is a 6-digit PIN [000000] and is deactivated at the factory.

The first time you use the unit, activate the password protection *Control* = *On* and enter login with the password 000000.

Then go back to the PIN again and enter [User], [Service] and [Admin] password.

Once the password protection has been activated, enter your PIN under *Login* and the *lock open* symbol appears.

The PIN grants you access to Administrator, Service or User levels with the respective access rights. You can now move to the menu and enter parameters.

Without a login, you can read all parameters, but cannot change them.

Control	Activate and deactivate the PIN
User	User logged in with this PIN can access all User levels, but do not have access to Service or Admin functions.
Service	User logged in with this PIN will have access to both service and user-level procedures. User at this level will not have access to administrative functions.
Admin	User logged in with this PIN will have access to both service and user-level procedures.
Random Number	In case of losing PIN read the random number. This number has to be sent to Badger Meter support, which is able to generate the Emergency PIN. Between reading random number and entering received emergency PIN, do no try to play with emergency PIN and do not restart the meter.
Emergency PIN	In case of losing PIN read the random number. This number has to be sent to Badger Meter support, which is able to generate the emergency PIN. Between reading random number and entering received emergency PIN, do no try to play with emergency PIN and do not restart the meter.

Login Menu

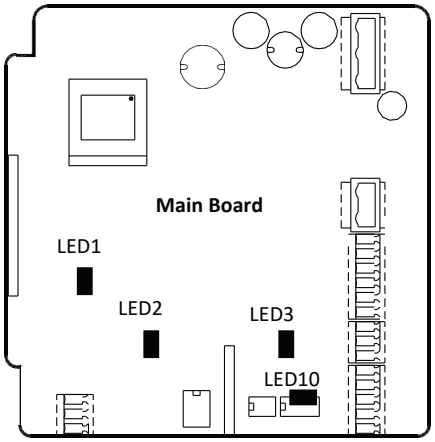
Login	Once the password protection has been activated, enter your PIN.

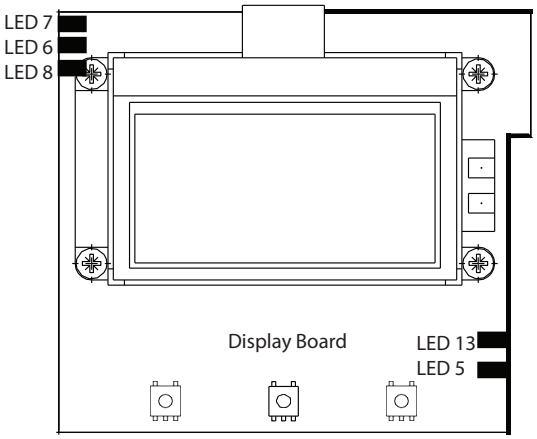
TROUBLESHOOTING

The following error messages may display:

Description	Possible Cause	Recommended Action
Pulse Output	Pulse rate exceeds the maximum	Reduce pulse scale (pulse/unit) and/or reduce pulse width configuration
EEPROM	Configuration file is missing	Contact support
Configuration	Configuration file is corrupted	Contact support
Low Battery	Low backup battery (memory)	Contact support
Measure Timeout	Measurement was not completed within specific time	Contact support

Control LED





The following LEDs on the board control the operation of the device:

LED1 No function attached
LED3 Communication – transmit (On = active)
LED5 Flash memory activity (DISK)
LED6 Digital output #1 (On = active)
LED7 Digital output #2 (On = active)
LED8 No function attached
LED10 Power ON (On = active)
LED13 USB, HOST mode (On = active)

Replace Meter's Electronics

⚠ WARNING

DISCONNECT AUXILIARY POWER BEFORE OPENING THE BODY COVER.

1. Pull out all the plugs.
2. Loosen screws S1-S4 and take out circuit board.
3. Insert the new circuit board and attach it by fastening the screws S1-S4.
4. Plug in all plugs.
5. If necessary, configure the new board.

SPECIFICATIONS

Type	iSonic 4000					
Auxiliary power	92…275V AC (50/60 Hz), < 14 VA optional 9…36V DC, < 4 W					
Analog output	4…20 mA, 0…20 mA, 0…10 mA ≤ 800 Ohm, active or passive; Assigned parameter depends on flow meter mode					
Level sensor input	4…20 mA from level sensor					
Digital outputs	2 open collectors; passive: max. 32V DC, 0…100 Hz 100 mA, 100…10.000 Hz 20 mA; active: 24V DC, max 20 mA; Select active pulse, min/max alarm, error messages or pump control					
	Solid-state relay (n.o./n.c.) max 230V AC, 500 mA, 1 Hz; Function is linked with open collector output 2					
Digital input	5…30V DC; totalizer reset, positive return zero, BEACON/AquaCUE connectivity					
Programming port	Mini USB, IP67					
Configuration	3 front-panel mounted push-buttons					
Communication	RS485 Modbus RTU, Modbus TCP/IP Ethernet, BEACON/AquaCUE connectivity					
Pulse length	Configurable up to 2000 msec					
Datalogger	2 MB capacity with 130,000 logged lines: date, level, flow rate, tank volume					
Display	Graphical LCD 64 × 128, backlight, actual flow rate, totalizers, status display					
Body	Die cast powder-coated aluminium, protection class IP67					
Cable inlet	Supply and signal cables 2 × M20; cable glands included					
Signal cable	From meter M20; cable gland included					
Ambient temperature	-20…60° C					
Sensors	**Measuring range**	**Offset**	**Beam width**	**Material**	**Accuracy**	**Deadband**
	4. 92 in. (0…1250 mm)	2 in. (50 mm)	2 in. (50 mm)	PVDF	0.125 in. (3 mm)	2 in. (50 mm)
Security	Three level password					
Languages	English, Spanish, French, German, Italian, Czech, Russian					
Channel selection	Contracted rectangular weir, suppressed rectangular weir, Cipoletti weir; V-notch weir (30°, 45°, 60°, 90°); Parshall flume (1, 2, 3, 6, 9, 12, 18, 24, 36, 48 and 60 in.); Manhole flume (4, 6, 8, 10 and 12 in.); table entry, exponential equation, Manning rectangle flume, Manning pipe					

DIMENSIONS

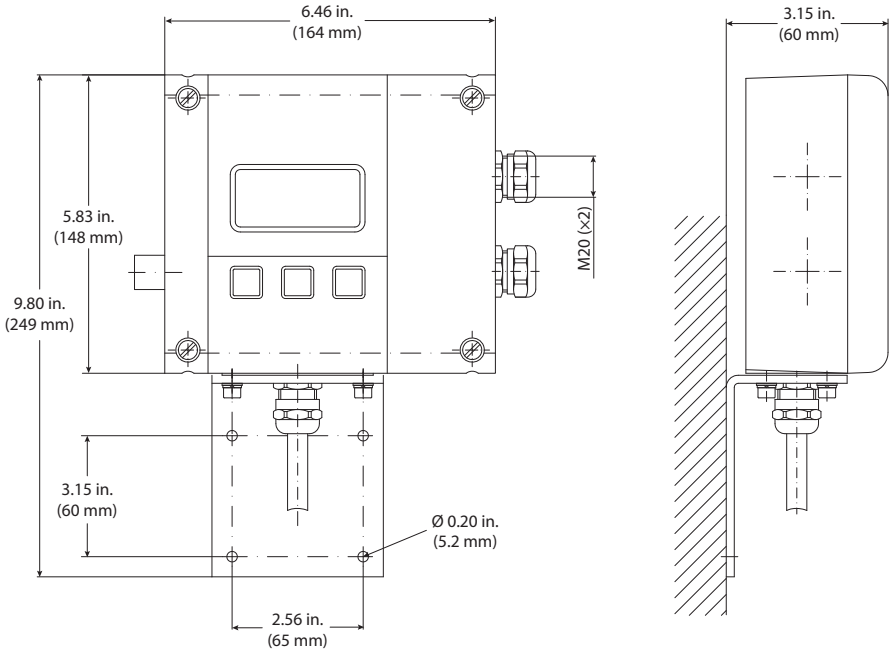


Figure 4: iSonic 4000 flow computer

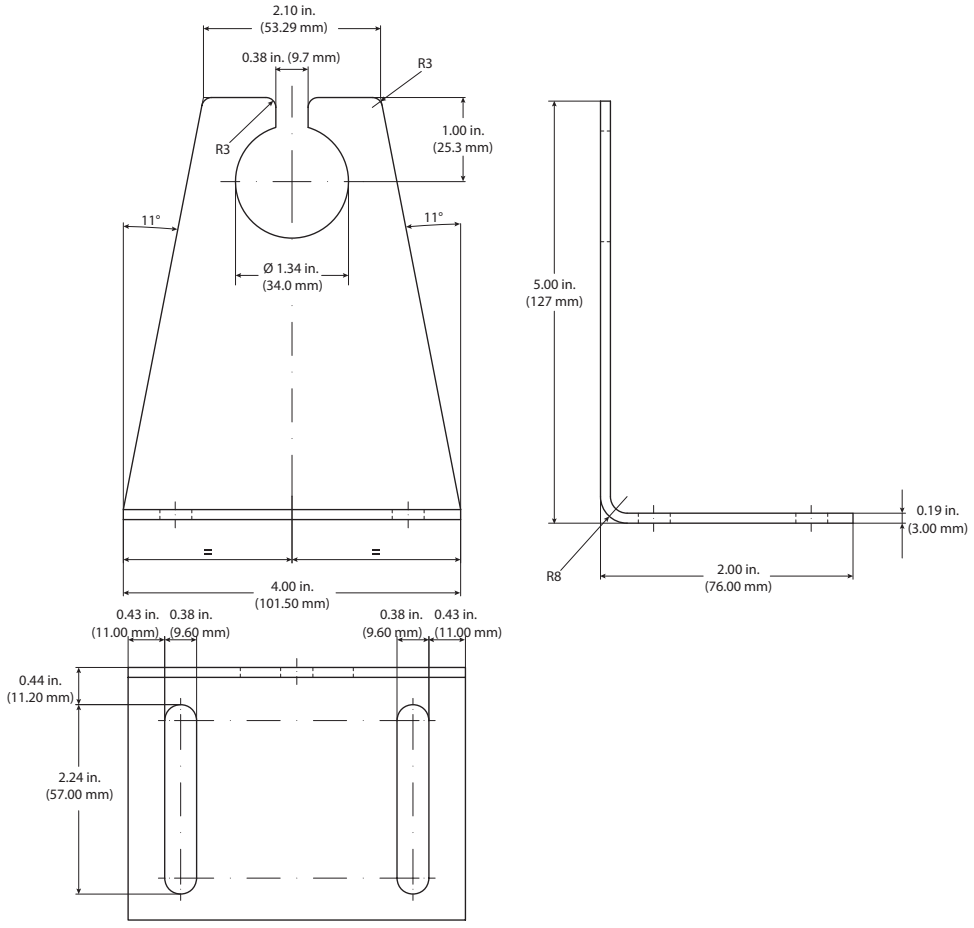


Figure 5: Sensor bracket

MAIN MENU PROGRAM STRUCTURE

Meter Setup

Application	Tank
	Open Channel
Sensor	Interval
	Warm Up Time
	Lower Range Value
	Upper Range Value
	Offset

Measurements

Length	Unit	ft
		m
		in
		cm
		mm
	Decimal Places	
Flow Rate	Unit	L/s
		L/min
		L/h
		m^3/s
		m^3/min
		m^3/h
		ft^3/s
		ft^3/min
		ft^3/h
		gal/s
		gal/min
		gal/h
		MG/D
		IG/s
		IG/min
		IG/h
		bbl/min
	Decimal Places	
Volume	Unit	L
		hL
		m^3
		ft^3
		gal
		MG
		IG
		bbl
		Aft
	Decimal Places	

Measurements (continued)

Equation Selection	Table	
	Exponential Eq	
	Contract. Weir	
	Suppress. Weir	
	Cipoletti Weir	
	V NotchWeir30°	
	V NotchWeir45°	
	V NotchWeir60°	
	V NotchWeir90°	
	Manning Rect.	
	Manning Pipe	
	Pars. Flume 1"	
	Pars. Flume 2"	
	Pars. Flume 3"	
	Pars. Flume 6"	
	Pars. Flume 9"	
	Par. Flume 12"	
	Par. Flume 18"	
	Par. Flume 24"	
	Par. Flume 36"	
	Par. Flume 48"	
	Par. Flume 60"	
	Manh. Flume 4"	
	Manh. Flume 6"	
	Manh. Flume 8"	
	Manh. Flume 10"	
	Manh. Flume 12"	
Equation Params	Exponent	
	Coefficient	
	Width	
	Angle	
	Radius	
	Water Surface Slope	
	Surface Roughness	
	Max. Water Level	SetDefaultVal.
		Exit
	Max. Water Level	
	Upper Range Value	Calculate
		Exit

Inputs/Outputs

Analog Output	Select Range	4…20 mA
		0…20 mA
		0…10 mA
	Alarm Mode	Off
		23 mA
		3.5 mA
	Compensation	
Digital Input	Off	
	Remote Reset	
	Pos Zero Reset	
	ADE	
Digital Output	Pulse Width	
	Pulse/Unit	
	Out 1 function	Off
		Forward Pulses
		Min/Max Alarm
		Error Alarm
		Test
		Pump Control
		ADE
	Out 1 Type	Normally Open
		Normally Close
	Out 1 Set Min	
	Out 1 Set Max	
	Out 2 Function	Off
		Forward Pulses
		Min/Max Alarm
		Error Alarm
		Test
		Pump Control
	Out 2 Type	Normally Open
		Normally Close
	Out 2 Set Min	
	Out 1 Set Min	
Simulation	Off	
	+100.0%	
	+90%	
	+80%	
	+70%	
	+60%	
	+50%	
	+40%	
	+30%	
	+20%	
	+10%	
	0.0%	

Total

Total	Clear Tot
	Exit

Communications

Modbus	MODBUS Address		
	RS-232/422/485	Baud Rate	1200
			2400
			4800
			9600
			19200
			38400
			115200
		Parity	Even
			Odd
Ethernet	Received Packets		
	Sent Packets		
	IP Address		
	IP Gateway		
	MAC Address		
ADE	Control	On	
		Off	
	Protocol	1	
		2	
	Dial	4…9	
	Resolution	0.0001…10000	

Miscellaneous

Power up			
Language	English	Español	Italiano
	Deutsch	Français	Türkçe
	Český	Русский	Polski
Date [DDMMYY]			
Time [HHMMSS]			
EEPROM	Format		
	Exit		
Contrast			
Datalog Period	10 min		
	20 min		
	30 min		
	1 h		
	24 h		

Info

Serial Number
Version
Compilat. Date
Otp CRC
Applicat. CRC

Pin

Control
User
Service
Admin
Random Number
Emergency PIN

Login

Login

FLOW METER MODBUS® REGISTER TABLE

Address	Registers	Rights	Name	iSonic
0x0000	U16	Read only	PRODUCT_CODE	7: iSonic
0x0001	8	Read only	PRODUCT_NAME	“iSonic 4000”
0x0009	16	Read only	FW_NAME	"iSonic_A_STM32F107RC"
0x0019	10	Read only	APP_VERSION	Version
0x0023	16	Read only	COMPILATION_DATE	Date of compilation
0x0033	16	Read only	COMPILATION_TIME	Time of compilation
0x0043	5	Factory	IDENTIFICATION_NUMBER	Unique number
0x0048	3	Read only	OTP_BOOT_CHECKSUM	Checksum
0x004B	3	Read only	FLASH_OS_CHECKSUM	Checksum
0x0081	U16	User	POWER_LINE_FREQUENCY	0: 50 Hz 1: 60 Hz
0x0095	U16	Service	ANALOG_OUTPUT_RANGE	1: 4…20 mA 2: 0…20 mA 3: 0…10 mA
0x00A1	U16	Service	OUT1_LOW	Digital Output setting
0x00A2	U16	Service	OUT1_HIGH	Digital Output setting
0x00A3	U16	Service	OUT1_MODE	0 normally open 1 normally closed
0x00A4	U16	Service	OUT1_OPERATION	0: Off 1: Comparator 3: Error alarm 4: Forward 10: Test 14: Pump
0x00AE	U16	Service	OUT2_LOW	Digital Output setting
0x00AF	U16	Service	OUT2_HIGH	Digital Output setting
0x00B0	U16	Service	OUT2_MODE	0 normally open 1 normally closed
0x00B1	U16	Service	OUT2_OPERATION	0 Off 1 Min/Max Alarm 3 Error alarm 4 Forward pulses 10 Test 14 Pump control
0x0114	U16	User	LANGUAGE	0 English 1 German 2 Czech 3 Spanish 4 French 5 Russian 6 Italian 7 Turkish
0x0115	Float	Read only	MEASURE	Dry calibration
0x0119	U16	Read only	MEASURE_COUNTER	Dry calibration

Address	Registers	Rights	Name	iSonic
0x0125	U16	Admin	COMMAND	1: save configuration 2: restore configuration 6: save totalizers 7: clear totalizers 8: clear totalizers 14: current loop calibration point A 15: current loop calibration point B 16: current loop calibration complete 22: default save 23: remote reset 24: default restore 26: make file system 34: press key up 35: press key right 36: press key save exit 38: print screen 41: open channel – calculate upper range 42: open channel – use default water level
0x0126	Float	Factory	CURRENTLOOP_POINTA	Dry calibration
0x0128	Float	Factory	CURRENTLOOP_POINTB	Dry calibration
0x012A	U16	Service	SIMULATION	Not stored in non-volatile memory 0: 0.0% 10: + 10.0% 20: + 20.0% 30: + 30.0% 40: + 40.0% 50: + 50.0% 60: + 60.0% 70: + 70.0% 80: + 80.0% 90: + 90.0% 100: +100.0% 65408: Off 65436: -100.0% 65446: - 90.0% 65456: - 80.0% 65466: - 70.0% 65476: - 60.0% 65486: - 50.0% 65496: - 40.0% 65506: - 30.0% 65516: - 20.0% 65526: - 10.0%
0x012B	U32	Read only	RANDOM	Security
0x012E	U16	Service	ALARM_MODE_OF_ ANALOG_OUTPUT	0: none 3: 23 mA 4: 3.5 mA
0x012F	U32	Write only	REMOTE_LOGIN	Security
0x0202	Float	Service	PULSE_PULSES_PER_M3	Digital Output setting
0x0204	U16	Service	PULSE_WIDTH	Digital Output setting
0x0205	U16	Service	OUT_LOW	OBSOLETE

Address	Registers	Rights	Name	iSonic
0x0206	U16	Service	OUT_HIGH	OBSOLETE
0x0226	6	Service	DATETIME	Date & Time
0x0232	U16	Read only	FAULT	Bit0: Low Battery Bit1: Measure Timeout Bit2: Table Error Bit6: Flow Overload Warning Bit7: Disk Error Bit8: Configuration Error Bit9: Pulse Overload Warning Bit10: Sensor Disconnected Error Bit11: Sensor Shorted Error
0x0233	8	Read only	PORT	Debug information
0x023D	U16	Admin	PASSWORD_CONTROL	Security
0x023E	4	User	PASSWORD_SET_USER	Security
0x0242	4	Service	PASSWORD_SET_SERVICE	Security
0x0246	4	Admin	PASSWORD_SET_ADMIN	Security
0x025B	U64	Read only	FS_TOT	Internal Disk Size [byte]
0x025F	U64	Read only	FS_FRE	Internal Disk Free Space [byte]
0x0263	U16	Service	DATALOGGER_PERIOD	10: 10 min 20: 20 min 30: 30 min 61: 1 hour 84: 24 hour
0x0267	U16	Service	MEDIAN	Filter setting
0x0268	U16	Service	MOVING_AVERAGE	Filter setting
0x0279	Float	Read only	ANALOG_OUTPUT_K	Dry calibration
0x0281	Float	Read only	ANALOG_OUTPUT_Q	Dry calibration
0x02B3	Float	Service	ANALOG_OUTPUT_ COMPENSATION	Analog Output Compensation
0x02E3	U32	Read only	POWER_UP_COUNTER	Power up counter
0x0300	U16	Admin	DATAPROCESSING_TANK_ OPENCHANNEL	0 Tank 1 Open Channel
0x0301	U16	User	UNITCODES_LENGTH	44 Feet 45 Meters 47 Inches 48 Centimeters 49 Millimeters
0x0302	U16	User	UNITCODES_ VOLUMETRICFLOW	15 Cubic Feet Per Minute 16 Gallons Per Minute 17 Liters Per Minute 18 Imperial Gallons Per Minute 19 Cubic Meter Per Hour 22 Gallons Per Second 23 Million Gallons Per Day 24 Liters Per Second 26 Cubic Feet Per Second 28 Cubic Meters Per Second 30 Imperial Gallons Per Hour 130 Cubic Feet Per Hour 131 Cubic Meters Per Minute 133 Barrels Per Minute 136 Gallons Per Hour 137 Imperial Gallons Per Second 138 Liters Per Hour

Address	Registers	Rights	Name	iSonic
0x0303	U16	User	UNITCODES_VOLUME	40 Gallons 41 Liters 42 Imperial Gallons 43 Cubic Meters 46 Barrels 112 Cubic Feet 236 Hectoliters 240 Mega Gallons 241 Acre Feet
0x0304	U16	User	DECIMALPLACES_LENGTH	Number of decimal places of length
0x0305	U16	User	DECIMALPLACES_ VOLUMETRICFLOW	Number of decimal places of volumetric flow
0x0306	U16	User	DECIMALPLACES_VOLUME	Number of decimal places of volume
0x0307	U16	Admin	OPENCHANNEL_EQUATION	0: Open Channel Table 3: Contracted Rectangular Weir 4: Suppressed Rectangular Weir 5: Cipoletti Weir 7: Manning Equation Rectangular Channel 8: Manning Equation Pipe 9: V Notch Weir 30° 10: V Notch Weir 45° 11: V Notch Weir 60° 12: V Notch Weir 90° 13: Parshall Flume 1" 14: Parshall Flume 2" 15: Parshall Flume 3" 16: Parshall Flume 6" 17: Parshall Flume 9" 18: Parshall Flume 12" 19: Parshall Flume 18" 20: Parshall Flume 24" 21: Parshall Flume 36" 22: Parshall Flume 48" 23: Parshall Flume 60" 24: Manhole Flume 4" 25: Manhole Flume 6" 26: Manhole Flume 8" 27: Manhole Flume 10" 28: Manhole Flume 12" 29: Exponential Equation
0x0308	Float	Admin	SENSOR_ UPPERRANGEVALUE	Sensor description [m]
0x030A	Float	Admin	SENSOR_ LOWERRANGEVALUE	Sensor description [m]
0x030C	Float	Factory	SENSOR_ DIVISIONTOCURRENT_K	Dry calibration
0x030E	Float	Factory	SENSOR_ DIVISIONTOCURRENT_Q	Dry calibration
0x0310	Float	Read only	SENSOR_WATERLEVEL	Actual water level
0x0312	Float	Read only	DATAPROCESSING_ OPENCHANNELFLOW	Actual volumetric flow
0x0314	Float	Read only	DATAPROCESSING_TANKVOLUME	Actual tank volume
0x0316	Float	Read only	TOTALIZER	Totalizer
0x0318	Float	Read only	SENSOR_CURRENT	Sensor actual current
0x031A	Float	Service	OPENCHANNEL_ UPPERRANGEVALUE	Open channel description
0x031C	Float	Service	TANK_ UPPERRANGEVALUE	Tank description
0x031E	U16	Service	MEASURE_WARMUPTIME	Sensor setting
0x031F	U16	Service	MEASURE_INTERVAL	Sensor setting

Address	Registers	Rights	Name	iSonic
0x0320	16	User	DESIGNATION_CURRENT	UTF-8 Designation of sensor current
0x0330	16	User	DESIGNATION_ WATERLEVEL	UTF-8 Designation of water level
0x0340	16	User	DESIGNATION_FLOW	UTF-8 Designation of flow
0x0350	16	User	DESIGNATION_VOLUME	UTF-8 Designation of volume
0x0360	32	User	DESIGNATION_TAG	UTF-8 Designation of device
0x0380	Float	Service	SENSOR_ WATERLEVELOFFSET	Offset
0x0388	Float	Admin	SENSOR_ UPPERRANGEVALUE_ ACTUALUNIT	Sensor description
0x038A	Float	Admin	SENSOR_ LOWERRANGEVALUE_ ACTUALUNIT	Sensor description
0x0390	Float	Read only	SENSOR_WATERLEVEL_ ACTUALUNIT	Actual water level
0x0392	Float	Read only	DATAPROCESSING_ OPENCHANNELFLOW_ ACTUALUNIT	Actual volumetric flow
0x0394	Float	Read only	DATAPROCESSING_ TANKVOLUME_ACTUALUNIT	Actual tank volume
0x0396	Float	Read only	TOTALIZER_ACTUALUNIT	Totalizer
0x0398	Float	Service	SENSOR_ WATERLEVELOFFSET_ ACTUALUNIT	Offset
0x039A	Float	Service	OPENCHANNEL_ UPPERRANGEVALUE_ ACTUALUNIT	Open channel description
0x039C	Float	Service	TANK_U PPERRANGEVALUE_ ACTUALUNIT	Tank description
0x0400	Float	Admin	OPENCHANNEL_ EXPONENT	Open channel calibration
0x0402	Float	Admin	OPENCHANNEL_ COEFFICIENT	Open channel calibration
0x0404	Float	Admin	OPENCHANNEL_WIDTH	Open channel calibration
0x0406	Float	Admin	OPENCHANNEL_ANGLE	Open channel calibration
0x040C	Float	Admin	OPENCHANNEL_RADIUS	Open channel calibration
0x040E	Float	Admin	OPENCHANNEL_ WATERSURFACESLOPE	Open channel calibration
0x0410	Float	Admin	OPENCHANNEL_ SURFACEROUGHNESS	Open channel calibration
0x0412	Float	Admin	OPENCHANNEL_ WATERLEVELMAXIMUM	Open channel calibration
0x0414	Float	Admin	OPENCHANNEL_ COEFFICIENT_ACTUALUNIT	Open channel calibration
0x0416	Float	Admin	OPENCHANNEL_ WIDTH_ACTUALUNIT	Open channel calibration
0x0418	Float	Admin	OPENCHANNEL_ RADIUS_ACTUALUNIT	Open channel calibration
0x041A	Float	Admin	OPENCHANNEL_ WATERLEVELMAXIMUM_ ACTUALUNIT	Open channel calibration
0x041C	Float	Admin	OPENCHANNEL_ SURFACEROUGHNESS_ ACTUALUNIT	Open channel calibration

iSonic 4000 Flow Meter Conversion Table

Address	Registers	Rights	Read	Write	Name	Note
0x0500	Float, Float	Admin	Yes	Yes	Conversion Table Point 0	Water Level [m], Volume [m^3] or Flow[m^3/s]
…					…	
0x08FC	Float, Float	Admin	Yes	Yes	Conversion Table Point 255	—

Points in conversion table have to be sorted in ascending order (higher address higher water level value).

Table can be shorter. First unused point has to contain NAN value.

Rights

1 User

2 Service

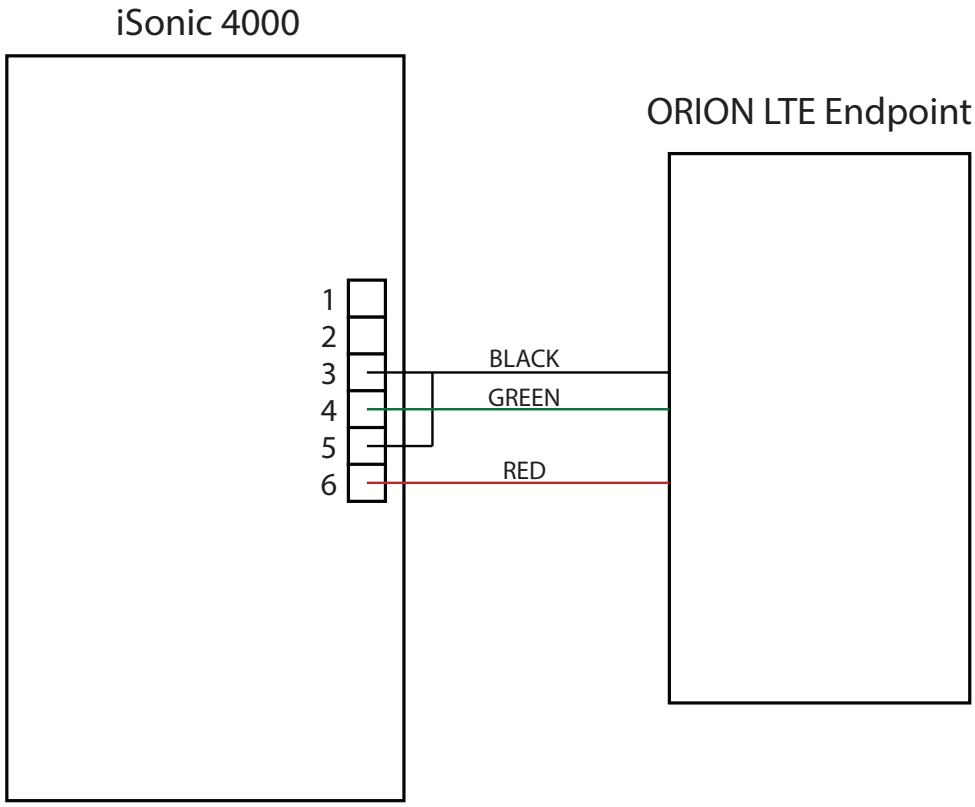
3 Admin

4 Factory

WIRING THE ISONIC 4000 METER TO AN ORION® CELLULAR LTE ENDPOINT

1. Connect the RED Encoder Clock signal wire from the endpoint to the Digital Input on the iSonic 4000.
2. Connect the GREEN Encoder Data signal wire from the endpoint to the Digital Output 1 positive signal on the iSonic 4000.
3. Connect the BLACK Encoder Ground signal wire from the endpoint to the Digital Output 1 negative signal on the iSonic 4000.
4. Jumper the iSonic 4000 Digital Output 1 negative signal to the Digital Input negative signal.

For detail information on installing and activating ORION Cellular LTE endpoints, see the *"ORION Water Endpoints User Manual"*, available on our website at *www.badgermeter.com*.



Control. Manage. Optimize.

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Survey Monuments

BRASS MARKERS

SURV-KAP offers a full line of brass survey markers for concrete. These survey markers are ideal for a wide variety of applications including highways, streets, cemeteries, landmarks and golf courses.

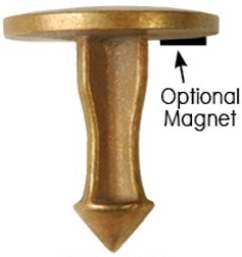
Brass survey markers for concrete are brass castings made to our design at our foundry. Many SURV-KAP brass survey markers for concrete are available in either flat or dome top.

Consecutive numbering is available on brass monument caps and survey markers. Magnets are also available as an option.

Pre-stamping is available on most SURV-KAP survey markers for concrete with flat tops. SURV-KAP survey markers can also be ordered without pre-stamping and can be hand-stamped in the field or in your office. There is no charge for pre-stamping if you order 25 or more survey markers with identical stamping.

Lettering patterns for brass survey markers with domed tops are part of the casting process. Please contact our Customer Service Team directly for pricing and lead times on your requirements for custom lettering on domed parts.

M/M-B2



M/M-3¼CBD

Model No.	Description	1-100	101-499	500+
M/M-B1 1/2	1-1/2" Flat Brass Monument Marker (Blank)	$ 14.55	$ 14.41	$ 14.26
M/M-B1 1/2S	1-1/2" Flat Brass Monument Marker (Stamped)	$ 19.59	$ 19.41	$ 19.22
M/M-B2	2" Flat Brass Monument Marker (Blank)	$ 12.45	$ 12.34	$ 12.21
M/M-B2S	2" Flat Brass Monument Marker (Stamped)	$ 16.77	$ 16.62	$ 16.45
M/M-B2D	2" Dome Brass Monument Marker (Blank)	$ 14.46	$ 14.33	$ 14.18
M/M-BCS-2 1/2F	2 1/2" Flat Brass M/M/Cast Corrugated Stem	$ 26.67	$ 26.41	$ 26.15
M/M-BCS-2 1/2FS	2 1/2" Flat Brass M/M/Cast Corrugated Stem (Stamped)	$ 30.86	$ 30.56	$ 30.26
M/M-BCS-2 1/2D	2 1/2" Dome Brass M/M/Cast Corrugated Stem	$ 27.62	$ 27.35	$ 27.08
M/M-B278F	2 7/8" Flat Brass M/M/Cast Corrugated Stem	$ 23.86	$ 23.62	$ 23.39
M/M-B278D	2 7/8" Dome Brass M/M/Cast Corrugated Stem	$ 23.86	$ 23.62	$ 23.39
M/M-BCS-3F	3" Flat Brass M/M/Cast Corrugated Stem	$ 26.67	$ 26.41	$ 26.15
M/M-BCS-3D	3" Dome Brass M/M/Cast Corrugated Stem	$ 30.43	$ 30.13	$ 29.84
M/M-B3F	3" Flat Brass M/M (or Inside 3/4" Pipe) Hex Stem	$ 29.02	$ 28.74	$ 28.46
M/M-B3D	3" Dome Brass M/M (or Inside 3/4" Pipe) Hex Stem	$ 29.02	$ 28.74	$ 28.46
M/M-BCS-3 1/4F	3 1/4" Flat Brass M/M/Cast Corrugated Stem	$ 26.67	$ 26.41	$ 26.15
M/M-BCS-3 1/4FS	3 1/4" Flat Brass M/M/Cast Corrugated Stem (Stamped)	$ 32.06	$ 31.75	$ 31.43
M/M-BCS-3 1/4D	3 1/4" Dome Brass M/M/Cast Corrugated Stem	$ 30.43	$ 30.13	$ 29.84
M/M-3 1/4CBF	3 1/4" Flat Brass M/M/Cast	$ 37.94	$ 37.57	$ 37.20
M/M-3 1/4CBD	3 1/4" Dome Brass M/M/Cast	$ 37.94	$ 37.57	$ 37.20
M/M-B3 1/4F	3 1/4" Flat Brass M/M (or Inside 3/4" Pipe) Hex Stem	$ 29.02	$ 28.74	$ 28.46
M/M-B3 1/4D	3 1/4" Dome Brass M/M (or Inside 3/4" Pipe) Hex Stem	$ 29.02	$ 28.74	$ 28.46
M/M-B3 1/4SPF	3 1/4" Flat Brass M/M/Cast Split-Stem	$ 28.55	$ 28.27	$ 27.99
M/M-B3 1/4SPD	3 1/4" Dome Brass M/M/Cast Split-Stem	$ 28.55	$ 28.27	$ 27.99
M/M-BTS-3 1/4F	3 1/4" Flat Brass M/M/Cast Tapered Stem	$ 28.08	$ 27.80	$ 27.53
M/M-BTS-3 1/4D	3 1/4" Dome Brass M/M/Cast Tapered Stem	$ 28.08	$ 27.80	$ 27.53
M/M-B3 1/2SPF	3 1/2" Flat Brass M/M/Cast Split-Stem	$ 28.55	$ 28.27	$ 27.99
M/M-B3 1/2SPD	3 1/2" Dome Brass M/M/Cast Split-Stem	$ 28.55	$ 28.27	$ 27.99
M/M-BCS-4F	4" Flat Brass M/M/Cast Corrugated Stem	$ 37.94	$ 37.57	$ 37.20
M/M-BCS-4D	4" Dome Brass M/M/Cast Corrugated Stem	$ 37.94	$ 37.57	$ 37.20
M/M-B4SPF	4" Flat Brass M/M/Cast Split-Stem	$ 41.70	$ 41.30	$ 40.89
M/M-B4SPD	4" Dome Brass M/M/Cast Split-Stem	$ 41.70	$ 41.30	$ 40.89

Inclinometer Casing

rst INSTRUMENTS
Monitor with Confidence

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Certified System
ISO 9001

Glue and Snap Inclinometer Casing

Snap Seal Inclinometer Casing (showing internal "O-ring")

Standard Bottom Cap

Bottom Cap with Grout Valve

PRODUCT CATEGORY:
INCLINOMETERS + TILT SENSORS

Inclinometer Casing

RST's Inclinometer Casing is engineered to be assembled quickly and accurately for long and short term monitoring in the most adverse field conditions. It is suited to be installed in boreholes, embankments, piles, set into concrete or attached to structures.

The casing serves as an access tube to guide a MEMS-based inclinometer probe in the two orthogonal directions of measurement. Changes in the output of the probe caused by the deformation of the casing, is proportional to the sine of the angle of inclination of the long sensor axis from vertical. These displacements are incrementally summed to provide profiles of total displacement versus depth.

Key to quality inclinometer casing is not only the material, but the quality and shape of the grooves. The inclinometer probe utilizes grooves in the casing to control the azimuth of the inclinometer probe.

RST casing is manufactured from non-recycled virgin ABS resin. While more costly than common PVC resin, ABS is preferred due to superior flexibility, stability and low temperature impact resistance. Using recycled resin degrades the performance of casing. All RST casing is machined to insure the highest quality possible.

> THIS PRODUCT

Provides alignment and displacement measurements in numerous applications.

Is available in either 'Snap Seal" or "Glue & Snap" coupling styles.

> APPLICATIONS

Pilings.	Landslides and slope stability.
Subsidence control.	Under large storage tanks.
Embankment and dam stability.	Bridge pier, abutments deflection.
Areas next to large excavations.	

> FEATURES

High precision, machined guide grooves.	Low spiral ≤ 0.005 Rad/3 m (≤ 0.3 deg./10 ft.)
Meets or exceeds all applicable standards.	Easy assembly.
Self-aligning, water and grout tight couplings.	70 mm (2.75 in.) and 85 mm (3.34 in.) OD sizes.
Compatible with all commercial probe types and in-place inclinometer sensors.	
Integral coupling reduces assembly induced spiral by 50% over conventional separate coupling methods.	
Compatible with inductance, reed switch, magnetic, or mechanical settlement monitoring devices.	
Snap Seal and Glue & Snap integral flush couplings that minimze field installation time.	
Low temperature, impact, and corrosion resistant ABS plastic.	
External key provides visual and tactile confirmation of proper installation.	

> BENEFITS

✓ **Increase Safety**	✓ **High Accuracy**
✓ **Increase Productivity**	✓ **Upgradable**
✓ **High Reliability**	

Available for **IMMEDIATE DELIVERY** Info on reverse.

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Monitor with Confidence

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Maple Ridge, BC V2X 0Z5 Canada

ISO 9001

Inclinometer Casing

PRODUCT CATEGORY:
INCLINOMETERS + TILT SENSORS

SPECIFICATIONS + ORDERING

CASING SPECS

DESCRIPTION	70 MM (2.75 IN.) OD	85 MM (3.34 IN.) OD
Casing OD (including coupling)	70 mm (2.75 in.)	85 mm (3.34 in.)
Casing ID	59 mm (2.32 in.)	73 mm (2.87 in.)
Casing Length	5 or 10 ft. (1.5 or 3 m)	5 or 10 ft. (1.5 or 3 m)
Casing Weight	1.27 kg/m (.85 lbs/ft.)	1.49 kg/m (1.0 lbs/ft.)
Material	ABS Plastic	
Groove Spiral	≤ 0.3 deg./10 ft.	
GLUE & SNAP SPECIFICATIONS - 70 MM		
Load Test	738 kg (1630 lbs.)	
Collapse Test	17.2 bar (250 psi)	

TELESCOPIC SECTION SPECS

DESCRIPTION	70 MM (2.75 IN.) CASING	85 MM (3.34 IN.) CASING
Telescopic Section OD	76.96 mm (3.03 in.)	91.44 mm (3.6 in.)
Compressed Length	457 mm (18 in.)	457 mm (18 in.)
Extended Length	609 mm (24 in.)	609 mm (24 in.)
Range	152 mm (6 in.)	152 mm (6 in.)
Weight	0.77 kg (1.7 lbs.)	0.9 kg (2 lbs.)

SNAP SEAL CASING

Snap Seal is the original O-ring sealed coupling system, which does not require glue, pop rivets, screws, or shear wires. This patented, innovative system allows casing sections to lock together while maintaining precise groove alignment and high collapse strength. The Snap Seal system is flush coupled for ease of installation in hollow stem augers and casing advancers.

GLUE + SNAP CASING

Glue & Snap provides the speed and convenience of a snap-together flush coupling combined with the low cost and high tensile/high torsional strength of a glue joint. Installation is simply done by applying a bead of glue to the male end, snap casing together and insert down hole.

ORDERING

Available for IMMEDIATE DELIVERY

Contact RST for Details

DESCRIPTION	GLUE & SNAP		SNAP SEAL	
	70 MM (2.75 IN.)	85 MM (3.34 IN.)	70 MM (2.75 IN.)	85 MM (3.34 IN.)
1.52 m length (5 ft.)	ICGC205	ICGC305	ICSC205	ICSC305
1.50 m length (4.92 ft.)	ICGC205M	ICGC305M	ICSC205M	ICSC305M
3.05 m length (10 ft.)	ICGC210	ICGC310	ICSC210	ICSC310
3 m length (9.84 ft.)	ICGC210M	ICGC310M	ICSC210M	ICSC310M
Top Cap	ICC2TC	ICC3TC	ICC2TC	ICC3TC
Bottom Cap	ICGC2BC	ICGC3BC	ICSC2BC	ICSC3BC
Casing Anchor	ICGC2CA	ICGC3CA	ICSC2CA	ICSC3CA
Casing Anchor with Grout Cap	ICGC2CG	ICGC3CG	ICSC2CG	ICSC3CG
Grout Cap	ICGC2CP	ICGC3CP	ICSC2CP	ICSC3CP
Repair Coupling	ICGC2RC	ICGC3RC	ICSC2RC	ICSC3RC
Alignment Tool for Coupling	IC1002	IC1003	IC1002	IC1003
ABS Solvent Cement (1/2 pint) (NOTE: cannot be air shipped)	IC1020			
Female Grout Adapter 3/4" NPT	IC1200			
Telescopic Section	ICGC2TS	ICGC3TS	ICSC2TS	ICSC3TS

Telescopic Section

Below: A top view of an Inclinometer Casing Anchor with its arms fully extended. Both Snap Seal (shown) and Glue & Snap coupling styles are available.

INCLINOMETER CASING ANCHOR

The Inclinometer Casing Anchor prevents buoyant uplift of inclinometer casing during installation. It is affixed to the bottom of the inclinometer casing prior to inserting it into the drill-rod/borehole. As soon as the anchor exits the bottom opening of the drill-rod/borehole, the spring loaded arms of the anchor are automatically extended to grip the borehole wall.

TELESCOPIC SECTION

When vertical heave or settlement is anticipated to exceed 1-2%, Inclinometer Casing Telescoping Sections must be used to allow axial movement of the casing while minimizing distortion due to vertical strain. Telescopic sections must be inserted appropriately extended or collapsed to accommodate the expected settlement/rebound. Settlement sections are available in 70 mm (2.75 in.) and 85 mm (3.34 in.) and each section can accommodate up to 150 mm (6 in.) of compression or heave.

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RST INSTRUMENTS LTD.

Installation Instructions for Snap Seal Inclinometer Casing

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Installation Instructions for Snap Seal Inclinometer Casing

Although all efforts have been made to ensure the accuracy and completeness of the information contained in this document, RST Instruments reserves the right to change the information at any time and assumes no liability for its accuracy.

Product: Installation Instructions for Snap Seal Inclinometer Casing

Document number: ICM0011B
Revision: 1.2
Date: May 27, 2004

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1 Forward

Please note that these instructions are a general guideline for typical field practices, and may require modification to suit site-specific applications. This equipment should be installed, maintained, and operated by technically qualified personnel. Any errors or omissions in the installation, data or data interpretation, are not the responsibility of RST Instruments Ltd.

2 Advantages of RST Snap Seal Inclinometer Casing

Traditional Inclinometer Casing installation methods dictate that screws or pop rivets must be utilized to hold the coupling in place until the ABS cement cures. The requirements for rivets are increased in deep boreholes.

Snap Seal is the *original O-ring sealed coupling system*, which does not require glue, pop rivets, screws or shear wires. This patented, innovated system allows casing sections to lock together while maintaining precise groove alignment and high collapse strength.

The Snap Seal system is flush coupled for ease of installation in hollow stem augers and casing advancers.

3 RST Snap Seal Casing Part Numbers

70 mm (2.75 inch) Casing	**Part No.**
1.5 m Length	ICSC-205M
3 m Length	ICSC-210M
5 ft. Length	ICSC-205
10 ft. Length	ICSC-210
Top Cap	ICC-2TC
Bottom Cap	ICSC-2BC
Grout Cap	ICSC-2CP
Telescopic Section	ICSC-2TS

85 mm (3.34 inch) Casing	**Part No.**
1.5 m Length	ICSC-305M
3 m Length	ICSC-310M
5 ft. Length	ICSC-305
10 ft. Length	ICSC-310
Top Cap	ICC-3TC
Bottom Cap	ICSC-3BC
Grout Cap	ICSC-3CP
Telescopic Section	ICSC-3TS

4 Pre-Installation

Before beginning the installation, ensure that all equipment, accessories and spares are available:

- Casing and caps
- Spare bottom and top caps
- Spare casing length(s)
- Grout tremie line
- Grout valved bottom cap (if employing this method); c/w spare female grout valve
- Drill rods to weigh casing
- Safety line (if required)
- Clean water supply to ballast casing
- Repair Coupling and Alignment Tool (if required)
- Hand saw
- Casing collar protection (as required)
- Chain or casing clamps

Inspect casing lengths to insure that damage during transit has not occurred. Ensure that the inside of the casing is clean. To ensure the joint and casing interior will remain clean, only remove the protective end caps prior to installing the casing. Store the casing horizontally, fully supported, and out of the sunlight. Number each length, and assemble numerically to avoid errors, and to confirm correct depth.

Do not assemble the casing prior to insertion in the borehole.

Drill the borehole as vertical as possible, preferably within 1 degree. Flush the borehole clean, and verify that the borehole is fully open to the bottom.

5 Assembly of Snap Seal Casing

5.1 Snap Seal Casing Sections

Each section of casing has a male end with an alignment key, and a lock ring, and a female end with a keyway, O-ring, and lock ring (Figure 1). Casing is installed with the female end facing up. O-rings come greased from the factory, and are protected by a cap. In the field, remove the cap and ensure that that the O-ring is still greased. Take care to keep the casing ends clean to ensure a proper seal. Please note the female ends of the casing have three slots in them. These are stress relief cuts which facilitate the insertion of the male end of the subsequent casing section.

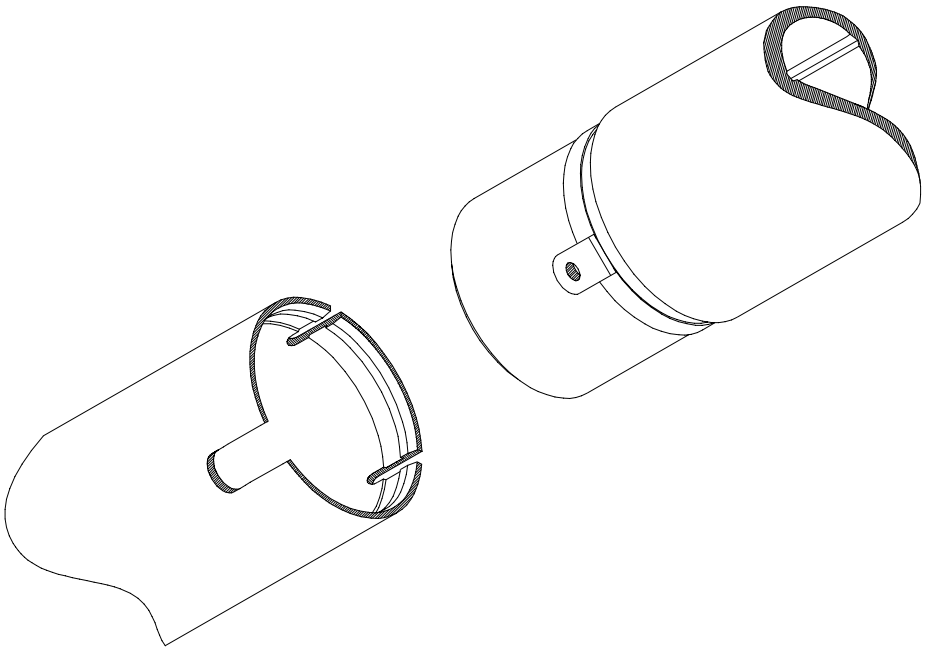


Figure 1 – RST Snap Seal Casing

5.2 Installing an End Cap

Before installing the first section of casing in the borehole, an end cap must be installed as indicated in Figure 2.

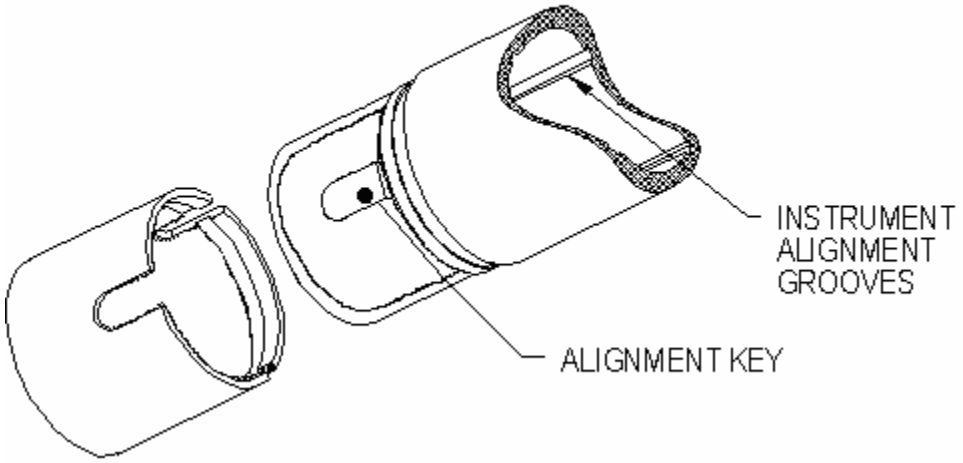


Figure 2 – End Cap Joint

Align the notch on the cap with the key on the casing. Slide the cap on to fully engage the notch and key (you will hear a “snap” as the lock ring is seated). Visually ensure proper assembly. Typically, a grout tube will be attached to the first section of casing. Additional grout tubes may be added during installation for multistage grouting. In some situations, a special grout cap will be required instead of the standard end cap. Installation is the same, except for the fact that the grout cap has a provision for a grout tube.

The casing, with attached cap, can then be lowered into the hole. If applicable, attach a safety line, and a grout tremie line.

5.3 Assembling Casing Sections

Subsequent casing sections in a borehole should be assembled in the same manner as the end cap (described above). Remove the protective caps and check that the O-ring and lock ring are greased. Align the key and the keyway of the two sections. Push the sections together until the joint snaps closed. In some cases, the user may find it easier to push the sections together using a twisting motion. In each case, the alignment button should be aligned with the notch in the female end (Figure 1).

Some practitioners use a 2-inch wide waterproof duct tape over the joint. Just a single wrap of this tape will improve the lateral strength of the joint by more than 100% and in tension by 50%.

5.4 Installing the Top Cap

After all the inclinometer sections have been installed, place a Top Slip Cap over the last piece of casing when finished and/or not in use. Do not cement into place. The cap is provided as a removable protective cover (Figure 3).

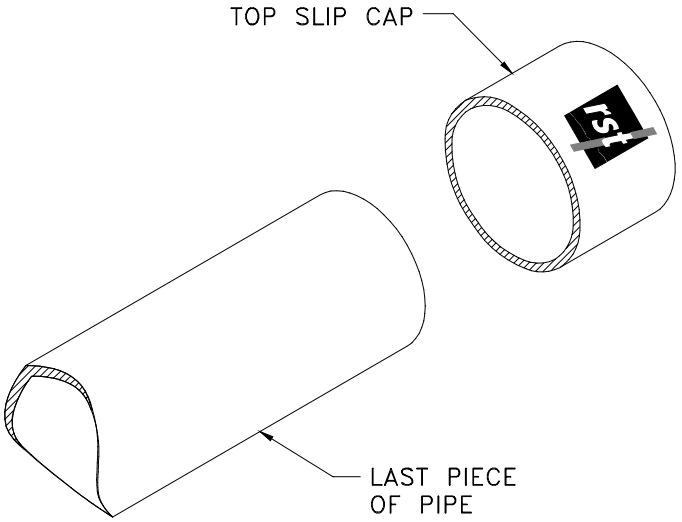


Figure 3 – Top Cap

5.5 Assembling Telescopic Sections

Each telescoping section is 2ft. (24”) in length and allows for six inches of compression or extension (Figure 4). Settlement sections may be inserted extended or collapsed, to accommodate the expected settlement/rebound. Typically, sections are shipped in the fully extended condition to accommodate settlement in the borehole. However, sections can be ordered in any configuration, depending on the site specific requirements. The telescopic section is equipped with Snap Seal ends, thus allowing it to be installed similar to a standard piece of casing (section 5.3).

If the telescoping sections are equipped with settlement rings, then lower the sensor into the casing and record the initial readings for each settlement ring. Contact RST Instruments Ltd for more information on Settlement Monitoring Systems.

The moving joint of the section is sealed by two O-rings (one at either end). Each telescoping section contains four set-screws two on each side (Figure 4), which are individually sealed with O-rings These screws are set in tracks which are blocked by a small web of ABS material. When sufficient force, >200lbs, is exerted on the casing (very small in a geotechnical setting), the material will break allowing the casing to compress (or extend). This design allows the telescopic section to bear the weight of the casing above it, and collapse under the force of ground settlement and/or rebound.

To prevent mis-tracking of the inclinometer probe as it passes through the telescoping section, the end of the grooves have a tapered “V-notch”. This notch ensures that the wheels of the probe re-establish themselves in the correct track.

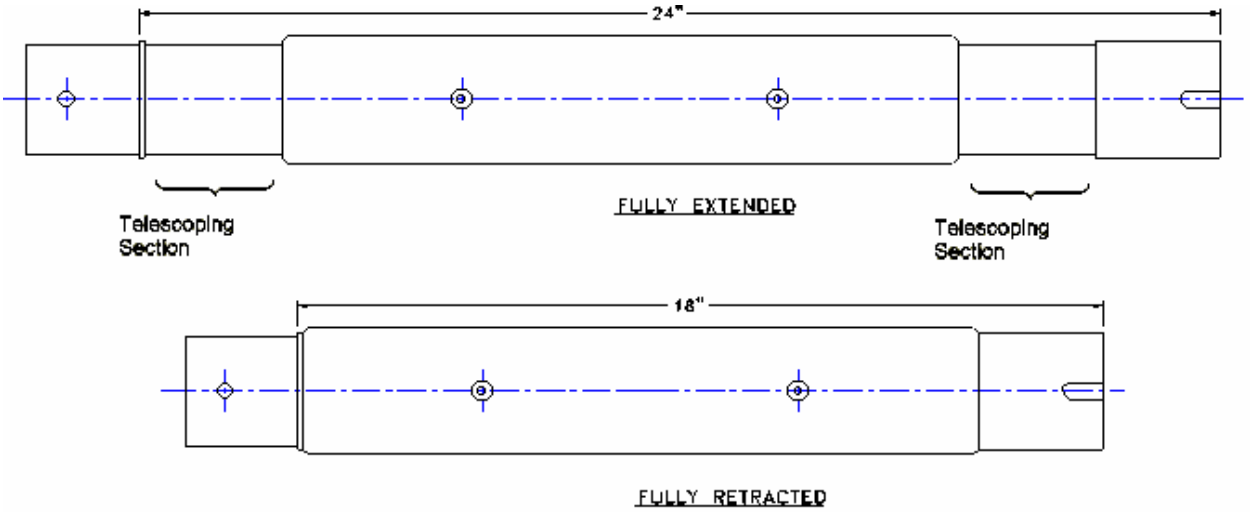


Figure 4 – RST Snap Seal Telescoping Section

6 Installing Snap Seal Casing

6.1 Installation Notes

Casing Storage

Casing should be stored horizontally and supported evenly so that it does not warp or bend. Whenever possible, casing should be stored in the shade since prolonged exposure to the heat of direct sunlight can cause deformation.

The Borehole

Drill the borehole as vertical as possible, preferably within 1 degree. Flush the borehole clean, and verify that the borehole is fully open to the bottom. Check the depth of the borehole before you begin installing the casing. Also consider that grout valves or external weights may be required for deeper boreholes.

Groove Alignment

It is important to have one set of grooves oriented down slope, in the direction of expected movement. If the direction cannot be determined, orient North/South. **Alignment must be maintained throughout the installation, to avoid introducing torsion to the casing, thereby causing spiraling of the grooves. Never push the casing from the top or twist the casing during installation.**

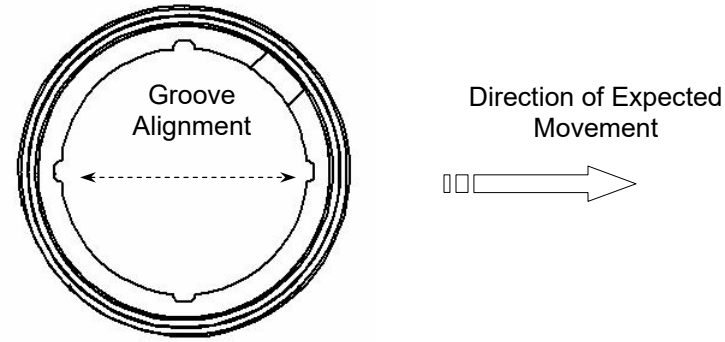


Figure 5 – Groove Alignment

6.2 Installation Methods

Pipe Clamp Method

This method involves using pipe clamps to hold the casing at the borehole collar while you add the next section of casing. Two pipe clamps are needed. In dry boreholes or in situations where down-hole problems seem likely, rig a safety line to provide extra security and a way to retrieve the casing if necessary.

1 Install an end cap on the first section of casing (section 5.2).

2 Attach one clamp to the top of the first section of casing. Lower the casing into the borehole until the clamp rests on the borehole collar.

3 Attach a second clamp to the top of the next section of pipe. Connect the two sections according to the instructions outlined in section 5.3. Remove the first clamp and lower the section into the borehole.

Repeat steps 2 and 3 until installation is complete. When to depth, verify the alignment of the grooves by running a dummy probe to the hole bottom. If the probe will not pass, jumps track, or returns in another set of grooves, pull the casing and rectify the problem.

In deep boreholes, it is advantageous to use a safety line to restrain the casing during installation. This can be used in conjunction with the casing clamps to lower the casing a controlled rate. Note that using the safety line *by itself* may induce spiraling due to the spiral lay of the rope, and is not recommended.

6.3 Casing Buoyancy

If the borehole is filled with water or mud, ballasting the casing with clean water can neutralize the casings' buoyancy. Exercise caution with this technique, as in dry boreholes, the differential pressure caused by the head of water may cause the casing to fail.

Casing also becomes buoyant during the process of grouting the borehole. The two following methods can be used to prevent the casing from floating out of the borehole during grouting:

1 Drill rods may be inserted inside the casing to hold the string from the bottom.

2 The bottom of the casing may be anchored in grout, then the balance of the borehole grouted.

> **Note**
>
> Applying a down-force to the top of the casing will likely distort the casing profile. Never use the drilling rig as a reaction force, or wedge the collar of the borehole. This will cause the casing to assume a large radius bend, making readings virtually useless.

In many cases, it is standard practice to attach a weight to the bottom of the casing to counteract the buoyancy effects of the casing. In situations where the casing is being inserted into a freshly grouted borehole, these buoyancy forces can be significantly large. RST cautions against using too large of a weight as it may fail the joint on the bottom cap or elsewhere in the casing.

6.4 Grouting

Properly mixed grout must be thin enough to pump, but thick enough to set in a reasonable amount of time. Ensure that the grout is free of lumps. If the mixture is too watery, it will shrink excessively, leaving the upper portion of the borehole un-grouted. Also, avoid the use of grouts that cure at high temperature since these may damage the casing.

Begin to tremie in grout as directed by the engineer. Grouting, via a high shear filtered grouting machine is recommended to avoid problems with lumps obstructing the tube.

Observe the water meniscus in the casing as an indication of casing collapse, or grout ingress (i.e. if the water in the casing rises, grout ingress can be assumed). Ensure that differential pressures are kept to a minimum, as the casing will collapse at 240 PSI differential.

Deeper boreholes will require a stage grouting procedure, with appropriate stages dependant on borehole water level, grout density, grout pump type, etc.

Note

Proper grouting of inclinometer casing is crucial to a successful inclinometer installation. The on-site engineer is required to have experience and can work with the drill crew on the proper mixture for the grout. Grout consistency is very important to ensure proper curing and to avoid separation of the solids and water. Grout must also have the proper viscosity which will enable it to be pumped easily.

In summary, grouting needs to be performed by experienced personnel, site conditions vary to the extent that each inclinometer installation is unique. Good judgment by on-site personnel and previous experience is the key to a successful installation.

7 Repairing Damaged Casing

Damaged Snap Seal Casing can be repaired using RST repair couplings. Most of the time, casing becomes damaged near the top of the borehole due to movement of heavy equipment etc. In any case, the damaged portion of the casing needs to be removed.

1. Cut off the damaged portion of the casing using a hacksaw. Be sure to make this cut as square as possible. Remove all burrs.
2. Apply ABS 771 Cement to the inclinometer casing (Figure 6). The repair coupler will slide over top and the alignment tool will be used.

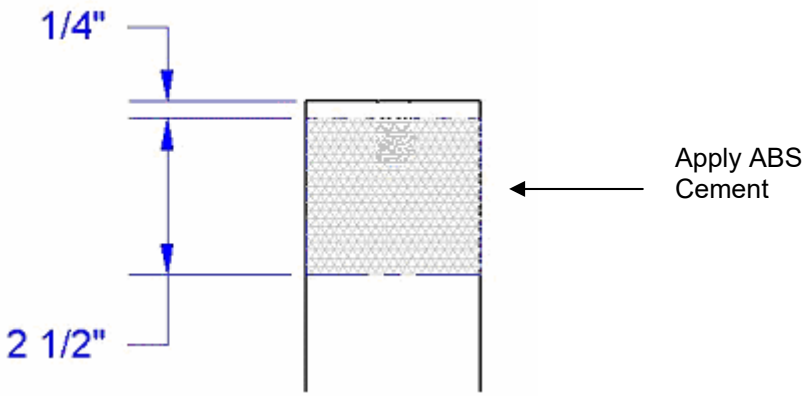


Figure 6 – Casing Preparation

3. Slide the RST repair coupling onto the casing and align the grooves using the RST Coupling Tool (Figure 7). Allow the cement to cure, according to the directions on the label.

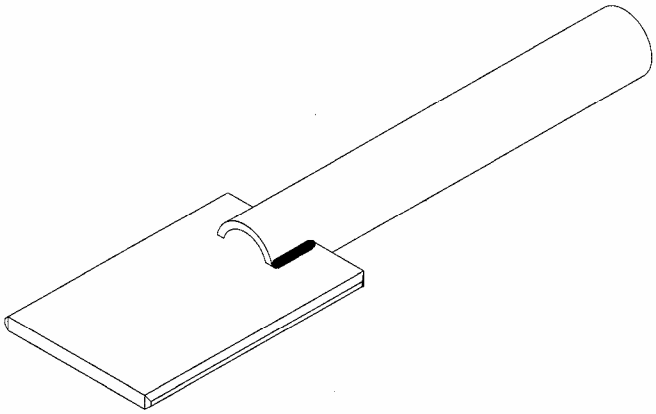


Figure 7 – RST Coupling Tool

4. Install the next section of Snap Seal casing as usual (section 5.3). Ensure that the keys and keyways are aligned.

8 Installing Corrugated Settlement Sheath Pipe

Another option to using Telescopic Sections is the use of Corrugated Settlement Sheath Pipe. This allows the inclinometer casing to remain in a static position while the ground moves around it. Settlement can thus be observed at the collar of the borehole. For example, if the ground settles, the casing will be observed to extend farther out of the ground than previously.

Installation Method:

1. Insert a weight into the bottom of the sheath with the groove side down, leaving room for the installation of the end cap.
2. Slide 2 band clamps over the sheath and tighten so that the clamps squeeze the sheath into the grooves locking the weight into place.
3. Install the End Cap onto bottom of the sheath.
4. Seal with Denso tape and Duct tape.
5. Lower Corrugated Settlement Sheath Pipe into the borehole.

Note: Ballasting the pipe with clean water may be necessary to counter the buoyancy encountered with wet bore holes.

6. Install Inclinometer casing inside the Corrugated Settlement Sheath Pipe.
7. Eliminate any slack by pulling on it by hand (hold in place while performing step 8).
8. Fill the void between the sheath and borehole with grout, ensuring that no grout gets into the sheath or casing.
9. If Corrugated Settlement Sheath is equipped with settlement rings, then lower the sensor into the casing and record the initial readings of each Settlement Ring. Refer to the RST Instruments Manual “Settlement Monitoring System”.

Inclinometer Digital MEMS System

VIEW THIS SYSTEM IN ACTION!

YouTube http://youtu.be/1nqpiQUzh4o

DIGITAL MEMS INCLINOMETER SYSTEM

MEMS TILT & INCLINATION SERIES

inclinalysis™
digital inclinometer analysis software

EVOLUTION + INNOVATION

INCLINOMETER SYSTEMS

WIRELESS COMMUNICATION | DIGITAL MEMS TECHNOLOGY

rst INSTRUMENTS

innovation in geotechnical instrumentation

DIGITAL MEMS TECHNOLOGY | WIRELESS COMMUNICATION

SINCE 2003

THE SHORTEST OVERALL LENGTH

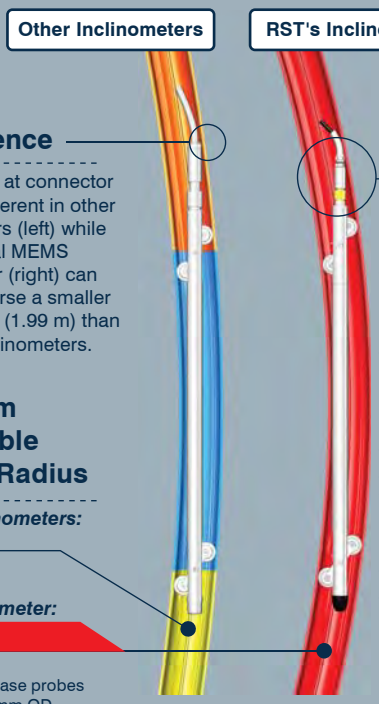
The RST Digital MEMS Inclinometer Probe with industry leading system accuracy of ±2 mm per 25 m, shown connected to the cable.

Since 2003, RST's Inclinometer systems have had the shortest overall length available for a given base length compared to competitive inclinometers. Undaunted, we've forged ahead and improved on our very own industry-leading specifications. With a new minimum negotiable casing radius of 1.99 m, RST's Digital MEMS Inclinometer can still traverse a smaller radius bend than all other inclinometers available in the industry. A local microcontroller in the probe manages data collection, applies precision digital calibration, and provides a fast settling time which results in very efficient data collection.

The Ultra-Rugged Field PC^2 functions as the data collector. It provides a high-level user interface, "at-the-borehole" data analysis and graphical comparison to previous data sets.

CONNECTOR COMPARISON

LEAST INTERFERENCE



Interference

Interference at connector is visibly inherent in other inclinometers (left) while RST's Digital MEMS Inclinometer (right) can clearly traverse a smaller radius bend (1.99 m) than all other inclinometers.

Minimum Negotiable Casing Radius

Other Inclinometers:
3.12 m

RST Inclinometer:
1.99 m

0.5 m wheelbase probes shown in 70 mm OD inclinometer casing.

RST Connector

Cable connector material made of 316 stainless steel.

Rating for underwater use, with wet connection at 5000 ft. (1524 m) in salt water.

Includes a spring strain relief to enhance cable durability at the connector entrance.

ULTRA-RUGGED Field PC^2

Rock solid and field ready for the most extreme environments. Wireless communication between the inclinometer control cable and the Ultra-Rugged Field PC^2 ensures ease of use and reliability since there is no concern with fragile connectors, cable related failure and reliability problems.

PROCESSOR OPERATING SYSTEM MEMORY

- 1.0GHz ARM Cortex A8 i.MX53 processor
- Microsoft® Windows Embedded Handheld 6.5.3
- Microsoft® Office Mobile 2010 (Word, Excel, PowerPoint, Outlook)
- Bluetooth® Wireless Communication
- Wi-Fi® 802.11b/g/n with extended range
- Internal solid state 512 MB Flash memory (2 million biaxial data sets)
- 8GB flash storage, user-accessible micro SD/SDHC slot
- Both USB Host and Client plus 9-pin RS-232
- Real-time clock keeps correct date & time, even without battery

DISPLAY

- Active viewing area of 109 mm (4.3 in.) diagonal
- WVGA LCD TFT (800x480) - portrait or landscape orientation
- High visibility backlit LCD - brilliant contrast in direct sunlight
- Projected capacitive touch interface, "optically bonded" to display for increased visibility.
- Scratch-resistant screen
- On-board stylus with tether

POWER

- Intelligent Li-Ion battery 3.7VDC @ 10600mAh, 38.16Whr
- 20 hour battery life on single charge (2 to 4 hrs. charge time)
- Battery easily changeable in field

ENVIRONMENTAL

- Operating temperature: -30 to 60°C (-22 to 140°F)
- Bluetooth® rated to -20°C (-4°F)
- IP68 waterproof and dustproof
- Shockproof (multiple drops from 1.5 m (5 ft.) on to concrete
- MIL-STD-810G: high/low temp., temp. shock, rain, humidity, sand & dust, immersion, vibration, altitude, shock.

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DIGITAL MEMS INCLINOMETER SYSTEM

THE FIRST

IN EVOLUTION + INNOVATION

For measuring any lateral movement down in the earth, via inclinometer casing, the Digital MEMS Inclinometer System from RST Instruments Ltd. was the first, and is still the best, Digital MEMS Inclinometer System available.

MEMS TILT & INCLINATION SERIES

The inclinometer reel can be charged without removing the battery and offers up to 30 hours of continuous use from a full charge. Its battery life can also be viewed with the Ultra-Rugged Field PC²

SPECIFICATIONS

INCLINOMETER	METRIC SYSTEM	IMPERIAL SYSTEM
Wheelbase	0.5 m	24 in
Probe diameter	25.4 mm	1.00 in
Probe length (including connector)	719 mm	32.6 in
Probe weight	1.06 kg	2.45 lbs
Probe material	Stainless steel	Stainless steel
Full-scale range (other ranges available)	±30 degrees	±30 degrees
Data resolution	0.005 mm per 500 mm	0.00002 ft per 2 ft
Memory	>1,000,000 readings	>1,000,000 readings
Repeatability	±0.002°	±0.002°
System Accuracy	±2 mm per 25 m	±0.1 in. per 100 ft
Axis alignment	Digitally nulled	Digitally nulled
Temperature rating	-40 to +70°C	-40 to +158°F
Sensor Type	MEMS Accelerometer, Biaxial	
CABLE		
Cable diameter	6.40 mm (±0.1 mm)	0.25 in
Cable weight	2.3 kg / 50 m	3.1 lbs / 100 ft
Cable breaking strength	5.90 kN	1325 lbs
Cable reinforcement	Kevlar® ‡	Kevlar® ‡
Cable jacket	Polyurethane	Polyurethane
Cable stretch (suspended in 50 m dry borehole)	7.0 mm	0.27 in
CABLE REELS		
Up to 75 m cable reel diameter	310 mm	12.2 in
100 to 200 m cable reel diameter	380 mm	15 in
+225 m cable reel diameter	460 mm	18 in
Reel weight with 50 m (100 ft.) cable	4.7 kg	8.4 lbs

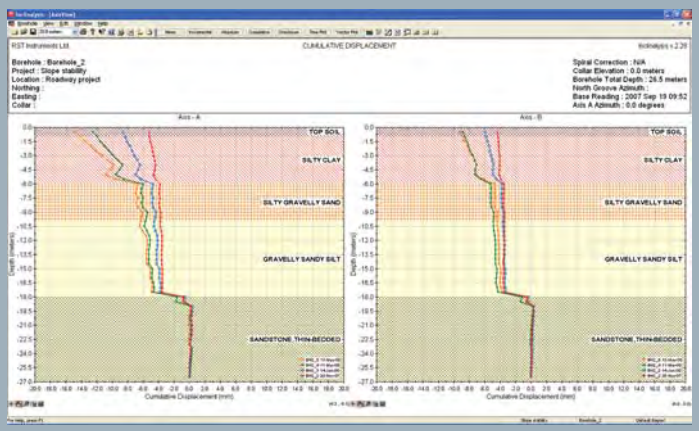
RST's newly developed connector is by far the industry leader for the least amount of connector interference.

RST also provides the most robust cable on the market with a breaking strength of 5.90 kN (1325 lbs.) Also, our new non-slip, swaged cable marks are unmatched in grip strength.

The compact reel system with 50 m cable weighs a very manageable 4.7 kg and can be easily held with one hand. A padded carrying case is included.

ANALYSIS SOFTWARE

THE PERFECT PAIR



RST Inclinalysis™ Software screen capture shows cumulative displacement of a borehole.

inclinalysis™

digital inclinometer analysis software

The RST Digital MEMS Inclinometer System and Inclinalysis™ Software offer a powerful combination for quick and efficient reduction of large volumes of inclinometer data. Data can be analyzed and presented quickly in a variety of formats.

RST Inclinalysis™ Software is powerful, yet easy to use. Plotting, manipulating data and printing are all only a few clicks away. Menu and plot functions are designed to be intuitive making the program very easy to learn. Designed to complement the Digital MEMS Inclinometer System, data is organized in a standard file structure which makes importing data seamless between Inclinalysis™ and the Ultra-Rugged Field PC^2.

Plot

Plot data at the click of a button. View several plots simultaneously across the screen. Ability to save multiple reports for a single borehole.

Customize

Create custom plot titles and change graph properties. Change reading units instantly to millimeters, metres, inches or feet. Specify top or bottom data reference. Correct for bias-shift.

Import

Import inclinometer data in a variety of formats from different manufacturers including spiral data.

Assess

Create vector plots displaying change in magnitude and direction, and time plots to assess the rate of movement at a particular depth or in a specific movement zone. Instant visual data validation by plotting checksum data.

Compare

Display data in tabular format and compare directly to plots. Take direct measurements off any plot.

Intuitive

Menu and plot functions are designed to be intuitive and easy to learn. Cascade windows to display multiple plots and tabular data on the same screen.

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ORDERING INFO

SYSTEMS - Metric	
IC32003	30 m complete system with 0.5 m probe
IC32005	50 m complete system with 0.5 m probe
IC32075	75 m complete system with 0.5 m probe
IC32010	100 m complete system with 0.5 m probe
125, 150, 200, 250, 300 m and longer systems available	
SYSTEMS - Imperial	
IC32110	100 ft complete system with 2 ft probe
IC32115	150 ft complete system with 2 ft probe
IC32120	200 ft complete system with 2 ft probe
IC32130	300 ft complete system with 2 ft probe
400, 500, 600, 800, 1000 ft and longer systems available	
OPTIONAL SYSTEM ACCESSORIES	
IC35805	Dummy Probe 0.5 m wheelbase - METRIC
IC35802	Dummy Probe 2 ft wheelbase - IMPERIAL
IC32705	Digital MEMS Inclinometer Spiral Sensor (see separate brochure)
IC35600	RST Inclinalysis™ - Digital Inclinometer Analysis Software
IC35650	Protective Aluminum Carrying Case - for Inclinometer Probe
Horizontal MEMS Inclinometer (probe available in custom lengths in Metric and Imperial units - view separate brochure or contact sales at RST Instruments).	

INCLUDED SYSTEM COMPONENTS
MEMS Digital Inclinometer probe with protective case
Cable Reel with Wireless Communication System
Cable Reel Carrying Case
Silicone spray for probe/cable connectors
Data collection & transfer software
70 & 85 mm cable grips
Ultra-Rugged Field PC^2 (with rechargeable Li-Ion battery)
AC Adapter for Ultra-Rugged Field PC^2
AC Adapter for Reel Battery Charger
USB cable for Ultra-Rugged Field PC^2
Quick start guide for Ultra-Rugged Field PC^2
Ultra-wide hand strap for Ultra-Rugged Field PC^2
Stylus with tether for Ultra-Rugged Field PC^2

rst INSTRUMENTS

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Certified System ISO 9001

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RST INSTRUMENTS LTD.

RST MEMS Digital Inclinometer
System Instruction Manual

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RST MEMS Digital Inclinometer System

Although all efforts have been made to ensure the accuracy and completeness of the information contained in this document, RST Instruments reserves the right to change the information at any time and assumes no liability for its accuracy.

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1 GENERAL DESCRIPTION

The RST MEMS Digital Inclinometer System represents a breakthrough in inclinometer system technology, providing unprecedented accuracy, efficiency and ease of use. The system is comprised of a Digital Inclinometer Probe, Cable system, Reel with battery power, and an Ultra-Rugged Field PC running Mobile Microsoft Windows™ that functions as a readout, analysis, and data storage device.

Wireless communication between the inclinometer control reel and the Ultra-Rugged Field PC ensures ease of use and reliability, by removing two weaknesses inherent in conventional analog inclinometer systems. By removing the physical connection between the inclinometer control cable and the readout instrument there is no concern with fragile connectors, cable related failure and related reliability problems. The Achilles heel of any inclinometer control cable reel is the slip ring required to maintain electrical contact as the reel revolves. As the RST system is wireless from the control cable to the readout, a slip ring is not required, and there are no associated electrical continuity problems.

The RST digital inclinometer probe incorporates cutting edge MEMS (Micro Electro Mechanical Systems) technology providing high precision and durability. A highly accurate survey of the inclinometer casing is used to establish the initial position of the casing. Any subsequent deviations in the casing from this initial value (i.e. baseline reading) represent changes occurring in the subsurface. The RST MEMS Digital Inclinometer System can accurately measure the rate, depth and magnitude of these deviations.

The information included in this manual outlines the use and care of the RST MEMS Digital Inclinometer System. It provides examples of how to take readings and interpret the data. For more information on the installation of inclinometer casing, and other related issues, please contact RST Instruments Ltd.

Note

Proper care and maintenance of the MEMS Digital Inclinometer System will greatly extent the life of the instrument and accuracy of the readings. Please take the time to read this manual thoroughly. If any questions arise, do not hesitate to contact RST Instruments Ltd. Contact information is given in section 14. Proper maintenance of the probe ***after each use*** is outlined in section 12.

Functions:

- Measure lateral movement of earthworks or structures
- Landslides
- Embankment fills
- Stability adjacent to excavations or underground workings
- Deflection of piles, piers, abutments or retaining walls

Figure 1 – System Overview

1. Soft Shell Case
2. Digital Inclinometer Probe (w/ protective end cap)
3. 70mm/2.75” OD Cable Grip
4. 85mm/3.34” OD Cable Grip
5. Ultra-Rugged Field PC
6. Silicone Lubricant (for use on connectors)
7. Field PC stylus
8. USB Cable for Ultra-Rugged Field PC
9. AC Adapter for Ultra-Rugged Field PC
10. AC Adapter for Reel Battery Charger
11. Cable Reel with Wireless Communication System
12. Reel Carrying Case
13. Micro-fiber cleaning Cloth
14. Software Installation DVD

2 DIGITAL PROBE

In general terms, the new Digital Probe resembles that of the traditional analog probes sold by RST. The RST Digital Inclinometer has the smallest package available for a given wheel spacing, with the best ability to track deformed casings. This means that the Digital Probe can handle greater bends in the casing without fouling. The RST metric probe can negotiate a radius of 1.88m (74") in 70mm (2.75") OD inclinometer casing. The RST Digital Inclinometer will thus continue to provide readings past the limit for other probes on the market (see Figure 2).

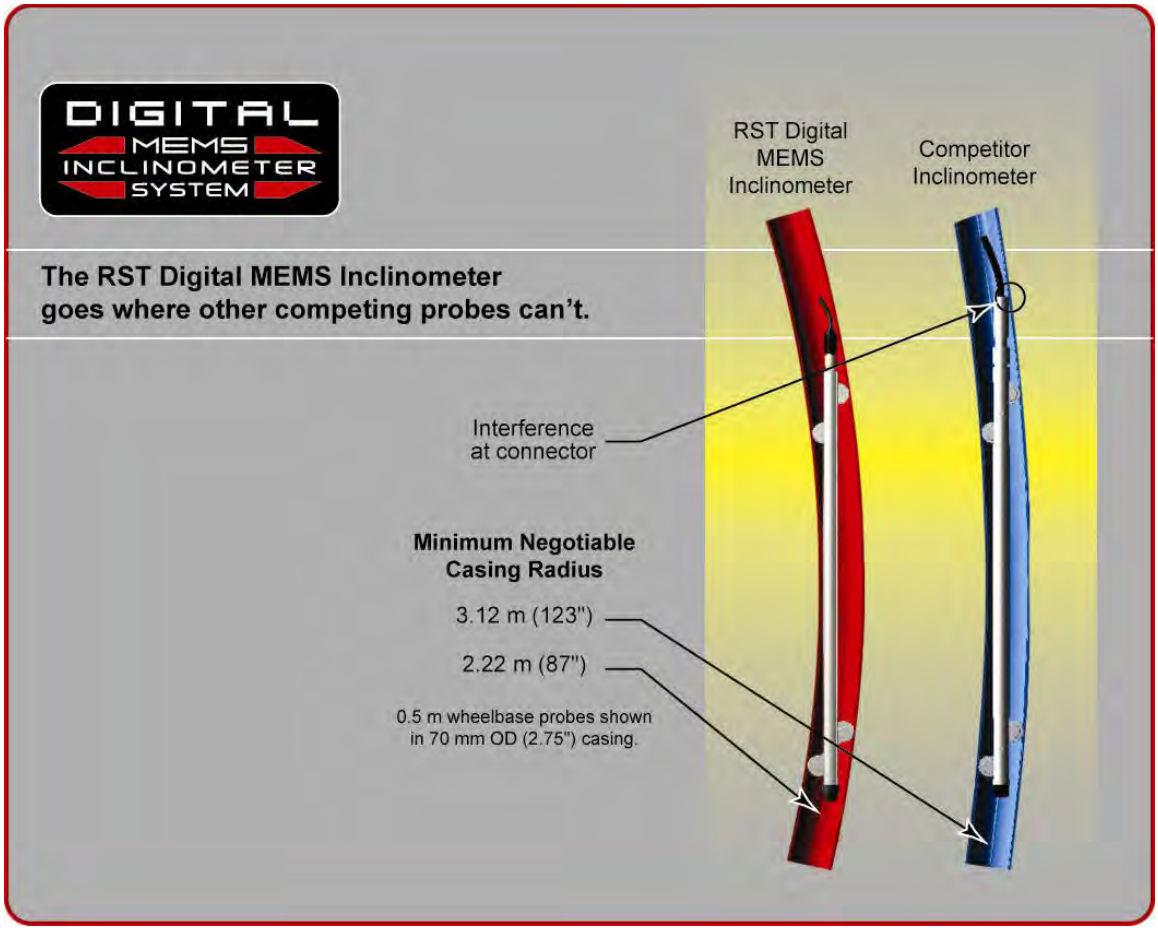

Figure 2 – Digital Probe Sizing

The connectors, wheels, and wheel carriages are the most precise and durable in the industry. The probe wheels are made of high grade hardened and heat-treated stainless steel. These are extremely durable and the most robust on the market.

The digital probe also incorporates shear pins on the wheel assemblies. In the event that the probe gets stuck in the inclinometer casing, a force of approximately 300 lbs is required to shear the shear pin. No damage to the probe or cable will result. Please contact RST Instruments Ltd. for further instructions on the replacement of shear pins.

2.1 DUMMY PROBE

Dummy inclinometer probes are available for purchase from RST for testing purposes in a borehole. RST encourages customers to try the new digital dummy probe in existing holes where the competitor's probes do not work. If it is found that the dummy probe passes through all areas of the casing, the RST MEMS Digital Inclinometer System will function. Therefore the existing hole will still be viable and a new hole will not need to be drilled.

The RST dummy probe has the exact same weight and dimensions as the standard probe. A ring is provided in place of the connector which allows the dummy probe to be lowered by a rope. For further information on purchasing a RST Dummy Probe, please contact RST Instruments Ltd (Section 14).

2.2 SIGN CONVENTION

The Digital Inclinometer Probe houses two MEMS accelerometers, which measure tilt in two axes. Proper installation of the inclinometer casing attempts to align one set of grooves in line with the axis of expected movement. This is called the *A axis*. The perpendicular set of grooves is the *B axis*.

When an inclinometer casing is surveyed for the first time (i.e. baseline readings), it is necessary to select a fixed direction reference for the probe so that each time a survey is repeated, the probe will always have the same orientation in the casing.

For example, in an area suspected of landslide activity, the first set of readings would be taken by placing the upper wheels of the probe in the casing groove closest aligned to the downslope direction. Figure 3 illustrates an inclinometer casing installed with a groove orientation in the general downslope direction.

In practice, it is often difficult to achieve exact orientation of grooves relative to some predetermined direction. The groove closest to the anticipated movement direction is usually chosen as the main reference direction. It is recommended that this direction (A+) be marked on the casing itself to ensure surveys are performed in the same manner each time.

The azimuth of this groove direction can be measured in a clockwise direction from the main reference direction (A+). All subsequent measured inclinometer movements would be referred to this direction.

Readings taken from the inclinometer probe (see Section 4.2.7) are actually deviations from the vertical over the distance between the upper and lower wheels (see Figure 4), calculated as:

$$D = L \times sine(\alpha)$$

Where: *L = inclinometer probe length (typically 0.5m for a metric probe or 2 ft for an imperial probe, as defined in Section 0)*

α = inclination angle of probe from vertical axis

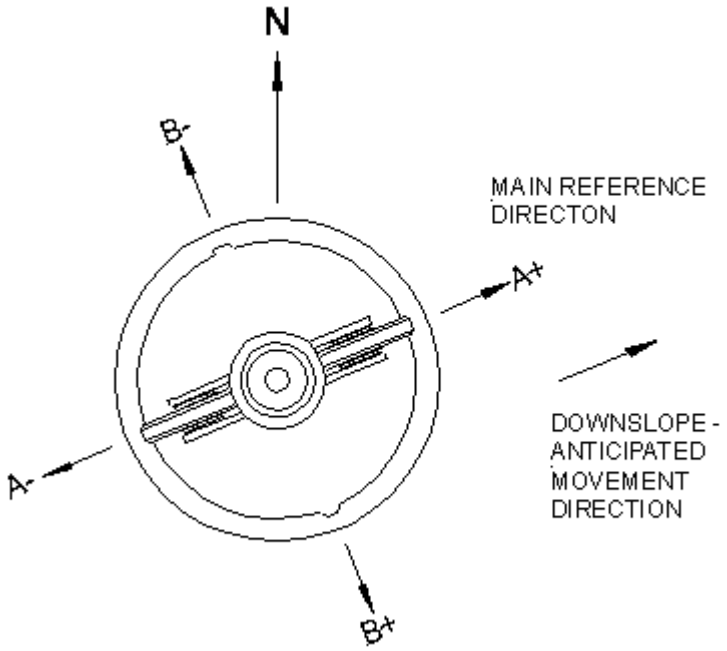

Figure 3 – Probe Orientation

The RST Digital Inclinometer System uses the industry standard sign convention, where tilt in the direction of the upper wheels results in a positive deviation and tilt in the direction of the lower wheels results in a negative deviation (Figure 4).

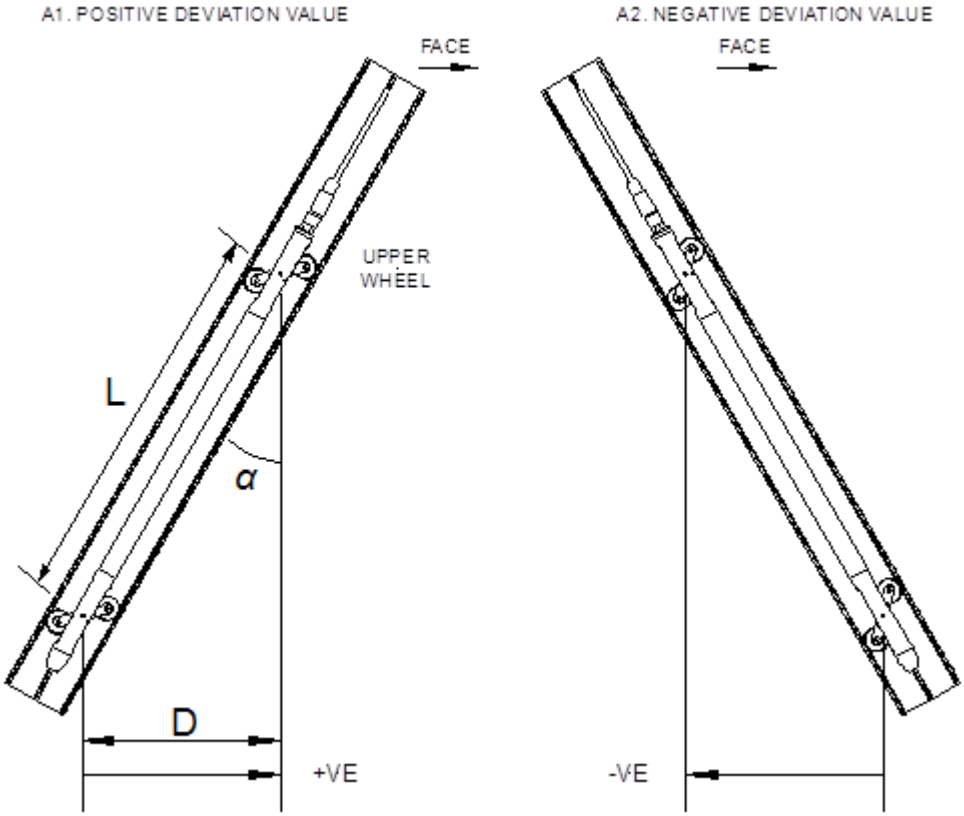

Figure 4 – Sign Convention in the A-axis and deviation D measured by inclinometer probe

Figure 5 shows the sign convention for the A and B axis.

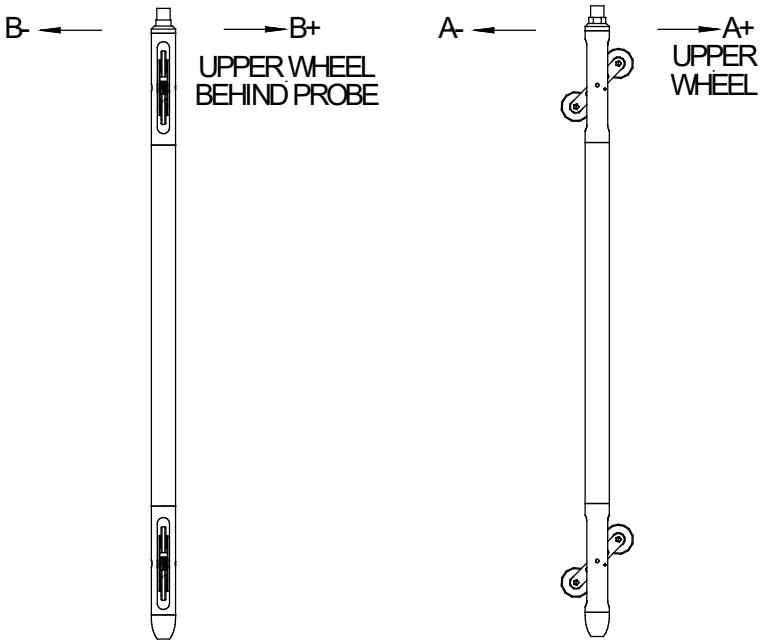

Figure 5 – Probe Axes

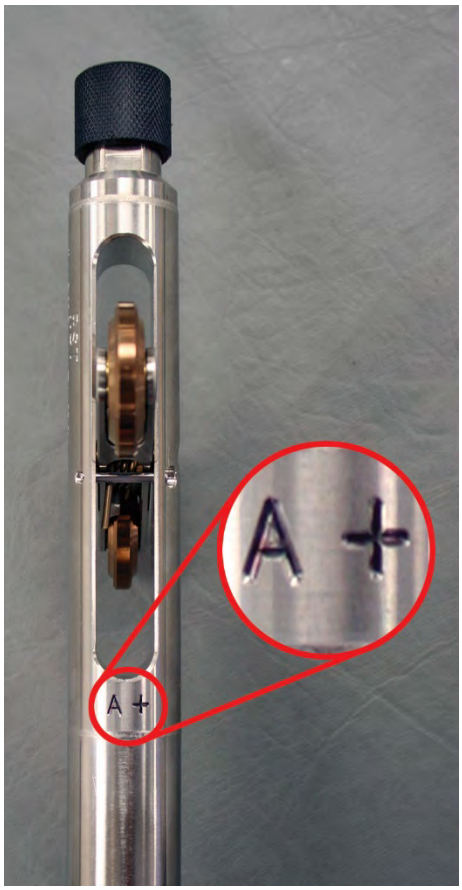

Figure 6 – A+ Marking on the Inclinometer Probe

2.3 TAKING READINGS

1. Upon arrival at the site, remove the protective caps from the casing, the probe and the control cable. Attach the probe to the reel by aligning the keyways and threading the connector onto the probe. Take care to only turn the threaded ring, not the cable itself. Do not over tighten the connector, make it hand tight.
2. Handle the inclinometer probe very carefully as the accelerometers are very susceptible to shock.
3. Once connected, turn on the power to the reel. This energizes the MEMS accelerometers and makes them less susceptible to shock.
4. Insert the probe into the borehole aligning the upper wheel in the direction of the A+ axis (see section 2.2).
5. Lower the probe to the desired depth *slowly* and as *smoothly* as possible. *Be extremely careful not to bounce the probe off the bottom of the hole.*
6. Once the desired location has been reached (i.e. base of the borehole), place the cable grip on the top of the casing and hang the cable by the aluminum crimps. The objective is placement repeatability within 5mm (0.25 inch). This is extremely important to ensure accurate and repeatable results.
7. Always pull the probe upwards to the desired location. If you accidentally pull the probe too far, lower the probe back down to the previous depth, and then pull it back to the intended depth. This procedure ensures that the readings will remain consistent.

> **Warning**
>
> Do not drop the cable marks onto the cable grip. The cable has very little stretch, especially near the top of hole, and the impact on the cable marks may “hammer” them out of position or break the cable. This effect has been demonstrated for drops as little at 70 mm

8. At each location allow the readings to stabilize. Reading stability can be gauged by both the noise bar and the standard deviation which are displayed on the Readings Screen (sections 4.2.7).
9. Once the readings have stabilized, press the *Accept* button and move the probe to the next interval as prompted by the software.
10. Continue logging the borehole until the top is reached, the software will then prompt you to turn the probe 180 degrees and repeat the survey, this time with the lower probe wheels in the A+ groove.

> **Warning**
>
> When the probe has reached the top of the casing, avoid allowing the wheel assemblies to snap out of the casing. As the wheels reach the top, grasp them with your hand and release the wheel assembly slowly until it reaches its stops. Failure to do so will damage the stops and subject the MEMS accelerometers to sudden shock which can damage them and affect the calibration of the probe.

11. Prior to lowering the probe for the second pass, remove the cable grip to avoid accidentally catching the marks on the cable grip, which would otherwise impact load the marks, cable, and probe. Once the probe is at the bottom of the hole, replace the cable grip and position the probe for the deepest reading.
12. During the second pass, checksum data will be displayed underneath each reading. Ensure that these remain small and consistent; however checksums can vary due to different site conditions. Large checksums can indicate errors in probe positioning

or fouling of the probe. Expect checksums to be slightly larger when the probe encounters an expansion coupling in the casing (if applicable).

13. The RST MEMS Digital Inclinometer has the ability to perform data reduction in the field, please refer to section 4.2.8 for information on viewing and validating the data.
14. Upon completion of the survey, close the inclinometer program, turn off the power to the reel, and disconnect the probe. Wipe off the probe and cable. Replace end-caps on the cable and probe. Replace the protective cap on the casing.
15. Upon returning to the office, clean the instrument and reel once more to remove any moisture from the instruments and the case. Recharge the batteries for the Reel and connect the power and USB communication cables to the Ultra-Rugged Field PC (Figure 7). Please refer to section 12 for proper care and maintenance of the system.
16. Transfer data to a desktop PC using Microsoft ActiveSync™ or Microsoft Mobile Device Center software (section 6).

3 INCLINOMETER CABLE AND REEL

The RST MEMS Digital Inclinometer System comes with a durable lightweight reel that is easy to handle. Since only a pair of conductors is needed in the cable, the weight and dimensions of the cable are drastically reduced as compared to a traditional analog cable. The reel is battery powered and houses the electronics used for wireless communication.

An important part to any inclinometer casing survey is the repeatability of the depth measurements. It is extremely important that measurements be consistently within 5mm (0.25in) of one another between subsequent surveys. To facilitate accurate repeatability, two aluminum seats are provided with the system, for 70mm (2.75") and 85mm (3.34") OD casing respectively. The seats provide a solid reference for the cable crimps to sit in. The result is that operator error is reduced, checksums will be smaller and surveys more accurate.

The thin, strong cable contains a Kevlar® strength member, allowing a long length of cable to fit on a small reel with no stretch. The aluminum sleeved measure marks are precision swaged to the cable and are not subject to tearing when handling. The measure marks are spaced at 0.5 metre or 2 feet intervals. The cable is marked with a red measure mark and a label every 5 metres or 10 feet depending on whether the metric or imperial system is being used. The urethane jacket is highly abrasion resistant, and maintains flexibility at low temperatures. It is good practice to avoid running the cable over sharp edges and to periodically clean it with a clean soft cloth. Be sure to keep the protective cap on the connector whenever the probe is not in use and avoid dropping or banging the cable end. Always keep the connectors and threads clean by rinsing them with water. Exercise care when connecting and removing the cable from the probe. Make sure to only turn the connector ring, not the entire cable.

Note

For reels with the serial number **under 2500**, refer to Appendix A for instructions on how to remove and recharge the battery. Only reels with a serial number under 2500 may be removed from the reel. Do not attempt to remove the battery from the reel if the serial number on the reel is 2500 or higher.

For reels with the serial number at 2500 or higher, refer to Section 3.1 for battery status and Section 3.2 for instructions on how to recharge the battery. Only reels with a serial number of 2500 or higher may be recharged. Do not attempt to remove the battery from the reel if the serial number of the reel is 2500 or higher.

3.1 INCLINOMETER REEL BATTERY

The battery is contained inside the inclinometer reel. The inside of the reel is inaccessible to the user and the battery is not removable. **Do not attempt to remove the battery.**

The inclinometer reel has a green LED light that will flash to indicate battery status. The LED light on the reel will flash when the power button is pressed.

Monitor the battery status. **Do not let the battery completely discharge**. A full charge will last around 30 hours.

LED Flash	Battery Status
1 flash, reel does not power on	Battery completely discharged
2 flashes, reel does not power on	Battery discharged below level required to connect
1 flash, reel powers on	Battery discharged below 25%
2 flashes, reel powers on	Battery discharged below 50%
3 flashes, reel powers on	Battery discharged below 75%
4 flashes, reel powers on	Battery is at full charge.

3.2 Charging the Battery (for reels with serial number of 2500 or higher)

Note

Refer to Appendix A if the reel serial number is under 2500. Do **not** proceed with the following instructions if the reel serial number is under 2500.

The following instructions are for reels with the serial number of 2500 or higher.

The battery will need to be recharged using the provided charger. The battery port may be accessed by unscrewing the cap on the reel. Refer to Figure 7 for the location of the battery cap.

Figure 7 – Unscrewing the Battery Cap

Unscrew the battery cap by turning it counter clockwise. The charger will plug into the port and begin charging the battery. Replace and tighten the cap to ensure debris does not enter the battery port.

3.3 Wireless Communication

Turn on the power to the reel by pressing the button located to the left of the battery housing on the Reel Hub. A solid green light indicates the reel has been powered on. After turning on the power to the reel, it automatically searches for a connection to the Ultra-Rugged Field PC. Once the Ultra-Rugged Field PC is powered up, and the RST Digital Inclinometer software is launched, it will automatically try and link to the reel. The light indicator will flash rapidly when the reel is communicating with the probe. During Ultra-Rugged Field PC wireless communication, the reel indicator light will blink with 1 second intervals. The status of the connection is also displayed on the status screen or on the bottom of the main menu screen (see section 4.2.6).

Note

The reel incorporates power saving feature. After 5 minutes of inactivity and lack of Ultra-Rugged Field PC wireless communication, the reel will power down automatically to save battery charge.

4 Ultra-Rugged Field PC

The RST MEMS Digital Inclinometer System comes with an Ultra-Rugged Field PC running Microsoft Mobile Windows™, which is the heart of the system. This hand-held device functions as a readout and data storage device. Data reduction can be performed “at-the-borehole” as soon as the survey is complete. The program has the ability to create plots of the data instantly. This is important if on-site personnel require immediate results to verify that data is accurate. No time is wasted by having to take the readout back to the office to download and process the data.

An overview of the Ultra-Rugged Field PC2 is provided in the following sections. The Field PC2 consists numerous features that may be omitted in this manual. A more thorough guide may be accessed here.

4.1 OVERVIEW

The Ultra-Rugged Field PC is well suited for use in the often demanding field conditions.

Figure 8 – Ultra-Rugged Field PC

4.2 USING THE ULTRA-RUGGED FIELD PC

Once the inclinometer probe is connected to the reel and the probe is ready to be placed in the borehole, turn on the power to the Ultra-Rugged Field PC by pressing the power button (Figure 9).

Figure 9 – Overview of Ultra-Rugged Field PC

Front Image

1. Elastomer overmold
2. Touchscreen
3. Buttons Control
4. Hold-to-Zoom
5. Pictures and Videos
6. Tab button
7. Home Screen
8. Shift Function
9. Microphone
10. Keypad buttons
11. LED Indicator
12. Power button
13. Enter button
14. Backspace
15. Context Menu Button
16. Right Soft Key

Back Image

17. Speaker
18. Battery Door
19. Hand Strap
20. Stylus
21. Stylus Tether

Bottom Image

22. USB client (micro USB)
23. Microphone/Headphones jack

24. 12V DC jack
25. USB host (full size USB)
26. 9-pin serial port

Note

DC charging is done through the 12V DC jack (barrel connector, bottom left of the unit).

Once the power is turned on, use the stylus to navigate through the operating environment. If you are unfamiliar with the Microsoft Mobile Windows™ operating environment, please refer to the "*Getting Started Guide*" which is supplied on CD-ROM with the Ultra-Rugged Field PC. From the *Start* menu, choose: *Digital Inclinometer* to launch the Digital Inclinometer Software. A screen similar to the following will appear:

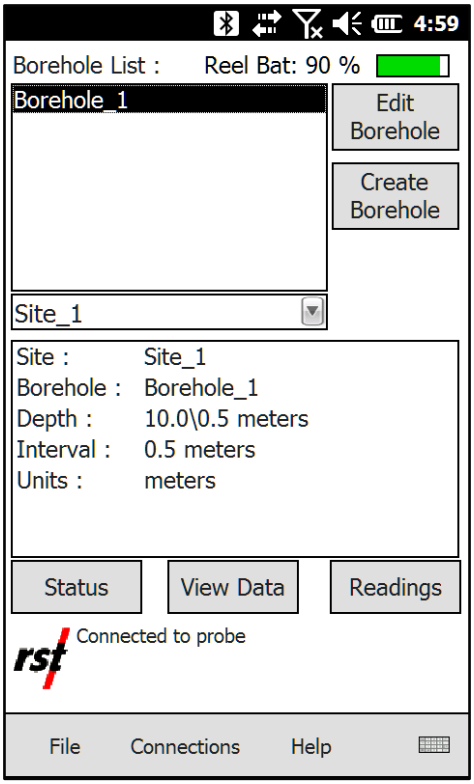

Figure 10 – RST Digital Inclinometer Software Main Menu

Upon start-up, the inclinometer will automatically begin searching for the Reel and Inclinometer Probe. This status is displayed at the bottom of the screen.

The opening screen (Figure 10) displays the current set-up and status of the system. The top menu provides a list of the current boreholes (a default site/borehole will appear, if none have been created). Underneath the borehole list is a drop-down dialog which is used to choose the site.

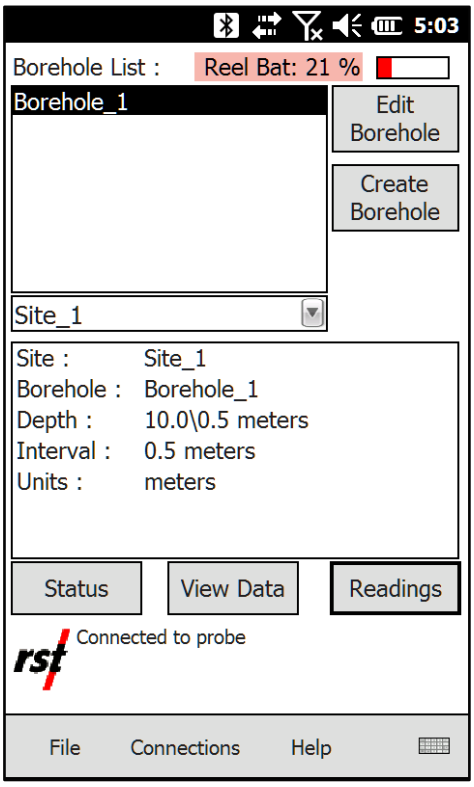

Figure 11 – RST Digital Inclinometer Software Main Menu

4.2.1 Battery Status

The reel battery status is located at the top right of the main menu screen. It shows the real-time status of the battery

Should the battery charge drop below 25%, the battery status will turn red (Figure 11). This indicates that the battery will not last more than a few more hours. The device should be plugged into a power source to recharge the battery.

4.2.2 Menu Items

The *File* menu allows the user to backup the current files to the Field PC non-volatile memory location and also Exits the Digital Inclinometer program. For more information on the backup function please refer to section 9.

The *Connections* menu allows the user to view the status of the Bluetooth (radio) connection and allows the user to disconnect and reconnect to the reel and probe manually. Should a new Reel be used (i.e. a replacement which was not supplied with the original system), the Ultra-Rugged Field PC needs to be made aware of this new instrument, and thus the Bluetooth Connections must be changed. For further information please refer to section 16.

4.2.3 Creating a Site and Borehole

To create a new borehole and site, click on the "*Create Borehole*" button on the Main Menu and the following screen will appear:

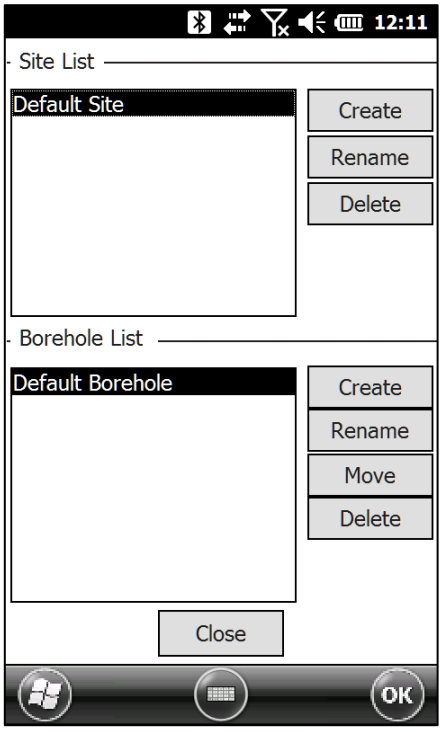

Figure 12 – Creating a Site and Borehole

First, create a new site by pressing the *Create* button under the *Site List* heading. This brings up the following screen:

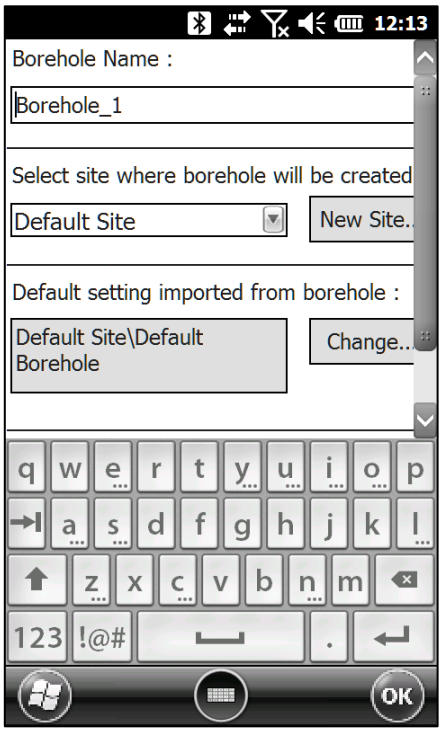

Figure 13 – Create Site

Please note that the remote keyboard automatically pops up when this screen is selected. Touching the keyboard icon in the bottom of the screen can hide the keyboard. Press *New Site…* and enter the new site name and borehole name in the appropriate dialog boxes. Once the new site and borehole is entered, press *OK*. Both site name and borehole names

can be edited, deleted, re-named and moved by pressing the appropriate options on this screen. To return to the main menu, press the *Close* button at the bottom of the screen (after hiding the remote keyboard), or press *OK* at the top right of the screen.

4.2.4 EDITING A BOREHOLE

Pressing the *Edit Borehole* button on the main menu screen invokes the following screen:

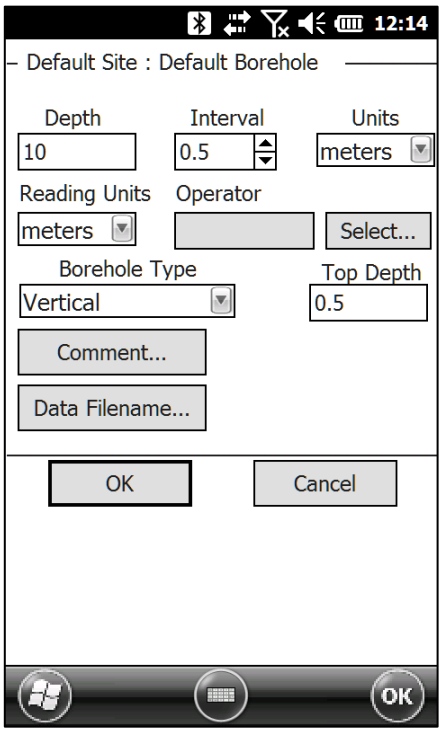

Figure 14 – Edit Borehole Screen

The site and borehole name appear at the top of the screen (in this case they are “default”) followed by *depth, interval, units* and *reading units.* Set *depth* to the depth of the borehole of the lowest reading you wish to take (match this to the cable marking). Choose the *interval* and *units* based on whether you are using a metric or imperial probe. In most cases this will be either 0.5 metres or 2 feet, which is equal to both the length of the probe and the divisions marked on the inclinometer cable.

The Horizontal Borehole checkbox should be used only when connecting horizontal probe. For all other probes, the Horizontal Borehole checkbox should be cleared.

Pressing the *Comment* button invokes a screen where comments can be made about the site, borehole information etc. Comments are entered using the remote keyboard.

Pressing the *Data Filename* button brings up the following screen:

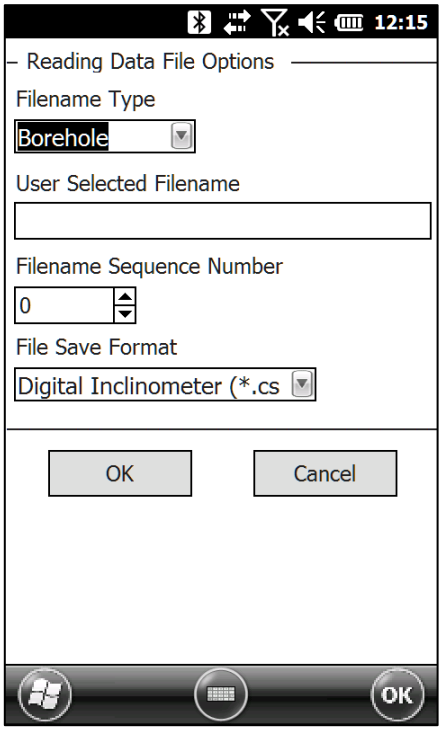

Figure 15 – Data Filename Screen

Filename Type can be chosen by the drop-down menu. Options under this menu include *User Selected, Borehole, Site* and *Site Borehole.* These options specify the name of the file to be written after the borehole is surveyed. If *User Selected* is chosen, enter the name in the dialog box under *User Selected Filename*. The *Filename Sequence Number* defines the numeric label of the file name. All subsequent files will be named in sequence. For instance, if you had a *User Selected File* named "Test", subsequent files will be named: Test(2), Test(3), etc. (incremented by 1).

Note

The default filename for an inclinometer survey is the *Borehole* name. If *User Selected* is chosen as the file format, and the *User Selected Filename* dialog box (Figure 15) is left blank, the software will default to the *Borehole* name. In most cases, it is recommended that the data files be managed using the *Borehole* name, as this will avoid confusion between multiple sets of data under a single *Site*.

4.2.5 FILE SAVE FORMATS

File Save Format enables the user to choose which format to save the inclinometer file in. To change the file save format choose the appropriate option from the drop-down list as shown in Figure 15. These are outlined below:

1. ***Digital Inclinometer (*.csv)*** format: Files are saved in a format which includes the probe serial number in the header file.
2. ***Standard RST(*.csv)*** format: This is the default file setting and is compatible with RST Inclinalysis™ software. Files are saved as *.csv (comma separated value). This data format also has the ability to be imported into most popular spreadsheet software. Files of this type can also be imported into GTilt (section 17.3).
3. ***RPP Format (*.rpp)***: This type of file can be imported into Inclinalysis™ and is also compatible with Slope Indicator's software including DMM for Windows and DigiPro. GTilt and GTilt Plus software also has the ability to import *.rpp file formats. If directly comparing data between two inclinometer systems, please ensure that the depth placement of the probe is identical between the surveys with the two different systems. For further reference on importing *.rpp files into Slope Indicator's software, please see section 17.1.
4. ***Standard RST (*.dty):*** File format designed to be imported directly into GTilt and GTilt Plus software. Please note however, that the other file types listed above can also be imported into GTilt.

Once the correct data file options have been chosen, exit the *Reading Data File Options* screen by pressing *OK*. If you want to exit without saving the changes, press *Cancel.* You will be returned to the *Edit Borehole* screen. If all the parameters in the *Edit Borehole* screen are correct press *OK*, else press *Cancel* and you will be returned to the *Main Menu*. The new borehole information will be displayed in the bottom half of the *Main Menu* screen. Verify that these settings are correct.

4.2.6 STATUS SCREEN

Navigate to the *Status Screen* by pressing the *Status* button on the main menu. The following screen will appear:

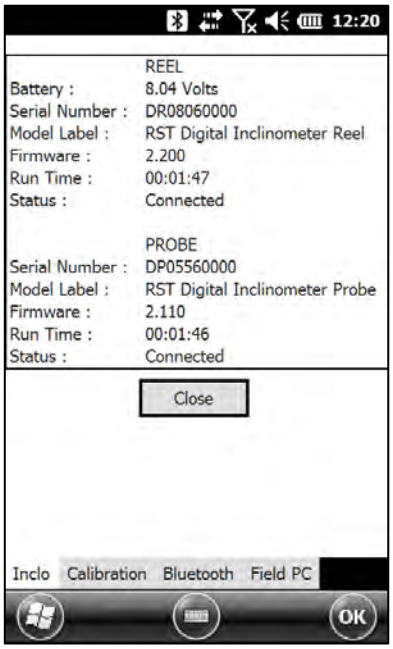

Figure 16 – Status Screen

If the Ultra-Rugged Field PC is connected to the Reel and the Probe, information will appear in the appropriate areas. If there is no connection the information fields will be blank (and the status will read *not connected*). Vital information for both the Reel and the Probe is displayed which includes: Battery Voltage, Serial Number, Model Label, Firmware Version, Run Time and Status.

Choosing the *Calibration* tab invokes the following screen:

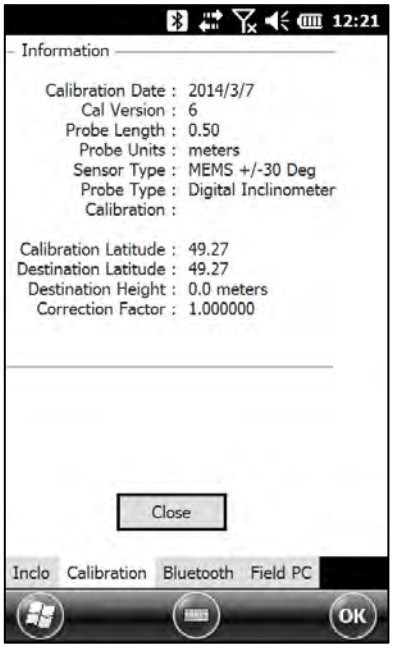

Figure 17 – Calibration Screen

The *Calibration Screen* provides information about the calibration date, calibration version, probe length and probe units (metric or imperial). Corrections can also be made to individual inclinometer probes to account for latitude and elevation changes.

Note

RST highly recommends that the inclinometer probe be calibrated on an annual basis. The probe should also be recalibrated if it has been exposed to any type of shock or shows high checksum values for no apparent reason.

Clicking on the *Bluetooth* tab brings up the following screen:

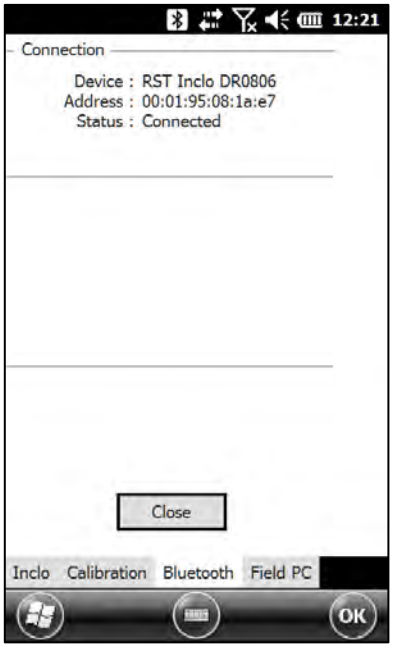

Figure 18 – Bluetooth Status Screen

The Bluetooth Status screen indicates which device is connected and the status of the connection. Please note that the range of the Bluetooth radio is approximately 10 metres and this distance may vary depending on objects and line of site.

The above two screens are used primarily to confirm that the Ultra-Rugged Field PC has established wireless communication with the Reel and Digital Probe and to display the hardware information. If communication has not been established, the hardware information will not display until a satisfactory connection has been made.

Pressing the *Field PC* tab brings up specific information about the Ultra-Rugged Field PC serial # as shown in the following screen:

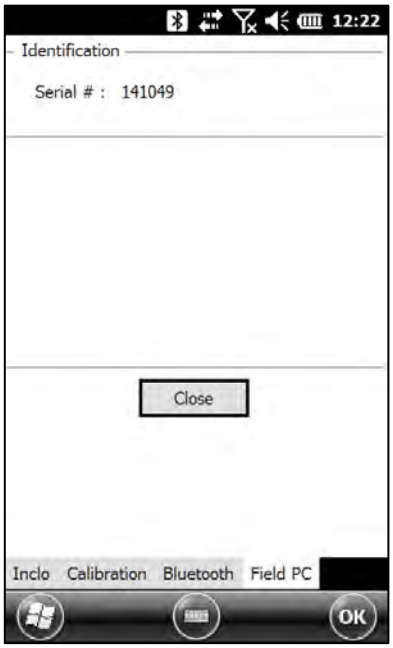

Figure 19 – Field PC Status Screen

4.2.7 READINGS

Once you have set up the Site Name, Borehole Name, Filename and the Ultra-Rugged Field PC has successfully connected to the Reel and Digital Probe (see *Status* Screen) you are ready to begin logging the borehole. This menu is only accessible once the readout is connected to both the Reel and the Digital Probe. From the *Main Menu*, pressing the R*eadings* button invokes the following screen:

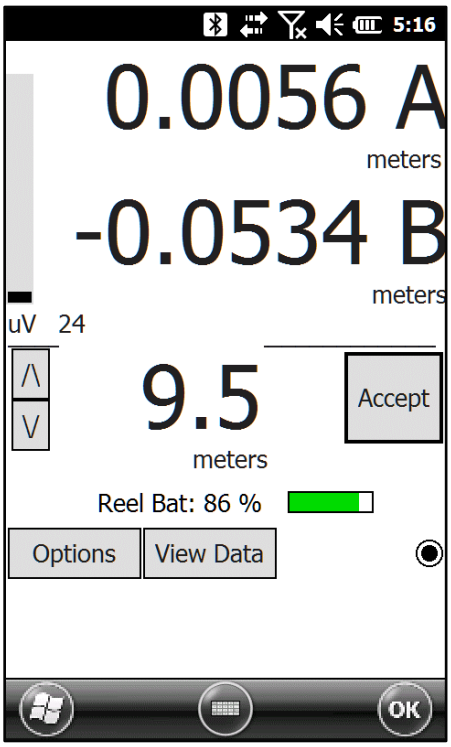

Figure 20 – Readings Screen

After a few seconds the real-time reading should appear as in Figure 20. This screen shows the real-time data in both the A and B axes. The units are displayed underneath both sets of readings. To the left of the readings is a dynamic bar which indicates the noise level (i.e. the difference, reported in microVolts, between subsequent readings). The user should wait until the noise level is at a minimum before taking a reading. This minimum can vary depending on the site conditions. In particularly noisy environments (i.e. heavy equipment is moving in the vicinity) the amount of averaging can be adjusted to help reduce the noise (for more info. please refer to the *Averaging Data* section in this manual, section 6.5 and Figure 21). The number displayed under the noise bar reports the microVolt change between successive readings. It should simply be used as a reference as to how noisy the readings are, this number does not correlate directly to the measurement units, it simply indicates the microVolt change between each subsequent measurement (1 measurement per 0.4 second).

The current depth of the instrument in this example is set to 10.0 metres. Pressing the *Accept* button will store the reading and the depth will move to whatever the next interval is set at (i.e. 9.5m). The arrow keys allow the user to scroll up and down the readings which permits re-taking readings if necessary.

Note

Be careful not to miss any data intervals when using the scroll feature as this can offset the data. At any time the user is able to view the data by pressing the *View Data* button to confirm that they have the probe in the correct location and the readings at that depth have been taken correctly.

The small black dot on the right hand side of the screen appears whenever data is being sent from the probe.

Once the top of the hole has been reached, the software will prompt the user to turn the probe 180° and lower it back to the bottom of the hole (unless the user specifically sets the software to only take a single set of readings, please see the *Advanced Options Menu,* Figure 22). The readings will automatically start at 10.0 metres once again (in this example). Check-Sum data will appear in a smaller font underneath the current readings. The real-time check-sums allow the user to monitor the second set of readings. If the check-sum is large or inconsistent, either the probe has fouled or the probe is not at the correct measurement depth. Continue logging until the top of the hole is reached. If the probe has been accidentally raised above the measurement point, lower the probe back down below the proper depth and then raise it slowly to the correct depth. This ensures consistent and accurate readings. Once the top is reached on the second pass, a dialog box will appear that says "Readings Complete". The software will then save the data to the filename which was specified in the *Reading Data File Options* screen.

Pressing the *Options* button on the readings screen brings up the *Readings Options* screen:

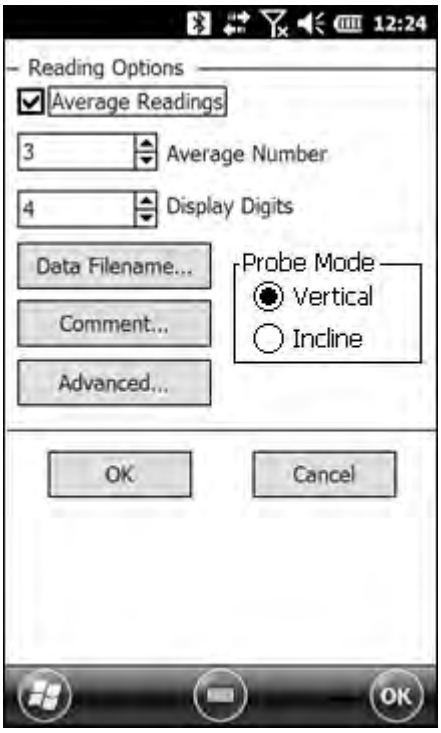

Figure 21 – Readings Options Screen

This option allows the user to specify whether or not the data from the probe is to be averaged. The number of readings to be averaged can be set in *Average Number* dialog box.

Note

Readings from the probe are taken once 0.4 second, therefore increasing the amount of averaging means that you increase the wait time between taking readings (i.e. if an averaging value of 5 is chosen, you must wait at least 2 seconds after moving the probe before taking a reading).

The number of decimals shown can be changed in the *Display Digits* dialog box. Pressing the *Comment* button permits the user to make any comments about the data set and the *Data Filename* allows the user to change the name of the data file the information is written

to upon completion of logging the borehole (for additional information please see section 4.2.3).

When the incline capable probe is connected, the Probe Mode settings allow switching between vertical mode and incline mode. The Probe Mode settings do not appear for single mode probes. For further info regarding Incline probe, refer to Section 5.3.

Pressing the *Advanced* button brings up the following screen:

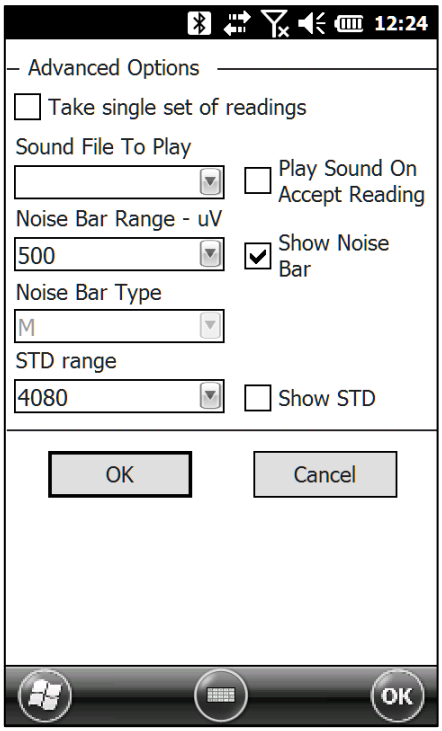

Figure 22 – Advanced Options Menu

The first check box allows the user to specify whether or not to take a single set of readings during a borehole survey. The inclinometer readout will save the data after a single pass of the borehole. A sound option allows the user to turn on/off the sound upon acceptance of a reading. User specified sound files (*.wav) can be placed in the following directory:

My Device\My Documents\Digital Inclinometer\SoundFiles\

This allows the user the option to have a custom sound played each time a reading is taken. The default sound is a simple beep.

The Noise Bar can be turned on and off and the drop-down menu provides a choice for the limit of the range of the Noise Bar. The numbers represent microVolt reading from the inclinometer probe. The last pull-down menu allows the option to display the standard deviation of the incoming data. This range can also be adjusted, depending on how noisy the readings are in the field. Measurements should be taken at the point of least noise whenever possible to obtain the most accurate readings.

4.2.8 VIEW DATA

By pressing the *View Data* button from the main menu, the following screen appears:

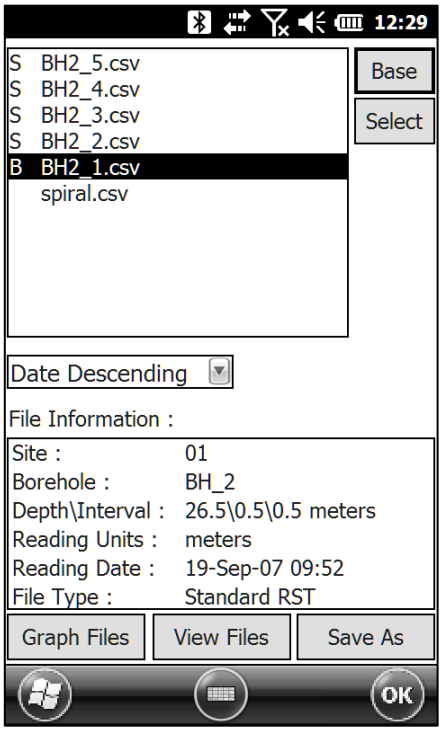

Figure 23 – View Data Screen

All borehole data files associated with the particular borehole that has been selected (from the Main Menu) will appear in the top dialog box. The detailed file information appears on the lower half of the screen and this includes: *site, borehole, depth/interval, reading units, reading date and file type*. Filenames can be sorted by date, type or name by selecting the appropriate option in the drop-down box.

In order to display the data, the appropriate files must be chosen from the list. To select a file, first highlight the file in the top dialog box and then press the S*elect* button. If the file has been selected, an "S" will appear to the left of that file. To choose a base file, highlight the appropriate file and press the *Base* button. A "B " will appear to the left of the file name confirming that this file is now the base file. Note that the *Base file* and the *Selected files* can be changed at any time by highlighting the file and pressing the *Base* or *Select* buttons. The software only allows the user to have a single *Base File*. To unselect any file, simply highlight that particular file and press either *select* or *base* a second time and the *B* or *S* to the left of the file will subsequently disappear.

The base file represents the original survey of the inclinometer hole, from which all other measurements are compared. Typically, a base file is chosen and kept the same throughout the life of the inclinometer hole in order to quantify any lateral displacements which occur.

Once the appropriate files are chosen, the user can choose to display the data in tabular format by pressing the *View Files* button, or in graphical format by pressing the *Graph Files* button.

Pressing the *Graph Files* button will bring up the following screen:

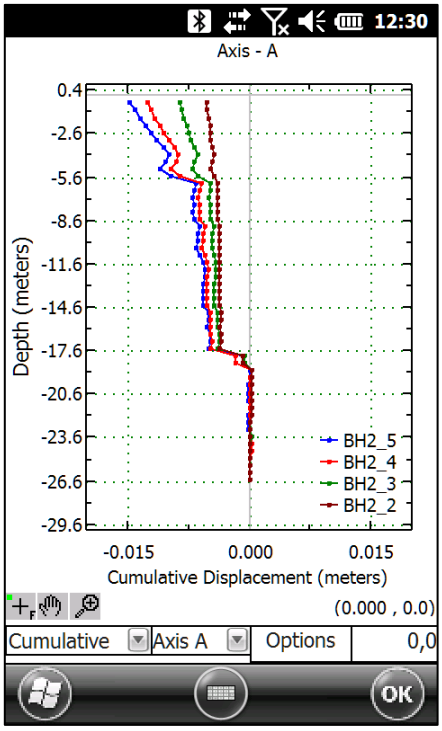

Figure 24 – Graphing Files

Several tools are available in the bottom pull-down menus to allow manipulation of the graph. The left-hand pull down allows the user to choose how the data is displayed, with Mean, Absolute, Cumulative or Checksum options. The centre menu allows the user to choose between plotting either the A or B axis. The third menu *Options*, allows the user to manipulate the cursor, zoom, pan, change the scale, move the legend, or change the appearance of the graph. Three icons also appear in the bottom left of the screen which allow further manipulation of the graph. These are self-explanatory and the user is encouraged to explore these options if required. The default setting for all plots is *auto-scale*.

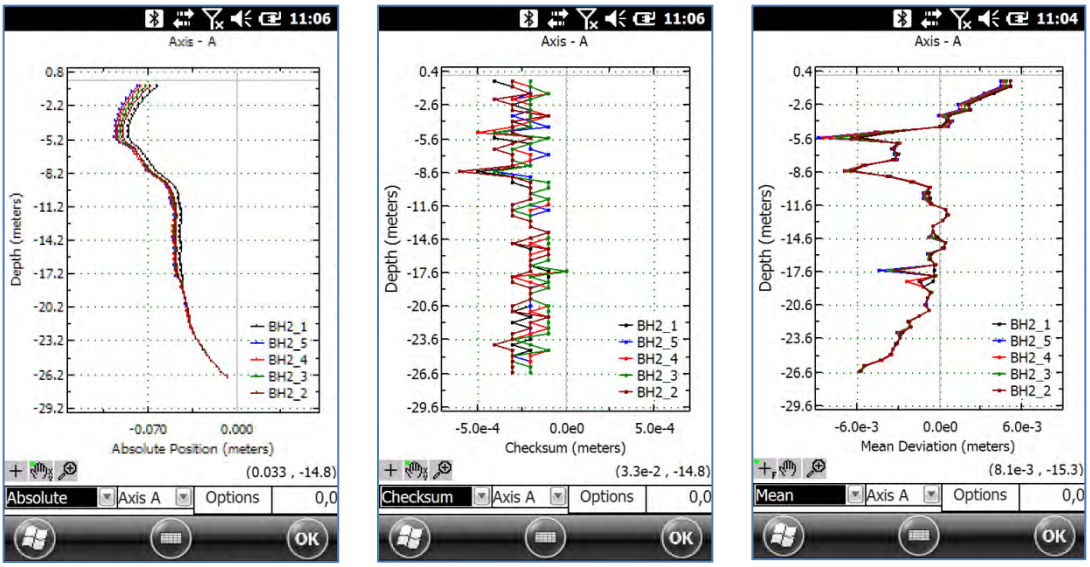

Figure 25 – Other Graph Types

To exit the graphical display, hit the *OK* button in the top right corner of the screen.

Pressing the *View Files* button invokes the following screen:

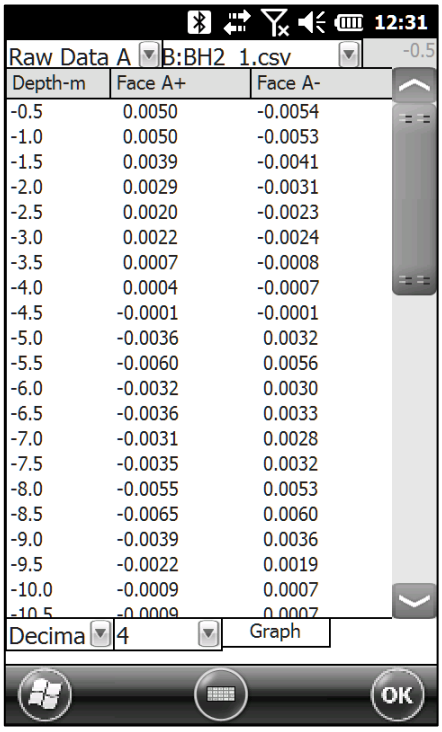

Figure 26 – Viewing Files

The top left pull-down menu allows the user to change the type of data that is reported in the table. The options include: Raw Data A, Raw Data B, Checksum, Mean, Absolute and Cumulative. The top right pull-down menu is used to choose which of the selected data files is currently being displayed. Please note that the base data file will contain the prefix "*B:"* so that it can be easily identified.

The bottom portion of the screen has three menus which allow the user to display the data in either decimal or scientific notation, change the number of decimal places displayed, and a *graph* button which takes you to the graph data screen. At any time you may exit from this screen by pressing *OK* in the top right corner of the screen.

Pressing the *Save As* button invokes the following screen:

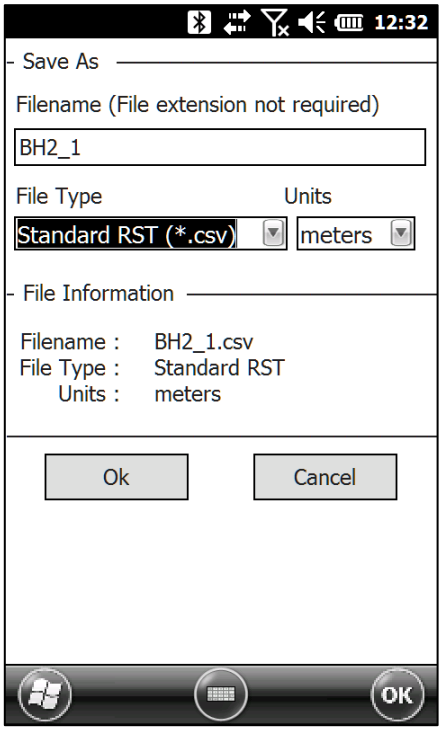

Figure 27 – Save As… Option

This function allows the user to edit the filename, file type and the measurement units. For more on file formats please refer to section 4.2.5.

5 PROBE TYPES

5.1 VERTICAL PROBE

Vertical probe collects data in A and B axis. It is the most commonly used probe. Readings taken from the inclinometer probe are actually deviations from the vertical over the distance between the upper and lower wheels. The probe is passed through the inclinometer casing, and every 0.5m (or 2ft.) a reading is taken. When the probe is at rest, MEMS accelerometers sense the inclination of the access tube in two planes. This inclination is displayed in terms of angular DEVIATION, which is recorded at that particular depth.

5.2 HORIZONTAL PROBE

The function of the MEMS Horizontal Inclinometer Probe is very similar to the standard biaxial (vertical) probe. Each individual survey requires the probe to be drawn or pulled through the casing, then reversed and passed through the casing again (probe is reversed end for end – not rotated axially 180° as in a vertical inclinometer survey). Measurements are collected at 0.5m intervals with the metric probe or 2 ft. intervals with the imperial probe. The readings taken represent the vertical displacement, defined by (½m)*(SIN (a)), where "a" is the angle between the horizon and the longitudinal axis of the probe.

5.3 INCLINE PROBE

Incline probe gives readings in borehole at 35 degree tilt.
There is one data set of interest, and that is axis A. Since there is only one pass, A- is filled up with A+ readings of opposite sign. A axis data represent displacements from 35 degree angle on the length of the probe.
B axis data is collected from other vertical sensor. Since that sensor is at an angle too big to read accurately, it is used here for a reference to show that the probe was inserted correctly. Data in B axis should be as close to zero as possible.
There is no need to edit data file to be able to display graphs in Inclinalysis. Graphs will be shown. Inclinalysis can be easily switched to A graph only to show important graph only.

5.4 COMPASS PROBE

Compass probe provides azimuth data for horizontal installations. The probe is passed through the inclinometer casing and compass sensors read azimuth at pre-set intervals.

5.5 SPIRAL PROBE

The RST Digital Spiral Probe is designed to complement the RST Digital Inclinometer System. In situations were excessive spiral is present in the inclinometer casing, it becomes important to correct for the spiral in order to have the correct magnitude of displacement in the A and B axes.

The software displays the spiral readings directly in degrees. Logging the spiral data is done in a similar manner as an inclinometer survey. To begin the survey, push *Start* button. The initial position is then measured. *Accept* button needs to be pressed when in manual mode. In *Auto Accept* mode, the probe will sense movements and the reading will be taken automatically without the need to press any buttons. The reading mode can be changed on Options screen

6 DOWNLOADING DATA TO A DESKTOP PC

The software used to transfer data will depend on the version of Microsoft Windows installed on a desktop PC.

For Windows XP versions, ActiveSync™ is required. Windows Vista, windows 7, 8,8.1, and Windows 10 needs Mobile Device Center 6.1. It is highly recommended to download and install the newest updates from Microsoft website.

6.1 INSTALLING MICROSOFT ACTIVESYNC™ ON WINDOWS XP

In order to communicate between the Ultra-Rugged Field PC and a desktop PC or laptop, Microsoft's ActiveSync™ software is required and is included with the Digital Inclinometer System. Communication between the two devices is achieved through an USB connection.

Note

Microsoft's ActiveSync™ software can be freely downloaded from Microsoft's website.

Important

Don't connect the USB cable before installing ActiveSync™ software. Doing so will result in installation of generic Windows USB drivers which will not work with Ultra-Rugged Field PC.

To install Microsoft ActiveSync™:

1. Insert the Ultra-Rugged Field PC Companion CD into the CD-ROM drive. On most systems, Windows will automatically launch the setup program. Minimum system requirements are outlined in the jacket of the CD-ROM. Once the CD is up and running, a graphical window will open. Press the *play* icon on this window.
2. Click the link marked *Start Here.*
3. Click *Install ActiveSync.* Note: When prompted to download the file, select *Run this program from its current location.* Installing Microsoft Outlook is **not** necessary, for the Digital Inclinometer System to function. If you wish to use the Ultra-Rugged Field PC for e-mail, install Outlook.
4. Follow the on-screen instructions until you reach the screen shown below, and then continue with Step 5.

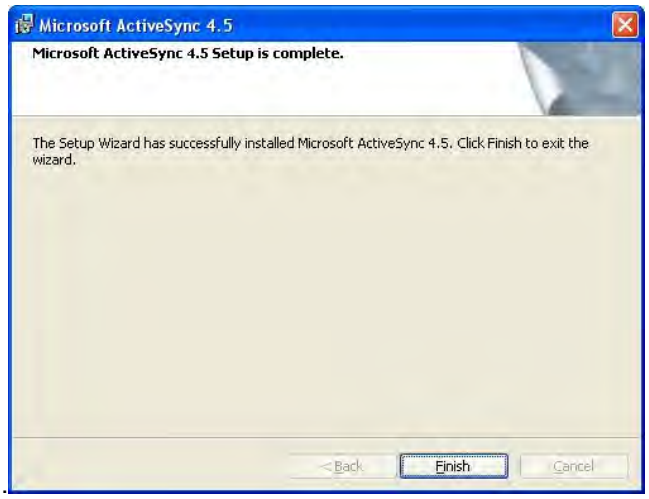

Figure 28 – ActiveSync Connection Screen

5. Click Finish button.

6. Insert the AC Adapter plug into an electrical outlet (Figure 1, item 10). Connect the AC connector barrel connection on the base of the Ultra-Rugged Field PC (Figure 9, item 24).
7. If you have not already done so, connect the micro USB connector to the connector on the base of the rugged case and the USB connector to the USB port on either the front or back of your personal computer.

Note

ActiveSync will automatically detect the Ultra-Rugged Field PC connection.

8. Continue to follow the ActiveSync instructions to establish a partnership. Eventually you will come to a screen like the one below:

Figure 29 – Setting Up a Partnership

In order to synchronize the data in real-time between the Ultra-Rugged Field PC and the desktop PC, you must set up a *sync partnership.* If you do not wish to synchronize data and simply use Windows Explorer to copy files to and from the Ultra-Rugged Field PC, click Cancel to leave the connection as *Guest Partnership* and skip the remaining instructions.

1. To set up a *sync partnership,* press *Next.*
2. Uncheck the option for synchronizing with Microsoft Exchange Server, press *Next.*
3. Decide what type of information you would like synchronized with the desktop computer. If you are only using the Ultra-Rugged Field PC for the purposes of transferring Digital Inclinometer information, uncheck all the options and place a check mark next to the *Files Folder* (see below).

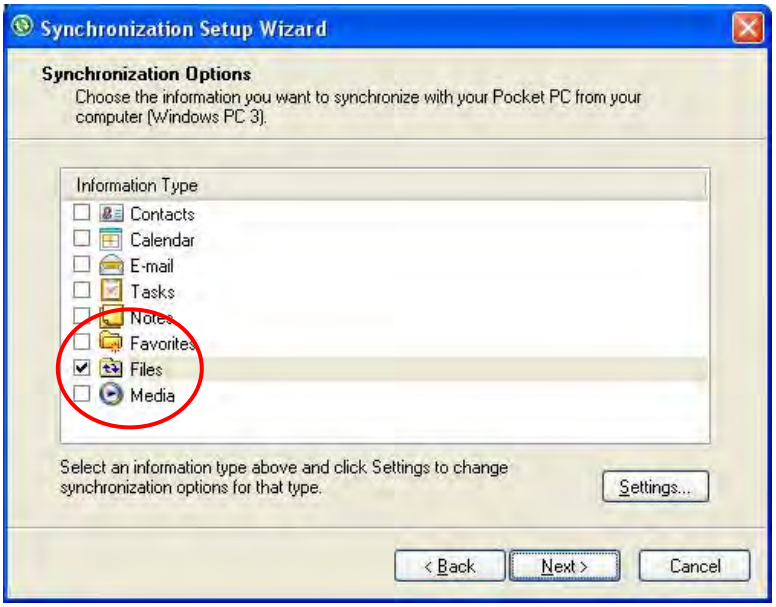

Figure 30 – Synchronization Settings

The software will notify you that it will create a folder on the desktop which links directly to the Ultra-Rugged Field PC (*press OK*). Click Next, and then Next on following dialog, then Finish the installation. Once the partnership is established, the PC will recognize and automatically synchronize to the Ultra-Rugged Field PC each time it is connected with the USB cable.

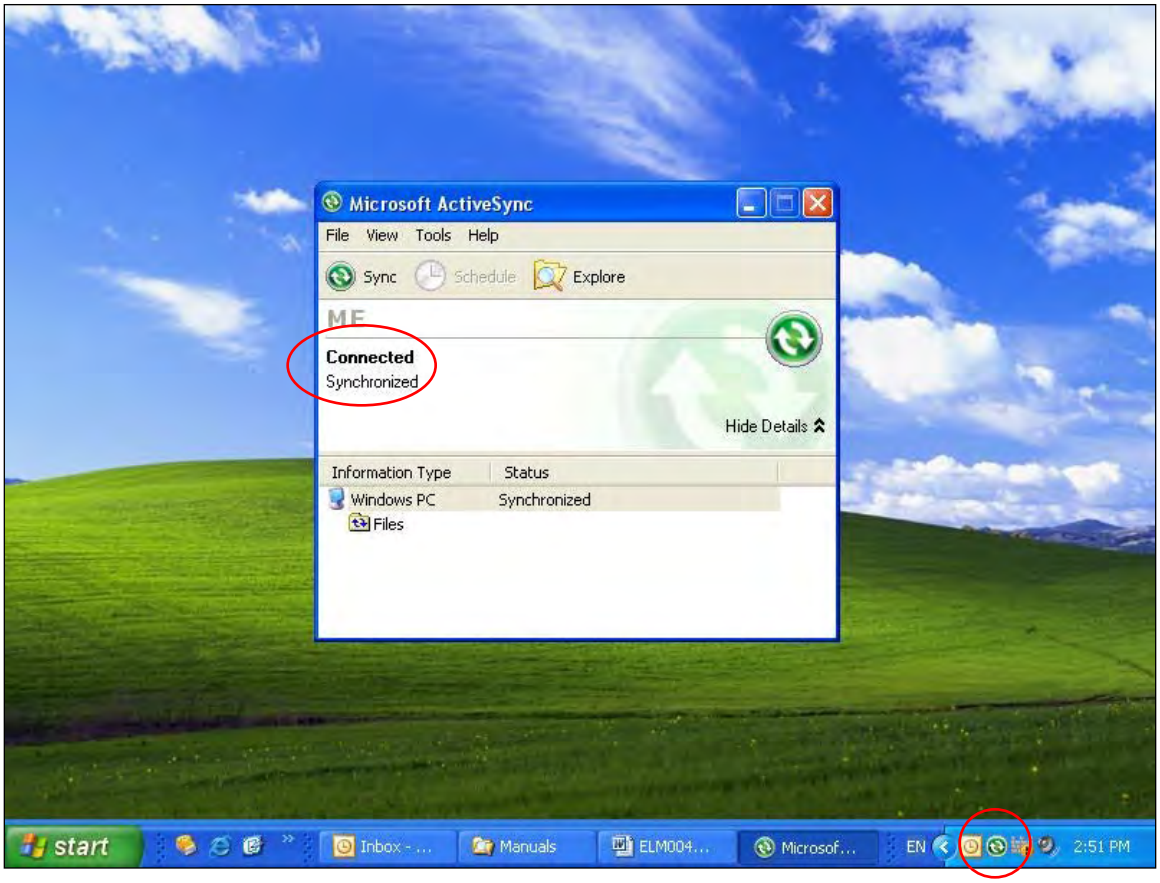

Figure 31 – ActiveSync Screen

Important

It is extremely important that the user realizes that the synchronized folder created on the desktop is an **active** link to the Ultra-Rugged Field PC. Any changes you make in that folder will be reflected on the Ultra-Rugged Field PC. For example, if you delete a file in the folder, the same file will be deleted on the Ultra-Rugged Field PC. If the Ultra-Rugged Field PC happens to be disconnected at the time, as soon as it is re-connected it will automatically see the missing file in the folder and the file will be deleted during the connection. It is therefore important to exercise good data management. Once the data is synchronized to the PC, move the inclinometer files to a safe location (i.e. a network server or hard drive).

For further instructions regarding synchronizing data between a PC and the Ultra-Rugged Field PC, please refer to the supplied documentation and software which comes with the Ultra-Rugged Field PC (CD-ROM).

6.2 SETTING UP MOBILE DEVICE CENTER ON WINDOWS VISTA, WINDOWS 7, 8, 8.1, 10

Before connecting to Ultra-Rugged Field PC, it should be verified that desktop PC or laptop contains current version of Microsoft Mobile Device Center™. Communication between the two devices is achieved through an USB connection.

Note

Microsoft's Mobile Device Center™ software can be freely downloaded from Microsoft's website. Choose 32 bit or 64 bit version depending on Windows Vista™, Windows 7 or Windows 8 operating system.

After Mobile Device Center™ is installed, connect the Ultra-Rugged Field PC to desktop or laptop computer using USB cable provided with the Digital Inclinometer System. Microsoft Windows ™ should detect new connection and display following dialog box.

Figure 32 – Mobile device Center Screen

In order to synchronize the data in real-time between the Ultra-Rugged Field PC and the desktop PC, you must click on *Set up your device.* If you do not wish to synchronize data and simply use Windows Explorer to copy files to and from the Ultra-Rugged Field PC, click *Connect without setting up your device.* Data files can be copied from Ultra-Rugged Field PC using File Management, as shown on Figure 34.

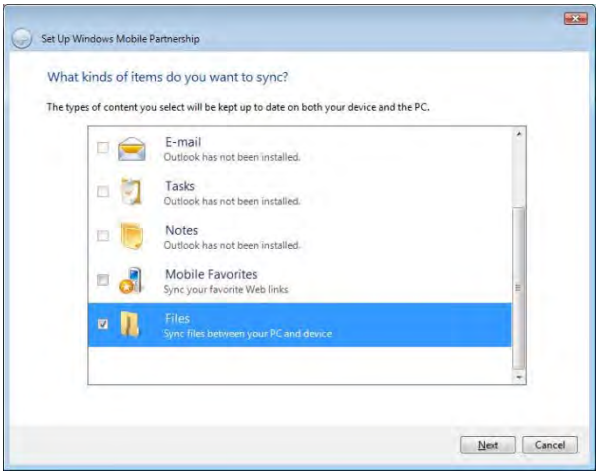

Figure 33 – Synchronization Settings on Windows Vista™, Windows™ 7, 8, 8.1, 10

If synchronizing files, decide what type of information you would like synchronized with the desktop computer. If you are only using the Ultra-Rugged Field PC for the purposes of transferring Digital Inclinometer information, uncheck all the options and place a check mark next to the *Files* (see above).

Figure 34 – Accessing Files on Windows Vista™, Windows™ 7 ,8, 8.1, 10

Important

It is extremely important that the user realizes that the synchronized folder created on the desktop is an **active** link to the Ultra-Rugged Field PC. Any changes you make in that folder will be reflected on the Ultra-Rugged Field PC. For example, if you delete a file in the folder, the same file will be deleted on the Ultra-Rugged Field PC. If the Ultra-Rugged Field PC happens to be disconnected at the time, as soon as it is re-connected it will automatically see the missing file in the folder and the file will be deleted during the connection. It is therefore important to exercise good data management. Once the data is synchronized to the PC, move the inclinometer files to a safe location (i.e. a network server or hard drive).

For further instructions regarding synchronizing data between a PC and the Ultra-Rugged Field PC, please refer to the supplied documentation and software which comes with the Ultra-Rugged Field PC (CD-ROM).

6.3 FILE MANAGEMENT

Once the Ultra-Rugged Field PC has been synchronized to a desktop computer, file management simply takes place using Windows Explorer. Files can be copied and/or deleted easily using drag and drop features. Using Windows Explorer is the easiest and most effective way of managing the Inclinometer Data on the Ultra-Rugged Field PC. File structure is straight forward and has the following format:

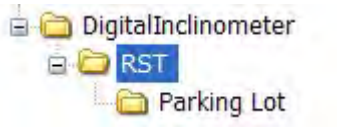

Figure 35 – File Structure

Where:

- RST = Site Name (user defined)
- Parking Lot = Borehole Data (user defined)

For additional information on the naming of sites and boreholes please refer to section 4.2.4.

Note

As with any modern digital peripheral device, data management is very important. In order to keep the system un-cluttered, it is extremely important to delete site and/or borehole data files off the Ultra-Rugged Field PC once the data is saved in a safe location on your PC and when the data is no longer required to reside on the Ultra-Rugged Field PC. Deleting files is simple with Microsoft ActiveSync™, because it creates an “active” connection. Any files which are deleted from the synchronized folder on the PC will be deleted on the Ultra-Rugged Field PC.

The Digital Inclinometer Software does not provide a means to delete the data files within the Ultra-Rugged Field PC. Data file management should be performed solely through the desktop PC. Once you have copied the data to a safe location, delete the necessary files/folders within the synchronized folder, and the corresponding files will be deleted on the Ultra-Rugged Field PC.

6.4 POST- PROCESSING THE DATA

The RST Digital Inclinometer system currently stores borehole survey data in a variety of formats, including *.csv format. Once the data has been downloaded/synchronized to a desktop PC or laptop (see section 6) it can be opened directly with RST Inclinalysis™ Software or Microsoft Excel™. If opened in MS Excel, the data will have a format similar to the one outlined below:

INCLINOMETER DATA
SITE CODE : RST Test
BOREHOLE CODE : Test Hole 1
FACES LOGGED : ABCD
TIME/DATE TAKEN : 12:12 ON 03/09/03
DEPTH OF TUBE : -15.0
READING INTERVAL : 1.0
OPERATING UNITS : meters

DEPTH meters	FACE A+ mm	FACE A- mm	FACE B+ mm	FACE B- mm
-0.5	-4.99404	5.01203	0.03442	-0.02147
-1.0	-5.00647	4.99654	0.01457	-0.00124
-1.5	-4.99182	5.02145	0.03603	-0.02984
-2.0	-5.00846	4.98021	0.04696	-0.03421
-2.5	-4.99441	5.01894	0.036	-0.03129
-3.0	-5.0068	5.01754	0.01508	-0.02913
-3.5	-4.99241	4.98564	0.03802	-0.04182
-4.0	-5.00809	5.00215	0.04617	-0.03191
-4.5	-4.99422	4.99412	0.0353	-0.0347
-5.0	-5.00706	5.01247	0.01538	-0.00897
-5.5	-4.99226	4.98542	0.03863	-0.02974
-6.0	-5.00885	5.00214	0.04342	-0.03487
-6.5	-0.0848	0.06547	4.94198	-4.98447
-7.0	-0.05701	0.06214	5.00787	-5.01914
-7.5	-0.07299	0.05237	4.93971	-4.95647

Figure 36 – Sample Data File

As shown in Figure 36, the header information is display followed by the data. In this example, the total hole depth is 7.5 metres, with readings taken at 0.5 metre intervals.

The units that the readings were taken in are displayed at the top of each column (in this case, millimetres). Readings are taking in two directions as outlined in section 2.3

6.5 DATA AVERAGING

The RST Inclinometer software automatically averages the real time inclinometer data streaming up from the probe every second. Pressing the *Options* button in the *Readings* screen allows averaging to be enabled and adjusted. While in the real time data display window, the current status of data averaging can be viewed on the left hand side of the screen (Figure 20). The bar indicates how stable the readings are. If the bar is full, averaging is being performed and the readings have not yet stabilized. The user should wait until this bar goes down before recording a reading for that section of the borehole. The number displayed under the averaging bar represents *bits*. They are simply there to give the user an indication of the change in bits between subsequent readings. Site conditions and the nature of the installation determine how noisy (or not noisy) the readings are. The software allows the flexibility of going back and re-taking readings if necessary.

The averaging is a running average of the previous readings. To change the amount of averaging that the software performs, simply change the *average number* (Figure 21). With the stylus, select the dialog box and enter in the value using the pop-up keyboard at the bottom of the screen.

7 WHAT DOES THE DATA MEAN

The system has been developed to measure accurately the lateral movement of earthworks and structures. The probe is passed through the inclinometer casing, and every 0.5m (or 2ft.) a reading is taken. When the probe is at rest, MEMS accelerometers sense the inclination of the access tube in two planes. This inclination is displayed in terms of angular DEVIATION, which is recorded at that particular depth.

A+ = Face A+ deviation
A- = Face A- deviation
B+ = Face B+ deviation
B- = Face B- deviation

The Checksum:

Checksum in A+/A- plane = A+ plus A-

Checksum in B+/B- plane = B+ plus B-

Checksum should be reasonably constant and of small magnitude, large and inconsistent Checksums may indicate that a problem exists. However, the consistency of checksums from survey to survey is more important than the actual value of the checksums. Checksum data should be monitored during the survey as a check on data integrity. Note that high checksums can be expected if a settlement coupling has been encountered, a checksum of the order of (+0.0045m and -0.0035m) or (+0.0147ft and –0.0114ft) would be reasonable at consecutive depths/couplings.

7.1 MEAN DEVIATION

A+/A- mean deviation in the A+/A- plane = (A+ minus A-)/2

B+/B- mean deviation in the B+/B- plane = (B+ minus B-)/2

This represents the mean deviation at each depth.

7.2 ABSOLUTE POSITION

An absolute position value at a particular depth is the summation of mean deviations starting from the bottom up to that particular depth. Absolute position is the profile of the access tube with respect to the vertical axis in a given plane. Absolute position can also be calculated from the top down if required using Inclinalysis™ software.

7.3 INCREMENTAL DISPLACEMENT

This is the difference in values of mean deviation between the base file, (first set of readings taken) and a compatible file, (usually the latest set of readings) at each depth. This plot can be generated using Inclinalysis™ software.

7.4 CUMULATIVE DISPLACEMENT

This is the result of comparing two sets of mean deviations, usually the base file and the latest or comparison file. The profile represents the actual movement (or displacement) which has occurred at all depths between the times that the two sets of readings were obtained.

Note:
The RST Digital Inclinometer Software has the ability to reduce the data in the field on the Ultra-Rugged Field PC itself. Please refer to section 4.2.8 (Viewing the Data) for additional information.

8 SYSTEM COMPATIBILITY

Regardless of the inclinometer system being used, it is imperative that the **probe wheels** be placed at the same locations during the profiling of the borehole (this is not necessarily the same depth marked on the inclinometer cable). Always use a consistent top reference, such as the aluminum cable grip which is provided with all RST Inclinometer systems.

The zero depth reference on the new RST Digital Inclinometer System is in reference to the midpoint of the probe (between the wheel assemblies). This is the industry standard. The old RST analog system is referenced to the uppermost set of wheels. Therefore, this *must* be taken into account if the customer wishes to directly compare the two sets of readings. It is very important that the data be within 4mm (0.25”). Otherwise, the data will not match and the comparison will not be valid.

Note

Those customers wishing to compare surveys between RST’s old analog system and the new digital system must ensure that the readings are taken at the same depths between the two systems (with the proper depth reference). If you are changing over to the new Digital Inclinometer System, as with any new system, it is good practice to survey the borehole with both systems. When it is determined that the data from the new Digital System is satisfactory, the user can stop using the older system and continue from that point forward.

Note

Some competitor’s inclinometers have different cable gripping/locating systems resulting in different depth locations. Therefore you must be aware of these differences when trying to directly compare data between the two different systems.

9 BACKING UP THE ULTRA-RUGGED FIELD PC INCLINOMETER DATA

Data file management between the Ultra-Rugged Field PC and a computer is handled by the mobile device communication software. On Windows XP based computers, ActiveSync software is used (see section 6.1). Windows Vista, Windows 7 and Windows 8 requires Mobile Device Center (section 6.2). Data files can be shared or mirrored on both the PC and the Ultra-Rugged Field PC. However, the normal synchronization process does not back up the data. An easy way to backup the data is to always copy synchronized information to a safe location on your desktop PC or network server.

The RST Digital Inclinometer software automatically backs up the most current data files upon returning to the main menu screen. Therefore, anytime the user returns to the main menu screen, the data will be automatically backed up to the non-volatile (Field PC) memory location. The Field PC storage folder is accessible through Windows Explorer when the Ultra-Rugged Field PC is connected to a peripheral computer

9.1 MANUAL BACKUPS

The RST Digital Inclinometer Software has provision for making manual backups of the data, in addition to automatic backups.

1. From the main menu of the Digital Inclinometer Software, under the *File* menu select *Backup…*

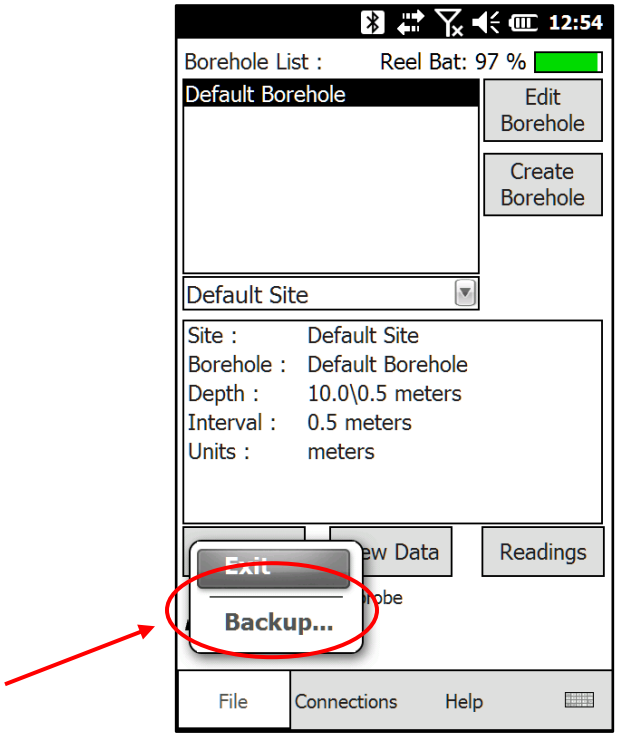

Figure 37 – File Backup

2. Once selected, the following screen will appear:

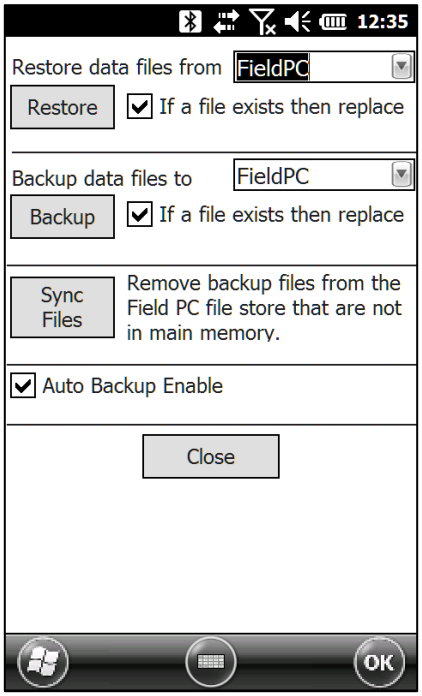

Figure 38 – File Backup Options

3. Using the drop-down box at the top of the screen, select the location in which you would like to restore the files from. All Ultra-Rugged Field PC's come with the Field PC storage location however, optional Flash™ Storage Cards are additional and are available through RST.
4. Choose from the several options whether you would like to *Restore*, *Backup* or *Synchronize* the files. Check boxes allow the options of overwriting files if desired.
5. Press the desired button to initiate the function.
6. Press *Close* to exit this screen.

Note

Proper data management is very important. The Ultra-Rugged Field PC, in conjunction with its onboard and optional non-volatile memory storage areas, and its ability to synchronize with a desktop PC, allows several options for backing up the data. At the same time, with all these options, data files can be confused with each other if not managed properly. After taking readings in the field it is always a good idea to back the files up in a safe location (i.e. network server etc…) back at the office using the ActiveSync software. Additional copies of this information will always be stored in the Field PC memory area should the main memory of the Ultra-Rugged Field PC become erased. Be sure to clear the Field PC memory of unneeded files on a regular basis to keep the files easily manageable.

Important

Because the Ultra-Rugged Field PC uses some power to maintain files in RAM and the clock, you need to recharge the battery regularly. Keep the Ultra-Rugged Field PC connected on AC or DC power while you are at your desk. The best policy is to keep the Ultra-Rugged Field PC connected to your computer when working at your desk and carry your AC adapter and DC adapter plug with you when traveling. Your Ultra-Rugged Field PC is shipped with a charge on the battery. You may want to ensure that it is fully charged before synchronizing. The Ultra-Rugged Field PC battery will provide approximately 20 hours of borehole survey time (when connected to the probe).

10 RESTORING FILES ON THE ULTRA-RUGGED FIELD PC

10.1 INSTALLATION THE RST DIGITAL INCLINOMETER PROGRAM

Use the following steps to reinstall the RST Digital Inclinometer Program:

1. Establish a connection to the Ultra-Rugged Field PC using Microsoft ActiveSync.
2. Using Windows Explorer, copy the file "Digital Inclinometer X.XX.CAB" to the folder on the Ultra-Rugged Field PC (My Documents for example). The "X.XX" will mean the software version.
3. On Ultra-Rugged Field PC, select *Start* and then *File Explorer* from pull down menu.
4. Navigate to the folder where the file "Digital Inclinometer X.XX.CAB" was copied to.
5. Click on the "Digital Inclinometer X.XX.CAB" file to begin installation.

Note

If an older version of the RST Digital Inclinometer Software is already present, uninstall the previous version by going to *Start*, then *Settings* and tapping on *Remove Programs* located in *System* tab. Highlight the program to be removed and tap *Remove*.
If the Digital Inclinometer entry is not present in the list, the program must be manually removed by deleting files in *Windows* directory and shortcut in *Start Menu*.

10.2 RESTORING THE INCLINOMETER DATA FILES

The inclinometer data files are backed up to the Field PC storage area of the Ultra-Rugged Field PC on a regular basis, each time the user returns to the Main Menu Screen of the Digital Inclinometer program. In order to restore the files, the user may navigate to the Field PC storage area using Windows Explorer. This is most easily accomplished when the Ultra-Rugged Field PC is ActiveSync'ed to the desktop PC. The following text explains this procedure:

Using *Windows Explorer,* navigate to*:*

Mobile Device: My Pocket PC\Field PC File Store\Digital Inclinometer

The files will be stored in directories according to their *Site Name*. If you need to restore all the files, simply copy the entire folder named "Digital Inclinometer" to the current directory.

The current folder resides in:

Mobile Device: My Pocket PC\My Documents

Else, you can copy the folder to the ActiveSync folder you created on your desktop. The files will automatically be sync'ed to the Ultra-Rugged Field PC.

Data file management between the Ultra-Rugged Field PC and a computer is handled by the supplied ActiveSync software (see section 6.1). This allows the mirroring of information on both the PC and the Ultra-Rugged Field PC. It makes file sharing easy and efficient between the two platforms. However, the normal synchronization process does not back up the data, it only reflects the current programs found on the Ultra-Rugged Field PC. An easy way to backup the data is to always copy synchronized information to a safe location on your desktop PC or network server.

11 ULTRA-RUGGED FIELD PC BATTERY

It is recommended that whenever the Ultra-Rugged Field PC is not being used in the field, it should be on charge. This ensures that the Ultra-Rugged Field PC is always ready to be used in the field. A flashing red light on the front of the Ultra-Rugged Field PC confirms that the battery is being charged. A solid red light indicates that the batteries are at full charge.

Battery status can be checked within Windows Mobile:

1. Under the *Start* menu, choose *Settings.*
2. Touch the *System* tab at the bottom of the screen.
3. Touch the icon labelled *Power*.

The *Power* screen indicates the status of the main battery and the current power settings. The backlight and auto turn-off can be adjusted to conserve power.

The Ultra-Rugged Field PC should be charged on a regular basis. Whenever not in use, the Ultra-Rugged Field PC should be on charge using one of the supplied chargers to maintain a full charge on its battery. The Ultra-Rugged Field PC will warn the user when its battery is getting low. In situations where AC power is not available, use the DC adapter (Figure 1, item 9) to charge the Ultra-Rugged Field PC in the field.

12 CARE AND MAINTENANCE

12.1 PROBE & REEL CONNECTORS

Proper care and maintenance of the digital probe and reel connectors will ensure trouble-free operation of the Digital Inclinometer System. The following guidelines should be strictly adhered to. Failure to adhere to these guidelines can result in premature connector wear, and ultimately connector failure.

- Ensure the keyway is aligned before threading the connector together.
- Never over-tighten the bulkhead connectors when mounting. Snug (hand-tight) is more than sufficient.
- Only twist the brass coupling on the connector, do not twist the signal cable itself.
- Avoid sharp bends at the cable entry to the connector.
- Clean the plugs and receptacles with a mild soap and fresh water on a regular basis. Do not allow the connectors to get excessively dirty.
- Rinse out with alcohol, allowing the connector to air dry. Replace dust caps, once the connector is dry.
- On a regular basis, lubricate the mating surfaces with the **supplied silicone spray**. The supplied product is *3M Silicone Spray part # 6204678-4930-3*. **DO NOT GREASE and avoid the use of any solvent based lubricants.**
- Amount of silicone spray used should be based on the frequency of use of the probe. One light spray to cover all contacts is enough after cleaning of the connector. Ensure the connector is clean and dry before applying the silicone spray.
- Elastomers contained in the connector can be seriously degraded if exposed to solvent, direct sunlight or high ozone levels for extended periods of time. Always replace dust caps once the connector is clean and dry.
- Always keep the dust caps clean and free of any foreign materials. Do not place the dust caps where they have the potential to become contaminated.
- Always use the dust caps and keep the connectors clean to prevent damage in storage and when in use.

Warning

In no case should solvent-based lubricants (such as WD-40) be used as a lubricant on the connectors. These products will damage the elastomers in the connectors resulting in loss of communication with the digital probe. **ONLY use the supplied silicon lubricant or RST approved equivalent.** If ever in doubt or any questions arise, do not hesitate to contact RST Instruments for further information.

12.2 INCLINOMETER PROBE

The digital inclinometer probe consists of high-grade stainless steel components and is completely sealed. After the survey is complete, wipe all moisture off the probe and replace the protective caps over the connectors. If required, rinse the probe in clean water and dry. If the probe is exceptionally dirty, use a mild soap and fresh water to clean. *Never use solvents to clean the probe and connectors*.

Always store the probe in its original case whenever it is not in use. The high precision accelerometers in the probe can be damaged if the probe is subjected to excessive shock or vibration. Keep both the probe and its case clean and dry. If the probe is not cleaned and dried in the field, be sure to clean and dry it (including the case) upon return to the office. It is good practice not to leave corrosive solutions (i.e. salt water) on the probe, connectors and cable, be sure to clean the parts if these conditions exist.

The probe wheels are made with high-grade hardened and heat-treated stainless steel. These are the most robust on the market and are extremely durable. The wheels contain sealed bearings which require no maintenance except keeping them clean and dry.

12.3 REEL AND CABLE

If required, wipe the cable with a clean rag to dry it off. The cable has a durable polyethylene jacket, simply use water and a mild soap to clean it off if necessary.

12.4 READOUT UNIT

To keep the Ultra-Rugged Field PC in good condition and working properly, please adhere to the following guidelines:

- Keep the Ultra-Rugged Field PC away from excessive moisture and extreme temperatures. Do not expose the Ultra-Rugged Field PC to liquids or precipitation. The supplied *Rugged Field PC* meets the IP54 standard for water and dust resistance, as well as being impact-resistant if dropped up to four feet from the ground.
- Do not place anything on top of the Ultra-Rugged Field PC to prevent damage to the screen.
- Clean the unit by wiping the screen and the exterior with a soft, damp cloth moistened only with water.
- Avoid exposing the Ultra-Rugged Field PC to direct sunlight or strong ultraviolet light for extended periods of time. Also avoid scratching the surface of the screen and banging it against hard objects.
- Only use the Ultra-Rugged Field PC stylus to prevent scratching the screen.

For further reference please see the supplied manufacturer's manuals for the Ultra-Rugged Field PC.

12.5 CALIBRATION

RST strongly recommends that the probe be sent in for calibration annually. Due to the high precision nature of the sensors and the sensitivity of the probe, calibration must be done to ensure quality results and continued performance of the probe. Heavy use in adverse conditions may require calibrations to be done more often.

Calibration should also be performed if the probe has been dropped or become damaged in any way. If checksums become significant and they are not due to errors in probe positioning or noise, the probe likely needs to be re-calibrated.

Calibration should also be performed after any wheel assembly replacement.

12.6 STORAGE & BATTERY LIFE

The Ultra-Rugged Field PC included with the Digital Inclinometer System has a limited battery life. In this regard, it is important to keep the unit charged, otherwise it loses any peripheral programs which are installed on it. This includes the RST Digital Inclinometer Program. Please refer to section 11 for more information on the Ultra-Rugged Field PC Battery.

Even if the Ultra-Rugged Field PC is turned off, it still consumes power. Therefore if left “on the shelf” and unused, it will eventually deplete its batteries. The Ultra-Rugged Field PC should be charged on a regular basis. Whenever not in use, the Ultra-Rugged Field PC should be on charge using one of the supplied chargers to maintain a full charge on its battery

13 TROUBLESHOOTING

Cannot connect to reel:

- Check the status of the Bluetooth Manager (see section 16). If the icon is not present on the desktop, launch the Bluetooth Manager software under the *Start* menu.
- Make sure that the Bluetooth radio is turned on (Figure 41).
- Exit the Digital Inclinometer software and cycle the power on the reel. Re-start the software and allow it to automatically make the connection to the probe. If this fails, repeat the procedure, this time giving the Ultra-Rugged Field PC a soft reboot (by pressing the power button for about 10 seconds until the screen goes dark).
- Follow the instructions outlined in section 16.1, Changing the Reel. This section outlines how to search for Bluetooth devices and establish a new connection.

Cannot connect to the Probe:

- Check the threaded electrical connection between the probe and the reel.
- Ensure that the connector is clean.
- Check the connector for damage.

Cannot connect a desktop PC to the Ultra-Rugged Field PC:

- Check physical connections between the PC and Ultra-Rugged Field PC.
- Microsoft ActiveSync only allows full synchronization between two different PC's and a single Ultra-Rugged Field PC. Ensure you are not trying to make more than two of these types of connections. However, manual data transfer can be accomplished on any PC running the ActiveSync Software. Simply choose not to sync to the Ultra-Rugged Field PC when prompted to do so (please refer to the Ultra-Rugged Field PC reference manual CD-ROM, for further information).

Readings fluctuate and/or are noisy:

- Ensure probe placement is within 4 mm (0.25") at each depth.
- Increase the averaging of the readings (section 4.2.6)
- Do not perform inclinometer surveys when heavy equipment is moving around the borehole. Choose "quiet" times.

Reset or turn off the Ultra-Rugged Field PC:

- Hold down the power button for about 10 seconds. A menu appears.
- Tap Reset or Power Off, then tap OK or Cancel if you are powering off.

Manually reset the Ultra-Rugged Field PC:

- In order to completely re-boot the Ultra-Rugged Field PC, hold down the power button for 10 seconds or until the screen goes dark. The Ultra-Rugged Field PC resets after a few seconds Refer to the Ultra-Rugged Field PC user manual for further information.

14 CONTACT US

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15 SYSTEM SPECIFICATIONS

Inclinometer	
Wheelbase	0.5 m (24 inches)
Probe Length Including Connector	710 mm (28 inches)
Probe Diameter	25.4 mm (1.00 inch)
Probe Weight	1.4 kg (3.0 lbs.)
Probe Material	Stainless Steel
Memory	> 1 000 000 readings
Displacement Error	±2 mm per 25m (±0.1 in. per 100 ft.)
Temperature Rating	-40 to +70°C (-40 to +158°F)
Data Resolution	0.005 mm per 500 mm (0.00002 ft. per 2 ft.)
Full Scale Range	±30 °
Repeatability	±0.002°
Axis Alignment	Digitally Nulled
Ultra-Rugged Field PC²	
Water Proof	IP68
Rugged Case	1.5 m or 5' drops onto concrete
Operating Temperature	Optimized for excellent performance in cold temperatures Operating temperature: –22F to 140F (–30C to 60C) Note: Bluetooth® wireless technology is rated to –4F (–20C)
Processor	1.0GHz ARM Cortex A8 i.MX53 processor
Memory	512 MB DDR2 RAM
Internal Flash Disk	8 GB
Operating System and Software	Microsoft® Windows Embedded Handheld 6.5.3 Microsoft Office Mobile 2010* (Word Mobile, Excel Mobile, PowerPoint Mobile, Outlook Mobile) Multiple languages (English, French, Spanish, German, Portuguese) Adobe Reader® LE
Battery	Intelligent Li-Ion battery 3.7VDC @ 10600mAh,38.7Whr Operates for up to 20 hours on one charge Charges in 2 to 4 hours Battery easily changeable in field
Wireless Connectivity Options	Bluetooth® wireless technology, 2.1 +EDR, Class 1.5, range greater than 100 feet (30m) Wi-Fi® 802.11b/g/n with extended range
Certifications and Standards	FCC Class B CE Marking (applicable EMC, R&TTE, and LVD directives) Industry Canada EN60950 Safety
Cable	
Cable Diameter	6.4 mm (0.25 inches)
Cable Weight	2.3 kg/50 m (3.1 lbs./100 ft.)
Cable Tensile Strength	5.9 kN (1325 lbs.)
Cable Jacket	Polyurethane
Cable stretch suspended in 30m dry borehole	4 mm (0.16 inches)
Cable Reel	
Up to 75 m cable reel diameter	310 mm (12.2 inches)
100 to 200m cable reel diameter	380 mm (15 inches)
+225m cable reel diameter	460 mm (18 inches)
Reel weight with 75m (246') cable	5 kg (11 lbs.)

16 BLUETOOTH COMMUNICATION

The Ultra-Rugged Field PC uses Bluetooth technology to establish a wireless radio link between the readout unit and the inclinometer reel. To verify the status of the Bluetooth connection, touch the Bluetooth icon located on the opening screen of the Ultra-Rugged Field PC desktop. Please note that the Ultra-Rugged Field PC is continually undergoing updates and the Bluetooth configuration screens may vary slightly from those shown.

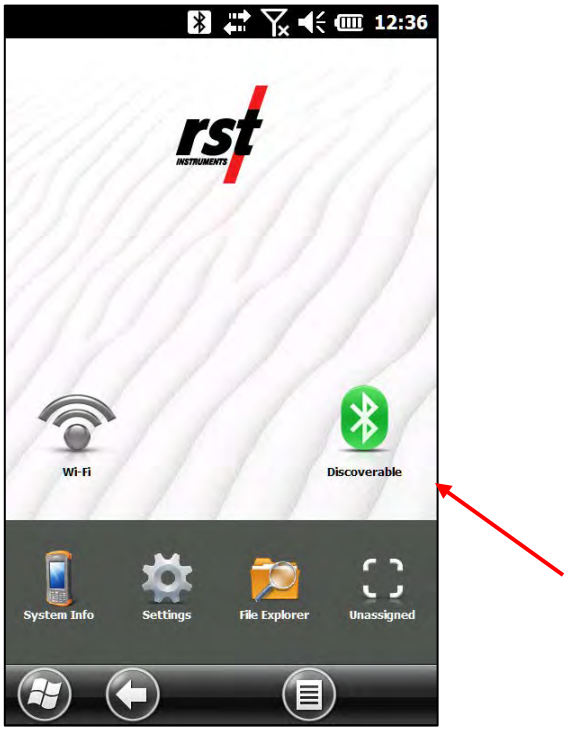


Figure 39 – Field PC Wireless Icon

Clicking on the Field PC Wireless icon opens the following screen:

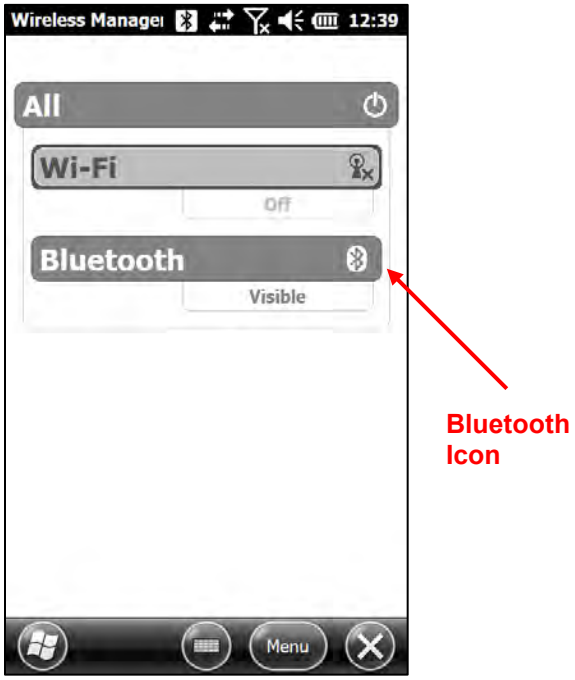


Figure 40 – Field PC Wireless Main Menu

Press the Bluetooth icon to turn on the Bluetooth Radio. Clicking on the *Bluetooth Settings* under *Menu* opens the following screen:

Figure 41 – Bluetooth Options

The user has the option of turning the Bluetooth radio on and off and can use the Devices tab to view the current Bluetooth devices within the vicinity of the Ultra-Rugged Field PC. In general, the user is not required to edit any of these settings because the RST Digital Inclinometer software will automatically search and connect to the reel and probe supplied with the system.

16.1 CHANGING THE REEL

Should the situation arise where the reel needs to be changed, the inclinometer software and the Bluetooth radio need to be reconfigured to recognize the new reel. To change which device the inclinometer software connects to, launch the RST digital Inclinometer software. From the *Main Menu Screen* (Figure 10) touch the *Connections* menu and choose *Bluetooth…* The following screen will appear:

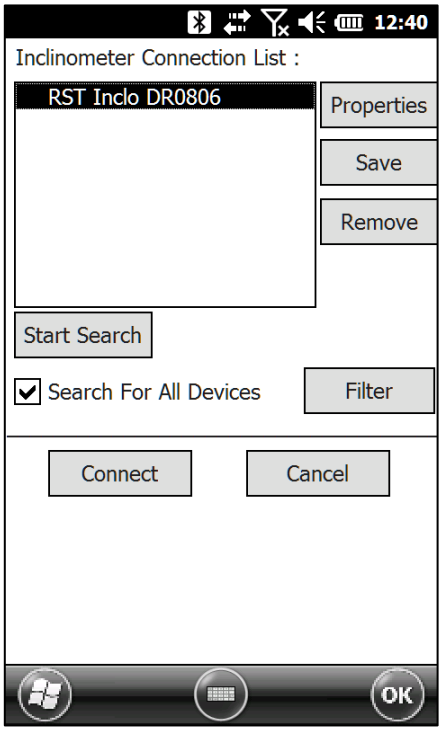


Figure 42 – Inclinometer Connection List

The current inclinometer connection list that the software recognizes is displayed. To search for any new devices, press the *Search* button. The window gives the option of searching for all Bluetooth devices, or filtering for only certain types of devices. Press the *Filter* button to specify which devices to search for (i.e. filter by name). Once a device is discovered (this may take a few moments) an "F" will appear to the left of the device if it is currently in the existing list, indicating that it was found. An "N" will appear if a new device is found.

If the user wishes to add a new inclinometer reel to the list, search for this device first and then press the *Save* button once the device is discovered. This saves the new reel in the list so that the software recognizes it the next time the Digital Inclinometer software is launched. To specify which device the software connects to, simply highlight which one you would like in the list and press *Connect*. You can remove any devices from the list by pressing the *Remove* button.

Pressing the *Properties* button invokes the following screen:

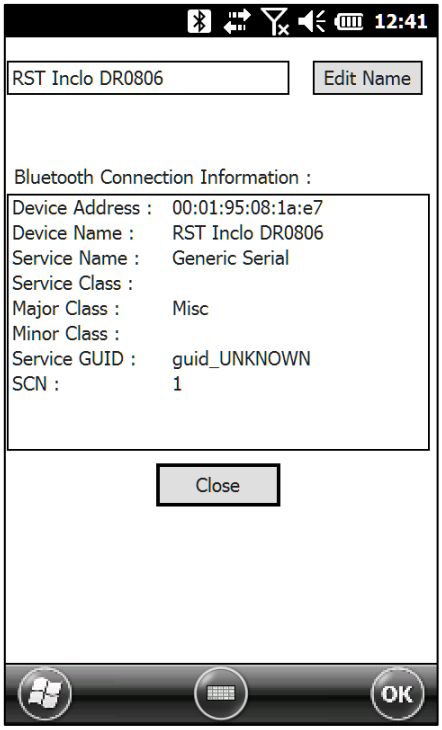


Figure 43 – Inclinometer Reel/Bluetooth Properties

This option allows the user to change the name of Reel if desired. This is simply an identification name that the software uses to distinguish between different devices. The Bluetooth Connection Information is detailed information for use by RST and in most cases is not important for the user.

17 IMPORTING AND EXPORTING FILES

17.1 SAVING AND IMPORTING INCLINOMETER DATA INTO SLOPE INDICATOR SOFTWARE

The RST Digital Inclinometer Program has the ability to save data in the *.rpp format which is able to be imported into Slope Indicator's Management software (DMM for Windows). This allows the user to compare data sets taken with the Digitilt System and RST's Digital Inclinometer.

Note

Whenever comparing data between two different systems it is **Extremely Important** that the probe be placed at the same depth for both systems. RST and SINCO instruments use a different reference at the collar of the borehole. You must ensure that placement of the probe is within 5mm (0.25") or the data will be difficult to compare. Please also refer to section 8.

To ensure that the survey is being saved in the correct format, select **RPP Format** from the data filename options screen (see Figure 15). This Data Filename Options screen is found by navigating through *Edit Borehole>Data Filename…* For further information regarding editing a borehole please refer to section 4.2.4.

Once the survey of the borehole is complete, return to the office and connect the Ultra-Rugged Field PC to your desktop computer using Microsoft ActiveSync. Using Windows Explorer, copy the data to a safe location.

Importing a *.rpp file into DMM for Windows:

1. Launch the DMM for Windows application.
2. Either create a new project database or open an existing database in which you would like to place the inclinometer data.
3. Under the *File* menu, select *Import* and then choose *Import RPP File*.
4. Navigate to the location in which you saved the *.rpp file created by the RST Digital Inclinometer Program. Click *Open.*

DMM for Windows will then bring the *.rpp into the database. The database can now be saved as a *.mdb (Microsoft Access) file. The new *.mdb file can also be accessed by Slope Indicator's DigiPro software.

For additional information on DMM for Windows and DigiPro software, please consult the appropriate documentation provided with Slope Indicator's software.

17.2 USING SLOPE INDICATOR DATA WITH INCLINALYSIS

Slope Indicator files (in *.rpp format) can be directly imported into RST Inclinalysis Software. Please refer to the Inclinalysis Manual for further information (included on the Digital Inclinometer Support CD).

17.3 IMPORTING INCLINOMETER DATA INTO GTILT

Standard RST Format Inclinometer files (*.csv) and Standard RST (*.dty) files (section 4.2.5) can be imported into GTilt by performing the following steps:

1. Start GTilt
2. Select *File - New*
3. Select *File - Import - DT/DTY or DT and DTX Data*
4. Navigate to the directory containing the RST data files
5. Change *List File Types* to *All Files (*.*)* from *DT & DTY (*.DT)*
6. Select data file to import (*.csv or *.dty format)
7. Repeat steps 3 to 6 until all files for this borehole have been imported
8. Select *File - Save As* Input file name for this site and borehole
9. Select *Edit - Main header* - Insert 0.5 into Shallowest rdg Depth
10. Select *Edit - Main header* - Insert 2500 into Probe Sensitivity

Note

The *.csv files can also be opened directly in Excel, however, **do not save the files in *.csv format from Excel.** This will change the format of the file and you will no longer be able to import the file into GTilt. Always backup your data.

Note

The inclinometer program also allows the option to save the files in *.rpp format (section 4.2.5). GTilt also recognizes this format and the files are imported in a similar fashion as described above.

Appendix A CHANGING THE BATTERY (FOR REELS WITH SERIAL NUMBERS UNDER 2500)

Batteries inside reels with serial numbers under 2500 may be removed for recharging. The reel uses a 7.4V lithium-ion camcorder battery. The system comes with a battery housed inside the reel and a charger. Adapters are supplied to allow the charger to function in a vehicle (12V DC), or 110-240V AC power (see Figure 1). It is also highly recommended that the Reel batteries be kept at a state of full charge whenever the probe is not in use.

To remove the battery, simply unscrew the cap off the reel hub by turning it counter-clockwise (Figure 44).

Figure 44 – Battery Removal / Installation

Remove the battery and place on the Mach 1™ Speed Charger.

Mach 1 Speed Charger Operating Instructions

Status LED's

Together, the three LED's on the front of the Mach 1 charger will indicate the status of the battery and the charger. The descriptions and diagrams included in the following sections describe the various indicators and their meaning.

Standby Mode

Without any battery installed, the charger will flash the LED on the left, marked *MED*, indicating that the charger is standing by and waiting for a battery to be connected.

STANDBY	FLASHING	OFF	OFF
	MED	HI	MAX

Figure 45 – Standby Mode

Once a battery has been properly connected to the charger, it will determine the status of the battery and begin the proper phase of the charging cycle. There are 3 phases to the charge cycle. The battery may be removed during any of the charging phases without harm to the battery or charger unit.

Phase I – Initial Charge

All 3 LED's flashing in sequence from *MED* (left) to *MAX* (right). If the battery is low, this will be the first charge phase. With high capacity batteries, this phase can sometimes be the longest of the 3 phases. Similarly, with some low capacity batteries and batteries reaching the end of their life, this phase can be very short.

	MED	HI	MAX
LED's Phase I	Sequential Flashing	Sequential Flashing	Sequential Flashing

Figure 46 – Initial Charge

Note: When the battery is first connected, the LED's may instantly indicate *MED, HI* or *MAX* charge depending on the charge status of the battery. The process will continue normally from that point forward.

Note: It is normal for the charger, AC adapter, or the battery to become warm during charging.

Phase II – MED Charge

The *MED* LED is on continuously and the other LED's are flashing in sequence. At this point the battery is typically about 50% charged. Some very small capacity batteries (650mAh) and worn out batteries can be as low as 10% charged.

	MED	HI	MAX
LED's Phase II	ON	Sequential Flashing	Sequential Flashing

Figure 47 – MED Charge

Phase III – HI Charge

The *MED* and *HI* LED's are on and the *MAX* LED is flashing. At this point the battery is typically about 70% charged.

	MED	HI	MAX
LED's Phase II	ON	Sequential Flashing	Sequential Flashing

Figure 48 – HI Charge

Charge Complete – MAX Charge

All three LED's are on at the same time. Charging has completed and the battery is fully charged. It is recommended to remove the battery at this time.

	MED	HI	MAX
Charge Complete	ON	ON	ON

Figure 49 – MAX Charge

Error Condition – Charge Terminated

If the battery is removed before a complete charge has been reached, **the charger will continue indicating the last complete charging phase for up to 1 minute.** After that time, an "Error" indication will appear on the LED's, shown by the *MED* and *MAX* LED's coming on together while the *HI* LED is off.

	MED	HI	MAX
Error Condition	ON	OFF	ON

Figure 50 – Error in Charging

The Error Condition will also be indicated if the charger senses and problem with the battery being charged. To reset the error condition, unplug the charger from the power adapter for a few seconds, and then reconnect it. If the Error occurs again, there may be a defect in the battery that will prevent safely charging.

Charging Time

The 7.4V 2200mAh Lithium-Ion batteries supplied with the inclinometer system will take approximately 80 minutes to fully charge if they are depleted.

Note
RST strongly recommends that all batteries should be taken out into the field fully charged at the beginning of each day.

Be aware that cold temperatures can also have an effect on the performance of the batteries. Expect a somewhat shorter operation in extremely cold temperatures. Under adverse conditions, it is recommended that extra batteries be taken to the field, where one can be charging in between readings of several boreholes. The reel batteries are a standard camcorder battery and are readily available.

Note
The batteries will self discharge when not in use whether they are installed in the inclinometer reel or not. Batteries can be kept fresh if recharged on a regular basis.

Upon replacement of the battery, ensure to align the battery contacts with the contacts in the Reel hub to allow proper operation. Installation is the exact opposite of removal. Please ensure that the battery contacts line up with the contacts contained within the hub for correct operation.

Battery Life

A single Reel battery has the ability to last for up to 1 week on standby mode (i.e. no connection to the Ultra-Rugged Field PC). However, it is a good practice to turn off the Reel power whenever the survey is complete, as leaving the power on will eventually drain the battery. At room temperature, while taking readings, battery life is approximately 30 hours. In extreme environmental conditions (extreme cold or hot temperatures) fully expect useable battery life to decrease. Therefore it is always a good practice to take 2 or more fully charged batteries out in the field before performing inclinometer survey work.

APPENDIX B

Instrumentation Data Sheet Examples

Vibrating Wire Piezometers

PIEZOMETER ID:	PZ-XX-XX	**COORDINATES (ft):**	**Northing:**	XX,XXX,XXX	**LOCATION NOTES:**
DATE INSTALLED:	DD/MM/YYYY		**Easting:**	X,XXX,XXXX	
DEPTH (ft, bgs):	10.0	**GROUND SURFACE ELEVATION (ft):**		3600.0	
MANUFACTURER:	RST	**ELEVATION CORRECTION (psi):**		1.90	
MANUFACTURER PART #:	VW2100	**MANUFACTURER SN:**		XXXXXX	**RANGE (psi):** 100

MANUAL ABC FACTORS: A = -0.000019305 B = 0.01007729 C = 118.67

TEMPERATURE CORRECTIONS: m = 0 b = 0 offset = 0

Reading Date (MM/DD/YY)	Measured HZ	Measured Temp.	Pressure psi	Temp Correction	Altitude Correction	Corrected Pressure psi	Head on Piezo. ft	Piezometric Elev. ft	Notes
1/1/2021	2782.2	26.6	-2.729	0.000	1.899	-0.830	-1.92	3588.1	Intital Reading On-ground
									Reading after burial - install check
									Initial w/ Portable Readout - install check
									Initial w/ Datalogger

Survey Monuments

MONUMENT ID: SMX-XX
DATE INSTALLED: DD/MM/YYYY

MONUMENT COORDINATES (ft): **Northing:** XX,XXX,XXX
Easting: X,XXX,XXXX
Elevation: 3600.0

LOCATION NOTES:

Survey Data				Elapsed Time		East Movement (in)		North Movement (in)		Vert. Movement (in)		Horiz. Movement (in)		Movement Vector: XYZ (in)		Movement Vector: Bearing (°)		Movement Vector: Dip (°)		Velocity		
DATE	East	North	Elev.	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Incremental	Cumulative	Daily	Cumulative	Inverse Cumulative
44,197.00	15,866,537.00	1,544,596.00	3,593.40	0.00	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.000	0.000	0.000	0	0.000	90	0.000	0.00	0.00

Inclinometers

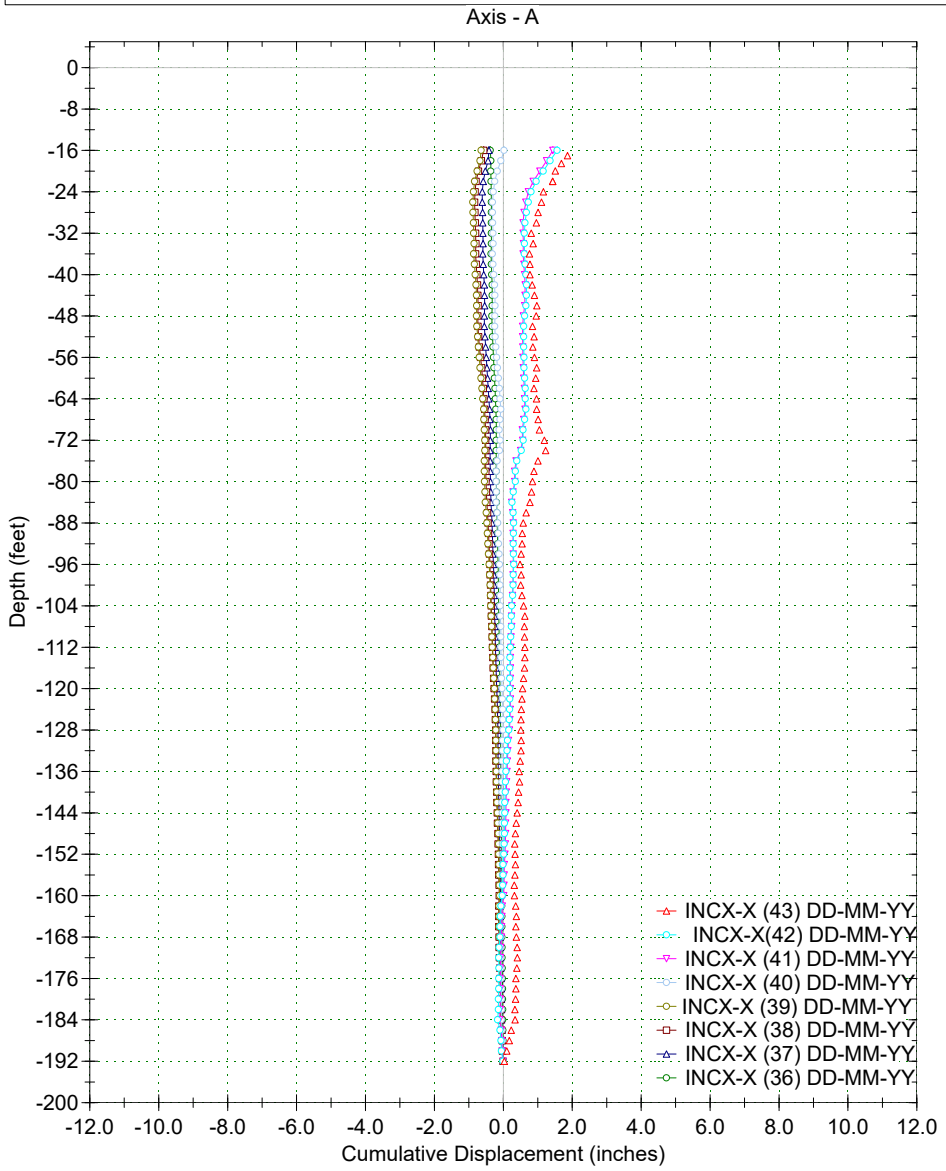
RST Instruments Ltd.

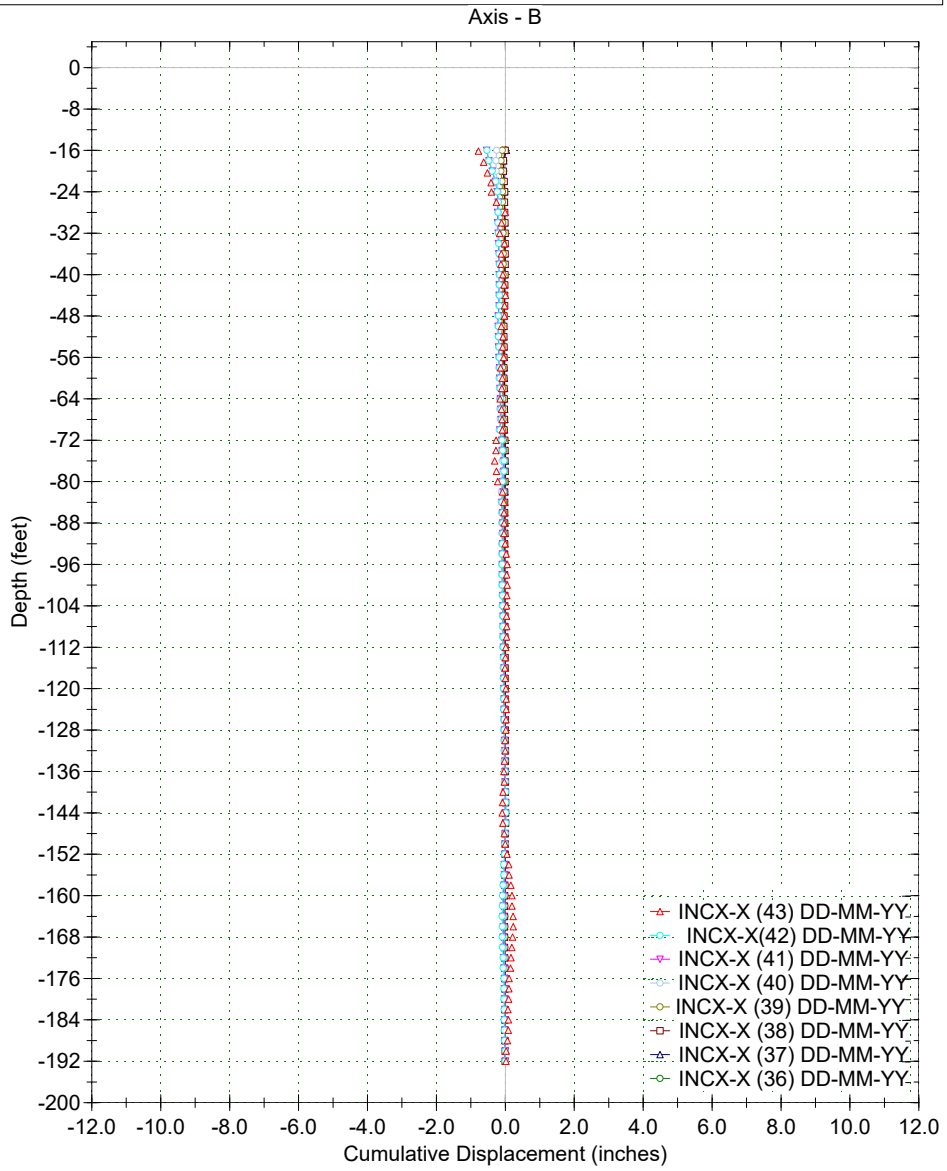
CUMULATIVE DISPLACEMENT

Inclinalysis v. 2.48.4

Borehole : INCX-X
Project : Grassy Mountain TSF
Location : Embankment Crest
Northing : XX,XXX,XXX
Easting : X,XXX,XXX
Collar : -

Spiral Correction : N/A
Collar Elevation : 0.0 feet
Borehole Total Depth : XX.X feet
A+ Groove Azimuth : XXX
Base Reading : YYYY MMM DD mm:ss
Applied Azimuth : 0.0 degrees





Visual Inspection Checklist Example

CHECK LIST FOR SITE INSPECTOR

FORM 1 – GENERAL INFORMATION

(This page must be completed by the inspector before entering project area)

1. General Information

Inspector Name: _____ Employee ID: _____

Date: _____ Expected Start Time: _____

Weather: _____ Temperature: _____

Location of Inspection: _____

_____

2. Equipment

- Safety Equipment: ☐ Safety Boots ☐ Hard Hat ☐ Safety Glasses
- ☐ First-Aid Kit ☐ Others (specify)_____
- Communication: ☐ Radio (Channel_____ Emergency No.: ____) ☐ Battery Checked
- ☐ Others (specify)_____
- Transportation: ☐ 4WD Vehicle ☐ Gas Checked
- Monitoring Equipment: ☐ For Monument ☐ For Inclinometer ☐ For Piezometer / Settlement Cell
  ☐ Tape Measure ☐ Others (specify)_____

3. Job Functions/Tasks

☐ Check the condition of monitoring equipment and monitoring points

☐ Observe surface water conditions (if any)

☐ Inspect for changes in ground surface and slope features

☐ Report the findings to the superintendent

☐ Others (specify)_____

Signature:_____ Time:_____ Date:_____

CHECK LIST FOR SITE INSPECTOR

FORM 2 - VISUAL INSPECTION SHEET FOR INSTRUMENTS AND SLOPE FEATURES

Check Point	Observation		Explanations	Action Taken		Notes
	Yes	No		Notification	Measure	
a. Is the investigation and instrumentation site accessible?	☐	☐	If "No", describe problem	☐	☐	Optional
b. Large scale change of topography?	☐	☐	If "Yes", describe location and magnitude	☐	☐	Optional
c. New cracks, bulges, or sag ponds on the ground?	☐	☐	If "Yes", describe location, direction and size	☐	☐	Optional
d. Tilting of structures or trees?	☐	☐	If "Yes", describe location and tilting degree	☐	☐	Optional
e. Malfunction of TSF?	☐	☐	If "Yes", describe location and magnitude	☐	☐	Optional
f. New seeps or springs?	☐	☐	If "Yes", describe location and/or direction	☐	☐	Optional
g. Disturbance of animals?	☐	☐	If "Yes", describe the phenomena	☐	☐	Optional
h. Disturbance / Damage of Instruments?	☐	☐	If "Yes", describe the ID and phenomena	☐	☐	Optional
i. Suspicious Readings of Instruments?	☐	☐	If "Yes", describe the ID and phenomena	☐	☐	Optional
j. Silting or Sedimentation of Underflow monitoring?	☐	☐	If "Yes", describe the ID and phenomena	☐	☐	Optional

Other Information

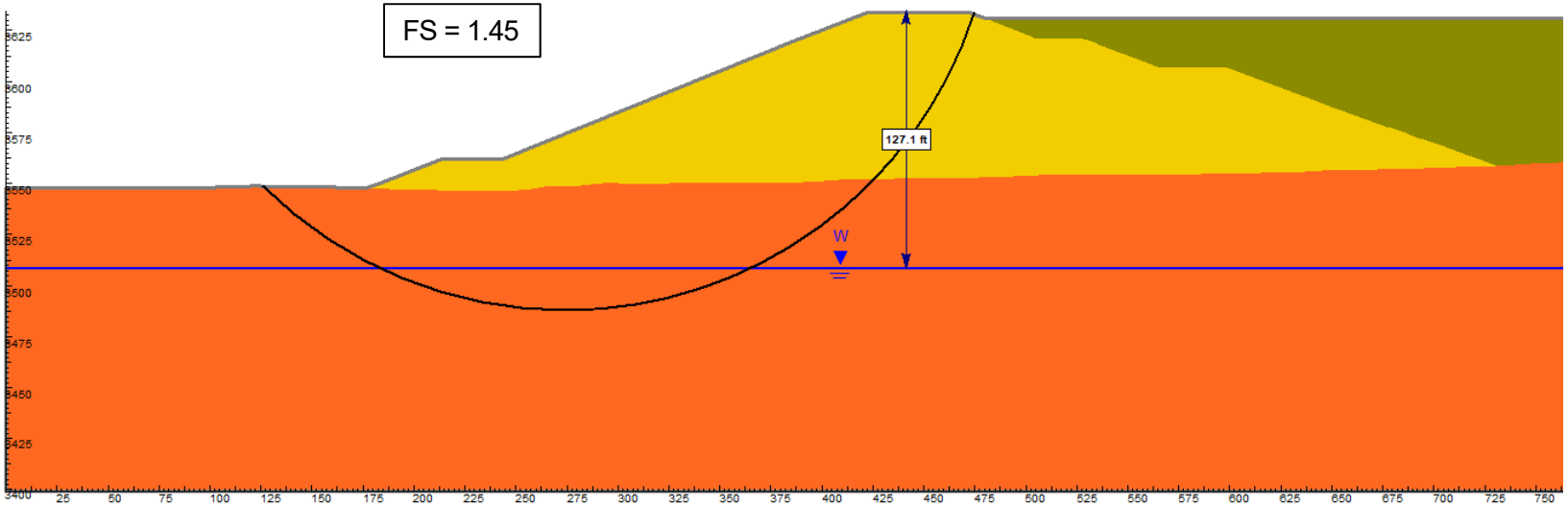
_____

_____

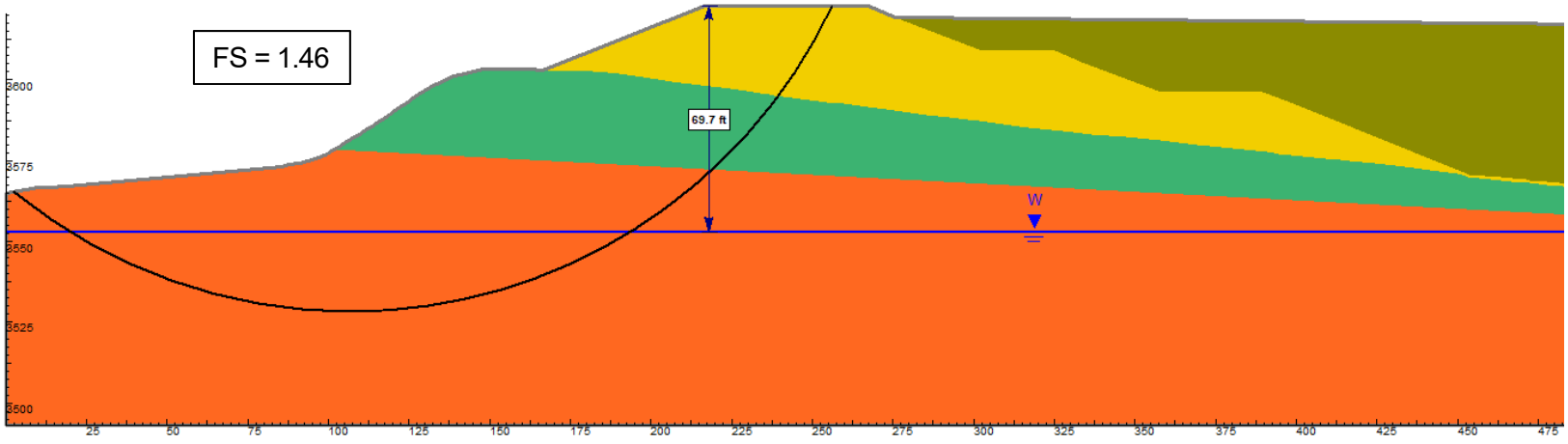
Signature: _____ Date: _____

APPENDIX C

VW Foundation Piezometer Trigger Level Stability Analyses



NORTH EMBANKMENT – TRIGGER LEVEL 1



WEST EMBANKMENT – TRIGGER LEVEL 1

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		125	Mohr-Coulomb	0	32
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

CLIENT
CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

YYYY-MM-DD	2019-10-29
PREPARED	JRP
DESIGN	MDB
REVIEW	CJM
APPROVED	RAB

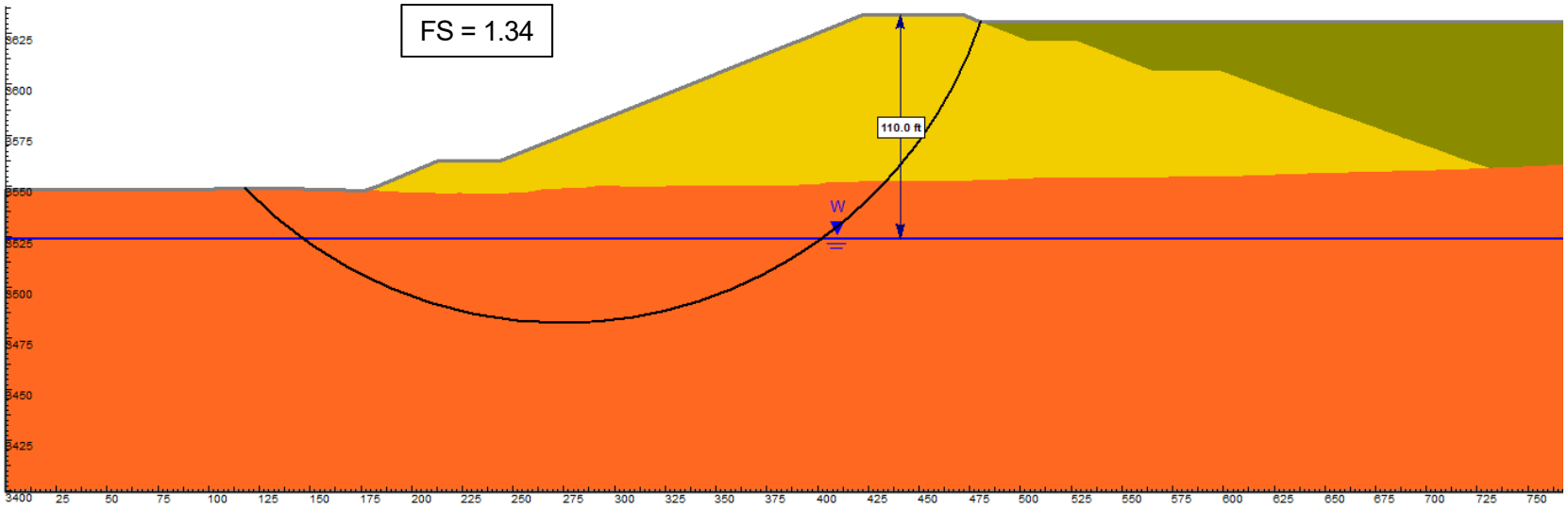
PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL MONITORING PLAN
APPENDIX C – STABILITY ANALYSIS
TRIGGER LEVEL 1

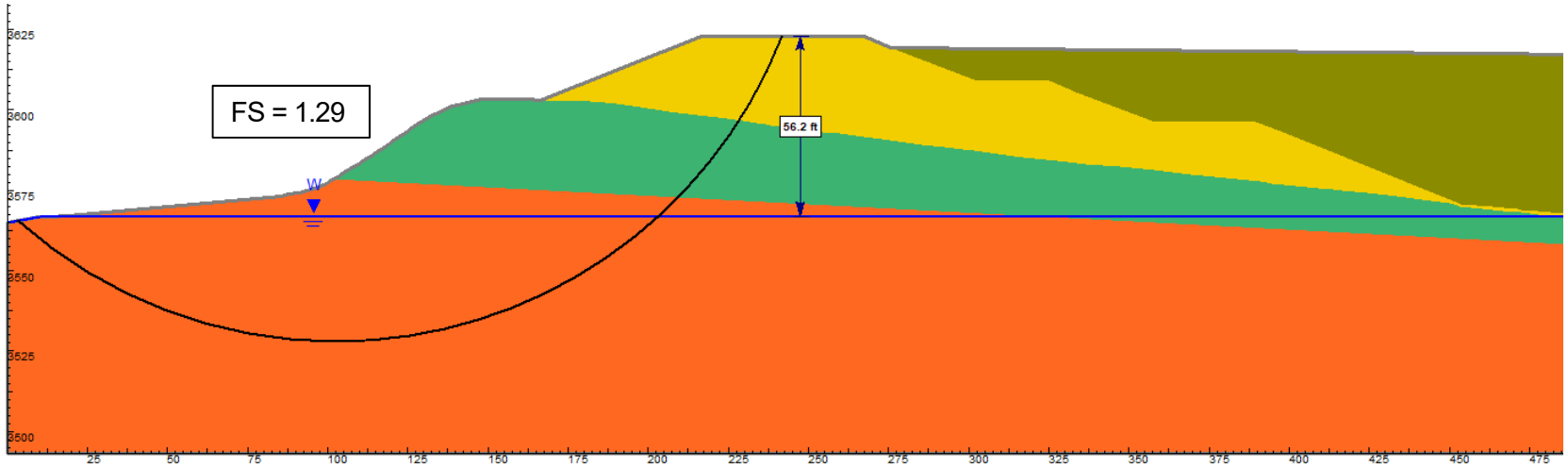
PROJECT No.
1663241

FIGURE
1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



NORTH EMBANKMENT – TRIGGER LEVEL 2



WEST EMBANKMENT – TRIGGER LEVEL 2

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		125	Mohr-Coulomb	0	32
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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MALHEUR COUNTY, OREGON

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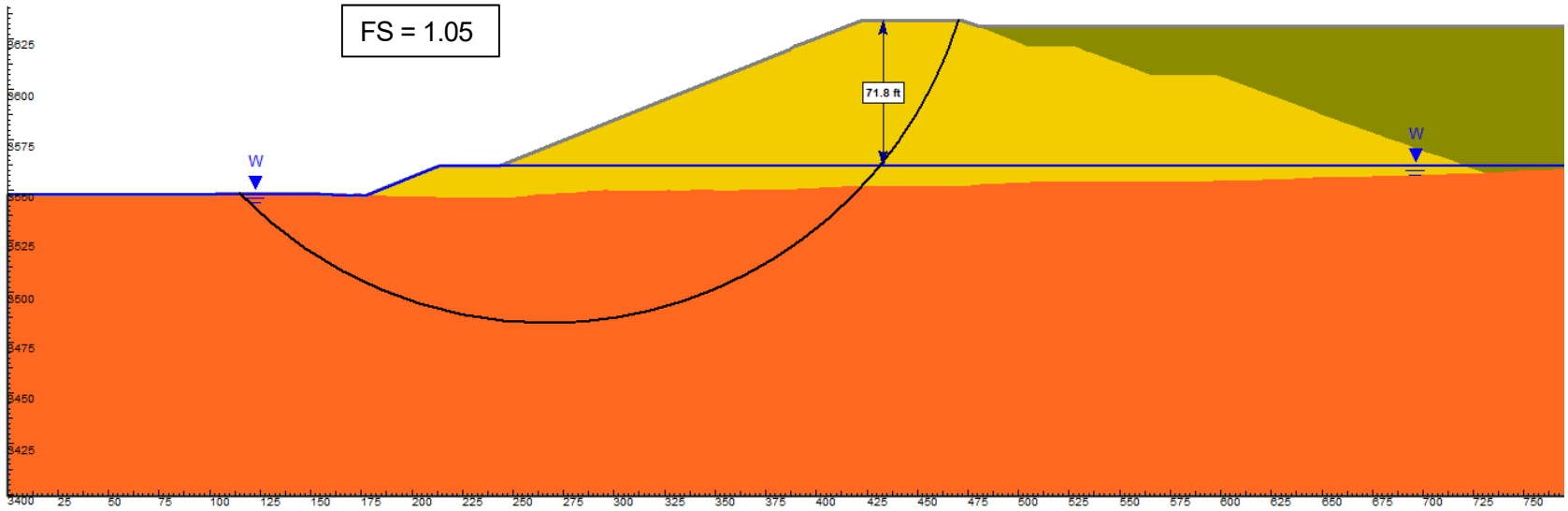
PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL MONITORING PLAN
APPENDIX C – STABILITY ANALYSIS
TRIGGER LEVEL 2

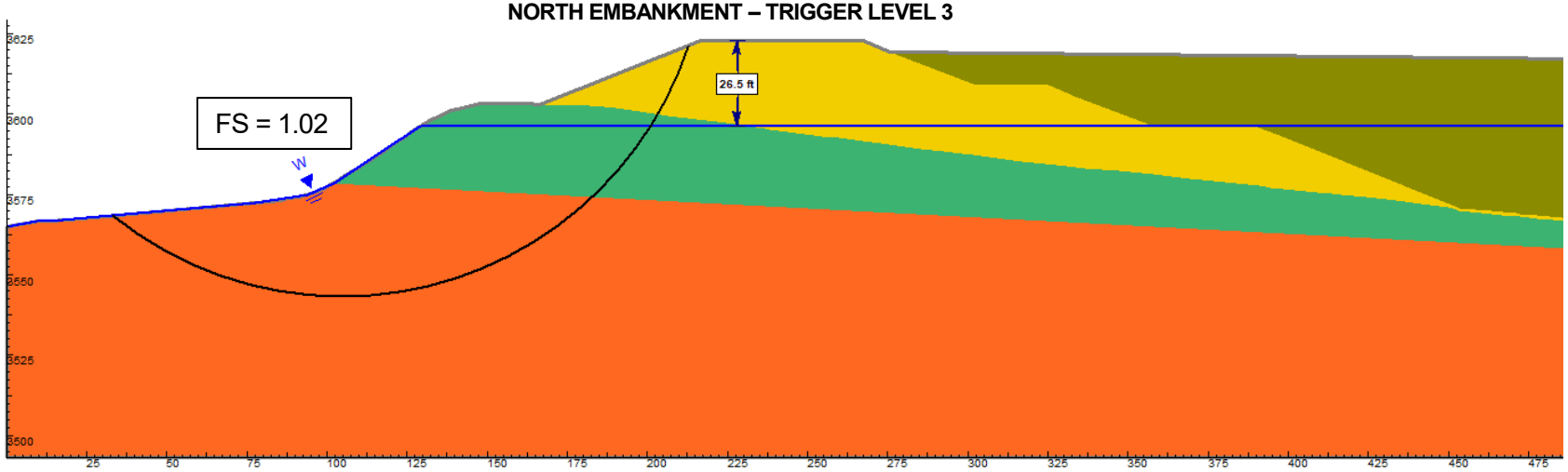
PROJECT No.
1663241

FIGURE
2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



NORTH EMBANKMENT – TRIGGER LEVEL 3



WEST EMBANKMENT – TRIGGER LEVEL 3

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Embankment Fill		135	Mohr-Coulomb	0	40
Alluvium		125	Mohr-Coulomb	0	32
Clay		120	Mohr-Coulomb	315	14
Tailings		95	Mohr-Coulomb	0	15

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CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

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GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY AND WASTE ROCK DUMP
DETAILED DESIGN

TITLE
GEOTECHNICAL MONITORING PLAN
APPENDIX C – STABILITY ANALYSIS
TRIGGER LEVEL 3

PROJECT No.
1663241

FIGURE
3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0

golder.com

APPENDIX L

Dam Breach Modeling

November 6, 2019 Project No. 1663241-051-L-Rev0

Ms. Nancy Wolverson
Calico Resources USA Corp
665 Anderson St.
Winnemucca, Nevada 89445

DAM BREACH INUNDATION ANALYSIS
TAILINGS STORAGE FACILITY (TSF)
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

Dear Ms. Wolverson,

This letter presents the results of the dam breach inundation analysis performed by Golder Associates, Inc. (Golder) for Calico Resources USA Corp.'s (Calico's) proposed tailings storage facility (TSF) at the Grassy Mountain Project located in Malheur County in southeastern Oregon.

Golder has completed a detailed engineering design for the Grassy Mountain TSF which is included in the Consolidated Permit Application as Appendix C. The purpose of this inundation analysis is to evaluate the failure consequence, not probability of failure. This simulated dam breach scenarios presented is considered a worst-case scenario and is not a reflection of TSF embankment stability or integrity of the TSF.

1.0 INTRODUCTION

The dam breach inundation analysis was completed in accordance with the Water Resources Department, Oregon Administrative Rules, Section 690-020-0120. The results of this analysis will be incorporated into a facility-specific Emergency Action Plan (EAP) prepared prior to construction of the facility.

It is important to note that the purpose of this study is to evaluate the consequence of failure, and not the probability of failure. The simulated dam breach scenario presented is hypothetical and is not a reflection of the embankment integrity or stability of the TSF.

The dam breach flood from a potential failure of the TSF would travel to the north for approximately 12 miles, along Rock Canyon Road as shown in Figure 5. There are no known major water tributaries by which the flood route would be controlled, the flow path will be controlled by sloping topography.

This letter presents the following:

- TSF configuration at the time of the simulated breach.
- Dam breach flood routing from the TSF embankment towards the north.

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Reno, Nevada, USA 89521
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- Dam breach flood inundation mapping along the study reaches.
- Summary of the study assumptions, results, findings, and recommendations.

2.0 TSF CONFIGURATION

Development of the Grassy Mountain TSF is currently in the permitting process, with engineering support and design provided by Golder. The TSF will have an ultimate capacity of 3.67 million tons of tailings solids and has been designed as a valley fill facility with embankments constructed within the natural drainages bounding the northern side of the TSF and within saddles along the western ridge. The embankments will have a maximum overall upstream slope of 3H:1V with a downstream slope of 2.5H:1V. The upstream slope of the embankments will be geomembrane-lined to maintain a continuous lining system within the facility. The TSF will be constructed in three stages utilizing downstream construction techniques.

The hypothetical dam breach simulated for this analysis focused on the TSF configuration when Stage 3 has been completely filled. Golder assumed that if the TSF were to breach, it would occur within the northern embankment along the critical stability and deepest dam section. A stability analysis was performed on the TSF as part of the detailed design and shows the location of this section (Golder 2019). The breach location for the TSF is shown in Figure 1.

The configuration of the embankment at the end of Stage 3 is summarized in Table 1.

Table 1: Configuration of TSF at the Modeled Breach Location – Stage 3 (Ultimate Configuration)

Parameters	Value at Ultimate Configuration (Stage 3)
Embankment Crest Elevation	3622 ft
Tailings Elevation	3619 ft
Crest Height[1]	82 ft
Released Tailings Volume at Ultimate Elevation[2]	986,920 yd^3
Supernatant Pool	52,500 yd^3
500-yr, 24-hr Storm Volume	32,640 yd^3
Minimum Crest Width Along Northern Embankment	50 ft
Northern Embankment Crest Length	1888 ft

Note: 1. Crest height is measured from the elevation of the embankment toe (breach bottom elevation), to the embankment crest elevation.
2. Includes the maximum volume of tailings, with a full operating pool and the additional volume of water generated by the 500-yr, 24-hour storm event.

3.0 DAM BREACH MODELING

3.1 Data Sources

The following data sources and information were used in this study:

- 2-foot topographic contour data from the 2017 flyover of the Grassy Mountain project site (provided by MDA on March 29, 2017 in an electronic file titled “contours_2ft_expanded_project_area.dxf”)
- 30-meter (100 foot) topographic contour data from 1998 as digital elevation model (DEM) files of the *Grassy Mountain, Sourdough Spring, Double Mountain and Kane Spring Gulch* 7.5-minute quadrangle United States

Geological Survey (USGS) maps downloaded from WebGIS. This data was used for the topography downstream of the TSF where current flyover data was unavailable

- Geo-image TIFF files from 2013 of the *Grassy Mountain, Sourdough Spring, Double Mountain and Kane Spring Gulch Quads* downloaded from the USGS
- Tailings rheology data (SGS Mineral Services 2018)
- Tailings geotechnical data (Golder 2019)
- TSF Design Report (Golder 2019)

3.2 MODELING APPROACH

The dam breach flood simulation was performed using two hydrodynamic models, FLDWAV and FLO-2D. Summary descriptions of these models are provided below.

- FLDWAV is a dam breach and flood routing model developed by the U.S. National Weather Service (Version 2-0-0, dated June 2000). This model is widely used in North America for dam breach flood inundation studies. The model offers empirically-based formulations for characterizing a dam breach. The FLDWAV model was used in this study to simulate the potential breach of the north side of the TSF and to generate dam failure flood hydrographs at the breach location.
- The FLO-2D model (FLO Pro Model, December 2018), developed by Dr. Jim O'Brien with FLO-2D Software Inc., was used to route the non-Newtonian tailings dam breach flood hydrographs from the TSF along the downstream study reaches. FLO-2D is a two-dimensional hydraulic model with an unsteady-state flow routing component. FLO-2D has been approved by the U.S. Federal Emergency Management Agency (FEMA) for riverine studies and unconfined flood analyses. FLO-2D can be applied to a number of complex flood problems including mud and debris consisting of non-homogenous, non-Newtonian flows. The high solids content of a tailings flow categorizes it as a non-Newtonian flow; therefore, FLO-2D is considered an appropriate method for tailings flood routing and has gained wide acceptance for routing of tailings.

3.2.1 TSF Breach Scenario

A tailings dam breach analysis is generally more complicated than a water dam breach analysis. Depending on the solid content of the released tailings and water, the slurry flow can behave as Newtonian flow (i.e., water flood) or non-Newtonian flow (i.e., mud flood). Section 3.5 presents the tailings flow properties used in this analysis.

Golder evaluated the following critical scenario in a dam breach analysis:

- Full Capacity Breach: The TSF is filled to the ultimate capacity at the end of Stage 3 with a maximum operating pool.
- Rainy Day Breach Event: The breach would occur concurrent with the addition of water from the Inflow Design Flood generated from the 500-year, 24-hour storm event (storm depth of 2.91 inches) during operation of the facility.

- Full-Depth Breach: To justify use of a full-depth breach from an engineering view, Golder assumed that the embankment breach would occur due to piping failure at a location along the downstream toe of the north embankment corresponding to the location of the maximum embankment height.

A dam break that occurred after the TSF has been reclaimed would result in a smaller downstream inundation area. Reclamation will shape the surface of the TSF to shed water to prevent ponding, so would eliminate the volume of the supernatant pool and the volume of the storm event from the model.

Tailings dam failures result from a variety of causal mechanisms e.g. overtopping, liquefaction, piping or a combination. Overtopping is caused by fluids spilling over the top of a dam due to inadequate spillway design or settlement of the dam crest. At maximum operating level, the TSF is designed to accommodate runoff from the 500-yr, 24-hr storm event with a storm depth of 2.91 inches within the design freeboard without overtopping. Based on the design requirements for the breach, an overtopping failure of Stage 3 TSF at its maximum operating levels is considered an unlikely failure mechanism.

Due to the TSF being constructed using downstream raise techniques, the embankment does not rely on the tailings to provide embankment stability. Liquefaction of the tailings during a seismic event, or statically, would not jeopardize the stability of the embankment. The foundation conditions below the TSF have been determined to not be susceptible to liquefaction. Therefore, a liquefaction-induced failure mechanism is considered unlikely.

Piping failures occur when the initial breach formation take place at some point below the top of the dam due to erosion of an internal channel through the dam by the escaping water. As erosion proceeds, a larger opening is formed and is eventually hastened by caving-in of the top portion of the dam. Based on the TSF design including a fully geomembrane-lined upstream slope and basin, this is considered an unlikely failure mechanism.

The dam breach flood from a potential failure of the north side of the TSF would travel to the north, along Rock Canyon Road, as shown on Figure 5. There are no known major water tributaries by which the flood could be routed; the flow path would be routed by sloping topography only.

The domain boundary, presented on Figure 1, was based on a review of the site topography and potential flow path in the event of a breach. The domain boundary was refined after preliminary model runs to confirm that the domain coverage was sufficient to minimize the boundary effects on the modeling results. The selected model domain includes the Project Site, and *Sourdough Spring, Kane Spring Gulch, Double Mountain and Grassy Mountain* 7.5-minute USGS quadrangle topographic maps.

3.3 Dam Breach Release Volume Estimate

3.3.1 Methods for Estimating Release Volume

Studies of historic tailings dam failures indicate that released tailings volumes are governed by the impoundment construction method and history, tailings dam height, geotechnical properties of tailings, and geometries of tailings ponds and downstream floodway.

Golder reviewed three methods for estimating the released tailings volume:

- Azam and Li (2010)
- Rico et al. (2008)

- Ishihara (1996)

A review of over 200 historic tailings dam failures around the world indicates that, on average, about 20 percent of the tailings contained within the tailings storage facilities is lost as part of the breach events (Azam and Li, 2010). Rico M. et al. (2008) developed an empirical relationship between the tailings storage volume and the quantity of tailings released in the event of a tailings dam failure based on the available information for the 29 historic tailings dam failures with tailings dam heights ranging from 5 meters (16 feet) to 66 meters (217 feet). This relationship is provided below:

$$V_F = 0.354\ V_T^{1.01}$$

Where: V_F = tailings release volume

V_T = total tailings volume contained in the pond

This equation suggests that, on average, about one-third of the tailings volume and the entire water volume of tailings ponds is released during dam failures. This is slightly higher than estimates developed by Azam and Li (2010).

An analytical approach to breach volume estimates involves a mechanism that creates a geometry into the tailings starting at the outflow location at the base of the dam centerline that extends up into the tailings in the shape of a cone until the cone daylights back in the basin at the top of the tailings. Under this scenario, tailings and water above this cone would leave the impoundment, while tailings beneath the cone would remain.

This failure mechanism, referred to as the “cone failure” assumes that the breach of the dam will cause static liquefaction of the tailings, reducing the undrained shear strength (s_u/p) ratio. Based on empirical relationships developed by Ishihara (1996) for non-plastic tailings, the liquefied undrained shear strength of the tailings can be conservatively modeled with an s_u/p of 0.06. Stability models based on this shear strength result in a cone slope of approximate eight percent grade (five degrees). Using this method, the total volume released is highly dependent on the height and shape of the facility. It should be noted that this failure mechanism refers to the upstream tailings and is used to estimate the volume of tailings released during a breach only.

For the Grassy Mountain TSF, Golder estimated the released tailings volumes considering both the relationship proposed by Rico M. et al. (2008) and the cone failure method.

3.3.2 Modeled Release Volume

The TSF is designed to contain approximately 3.2 million cubic yards of consolidated tailings. An additional fluid volume of 52,500 cubic yards is included in the impoundment volume; this accounts for the volume of the supernatant pool with a depth of 5 feet. For estimating the dam breach volume, it was assumed that failure would be preceded by accumulation of run-on from the 500-yr, 24-hr storm event. In the event of the 500-yr, 24-hr storm event, an additional water volume of 32,600 cubic yards for Stage 3 is introduced in the impoundment above the supernatant pool.

Golder estimated the tailings released volume using the methods described in Section 3.3.1. The relationship proposed by Rico M. et al. (2008) estimates 41 percent of the total tailings volume in the Stage 3 impoundment will be released in the event of the embankment breach (corresponding to 1.22 Myd^3). The cone failure method estimates that approximately 24 percent of the tailings would be mobilized due to an embankment failure

(corresponding to 0.71 Myd^3) as well as the embankment fill within the cone failure and the breach width downstream (corresponding to 0.28 Myd^3). It was assumed that this embankment fill will be displaced and carried away by the tailings mass and was modeled with the tailings flow characteristics

For selecting a tailings release volume for the Grassy Mountain TSF, Golder considered the estimate from both methods, along with the geometry of the impoundment. A value of 33 percent of the total material release volume (corresponding to 0.99 Myd^3) was chosen to accommodate the embankment fill that will be carried away as a part of the tailings mass as described in the above paragraph. This is a conservative approach when compared to the proposed estimated volume released of about one-fifth of the total TSF volume proposed by Azam and Li (2010), which considers a much larger dam failure database than Rico M. et al (2008).

Additionally, all the water from the combined operational supernatant pool and the 500-yr, 24-hr storm (0.08 Myd^3) would be mobilized. The total released volume is estimated as 1.07 Myd^3. The tailings, water, and total release volumes for the analyzed breach scenario are summarized in Table 2.

Table 2: Estimates of Released Tailings Volumes

Breach	Dam Breach Volume (Myd^3)			
	Tailings Volume Released	**Supernatant Pool Volume**	**500-yr, 24-hr Storm Event**	**Total Volume Released**
Full Depth of Stage 3 TSF	0.99	0.05	0.03	1.07

3.4 Dam Breach Model Parameters

The dam breach outflow hydrograph was generated by FLDWAV and is presented as the rate of tailings flow vs time at the toe of the dam along the failure surface. The dam breach outflow hydrograph is a function of the dam breach model parameters that are related to the breach mechanism and embankment geometry. Table 3 presents the dam breach outflow input parameter values that were used in FLDWAV. These values are based on the recommendations by the U.S. Federal Energy Regulatory Commission (FERC 1994) and empirical formulations developed by Fread (2001), and in consideration of historical dam failures, as well as site-specific characteristics of the TSF.

Table 3: Dam Breach Model Parameters

Breach Scenario	Failure Mode	Average Breach Width (BR) (ft)	Breach Side Slope	Time to Failure (TFH) (hour)	Elevation of Tailings at Dam Failure (HFDD) (ft)	Breach Bottom Elevation* (ft)
Stage 3 Rainy Day	Full Depth	102.4	1H:1V	0.2	3619	3534

* Bottom breach elevation is the elevation of the embankment toe at the assumed breach location, assuming the failure extended from the native ground to the crest of Stage 3.

The basis for the selected modeling parameter values is provided below.

- The average breach width (BR) was selected using the empirical relationship suggested by Fread (2001):

$$BR = 9.5\ k_0\ (V_r\ H)^{0.25}$$

Where: BR = average breach width (ft)

k_0 = a coefficient (equal to 0.7 and 1.0 for piping and overtopping failures respectively)

V_r = water volume (acre-ft)

H = height of water over the breach bottom (feet); measured from the elevation of the embankment toe to the elevating of the tailings and/or water.

Fread (2001) indicates the range for BR should be 0.5HD ≤ BR ≤ 8HD; where HD is the total height of the dam embankment. This relationship suggests that the selected BR value is reasonable for modeling breach of the TSF.

- Time to failure (TFH) was estimated to be 0.2 hours for a piping failure of the Stage 3 embankment. This value is within the recommended range by FERC for engineered earthen dams (0.1 ≤ TFH ≤ 1.0). The following empirical relationship is suggested by Fread (2001) for estimating TFH:

$$TFH = 0.3\ V_r^{0.53}/H^{0.9}$$

- For the breach modeling, the horizontal component of the side slope of the breach opening (Z) was selected to be 1, which is at the higher end of the normal range (1/4 ≤ Z ≤ 1) recommended for engineered earthen dams by FERC. The simulated downstream maximum flood levels are not expected to be sensitive to this parameter.

3.5 Tailings Flow Properties

In the event of a breach, viscous tailings slurry would leave the Grassy Mountain TSF and would travel downstream as a mudflow. This would constitute a non-homogeneous, non-Newtonian, transient flood event. Mudflow behavior is a function of the fluid matrix properties as well as floodway geometry, slope and roughness. The fluid would consist of water and fine solids (tailings). At sufficiently high concentrations, fine solids are expected to alter properties of the fluid including density, viscosity and initial yield stress.

The properties of the outflow resulting from a tailings dam breach are likely to vary over the mudflow duration. The solids in the outflow are expected to have significant effects on the hydraulics of the resulting flow, which would be highly turbulent. Therefore, the fluid flow from the failure was simulated as non-Newtonian flow. The model assumed that the outflow would comprise a mudflow represented by a blended mixture of the materials that will be released from the tailings impoundments (tailings, embankment fill and water). The material properties that FLO-2D uses to model the flow are yield stress (remolded strength), dynamic viscosity of the breach outflow, and solids volume content.

The following empirical relationships are used within the FLO-2D model to compute the yield stress (τ_{YS}) and dynamic viscosity (η) coefficients α and β of the mudflow during model simulation:

$$\tau_{YS} = \alpha_{YS} e^{\beta_\eta C_v} \quad \text{and} \quad \eta = \alpha_\eta e^{\beta_\eta C_v}$$

Where: α and β = empirical coefficients defined by laboratory testing results.

Laboratory results for the yield stress (τ_{YS}) and dynamic viscosity (η) of the tailings slurry are plotted against the different solids volume content (Cv) for which each test was performed. From these plots the empirical coefficients α and β are estimated. Site-specific laboratory data that was not developed for the target Cv can still be extrapolated parameters using the laboratory relationships.

SGS Mineral Services (SGS) performed laboratory testing to measure the rheological properties of pilot tailings slurry samples for the Grassy Mountain Project (SGS, 2018). The measured specific gravity (SG) of the tailings slurry averaged at 2.64. Tailings rheological properties were measured at six solids contents and the collected data sets are presented in Table 4.

Table 4: Tailings Slurry Rheological Testing Results (SGS, 2018)

Solids Content, Cw (by weight)	Solids Content, Cv (by volume)	Dynamic Viscosity (poises)	Yield Stress (dynes/cm^2)
67.0%	43.5%	0.77	160
64.6%	40.9%	0.62	130
62.2%	38.4%	0.33	100
59.2%	35.5%	0.22	58
55.6%	32.2%	0.15	40
51.6%	28.8%	0.23	10

The dynamic viscosity and yield stress for the tailings were obtained at solids volume content (Cv) values that ranged from 28.8 percent to 43.5 percent; this represents a tailings solids content range appropriate for the Cv value developed for the tailings during a breach of 48.6 percent (see Section 3.6). The dynamic viscosity and yield stress were plotted to estimate the α and β coefficients needed for input into FLO-2D. Figures 2 and 3 show the plot of the dynamic viscosity and yield stress test results, respectively, along with their estimated α and β coefficients.

Table 5 presents the tailings mudflow properties used as input for the FLO-2D model.

Table 5: Tailings Slurry Mudflow Properties

Viscosity Coefficients		Yield Stress Coefficients		Specific Gravity	Laminar Flow*
α_η	β_η	α_{YS}	β_{YS}		
0.008054	10.13	0.091257	17.78	2.64	2000

*Laminar flow resistance was estimated using the range for “sparse vegetation” listed in the FLO-2D PRO

3.6 Tailings Solids Content

To simulate a flood model, the flood hydrographs (as predicted by the FLDWAV model) input into the FLO-2D program are assumed to represent the outflow of water at the breach location. However, the volume released from the TSFs includes a mixture of the tailings slurry and water from the supernatant pool and the 500-yr, 24-hr storm event, and is expected to behave as a mudflow. To simulate a mudflow in FLO-2D, the flood hydrographs for each breach scenario must be adjusted to represent the total volume of the mixture of water and tailings. This can be determined by multiplying the water volume by the bulking factor (BF):

$$BF = 1/(1-Cv)$$

Where: Cv = assumed solids content of the mudflow mixture by volume.

The estimated tailings volumes released for the dam scenario (described in Section 3.3.2 and listed in Table 2) are assumed to consist of a well-mixed slurry of tailings solids and water. The dry density of the tailings solids is estimated be 80 pounds per cubic foot (Golder 2019) and the tailings solids SG is 2.64. Using this data, Golder estimated the Cv in the dam breach tailings slurry to be 48.6 percent.

Table 6 lists the estimated Cv values and bulking factor for the breach scenario.

Table 6: Grassy Mountain Mudflow Solids Content and Bulking Factor

Dam Failure Mode	Tailings Volume Released (Myd^3)	Tailings Solids Volume (Myd^3)	Tailings Water Volume (Myd^3)	Storm and Pool Water Volume (Myd^3)	Total Volume Released (Myd^3)	Cv (%)	BF
Rainy Day Full Depth	0.99	0.48	0.51	0.08	1.07	48.6	1.94

3.7 Initial Hydraulic Conditions and Manning's Roughness Coefficient

The assumed initial hydraulic conditions for routing the dam breach flood are estimated to have negligible effects on the modeling results, particularly on the resulting flood peak levels. However, a reasonable approximation of the initial hydraulic conditions is required for numerical computation and to represent the likely hydraulic conditions during the potential dam breach flood events.

Presented below are the considerations and assumptions made in this study for specifying the initial hydraulic conditions at the TSF and the downstream flood way:

- initial tailings surface Elevation 3619 ft in the impoundment.
- initial supernatant pool surface Elevation 3610 ft in the impoundment (1 foot of freeboard).
- downstream hydraulic boundary conditions for FLO-2D modeling assumed to be normal flow conditions.
- there are no known major water tributaries by which initial flow may be introduced into the impoundments. Stormwater would be diverted around the facility and only stormwater runoff falling below the permanent diversion channel contributes to the TSF in the 500-yr, 24-hr storm event.

The selection of a Manning's roughness coefficient, *n,* value was based on Golder's interpretation of the available Google Earth images, site-visit photographs, relevant project experience and judgement of Golder's team and consideration of the vegetation cover and the overland form roughness. The Manning's *n* value was estimated as 0.15 for downstream areas with short prairie grass.

3.8 2-D Model Domain and Mesh Resolution

A FLO-2D model domain was defined based on the TSF design surface, 2017 aerial survey within the Project Boundary, and 7.5-minute DEM files obtained from USGS to cover the areas of interest downstream of the breach location. The domain and associated boundaries were refined after preliminary model runs to minimize the boundary effects on the modeling results and to confirm that the available quad DEM's and the domain coverage

were sufficient to cover the maximum possible flood extents. A rectangular mesh system was used for the domain, and the final model run was based on a 50-foot mesh resolution.

4.0 MODELING RESULTS

The outflows from a potential breach of the Stage 3 TSF embankment would contain tailings solids, water from the supernatant pool, and additional water from the 500-yr, 24-hr storm event. In the case of a full-depth dam breach on the north side of the embankment, the total volume of materials (1.07 Myd^3) to be released from the failure of the ultimate TSF would include 0.48 Myd^3 of tailings solids (45 percent of the total material volume), 0.51 Myd^3 of slurry water (47 percent of the total material volume), 0.03 Myd^3 of additional runoff water during the 500-yr, 24-hr storm event (3 percent of the total material volume) and 0.05 Myd^3 of supernatant pool water (5 percent of the total material volume).

FLDWAV software, Version 1.0.0, developed by the National Weather Service (FLDWAV, 1998) was used in this study to model the potential breach of the north side of the TSF using the dam breach model parameters presented in Section 3.4. Figure 4 presents the simulated dam breach flood hydrograph at the breach location generated in FLDWAV. The simulated peak discharge is 75,500 cubic feet per second (cfs).

The FLDWAV and FLO-2D models were used to generate the dam breach flood inundation mapping downstream of the Grassy Mountain TSF. Figures A-1 through A-4 in Attachment A present the FLO-2D modeling results along the study reach. The inundation area was ended when the Flood Hazard Intensity (depth x velocity) fell below 0.04 m^2/sec, lower than the commonly-accepted level of about 0.4 m^2/sec. The results of the dam breach scenario modelled for this analysis indicate that:

- The TSF flood flows would follow an existing ephemeral drainage running adjacent to Rock Canyon Road;
- The total tailings slurry deposition area inundated would be approximately 834 acres;
- Golder reviewed aerial imagery, and it is our understanding that there are no occupied structures within the tailings slurry inundation area;
- The modeled maximum tailings runout distance from the TSF is approximately 12 miles, beyond which flows would not pose a significant risk to human life; and
- The peak flood travel time from the TSF to the maximum tailings runout distance (12 miles) would be approximately 48 hours.

4.1 Flood Inundation Maps

The flood inundation map was prepared at a scale of 1 inch:2000 feet for the dam breach modeling scenario to show the flood delineation on the base map consisting of contours, roads and other mapping features with the aerial imagery as a background. Figure 5 presents the map, which includes the following information:

- The tailings runout extents delineated based on the simulated maximum tailings deposition levels, which were simulated using the FLO-2D model
- Mile marker locations and labels used in the FLDWAV and FLO-2D models

Depending on the local terrain slopes, the accuracy of contour interval leads to various levels of horizontal accuracy. However, the delineation provides a sufficiently accurate definition of the areal extents of the tailings dam breach flood.

4.2 Potentially Impacted Areas

4.2.1 General

The key flooding information downstream of the TSF is summarized at mile markers on Figure 5. The areas potentially impacted by the simulated tailings dam breach floods are discussed in the following section.

4.2.2 Project Site

The primary access roads to the Grassy Mountain Mine site will be flooded in the event of a full-depth breach on the north side of the TSF embankment. The flood arrival time is immediate with a maximum tailings runout velocity and maximum tailings deposition depth of 20.6 ft/s and 37.7 feet, respectively.

4.2.3 Rock Canyon Road and Twin Springs Road

Lower lying portions of the Rock Canyon Road and the Twin Springs Road would likely be flooded in the event of a full-depth breach on the north side of the TSF embankment. The flood arrival time to the Rock Canyon Road is approximately 41 minutes with a maximum tailings runout velocity and maximum tailings deposition depth of approximately 8.0 ft/s and 13.0 feet, respectively.

5.0 CONCLUSIONS

The purpose of this study is to evaluate the consequence of failure, and not the probability of failure, for the dam breach scenario. The results of this study support the following conclusions:

- Potential piping failure of the TSF embankment under the 500-yr, 24-hr storm inflow conditions, provides a mechanism for a breach of the full depth of the dam, and represents a ‘reasonable worst-case’ scenario for analyzing the downstream impact of a potential dam breach for delineating a runout inundation area.
- In the event of a full-depth breach at the north side of the TSF under the ‘reasonable worst-case’ scenario:
  - While the inundation area just downstream of the breach is broad, it quickly narrows to a thin flow constrained in the walls of a relatively narrow drainage feature.
  - The maximum tailings deposition levels are, on average, about eight feet above the ground surface and range from about 38 feet immediately downstream of the reach to about 1½ feet at the end of the inundation map.
  - Within approximately 41 minutes of the initial dam breach, Rock Canyon Road would be inundated with tailings to a maximum depth of approximately 13 feet where it crossed the drainage.
  - The tailings runout distance would be approximately 12 miles from the dam breach location and would be reached in approximately 48 hours. Flows may extend beyond this distance, depending on base flow in the drainage along the reach of the inundation area, but the depth and velocity of flow would be sufficiently low beyond this point to pose minimal risk to human life.
- No habitations or lifelines would be impacted by a piping failure of the TSF under the conditions evaluated.

- Public access to the project site and areas south along Rock Canyon Road and Twin Springs would either be inaccessible or access limited in the event of a piping failure of the TSF, until tailings solids could be removed. Alternative public access routes would remain operational.

6.0 CLOSING

Golder is pleased to present this breach analysis of the tailings storage facility at the Grassy Mountain Mine. If you have any questions or comments regarding the information presented herein, please contact the undersigned at (775) 828-9604.

Respectfully,

Golder Associates Inc.

Christopher J. MacMahon, PE
Associate, Engineer of Record

Russell A. Browne, PE (NV)
Principal, Senior Tailings Practice Leader

MDB/CJM/RAB/vk

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7.0 REFERENCES

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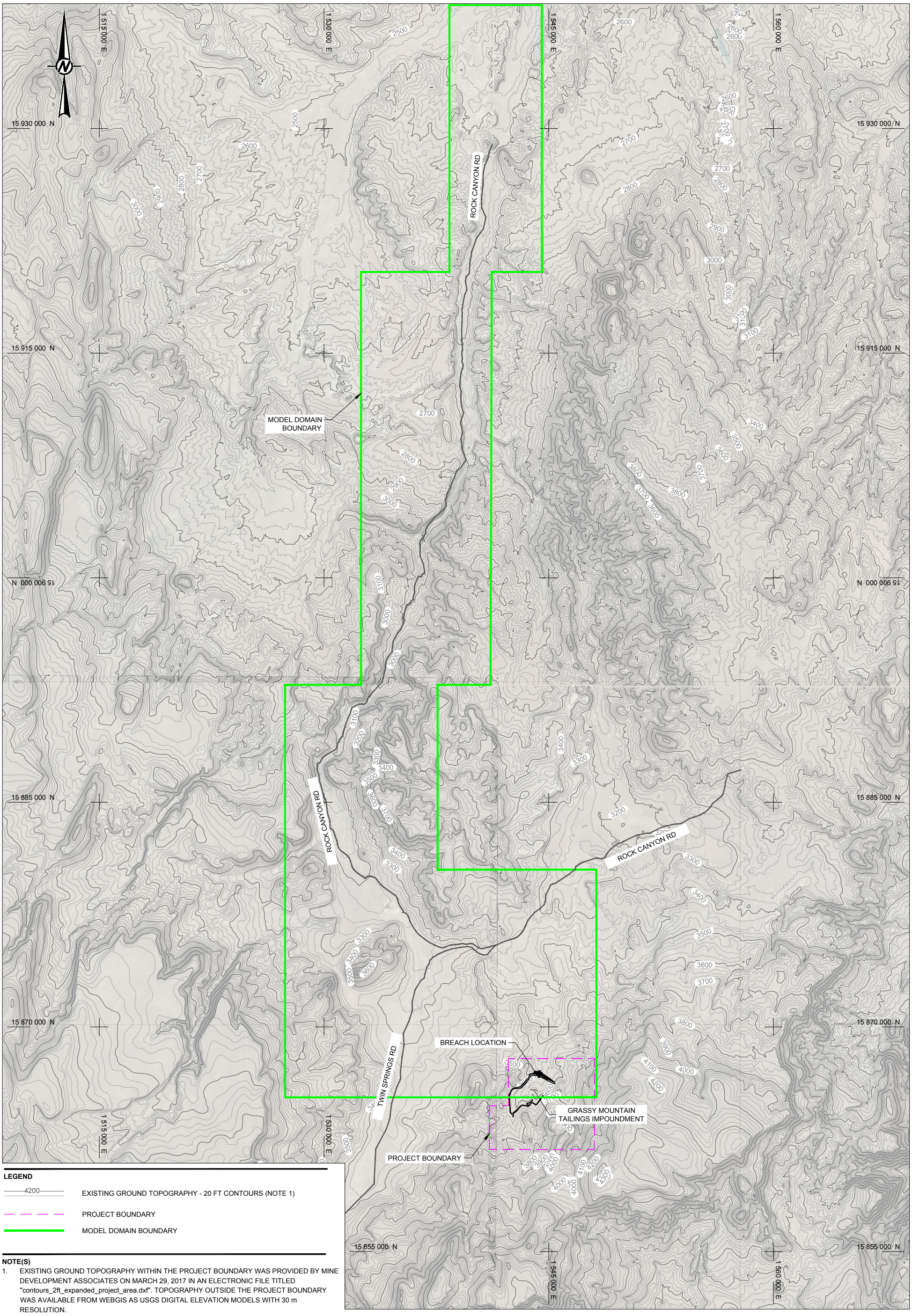
FIGURES



LEGEND

- 4200 — EXISTING GROUND TOPOGRAPHY - 20 FT CONTOURS (NOTE 1)
- PROJECT BOUNDARY
- MODEL DOMAIN BOUNDARY

NOTE(S)

1. EXISTING GROUND TOPOGRAPHY WITHIN THE PROJECT BOUNDARY WAS PROVIDED BY MINE DEVELOPMENT ASSOCIATES ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf". TOPOGRAPHY OUTSIDE THE PROJECT BOUNDARY WAS AVAILABLE FROM WEBGIS AS USGS DIGITAL ELEVATION MODELS WITH 30 m RESOLUTION.
2. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.
3. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".

0 3000 6000
1" = 3000' FEET

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GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-30
DESIGNED	MCJ
PREPARED	MDB
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
MODEL DOMAIN BOUNDARY

PROJECT NO.	REV.	FIGURE
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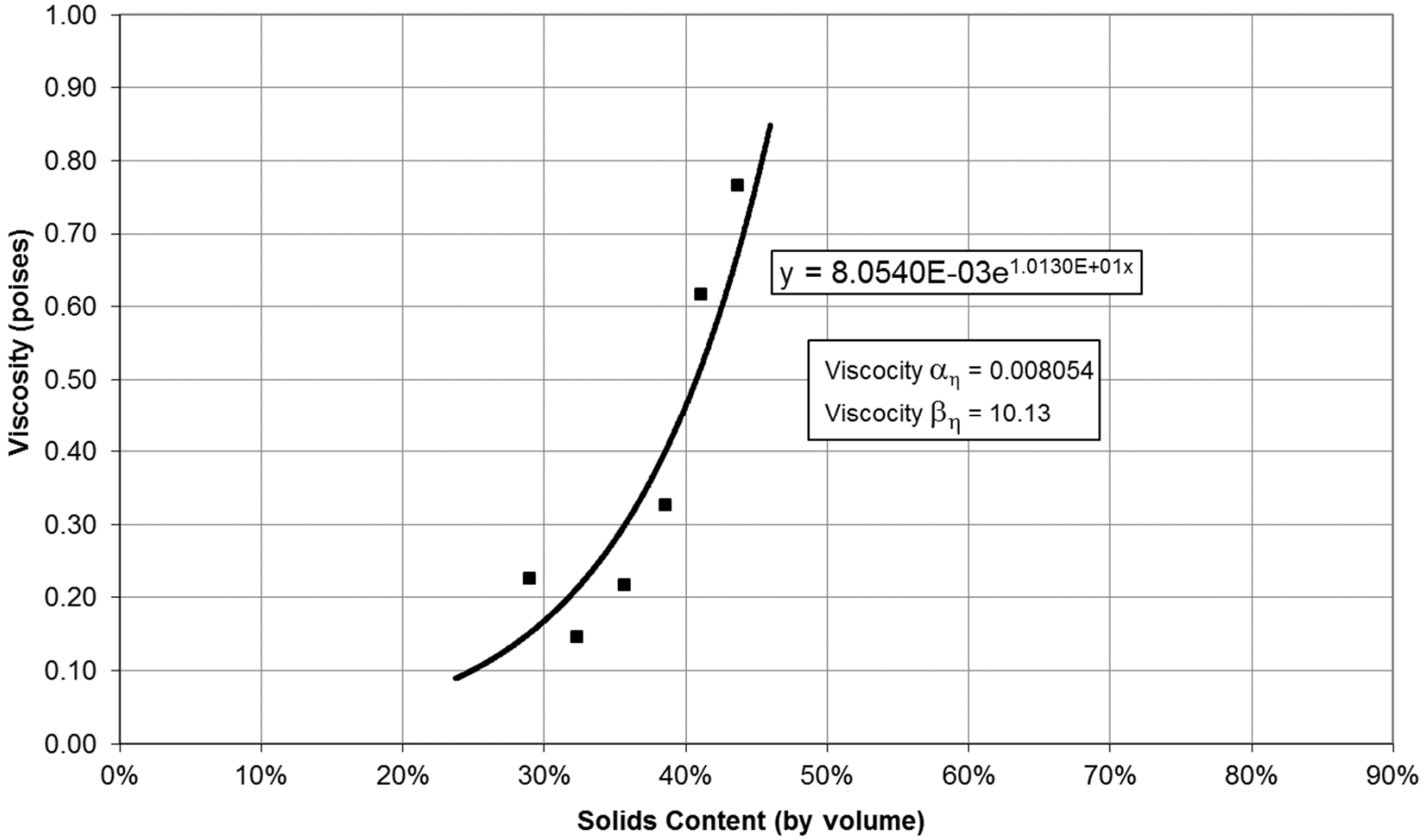

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DESIGN	MDB
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APPROVED	RAB

PROJECT
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DETAILED DESIGN

TITLE
TAILINGS PARAMETERS
DYNAMIC VISCOCITY

PROJECT No. 1663241 | Rev. 0 | FIGURE 2

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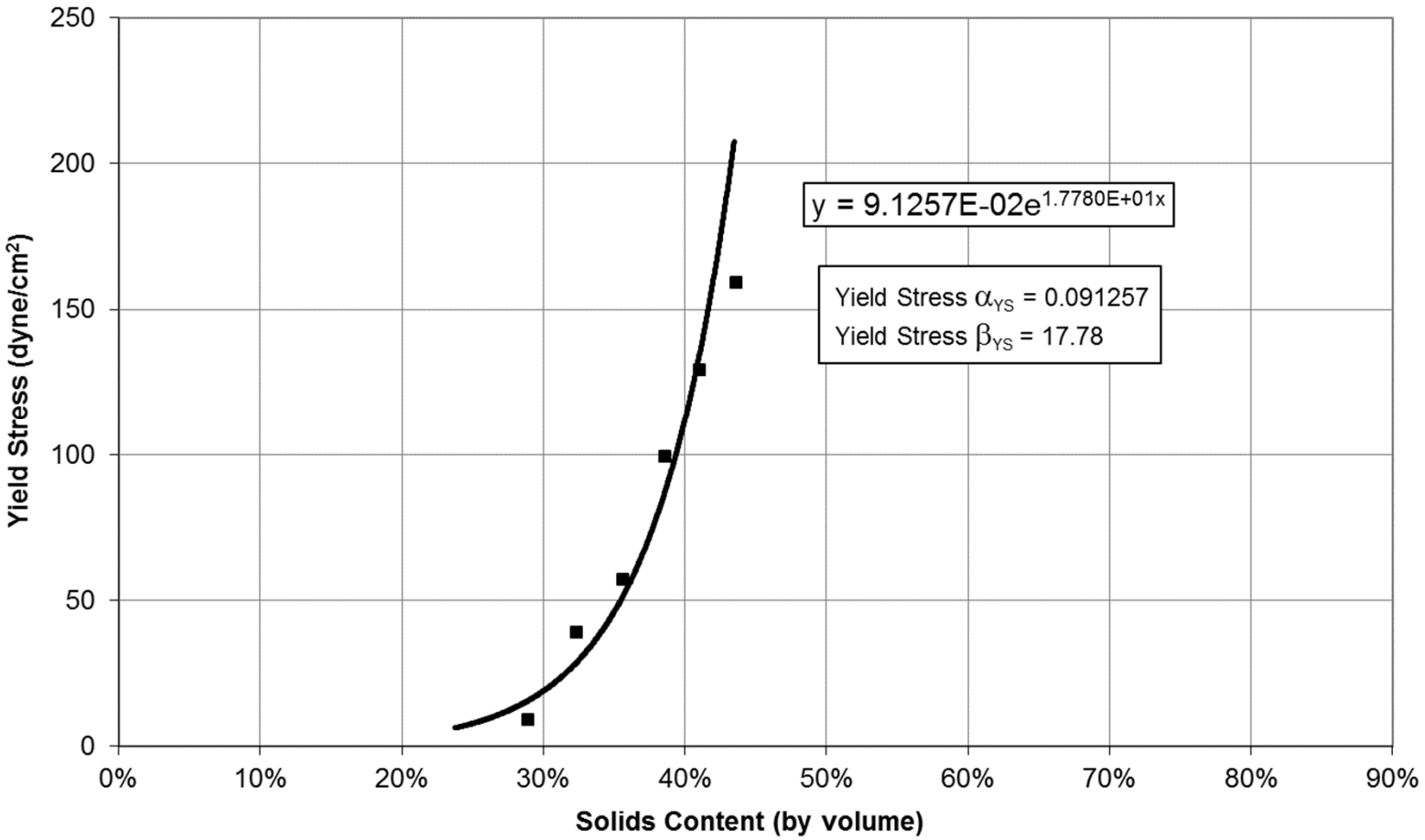

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REVIEW	CJM
APPROVED	RAB

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TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
TAILINGS PARAMETERS
YIELD STRESS

PROJECT No. 1663241 | Rev. 0 | FIGURE 3

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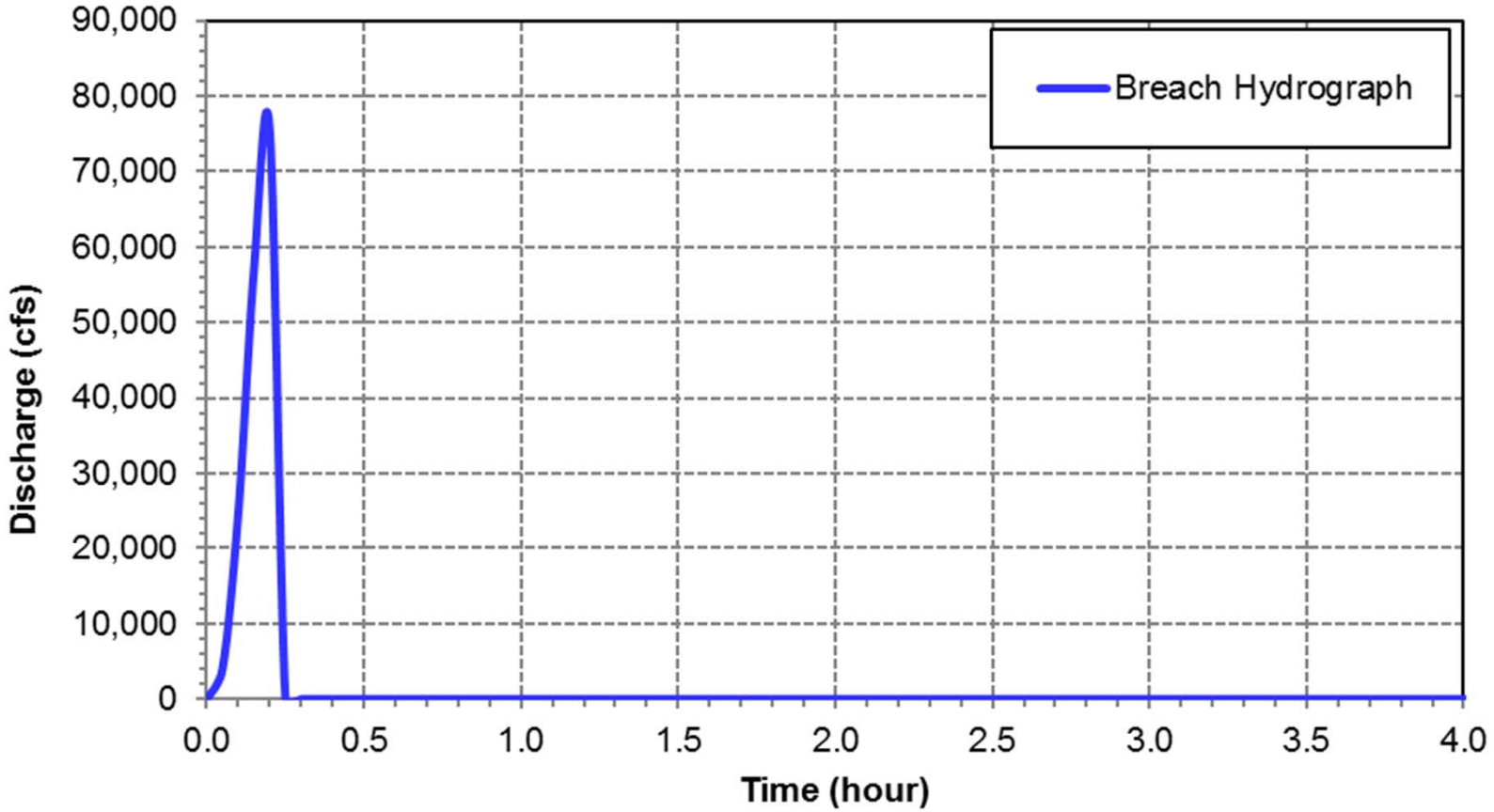

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DESIGN	MDB
REVIEW	CJM
APPROVED	RAB

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GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
TAILINGS OUTFLOW HYDROGRAPH

PROJECT No.	Rev.	FIGURE
1663241	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
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LEGEND

- 4200 — EXISTING GROUND TOPOGRAPHY - 20 FT CONTOURS (NOTE 4)
- INUNDATION AREA
- PROJECT BOUNDARY

NOTE(S)

1. EXISTING GROUND TOPOGRAPHY WITHIN THE PROJECT BOUNDARY WAS PROVIDED BY MINE DEVELOPMENT ASSOCIATES ON MARCH 29, 2017 IN AN ELECTRONIC FILE TITLED "contours_2ft_expanded_project_area.dxf". TOPOGRAPHY OUTSIDE THE PROJECT BOUNDARY WAS AVAILABLE FROM WEBGIS AS USGS DIGITAL ELEVATION MODELS WITH 30 m RESOLUTION.
2. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.
3. PROJECT AREA BOUNDARY PROVIDED BY PARAMOUNT ON JANUARY 12, 2017 IN AN ELECTRONIC FILE TITLED "grassymtn_updated_permitareaboundary.dxf".
4. INUNDATION MAP PRESENTED IS BASED ON 2019 BREACH ANALYSIS OF THE STAGE 3 GRASSY MOUNTAIN DAM PERFORMED FOR THE EAP DATED JULY, 2019.
5. ARRIVAL TIMES WERE ESTIMATED USING THE FLO-2D MODEL. THESE ESTIMATES ARE APPROXIMATE AND THEREFORE ALL PERSONNEL SHOULD EVACUATE THE INUNDATION AREAS AS SOON AS POSSIBLE AS THE FLOODWAVE MAY ARRIVE QUICKER THAN INDICATED ON THIS MAP.
6. THE DAM BREACH WAS MODELED WITH THE 500-YEAR 24-HOUR STORM VOLUME (APPLIED OVER THE ENTIRE TAILINGS SURFACE AREA), AND THE ENTIRE SUPERNATANT POOL VOLUME (ASSUMING A DEPTH OF 5 FT) INTEGRATED INTO THE TOTAL BREACH OUTFLOW.

0 2000 4000
1" = 2000' FEET

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PREPARED	MDB
REVIEWED	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
STAGE 3 INUNDATION MAP

PROJECT NO.	REV.	FIGURE
1663241	0	5

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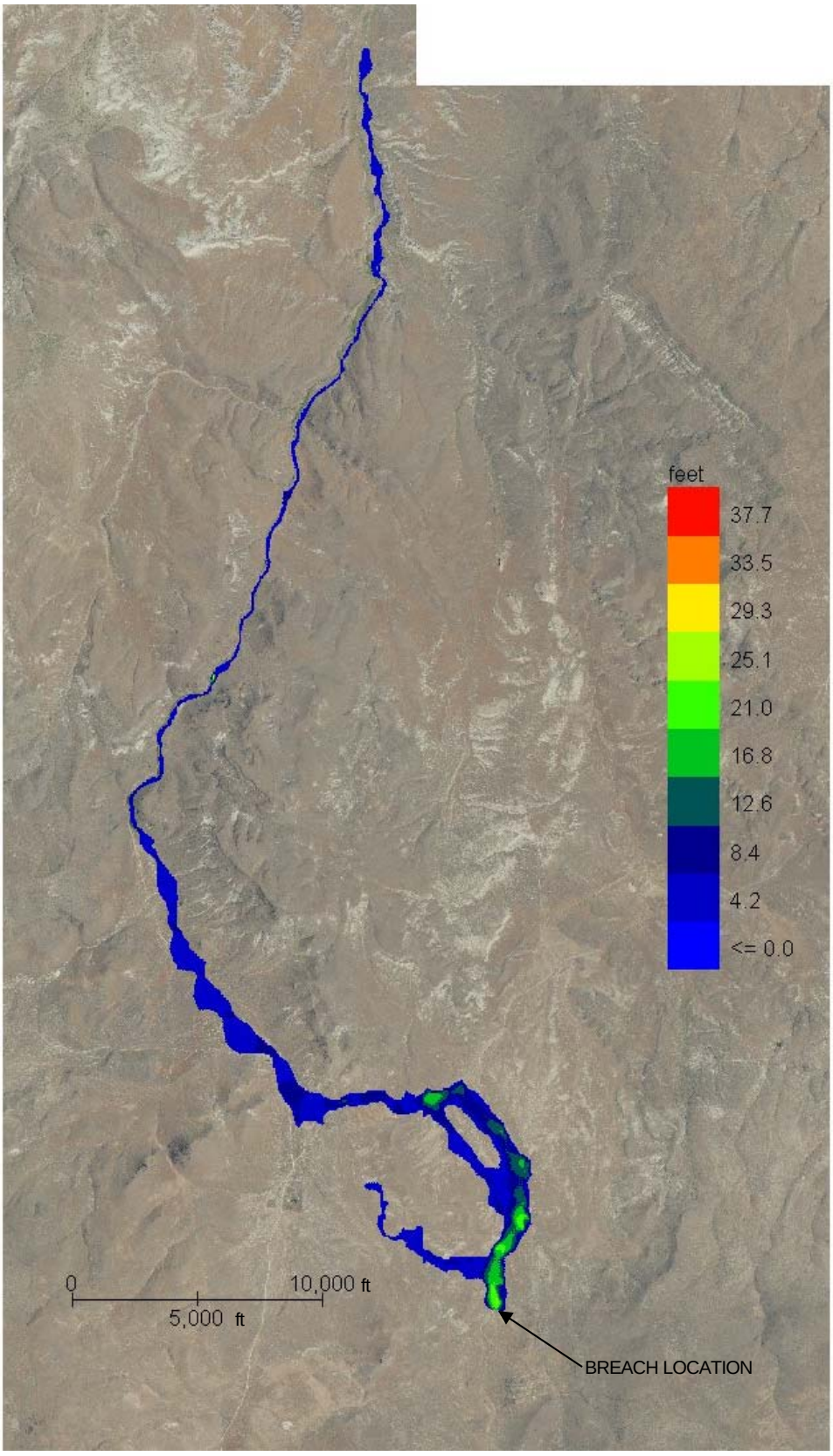

NOTE(S)

1. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.

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REVIEW	CJM
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PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
MODELING OUTPUT
MAXIMUM TAILINGS DEPOSITION DEPTH

PROJECT No. 1663241 | Rev. 0 | FIGURE 6

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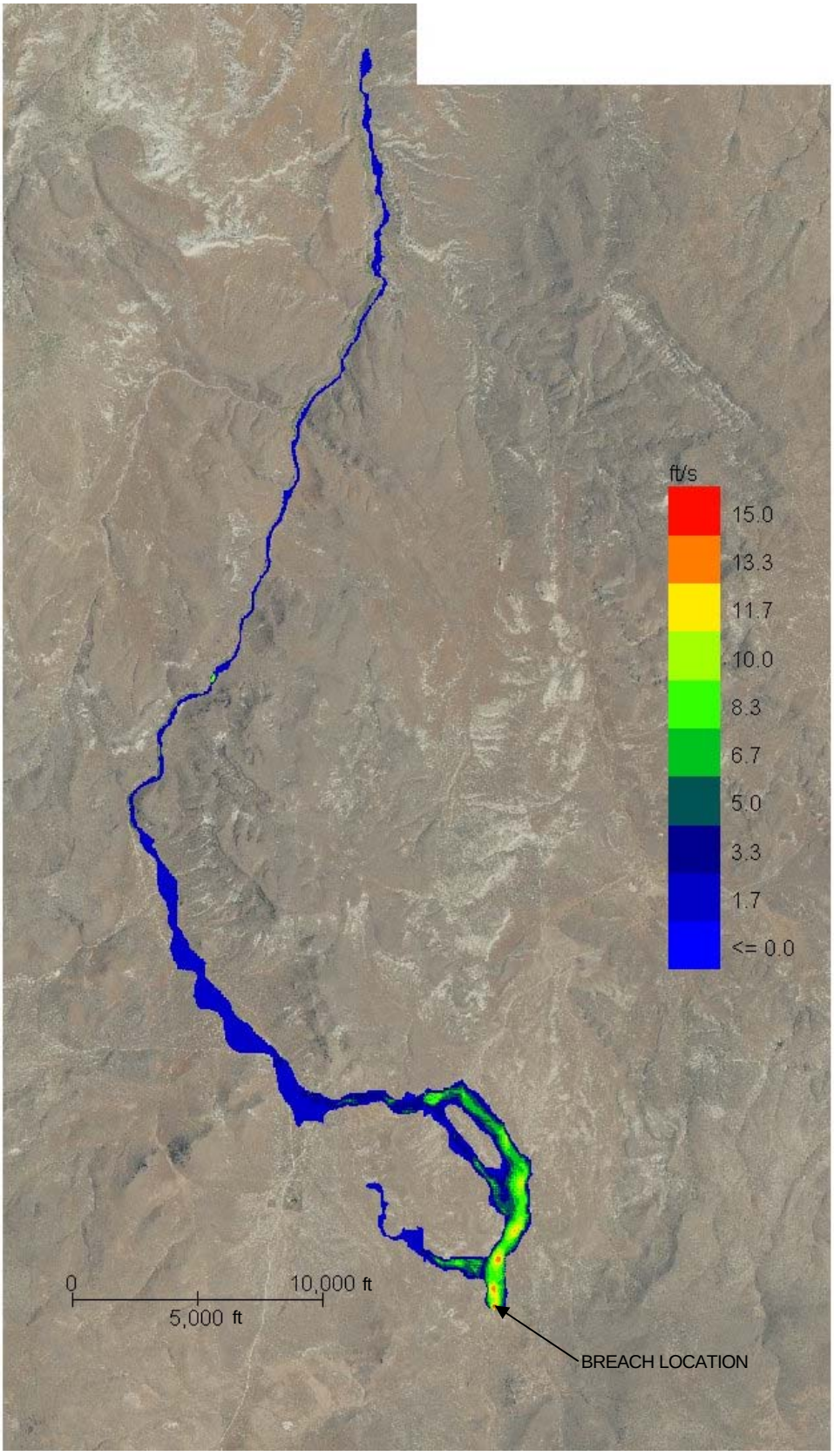

NOTE(S)

1. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.

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DESIGN	MDB
REVIEW	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
MODELING OUTPUT
MAXIMUM TAILINGS RUNOUT VELOCITY

PROJECT No. 1663241 | Rev. 0 | FIGURE 7

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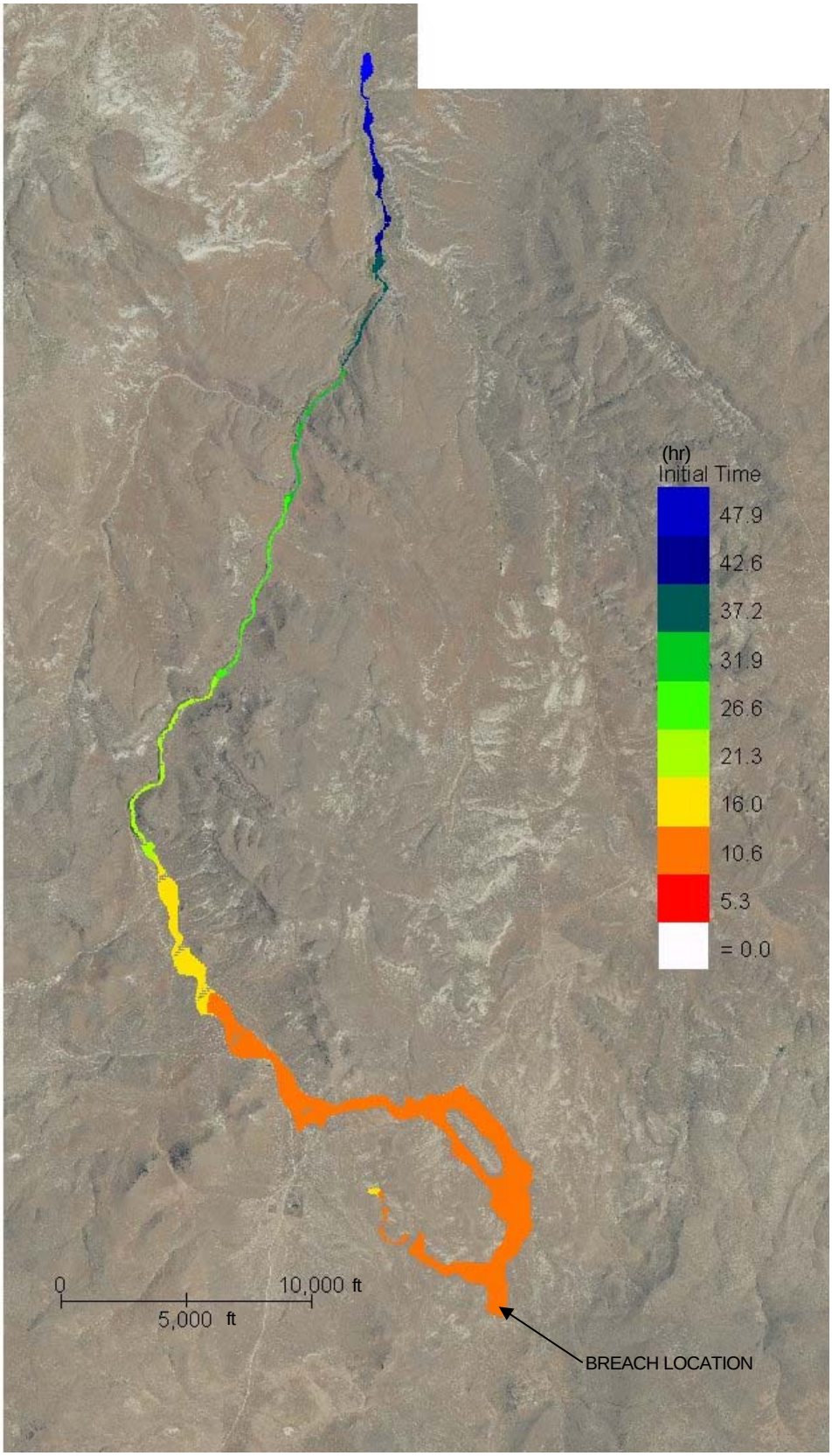

NOTE(S)

1. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.

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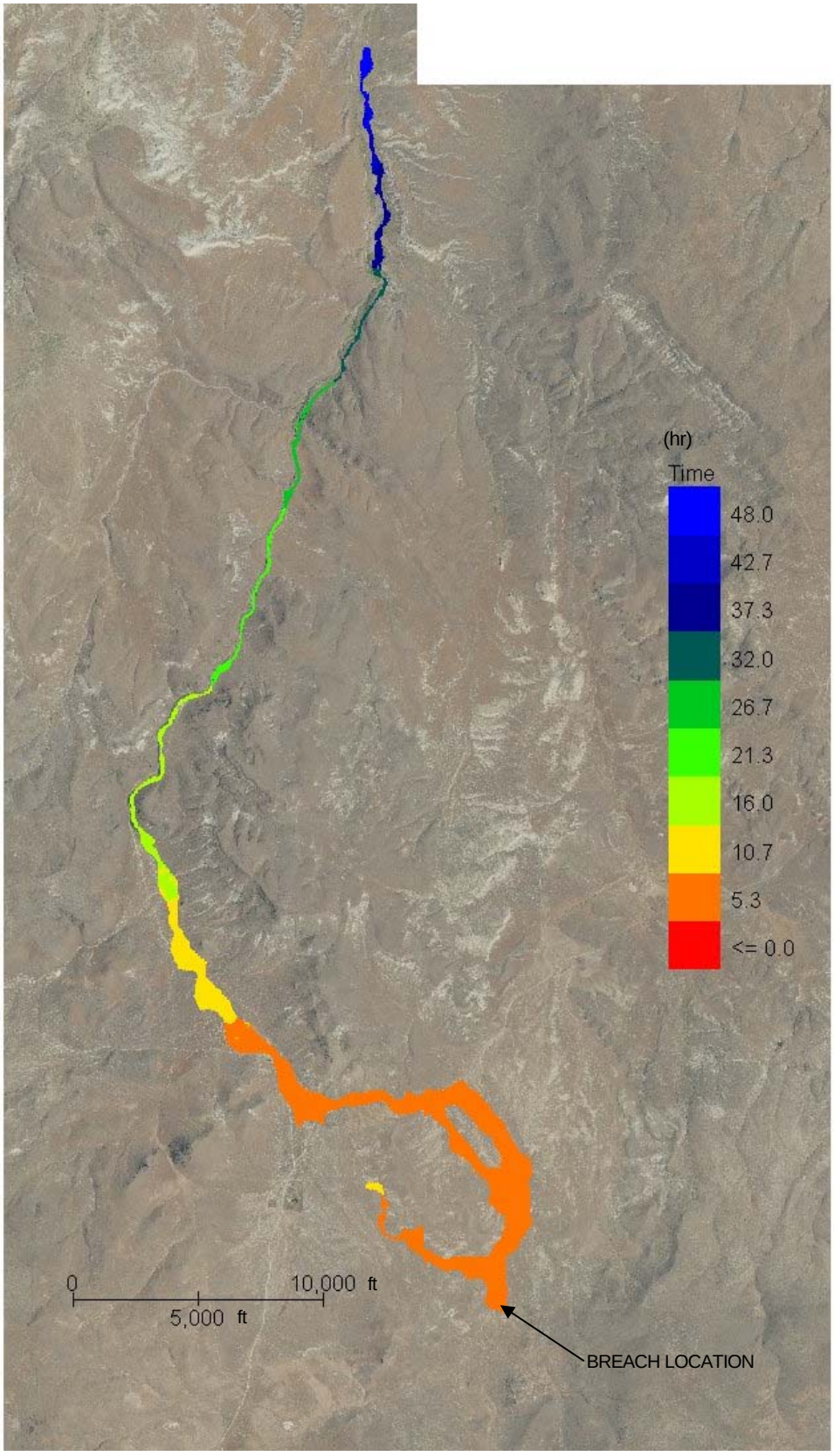
REVIEW	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
MODELING OUTPUT
FLOOD ARRIVAL TIME (1 FT MINIMUM)

PROJECT No. 1663241 | Rev. 0 | FIGURE 8

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



NOTE(S)

1. GEOIMAGE TIFF FILES FROM 2013 OF THE GRASSY MOUNTAIN, SOURDOUGH SPRING, DOUBLE MOUNTAIN AND KANE SPRING GULCH QUADS WERE AVAILABLE FROM THE USGS.

CLIENT
CALICO RESOURCES USA CORP
GRASSY MOUNTAIN PROJECT
MALHEUR COUNTY, OREGON

CALICO RESOURCES

CONSULTANT
GOLDER

YYYY-MM-DD	2019-09-30
PREPARED	MCJ
DESIGN	MDB
REVIEW	CJM
APPROVED	RAB

PROJECT
GRASSY MOUNTAIN
TAILINGS STORAGE FACILITY
DETAILED DESIGN

TITLE
MODELING OUTPUT
TIME TO MAXIMUM TRAILINGS DEPOSITION DEPTH

PROJECT No. 1663241
Rev. 0
FIGURE **9**

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

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