US Army Corps
of Engineers

ARGONAUT MINE TAILINGS STORAGE SITE

EARTH TAILINGS DAM AND CONCRETE MULTI-ARCH DAM (ARGONAUT DAM)

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GEOTECHNICAL REPORT

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Abbreviations

a_{max}	Maximum Horizontal Ground Surface Acceleration
bgs	Below Ground Surface
ASTM	American Society of Testing Materials
CMA dam	Concrete Multi-Arch Dam
CME	Central Mine Equipment

CRR	Cyclic Resistance Ratio
CSR	Cyclic Stress Ratio
cu. yd.	cubic yards
D_{50}	Grain Size Diameter at 50% passing
D_R	Relative Density
DSOD	Division of Safety of Dams
DWR	Department of Water Resources
EPA	Environmental Protection Agency
LETS dam	Lower Earth Tailings Storage Dam
FS_{liq}	Factor of Safety Against Liquefaction Triggering
LI	Liquidity Index
LL	Liquid Limit
mm	millimeter
m/s	meters per second
M	Earthquake Magnitude
MSL	Mean Sea Level
$(N_1)_{60}$	SPT Blow Count Corrected to 1 atm and 60% Energy
$(N_1)_{60CS}$	Equivalent Clean Sand $(N_1)_{60}$
NAVD88	North American Datum 1988
NEHRP	National Earthquake Hazards Reduction Program
NGVD29	National Geodetic Vertical Datum 1929
p	Mean Total Stress
p'	Mean Effective Stress
PI	Plasticity Index
PL	Plastic Limit
PSHA	Probabilistic Seismic Hazard Analysis
psi	Pounds per Square Inch
PVC	Poly Vinyl Chloride
q	Deviator Stress
SPT	Standard Penetration Test
tsf	Tons per Square Foot
UETS dam	Upper Earth Tailings Storage Dam
USACE	U. S. Army Corps of Engineers
USCS	Unified Soil Classification System
USGS	U. S. Geological Society
Vs	Volume of solids
Vs_{30}	Average Shear-Wave Velocity in top 30 meters (or 100 feet)
Vv	Volume of Voids
WC	Water Content

Argonaut Mine Site

Pertinent Dam Data

Concrete Multi-Arch Dam

Crest Elevation	~1366 feet (NAVD88)*[a]
Maximum Height	46 feet
Length	392 feet[b]
Freeboard	1 to 3 feet
Water Storage (free water)	<10 acre-feet
Number of Arches	13[b]
Spillway	Removed or Demolished
Low Level Outlet	Clogged

Lower Earth Tailings Storage Dam

Crest Elevation (from left to right abutment)	~1453 to 1433 feet (NAVD88)*
Maximum Height	~60 feet
Length	~880 feet
Freeboard	N/A (breached)
Water Storage (free water)	N/A (breached)
Breach Elevation	~1415 feet (right side)

*Elevations from aerial survey, photo date 01-27-2014, Synergy Mapping Inc.

[a]The crest elevation was listed as 1364 MSL in the 1931 design documents. There has been no official field survey to verify the conversion from MSL (or NGVD 1929) to NAVD88.

[b] (Eastwood, 1917) has listed the original length as 450 feet, with 14 arches of 32-ft span each, and 15 buttresses. An arch on the left side has been demolished (cause unknown) and the spillway has been removed.

1. Introduction

The Argonaut mine tailings storage site originally contained three dams, a concrete multi-arch (CMA) dam and upper and lower earth tailings storage dams. The upper earth tailings storage dam (UETS) has been eroded and breached extensively and barely resembles a dam structure anymore, and was not investigated as part of this scope. The purpose of this letter-style report is to examine the data primarily collected from explorations and laboratory tests conducted towards the end of 2014, and to determine the geotechnical engineering properties of the materials encountered at the site. These properties are intended to be used for the slope stability analysis of the lower earth tailings storage (LETS) dam, and to provide engineering parameters for the structural stability analysis of the CMA dam. The project is being funded by the U. S. Environmental Protection Agency (EPA), as part of a greater overall assessment of the site. The EPA funded and selected the contractors that conducted the explorations and laboratory tests used for this report.

The main dam at the site is a concrete multi-arch (Eastwood) dam that stores tailings from the Argonaut mine operations of the early 1900s. The dam is located in Amador County approximately 1 mile north of Jackson, CA, at the corner of Argonaut and Sutter streets. State documents from 1931-32 indicate the dam was completed in 1916, had a height of 46 feet, a crest length of 392 feet, and a crest elevation of 1364 feet - MSL (DWR, 26 Feb 1931). The concrete multiple arch (CMA) dam has no spillway or low level outlet. There is also an earth tailings storage dam (LETS) that is about 700 feet upslope (or upstream) of the CMA dam, and has been breached on the right side or abutment (cause or time unknown). A photograph of the CMA dam from the early 1900s is shown in Photo 1-1.

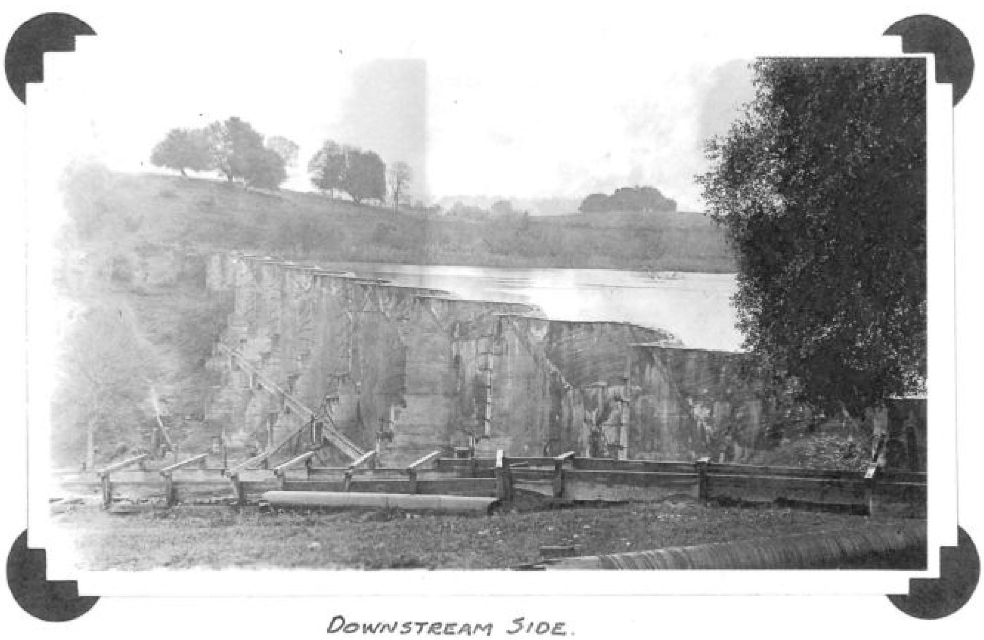

Photo 1-1. Argonaut Concrete Multi-Arch Tailings Storage Dam - Early 1900s.

Photo 1-1 is taken from the left abutment of the dam, and a sluice box can be seen in the foreground, which was most likely part of the original spillway. This spillway (and an arch) has since been removed or demolished (cause unknown), but Argonaut lane now passes through this left abutment.

Reconnaissance level geotechnical explorations were conducted to determine the engineering properties of the tailings and the foundation materials, primarily behind the CMA dam and the LETS dam. Other explorations were conducted in 2008 (URS 2009), but were more focused on the contaminant properties of the tailings, sediments, and groundwater. Therefore, exploration methods and soil descriptions did not address important factors required for engineering stability analyses, shear strength of soils, and liquefaction potential.

A more recent photograph of the dam from November 2013 is shown in Photo 1-2. This photo is also taken from the left abutment on the downstream side, and it can be seen how heavy the vegetation growth has become (even after a lot of it was recently cleared).

Photo 1-2. Argonaut CMA Tailings Storage Dam - Nov 2013

USACE visual inspections of the CMA dam were first conducted in July 2013, where it was found to be very difficult to inspect the dam due to the overgrowth of tress and other vegetation. The results of the inspections can be found in the USACE references of 2013 (USACE, 23 Jul 2013) (USACE, 30 Jul 2013).

2. Site and Geology

The site slopes generally downward towards the east-southeast. An intermittent creek runs the length of the site, and carries surface drainage from its northern portion through multiple drainage areas. The creek flows southeastward to the concrete dam at the eastern portion of the site. The site is primarily covered with gray sands which are considered processed tailings from the Argonaut Mine. It is estimated that the depth of the gray sands at the northern area of the site is 25 feet, and the sand extends deeper toward the southern portion of the site to at least 80 feet bgs. The surface material (tailings) is lighter color near the surface, becoming progressively darker with depth. (URS, 30 Mar 2009).

From the 2009 URS report, the following is a general description of the geology in the Jackson-Plymouth Gold District (Clark, 1980). Gold deposits are in a north- and northwest-trending mile-wide belt of gray to black slate of the Mariposa Formation (Upper Jurassic age), with some interbedded coarse and locally sheared conglomerate and minor sandy layers. Massive greenstone of the Logtown Ridge Formation (Upper Jurassic) lies west of the belt of Mariposa Formation slate. Metasedimentary rocks, chiefly graphitic schist, metachert, and amphibolite of the Calaveras Formation (Carboniferous to Permian) are to the east. Several deposits of Tertiary auriferous (gold bearing) channel gravels are exposed south of Jackson. Alluvial soils, such as Pardee cobbly loam, are found throughout the ground surface in the Jackson area. A brief discussion of the nature of the ore deposits in this mining district is important to understand the characteristics of the native rock at the site. The ore deposits occur in massive and sheared quartz veins commonly with abundant fault gouge. The veins are mainly in Mariposa Formation slate, sometimes tens of feet thick. Veinlets or stringers are also common. The ore deposits contain disseminated fine free gold, pyrite (iron sulfide), and minor amounts of other sulfides. The sulfides usually average one to two percent of the ore. Greenstone masses with disseminated auriferous pyrite known as "gray ore" are locally adjacent to the quartz veins at depth (Clark, 1980).

The tailings storage site consists of a concrete multi-arch dam at the eastern end of the project, and an earth tailings dam located west and upslope of the CMA dam. The gray tailings were placed behind the CMA dam and the upper and lower earth tailings storage dams. The UETS dam was the primary storage area for the grey tailings sands generated from the nearby cyanide plant. The dams at the mine site are primarily located within the Mariposa formation. The bedrock types encountered in the boreholes include highly weathered meta-volcanics and basalt, and siltstone or slate at the foundation of the LETS dam.

3. SPT Explorations

Several standard penetration test (SPT) explorations were conducted behind the CMA dam and at the LETS dam. The boreholes were selected to evaluate the engineering properties of the tailings and the foundation materials for the purposes of conducting stability analyses of the dam structures. The boreholes extended through the tailings and into the weathered bedrock (the scope did not include sampling beyond materials that reached refusal). The objectives of the explorations are outlined in the list below:

i. Obtain samples for lab testing.
ii. Determine blow counts of materials.
iii. Conduct visual examinations of the materials.

Laboratory testing included gradation (ASTM D422 with hydrometer), plasticity (ASTM D4318), moisture content (ASTM D2216), and triaxial shear strength testing (ASTM 4767).

Blow counts were used in determining engineering properties of the materials with the use of correlation tables, including; the density of the material, friction angle, liquefaction potential, and other properties. SPT energy tests were conducted during the blow counts of the first two explorations. Energy tests are used in determining the amount of energy delivered to the SPT hammer and rod, so that they the blow counts can be converted to a common energy standard of 60 percent.

The location of the borings can be seen in Figure 3-1, along with the identification of the CMA dam, the UETS and LETS dams, and the LETS dam breach location. Borehole coordinates and depth information are shown in Table 3-1.

Table 3-1. Exploration Locations and Depths

Boring #	X (Easting)*	Y (Northing)*	Z (Elevation)*	Depth (ft)
2F-14-01	6910733.51	1892663.73	1367	40
2F-14-02	6910732.33	1892615.54	1367	35.7
2F-14-03	6910094.28	1892938.84	1443	63.1
2F-14-04	6909972.43	1892866.38	1433	62.3

*Coordinates in NAD83 U.S. State Plane CA Zone 2 in US feet, using a Trimble GeoXT Geoexplorer 6000. Elevations are from topography maps in NAVD88 feet.

A CME 1050 drill rig was used to conduct the hollow stem-auger drilling and no drilling fluid was used. An automatic trip hammer was used for the SPT tests and the auger casing was left in the hole during blow count testing to help reduce heaving of sands.

Several deficiencies noted during the drilling were the poor shoe quality of the sampler (one was rejected due to its poor shape). Defective shoes can lead to increases in blow counts. The required 6-inch cleanout interval between blow counts was not conducted as requested in the scope of work. The cleanout interval is typically required to remove slough material from the augering operation, and the possible occurrence of heaving sands. The groundwater levels were low and most of the materials had some minimum plasticity to reduce the chance of heaving. Heaving of sands was not encountered. Also, as standard practice requires, the 1st 6-inch interval of the SPT is not included in the blow count measurement.

Piezometers (open tube) were installed in 3 of the 4 borings to monitor the groundwater levels. Two were installed behind the CMA dam (borings 2F-14-01 and -02) and one behind the LETS dam (2F-14-04). The piezometers were installed with 2"-diameter schedule 40 PVC, with a 10'-long slotted interval (0.010"), #2/12 Monterey sand, and a bentonite seal. Details of the piezometer installations and initial readings can be seen in the geologic boring logs. The wells will be monitored by the EPA (schedule unknown). Readings from the piezometers installed in 2014 are shown in Table 3-2 below.

Table 3-2. 2014 Piezometer Readings

Piezometer Number	Top of Casing Elevation[a] (ft)	Well Water Elevation[a] (10/7/14) (ft)	Well Water Elevation[a] (12/19/14) (ft)
2F-14-01	1369.5	1339.55	1340.45
2F-14-02	1368.5	1341.95	1345.10
2F-14-04	1435.5	1382.07	1385.05

[a]All Elevations in NAVD88

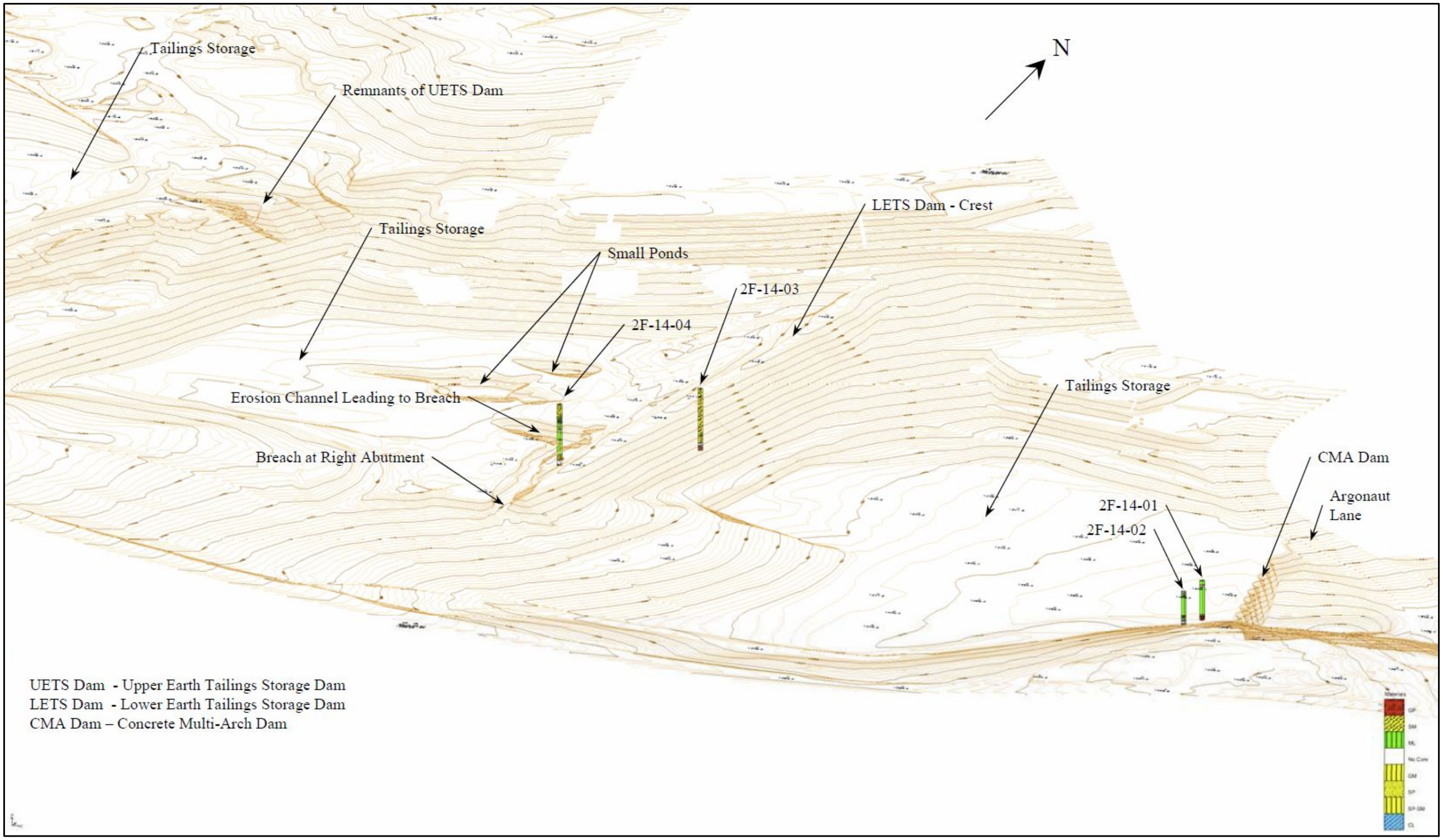

Figure 3-1. Site Topography Overview and Location of USACE 2014 Borings

4. Laboratory Data

Gradations (including hydrometer) and plasticity were conducted for the samples shown in Table 4-1. The table outlines the type of material, the sample depth, the percent passing the #40 (fine sand) and #200 sieves (fines), the field water content (wc), the liquid limit (LL), the plasticity index (PI), the liquidity index (LI), and the USCS classification. Most of the tailings classified as silts (ML), including the visual examinations, but three of the samples tested were classified as lean clays (CL). These plotted just above the "A" line in the plasticity chart of ASTM D2487, and may more closely exhibit the behaviors of low plastic silts (ML). Original lab data sheets can be found in Appendix B.

From the gradations plotted in Figure 4-1, one can see gradational distinctions between the different types of materials. The three tailing samples collected behind the concrete multi-arch dam classified as low-plasticity lean clays (CL), with an average 100% minus the #-200 sieve (0.075mm), an average D_{50} = 0.0065 mm, an average liquid limit (LL) = 33, an average plasticity index (PI) = 13, and an average liquidity index (LI) = 2.0. Most of the field descriptions classified these tailings as low plasticity silts, which is not that unusual since these materials are borderline silts and clays. According to the hydrometer tests, only approximately 19% of the particles were smaller than 0.002mm (which can be considered clay size particles).

For the tailings behind the earth tailings dam, the materials contain more silt than those behind the CMA dam. These tailings primarily classified as non-plastic silts, with approximately 90% minus the #-200 sieve, a D_{50} = 0.045 mm, an average liquid limit (LL) = 17, a plasticity index (PI) = 1, and a liquidity index (LI) = 4.0. These materials, as with the tailings behind the CMA dam, are highly erodible and compressible, and exhibit fluid-like behavior when sheared.

The materials that comprise the earth tailings dam classify as non-plastic silty sands or poorly graded sands. They are coarser than the tailings behind this dam, with a 100% minus the #-50 sieve (0.3mm), a D_{50} = 0.7 mm, and an average field moisture content of only 6.5% (at the time of sampling).

Table 4-1. Sample Gradations and Plasticity

Boring #	Material Type	Sample Depth (ft)	% - #40 sieve (fine sand)	% - #200 sieve (fines)	WC, LL, PI (%)	Liquidity Index (LI)	USCS Classification
2F-14-01	Tailings	18.5	100	100	46.6, 32, 10	2.5	CL, Lean Clay
2F-14-01	Tailings	25.5	100	99	47.6, 34, 15	1.9	CL, Lean Clay
2F-14-02	Tailings	16	100	100	44.7, 34, 15	1.7	CL, Lean Clay
2F-14-02	Tailings	27	100	65	32.6, 19, 5	3.7	CL-ML, Sandy Silty Clay
2F-14-03	Tailings Dam	15	100	29	6, NP	n/a	SM, (non-plastic) Silty (fine) Sand
2F-14-03	Tailings Dam	45	100	24	6.8, NP	n/a	SM, (non-plastic) Silty (fine) Sand
2F-14-04	Tailings	16	100	59	15.2, NP	n/a	ML, (fine) sandy (non-plastic) silt
2F-14-04	Tailings	28	100	88	28.1, 25, 0	n/a	ML, (non-plastic) Silt
2F-14-04	Tailings	40.5	100	93	32.5, 26, 2	4.3	ML, (low-plastic) Silt
2F-14-04	Tailings and Weathered Bedrock	57	55	34	33.1, 26, 1	8.1	SM, (low-plastic) Silty Sand with Gravel

WC - field water content

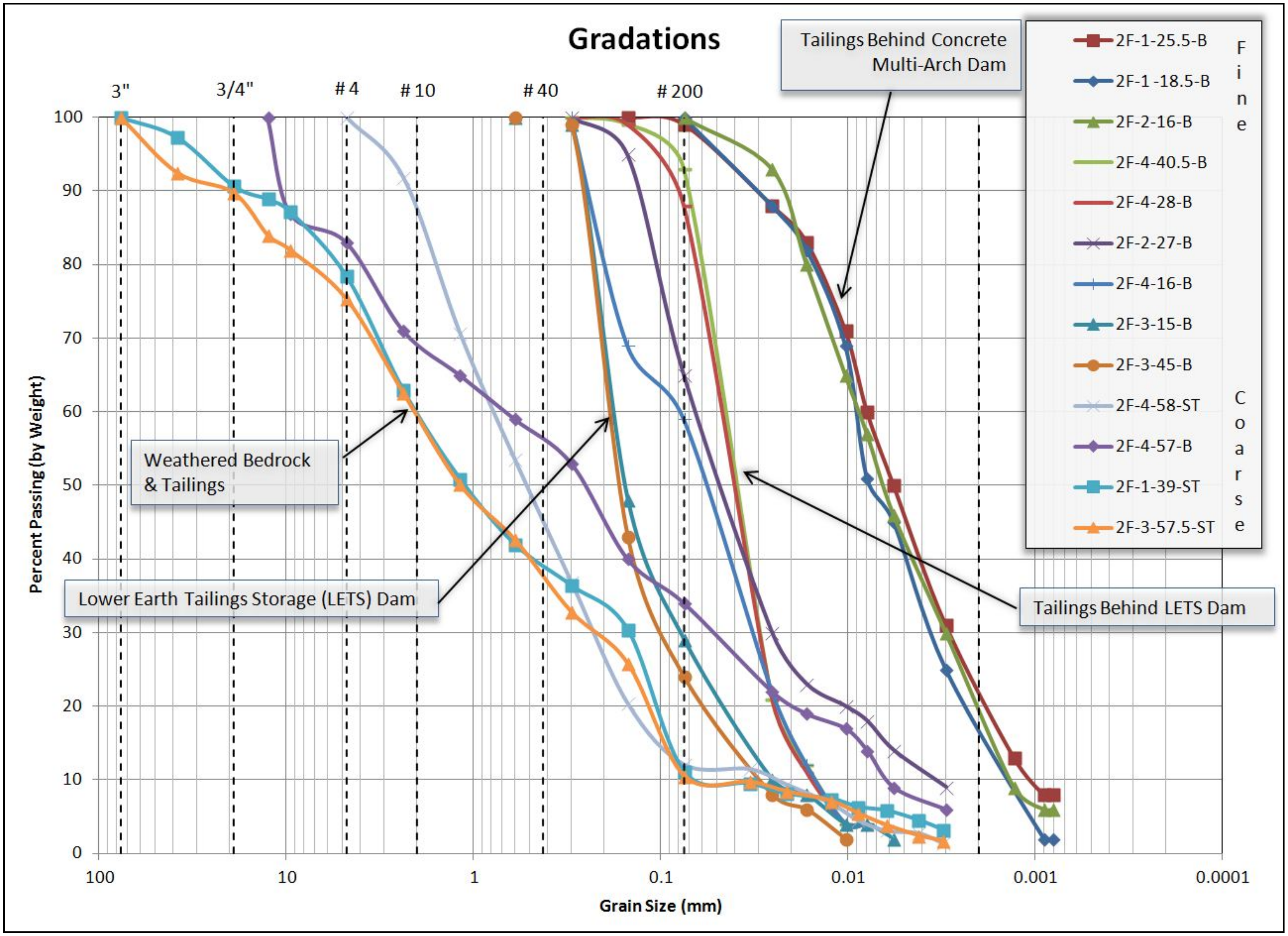

Figure 4-1. Gradations of Sample Materials from 2014 USACE borings.

The liquidity index (LI) is an index for scaling the natural water content of a soil. From this measure, it can be determined if the soil will behave as a plastic, a brittle solid, or a liquid.

$$LI = (w_n - PL) / (PI)$$

where,
LI = Liquidity Index
w_n = natural moisture content
PL = Plastic limit
LL = Liquid Limit
PI = Plasticity Index = (LL-PL).

If the LI is less than zero, the soil will have a brittle fracture when sheared. If the LI is between zero and one, the soil will behave like a plastic. If the LI is greater than one, the soil will behave like a very viscous liquid when sheared. Such soils can be extremely sensitive to breakdown of the soil structure, and if they are sheared, they can literally flow like a liquid (Holtz & Kovacs, 1981).

Most of the tailings have a LI > 1, and will more closely follow the stress-strain behavior for the curves where the water content is equal to or greater than the liquid limit (labeled w ~= LL and w > LL in Figure 4-2).

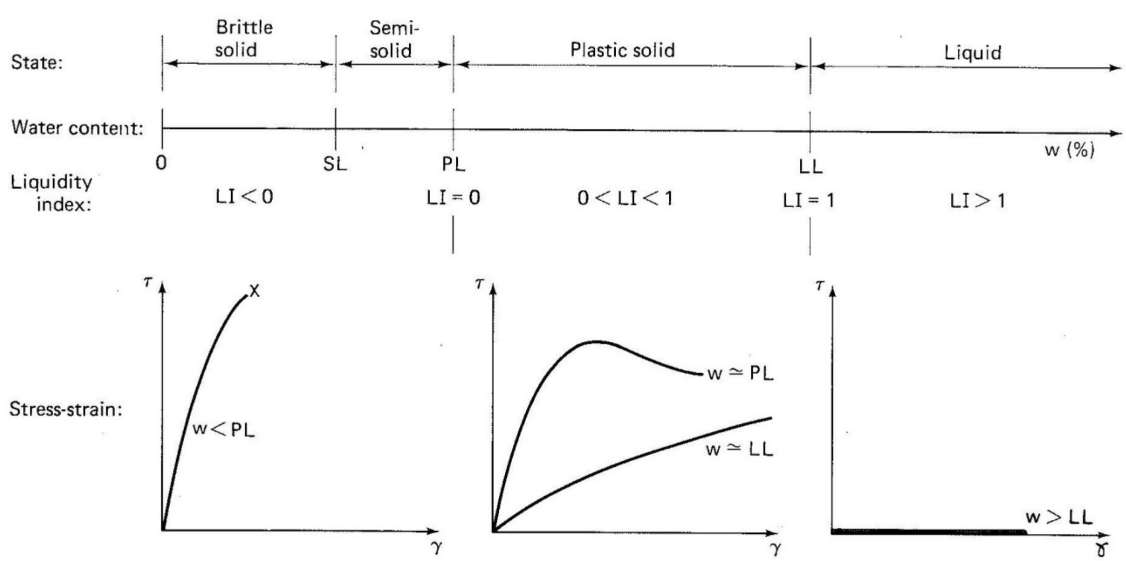

Figure 4-2. Water content continuum showing various states of soil and generalized stress-strain response **(Holtz & Kovacs, 1981)**.

Triaxial tests were conducted on samples obtained with shelby tubes. Shelby tubes were used to obtain relatively undisturbed samples of the tailings and foundation. Previous borings classified the foundation materials as claystone and sandstone, so shelby tubes were intended to be used in these materials. Most of the tailings are so soft and loose that obtaining an undisturbed sample is difficult. Sample disturbance and consolidation most likely occurred during the sampling, shipping, and specimen preparation processes. So consideration was given that the laboratory shear strengths could be slightly higher than in-situ conditions. Other beneficial information from the triaxial tests can also be obtained including void ratio and density. Triaxial sample and testing data are shown in Table 4-2.

Tailing samples behind the CMA dam were taken from borehole 2F-14-01 at depths of 17 and 39 feet. These samples were very similar to each other and indicative of the tailings sampled through most of these two boreholes. The samples tested are described as low plastic silts with an average dry density = 78 lb/ft^3 and an average wet density = 107.5 lb/ft^3, with an average void ratio = 1.15. This high of void ratio is indicative of a very loose density condition.

The samples were tested at 3 confining pressures, 7, 14, & 28 psi, and were sheared to a maximum of 15% strain. The following sentences will discuss the results for the sample at a depth of 17 feet. It can be seen in the stress strain curves of Figure 4-3 that the samples tested at 7 and 14 psi had some rearrangement of particles during shear, and were then able to take more stress beyond 6 to 7 % strain. The sample tested at 28 psi confining stress showed a more typical behavior with a failure occurring at about 7% strain, where it can be seen the sample continued to strain without much increase in normal stress.

The stress paths in Figure 4-4 show that the samples exhibited contractive behavior during shear since the effective stress paths are to the left (or less than) the total stress paths (positive pore pressures were developed during shear). As can be seen in Figure 4-5, the change in pore pressures were mostly positive until about 11% strain, where they went negative indicating some dilation was occurring during shear (Figure 4-5). Similar investigations of the stress-strain and stress path data were made for other samples tested, which lead to the development of the Mohr circle plots for those tests. It is not recommended that the Mohr circle plots in the lab data sheets be used, since these are not based on a critical review of the data. The lab reports typically use a computer program that assumes failure occurs at 15% strain (for example), and this may not be the point at which failure actually occurred.

Table 4-2. Triaxial Test Samples

Boring #	Depth (ft)	Material Type	USCS Class.	Dry Density Avg.[c] (lb/ft^3)	Moisture Content Avg.[c] (%)	Insitu Wet Density Avg.[c] (lb/ft^3)	Void Ratio Avg.[c] (V_v / V_s)[a]	Degree of Saturation[b] Avg. (%)	Degree of Saturation[e] Avg. (%) 7, 14, 28 psi
2F-14-01	17	Tailings	ML	78	40	109	1.2	39	100, 74, 100
2F-14-01	39	Tailings & Weathered Bedrock	SP-SMg[d]	78	36	106	1.1	36	83, 100, 72
2F-14-03	57.5	Weathered Bedrock & Soil	SP-SMg	106	21	128	0.59	25	99, 99, 88
2F-14-04	58	Weathered Bedrock & Tailings	SM	103	24	127	0.65	27	100, 86, -

a - Vv = Volume of Voids, Vs = Volume of solids

b - Sample Values Before Testing

c - Averages from Shelby tube samples

d - The gradation indicated SP-SMg (poorly graded sand with silt and gravel), but the test results appeared very similar to the silt ML at the depth of 17 feet.

e - After Back-Pressure Saturation (but before shear)

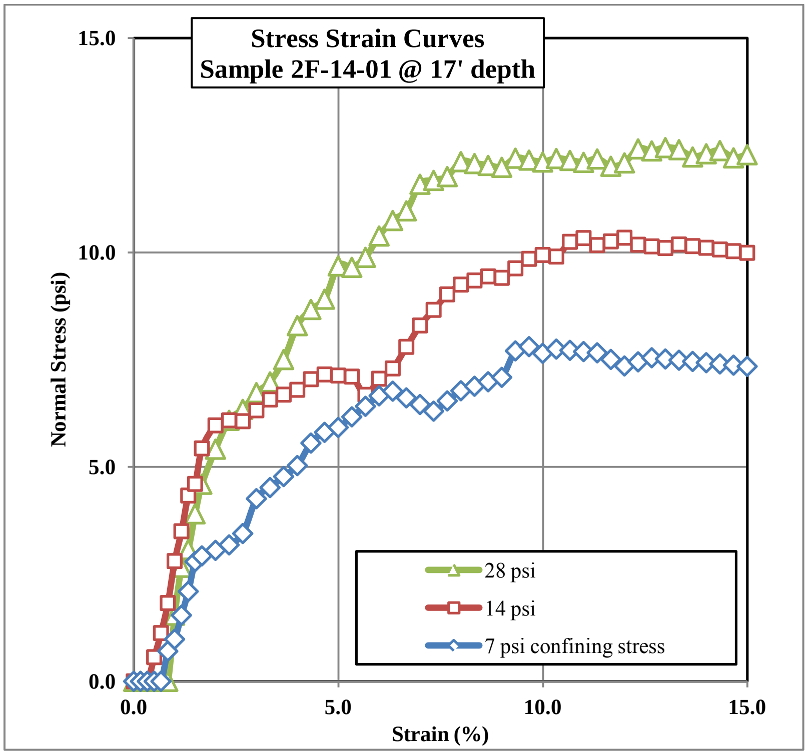

Figure 4-3. Stress-Strain Curves (Sample 2F-14-01 @ 17' Depth)

Mohr circle plots were developed for the four samples tested and the failure envelopes were constructed based on a review of the stress paths and Mohr circle stress plots. The shear strength envelopes of the tailings are shown in the Mohr circle plots in Figures 4-6 and 4-7, and developed very similar strength envelopes. The shear strength envelopes of the weathered bedrock (although appeared to be mixed with tailings and soil materials) are shown in the Mohr circle plots in Figures 4-8 and 4-9. The shear strength envelope parameters are shown on each chart for total (c, ϕ) and effective stress (c', ϕ') conditions. The effective stress envelopes could have zero cohesion if the envelopes were drawn curved towards the origin. But for the simplicity of analysis (and structural design input requirements), straight line envelopes were used. Selection of the shear strength values for design purposes are discussed in the section *Engineering Analyses and Results*.

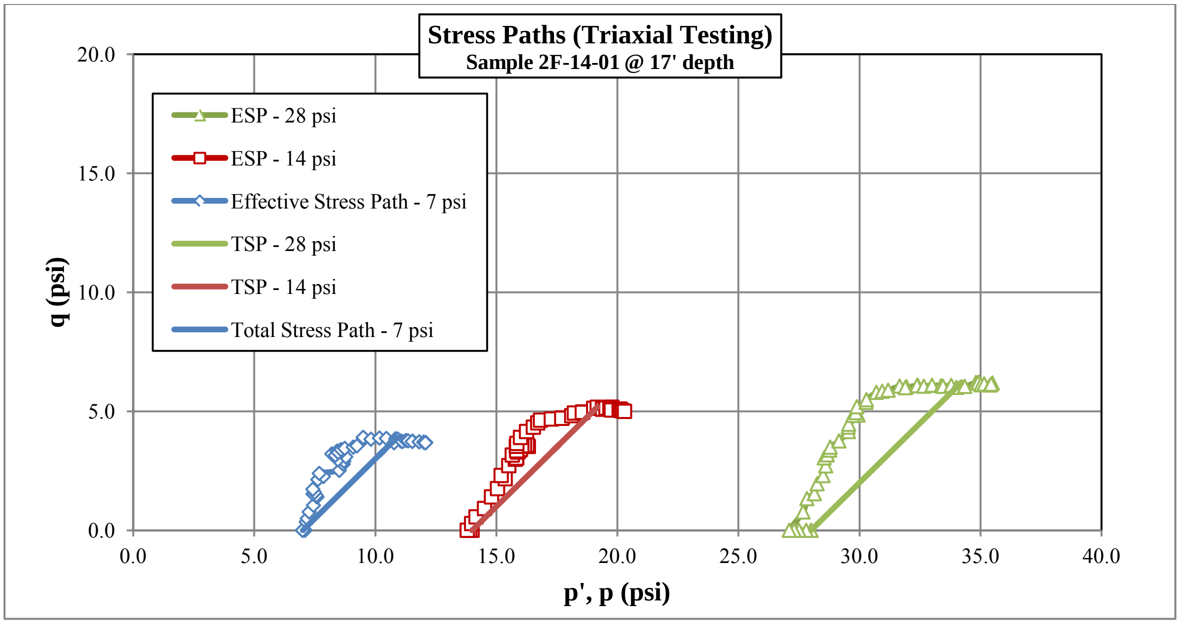

Figure 4-4. Stress Paths During Triaxial Testing (Sample 2F-14-01 @ 17' Depth)

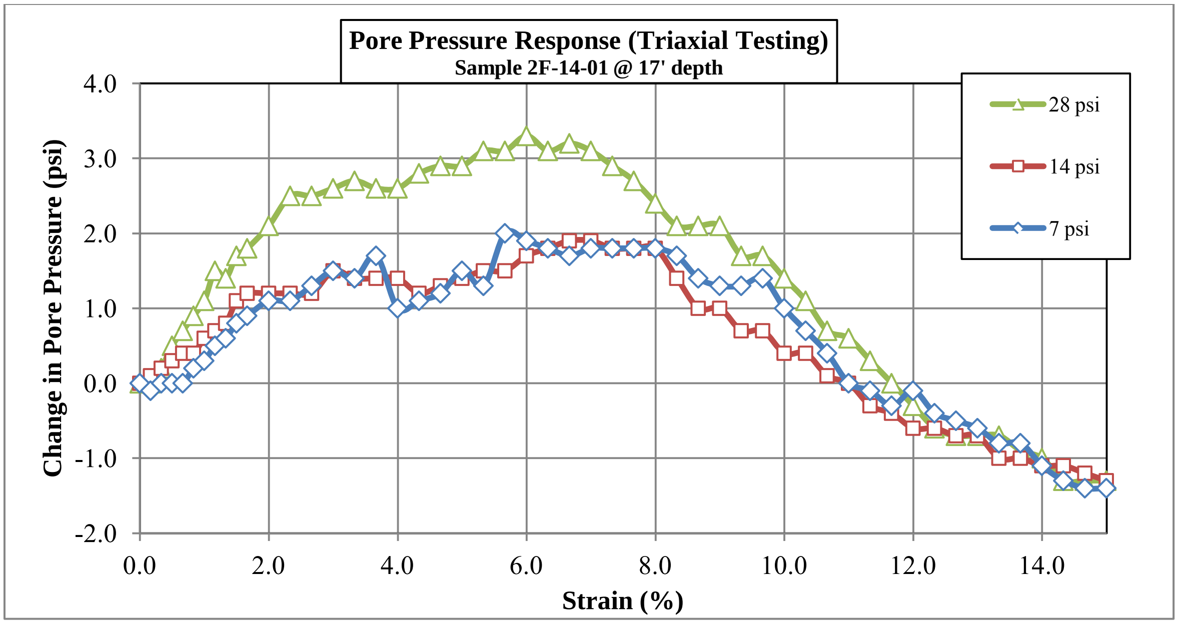

Figure 4-5. Pore Pressure Response During Triaxial Testing (Sample 2F-14-01 @ 17' Depth)

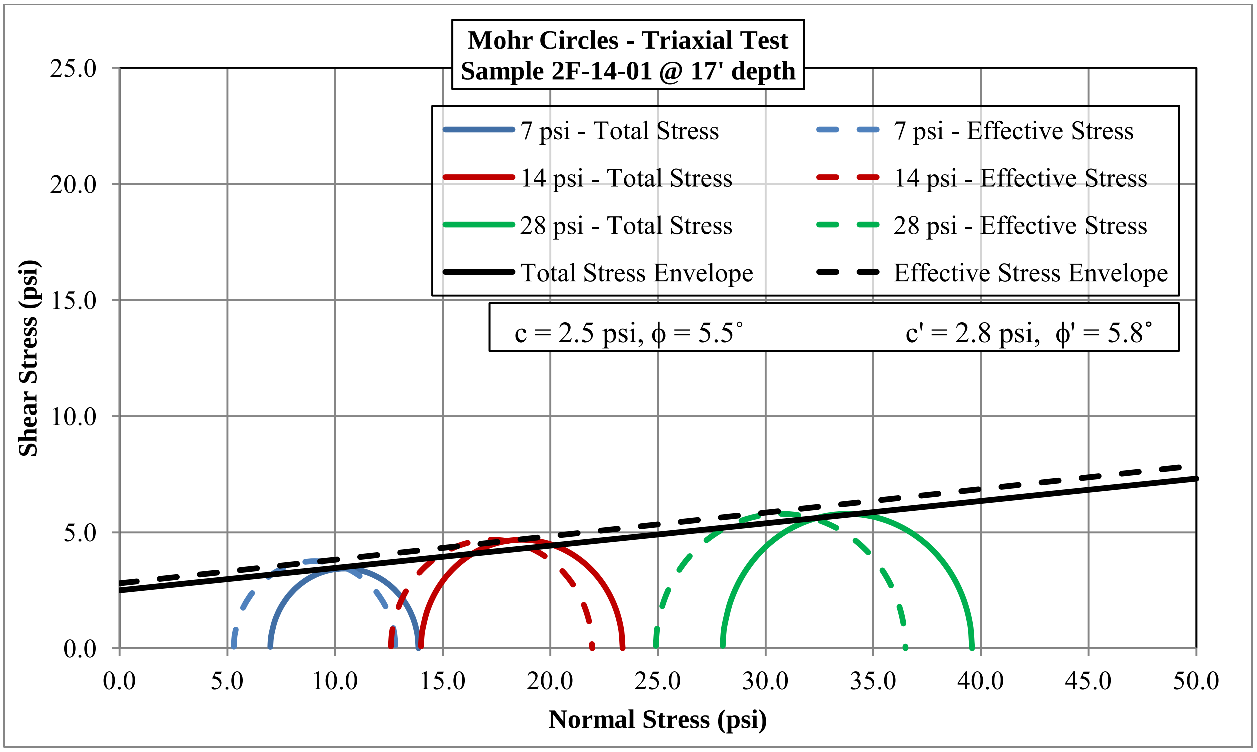

Figure 4-6. Mohr Circles and Failure Envelopes - (Sample 2F-14-01 @ 17' Depth)

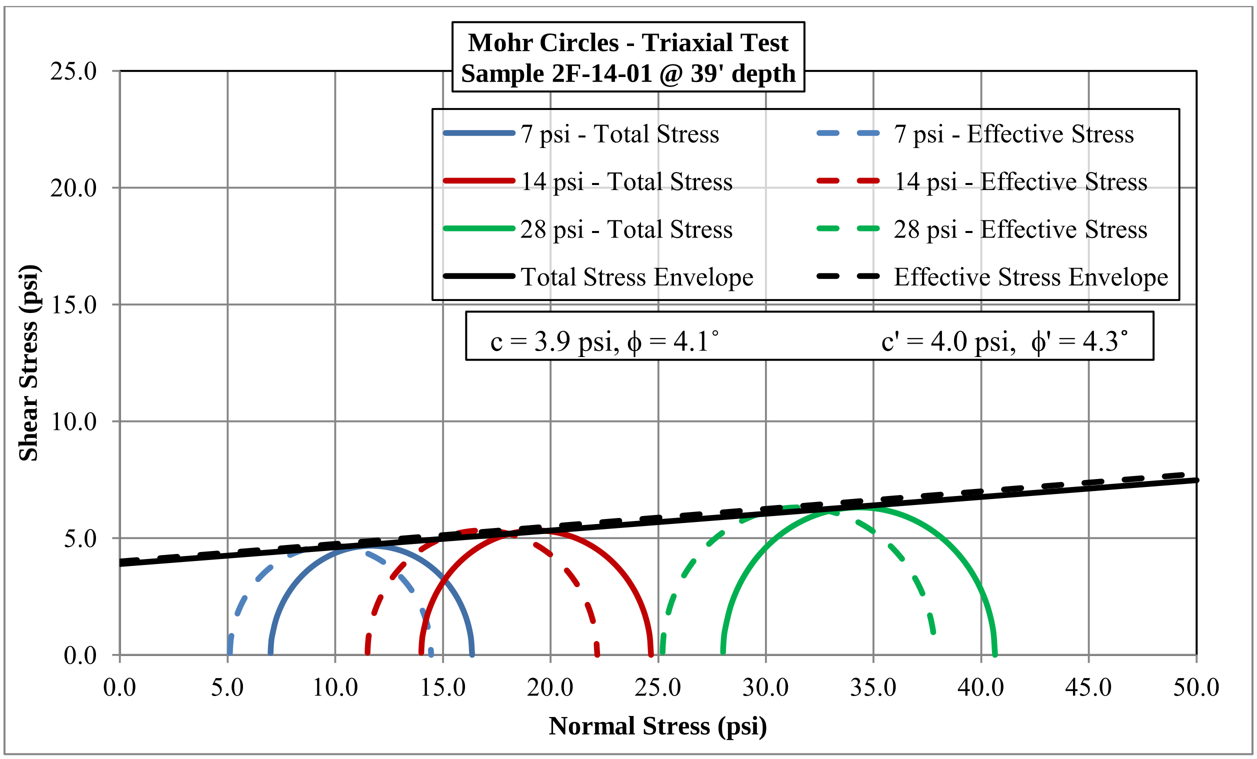

Figure 4-7. Mohr Circles and Failure Envelopes - (Sample 2F-14-01 @ 39' Depth)

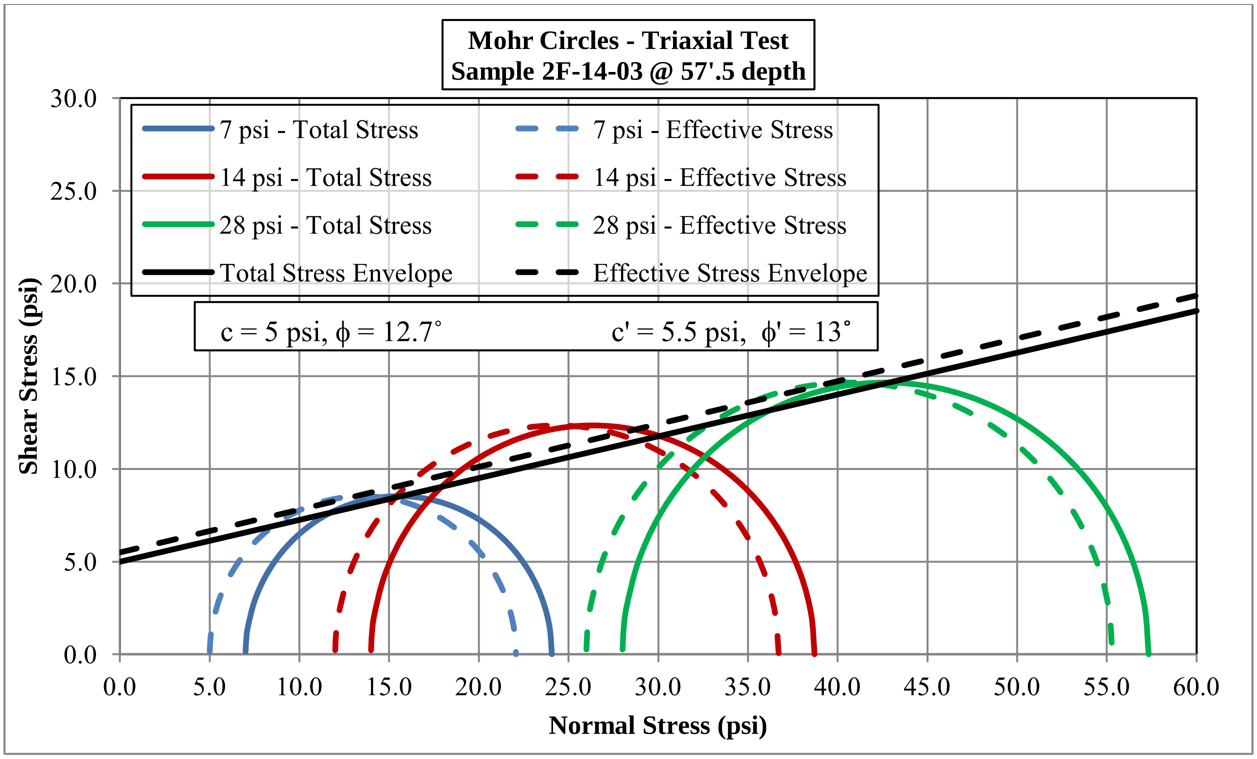

Figure 4-8. Mohr Circles and Failure Envelopes - (Sample 2F-14-03 @ 57.5' Depth)

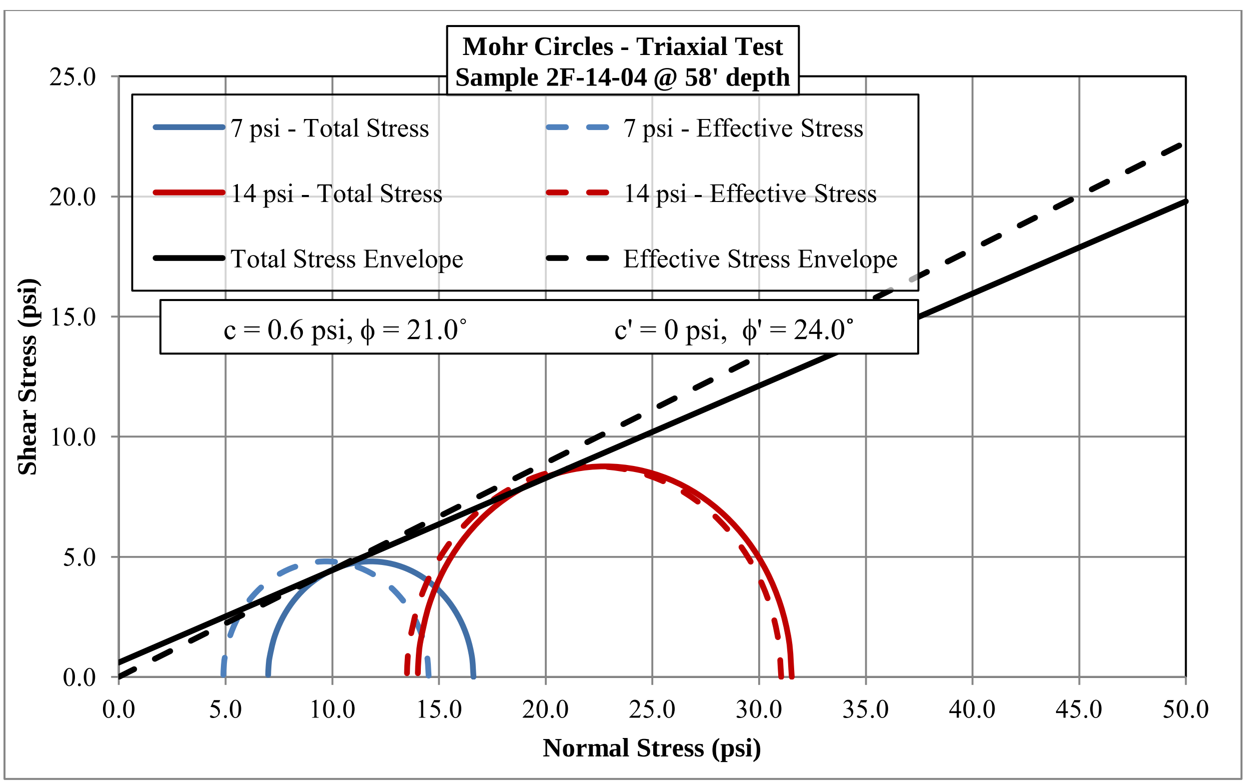

Figure 4-9. Mohr Circles and Failure Envelopes - (Sample 2F-14-04 @ 58' Depth)

5. Liquefaction Analysis

The method used to evaluate the blow counts and determine the factor of safety against liquefaction potential were based on the procedures described in EERI Monograph No. 12 (Idriss & Boulanger, 2008). The SPT tests were conducted using a 140-pound hammer with 30 inches of freefall and from an automatic trip hammer to drive the samplers into the soil. The sampler had an inside diameter of 1-3/8" and no liners were used for the tests. SPT energy tests were conducted during the first two borings (2F-14-01 & -02). There can be a slight variation in transferred energy per blow count, but the average energy measured was 85.5 percent.

Earthquake parameters for the site and used for the liquefaction analysis were based on the USGS 2008 PSHA deaggregation website (http://geohazards.usgs.gov/deaggint/2008/). The input parameters included the following: Latitude = 38.353˚ North, -120.782˚ West, an exceedance probability = 2% in 200 years (mean return time = 9,900 yrs), and a Vs_{30} = 760 m/s (or NEHRP BC rock classification). The output from the deaggregation can be seen in Figures 5-1 and 5-2. The figures show how the different magnitude earthquakes contribute to the seismic hazard at the site. The geographic deaggregation is interesting in that it shows the contribution of magnitude and distance from the site to the seismic hazard graphically. For this site, a peak ground acceleration of a_{max} = 0.21g was selected, and a magnitude of M = 6.5. Although there's little information on the groundwater table history at the site, for the liquefaction analysis it was estimated that the depth to groundwater would be 5 feet (at the time of the earthquake). Piezometers were installed during these explorations that will aid in determining future variations of groundwater levels with precipitation. Using these parameters, the tailings stored behind the dams have a high probability of liquefaction (which is not unexpected given the low blow counts of the tailings).

Plots of factor of safety against liquefaction for the 4 boreholes conducted in 2014 are shown in Figures 5-3 to 5-6. The first chart in the figures (on the left) show the $(N_1)_{60cs}$ blow counts versus depth, the 2nd chart shows the fines content (minus #200 sieve) versus depth, the 3rd chart shows the cyclic stress ratio (CSR) and cyclic resistance ratio (CRR) versus depth, and the 4th chart (on the far right) indicates the factor of safety against liquefaction (FS_{liq}) versus depth. A $FS_{liq} < 1$, indicates liquefaction will most likely occur, and a value > 1 indicates liquefaction will most likely not occur.

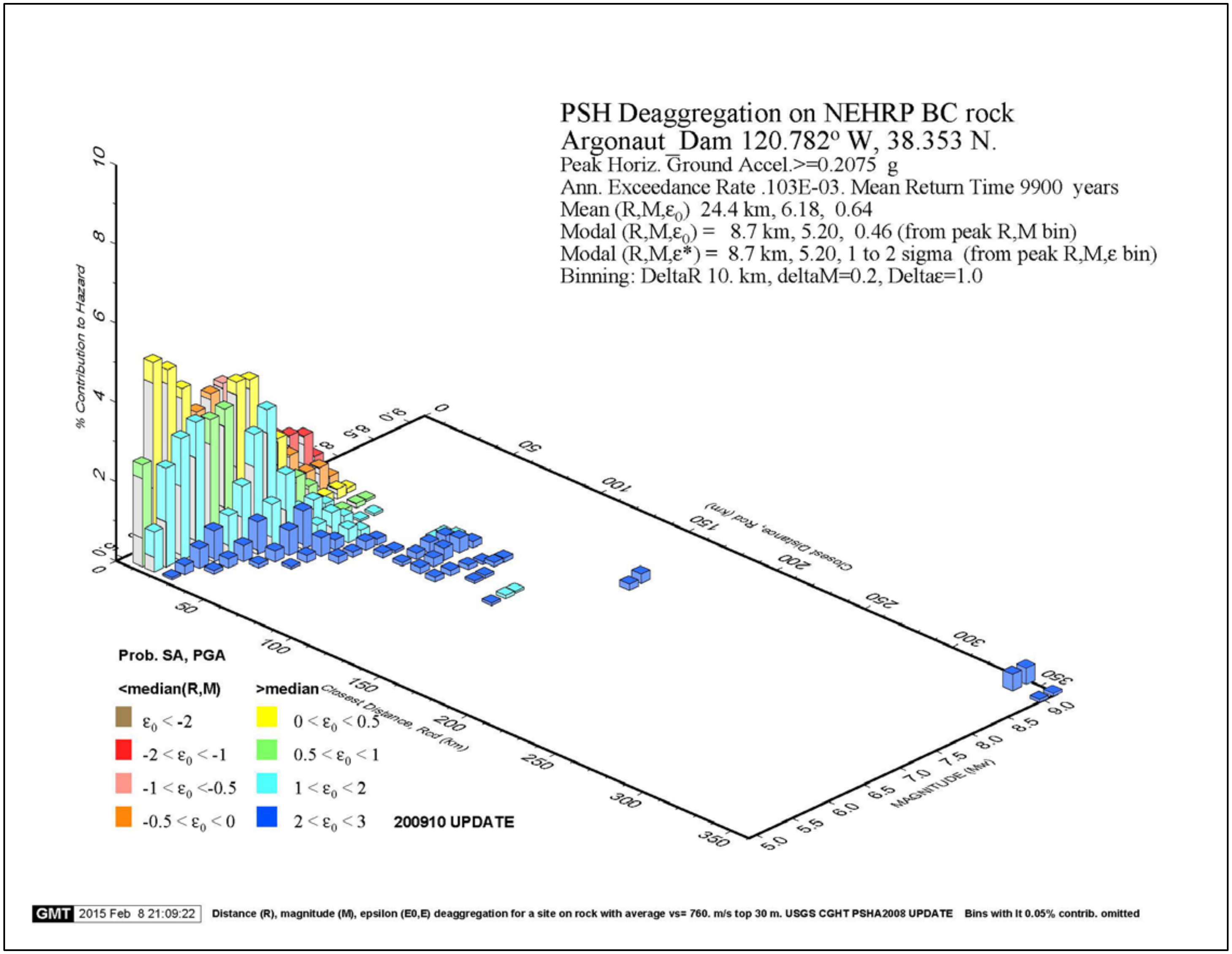

Figure 5-1. PSH Deaggregation - Argonaut Dam Site (2% in 200 yrs)

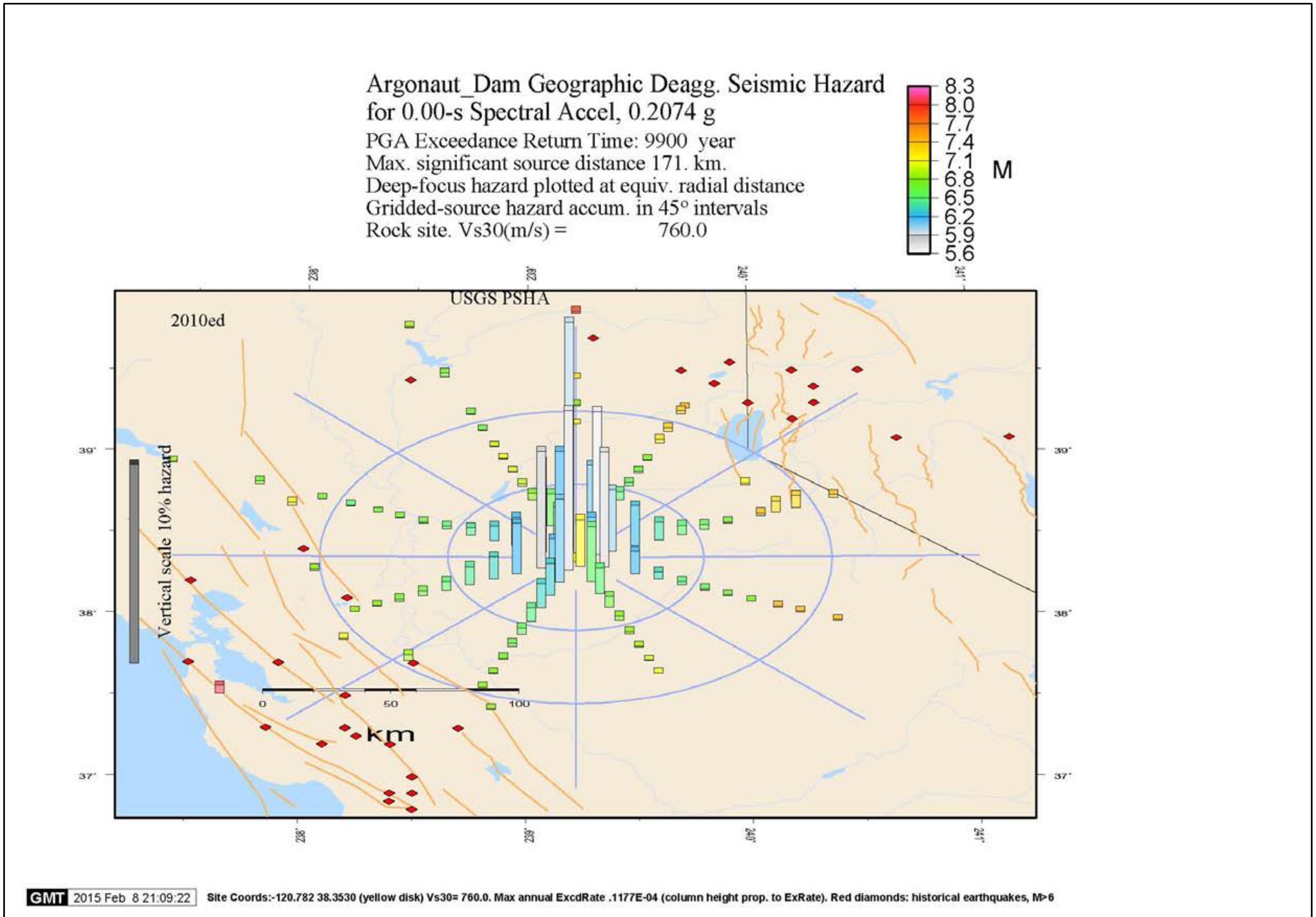

Figure 5-2. PSH Geographic Deaggregation - Argonaut Dam Site (2% in 200 yrs)

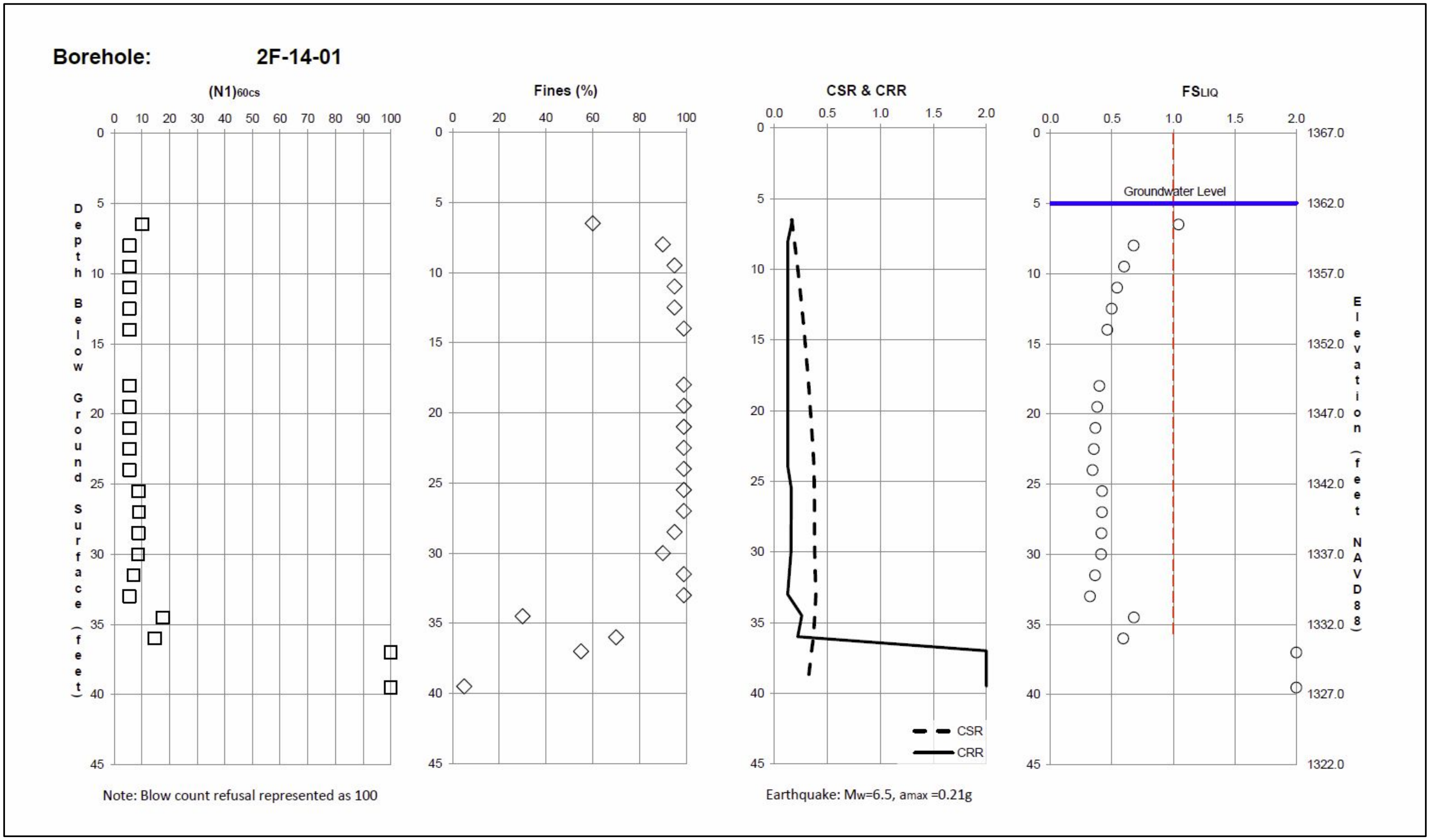

Figure 5-3. Liquefaction Analysis for Borehole 2F-14-01

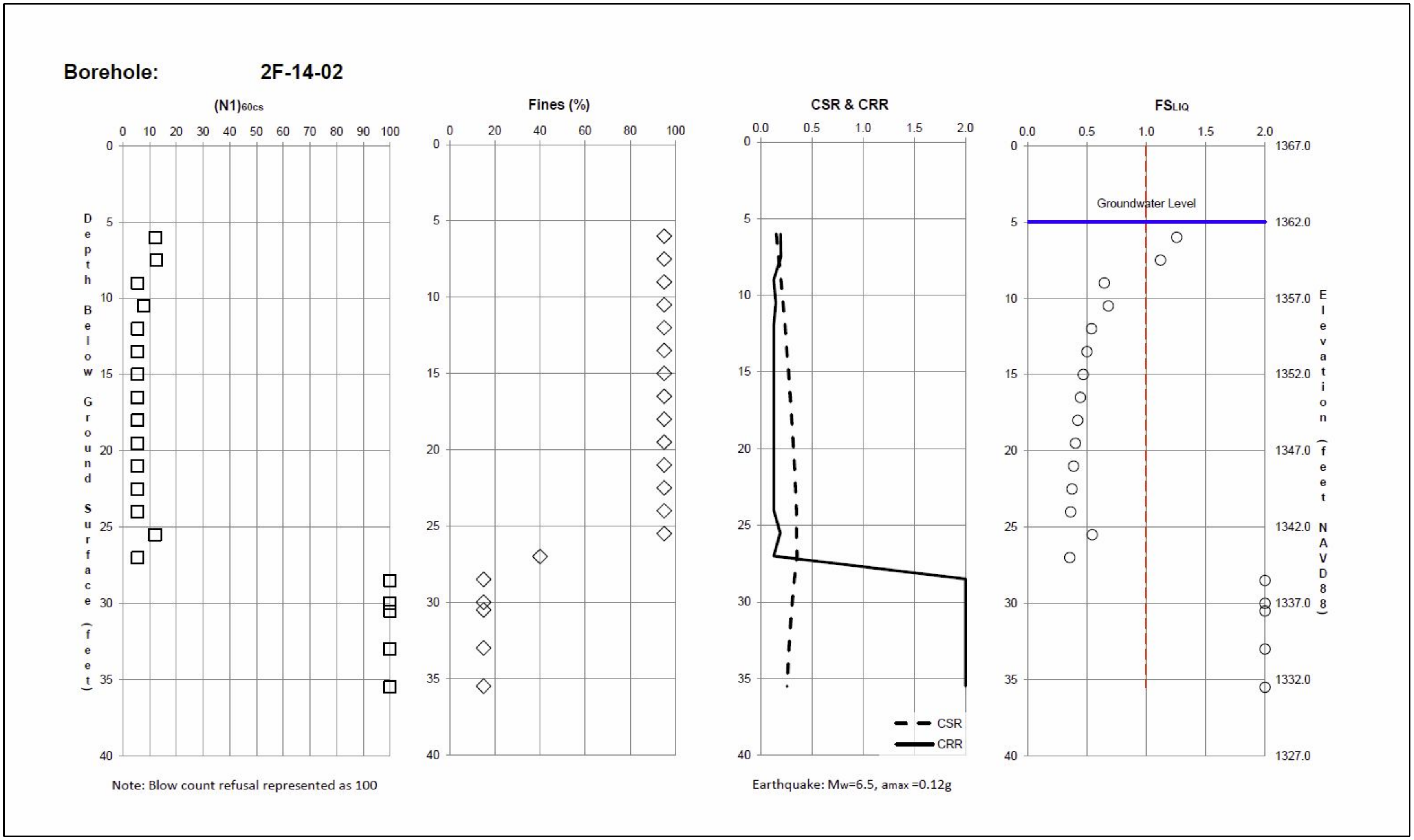

Figure 5-4. Liquefaction Analysis for Borehole 2F-14-02

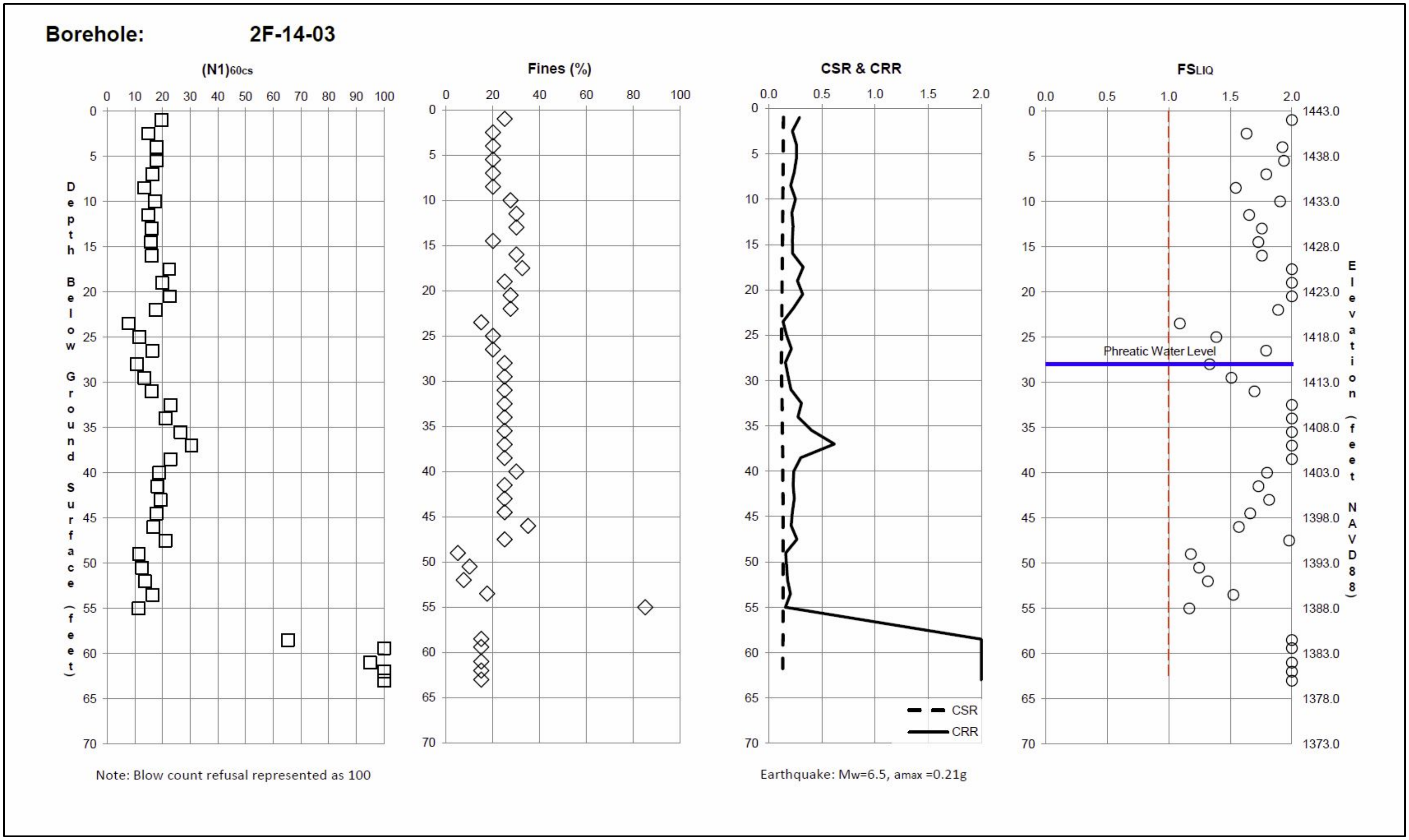

Figure 5-5. Liquefaction Analysis for Borehole 2F-14-03

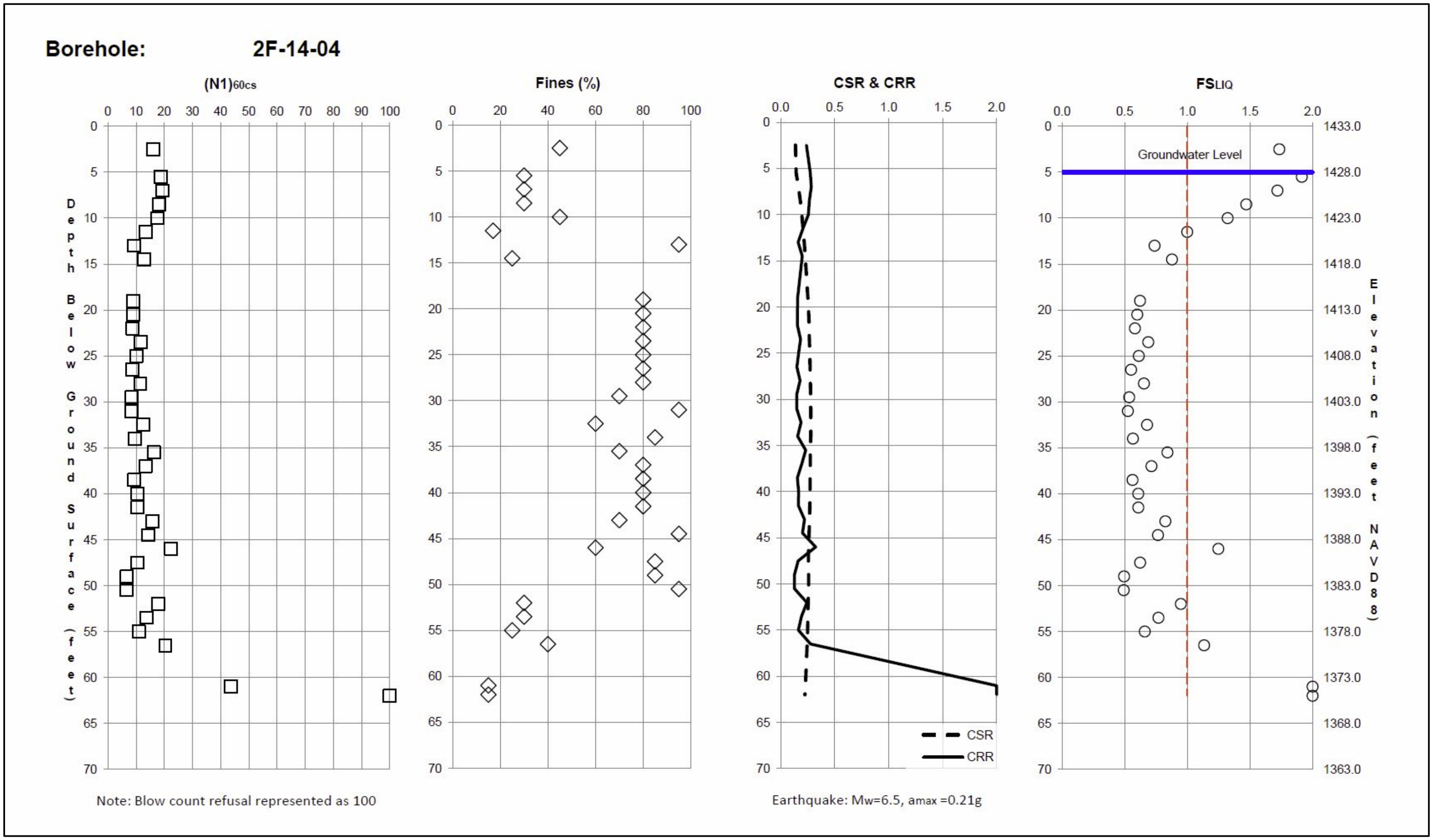

Figure 5-6. Liquefaction Analysis for Borehole 2F-14-04

6. Engineering Analyses and Results

6.1. Tailings - Shear Strength

The materials behind the concrete multi-arch dam were characterized by borings 2F-14-01 and 2F-14-02. These boreholes extended from the top of the mine tailings, and into the weathered bedrock. The tailings, which have a liquidity index > 1 and are very loose as evidenced by the void ratios (> 1.1) and blow counts [average $(N_1)_{60} < 2$], have very low shear strength. Shear strength is represented by the components of cohesion (c) and the angle of internal friction (ϕ) of the material, and is given by the Mohr-Coulomb equation:

$$\tau = c + \sigma \tan \phi$$

In the selection of the design shear strength for the tailings, some consideration is given that the loose samples consolidated somewhat during sampling, transporting, and sample preparation. Therefore, a strength envelope slightly lower than that shown for the triaxial tests was selected. Consequently, the design effective stress shear strength for the tailings material was determined to be the following:

(effective stress) cohesion (c') = 3 psi, friction angle (ϕ') = 3 degrees (**tailings**)

6.2. Weathered Bedrock - Shear Strength, Modulus of Subgrade Reaction

Samples of weathered bedrock were described as a highly fractured, weathered, siltstone or slate, (2F-14-03), or fine-grained, weathered, meta-volcanics or meta-basalt (2F-14-01 & 2F-14-02). Less weathered bedrock is expected with depth, but the strength for this type of rock could be governed by the shear strength of the rock joints or fractures. The blow counts in the weathered bedrock material all reached refusal. This could be due to the fact that the materials are denser, or are due to the sampler impacting stones (gravels) at the shoe, and thus artificially increasing blow count.

Weathered bedrock was all that could be sampled with the drilling measures employed (SPT). The dam foundation is deeper than the borings could penetrate. Therefore, the strengths for weathered bedrock may not represent the foundation materials at the maximum section of the CMA dam, and could indicate a lower bound strength. The effective stress shear strength of the weathered bedrock was selected as the following from a review of the triaxial tests and engineering judgment for these types of materials:

(effective stress) cohesion (c') = 5 psi, friction angle (ϕ') = 25 degrees (**highly weathered**)

For the stability analysis of the CMA dam, it might be more appropriate to consider that the structure was placed on moderately weathered rock. No clear records have been found to date to verify the foundation conditions for the dam. Therefore, the effective stress shear strength was based on engineering judgment:

(effective stress) cohesion (c') = 10 psi, friction angle (ϕ') = 35 degrees (**moderately weathered**)

The CMA dam was keyed into bedrock having a base thickness of 1.65 ft as shown in the historic document in Figure 6-1 (which shows a maximum section of the dam). The depth of the key is not indicated, but in another reference (Eastwood, 1917), it was indicated that *"in order to get a firm foundation, the excavation was carried to an average depth of 6 ft. into this bedrock requiring the removal of 1167 cu. yd. of earth and rock."* The degree of weathering of the bedrock into which the key was placed is unknown, but is more likely less weathered than the material sampled with the SPT.

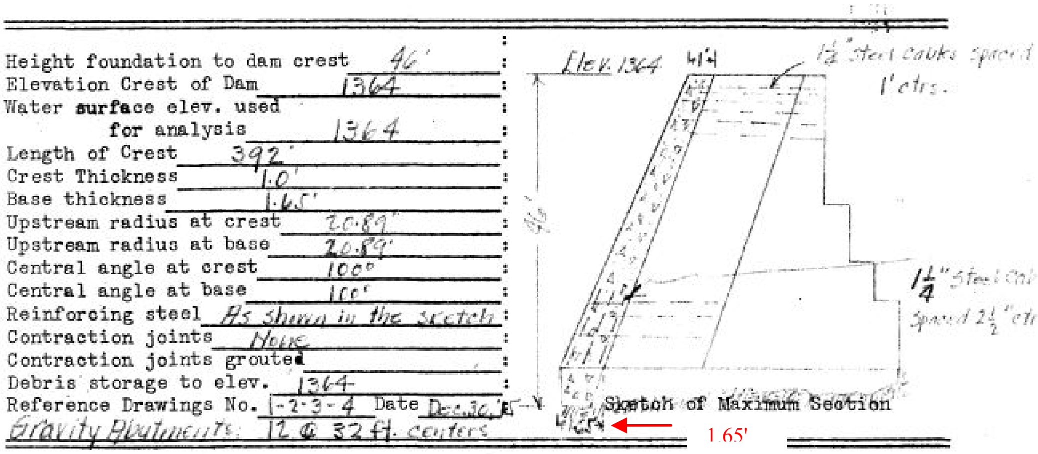
Height foundation to dam crest 46'
Elevation Crest of Dam 1364
Water surface elev. used for analysis 1364
Length of Crest 392'
Crest Thickness 1.0'
Base thickness 1.65'
Upstream radius at crest 20.89'
Upstream radius at base 20.89'
Central angle at crest 100°
Central angle at base 100°
Reinforcing steel As shown in the sketch
Contraction joints None
Contraction joints grouted
Debris storage to elev. 1364
Reference Drawings No. 1-2-3-4 Date Dec. 30
Gravity Abutments: 12 @ 32 ft. centers

Figure 6-1. Arch Dam Analysis Cross Section - Early 1900s (see full Figure in Appendix E)

The following parameters were developed for the use in structural analysis of the CMA dam. Bearing capacity can be used to estimate the modulus of subgrade reaction. The modulus of subgrade reaction is a conceptual relationship between soil pressure and deflection (Moayed & Naeini, 2006). The allowable bearing pressures given in EM 1110-1-1905, *Bearing Capacity of Soils* (USACE, 30 Oct 1992), Table 4-8, for "weathered or broken bedrock," or "soft rock," is:

q_{na} = 20 ksf (soft or weathered broken rock)

where,
q_{na} = nominal allowable bearing pressure
ksf = kips per square foot

The allowable bearing pressures given in EM 1110-1-1905 (USACE, 30 Oct 1992), Table 4-8, for "foliated metamorphic rock, slate, or schist (sound condition rock allows minor cracks)," or "medium hard sound rock" is:

$$q_{na} = 70 \text{ ksf} \quad \text{(medium hard sound rock)}$$

An average of these 2 materials will be used for the estimate of allowable bearing capacity, which would be equal to **45 ksf**.

The modulus of subgrade reaction for the weathered to medium to hard sound rock can be estimated using the following relationship from the textbook *Foundation Analysis and Design*, (Bowles, 1988):

$$k_s = 12\ (FS)\ q_a\ (k/ft^3)$$

$$k_s = 12\ (3)\ 45 = \mathbf{1620}\ (k/ft^3 \text{ or } k/ft^2/ft)$$

where,
k_s = modulus of subgrade reaction
FS = Factor of Safety
q_a = allowable bearing capacity

Another relationship based on SPT blow counts in gravelly soils and verified by plate load tests is shown in the 2006 technical paper (Moayed & Naeini, 2006) as:

$$k_s\ (kg/cm^3) = 3.143\ ((N_1)_{60})^{0.489}$$

Since refusal was reached in the weathered bedrock materials, a $(N_1)_{60}$ blow count of 100 would be representative of the medium to hard sound rock material and results in a ks value of:

$$k_s = \mathbf{1865}\ (k/ft^3)$$

This is very close to the estimation determined by using bearing capacity. The selected design value is based on averaging the two values above and results in an approximate value of the modulus of subgrade reaction equal to:

$$k_s = \mathbf{1750}\ (k/ft^3)$$

6.3. Earth Tailings Dam

The lower earth tailings storage (LETS) dam is considered to be a non-zoned embankment (homogeneous) with no core zone or provisions for internal drainage (such as gravel chimney or blanket drains). The dam is approximately 60 feet tall (from crest to downstream toe), has a crest width of approximately 12 feet, and the downstream slope has a gradient of 1.5H:1V (Horizontal to Vertical). A cross-section of the dam is shown in Figure 6-3. The properties of the materials composing the embankment are based on the SPT results of borehole 2F-14-03. The dam shows significant signs of surface erosion and the crest elevation varies from 1453 feet at the left abutment to 1433 feet (NAVD88) at the right abutment (see Figure 6-5). As previously noted, the tailings that comprise the earth dam are coarser than the tailings behind the dam, which would have been common practice to use the coarse fraction of the tailings for embankment construction (Azam & Li, Dec 2010).

The LETS dam has already been breached on the right side (looking downstream) down to approximate elevation 1415 feet (NAVD88). The cause of the breach is unknown but could have been created to release surface water from the tailings and most likely has further eroded over time. The tailings behind the dam, being highly erodible and subject to internal erosion (piping), could develop significant piping potential through the dam and foundation. However, since the dam is unable to store water and develop large hydraulic gradients across the structure, it is less prone to significant failure and damaging consequences.

There are some small ponds and sinkholes on the upstream side of the dam that have most likely developed as the result of settlement and erosion over time. If the groundwater levels are high and the tailings are saturated and the dam does fail, some of the tailings could flow down slope to the CMA dam and increase the loads on that structure, or possibly overtop the dam. A view from the upstream side of the dam, looking Northeast, can be seen in Photo 6-1. This photo shows a sinkhole and the erosion scarp and channel that leads to the breach at the right abutment of the dam. A view of the breach at the right abutment of the earth tailings dam is shown in Photo 6.2.

Photo 6-1. Earth Tailings Dam from Upstream Side - Looking Northeast (25 Sep 2013)

Photo 6-2. Breach at Right Abutment - Looking Downstream or Southeast (25 Sep 13)

6.3.1. Slope Stability Analysis

The computer program UTEXAS4 - Spencer's method was used for the slope stability analysis. A complete view of the profile and cross section of the dam can be seen in Figure 6-5. The shear strength of the tailings was based on the values shown in Section 6.1. The phreatic surface was based on starting the groundwater level at the breach elevation upstream of the dam, and using a shallow gradient through the embankment to the downstream slope. There are several small settlement and erosion ponds (including sinkholes) that have formed behind the dam, which can store small amounts of water. A piezometer has been installed behind the dam to monitor future water tables. The strength of the material in the earth tailings dam was determined from the SPT blow counts using the chart shown in Figure 6-2 (Figure 7 - UFC, 8 June 2005). The sands (SP) and silty sands (SM) in the tailings dam from the ground surface to a depth of 54 feet had an average blow count $(N_1)_{60} = 13$ and an average $(N)_{60} = 14$ (from borehole 2F-14-03). This corresponds to an approximate relative density, $D_r = 55\%$ (from Figure 3, UFC 8 June 2005), and a friction angle approximately equal to:

(effective stress) friction angle (ϕ') = **33 degrees** (**Tailings Dam**)

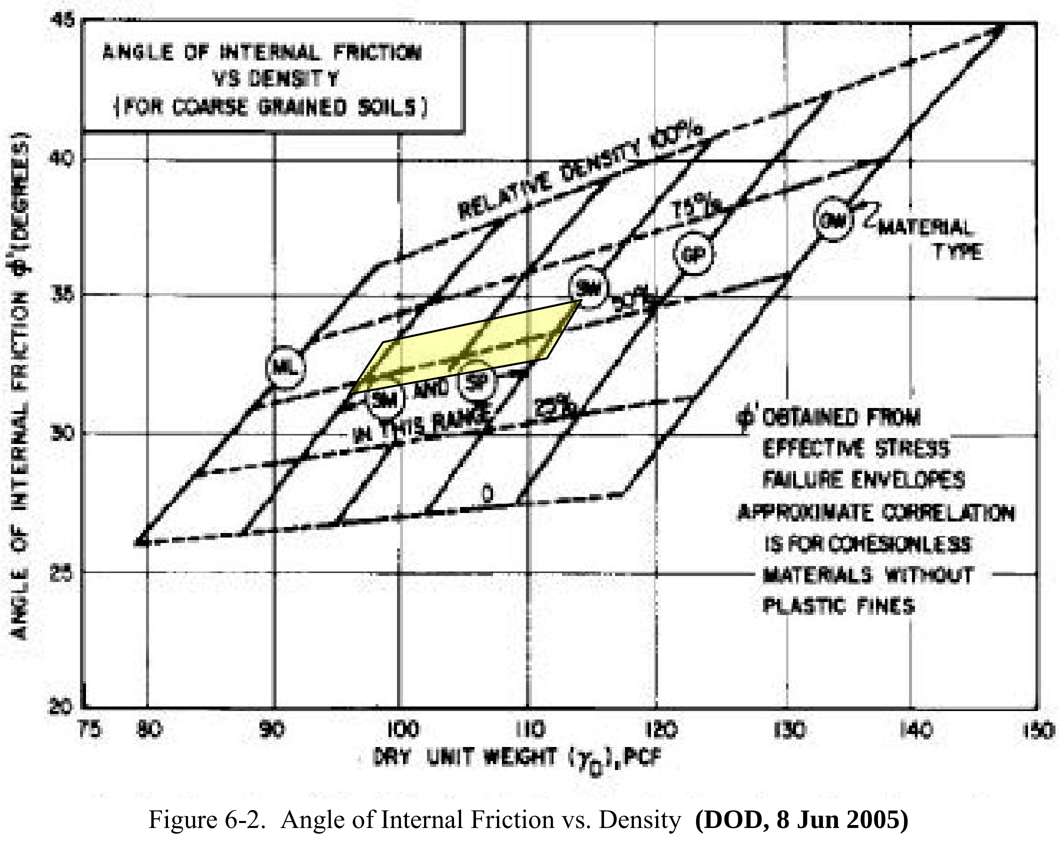

Figure 6-2. Angle of Internal Friction vs. Density **(DOD, 8 Jun 2005)**

The line of distinction between the tailings in the earth dam and those stored behind the dam, were estimated by a 1.8H:1V slope line extending from the crest of the dam in the upstream direction. It is unknown how the dam was constructed, but this represents a reasonable assumption at this time, and may correlate with the silty sand (SM) materials encountered near the bottom of borehole 2F-14-04. The results of the static slope stability analysis are shown in Figure 6-4, with a Factor of Safety against sliding, FS = 1.06. This corresponds well with the static condition observed in the field given the loose materials encountered in the embankment and the steepness of the slopes.

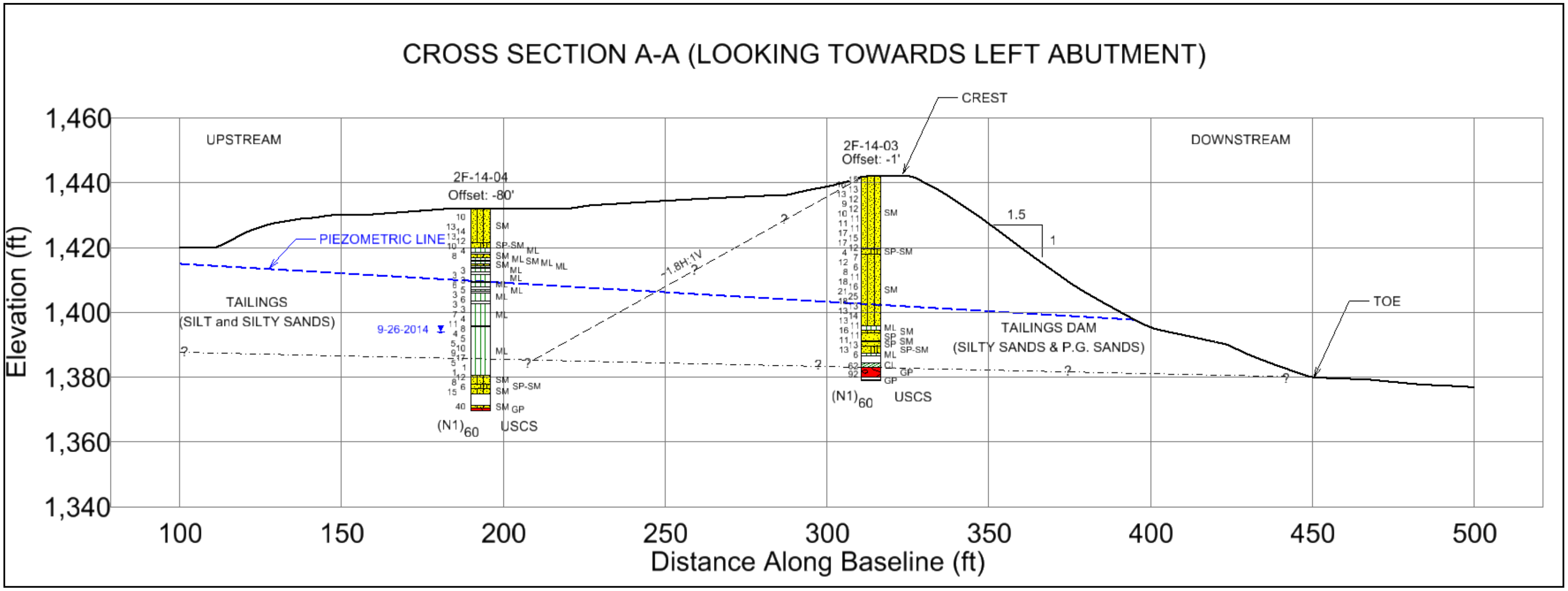

Figure 6-3. Earth Tailings Storage Dam - Cross Section

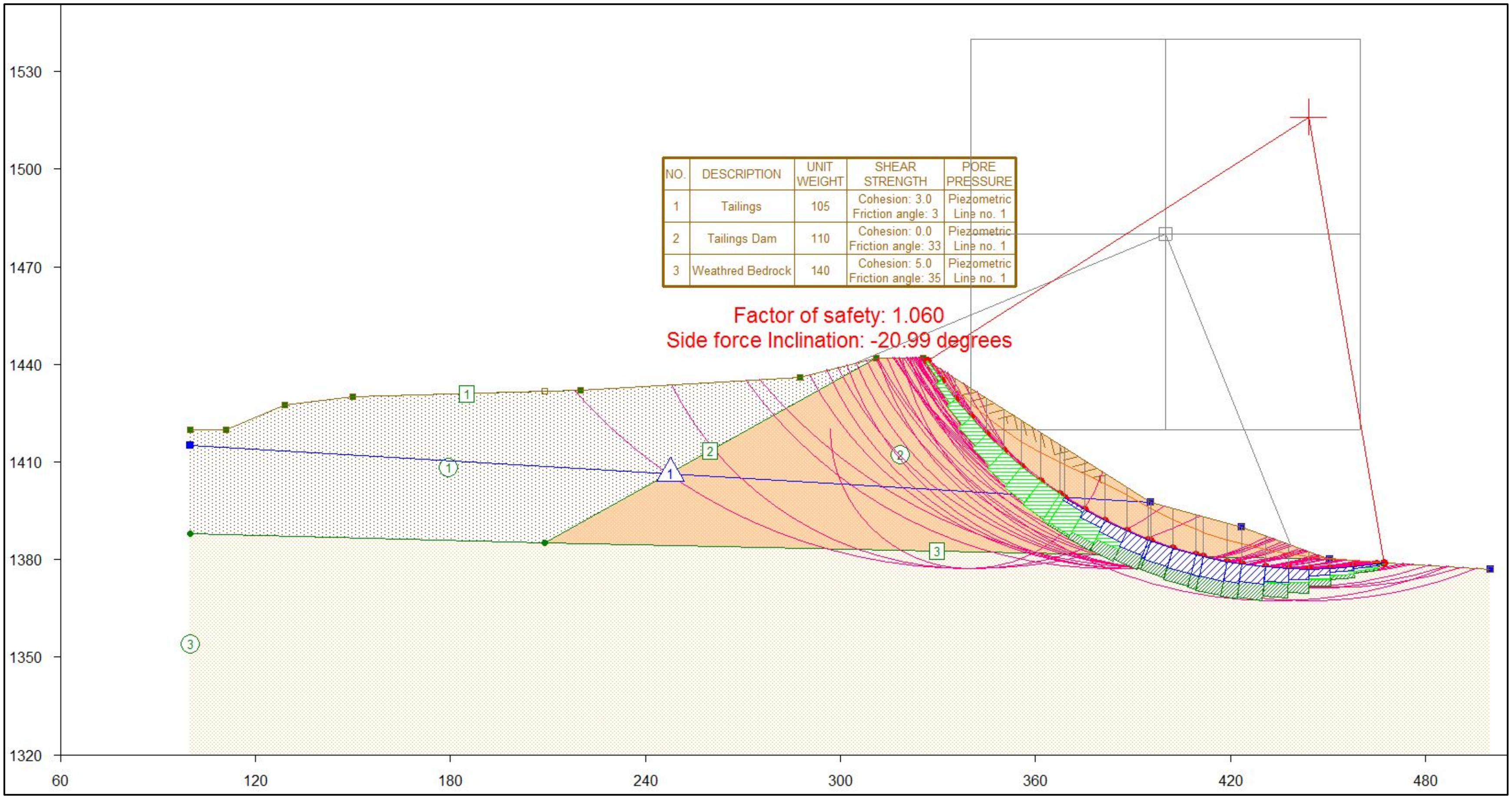

Figure 6-4. Earth Tailings Storage Dam - Slope Stability Results

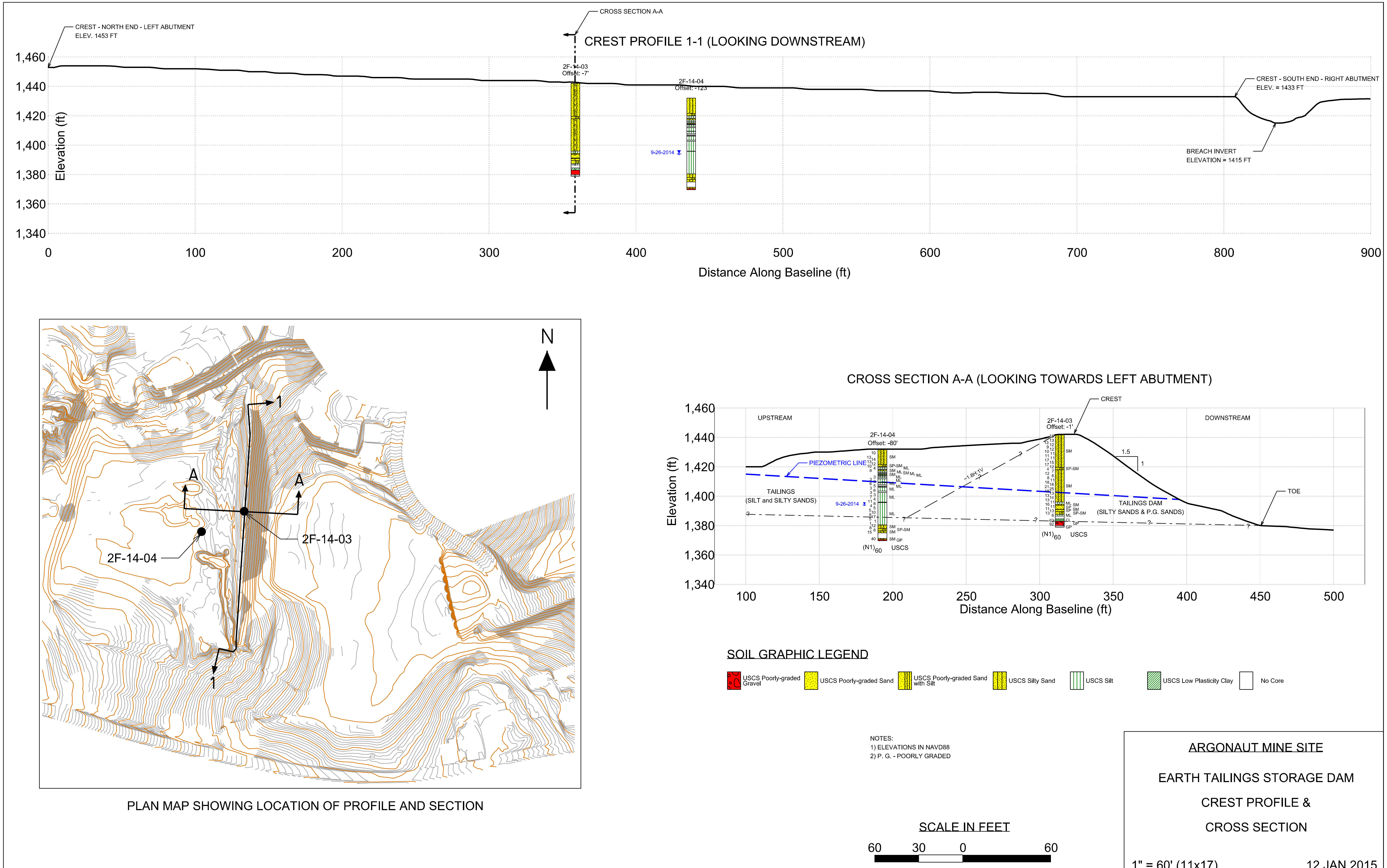

Figure 6-5. Earth Tailings Storage Dam - Profile and Cross Section (11x17)

7. Conclusions and Recommendations

The lower earth tailings storage (LETS) dam was found to be marginally stable with regards to slope stability. The LETS dam has been breached at the right abutment and fortunately does not store water. The materials that comprise the LETS dam were found to be coarser and stronger with regards to shear strength than the tailings behind the dam. There are several small ponds and sinkholes behind the LETS dam, and it would beneficial to re-grade and drain these towards the right abutment breach to reduce the chance that the stored water in the ponds could cause erosion and possible internal instability of the dam. The ponds and sinkholes could also be backfilled as long as the area is graded so that water drains towards the right abutment breach. These materials will not flow very far if water tables are kept low, and this will reduce the chance that these materials will flow downhill and impact the concrete multi-arch (CMA) dam.

The tailings behind the CMA dam were found to be very loose, of low shear strength, and liquefiable. These materials have the potential to flow a significant distance when they are saturated and loose the support or restraint of the dam. It would be beneficial to keep the water table as low as possible behind the CMA dam. The low level outlet could be investigated to see if it can be located and unclogged, or a new one could be installed. The tailings can also be drained by drilling and installing small drains (slotted PVC drain pipe) through the arches that extend upstream. This will aid in lowering the water table near the dam and will increase the effective stress of the material and the available shear strength thru consolidation. Water does occasionally overtop the dam during large storms, but routing of this drainage water for the purposes of public safety would have to be determined.

Techniques to stabilize the CMA dam will be analyzed by structural engineering, but one possible alternative would be to fill the spaces in between the arches with compacted granular material, and thus reduce the structural height of the dam and increase stability. There is space between the dam and Argonaut lane that could be utilized for the stability buttress. Other arch dams have used roller compacted concrete (RCC) between the arches as a buttress, but the granular fill option should be less costly, and may allow the local agencies to use fill that would otherwise be wasted (such as gravels, cobbles, and boulders). Geotechnical and structural stability analyses would have to be conducted to determine the quantity and dimensions of this type of buttress, along with other possible alternatives. A conceptual drawing of the proposed drain and buttress fill alternatives is shown in Figure 7-1.

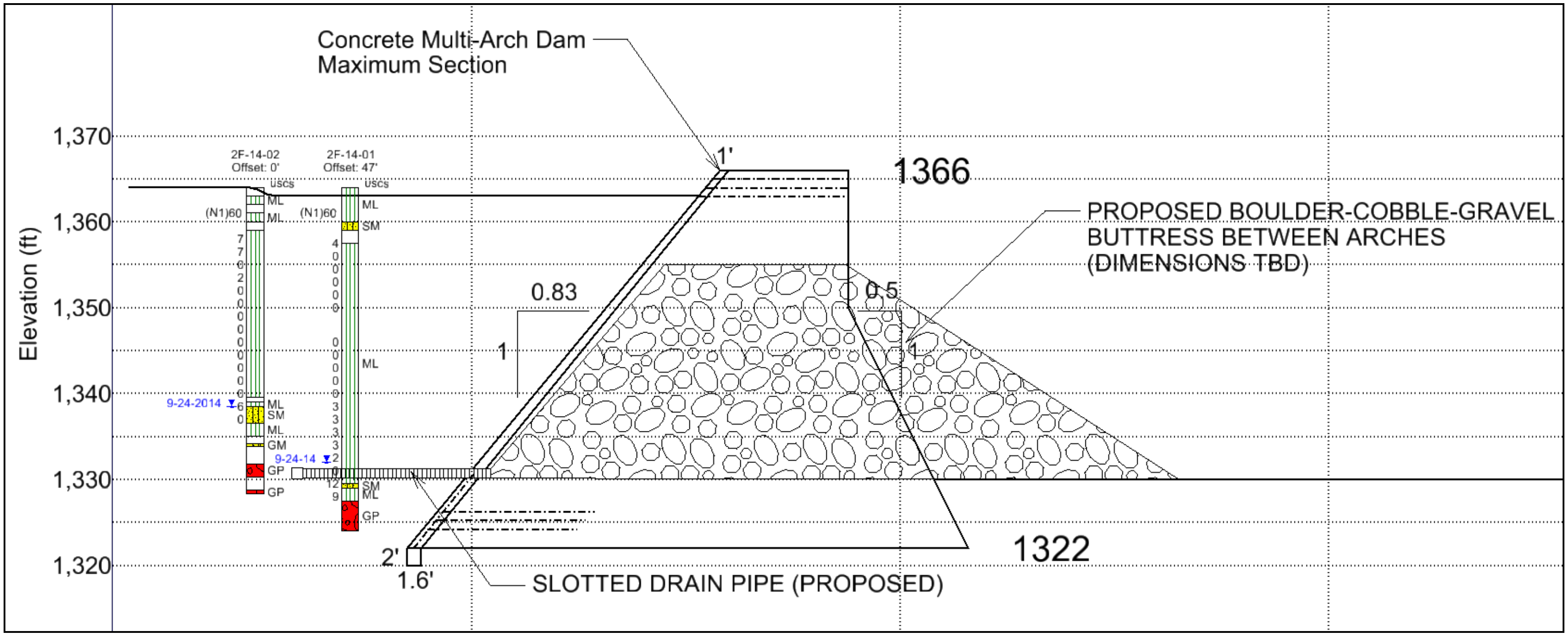

Figure 7-1. CMA Dam - Proposed Drains and Gravel Buttress (Theoretical)

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APPENDICES

NOTE:

Borehole and sample number differences between USACE and other designations:

	USACE		
Others	Borehole #*	Depth	
2F-1	2F-14-01		
2F-2	2F-14-02		
2F-3	2F-14-03		
2F-4	2F-14-04		
2F-1-17 ST	2F-14-01	17	ST = Shelby Tube
2F-1-39 ST	2F-14-01	39	"
2F-3-57.5 ST	2F-14-03	57.5	"
2F-4-58 ST	2F-14-04	58	"
2F-1-18.5-B	2F-14-01	18.5	B = Bulk Sample
And so on...			

*2F = Auger Foundation, 14 = Year = 2014, 01 = Borehole Number

APPENDIX A
GEOLOGIC BORING LOGS

Proposed Geotechnical Borings
Argonaut Mine Tailings Area
Argonaut Mine
Jackson, California

Figure
1

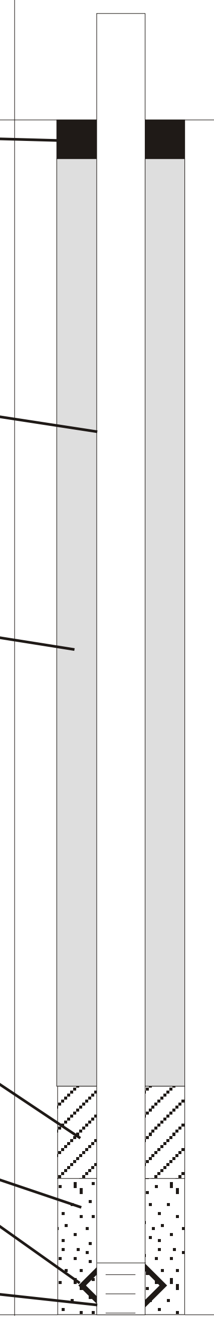
Station Name: 2F-1

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-1
Start Date: September 22, 2014
Completion Date: September 24, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

Weston Solutions, Inc.
9301 Oakdale Ave., Ste 320
Chatsworth, CA 91311

Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithologic Description	Comment
				1,367′	0		GROUND SURFACE	Concrete
			Post hole dig to 5 ft.			ML	Dark gray (5Y4/1) SILT (<5% sand), rootlets and root casts, oxides, low toughness, rapid dilatancy, non-plastic, moist, medium soft to firm.	
						SM	Gray (5Y5/1) SILTY VERY FINE SAND (30% silt), very well sorted, slightly moist to moist, medium dense.	
	0.7′		2,1,1,1		5	ML	Slightly mottled dark gray to dark grayish brown (2.5Y4/1 to 2.5Y4/2) VERY FINE SANDY SILT (40% sand), non-plastic, slightly moist, soft.	2″ diameter Schedule 40 PVC Blank Casing
	1.5′		P,P,P			ML	Very dark gray (5Y3/1) SILT (<10% sand), low toughness, slow dilatancy, low plasticity, medium soft.	
	1.5′		P,P,P			ML	Very dark greenish gray (Gley 2 3/1 10G) SILT, trace very fine sand (5% sand), rapid dilatancy, low toughness, low plasticity, wet, very soft.	
	1.5′		P,P,P		10	ML	Very dark greenish gray (Gley 1 3/1 5G) SILT, trace very fine sand (<5% sand), slow dilatancy, low plasticity, very moist, medium soft.	
	1.5′		P,P,P			ML	Very dark greenish gray SILT, as at 9.5 ft., low dilatancy, low plasticity, very moist, very soft.	Portland Cement Grout
	1.5′		P,P,P			ML	Very dark greenish gray (Gley 1 3/1 5GY) SILT (1% sand), low toughness, slow to rapid dilatancy, low to medium plasticity, sticky, wet, very soft.	
	1.5′		Push Shelby Tube 30″		15			Shelby Tube Sample 2F-1-17-ST
	1.5′		P,P,P			ML	Very dark greenish gray (Gley 1 3/1 5GY) SILT (1% sand), low toughness, medium dry toughness, slow to rapid dilatancy, low to medium plasticity.	Bulk Sample 2F-1-18.5-B
	1.5′		P,P,P					
	1.5′		P,P,P		20	ML	Very dark greenish gray (Gley 1 3/1 5GY) SILT (1% sand), low toughness, rapid dilatancy, low plasticity, wet, very soft..	
	1.5′		P,P,P			ML	Very dark greenish gray CLAYEY SILT, low toughness, medium plasticity, sticky, wet, very soft.	Medium Bentonite Chips, Hydrated
	1.5′		P,P,P			ML	Very dark greenish gray SILT, low toughness, low plasticity, less sticky, wet, very soft.	
	1.5′		P,1,1		25	ML	Very dark greenish gray SILT, similar to 23 ft.	Bulk Sample 2F-1-25.5-B
	1.5′		P,1,1			ML	Very dark greenish gray SILT, similar to 23 ft, except non-plastic interval at 26.5-27 ft.	#2/12 Monterey Sand
	1.5′		P,1,1			ML	Very dark greenish gray SILT, trace very fine sand (to 5% sand), low plasticity to non-plastic, wet, very soft.	Centralizer
	1.5′		2,1,1		30	ML	Very dark greenish gray SILT, trace to little very fine sand (5-10% sand), couple thin intervals without sand, low plasticity to non-plastic, wet, medium soft.	2″ diameter Schedule 40 PVC Slotted Well Screen 0.010″ Slots
	1.5′		P,P,1					



Northing:
Easting:
Ground Elevation: 1,367′
TOC Elevation:

Borehole Diameter: 8″
Borehole Total Depth: 40′ bgs
Well Diameter: 2″
Well Total Depth: 40′ bgs

Water Bearing Zone: First
Static Water Level: Enc. ~32′ bgs
Screen Interval: 29.7-39.7′ bgs
Hammer Weight: 140 lbs.

Sand: 27.6-40′
Grout/Seal: 0-25.2′/25.2-27.6′
Screen Slot: 0.010″

Station Name: 2F-1

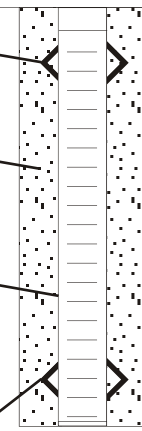
Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-1
Start Date: September 22, 2014
Completion Date: September 24, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

Weston Solutions, Inc.
9301 Oakdale Ave., Ste 320
Chatsworth, CA 91311

SAMPLE				SUBSURFACE PROFILE					
Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithology	Lithologic Description	Comment
	1.5′		2,1,1		30	ML		Very dark greenish gray SILT, trace to little very fine sand (5-10% sand), couple thin intervals without sand, low plasticity to non-plastic, wet, medium soft.	Centralizer
	1.5′		P,P,1			ML		Very dark greenish gray SILT (1% sand), low plasticity, wet to saturated, soft to very soft.	#2/12 Monterey Sand
	1.5′		P,P,P			ML		Very dark greenish gray SILT, trace silt (1-5% sand), low plasticity, wet/saturated, very soft.	
	1.5′		P,2,6			SM		Very dark greenish gray SILTY FINE SAND (30% silt), cohesive, very well sorted, wet, medium dense.	2″ diameter Schedule 40 PVC Slotted Well Screen 0.010″ Slots
	1.5′		7,3,3		35	ML		Very dark grayish brown (2.5Y3/2) FINE TO MEDIUM SANDY SILT (10-30% sand), trace clay (5-10% clay), with little angular gravel to 3/4″ (10-15% gravel), very moist to wet, firm.	
	1.0′		8,50/6″			ML		Black (2.5Y2.5/1) SILT, TRACE VERY FINE SAND (1-5% sand), some rootlets, very moist, soft.	
	1.5′		Push Shelby Tube 18″			ML		Very dark grayish brown FINE TO MEDIUM SANDY SILT (25% sand), trace clay (5% clay), with little angular gravel to ½″ (15% gravel), moist, firm.	Shelby Tube Sample 2F-1-39-ST
	0.7′		17, 50/4″		40	GP/ Bedrock		Olive gray and light brownish gray (5Y5/2 and 2.5Y6 /2) angular GRAVEL to 3/4″, little fine to coarse sand (15% sand), weathered, fractured possible meta-basalt.	Centralizer
					45				
					50				
					55				
					60				

END OF BORING 2F-1 AT 40′ BGS



Northing:
Easting:
Ground Elevation: 1,367′
TOC Elevation:

Borehole Diameter: 8″
Borehole Total Depth: 40′ bgs
Well Diameter: 2″
Well Total Depth: 40′ bgs

Water Bearing Zone: First
Static Water Level: Enc. ~32′ bgs
Screen Interval: 29.7-39.7′ bgs
Hammer Weight: 140 lbs.

Sand: 27.6-40′
Grout/Seal: 0-25.2′/25.2-27.6′
Screen Slot: 0.010″

Station Name: 2F-2

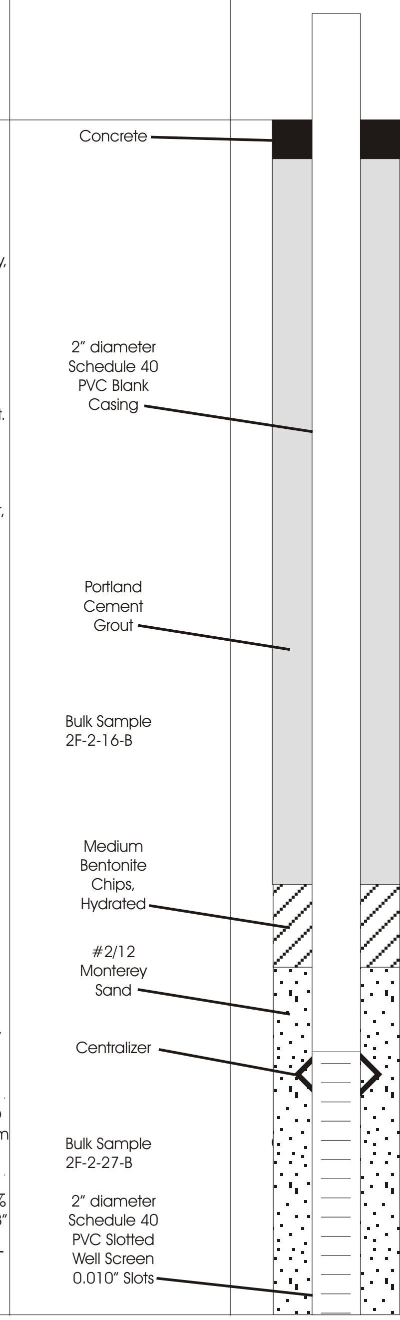
Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-2
Start Date: September 23, 2014
Completion Date: September 24, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

WESTON SOLUTIONS
Weston Solutions, Inc.
9301 Oakdale Ave., Ste 320
Chatsworth, CA 91311

SAMPLE				SUBSURFACE PROFILE				
Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithology	Lithologic Description
				1,367'				GROUND SURFACE
			Hand Auger and Post Hole to 5 ft.			ML		Gray (2.5Y5/1 to 2.5Y6/1) VERY FINE SANDY SILT (30% sand), few rootlets, locally weakly laminated, non-plastic to low plasticity.
						ML		Very dark greenish gray (Gley 1 3/1 5GY) SILT (1% very fine sand), low toughness, rapid dilatancy, low to medium plasticity, weakly laminated to platy, moist, medium soft.
	1.5'		1,1,2		5	ML		Very dark greenish gray SILT similar to 3.5 ft., more massive, with one 1/4" layer of light yellowish brown SILTY VERY FINE SAND (40% silt) at 5.5 ft.
	1.5'		1,1,2			ML		Very dark greenish gray (Gley 1 3/1 5GY) SILT, trace rootlets at 7 ft., low plasticity, increasing moisture downward to very moist.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, low plasticity, very moist, soft to very soft.
	1.5'		P,P,1		10	ML		Very dark greenish gray SILT, as at 8 ft., low plasticity, very moist, very soft.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, as at 9.5 ft., low plasticity, very moist, very soft.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, as at 11 ft., low plasticity, very moist, very soft.
	1.5'		P,P,P		15	ML		Very dark greenish gray SILT, as at 12.5 ft., low plasticity, very moist, very soft.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, as at 14 ft.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, as at 15.5 ft., but sticky.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, as at 17 ft., moderately sticky.
	1.5'		P,P,P		20	ML		Very dark greenish gray SILT, as at 18.5 ft., very moist to wet, very soft.
	1.5'		P,P,P			ML		Very dark greenish gray (Gley 1 3/1 5GY) SILT, low to medium plasticity (higher plasticity occurs across 1-2" intervals), sticky, very moist to wet, soft to very soft.
	1.5'		P,P,P			ML		Very dark greenish gray SILT, similar to 21.5 ft., but low plasticity, less sticky, wet.
	1.0'		1,2,2		25	ML		Very dark greenish gray SILT, similar to 23.5 ft.
	1.0'		P,P,P			SM		Very dark greenish gray (Gley 1 3/1 10GY) SILTY VERY FINE SAND (35-40% silt), very well sorted, cohesive, wet/saturated, medium loose.
	1.5'		3,6,50/5"			ML		Very dark greenish gray SILT, similar to 21.5 ft.
						ML		Black at top to very dark greenish gray FINE SANDY SILT (40-45% sand), with clay (15% clay), trace to little angular gravel to 3/8" (5-10% gravel), wet.
	0.4'		P,P,50/2"		30	GM		Very dark grayish brown (10YR3/2) weathered to hard angular ROCK FRAGMENTS with CLAYEY TO SANDY SILT, wet.

Comment



Northing:
Easting:
Ground Elevation: 1,367'
TOC Elevation:

Borehole Diameter: 8"
Borehole Total Depth: 35.7' bgs
Well Diameter: 2"
Well Total Depth: 34.6' bgs

Water Bearing Zone: First
Static Water Level: Enc. ~25.5' bgs
Screen Interval: 24.2-34.2' bgs
Hammer Weight: 140 lbs.

Sand: 22.1-34.6'
Grout/Seal: 0-19.9'/19.9-22.1'
Screen Slot: 0.010"
Sheet: 1 of 2

Station Name: 2F-2

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-2
Start Date: September 23, 2014
Completion Date: September 24, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

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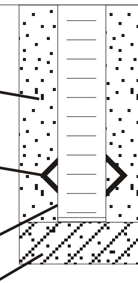
Chatsworth, CA 91311

SAMPLE				SUBSURFACE PROFILE					Comment
Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithology	Lithologic Description	
								Very dark grayish brown (10YR3/2) weathered to hard angular ROCK FRAGMENTS with CLAYEY TO SANDY SILT, wet.	#2/12 Monterey Sand
	0.4' 0.5'		P.P.50/2" 50/6"		30	GM GM		Olive gray to olive brown (5Y4/2 to 2.5Y4/3) ROCK FRAGMENTS with SANDY SILT with clay, wet.	
			Drilled						
	1.5'		49,59,50/5"			GP/ Bedrock		Greenish gray to olive brown ROCK AND ROCK FRAGMENTS, highly weathered, with interstitial SILTY SAND with clay along fractures and in pockets, wet.	Centralizer
			Drilled						2" diameter Schedule 40 PVC Slotted Well Screen 0.010" Slots
	0.4'		28, 53/2"		35	GP/ Bedrock		Olive to olive brown ROCK AND ROCK FRAGMENTS, possible metavolcanics,highly weathered, weakly foliated, with SILTY SAND with clay along fractures and in pockets, wet.	
								END OF BORING 2F-2 AT 35.7' BGS	Slough
					40				
					45				
					50				
					55				
					60				



Northing:
Easting:
Ground Elevation: 1,367'
TOC Elevation:

Borehole Diameter: 8"
Borehole Total Depth: 35.7' bgs
Well Diameter: 2"
Well Total Depth: 34.6' bgs

Water Bearing Zone: First
Static Water Level: Enc. ~25.5' bgs
Screen Interval: 24.2-34.2' bgs
Hammer Weight: 140 lbs.

Sand: 22.1-34.6'
Grout/Seal: 0-19.9'/19.9-22.1'
Screen Slot: 0.010"

Station Name: 2F-3

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-3
Start Date: September 24, 2014
Completion Date: September 25, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

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Chatsworth, CA 91311

SAMPLE				SUBSURFACE PROFILE						
Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithology	Lithologic Description	Comment	Well Completion Details
				1,443'				GROUND SURFACE		
	1.1'		1,3,4			SM		Gray (5Y5/1) SILTY VERY FINE TO FINE SAND (25% silt), slightly cohesive to non-cohesive, trace organic material (leaves, twig), slightly moist, medium loose.		
	1.3'		2,2,3			SM		SILTY VERY FINE TO FINE SAND similar to above, with local weak layering, (20% silt), no organic material, slightly moist, medium loose to medium dense.		
	1.5'		2,3,3			SM		Gray (2.5Y5/1) SILTY VERY FINE TO FINE SAND (20% silt), locally laminated, oxides, medium dense.		
	1.5'		3,3,3		5	SM		Dark gray to gray (2.5Y4/1 to 2.5Y6/1) SILTY VERY FINE TO FINE SAND (20% silt), few laminations, moist, medium dense.		
	1.5'		2,2,3			SM		Gray (2.5Y5/1) SILTY VERY FINE TO FINE SAND (20% silt), few laminations to massive, moist, medium dense.		
	1.5'		1,2,2			SM		Grayish brown (2.5Y5/2) SILTY VERY FINE TO FINE SAND (20% silt), mostly laminated, one thin 1/8" SILT interbed, moist, medium dense.		
	1.5'		2,3,3		10	SM		Gray (2.5Y5/1) SILTY VERY FINE TO FINE SAND, increased silt (20-35% silt), scattered laminations, moist, medium dense.		
	1.5'		2,2,3			SM		Gray (2.5Y5/1) changing at 11.5 ft to dark gray to very dark gray (2.54/1 to 2.5Y3/1) SILTY VERY FINE TO FINE SAND, increased silt (20-40% silt), upper 1 ft laminated, massive below.		
	1.3'		2,3,3			SM		Gray (2.5Y5/1) SILTY VERY FINE SAND (30% silt), mostly massive, moist, medium dense.		
	1.1'		2,2,4		15	SM		Gray to dark gray (2.5Y5/1 to 2.5Y4/1) SILTY VERY FINE TO FINE SAND (20% silt), mostly massive, trace laminations.	Bulk Sample 2F-3-15-B	
	1.5'		2,3,3			SM		Gray to dark gray SILTY VERY FINE TO FINE SAND (variable 20-40% silt).		
	1.5'		3,5,5			SM		Dark gray to very dark gray (2.5Y4/1 to 2.5Y3/1) SILTY VERY FINE TO FINE SAND (variable 20-45% silt), few siltier laminations/beds to 1/4" toward top, to moderately cohesive.		
	1.5'		3,4,5			SM		Dark gray (5Y4/1) SILTY VERY FINE SAND (25% silt), trace laminations, to moderately cohesive..		
	1.5'		3,5,6		20	SM		SILTY VERY FINE SAND (variable 20-35% silt), mostly massive, moderately cohesive.		
	1.5'		3,4,4							
	1.4'		1,1,2			SM to SP		VERY FINE SAND with variably trace to little silt (10% silt) to little to some silt (15-20% silt), very well sorted, slightly cohesive to non-cohesive, medium loose.		
	1.5'		2,2,3		25	SM		Dark gray to very dark gray (5Y4/1 to 5Y3/1) SILTY VERY FINE SAND (20% silt), one 2" layer with 40% silt, one 2" layer of VERY FINE SANDY SILT (35% sand), non-plastic.		
	1.5'		3,4,4			SM		Dark gray to dark grayish brown (5Y4/1 to 2.5Y4/2) SILTY VERY FINE TO FINE SAND (mostly 20% silt), few 3" layers with up to 40% silt, slightly cohesive.		
	1.5'		3,2,2			SM		Very dark gray (2.5Y3/1) SILTY VERY FINE TO FINE SAND (mostly 25% silt), few siltier pockets, slightly cohesive.		
	1.5'		2,2,4			SM		Dark grayish brown to dark gray (2.5Y4/2 to 2.5Y4/1) SILTY VERY FINE SAND (25% silt), massive, uniform, slightly to moderately cohesive.		
	1.5'		3,3,5		30	SM		Dark gray SILTY VERY FINE SAND (25% silt), slightly to moderately cohesive, medium dense.	Bulk Sample 2F-3-30-B	

Northing:
Easting:
Ground Elevation: 1,443'
TOC Elevation:

Borehole Diameter: 8"
Borehole Total Depth: 63.1' bgs
Well Diameter: NA
Well Total Depth: NA

Water Bearing Zone: NA
Static Water Level: Not encountered
Screen Interval: NA
Hammer Weight: 140 lbs.

Sand: NA
Grout/Seal: 0-63.1'
Screen Slot: NA
Sheet: 1 of 2

Station Name: 2F-3

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-3
Start Date: September 24, 2014
Completion Date: September 25, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

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Chatsworth, CA 91311

SAMPLE				SUBSURFACE PROFILE						
Sample	Recovery	PID	Blows	Elevation	Depth	USCS	Lithology	Lithologic Description	Comment	Well Completion Details
	1.5′		2,2,4		30	SM		Dark grayish brown to dark gray (2.5Y4/2 to 2.5Y4/1) SILTY VERY FINE SAND (25% silt), massive, uniform, slightly to moderately cohesive.		
	1.5′		3,3,5			SM		Dark gray (5Y4/1) SILTY VERY FINE SAND (25% silt), slightly to moderately cohesive, medium dense.		
	1.5′		4,5,8			SM		Olive gray to gray (5Y4/2 to 5Y5/1) SILTY VERY FINE SAND (25% silt), uniform, moderately cohesive, medium dense to dense.		
	1.5′		5,6,6					Color varies slightly to dark gray to gray (2.5Y4/1 to 5Y5/1).		
	1.5′		5,8,8		35	SM		Gray to dark gray (5Y5/1 to 5Y3/1) SILTY VERY FINE SAND (25% silt), uniform, moderately cohesive, medium dense.		
	1.5′		5,8,11			SM		Dark gray (5Y3/1) SILTY VERY FINE SAND (25% silt), uniform, cohesive, dense.		
	1.5′		6,7,7					One thin 1/8″ VERY FINE SANDY SILT layer at 38.5 ft.		
	1.5′		3,5,6		40	SM		Gray to very dark gray (5Y5/1 to 2.5Y3/1) SILTY VERY FINE SAND (varies 25-35% silt), weak layering with differing silt content, moderately cohesive, moist, medium dense.		
	1.5′		5,5,6			SM		Olive gray (5Y4/2) SILTY VERY FINE SAND (25% silt), uniform, slightly to moderately cohesive, dense.		
	1.5′		4,6,6					Similar to above.		
	1.5′		5,5,6					Similar to above.		
	1.5′		5,6,4		45	SM& ML		Gray and dark grayish brown (5Y5/1 and 2.5Y4/2) SILTY VERY FINE SAND (35% silt), with 1/4″ to ½″ interbeds of FINE SANDY SILT.	Bulk Sample 2F-3-45-B	
	1.5′		4,6,8			ML		Black (2.5Y2.5/1) VERY FINE SANDY SILT (35% sand), non-plastic, moist, firm.		
						SM		Gray (5Y5/1) SILTY VERY FINE SAND (25% silt), some weak laminations, slightly to moderately cohesive, moist.		
	1.5′		4,5,6			SP		Sharp change to bluish gray (Gley 2 5/1 5PB) VERY FINE SAND with trace silt (5% silt), very sell sorted, non-cohesive to slightly cohesive, moist, medium dense.		
	1.5′		3,5,6		50	SM		Grading downward to gray (5Y5/1) VERY FINE SAND with little silt (15% silt).		
	1.5′		5,6,7			SP		VERY FINE SAND similar to 41.5 ft but more silt (5-10% silt), very weakly laminated, moist, medium dense.		
	1.5′		5,5,7			SM/SP		Bluish gray VERY FINE SAND to SILTY VERY FINE SAND (variable 5-30% silt), siltier material in pockets or crude layers, medium dense.		
	1.5′		2,2,4		55	ML		Greenish black to very dark greenish gray (Gley 2 2.5/1 5BG to Gley 2 3/1 10G) SILT with trace very fine to medium sand (1-5% sand), trace angular gravel to 3/8″, rapid dilatancy, low plasticity, moist, medium soft.		
	1.3′		Push Shelby Tube 26″			ML	?	Very dark greenish gray CLAYEY SILT, trace very fine to medium sand (5% sand), trace to little angular gravel to 3/8″ (10% gravel), low plasticity, medium firm.	Shellby Tube Sample 2F-3-57.5-ST	
	1.4′		23,33,17			CL/ Bedrock		Light yellowish brown, pale olive, to light reddish brown with dark brown to orange oxides SILTSTONE or SLATE, highly fractured and weathered; grading to SILTY CLAY with rock fragments texture, medium plasticity.		
	0.8′		45, 50/4″			GP/ Bedrock		Becoming olive gray, hard fractured rock fragments with clay, SILTSTONE or SLATE.		
	1.5′		34,27,48		60	GP/ Bedrock		Yellowish brown (10YR5/6) highly weathered SILTSTONE OR SLATE, consists of angular rock fragments with soil texture material in pockets and along fractures, breaks into small hard chips, some appears foliated and greenish.		
	0.7′		20,50/2″			GP/ Bedrock				
	0.2′		50/2″					END OF BORING 2F-3 AT 63.1′ BGS		

Northing:
Easting:
Ground Elevation: 1,443′
TOC Elevation:

Borehole Diameter: 8″
Borehole Total Depth: 63.1′ bgs
Well Diameter: NA
Well Total Depth: NA

Water Bearing Zone: NA
Static Water Level: Not encountered
Screen Interval: NA
Hammer Weight: 140 lbs.

Sand: NA
Grout/Seal: 0-63.1′
Screen Slot: NA

Station Name: 2F-4

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-4
Start Date: September 25, 2014
Completion Date: September 26, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

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Chatsworth, CA 91311

SAMPLE

Recovery	Blows
1.0′	NR
1.5′	1,1,4
1.5′	NR
1.5′	3,3,3
1.5′	3,3,3
1.5′	3,3,3
1.5′	3,3,3
1.5′	2,2,3
1.3′	1,1,1
1.1′	1,2,2
1.5′	NR
1.5′	NR
1.0′	1,1,1
0.8′	1,1,1
1.5′	P,P,2
1.4′	3,2,2
0.6′	P,1,2
1.1′	P,1,1
1.4′	2,2,2
0.5′	1,1,1
1.5′	1,1,1

SUBSURFACE PROFILE

Elevation: 1,433′ — GROUND SURFACE

USCS	Lithologic Description
SM	Light brownish gray (2.5Y6/2) SILTY VERY FINE SAND (25% silt), trace rootlets, dry to slightly moist, medium loose.
SM& ML	Light brownish gray SILTY VERY FINE SAND similar to above, with locally interbedded VERY FINE SANDY SILT TO SILT (5-20% sand), laminated, silt layers 2-3”, nonplastic.
SM	Gray to dark gray (2.5Y6/1 to 2.5Y4/1) SILTY VERY FINE SAND, (20-40% silt), few 1/4” to 1.5” very fine sandy silt layers, silt layers laminated, slightly moist to moist, medium loose to medium dense.. Increasing silt (to 45% silt).
SP-SM	Light bluish gray VERY FINE SAND to SILTY VERY FINE SAND (5-30% silt), two 1” to 1.5” SILT layers, silt low plasticity.
ML	Very dark greenish gray (Gley 1 3/1 10Y) SILT (1% very fine sand), rapid dilatancy, low plasticity, sticky, wet, very soft.
SM	Very dark greenish gray to gray (Gley 2 3/1 5BG to 5Y5/1) SILTY VERY FINE SAND (15-40% silt), silt content varies between 1” to 3” intervals, moist, medium loose.
ML	Dark gray SILT to VERY FINE SANDY SILT (1-20 % very fine sand), low plasticity to non-plastic.
SM& ML	Interbedded SILTY VERY FINE SAND (15-40% silt), cohesive, medium loose to medium dense; and VERY FINE SANDY SILT (30% very fine sand), non-plastic.
ML	Very dark greenish gray (Gley 2 3/1 5BG) SILT to VERY FINE SANDY SILT (varies 1-5% to 15-30% very fine sand), rapid dilatancy, mostly low plasticity to non-plastic, locally sticky, wet, very soft to medium soft; with one 2” bed of silty fine sand at 19 ft.. Grading to medium plasticity.
ML	Very dark greenish gray SILT with very fine sand to VERY FINE SANDY SILT (varies 5-15% to 25% very fine sand), low plasticity to non-plastic.
ML	Very dark greenish gray SILT and VERY FINE SANDY SILT (varies 1-5% to 30-35% very fine sand in crude layers/zones), low plasticity to non-plastic, locally sticky, wet to saturated, medium soft to soft.
ML	Very dark greenish gray SILT, to trace very fine sand (1-5% very fine sand), rapid dilatancy, low to medium plasticity, wet, soft.

Comment

Concrete

2” diameter Schedule 40 PVC Blank Casing

Bulk Sample 2F-4-16-B

Portland Cement Grout

Bulk Sample 2F-4-28-B

Northing:
Easting:
Ground Elevation: 1,433′
TOC Elevation:

Borehole Diameter: 8”
Borehole Total Depth: 62.3′ bgs
Well Diameter: 2”
Well Total Depth: 60′ bgs

Water Bearing Zone: First
Static Water Level: Enc. ~<38′ bgs
Screen Interval: 50-60′ bgs
Hammer Weight: 140 lbs.

Sand: 48-61′
Grout/Seal: 0-44′/44-47′
Screen Slot: 0.010”

Station Name: 2F-4

Project Name: Argonaut Mine Tailings Area
Client: U.S. EPA
Site Location: Jackson, CA
WESTON WO#: 20409.013.002.0004.00
Geologist: Bill Clarke

Boring Name: 2F-4
Start Date: September 25, 2014
Completion Date: September 26, 2014
Driller: Cascade Drilling
Drilling Method: Hollow Stem Auger (CME 1050)

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Chatsworth, CA 91311

SAMPLE

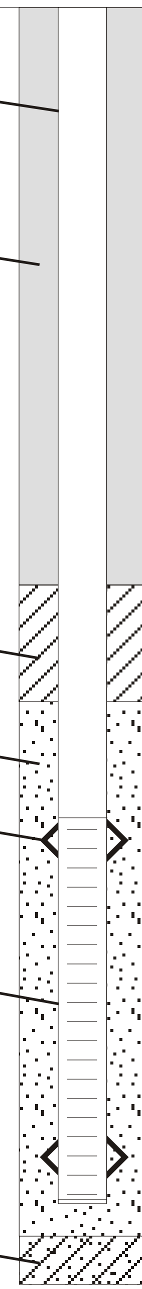
Sample	Recovery	PID	Blows
	1.5'		1,1,1
	1.5'		1,1,1
	1.5'		1,1,4
	1.5'		P,1,2
	1.5'		1,4,4
	1.0'		2,2,4
	1.5'		P,1,2
	1.5'		1,2,2
	1.5'		1,2,2
	1.4'		2,3,5
	1.5'		P,3,4
	1.5'		4,6,7
	1.5'		1,2,2
	1.5'		P,P,1
	1.5'		P,P,1
	1.5'		2,4,6
	0.8'		3,3,4
	1.5'		1,1,4
	1.5'		3,5,7
	0.8'		Push Shelby Tube 12" Drilled to 60'
	0.8'		6,13,17
	0.8'		26,50/3"

SUBSURFACE PROFILE

Elevation	Depth	USCS	Lithology	Lithologic Description
		ML		Very dark greenish gray VERY FINE SANDY SILT (30% very fine sand), non-plastic.
	30	ML		Very dark greenish gray (Gley 2 3/1 5 BG) SILT, to trace very fine sand (1-5% very fine sand), rapid dilatancy, low to medium plasticity, sticky, wet to saturated, soft.
		ML		Very dark greenish gray (Gley 1 3/1 10GY) VERY FINE SANDY SILT (35-40% very fine sand), non-plastic, wet, medium firm.
		ML		Very dark greenish gray SILT, trace to little very fine sand (varies 1-15% very fine sand), rapid dilatancy, low to medium plasticity, wet to saturated, soft.
	35	ML		VERY FINE SANDY SILT (30% very fine sand), non-plastic, wet to saturated, medium firm.
		ML		SILT, trace very fine sand (1-5% very fine sand), rapid dilatancy, low plasticity, wet to saturated, soft.
		ML		VERY FINE SANDY SILT (20-25% very fine sand), non-plastic, wet, medium soft.
		ML		Very dark greenish gray SILT, with trace to little very fine sand (varies 1-5% to 1-15% very fine sand), rapid dilatancy, low plasticity to non-plastic, wet, medium soft to soft.
	40			
		ML		VERY FINE SANDY SILT (25-35% very fine sand), non-plastic, wet/saturated, medium firm.
		ML		SILT, trace very fine sand (1-5% very fine sand), low plasticity, wet, very soft.
		ML		Very dark greenish gray VERY FINE SANDY SILT (25-45% very fine sand increasing downward), non-plastic, wet/saturated, medium firm.
	45			Softer.
		ML		Very dark greenish gray SILT, with trace to little very fine sand (varies 1-5% to locally 10-15% very fine sand), low plasticity, wet/saturated, soft.
	50			Less sand (1-5%).
		SM		Black to very dark bluish gray SILTY VERY FINE SAND (25-35% silt, decreasing downward), cohesive, wet, medium dense. Wood fragment 1.5" x 0.25".
		SM/SP		Very dark bluish gray SILTY VERY FINE TO FINE SAND (25% silt) grading to FINE SAND with trace to little silt (5-15% silt), slightly to moderately cohesive, wet/saturated, medium loose to medium dense.
	55	SM		Black SILTY VERY FINE SAND (40% silt), cohesive, saturated, medium dense.
		SM		Very dark grayish brown to very dark gray (2.5Y3/2 to 2.5Y3/1) SILTY FINE TO MEDIUM SAND (20% silt), trace clay (10% clay), trace to little angular gravel to 1" (5-20% gravel, increasing downward), very moist, medium dense.
				Very dark grayish brown SILTY VERY FINE TO MEDIUM SAND (20% silt), trace clay (5% clay), little angular gravel to 1", (15% gravel).
	60	SM		Changing downward to mottled light olive brown, olive brown, olive, and green angular GRAVEL to 1" (80% rock fragments and weathered rock), with SILTY FINE TO COARSE SAND with trace clay fracture filling/matrix, resembles fine grained highly weathered metavolcanics..
		GP/ Bedrock		

END OF BORING 2F-4 AT 62.3' BGS

Comment / Well Completion Details



Northing:
Easting:
Ground Elevation: 1,433'
TOC Elevation:

Borehole Diameter: 8"
Borehole Total Depth: 62.3' bgs
Well Diameter: 2"
Well Total Depth: 60' bgs

Water Bearing Zone: First
Static Water Level: Enc. ~<38' bgs
Screen Interval: 50-60' bgs
Hammer Weight: 140 lbs.

Sand: 48-61'
Grout/Seal: 0-44'/44-47'
Screen Slot: 0.010"

APPENDIX B
LABORATORY DATA
GRADATIONS
PLASTICITY
MOISTURE

SOIL AND AGGREGATE REPORT

Ninyo & Moore

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-1-18.5-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/22/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings

SAMPLE DESCRIPTION:

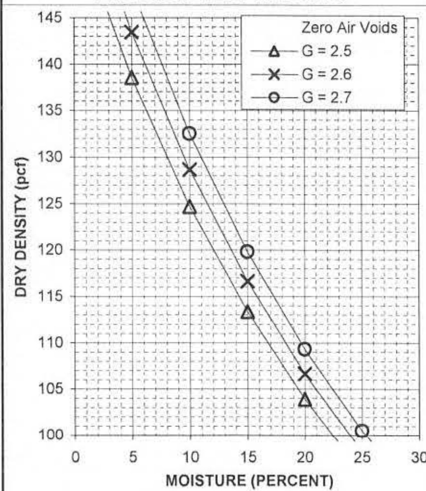
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	46.6			
LIQUID LIMIT	D 4318	32%			
PLASTIC LIMIT	D 4318	22%			
PLASTICITY INDEX	D 4318	10%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

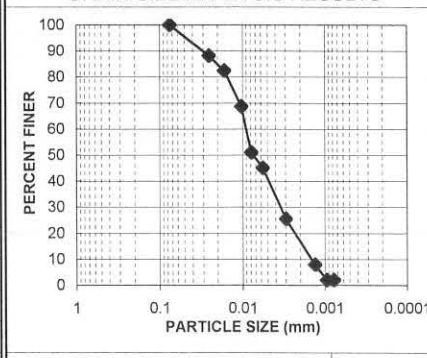
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 200	0.0750	100			
	0.0254	88			
	0.0166	82			
	0.0103	69			
	0.0079	51			
	0.0057	45			
	0.0030	25			
	0.0009	2			
	0.0008	2			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore

SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-1-25.5-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/22/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

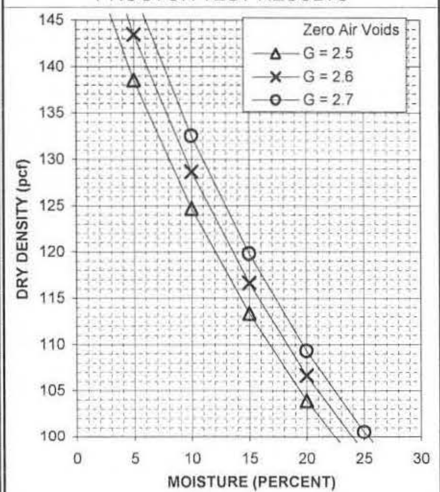
SAMPLE SOURCE: Argonaut Mine Tailings
SAMPLE DESCRIPTION:
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	47.6			
LIQUID LIMIT	D 4318	34%			
PLASTIC LIMIT	D 4318	19%			
PLASTICITY INDEX	D 4318	15%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

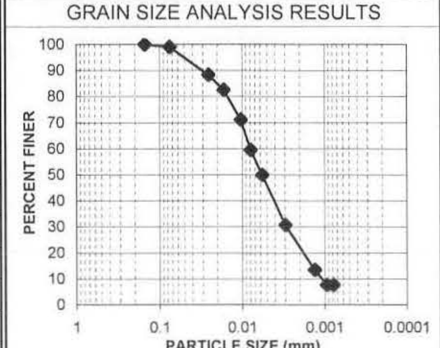
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 100	0.1500	100			
No. 200	0.0750	99			
	0.0254	88			
	0.0166	83			
	0.0103	71			
	0.0079	60			
	0.0057	50			
	0.0030	31			
	0.0013	13			
	0.0009	8			
	0.0008	8			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore

SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-2-16-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/23/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

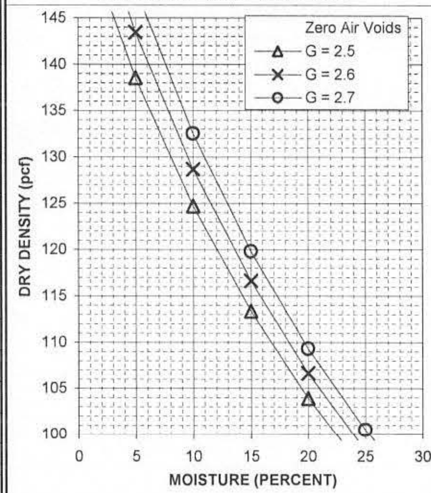
SAMPLE SOURCE: Argonaut Mine Tailings
SAMPLE DESCRIPTION:
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	44.7			
LIQUID LIMIT	D 4318	34%			
PLASTIC LIMIT	D 4318	19%			
PLASTICITY INDEX	D 4318	15%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

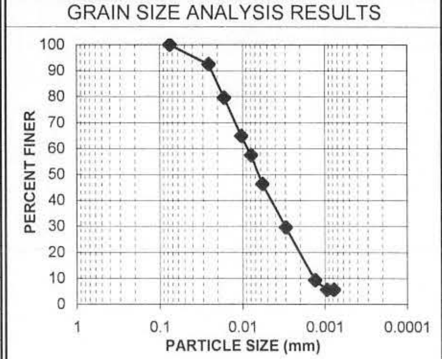
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 200	0.0750	100			
	0.0254	93			
	0.0166	80			
	0.0103	65			
	0.0079	57			
	0.0057	46			
	0.0030	30			
	0.0013	9			
	0.0009	6			
	0.0008	6			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

AGGREP 2F-2-16-B.xls

SOIL AND AGGREGATE REPORT

Ninyo & Moore

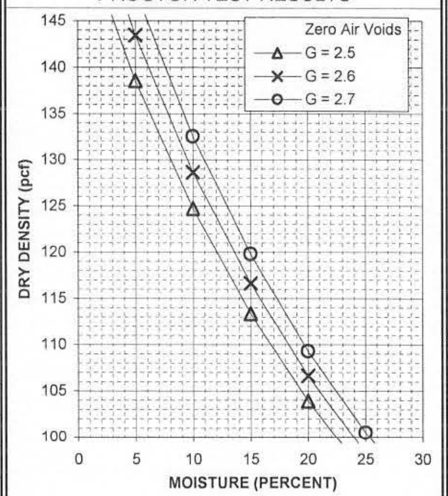
JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-2-27-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/23/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings
SAMPLE DESCRIPTION:
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	32.6			
LIQUID LIMIT	D 4318	19%			
PLASTIC LIMIT	D 4318	14%			
PLASTICITY INDEX	D 4318	5%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

PROCTOR TEST RESULTS

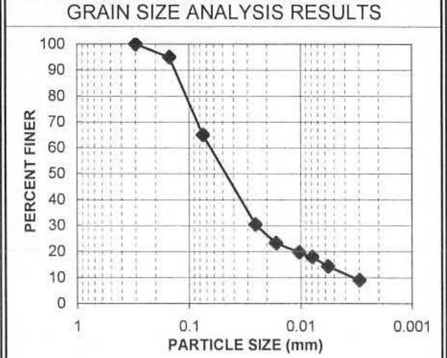


TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS (ASTM D422)

SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 50	0.3000	100			
No. 100	0.1500	95			
No. 200	0.0750	65			
	0.0254	30			
	0.0166	23			
	0.0103	20			
	0.0079	18			
	0.0057	14			
	0.0030	9			

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore — SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-3-15-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/24/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings

SAMPLE DESCRIPTION:

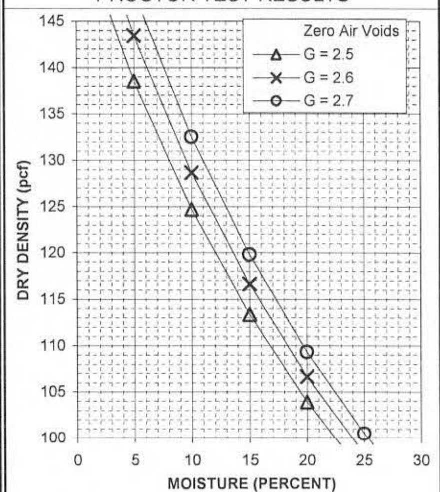
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	6			
LIQUID LIMIT					
PLASTIC LIMIT					
PLASTICITY INDEX	D 4318	NP			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

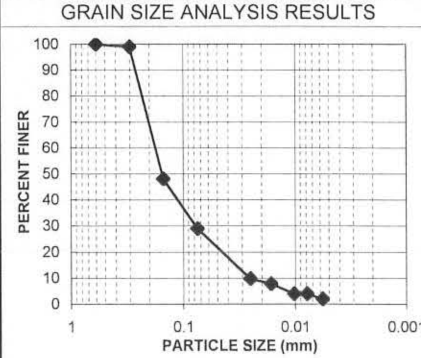
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 30	0.6000	100			
No. 50	0.3000	99			
No. 100	0.1500	48			
No. 200	0.0750	29			
	0.0254	10			
	0.0166	8			
	0.0103	4			
	0.0079	4			
	0.0057	2			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore

SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-3-45-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/24/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings

SAMPLE DESCRIPTION:

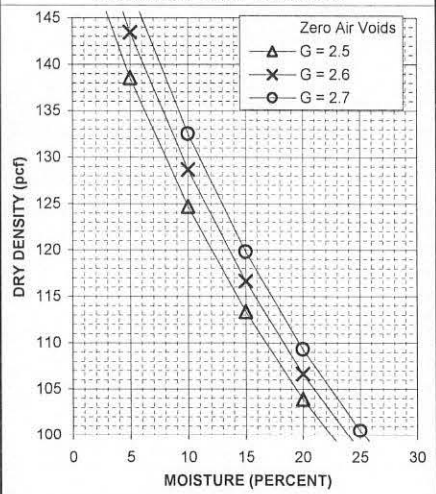
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	6.8			
LIQUID LIMIT					
PLASTIC LIMIT					
PLASTICITY INDEX	D 4318	NP			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

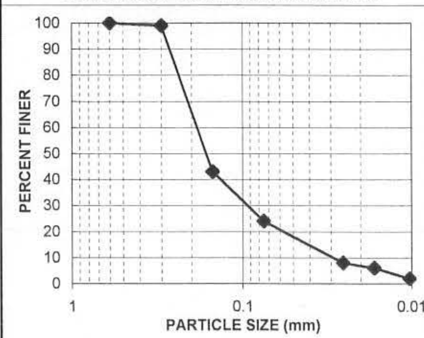
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 30	0.6000	100			
No. 50	0.3000	99			
No. 100	0.1500	43			
No. 200	0.0750	24			
	0.0254	8			
	0.0166	6			
	0.0103	2			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore

SOIL AND AGGREGATE REPORT

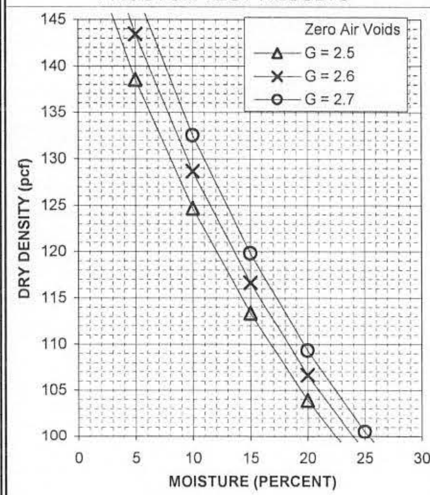
JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-4-16-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/25/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings
SAMPLE DESCRIPTION:
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	15.2			
LIQUID LIMIT					
PLASTIC LIMIT					
PLASTICITY INDEX	D 4318	NP			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

PROCTOR TEST RESULTS

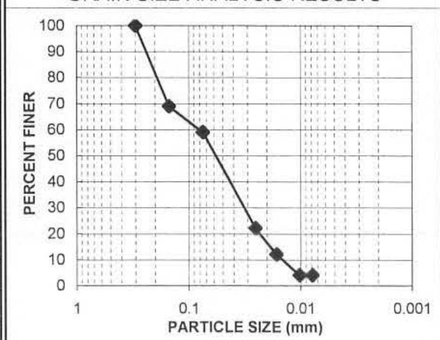


TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS (ASTM D422)

SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 50	0.3000	100			
No. 100	0.1500	69			
No. 200	0.0750	59			
	0.0254	22			
	0.0166	12			
	0.0103	4			
	0.0079	4			

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

AGGREP 2F-4-16-B.xls

Ninyo & Moore

SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-4-28-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/26/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings

SAMPLE DESCRIPTION:

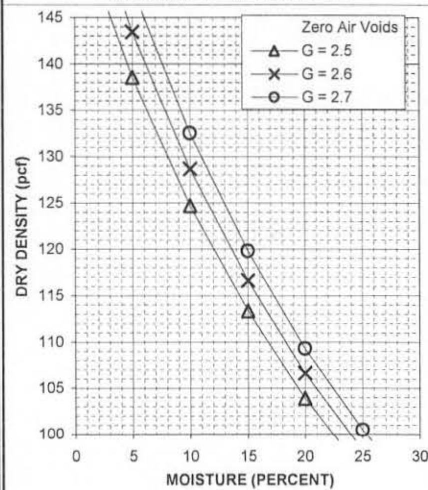
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	28.1			
LIQUID LIMIT	D 4318	25%			
PLASTIC LIMIT	D 4318	25%			
PLASTICITY INDEX	D 4318	0%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 50	0.3000	100			
No. 100	0.1500	99			
No. 200	0.0750	88			
	0.0254	21			
	0.0166	11			
	0.0103	4			
	0.0079	4			

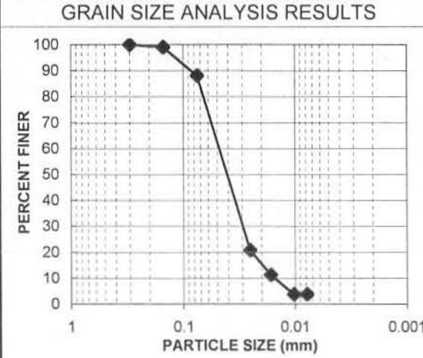
PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	

*WITH OVERSIZE CORRECTION

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore — SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-4-40.5-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/26/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

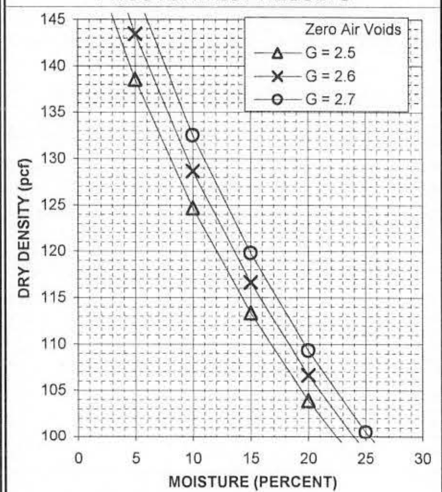
SAMPLE SOURCE: Argonaut Mine Tailings
SAMPLE DESCRIPTION:
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	32.5			
LIQUID LIMIT	D 4318	26%			
PLASTIC LIMIT	D 4318	24%			
PLASTICITY INDEX	D 4318	2%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

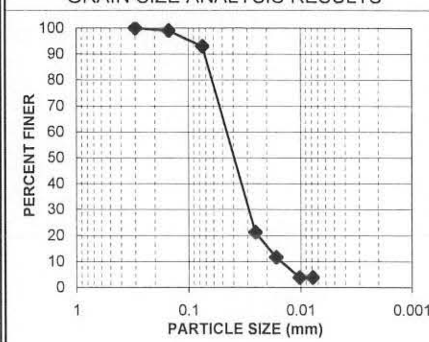
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
No. 50	0.3000	100			
No. 100	0.1500	99			
No. 200	0.0750	93			
	0.0254	21			
	0.0166	12			
	0.0103	4			
	0.0079	4			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

Ninyo & Moore

SOIL AND AGGREGATE REPORT

JOB STAMP:

PROJECT NO.:	402277002	SAMPLE NO.:	2F-4-57-B
PROJECT NAME:	Weston Argonaut	SAMPLED BY:	Weston
CLIENT:	Weston Solutions	DATE SAMPLED:	09/26/14
FILE/PLAN NO.:		TESTED BY:	JMK
		REVIEWED BY:	KG

SAMPLE SOURCE: Argonaut Mine Tailings

SAMPLE DESCRIPTION:

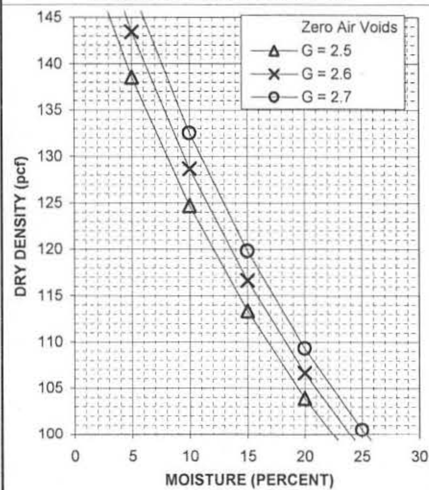
INTENDED USE:

PARAMETER	TEST METHOD	TEST RESULT	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
USCS CLASS.					
WATER CONTENT	D 2216	33.1			
LIQUID LIMIT	D 4318	26%			
PLASTIC LIMIT	D 4318	25%			
PLASTICITY INDEX	D 4318	1%			
SPECIFIC GRAVITY					
ABSORPTION					
SAND EQUIVALENT					
CLEANNESS VALUE					
DURABILITY INDEX					
EXPANSION INDEX					
R-VALUE					
pH					
RESISTIVITY					
CHLORIDE CONTENT					
SULFATE CONTENT					

GRAIN SIZE ANALYSIS (ASTM D422)

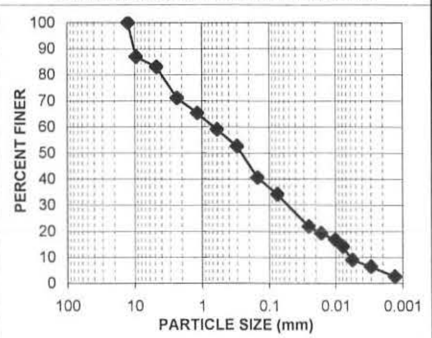
SIEVE	PARTICLE SIZE (mm)	PERCENT PASSING	SPEC RANGE MIN	SPEC RANGE MAX	COMMENTS
	mm	% Finer			
1/2"	12.5000	100			
3/8"	9.5000	87			
No. 4	4.7500	83			
No. 8	2.3600	71			
No. 16	1.1800	65			
No. 30	0.6000	59			
No. 50	0.3000	53			
No. 100	0.1500	40			
No. 200	0.0750	34			
	0.0254	22			
	0.0166	19			
	0.0103	17			
	0.0079	14			
	0.0057	9			
	0.0030	6			

PROCTOR TEST RESULTS



TEST METHOD:	
MAX PARTICLE SIZE:	
PERCENT OVERSIZE:	
MAX DRY DENSITY (pcf):	
OPTIMUM MOISTURE (%):	
MAX DRY DENSITY* (pcf):	
OPTIMUM MOISTURE* (%):	
*WITH OVERSIZE CORRECTION	

GRAIN SIZE ANALYSIS RESULTS



10% FINER DIAMETER (mm):	
30% FINER DIAMETER (mm):	
60% FINER DIAMETER (mm):	
UNIFORMITY COEFFICIENT:	
CURVATURE COEFFICIENT:	

APPENDIX C
LABORATORY DATA
TRIAXIAL TEST DATA

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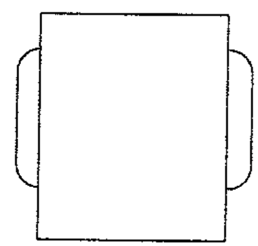
SUMMERY OF LABORATORY TEST RESULT

PROJECT NAME.: Argonaut Mine Tailings
PROJECT NO.: 402277002
DATE.: 11/10/2014

KTL NO.: 05-318-123
CLIENT.: Ninyo & Moore
SUMMARIZED BY.: K. Tan

Boring NO.	DEPTH (FT)	Diameter (In)	Height (In)	MOISTURE CONTENT (%) ASTM D 2937	DRY DENSITY (pcf) ASTM D 2937	WET DENSITY (pcf) ASTM D 2937	Void Ratio	Degree Of Saturation (%)
2f-1-17-ST	n/a	3	5	42.59	79.34	113.13	1.117	40
2f-1-17-ST	n/a	3	5	39.03	69.92	96.79	1.430	38
2f-1-17-ST	n/a	3	5	37.96	85.67	118.2	.953	38

Soil Description: Color: Black, Moisture: Wet, Grain: Fine
Atterberg Limit: Non Plastic
Specimen Type: Undisturbed Drive
Remark:



Failure Sketch

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TRIAXIAL TEST RESULTS
TEST TYPE: CIU

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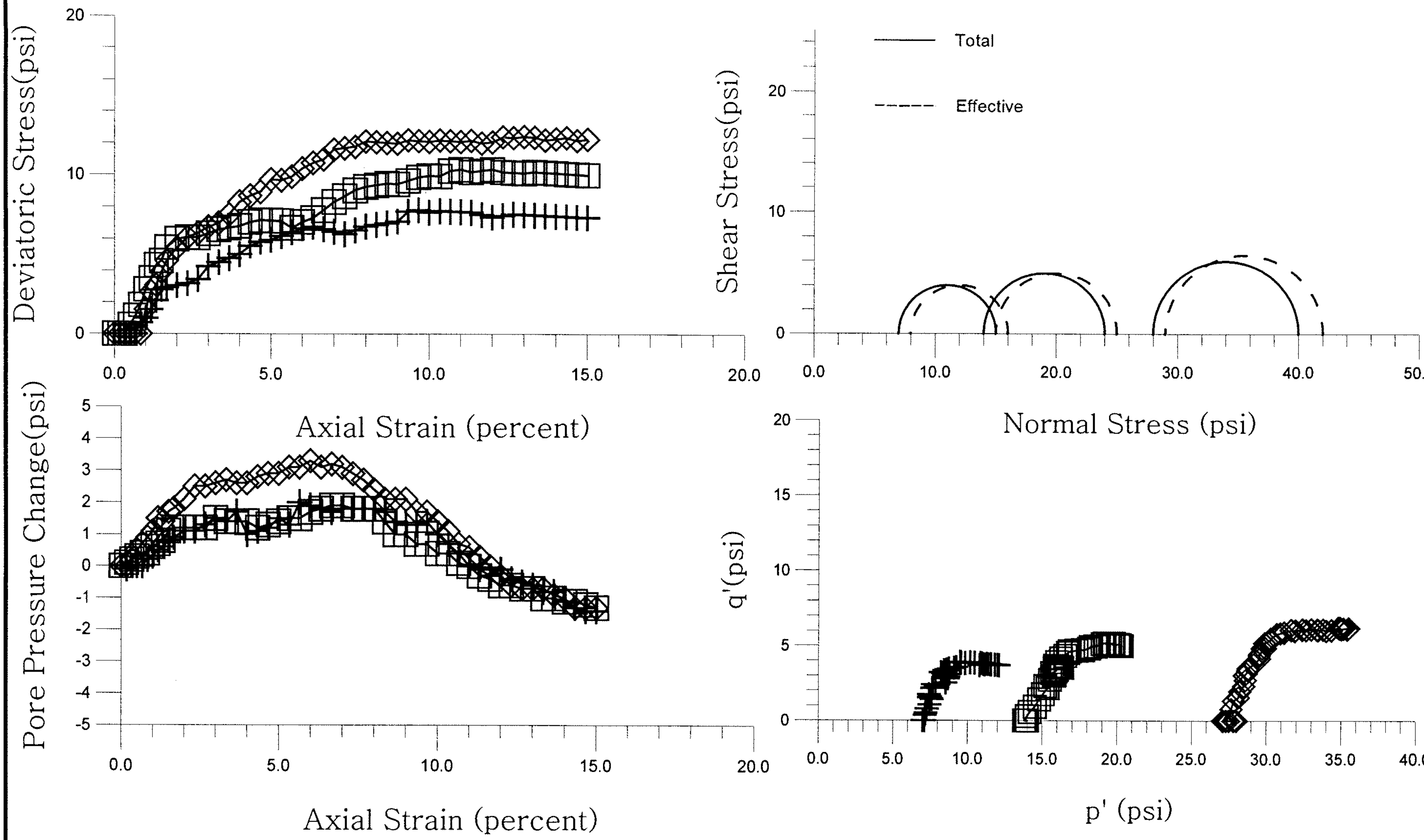
PROJECT NAME: Argonaut Mine Tailings
PROJECT NO.: 402277002



Symbol	BORING NO.	SAMPLE NO.	DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	CELL PRESSURE (PSI)	BACK PRESSURE (PSI)	EFFECTIVE STRESS (PSI)	MAX DEVIATOR STRESS (PSI)
+	N/A	2f-1-17-ST	n/a	42.6	79.3	87.0	80	7.0	7
□	N/A	2f-1-17-ST	n/a	39.0	69.9	94.0	80	14.0	10
○	N/A	2f-1-17-ST	n/a	37.9	85.7	108.0	80	28.0	12

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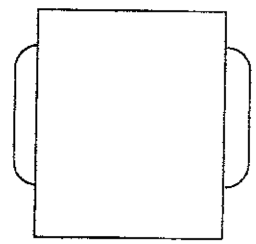
SUMMERY OF LABORATORY TEST RESULT

PROJECT NAME.: Argonaut Mine Tailings
PROJECT NO.: 402277002
DATE.: 11/10/2014

KTL NO.: 05-318-123
CLIENT.: Ninyo & Moore
SUMMARIZED BY.: K. Tan

Boring NO.	DEPTH (FT)	Diameter (In)	Height (In)	MOISTURE CONTENT (%) ASTM D 2937	DRY DENSITY (pcf) ASTM D 2937	WET DENSITY (pcf) ASTM D 2937	Void Ratio	Degree Of Saturation (%)
2f-1-39-ST	n/a	3	5	39.65	73.35	102.43	1.298	39
2f-1-39-ST	n/a	3	5	34.33	87.05	116.93	.922	35
2f-1-39-ST	n/a	3	5	32.77	75.02	99.61	1.222	34

Soil Description: Color: Black, Moisture: Wet, Grain: Silt with Gravel
Atterberg Limit: Non Plastic
Specimen Type: Undisturbed Drive
Remark: Sieve with Hydrometer included

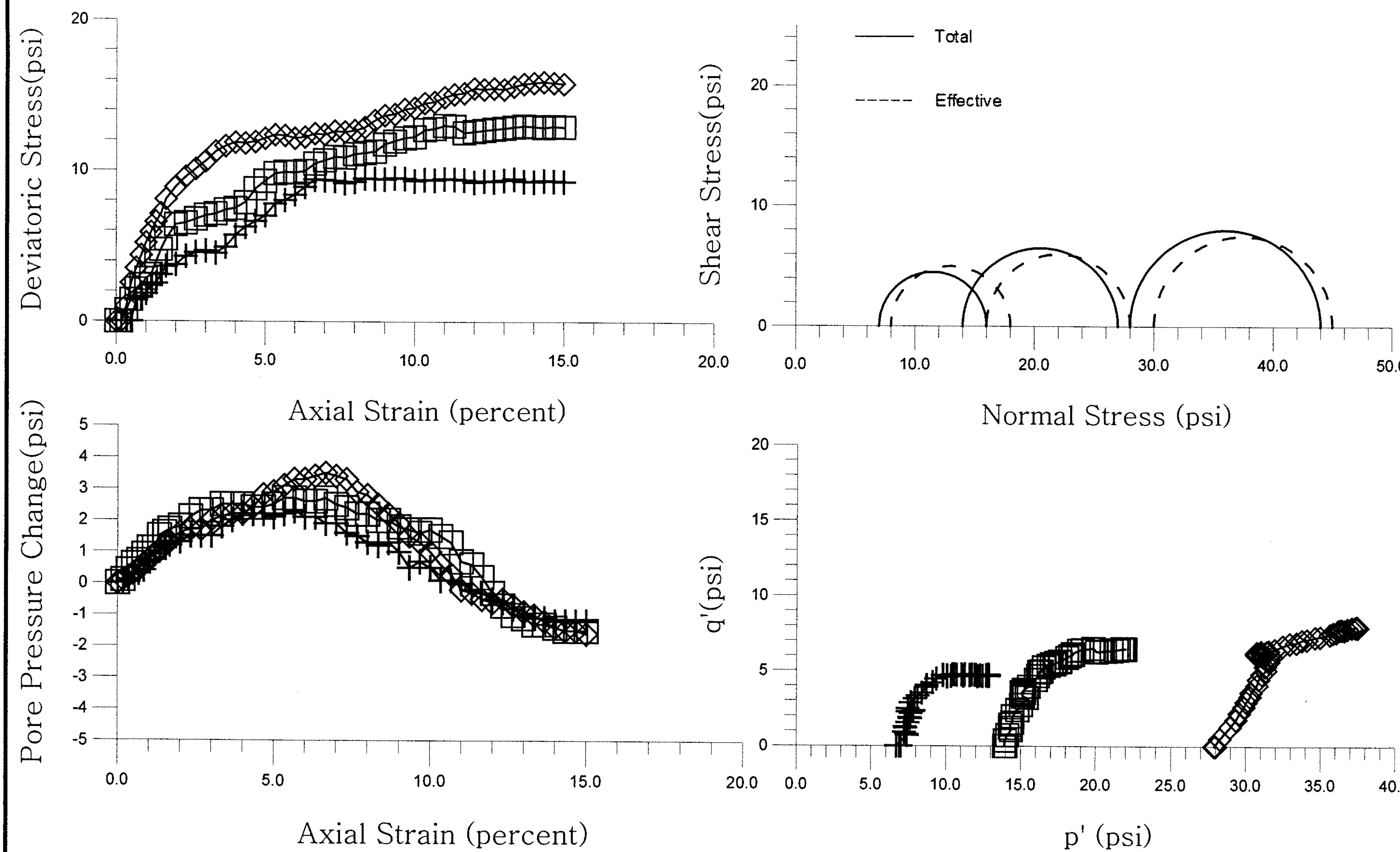


Failure Sketch

TRIAXIAL TEST RESULTS
TEST TYPE: CIU

KEANTAN LABORATORIES

PROJECT NAME: Argonaut Mine Tailings
PROJECT NO.: 402277002



Symbol	BORING NO.	SAMPLE NO.	DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	CELL PRESSURE (PSI)	BACK PRESSURE (PSI)	EFFECTIVE STRESS (PSI)	MAX DEVIATOR STRESS (PSI)
+	N/A	2f-1-39-ST	n/a	39.7	73.4	87.0	80	7.0	10
□	N/A	2f-1-39-ST	n/a	34.3	87.1	94.0	80	14.0	13
○	N/A	2f-1-39-ST	n/a	32.7	75.0	108.0	80	28.0	16

KEANTAN LABORATORIES

GRAIN SIZE DISTRIBUTION

ASTM D422

Sieve and Hydrometer

KTL NO.: 05-318-123

PROJECT NAME: Argonaut Mine Tailings — PROJECT NO.: n/a

SAMPLE NO.: 2F-1-39-ST — DEPTH(FT) n/a — DATE: 11/10/2014

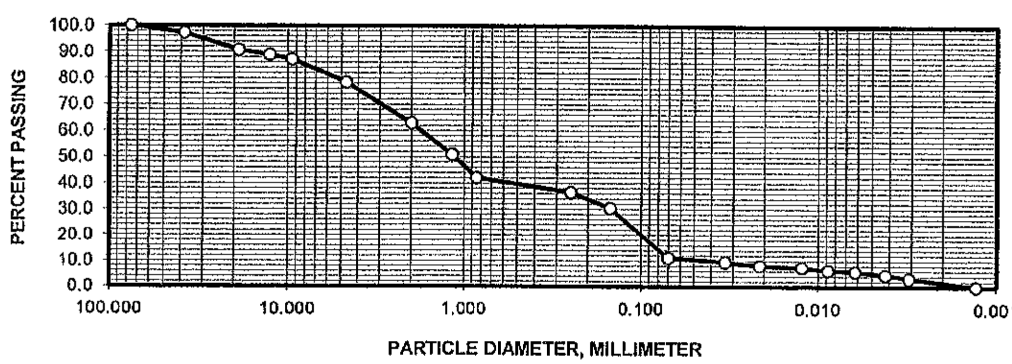
DESCRIPTION: — TECH.: jk

UNIFIED SOIL CLASSIFICATION: NEED DATA

Moisture Content Determination:	35.25%
Pan Number:	KB-23
Pan + Dry Soil, gms.	1121.0
Wt. of Pan, gms.	84.7
Wt. of Dry Soil, gms.	1036.3

SIEVE SIZE (U.S. STANDARD)	PARTICLE SIZE, (inches)	PARTICLES DIAMETER, (mm)	WEIGHT RETAINED (gms)	ACCUMULATED WEIGHT RETAINED (gms)	PERCENT PASSING (%)
5"	5.000	127.00			100.0
3"	3.000	76.20			100.0
1 1/2"	1.500	38.10			97.3
3/4"	0.750	18.90			90.7
.5"	0.500	12.70			88.9
3/8"	0.375	9.52			87.2
#4	0.185	4.70			78.4
#10	0.078	2.00			62.9
#20	0.033	1.17			50.9
#40	0.017	0.85			42.0
#60	0.009	0.25			36.4
#100	0.006	0.15			30.4
#200	0.003	0.07			11.1
	0.001	0.0334			9.5
	0.0008	0.0213			8.1
	0.0004	0.0123			7.4
	0.0003	0.0088			6.3
	0.0002	0.0062			5.8
	0.00016	0.0042			4.5
	0.00012	0.0031			3.2
	0.00005	0.0013			

Percent Passing	
200	11%



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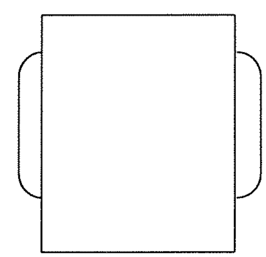
SUMMERY OF LABORATORY TEST RESULT

PROJECT NAME.: Argonaut Mine Tailings
PROJECT NO.: 402277002
DATE.: 11/10/2014

KTL NO.: 05-318-123
CLIENT.: Ninyo & Moore
SUMMARIZED BY.: K. Tan

Boring NO.	DEPTH (FT)	Diameter (In)	Height (In)	MOISTURE CONTENT (%) ASTM D 2937	DRY DENSITY (pcf) ASTM D 2937	WET DENSITY (pcf) ASTM D 2937	Void Ratio	Degree Of Saturation (%)
2f-3-57.5-ST	n/a	3	5	19.29	110.83	132.21	.532	23
2f-3-57.5-ST	n/a	3	5	22.67	103.73	127.24	.613	27
2f-3-57.5-ST	n/a	3	5	20.08	103.91	124.78	.622	24

Soil Description: Color: Brown, Moisture: Wet, Grain: Silt with Gravel
Atterberg Limit: Non Plastic
Specimen Type: Undisturbed Drive
Remark: Sieve with Hydrometer included



Failure Sketch

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GRAIN SIZE DISTRIBUTION

ASTM D422

Sieve and Hydrometer

KTL NO.: 05-318-123

PROJECT NAME: Argonaut Mine Tailings — PROJECT NO.: n/a

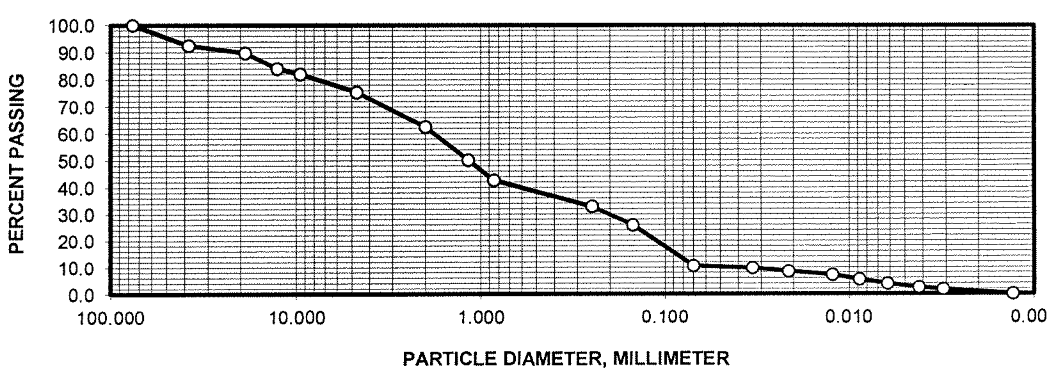
SAMPLE NO.: 2F-3-57.5-ST — DEPTH(FT) n/a — DATE: 11/10/2014

DESCRIPTION: — TECH.: jk

UNIFIED SOIL CLASSIFICATION: NEED DATA	
Moisture Content Determination:	20.68%
Pan Number:	KB-44
Pan + Dry Soil, gms.	1409.7
Wt. of Pan, gms.	84.5
Wt. of Dry Soil, gms.	1325.2

SIEVE SIZE (U.S. STANDARD)	PARTICLE SIZE, (inches)	PARTICLES DIAMETER, (mm)	WEIGHT RETAINED (gms)	ACCUMULATED WEIGHT RETAINED (gms)		PERCENT PASSING (%)
5"	5.000	127.00				100.0
3"	3.000	76.20				100.0
1 1/2"	1.500	38.10				92.5
3/4"	0.750	18.90				89.8
.5"	0.500	12.70				84.0
3/8"	0.375	9.52				82.0
#4	0.185	4.70				75.3
#10	0.078	2.00				62.5
#20	0.033	1.17				50.1
#40	0.017	0.85				42.6
#60	0.009	0.25				32.8
#100	0.006	0.15				25.8
#200	0.003	0.07				10.5
	0.001	0.0334				9.7
	0.0008	0.0213				8.4
	0.0004	0.0123				7.1
	0.0003	0.0088				5.4
	0.0002	0.0062				3.8
	0.00016	0.0042				2.4
	0.00012	0.0031				1.7
	0.00005	0.0013				

Percent Passing	
200	**11%**



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TRIAXIAL TEST RESULTS
TEST TYPE: CIU

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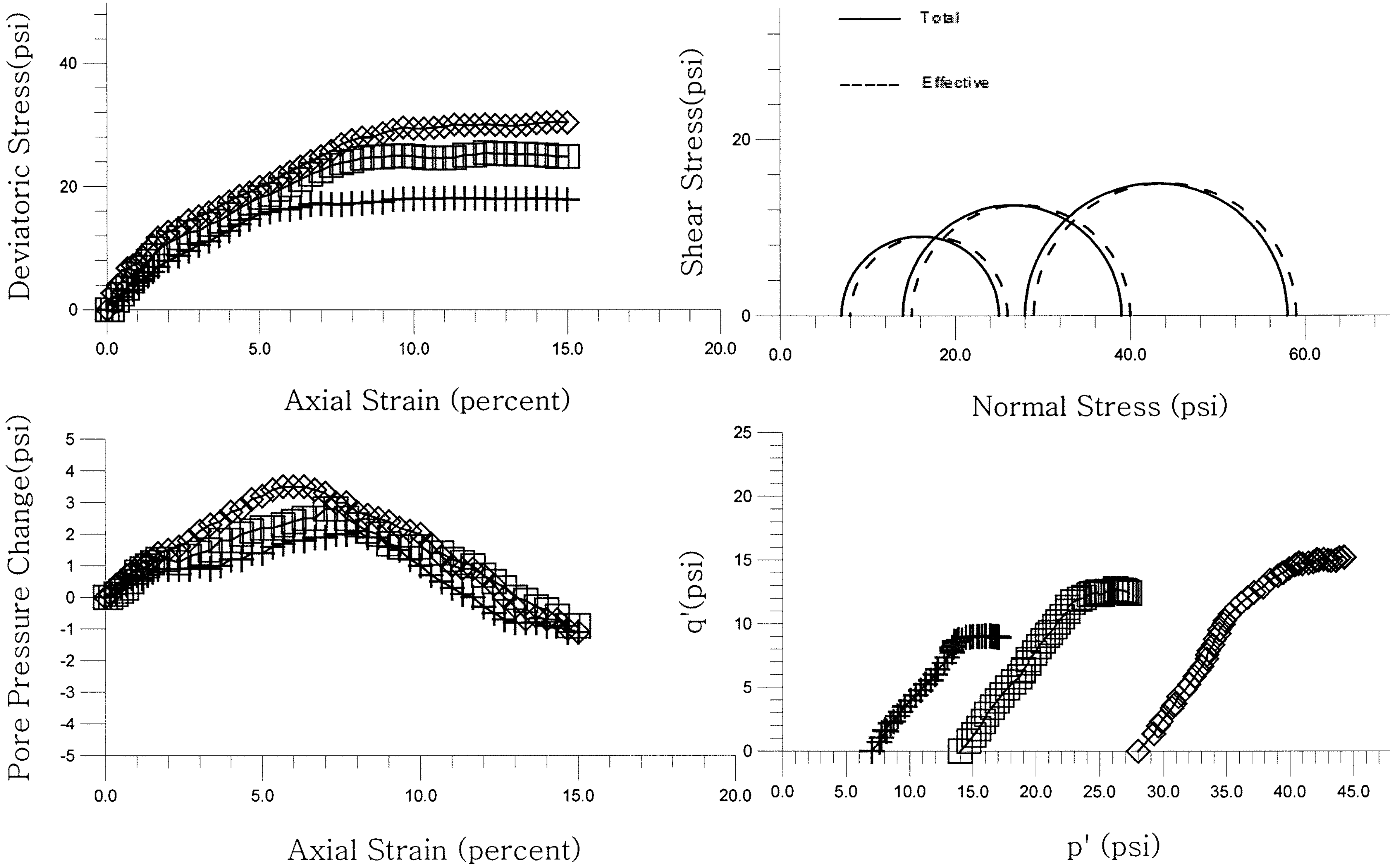

Symbol	BORING NO.	SAMPLE NO.	DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	CELL PRESSURE (PSI)	BACK PRESSURE (PSI)	EFFECTIVE STRESS (PSI)	MAX DEVIATOR STRESS (PSI)
+	N/A	2f-3-57.5-ST	n/a	19.3	110.8	87.0	80	7.0	18
□	N/A	2f-3-57.5-ST	n/a	22.7	103.7	94.0	80	14.0	25
○	N/A	2f-3-57.5-ST	n/a	20.0	103.9	108.0	80	28.0	30

PROJECT NAME: Argonaut Mine Tailings
PROJECT NO.: 402277002

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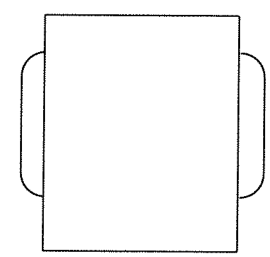
SUMMERY OF LABORATORY TEST RESULT

PROJECT NAME.: Argonaut Mine Tailings
PROJECT NO.: 402277002
DATE.: 11/10/2014

KTL NO.: 05-318-123
CLIENT.: Ninyo & Moore
SUMMARIZED BY.: K. Tan

Boring NO.	DEPTH (FT)	Diameter (In)	Height (In)	MOISTURE CONTENT (%) ASTM D 2937	DRY DENSITY (pcf) ASTM D 2937	WET DENSITY (pcf) ASTM D 2937	Void Ratio	Degree Of Saturation (%)
2f-4-58-ST	n/a	3	5	23.79	109.48	135.52	.540	27
2f-4-58-ST	n/a	3	5	24.23	96.07	119.34	.761	28

Soil Description: Color: Black, Moisture: Wet, Grain: Silt
Atterberg Limit: Non Plastic
Specimen Type: Undisturbed Drive
Remark: Sieve with Hydrometer included, Only two samples we extracted



Failure Sketch

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GRAIN SIZE DISTRIBUTION

ASTM D422

Sieve and Hydrometer

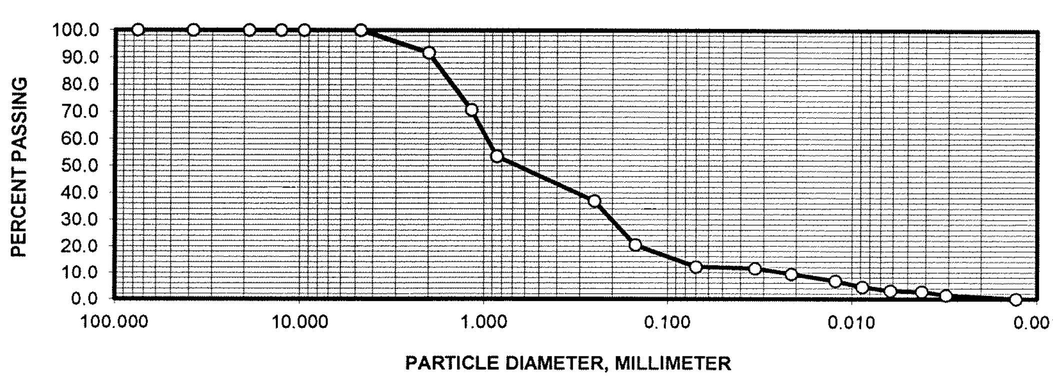
KTL NO.: 05-318-123

PROJECT NAME:	Argonaut Mine Tailings		PROJECT NO.:	n/a
SAMPLE NO.:	2F-4-58-ST	DEPTH(FT) n/a	DATE:	11/10/2014
DESCRIPTION:			TECH.:	jk

UNIFIED SOIL CLASSIFICATION:	NEED DATA
Moisture Content Determination:	35.58%
Pan Number:	KB-19
Pan + Dry Soil, gms.	379.3
Wt. of Pan, gms.	85.8
Wt. of Dry Soil, gms.	293.5

SIEVE SIZE (U.S. STANDARD)	PARTICLE SIZE, (inches)	PARTICLES DIAMETER, (mm)	WEIGHT RETAINED (gms)	ACCUMULATED WEIGHT RETAINED (gms)		PERCENT PASSING (%)
5"	5.000	127.00				100.0
3"	3.000	76.20				100.0
1 1/2"	1.500	38.10				100.0
3/4"	0.750	18.90				100.0
.5"	0.500	12.70				100.0
3/8"	0.375	9.52				100.0
#4	0.185	4.70				100.0
#10	0.078	2.00				91.8
#20	0.033	1.17				70.7
#40	0.017	0.85				53.5
#60	0.009	0.25				36.9
#100	0.006	0.15				20.4
#200	0.003	0.07				12.1
	0.001	0.0334				11.5
	0.0008	0.0213				9.4
	0.0004	0.0123				6.8
	0.0003	0.0088				4.5
	0.0002	0.0062				3.1
	0.00016	0.0042				2.8
	0.00012	0.0031				1.4
	0.00005	0.0013				

Percent Passing	
200	**12%**



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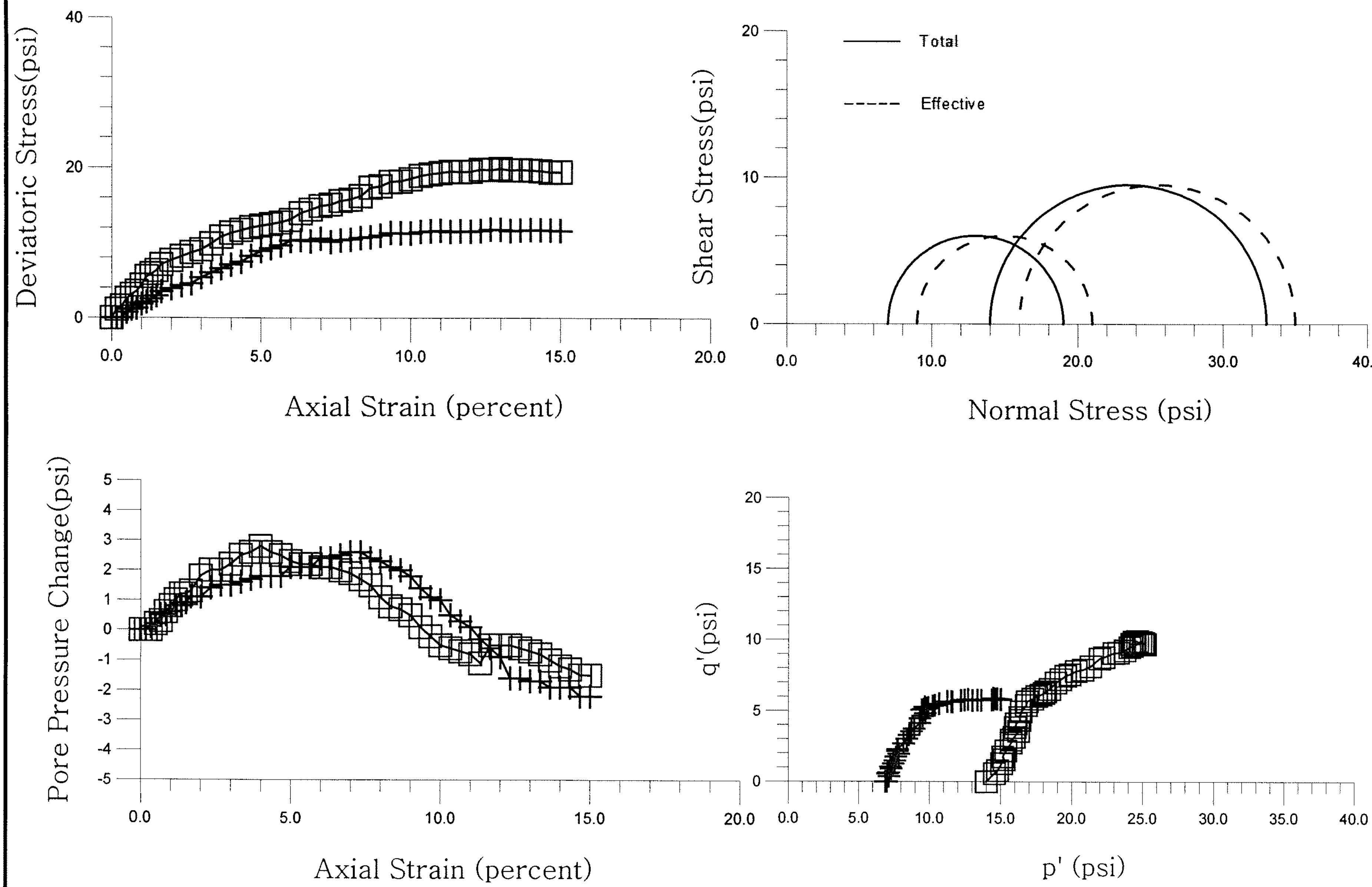

TRIAXIAL TEST RESULTS
TEST TYPE: CIU

KEANTAN LABORATORIES

Symbol	BORING NO.	SAMPLE NO.	DEPTH (FT)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	CELL PRESSURE (PSI)	BACK PRESSURE (PSI)	EFFECTIVE STRESS (PSI)	MAX DEVIATOR STRESS (PSI)
+	N/A	2f-4-58-ST	n/a	23.8	109.5	87.0	80	7.0	12
□	N/A	2f-4-58-ST	n/a	24.2	96.1	94.0	80	14.0	20
○	NO SAMPLE								

PROJECT NAME: Argonaut Mine Tailings
PROJECT NO.: 402277002

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Customer	Ninyo and Moore	**Project Number**	05-318-123
Site Name	Argonaut Mine Tailings	**Site Location**	

Photograph ID	1	
Date	11/14/14	
Location		
Direction		
Comments: 2f-1-39-ST Fine Silt with Gravel		
Photograph ID	2	
Date	11/14/14	
Location		
Direction		
Comments: ~~2f-1-57.5-ST~~ Brown silt with Gravel 2F-14-03 at 57.5 Depth		

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Customer	Ninyo and Moore	Project Number	05-318-123
Site Name	Argonaut Mine Tailings	Site Location	

Photograph ID	3
Date	11/14/14
Location	
Direction	

Comments:
~~2f-1-58-ST~~
Black Fine Silt

2F-14-04 at 58' Depth

Photograph ID	4
Date	
Location	
Direction	

Comments:

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APPENDIX D
SPT ENERGY TEST DATA

Taber DRILLING

Summary of Field Results
SPT Energy Measurements

Project Name	Argonaunt Talings Site
Boring No.	2F-1
Client Proj. No.	
Date	9/22/14
Drill Rig	CME L1241
Hammer Type	Auto
SPT Analyzer Operator	Tim d'Arcy
Taber Project No.	D14-0215

Sampler Depth (ft)	Number of Blows Analyzed	Average Energy Transfer* ft-lbs	Hammer Operating Rate bpm	Average Transfer Efficiency* %
5-6.5	5	268	44	77
27.5-29	2	328	57	94
29-30.5	5	310	38	89
32.5-34	8	320	54	91
35-36.5	13	308	50	88
36.5-37.5	60	295	41	84
37.5-39	70	307	43	88
	Ave	**305**	**47**	**87**
	Max	320	54	91
	Min	295	41	84
	Std Dev	10	6	3

Note:
Transfer Efficiency is based on 350 ft-lbs, 140# hammer with a nominal 30-inch drop.

Taber DRILLING

Summary of Field Results
SPT Energy Measurements

Project Name	Argonaunt Talings Site
Boring No.	2F-2
Client Proj. No.	
Date	9/23/14
Drill Rig	CME L1241
Hammer Type	Auto
SPT Analyzer Operator	Tim d'Arcy
Taber Project No.	D14-0215

Sampler Depth (ft)	Number of Blows Analyzed	Average Energy Transfer* ft-lbs	Hammer Operating Rate bpm	Average Transfer Efficiency* %
27.5-29	58	301	45	86
29-30.5	51	293	41	84
30.8-32.3	161	299	40	85
35-36.5	82	289	36	83
	Ave	**296**	**40**	**84**
	Max	301	45	86
	Min	289	36	83
	Std Dev	6	4	2

Note:
Transfer Efficiency is based on 350 ft-lbs, 140# hammer with a nominal 30-inch drop.

APPENDIX E
OTHER FIGURES

Files

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF WATER RESOURCES

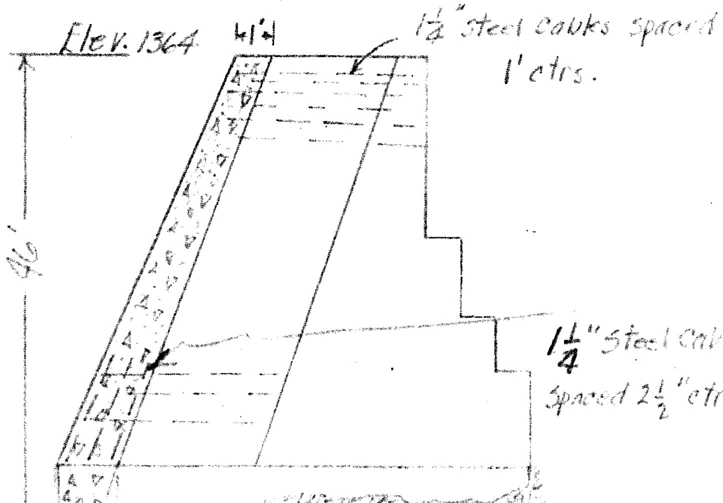
FEB 26 1931 S.A.H.

Dam No. 478

ARCH DAM ANALYSIS

Name of Dam: ARGONAUT Type of Dam: MULTIPLE ARCH

Height foundation to dam crest: 46'
Elevation Crest of Dam: 1364
Water surface elev. used for analysis: 1364
Length of Crest: 392'
Crest Thickness: 1.0'
Base thickness: 1.65'
Upstream radius at crest: 20.89'
Upstream radius at base: 20.89'
Central angle at crest: 100°
Central angle at base: 100°
Reinforcing steel: As shown in the sketch
Contraction joints: None
Contraction joints grouted:
Debris storage to elev.: 1364
Reference Drawings No. 1-2-3-4 Date Dec.30,'25
Gravity Abutments: 12 @ 32 ft. centers



Sketch of Maximum Section

Method of Analysis: Elastic Theory for water load, dead load, and ± 20° Temp. change. 1¼" steel cables were used for the steel reinforcing and the calculations for the stresses in the steel have been omitted.

Maximum Arch Stresses		Concrete	Steel	Elev.
Crown	Extrados	+528		1318
	Intrados	+190		1318
Abutment	Extrados	-58		1354
	Intrados	+755		1318
	Shear	21		1318
Maximum Cantilever Stresses				
	Extrados			
	Intrados			

NOTE: All stresses in lbs. per sq. in. and compression unless preceded by minus sign indicating tension.

Remarks: Arch design satisfactory.

F.E.R. 2-26-31

Computed by D.C. 7-3-1930. Checked by JCM 2-11-1931.