TETRA TECH

# Report of Geotechnical Investigation

## Weir Dewatering Treatment, Central Treatment Plant Nevada Environmental Response Trust, Henderson, Nevada

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# EXECUTIVE SUMMARY

The Southern Nevada Water Authority (SNWA) is planning to construct two new weirs on land that is under the jurisdiction of the Bureau of Reclamation (BOR) and managed as Clark County Wetlands Park in the Las Vegas Wash. The groundwater generated from the weir construction dewatering operations is anticipated to be contaminated with low concentrations of perchlorate. Therefore, the combined water from the installation of the two weirs will be pumped from the two construction locations using dedicated pump stations via a buried 18-inch diameter, schedule 40, carbon steel pipeline and treated at the Central Treatment Plant before permitted discharge to the wash. The treatment process consists of using cyclones to remove large solid particles from the groundwater, then multi-media filters to remove the suspended solids, followed by ion exchange to remove the perchlorate from the water.

Construction of two cyclones, six multi-media filters, six ion exchange units, three treated water tanks, two wastewater tanks, four waste pumps and five water pumps are required to treat the impacted water prior to discharge to the Nevada Wash site in Henderson, Nevada. The central treatment plant will be located in an existing area of barren undeveloped land measuring about 150 by 200 feet in plan. Foundations will consist of Portland cement concrete mat footings ranging in plan dimension from the smaller pump pads at approximately 5 x 13 ft. to the larger pump pads, treated water tank and ion exchange pads measuring 12 x 56 ft., 15x39 ft., 38.5 x 70 ft., and 67 x 70 ft., respectively.

Three geotechnical borings were drilled for this investigation. Borings BH-L09-1 through BH-L09-3 drilled within the area of the proposed Central Treatment Plant encountered a granular surface layer of generally medium dense to very dense sand with varying amounts of gravel to depths of 9 to 11.5 feet below existing grade. Soils classified as silty sand to poorly graded sand with silt and gravel. A highly compressible, low plasticity silty clay to lean clay lies below the sand to the maximum depth explored, 21.5 feet. Subsurface water accumulated in borings BH-L09-1 through BH-L09-3 at depths of about 10 to 11 feet at the time of drilling, October 2016.

This executive summary has been prepared solely to provide a general overview and should not be used for any purpose except for that for which it was prepared. The full report must be referenced for information about findings, recommendations and other concerns.

# PURPOSE AND SCOPE OF STUDY

The purpose of this study was to determine the subsurface conditions and provide recommendations for design and construction of foundations for the proposed Central Treatment Plant process tanks, pumps, cyclones and other support equipment. The Nevada Environmental Response Trust (NERT) will construct and operate two pump stations and a central water treatment plant to treat perchlorate-contaminated groundwater during Southern Nevada Water Authority's (SNWA) construction of the Sunrise Mountain Wear and Historic Lateral Weir in the Las Vegas Wash. According to SNWA, the system should have a capacity to treat intermittent flows on the order of 6,900 gallons per minute over the course of approximately 18 months until weir construction is complete. Tetra Tech conducted a field exploration program consisting of three (3) exploratory borings (BH-L09-1 to BH-L09-3) at the location of the central treatment plant. The borings were drilled to obtain information on subsurface soil conditions for the proposed equipment foundations and tanks, Drawing No. C-401. The geotechnical study was performed in accordance with Tetra Tech's scope of work dated September 13, 2016, and Le Petomane Environmental Trusts Work Authorization with Tetra Tech dated February 18, 2015.

Samples obtained during the field investigation were tested in a Las Vegas, Nevada geotechnical engineering laboratory (Geotechnical & Environmental Services, Inc.) to determine the physical and engineering characteristics of on-site soils. This report summarizes the field data and presents conclusions and recommendations for design and construction of the L09 tank and equipment foundations for the Las Vegas Wash, Central Treatment Plant and planned grading based on the proposed construction and subsurface conditions encountered. The report also includes design parameters and geotechnical engineering considerations related to construction.

# PROPOSED CONSTRUCTION

The proposed Central Treatment Plant will be located to the west of the existing lift station on property owned by Basic Environmental LLC. Primary equipment for water treatment at the plant will consist of two cyclones for removal of large solid particles from the groundwater, six ten-foot diameter, multi-media filters to remove the suspended solids, and six ion exchange units to remove the perchlorate from the water. Water will be transferred by nine 2,300-gpm large 300 to 350 horsepower pumps to large waste tanks between process steps and clean water to three large treated water tanks prior to discharge to the Las Vegas Wash.

The earthen containment berms surrounding the central treatment plant will vary in height from about 1 to 5 feet above the surrounding topography and have a 15-foot wide top crest and 3:1 (H: V) side slopes. Interior freeboard ranges from approximately 3 to 4 feet from base of the containment area to the top of the berm. The containment area below the plant will be: 1) excavated 2 feet below finished grade, 2) lined with a 60-mil HDPE liner which is then, 3) covered by a 2-foot thick layer of drainage gravel to finished grade. The subgrade at the containment will be sloped down to a drainage sump in the northeast corner for positive leak detection and collection of any lost intake waters.

The tanks, ion exchange units, cyclones, and pumps will each be supported on a single reinforced concrete rectangular mat foundation with turn down edges that extends at least 2 feet below grade. Waste and treated water transfer pumps will be located on an individual external support concrete pad positioned about 12 to 15 feet equal distance to the north or east of the five tank footprints. Proposed equipment/tank dimensions with estimated anticipated loading conditions were provided by Tetra Tech's structural design team, and are shown below in Table No. 1:

**Table No. 1.**

| Equipment | Empty weight (lbs.) | Design Empty Weight | Operating weight (lbs.) | Design Operating Weight (lbs.) | Notes |
|---|---|---|---|---|---|
| Transfer Pumps at Sunrise Mountain Weir 2,300 gpm at 360 ft. TDH | 2,740 | 3,288 | N/A | N/A | |
| Transfer Pump at Historic Lateral Weir 2,300 gpm at 460 ft. TDH | 2,740 | 3,288 | N/A | N/A | |
| Influent Tanks | 27,000 | 32,400 | 193,800 | 232,560 | |

| | | | | | |
|---|---|---|---|---|---|
| Cyclones | 9,184 | 11,021 | 12,058 | 14,470 | Per tank |
| Multi-media filter | 96,543 | 115,852 | 143,220 | 171,864 | Per skid |
| Cyclone Waste Tank | 31,650 | 37,980 | 173,430 | 208,116 | |
| Rinse/Backwash Waste Tank | 31,650 | 37,980 | 173,430 | 208,116 | |
| Backwash waste Pump | 264 | 317 | N/A | N/A | Per pump |
| Cyclone waste pump | 264 | 317 | N/A | N/A | Per pump |
| Treated Water Tank | 27,000 | 32,400 | 193,800 | 232,560 | |
| Treated water pump | 2,208 | 2,650 | N/A | N/A | |
| Rinse/Backwash pump | 1,451 | 1,742 | N/A | N/A | Per pump |
| Ion Exchange System | 43,500 | 52,200 | 169,000 | 338,000 | Per skid |

# SITE DESCRIPTION

The project area is adjacent to the Las Vegas Wash on private land and on land that is under the jurisdiction of the BOR and managed as the Clark County Wetlands Park. Developed park infrastructure includes roadways and parking lot, picnic shelters and bathroom facilities, a paved bike path and unpaved trails. A high voltage transmission line crossed over the project area. At the time of the field investigation (October 2016), the central treatment plant site is undeveloped adjacent to the developed parkland. The topography is relatively flat-lying to rolling hills of open desert shrubland with a slope to the north-northeast. The water conveyance pipeline alignment skirts north of the southern boundary of the parkland and Russell road across similar rolling topography.

At the time of the field investigation (October 2016), the site was undeveloped barren land. The topography is relatively flat-lying with a minor slope to the north-northeast and generally void of vegetation except for some scattered brush. The treatment plant site is currently undeveloped ground with several small stockpiles of soil and random wood debris scattered across the surface in the general project area. Future grading is anticipated to excavate for the planned foundations and for construction of the bermed containment. There were two buried GWETS water pipelines located along the north boundary of the tract. Future grading is anticipated to excavate for the planned foundations and for construction of the bermed containment with underlying HDPE liner. Photos 1 through 3 show the site features at the general boring locations.

Photo 1. Borehole BH-L09-3, View looking northwest towards the Las Vegas Wash.

Photo 2. Borehole BH-L09-2, View looking east towards lift station.

Photo 3. Borehole BH-L09-1, View looking southeast.

## FIELD EXPLORATION

Geotechnical exploratory borings were drilled at the noted locations for the future pump equipment and tanks based on Drawing No. C-401 of the L095 Weir Dewatering Treatment Project, Central Treatment Plant Construction Drawings dated October 14, 2016, provided by Tetra Tech.

All work on the project site was performed under the conditions outlined in Tetra Tech's most recent project specific Health and Safety Plan, dated May 10, 2016. Tetra Tech's personnel and subcontractor personnel performed the field investigation in Level D PPE, which included at a minimum:

- Hard Hat, ANSI Z89.1-2003 Type 1, Class E approved.
- ASTM Compliant and/or CSA Grade Steel-toed boots (minimum of 6-inch ankle support)
- Safety Glasses with side-shields, or goggles as determined appropriate.
- Gloves for drilling tasks and cut resistant gloves if needed.
- Hearing protection worn when noise is generated where equipment is running.
- High visibility apparel, ANSI Class II approved.
- Additional PPE as identified during completion of JSAs and spot hazard analysis in the field.

Locations of the exploration borings were staked in the field by Tetra Tech's project geologist by tape measure from existing site features. Prior to mobilization, Eagle Drilling Services drilling company personnel contacted Nevada Dig Alert to request the location and clearance of public underground utilities before performing drilling. Site utilities were located and physically marked in the field at each respective boring location. Boring locations were reviewed with available data sources prior to drilling to avoid accidental encroachment into below-ground GWETS piping components to the adjacent lift station.

The field exploration drilling was conducted on October 25 and 26, 2016. Three (3) exploratory borings were drilled for the L09 equipment and storage tank foundations to depths of 21.5 feet. Existing elevations and northing and easting coordinates at the boring locations were obtained by GPS hand held survey. The boring locations are noted on Drawing Nos. C-101 and C-401 in the Appendix.

Tetra Tech's drilling subcontractor (Eagle Drilling Services) advanced the borings through the overburden soils with a track-mounted Dietrich D-50 drill rig equipped with 8-inch diameter hollow-stem augers. The borings were logged by Tetra Tech's field engineer. The borings were reclaimed by pressure grouting using a cement-bentonite grout admixture. Logs of the exploratory borings are presented in the Appendix.

Samples of the subsurface materials were obtained with 1⅜-inch inside diameter split-barrel samplers and by collecting disturbed bulk samples of auger cuttings. Split barrel samplers were driven into the various strata using a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler each of three successive 6-inch increments was recorded. When using the split-spoon sampler, the total number of blows required to advance the sampler the second and third 6-inch increments is the penetration resistance (N value) as described by ASTM Method D1586. Penetration resistance values generally indicate the relative density or consistency of the subsurface soils. The penetration resistance values presented on the logs are not corrected for sampler depth. Thin-wall Shelby tube samplers were hydraulically pushed into fine-grained subsurface clay soils at select locations. Boring logs were prepared noting the borehole location and plan elevation, equipment and drill methods used, subsurface profile and descriptions per ASTM D2487, and groundwater conditions. Depths at which the samples were obtained along with the penetration resistance values are shown on the logs of exploration borings.

## Multichannel Analysis of Surface Waves (MASW) Refraction Survey

The MASW data was collected from the Central Treatment Plant location and consists of two orthogonal 24-channel seismic lines located through borehole locations BH-L09-1 and BH-L09-3. The depth of investigation for the MASW method is 60 feet below ground surface. The geophone spacing interval was 5 feet. A 10-pound hammer and plate were used as a seismic source. Multiple shots were collected to facilitate high resolution data collection. Optimum shot geometry was determined in the field by Tetra Tech's qualified geophysicist to maximize data acquisition for processing of the MASW data. The data was collected using a multi-channel digital seismograph. SeisImager/Surface Wave was be used to process the shot gathers into one dimensional (1-D) shear wave velocity verses depth profiles. Two dimensional (2-D) cross sections of the 1-D shear wave velocities were constructed. Compressional-wave (P-wave) refraction data was also collected, processed and presented as 2-D cross sections. The data from this investigation is used to determine values of dynamic shear modulus and Poisson's ratio. The results from this geophysical survey are presented in the Appendix of this report and includes the 1-D and 2-D shear wave data from the MASW assessment and 2-D refraction cross sections presenting the P-wave velocity data.

# LABORATORY TESTING

Samples obtained during the field exploration were transported to Geotechnical and Environmental Services, Inc., and relinquished via chain-of-custody for testing. The samples were observed and visually classified in accordance with ASTM Method D2487, which is based on the Unified Soil Classification System. Representative subsurface soil samples were selected for testing by Tetra Tech's geotechnical project engineer. The selected samples were tested to determine the physical properties of the soils in general accordance with ASTM or other approved procedures. A summary of the tests conducted and the purposes of those tests is presented below. A sample handling protocol was established per the Health and Safety Plan prepared by GES governing their laboratory personnel and submitted to Tetra Tech.

| Tests Conducted: | To Determine: |
|---|---|
| Grain-size Distribution | Size and distribution of soil particles; that is, clay, silt, sand and gravel. |
| Atterberg Limits | The effect of varying water content on the consistency of fine-grained soils. |
| Natural Moisture Content | Moisture content representative of field conditions at the time samples were taken. |
| Moisture-Density Relationship | The optimum moisture content for compacting soil and the maximum dry unit weight (density) for a given compactive effort. |
| Resistivity, chlorides and pH | The combination of these characteristics determines the potential of soil to corrode metal. |
| Soluble Sulfate Content | Potential of soil to deteriorate normal strength concrete. |

Field and laboratory test results are presented on Figures 4 through 12 in the Appendix. These data, along with the field information, were used to prepare the exploration boring logs on Figures 1 through 3 in the Appendix.

# SEISMIC ASSESSMENT OF PROJECT AREA

## Seismic Design Parameters

The project site is located in a geographic region considered to have a low potential for strong ground motion in response to seismic events. The USGS US Seismic Design Maps web application (http://earthquake.usgs.gov/designmaps/us/application.php) provides seismic design parameter values for various design codes on a site specific basis. ASCE/SEI 7-10 design criteria referenced in API Standard 650 is based on a 2 percent probability of exceedance or in other words a 98 percent probability of not being exceeded in any 50 year period. Based on the USGS National Seismic Hazard Mapping on-line mapping tool, the peak ground acceleration at the Las Vegas Wash site having a 2 percent probability of exceedance in any 50 year period is 0.199g.

The USGS database presents spectral response acceleration data in bedrock for short (0.2 sec) periods ($S_s$) and for long (1 sec) periods ($S_1$) for similar probability and 50-year return periods. According to USGS design procedures, these acceleration data are then adjusted upward or amplified depending on soil classification to reflect magnification effects as the earthquake wave energies pass from bedrock into soil. The values are then reduced by a factor that accounts for partial damping of the wave energy by the structure. The final values obtained (known as $S_{DS}$ and $S_{D1}$) become the basis for the structural design and in this case at the Las Vegas Wash site are estimated as 0.460 g ($S_{DS}$) and 0.231 g ($S_{D1}$). The data is summarized in the table below.

The methods of ASCE/SEI 7-10 require the properties of the soil at proposed site be classified as one of several site classes. The seismic design parameters for this site include a seismic zone soil profile type of (D), in accordance with the above referenced standard. Site Class D corresponds to a soil profile having stiff soil with an undrained shear strength between 1,000 and 2,000 psf, shear wave velocity between 600 and 1,200 ft. /s and average standard penetration resistance values between 15 and 50 blows per foot. This classification is based on the laboratory test data, MASW survey data and exploration boring information.

**Earthquake and Seismic Design Parameters**

| Site | Latitude (North) | Longitude (West) | PGA | $S_s$ | $S_1$ | Site Class | $F_a$ | $F_v$ |
|---|---|---|---|---|---|---|---|---|
| Las Vegas Wash site | 36.08545 | -114.98753 | 0.199g | 0.490 | 0.161 | D | 1.41 | 2.15 |

Notes: **PGA** = Peak Ground Acceleration
**$S_s$** = 0.2 sec. Spectral Response Acceleration
**$S_1$** = 1.0 sec. Spectral Response Acceleration
**$F_a$** = Short Period Seismic Design Factor
**$F_v$** = Long Period Seismic Design Factor
Return period = 2%
Time period = 50 years

# EARTHQUAKE INDUCED LIQUEFACTION

In review of the subsurface information to determine the potential for liquefaction triggered by strong ground motion, consideration was given to the type and age of the sediment, soil classification and stratigraphy, groundwater conditions, relative soil density, and peak ground acceleration for the site location.

The treatment plant facility will be constructed in a relatively flat area within the Las Vegas Wash property underlain by predominantly medium dense to very dense silty sand and poorly graded sand with gravel overlying clay soil to the maximum depth investigated, 21.5 feet. Groundwater accumulated in the exploration borings at depths of 10 to 11 feet at the time of drilling (October 2016).

A review of published geologic information for the site location was performed. Mapping identifies the soils as “alluvium” deposits of Holocene age (Qa), Bingler, E.C., 1977. Youd and Perkins, (1978) published a paper which estimated the susceptibility of sedimentary soil deposits to liquefaction during strong seismic shaking based on geologic age and depositional environment. According to the referenced document, continental alluvial fan deposits such as this are classified as having a low potential for liquefaction.

The USGS U.S. Seismic Design Maps web application provides seismic design parameter values for various design codes on a site specific basis. Based on the USGS National Seismic Hazard Mapping on-line mapping tool, the peak ground acceleration at the Las Vegas Wash site having a 10 percent probability of exceedance in any 50 year period is 0.135g and a having a 2 percent probability of exceedance in any 50 year period is 0.199g. Therefore, the Las Vegas Wash project location is in a geographic region considered to have a low potential for strong ground motion in response to seismic events.

A quantitative liquefaction evaluation of the Las Vegas Wash Treatment Plant location subsurface soils below the groundwater level of 11.5 feet to a depth of 50 feet was performed using the subsurface information, MASW survey results and laboratory test data in conjunction with the *Simplified Method* per (Seed and Idris, 1971). Unsaturated soils located above the groundwater table will not liquefy and soils deeper than 50 feet generally do not liquefy due to the high confining pressures. The quantitative liquefaction analysis determined factors of safety of 2.0 against liquefaction for the depth interval and sand soil types evaluated. The clay soils are not liquefiable considering their plasticity and clay contents. Therefore, potential for seismically induced liquefaction of the soils at the project site is negligible.

# SUBSURFACE CONDITIONS

## Stratigraphy

Borings BH-L09-1 through BH-L09-3, drilled within the area of the proposed Central Water Treatment Plant, encountered a granular surface layer of medium dense to very dense, silty sand and poorly graded sand with gravel to depths of 9.0 to 11.5 feet below existing grade overlying low plasticity silty clay and lean clay. The fine-grained clay soils extend beyond the depths of the boreholes of 21.5 feet. Engineering characteristics of these two fine-grained clays are similar, only differing by their plasticity characteristics. Soil stiffness tends to decrease slightly in the underlying clay at or below the depth of the phreatic surface on the order of 10 to 12 feet as indicated by a general decrease in penetration resistance values.

The boring logs should be referenced for complete descriptions of the soil types and their estimated depths. A characterization of the subsurface profile normally includes grouping soils with similar physical and engineering properties into a number of distinct layers. The representative subsurface layers at the site are presented below, starting at the ground surface.

## Sand (SM) & (SP-SM)

Standard penetration resistance (SPT) N-values obtained in the silty sand and poorly graded sand with gravel ranged from 12 to 60 blows per foot, averaging 17, indicating a medium dense to very dense relative density. Natural moisture contents in the sands ranged from 4 to 18 percent in the upper ten feet of the layer with the lower percentage values in the sands indicative of samples having a lower percentage of silt fines. Liquid and plastic limit tests indicate these soils have a liquid limit of granular non-plastic and a plasticity index of non-plastic. Gradation test results for samples of the sand are presented on Figures 4, 6 and 8.

Results of three moisture-density relationship tests (ASTM D1557) performed on bulk samples of the sand obtained from the borings indicate maximum dry densities ranging from 126.5 to

133.5 pcf and optimum moisture contents ranging from 9.9 to 11.2 percent (Figures 10, 11 and 12).

Analytical chemical testing was performed on three representative samples of silty sand with gravel from BH-L09-1, BH-L09-2 and BH-L09-3 at depths of 0-5.0 feet, respectively. Samples were submitted for testing to Silver State Analytical Laboratories of Las Vegas Nevada. Analytical chemical data indicates the sand has pH values of 8.41, 8.44 and 8.54 with minimum resistivity values ranging from 267 to 575 ohm-cm, respectively. Soluble chloride concentrations in soil of 380, 410 and 2,500 mg/kg were determined for the sand. Based on soil resistivity and pH data, the subgrade soils encountered at the project site present a moderate potential for corrosion of steel and galvanized steel in contact with the soil and a bituminous or polymeric coating is recommended.

Sulfate content tests determine the potential of soil to deteriorate normal strength concrete. The concentration of water soluble sulfates measured on these three samples typical of the silty sand stratum were 0.08 and 0.20 percent. This concentration of water soluble sulfates is indicative of a negligible to positive exposure to sulfate attack in normal strength concrete when exposed to the sand. The degree of attack is based on a range of negligible, positive, severe and very severe as presented in the U.S. Bureau of Reclamation Concrete Manual and as referenced in Table 7-2 of standard ACI 318-11.

### Silty Clay and Lean Clay (CL-ML) & (CL)

The silty clay and lean clay contain varying amounts of fine grained sand throughout the layer. Standard penetration resistance (SPT) N-values obtained in the clays range from 4 to 25 blows per foot, averaging about 11, indicating a medium stiff to very stiff soil consistency. The soil strata is below the local groundwater table and is considered saturated. Liquid and plastic limit tests indicate these soils have liquid limits of 13 and 16 percent and a plasticity index of 6 to 9. Gradation test results for samples of the clay are presented on Figures 5 and 7.

### Groundwater

Subsurface water accumulated in borings BH-L09-1 through BH-L09-3 at depths of about 10 to 11 feet at the time of drilling, October 2016. Typical fluctuations in groundwater elevations are attributed to seasonal variations in rainfall during a particular year. Numerous factors contribute to groundwater fluctuations, and evaluation of such factors is beyond the scope of this study.

## ENGINEERING ANALYSIS AND RECOMMENDATIONS

### Site Grading and Embankment Berm Construction

Grade at the containment area is relatively flat lying ranging in elevation from 1,556 to 1,558 feet according to the site survey map. Topography will be graded to construct a sloping containment pad surrounded by an earthen containment dike having a top elevation on the order of 1,561 ft. according to the elevations presented on Drawing C-401 (10/14/16). Based on the site contours and the proposed site grading indicated on the project drawings, earthen embankment fills up to 5.0 feet high are required for the berm construction. Surrounding natural topography across the proposed L09 project area consists of relatively flat-lying to gently sloping terrain down to the east/northeast.

It is anticipated that final site grading will consist of excavating and placing excavated structural sand fill to complete the above-grade embankment berms of the containment. Placement requirements for structural fill and built slope ratios for the cut and fill embankment slopes are discussed herein. In general, the containment area construction sequence below the water treatment station will consist of the following steps: 1) excavate 2 feet below finished grade to desired finished subgrade for the containment contours, 2) place and weld 60-mil HDPE liner on the prepared and rolled subgrade, and 3) cover the HDPE liner with a 2-foot thick layer of drainage gravel to finished grade. The subgrade at both containments will be sloped down to a drainage sump for positive leak detection and collection of any lost intake waters.

Based on the proposed site grading and results of this investigation, the tanks and pump pads can be supported on the gravel fill subgrade utilizing conventional reinforced concrete mat foundations with turn down edges. If site grading significantly differs from what is described herein, the recommendations of this report must be reviewed and revised as necessary to reflect the final grading plan.

Site grading plans must include drainage features to rapidly drain surface run-off away from the tanks and containment area. All grades must provide effective drainage away from the tanks during and after construction. Water permitted to pond next to foundations can result in greater soil movements than those discussed in this report. These greater movements can result in unacceptable differential tank, piping connection problems and on-grade concrete slab movements for the tanks or pumps.

Drilling information indicates that natural moisture content in the excavated sand could be as much as 3 to 7% lower than optimum moisture content. Moisture conditioning the site soil to add moisture will be required to obtain moisture contents within +/-2% of optimum in order to achieve compaction. Proper mixing and moisture conditioning will be required to obtain a well-mixed uniform soil suitable for use in constructing compacted fill. Engineering properties of the site soils should be suitable for processing to adjust the moisture content and will require effort to disc and blend the silty sand to achieve uniform results.

Excavation of the site sand to subgrade depth can be accomplished with heavy-duty earth excavating equipment such as scrappers, loaders, and excavators. According to the information collected during the subsurface exploration, groundwater levels are expected to be below the anticipated excavation depths for this project. The on-site soils are suitable for use as structural fill. Shrinkage values of 5 to 10% should be anticipated for the sands.

Design and construction criteria presented below must be observed for site preparation purposes and when preparing project documents.

1. Any site surface fill, organics or site debris should be removed from the proposed construction areas.

2. Fill slopes should be constructed to 3H (horizontal):1V (vertical) or flatter. Fill slopes should be overbuilt beyond final line and grade and then cut back to develop an adequately compacted slope face. Where fill is placed on existing slopes steeper than 5H: 1V, benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will

help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface.

3. Prior to placing new site fill, the stripped subgrade should be proof-rolled with a loaded dump truck or similar equipment. If loose or soft areas are encountered during the proof-rolling, the soft or loose soil should be over-excavated, replaced with structural fill and compacted to the specification noted below.

4. All fill and backfill should be approved by a geotechnical engineer, moisture-conditioned to within +/- 2% of optimum moisture content and placed in uniform maximum lifts of 6 inches in thickness. It should then be compacted to the following minimum dry densities as determined by ASTM D1557 or to the minimum percentage of the relative density determined by the combination of ASTM D4253 and D4254, whichever method is applicable for the material being compacted.

| | ASTM D1557 | ASTM D4253 & D4254 |
|---|---|---|
| Roadway Areas | 95% | 75% |
| Embankment Fill | 95% | 75% |
| Below Foundations | 100% | 75% |
| Utility Trench Backfill | 95% | 70% |
| Spread Footing Foundations | 100% | 75% |
| Foundation Backfill | 100% | 75% |

5. The on-site soils are suitable for use as structural fill for construction of the earthen containment berms and may be used as general site grading provided they are segregated and then processed to within +/-2% of optimum moisture and are compacted in accordance with Item 4 above.

6. The contractor is responsible for providing safe working conditions in connection with underground excavations. Temporary construction excavations which workers will enter will be governed by OSHA guideline 1926.6542, Appendix B to subpart P. For planning purposes, the soils encountered in the exploratory borings classify as Type C.

7. Site grading must be developed and maintained during and after construction to rapidly drain surface run-off well away from the process tank and pump foundations. The ground surface adjacent to the exterior foundations should be sloped to drain away from the foundation in all directions. A minimum slope of 6 inches in the first 10 feet should be used for site drainage requirements.

## Foundations

### *L09 Storage Tanks, Multi-Media Filters, Ion Exchange System*

Estimated total settlement of the foundations will likely govern design rather than allowable bearing pressure. In consideration of the subsurface soil conditions and their engineering properties determined from the geotechnical investigation, concrete mat foundations can be used to support the water treatment plant equipment and tanks. Tetra Tech’s analysis is based on an assumed minimum foundation depth of 2 feet below grade and a footing widths of 2 to 5 feet for the smaller equipment and up to 12 feet or greater for the tanks or pumps. Calculations indicate typical smaller equipment footings 2to 5-foot wide bearing on the compacted gravel fill can be proportioned for an allowable bearing pressure of 2,000 pounds per square foot (psf). The larger mat foundations for the tanks or pumps can be proportioned for an allowable bearing pressure of 4,500 psf or less. Contact pressures from the largest dimension tank foundations are expected to be less than the allowable bearing pressure according to the design information in Table No. 1.

Total settlement calculations were performed for the heavier structures/equipment listed in Table No. 1. Based on a combination of elastic theory in the gravel fill and sand and one-dimensional consolidation for the underlying clay, and using an actual contact pressure of 750 to 800 psf for the treated water tank and ion exchange skids (Table No. 1 design calculations), the total settlement is estimated to be approximately 1 to 1.25 inches. Total settlement is estimated to be on the order of ¾ inches for the multi-media filters. A majority of the settlement will occur long term through the consolidation of the underlying clay layers throughout the duration of the project, while immediate elastic settlement is estimated to be less than ¼ inch in the sand and should occur during construction and hydrostatic loading of the tanks. Differential settlement will be approximately one half of the estimated total settlement.

Normal pump operations create dynamic foundation loads generated through vibration by unbalanced machine forces. Vibration analysis of the foundations requires input of soil properties of shear modulus and Poisson's ratio to describe the motion and determine the necessary spring constants and dampening ratios. The data from the MASW refraction survey investigation is used to determine values of dynamic shear modulus and Poisson's ratio. The location of the geophysical survey and results from this survey are presented in the Appendix. Values for shear wave velocity, soil density, Poisson's ratio, shear modulus, Young's modulus and Bulk modulus are present versus depth in summary tables generated for each seismic line.

The lateral resistance of a mat foundations is controlled by a combination of sliding resistance between the mat and the foundation materials and passive earth pressure against the side of the mat. Criteria for calculating the lateral resistance are presented below.

The following design and construction criteria should be observed. The construction details should be considered when preparing the project documents.

1. Temporary excavation slopes in the natural sand, or gravel fill for the foundation construction should be sloped to 2H: 1V or flatter.

2. The process storage tanks, multi-media filters and ion exchange system should be supported on concrete mat foundations with a minimum thickness of 2 feet or greater based on structural requirements to support loading conditions.

3. The smaller concrete footings supported on the compacted gravel fill should be designed for an allowable contact pressure of 2,000 psf or less, The large mat foundations supported on the gravel fill should be designed for an allowable contact pressure of 4,500 psf or less, with anticipated settlement on the order of 3/4 inch to 1.25 inches or less depending on actual contact pressures estimated from Table No. 1 for the anticipated equipment listed.

4. The minimum width of the spread footings should be at least 18 inches or in accordance with applicable building codes, whichever is more restrictive.

5. Footing lateral loads may be resisted by friction between the footing base and supporting soil, and lateral bearing pressure against the sides of footings. For design purposes, a friction coefficient of 0.42 for concrete on the natural sand or gravel fill and a lateral

bearing pressure of 225 pcf per foot of depth for natural sand or gravel fill should be used. A Modulus of Subgrade reaction of 300 pci is applicable for the sand and gravel fill.

6. Compacted sand or gravel should be placed as backfill around all exterior foundations. The sand or gravel should be moisture-conditioned to within +/- 2% of optimum moisture content and placed in uniform maximum lifts of 6 inches in thickness. It should then be compacted to 100 percent of the maximum dry density as determined by ASTM D1557 in accordance with *Site Grading,* Item 4 and the surfaced sloped to drain per *Site Grading,* Item 7*.*

7. A representative of the geotechnical engineer should observe and test the placement of all engineered fill and all foundation excavations prior to placement of concrete forms.

### *Ancillary Equipment Foundations*

Concrete spread footing foundations are suitable for support of ancillary structures and pump equipment. Based on the subsurface conditions, concrete spread footing or mat foundations should be placed on gravel fill and be proportioned for a maximum contact pressure of 2,000 pounds per square foot. Settlements are estimated to be less than 1 inch. Tetra Tech's analysis is based on an assumed minimum foundation depth of 2 feet below grade and a minimum width of at least 24 inches.

### *Lateral Earth Pressures*

Design for lateral earth pressures should be computed on the basis of the lateral earth pressure coefficients provided in the table below. Resistance to overturning and sliding can be provided by passive earth pressure and sliding friction. Passive earth pressure should be computed on the basis of the passive lateral earth pressure coefficients presented in the table below. Compacted fill placed against the sides of the mat to resist lateral loads should be compacted in accordance with *Site Grading, Item 4* and the surfaced sloped to drain per *Site Grading, Item 7.* Conventional safety factors used in structural analysis for items such as overturning moments and sliding should be used in the design.

**Lateral Earth Parameters**

| **DESIGN PARAMETER** | **SOIL TYPE** |
|---|---|
| | **Silty Sand** |
| Lateral Earth Pressure<br>Ko (at-rest)<br>Ka[1] (active)<br>Kp[1] (passive) | <br>0.47<br>0.35<br>3.25 |
| Unit Weight (pcf) | 105 |
| Coefficient of Friction[2] | 0.41 |
| Soil Friction Angle | 32 |

Notes:
Assumptions: Wall slope = vertical
Friction angle between concrete wall and sand = 24 degrees

[1] Wall rotation or translation

*Wall rotation of translation = δ/H where δ is

| Translation or Wall Rotation* (Horizontal or Sloping Backfill) | |
|---|---|
| Active | Passive |
| -0.002H | +0.02H |

horizontal deformation of the wall and H is the wall height. (Negative values indicate movement away from backfill; positive values indicate movement toward backfill.)

[2] Factor of Safety = 1.5 applied

### *Piping*

All piping including tank nozzles and attachments will need to be designed to account for the range of settlements discussed in this report. The design of the flexible connections to the tanks should consider the estimated range of settlement (up to 1.25-inches) anticipated along the edge of the storage tanks.

## Containment Embankments and Basins

It is anticipated that containment basins will consist of primarily fill slopes. The on-site soils are suitable to construct containment embankments. The fill slopes should be designed with side slopes of 3H: 1V or flatter. In addition, embankments will be subject to some settlement over time associated with loading from the adjacent tank. Embankments will need to be constructed to account for this settlement and an over-build of at least 1-inch should be considered.

## Soil Resistivity

Soil Resistivity testing indicated the sand soils present in the upper 11 feet are deleterious to buried metals in contact with the soils and should be considered to have a moderate corrosive potential. Laboratory testing of representative samples had resistivity results ranging from 267 to 575 ohm-cm.

# CONTINUING SERVICES

Two additional elements of geotechnical engineering service are important to the successful completion of this project.

1. **Consultation with Tetra Tech during the design phase.** This is essential to ensure that the intent of our recommendations is incorporated in design decisions related to the project and that changes in the design concept consider geotechnical aspects.

2. **Observation and monitoring during construction.** Tetra Tech should be retained to observe the earthwork phases of the project, including the site grading and excavations, to determine that the subsurface conditions are compatible with those described in our analysis. In addition, if environmental contaminants or other concerns are discovered in the subsurface, our personnel are available for consultation.

# LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in the region where the work was conducted. The conclusions and recommendations submitted in this report are based upon project information provided to Tetra Tech, data obtained from the exploratory borings drilled at the locations indicated. The nature and extent of subsurface variations across the site may not become evident until construction. Tetra Tech should be on site during construction to verify that actual subsurface conditions are consistent with those described herein.

This report has been prepared exclusively for our client. This report and the data included herein shall not be used by any third party without the express written consent of both the client and Tetra Tech. Tetra Tech is not responsible for technical interpretations by others. As the project evolves, we should provide continued consultation and field services during construction to review and monitor the implementation of our recommendations, and verify that our recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications of the recommendations presented herein. Tetra Tech recommends on-site observation of excavations and foundation bearing strata and testing of fill by a representative of the geotechnical engineer.

| Prepared by: | | Reviewed by: | |
|---|---|---|---|
| | Richard Dombrouski, P.E. (MT)<br>Principal. Geotechnical Engineer | | Marco Fellin, P.E. (NV)<br>Sr. Geotechnical Engineer |

PROFESSIONAL ENGINEER-STATE OF NEVADA
MARCO J. FELLIN
Exp: 6-30-17
CIVIL
No. 23546
2/14/17

# APPENDIX

# IMPORTANT INFORMATION

## ABOUT YOUR

# GEOTECHNICAL ENGINEERING REPORT

More construction problems are caused by site subsurface conditions than any other factor. As troublesome as subsurface problems can be, their frequency and extent have been lessened considerably in recent years, due in large measure to programs and publications of ASFE/The Association of Engineering Firms Practicing in the Geosciences.

The following suggestions and observations are offered to help you reduce the Geotechnical-related delays, cost-overruns and other costly headaches that can occur during a construction project.

## A GEOTECHNICAL ENGINEERING REPORT IS BASED ON A UNIQUE SET OF PROJECT-SPECIFIC FACTORS

A Geotechnical engineering report is based on a subsurface exploration plan designed to incorporate a unique set of project-specific factors. These typically include: the general nature of the structure involved, its size and configuration; the location of the structure on the site and its orientation; physical concomitants such as access roads, parking lots, and underground utilities, and the level of additional risk which the client assumed by virtue of limitations imposed upon the exploratory program. To help avoid costly problems, consult the geotechnical engineer to determine how any factors which change subsequent to the date of the report may affect its recommendations.

Unless your consulting Geotechnical engineer indicates otherwise, *your Geotechnical engineer report should not be used:*

- When the nature of the proposed structure is changed, for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one;
- when the size or configuration of the proposed structure is altered;
- when the location or orientation of the proposed structure is modified:
- when there is a change of ownership, or
- for application to an adjacent site.

*Geotechnical engineers cannot accept responsibility for problems which may develop if they are not consulted after factors considered in their reports' development have changed.*

## MOST GEOTECHNICAL "FINDINGS" ARE PROFESSIONAL ESTIMATES

Site exploration identifies actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are extrapolated by Geotechnical engineers who then render an opinion about overall subsurface conditions, their likely reaction to proposed conditions, their likely reaction to proposed construction activity, and appropriate foundation design. Even under optimal circumstances actual conditions may differ from those inferred to exist, because no Geotechnical engineer, no matter how qualified, and not subsurface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock and time. The actual interface between materials may be fare more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. *Nothing can be done to prevent the unanticipated, but steps can be taken to help minimize their impact.* For this reason, *most experienced owners retain their Geotechnical consultants through the construction stage*, to identify variances, conduct additional tests which may be needed, and to recommend solutions to problems encountered on site.

## SUBSURFACE CONDITIONS CAN CHANGE

Subsurface conditions may be modified by constantly-changing natural forces. Because a Geotechnical engineering report is based on conditions which existed at the time of subsurface exploration, *construction decisions should not be based on a Geotechnical engineering report whose adequacy may have been affected by time.* Speak with the Geotechnical consultant to learn if additional tests are advisable before construction starts.

Construction operations at or adjacent to the site and natural events such as flood, earthquakes or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical report. The geotechnical engineer should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

## GEOTECHNICAL SERVICES ARE PREFORMED FOR SPECIFIC PURPOSES AND PERSONS

Geotechnical engineers' reports are prepared to meet the specific needs of specific individuals. A report prepared for a consulting civil engineer may not be adequate for a construction contractor, or even some other consulting civil engineer. Unless indicated otherwise, this report was prepared expressly for the client involved and expressly for purposes indicated by the client. Use by any other persons for any purpose, or by the client for a different purpose, may result in problems. *No individual other than the client should apply this report for its intended purpose without first conferring with the* *geotechnical engineer. No person should apply this report for any purpose other than that originally contemplated without first conferring with the geotechnical engineer.*

## A GEOTECHNICAL ENGINEERING REPORT IS SUBJECT TO MISINTERPRETATION

Costly problems can occur when other design professionals develop their plants based on misinterpretations of a geotechnical engineering report. To help avoid these problems, the geotechnical engineer should be retained to work with other appropriate design professionals to explain relevant geotechnical findings and to review the adequacy of their plans and specifications relative to geotechnical issues.

## BORING LOGS SHOULD NOT BE SEPARATED FROM THE ENGINEERING REPORT

Final boring logs are developed by geotechnical engineers based upon their interpretation of field logs (assembled by site personnel) and laboratory evalution of field samples. Only final boring logs customarily are included in geotechnical engineering reports. *These logs should not under any circumstances be redrawn* for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process. Although photographic reproduction eliminates this problem, it does nothing to minimize the possibility of contractors misinterpreting the logs during bid preparation. When this occurs, delays, disputes and unanticipated costs are the all-too-frequent result.

To minimize the likelihood of boring log misinterpretation, *give contractors ready access to the complete geotechnical engineering report* prepared or authorized for their use. Those who do not provide such access may proceed under the *mistaken* impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes which aggravate them to disproportionate scale.

## READ RESPONSIBILITY CLAUSES CLOSELY

Because geotechnical engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against geotechnical consultants. To help prevent this problem, geotechnical engineers have developed model clauses for use in written transmittals. These are *not* exculpatory clauses designed to foist geotechnical engineers' liabilities onto someone else. Rather, they are definitive clauses which identify where geotechnical engineers' responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your geotechnical engineering report, and you are encouraged to read them closely. your geotechnical engineer will be pleased to give full and frank answers to your questions.

## OTHER STEPS YOU CAN TAKE TO REDUCE RISK

Your consulting geotechnical engineer will be pleased to discuss other techniques which can be employed to mitigate risk. In addition, ASFE as developed a variety of materials which may be beneficial. Contact ASFE for a complimentary copy of its publications directory.

*Published by*

ASFE

THE ASSOCIATION OF ENGINEERING FIRMS PRACTICING IN THE GEOSCIENCES

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TETRA TECH

# Tetra Tech Boring Log Descriptive Terminology
# Key to Soil Symbols and Terms

## SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS GRAPH | SYMBOLS LETTER | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS (LITTLE OR NO FINES) | | GW | Well-graded gravels, gravel sand mixtures, little or no fines. |
| | | | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. |
| | | GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | GM | Silty gravels, gravel-sand-silt mixtures. |
| | | | | GC | Clayey gravels, gravel-sand-clay mixtures. |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS (LITTLE OR NO FINES) | | SW | Well-graded sands, gravelly sands, little or no fines. |
| | | | | SP | Poorly graded sands, gravelly sands, little or no fines. |
| | | SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES) | | SM | Silty sands, sand-silt mixtures. |
| | | | | SC | Clayey sands, sand-clay mixures. |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. |
| | | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. |
| | | | | OL | Organic silts and organic silty clays of low plasticity. |
| | SILTS AND CLAYS | LIQUID LIMIT GREATER THAN 50 | | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. |
| | | | | CH | Inorganic clays of high plasticity, fat clays. |
| | | | | OH | Organic clays of medium to high plasticity, organic silts. |
| HIGHLY ORGANIC SOILS | | | | PT | Peat and other highly organic soils. |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

### Notes

***See Soil Boring Information Special Provision.***

SPT (Standard Penetration Test-ASTM D1586):
The number of blows of a 140 lb (63.6 kg) hammer falling 2.5 ft (750 mm) used to drive a 2 in (50 mm) O.D. Split Spoon sampler for a total of 1.5 ft (0.45 m) of penetration.
Written as follows:
first 0.5 ft (0.15 m) - second 0.5 ft (0.15 m) - third 0.5 ft (0.15 m) (ex: 1-3-9)
Note: if the number of blows exceeds 50 before 0.5 ft (0.15 m) of penetration is achieved, the actual penetration rounded to the nearest 0.1 ft (0.03 m) follows the number of blows in parentheses (ex: 12-24-50 (0.09 m), 34-50 (0.4 ft), or 100 (0.3 ft)).WR denotes a zero blow count with the weight of the rods only.
WH denotes a zero blow count with the weight of the rods plus the weight of the hammer.

MC=Moisture Content, LL=Liquid limit, PL=Plastic Limit
-200%=percent soil passing 200 sieve, DD=Dry Density

**Soil Classifications are Based on the Unified Soil Classification System, ASTM D2487 and D2488. Also included are the AASHTO group classifications (M145). Descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

### Order of Descriptors

- Group Name
- Consistency or Relative Density
- Moisture Condition
- Color
- Particle size descriptor(s) (coarse grained soils only)
- Angularity of coarse grained soils
- Other relevant notes

### Criteria For Descriptors

***Consistency of Fine Grained Soils***

| Consistency | N-Value (uncorrected) |
|---|---|
| Very Soft | < 2 |
| Soft | 2 - 4 |
| Medium Stiff | 5 - 8 |
| Stiff | 9 - 15 |
| Very Stiff | 16 - 30 |
| Hard | > 30 |

***Apparent Density of Coarse Grained Soils***

| Relative Density | N-Value (uncorrected) |
|---|---|
| Very Loose | < 4 |
| Loose | 4 - 10 |
| Medium Dense | 11 - 30 |
| Dense | 31 - 50 |
| Very Dense | > 50 |

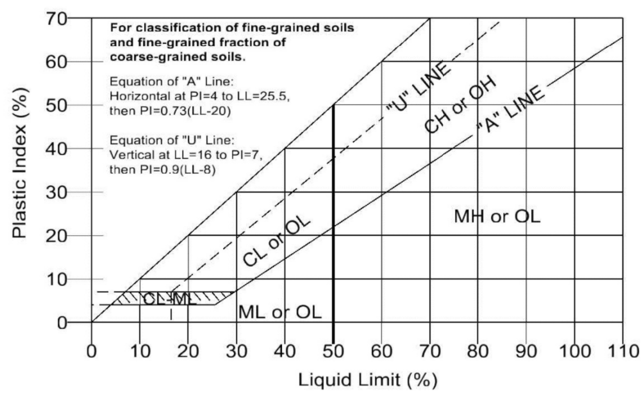
***Moisture Condition***

| | |
|---|---|
| Dry | -Absence of moisture, dusty, dry to the touch. |
| Moist | -Damp, but no visible water. |
| Wet | -Visible free water. |

***Definition of Particle Size Ranges***

| Soil Component | Size Range |
|---|---|
| Boulder | > 12 in (300 mm) |
| Cobble | 3 in (75 mm) - 12 in (300 mm) |
| Gravel | No. 4 Sieve (4.75 mm) to 3 in (75 mm) |
| Sand | No. 200 (0.075 mm) to No. 4 Sieves (4.75 mm) |
| Silt | < No. 200 Sieve (0.075 mm)* |
| Clay | < No. 200 Sieve (0.075 mm)* |

*Atterberg limits and chart below to differentiate between silt and clay.




***Angularity of Coarse-Grained Particles***

| | |
|---|---|
| Angular | -Particles have sharp edges and relative plane sides with unpolished surfaces. |
| Subangular | -Particles are similar to angular description, but have rounded edges. |
| Subrounded | -Particles have nearly plane sides, but have no edges. |
| Rounded | -Particles have smoothly curved sides and well-rounded corners and edges. |

Example soil description: Sandy FAT CLAY (CH), soft, wet, brown. (A-7)

TETRA TECH

# Tetra Tech Boring Log Descriptive Terminology
# Key to Rock Symbols and Terms

| Rock Type | Symbol | Rock Type | Symbol | Rock Type | Symbol |
|---|---|---|---|---|---|
| Argillite | | Dolomite | | Quartzite | |
| Basalt | | Gneiss | | Rhyolite | |
| Bedrock (other) | | Granitic | | Sandstone | |
| Breccia | | Limestone | | Schist | |
| Claystone | | Siltstone | | Shale | |
| | | Conglomerate | | | |

Order of Descriptors

- Rock Type
- Color
- Grain size (if applicable)
- Stratification/Foliation (as applicable)
- Field Hardness
- Other relevant notes

Criteria For Descriptors

*Grain Size*

| Description | Characteristic |
|---|---|
| Coarse Grained | -Individual grains can be easily distinguished by eye |
| Fine Grained | -Individual grains can be distinguished with difficulty |

*Stratum Thickness*

| | |
|---|---|
| Thickly Bedded | 3-10 ft (1-3 m) |
| Medium Bedded | 1-3 ft (300 mm - 1 m) |
| Thinly Bedded | 2-12 in (50-300 mm) |
| Very Thinly Bedded | < 2 in (50 mm) |

*Rock Field Hardness*

| | |
|---|---|
| Very Soft | -Can be carved with knife. Can be excavated readily with point of rock hammer. Can be scratched readily by fingernail. |
| Soft | -Can be grooved or gouged readily by knife or point of rock hammer. Can be excavated in fragments from chips to several inches in size by moderate blows of the point of a rock hammer. |
| Medium | -Can be grooved or gouged 0.05 in (2 mm) deep by firm pressure of knife or rock hammer point. Can be excavated in small chips to pieces about 1 in (25 mm) maximum size by hard blows of the point of a rock hammer. |
| Moderately hard | -Can be scratched with knife or pick. Gouges or grooves to 0.25 in (6 mm) can be excavated by hard blow of rock hammer. Hand specimen can be detached by moderate blows. |
| Hard | -Can be scratched with knife or pick only with difficulty. Hard hammer blows required to detach hand specimen. |
| Very Hard | -Cannot be scratched with knife or sharp rock hammer point. Breaking of hand specimens requires several hard blows of a rock hammer. |

Notes:

UCS = Unconfined Compressive Strength obtained from laboratory testing at the given depth.

***See Soil Boring Information Special Provision.***

# Miscellaneous Soil/Rock Symbols and Terms

- Concrete
- Asphalt
- Water
- Boulders and Cobbles
- Coal
- Fill
- Millings
- Topsoil

**Explanation of Text Fields in Boring Logs:**

Material Description: Lithologic Description of soil or rock encountered.

Remarks: Comments on drilling, including method, bit type, and problems encountered.

Unless stated on logs as being surveyed by district survey, all locations are considered approximate.

**General Notes**

- Descriptions on these boring logs apply only at the specific boring, and at the time the time the borings were made. These logs are not warranted to be representative of subsurface conditions at other locations or times.
- Water level observations apply only at the specific boring, and at the time the borings were made. Due to the variability of groundwater measurements given the type of drilling used, and the stratification of the soil in the boring, these logs are not warranted to be representative of groundwater conditions at other locations or times.
- Other terms may be used as descriptors, as defined by the profession.

Operation Types: Auger; Casing Advancer; Core Barrel; Drive Casing

Sample Types: Split Spoon; Shelby; Bulk Sample; Grab Sample; Cone Penetrometer; Vane Shear; Special Samplers; Testpit

**-Soil and Rock descriptions are based on visual observation, except where they have been modified to reflect results of laboratory tests as deemed appropriate.**

*Example Rock Log*

*SANDSTONE, gray, fine grained, thickly bedded, hard field hardness.*

**TETRA TECH**

# CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487 – 83

*(Based on Unified Soil Classification System)*

| MAJOR DIVISIONS | | | | GROUP SYMBOL | GROUP NAME |
|---|---|---|---|---|---|
| Coarse-Grained Soils More than 50% retained on No. 200 sieve | Gravels More than 50% coarse fraction retained on No. 4 sieve | Clean Gravels Less than 5% fines | $C_u \geq 4$ and $1 \leq C_c \leq 3$[E] | GW | Well graded gravel [F] |
| | | | $C_u < 4$ and/or $1 > C_c > 3$[E] | GP | Poorly graded gravel [F] |
| | | Gravels with Fines More than 12% fines | Fines classify as ML or MH | GM | Silty gravel [F G H] |
| | | | Fines classify as CL or CH | GC | Clayey gravel [F G H] |
| | Sands 50% or more of coarse faction passes No. 4 sieve | Clean Sands Less than 5% fines | $C_u \geq 6$ and $1 \leq C_c \leq 3$[E] | SW | Well-graded sand [I] |
| | | | $C_u < 6$ and/or $1 > C_c > 3$[E] | SP | Poorly graded sand [I] |
| | | Sands with Fines More than 12% fines | Fines classify as ML or MH | SM | Silty Sand [G H I] |
| | | | Fines classify as CL or CH | SC | Clayey sand [G H I] |
| Fine-Grained Soils 50% or more passes the No. 200 sieve | Silts and Clays Liquid limit less than 50 | Inorganic | PI > 7 and plots on or above "A" line | CL | Lean clay [K L M] |
| | | | PI < 4 or plots below "A" line | ML | Silt [K L M] |
| | | Organic | $\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$ | OL | Organic clay [K L M N]<br>Organic silt [K L M O] |
| | Silts and Clays Liquid limit 50 or more | Inorganic | PI plots on or above "A" line | CH | Fat clay [K L M] |
| | | | PI plots below "A" line | MH | Elastic silt [K L M] |
| | | Organic | $\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$ | OH | Organic clay [K L M O]<br>Organic silt [K L M O] |
| Highly organic soils | Primarily organic matter, dark in color, and organic odor | | | PT | Peat |

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $C_u = D_{60}/D_{10}$ $C_c = (D_{30})^2 / (D_{10} \times D_{90})$

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name. If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K]. If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If solid contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

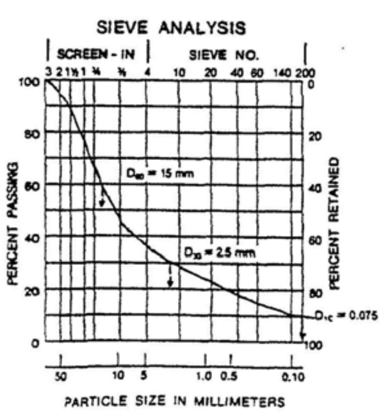
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

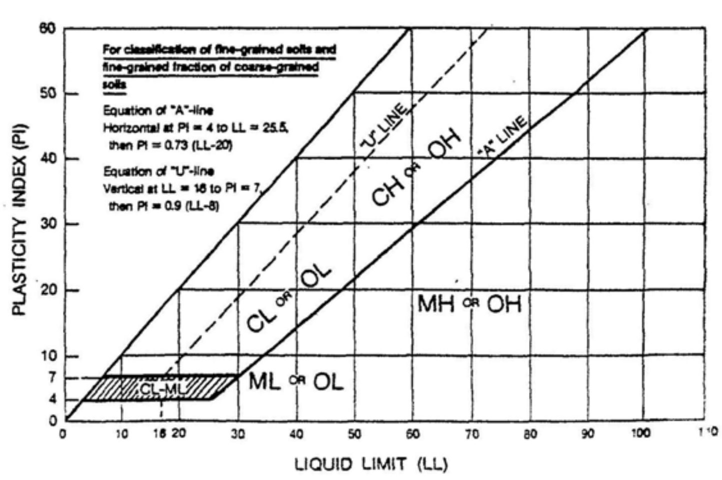
[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A: line.

[P] PI plots on or above "A: line.

[Q] PI plots below "A: line.




$C_u = \frac{D_{50}}{D_{1e}} = \frac{15}{0.075} = 200 \quad C_c = \frac{(D_{30})2}{D_{12} \times 10_{36}} + \frac{(2.5)\text{-}}{0.075 \times 15} = 5.6$


LEGEND

● SOIL BORING LOCATIONS

NOTES:

BASIS OF BEARING:

THE BASIS OF BEARINGS FOR THIS PROJECT IS GRID NORTH AS DEFINED
BY THE NEVADA COORDINATE SYSTEM OF 1983 (NCS83), EAST ZONE, (2701), CORS2011 (EPOCH 20010.00).

BENCHMARK:

CITY OF HENDERSON BENCHMARK No.632 (REVISION DATE 2004)

2" ALUMINUM CAP IN THE TOP OF CURB AT THE NORTHEAST CORNER OF OLSON STREET AND CALICO RIDGE DRIVE.

ELEVATION = 482.948m (NAVD'88)
= 1984.47 ft (NAVD'88)

TETRA TECH
www.tetratech.com
1489 West Warm Springs Road, Suite 110
Henderson, NV 89014
Phone: 702.946.6700 Fax: 702.997.7140

| MARK | DATE | DESCRIPTION | BY |
|---|---|---|---|
| A | 02/14/17 | ISSUED FOR REVIEW | SEF |

NEVADA ENVIRONMENTAL RESPONSE TRUST
HENDERSON, NEVADA

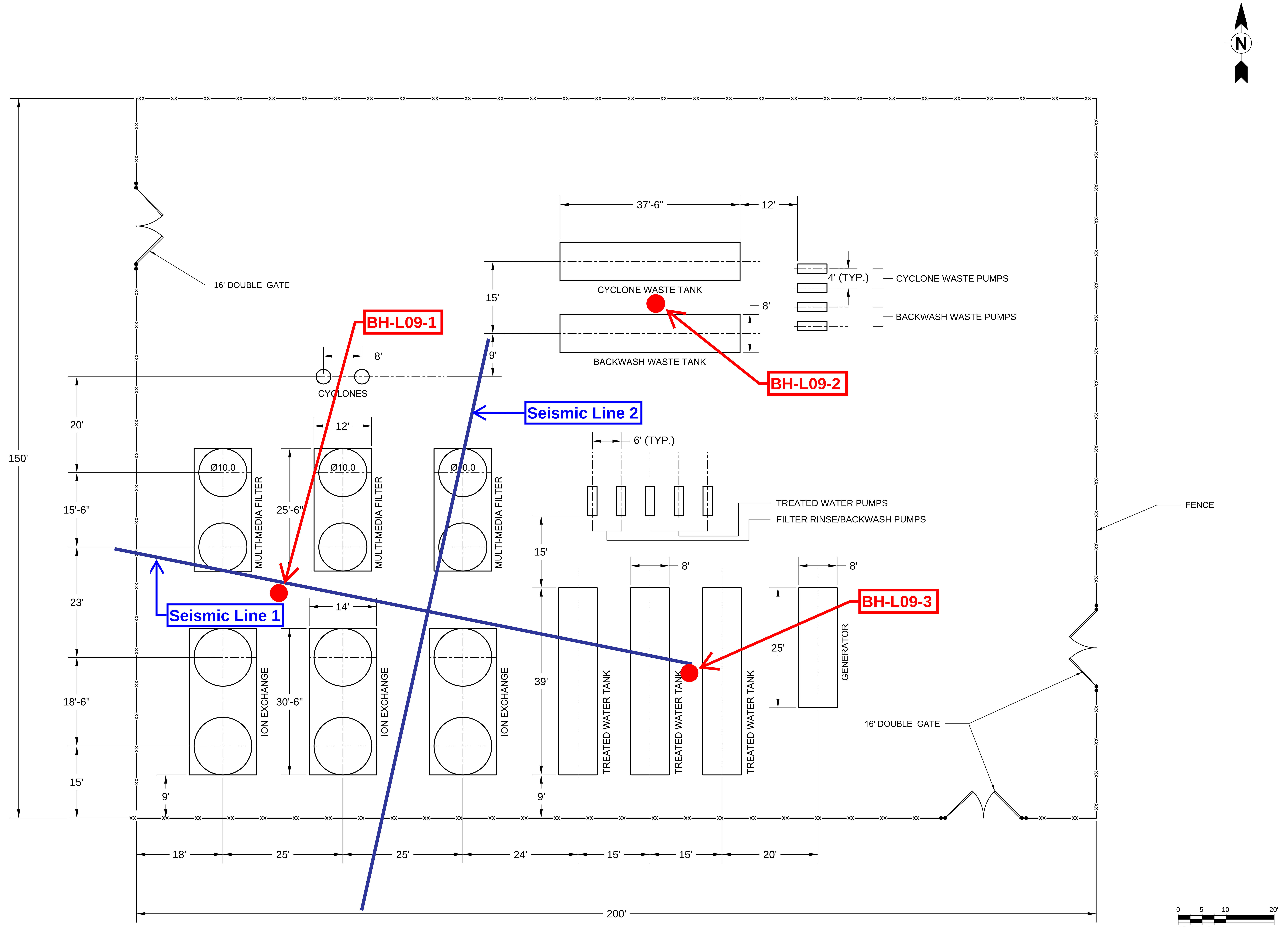
WIER DEWATERING TREATMENT

# LOCATION OF EXPLORATORY BORINGS

Project No.: 114-571148X
Designed By: R. DOMBROUSKI
Drawn By: S. FIELD
Checked By: R. DOMBROUSKI

GEOTECH DRAWING

C-101




DRAFT - FOR INTERNAL REVIEW ONLY

TETRA TECH
www.tetratech.com
1489 West Warm Springs Road, Suite 110
Henderson, NV 89014
Phone: 702.946.6700 Fax: 702.997.7140

| MARK | DATE | DESCRIPTION | BY |
|---|---|---|---|
| 1 | 10/14/16 | ISSUED FOR 30% SUBMITTAL | CG |

NEVADA ENVIRONMENTAL RESPONSE TRUST
HENDERSON, NEVADA

WEIR DEWATERING TREATMENT
CENTRAL WATER TREATMENT PLANT
GENERAL ARRANGEMENT

| | |
|---|---|
| Project No.: | 200-01299-16015 |
| Designed By: | JG |
| Drawn By: | CG |
| Checked By: | JG |

C-401



10/19/2016 11:02:47 AM - P:\IER\01299\200-01299-16015\CAD\SHEETFILES\C-401 - PLANT LAYOUT.DWG - GULMIRE, CALEB

2525 Palmer St, Suite 2
Missoula, Montana 59808
Phone: 406.543.3045
Fax: 406.543.3088

Figure No. 1

# LOG OF BORING

**Boring BH-L09-1**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** NERT - Central Water Treatment Plant | **Rig:** Diedrich D-50<br>**Hammer:** Auto | **Boring Location Coordinates** N: 36.08545 E: 114.98782 | |
| **Project Number:** 114-571131 | **Boring Diameter:** 8" | **System:** Local Coordinates<br>**Datum:** NAD83 | **Top of Boring Elevation:** 1547.5 ft |
| **Date Started:** 10/26/16 | **Date Finished:** 10/26/16 | **Drilling Fluid:** None | **Abandonment Method:** Bentonite |
| **Driller:** Eagle Drilling<br>**Logger:** Jim Maus | | **Location:** See Site Plan. Multimedia Filter | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 80 | | 9 - 10 - 12 | | Poorly-Graded SAND with silt (SP-SM), medium dense, dry to moist, brown, fine grained, Gravel content increases with depth. | | 4 | NV | NP | 11 | | |
| 5 / 1542.5 | | | 80 | | 8 - 10 - 50 | | | | 7 | | | | | |
| | | | 100 | | 13 - 7 - 9 | | Poorly-Graded SAND with gravel (SP), medium dense, very moist, brown, fine to coarse grained. | 8.5 / 1539.0 | 23 | | | | | |
| 10 / 1537.5 | | | 100 | | 3 - 3 - 4 | | Lean CLAY with sand (ML), soft to stiff, very moist to wet, brown, fine grained. | 9.0 / 1538.5 | | | | | | |
| 15 / 1532.5 | | | 100 | | 2 - 2 - 2 | | | | | 16 | 7 | 84 | | |
| 20 / 1527.5 | | | 70 | | 4 - 6 - 9 | | | 21.5 / 1526.0 | | | | | | |

Boring Depth: 21.5 ft, *Elevation: 1526.0 ft*

| *Water Level Observations* | During Drilling: 10.0 ft *(1537.5 ft)* | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

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# Figure No. 2
# LOG OF BORING
**Boring BH-L09-2**

TETRA TECH



| | | | |
|---|---|---|---|
| **Project:** NERT - Central Water Treatment Plant | **Rig:** Diedrich D-50 **Hammer:** Auto | **Boring Location Coordinates** N: 36.0856 E: 114.98753 | |
| **Project Number:** 114-571131 | **Boring Diameter:** 8" | **System:** Local Coordinates **Datum:** NAD83 | **Top of Boring Elevation:** 1547.1 ft |
| **Date Started:** 10/26/16 **Date Finished:** 10/26/16 | **Drilling Fluid:** None | **Abandonment Method:** Bentonite | |
| **Driller:** Eagle Drilling **Logger:** Jim Maus | **Location:** See Site Plan. Cyclone Waste Tank | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 70 | | 4 - 8 - 8 | | Silty SAND with gravel (SM), medium dense, dry to moist, brown, fine to coarse grained, low plasticity. | | 6 | NV | NP | 25 | | |
| 5 / 1542.1 | | | 60 | | 6 - 6 - 6 | | Poorly-Graded SAND with silt and gravel (SP-SM), medium dense, very moist, brown, fine to coarse grained. | 5.0 / 1542.1 | 6 | | | | | |
| | | | 60 | | 7 - 7 - 12 | | | | 6 | | | | | |
| 10 / 1537.1 | | | 70 | | 9 - 8 - 7 | | | | 18 | | | | | |
| | | | | | | | Silty CLAY (CL-ML), stiff, moist to wet, brown, fine grained. | 11.5 / 1535.6 | | | | | | |
| 15 / 1532.1 | | | 100 | | 4 - 4 - 4 | | | | | 13 | 7 | 94 | | |
| 20 / 1527.1 | | | 100 | | 3 - 4 - 6 | | | 21.5 / 1525.6 | | | | | | |

Boring Depth: 21.5 ft, *Elevation: 1525.6 ft*

| ***Water Level Observations*** | During Drilling: 11.0 ft *(1536.1 ft)* | Remarks: |
|---|---|---|
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

TT LOG OF BORING - MDT_REVISED_2009+.GDT - 2/14/17 11:48 - N:\GEOTECH\REPORTS\REPORT 2016\NERT\NEVADA WASH TASK L09\CENTRAL TREATMENT PLANT DRILLING - OCTOBER 2016\LAB DATA\LOGS - TREATMENT PLANT.GPJ

2525 Palmer St, Suite 2
Missoula, Montana 59808
Phone: 406.543.3045
Fax: 406.543.3088

Figure No. 3

# LOG OF BORING

**Boring BH-L09-3**

TETRA TECH



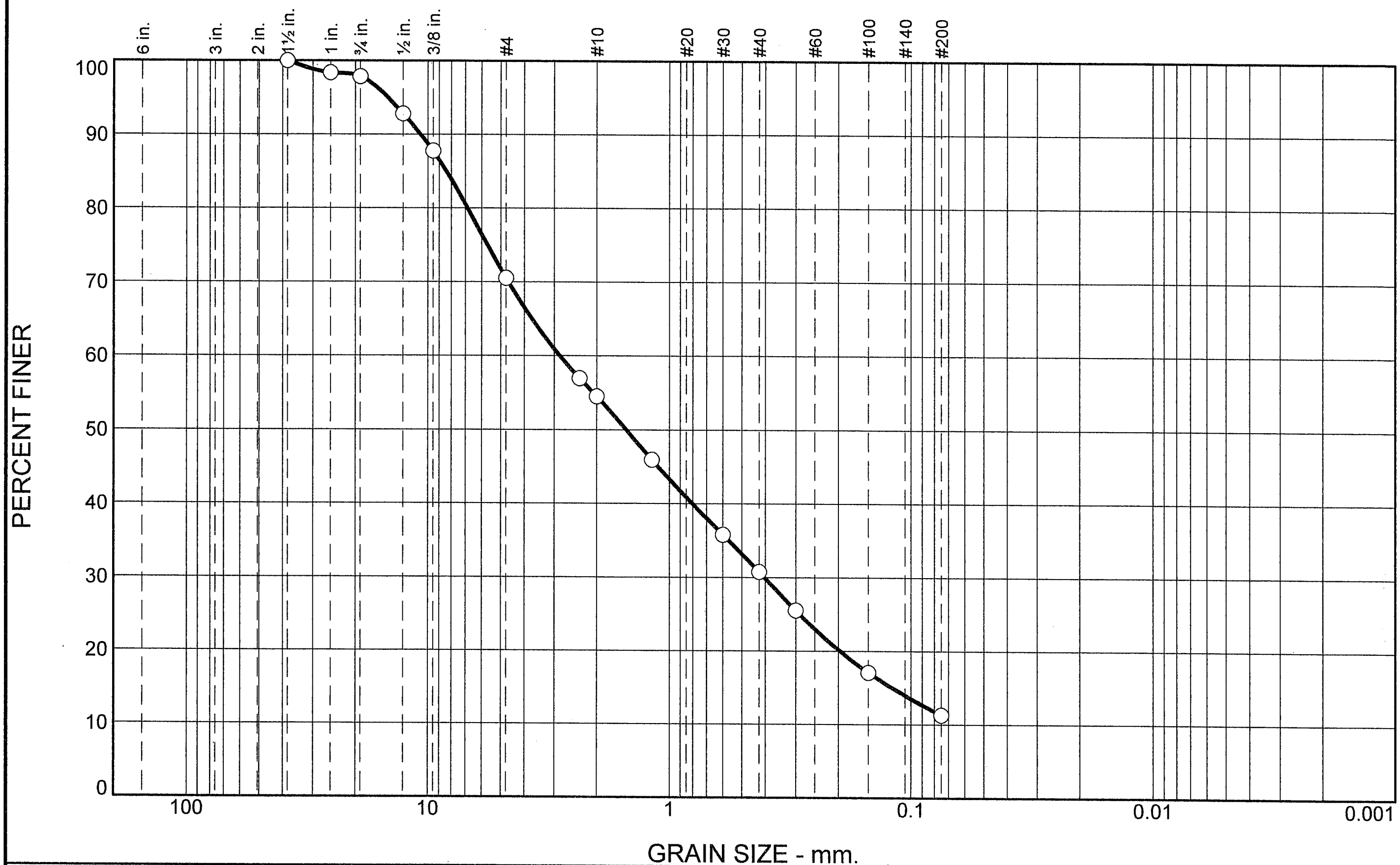
| | | | |
|---|---|---|---|
| **Project:** NERT - Central Water Treatment Plant | **Rig:** Diedrich D-50<br>**Hammer:** Auto | **Boring Location Coordinates** N: 36.08537 E: 114.98753 | |
| **Project Number:** 114-571131 | **Boring Diameter:** 8" | **System:** Local Coordinates<br>**Datum:** NAD83 | **Top of Boring Elevation:** 1547.7 ft |
| **Date Started:** 10/26/16 / **Date Finished:** 10/26/16 | **Drilling Fluid:** None | **Abandonment Method:** Bentonite | |
| **Driller:** Eagle Drilling<br>**Logger:** Jim Maus | **Location:** See Site Plan. Treated Water Tank | | |

| Depth (ft) / Elev. (ft) | Operation | Sample Type | Recovery (%) | RQD (%) | Blow Count | Lithology | Material Description | Depth (ft) / Elev. (ft) | MC (%) | LL | PL | -200 (%) | DD | Remarks and Other Tests |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | | | 60 | | 6 - 4 - 10 | | Silty SAND with gravel (SM), medium dense, dry to moist, brown, fine to coarse grained. | | 5 | NV | NP | 20 | | |
| 5 / 1542.7 | | | 70 | | 8 - 9 - 12 | | Poorly-Graded SAND with silt and gravel (SP-SM), medium dense to very dense, moist, brown, fine to coarse grained. | 5.0 / 1542.7 | 5 | | | | | |
| | | | | | | | | | 9 | | | | | |
| | | | 10 | | 50/0.5ft | | | | | | | | | |
| 10 / 1537.7 | | | | | | | Silty CLAY (CL-ML), stiff to very stiff, very moist to wet, brown, fine grained. | 10.0 / 1537.7 | | | | | | |
| 15 / 1532.7 | | | 100 | | 4 - 4 - 6 | | | | | | | | | |
| 20 / 1527.7 | | | 100 | | 6 - 8 - 17 | | | 21.5 / 1526.2 | | | | | | |

Boring Depth: 21.5 ft, *Elevation: 1526.2 ft*

| *Water Level Observations* | | Remarks: |
|---|---|---|
| | During Drilling: 10.0 ft *(1537.7 ft)* | |
| After Drilling: Not Recorded | After Drilling: Not Recorded | |

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0 | 2 | 28 | 15 | 24 | 20 | 11 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| 1.5 | 100 | | |
| 1 | 98 | | |
| .75 | 98 | | |
| .5 | 93 | | |
| .375 | 88 | | |
| #4 | 70 | | |
| #8 | 57 | | |
| #10 | 55 | | |
| #16 | 46 | | |
| #30 | 36 | | |
| #40 | 31 | | |
| #50 | 26 | | |
| #100 | 17 | | |
| #200 | 11 | | |

* (no specification provided)

**Soil Description**

Poorly graded sand with silt and gravel

**Atterberg Limits**

PL= NP LL= NV PI= NP

**Coefficients**

$D_{90}$= 10.7424 $D_{85}$= 8.3935 $D_{60}$= 2.8559
$D_{50}$= 1.5081 $D_{30}$= 0.4035 $D_{15}$= 0.1198
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= SP-SM AASHTO= A-1-b

**Remarks**

**Location:** BH-L-09-1 @ 0.0'-5.0'
**Sample Number:** BH-L-09-1 **Depth:** 0.0'-5.0' **Date:** 11/03/16

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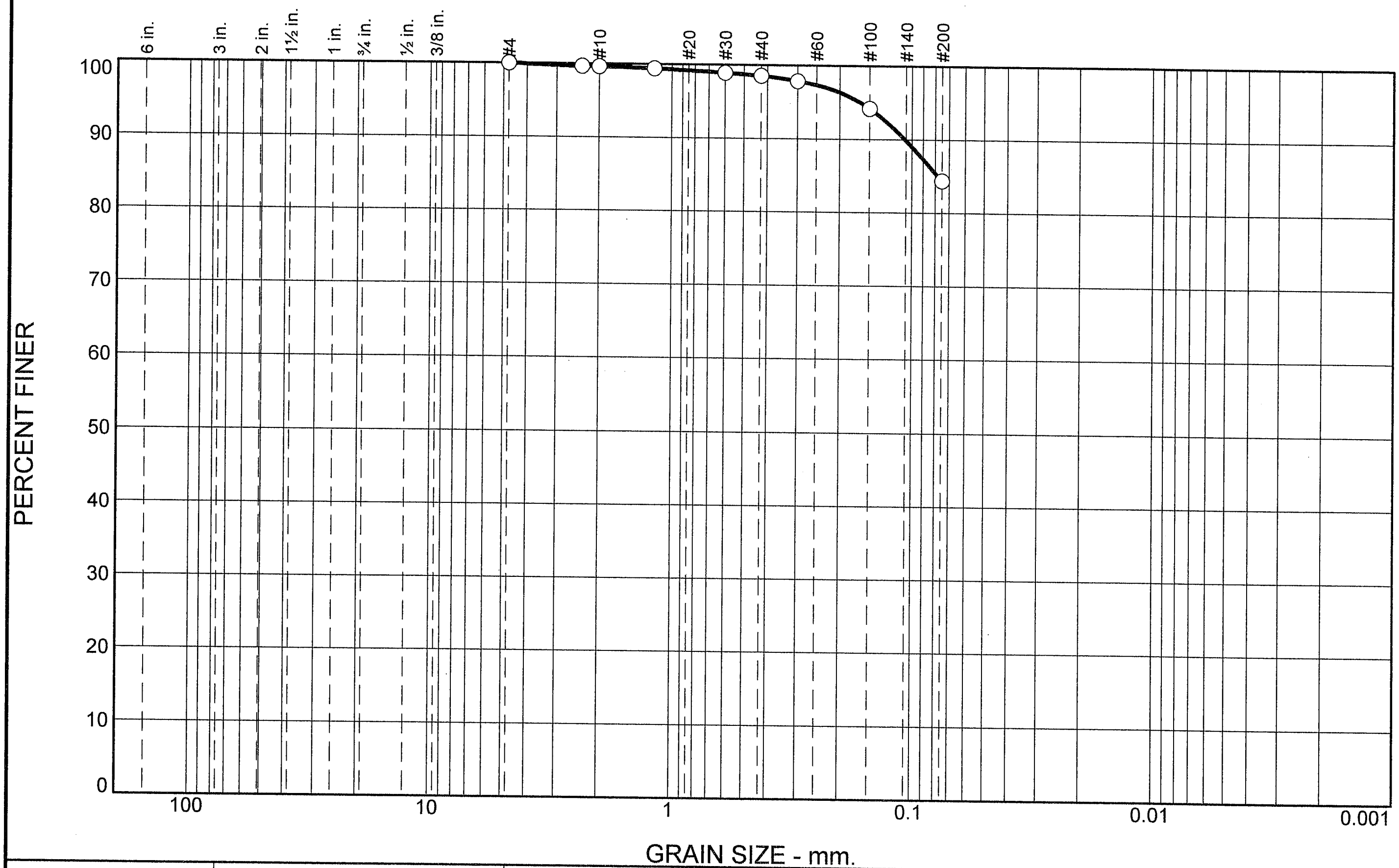
**Client:** TETRA TECH
**Project:** NERT - Central Treatment Plant
**Project No:** 2016 MISC **Figure** 4

**Tested By:** A. SANDERS

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0 | 0 | 0 | 0 | 1 | 15 | 84 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| #4 | 100 | | |
| #8 | 100 | | |
| #10 | 100 | | |
| #16 | 99 | | |
| #30 | 99 | | |
| #40 | 99 | | |
| #50 | 98 | | |
| #100 | 94 | | |
| #200 | 84 | | |

* (no specification provided)

**Soil Description**

Lean clay with sand

**Atterberg Limits**

PL= 7 LL= 15 PI= 8

**Coefficients**

$D_{90}$= 0.1071 $D_{85}$= 0.0778 $D_{60}$=
$D_{50}$= $D_{30}$= $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= CL AASHTO= A-4(2)

**Remarks**

**Location:** BH-L-09-1 @ 15.0'-16.5'
**Sample Number:** BH-L-09-1 **Depth:** 15.0'-16.5' **Date:** 11/03/16

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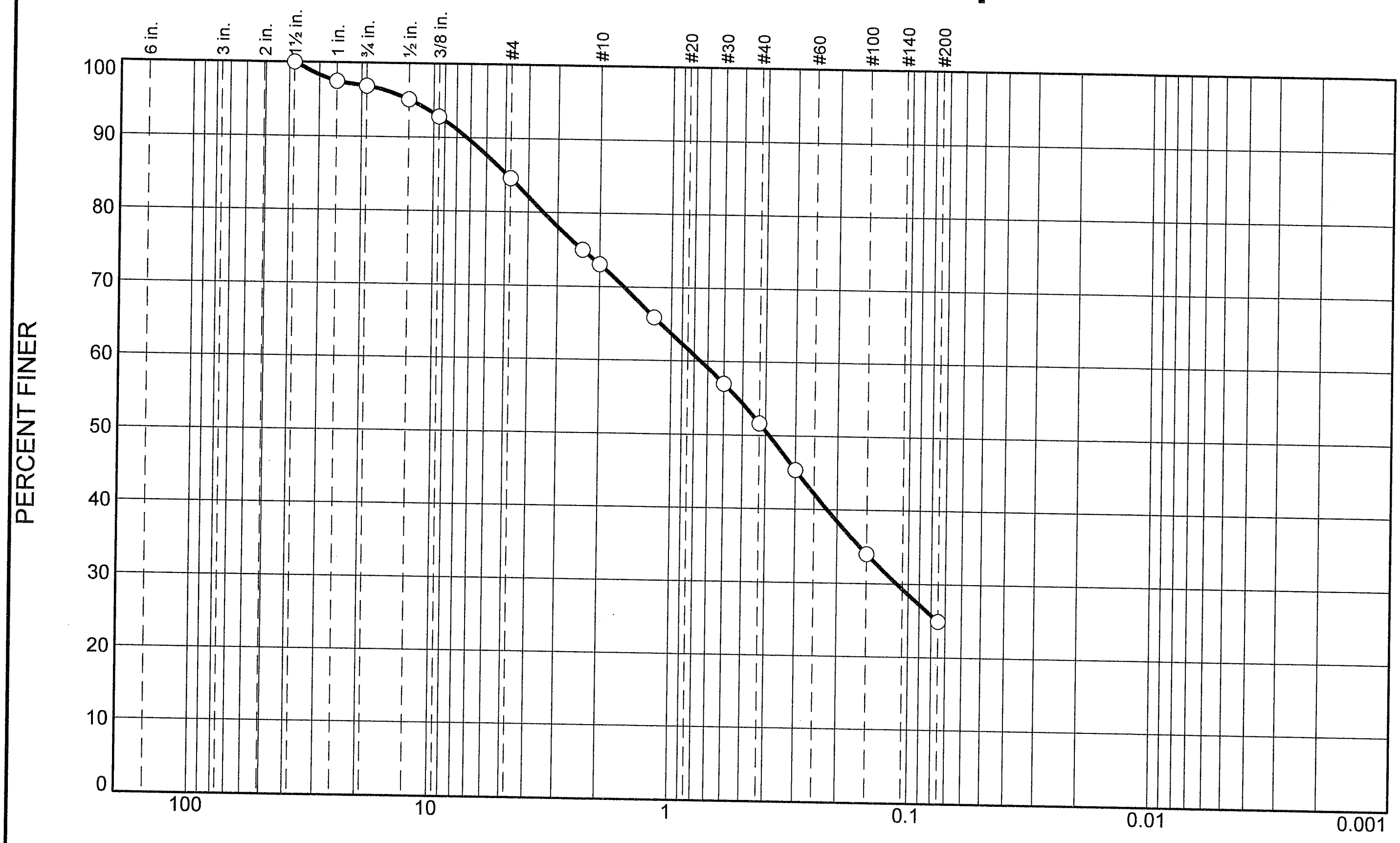
**Client:** TETRA TECH
**Project:** NERT - Central Treatment Plant
**Project No:** 2016 MISC **Figure** 5

**Tested By:** A.SANDERS

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0 | 3 | 12 | 12 | 21 | 27 | 25 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| 1.5 | 100 | | |
| 1 | 97 | | |
| .75 | 97 | | |
| .5 | 95 | | |
| .375 | 93 | | |
| #4 | 85 | | |
| #8 | 75 | | |
| #10 | 73 | | |
| #16 | 66 | | |
| #30 | 57 | | |
| #40 | 52 | | |
| #50 | 45 | | |
| #100 | 34 | | |
| #200 | 25 | | |

* (no specification provided)

**Soil Description**

Silty sand with gravel

**Atterberg Limits**

PL= NP  LL= NV  PI= NP

**Coefficients**

$D_{90}$= 7.2629  $D_{85}$= 4.9032  $D_{60}$= 0.7516
$D_{50}$= 0.3872  $D_{30}$= 0.1118  $D_{15}$=
$D_{10}$=  $C_u$=  $C_c$=

**Classification**

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

**Remarks**

**Location:** BH-L-09-2 @ 0.0'-5.0'
**Sample Number:** BH-L-09-2  **Depth:** 0.0'-5.0'  **Date:** 11/03/16

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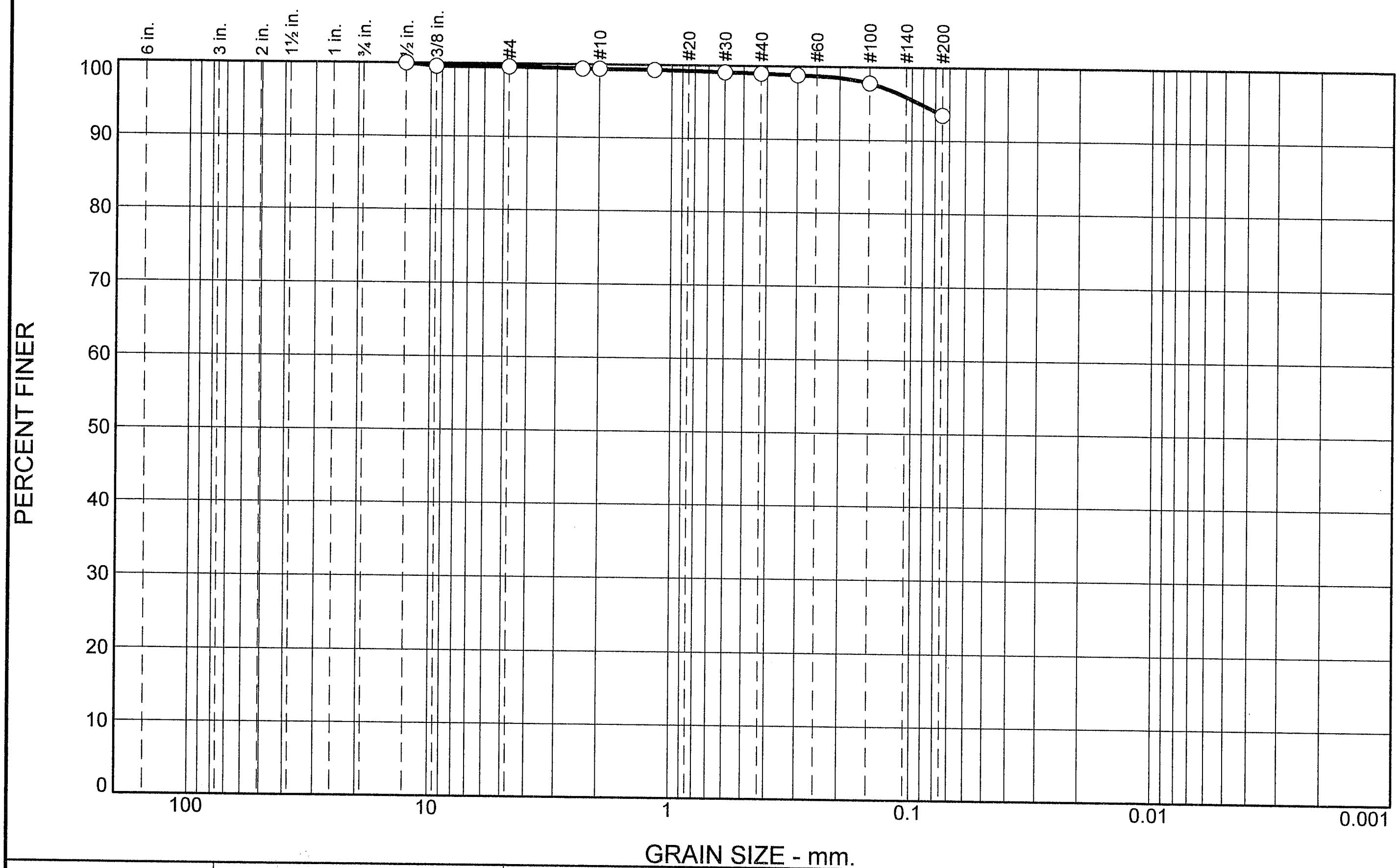
**Client:** TETRA TECH
**Project:** NERT - Central Treatment Plant
**Project No:** 2016 MISC  **Figure** 6

**Tested By:** A. SANDERS

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0 | 0 | 0 | 1 | 0 | 5 | 94 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| .5 | 100 | | |
| .375 | 100 | | |
| #4 | 100 | | |
| #8 | 99 | | |
| #10 | 99 | | |
| #16 | 99 | | |
| #30 | 99 | | |
| #40 | 99 | | |
| #50 | 99 | | |
| #100 | 98 | | |
| #200 | 94 | | |

* (no specification provided)

**Soil Description**

Silty clay

**Atterberg Limits**

PL= 7 LL= 13 PI= 6

**Coefficients**

$D_{90}$= $D_{85}$= $D_{60}$=
$D_{50}$= $D_{30}$= $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

USCS= CL-ML AASHTO= A-4(1)

**Remarks**

**Location:** BH-L-09-2 @ 15.0'-16.5'
**Sample Number:** BH-L-09-2 **Depth:** 15.0'-16.5' **Date:** 11/3/16

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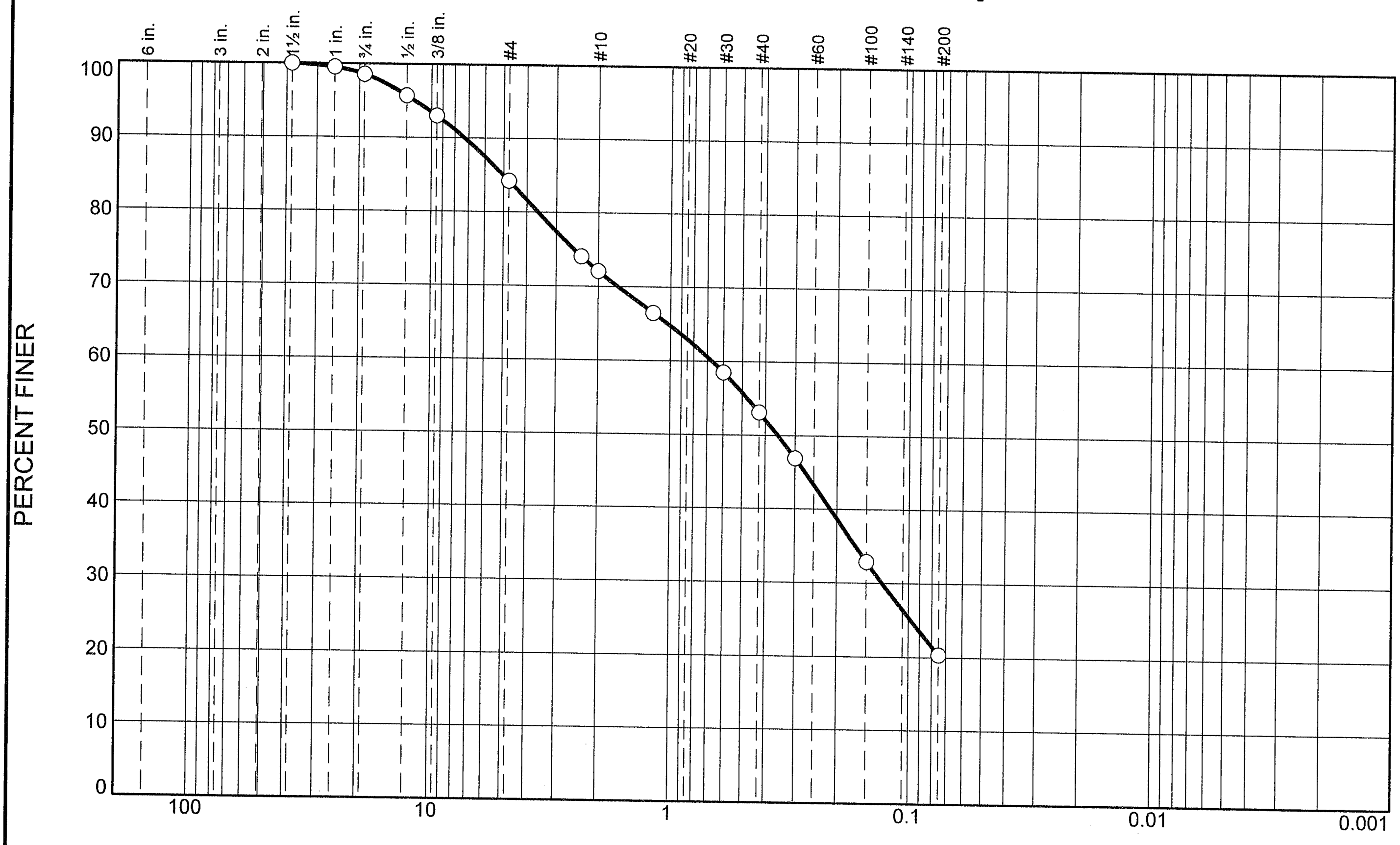
**Client:** TETRA TECH
**Project:** NERT - Central Treatment Plant
**Project No:** 2016 MISC **Figure** 7

**Tested By:** A. SANDERS

# Particle Size Distribution Report




| % +3" | % Gravel | | % Sand | | | % Fines | |
|---|---|---|---|---|---|---|---|
| | Coarse | Fine | Coarse | Medium | Fine | Silt | Clay |
| 0 | 1 | 15 | 12 | 19 | 33 | 20 | |

| SIEVE SIZE | PERCENT FINER | SPEC.* PERCENT | PASS? (X=NO) |
|---|---|---|---|
| 1.5 | 100 | | |
| 1 | 100 | | |
| .75 | 99 | | |
| .5 | 96 | | |
| .375 | 93 | | |
| #4 | 84 | | |
| #8 | 74 | | |
| #10 | 72 | | |
| #16 | 66 | | |
| #30 | 58 | | |
| #40 | 53 | | |
| #50 | 47 | | |
| #100 | 33 | | |
| #200 | 20 | | |

* (no specification provided)

**Soil Description**

Silty sand with gravel

**Atterberg Limits**

PL= NP LL= NV PI= NP

**Coefficients**

$D_{90}$= 7.3009 $D_{85}$= 5.0136 $D_{60}$= 0.6703
$D_{50}$= 0.3555 $D_{30}$= 0.1291 $D_{15}$=
$D_{10}$= $C_u$= $C_c$=

**Classification**

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

**Remarks**

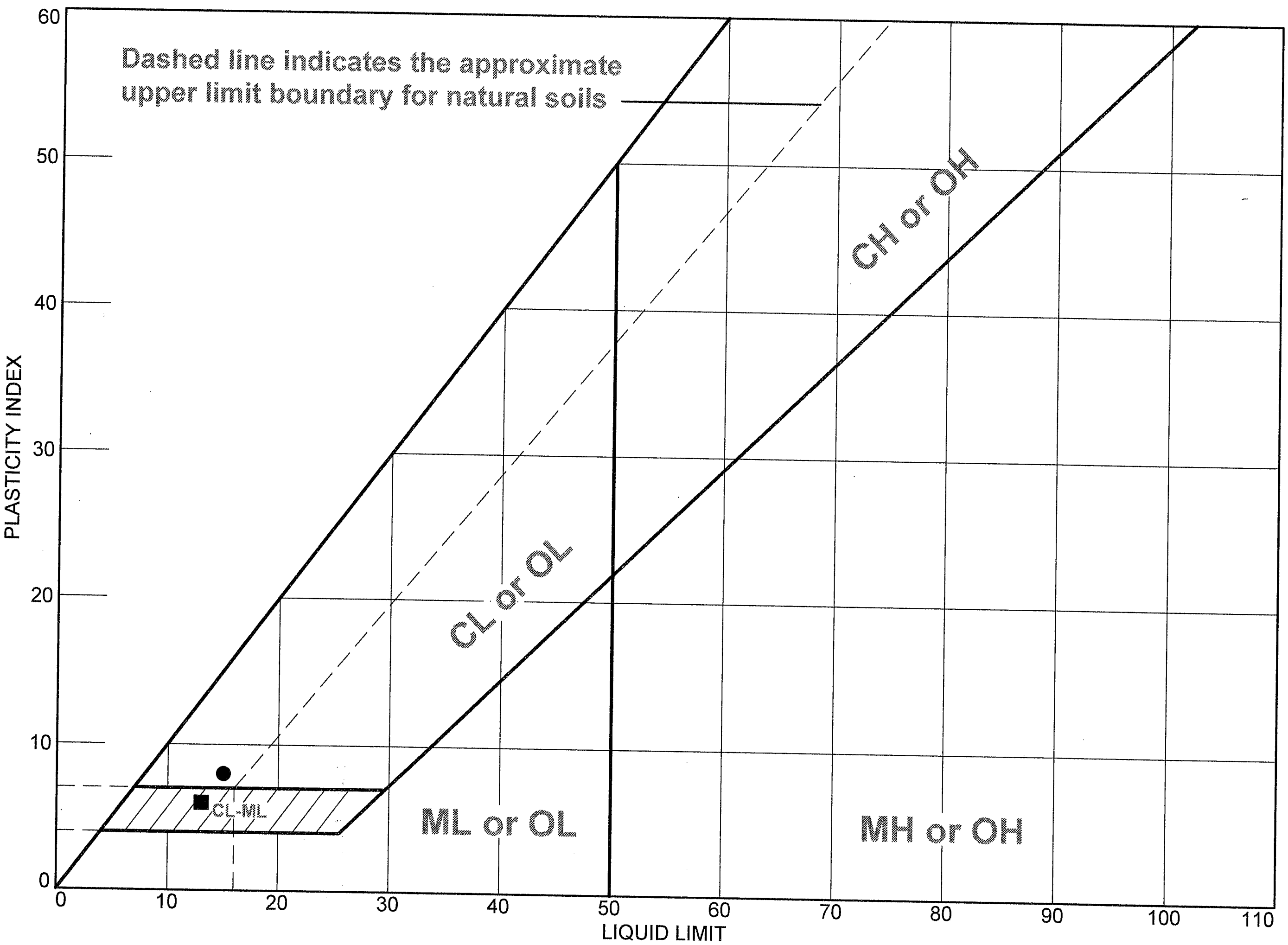
**Location:** BH-L-09-3 @ 0.0'-5.0'
**Sample Number:** BH-L-09-3 **Depth:** 0.0'-5.0' **Date:** 11/03/16

GES GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

**Client:** TETRA TECH
**Project:** NERT - Central Treatment Plant
**Project No:** 2016 MISC **Figure** 8

**Tested By:** A. SANDERS

# LIQUID AND PLASTIC LIMITS TEST REPORT




| | Material Description | Sampled | Tested | Technician | LL | PL | PI | %<#40 | USCS |
|---|---|---|---|---|---|---|---|---|---|
| ○ | Lean clay with sand | 11/03/16 | 11/2/16 | A. SANDERS | 15 | 7 | 8 | 99 | CL |
| □ | Silty clay | 11/3/16 | 11/2/16 | A. SANDERS | 13 | 7 | 6 | 99 | CL-ML |
| △ | Poorly graded sand with silt and gravel | 11/03/16 | 11/02/16 | A. SANDERS | NV | NP | NP | 31 | SP-SM |
| ◇ | Silty sand with gravel | 11/03/16 | | A.SANDERS | NV | NP | NP | 52 | SM |
| ▽ | Silty sand with gravel | 11/03/16 | | A.SANDERS | NV | NP | NP | 53 | SM |

**Project No.** 2016 MISC **Client:** TETRA TECH

**Project:** NERT - Central Treatment Plant

○ **Location:** BH-L-09-1 @ 15.0'-16.5' **Depth:** 15.0'-16.5' **Sample Number:** BH-L-09-1

□ **Location:** BH-L-09-2 @ 15.0'-16.5' **Depth:** 15.0'-16.5' **Sample Number:** BH-L-09-2

△ **Location:** BH-L-09-1 @ 0.0'-5.0' **Depth:** 0.0'-5.0' **Sample Number:** BH-L-09-1

◇ **Location:** BH-L-09-2 @ 0.0'-5.0' **Depth:** 0.0'-5.0' **Sample Number:** BH-L-09-2

▽ **Location:** BH-L-09-3 @ 0.0'-5.0' **Depth:** 0.0'-5.0' **Sample Number:** BH-L-09-3

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GES

**Checked by:**

**Title:**

**Figure** 9

**Tested By:** ○ A. SANDERS □ A. SANDERS △ A. SANDERS ◇ A.SANDERS ▽ A.SANDERS

# COMPACTION TEST REPORT

**Curve No.: BH-L-09-1**

**Project No.:** 2016 MISC **Date:** 11/03/16
**Project:** NERT - Central Treatment Plant
**Client:** TETRA TECH
**Location:** BH-L-09-1 @ 0.0'-5.0'
**Sample Number:** BH-L-09-1 **Depth:** 0.0'-5.0'
**Remarks:**

## MATERIAL DESCRIPTION

**Description:** Poorly graded sand with silt and gravel

**Classifications -** **USCS:** SP-SM **AASHTO:** A-1-b
**Nat. Moist. =** **Sp.G. =** 2.65
**Liquid Limit =** NV **Plasticity Index =** NP
**% < No.200 =** 11 %

| ROCK CORRECTED TEST RESULTS |
|---|
| Maximum dry density = 128.2 pcf |
| Optimum moisture = 11.2 % |

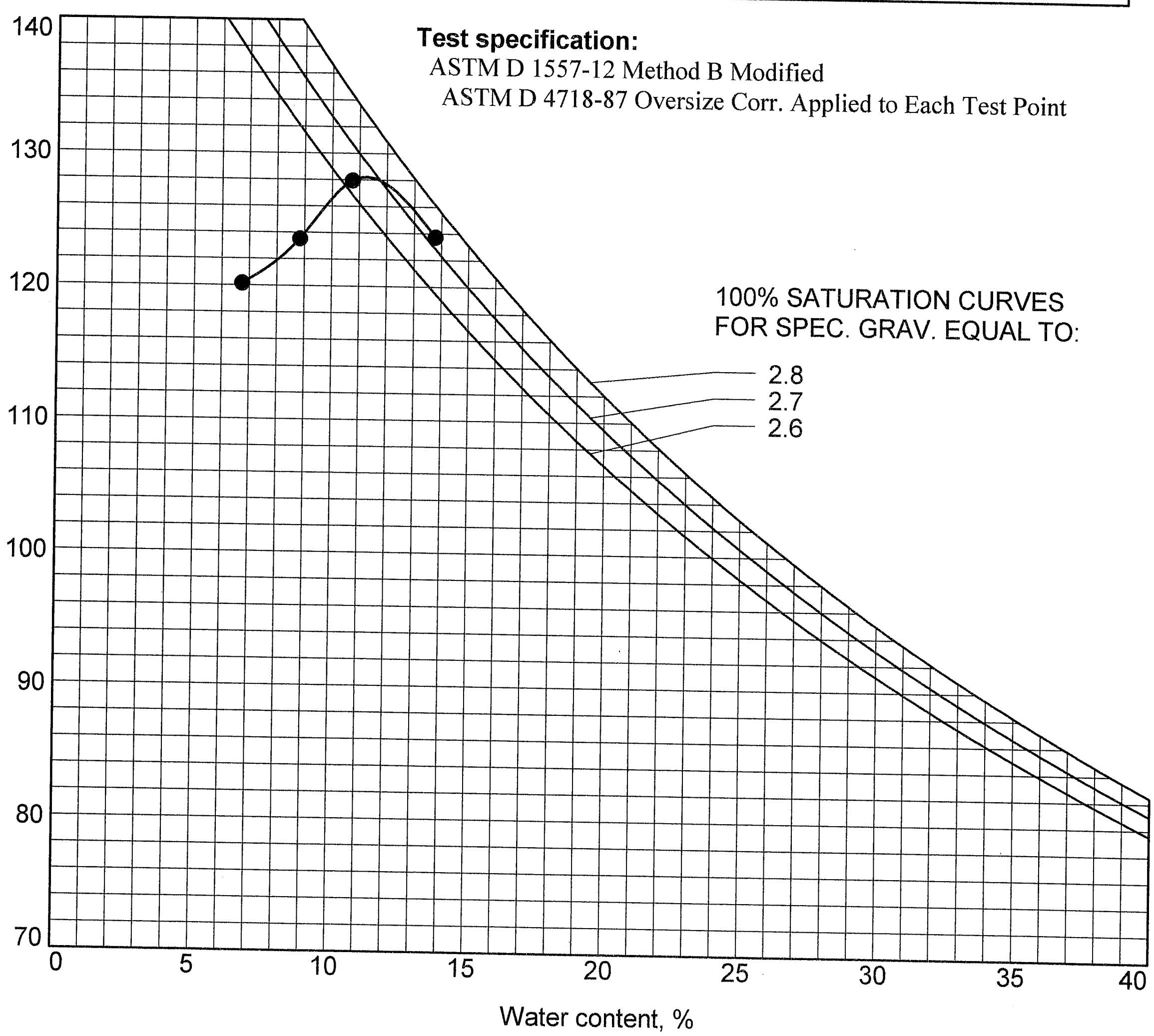



**Figure** 10

**GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.**

**Tested By:** K. KIMBLE

# COMPACTION TEST REPORT

**Curve No.:** BH-L-09-1

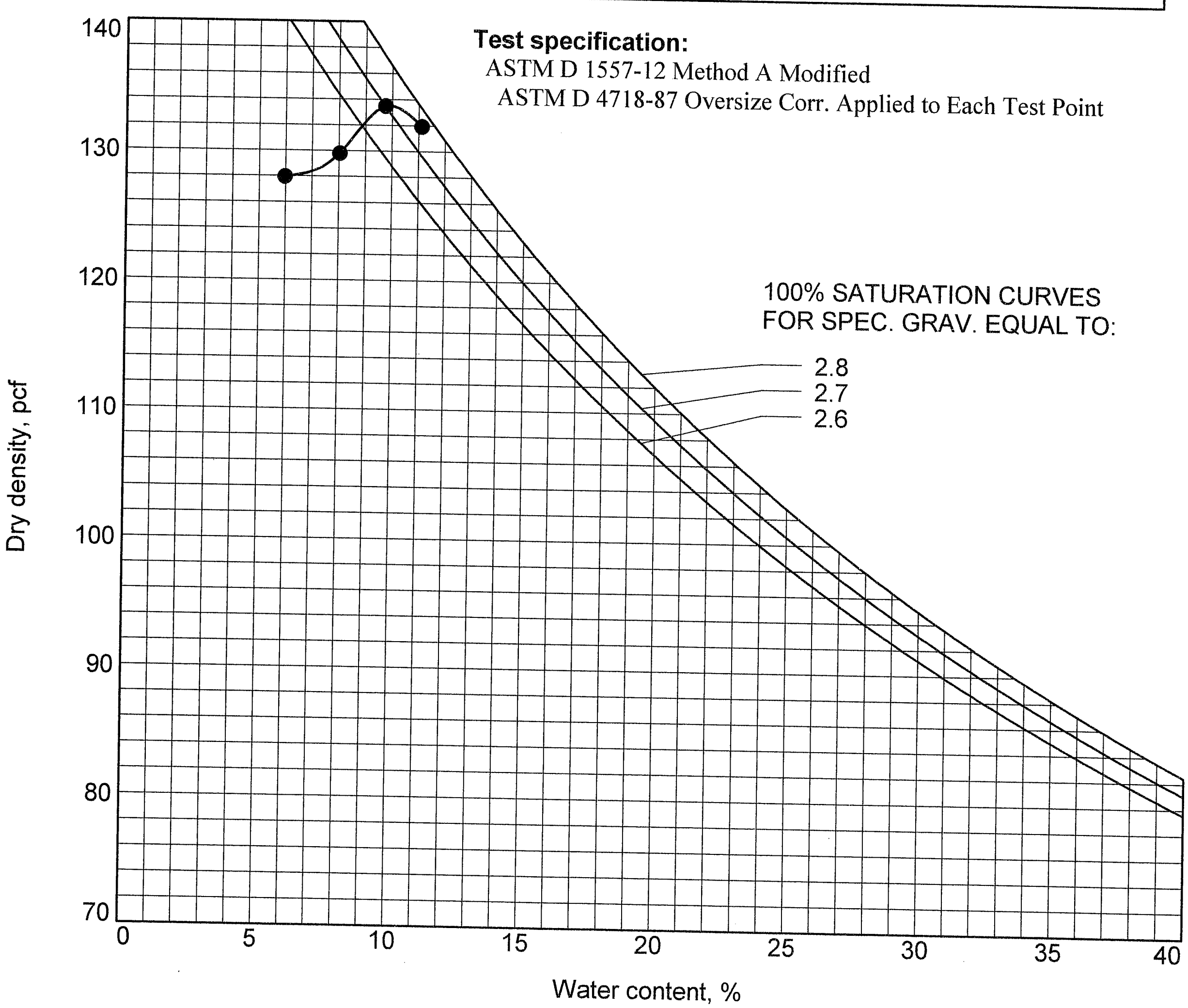
**Project No.:** 2016 MISC **Date:** 11/03/16
**Project:** NERT - Central Treatment Plant
**Client:** TETRA TECH
**Location:** BH-L-09-2 @ 0.0'-5.0'
**Sample Number:** BH-L-09-2 **Depth:** 0.0'-5.0'
**Remarks:**

## MATERIAL DESCRIPTION

**Description:** Silty sand with gravel

**Classifications -** **USCS:** SM **AASHTO:** A-2-4(0)
**Nat. Moist. =** **Sp.G. =** 2.65
**Liquid Limit =** NV **Plasticity Index =** NP
**% < No.200 =** 25 %

| ROCK CORRECTED TEST RESULTS |
|---|
| Maximum dry density = 133.5 pcf |
| Optimum moisture = 9.9 % |




**Test specification:**
ASTM D 1557-12 Method A Modified
ASTM D 4718-87 Oversize Corr. Applied to Each Test Point

**Figure** 11

GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.

**Tested By:** K. KIMBLE

# COMPACTION TEST REPORT

**Curve No.: BH-L-09-3**

**Project No.:** 2016 MISC

**Date:** 11/03/16

**Project:** NERT - Central Treatment Plant

**Client:** TETRA TECH

**Location:** BH-L-09-3 @ 0.0'-5.0'

**Sample Number:** BH-L-09-3 **Depth:** 0.0'-5.0'

**Remarks:**

## MATERIAL DESCRIPTION

**Description:** Silty sand with gravel

**Classifications -** **USCS:** SM **AASHTO:** A-2-4(0)

**Nat. Moist. =** **Sp.G. =** 2.65

**Liquid Limit =** NV **Plasticity Index =** NP

**% < No.200 =** 20 %

| ROCK CORRECTED TEST RESULTS |
|---|
| Maximum dry density = 126.5 pcf |
| Optimum moisture = 11.2 % |

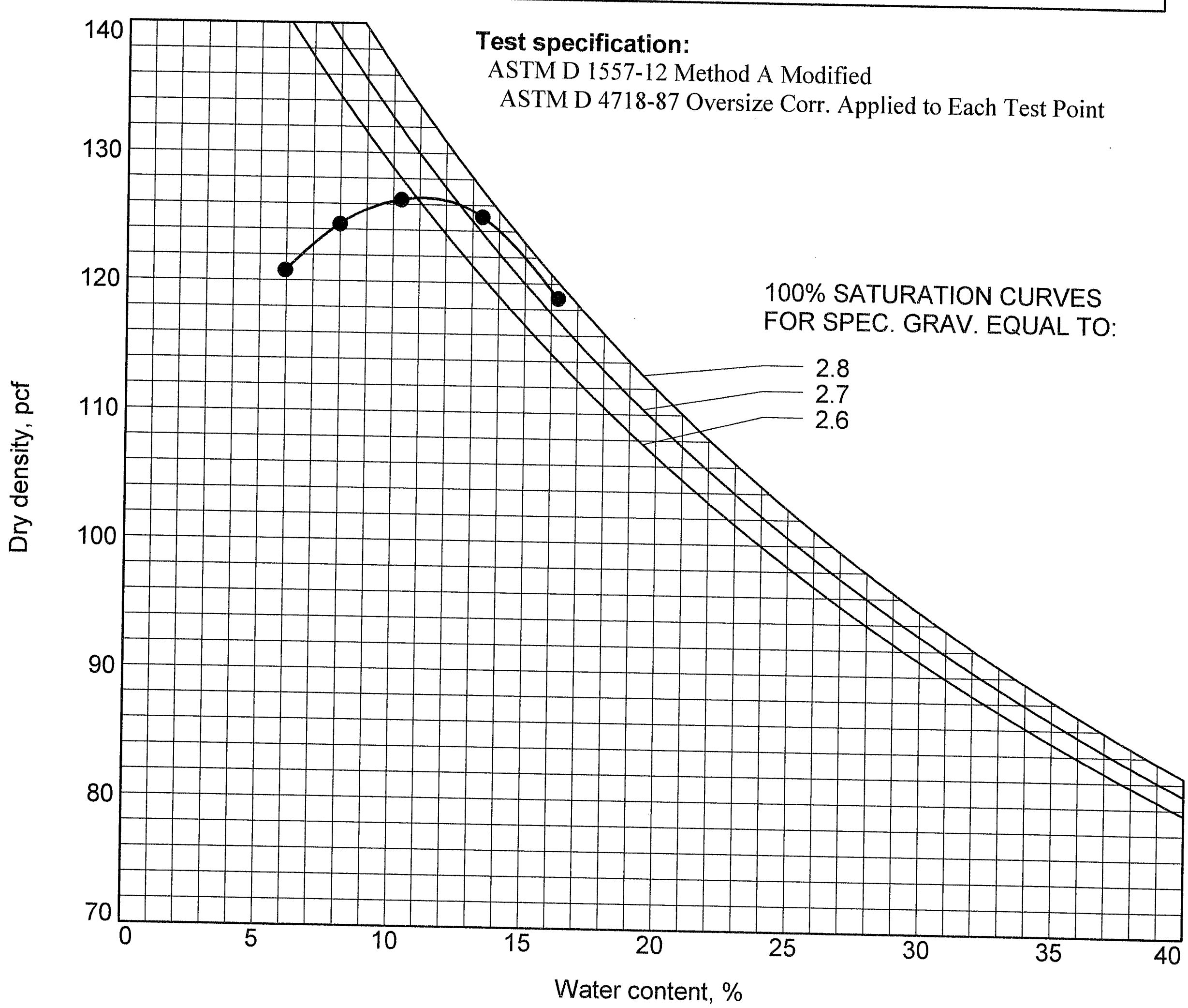



**Figure** 12

**GEOTECHNICAL & ENVIRONMENTAL SERVICES, INC.**

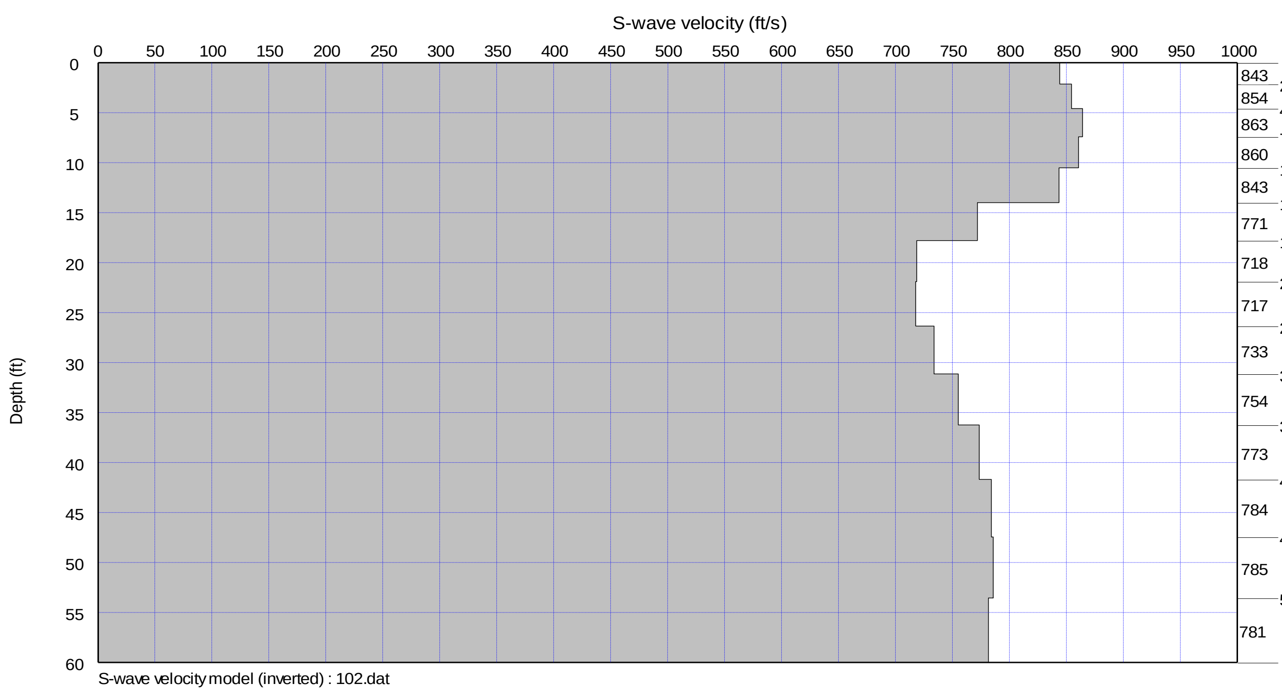
**Tested By:** K. KIMBLE

**MASW S and P Wave Seismic Testing**
**NERT L-09, Proposed Water Treatment Plant Site**
**Seismic Line 1**

## Summary Table of S and P Wave Data at Depth with Dynamic Modulus

| Depth (ft) | S-Wave Velocity (ft/sec) | P-Wave Velocity (ft/sec) | Density (pcf) | Poisson's Ratio $\sigma p=[(Vp/Vs)^2-2]/[2(Vp/Vs)^2-2]$ | Shear Modulus $G = dVs^2$ (psi) | Young's Modulus $E = 2G(1+\sigma p)$ | Bulk Modulus $K = 1/3(E/(1-2\sigma_p))$ |
|---|---|---|---|---|---|---|---|
| 0.00 | 844 | 5180 | 113 | 0.49 | 17365 | 51622 | 631134 |
| 2.14 | 855 | 5189 | 113 | 0.49 | 17802 | 52910 | 632797 |
| 4.62 | 864 | 5197 | 113 | 0.49 | 18195 | 54068 | 634203 |
| 7.42 | 860 | 5192 | 113 | 0.49 | 18046 | 53629 | 633246 |
| 10.55 | 843 | 5175 | 113 | 0.49 | 17345 | 51561 | 629836 |
| 14.01 | 772 | 5097 | 113 | 0.49 | 14475 | 43086 | 612267 |
| 17.80 | 719 | 5038 | 112 | 0.49 | 12525 | 37314 | 598742 |
| 21.92 | 717 | 5032 | 112 | 0.49 | 12480 | 37182 | 597168 |
| 26.37 | 734 | 5042 | 112 | 0.49 | 13048 | 38861 | 598882 |
| 31.15 | 755 | 5057 | 112 | 0.49 | 13819 | 41142 | 601627 |
| 36.26 | 773 | 5071 | 112 | 0.49 | 14503 | 43163 | 604200 |
| 41.70 | 784 | 5080 | 112 | 0.49 | 14905 | 44351 | 605837 |
| 47.47 | 786 | 5082 | 112 | 0.49 | 14966 | 44531 | 606225 |
| 53.57 | 781 | 5079 | 112 | 0.49 | 14801 | 44043 | 605773 |
| 72.86 | 888 | 5201 | 113 | 0.48 | 19246 | 57159 | 633726 |

## One-Dimensional MASW Analysis

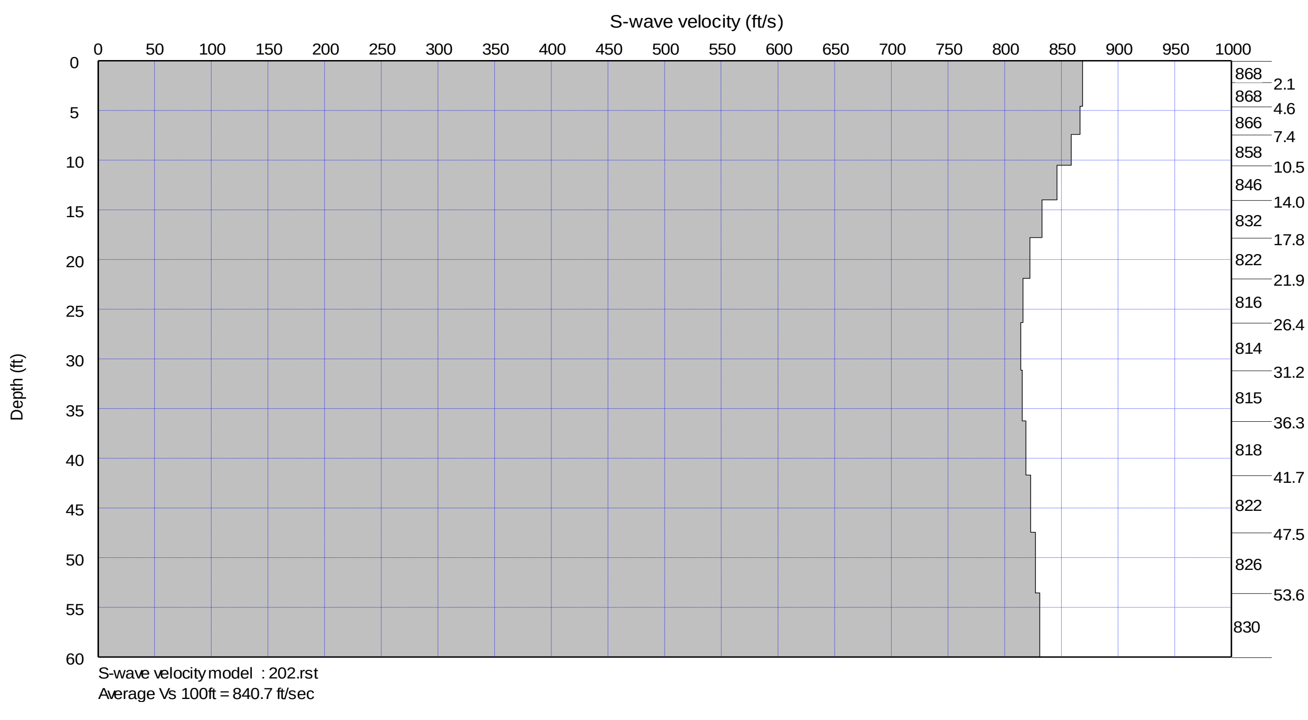


**MASW S and P Wave Seismic Testing**
**NERT L-09, Proposed Water Treatment Plant Site**
**Seismic Line 2**

## Summary Table of S and P Wave Data at Depth with Dynamic Modulus

| Depth (ft) | S-Wave Velocity (ft/sec) | P-Wave Velocity (ft/sec) | Density (pcf) | Poisson's Ratio $\sigma p=[(Vp/Vs)^2-2]/[2(Vp/Vs)^2-2]$ | Shear Modulus $G = dVs^2$ (psi) | Young's Modulus $E = 2G(1+\sigma p)$ | Bulk Modulus $K = 1/3(E/(1-2\sigma_p))$ |
|---|---|---|---|---|---|---|---|
| 0.00 | 869 | 5196 | 113 | 0.49 | 18421 | 54734 | 634851 |
| 2.14 | 869 | 5196 | 113 | 0.49 | 18424 | 54742 | 634868 |
| 4.62 | 866 | 5194 | 113 | 0.49 | 18327 | 54455 | 634280 |
| 7.42 | 858 | 5185 | 113 | 0.49 | 17988 | 53456 | 632218 |
| 10.55 | 846 | 5171 | 113 | 0.49 | 17457 | 51891 | 628953 |
| 14.01 | 833 | 5157 | 113 | 0.49 | 16903 | 50256 | 625491 |
| 17.80 | 822 | 5145 | 113 | 0.49 | 16464 | 48959 | 622707 |
| 21.92 | 816 | 5138 | 113 | 0.49 | 16211 | 48214 | 621090 |
| 26.37 | 814 | 5136 | 113 | 0.49 | 16129 | 47972 | 620563 |
| 31.15 | 815 | 5137 | 113 | 0.49 | 16179 | 48120 | 620884 |
| 36.26 | 818 | 5141 | 113 | 0.49 | 16311 | 48510 | 621732 |
| 41.70 | 823 | 5145 | 113 | 0.49 | 16480 | 49008 | 622812 |
| 47.47 | 827 | 5150 | 113 | 0.49 | 16656 | 49529 | 623933 |
| 53.57 | 831 | 5154 | 113 | 0.49 | 16815 | 49995 | 624934 |
| 72.86 | 869 | 5196 | 113 | 0.49 | 18424 | 54742 | 634868 |

## One-Dimensional MASW Analysis



SilverState
Analytical Laboratories

Sierra Environmental Monitoring

EnviroTech

November 03, 2016

Ryan Carey
GES
7150 Placid Street
Las Vegas, NV 89119

Lab ID:
☒ Las Vegas, NV (NV930, CA2885)
☐ Reno, NV (NV015, CA2526)

Project: 2016 Misc

Workorder No.: 16110007

Dear Ryan Carey:

Silver State Labs-Las Vegas received 3 sample(s) on 11/1/2016 for the analyses presented in the following report.

There were no problems with the analytical events associated with this report unless noted in the Case Narrative. Analytical results reported as non-detect (ND) in the result field are below the Practical Quantification Limit (PQL). Analytical results above the PQL are reported as the measured value in the results field. The results for each constituent denote the percentage (%) for that particular element which is soluble in a 1:5 (soil to water) extraction ratio and corrected for dilution.

Quality control data is within laboratory defined or method specified acceptance limits except if noted.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Dave Faircloth

Dave Faircloth
Laboratory Manager
3626 E. Sunset Road, Suite 100
Las Vegas, NV 89120

SilverState Analytical Laboratories
Sierra Environmental Monitoring

Silver State Labs-Las Vegas
3626 E. Sunset Road, Suite 100
Las Vegas, NV 89120
(702) 873-4478 FAX: (702) 873-7967
www.ssalabs.com

# Analytical Report

WO#: 16110007
Date Reported: 11/9/2016

| | | | |
|---|---|---|---|
| **CLIENT:** | GES | **Collection Date:** | |
| **Project:** | 2016 Misc | | |
| **Lab ID:** | 16110007-01 | **Matrix:** | SOIL |
| **Client Sample ID** | 16-478, BH-L-09-1 | | |

| Analyses | Result | PQL | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SULFIDE - SOILS** | | | | **SM 4500S2 F** | | Analyst: **NM** |
| Sulfide | ND | 1.00 | | mg/L | 1 | 11/2/2016 2:50:19 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO CHLORIDE - SOILS** | | | | **SM 4500 CL-B** | | Analyst: **NM** |
| Chloride | 380 | 100 | D | mg/Kg | 10 | 11/1/2016 2:12:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SODIUM SULFATES - CALCULATION ONLY.** | | | | **CALCULATION** | | Analyst: **NM** |
| Sodium Sulfate as Na2SO4 | 0.123 | 0 | | % | 1 | 11/1/2016 3:35:00 PM |
| **PH - SOILS** | | | | **SM 4500H+ B** | | Analyst: **NM** |
| pH | 8.41 | 0 | | pH Units | 1 | 11/1/2016 12:09:43 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO REDUCTION - OXIDATION POTENTIAL - SOILS** | | | | **SM 2580 B** | | Analyst: **NM** |
| Oxidation-Reduction Potential | 233 | 1.00 | | mV | 1 | 11/1/2016 2:14:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO RESISTIVITY BY AASHTO T-288** | | | | **AASHTO T288** | | Analyst: **NM** |
| Resistivity, Minimum | 575 | 0 | | Ohms-cm | 1 | 11/2/2016 4:19:40 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SODIUM (NA)** | | | | **ASTM D2791** | | Analyst: **NM** |
| Sodium | 0.0300 | 0.0100 | | % | 1 | 11/1/2016 2:13:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SULFATE (SO4)** | | | | **SM 4500 SO4 E** | | Analyst: **NM** |
| Sulfate | 0.0800 | 0.0100 | | % | 1 | 11/1/2016 2:10:00 PM |

**Qualifiers: (Qual)**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | C | Value is below Minimum Compound Limit. |
| DF | Dilution Factor. | H | Holding times for preparation or analysis exceeded. |
| MCL | Maximum Contaminant Level. | ND | Not Detected at the PQL. |
| PQL | Practical Quantitation Limit. | U | Sample was analyzed for, but not detected. |

Revision v2

SilverState Analytical Laboratories
Sierra Environmental Monitoring

Silver State Labs-Las Vegas
3626 E. Sunset Road, Suite 100
Las Vegas, NV 89120
(702) 873-4478 FAX: (702) 873-7967
www.ssalabs.com

# Analytical Report

WO#: 16110007
Date Reported: 11/9/2016

| | | | |
|---|---|---|---|
| **CLIENT:** | GES | **Collection Date:** | |
| **Project:** | 2016 Misc | | |
| **Lab ID:** | 16110007-02 | **Matrix:** | SOIL |
| **Client Sample ID** | 16-478, BH-L-09-2 | | |

| Analyses | Result | PQL | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SULFIDE - SOILS** | | | | **SM 4500S2 F** | | Analyst: **NM** |
| Sulfide | ND | 1.00 | | mg/L | 1 | 11/2/2016 2:50:19 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO CHLORIDE - SOILS** | | | | **SM 4500 CL-B** | | Analyst: **NM** |
| Chloride | 410 | 100 | D | mg/Kg | 10 | 11/1/2016 2:12:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SODIUM SULFATES - CALCULATION ONLY.** | | | | **CALCULATION** | | Analyst: **NM** |
| Sodium Sulfate as Na2SO4 | 0.106 | 0 | | % | 1 | 11/1/2016 3:35:00 PM |
| **PH - SOILS** | | | | **SM 4500H+ B** | | Analyst: **NM** |
| pH | 8.54 | 0 | | pH Units | 1 | 11/1/2016 12:09:43 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO REDUCTION - OXIDATION POTENTIAL - SOILS** | | | | **SM 2580 B** | | Analyst: **NM** |
| Oxidation-Reduction Potential | 237 | 1.00 | | mV | 1 | 11/1/2016 2:14:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO RESISTIVITY BY AASHTO T-288** | | | | **AASHTO T288** | | Analyst: **NM** |
| Resistivity, Minimum | 336 | 0 | | Ohms-cm | 1 | 11/2/2016 4:19:40 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SODIUM (NA)** | | | | **ASTM D2791** | | Analyst: **NM** |
| Sodium | 0.0300 | 0.0100 | | % | 1 | 11/1/2016 2:13:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SULFATE (SO4)** | | | | **SM 4500 SO4 E** | | Analyst: **NM** |
| Sulfate | 0.0800 | 0.0100 | | % | 1 | 11/1/2016 2:10:00 PM |

**Qualifiers: (Qual)**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | C | Value is below Minimum Compound Limit. |
| DF | Dilution Factor. | H | Holding times for preparation or analysis exceeded. |
| MCL | Maximum Contaminant Level. | ND | Not Detected at the PQL. |
| PQL | Practical Quantitation Limit. | U | Sample was analyzed for, but not detected. |

Revision v2

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# Analytical Report

WO#: 16110007
Date Reported: 11/9/2016

**CLIENT:** GES
**Project:** 2016 Misc
**Lab ID:** 16110007-03
**Client Sample ID** 16-478, BH-L-09-3
**Collection Date:**
**Matrix:** SOIL

| Analyses | Result | PQL | Qual | Units | DF | Date Analyzed |
|---|---|---|---|---|---|---|
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SULFIDE - SOILS** | | | | **SM 4500S2 F** | | Analyst: **NM** |
| Sulfide | ND | 1.00 | | mg/L | 1 | 11/2/2016 2:50:19 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO CHLORIDE - SOILS** | | | | **SM 4500 CL-B** | | Analyst: **NM** |
| Chloride | 3500 | 1300 | D | mg/Kg | 125 | 11/1/2016 2:12:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO SODIUM SULFATES - CALCULATION ONLY.** | | | | **CALCULATION** | | Analyst: **NM** |
| Sodium Sulfate as Na2SO4 | 0.298 | 0 | | % | 1 | 11/1/2016 3:35:00 PM |
| **PH - SOILS** | | | | **SM 4500H+ B** | | Analyst: **NM** |
| pH | 8.44 | 0 | | pH Units | 1 | 11/1/2016 12:09:43 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO REDUCTION - OXIDATION POTENTIAL - SOILS** | | | | **SM 2580 B** | | Analyst: **NM** |
| Oxidation-Reduction Potential | 225 | 1.00 | | mV | 1 | 11/1/2016 2:14:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO RESISTIVITY BY AASHTO T-288** | | | | **AASHTO T288** | | Analyst: **NM** |
| Resistivity, Minimum | 267 | 0 | | Ohms-cm | 1 | 11/2/2016 4:19:40 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SODIUM (NA)** | | | | **ASTM D2791** | | Analyst: **NM** |
| Sodium | 0.100 | 0.0100 | | % | 1 | 11/1/2016 2:13:00 PM |
| **SOIL-CORROSION SUITE W/RESISTIVITY-AASHTO WATER SOLUBLE SULFATE (SO4)** | | | | **SM 4500 SO4 E** | | Analyst: **NM** |
| Sulfate | 0.200 | 0.0100 | | % | 1 | 11/1/2016 2:10:00 PM |

**Qualifiers: (Qual)**

| | | | |
|---|---|---|---|
| * | Value exceeds Maximum Contaminant Level. | C | Value is below Minimum Compound Limit. |
| DF | Dilution Factor. | H | Holding times for preparation or analysis exceeded. |
| MCL | Maximum Contaminant Level. | ND | Not Detected at the PQL. |
| PQL | Practical Quantitation Limit. | U | Sample was analyzed for, but not detected |

Revision v2