
TECHNICAL MEMORANDUM

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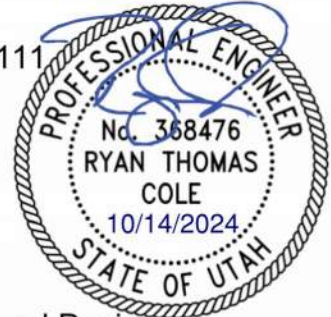
From: Richard Buhler, PE;

Reviewed by: Ryan Cole, PhD, PE, DGE

Date: October 14, 2024

Job Number: 22-1522

Subject: Bear Lake Marina Expansion – Geotechnical Data and Design

**INTRODUCTION AND SCOPE OF WORK**

State of Utah Division of Facilities Construction and Management (DFCM) and Utah State Parks is planning to expand the existing Bear Lake Marina located in Garden City, Utah. DFCM has asked for assistance in preparing a plan for the Marina expansion. DFCM has retained Kimley Horn (KH) to assist with design and Whitaker Construction (Whitaker) to design and construct the Marina using Construction Manager/General Contractor (CM/GC) project delivery. Gerhart Cole (GC) has been retained by KH and Whitaker to provide geotechnical engineering support.

This technical memorandum (TM) presents results of our scope of work as outlined in our Subconsultant Agreement with Kimley Horn (KH) dated July 19, 2022. This work includes:

- Field studies consisting of drilled test holes (TH) and excavated test pits (TP).
- Laboratory testing of select samples.
- Development and evaluations of breakwaters materials (i.e. dikes / embankments) for the planned Marina expansion.
- Evaluation of borrow source materials.
- Geotechnical design recommendations for: breakwaters (dikes), preparation of site for floating docks, future administration building, boat ramp concrete pavement, and pavement for Marina access and parking.

BACKGROUND INFORMATION

The project location is in Garden City, Utah and is shown in a vicinity map in Figure 1. The proposed Marina expansion will be constructed north of the existing Marina and will include: Marina excavating, breakwaters (dikes), a boat ramp, boat docks, parking lots, restrooms, and site preparation for a future administration building. A site plan, provided by KH on February 16, 2024, showing the outline of the new Marina is provided in Figure 3.

Based on discussions with Whitaker we understand their plans to construct the Marina include the following:

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- Constructing the lake-side dike/breakwater in the wet from the shore out into the lake and temporarily enclosing the entire Marina as a temporary coffer.
 - Dewatering the Marina.
 - Construct the remaining breakwater in the dry.
 - Excavate the Marina to planned depths.
 - Place breakwater armor.
 - Remove temporary coffer and armor the entrance.
 - Construct land and water-based facilities for the Marina.

We understand the administration building, that was planned to be built in the southwest corner of the Marina (near 23-TH-05), has been temporarily removed from the project. However, the site is being prepared to accommodate its future construction when funding becomes available. We also understand that a retaining wall is needed to accommodate an additional lane along US-89 to facilitate parking and access to the Marina. Recommendations for this wall will be addressed in a separate TM that will be submitted and coordinated with the Utah Department of Transportation (UDOT) for review and approval.

REVIEW OF EXISTING INFORMATION

GC reviewed the following geotechnical studies which were completed at or near the existing Marina:

- Preliminary Geotechnical Engineering Report – Bear Lake State Park New Marina Expansion – Programming, Terracon Project No. 611555051, Prepared for JUB Engineers Inc. Logan, Utah. October 27, 2015.
- Geotechnical Report – US-89; Bear Lake Marina Access Improvements, Gerhart Cole Project No. 19-1196, Prepared for UDOT Project No. S-0089(500) / OPIN 17130, July 2020.

The Preliminary Geotechnical Engineering Report completed for Bear Lake State Park New Marina Expansion by Terracon (2015); was completed on the south side of the existing Marina and consisted of three geotechnical borings (B1 to B3), five test pits (TP-1 to TP-5), and two seismic arrays.

In 2020 GC completed a geotechnical study for access improvements at the Bear Lake Marina. The geotechnical study consisted of drilling seven (7) test holes along US-89 for the planned highway improvements with a focus on the southside of the existing Marina and along the eastside of US-89. This report provides information and recommendations about the following items:

- Subsurface conditions,
- Seismic hazards, and
- Earthwork and pavement design recommendations.

GC also completed a borrow studies for two proposed quarries to support Whitaker.

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- State Site (Southwest Range Quarry) – This site is located south of Garden City and was studied in the summer 2023. This study consisted of drilling four (4) geotechnical test holes and performing gradations on bulk samples collected by Whitaker from excavated test pits.
 - Ken Johnson Site – This site is located south of Laketown and was studied in the summer of 2024 (Gerhart Cole, 2024). This study included excavation of seven (7) test pits onsite by Whitaker and logged by GC.

REGIONAL GEOLOGIC SETTING

The project area is located in the Bear Lake Valley, within the Middle Rocky Mountain Physiographic Province, near the northern and eastern junctures of the Basin and Range Province and the Colorado Plateau. Bear Lake is situated in the northern section of the Bear River Basin and is fed primarily by the Bear River. The Bear River is a northward-flowing river system that originates from the north flank of the Uinta Mountains, Utah, and meanders through western Wyoming, Utah, and southern Idaho before eventually draining into the Great Salt Lake. The Bear River Basin and Bear Lake Valley are characterized by horst-and-graben style block faulting that created the Bear River Range, which lies just to the west of the project location, as well as the Crawford Mountains to the southeast. Faults in this region consist of north-south trending Larimide thrust faults, some of which reactivated to normal-slip during Basin-and-Range crustal extension that began in the Late Cenozoic era, and continues to this day. The resulting geologic structures that formed during these episodes are complex and are thought to be the primary control of the Bear River drainage system (Raheis et al., 2009).

The influence of the Bear River on the surficial geology of the Bear River Basin and Bear Lake Valley began during the Pliocene to Early Pleistocene, where the river repeatedly incised new paths throughout the region, conforming to newly found space made from crustal extension and faulting. Throughout the remainder of the Quaternary Period, the river has undergone many alternating phases of diversion, fluctuating flowrate, and migration (generally northward), reflected by observations of the ancestral Bear Lake's highstand levels (Raheis et al., 2009). These fluctuations typically correspond with periods of glaciation in the Uinta Mountains, regional climate changes, mass wasting events, and periods of increased slip along the structural faults in the area (McCalpin, 2003; Raheis et al., 2009). These events in-turn modify the flowrate of the Bear River and its interaction with Bear Lake, resulting in periods of time where the river was entirely cutoff from the lake. Per Raheis et al., the modern Bear River is believed to be at a relatively low flowrate historically, which has allowed the river to meander widely, filling the valley floor with alluvial sediments atop alluvial fans on the west end of the valley, and steeply dipping bedrock units along the eastern margin of the valley.

Surficial Site Geology

The surficial geology of the project area, is comprised primarily of late alluvial and lake deposits (Dover, 2007), as shown in Figure 2a. Raheis (2005) maps shoreline dominated by lake deposits.

Inland to the west of the project area is dominated by bedrock of the Wasatch, Garden City, and St. Charles Formation (Tw, Og, OCs,) with small pockets of side stream alluvial and fan deposits (Qaf). Descriptions of these units are provided in Figure 2b.

GEOLOGIC HAZARDS

Landslides

The Marina area is not located near enough to slopes that would pose a significant risk of fast-moving mass wasting events such as debris flows, rock topples/rock avalanches, earthflows, etc. As such, landslide related risks to the Marina are considered low.

Surface Fault Rupture Hazard

The project area lies within the Intermountain Seismic Belt (ISB), a northerly-trending zone of earthquake activity that runs through the intermountain west from northwest Montana, through eastern Idaho, western Wyoming, and central Utah to southern Nevada and northern Arizona (Smith and Arabasz, 1991). Since 1876 there have been about 49 moderate-to-large (magnitude 5.0 to 7.5) earthquakes in this zone (UUSS, 2022), with the most recent occurring in March 2020. The ISB is characterized by abundant late-Pleistocene and Holocene fault scarps, and has experienced three surface-rupture earthquakes in historic time: Hansel Valley, Utah, 1934, magnitude MS 6.6, maximum displacement of 1.6 feet; Hebgen Lake, Montana, 1959, magnitude MS 7.5, maximum displacement of 18 feet; and Borah Peak, Idaho, 1983, magnitude MS 7.3, maximum displacement of 9 feet.

The project area lies near two major fault zones belonging to the ISB called the Eastern and Western Bear Lake Fault Zones (EBF and WBF, respectively). The project area is about 6.6 miles west of the EBF and 8.5 miles south of the WBF (Haller et. al. 2010). Another fault zone approximately 15 to 20 miles to the southeast called the Crawford Mountain Fault Zone and Dover (2007) show its trace to project under Bear Lake but due to depth and distance it poses little risk to the Marina.

McCalpin, 2003 conducted several trench studies on the EBF and WBF. McCalpin, 2003 estimates maximum earthquake magnitude based on per-event fault displacement and rupture length at magnitude 6.6 to 7.0 for the EBF, and magnitude 6.7 to 6.8 for the WBF. Seismic intervals for events within these zones also range from as little as 2 to 3 thousand years (ky), to 6.7 to 7.4 ky, with fault displacement of up to 20 feet (McCalpin, 2003). The project's proximity to these Holocene-active faults, risk of ground shaking may be considerable. Design information for the ground shaking is provided below.

The risk of surface ground rupture at the Marina site is considered low given that the nearest mapped faults is 6.6 miles from the site.

FIELD AND LABORATORY STUDIES

Field and laboratory studies were completed in December 2022 and May 2023 to collect data for the proposed Marina expansion. Test pits, test holes, and CPT soundings were completed as part of our field studies. Study depths and approximate locations are indicated in Table 1. Test holes and CPTs were completed within the proposed Marina expansion area. Test pits were completed in the Marina area and at potential borrow source areas.

Details regarding field and laboratory studies are addressed in the following sections. Locations of test holes and test pits were surveyed by Meridian Engineering. Geotechnical study locations are plotted in Figures 3 and 4.

Field Studies

Test Pits

Sixteen (16) test pits (22-TP-01 through 22-TP-16) were excavated using a track hoe (Deere 135G) operated by Whitaker Construction. Test pits were completed December 20 and December 22, 2022 and at three locations: the North Marina Area, West Parking Area, and the Rainbow Cove campground on the east shore of Bear Lake (see Figures 3 and 4). Test pits were completed to assess potential borrow materials needed for breakwater (dike) construction. Through the CM/GC process the Rainbow Cove borrow area was removed due to the distance and costs to haul these materials to the Marina.

Test pit depths ranged from 13 to 15 feet below existing ground surface. Bulk soil samples were collected and transported to our laboratory for testing. As specified in the US Army Corp of Engineers (USACE) Nationwide Permit Summary (NWP), TP were excavated and backfilled with excavated spoils to the original ground surface elevation. Some settlement of this material should be expected, and these areas may need to be replaced as part of construction depending on the nature of work in the vicinity of these test pit excavations. TP logs and corresponding photographs can be found in Appendix A. Lines designating boundaries between different materials on the TP logs should be considered approximate; transitions between subsurface materials may be gradual or occur between sampling depths.

Drilled Test Holes

Six (6) test holes (TH) were drilled between May 8 and May 11, 2023. Test holes were completed to depths of 10 to 70 feet by ConeTec under subcontract to GC. Table 1 summarizes locations, elevations, and general details for each test hole. TH were drilled using a track-mounted drill rig with both hollow stem and mud-rotary drill tooling. Test holes were backfilled using cement- bentonite grout. Test hole logs are provided in Appendix B. Lines designating boundaries between different materials on the TH logs should be considered approximate; transitions between subsurface materials may be gradual or occur between sampling depths.

Soil samples were collected at select intervals and included pushed thin-wall “Shelby tubes” to obtain relatively undisturbed samples of fine-grained materials and driven Standard Penetration Test (SPT). The SPT is performed by driving a 2-inch O.D. (outside diameter) by 1-3/8-inch I.D. (inside diameter) sampler with an automatic-trip hammer, consisting of a 140-pound weight falling 30 inches. The field results of the SPT are reported on the logs in blows per foot. The efficiency of the automatic sampling hammer was reported to be 74.1 percent. The blowcounts can be correlated to the relative consistency or relative density of the soil in-situ. Our analyses correct field blowcounts for sampler type as well as hammer energy. “Shelby tube” sampling was also used in fine-grained deposits.

Extrapolation of subsurface conditions beyond study locations may not be appropriate or yield representative results. Relative density and consistency descriptions shown on test hole logs may deviate from typical criteria for a number of reasons, including reliance on other laboratory test results, visual observation and/or manual manipulation of disturbed field samples, or the engineer's judgement.

Cone Penetration Testing

The CPT soundings were advanced using a Vertex CPT mounted on a 246B CAT skid steer operated by A Cache Corp. under subcontract to GC. CPT data is summarized in Appendix C, and the approximate locations are plotted in Figure 3. Table 1 summarizes the locations, elevations, and general details for each CPT sounding. Of the six (6) CPT soundings attempted, five (5) refused between depths of 4.5 to 14 feet. Seismic shear wave velocities were also measured at approximate 5-foot intervals down to 50 feet as part of 23-CPT-06. The shear wave velocity profile is provided in Appendix C on page C-9.

When interpreting soil type from CPT results, it is important to recognize that the soil behavior type (SBT) shown on the logs reflects an interpretation of the soil behavior during undrained shear and *do not* reflect actual soil types. SBT found in the CPT plots reflect the Robertson (2009 and 2010) relationships. It has been our experience that these SBT relationships often suggest more silt like behavior when compared with the actual soil types classified using laboratory testing. As such, proper use of CPT data requires skill, experience, and judgment.

Laboratory Testing – Borrow Areas

Laboratory testing was performed on select bulk soil samples obtained from our test pits to help classify and assess engineering properties and potential use as borrow materials. Laboratory testing included index testing (particle-size distributions, Atterberg limits, unit weights, and natural moisture contents), density-moisture relationships (i.e., Proctor compaction tests), and California Bearing Ratio (CBR). Laboratory test results are summarized in Table 2 with supplemental information and data in Appendix D.

Laboratory Testing – Marina

Laboratory testing was completed on select soil samples obtained from our test holes to refine field classifications and evaluate their engineering properties. Laboratory testing consisted of index testing (particle-size distributions, Atterberg limits, unit weights, and natural moisture contents), unconsolidated-undrained triaxial compression strength testing, and one-dimensional consolidation (compressibility) testing. Chemical assessments were also completed to evaluate corrosion potential of the soils. Laboratory test results are summarized in Table 3, with additional data and plots in Appendix E.

Temporary Piezometer and Groundwater Data

A temporary standpipe piezometer was installed in 23-TH-01 to a depth of 30 feet. The piezometer was constructed with 10 feet PVC screen from the bottom to 20 feet. Non-perforated riser pipe extended from 20 feet to the surface and was sealed with bentonite chips. A flush mount cover was installed to seal out runoff and prevent tampering. GC returned to the project area two times after field study completion to measure groundwater

levels. Temporary piezometer construction details are summarized in Appendix B. Groundwater measurements are summarized in Table 1 and discussed in the Subsurface Conditions section of this TM.

Temporary piezometers were left in place for use by the project team. The piezometers will need to be properly abandoned during construction; the CM/GC team should include provisions for such within the project plans and specifications.

SITE CONDITIONS

Subsurface Conditions Borrow Areas

North Marina Area

The North Marina Area stretches from the edge of the existing Marina dike on the north side approximately 1300 feet along the beach. The beach surface consists of sands and gravels and slopes gently from the highway, northeast to the edge of water. The Marina and beach area are made up of Holocene alluvial deposits from past floodplains. The alluvium consists of unconsolidated clay to boulder size material with thickness generally a few meters or less.

The test pits, test holes, and CPTs showed varying soils consisting of granular and fine-grained soils both of native and fill soils. In general, the native soils seemed to consist of loose silty sands and soft sandy silts to silt, overlying stiff to very stiff clays. Additional discussion about certain areas for the proposed Marina are provided in the following sections.

At the future administration building area (23-CPT-06 and 23-TH-05) about 15 feet of silty sand and silt with a thin seam of gravel, overlaying stiff to hard clay was found.

Test hole 23-TH-07 was completed in the northeast corner of the existing Marina to assess conditions of the dike fill material. The dike fill consisted of 6 inches of asphalt over about 6 inches of sandy gravel of road base. Underlying the sandy gravel was about 7 feet of medium stiff high plastic clay followed by 16 feet of low to medium plastic medium stiff clay. Native soil underlying the dike consisted of about 8 feet of very loose to medium dense sand then 16 feet of very stiff to medium stiff silt. At about 49 feet medium dense silty sand was found to a depth of 57 feet followed by very dense gravel consisting of gravel with cobbles and boulders to a depth of 70 feet.

Along the northern limits of the proposed Marina two test holes (23-TH-04 and 23-TH-09) and one CPT (23-CPT-10) and a test pit (22-TP-04) was completed. The test hole (23-TH-09), CPT, and test pit were completed as far out on the beach as the equipment could get without lake restriction. Rising lake levels in 2023 limited the distance the equipment could travel in the proposed Marina area. Test hole 23-TH-04 found boulders and cobbles from the surface to about 2 feet followed by medium dense sand medium dense gravel soils to 8 feet followed by stiff to hard clay which became cemented at about 12 feet.

It is noted that both the test holes and test pits found portions of the stiff silt and clay soil to be partially cemented and is noted in the logs. These cemented soils likely contributed to early refusal of several CPT soundings.

West Overflow Parking Area

The West Overflow Parking Area is located on a bench approximately 90 feet higher than the beach and Marina area. The area is used for overflow parking and boat storage during peak seasons. The surface slopes gently uphill from south to north and is covered with grasses and patchy soil. West Marina Drive divides the area, running from east to west. During a site visit a park ranger with Utah State Parks informed us that the southern portion of the overflow parking area was used for Marina spoils disposal from dredging activities during the 1980's. We believe this dredged material was found in 22-TP-08.

Six (6) test pits were completed in the overflow parking area to assess material suitability as borrow for construction of the new Marina embankments and dikes. The material generally consisted of fine-grained silt and clay soils with some sand.

Southwest Range Area

The Southwest Range Area site sits in a small valley with some slope variability about 100 feet above North Bear Lake Highway (SR-30). The site is largely covered in sage brush and grasses with surficial cobbles and boulders and a small dirt road crossing the central part of the valley. Other than the dirt road it doesn't appear any disturbance or development has occurred in this area.

Four (4) test holes were completed in the area and Whitaker also completed a few buckets of material they collected from some shallow excavations they performed on site. The material generally consisted of coarse-grained gravels and cobbles overlying siltstones and mudstones. A summary of the test results on the material collected is found in Table 2 and results presented in Appendix D. Additional discussion about the location of the test holes, test hole logs, material collected, and laboratory results are found in the TM provided to Whitaker (GC, 2024).

Ken Johnson Area

The Ken Johnson site sits on a small hill above the lower farmlands south of Laketown. The eastern end of the site appears to have been used as a previous borrow source while the western end is generally undisturbed with sage brush and grasses covering the hill.

Seven (7) test pits were completed in the area and Whitaker also completed a few buckets of material they collected from some shallow excavations they performed on site. The material generally consisted of coarse-grained sand and gravel with clay and some cobbles. A summary of the test results on the material collected is found in Table 2 and results presented in Appendix D. Additional discussion about the location of the test pits, test pit logs, material collected, and laboratory results are found in the TM provided to Whitaker (GC, 2024).

Groundwater

Groundwater was found in all the test pits in the Marina between depths of 10 to 14 feet except 22-TP-06 where no groundwater was found. No groundwater was found in test pits excavated in the west parking area nor in the Rainbow Cove area.

The test holes in the Marina area suggest groundwater at depths between 7 to 16.2 feet. A few test holes did not find any groundwater which could be attributed to test holes not going deep enough, drilling method used, and/or more time needed for completed test holes to stabilize. Groundwater levels were estimated during drilling based on drilling conditions and feedback as well as field measurements using a water level indicator. Following test hole drilling, one temporary piezometer (23-TH-01) was installed (see Temporary Piezometer and Groundwater Data Section of this TM). Groundwater and temporary piezometer data along with measurements are summarized in Table 1.

It should be recognized that groundwater levels are not static and should be expected to change as Bear Lake Levels rise and fall, and in addition will respond to precipitation, runoff and irrigation.

SEISMICITY AND SEISMIC EFFECTS

We understand that seismic design for the project buildings will be based on the 2018 International Building Code (IBC) / ASCE Standard 7-16. Based on shear wave velocity testing (see Appendix C; 23-CPT-06), the National Earthquake Hazards Reduction Program (NEHRP) seismic site classification for this site is 'D', representative of a "stiff soil" profile.

Table 4 presents seismic design parameters consistent with the general spectral acceleration response spectrum procedure (with 5% damping) of the 2021 IBC / ASCE Standard 7-16 (USGS, 2023a). Acceleration parameters presented in the table have not been adjusted to account for any particular occupancy category or seismic importance factor. With respect to implementation of the seismic design provisions of the 2021 IBC, we have assumed that the Designer will implement code exceptions rather than perform site-specific seismic studies. However, we can provide additional information and services related to site-specific seismic studies upon request. As seen in the table, the parameter SD1 is not explicitly provided (and would be 0.44 if it were applicable); this is a result of the exception requirement that a modified seismic response coefficient C_s be used with ELF or MRSA methods.

A deaggregation of the probabilistic portion of the MCE (maximum considered earthquake) hazard level at a structural period of zero (i.e., at peak ground acceleration, PGA) indicates that the modal magnitude-distance pair is 7.1 and 8.2 km and contributes about 20% to the total hazard (USGS, 2023b).

Liquefaction Triggering and Induced Settlement

To assess the liquefaction hazard for the Marina project, we have considered the geologic setting together with CPT soundings and [drilled] test hole data standard penetration test (SPT) blow counts. We have used Youd et al.'s NCEER (2001) method of liquefaction triggering analysis, coupled with predictions of accompanying settlement using the method

of Yoshimine et al. (2006) and Tokimatsu and Seed (1987). In performing the analyses, we have assumed the groundwater at the surface based on the potential of the lake level to rise to elevation 5930 and saturate the soil.

In our liquefaction triggering analyses using CPT data, the data has been screened for points with a high rate of change (“delta”) in the soil behavior type (SBT) index (also referred to as ‘Ic’) to identify data along transitions (boundaries) between sand and clay layers. This data tends to under-represent the apparent density of sand as the tip of the cone enters or leaves a particular soil stratum. Such data was removed from further analysis, considered as being non-representative.

In our liquefaction triggering analyses using SPT data, in the case of finer grained soils for which the analysis suggested liquefaction had triggered, we screened out (removed from consideration) all soils with a plasticity index of 7 or more, consistent with recommendations of Idriss and Boulanger (2008) and AASHTO (2020) guidance.

Results of our liquefaction triggering analyses are presented in Appendix F and summarized in Table 5. In the summarized data, the elevation of liquefiable strata deemed to be substantial are provided; not all potentially liquefiable strata are included. The table also includes corresponding amounts of calculated settlement. In general, as shown in Table 5 it seems from about elevation 5920 to 5910 there are layers that are liquefiable. It is noted that portions of this zone are liquefiable, not the whole zone. We also point out that the calculated liquefaction settlement is between 1 to 2 inches at the proposed restroom building, between about 0.5 to 2 inches in the main parking area, between 2.5 to 5.5 inches in the area where the administration building could be constructed in the future, and between 4 to 7 inches near the southern breakwater.

Lateral Spread

In addition to vertical settlement, liquefaction can also induce lateral spreading of the ground. The potential for, and magnitude of, lateral spread was assessed using Youd et al. (2002). This method is based on SPT blowcounts and uses soil parameters such as fines content and mean grain size to characterize soil conditions. To use this method with CPT sounding data, we have converted CPT penetration resistances to equivalent SPT blowcounts. This predictive method also considers the slope of the ground, the continuity and thickness of liquefiable strata, and the depth of that strata. Due to CPTs being able to better distinguish the interbedded nature of soils at this site we have assessed the lateral spread hazard based only on CPT soundings.

Based on the CPT data, it appears there are no liquefaction-susceptible layers that have SPT blowcounts less than 15 and which are greater than 2 feet in thickness. Hence, lateral spread risks as applicable to the Marina are considered negligible (see Table 5).

MARINA EMBANKMENT ENGINEERING ANALYSES

General

The objective of our work is to provide geotechnical recommendations for the proposed Marina. The following sections provide recommendations and analysis for Marina

breakwaters (dikes / embankments), preparation of site for floating docks, boat ramp concrete pavement, and pavement for Marina access.

Based on cross sections provided by KH, proposed breakwater slopes are 2H:1V on both the Marina and lake side. The top of the breakwaters will be constructed to about elevation 5935 feet. The proposed elevation of the Marina mud line will be about elevation 5901 feet. The maximum breakwater section on the lake side will be on the eastern side of the Marina with the lake bottom elevation between about 5894 and 5904 feet. The maximum level of the lake is elevation 5930.54 feet. The proposed cross sections for the breakwater are provided in the plans and are shown in Appendix G.

Breakwater Construction

Planning and Design Guidelines for Small Craft Harbors (ASCE, 2020) describes three forms of breakwaters; rubble structure, cantilevered walls, or gravity containment. The existing Marina is a rubble structure, and we understand a rubble structure is the preferred type for the expansion due to costs, availability of material to construct the breakwater, and performance capabilities. Bowen Collins & Associates (BCA, 2023) provided riprap recommendations needed to armoring the breakwaters which include, a D50 of 30 inches for lake side and a D50 of 6 inches for Marina side.

ASCE (2020) discusses the most critical part of the breakwater is the core of the breakwater and should be constructed up to at least up to the full lake level with some consideration of going a bit higher to account for waves during storms such that to prevent wave action through the breakwater. The inner zones should be sized to reduce wave action, be filtered, and provide bedding for outer layers. The breakwater cross sections are based on recommendations in the ASCE (ASCE, 2020), and Whitakers preference in terms of constructability and borrow source availability which we understand is currently is limited to the Southwest Range Quarry (see Gerhart Cole, 2023). Breakwater zones planned include:

- Dike (Subarmor) Material.
- Core.
- Lake Armor.
- Marina Armor.
- General Fill.

The recommended material gradations for the breakwater zones are shown in Table 6 and plotted in Figure 5. The breakwater will utilize dike (subarmor) material, lake armor, Marina armor, and core material. We understand Whitaker feels like they will have sufficient quantity of Dike Material, but General Fill could replace the dike material above the full lake level if needed. We do note that if General fill is utilized that no particles larger than 3 inches are allowed in the material within 18 inches of the pavement section. The recommended armor material are based on recommended D50 that are then sized to keep the ratio of D85/D15 of armor between 2.5 to 3.0 (d'Angremond et. al. 2008).

The predominate material needed for the breakwater (referred to as dike material) will also be used to construct access dikes from the shore into the lake for equipment access and for

temporary coffer construction. Access dikes have been included as a zone in typical dike cross-sections (see Appendix G). This dike material will need to have sufficient coarse-grained cobble and gravel-sized particles to construct a stable base and will also need enough fines to promote interlocking to help bridge lakebed such that construction equipment can continually access and build the dikes to final configuration. We note that localized turbidity should be expected as this dike materials are pushed into the lake.

Borrow Sources.

Southwest Range and Ken Johnson sites are currently being permitted to be used as borrow material for the construction of the Marina. We understand that the Ken Johnson site will be available to be used by September 2024 while the Southwest Range material might not be available until late fall or early winter 2024. The material found at the Southwest Range generally consisted of angular to subangular gravel and cobbles and with sand and some silt. Materials from Ken Johnson Site are generally more alluvial in nature consisting of clayey sands and gravel with some cobbles.

In terms of suitability of the material for breakwater construction, the Southwest Range material appear to be best suited for the Dike, and General Fill materials with the potential for some Marina Armor materials. Ken Johnson borrow could be used for use of General Fill (Upland Marina areas (i.e. main parking lot and widening of existing northern or shared dike)).

Given the desire to begin construction in the fall of 2024 we understand Whitaker is looking to begin construction with the Upland areas using Ken Johnson borrow area materials and then constructing the dikes with the better suited Southwest Range materials once they receive the necessary approvals from Federal and State agencies.

Slope Stability

Three critical cross sections for the breakwaters have been analyzed for global stability (Section A-2, A-3, and A-4). The cross sections are shown in Appendix G and were provided by KH. Sections A-2 and A-4 are located out on the east side of the breakwaters in the deeper section of the Marina.

Soil Parameters

Materials properties and subsurface conditions for the soils used in our slope stability analyses are summarized in Table 7 and presented in Appendix G. Given the inability to complete field studies along all the areas of the proposed breakwaters (given high lake levels) we have reasonably, yet conservatively, estimated subsurface conditions in this area based on findings from all subsurface data collected in the Marina area. Shear strength parameters of the breakwater (dike) materials are based on triaxial shear strength testing at the Southwest Range quarry which showed an effective friction angle of 34 degrees and effective cohesion of about 400 psf. Our experience suggests that cohesion can be a somewhat transient parameter affected by the environment, as such we have applied judgement and conservatively reduced this value by about 60% (corresponding to a cohesion of about 150 psf) for our analyses. We recommend additional triaxial strength

testing be completed on these materials as the pit is developed and compared with values used in our analyses.

The native lake material soil properties were selected based on correlations with our field test data (particularly the CPT data) and, in the case of the clayey native soils, laboratory testing. The native sand material we estimated a friction angle of 32 degrees. We utilized an undrained shear strength of 1300 psf for the native clays. This value selected is conservatively $\frac{1}{2}$ standard deviation less than the average value based on field and laboratory testing.

Design Scenarios

With respect to water, we have completed analyses based on different lake levels based on how the lake level is managed and historical readings that are provided in the United States Geological Service Water Database (USGS, 2024). Discussion about lake levels are provided in each scenario. Analyses were performed using Geo-Studio's Slope/W computer program as integrated into its GeoStudio 2022 software package (GeoStudio 2022). We have used Morgenstern and Price's method of slices with circular failure surfaces to evaluate minimum (critical) factors of safety under the following:

- End of construction conditions with a sensitivity analysis for two lake levels; one with a full (maximum) lake level (EL. 5930 feet) and one with near current elevation (EL. 5925 feet).
- Long term conditions, with the maximum lake elevation (EL. 5930 feet) and minimum lake elevation (EL. 5908 ft). KH has stated the minimum lake elevation based on current water level management is elevation 5908 feet based on their conversations with State Parks personnel.
- Psuedo Static Conditions, utilizing the median lake level of 5922 over the last four years based on the USGS Database (USGS, 2024).

ASCE Breakwater Manual (ASCE, 2020) or Breakwater and Closure Dams (d'Angremond et. al., 2008) do not provide guidance for critical factors of safety for breakwaters; therefore, we have utilized standard of practice factors of safety of 1.3 for long term stability, 1.2 for short term construction, and 1.0 for seismic conditions following UDOT guidance for embankment stability which we believe to be applicable to the breakwater (dike). Results of our slope stability analyses are summarized in Table 8; more detailed analyses outputs are found in Appendix G. All calculated minimum (i.e., critical) factors of safety exceed minimum values referenced.

Settlement

In addition to stability analyses, we have performed settlement analyses to estimate the amount of settlement which would occur due to placement and construction of the breakwaters and parking lot area. Analyses were performed using traditional methods based on soil mechanics (e.g., consolidation theory for clays and silts, elastic deformation for granular deposits, and Boussinesq stress distribution). We also calculated settlement based on direct CPT-based methods with moduli computed based on both Robertson (2012) and Kulhawy and Mayne (1990). The drilling showed the clay soils are very stiff to

hard below a depth of about 30 feet and the settlement model was cut off below this depth. For the purposes of analyses, we modelled the levee embankment cross-section as being 25 to 30 feet high with a 2H:1V side slopes, with settlements being calculated near the centerline. In the idealized model of silty sand over clay, we calculate settlement to be on the order of 3 to 4 inches for the larger breakwater (dike) sections. This settlement should primarily occur during construction. We estimate post-construction settlements to be on the order of 1 to 2 inches; occurring over about 2 to 4 months.

CONSTRUCTION CONSIDERATIONS

To assist with anticipated construction efforts, we present the following geotechnical construction items for consideration:

- All armor material should be fresh, dense, sound, sub-angular to angular resistant to abrasion, and durable against disintegration under conditions to be met in handling and placing. In addition, testing should be submitted by the contractor before placement to document the material is sound material.
- Quality control of the breakwater (dike) in the wet will require a methods Specification which will be developed and implemented by the contractor and GC through test sections and field observations. We recommend the UDOT Material Manual of Instruction Section 989 be followed for placing this material. Additional details will be provided in the project specifications.
- During the 2nd and 3rd phase of the breakwater that is constructed in the dry, material should be placed and compacted in the dry and should be compacted to meet 95% compaction following ASTM D698 (Standard Proctor) guidelines. This compaction specification may be modified following the test section construction and observations.
- The upper 2 feet of the breakwater, including the Pavement section (UTBC and granular borrow) material, should be compacted to 95% of ASTM D1557 (Modified Proctor) and at moisture content within 2 percentage points of optimum (OMC).
- We recommend settlement plates be placed once the breakwaters are constructed above lake level to monitor settlement. This information should be utilized to provide guidance when pavement and structures can be built.
- Additional discussion about the pavement section is provided in later sections.

MARINA INFRASTRUCTURE GEOTECHNICAL DESIGN RECOMMENDATIONS

General

Based on the 90% design plans, provided to us by KH, we understand the current plan is to construct the majority of the infrastructure for the Marina including the parking lots, driveways, new docks and ramps, restroom, and fee station. We understand the new administration building, planned for the southeast corner of the Marina, will not be constructed at this time. The following sections provide recommendations for the new restroom building, lateral resistance parameters for the dock piles, and pavement recommendations for the parking lot and driveways.

Restroom Building

Based on the KH 90% design plans we understand the new restroom facility and a fee station will both be constructed with the new Marina. The restroom facility will be an at grade structure that is 28 feet wide by about 74 feet long. The fee station will be about 12 feet wide by about 23 feet long. Both structures will be supported on strip footings and slabs on grade.

Geotechnical Site Preparation

We recommend during construction of the Marina a settlement plate be placed near the proposed structures. Foundation construction should not begin until settlement plates suggest settlement has stopped or minimal settlement is still occurring. We recommend a minimum of 12 inches of granular backfill borrow (UDOT Specifications, 2024) be placed below the proposed footings or walls and be compacted to a minimum density of 95% maximum dry density (MDD) as determined by ASTM D 1557 at moisture content within 2 percentage points of optimum (OMC).

Bearing Capacity

An allowable bearing capacity (i.e., resistance) of 2.0 kips per square foot (ksf) can be used for the design of strip footings under static loading conditions. This value assumes a 3-foot footing embedment, a minimum of 1 foot of dike material below the bottom of the footings, and is based on a nominal minimum factor of safety of 3 against general shear failure with strip dimensions ranging from 2 to 4 feet wide by 10 to 75 feet long. To protect against the effects of frost the footings should be embedded at least 36 inches. This assessment is based on Rich County requirements for frost protection.

These bearing capacities are net allowable values, meaning that the weight of all components above the foundation bearing level up to (but below) the lowest adjacent grade need not be included in the calculation of the structural bearing load when making comparison(s) with allowable bearing capacity.

The allowable bearing capacity for static load conditions may be increased by one-third for temporary loading conditions such as transient wind and seismic loadings.

Modulus of Subgrade Reaction

We understand the slabs for the restroom and pay structure will be designed as an integral continuous slab/mat. As such, a modulus of vertical subgrade reaction may be needed for design. Not a true soil property (i.e. it is an engineering construct commonly used to simplify foundation design), modulus of subgrade reaction varies with soil type, soil density, foundation stiffness, and foundation size. Given the loadings and plan dimensions described previously, a representative, median value of 140 pci is recommended for design. Recognizing that the subgrade modulus does vary with position beneath the foundation, consideration should be given to doubling the modulus along the perimeter of the foundation in analyses to account for these variations and boundary (i.e. edge) effects. The designer should consult ACI 336.2R-88 (or similar reference) for guidance in the appropriate use of a modulus of subgrade reaction value.

Settlement

Static – We estimate static settlements of less than 0.5 inch, for the footing sizes described loaded up to the allowable bearing pressure of 2.0 ksf. This calculated settlement assumes all breakwater (dike) settlement is complete. No structures should be built until breakwater (dike) settlement is complete.

Lateral Earth Pressure

We understand foundations may be subjected to lateral loads associated with seismic forces, and wind forces. We recommend neglecting the passive force in the frost-active zone (upper 3 feet) due to disturbance. To utilize passive pressures, footings deeper than 3 feet are recommended. Lateral earth pressure coefficients to be used in the design of the foundations are presented in Table 9.

Lateral earth loads acting on foundation walls may be computed using the earth pressure coefficients listed in Table 9. “At-rest” lateral earth pressures are generally assumed for buried structural elements that are designed for little or no movement/rotation. Elements that can move or deflect sufficiently to develop the strength of the soils and backfill behind a wall can be designed assuming “active” lateral earth pressures for structures. A movement or rotation equal to about 0.2 percent of the buried depth of the element is required to develop active lateral earth pressures adjacent to granular soils. Passive lateral earth pressures are generally assumed to resist structure movement. Structure movement of at least 2 percent of the buried depth of the structure element is necessary to develop full passive lateral earth pressures. Walls that support potentially “movement sensitive” facilities should be designed using at-rest earth pressures. These earth pressures can also be utilized for other minor walls that might be needed for construction of gangways to dock ramps where they will be backfilled with dike or general fill material.

Lateral earth pressure coefficients shown in the table assume horizontal backfill and forefill (i.e., backslopes and foreslopes) and vertical wall face conditions. Hydrostatic pressures and surcharge loadings (such as from equipment and soil piles) should be added to lateral earth pressures as applicable. Over-compaction behind walls should be avoided. Resistive passive earth pressures developed from soils subject to frost or heave, or otherwise above prescribed minimum depths of foundation embedment, should usually be neglected in design. Seismic coefficients provided in Table 9 should be added to their respective static values.

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and friction between the base of the footing and the supporting soils.

Base Sliding

Resistance of the footing to lateral loading is anticipated to be provided by frictional resistance of the soil below the bearing depth. Foundations may be designed with a coefficient of friction of 0.45 when bearing on granular backfill borrow over properly prepared subgrade. Passive earth pressures developed in the soils placed against the footing above

prescribed minimum depths of foundation embedment, should usually be neglected in design.

Floating Dock Piles

To anchor the floating docks in the Marina, piles will be utilized that will allow the docks to adjust with the lake level. We understand the dock piles for the existing Marina were originally constructed with wood piles but had to be replaced and were replaced with steel pipe piles. We also understand that some of the piles had to be predrilled due to the stiff and cemented clays. We also found similar material during the test pits and drilling at the proposed Marina.

Lateral pile capacities were not assessed as part of this geotechnical report, and the structural engineer (KH) and the Marina engineer for the project will be performing these calculations. We have put together the generalized soil profile including soil parameters for use in LPILE and they are summarized in Tables 10a and 10b, for the Marina area. Due to the potential of some variability, we have provided two profiles that the structural engineer can utilize for the area by running both scenarios and using the more conservative results. We also recommend a 75 year reduced pile section, due to corrosion, will need to be addressed by the structural engineer in the lateral calculations. We recommend using a total corrosion of 0.1 inches at 75 years in these calculations.

Pavement Analysis and Design Recommendations

Our work for this project includes the development of two pavement section alternatives. Design of the pavement section was performed using guidance from AASHTO 1993 Guide for Design of Pavement Structures (AASHTO 1993), as modified for more local use by UDOT (UDOT, 2008).

The nominal design life of the asphalt pavement is 20 years. Of course, realization of any targeted design life requires that maintenance be performed on a regularly scheduled basis.

KH provided an average daily traffic of 645 vehicles per day but to account for the use of trucks and trailers. This count is based on averaging the peak summer traffic with the slower season in the winter. KH recommend that a growth rate of 4.4% be used. The resulting traffic loading information, including AADT and recommended distribution of vehicle types, is presented in Table 12 for the main traffic flow areas. For the dike areas where there will be some parking but not the main flow of traffic KH asked that we utilize half the traffic count as shown in Table 12. We recommend Utah State Parks and KH review the final assumption for vehicle classification.

We have assumed two different subgrades for support of the pavement section. One being the dike material which is similar to granular borrow and should be able to provide a CBR of at least 10. The other material could be material from the overflow parking lot and CBR testing showed a value between 4.8 to 8.1. As a basis of design, we selected

a CBR value of 4.0 (which is lower than the range in the lab and accounts for less favorable field densities and moisture conditions existing in the field). This value equates to a resilient modulus of about 6,000 psi.

Our recommended asphalt (e.g., “hot mix asphalt” or HMA) pavement sections are presented in Tables 13 and 14 for the different parking areas for two alternatives. The first asphalt pavement section alternative (Alternative #1) is structurally viable if the subgrade in the area of the pavement is constructed with dike material. If general fill is utilized for the subgrade, the second alternative (“Alternative #2”) consisting of a section of compacted granular borrow (GB) subbase should be used. If general fill is utilized in the pavement areas, and given the fine-grained nature of these soils, we recommend that a separation geotextile be used at the subgrade/subbase interface. We also recommend if general fill is used any particles larger than 3 inches should not be permitted within the 18 inches of pavement section.

Asphalt Pavement Construction Considerations

All subgrade preparation and earthwork activities for the pavement should conform to the recommendations herein and UDOT’s 2024 Standard Specifications for Road and Bridge Construction. Any imported granular subbase should conform to UDOT’s requirements for granular borrow.

For the asphalt pavement section, we recommend that the hot mix asphalt (HMA) be a full-depth ½-inch mix with a performance graded 58-28 asphalt binder. Additionally, untreated base course (UTBC) should possess a minimum resilient modulus value of at least 25,000 psi, and the granular subbase should possess a minimum resilient modulus value of 15,000 psi.

Drainage conditions, as well as maintenance, affect the long-term performance of pavements. Consequently, we recommend that all pavement grades be set to provide positive drainage to suitable drainage features such as catch-basins. We also recommend that a pavement maintenance plan be established by State Parks once the new pavement is constructed and that the funding for the plan be consistently provided.

Rigid (Concrete) Pavement Installation Considerations

We understand the boat ramp pavement will consist of a concrete slab supported on road base. KH has asked for recommendations such that the road base can provide a subgrade modulus (k) support of 150 to 300 pci. The support of the roadbase depends not only on the material utilized for the road base but also the subgrade material under the road base. We recommend the road base consist of an untreated road base (UTBC) as recommended by UDOT (UDOT, 2024). Due to the difference in the subgrade between the portion of the ramp that will be constructed above native grade and then below grade we recommend two different sections be utilized to achieve these subgrade modulus.

The portion of the ramp that will be above native grade and constructed with Dike Material should have a minimum thickness of 6 inches of UTBC under the pavement. The portion of the ramp below the native grade will require different minimum thicknesses of UTBC to

achieve the k values as prescribed. Following the AASHTO (1993) procedures for determining a modified subgrade modulus based on fill thickness, we recommend the following thicknesses:

- To achieve a k value of 150 pci; 6 inches of UTBC.
- To achieve a k value of 200 pci; 8 inches of UTBC
- To achieve a k value of 300 pci; 12 inches of UTBC

Subgrade Preparation of Boat Ramp Pavement Section

Based on provided cross sections a portion of the new boat ramp will be constructed below native grade to extend it down to bottom elevation of the new Marina of 5900 feet. In areas where the boat ramp will be below the current ground surface any fill, topsoil, and native soils containing organic matter, debris, deleterious or loose materials should be completely removed from below the pavement section prior to placing the pavement section. The exposed subgrade should be proof rolled to identify any remaining soft, loose, or disturbed soils. Where found, these materials should be excavated to expose competent, undisturbed, native subgrade materials. After the proof roll, a stabilization geotextile should be placed underneath the UTBC. The geotextile should be similar to a Mirafi 600X or approved substitute. The proof roll should be observed by a Geotechnical Engineer.

ADDITIONAL SERVICES

Subsurface conditions are inherently variable. It is important that we observe subsurface materials and conditions found at the site during construction, thereby taking advantage of opportunities to recognize potentially differing site conditions and reduce the risk of unanticipated and/or adverse outcomes. Such activities include, but are not necessarily limited to:

1. Observation and testing of site preparation and earthwork activities, including inspection during construction of the dikes, and foundation subgrade.
2. Review of Settlement Plate Data.
3. Consultation as may be required during construction.

We also recommend that we review project plans for compatibility with our assessments and recommendations. Additional information regarding such services can be obtained from our office.

LIMITATIONS

The assessments and recommendations presented in this document are based on limited field studies and laboratory testing, as well as our understanding of the project's design and manner of construction. If the project's design or manner of construction changes, or if conditions are found that are different from those described, we should be notified immediately so that we can make revisions as necessary. We recommend that project plans, specifications, and construction-related submittals be reviewed by GC for compatibility with our recommendations.

This document was prepared solely for the use of the addressee (our Client) for the specified project and may not contain sufficient information for other parties or uses. Also, this document does not constitute a specification and should not be treated or referred to as such in project design drawings or contract documents.

We represent that our services are performed within the limitations prescribed by our Client, in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation, expressed or implied, and no warranty or guarantee is included or intended. We do not assume responsibility for the accuracy of information provided by others.

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Table 1: Field Study Locations

Bear Lake Marina Expansion



Location ID	Date Started	Latitude ^a	Longitude ^a	Elevation (ft) ^a	Total Depth (ft)	Ground Water Depth (ft)	Field Study Method	Site	Comments
22-TP-01	12/20/2022	41.9665634	-111.3975970	5918.3	14.5	14	Excavator	Marina Area	
22-TP-02	12/20/2022	41.9667878	-111.3975760	5918.1	14.0	14	Excavator	Marina Area	
22-TP-03	12/20/2022	41.9685955	-111.3993755	5917.4	14.0	11	Excavator	Marina Area	
22-TP-04	12/20/2022	41.9689395	-111.4001052	5919.4	15.0	10	Excavator	Marina Area	
22-TP-05	12/20/2022	41.9678570	-111.3988270	5917.5	15.0	10	Excavator	Marina Area	
22-TP-06	12/20/2022	41.9664919	-111.3970447	5917.6	13.5	Not Found	Excavator	Marina Area	
22-TP-07	12/20/2022	41.9673990	-111.3983238	5917.2	15.0	10	Excavator	Marina Area	
22-TP-08	12/20/2022	41.9648981	-111.4009587	6008.1	15.0	Not Found	Excavator	West Parking Area	
22-TP-09	12/20/2022	41.9650499	-111.4006289	6004.0	15.0	Not Found	Excavator	West Parking Area	
22-TP-10	12/20/2022	41.9653241	-111.4013478	6012.0	15.0	Not Found	Excavator	West Parking Area	
22-TP-11	12/20/2022	41.9656076	-111.4013656	6014.8	15.5	Not Found	Excavator	West Parking Area	
22-TP-12	12/20/2022	41.9659056	-111.4009808	6007.9	15.0	Not Found	Excavator	West Parking Area	
22-TP-13	12/22/2022	41.9680300	-111.2714300	5967.0	14.0	Not Found	Excavator	Rainbow Cove Area	
22-TP-14	12/22/2022	41.9688700	-111.2708300	5974.0	15.0	Not Found	Excavator	Rainbow Cove Area	
22-TP-15	12/22/2022	41.9711300	-111.2701000	5965.0	15.0	Not Found	Excavator	Rainbow Cove Area	
22-TP-16	12/22/2022	41.9744700	-111.2692400	5966.0	15.5	Not Found	Excavator	Rainbow Cove Area	
23-TH-01	5/8/2023	41.9658061	-111.3991168	5935.6	31.0	Not Found	HSA	Marina Area	Piezometer Measurements
23-TH-01-PZ	5/12/2023					2.8			
	3/11/2024					4.0			
23-CPT-02	5/9/2023	41.9665880	-111.3991998	5930.8	10.4	--	CPT	Marina Area	
23-TH-03	5/9/2023	41.9672220	-111.3994155	5924.6	22.0	7	HSA	Marina Area	

Table 1: Field Study Locations

Bear Lake Marina Expansion



Location ID	Date Started	Latitude ^a	Longitude ^a	Elevation (ft) ^a	Total Depth (ft)	Ground Water Depth (ft)	Field Study Method	Site	Comments
23-TH-04	5/9/2023	41.9682516	-111.3999499	5920.1	22.0	Not Found	HSA	Marina Area	
23-TH-05	5/10/2023	41.9665315	-111.3978200	5920.0	52.0	7.5	HSA/Mud Rotary	Marina Area	
23-CPT-06	5/9/2023	41.9664743	-111.3978438	5920.6	50.0	--	CPT	Marina Area	
23-TH-07	5/11/2023	41.9662112	-111.3954012	5934.1	70.0	16.2	HSA/Mud Rotary	Marina Area	
23-CPT-08	5/9/2023	41.9676137	-111.3994367	5919.9	10.4	--	CPT	Marina Area	
23-TH-09	5/9/2023	41.9685727	-111.3999739	5919.3	41.8	At Ground Surface	HSA	Marina Area	
23-CPT-10	5/9/2023	41.9689091	-111.4002784	5919.2	4.5	--	CPT	Marina Area	
23-CPT-10a	5/9/2023	--	--	--	8.5	--	CPT	Marina Area	Attempted near CPT-10
23-CPT-10b	5/9/2023	--	--	--	9.3	--	CPT	Marina Area	Attempted near CPT-10
23-TH-11	5/8/2023	41.9657270	-111.3990688	5935.3	12.0	Not Found	HSA	Marina Area	
23-TH-12	5/8/2023	41.9653100	-111.3992300	5935	10.0	Not Found	HSA	Marina Area	
23-CPT-13	5/9/2023	41.9673500	-111.3992600	5920.2	13.8	--	CPT	Marina Area	

Note:

- a) Locations surveyed by Meridian Engineering
- b) Locations 23-TH-12 and 23-CPT-13, Latitude/Longitude data established by Gerhart Cole via hand held GPS.
- c) Locations 23-TH-12 and 23-CPT-13, elevations approximated from topographic survey provided by KH.

Table 2: Laboratory Test Results Summary - Test Pits
Bear Lake Marina Expansion



Borrow Area	Test Pit ID	Depth (ft)	Moisture content (%)	Atterberg Limits			Grain-Size				Grain-Size Analysis (Percent Finer)												Std. Proctor		Comments
				LL (%)	PL (%)	PI (%)	COBBLES (3" - 6")	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	6-in (150 mm)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Max. dry unit weight, γ_{d-max} (pcf)	Optimum moisture content, w_{opt} (%)	
N. Marina	22-TP-01	1-14.5 ft	31.0	NP	NP	NP	0	0	35	65	100	100	100	100	100	100	99	98	97	96	92	65	105.1	17.1	CBR
N. Marina	22-TP-03	1-14 ft	33.8	50	24	26	6	3	33	61	100	100	100	97	95	94	90	86	83	80	75	61			Collapse/Swell; LPS
N. Marina	22-TP-06	1-13.5 ft	29.7	NP	NP	NP	0	0	33	67	100	100	100	100	100	100	100	99	98	95	87	67	105.1	16.7	CBR
N. Marina	22-TP-07	10-12 ft	19.8	NP	NP	NP	13	4	54	33	100	100	100	96	91	87	69	58	51	48	46	33			
W. Parking	22-TP-08	0-1.5 ft	14.4	29	20	9	28	28	42	30	100	100	100	100	89	72	57	48	44	41	38	30			Collapse/Swell
W. Parking	22-TP-08	1.5-3.5 ft	5.3	NP	NP	NP	1	1	14	85	100	100	100	100	99	99	99	98	98	98	97	85			
W. Parking	22-TP-08	3.5-15 ft	24.9				2	2	14	84	100	100	100	100	99	98	97	95	92	89	87	84			
W. Parking	22-TP-09	1-14 ft	40.6				4	1	44	52	100	100	98	97	97	96	94	84	74	66	60	52			
W. Parking	22-TP-10	0-3 ft	16.2	58	18	40	20	1	8	72	100	100	81	81	81	80	79	78	77	75	74	72			Collapse/Swell
W. Parking	22-TP-10	3-15 ft	29.4				5	1	42	53	100	100	97	96	95	95	92	83	73	65	59	53	88.6	30.9	Collapse/Swell, CBR, LPS
W. Parking	22-TP-12	3-15 ft	21.6				3	2	13	84	100	100	100	99	98	97	96	95	92	90	88	84	99.7	21.2	
Rainbow Cove	22-TP-13	5-14 ft	7.7	25	14	11	0	12	52	48	100	100	90	81	74	69	67	65	63	60	55	48			Collapse/Swell; LPS
Rainbow Cove	22-TP-15	8-15 ft	7.4	33	18	15	6	17	51	37	100	94	84	74	64	57	54	48	46	44	41	37	123.0	10.5	
Gun Range	Bucket 1	-	2.9				29	29	37	5	100	71	63	51	46	42	40	35	23	14	8	5			
Gun Range	Bucket 2	-	3.4				18	38	39	5	100	82	70	56	48	44	41	36	23	14	8	5			
Gun Range	Bucket 3	-	4.1				18	46	29	7	100	82	65	51	41	36	32	27	19	12	9	7			
Gun Range	Combined Samples																						140.8	5.6	Combined Bucket 1, 2, 3; CU

Table 2: Laboratory Test Results Summary - Test Pits
Bear Lake Marina Expansion



Borrow Area	Test Pit ID	Depth (ft)	Moisture content (%)	Atterberg Limits			Grain-Size				Grain-Size Analysis (Percent Finer)												Std. Proctor		Comments
				LL (%)	PL (%)	PI (%)	COBBLES (3" - 6")	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	6-in (150 mm)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Max. dry unit weight, γ_{d-max} (pcf)	Optimum moisture content, w_{opt} (%)	
Johnson Site	24-TP-01 at 3-5 ft	-	10.5	35	18	17	14	22	31	33	100	86	81	74	68	64	60	56	51	47	41	33			
Johnson Site	24-TP-01 at Mixed	-	12.6	31	16	15	1	42	27	29	100	99	76	70	62	57	53	49	45	41	37	29			
Johnson Site	24-TP-02 at 8-10 ft	-	11.4	27	20	7	3	47	32	17	100	97	84	74	59	50	43	37	32	27	23	17			
Johnson Site	24-TP-03 at 9 ft		21.1	56	21	35																			
Johnson Site	24-TP-06 at Mixed		10.8	38	17	21	0	19	31	50	100	100	89	86	84	81	78	75	70	66	61	50			
Johnson Site	24-TP-07 at Mixed		9.5	31	24	7	8	32	39	21	100	92	82	74	67	60	54	46	38	33	28	21			
Johnson Site	Composite Sample		10.4	32	19	13	0	23	36	41	100	100	100	100	84	77	72	66	60	55	50	41	107.2	13	CU

Notes

- 1) LPS - Load to prevent Swell Testing - See Results in Appendix D
- 2) Collapse/Swell Testing - See Results in Appendix D
- 3) CBR - California Bearing Ratio - See Results in Appendix D
- 4) CU - Consolidated Undrained Triaxial Test - See Results in Appendix D

Table 3: Laboratory Test Results Summary - Test Holes
Bear Lake Marina Expansion



Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)										Strength Parameters		Corrosion				Other Tests		
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)		Soluble sulfate (ppm)	
23-TH-01	2.5-4.5 ft	70.6						0	21	79	100	100	100	100	100	99	98	97	94	89	79								
23-TH-01	5-7 ft	43.6	73	104	57	34	23															2256	576	325					CON
23-TH-01	7.5-9.5 ft	58.2						1	40	59	100	100	100	100	99	97	93	88	82	75	59				8.3	79	ND		
23-TH-01	12.5-14.5 ft	26.5						1	11	88	100	100	100	100	99	99	99	98	96	94	88								
23-TH-01	20-20.9 ft	13.5						12	32	56	100	100	100	96	88	77	70	66	63	60	56								
23-TH-01	25-27 ft	21.3						0	43	57	100	100	100	100	100	100	95	85	77	68	57								
23-TH-03	2.5-4.5 ft	16.2						7	26	67	100	100	100	97	93	90	86	82	78	75	67								
23-TH-03	7.5-9.5 ft	20.9	94	113	58	21	37															2660	432						CON
23-TH-03	12.5-13.9 ft	19.7			53	19	34	0	15	85	100	100	100	100	100	100	97	93	90	88	85								
23-TH-04	2.5-4.5 ft	10.4						29	53	18	100	100	97	84	71	49	42	39	36	29	18								
23-TH-04	5-7 ft	15.5						31	38	31	100	92	89	79	69	55	48	45	43	39	31								
23-TH-04	7.5-9.5 ft				46	22	24																						
23-TH-04	7.5-14.5 ft				61	21	40																						Collapse/Swell
23-TH-04	10-12 ft	32.0	91	120																		1210	576						CON
23-TH-04	15-17 ft	18.5			48	18	30																						
23-TH-05	2.5-4.5 ft				NP	NP	NP																						Collapse/Swell
23-TH-05	5-7 ft	32.6	90	119	NP	NP	NP															956	432						CON
23-TH-05	7.5-9.5 ft	28.6						0	46	54	100	100	100	100	100	97	94	89	84	80	54								
23-TH-05	12.5-14.5 ft	11.9						31	54	15	100	100	100	85	69	48	38	32	28	24	15			1,150	8.4	15	61		
23-TH-05	15-17 ft	23.0			38	16	22																						

Table 3: Laboratory Test Results Summary - Test Holes
Bear Lake Marina Expansion



Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)										Strength Parameters		Corrosion				Other Tests	
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES (<No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)		Soluble sulfate (ppm)
23-TH-05	20-22 ft				58	19	39																					
23-TH-05	30-32 ft	50.1			59	31	28																					
23-TH-05	45-47 ft	43.9			80	50	30																					
23-TH-05	15-27 ft				76	24	52																					Collapse/Swell
23-TH-07	2.5-4.5 ft	27.9			59	27	32																					
23-TH-07	7.8-9.5 ft	24.3			46	20	26																					
23-TH-07	7-12 ft	21.0			38	19	19	8	19	73	100	100	100	95	92	89	86	83	81	79	73							CBR, Proctor
23-TH-07	20-22 ft	27.9	96	120	32	22	10															834	2275					CON
23-TH-07	25-27 ft	29.3						5	86	9	100	100	97	96	95	94	85	63	35	17	9							
23-TH-07	35-37 ft	30.5	91	119	NP	NP	NP															2472	3168					CON
23-TH-07	45-47 ft	35.9	80	109	37	25	12															776	3744					CON
23-TH-07	50-52 ft	32.5						4	51	45	100	100	96	96	96	88	79	73	70	65	45							
23-TH-07	55-56 ft	18.4						4	91	5	100	100	100	100	96	62	17	11	9	7	5							
23-TH-07	56-57 ft	17.0						13	47	40	100	100	100	96	87	74	68	64	60	52	40							
23-TH-07	57-58.3 ft	12.1						58	29	13	100	100	64	49	42	35	25	21	18	16	13							
23-TH-09	5-7 ft	19.8			26	19	7	9	60	31	100	100	96	94	91	80	70	60	51	43	31							
23-TH-09	7-9 ft	10.0						45	47	8	100	81	71	63	55	34	25	21	18	15	8							
23-TH-09	10-12 ft	28.4			43	20	23																					
23-TH-09	15-17 ft	23.9			50	20	30																					CON
23-TH-09	25-26.9	16.3			39	17	22																					
23-TH-11	5-7 ft	40.5			65	34	31	3	37	60	100	100	100	99	97	95	91	87	83	76	60							
23-TH-11	0-10 ft	20.8			44	18	26	23	44	33	100	100	99	91	77	66	57	50	44	39	33							CBR, Proctor

Table 3: Laboratory Test Results Summary - Test Holes
Bear Lake Marina Expansion



Test Hole	Depth (ft)	Moisture content (%)	Dry unit weight (pcf)	Moist / Sat. unit weight (pcf)	Atterberg Limits			Grain-Size			Grain-Size Analysis (Percent Finer)										Strength Parameters		Corrosion				Other Tests		
					LL (%)	PL (%)	PI (%)	GRAVEL (No.4 - 3")	SAND (No.200-No.4)	FINES ($<$ No.200)	3-in (75 mm)	1.5-in (37.5 mm)	3/4-in (19 mm)	3/8-in (9.5 mm)	No.4 (4.75 mm)	No.10 (2 mm)	No.20 (0.85 mm)	No.40 (0.425 mm)	No.60 (0.25 mm)	No.100 (0.15 mm)	No.200 (0.075 mm)	Peak shear stress, (s1-s3)/2 (psf)	Confining stress, (psf)	Resistivity (ohm-cm)	pH	Soluble chloride (ppm)		Soluble sulfate (ppm)	
23-TH-12	7.5-9.5 ft	26.2			47	18	29	3	46	51	100	100	100	99	97	90	80	71	65	60	51								
23-TH-12	2.5-10 ft	10.9			25	16	9	22	44	34	100	100	99	92	78	63	54	48	43	39	34								CBR, Proctor

Notes

- 1) CON - Consolidation Testing - See Results in Appendix E
- 2) Collapse/Swell Testing - See Results in Appendix E
- 3) CBR - California Bearing Ratio - See Results in Appendix E

Table 4: Seismic Design Parameters
 Bear Lake Marina Expansion - Structures



Site Class	Type of MCE Acceleration	Mapped [B/C Boundary] Acceleration (g)			Site Coefficient			Design Acceleration (g)			
		---	S_s	S_1	---	F_a	F_v	Multiplier	PGA_R	S_{DS}	S_{D1}
D (with data)	Risk-targeted (structural)	---	1.02	0.34	---	1.09	N/A	0.667	0.30	0.74	N/A
		(with exceptions, if any)			---	(1.09)	(1.96)		(0.30)	(0.74)	(---)
	Geo-mean (geotechnical)	PGA	---	---	F_{pga}	---	---	Multiplier	PGA_M	---	---
		0.45	---	---	1.15	---	---		0.52	---	---
		(with exceptions, if any)			(1.15)	---	---	1.0	(0.52)	---	---

- Notes:
1. TL = 6 sec.
 2. "N/A" indicates site specific study is required.
 3. Exceptions taken include: #2: Seismic Response Coefficient C_s is modified, and ELF or MRSA is used.

Table 5: Calculated Liquefaction-Induced Settlement and Lateral Spread

Bear Lake Marina Expansion



Location	Substantial Liquefiable ^a Layers (Elev., feet)	Liquefaction-Induced Settlement (in)		Lateral Spread (ft)
		Youd et al. (2001) with Yoshimine et al. (2006)	Youd et al. (2001) with Tokimatsu and Seed (1987)	Youd et al. (2002) with CPT correlations
23-CPT-02	5920-5918 ^a	0.4	---	0
23-CPT-06	5920-5917 ^a ; 5915-5910	2.4	---	0
23-CPT-08	5918-5917 ^a	0.5	---	0
23-CPT-10b	5919-5911 ^a	1.7	---	0
23-CPT-13	5917-5916 ^a	0.3	---	0
23-TH-04	---	0	0	---
23-TH-05	5920 - 5910	5.4	3.2	---
23-TH-07	5910 - 5902; 5881-5877	7.1	3.8	---
23-TH-09	5919 - 5915	1.8	1	---

Note:

a) Interval includes multiple interbedded layers that alternate between liquefiable and nonliquefiable, with the liquefiable layers generally being less than 2 feet in thickness at CPTs

Table 6: Recommended Gradations of Breakwater Material

Bear Lake Marina Expansion

Lake Armor		Marina Armor		Dike Material / Subarmor		Core		General Fill	
Nominal Diameter (in)	Percent Passing	Nominal Diameter (in)	Percent Passing	Nominal Diameter (in) / Sieve Size	Percent Passing	Nominal Diameter (in) / Sieve Size	Percent Passing	Nominal Diameter (in) / Sieve Size	Percent Passing
--	--	--	--	12 ^b	95	--	--	--	--
--	--	--	--	6	70-100	--	--	--	--
48	100	--	--	3	50-100	--	--	--	--
40	75-100	12	100	2	40-80	--	--	--	--
30	30-70	10	70-100	1	30-65	3	100	--	--
20	20-40	7	30-70	#4	15-50	#4	80-100	--	--
12	5-20	5	0-40	#20	8-45	#20	70-100	12	100
8 (min)	0-5	3 (min)	0-5	#200 (0.075 mm)	0-20	#200 (0.075 mm)	40-90	#200 (0.075mm) ^a	0-40

Note

a) Maximum plasticity index (PI) < 15

b) Larger particles up to 18 inches should be pushed to outer sides of dike material to be near either Lake or Marina Armor.

Table 7: Summary of Material Properties for Global Stability Analyses

Bear Lake Marina Expansion



Idealized Material	Moist Unit Weight (pcf)	Construction Case (Undrained)	Long Term Case (Drained)	Pseudo-Static Seismic Case	Data Source
		Phi S_u (psf)	Phi c (psf)	Phi c (psf)	
Native Soil - Clayey Soil	115	0 1300	28 100	0 1300	Correlations/GC Testing
Dike Material	135	(N/A; use Long Term)	34 150	30 500	GC Testing
Riprap	125	(N/A; use Long Term)	40 0	40 0	Correlations
Native Soil - Sand to Sandy Silt	115	(N/A; use Long Term)	32 0	32 0	Correlations/GC Testing

Table 8: Summary of Global Stability Analyses

Bear Lake Marina Expansion



Description/Location (Wall Height [ft])	Lake Level	Construction/ Short-Term	Lake Level	Long-Term Static	Lake Level	Horizontal Seismic Coefficient	Pseudostatic Seismic
	ft	FS ⁽¹⁾	ft	FS ⁽¹⁾	ft	Kh	FS ⁽¹⁾
Section A-2; Marina Side	5930	1.47	5930	1.65	5922	0.175	1.83
	5925	1.48	5908	1.47	--	--	--
Section A-2; Lake Side	--	--	5930	1.77	5922	0.175	1.17
	--	--	5908	1.57	--	--	--
Section A-3; Marina Side	5901	1.62	5930	1.75	5922	0.175	2.09
	--	--	5908	1.44	--	--	--
Section A-4; Marina Side	5930	1.51	5930	1.65	5922	0.175	1.24
	5925	1.53	5908	1.47	--	--	--
Section A-4; Lake Side	--	--	5930	1.65	5922	0.175	1.08
	--	--	5908	1.44	--	--	--

⁽¹⁾ Minimum Required Factors of Safety (FS) near bridges or critical facilities [GMOI, Section 12.2.3]:

End of Construction and Temporary Slopes:	FS = 1.2 under static loads
Long Term Static:	FS = 1.3 under static loads for permanent embankments and cut slopes
Seismic (Pseudostatic):	FS = 1.0 under pseudostatic (seismic) loads for embankments and cut slopes ($k_h = 0.5 A_s$)
Post-Earthquake:	FS = 1.1 under post earthquake loads

Table 9: Lateral Earth Pressures - Marina Infrastructure

Bear Lake Marina Expansion



Material	Moist Unit Weight (pcf)	Earth Pressure Coefficients				
		Active Static	Active Seismic Component	At-Rest	At-Rest Seismic Component	Passive Static
General Fill	130	0.33	0.19	0.50	0.39	3.00
Dike Material / Subarmor	135	0.28	0.18	0.44	0.39	3.54

Notes:

- a. Buoyant unit weights should be used below design water elevations and hydrostatic pressures added to these values.
- b. Seismic components should be added to the static coefficients.

Table 10a: Generalized Soil Profile for Lateral Pile Capacity Analyses; Dock Piles - Clay Profile

Bear Lake Marina Expansion



Soil Layer	Bottom of Layer Elevation (ft)	Effective unit weight (pcf)	P-Y Curve	Initial soil modulus, k (pci)	Drained friction angle, ϕ' (deg)	Undrained shear strength (psf)	Reference strain for 50% strength, e50
1 (CL) Clay below the water table; cemented layers	5880	53	Stiff Clay w/Free Water (Reese)	---	---	2000	0.005

Notes

(1) Calculated corrosion losses for a 75 year design life are 0.1 inches within native soils.

Table 10b: Generalized Soil Profile for Lateral Pile Capacity Analyses; Dock Piles - Mixed Profile

Bear Lake Marina Expansion



Soil Layer	Bottom of Layer Elevation (ft)	Effective unit weight (pcf)	P-Y Curve	Initial soil modulus, k (pci)	Drained friction angle, ϕ' (deg)	Undrained shear strength (psf)	Reference strain for 50% strength, ϵ_{50}
1 (ML) Silt and Clay below the water table	5885	53	Stiff Clay w/Free Water (Reese)	---	---	1300	0.007
2 (SM) - Sand, some silt	5877	68	API Sand	30	30	---	---
3 (CL) Clay below the water table	5865	68	API Sand	70	34	---	---

Notes

(1) Calculated corrosion losses for a 75 year design life are 0.1 inches within native soils.

Table 11: Traffic Information

Bear Lake Marina Expansion



Marina Traffic		
Parameter	Year 2021	Year 2041
AADT	645	1,413
AASHTO Vehicle Class	% of AADT	% of AADT
Class 1 and 2	0.000	0.000
Class 3	93.750	93.750
Class 4	1.000	1.000
Class 5	0.000	0.000
Class 6	5.000	5.000
Class 7	0.000	0.000
Class 8	0.000	0.000
Class 9	0.000	0.000
Class 10	0.250	0.250
Class 11	0.000	0.000
Class 12	0.000	0.000
Class 13	0.000	0.000
Sum =	100	100
ESAL	355,326	

- Notes:
1. AADT = average annual daily traffic.
 2. AADT for one direction traffic.
 3. AADT interpreted from traffic data provided by KH.
 - 4 ESAL = Equivalent Single Axial Load

Table 12 Recommended Pavement Sections
- Main Parking Lot & Access Roads
 Bear Lake Marina Expansion



% Trucks (Larger Boats & Service Trucks)		6.25%
ESAL		355,326
Thickness (in)		
Component	Alternative 1	Alternative 2
HMA	4.5	4.5
UTBC	6.0	6.0
GB Subbase	- - -	12.0
Total Pavement Section	10.5	22.5

Notes: 1. HMA = hot mix asphalt; UTBC = untreated base course; GB = granular borrow
 2. See text for additional details

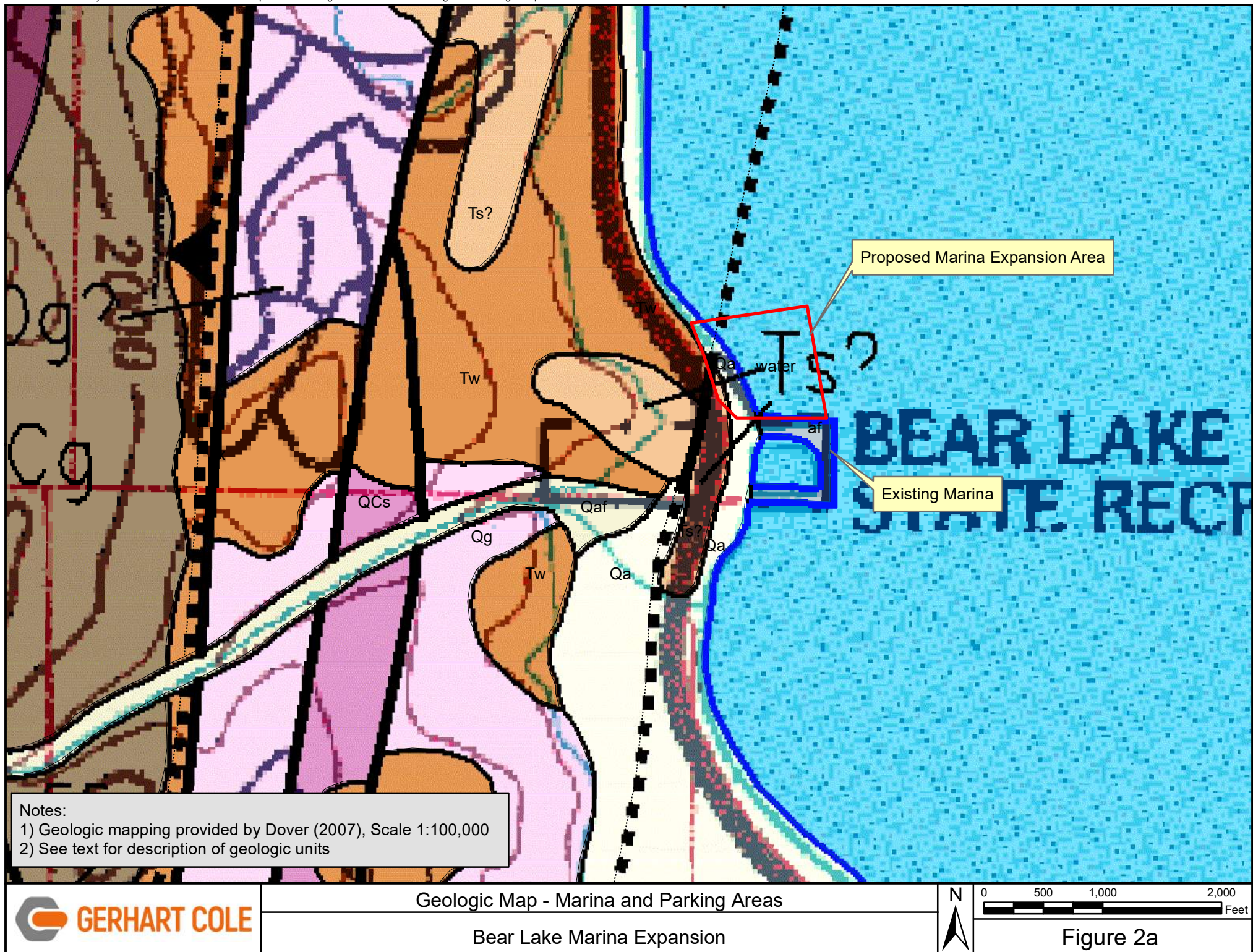
Table 13: Recommended Pavement Sections
- Breakwater/Dike Parking Lots
 Bear Lake Marina Expansion



% Trucks (Larger Boats & Service Trucks)		6.25%
ESAL		177,663
Thickness (in)		
Component	Alternative 1	Alternative 2
HMA	4.0	4.0
UTBC	6.0	6.0
GB Subbase	- - -	12.0
Total Pavement Section	10.0	22.0

Notes: 1. HMA = hot mix asphalt; UTBC = untreated base course; GB = granular borrow
 2. See text for additional details





DESCRIPTION OF GEOLOGIC MAP UNITS

From Dover (2007) Geologic Map of Logan (30'x60') Quadrangle

- Qa Main-stream alluvium (Holocene)** - Unconsolidated, crudely stratified, clay- to boulder size material deposited in channels and flood plains of major streams, including Bear, Little Bear, and Logan Rivers, and Blacksmith Fork; locally includes alluvial fan and terrace deposits, colluvium, talus, or lake deposits. Contacts with side-stream alluvium (unit Qaf) are gradational and arbitrarily drawn in places. Thickness generally a few meters or less.
- Ts? Salt Lake Formation (Pliocene and Miocene)** - White to pale-green or gray, poorly consolidated, tuffaceous to marly sand and silt and subordinate thin interbeds of volcanic ash and gravel; locally contains intermixed red mud, sand, and gravel thought to be reworked from adjacent exposures of the Wasatch Formation. Thickness of as much as several thousand feet reported by Williams (1964) may include some beds now mapped as the Fowkes Formation or Norwood Tuff. Pliocene to Miocene age based on fossil plants (Brown, 1949), ostracods, and mollusks (Yen, 1947; Adamson and others, 1955); K-Ar dates of 11.6 ± 1.4 m.y. and 18.9 ± 1.6 m.y. reported by Williams (1964); fission-track age on zircon of 7.9 ± 2.0 m.y. (at 2 sigma level) reported by G.A. Izett (written commun., 1981). Mapped only in Cache Valley and Bear Lake areas; appears to be patchy and to occupy erosional depressions on Wasatch Formation in Bear Lake area.
- Tw Wasatch Formation (middle and lower Eocene)** - Red, pale-red, and reddish-buff, crudely stratified, poorly sorted grit, conglomerate, and siltstone; locally includes interbeds of lacustrine pisolitic limestone and marl. Some interbeds of conglomerate are gray and contain mainly well-rounded pebbles and cobbles of Paleozoic carbonate rocks. Characterized by abrupt facies changes and interfingering of lithic types. Maximum thickness is a few hundred meters in areas east of Bear Lake and west of Randolph, Utah.
- Qaf Side-stream alluvium and fan deposits (Holocene and Pleistocene)** - Unconsolidated, crudely stratified, clay to boulder-size material deposited in tributary stream channels and alluvial fans; commonly includes terrace deposits, colluvium, talus, or lake deposits. Gradational into main-stream alluvium and colluvium units. Thickness a few meters or less.
- Og Garden City Formation (Middle and Lower Ordovician)** - Mainly gray, thin-bedded, slabby limestone and argillaceous limestone characterized by intraformational limestone conglomerate and breccia; upper 70 m typically dolomitic and cherty (shown by dotted line on map). Thickness 370-520 m (Ross, 1951).
- OCs St. Charles Formation (Lower Ordovician and Upper Cambrian)** - Gray to dark-gray, mottled, thin-bedded to massive, algal-mat dolostone, dolomitic limestone, and limestone in upper member; basal Worm Creek Quartzite Member mapped separately in most places. Estimated thickness 300-400 m.
- af Artificial fill (Holocene)** - Includes unconsolidated materials used in highway and dam construction and waste rock produced by phosphate mining.

Notes: 1. See Figure 2a for geologic mapping (Dover 2007) near the project.

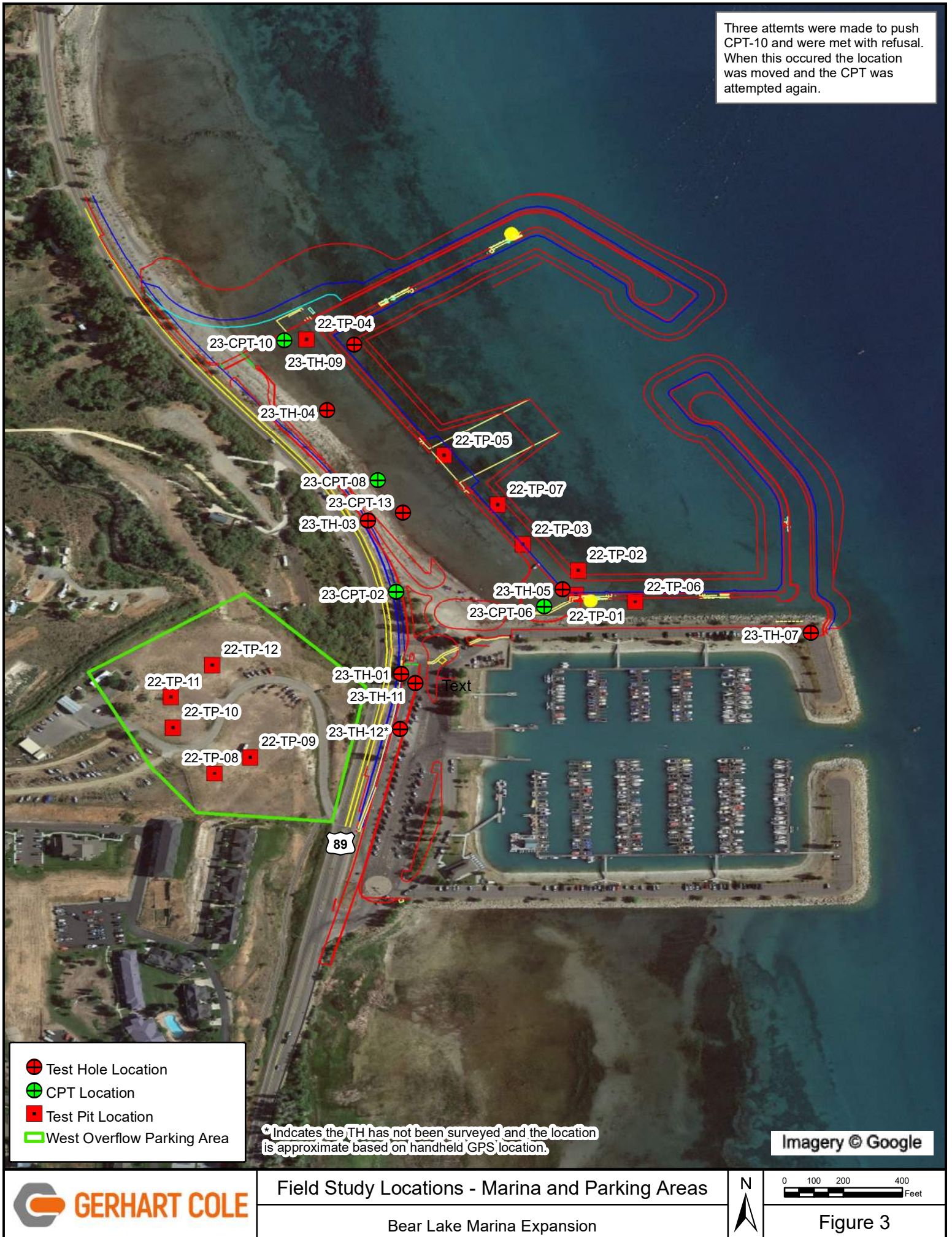


DESCRIPTION OF GEOLOGIC MAP UNITS

Bear Lake Marina Expansion

Figure 2b

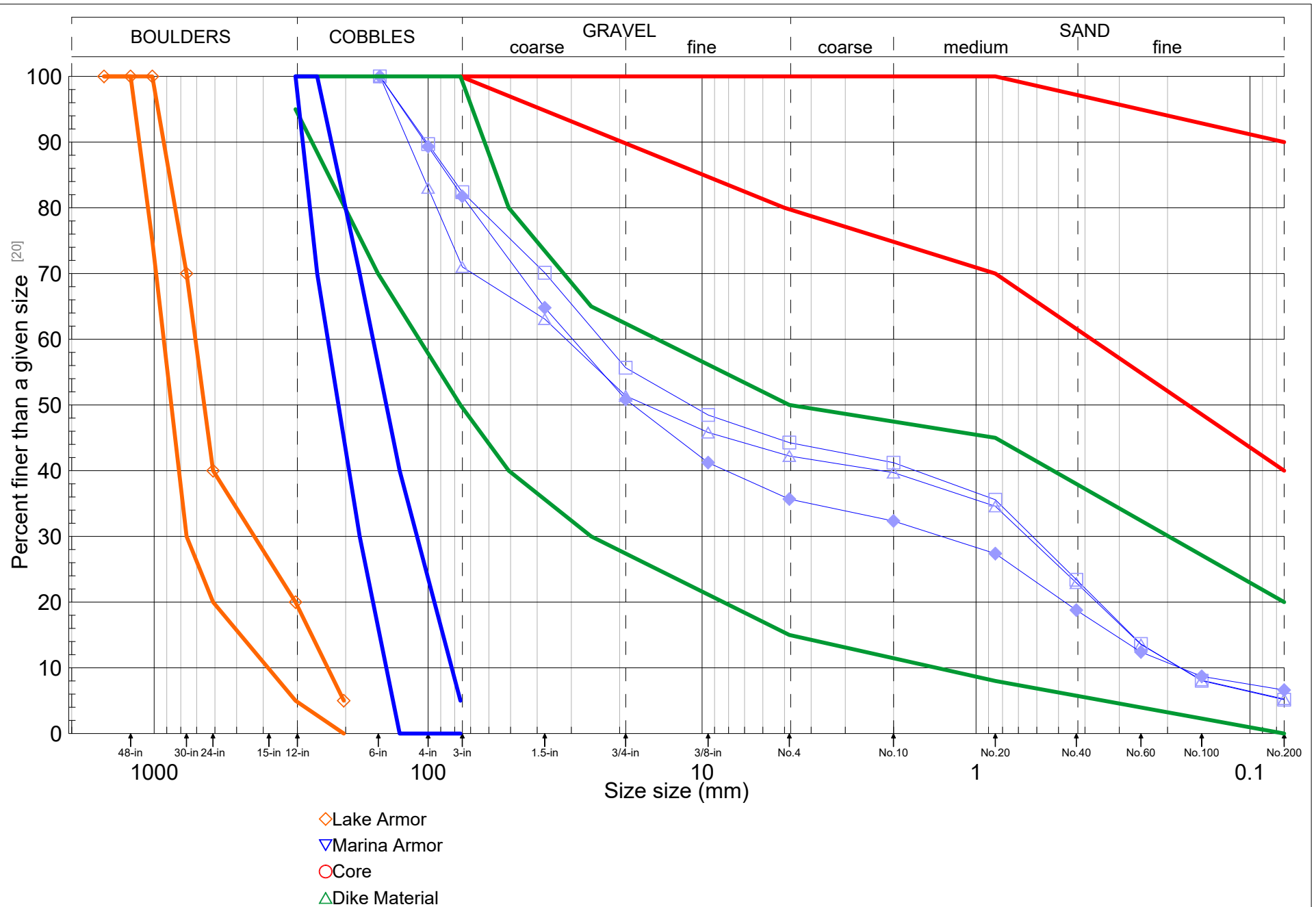
Three attempts were made to push CPT-10 and were met with refusal. When this occurred the location was moved and the CPT was attempted again.





Test Pit Locations

Imagery © Google





Appendix A

Test Pit Logs Bear Lake Marina Expansion

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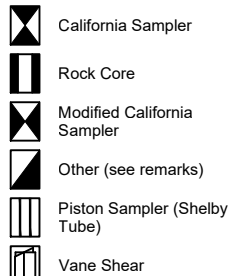
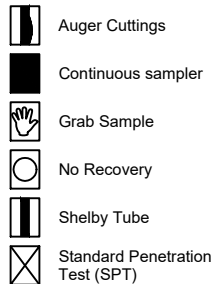
Unified Soil Classification System (USCS)

Material Types	Major Soil Divisions		Group Symbol and Legend		Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)		GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
				GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)		GM	Silty GRAVEL, GRAVEL-sand silt mixtures
				GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)		SW	Well-Graded SAND, SAND-gravel mixtures, few fines
				SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)		SM	Silty SAND, SAND-silt mixtures
				SC	Clayey SAND, SAND-clay mixtures
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
				ML	SILT, Gravelly/Sandy SILT, no to slight plasticity
		Organic		OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
				MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic		OH	Organic CLAY or SILT
	Highly organic soils		Primarily Organic Matter; Organic Odor		PT
Boulders / Cobbles		> 50% (by volume) particles > 3"	 COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")	

Other Material Symbols



Sample Types



Apparent water level Measured water level

Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID

MC - Modified California: 2.5" OD, 1.875" ID

CAL - California: 3" OD, 2.375" ID

R - Practical Refusal For Sampling Method

Stratification		Modifiers	
Description	Criteria	Description	Est. (%)
Seam	1/16" to 1/2"	Trace	<5
Layer	1/2" to 12"	Some	5-12
Occasional	<= 1 per ft. thickness	With	12-30
Frequent	> 1 per ft. thickness	-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

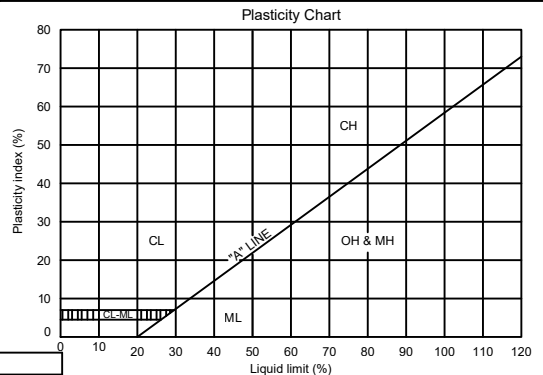
Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than an orange
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than a table salt grain
Fine Sand	No.200-40 : smaller than table salt grain

Descriptors for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviations for Laboratory Testing

Description	Criteria
Su	Peak Undrained Shear Stress
UU	Unconsolidated Undrained Triaxial
CON	One-dimensional Consolidation
AL	Atterberg Limits (LL=Liquid Limit & PI=Plasticity Index)
SV / GSD	Sieve / Grain-Size Distribution Testing
CORR	Corrosion - Resistivity



Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix
s = sandy
g = gravelly

Suffix
s = with sand
g = with gravel
c = with cobbles
b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:

- 1) Stratigraphic lines on the logs represent approximate boundaries.
- 2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
- 3) Logs represent soil conditions observed at the point of exploration on the date indicated.
- 4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.
- 5) Soil descriptions were developed based on visual/manual classification methods and drilling or sampling behavior. Where judged appropriate, soil descriptions, classifications, and consistency/apparent density have been refined based on laboratory testing or correlations with other field tests/observations.



Legend to Soil Descriptions

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-01
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	14.5
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	E to W
Groundwater Depth (feet)	14	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5918.3
Comments North Marina				Latitude / Longitude	41.96656 , -111.39760

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SILT, sandy - medium stiff, moist to wet, dark gray to dark bluish gray, fine to medium sand, (ML)	Consistencies/densities estimated from field observation and equipment effort during excavation.
	2					
	3					
5914	4					
	5					
	6					
	7					
	8	BULK-B-01				
5909	9					
	10					
	11					
	12					
	13					
5904	14					Water began entering test pit approximately 1 minute after excavation.
	15				Bottom of Hole at 14.5 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
5899	19					
	20					
	21					
	22					
	23					
5894	24					
	25					

Photo Identification: 22-TP-01	Date Taken: 12/20/2022
--	----------------------------------



Location:	22-TP-01	Description:	Inside view of the test pit.
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Date Taken:

12/20/2022

Photo Identification:

22-TP-01



Location:

22-TP-01

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-02
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	14.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	E to W
Groundwater Depth (feet)	14	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5918.1
Comments North Marina				Latitude / Longitude	41.96679 , -111.39758

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
5914	1				SILT, sandy - medium stiff to stiff, moist to wet, dark gray to bluish gray, fine to medium sand, (ML)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
	10					
	11					
	12					
	13					
5909	14					
5904	15				Bottom of Hole at 14 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
	19					
	20					
	21					
	22					
	23					
	24					
5894	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-02



Location:

22-TP-02

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:	12/20/2022
Photo Identification:	22-TP-02



Location:	22-TP-02	Description:	View of excavation spoils
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Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-03
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	14.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	SE to NW
Groundwater Depth (feet)	11	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5917.4
Comments North Marina				Latitude / Longitude	41.96860 , -111.39938

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
5913	1				CLAY, sandy, some gravel - medium stiff, moist to wet, dark gray to greenish gray, medium to high plasticity, pockets of lightly cemented silt and clay in angular clasts up to 3/8 inches, (CH)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
	5					
	6					
	7					
	8	BULK-01				
5908	9					
	10					
	11					Water entered test pit from sides approximately 1 minute after excavation.
	12					
	13					
5903	14				Bottom of Hole at 14 feet	Terminated test pit due to soil sloughing of sides of test pit at 14 feet.
	15					
	16					
	17					
	18					
5898	19					
	20					
	21					
	22					
	23					
5893	24					
	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-03



Location:

22-TP-03

Description:

Inside view of test pit

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-04
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	SE to NW
Groundwater Depth (feet)	10	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5919.4
Comments North Marina				Latitude / Longitude	41.96894 , -111.40011

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
5915	1				SAND, silty, trace gravels - soft to stiff, moist to wet, dark gray to dark purplish gray, fine to medium sand, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
	5					
	6					
	7					
	8					
	9					
5910	10					Water entered test pit from sides approximately 1 minute after excavation.
	11					
	12					
	13					
	14					
5905	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
	19					
5900	20					
	21					
	22					
	23					
	24					
5895	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-04



Location:

22-TP-04

Description:

Inside view of test pit

Date Taken:	12/20/2022
Photo Identification:	22-TP-04



Location:	22-TP-04	Description:	View of excavation spoils
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	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-05
---	--

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	S to N
Groundwater Depth (feet)	10	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5917.5
Comments North Marina				Latitude / Longitude	41.96786 , -111.39883

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
5913	1				SILT, sandy, trace cobbles - soft to medium stiff, wet to moist, dark gray to greenish gray, pockets of lightly cemented clay and silt in clasts up to 3 inches, (ML)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
	5					
	6					
	7					
	8		BULK-01			
	9					
5908	10					Water entered test pit from sides approximately 1 minute after excavation.
	11				CLAY - very stiff, lightly cemented angular clasts up to 8 inches, clasts easily scratched with finger nail and broken by hand, greenish gray to light greenish gray, (CL)	
	12					
	13					
	14					
5903	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
	19					
5898	20					

Date Taken:

12/20/2022

Photo Identification:

22-TP-05



Location:

22-TP-05

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:	12/20/2022
Photo Identification:	22-TP-05



Location:	22-TP-05	Description:	View of excavation spoils
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 GERHART COLE	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-06
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	13.5
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	E to W
Groundwater Depth (feet)	Not found	Date Measured		Approximate Surface Elevation (feet)	5917.6
Comments North Marina				Latitude / Longitude	41.96649 , -111.39704

Elevation, feet		Depth, feet		Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
5913		1					SILT, sandy - medium stiff, moist, dark gray to bluish gray, fine to coarse sand, nonplastic, (ML)	Consistencies/densities estimated from field observations and equipment effort during excavation.
		2						
		3						
		4						
		5						
		6						
		7						
		8						
		9						
		10						
		11						
		12						
		13						
5908		14					Bottom of Hole at 13.5 feet	Side walls of test pits began sloughing at 13 feet
		15						
		16						
		17						
		18						
		19						
		20						
		21						
		22						
		23						
		24						
		25						
5903		1						Terminated test pit due to soil sloughing side walls of test pit.
		2						
		3						
		4						
		5						
		6						
		7						
		8						
		9						
		10						
5898		11						
		12						
		13						
		14						
		15						
		16						
		17						
		18						
		19						
		20						
5893		21						
		22						
		23						
		24						
		25						

Date Taken:

12/20/2022

Photo Identification:

22-TP-06



Location:

22-TP-06

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:

12/20/2022

Photo Identification:

22-TP-06



Location:

22-TP-06

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-07
---	--

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	S to N
Groundwater Depth (feet)	10	Date Measured	12/20/2022	Approximate Surface Elevation (feet)	5917.2
Comments North Marina				Latitude / Longitude	41.96740 , -111.39832

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, silty, with gravel - loose, moist to wet, dark gray to purplish gray, nonplastic fines, fine to coarse sand, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
5913	4					
	5					
	6					
	7					
	8					
5908	9					
	10		GB-01		Transition to coarse wet sand	 Water slowly seeped into test pit from sides after excavation.
	11					
	12				CLAY - hard, lightly cemented angular clasts up to 8 inches, clasts easily scratched with finger nail and broken by hand, greenish gray to light greenish gray , (CH)	
	13		BULK-02			
5903	14					
	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
5898	19					
	20					

Date Taken:

12/20/2022

Photo Identification:

22-TP-07



Location:

22-TP-07

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:

12/20/2022

Photo Identification:

22-TP-07



Location:

22-TP-07

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-08
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	SE to NW
Groundwater Depth (feet)	Not found	Date Measured		Approximate Surface Elevation (feet)	6008.1
Comments West Parking Area				Latitude / Longitude	41.96490 , -111.40096

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1		GB-01		SAND, clayey, with gravel - loose, dry, dark red to dark yellow brown, nonplastic fines, angular to subangular gravel, roots, (SC). [FILL]	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2		BULK-02		SILT, with sand - soft, dry, light gray to light bluish gray, nonplastic, possibly dredged lake material, (ML), [FILL]	
6004	3					
	4				SILT, with sand, some gravel, some cobbles - soft to medium stiff, dry to moist, dark red to light brown, subrounded to subangular cobbles, occasional lightly to moderately cemented clasts up to 4 inches with calcium carbonate, (ML)	
	5					
	6					
	7					
	8					
	9		BULK-03			
5999	10					
	11					
	12					
	13					
5994	14					
	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
5989	19					
	20					
	21					
	22					
	23					
5984	24					
	25					
	26					
	27					
	28					
5979	29					
	30					

Date Taken:

12/20/2022

Photo Identification:

22-TP-08



Location:

22-TP-08

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken: 12/20/2022				
Photo Identification: 22-TP-08				
		Location:	22-TP-08	Description: Inside view of the test pit.
Date Taken: 12/20/2022				
Photo Identification: 22-TP-08				
		Location:	22-TP-08	Description: View of excavation spoils.
 GERHART COLE		FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
Bear Lake Marina Expansion		22-1523		

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-09
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By T. Kesler	Checked By R. Buhler
Approximate Length (feet)	19	Approximate Width (feet)	2
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction
Groundwater Depth (feet)	Not found	Date Measured	
Comments West Parking Area		Approximate Surface Elevation (feet)	6004.0
		Latitude / Longitude	41.96505 , -111.40063

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SILT, sandy, some gravel - soft to stiff. dry, pale olive brown to olive brown, nonplastic fines, clasts of soil from 3 inches to 6 inches, calcium carbonate staining, (ML)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
5999	5					
	6					
	7					
	8	BULK-01				
	9					
5994	10					
	11					
	12					
	13					
	14					
5989	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
	19					
5984	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-09



Location:

22-TP-09

Description:

Inside view of test pit

Date Taken:

12/20/2022

Photo Identification:

22-TP-09



Location:

22-TP-09

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-10
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By T. Kesler	Checked By R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction
Groundwater Depth (feet)	Not found	Date Measured	
Comments West Parking Area		Approximate Surface Elevation (feet)	6012.0
		Latitude / Longitude	41.96532 , -111.40135

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				CLAY, with gravel, some sand - soft, dry to moist, dark brown to dark olive gray, medium to high plasticity, roots, (CH)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2	☞	GB-01			
	3					
	4				SILT, sandy, some gravel - loose to dense. dry, pale olive brown to olive brown, clasts of soil lightly to moderately cemented ranging up to 4 inches to 6 inches, calcium carbonate staining, (ML)	
6007	5					
	6					
	7					
	8					
	9	☞	BULK-02			
6002	10					
	11					
	12					
	13					
	14					
5997	15				Bottom of Hole at 15 feet	
	16					Terminated test pit due to reaching maximum reach of excavator.
	17					
	18					
	19					
5992	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-10



Location:

22-TP-10

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:	12/20/2022
Photo Identification:	22-TP-10



Location:	22-TP-10	Description:	View of excavation spoils
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 GERHART COLE	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-11
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.5
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	NE to SW
Groundwater Depth (feet)	Not found	Date Measured		Approximate Surface Elevation (feet)	6014.8
Comments West Parking Area				Latitude / Longitude	41.96561 , -111.40137

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, silty - loose, dry to moist, dark brown to dark olive gray, roots (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2	Hand	GB-01			
	3					
	4					
6010	5				SILT, with sand, some gravel - soft to medium stiff, dry to moist, dark red to dark yellow brown, subangular to subrounded gravel, lightly cemented soil clasts ranging from 3 inches to 6 inches, calcium carbonate staining, (ML)	
	6					
	7					
	8					
	9					
6005	10	Hand	BULK-02			
	11					
	12					
	13					
	14					
6000	15					
	16				Bottom of Hole at 15.5 feet	Terminated test pit due to reaching maximum reach of excavator.
	17					
	18					
	19					
5995	20					
	21					
	22					
	23					
	24					
5990	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-11



Location:

22-TP-11

Description:

Inside view of test pit

Date Taken:	12/20/2022
Photo Identification:	22-TP-11



Location:	22-TP-11	Description:	View of excavation spoils
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Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-12
---	---------------------------------

Date(s) Excavated	12/20/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	E to W
Groundwater Depth (feet)	Not found	Date Measured		Approximate Surface Elevation (feet)	6007.9
Comments West Parking Area				Latitude / Longitude	41.96591 , -111.40098

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, with silt - loose, dry to moist, dark brown to black, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4				SILT, with sand, trace gravel - soft to medium stiff, dry to moist, dark red to dark yellow brown, subrounded to subangular gravel, lightly cemented clasts of soil ranging from 3 to 6 inches, calcium carbonate staining, (ML)	
6003	5					
	6					
	7				- some cobbles	
	8					
	9					
	10					
5998	11					
	12					
	13					
	14					
	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
5993	16					
	17					
	18					
	19					
	20					
5988	21					
	22					
	23					
	24					
	25					

Date Taken:

12/20/2022

Photo Identification:

22-TP-12



Location:

22-TP-12

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:	12/20/2022
Photo Identification:	22-TP-12



Location:	22-TP-12	Description:	View of excavation spoils
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 GERHART COLE	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-13
---	--

Date(s) Excavated	12/22/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	18	Approximate Width (feet)	2	Approximate Depth (feet)	14.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	W to E
Groundwater Depth (feet)	Not Found	Date Measured		Approximate Surface Elevation (feet)	5967.0
Comments Rainbow Cove				Latitude / Longitude	41.96803 , -111.27143

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, with silt, some gravel, cobbles and boulders - medium dense to very dense, moist, brown to pale olive brown, subrounded to subangular gravel cobbles and boulders, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
5962	5				GRAVEL, clayey, with sand, some gravel, cobbles, and boulders - medium dense to very dense, moist, brown to pale olive brown, low plasticity fines, subrounded to subangular gravel cobbles and boulders, (GC)	
	6					
	7					
	8					
	9					
5957	10	👤	BULK-B-01			
	11					
	12					
	13					
	14					
					Bottom of Hole at 14 feet	Terminated test pit due to reaching maximum reach of excavator.
5952	15					
	16					
	17					
	18					
	19					
5947	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:

12/22/2022

Photo Identification:

22-TP-13



Location:

22-TP-13

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:

12/22/2022

Photo Identification:

22-TP-13



Location:

22-TP-13

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-14
---	---------------------------------

Date(s) Excavated	12/22/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	18	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	N to S
Groundwater Depth (feet)	Not Found	Date Measured		Approximate Surface Elevation (feet)	5974.0
Comments Rainbow Cove				Latitude / Longitude	41.96887 , -111.27083

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, gravelly, with silt, some cobbles and boulders, some silt - medium dense, dry to moist, light brown to dark red, subrounded to subangular gravel and cobbles, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
5969	5					
	6					
	7					
	8	Hand	BULK-B-01			
	9					
5964	10					
	11					
	12					
	13					
	14					
5959	15				Bottom of Hole at 15 feet	Terminated test pit due to reaching maximum reach of excavator.
	16					
	17					
	18					
	19					
5954	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:

12/22/2022

Photo Identification:

22-TP-14



Location:

22-TP-14

Description:

Inside view of test pit

Date Taken:

12/22/2022

Photo Identification:

22-TP-14



Location:

22-TP-14

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-15
---	---------------------------------

Date(s) Excavated	12/22/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	19	Approximate Width (feet)	2	Approximate Depth (feet)	15.0
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	N to S
Groundwater Depth (feet)	Not Found	Date Measured		Approximate Surface Elevation (feet)	5965.0
Comments Rainbow Cove				Latitude / Longitude	41.97113 , -111.27010

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				GRAVEL, clayey, with sand - medium dense to dense, dry, brown to dark red, low plasticity fines, subrounded cobbles and gravels, (GC)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
5960	5					
	6					
	7					
	8	Hand	BULK-B-01			
	9					
5955	10					
	11					
	12					
	13					
	14					
5950	15				Bottom of Hole at 15 feet	Terminated test pit due to maximum extent of excavator.
	16					
	17					
	18					
	19					
5945	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:	12/22/2022
Photo Identification:	22-TP-15



Location:	22-TP-15	Description:	Inside view of test pit
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 GERHART COLE	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Date Taken:	12/22/2022
Photo Identification:	22-TP-15



Location:	22-TP-15	Description:	View of excavation spoils
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	FIELD STUDIES SUMMARY PHOTOS: TEST PITS		
	Bear Lake Marina Expansion		22-1522

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST PIT 22-TP-16
---	---------------------------------

Date(s) Excavated	12/22/2022	Logged By	T. Kesler	Checked By	R. Buhler
Approximate Length (feet)	20	Approximate Width (feet)	2	Approximate Depth (feet)	15.5
Excavation Equipment	John Deere 135G Excavator	Excavation Contractor	Whitaker Construction	Approximate Pit Trend	W to E
Groundwater Depth (feet)	Not Found	Date Measured		Approximate Surface Elevation (feet)	5966.0
Comments Rainbow Cove				Latitude / Longitude	41.97447 , -111.26924

Elevation, feet	Depth, feet	Sample Type	Number	Graphic Log	MATERIAL DESCRIPTION	FIELD NOTES
	1				SAND, gravelly, with silt, some cobbles - loose to medium dense, dry, dark red to dark yellow brown, rounded to subangular gravel and cobbles, (SM)	Consistencies/densities estimated from field observations and equipment effort during excavation.
	2					
	3					
	4					
5961	5					
	6					
	7					
	8	👉	BULK-B-01			
	9					
5956	10					
	11					
	12					
	13					
	14					
5951	15					
	16				Bottom of Hole at 15.5 feet	Terminated test pit due to reaching maximum reach of excavator.
	17					
	18					
	19					
5946	20					
	21					
	22					
	23					
	24					
	25					

Date Taken:

12/22/2022

Photo Identification:

22-TP-16



Location:

22-TP-16

Description:

Inside view of test pit



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522

Date Taken:

12/22/2022

Photo Identification:

22-TP-16



Location:

22-TP-16

Description:

View of excavation spoils



FIELD STUDIES SUMMARY PHOTOS: TEST PITS

Bear Lake Marina Expansion

22-1522



Appendix B

Test Hole Logs Bear Lake Marina Expansion

Table of Contents

<u>Description</u>	<u>Page #'s</u>
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23-TH-12.....	B-15

Unified Soil Classification System (USCS)

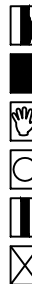
Material Types	Major Soil Divisions		Group Symbol and Legend		Typical Names
COARSE-GRAINED SOILS >50% retained on No. 200 sieve	GRAVELS >50% of coarse fraction retained on No. 4 Sieve	Clean GRAVELS (little or no fines)		GW	Well-Graded GRAVEL, GRAVEL-sand mixtures, few fines
		GRAVELS with fines (appreciable amount of fines)		GP	Poorly-Graded GRAVEL, GRAVEL-sand mixtures, few fines
				GM	Silty GRAVEL, GRAVEL-sand silt mixtures
				GC	Clayey GRAVEL, GRAVEL-sand clay mixtures
	SANDS >50% of coarse fraction passing the No. 4 sieve	Clean SANDS (little or no fines)		SW	Well-Graded SAND, SAND-gravel mixtures, few fines
		SANDS with fines (appreciable amount of fines)		SP	Poorly-Graded SAND, SAND-gravel mixtures, few fines
FINE-GRAINED SOILS >50% Passing No. 200 Sieve	SILTS and CLAYS liquid limit < 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CL	Lean CLAY, Gravelly/Sandy CLAY, low to med. plasticity
		Organic		OL	Organic CLAY or SILT
	SILTS and CLAYS liquid limit > 50	Inorganic 1) CF > 30%: + Sandy/Gravelly 2) CF = 15-30% + with sand/gravel		CH	Fat CLAY, Gravelly/Sandy Fat CLAY, high plasticity
				MH	Elastic SILT, Gravelly/Sandy Elastic SILT, low to high plasticity
		Organic		OH	Organic CLAY or SILT
	Highly organic soils	Primarily Organic Matter; Organic Odor		PT	PEAT
Boulders / Cobbles		> 50% (by volume) particles > 3"		COBBLES BOULDERS	Boulders (>12"); Cobbles (>3" and <12")

Other Material Symbols



Bedrock
Asphalt
Concrete
Topsoil
Fill

Sample Types



Auger Cuttings
Continuous sampler
Grab Sample
No Recovery
Shelby Tube
Standard Penetration Test (SPT)



California Sampler
Rock Core
Modified California Sampler
Other (see remarks)
Piston Sampler (Shelby Tube)
Vane Shear

Apparent water level

Measured water level

Descriptors for Coarse Grained Soils

Apparent Density	Dr (%)	SPT	MC	CAL
Very Loose	0-15	<4	<6	<8
Loose	15-35	4-10	6-15	8-20
Med. Dense	35-65	10-30	15-42	20-56
Dense	65-85	30-50	42-72	56-96
Very Dense	85-100	>50	>72	>96

Descriptors for Fine Grained Soils

Consistency	Su (psf)	SPT	MC	CAL
Very Soft	< 250	<2	<2	<2
Soft	250-500	2-4	2-4	2-5
Med. Stiff	500-1000	4-8	4-10	5-11
Stiff	1000-2000	8-15	10-19	11-22
Very Stiff	2000-4000	15-30	19-37	22-45
Hard	>4000	>30	>37	>45

SPT - Standard split spoon (SPT): 2" OD, 1.375" ID

MC - Modified California: 2.5" OD, 1.875" ID

CAL - California: 3" OD, 2.375" ID

R - Practical Refusal For Sampling Method

Stratification		Modifiers	
Description	Criteria	Description	Est. (%)
Seam	1/16" to 1/2"	Trace	<5
Layer	1/2" to 12"	Some	5-12
Occasional	<= 1 per ft. thickness	With	12-30
Frequent	> 1 per ft. thickness	-ly	>30

Descriptors for Moisture

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Descriptors for Particle Size

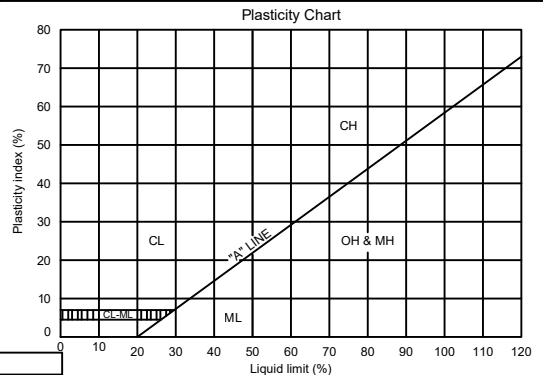
Description	Criteria
Boulder	>12" : larger than a basketball
Cobble	3-12" : larger than an orange
Coarse Gravel	3/4-3" : larger than a grape
Fine Gravel	No.4-3/4" : larger than a pea
Coarse Sand	No.10-4 : larger than a rock salt grain
Medium Sand	No.40-10 : larger than a table salt grain
Fine Sand	No.200-40 : smaller than table salt grain

Descriptors for Particle Angularity

Description	Criteria
Angular	Sharp edges, rel. plane sides, unpolished surface
Subangular	Similar to angular, but with rounded edges
Subrounded	Nearly plane sides, well-rounded corners & edges
Rounded	Smoothly curved sides and no edges

Abbreviations for Laboratory Testing

Description	Criteria
Su	Peak Undrained Shear Stress
UU	Unconsolidated Undrained Triaxial
CON	One-dimensional Consolidation
AL	Atterberg Limits (LL=Liquid Limit & PI=Plasticity Index)
SV / GSD	Sieve / Grain-Size Distribution Testing
CORR	Corrosion - Resistivity



Abbreviated Soil Classification Symbols (after ASTM D2488 X.5)

Prefix
s = sandy
g = gravelly

Suffix
s = with sand
g = with gravel
c = with cobbles
b = with boulders

Abbreviated system for supplementary presentations when complete description is referenced. Examples:

Group Symbol and Full Name	Abbreviated
Sandy Lean CLAY	s(CL)
Poorly Graded SAND with silt and gravel	(SP-SM)g
Poorly Graded Gravel with sand, cobbles, and boulders	(GP)scb
Gravelly SILT with sand and cobbles	g(ML)sc

General Notes:

- 1) Stratigraphic lines on the logs represent approximate boundaries.
- 2) No warranty is provided as to the continuity of soil conditions beyond or between points explored and sample locations.
- 3) Logs represent soil conditions observed at the point of exploration on the date indicated.
- 4) Visual methods were used to classify the materials in general accordance with Unified Soil Classification System; actual designations based on laboratory methods may vary.
- 5) Soil descriptions were developed based on visual/manual classification methods and drilling or sampling behavior. Where judged appropriate, soil descriptions, classifications, and consistency/apparent density have been refined based on laboratory testing or correlations with other field tests/observations.

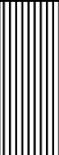


Legend to Soil Descriptions

Project Number: 22-1522

Sheet 1 of 2

Date(s) Drilled	05/08/2023	to	05/08/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA			Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	31.0
Drill Rig Type	CME 55 LC			Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	2.7			Latitude / Longitude	41.965806 , -111.399117	Ground Surface Elevation (feet)	5935.6
Station/Offset	/			Test Hole Backfill	2" Piezometer	Weather, H/L	

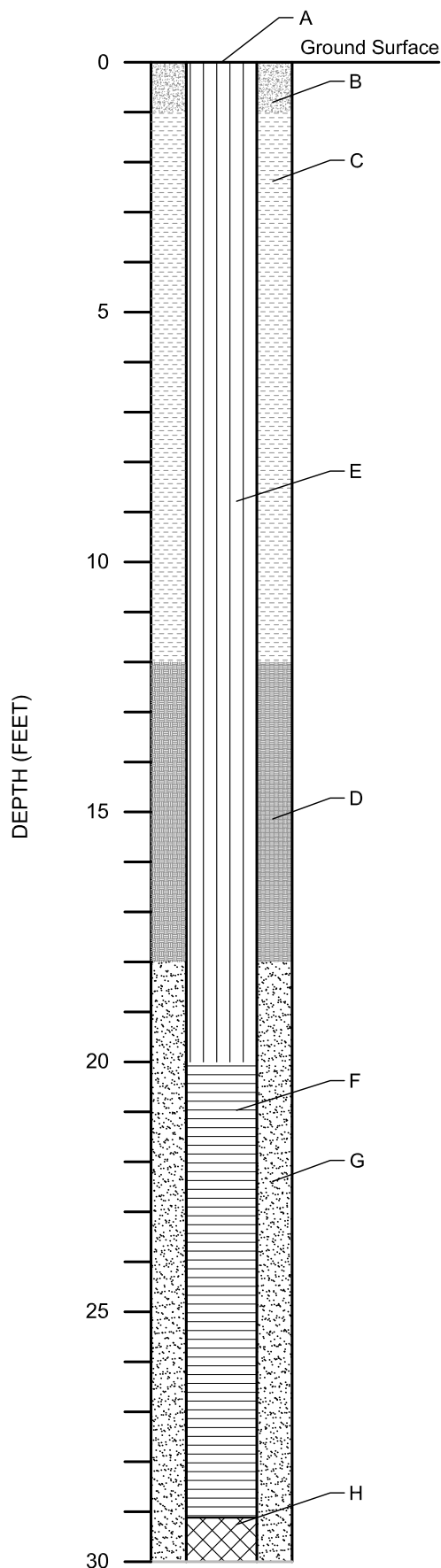
Elevation, feet	Depth, feet	SAMPLES				Graphic Log	Material Description	AASHTO Classification	Field Notes
		Type	Recovery, Inches	Sampling Resistance (Uncorrected) N	(N1)60				
							ASPHALT 6 inches		
							ELASTIC SILT, with sand - very stiff, moist, light tan to light brown, slight reaction to HCl, waxy, high plasticity, (MH)		Grinding and gravel and cobbles
5931	5		15	1-2-4-6 6	11			A-4	
			22				-Transitions to light greenish gray to light bluish gray, iron oxide varying		Driller indicates soft push
5926	10		19	4-9-9-10 18	28		-Grades to sandy, trace gravel	A-4	
			24	6-10-14-18 24	36		FAT CLAY, some sand - very stiff, moist, light tan to light brown, possible calcium carbonate concentration, reactive to HCl, waxy, (CH)		
5921	15		24	6-8-14-20 22	31		-Possible Bioturbation, Iron oxide staining	A-4	
			24	9-14-18-28 32	48				Driller indicates stiff drilling
5916	20		14	39-50/5" [R]	100		SILT, sandy with gravel - hard, moist, light brown to brown, reactive to HCl, cemented layers, (ML)		Shelby Tube refused at 20 feet, end of tube crushed. Drove SPT sample
5911	25		24	15-28-34-45 62	78		-Cemented, brown to red with gray to bluish gray nodules, calcarious		
5906	30								

Project Number: 22-1522

Sheet 2 of 2

Date(s) Drilled	05/08/2023	to	05/08/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA			Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	31.0
Drill Rig Type	CME 55 LC			Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	2.7			Latitude / Longitude	41.965806 , -111.399117	Ground Surface Elevation (feet)	5935.6
Station/Offset	/			Test Hole Backfill	2" Piezometer	Weather, H/L	

Elevation, feet	Depth, feet	SAMPLES				Graphic Log	Material Description	AASHTO Classification	Field Notes
		Type	Recovery, Inches	Sampling Resistance (Uncorrected) N	(N1)60				
		X	10	48-50/5" [R]	100		SAND, some silt - very dense, moist, light tan to light brown, quartz crystal, reactive to HCl, (SP-SM)		
							Bottom of Hole at 31 feet		
5901	35								
5896	40								
5891	45								
5886	50								
5881	55								
5876	60								



LEGEND

Water level (casing rim) at 2.67 feet on 5/10/23



A Steel surface monument



B Concrete surface seal



C Bentonite Chips/Seal



D Auger Cuttings



E 2-inch Schedule 40 PVC well casing



F 2-inch Schedule 40 PVC screen,

0.020-inch slot width



G 10-20 COLORADO SILICA sand backfill



H PVC END CAP

I _____

J _____

K _____

L _____

Monument/Casing Reference Elevation: 5935.6 feet

Ground Surface Elevation: 5935.6 feet

Casing Stickup: 0 feet

Test Hole Drilled Diameter: 6 inches

Base of Test Hole: 32 feet

Base of Piezometer: 30 feet

FIELD INSTALLATION NOTES

LOCATION

MATERIALS USED:

8 Bags - 10-20 COLORADO SILICA

4 Bags - Bentonite Chips

1 Bag - Ready Mix Concrete

10 Feet - PVC riser

20 feet - PVC riser

1 - Flush mount monument

1 - Bottom cap

PIEZOMETER CONSTRUCTION DETAILS

Client: Kimley Horn

Location:

Job No.: 22-1522

By: TK

23-TH-01

B-4

Date(s) Drilled	05/09/2023 to 05/09/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	22.0
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	6.82	Latitude / Longitude	41.96722 , -111.39942	Ground Surface Elevation (feet)	5924.6
Comments		Test Hole Backfill	Cuttings	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							COBBLES AND BOULDERS, with sand, with gravel - loose, gray to brown, moist	
		X	SPT-01	11-23-23-32 46	24		FAT CLAY, with sand, some gravel - very stiff, moist, light greenish gray to white, reactive to HCl, some iron oxide staining, (CH)	
5920	5	X	SPT-02	8-12-13-17 25	20			Driller indicates medium stiff drilling
		I	ST-03		14			
5915	10	X	SPT-04	7-11-17-26 28	24		-Grades to light brown to red, mottled -Calcium Carbonate cemented silty sand	Calcium carbonate cemented silty sand
		X	SPT-05	17-29-50/5" [R]	17		-Hard, mottled with light greenish gray to white	
5910	15	X	SPT-06	20-33-50/5" [R]	15			
		X	SPT-07	23-50/5" [R]	11		-Wet	
5905	20	X	SPT-08	7-12-17-24 29	24			
							Bottom of Hole at 22 feet	
5900	25							
5895	30							

Project: Bear Lake Marina Expansion

Project Location: Bear Lake State Park

Project Number: 22-1522

LOG OF TEST HOLE 23-TH-04

Sheet 1 of 1

Date(s) Drilled	05/09/2023 to 05/09/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	22.0
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not found	Latitude / Longitude	41.96825 , -111.39995	Ground Surface Elevation (feet)	5920.1
Comments		Test Hole Backfill	Cuttings	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							BOULDERS AND COBBLES, with sand, with gravel - moist, loose, white to gray	Grinding on cobbles and boulders
5916	5	X	SPT-01	7-8-7-4 15	10		SAND, with silt, with gravel - medium dense, wet, dark gray to black, (SM)	
		I	ST-02		8			
5911	10	X	SPT-03	1-3-2-3 5	17		CLAY, with sand - stiff, moist, light greenish gray to light bluish gray, reacts to HCl, (CL)	SPT 03 sank 3.5 inches with hammer weight
		I	PS-04		24			
5906	15	X	SPT-05	4-9-12-14 21	24		CLAY - very stiff to hard, moist, light brown to red, cemented, reacts to HCl, (CL)	
		X	SPT-06	6-9-15-20 24	24			
5901	20	X	SPT-07	12-50/5" [R]	10			
		X	SPT-08	13-16-17-25 33	16			
							Bottom of Hole at 22 feet	
5896	25							
5891	30							

Project: Bear Lake Marina Expansion

Project Location: Bear Lake State Park

Project Number: 22-1522

LOG OF TEST HOLE 23-TH-05

Sheet 1 of 2

Date(s) Drilled	05/10/2023 to 05/11/2023	Logged By	M. McNeill/T. Kesler	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	52.0
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	7.5	Latitude / Longitude	41.96653 , -111.39782	Ground Surface Elevation (feet)	5920.0
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							SAND, with silt - moist, loose, light brown to brown, bivalve shells, (SM)	
5916	5	X	SPT-01	1-1-1-2 2	21		SILT, some sand - soft to medium stiff, moist, light gray to gray, some organics, (ML)	sunk approximately 4 inches with weight of hammer
		I	PS-02		24			soft push
5911	10	X	SPT-03	2-4-2-5 6	24		- Grades to SILT, sandy - medium stiff	
		X	SPT-04	4-5-7-9 12	24		SAND, gravelly, with silt - medium dense, wet, light gray to gray, (SM)	
5906	15	X	SPT-05	1-8-13-8 21	14			sampler sunk approximately 2 inches with weight of hammer
		X	SPT-06	6-18-24-23 42	19		CLAY, trace sand - hard, moist, light greenish gray to light bluish gray, cemented, reactive to HCL, (CL)	switched to mud rotary drilling driller indicates 3 to 4 inches of hard
5901	20	I	PS-07		9			
5896	25	X	SPT-08	5-7-9-13 16	24			
5891	30							

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST HOLE 23-TH-05 Sheet 2 of 2
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Date(s) Drilled	05/10/2023 to 05/11/2023	Logged By	M. McNeill/T. Kesler	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	52.0
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	7.5	Latitude / Longitude	41.96653 , -111.39782	Ground Surface Elevation (feet)	5920.0
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
		X	SPT-09	9-12-16-25 28	24		FAT CLAY, trace sand - very stiff to hard, moist, light greenish gray to light bluish gray, cemented, (CH)	
5886	35	X	SPT-10	18-30-50-50/4" 80	22			
5881	40	X	SPT-11	15-24-35-50/5" 59	23			
5876	45	X	SPT-12	12-8-14-25 22	24		ELASTIC SILT, with sand - very stiff to hard, moist, light greenish gray to light bluish gray, (MH)	
5871	50	X	SPT-13	14-19-20-38 39	24		Bottom of Hole at 52 feet	
5866	55							
5861	60							

Project: Bear Lake Marina Expansion

Project Location: Bear Lake State Park

Project Number: 22-1522

LOG OF TEST HOLE 23-TH-07

Sheet 1 of 3

Date(s) Drilled	05/11/2023 to 05/15/2023	Logged By	T. Kesler	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	70.2
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.2	Latitude / Longitude	41.96621 , -111.39540	Ground Surface Elevation (feet)	5934.1
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							ASPHALT 6 inches	
							GRAVEL, sandy - loose, dry, dark gray to black, (GP), [FILL] 6 inches	
							FAT CLAY, some sand - medium stiff, moist, gray to bluish gray, (CH), [FILL]	
5930		X	SPT-01	3-3-5-5 8	12			
	5	X	SPT-02	2-4-7-5 11	22			
		X	SPT-03	2-4-3-8 7	16		CLAY, sandy - medium stiff, moist, red to dark gray, (CL), [FILL]	Collected one bucket of bulk sample auger cuttings from approximately 7 to 12 feet
5925			BULK-01					
	10		ST-04		10		- with gravel	
		X	SPT-05	1-2-5-6 7	20		CLAY, some sand, trace gravel - medium stiff, moist, gray to bluish gray, (CL), [FILL]	
5920		X	SPT-06	1-4-3-5 7	14			
	15							Measured water depth of 16.2 feet after first day of drilling
5915								
	20		ST-07		19		- wet	
5910								
	25	X	SPT-08	0-0-0-0 0	12		SAND, some silt, some gravel - very loose, wet, gray to light bluish gray, (SP-SM)	Switched to mud rotary drilling method after encountering loose sands and approximately 3 feet of heave in augers
5905								
	30							

Project: Bear Lake Marina Expansion

Project Location: Bear Lake State Park

Project Number: 22-1522

LOG OF TEST HOLE 23-TH-07

Sheet 2 of 3

Date(s) Drilled	05/11/2023 to 05/15/2023	Logged By	T. Kesler	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	70.2
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.2	Latitude / Longitude	41.96621 , -111.39540	Ground Surface Elevation (feet)	5934.1
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
		X	SPT-09	5-6-5-2 11	24		SAND, some silt, some gravel - very loose, wet, gray to light bluish gray, (SP-SM) - sea shells in sample	
							SILT, sandy - soft, very stiff, wet, gray to bluish gray, low to no plasticity, (ML)	
5900	35	I	ST-10		24			
5895	40	X	SPT-11	1-5-3-1 8	24			
5890	45	I	ST-12		24		- grade to medium stiff	
5885	50	X	SPT-13	3-13-12-7 25	12		SAND, silty, trace gravel - medium dense, wet, dark gray to green gray, reacts with HCL, (SM)	
5880	55	X	SPT-14	11-7-8-7 15	12		-coarse angular sand, with silt, trace gravel	Hit boulder SPT-14 split into 2 bags
		I	MC-15	37-26-75/3" [R]	12		GRAVEL, cobbles and boulders, with silt, with sand - medium dense to very dense, wet, gray to green gray, little reaction with HCL, (GM) -with cobbles and boulders	Boulder Pieces of cobbles and boulders collapsed into hole and caused drill bit to become stuck. Driller was able to retrieve drill bit
5875								
60								

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST HOLE 23-TH-07 Sheet 3 of 3
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Date(s) Drilled	05/11/2023 to 05/15/2023	Logged By	T. Kesler	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	70.2
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	16.2	Latitude / Longitude	41.96621 , -111.39540	Ground Surface Elevation (feet)	5934.1
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							GRAVEL, cobbles and boulders, with silt, with sand - medium dense to very dense, wet, gray to green gray, little reaction with HCL, (GM) -with cobbles and boulders	Drilling became difficult, drill bit grinding against cobbles and boulders
5870	65	X	SPT-16	35-50/3" [R]	9		-with cobbles and boulders	Added additional auger down to 65 feet to mitigate collapse of cobbles and gravel into hole. After augering to 65 feet drillers continued with mud rotary
5865	70	X	SPT-17	50/2" [R]	2		Bottom of Hole at 70.17 feet	Practical refusal at 70 feet, very slow drill rate due to gravel and cobbles, as well as refusal in SPT samples
5860	75							
5855	80							
5850	85							
5845	90							

Project: Bear Lake Marina Expansion

Project Location: Bear Lake State Park

Project Number: 22-1522

LOG OF TEST HOLE 23-TH-09

Sheet 1 of 2

Date(s) Drilled	05/09/2023 to 05/10/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	41.8
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	At Ground Surface	Latitude / Longitude	41.96857 , -111.39997	Ground Surface Elevation (feet)	5919.3
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							SAND, silty, clayey, with gravel - loose, moist, gray to dark gray, (SC-SM)	Water at ground surface
5915	5	X	SPT-01	0-3-3-4 6	13			Sampler sunk 6-in. with weight of hammer
		X	SPT-02	2-3-6-10 9	20			
5910	10	W	MC-03	74-26-34-32 60	12		-some gravel upto 1-in. SAND, gravelly, some silt, with cobbles - dense, wet, dark gray to black, reactive to HCL, (SW-SM)	Grinding on gravels and cobbles.
		X	SPT-04	1-3-5-9 8	18		CLAY, some sand - medium stiff, moist, light greenish gray to light bluish gray, waxy, (CL)	
5905	15	X	SPT-05	7-13-18-19 31	22		-transitions to red to light brown	
		I	ST-06		11			HSA drilling method to 15-ft. Changed to mud rotary at 15-ft. ST-06 damaged at bottom.
5900	20	X	SPT-07	48-48-50/3" [R]	12		CLAY, trace sand - hard, moist, light tan to white, cemented, reacts with HCL, (CL)	
5895	25	X	SPT-08	21-50-44-50/5" 94	23		-Iron oxide staining -occasional cobble	Driller indicates very dense drilling
5890	30							

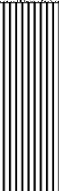
Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST HOLE 23-TH-09 Sheet 2 of 2
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Date(s) Drilled	05/09/2023 to 05/10/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA/Mud Rotary	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger, 3-7/8 Tricone	Total Depth Drilled (feet)	41.8
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	At Ground Surface	Latitude / Longitude	41.96857 , -111.39997	Ground Surface Elevation (feet)	5919.3
Comments		Test Hole Backfill	Grout	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
		X	SPT-09	31-35-50/5" [R]	11		CLAY, trace sand - hard, moist, light tan to white, cemented, reacts with HCL, (CL) -transitions to light brown to red	Clay hydrating during drilling. Drilling mud becoming very thick and heavy. Driller adding thinner mud.
5885	35	X	SPT-10	29-50/4" [R]	9		-transitions to light greenish gray to light bluish gray	
5880	40	X	SPT-11	26-27-45-50/4" 72	22			
							Bottom of Hole at 41.83 feet	
5875	45							
5870	50							
5865	55							
5860	60							

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST HOLE 23-TH-11 Sheet 1 of 1
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Date(s) Drilled	05/08/2023 to 05/08/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	12.0
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	41.96573 , -111.39907	Ground Surface Elevation (feet)	5935.3
Comments		Test Hole Backfill	Cuttings	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Samples				Graphic Log	Material Description	Field Notes
		Type	Number	Sampling Resistance	Recovery, inches			
							ASPHALT	
							SAND, silty - loose, moist, light brown to brown, (SM)	Grinding on gravels and possible cobbles with boulders to 8 inches possible Boulders at 1.5 feet off setting due to possible boulders
5931	5		BULK-01 SPT-01	1-2-3-6 5	13		Elastic SILT, sandy, trace gravel - stiff, moist, light bluish gray to light greenish gray, reactive to HCl, (MH)	
			SPT-02	3-4-5-8 9	19			
5926	10		BULK-02 SPT-03	4-6-10-11 16	20		SILT, sandy - very stiff, moist, moist, light brown to brown, waxy, white chalky layers at approximately 9.25 feet 1.5 inches thick, reactive to HCL, (ML)	
			SPT-04	5-7-12-15 19	21			
5921	15						Bottom of Hole at 12 feet	
5916	20							
5911	25							
5906	30							

Project: Bear Lake Marina Expansion Project Location: Bear Lake State Park Project Number: 22-1522	LOG OF TEST HOLE 23-TH-12 Sheet 1 of 1
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Date(s) Drilled	05/08/2023 to 05/08/2023	Logged By	M. McNeil	Checked By	R. Buhler
Drilling Method	HSA	Drill Bit Size/Type	2 Tooth Bit, 8-Inch Auger	Total Depth Drilled (feet)	11.8
Drill Rig Type	CME 55 LC	Drilling Contractor	ConeTec (Tyler)	Hammer Weight/ Drop (lbs/in.)	Automatic (SPT)
Apparent Groundwater Depth (feet)	Not Found	Latitude / Longitude	41.96531 , -111.39923	Ground Surface Elevation (feet)	5935 (Approx.)
Comments		Test Hole Backfill	Cuttings	Elevation Datum	NAVD 88

Elevation, feet	Depth, feet	Type	Number	Sampling Resistance	Recovery, inches	Graphic Log	Material Description	Field Notes
							ASPHALT	
							SILT, with sand, trace gravel - moist, stiff, light tan to light gray, waxy, low plasticity, (ML)	
5930	5		SPT-01 BULK-01	1-3-7-8 10	7			Driller indicates stiff drilling
			SPT-02	5-11-15-26 26	24		- Reactive to HCl, transitions to very stiff to hard	
			BULK-02					
			SPT-03	8-21-26-35 47	24		- Iron oxide veining - Hard	
5925	10		SPT-04	8-20-32-50/4" 52			SAND, silty - very dense, moist, light brown to tan, Iron Oxide staining, (SM)	
							Bottom of Hole at 11.83 feet	
5920	15							
5915	20							
5910	25							
5905	30							



Appendix C

CPT Soundings Bear Lake Marina Expansion Table of Contents

<u>Description</u>	<u>Page No.</u>
CPT Soundings	C-1
Shear Wave Velocity Profile	C-9



Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-02

Date: 09-May-2023

Estimated Water Depth: 5.0 ft

Rig/Operator: A Cache Drilling

Latitude: 41.966590

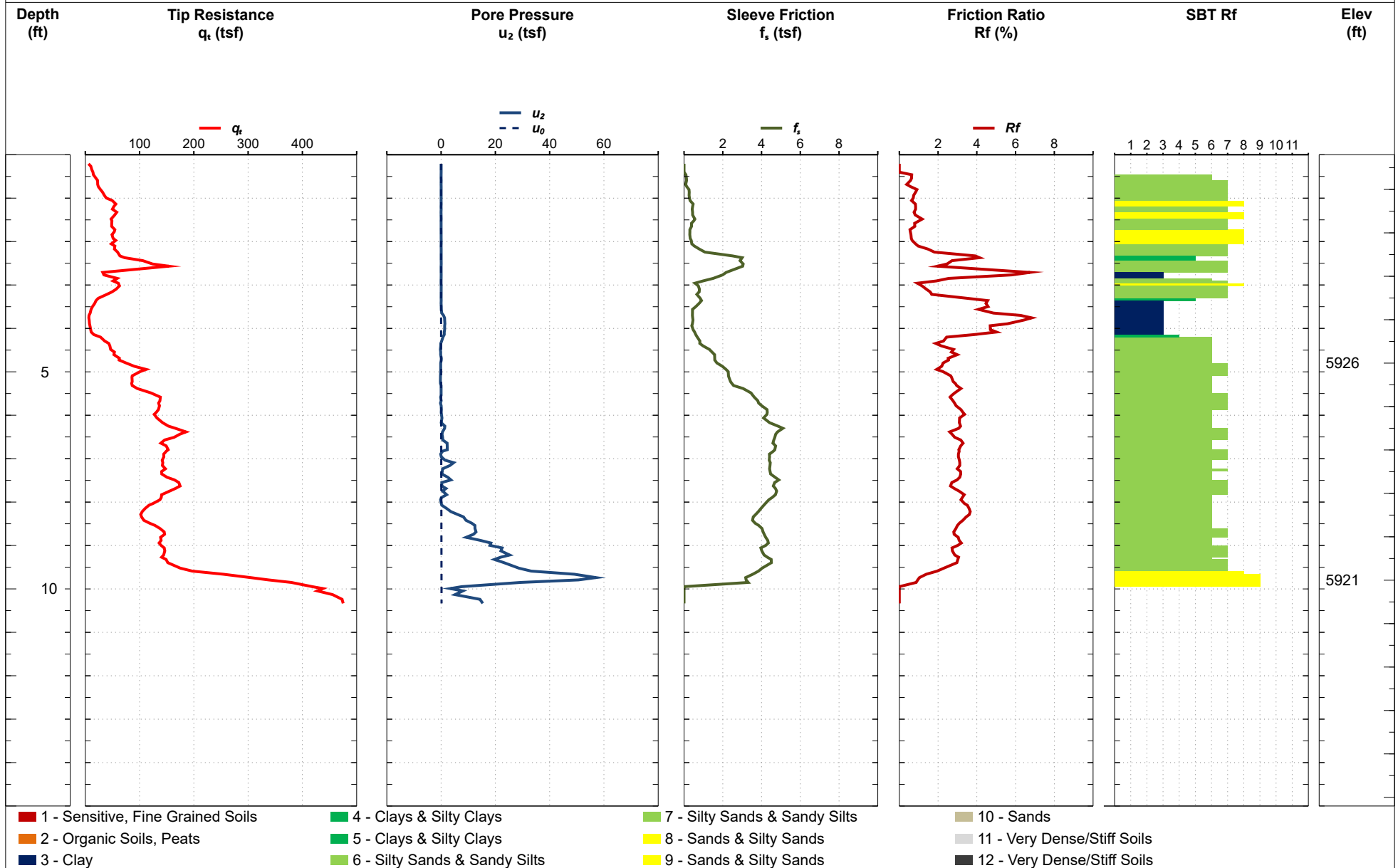
Longitude: -111.399200

Elevation: 5930.8

Total Depth: 10.4 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-06

Date: 09-May-2023

Estimated Water Depth: 0.2 ft

Rig/Operator: A Cache Drilling

Latitude: 41.966470

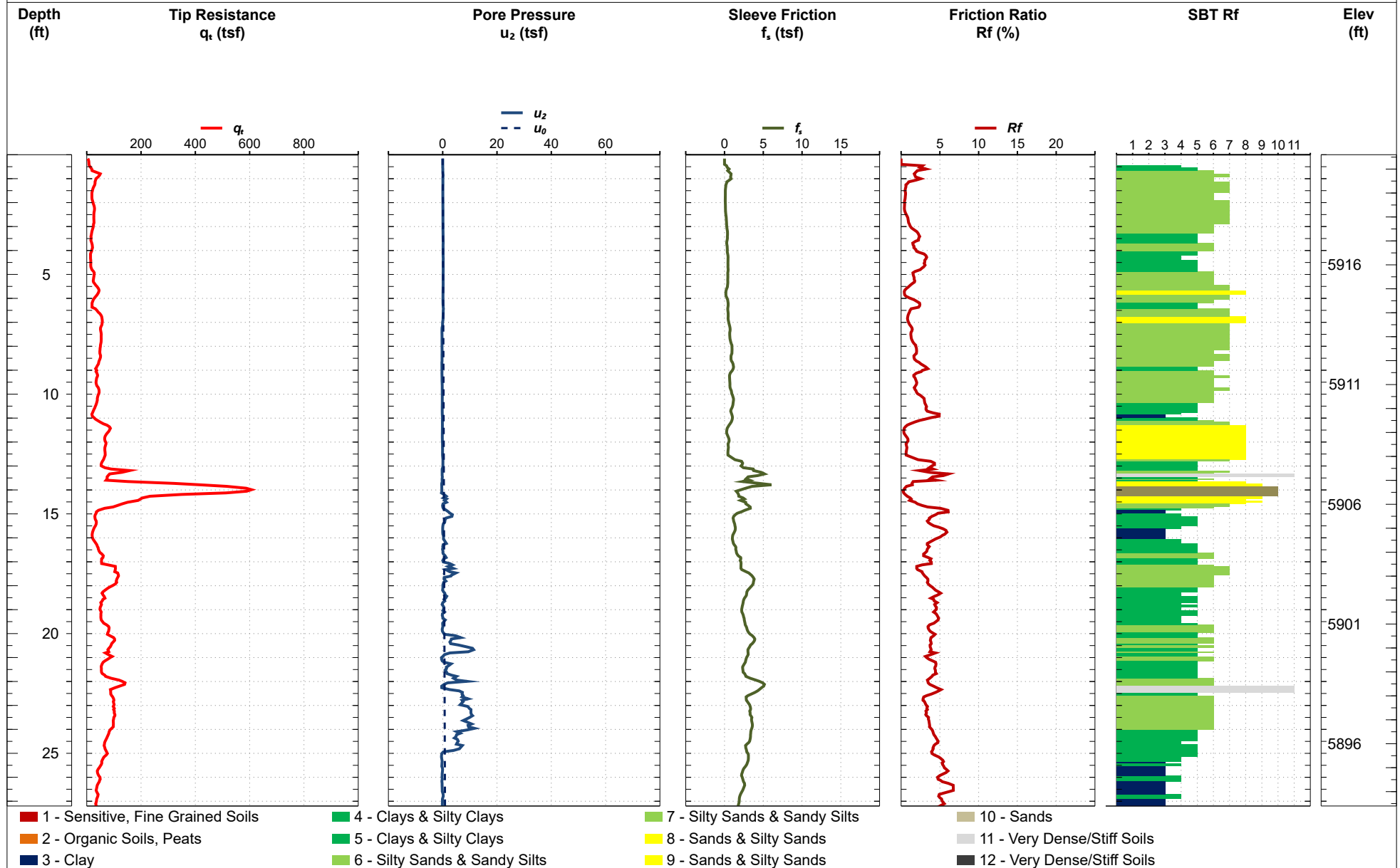
Longitude: -111.397840

Elevation: 5920.6

Total Depth: 50.0 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-06

Date: 09-May-2023

Estimated Water Depth: 0.2 ft

Rig/Operator: A Cache Drilling

Latitude: 41.966470

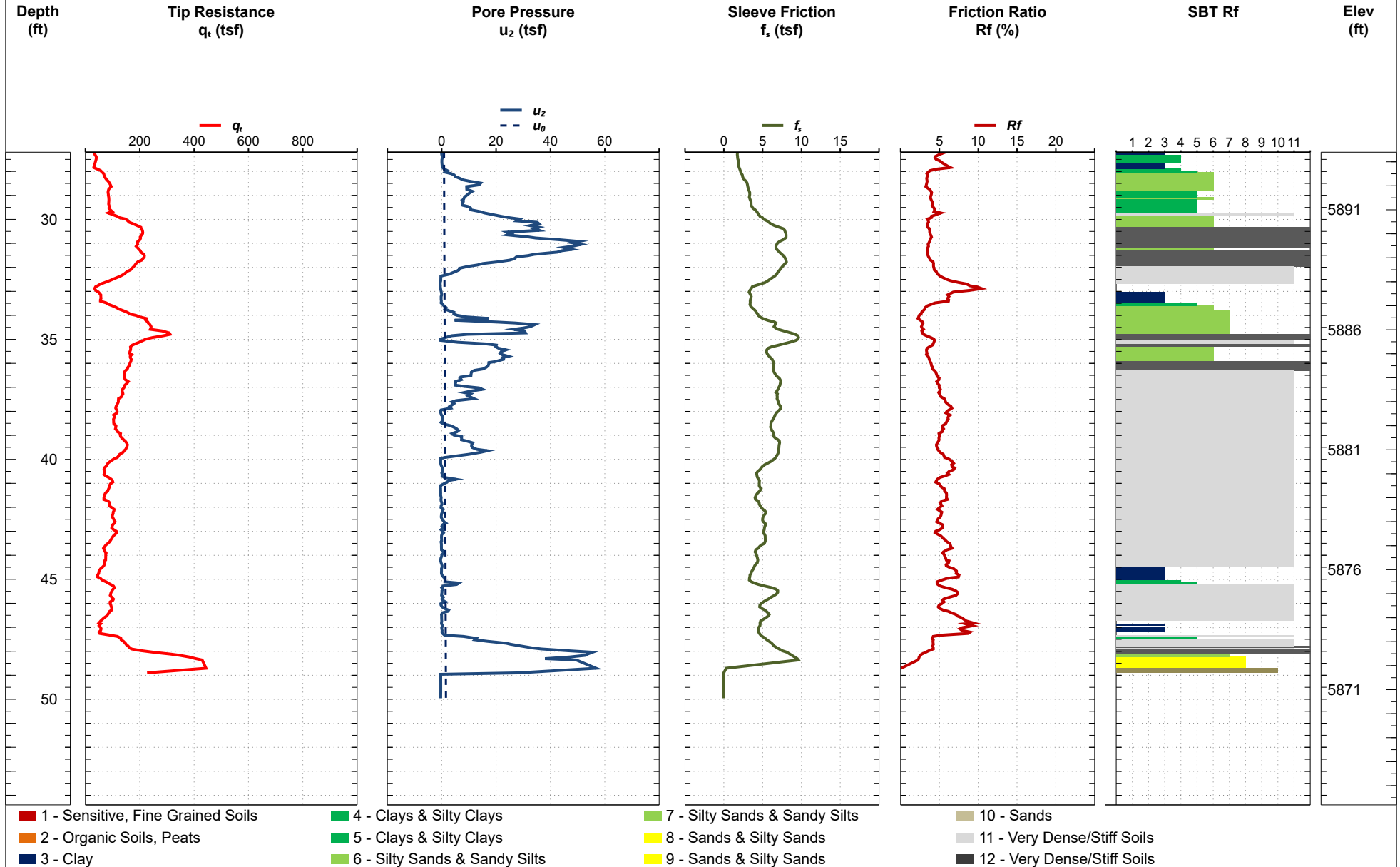
Longitude: -111.397840

Elevation: 5920.6

Total Depth: 50.0 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

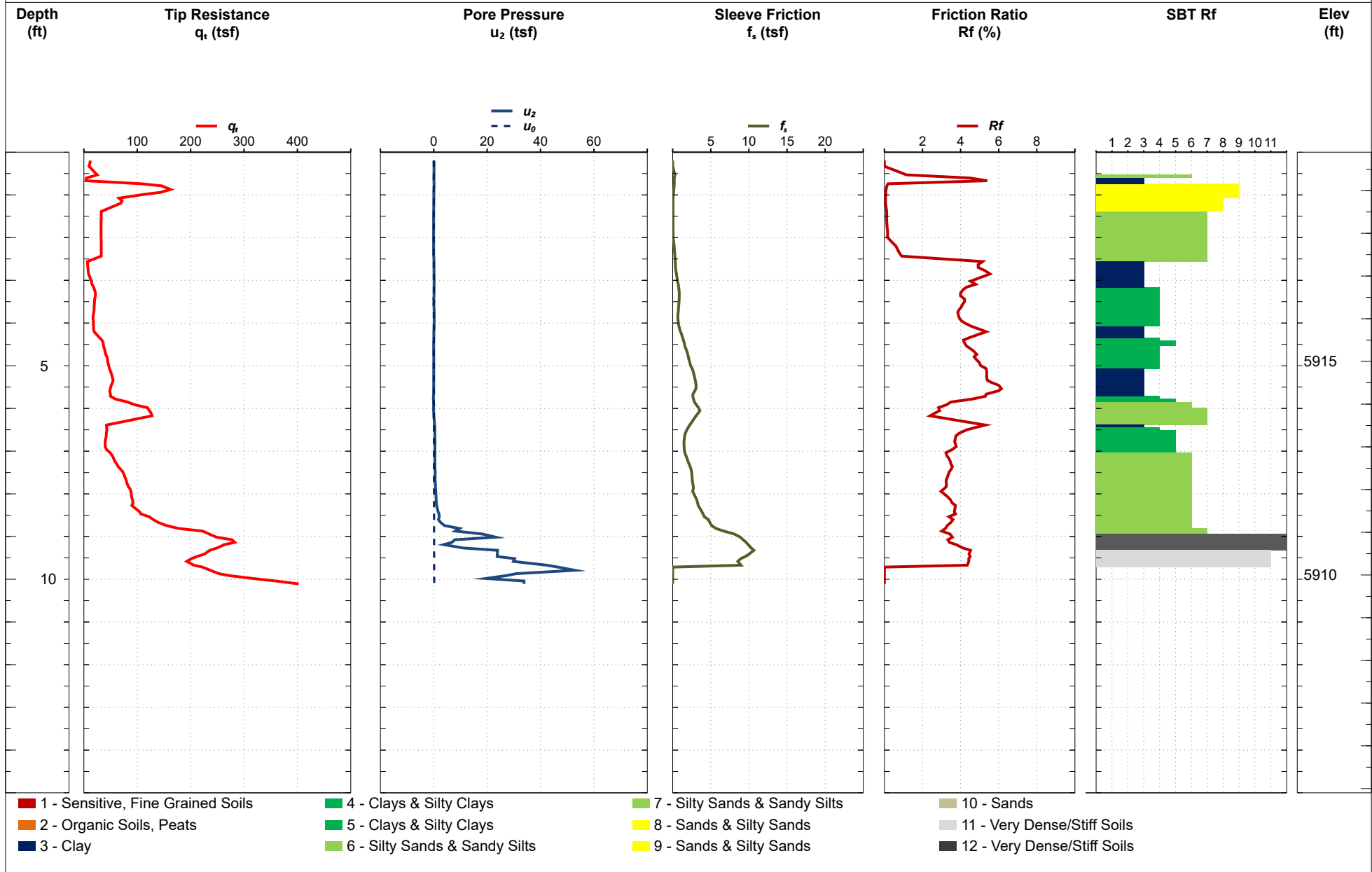
Bear Lake State Park

Cone Penetration Test 23-CPT-08

Date: 09-May-2023
Estimated Water Depth: 5.0 ft
Rig/Operator: A Cache Drilling

Latitude: 41.967610
Longitude: -111.399440
Elevation: 5919.9

Total Depth: 10.4 ft
Termination Criteria: Refusal
Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-10

Date: 09-May-2023

Estimated Water Depth: 5.0 ft

Rig/Operator: A Cache Drilling

Latitude: 41.968910

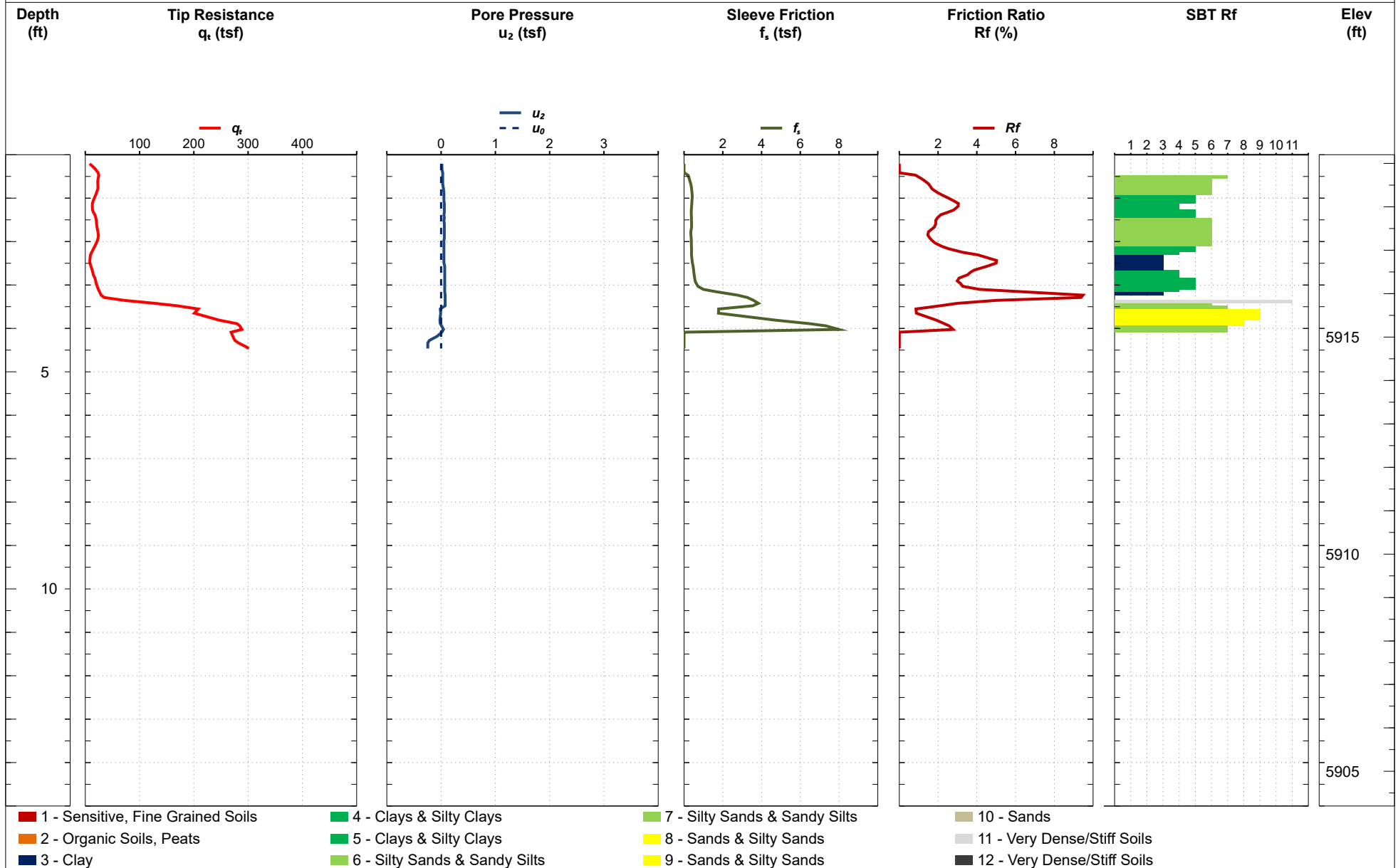
Longitude: -111.400280

Elevation: 5919.2

Total Depth: 4.5 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-10a

Date: 09-May-2023

Estimated Water Depth: -99.0 ft

Rig/Operator: A Cache Drilling

Latitude: 41.970000

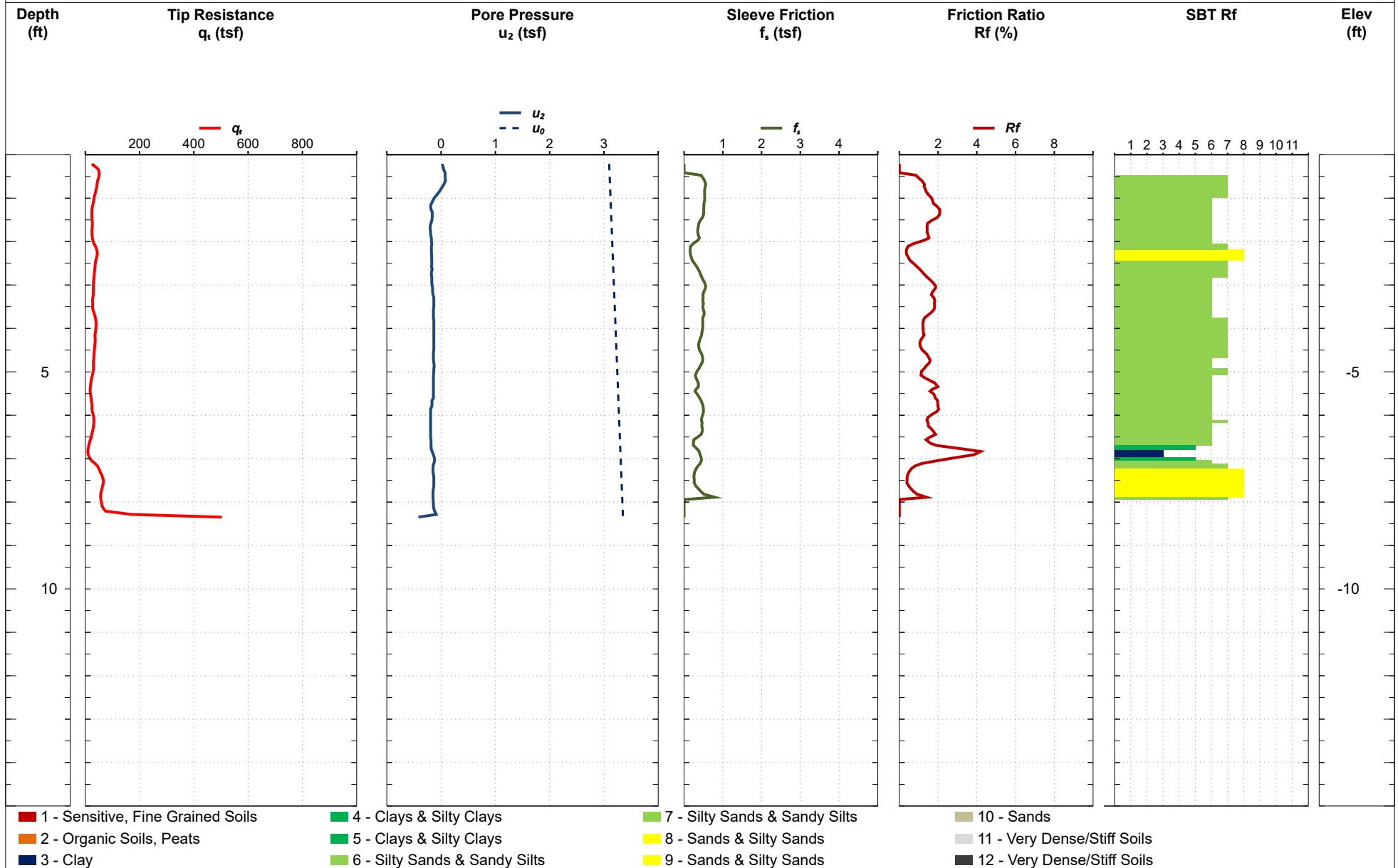
Longitude: -111.400000

Elevation:

Total Depth: 8.5 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-10b

Date: 09-May-2023

Estimated Water Depth: 5.0 ft

Rig/Operator: A Cache Drilling

Latitude: 41.969000

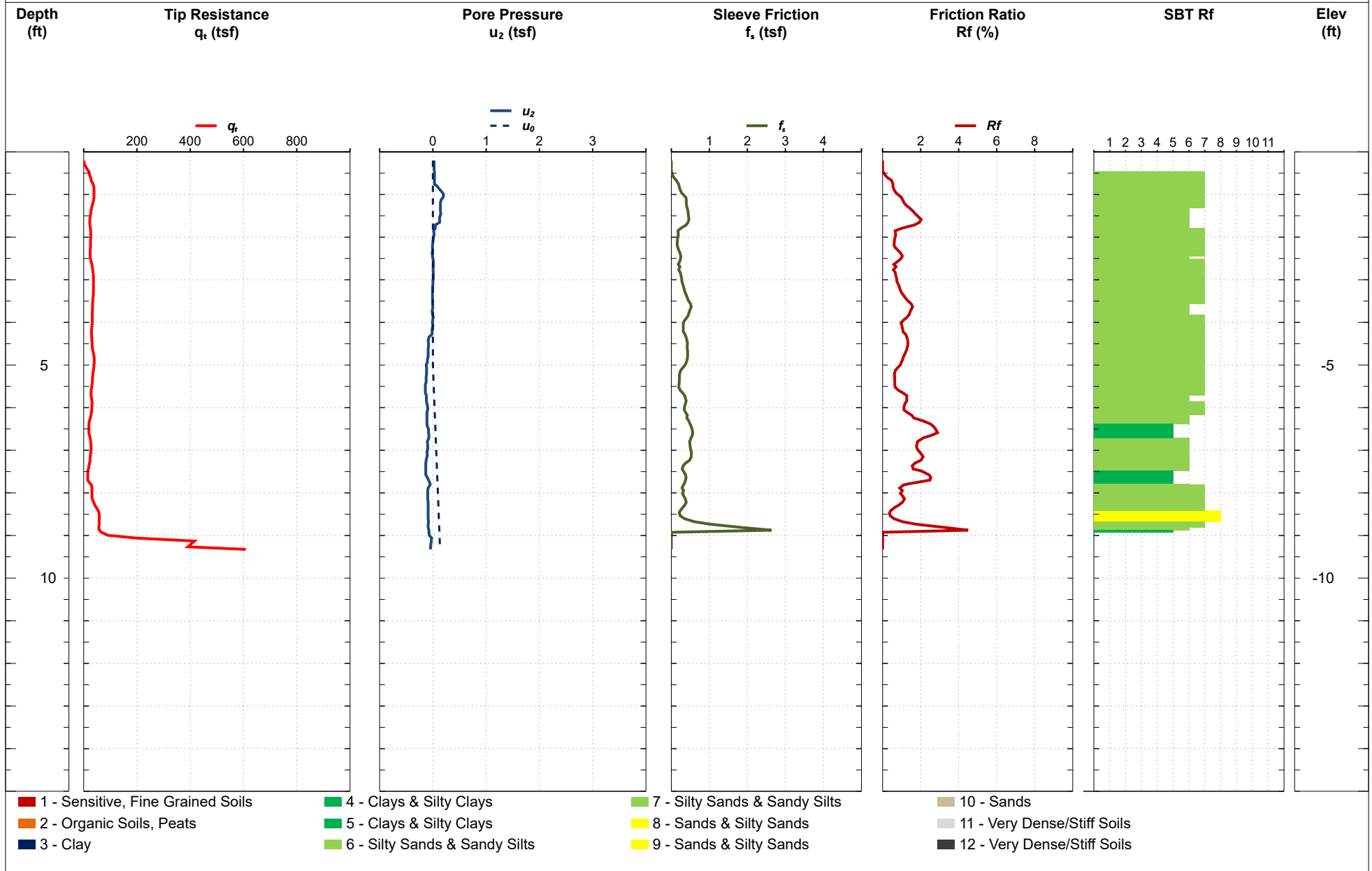
Longitude: -111.400200

Elevation:

Total Depth: 9.3 ft

Termination Criteria: Refusal

Cone Size:





Bear Lake Marina Expansion

Project Number: 22-1522

Bear Lake State Park

Cone Penetration Test 23-CPT-13

Date: 09-May-2023

Estimated Water Depth: 0.0 ft

Rig/Operator: A Cache Drilling

Latitude: 41.967350

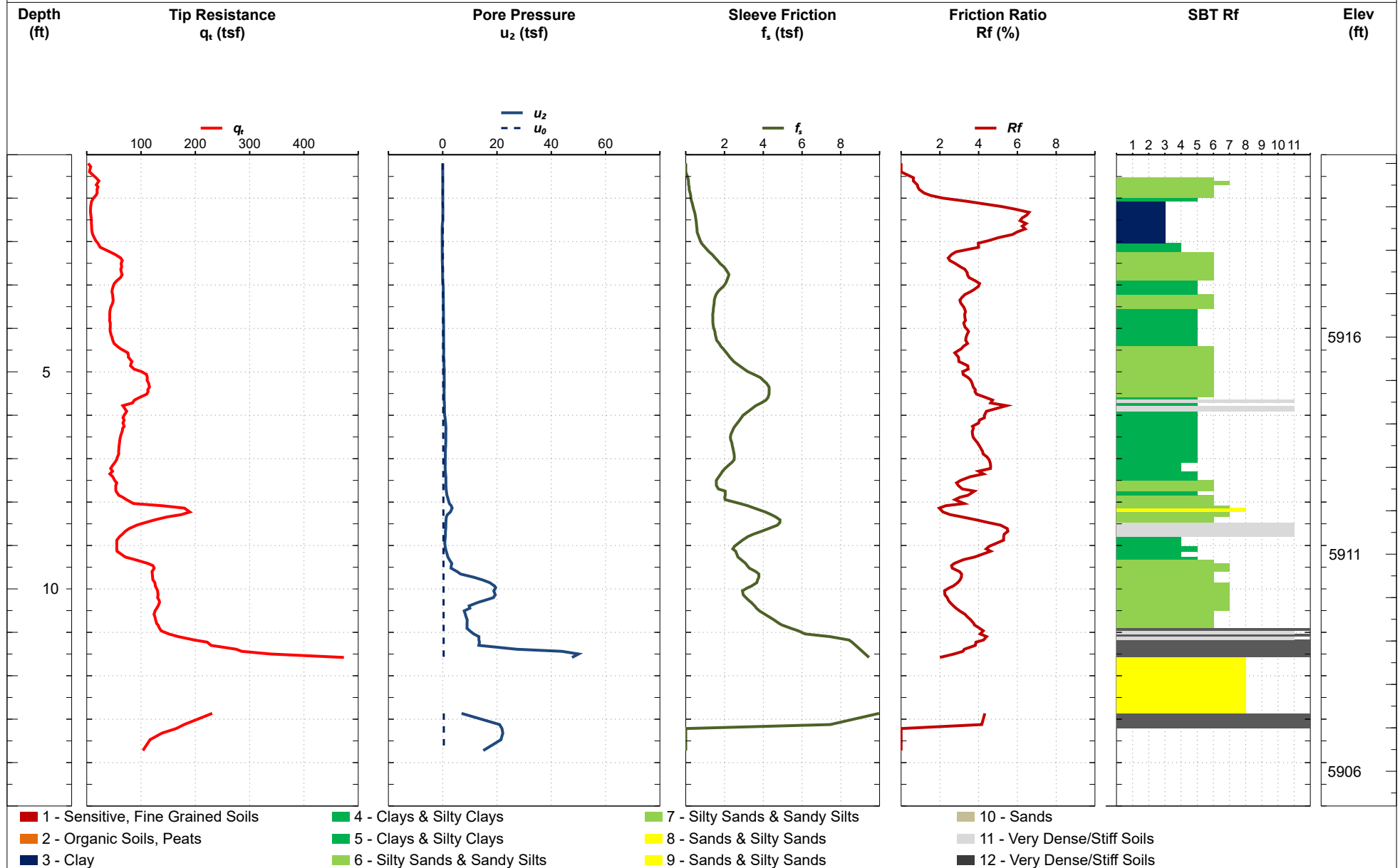
Longitude: -111.399260

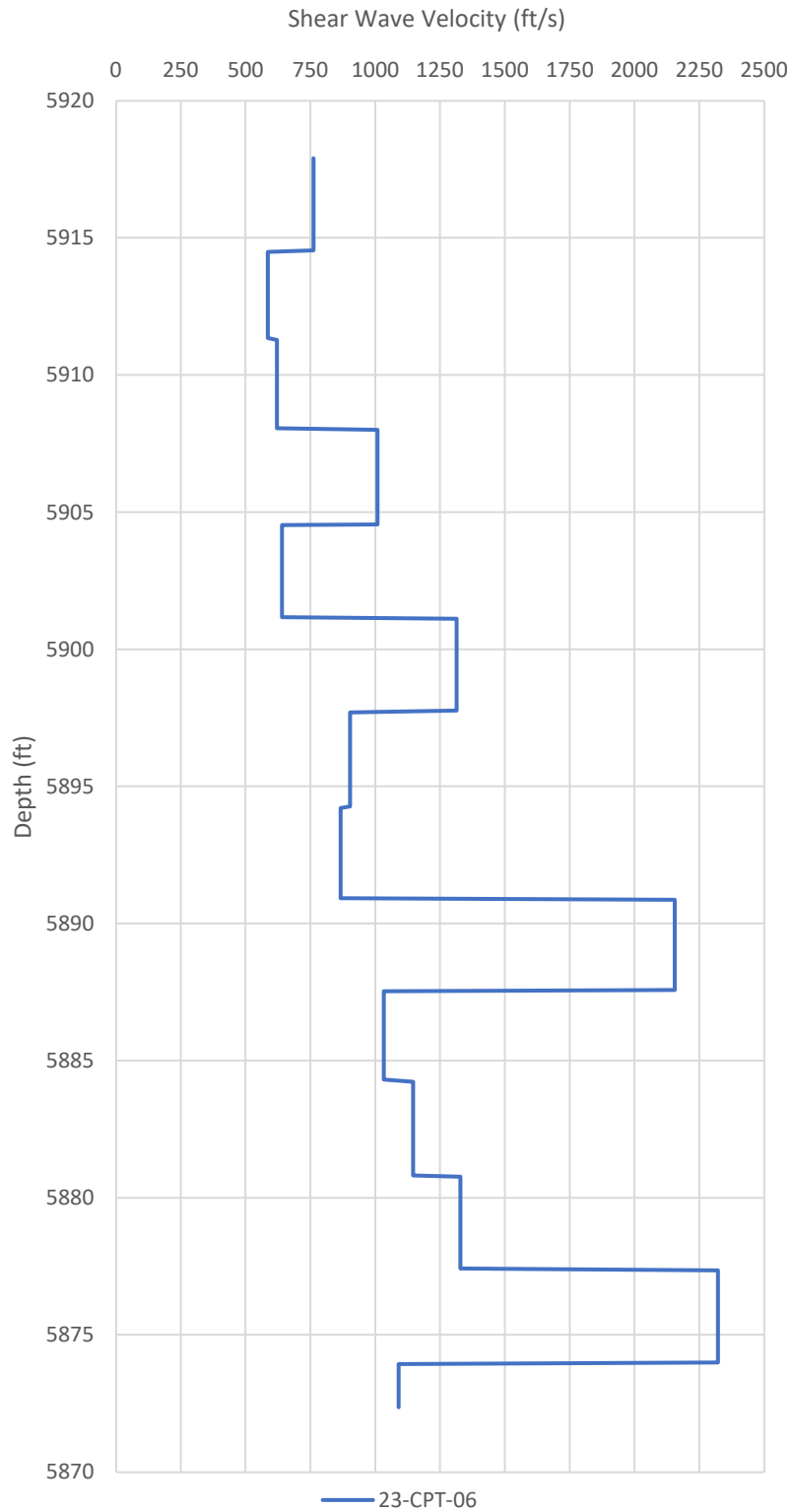
Elevation: 5920.2

Total Depth: 13.8 ft

Termination Criteria: Refusal

Cone Size:





CPT Shear Wave Velocity Profiles

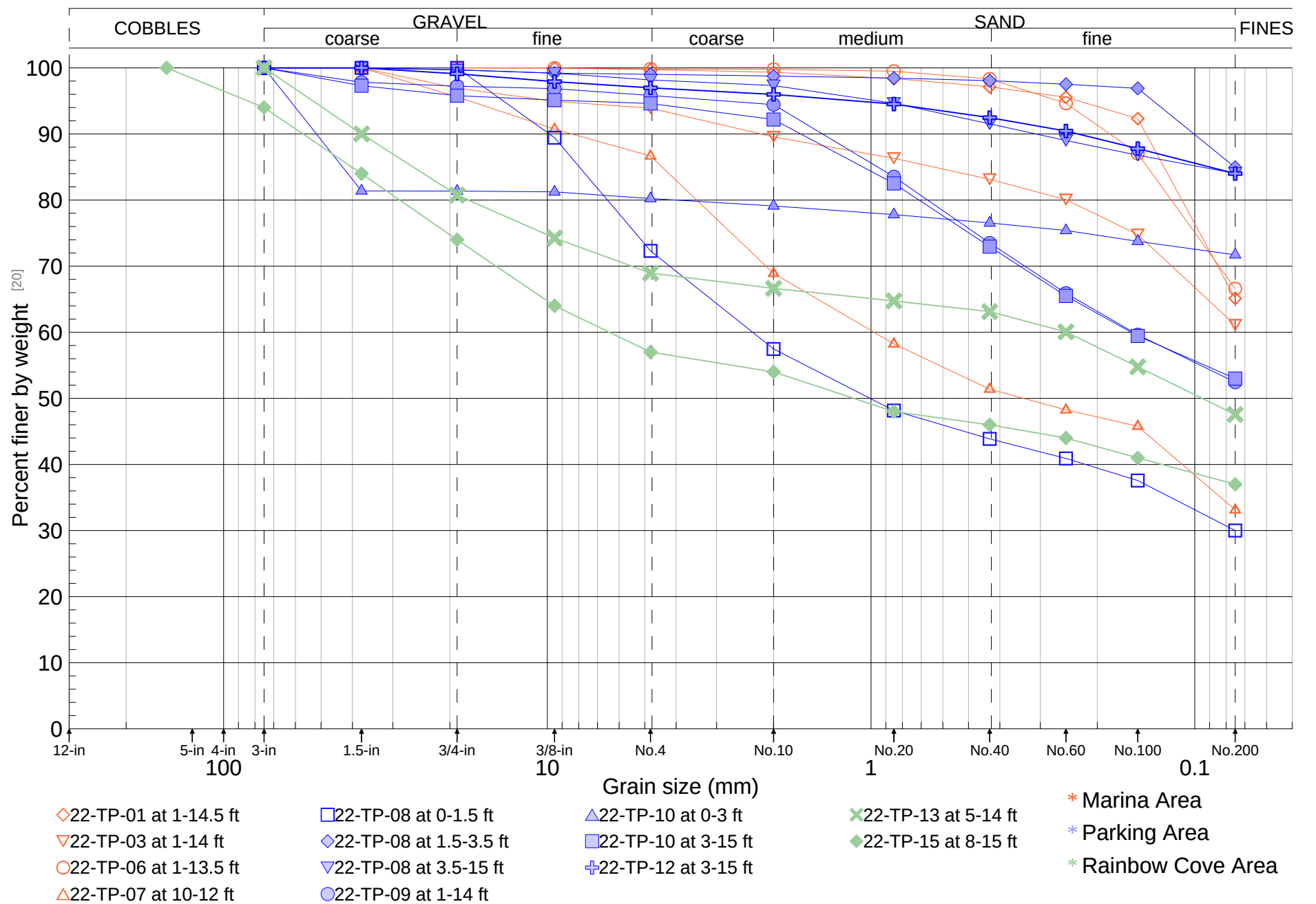
Bear Lake Marina Expansion

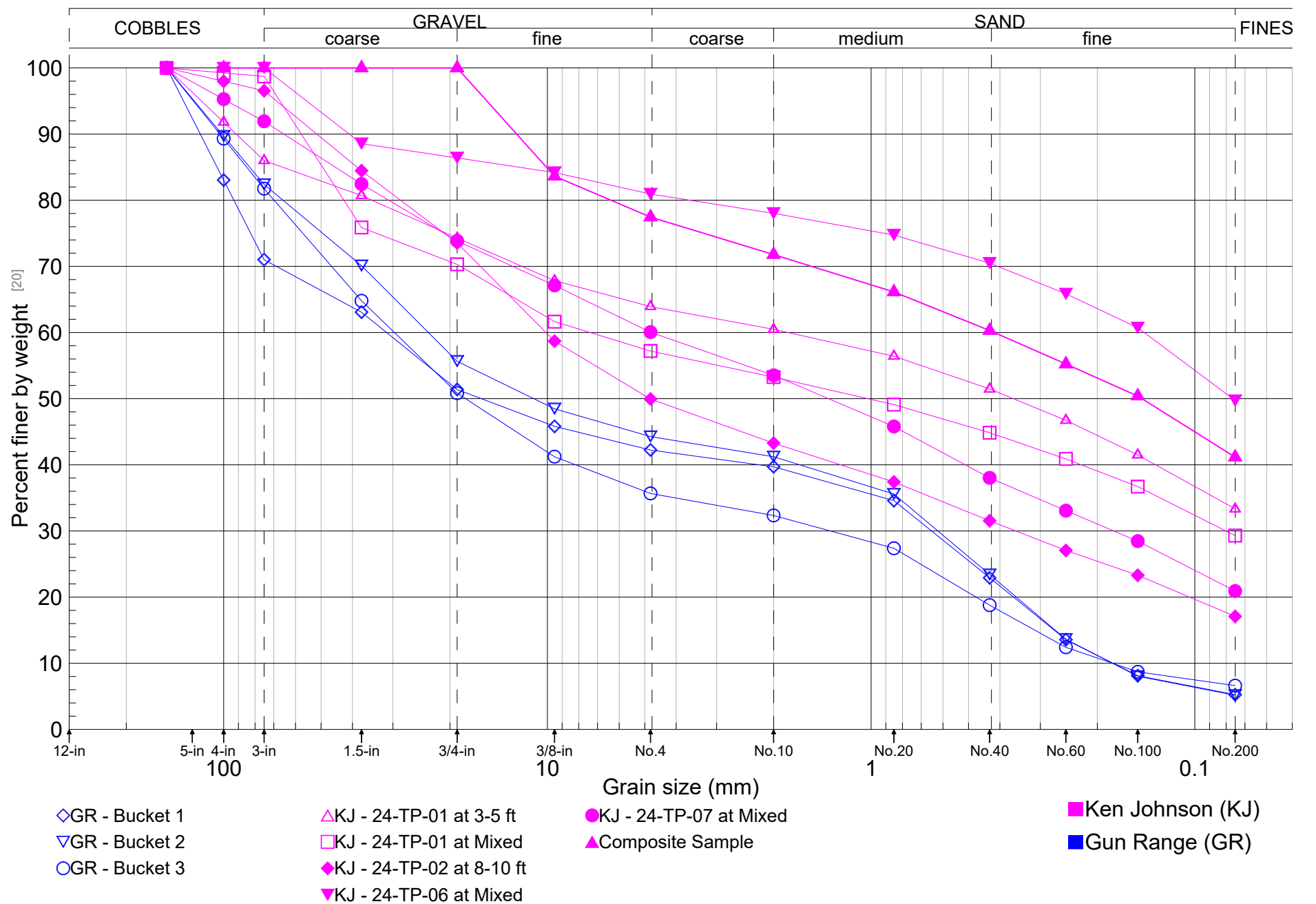


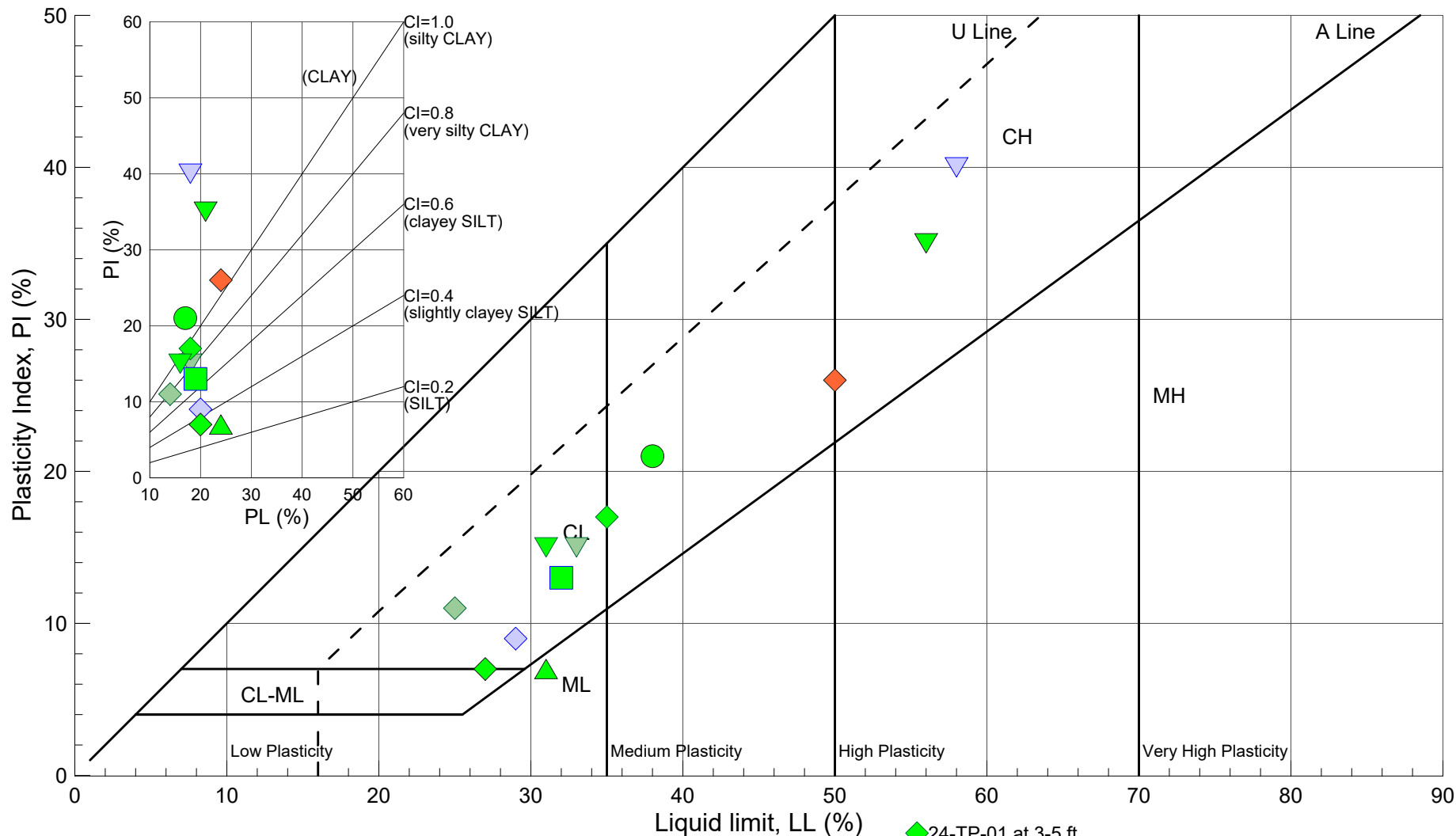
Appendix D

Laboratory Test Results – Test Pits Bear Lake Marina Expansion Table of Contents

<u>Description</u>	<u>Page No.</u>
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22-TP-03 at 1-14 ft

22-TP-08 at 0-1.5 ft

22-TP-13 at 5-14 ft

22-TP-15 at 8-15 ft

24-TP-01 at 3-5 ft

24-TP-01 at Mixed

24-TP-02 at 8-10 ft

24-TP-03 at 9 ft

24-TP-06 at Mixed

24-TP-07 at Mixed

Composite Sample

Marina

Parking Lot

Rainbow Cove

Ken Johnson

Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **03-Jan-22**

Tested by: **JCC**

Reduced by: **JCC/MGS**

Reviewed by: **AT**

Comments:

TH/TP/Sample: **22-TP-01**

Depth: **1-14.5 ft**

Location: **Bear Lake State Park, Utah**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 17.1

Maximum dry unit weight (pcf): 105.1

Laboratory sample description: **lt gray - gray silt**

Engineering Classification: **Not requested**

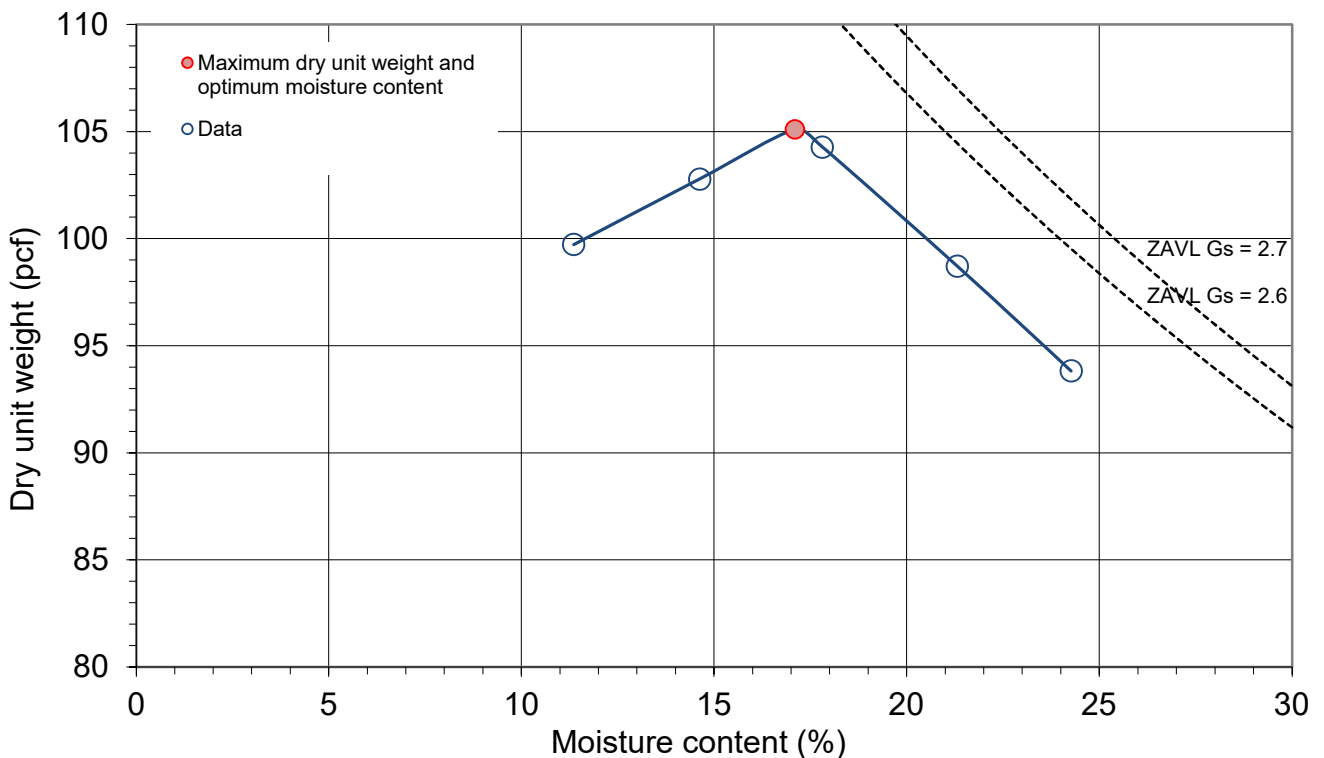
As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **No**

Point Number	+9	+12	+15	+18	+21
Wt. mold + wet soil (g)	5894.25	5996.50	6072.60	6025.80	5978.05
Wt. mold (g)	4215.05	4215.05	4215.05	4215.05	4215.05
Moist unit wt., gd (pcf)	111.1	117.8	122.9	119.8	116.6
Wet soil + tare (g)	355.29	576.12	522.80	600.54	613.68
Dry soil + tare (g)	330.90	517.70	461.46	529.71	522.05
Tare (g)	116.09	118.18	116.98	197.29	144.42
Moisture content, w (%)	11.4	14.6	17.8	21.3	24.3
Dry unit wt., gd (pcf)	99.7	102.8	104.3	98.7	93.8



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Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **03-Jan-22**

Tested by: **JCC**

Reduced by: **JCC/MGS**

Reviewed by: **AT**

TH/TP/Sample: **22-TP-06**

Depth: **1-13.5 ft**

Location: **Bear Lake State Park, Utah**

Comments: **Pooling on +21**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 16.7

Maximum dry unit weight (pcf): 105.1

Laboratory sample description: **lt brown - brown silt**

Engineering Classification: **Not requested**

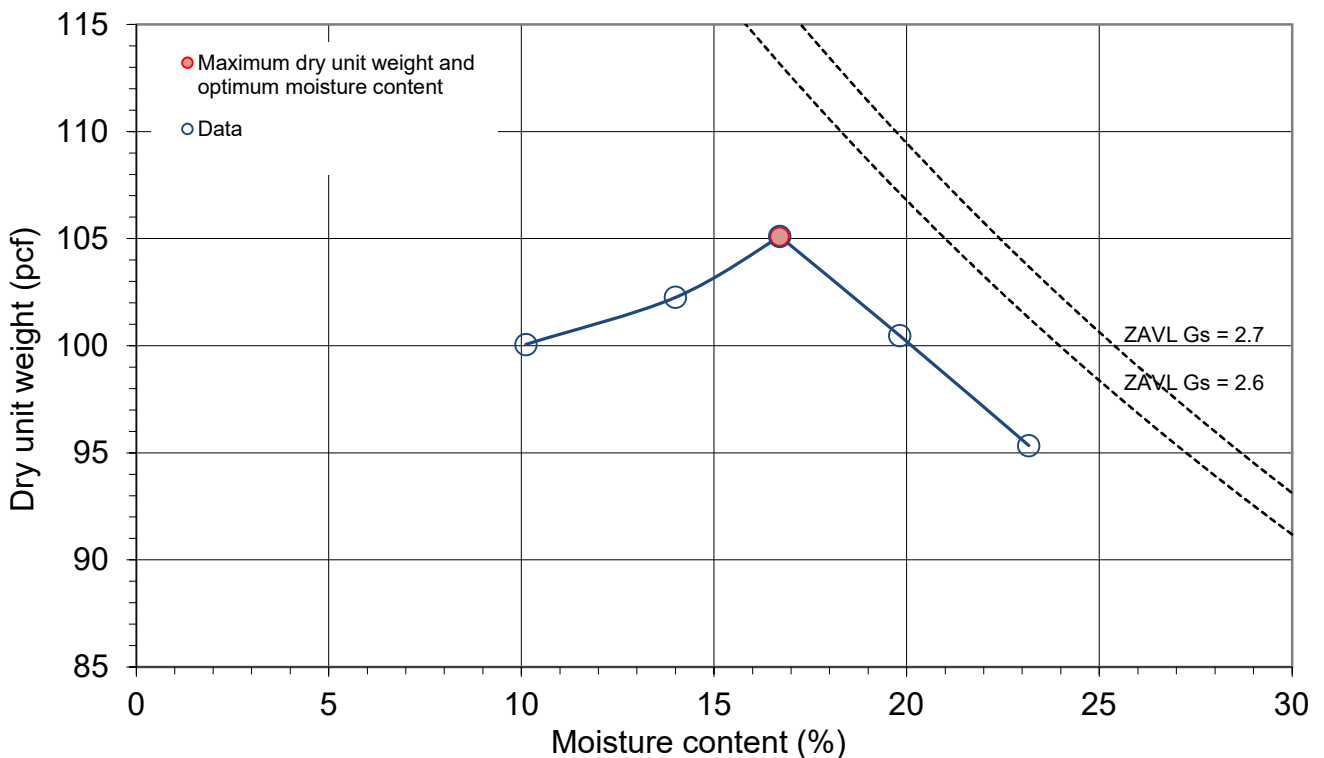
As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **No**

Point Number	+9	+12	+15	+18	+21
Wt. mold + wet soil (g)	5881.05	5977.70	6069.70	6035.40	5990.60
Wt. mold (g)	4215.05	4215.05	4215.05	4215.05	4215.05
Moist unit wt., gd (pcf)	110.2	116.6	122.7	120.4	117.4
Wet soil + tare (g)	505.94	690.90	426.34	610.68	707.39
Dry soil + tare (g)	477.29	630.04	382.23	542.23	601.62
Tare (g)	194.02	195.17	118.14	196.73	145.04
Moisture content, w (%)	10.1	14.0	16.7	19.8	23.2
Dry unit wt., gd (pcf)	100.1	102.3	105.1	100.5	95.3



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Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **03-Jan-22**

Tested by: **JCC**

Reduced by: **MGS**

Reviewed by: **AT**

Comments:

TH/TP/Sample: **22-TP-12**

Depth: **3-15 ft**

Location: **Bear Lake State Park, Utah**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 21.2

Maximum dry unit weight (pcf): 99.7

Laboratory sample description: **lt brown - brown silt**

Engineering Classification: **Not requested**

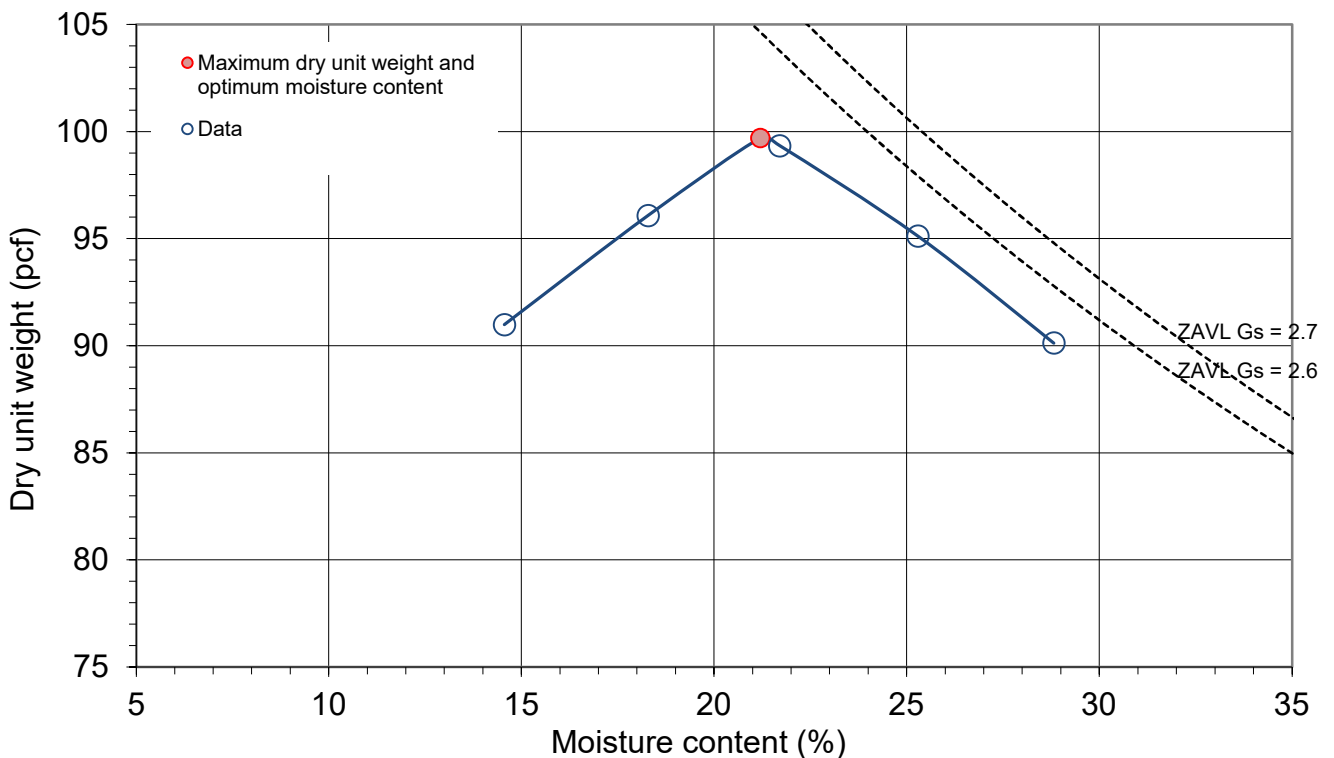
As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **No**

Point Number	-6	-3	As Is	+3	+6
Wt. mold + wet soil (g)	5791.55	5934.00	6043.50	6017.50	5970.95
Wt. mold (g)	4215.5	4215.5	4215.5	4215.5	4215.5
Moist unit wt., gd (pcf)	104.2	113.7	120.9	119.2	116.1
Wet soil + tare (g)	542.52	568.70	738.07	699.07	644.10
Dry soil + tare (g)	488.81	511.18	641.75	597.88	526.10
Tare (g)	119.86	196.62	197.93	197.75	116.61
Moisture content, w (%)	14.6	18.3	21.7	25.3	28.8
Dry unit wt., gd (pcf)	91.0	96.1	99.3	95.1	90.1



Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557

**Project: Bear Lake Marina Expansion****No: 22-1522**

Date: 03-Jan-22

Tested by: JCC

Reduced by: JCC/MGS

Reviewed by: AT

TH/TP/Sample: 22-TP-15**Depth: 1-15 ft**

Location: Bear Lake State Park, Utah

Comments: Moisture content for rock correction taken from +3/8" material.

Test Summary

Method: ASTM D698 B

Mold volume (ft³): 0.0750

Laboratory sample description: lt brown - brown silt

Engineering Classification: Not requested

As-received moisture content (%): Not requested

Preparation method: Moist

Rammer: Manual

Rock Correction: Yes

Optimum moisture content (%): 10.5**Maximum dry unit weight (pcf): 123**

Point Number	As-is	+2	+4	+6
Wt. mold + wet soil (g)	10856.60	11090.20	11151.15	11011.85
Wt. mold (g)	6579.15	6579.15	6579.15	6579.15
Moist unit wt., gd (pcf)	125.7	132.6	134.4	130.3
Wet soil + tare (g)	558.26	410.02	592.76	618.90
Dry soil + tare (g)	529.68	384.96	550.80	565.72
Tare (g)	140.35	117.48	196.61	196.63
Moisture content, w (%)	7.3	9.4	11.8	14.4
Dry unit wt., gd (pcf)	117.1	121.2	120.1	113.9

***Correction of Unit Weight and Water Content for Soils Containing Oversize Particles**

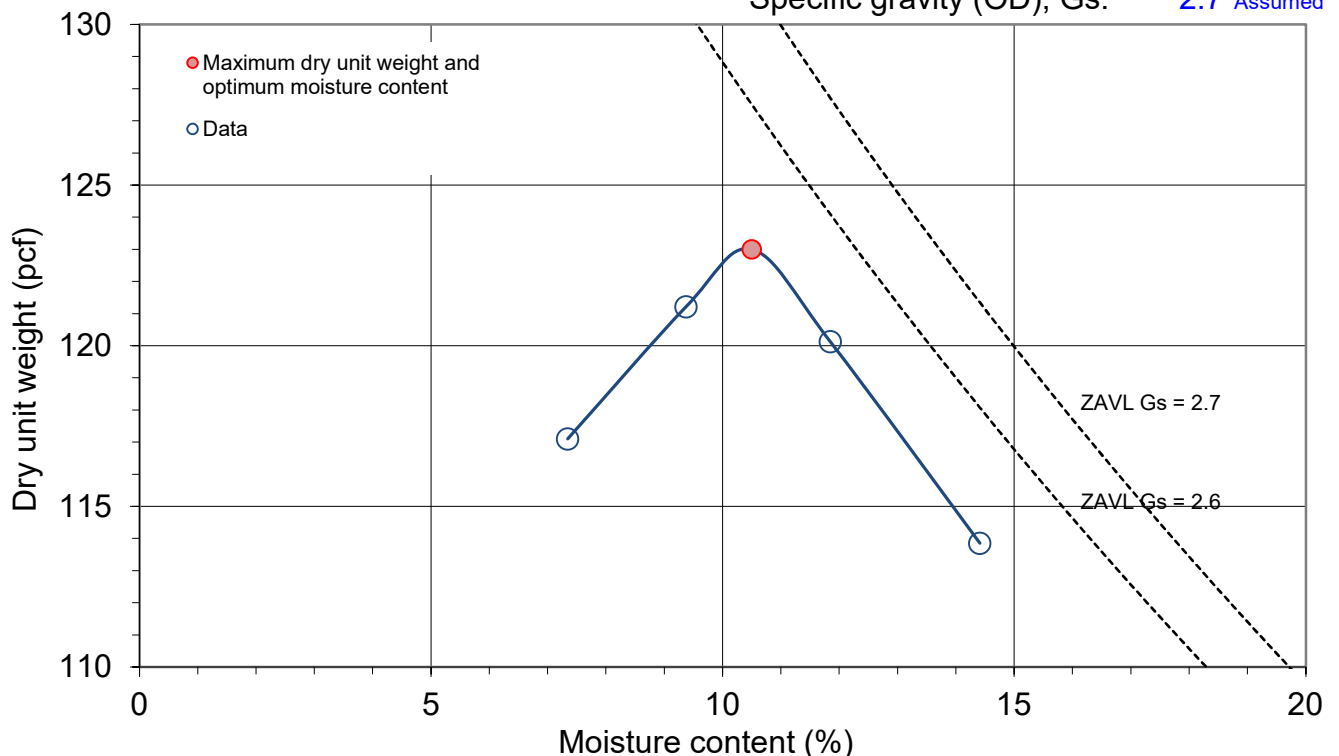
(ASTM D4718)

Oversized fraction, +3/4-in. (%): 26.4

Moisture content, +3/4-in. (%): 2.8

Sieve for oversized fraction: 3/4-in.

Specific gravity (OD), Gs: 2.7 Assumed

Corrected moisture content (%): 8.5**Corrected dry unit weight (pcf): 132.5**

Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **17-Feb-23**

Tested by: **JCC**

Reduced by: **JCC**

Reviewed by: **MGS**

Comments:

TH/TP/Sample: **22-TP-10**

Depth: **3-15 ft**

Location: **Bear Lake State Park**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 30.9

Maximum dry unit weight (pcf): 88.6

Laboratory sample description: **lt bn -bn silty clay**

Engineering Classification: **Not requested**

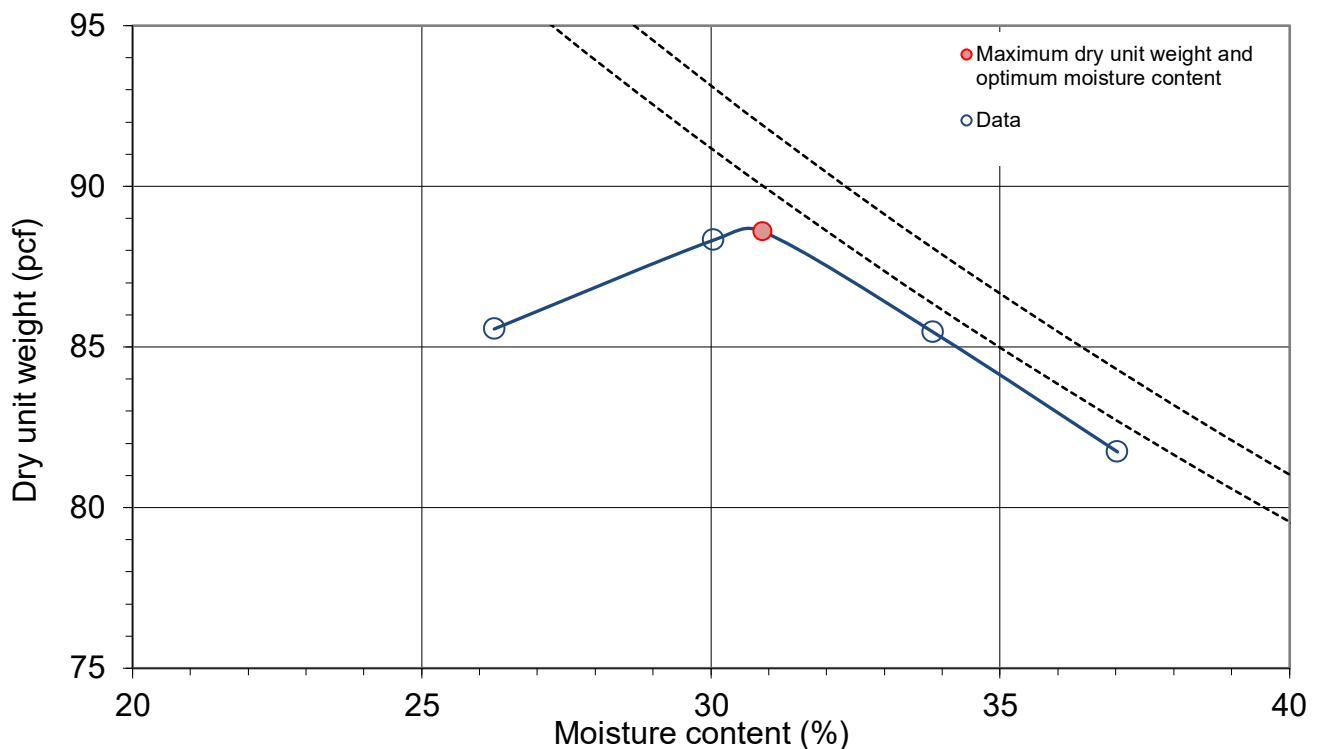
As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **No**

Point Number	-3	As-is	+3	+6
Wt. mold + wet soil (g)	5858.70	5962.0	5954.8	5918.7
Wt. mold (g)	4225.1	4225.1	4225.1	4225.1
Moist unit wt., gd (pcf)	108.0	114.9	114.4	112.0
Wet soil + tare (g)	854.2	607.35	549.31	577.62
Dry soil + tare (g)	805.5	512.25	439.25	474.64
Tare (g)	620	195.71	114.01	196.51
Moisture content, w (%)	26.3	30.0	33.8	37.0
Dry unit wt., gd (pcf)	85.6	88.3	85.5	81.7



Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522a**

Date: **05-Jun-23**

Tested by: **JC**

Reduced by: **JC**

Reviewed by: **AT**

TH/TP/Sample: **Combined Samples**

Depth: **Bucket Samples**

Location: **Rich County, Utah**

Comments: **Moderate bleeding on +12**

Gun Range

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Laboratory sample description: **or - rd sandy gravel**

Engineering Classification: **Not requested**

As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Optimum moisture content (%): 10.4

Maximum dry unit weight (pcf): 122.7

Rock Correction: **Yes**

Point Number	+6	+8	+10	+12
Wt. mold + wet soil (g)	6176.3	6241.0	6276.2	6263.0
Wt. mold (g)	4232.75	4232.75	4232.75	4232.75
Moist unit wt., gd (pcf)	128.5	132.8	135.1	134.3
Wet soil + tare (g)	787.03	1051.43	733.05	798.88
Dry soil + tare (g)	743.53	980.47	670.75	722.22
Tare (g)	119.23	194.10	118.15	118.48
Moisture content, w (%)	7.0	9.0	11.3	12.7
Dry unit wt., gd (pcf)	120.2	121.8	121.5	119.1

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/8-in. (%): **52.6**

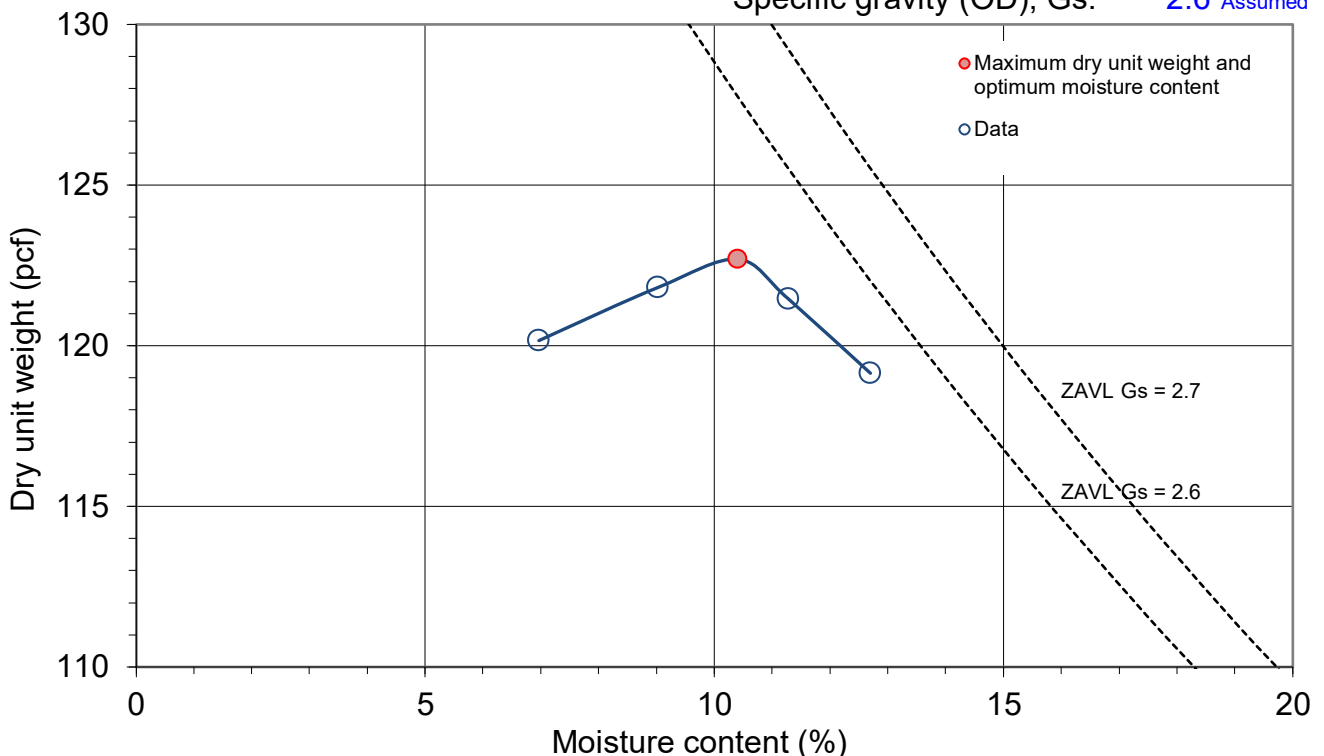
Moisture content, +3/8-in. (%): **1.3**

Corrected moisture content (%): 5.6

Corrected dry unit weight (pcf): 140.8

Sieve for oversized fraction: **3/8-in.**

Specific gravity (OD), Gs: **2.6 Assumed**



Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522a**

Date: **30-Jul-24**

Tested by: **CRC**

Reduced by: **CRC**

Reviewed by: **JC**

Comments:

TH/TP/Sample: **Composite Sample**

Depth: **-**

Location: **Rich County, Utah**

Ken Johnson

Test Summary

Method: **ASTM D698 C**
Mold volume (ft³): **0.0750**

Laboratory sample description: **dk yl bn - lt bn silt**

Engineering Classification: **Not requested**

As-received moisture content (%): **Not requested**

Preparation method: **Moist**

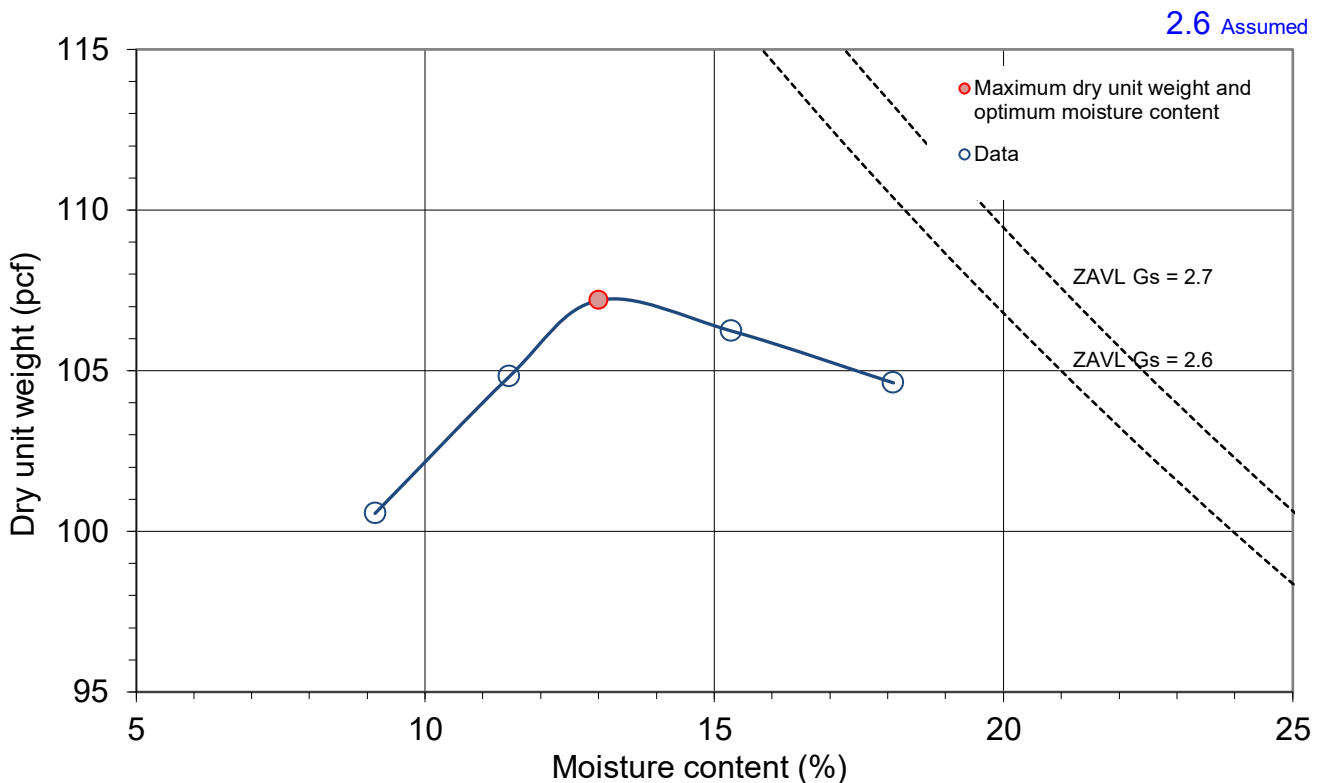
Rammer: **Manual**

Rock Correction: **No**

Optimum moisture content (%): 13

Maximum dry unit weight (pcf): 107.2

Point Number	+2.5	+5	+7.5	+10
Wt. mold + wet soil (g)	10306.6	10547.9	10740.4	10776.3
Wt. mold (g)	6571.95	6571.95	6571.95	6571.95
Moist unit wt., gd (pcf)	109.75	116.84	122.50	123.55
Wet soil + tare (g)	1120.64	1199.06	1181.05	841.51
Dry soil + tare (g)	1038.95	1096.12	1050.24	730.63
Tare (g)	144.80	197.66	195.05	117.88
Moisture content, w (%)	9.1	11.5	15.3	18.1
Dry unit wt., gd (pcf)	100.6	104.8	106.2	104.6



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One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Bear Lake State Park, Utah
Date: 12-Jan-23

TH/TP/Sample: 22-TP-03
Depth: 1-14 ft

Laboratory sample description: gy - dk gy sandy clay
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Recompacted
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: A
Preparation procedure: trimmed

Phase Relationships		
	Initial	Final
Height, H (in)		
0°	1.002	-
90°	1.001	-
180°	1.004	-
270°	1.003	-
Avg Height, Havg (in)	1.003	1.035
Height, H (cm)	2.546	2.629
Dia., D (in)		
0°	2.492	-
90°	2.498	-
Avg Dia., Davg (in)	2.495	2.495
Dia., D (cm)	6.337	6.337
Wt. rings + wet soil (g)	376.06	386.54
Wt. rings (g)	217.56	217.56
Wet soil + tare (g)	360.26	295.55
Dry soil + tare (g)	337.10	262.93
Tare (g)	196.76	126.88
Moisture cont., w (%)	16.5	24.2
Gs, assumed	2.70	2.70
Mass total (g)	158.5	169.0
Mass of solids (g)	136.0	136.0
Volume (cm ³)	80.3	82.9
Vol. of water (cm ³)	22.5	32.9
Vol. of solids (cm ³)	50.4	50.4
Vol. of voids (cm ³)	29.9	32.5
Vol. of air (cm ³)	7.5	-0.4
Area, A (cm ²)	31.5	31.5
Ht. solids, Hs (cm)	1.597	1.597
Void ratio, e	0.594	0.646
Porosity, n	0.373	0.392
Vol. moisture, T	0.280	0.397
Saturation, S (%)	75	101
Dry density (gm/cm ³)	1.694	1.641
Wet unit wt., gm (pcf)	123.2	127.2
Dry unit wt., gd (pcf)	105.7	102.4

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

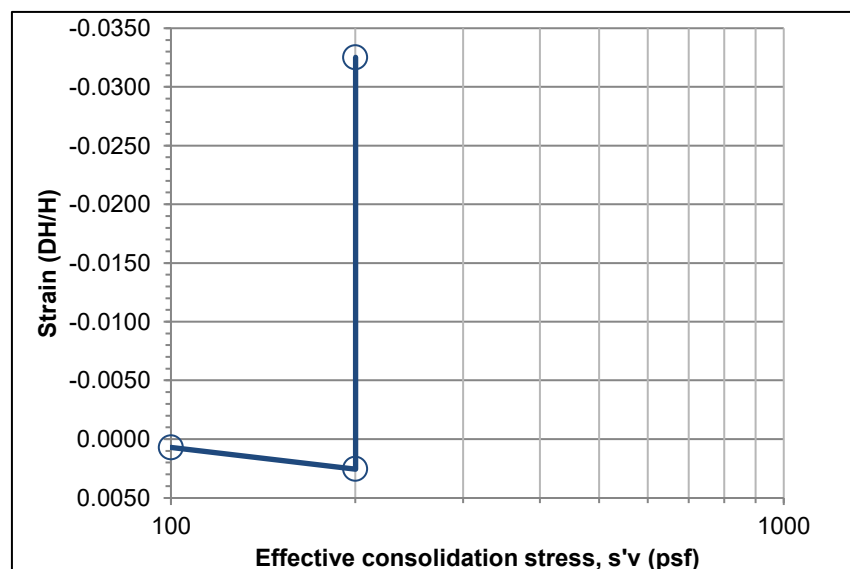
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf) 200
Swell strain (%) -3.51

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	1.0025	0.0000	0.5940	0
100	0.0007	1.0018	0.0007	0.5929	63
200	0.0026	0.9999	0.0025	0.5899	199
200	-0.0326	1.0351	-0.0325	0.6458	1440



One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Bear Lake State Park, Utah
Date: 16-Jan-23

TH/TP/Sample: 22-TP-08
Depth: 0-1.5 ft

Laboratory sample description: dk yl bn - bn sand
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Recompacted
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: A
Preparation procedure: trimmed

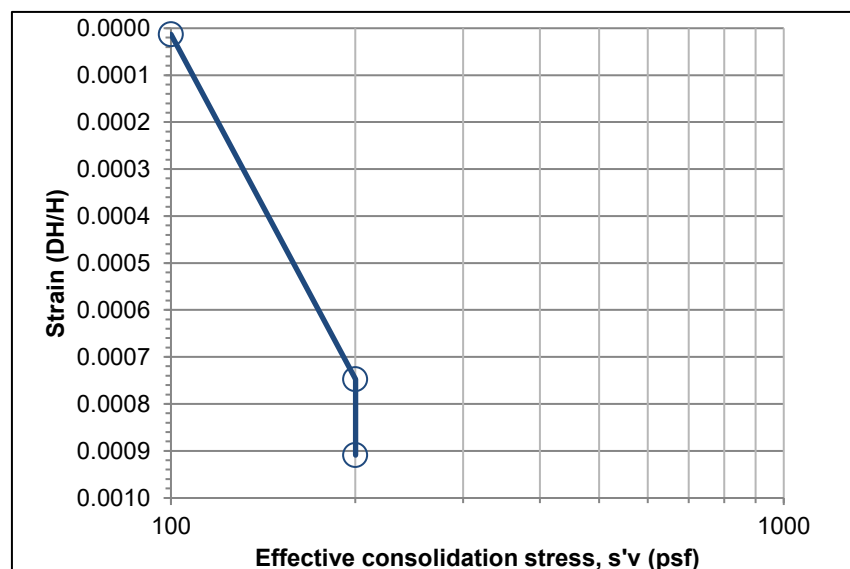
Phase Relationships		
	Initial	Final
Height, H (in)	0° 0.991	-
	90° 0.992	-
	180° 0.989	-
	270° 0.991	-
Avg Height, Havg (in)	0.991	0.990
Height, H (cm)	2.517	2.514
Dia., D (in)	0° 2.500	-
	90° 2.497	-
Avg Dia., Davg (in)	2.499	2.499
Dia., D (cm)	6.346	6.346
Wt. rings + wet soil (g)	386.17	392.54
Wt. rings (g)	214.64	214.64
Wet soil + tare (g)	406.89	373.03
Dry soil + tare (g)	390.05	353.22
Tare (g)	196.59	195.43
Moisture cont., w (%)	8.7	12.7
Gs, assumed	2.70	2.70
Mass total (g)	171.5	177.9
Mass of solids (g)	157.8	157.8
Volume (cm ³)	79.6	79.5
Vol. of water (cm ³)	13.7	20.1
Vol. of solids (cm ³)	58.4	58.4
Vol. of voids (cm ³)	21.2	21.1
Vol. of air (cm ³)	7.4	1.0
Area, A (cm ²)	31.6	31.6
Ht. solids, Hs (cm)	1.848	1.848
Void ratio, e	0.362	0.361
Porosity, n	0.266	0.265
Vol. moisture, T	0.173	0.253
Saturation, S (%)	65	95
Dry density (gm/cm ³)	1.982	1.984
Wet unit wt., gm (pcf)	134.5	139.7
Dry unit wt., gd (pcf)	123.8	123.9

Notes:

- ^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation
^b Hc = height at end of consolidation of each vert. stress

Test Results		
Collapse load (psf)	200	
Collapse strain (%)	0.02	

Vertical Stress - Deformation Results						
	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating		0.0000	0.9908	0.0000	0.3620	0
	100	0.0000	0.9907	0.0000	0.3620	100
	200	0.0007	0.9900	0.0007	0.3610	982
	200	0.0009	0.9898	0.0009	0.3608	1440



One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Bear Lake State Park, Utah
Date: 16-Jan-23

TH/TP/Sample: 22-TP-10
Depth: 0-3 ft

Laboratory sample description: bn - dk bn clay
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Highly compacted at approximately 2% dry of OMC. Run on -No. 40 material.

Sample type: Recompacted
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: A
Preparation procedure: trimmed

Phase Relationships

	Initial	Final
Height, H (in)		
0°	0.786	-
90°	0.801	-
180°	0.790	-
270°	0.799	-
Avg Height, Havg (in)	0.794	0.932
Height, H (cm)	2.017	2.368
Dia., D (in)		
0°	1.995	-
90°	1.997	-
Avg Dia., Davg (in)	1.996	1.996
Dia., D (cm)	5.070	5.070
Wt. rings + wet soil (g)	440.09	453.11
Wt. rings (g)	360.10	360.10
Wet soil + tare (g)	219.33	209.82
Dry soil + tare (g)	206.93	187.19
Tare (g)	117.26	117.26
Moisture cont., w (%)	13.8	32.4
Gs, assumed	2.70	2.70
Mass total (g)	80.0	93.0
Mass of solids (g)	70.3	70.3
Volume (cm ³)	40.7	47.8
Vol. of water (cm ³)	9.7	22.7
Vol. of solids (cm ³)	26.0	26.0
Vol. of voids (cm ³)	14.7	21.8
Vol. of air (cm ³)	5.0	-1.0
Area, A (cm ²)	20.2	20.2
Ht. solids, Hs (cm)	1.289	1.289
Void ratio, e	0.564	0.837
Porosity, n	0.361	0.456
Vol. moisture, T	0.239	0.476
Saturation, S (%)	66	104
Dry density (gm/cm ³)	1.726	1.470
Wet unit wt., gm (pcf)	122.7	121.5
Dry unit wt., gd (pcf)	107.8	91.8

Notes:

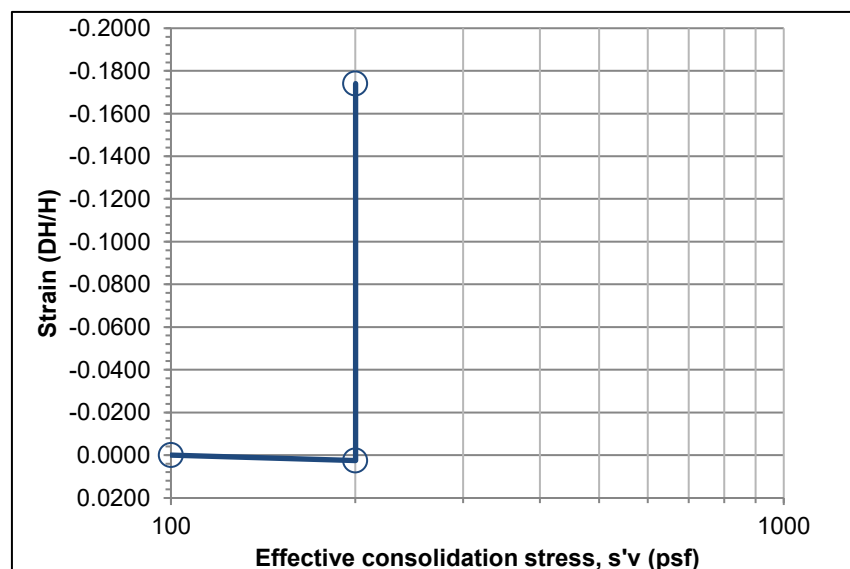
- ^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf)	200
Swell strain (%)	-17.66

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.7940	0.0000	0.5643	0
100	0.0000	0.7940	0.0000	0.5642	100
200	0.0020	0.7920	0.0025	0.5603	972
200	-0.1382	0.9322	-0.1741	0.8366	1440



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One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Bear Lake State Park, Utah
Date: 12-Jan-23

TH/TP/Sample: 22-TP-10
Depth: 3-15 ft

Laboratory sample description: tan - red clayey sand
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Recompacted
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: A
Preparation procedure: trimmed

Phase Relationships		
	Initial	Final
Height, H (in)	1.002	-
0°	1.000	-
90°	1.004	-
180°	1.002	-
270°	1.002	-
Avg Height, Havg (in)	1.002	0.995
Height, H (cm)	2.545	2.528
Dia., D (in)	2.487	-
0°	2.490	-
90°	2.489	2.489
Avg Dia., Davg (in)	2.489	2.489
Dia., D (cm)	6.321	6.321
Wt. rings + wet soil (g)	366.48	367.55
Wt. rings (g)	216.23	216.23
Wet soil + tare (g)	246.33	348.89
Dry soil + tare (g)	216.77	313.60
Tare (g)	117.18	197.88
Moisture cont., w (%)	29.7	30.5
Gs, assumed	2.70	2.70
Mass total (g)	150.3	151.3
Mass of solids (g)	115.9	115.9
Volume (cm ³)	79.9	79.3
Vol. of water (cm ³)	34.4	35.5
Vol. of solids (cm ³)	42.9	42.9
Vol. of voids (cm ³)	36.9	36.4
Vol. of air (cm ³)	2.6	1.0
Area, A (cm ²)	31.4	31.4
Ht. solids, Hs (cm)	1.368	1.368
Void ratio, e	0.861	0.849
Porosity, n	0.463	0.459
Vol. moisture, T	0.431	0.447
Saturation, S (%)	93	97
Dry density (gm/cm ³)	1.451	1.460
Wet unit wt., gm (pcf)	117.5	119.0
Dry unit wt., gd (pcf)	90.6	91.2

Notes:

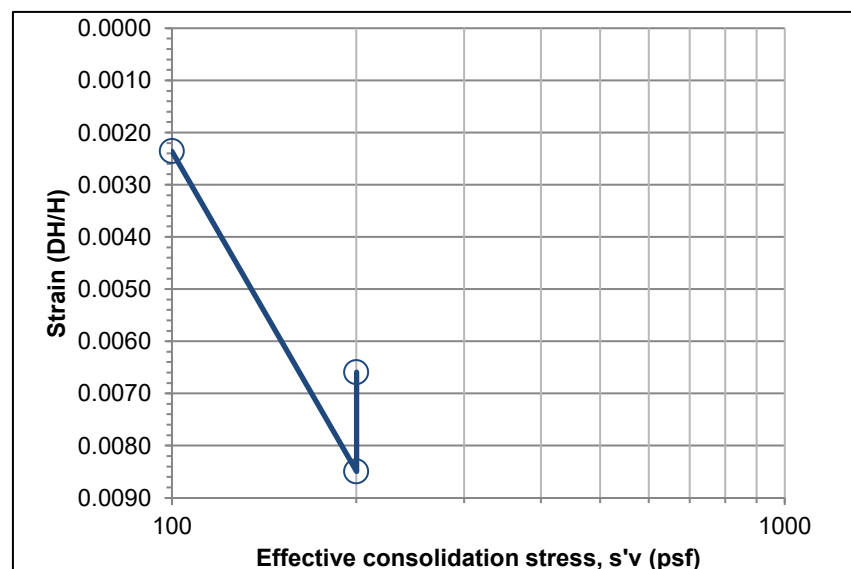
^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf) 200
Swell strain (%) -0.19

Vertical Stress - Deformation Results					
Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	1.0020	0.0000	0.8611	0
100	0.0024	0.9996	0.0024	0.8567	100
200	0.0085	0.9935	0.0085	0.8453	1042
200	0.0066	0.9954	0.0066	0.8488	1440



One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Bear Lake State Park, Utah
Date: 12-Jan-23

TH/TP/Sample: 22-TP-13
Depth: 5-14 ft

Laboratory sample description: dk yl bn - lt bn silty sand
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Recompacked
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: A
Preparation procedure: trimmed

Phase Relationships		
	Initial	Final
Height, H (in)	0° 0.988	-
	90° 0.982	-
	180° 0.984	-
	270° 0.985	-
Avg Height, Havg (in)	0.985	1.003
Height, H (cm)	2.501	2.548
Dia., D (in)	0° 2.491	-
	90° 2.491	-
Avg Dia., Davg (in)	2.491	2.491
Dia., D (cm)	6.327	6.327
Wt. rings + wet soil (g)	373.79	386.11
Wt. rings (g)	214.65	214.65
Wet soil + tare (g)	318.51	364.66
Dry soil + tare (g)	308.44	339.06
Tare (g)	196.68	194.36
Moisture cont., w (%)	9.0	17.7
Gs, assumed	2.70	2.70
Mass total (g)	159.1	171.5
Mass of solids (g)	146.0	146.0
Volume (cm ³)	78.6	80.1
Vol. of water (cm ³)	13.2	25.5
Vol. of solids (cm ³)	54.1	54.1
Vol. of voids (cm ³)	24.6	26.1
Vol. of air (cm ³)	11.4	0.6
Area, A (cm ²)	31.4	31.4
Ht. solids, Hs (cm)	1.720	1.720
Void ratio, e	0.455	0.482
Porosity, n	0.312	0.325
Vol. moisture, T	0.167	0.318
Saturation, S (%)	54	98
Dry density (gm/cm ³)	1.856	1.822
Wet unit wt., gm (pcf)	126.3	133.9
Dry unit wt., gd (pcf)	115.9	113.7

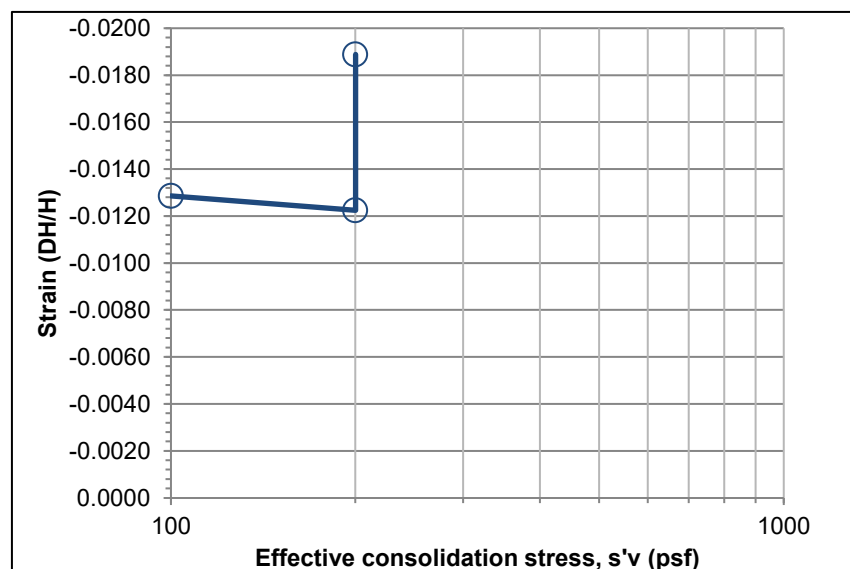
Notes:

- ^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf) 200
Swell strain (%) -0.66

Vertical Stress - Deformation Results					
Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9848	0.0000	0.4545	0
100	-0.0127	0.9974	-0.0129	0.4732	100
200	-0.0121	0.9968	-0.0122	0.4723	52
200	-0.0186	1.0033	-0.0189	0.4820	1440



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One-Dimensional Consolidation Properties of Soils

After ASTM D4546, D2435



Project: Bear Lake Marina Expansion

No: 22-1522

Location: Bear Lake State Park, Utah

Date: 12-Jan-23

TH/TP/Sample: 22-TP-03

Depth: 1-14 ft

Sample description: gy - dk gy sandy clay

USCS classification: Not Requested

Tested by: AT

Reduced by: AT

Checked by: MGS

Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Bulk Sample

Inundation stress (psf): 100

Load to prevent swell (psf): 1333

Test method: A

Preparation procedure: Laboratory compacted

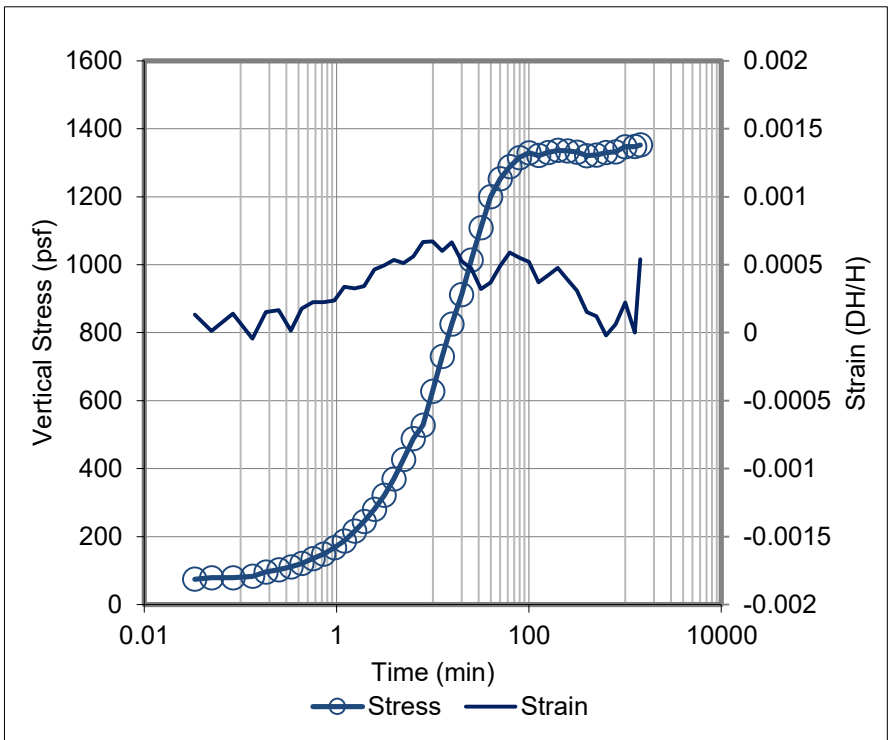
Target moisture content: 2% dry of OMC

Phase Relationships

	Initial	Final
Height, H	0° 1.000	-
(in)	90° 0.995	-
	180° 0.995	-
	270° 0.998	-
Avg Height, Havg (in)	0.997	0.996
Height, H (cm)	2.532	2.531
Dia., D (in)	0° 2.485	-
	90° 2.495	-
Avg Dia., Davg (in)	2.490	2.490
Dia., D (cm)	6.325	6.325
Wt. rings + wet soil (g)	375.43	383.63
Wt. rings (g)	217.27	217.27
Wet soil + tare (g)	264.54	362.10
Dry soil + tare (g)	243.51	331.80
Tare (g)	119.80	196.01
Moisture cont., w (%)	17.0	22.3
Gs, assumed	2.65	2.65
Mass total (g)	158.2	166.4
Mass of solids (g)	135.2	135.2
Volume (cm ³)	79.6	79.5
Vol. of water (cm ³)	23.0	31.2
Vol. of solids (cm ³)	51.0	51.0
Vol. of voids (cm ³)	28.5	28.5
Vol. of air (cm ³)	5.6	-2.7
Area, A (cm ²)	31.4	31.4
Ht. solids, Hs (cm)	1.624	1.624
Void ratio, e	0.560	0.559
Porosity, n	0.359	0.358
Vol. moisture, T	0.289	0.392
Saturation, S (%)	80	109
Dry density (gm/cm ³)	1.699	1.700
Wet unit wt., gm (pcf)	124.1	129.8
Dry unit wt., gd (pcf)	106.1	106.1

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, d _{fc} ^a (in)	H _c ^b (in)	Vert. strain, ϵ_v	Void ratio, e	Load duration (min)
Seating	0.0000	0.9970	0.0000	0.5596	0
100	0.0005	0.9965	0.0005	0.5588	1440



Notes:

^a D_{fc} = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b H_c = height at end of consolidation of each vert. stress

One-Dimensional Consolidation Properties of Soils

After ASTM D4546, D2435



Project: Bear Lake Marina Expansion

No: 22-1522

Location: Bear Lake State Park, Utah

Date: 12-Jan-23

TH/TP/Sample: 22-TP-10

Depth: 3-15 ft

Sample description: tan - red clayey sand

USCS classification: Not Requested

Tested by: AT

Reduced by: AT

Checked by: MGS

Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Bulk Sample

Inundation stress (psf): 100

Load to prevent swell (psf): 155

Test method: A

Preparation procedure: Laboratory compacted

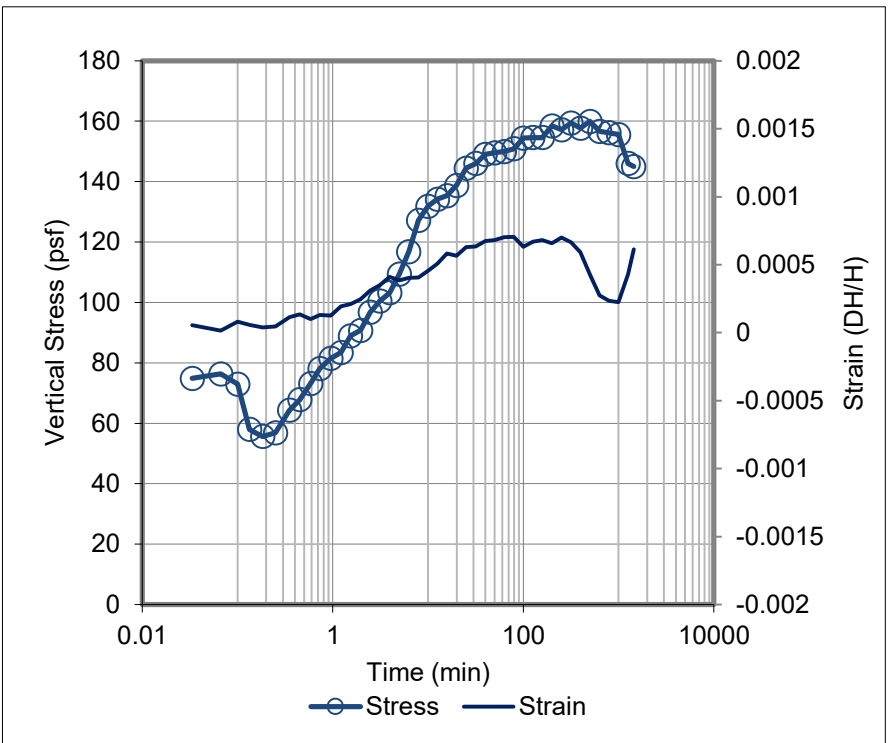
Target moisture content: 2% dry of OMC

Phase Relationships

	Initial	Final
Height, H	1.002	-
Height, H (in)	1.005	-
Height, H (in)	1.004	-
Height, H (in)	1.000	-
Avg Height, Havg (in)	1.003	1.002
Height, H (cm)	2.547	2.545
Dia., D (in)	2.498	-
Dia., D (in)	2.497	-
Avg Dia., Davg (in)	2.498	2.498
Dia., D (cm)	6.344	6.344
Wt. rings + wet soil (g)	368.10	369.51
Wt. rings (g)	217.30	217.30
Wet soil + tare (g)	222.44	270.01
Dry soil + tare (g)	198.45	234.13
Tare (g)	117.26	118.00
Moisture cont., w (%)	29.5	30.9
Gs, assumed	2.65	2.65
Mass total (g)	150.8	152.2
Mass of solids (g)	116.4	116.4
Volume (cm ³)	80.5	80.5
Vol. of water (cm ³)	34.4	35.8
Vol. of solids (cm ³)	43.9	43.9
Vol. of voids (cm ³)	36.6	36.5
Vol. of air (cm ³)	2.2	0.7
Area, A (cm ²)	31.6	31.6
Ht. solids, Hs (cm)	1.390	1.390
Void ratio, e	0.833	0.831
Porosity, n	0.454	0.454
Vol. moisture, T	0.427	0.445
Saturation, S (%)	94	98
Dry density (gm/cm ³)	1.446	1.447
Wet unit wt., gm (pcf)	116.9	118.2
Dry unit wt., gd (pcf)	90.3	90.3

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, d _{fc} ^a (in)	H _c ^b (in)	Vert. strain, e _v	Void ratio, e	Load duration (min)
Seating	0.0000	1.0028	0.0000	0.8326	0
100	0.0006	1.0021	0.0006	0.8315	1440



Notes:

^a D_{fc} = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b H_c = height at end of consolidation of each vert. stress

One-Dimensional Consolidation Properties of Soils

After ASTM D4546, D2435



Project: Bear Lake Marina Expansion

No: 22-1522

Location: Bear Lake State Park, Utah

Date: 12-Jan-23

TH/TP/Sample: 22-TP-13

Depth: 5-14 ft

Sample description: dk yl bn - lt bn silty sand

USCS classification: Not Requested

Tested by: AT

Reduced by: AT

Checked by: MGS

Comments: Highly compacted at approximately 2% dry of OMC.

Sample type: Bulk Sample

Inundation stress (psf): 100

Load to prevent swell (psf): 1833

Test method: A

Preparation procedure: Laboratory compacted

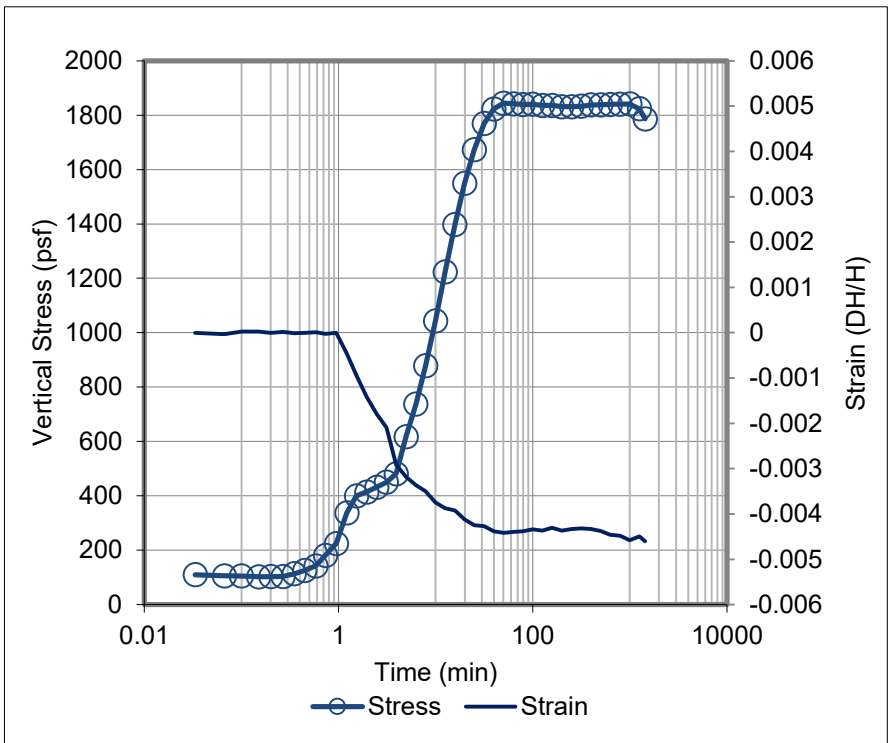
Target moisture content: 2% dry of OMC

Phase Relationships

	Initial	Final
Height, H	0.999	-
(in)	0.995	-
180°	0.999	-
270°	1.001	-
Avg Height, Havg (in)	0.999	1.003
Height, H (cm)	2.536	2.548
Dia., D (in)	2.498	-
90°	2.499	-
Avg Dia., Davg (in)	2.499	2.499
Dia., D (cm)	6.346	6.346
Wt. rings + wet soil (g)	377.58	388.61
Wt. rings (g)	216.67	216.67
Wet soil + tare (g)	265.05	316.18
Dry soil + tare (g)	252.74	291.77
Tare (g)	118.03	144.44
Moisture cont., w (%)	9.1	16.6
Gs, assumed	2.65	2.65
Mass total (g)	160.9	171.9
Mass of solids (g)	147.4	147.4
Volume (cm ³)	80.2	80.6
Vol. of water (cm ³)	13.5	24.5
Vol. of solids (cm ³)	55.6	55.6
Vol. of voids (cm ³)	24.6	25.0
Vol. of air (cm ³)	11.1	0.5
Area, A (cm ²)	31.6	31.6
Ht. solids, Hs (cm)	1.759	1.759
Void ratio, e	0.442	0.449
Porosity, n	0.306	0.310
Vol. moisture, T	0.168	0.304
Saturation, S (%)	55	98
Dry density (gm/cm ³)	1.838	1.829
Wet unit wt., gm (pcf)	125.2	133.1
Dry unit wt., gd (pcf)	114.7	114.2

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, d _{fc} ^a (in)	H _c ^b (in)	Vert. strain, e _v	Void ratio, e	Load duration (min)
Seating	0.0000	0.9985	0.0000	0.4419	0
100	-0.0046	1.0031	-0.0046	0.4485	1440



Notes:

^a D_{fc} = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b H_c = height at end of consolidation of each vert. stress

Project: **Bear Lake Marine Expansion**TH/TP/Sample: **22-TP-01**No: **22-1522**Depth: **1-14 ft**Date: **17-Feb-23**Location: **Bear Lake State Park**Tested by: **JCC**

Comments:

Reduced by: **JCC**Reviewed by: **MGS**

Test Summary

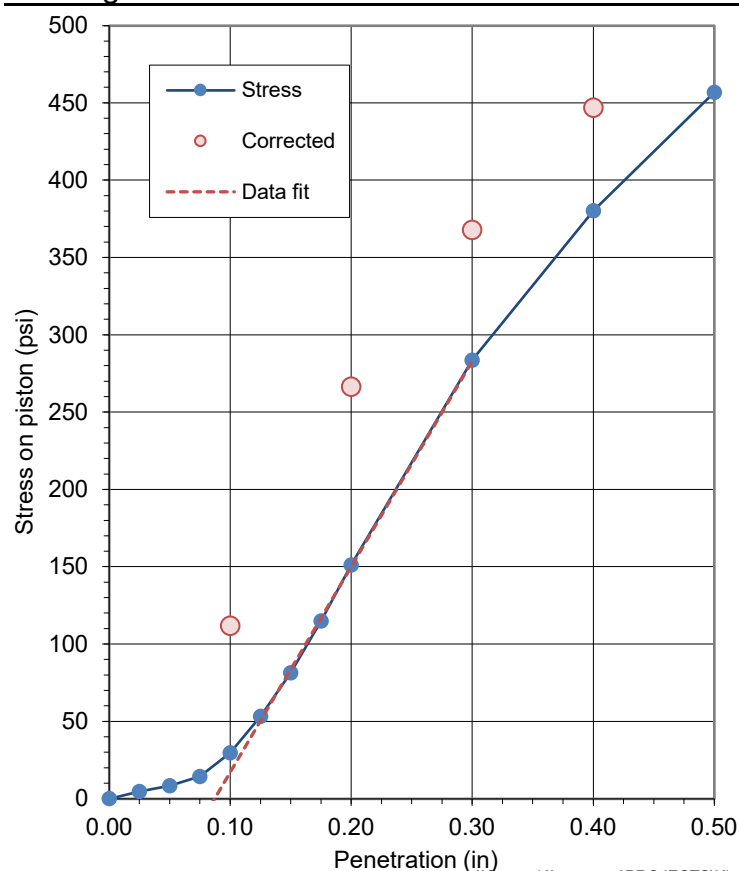
Maximum dry unit weight (pcf): **105.1**Reference method: **ASTM D698 B**Optimum moisture content (%): **17.1**Eng. classification: **Not requested**Relative compaction (%): **99.9**Condition of sample: **Soaked****Corrected CBR at 0.1-in. (%) 11.2**Scalp and replace: **No****Corrected CBR at 0.2-in. (%) 17.8**

Compaction Data

Swell Data

	As-Comp.	After Soak	Top 1-in.	Date	Time	Dial (in)
Wt. mold + moist soil (g)	8495.00	8561.05		2/18	14:05	0.083
Wt. mold (g)	4316.00	4316.00		2/22	16:00	0.095
Mold volume (ft^3)	0.0750	0.0752				
Moist unit wt., gm (pcf)	122.84	124.455		Soaking Period (hr) 98		
Moist soil + tare (g)	429.28	829.04	537.18		Ho (in)	4.584
Dry soil + tare (g)	395.41	719.06	483.20		Hf (in)	4.596
Tare (g)	196.28	117.68	194.85		Swell (%)	0.26
Moisture content, w (%)	17.0	18.3	18.7		Surcharge (psf)	20
Dry unit wt., gd (pcf)	105.0	105.2				

Bearing Test Results



Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	0	16		
0.025	5	18		
0.05	8	29		
0.075	14	68		
0.1	30	112	1000	11.2
0.125	53	151	1125	13.5
0.15	81	198	1250	15.8
0.175	115	241	1375	17.5
0.2	151	266	1500	17.8
0.3	284	368	1900	19.4
0.4	380	447	2300	19.4
0.5	457		2600	

Project: **Bear Lake Marine Expansion**TH/TP/Sample: **22-TP-06**No: **22-1522**Depth: **1-13.5 ft**Date: **17-Feb-23**Location: **Bear Lake State Park**Tested by: **JCC**

Comments:

Reduced by: **JCC**Reviewed by: **MGS**

Test Summary

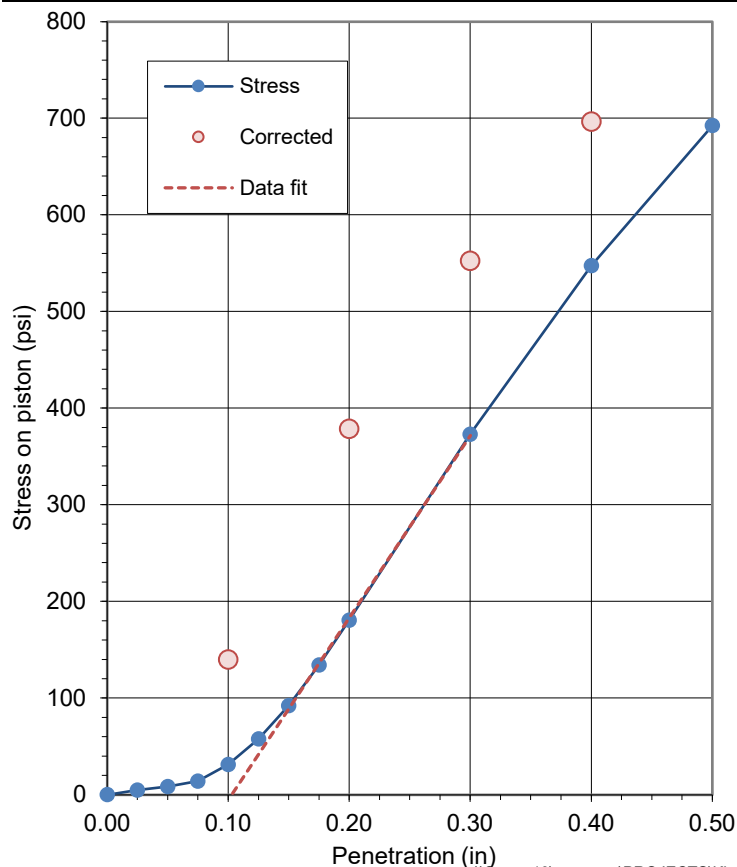
Maximum dry unit weight (pcf): **105.1**Reference method: **ASTM D698 B**Optimum moisture content (%): **16.7**Eng. classification: **Not requested**Relative compaction (%): **102.9**Condition of sample: **Soaked****Corrected CBR at 0.1-in. (%) 14.0**Scalp and replace: **No****Corrected CBR at 0.2-in. (%) 25.2**

Compaction Data

Swell Data

	As-Comp.	After Soak	Top 1-in.	Date	Time	Dial (in)
Wt. mold + moist soil (g)	8503.60	8560.40		2/18	14:20	0.231
Wt. mold (g)	4219.10	4219.10		2/22	16:20	0.23
Mold volume (ft^3)	0.0750	0.0750				
Moist unit wt., gm (pcf)	125.941	127.638		Soaking Period (hr)		98
Moist soil + tare (g)	515.94	625.77	300.16		Ho (in)	4.584
Dry soil + tare (g)	470.40	563.94	271.43		Hf (in)	4.583
Tare (g)	194.36	196.30	117.44		Swell (%)	-0.02
Moisture content, w (%)	16.5	16.8	18.7		Surcharge (psf)	20
Dry unit wt., gd (pcf)	108.1	109.3				

Bearing Test Results



Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	5	19		
0.025	5	20		
0.05	8	32		
0.075	14	84		
0.1	31	140	1000	14.0
0.125	58	200	1125	17.8
0.15	92	265	1250	21.2
0.175	134	325	1375	23.6
0.2	181	378	1500	25.2
0.3	373	552	1900	29.1
0.4	547	697	2300	30.3
0.5	692		2600	

Project: **Bear Lake Marine Expansion**TH/TP/Sample: **22-TP-10**No: **22-1522**Depth: **3-15 ft**Date: **17-Feb-23**Location: **Bear Lake State Park**Tested by: **JCC**

Comments:

Reduced by: **JCC**Reviewed by: **MGS**

Test Summary

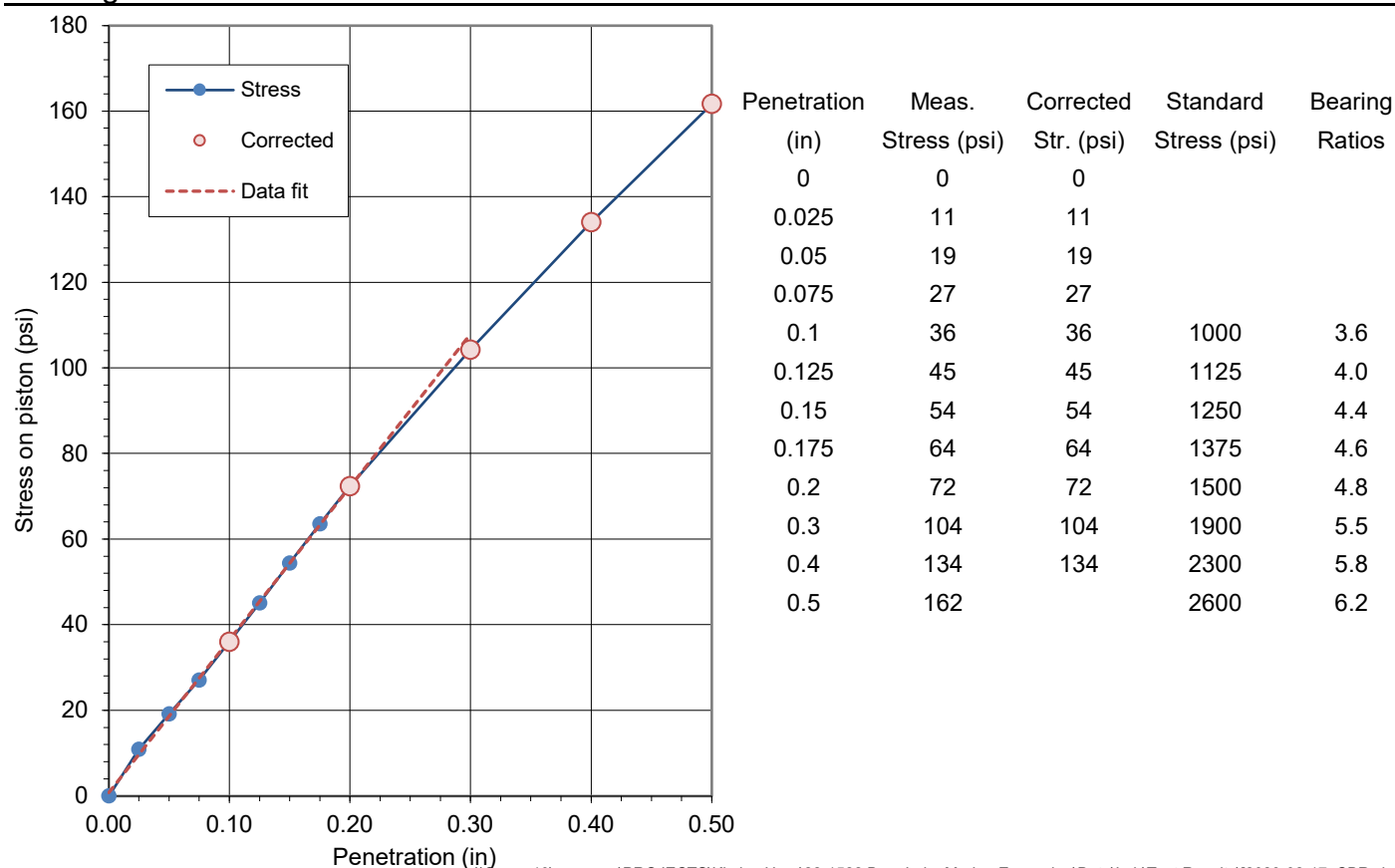
Maximum dry unit weight (pcf):	88.6	Reference method:	ASTM D698 B
Optimum moisture content (%):	30.9	Eng. classification:	Not requested
Relative compaction (%):	99.4	Condition of sample:	Soaked
CBR at 0.1-in. (%)	3.6	Scalp and replace:	No
CBR at 0.2-in. (%)	4.8		

Compaction Data

Swell Data

	As-Comp.	After Soak	Top 1-in.	Date	Time	Dial (in)
Wt. mold + moist soil (g)	8145.50	8173.55		2/20	13:30	0.167
Wt. mold (g)	4239.75	4239.75		2/24	13:40	0.177
Mold volume (ft^3)	0.0750	0.07516				
Moist unit wt., gm (pcf)	114.807	115.38		Soaking Period (hr)		96
Moist soil + tare (g)	475.81	662.85	357.15		Ho (in)	4.584
Dry soil + tare (g)	391.57	532.49	296.79		Hf (in)	4.594
Tare (g)	114.01	114.04	117.04		Swell (%)	0.22
Moisture content, w (%)	30.4	31.2	33.6		Surcharge (psf)	20
Dry unit wt., gd (pcf)	88.1	88.0				

Bearing Test Results



\\Server19\company\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2023-02-17_CBR.xlsx]3

Determination of the Point Load Strength Index of Rock*

After ASTM D 5731



Project: Bear Lake Marina Expansion

No: 22-1522a

Location: Bear Lake State Park, Utah

Date: 05-Jun-23

Sample Info.	Test Hole/Pit:	23-RC-01	23-RC-01	23-RC-01	23-RC-01
	Sample:	RC-1	RC-2	RC-3	RC-4
	Depth:	40.5 ft	43 ft	43.5 ft	45 ft
	Date Sampled:	24-May-23	24-May-23	24-May-23	24-May-23
	Sample type	Core	Core	Core	Core
	Moisture condition:	As received	As received	As received	As received
Test Data	Distance between platen points, D (in.):	2.4	2.4	1.9	1.2
	D (mm):	62	60	50	30
	Distance to nearest end, L (in.):	2.3	2.1	1.8	1.9
	Smallest specimen width, W (in.):	N/A	N/A	N/A	N/A
	W (mm):	N/A	N/A	N/A	N/A
	Equivalent core area, D_e^2 (mm ²):	3782.3	3600.0	2450.3	870.3
	Failure Pressure P_f (psi):	300	1448	48	786
	Failure load, P (lbf):	441	2128	71	1155
	P (N):	1960.9	9464.5	313.7	5137.5
	Effective area of jack piston A_e (cm ²):	9.48	9.48	9.48	9.48
	Effective area of jack piston A_e (in ²):	1.47	1.47	1.47	1.47
Test Results	Point load strength index, I_s (MPa):	0.52	2.63	0.13	5.90
	Size correction factor, F:	1.098	1.086	0.995	0.789
	PLSI 50mm equivalent, $I_{s(50)}$ (MPa):	0.57	2.85	0.13	4.66
	Strength Conversion factor, K:	24.6	24.5	22.9	18.9
	Uniaxial compressive strength, s_c (MPa):	14.0	69.9	2.9	88.2
	Uniaxial compressive strength, s_c (psi):	2,032	10,141	423	12,790
	Testing Apparatus:	RocSci	RocSci	RocSci	RocSci
	Break type:	⊥	⊥	≠	⊥
	Photo before break:				
	Photo after break:				
QC/QA	Tested By:	JCC	JCC	JCC	JCC
	Reduced By:	JCC	JCC	JCC	JCC
	Reviewed By:	AT	AT	AT	AT

Notes:

Determination of the Point Load Strength Index of Rock*

After ASTM D 5731



Project: Bear Lake Marina Expansion

No: 22-1522a

Location: Bear Lake State Park, Utah

Date: 05-Jun-23

Sample Info.	Test Hole/Pit:	23-RC-01	23-RC-02	23-RC-02	23-RC-02
	Sample:	RC-5	RC-6	RC-7	RC-8
	Depth:	49 ft	30.5 ft	31 ft	38.25 ft
	Date Sampled:	24-May-23	23-May-23	23-May-23	23-May-23
	Sample type	Core	Core	Core	Core
	Moisture condition:	As received	As received	As received	As received
Test Data	Distance between platen points, D (in.):	2.4	2.4	2.3	2.2
	D (mm):	62	60	58	57
	Distance to nearest end, L (in.):	0.6	1.3	0.9	1.0
	Smallest specimen width, W (in.):	N/A	N/A	N/A	N/A
	W (mm):	N/A	N/A	N/A	N/A
	Equivalent core area, D_e^2 (mm ²):	3844.0	3600.0	3364.0	3249.0
	Failure Pressure P_f (psi):	30	118	180	448
	Failure load, P (lbf):	44	173	264	658
	P (N):	196.1	771.3	1176.5	2928.2
	Effective area of jack piston A_e (cm ²):	9.48	9.48	9.48	9.48
	Effective area of jack piston A_e (in ²):	1.47	1.47	1.47	1.47
Test Results	Point load strength index, I_s (MPa):	0.05	0.21	0.35	0.90
	Size correction factor, F:	1.102	1.086	1.069	1.061
	PLSI 50mm equivalent, $I_{s(50)}$ (MPa):	0.06	0.23	0.37	0.96
	Strength Conversion factor, K:	24.7	24.5	24.3	24.3
	Uniaxial compressive strength, s_c (MPa):	1.4	5.7	9.1	23.2
	Uniaxial compressive strength, s_c (psi):	201	826	1,320	3,362
	Testing Apparatus:	RocSci	RocSci	RocSci	RocSci
	Break type:				
	Photo before break:				
	Photo after break:				
QC/QA	Tested By:	JCC	JCC	JCC	JCC
	Reduced By:	JCC	JCC	JCC	JCC
	Reviewed By:	AT	AT	AT	AT

Notes:

Determination of the Point Load Strength Index of Rock*

After ASTM D 5731



Project: Bear Lake Marina Expansion

No: 22-1522a

Location: Bear Lake State Park, Utah

Date: 05-Jun-23

Sample Info.	Test Hole/Pit:	23-RC-03			
	Sample:	RC-9			
	Depth:	22 ft			
	Date Sampled:	23-May-23			
	Sample type	Core			
	Moisture condition:	As received			
Test Data	Distance between platen points, D (in.):	2.3			
	D (mm):	58			
	Distance to nearest end, L (in.):	1.8			
	Smallest specimen width, W (in.):	N/A			
	W (mm):	N/A			
	Equivalent core area, D_e^2 (mm ²):	3364.0			
	Failure Pressure P_f (psi):	32			
	Failure load, P (lbf):	47			
	P (N):	209.2			
	Effective area of jack piston A_e (cm ²):	9.48			
	Effective area of jack piston A_e (in ²):	1.47			
Test Results	Point load strength index, I_s (MPa):	0.06			
	Size correction factor, F:	1.069			
	PLSI 50mm equivalent, $I_{s(50)}$ (MPa):	0.07			
	Strength Conversion factor, K:	24.3			
	Uniaxial compressive strength, s_c (MPa):	1.6			
	Uniaxial compressive strength, s_c (psi):	235			
	Testing Apparatus:	RocSci			
	Break type:	I			
	Photo before break:				
	Photo after break:				
	QC/QA	Tested By:	JCC		
Reduced By:		JCC			
Reviewed By:		AT			

Notes:

Bulk Solids Characterization by Carr Indices*



Angle of Repose

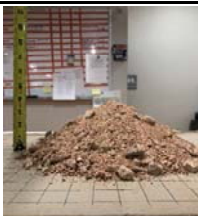
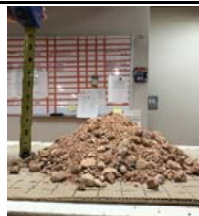
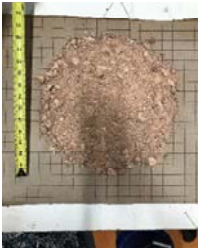
After ASTM D6393

Project: **Bear Lake Marina Expansion**

No: **22-1522a**

Gun Range

\\Server19\company\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2023-06-05_AOR.xlsx1

Sample Info.	Sample:	Combined	Combined	Combined
	Depth:	-	-	-
	Date Sampled:	11-May-23	11-May-23	11-May-23
	Date tested:	05-Jun-23	05-Jun-23	05-Jun-23
	Temperature (deg):	75	75	75
	Relative humidity (%):	41	41	41
	Laboratory sample description:	rd - tn sand	rd - tn sand	rd - tn sand
Moisture	Wet soil + tare (g):	1607.46	1607.46	1607.46
	Dry soil + tare (g):	1599.76	1599.76	1599.76
	Tare (g):	438.69	438.69	438.69
	Moisture content, w (%):	0.7	0.7	0.7
Carr Angle of Repose				
Data	Height of pile, H (in):	3.88	3.75	3.75
	Height of pile, H (mm):	98.4	95.3	95.3
	Diameter of pile, D (in):	13.00	13.00	12.80
	Radius of pile, R (in):	6.5	6.5	6.4
	Radius of pile, R (mm):	165.1	165.1	162.6
Test Results				
Results	Carr Angle of Repose (deg):	30.8	30.0	30.4
	Shape of cone:	Straight	Straight	Straight
Comments				
				
Tested By:		AT	AT	AC
Reduced By:		AT	AT	AT
Reviewed By:		ZMG	ZMG	ZMG

Bulk Solids Characterization by Carr Indices*



Angle of Repose

After ASTM D6393

Project: **Bear Lake Marina Expansion**

No: **22-1522a**

Ken Johnson

J:\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2024-07-24_AOR.xlsx1

Sample Info.	Sample:	Composite as-is	Composite oven dried	
	Depth:	-	-	
	Date Sampled:	-	-	
	Date tested:	13-Aug-24	14-Aug-24	
	Temperature (deg):	-	-	
	Relative humidity (%):	-	-	
	Laboratory sample description:	dk yl bn - lt bn silt	dk yl bn - lt bn silt	
Moisture	Wet soil + tare (g):	-	762.25	
	Dry soil + tare (g):	-	701.86	
	Tare (g):	-	119.24	
	Moisture content, w (%):	#VALUE!	10.4	#VALUE!
Carr Angle of Repose				
Data	Height of pile, H (in):	7.31	7.81	
	Height of pile, H (mm):	185.7	198.4	#VALUE!
	Diameter of pile, D (in):	25.70	23.82	
	Radius of pile, R (in):	12.8	11.9	#VALUE!
	Radius of pile, R (mm):	326.3	302.5	#VALUE!
Test Results				
Results	Carr Angle of Repose (deg):	29.6	33.3	#VALUE!
	Shape of cone:	Concave Up	Straight	
Comments				
				
Tested By: JGS JGS Reduced By: JGS JGS Reviewed By: ZMG ZMG				

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) - After ASTM D4767 and USBR 5750



Project: Bear Lake Marina Expansion

TH/TP/Sample: Combined Sample

No: 22-1522a

Depth: -

Location: Rich County, Utah

Laboratory sample description: or - rd sand

Date: 08-Jun-23

USCS classification: not requested

Tested by: AT

Sample type: #REF!

PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\Gun Range Quarry\[2023-06-05_TX_CU3pts.xlsx]SUM

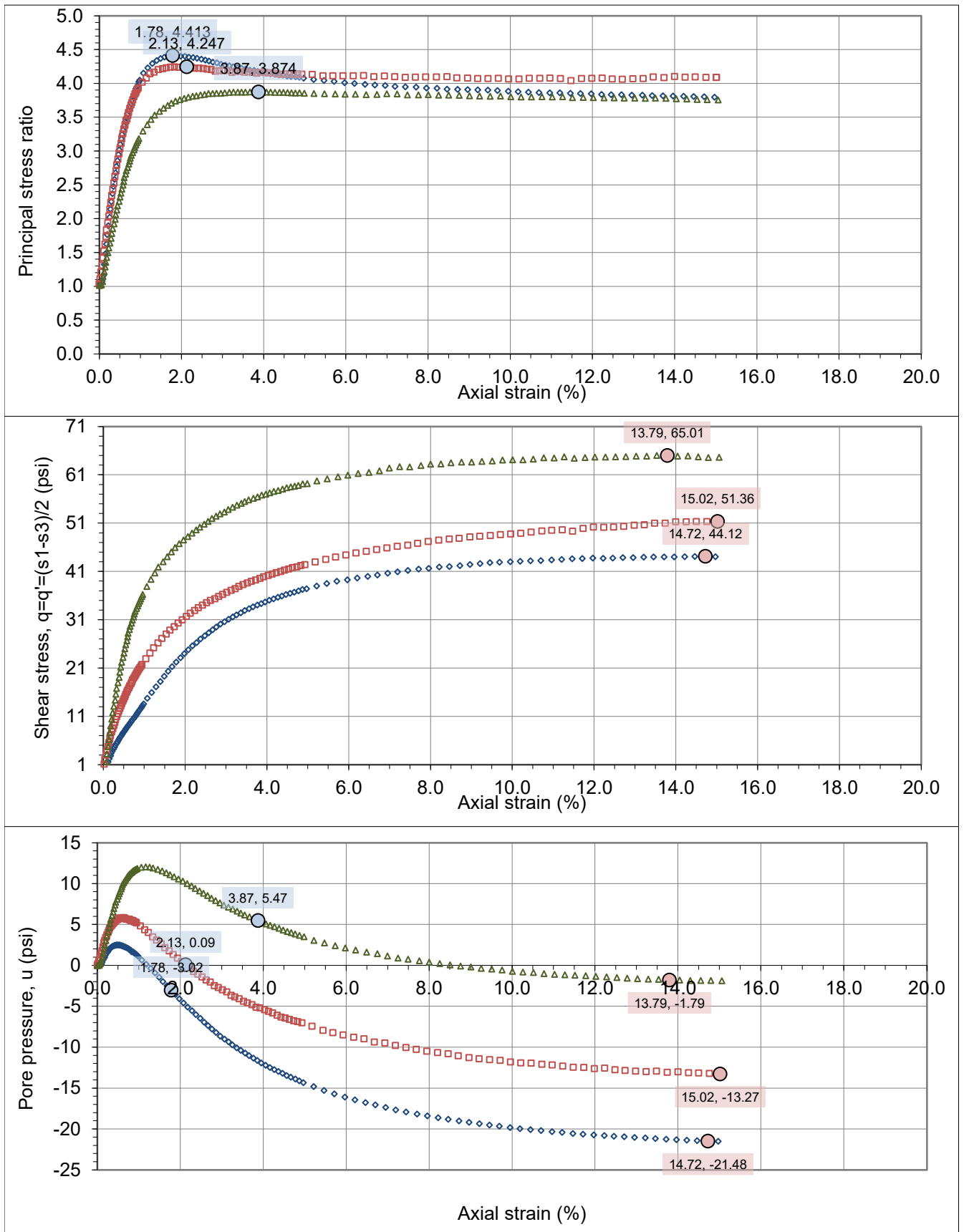
Test Number		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi
Test information	Total backpressure (psi)	55.0	65.0	55.0
	Skempton B	0.96	0.95	0.96
	t-90 (min)	1.4	1.4	1.1
	t-100 (min)	239.6	125.3	234.9
	t-50 (min)	0.3	0.3	0.3
	Strain rate (%/hr)	1.20	1.20	1.20
	Strain rate (%/min)	0.02	0.02	0.02
	Membrane correction	Yes	Yes	Yes
	Filter paper correction	No	No	No
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	1.78	2.13	3.87
	Time to failure, tf (min)	89.1	106.4	193.6
	Obliquity, s'1/s'3	4.413	4.247	3.874
	Excess pore pressure, u (psi)	-3.02	0.09	5.47
	q = q' = (s1+s3)/2 (psi)	22.22	32.33	56.81
	p' = (s'1+s'3)/2 (psi)	35.23	52.24	96.33
	p = (s1+s3)/2 (psi)	32.22	52.33	101.81
	Effective major principal stress, s'1 (psi)	57.45	84.57	153.14
	Effective minor principal stress, s'3 (psi)	13.02	19.91	39.53
	Total major principal stress, s1 (psi)	54.43	84.66	158.61
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	-0.07	0.00	0.05
	Secant friction angle, phi-s (deg)	39.1	38.2	36.1
		Effective stress	Total stress	
Peak deviator stress (s1-s3), failure criteria	Friction angle, phi (deg)	34.3	29.8	
	Cohesion intercept, c (psi)	3.1	7.2	
	Strain at failure, ef (%)	14.72	15.02	13.79
	Time to failure, tf (min)	736.0	750.8	689.5
	Deviator stress, s1-s3 (psi)	88.24	102.72	130.02
	Excess pore pressure, u (psi)	-21.48	-13.27	-1.79
	q = q' = (s1+s3)/2 (psi)	44.12	51.36	65.01
	p' = (s'1+s'3)/2 (psi)	75.60	84.63	111.80
	p = (s1+s3)/2 (psi)	54.12	71.36	110.01
	Effective major principal stress, s'1 (psi)	119.72	135.98	176.81
	Effective minor principal stress, s'3 (psi)	31.48	33.27	46.79
	Total major principal stress, s1 (psi)	98.24	122.72	175.02
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	-0.24	-0.13	-0.01
	Secant friction angle, phi-s (deg)	35.7	37.4	35.6
		Effective stress	Total stress	
	Friction angle, phi (deg)	34.0	21.7	
	Cohesion intercept, c (psi)	3.3	26.3	
Photo of sample after shearing		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi

Comments:



Project: Bear Lake Marina Expansion
No: 22-1522a

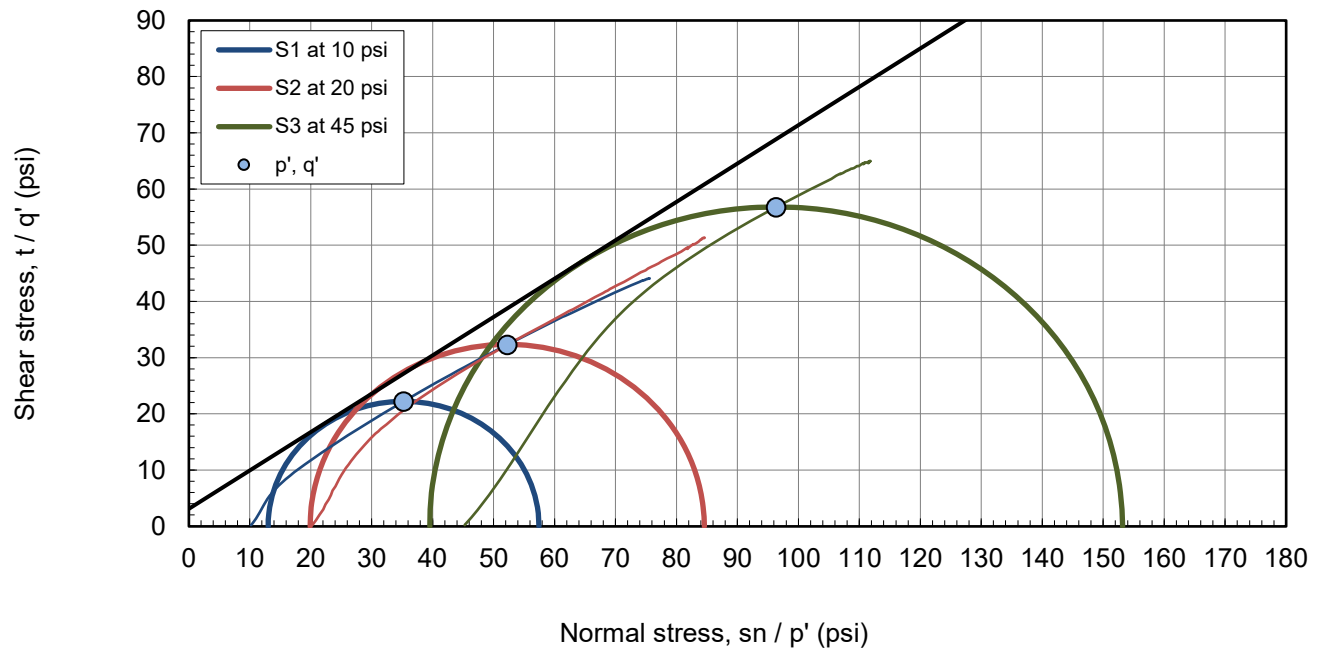
TH/TP/Sample: Combined Sample
Depth: -



Project: Bear Lake Marina Expansion
No: 22-1522a

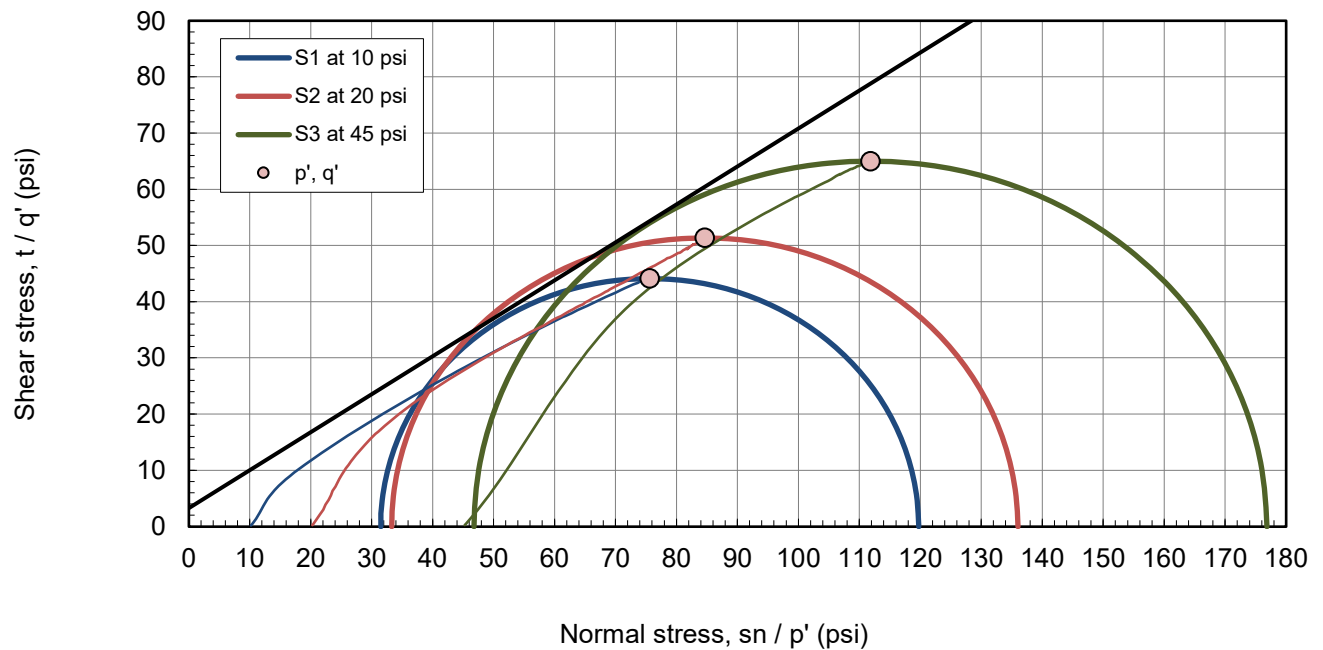
TH/TP/Sample: Combined Sample
Depth: -

Effective stress results



Max principal stress ratio (s'_1/s'_3), failure criteria Mohr and $p' - q'$ space plots

Effective stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and $p' - q'$ space plots

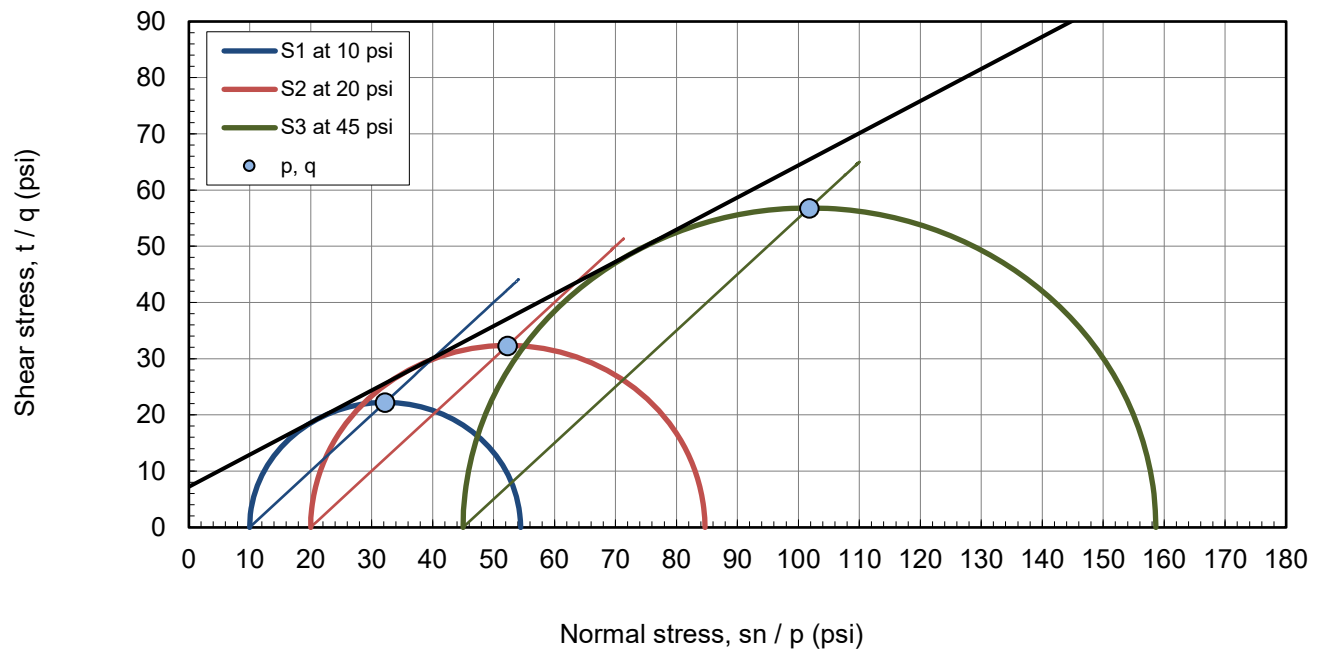
Project: Bear Lake Marina Expansion

TH/TP/Sample: Combined Sample

No: 22-1522a

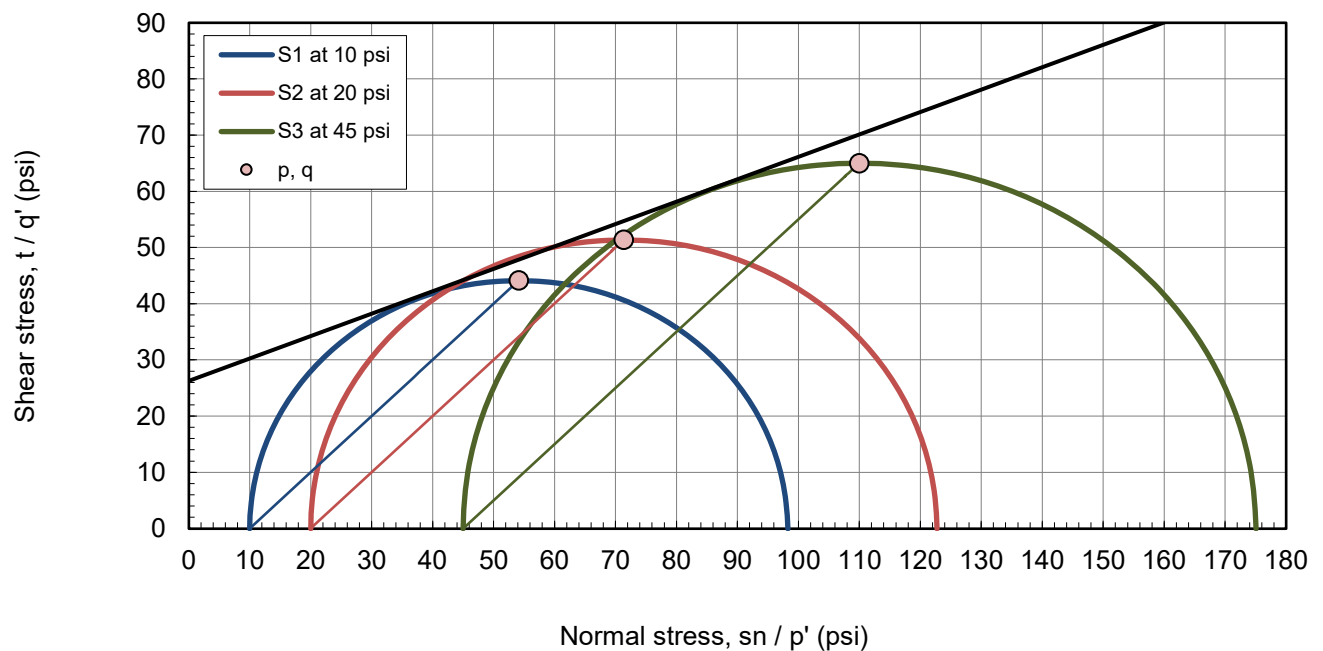
Depth: -

Total stress results



Max principal stress ratio (s_1/s_3), failure criteria Mohr and $p - q$ space plots - effective stress results

Total stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and $p - q$ space plots

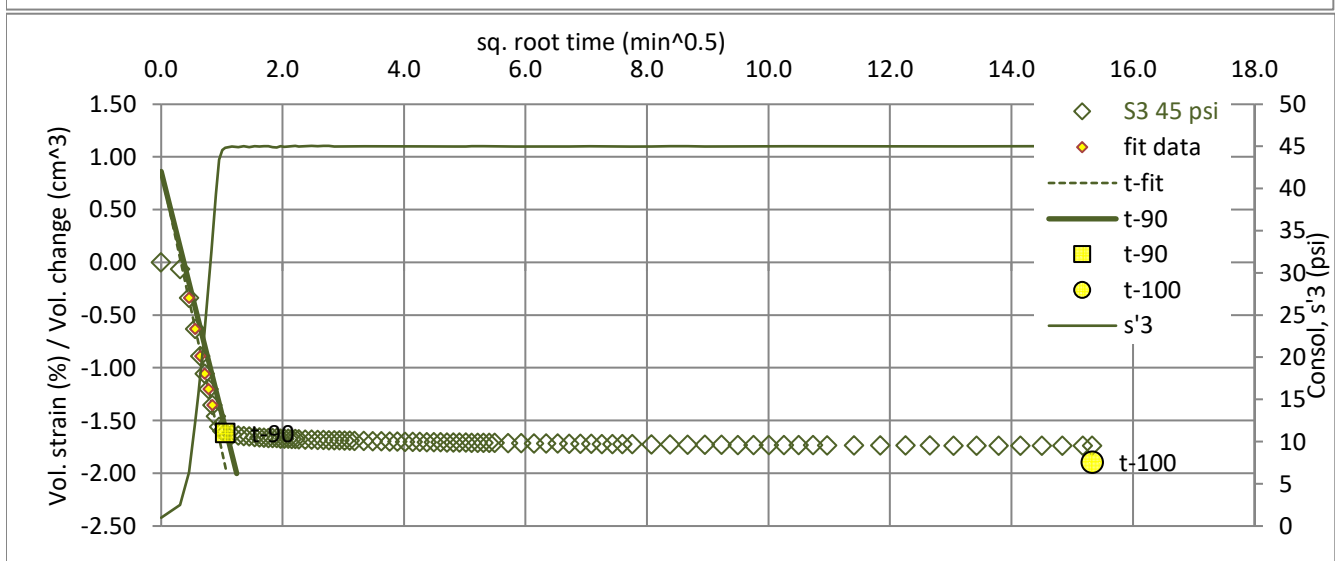
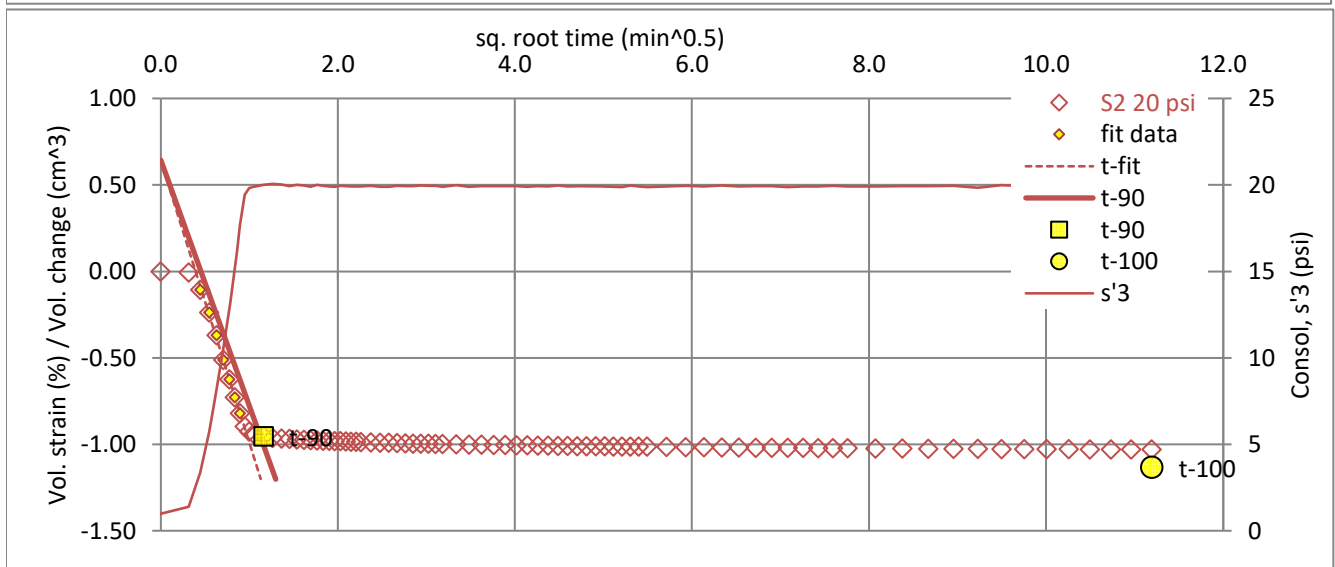
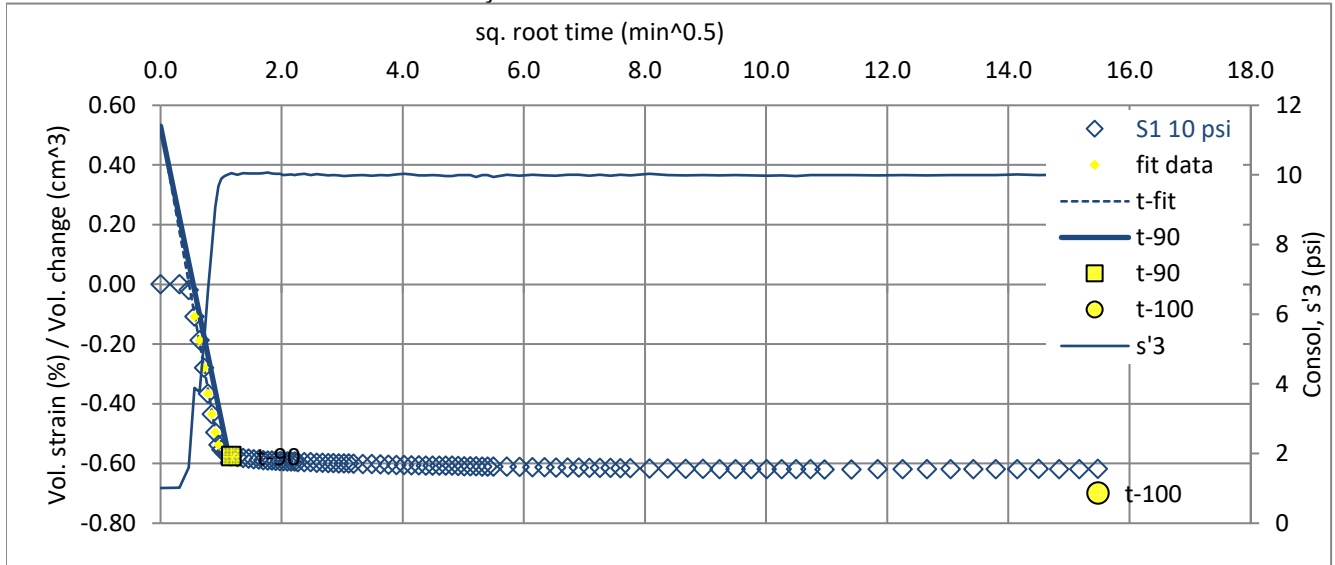
Project: Bear Lake Marina Expansion

TH/TP/Sample: Combined Sample

No: 22-1522a

Depth: -

Time rate of consolidation data and analysis



Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP)* - After ASTM D4767 and USBR 5750



Project: **Bear Lake Marina Expansion**

TH/TP/Sample: **Composite Sample**

No: **22-1522a**

Depth: **-**

Location: **Rich County, Utah**

Laboratory sample description: **dk yl bn - lt bn silt**

Date: **01-Aug-24**

USCS classification: **not requested**

Tested by: **JC**

Sample type:

Reduced by: **ZMG**

Remolded to 95% of st. Proctor at OMC.

Checked by: **AT**

	Test Number	S1	10 psi	S2	20 psi	S3	45 psi
		Initial	Bef. Shr. MethodB ^e	Initial	Bef. Shr. MethodB ^e	Initial	Bef. Shr. MethodB ^e
Unit weight data	0°	12.013		12.007		11.960	
	Sample ht., H (in) 120°	11.968		11.941		12.001	
	240°	12.019		11.974		11.952	
	Avg. height, Havg (in)	12.000	11.960	11.974	11.874	11.971	11.721
	Avg. height, Havg (cm)	30.480	30.378	30.414	30.160	30.406	29.771
	ΔHsc (in) ^a		0.040		0.100		0.250
	Sample dia., D (in) top	6.006		6.001		6.009	
	mid	5.999		5.995		5.998	
	bot	5.998		6.008		6.007	
	Avg. dia., Davg (in)	6.001	5.970	6.000	5.952	6.003	5.715
	Avg. dia., Davg (cm)	15.241	15.163	15.239	15.118	15.248	14.516
	Avg. area, Aavg (in^2)	28.279	27.990	28.272	27.822	28.303	25.651
	Avg. area, Aavg (cm^2)	182.445	180.579	182.399	179.495	182.597	165.491
	Wt. rings + wet soil (g)	10251.15		10251.20		10243.40	
	Wt. rings (g)	0.00	0.00	0.00	0.00	0.00	0.00
Moisture	Volume, Vo (in^3)	339.3	334.8	338.5	330.4	338.8	300.7
	Vo (cm^3)	5560.9	5485.7	5547.5	5413.6	5552.1	4926.9
	Vo (ft^3)	0.1964	0.1937	0.1959	0.1912	0.1961	0.1740
	Wet soil + tare (g)	888.89	4041.95	752.13	3835.55	638.48	6738.40
	Dry soil + tare (g)	804.14	3376.45	685.80	3220.90	586.01	5833.10
	Tare (g)	145.07	439.35	196.16	455.60	195.78	453.90
	Moisture content, w (%)	12.9	22.7	13.5	22.2	13.4	16.8
Phase Relationships	Gs, assumed	2.65	2.65	2.65	2.65	2.65	2.65
	Mass total (g)	10251.2	11141.2	10251.2	11034.9	10243.4	10548.9
	Mass of solids (g)	9083.1	9083.1	9028.2	9028.2	9029.3	9029.3
	Volume (cm^3)	5560.9	5485.7	5547.5	5413.6	5552.1	4926.9
	Volume of water (cm^3)	1168.0	2058.1	1223.0	2006.7	1214.1	1519.6
	Volume of solids (cm^3)	3427.6	3427.6	3406.9	3406.9	3407.3	3407.3
	Volume of voids (cm^3)	2133.3	2058.1	2140.6	2006.7	2144.8	1519.6
	Volume of air (cm^3)	965.3	0.0	917.6	0.0	930.7	0.0
	Void ratio, e	0.622	0.600	0.628	0.589	0.629	0.446
	Porosity, n	0.384	0.375	0.386	0.371	0.386	0.308
	Volumetric moisture, T	0.210	0.375	0.220	0.371	0.219	0.308
	Saturation, S (%) ^c	54.75	100.00	57.13	100.00	56.61	100.00
	Dry density (gm/cm^3)	1.633	1.656	1.627	1.668	1.626	1.833
	Wet unit wt., gm (pcf)	115.1	126.8	115.4	127.3	115.2	133.7
	Dry unit wt., gd (pcf)	102.0	103.4	101.6	104.1	101.5	114.4

Notes:

^a ΔHsc (in) = change in height during saturation and consolidation

^b ΔVs = change in volume during saturation, ΔVc = change in volume during consolidation

^c Saturation before shear set to 100% for phase calculations

^d Before shear Aavg using method A; where Ac (Method A) = (Vo-DVs - DVc)/(Ho-DHsc)

^e Before shear Aavg using method B; where Ac (Method B) = (Vwf + Vs)/Hc

\\Server19\company\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2024-07-24_Compsite_TX_CU3pts.xlsx\JMD

Compaction specifications:	Target	As Compacted Avg.
gd (pcf)	101.8	101.7
w (%)	13.0	13.3

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) - After ASTM D4767 and USBR 5750



Project: Bear Lake Marina Expansion
No: 22-1522a

TH/TP/Sample: Composite Sample
Depth: -

Location: Rich County, Utah
 Date: 01-Aug-24

Laboratory sample description: dk yl bn - lt bn silt
 USCS classification: not requested

Tested by: JC

Sample type: Remolded to 95% of st. Proctor

Company\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2024-07-24_Compsite_TX_CU3pts.xlsx]SUM

Test Number		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi
Test information	Total backpressure (psi)	90.0	84.7	80.0
	Skempton B	0.95	0.95	0.96
	t-90 (min)	11.2	7.1	7.8
	t-100 (min)	43.2	18.1	15.8
	t-50 (min)	2.6	1.7	1.8
	Strain rate (%/hr)	0.90	0.90	0.90
	Strain rate (%/min)	0.02	0.02	0.02
	Membrane correction	Yes	Yes	Yes
	Filter paper correction	No	No	No
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	4.81	5.28	8.40
	Time to failure, tf (min)	320.5	352.0	559.9
	Obliquity, s'1/s'3	3.771	3.561	3.830
	Excess pore pressure, u (psi)	6.25	14.44	32.10
	q = q' = (s1-s3)/2 (psi)	5.19	7.12	18.25
	p' = (s'1+s'3)/2 (psi)	8.94	12.68	31.15
	p = (s1+s3)/2 (psi)	15.19	27.12	63.25
	Effective major principal stress, s'1 (psi)	14.14	19.81	49.40
	Effective minor principal stress, s'3 (psi)	3.75	5.56	12.90
	Total major principal stress, s1 (psi)	20.39	34.24	81.51
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	0.60	1.01	0.88
	Secant friction angle, phi-s (deg)	35.5	34.2	35.9
		Effective stress	Total stress	
Peak deviator stress (s1-s3), failure criteria	Friction angle, phi (deg)	35.6	16.3	
	Cohesion intercept, c (psi)	0.0	0.3	
	Strain at failure, ef (%)	1.49	1.69	15.29
	Time to failure, tf (min)	99.5	112.8	1019.3
	Deviator stress, s1-s3 (psi)	10.95	14.73	36.85
	Excess pore pressure, u (psi)	5.78	13.01	31.57
	q = q' = (s1-s3)/2 (psi)	5.48	7.37	18.43
	p' = (s'1+s'3)/2 (psi)	9.69	14.35	31.86
	p = (s1+s3)/2 (psi)	15.48	27.37	63.43
	Effective major principal stress, s'1 (psi)	15.17	21.72	50.29
	Effective minor principal stress, s'3 (psi)	4.22	6.99	13.43
	Total major principal stress, s1 (psi)	20.95	34.73	81.85
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	0.53	0.88	0.86
	Secant friction angle, phi-s (deg)	34.4	30.9	35.3
		Effective stress	Total stress	
	Friction angle, phi (deg)	34.6	16.2	
	Cohesion intercept, c (psi)	0.0	0.6	
Photo of sample after shearing		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi

Comments:

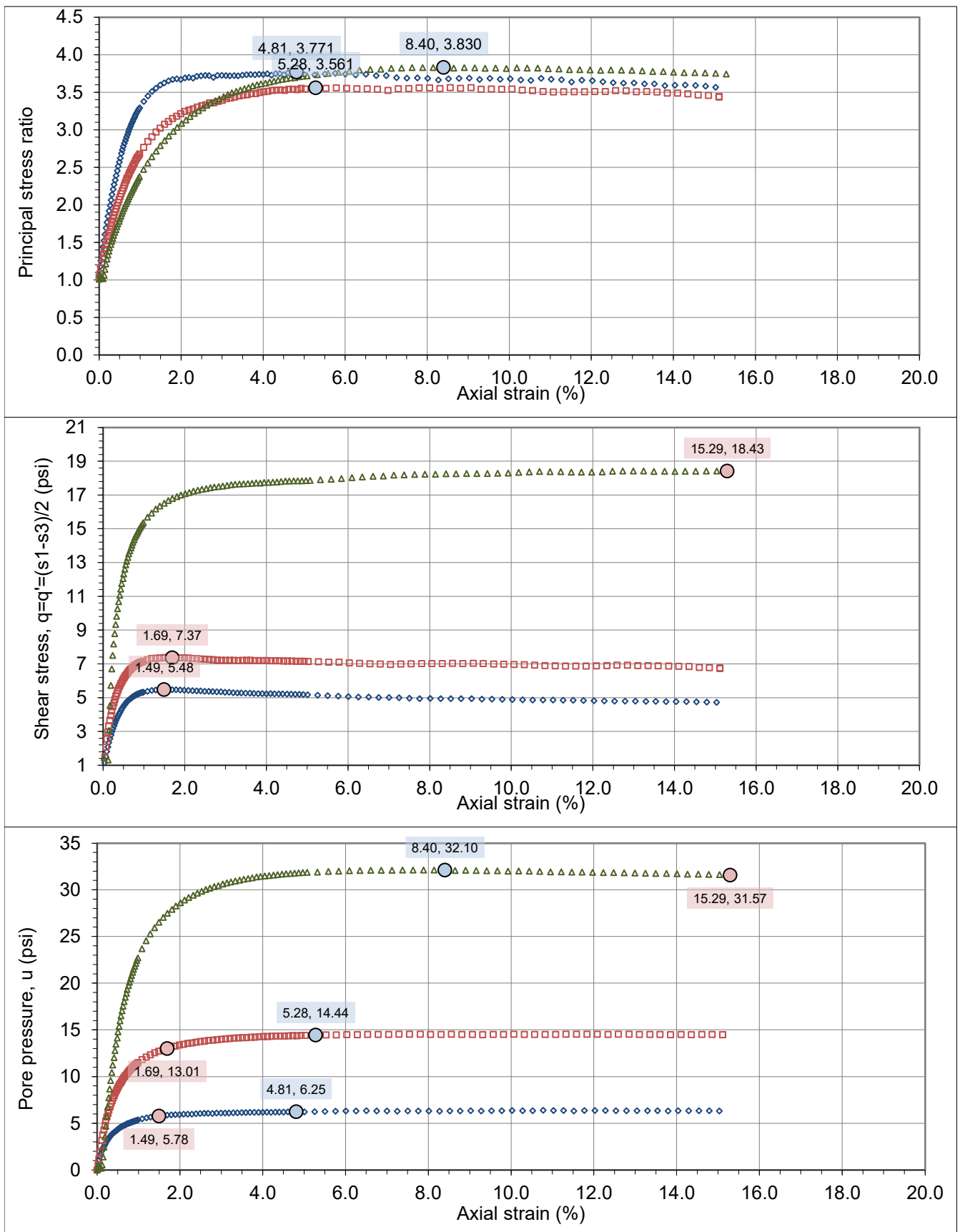


Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) - After ASTM D4767 and USBR 5750



Project: Bear Lake Marina Expansion
No: 22-1522a

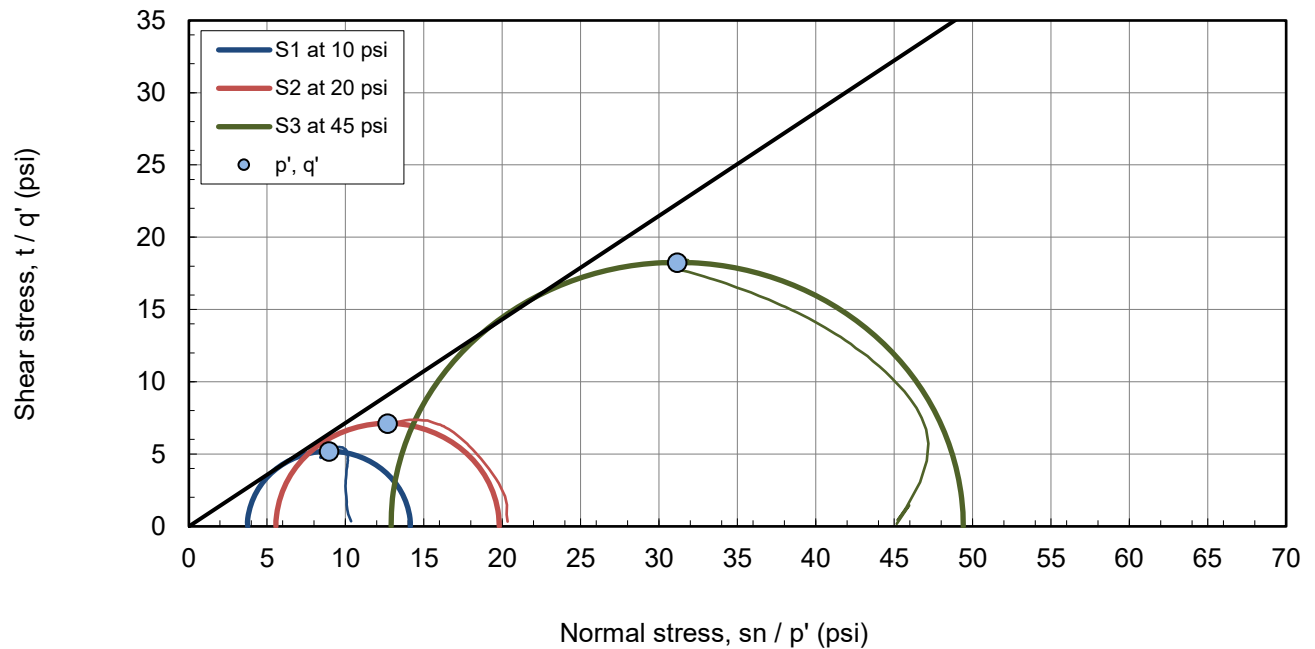
TH/TP/Sample: Composite Sample
Depth: -



Project: Bear Lake Marina Expansion
No: 22-1522a

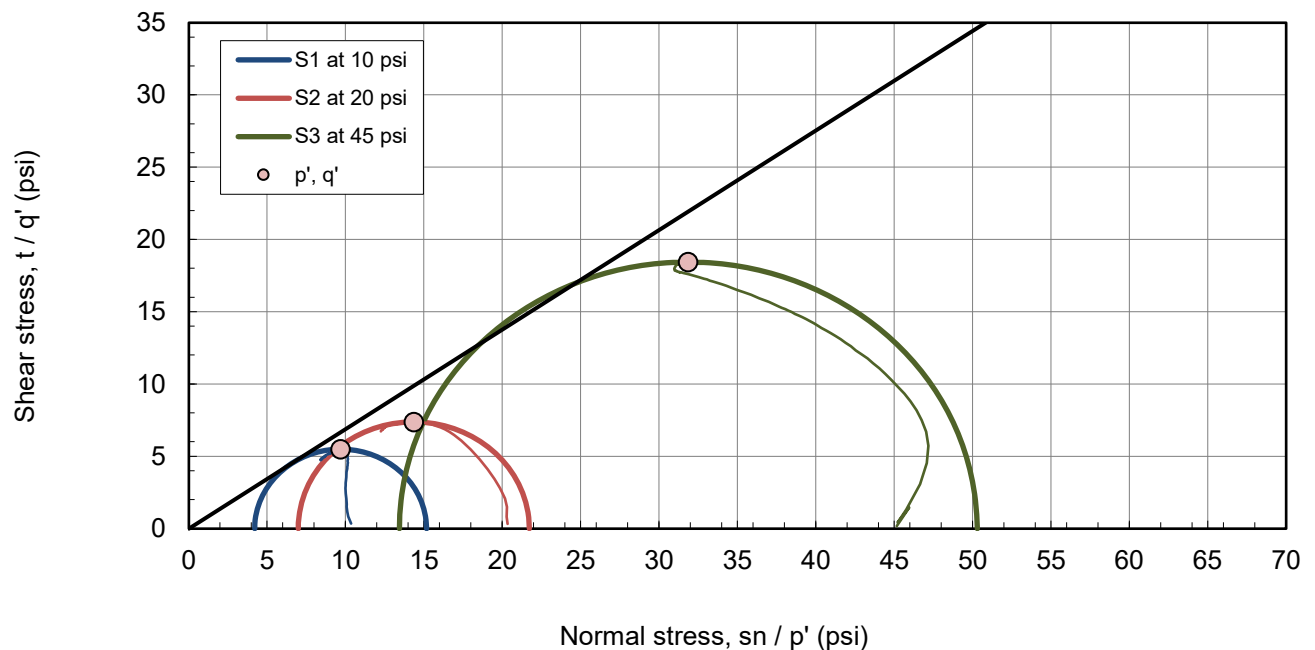
TH/TP/Sample: Composite Sample
Depth: -

Effective stress results



Max principal stress ratio (s'_1/s'_3), failure criteria Mohr and $p' - q'$ space plots

Effective stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and $p' - q'$ space plots

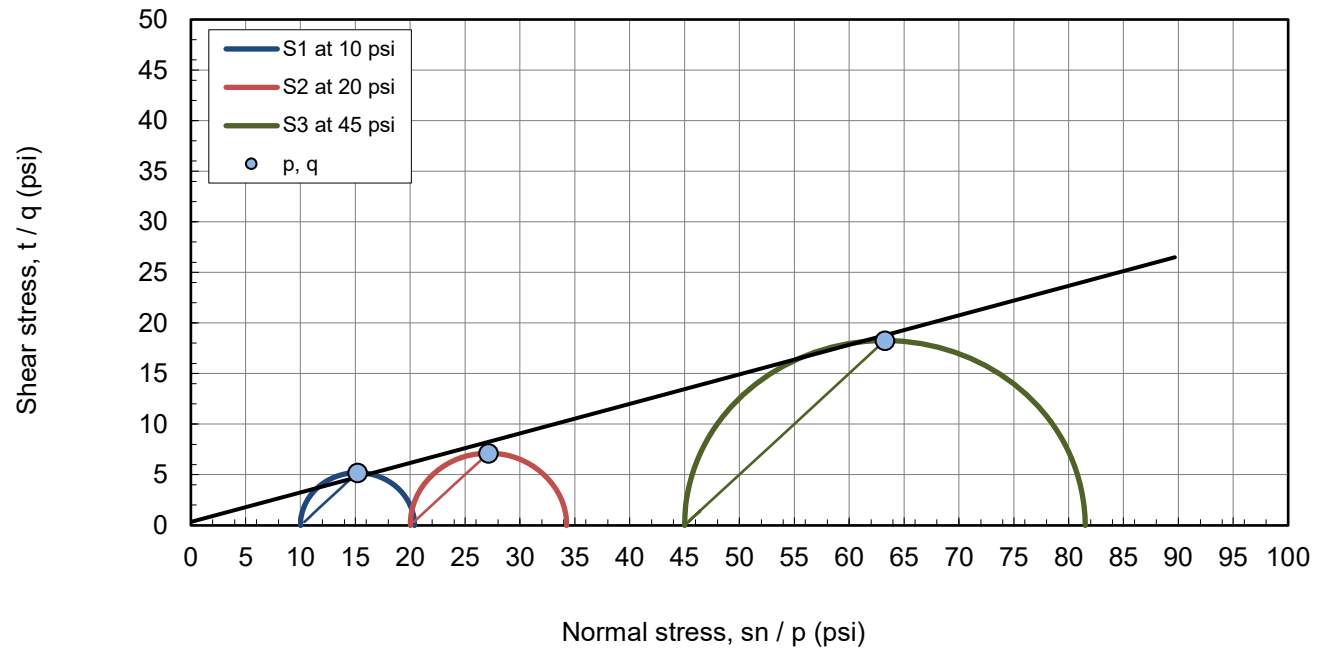
Project: Bear Lake Marina Expansion

TH/TP/Sample: Composite Sample

No: 22-1522a

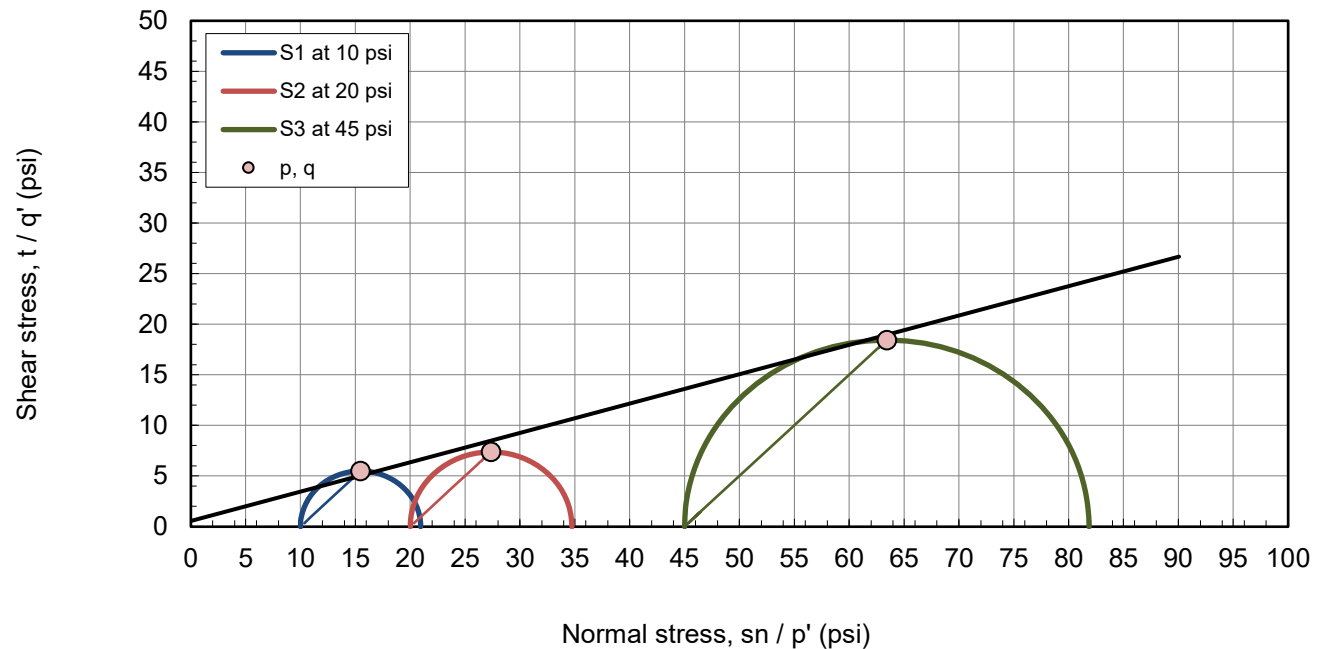
Depth: -

Total stress results



Max principal stress ratio (s_1/s_3), failure criteria Mohr and p - q space plots - effective stress results

Total stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and p - q space plots

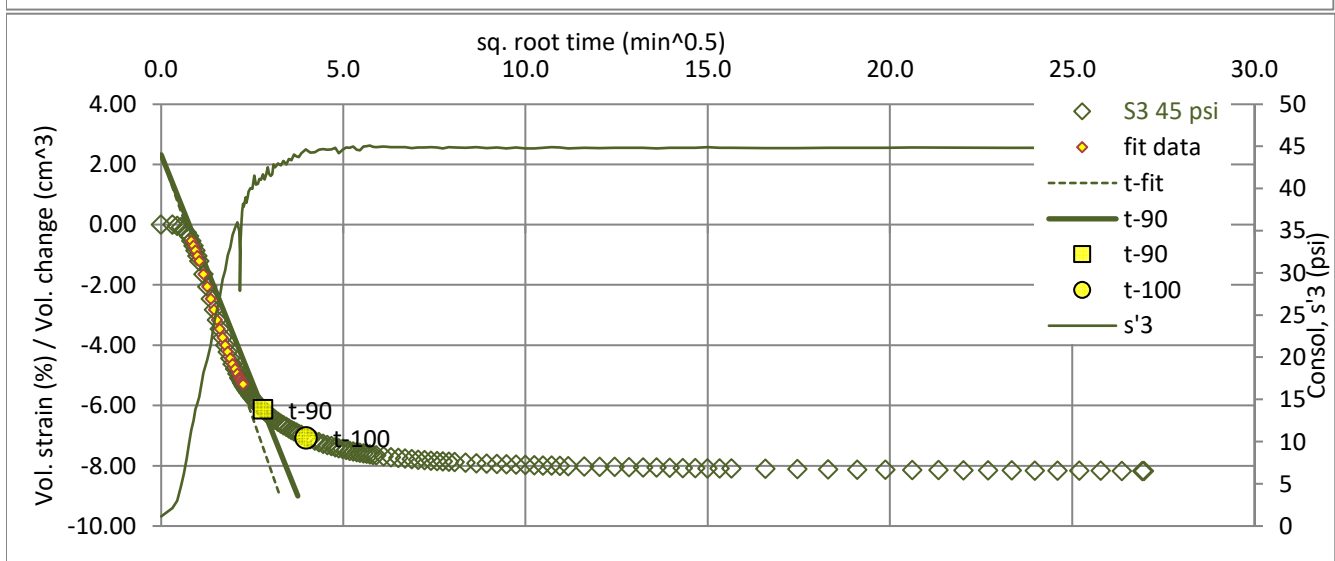
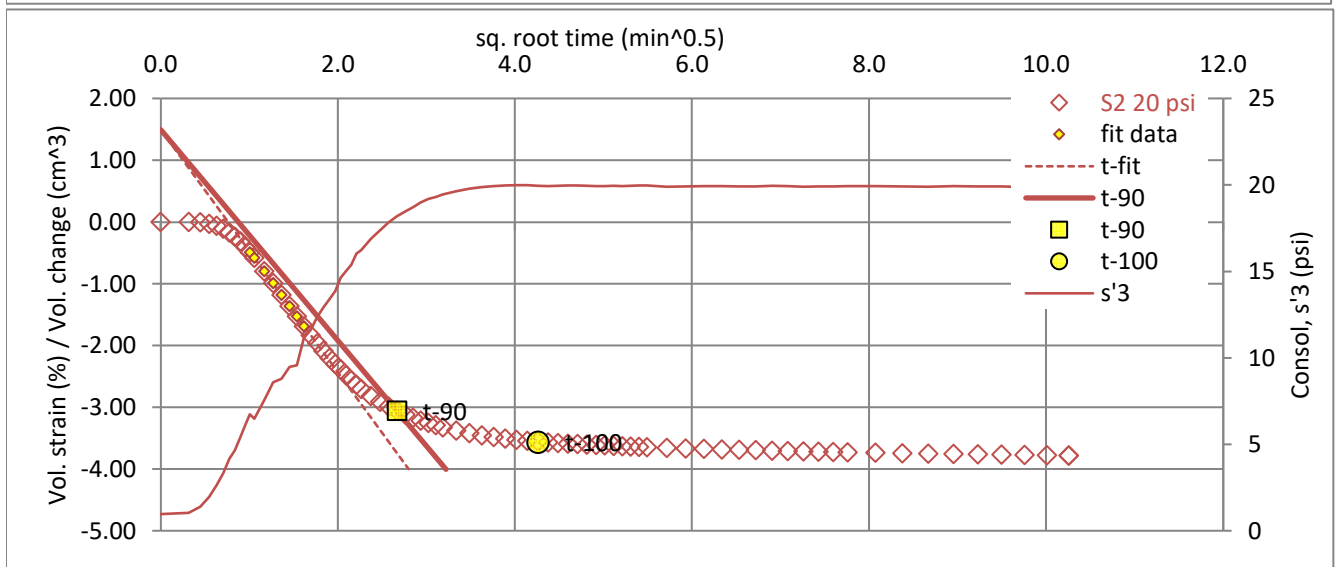
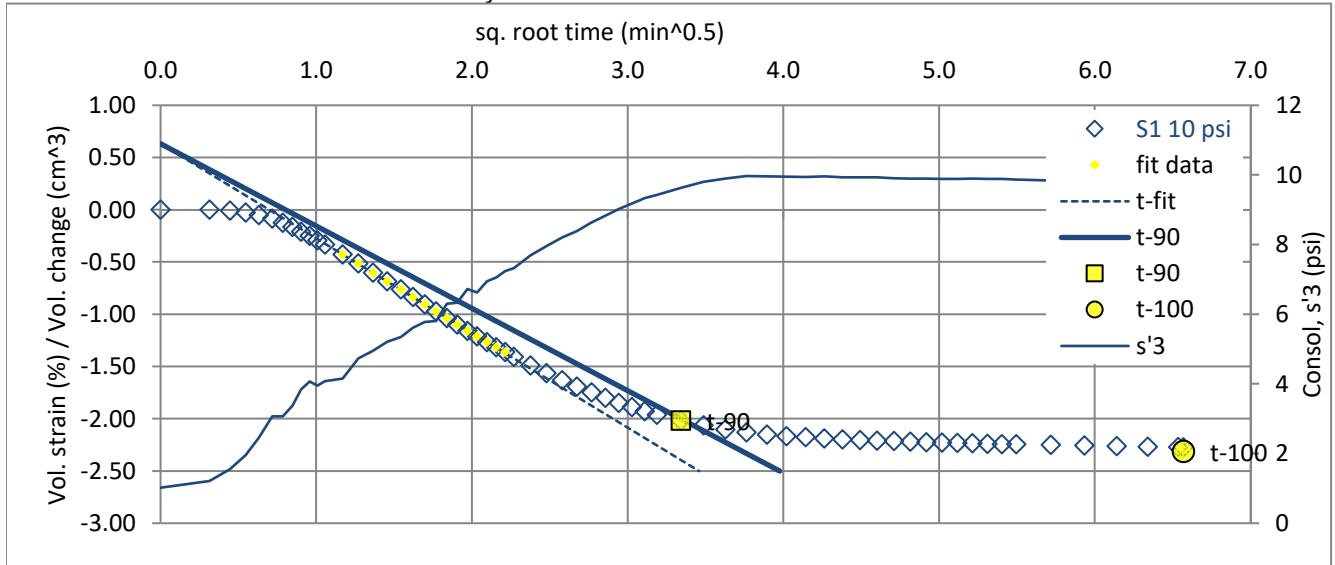
Project: Bear Lake Marina Expansion

TH/TP/Sample: Composite Sample

No: 22-1522a

Depth: -

Time rate of consolidation data and analysis





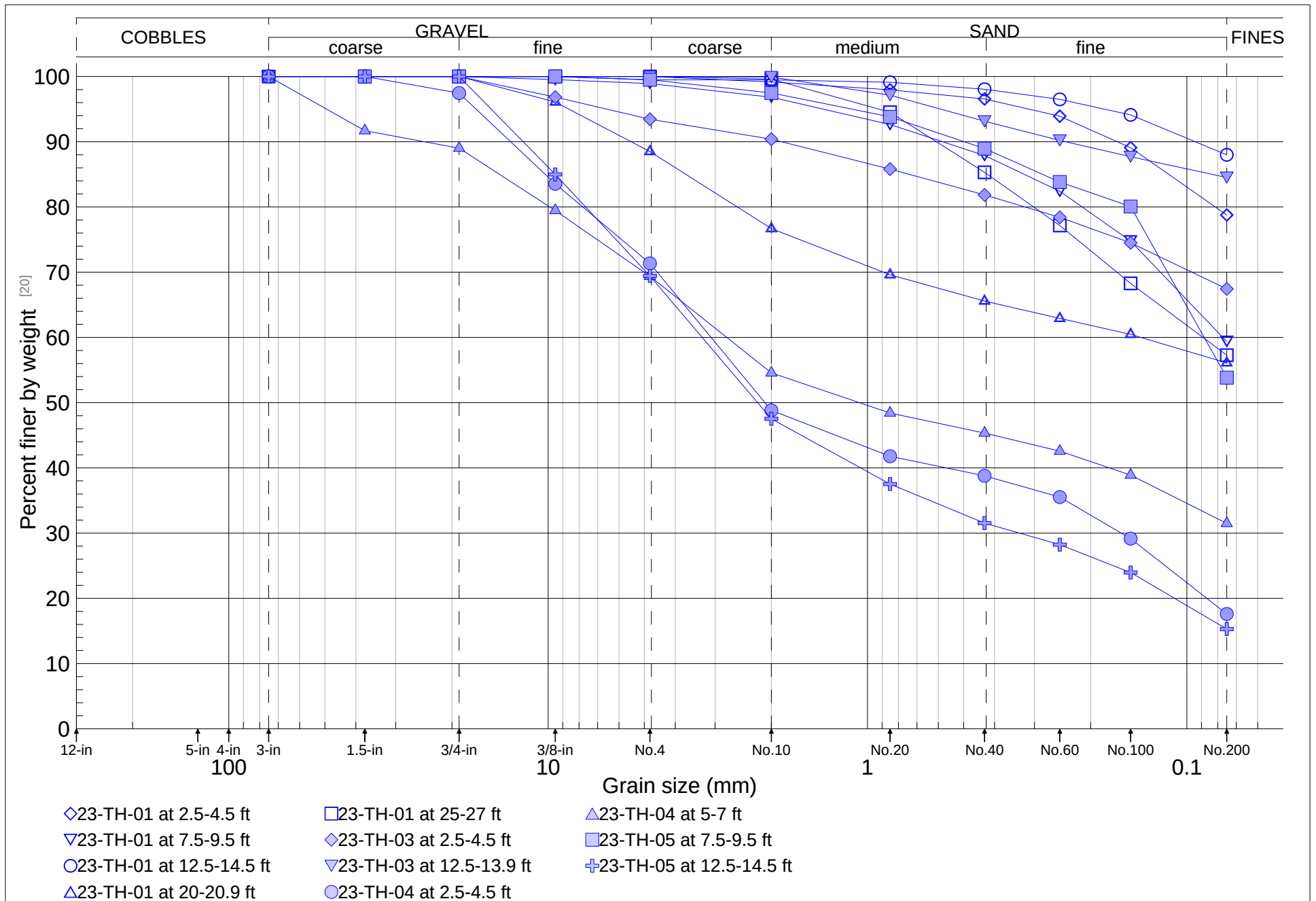
Appendix E

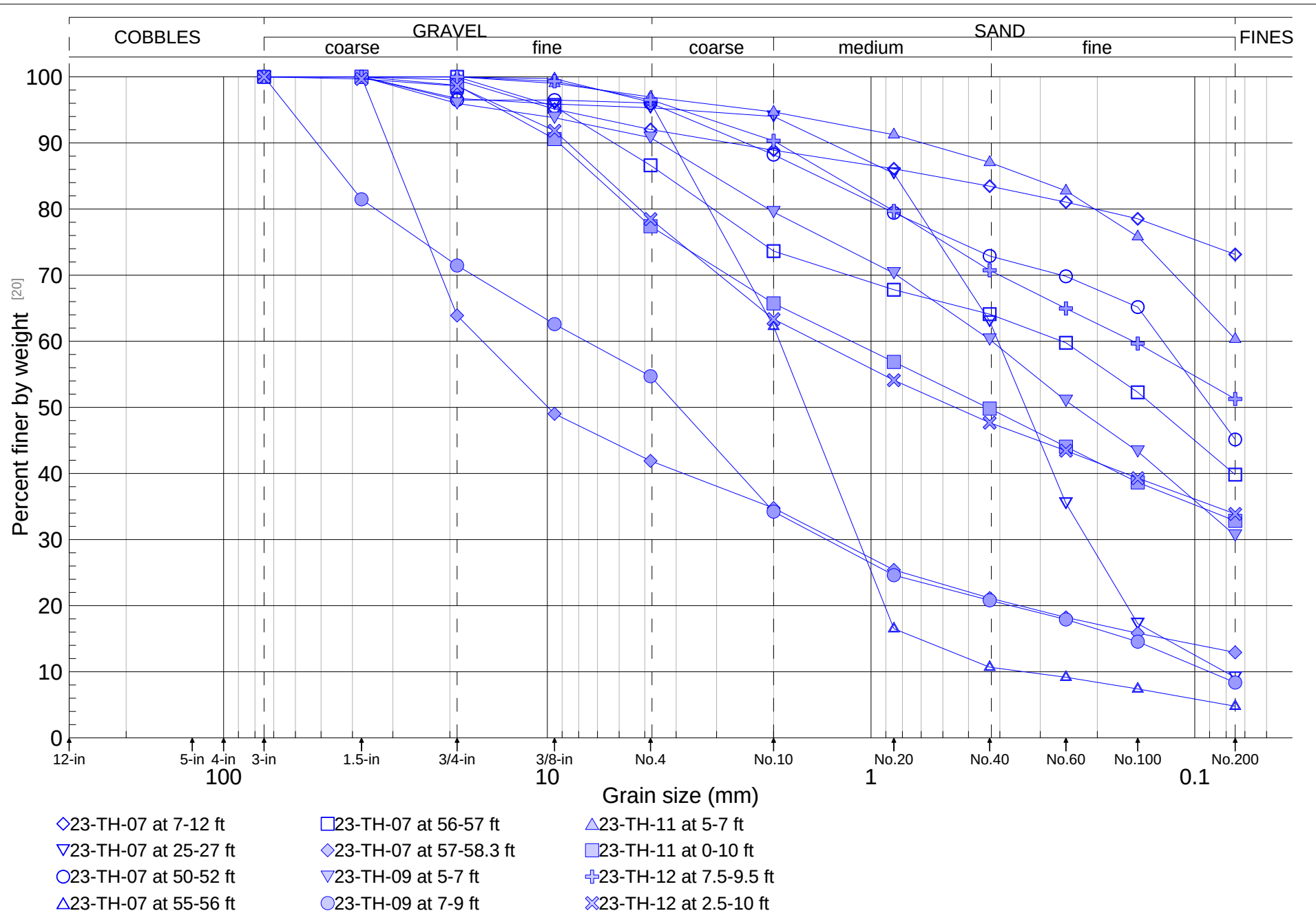
Laboratory Test Results – Test Holes

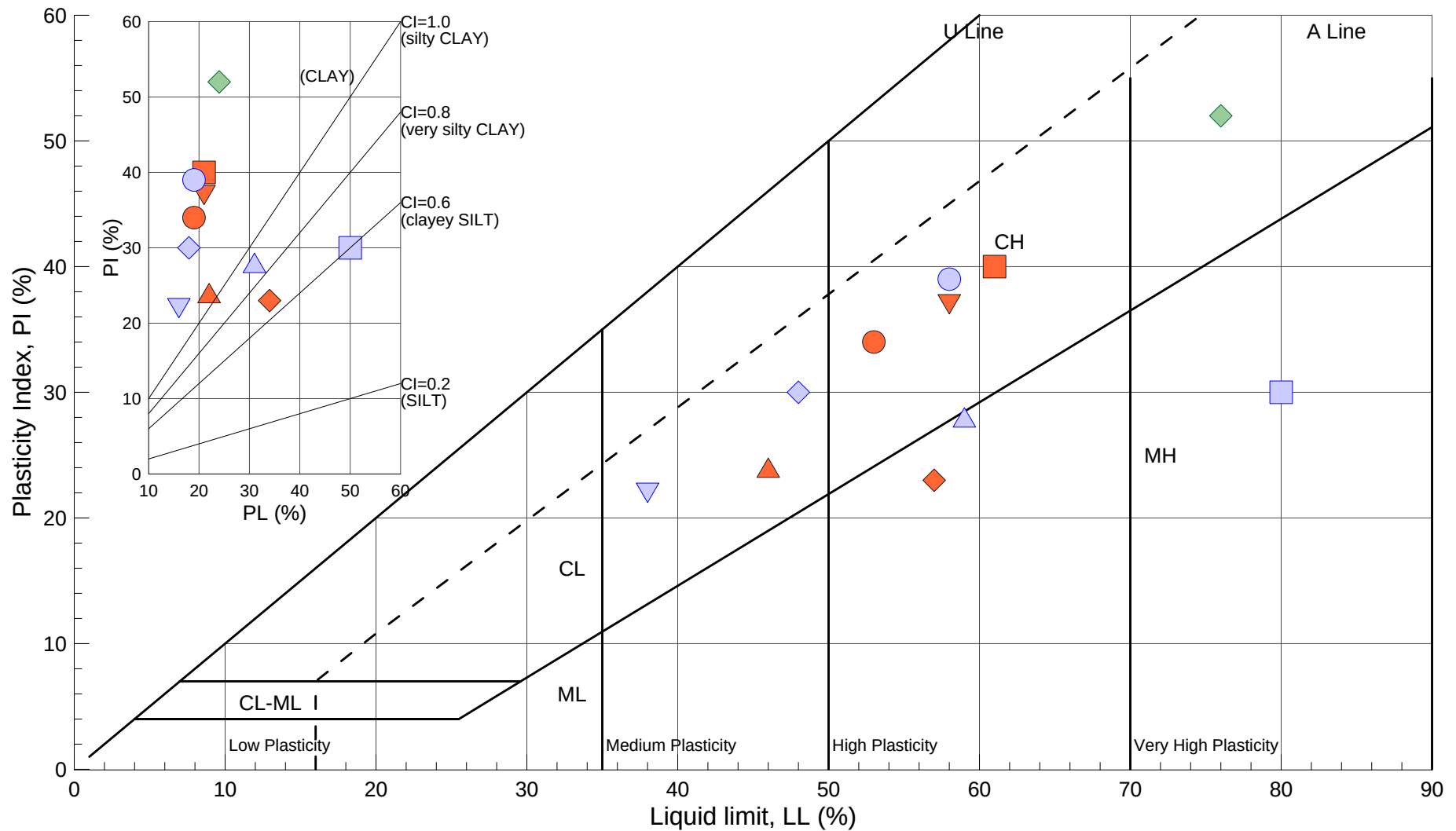
Bear Lake Marina Expansion

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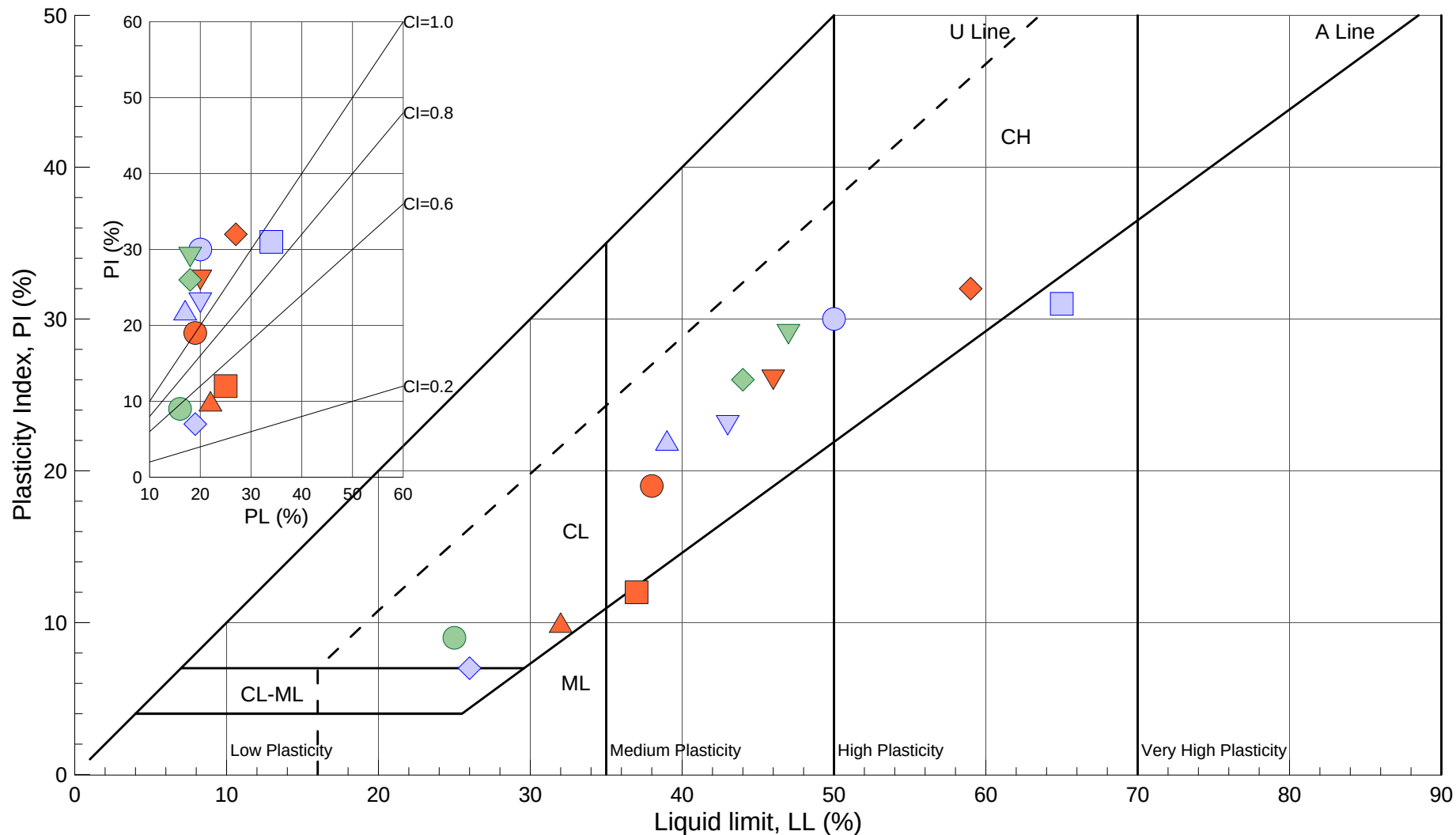
<u>Description</u>	<u>Page No.</u>
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- | | | | |
|----------------------------|---------------------------|------------------------|------------------------|
| ◆ 23-TH-01 at 5-7 ft | ▲ 23-TH-04 at 7.5-9.5 ft | ▼ 23-TH-05 at 15-17 ft | □ 23-TH-05 at 45-47 ft |
| ▼ 23-TH-03 at 7.5-9.5 ft | ■ 23-TH-04 at 7.5-14.5 ft | ● 23-TH-05 at 20-22 ft | ◆ 23-TH-05 at 15-27 ft |
| ● 23-TH-03 at 12.5-13.9 ft | ◆ 23-TH-04 at 15-17 ft | ▲ 23-TH-05 at 30-32 ft | |



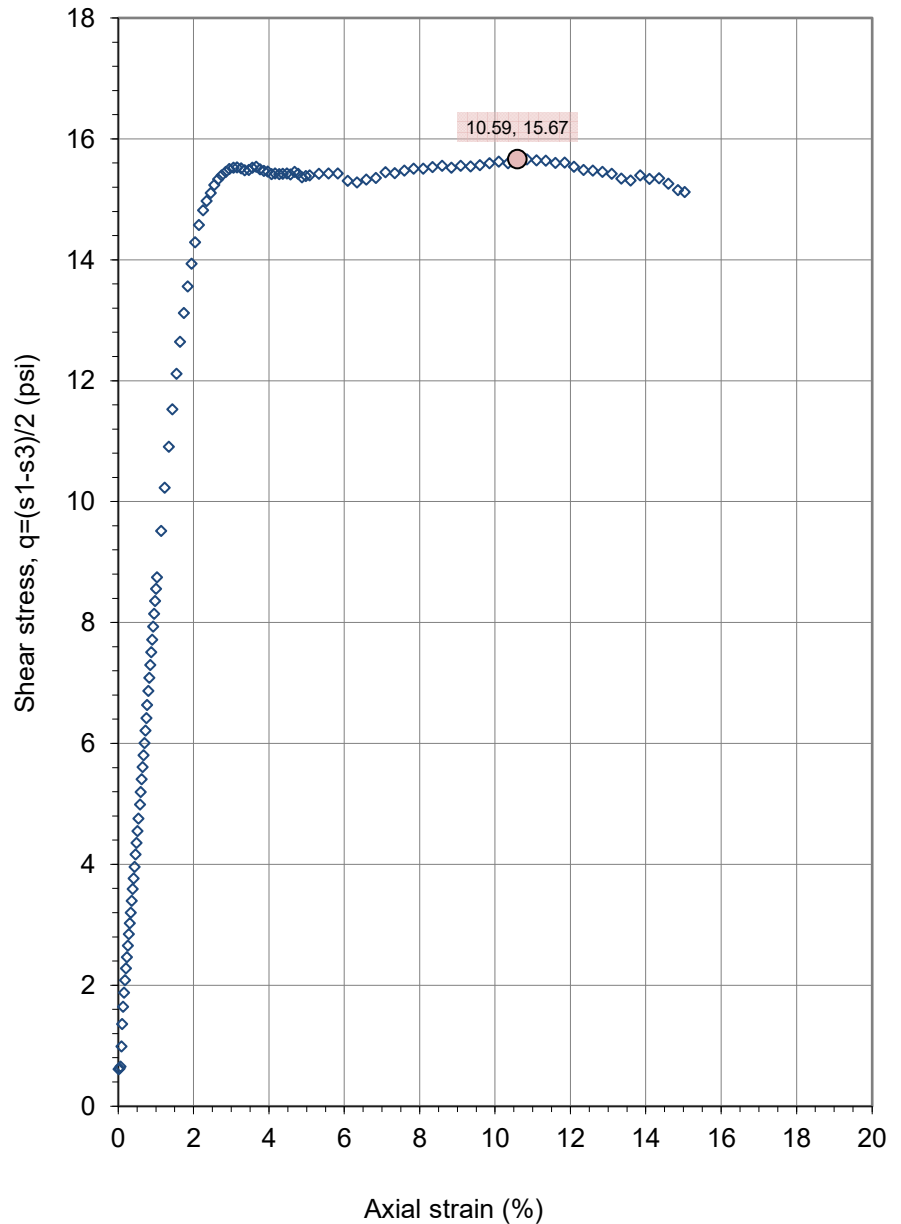
- | | | | | |
|--------------------------|------------------------|------------------------|--------------------------|-------------------------|
| ◆ 23-TH-07 at 2.5-4.5 ft | ▲ 23-TH-07 at 20-22 ft | ▼ 23-TH-09 at 10-12 ft | □ 23-TH-11 at 5-7 ft | ● 23-TH-12 at 2.5-10 ft |
| ▼ 23-TH-07 at 7.8-9.5 ft | ■ 23-TH-07 at 45-47 ft | ● 23-TH-09 at 15-17 ft | ◆ 23-TH-11 at 0-10 ft | |
| ● 23-TH-07 at 7-12 ft | ◇ 23-TH-09 at 5-7 ft | ▲ 23-TH-09 at 25-26.9 | ▼ 23-TH-12 at 7.5-9.5 ft | |

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 19-May-23**Tested by:** AT**Reduced by:** JC**Checked by:** AT**TH/TP/Sample:** 23-TH-01**Depth:** 5-7 ft**Laboratory sample description:** lt gn gy - tn clay**USCS classification:** not requested**Sample type:** Rel. undisturbed, Shelby Tube

Test Number S1 at 4 psi		
Unit weight data	0°	5.746
	Sample ht., H (in) 120°	5.767
	240°	5.756
	Avg. height, Havg (in)	5.756
	Avg. height, Havg (cm)	14.621
	top	2.912
	Sample dia., D (in) mid	2.897
	bot	2.897
	Avg. dia., Davg (in)	2.901
	Avg. dia., Davg (cm)	7.368
	Avg. area, Aavg (in^2)	6.609
	Avg. area, Aavg (cm^2)	42.636
	Wt. rings + wet soil (g)	1040.54
	Wt. rings (g)	0.00
	Volume, Vo (in^3)	38.0
	Vo (cm^3)	623.4
	Vo (ft^3)	0.0220
Moisture	Wet soil + tare (g)	758.88
	Dry soil + tare (g)	588.60
	Tare (g)	197.73
	Moisture content, w (%)	43.6
Phase Relationships	Gs, assumed	2.70
	Mass total (g)	1040.5
	Mass of solids (g)	724.8
	Volume (cm^3)	623.4
	Volume of water (cm^3)	315.8
	Volume of solids (cm^3)	268.4
	Volume of voids (cm^3)	354.9
	Volume of air (cm^3)	39.2
	Void ratio, e	1.322
	Porosity, n	0.569
	Volumetric moisture, T	0.507
	Saturation, S (%) °	88.96
	Dry density (gm/cm^3)	1.163
	Moist unit wt., gm (pcf)	104.2
	Dry unit wt., gd (pcf)	72.6



Results	Confining stress, s_3 (psi)	4.0
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	10.59
	Time to failure, t_f (min)	10.6
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	15.67
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	2,256
	Peak deviator stress, $s_1 - s_3$ (psi)	31.33

Photo/Sketch at Failure**Comments:**

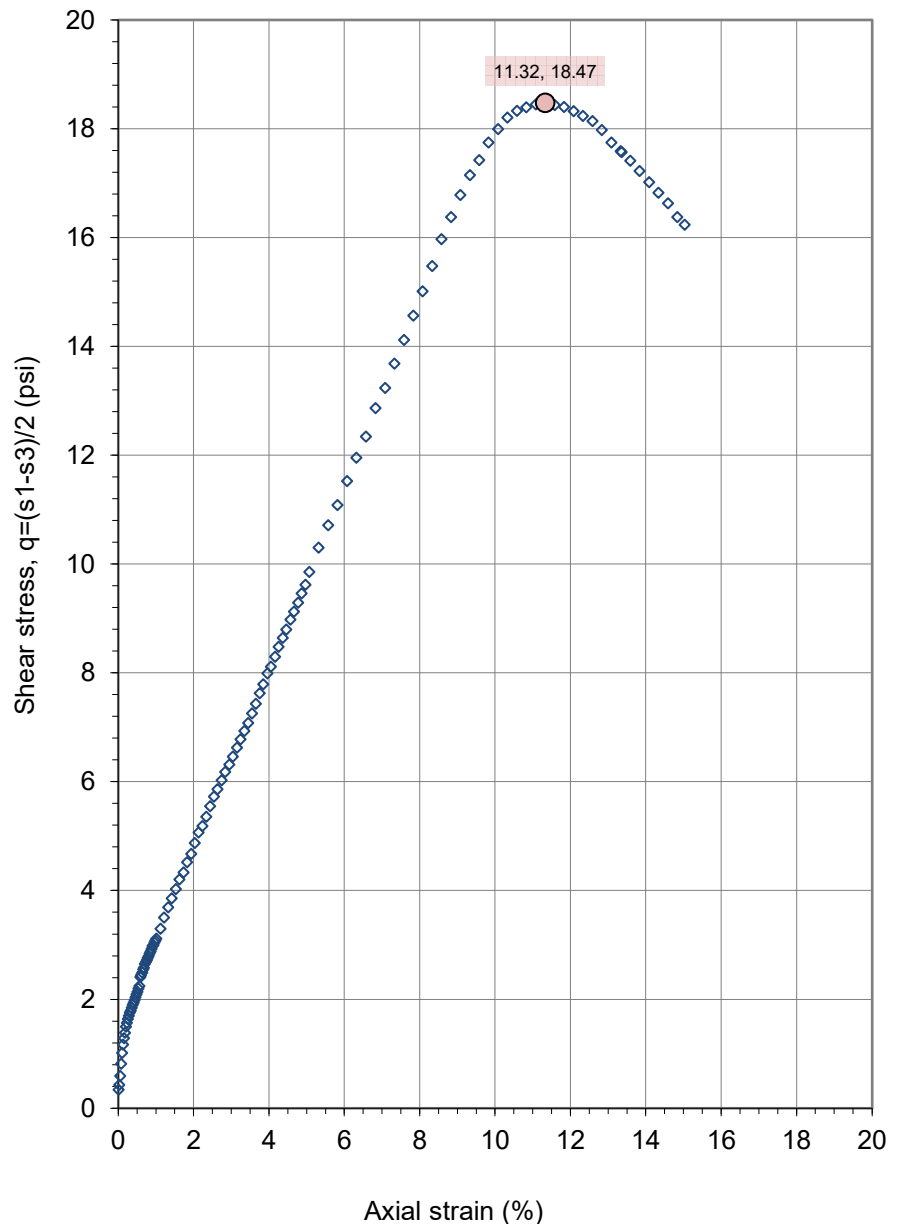
Gash down side of sample up to 1/2" deep.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 15-May-23**Tested by:** AT**Reduced by:** JC**Checked by:** AT**TH/TP/Sample:** 23-TH-03**Depth:** 7.5-9.5 ft (~8 ft)**Laboratory sample description:** lt gn gy - pl ol bn clay**USCS classification:** Not requested.**Sample type:** Undisturbed, Shelby Tube.

Test Number S1 at 3 psi		
Unit weight data	0°	5.518
	Sample ht., H (in) 120°	5.522
	240°	5.516
	Avg. height, Havg (in)	5.519
	Avg. height, Havg (cm)	14.017
	top	2.883
	Sample dia., D (in) mid	2.874
	bot	2.898
	Avg. dia., Davg (in)	2.882
	Avg. dia., Davg (cm)	7.321
	Avg. area, Aavg (in^2)	6.525
	Avg. area, Aavg (cm^2)	42.094
	Wt. rings + wet soil (g)	1068.88
	Wt. rings (g)	0.00
	Volume, Vo (in^3)	36.0
	Vo (cm^3)	590.0
	Vo (ft^3)	0.0208
Moisture	Wet soil + tare (g)	1007.08
	Dry soil + tare (g)	867.32
	Tare (g)	197.55
	Moisture content, w (%)	20.9
Phase Relationships	Gs, assumed	2.70
	Mass total (g)	1068.9
	Mass of solids (g)	884.3
	Volume (cm^3)	590.0
	Volume of water (cm^3)	184.5
	Volume of solids (cm^3)	327.5
	Volume of voids (cm^3)	262.5
	Volume of air (cm^3)	78.0
	Void ratio, e	0.801
	Porosity, n	0.445
	Volumetric moisture, T	0.313
	Saturation, S (%) °	70.30
	Dry density (gm/cm^3)	1.499
	Moist unit wt., gm (pcf)	113.1
	Dry unit wt., gd (pcf)	93.6



Results	Confining stress, s_3 (psi)	3.00
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	11.32
	Time to failure, t_f (min)	11.3
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	18.47
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	2,660
Peak deviator stress, $s_1 - s_3$ (psi)		36.95

Photo/Sketch at Failure**Comments:**

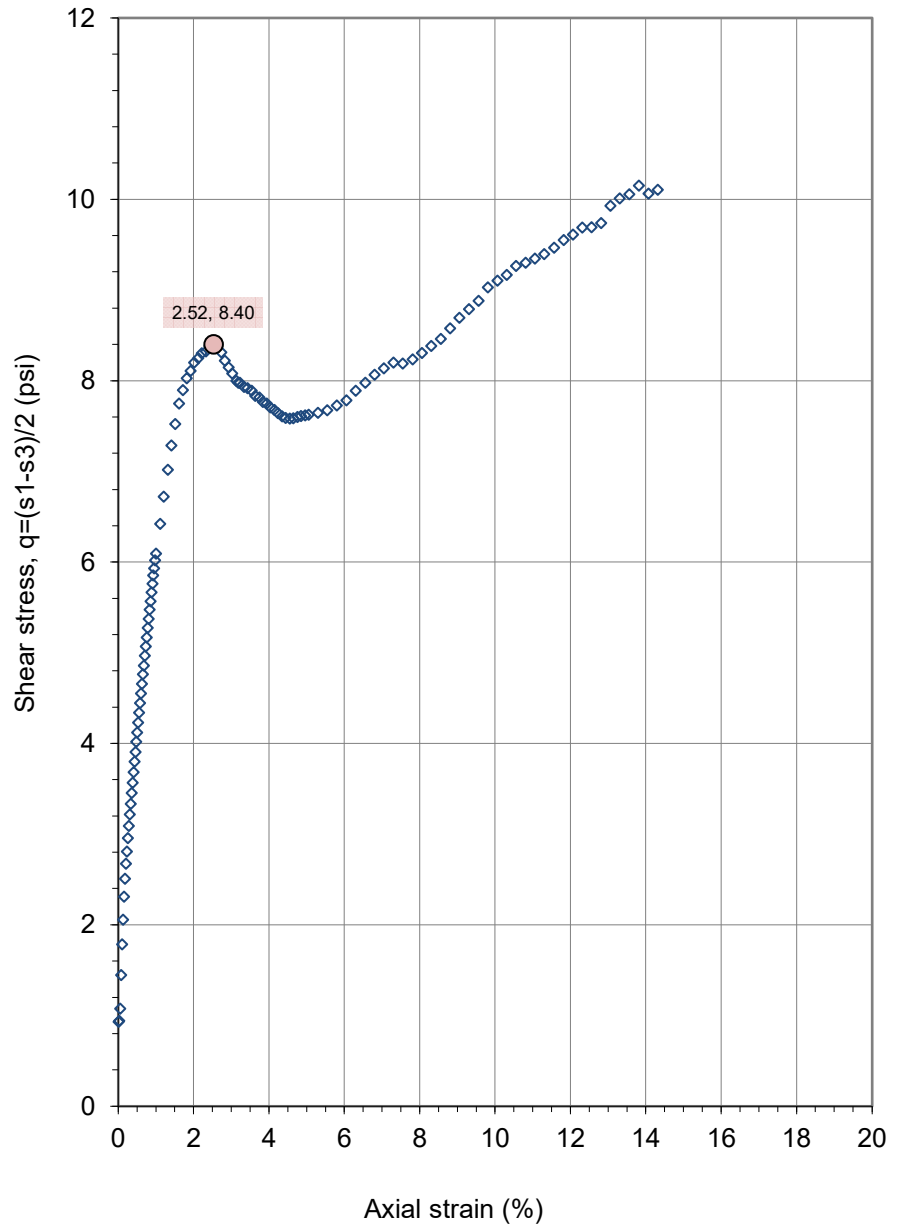
Sample shorter than 2:1 H:D ratio.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 15-May-23**Tested by:** AC**Reduced by:** AC**Checked by:** JC**TH/TP/Sample:** 23-TH-04**Depth:** 10-12 ft (~11 ft)**Laboratory sample description:** lt gn gy - lt bl gy clay**USCS classification:** Not requested.**Sample type:** Undisturbed, Shelby Tube.

Test Number S2 at 4 psi	
Unit weight data	0° 5.748
	Sample ht., H (in) 120° 5.755
	240° 5.751
	Avg. height, Havg (in) 5.751
	Avg. height, Havg (cm) 14.608
	top 2.866
	Sample dia., D (in) mid 2.849
	bot 2.874
	Avg. dia., Davg (in) 2.860
	Avg. dia., Davg (cm) 7.263
	Avg. area, Aavg (in^2) 6.422
	Avg. area, Aavg (cm^2) 41.432
	Wt. rings + wet soil (g) 1167.15
	Wt. rings (g) 0.00
	Volume, Vo (in^3) 36.9
Moisture	Vo (cm^3) 605.3
	Vo (ft^3) 0.0214
	Wet soil + tare (g) 473.72
	Dry soil + tare (g) 387.31
Moisture	Tare (g) 117.15
	Moisture content, w (%) 32.0
Phase Relationships	Gs, assumed 2.70
	Mass total (g) 1167.2
	Mass of solids (g) 884.3
	Volume (cm^3) 605.3
	Volume of water (cm^3) 282.8
	Volume of solids (cm^3) 327.5
	Volume of voids (cm^3) 277.7
	Volume of air (cm^3) -5.1
	Void ratio, e 0.848
	Porosity, n 0.459
	Volumetric moisture, T 0.467
	Saturation, S (%) ° 101.84
	Dry density (gm/cm^3) 1.461
	Moist unit wt., gm (pcf) 120.4
	Dry unit wt., gd (pcf) 91.2



Results	Confining stress, s_3 (psi)	4.00
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	2.52
	Time to failure, t_f (min)	2.5
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	8.40
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	1,210
	Peak deviator stress, $s_1 - s_3$ (psi)	16.80

Photo/Sketch at Failure**Comments:**

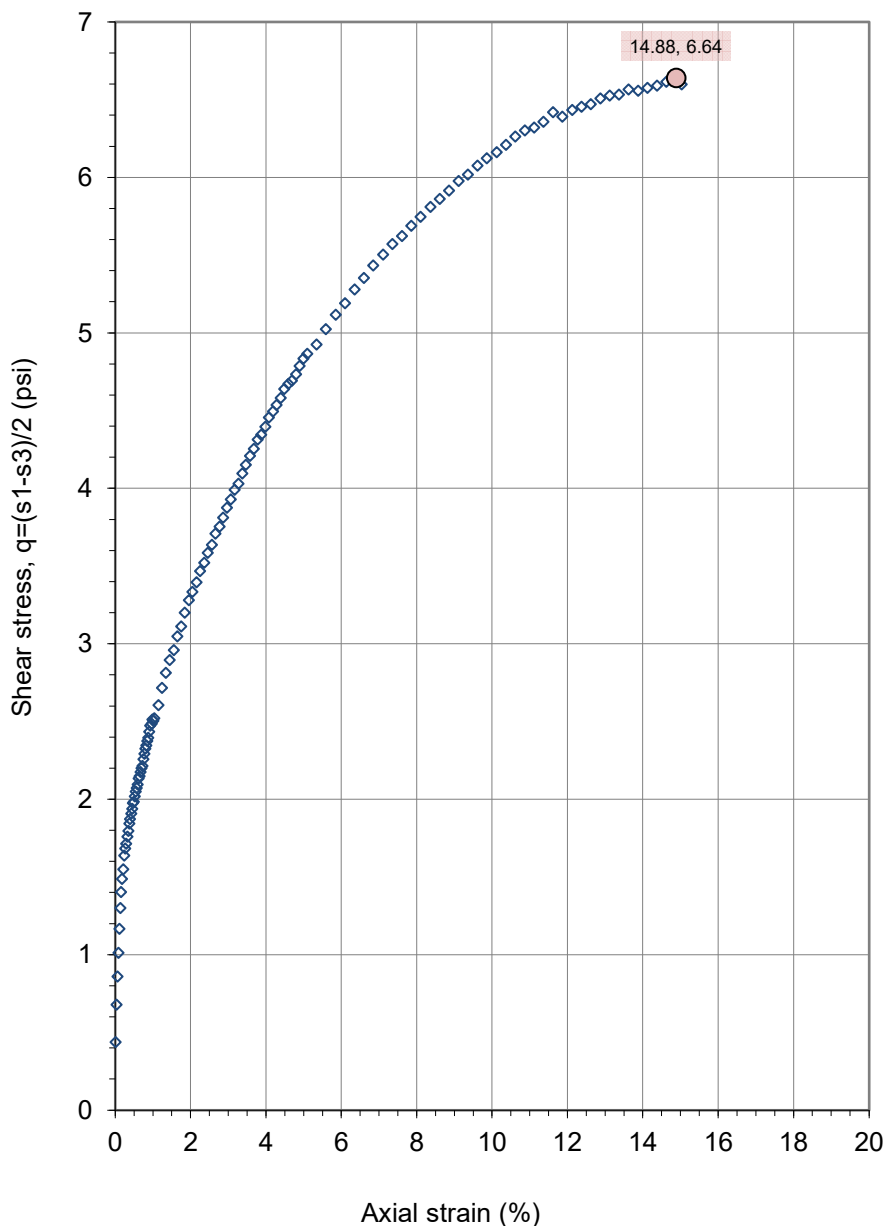
Sample possibly touched acrylic during shearing.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 15-May-23**Tested by:** AC**Reduced by:** AC**Checked by:** JC**TH/TP/Sample:** 23-TH-05**Depth:** 5-7 ft**Laboratory sample description:** gy - dk bn sand with clay**USCS classification:** Not requested.**Sample type:** Undisturbed, Shelby Tube.

Test Number S3 at 3 psi		
Unit weight data	0°	5.759
	Sample ht., H (in) 120°	5.740
	240°	5.750
	Avg. height, Havg (in)	5.750
	Avg. height, Havg (cm)	14.604
	top	2.830
	Sample dia., D (in) mid	2.829
	bot	2.831
	Avg. dia., Davg (in)	2.830
	Avg. dia., Davg (cm)	7.188
	Avg. area, Aavg (in^2)	6.289
	Avg. area, Aavg (cm^2)	40.575
	Wt. rings + wet soil (g)	1129.21
	Wt. rings (g)	0.00
	Volume, Vo (in^3)	36.2
	Vo (cm^3)	592.6
	Vo (ft^3)	0.0209
Moisture	Wet soil + tare (g)	414.70
	Dry soil + tare (g)	342.17
	Tare (g)	119.62
	Moisture content, w (%)	32.6
Phase Relationships	Gs, assumed	2.70
	Mass total (g)	1129.2
	Mass of solids (g)	851.7
	Volume (cm^3)	592.6
	Volume of water (cm^3)	277.6
	Volume of solids (cm^3)	315.4
	Volume of voids (cm^3)	277.1
	Volume of air (cm^3)	-0.4
	Void ratio, e	0.879
	Porosity, n	0.468
	Volumetric moisture, T	0.468
	Saturation, S (%) °	100.15
	Dry density (gm/cm^3)	1.437
	Moist unit wt., gm (pcf)	119.0
	Dry unit wt., gd (pcf)	89.7



Results	Confining stress, s_3 (psi)	3.00
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	14.88
	Time to failure, t_f (min)	14.9
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	6.64
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	956
	Peak deviator stress, $s_1 - s_3$ (psi)	13.28

Photo/Sketch at Failure

Comments:



Triaxial Test - Unconsolidated Sheared Undrained (UU)

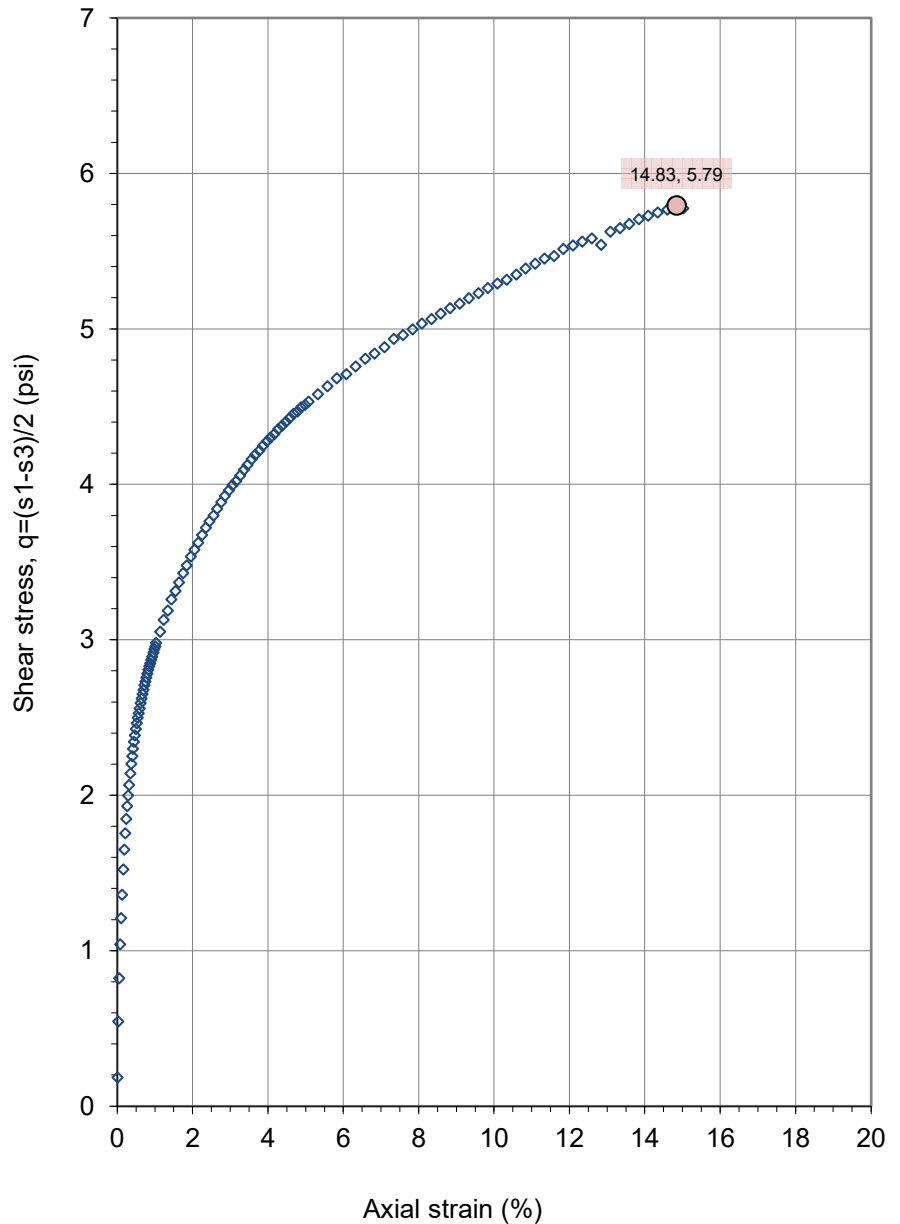
After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 24-May-23**Tested by:** AT**Reduced by:** JC**Checked by:** MGS**TH/TP/Sample:** 23-TH-07**Depth:** 20-22 ft (~21.5 ft)**Laboratory sample description:** lt gn - gy clay**USCS classification:** not requested**Sample type:** Rel. undisturbed Shelby Tube**Test Number** S1 at 15.8 psi

Unit weight data	0°	5.755
	Sample ht., H (in)	120° 5.757
	240°	5.756
	Avg. height, Havg (in)	5.756
	Avg. height, Havg (cm)	14.620
	top	2.895
	Sample dia., D (in)	mid 2.892
	bot	2.885
	Avg. dia., Davg (in)	2.891
	Avg. dia., Davg (cm)	7.343
	Avg. area, Aavg (in^2)	6.564
	Avg. area, Aavg (cm^2)	42.350
	Wt. rings + wet soil (g)	1194.44
	Wt. rings (g)	0.00
	Volume, Vo (in^3)	37.8

Moisture	Wet soil + tare (g)	1317.40
	Dry soil + tare (g)	1075.40
	Tare (g)	130.45
	Moisture content, w (%)	25.6

Phase Relationships	Gs, assumed	2.70
	Mass total (g)	1194.4
	Mass of solids (g)	950.9
	Volume (cm^3)	619.2
	Volume of water (cm^3)	243.5
	Volume of solids (cm^3)	352.2
	Volume of voids (cm^3)	267.0
	Volume of air (cm^3)	23.5
	Void ratio, e	0.758
	Porosity, n	0.431
	Volumetric moisture, T	0.393
	Saturation, S (%) °	91.22
	Dry density (gm/cm^3)	1.536
	Moist unit wt., gm (pcf)	120.4
	Dry unit wt., gd (pcf)	95.9



Results	Confining stress, s_3 (psi)	15.8
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	14.83
	Time to failure, t_f (min)	14.8
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	5.79
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	834
	Peak deviator stress, $s_1 - s_3$ (psi)	11.59

Photo/Sketch at Failure**Comments:**

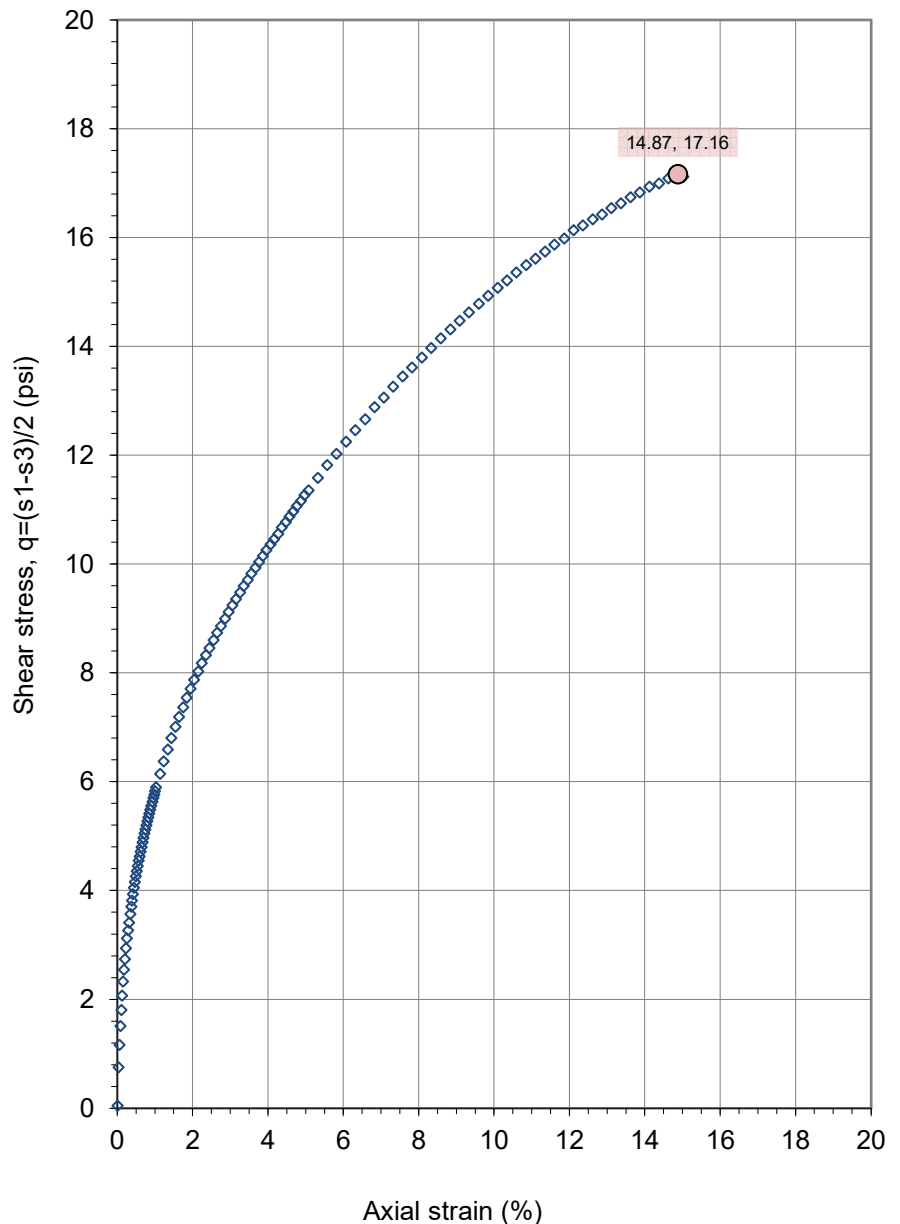
Sample mottled with clay and silt.

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 24-May-23**Tested by:** AT**Reduced by:** JC**Checked by:** MGS**TH/TP/Sample:** 23-TH-07**Depth:** 35-37 ft (~36.5 ft)**Laboratory sample description:** lt gy - gy silt**USCS classification:** not requested**Sample type:** Rel. undisturbed Shelby Tube

Test Number S2 at 22 psi	
Unit weight data	0° 5.756
	Sample ht., H (in) 120° 5.747
	240° 5.763
	Avg. height, Havg (in) 5.755
	Avg. height, Havg (cm) 14.619
	top 2.857
	Sample dia., D (in) mid 2.854
	bot 2.788
	Avg. dia., Davg (in) 2.838
	Avg. dia., Davg (cm) 7.209
	Avg. area, Aavg (in^2) 6.327
	Avg. area, Aavg (cm^2) 40.819
	Wt. rings + wet soil (g) 1136.62
	Wt. rings (g) 0.00
	Volume, Vo (in^3) 36.4
Moisture	Vo (cm^3) 596.7
	Vo (ft^3) 0.0211
	Wet soil + tare (g) 1333.50
	Dry soil + tare (g) 1067.43
Moisture	Tare (g) 195.94
	Moisture content, w (%) 30.5
Phase Relationships	Gs, assumed 2.70
	Mass total (g) 1136.6
	Mass of solids (g) 870.8
	Volume (cm^3) 596.7
	Volume of water (cm^3) 265.9
	Volume of solids (cm^3) 322.5
	Volume of voids (cm^3) 274.2
	Volume of air (cm^3) 8.4
	Void ratio, e 0.850
	Porosity, n 0.460
	Volumetric moisture, T 0.446
	Saturation, S (%) ° 96.95
	Dry density (gm/cm^3) 1.459
	Moist unit wt., gm (pcf) 118.9
	Dry unit wt., gd (pcf) 91.1



Results	Confining stress, s_3 (psi)	22.0
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ϵ_f (%)	14.87
	Time to failure, t_f (min)	14.9
	Peak shear stress, $(s_1 - s_3)/2$ (psi)	17.16
	Peak shear stress, $(s_1 - s_3)/2$ (psf)	2,472
	Peak deviator stress, $s_1 - s_3$ (psi)	34.33

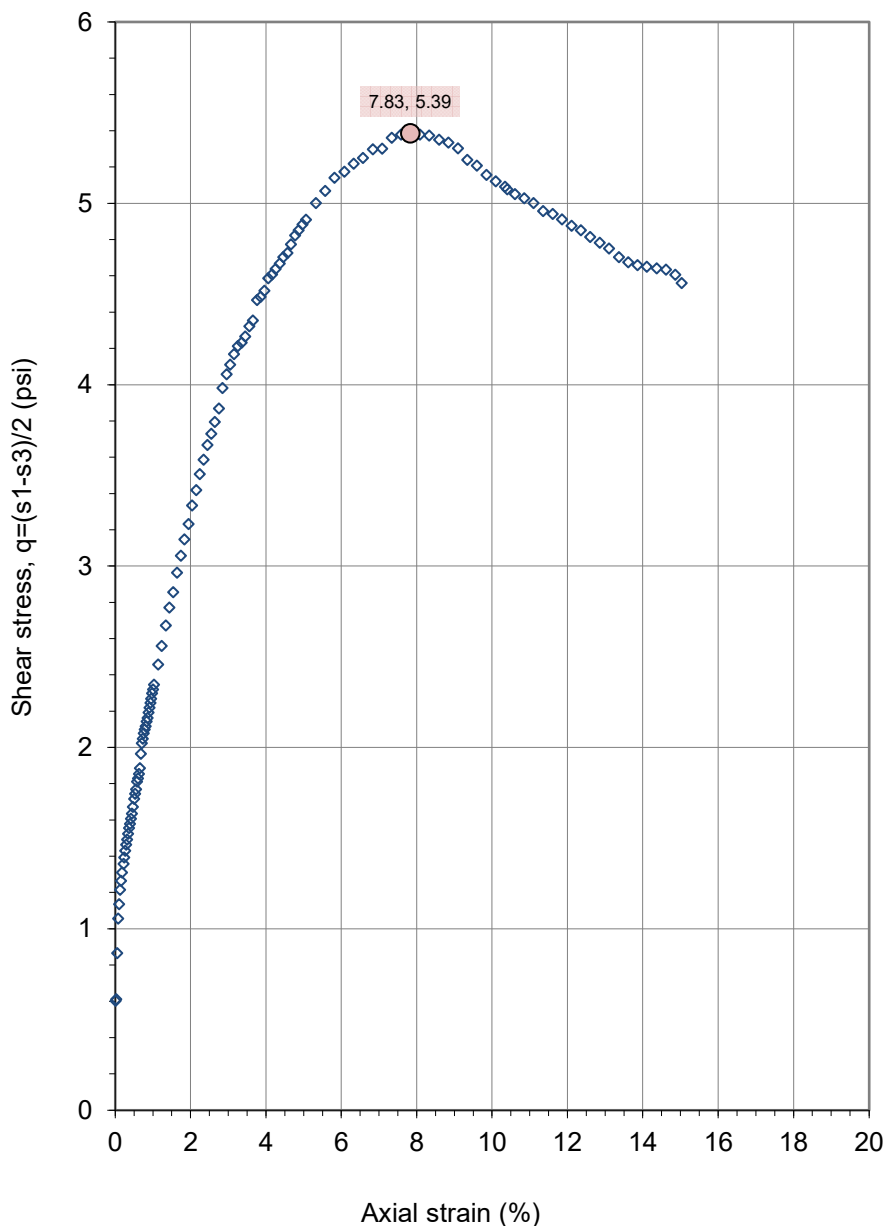
Photo/Sketch at Failure**Comments:**

Triaxial Test - Unconsolidated Sheared Undrained (UU)

After ASTM D2850, AASHTO T296, and USBR 5745

**Project:** Bear Lake Marina Expansion**No:** 22-1522**Location:** Rich County, Utah**Date:** 24-May-23**Tested by:** AT**Reduced by:** JC**Checked by:** MGS**TH/TP/Sample:** 23-TH-07**Depth:** 45-47 ft (~46.5 ft)**Laboratory sample description:** ol bn - gy clay**USCS classification:** not requested**Sample type:** Rel. undisturbed Shelby Tube

Test Number S3 at 26 psi	
Unit weight data	0° 5.748
	Sample ht., H (in) 120° 5.749
	240° 5.809
	Avg. height, Havg (in) 5.769
	Avg. height, Havg (cm) 14.652
	top 2.836
	Sample dia., D (in) mid 2.834
	bot 2.801
	Avg. dia., Davg (in) 2.826
	Avg. dia., Davg (cm) 7.179
	Avg. area, Aavg (in^2) 6.274
	Avg. area, Aavg (cm^2) 40.474
	Wt. rings + wet soil (g) 1300.95
	Wt. rings (g) 267.08
	Volume, Vo (in^3) 36.2
	Vo (cm^3) 593.0
	Vo (ft^3) 0.0209
Moisture	Wet soil + tare (g) 1236.09
	Dry soil + tare (g) 961.86
	Tare (g) 197.16
	Moisture content, w (%) 35.9
Phase Relationships	Gs, assumed 2.70
	Mass total (g) 1033.9
	Mass of solids (g) 761.0
	Volume (cm^3) 593.0
	Volume of water (cm^3) 272.9
	Volume of solids (cm^3) 281.8
	Volume of voids (cm^3) 311.2
	Volume of air (cm^3) 38.3
	Void ratio, e 1.104
	Porosity, n 0.525
	Volumetric moisture, T 0.460
	Saturation, S (%) ° 87.69
	Dry density (gm/cm^3) 1.283
	Moist unit wt., gm (pcf) 108.8
	Dry unit wt., gd (pcf) 80.1



Results	Confining stress, s3 (psi)	26.0
	Strain rate (%/hr)	60.00
	Strain rate (%/min)	1.00
	Membrane correction	Yes
	Strain at failure, ef (%)	7.83
	Time to failure, tf (min)	7.8
	Peak shear stress, (s1-s3)/2 (psi)	5.39
	Peak shear stress, (s1-s3)/2 (psf)	776
	Peak deviator stress, s1-s3 (psi)	10.77

Photo/Sketch at Failure

Comments:

Sample very soft clay.



One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 19-May-23

TH/TP/Sample: 23-TH-01
Depth: 5-7 ft (~6 ft)

Laboratory sample description: lt gn gy - tan clay
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: AT
Comments: Hard, overconsolidated clay. Very crumbly.
Sample possibly disturbed.

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): <100
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.988	-	Seating	0.0000	0.9878	0.0000	1.0654	0
Sample ht., 90°	0.992	-	100	0.0001	0.9876	0.0001	1.0652	54
H (in), 180°	0.985	-	200	0.0041	0.9837	0.0041	1.0569	16
H (in), 270°	0.986	-	400	0.0088	0.9790	0.0089	1.0471	240
Avg. height, Havg (in)	0.988	0.846	800	0.0145	0.9732	0.0147	1.0350	240
Avg height, Havg (cm)	2.509	2.149	1,600	0.0231	0.9646	0.0234	1.0170	480
Sample Dia., 0°	2.498	-	3,200	0.0342	0.9536	0.0346	0.9940	480
D (in), 90°	2.488	-	6,400	0.0462	0.9416	0.0468	0.9688	454
Avg dia., Davg (in)	2.493	2.493	12,800	0.0637	0.9241	0.0645	0.9323	480
Avg dia., Davg (cm)	6.332	6.332	25,600	0.0876	0.9002	0.0887	0.8823	72
Wt. rings + wet soil (g)	352.36	348.73	51,200	0.1278	0.8599	0.1294	0.7982	480
Wt. rings (g)	214.30	214.30	102,400	0.1691	0.8187	0.1712	0.7119	263
Wet soil + tare (g)	543.98	251.21	204,800	0.2116	0.7761	0.2142	0.6229	480
Dry soil + tare (g)	431.10	215.92	102,400	0.2041	0.7837	0.2066	0.6386	120
Tare (g)	119.18	117.04	25,600	0.1794	0.8084	0.1816	0.6904	240
Moisture cont., w (%)	36.2	35.7	6,400	0.1415	0.8462	0.1433	0.7694	1249
Gs, assumed	2.65	2.65						
Mass total (g)	138.1	134.4						
Mass of solids (g)	101.4	101.4						
Volume (cm^3)	79.0	67.7						
Vol. of water (cm^3)	36.7	33.1						
Vol. of solids (cm^3)	38.3	38.3						
Vol. of voids (cm^3)	40.8	29.4						
Vol. of air (cm^3)	4.1	-3.6						
Area, A (cm^2)	31.5	31.5						
Ht. solids, Hs (cm)	1.215	1.215						
Void ratio, e	1.065	0.769						
Porosity, n	0.516	0.435						
Vol. moisture, T	0.464	0.488						
Saturation, S (%)	90	112						
Dry density (gm/cm^3)	1.283	1.498						
Wet unit wt., gm (pcf)	109.1	126.9						
Dry unit wt., gd (pcf)	80.1	93.5						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 18,800
Compression ratio, CR 0.14
Recompression ratio, RR 0.037

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 17,000

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

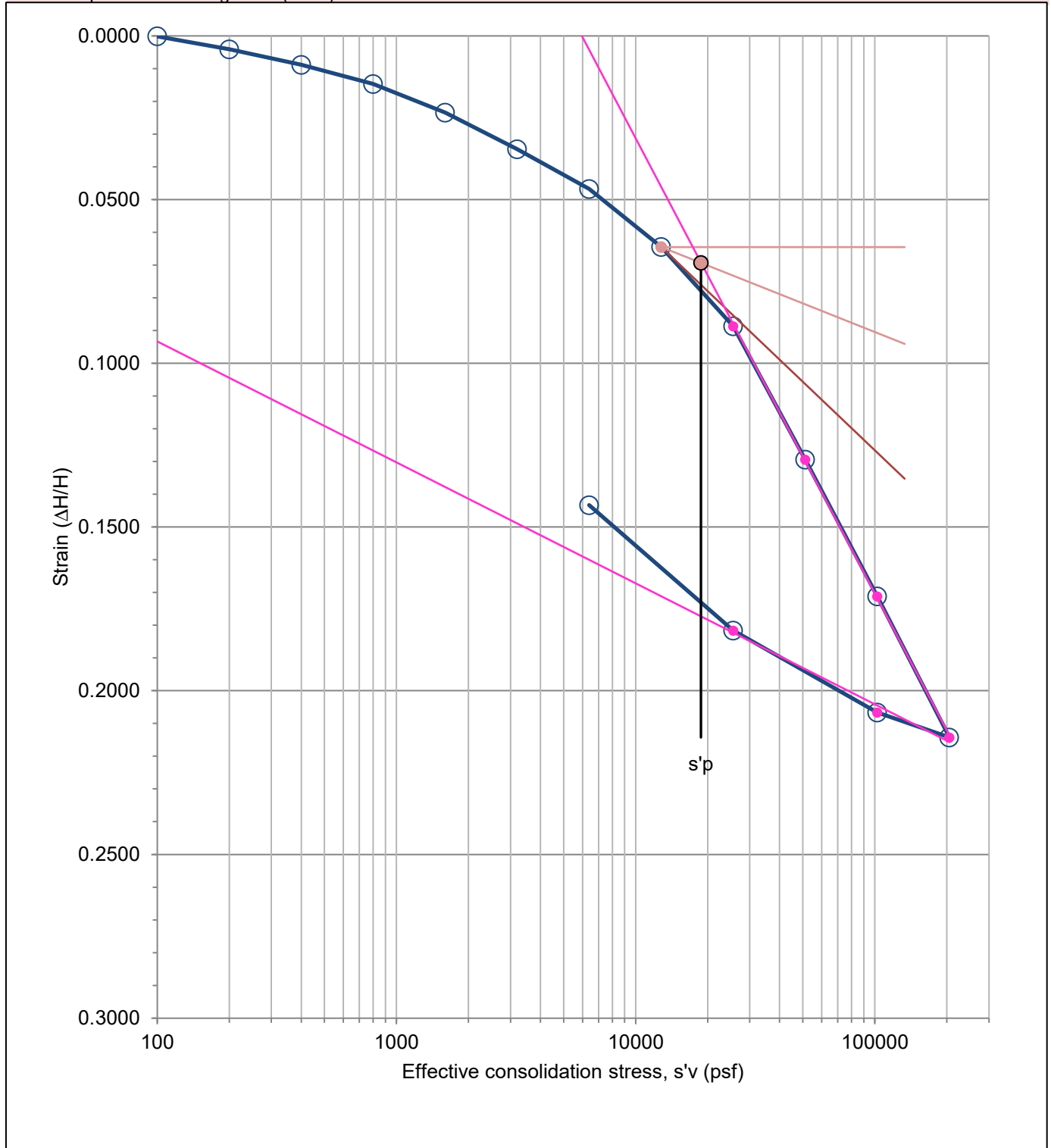
After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

TH/TP/Sample: 23-TH-01
Depth: 5-7 ft (~6 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	18,800
Compression ratio, CR	0.14
Recompression ratio, RR	0.037

One-Dimensional Consolidation Properties of Soils

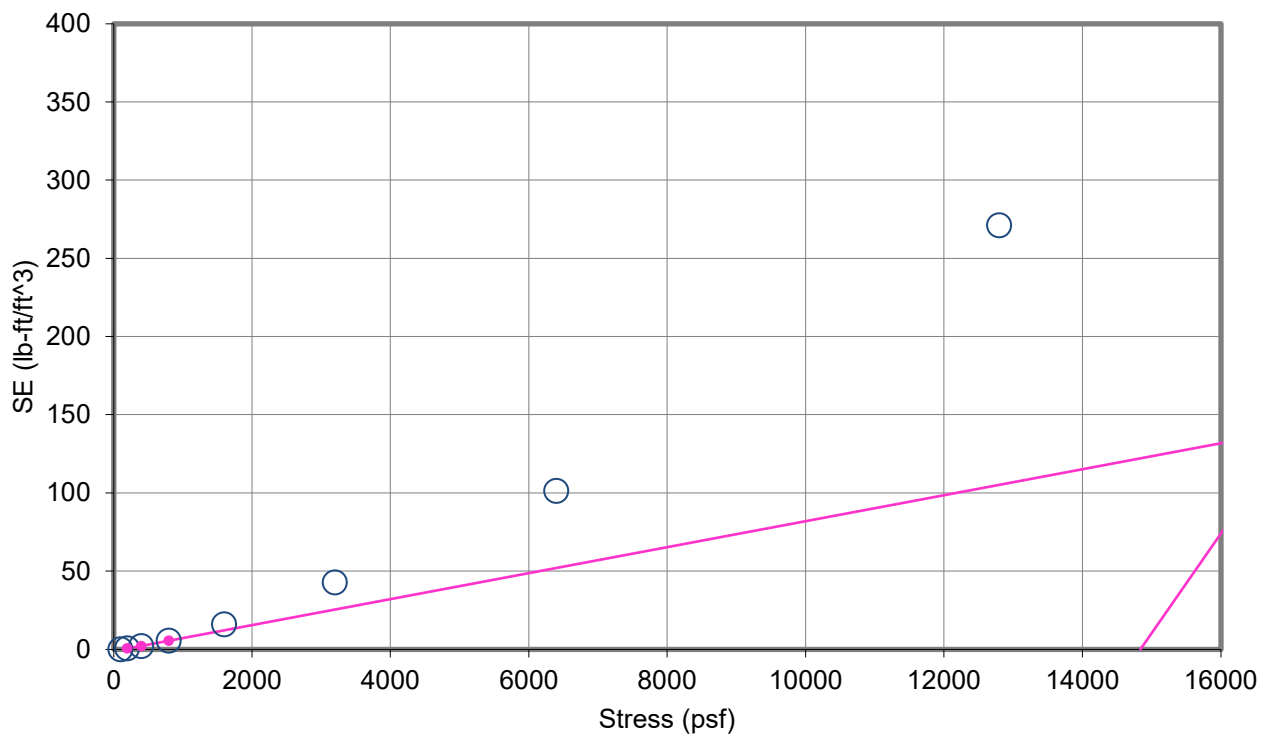
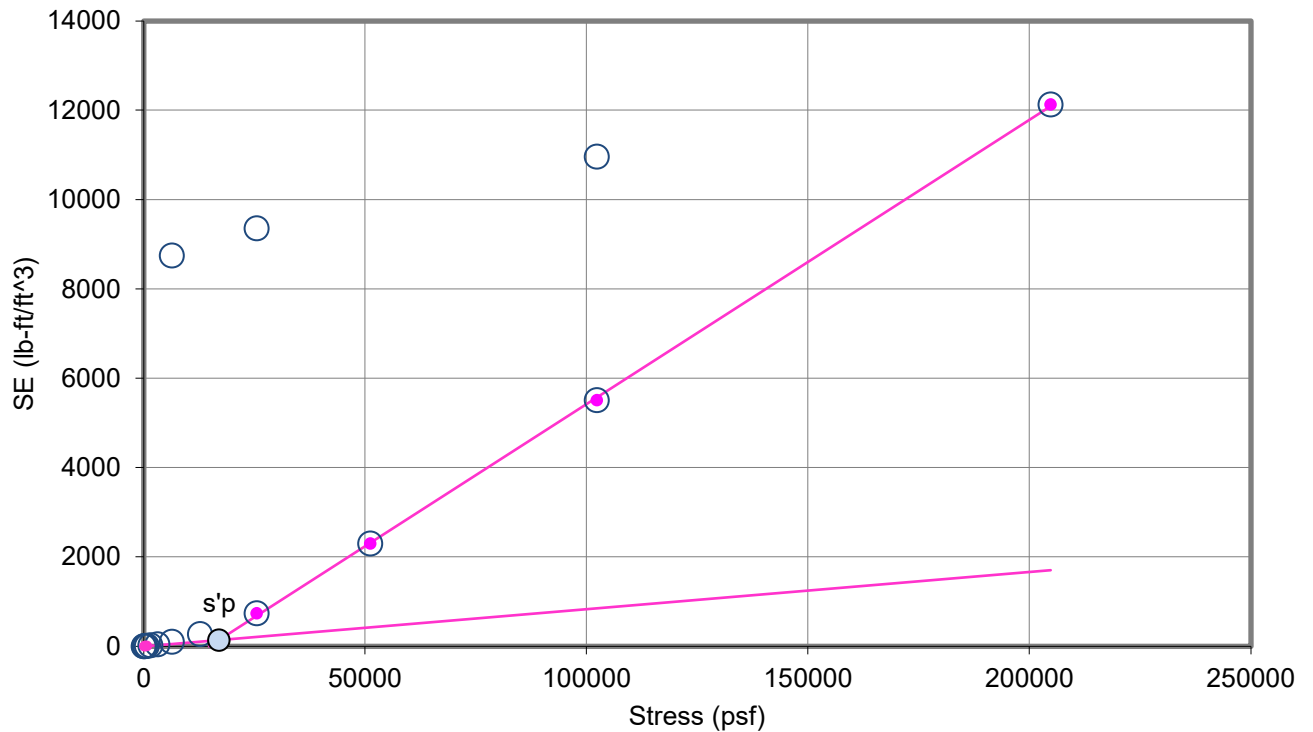
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-01**
Depth: **5-7 ft (~6 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 17,000

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 17-May-23

TH/TP/Sample: 23-TH-03
Depth: 7.5-9.5 ft (~9 ft)

Laboratory sample description: lt gn gy - pr gy clay
USCS classification: not requested

Tested by: AT
Reduced by: AT
Checked by: MGS
Comments: Sample very crumbly. Very hard clay with multiple fracture planes.

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): 225
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.997	-	Seating	0.0000	0.9990	0.0000	0.8064	0
Sample ht., 90°	1.001	-	225	0.0000	0.9990	0.0000	0.8064	40
H (in), 180°	0.997	-	400	0.0034	0.9956	0.0034	0.8002	161
H (in), 270°	1.001	-	800	0.0117	0.9873	0.0118	0.7852	91
Avg. height, Havg (in)	0.999	0.885	1,600	0.0263	0.9727	0.0264	0.7588	159
Avg height, Havg (cm)	2.537	2.249	3,200	0.0438	0.9552	0.0438	0.7273	164
Sample Dia., 0°	2.497	-	6,400	0.0658	0.9332	0.0659	0.6875	480
D (in), 90°	2.493	-	12,800	0.0897	0.9093	0.0897	0.6443	159
Avg dia., Davg (in)	2.495	2.495	25,600	0.1169	0.8821	0.1171	0.5950	146
Avg dia., Davg (cm)	6.337	6.337	51,200	0.1455	0.8535	0.1456	0.5434	40
Wt. rings + wet soil (g)	357.97	362.25	25,600	0.1410	0.8580	0.1411	0.5515	37
Wt. rings (g)	216.80	216.80	6,400	0.1274	0.8716	0.1275	0.5761	96
Wet soil + tare (g)	267.96	263.33	1,600	0.1135	0.8855	0.1137	0.6011	126
Dry soil + tare (g)	256.15	232.20						
Tare (g)	197.78	118.45						
Moisture cont., w (%)	20.2	27.4						
Gs, assumed	2.65	2.65						
Mass total (g)	141.2	145.5						
Mass of solids (g)	117.4	117.4						
Volume (cm ³)	80.0	70.9						
Vol. of water (cm ³)	23.8	28.0						
Vol. of solids (cm ³)	44.3	44.3						
Vol. of voids (cm ³)	35.7	26.6						
Vol. of air (cm ³)	12.0	-1.4						
Area, A (cm ²)	31.5	31.5						
Ht. solids, Hs (cm)	1.405	1.405						
Void ratio, e	0.806	0.601						
Porosity, n	0.446	0.375						
Vol. moisture, T	0.297	0.395						
Saturation, S (%)	66	105						
Dry density (gm/cm ³)	1.467	1.655						
Wet unit wt., gm (pcf)	110.1	131.6						
Dry unit wt., gd (pcf)	91.6	103.3						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s'_p (psf) 2,200
Compression ratio, CR 0.09
Recompression ratio, RR 0.022

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'_p (psf) 4,600

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

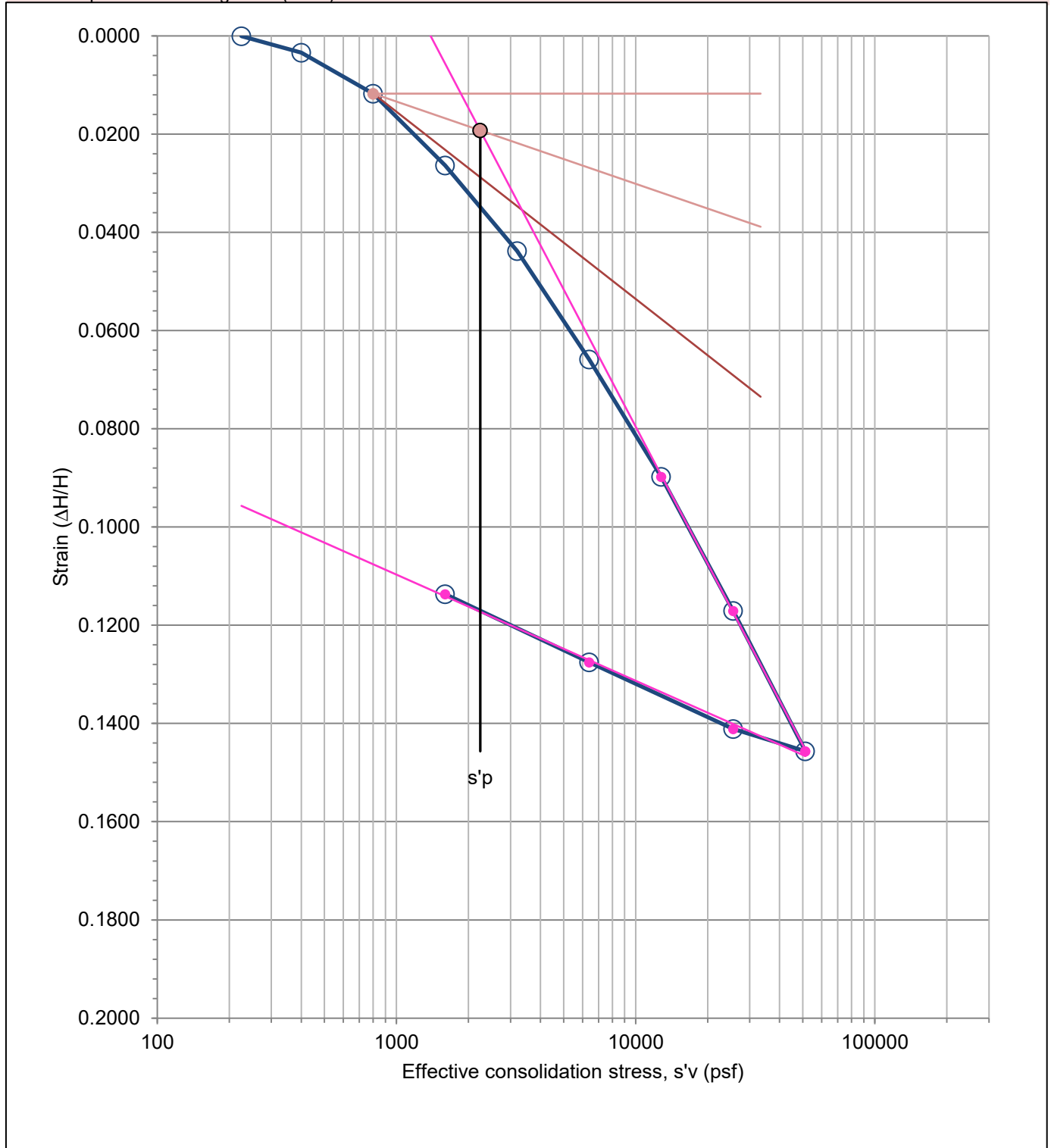
After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

TH/TP/Sample: 23-TH-03
Depth: 7.5-9.5 ft (~9 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	2,200
Compression ratio, CR	0.09
Recompression ratio, RR	0.022

One-Dimensional Consolidation Properties of Soils

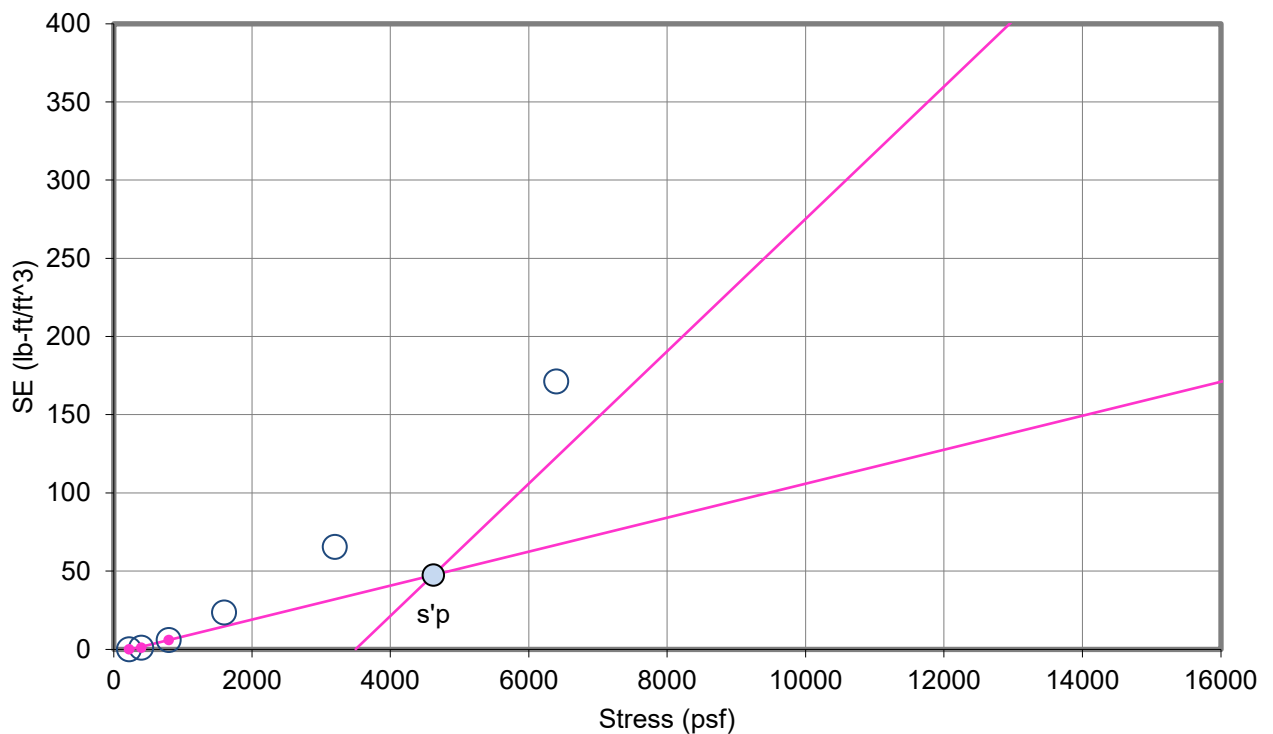
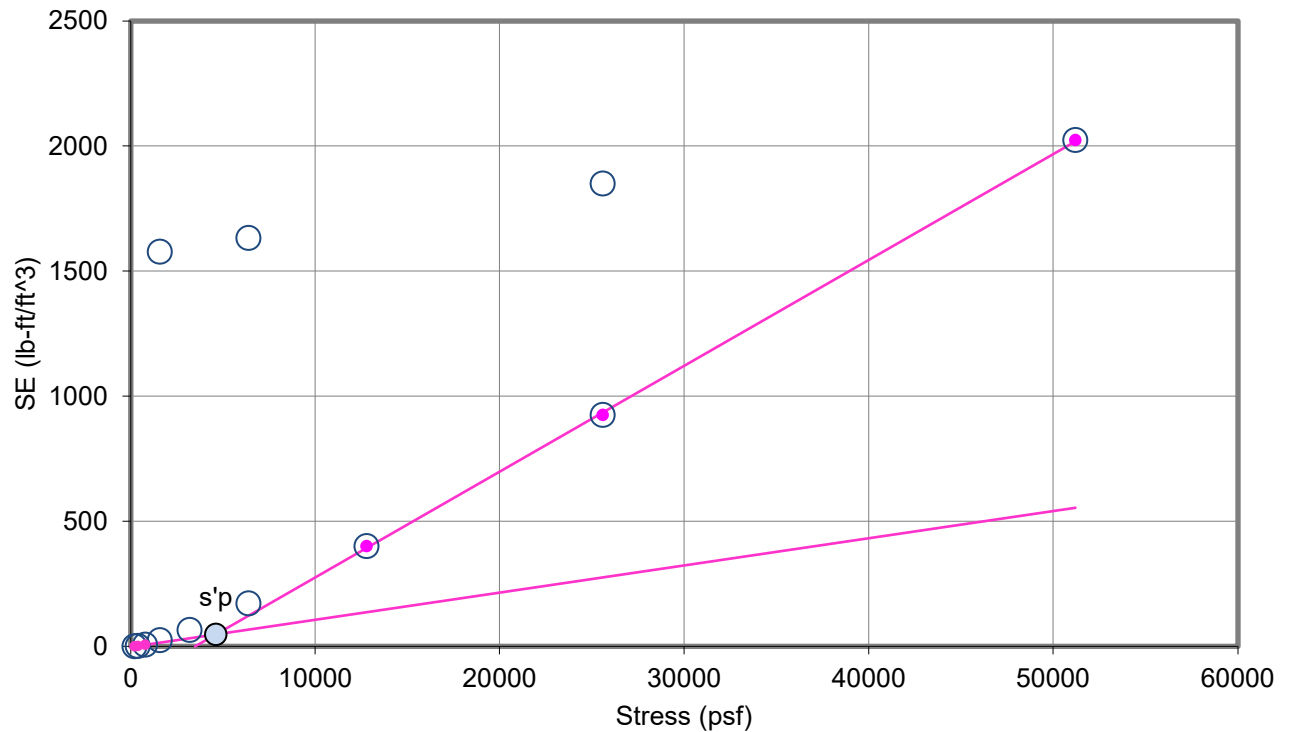
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-03**
Depth: **7.5-9.5 ft (~9 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'_p (psf) 4,600

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah

Date: 22-May-23

TH/TP/Sample: 23-TH-04
Depth: 10-12 ft (~11.5 ft)

Laboratory sample description: lt gn gy - lt bl gy clay

USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments: Hard clay. Restarted test after 1 minute on 100 psf loading, swell pressure may not be representative.

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): 136
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.999	-	Seating	0.0000	0.9988	0.0000	0.7346	0
Sample ht., 90°	0.997	-	136	0.0000	0.9988	0.0000	0.7346	95
H (in), 180°	0.998	-	400	0.0030	0.9958	0.0030	0.7294	60
270°	1.001	-	800	0.0057	0.9930	0.0057	0.7246	46
Avg. height, Havg (in)	0.999	0.895	1,600	0.0100	0.9887	0.0100	0.7172	40
Avg height, Havg (cm)	2.537	2.273	3,200	0.0174	0.9814	0.0174	0.7044	63
Sample Dia., 0°	2.498	-	6,400	0.0263	0.9724	0.0264	0.6888	44
D (in), 90°	2.466	-	12,800	0.0412	0.9576	0.0412	0.6631	71
Avg dia., Davg (in)	2.482	2.482	25,600	0.0660	0.9327	0.0661	0.6199	345
Avg dia., Davg (cm)	6.304	6.304	51,200	0.1003	0.8985	0.1004	0.5604	480
Wt. rings + wet soil (g)	374.26	370.30	102,400	0.1417	0.8571	0.1419	0.4885	291
Wt. rings (g)	217.27	217.27	51,200	0.1381	0.8606	0.1383	0.4947	81
Wet soil + tare (g)	536.63	346.48	12,800	0.1233	0.8755	0.1234	0.5205	132
Dry soil + tare (g)	440.55	317.92	3,200	0.1040	0.8947	0.1041	0.5539	1126
Tare (g)	117.78	193.75						
Moisture cont., w (%)	29.8	23.0						
Gs, assumed	2.65	2.65						
Mass total (g)	157.0	153.0						
Mass of solids (g)	121.0	121.0						
Volume (cm ³)	79.2	70.9						
Vol. of water (cm ³)	36.0	32.1						
Vol. of solids (cm ³)	45.7	45.7						
Vol. of voids (cm ³)	33.5	25.3						
Vol. of air (cm ³)	-2.5	-6.8						
Area, A (cm ²)	31.2	31.2						
Ht. solids, Hs (cm)	1.463	1.463						
Void ratio, e	0.735	0.554						
Porosity, n	0.423	0.356						
Vol. moisture, T	0.455	0.452						
Saturation, S (%)	107	127						
Dry density (gm/cm ³)	1.528	1.705						
Wet unit wt., gm (pcf)	123.8	131.0						
Dry unit wt., gd (pcf)	95.4	106.5						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 14,100
Compression ratio, CR 0.13
Recompression ratio, RR 0.028

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 16,900

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

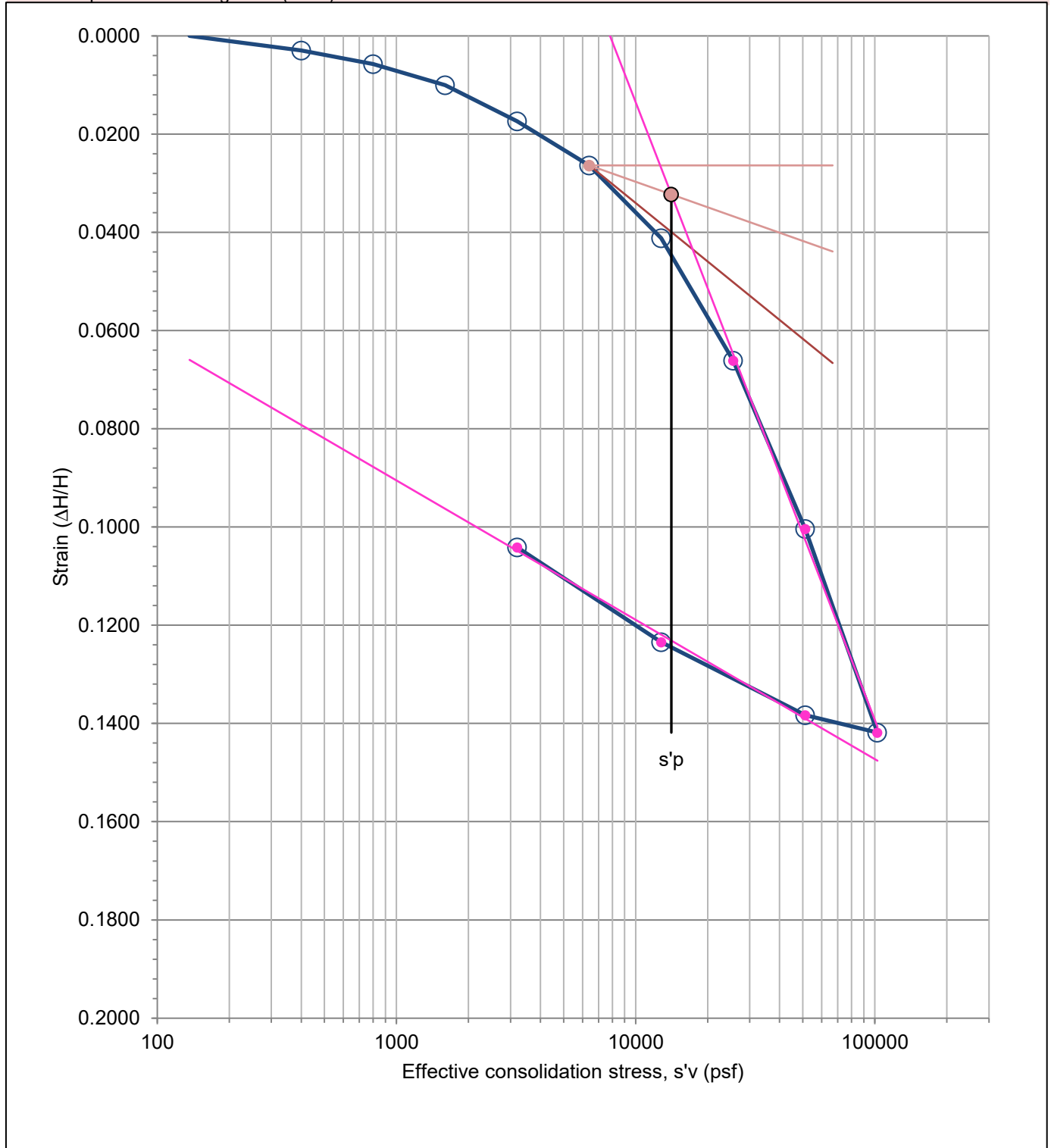
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-04**
Depth: **10-12 ft (~11.5 ft)**

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	14,100
Compression ratio, CR	0.13
Recompression ratio, RR	0.028

One-Dimensional Consolidation Properties of Soils

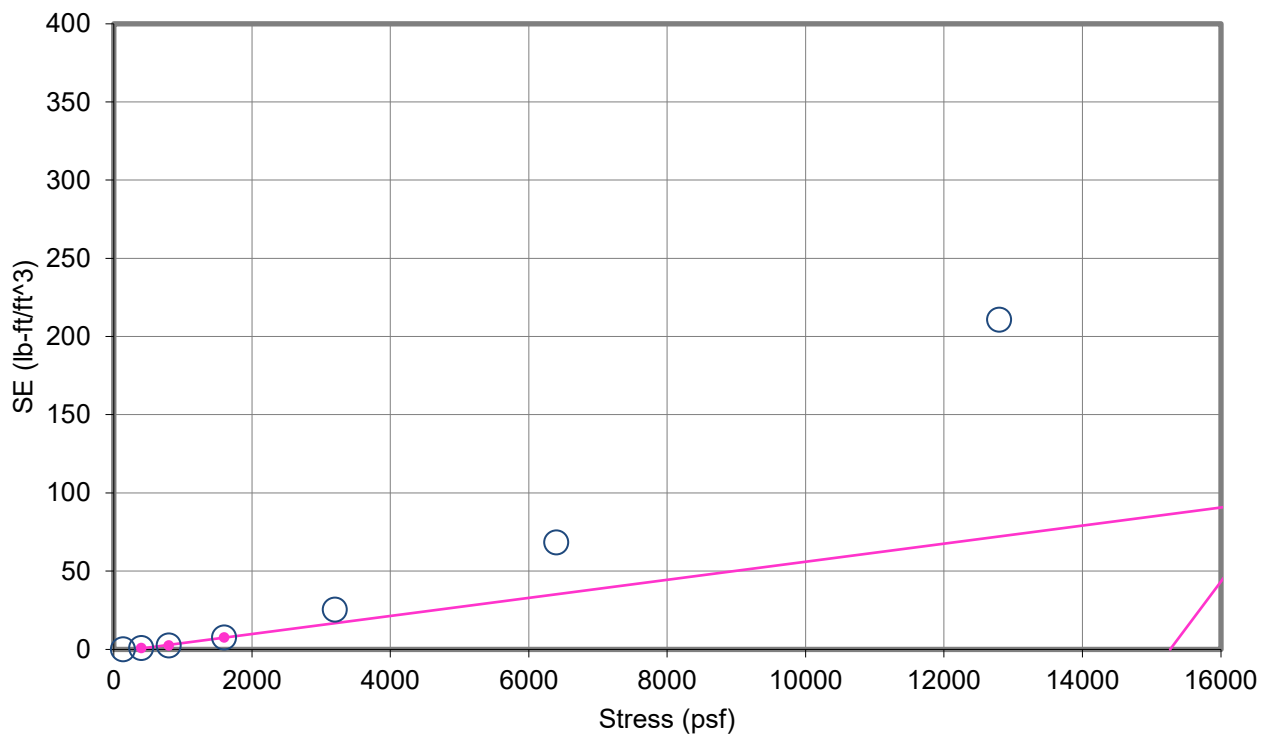
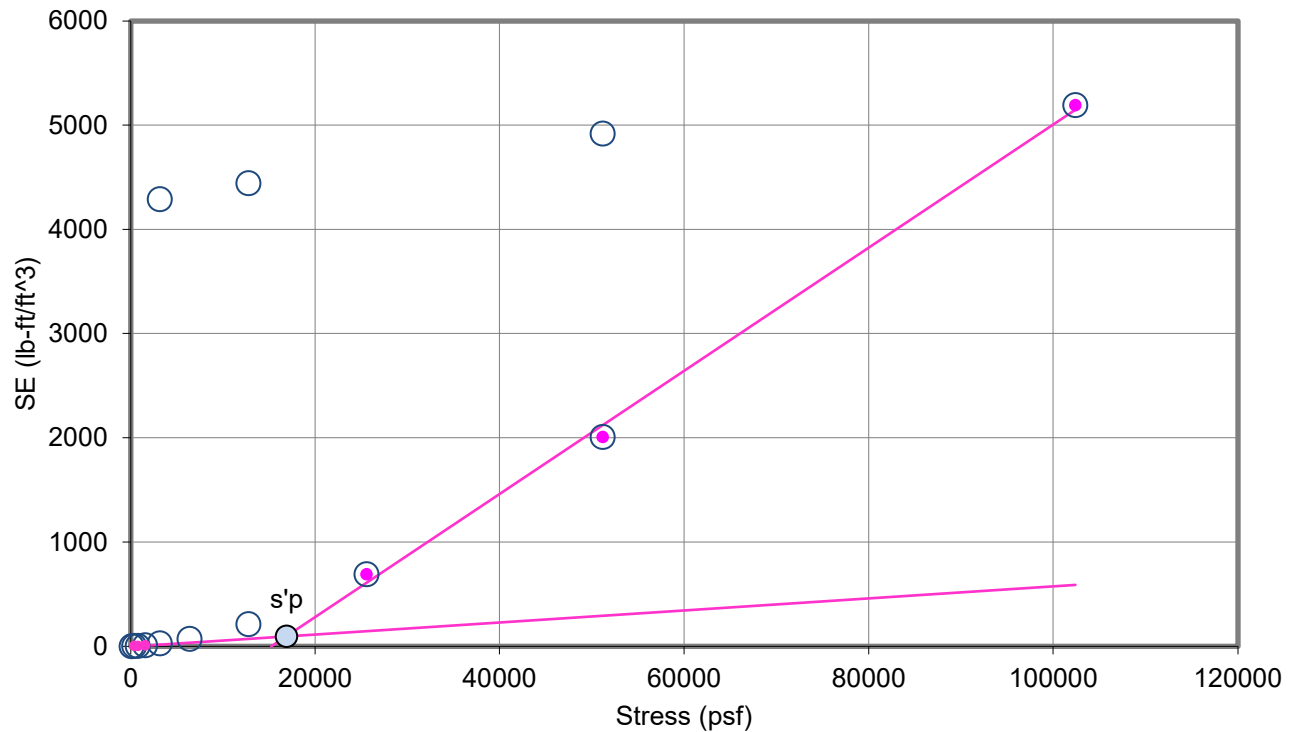
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-04**
Depth: **10-12 ft (~11.5 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 16,900

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 22-May-23

TH/TP/Sample: 23-TH-05
Depth: 5-7 ft (~5 ft)

Laboratory sample description: ol bn - gy silt
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): <100
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.997	-	Seating	0.0000	1.0033	0.0000	0.7620	0
90°	1.007	-	100	0.0000	1.0033	0.0000	0.7620	89
H (in) 180°	1.004	-	200	0.0009	1.0024	0.0009	0.7604	40
270°	1.005	-	400	0.0038	0.9994	0.0038	0.7552	71
Avg. height, Havg (in)	1.003	0.940	800	0.0075	0.9957	0.0075	0.7488	167
Avg height, Havg (cm)	2.548	2.387	1,600	0.0115	0.9918	0.0115	0.7418	92
Sample Dia., 0°	2.480	-	3,200	0.0178	0.9855	0.0177	0.7307	480
90°	2.488	-	6,400	0.0255	0.9777	0.0254	0.7171	135
Avg dia., Davg (in)	2.484	2.484	12,800	0.0350	0.9682	0.0349	0.7004	107
Avg dia., Davg (cm)	6.309	6.309	25,600	0.0510	0.9522	0.0509	0.6723	58
Wt. rings + wet soil (g)	373.47	371.68	51,200	0.0736	0.9297	0.0733	0.6328	46
Wt. rings (g)	216.58	216.58	25,600	0.0711	0.9321	0.0709	0.6371	40
Wet soil + tare (g)	579.09	273.29	6,400	0.0670	0.9362	0.0668	0.6442	23
Dry soil + tare (g)	488.20	241.73	1,600	0.0634	0.9398	0.0632	0.6506	10
Tare (g)	194.35	118.57						
Moisture cont., w (%)	30.9	25.6						
Gs, assumed	2.65	2.65						
Mass total (g)	156.9	155.1						
Mass of solids (g)	119.8	119.8						
Volume (cm ³)	79.7	74.6						
Vol. of water (cm ³)	37.1	35.3						
Vol. of solids (cm ³)	45.2	45.2						
Vol. of voids (cm ³)	34.5	29.4						
Vol. of air (cm ³)	-2.6	-5.9						
Area, A (cm ²)	31.3	31.3						
Ht. solids, Hs (cm)	1.446	1.446						
Void ratio, e	0.762	0.651						
Porosity, n	0.432	0.394						
Vol. moisture, T	0.465	0.473						
Saturation, S (%)	108	120						
Dry density (gm/cm ³)	1.504	1.605						
Wet unit wt., gm (pcf)	122.9	125.9						
Dry unit wt., gd (pcf)	93.9	100.2						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 13,000
Compression ratio, CR 0.07
Recompression ratio, RR 0.007

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 14,500

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

J:\PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\2023-05-15_CON.xlsm]3

One-Dimensional Consolidation Properties of Soils

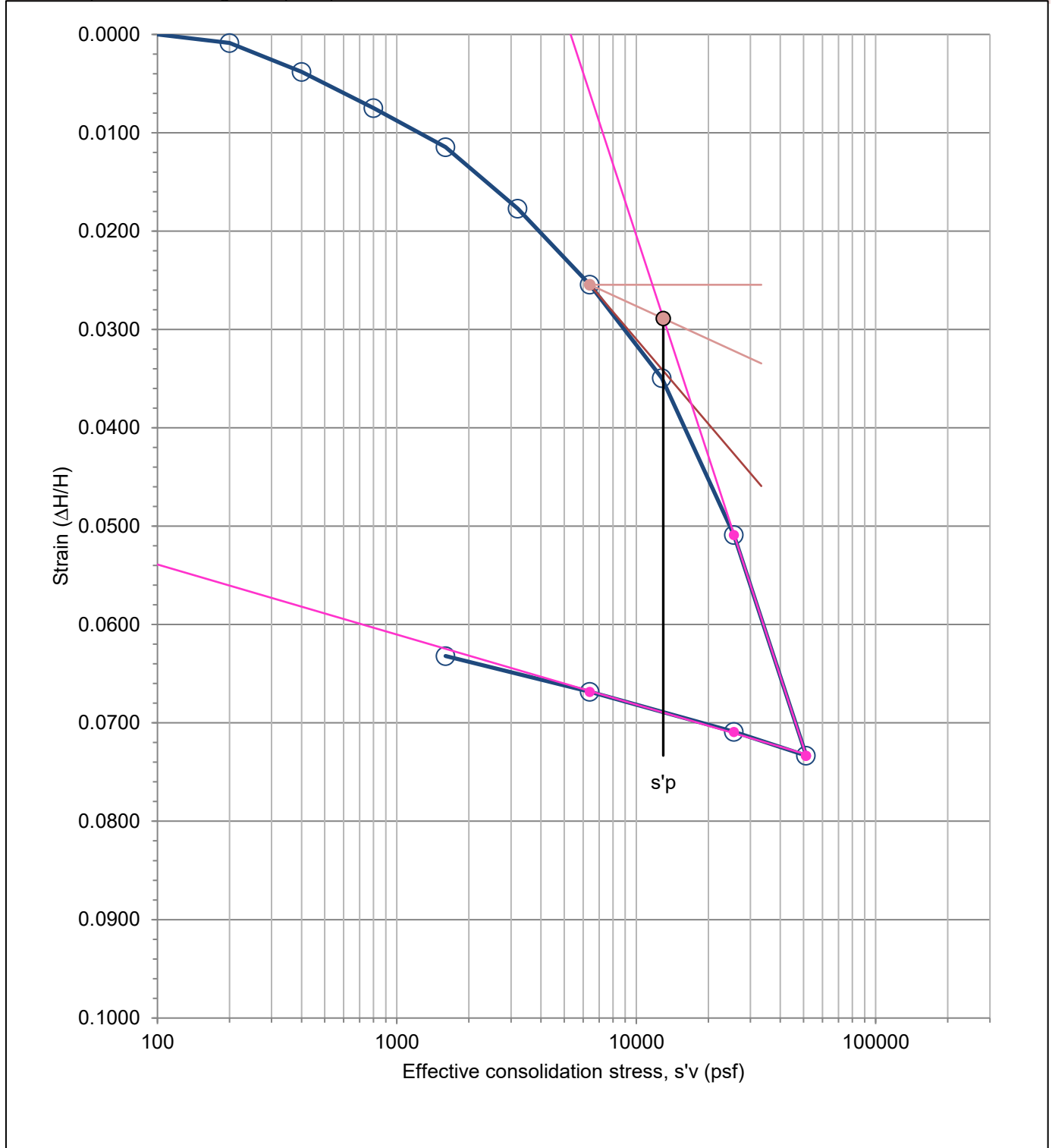
After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

TH/TP/Sample: 23-TH-05
Depth: 5-7 ft (~5 ft)

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	13,000
Compression ratio, CR	0.07
Recompression ratio, RR	0.007

One-Dimensional Consolidation Properties of Soils

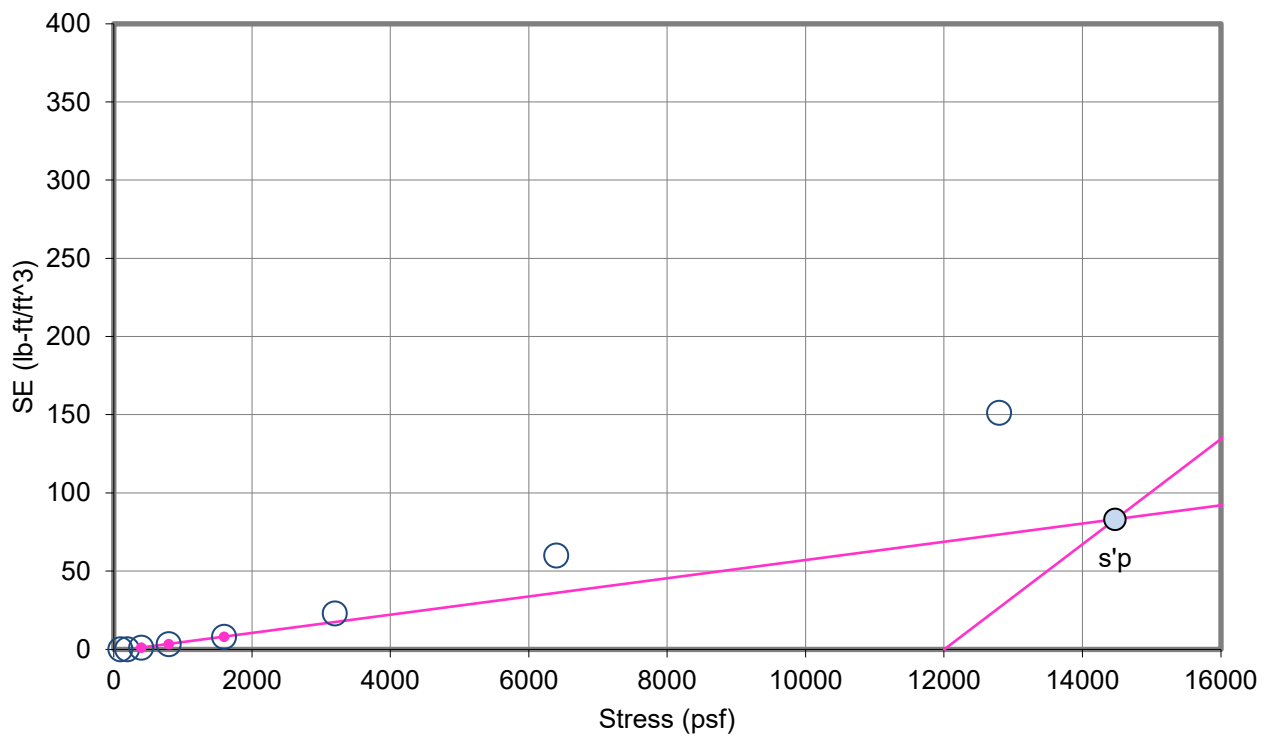
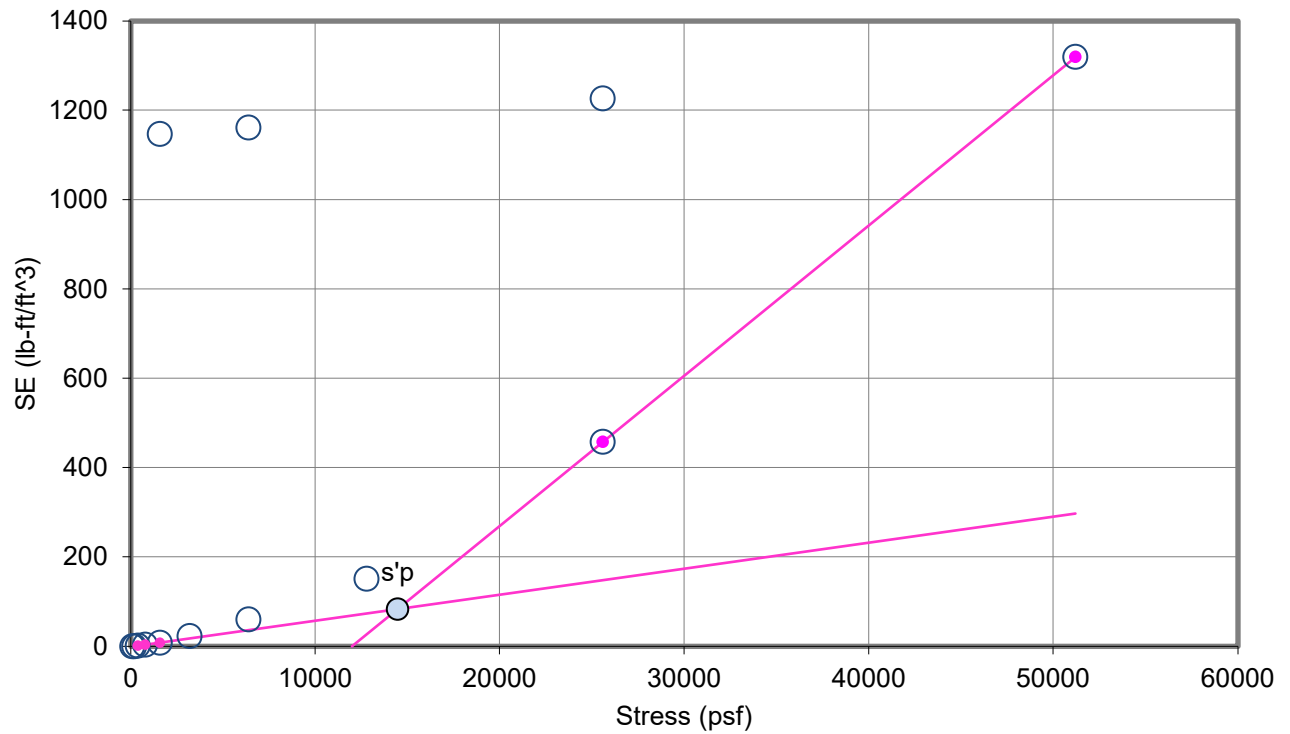
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-05**
Depth: **5-7 ft (~5 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 14,500

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 24-May-23

TH/TP/Sample: 23-TH-07
Depth: 20-22 ft (~21.5 ft)

Laboratory sample description: lt gn gy - gy clay
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): <100
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.997	-	Seating	0.0000	1.0003	0.0000	0.8418	0
Sample ht., 90°	0.999	-	100	0.0001	1.0001	0.0001	0.8416	37
H (in), 180°	1.001	-	200	0.0021	0.9981	0.0021	0.8379	64
270°	1.004	-	400	0.0046	0.9957	0.0046	0.8334	44
Avg. height, Havg (in)	1.000	0.904	800	0.0089	0.9913	0.0089	0.8253	61
Avg height, Havg (cm)	2.541	2.295	1,600	0.0156	0.9847	0.0156	0.8131	50
Sample Dia., 0°	2.498	-	3,200	0.0269	0.9734	0.0269	0.7923	80
D (in), 90°	2.489	-	6,400	0.0438	0.9565	0.0438	0.7611	84
Avg dia., Davg (in)	2.494	2.494	12,800	0.0681	0.9322	0.0681	0.7164	435
Avg dia., Davg (cm)	6.333	6.333	25,600	0.0985	0.9017	0.0985	0.6604	409
Wt. rings + wet soil (g)	362.54	357.88	51,200	0.1311	0.8692	0.1310	0.6005	133
Wt. rings (g)	216.57	216.57	25,600	0.1277	0.8726	0.1277	0.6067	33
Wet soil + tare (g)	568.03	255.14	6,400	0.1126	0.8876	0.1126	0.6345	104
Dry soil + tare (g)	473.02	223.03	1,600	0.0967	0.9035	0.0967	0.6637	251
Tare (g)	117.81	113.98						
Moisture cont., w (%)	26.7	29.4						
Gs, assumed	2.65	2.65						
Mass total (g)	146.0	141.3						
Mass of solids (g)	115.2	115.2						
Volume (cm ³)	80.0	72.3						
Vol. of water (cm ³)	30.8	26.1						
Vol. of solids (cm ³)	43.5	43.5						
Vol. of voids (cm ³)	36.6	28.8						
Vol. of air (cm ³)	5.8	2.7						
Area, A (cm ²)	31.5	31.5						
Ht. solids, Hs (cm)	1.379	1.379						
Void ratio, e	0.842	0.664						
Porosity, n	0.457	0.399						
Vol. moisture, T	0.385	0.362						
Saturation, S (%)	84	91						
Dry density (gm/cm ³)	1.439	1.593						
Wet unit wt., gm (pcf)	113.9	128.7						
Dry unit wt., gd (pcf)	89.8	99.4						

Data Interpretation Summary

Casagrande (1936)

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s'_p (psf) 4,700
Compression ratio, CR 0.10
Recompression ratio, RR 0.026

Preconsolidation stress, s'_p (psf) 6,400

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

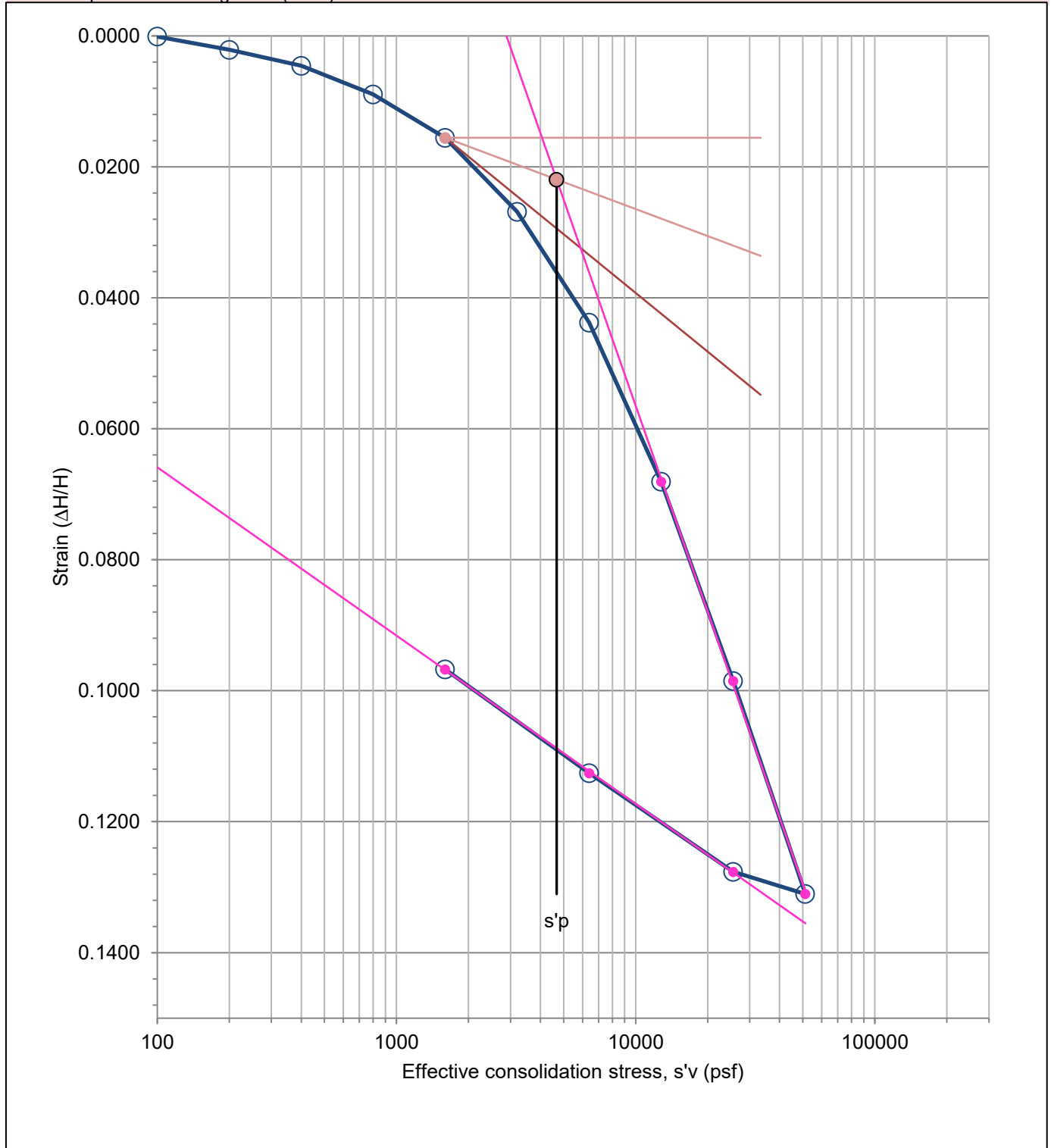
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **20-22 ft (~21.5 ft)**

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	4,700
Compression ratio, CR	0.10
Recompression ratio, RR	0.026

One-Dimensional Consolidation Properties of Soils

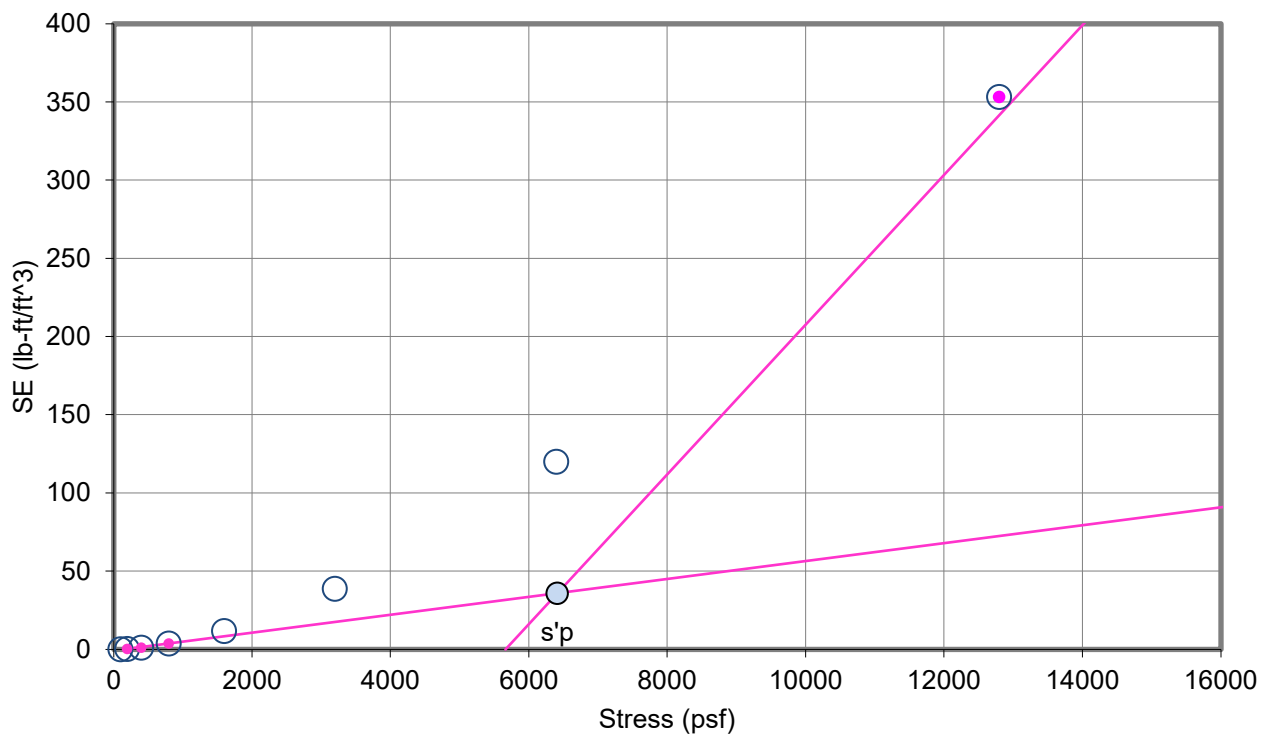
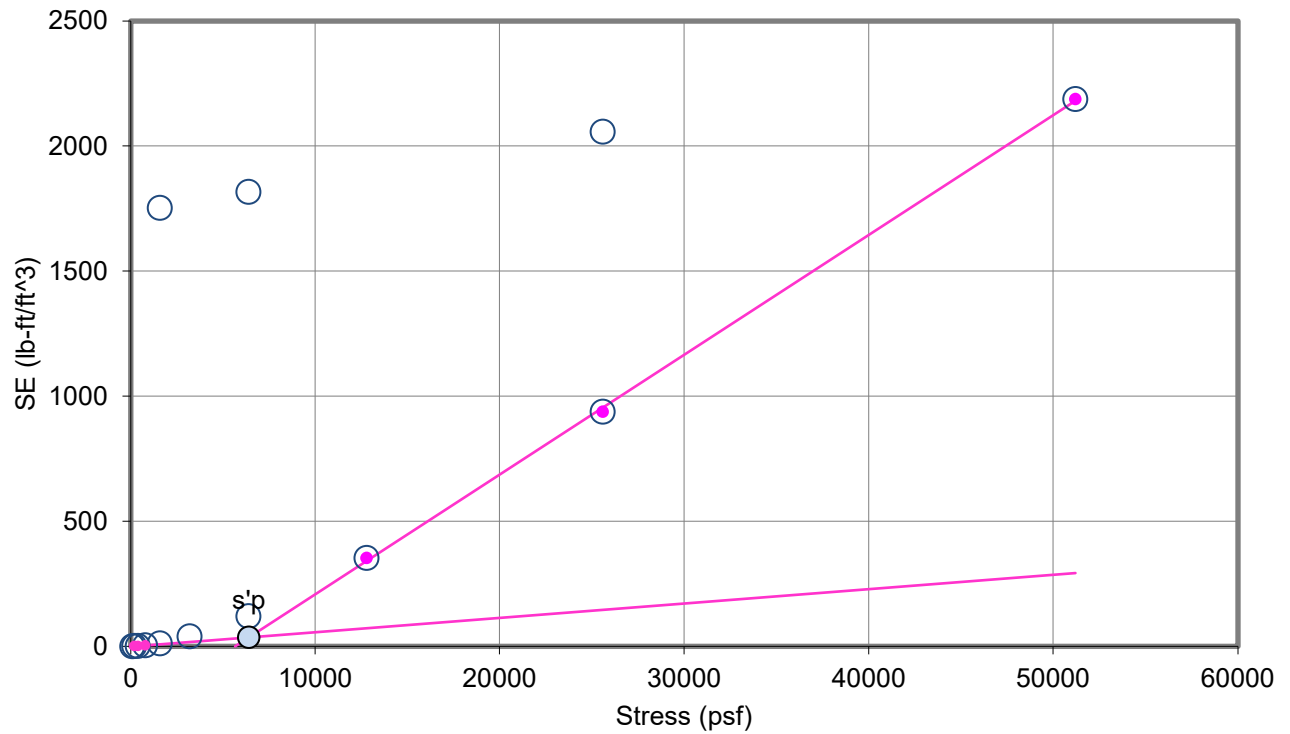
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **20-22 ft (~21.5 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 6,400

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah

Date: 24-May-23

TH/TP/Sample: 23-TH-07
Depth: 35-37 ft (~36.5 ft)

Laboratory sample description: lt gy - gy silt

USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): <100
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.987	-	Seating	0.0000	0.9865	0.0000	0.8064	0
Sample ht., 90°	0.985	-	100	-0.0008	0.9873	-0.0008	0.8079	83
H (in), 180°	0.986	-	200	0.0006	0.9859	0.0006	0.8054	45
H (in), 270°	0.988	-	400	0.0042	0.9823	0.0043	0.7986	64
Avg. height, Havg (in)	0.987	0.891	800	0.0080	0.9785	0.0081	0.7917	48
Avg height, Havg (cm)	2.506	2.263	1,600	0.0119	0.9746	0.0121	0.7846	76
Sample Dia., 0°	2.478	-	3,200	0.0194	0.9671	0.0196	0.7709	88
D (in), 90°	2.496	-	6,400	0.0321	0.9544	0.0326	0.7476	40
Avg dia., Davg (in)	2.487	2.487	12,800	0.0527	0.9338	0.0534	0.7099	394
Avg dia., Davg (cm)	6.317	6.317	25,600	0.0763	0.9102	0.0773	0.6667	409
Wt. rings + wet soil (g)	362.75	358.70	51,200	0.1068	0.8797	0.1083	0.6108	129
Wt. rings (g)	214.30	232.11	25,600	0.1063	0.8802	0.1078	0.6117	15
Wet soil + tare (g)	245.92	263.45	6,400	0.1019	0.8846	0.1033	0.6198	20
Dry soil + tare (g)	216.58	234.38	1,600	0.0955	0.8910	0.0968	0.6315	32
Tare (g)	114.91	119.18						
Moisture cont., w (%)	28.9	25.2						
Gs, assumed	2.65	2.65						
Mass total (g)	148.5	126.6						
Mass of solids (g)	115.2	115.2						
Volume (cm^3)	78.5	70.9						
Vol. of water (cm^3)	33.2	11.4						
Vol. of solids (cm^3)	43.5	43.5						
Vol. of voids (cm^3)	35.1	27.5						
Vol. of air (cm^3)	1.8	16.1						
Area, A (cm^2)	31.3	31.3						
Ht. solids, Hs (cm)	1.387	1.387						
Void ratio, e	0.806	0.631						
Porosity, n	0.446	0.387						
Vol. moisture, T	0.423	0.161						
Saturation, S (%)	95	41						
Dry density (gm/cm^3)	1.467	1.624						
Wet unit wt., gm (pcf)	118.0	127.0						
Dry unit wt., gd (pcf)	91.6	101.4						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 6,300
Compression ratio, CR 0.09
Recompression ratio, RR 0.006

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 10,800

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

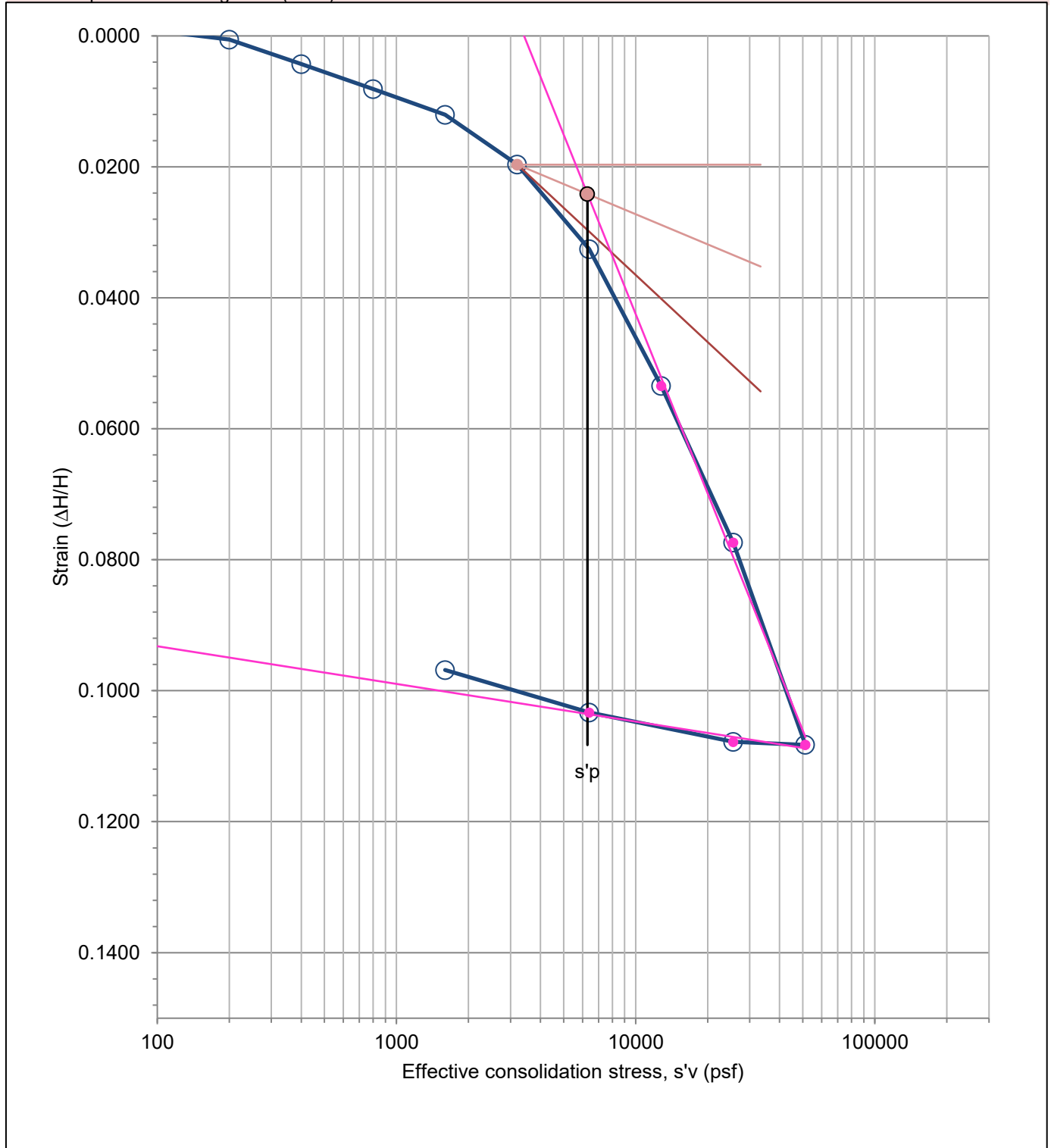
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **35-37 ft (~36.5 ft)**

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	6,300
Compression ratio, CR	0.09
Recompression ratio, RR	0.006

One-Dimensional Consolidation Properties of Soils

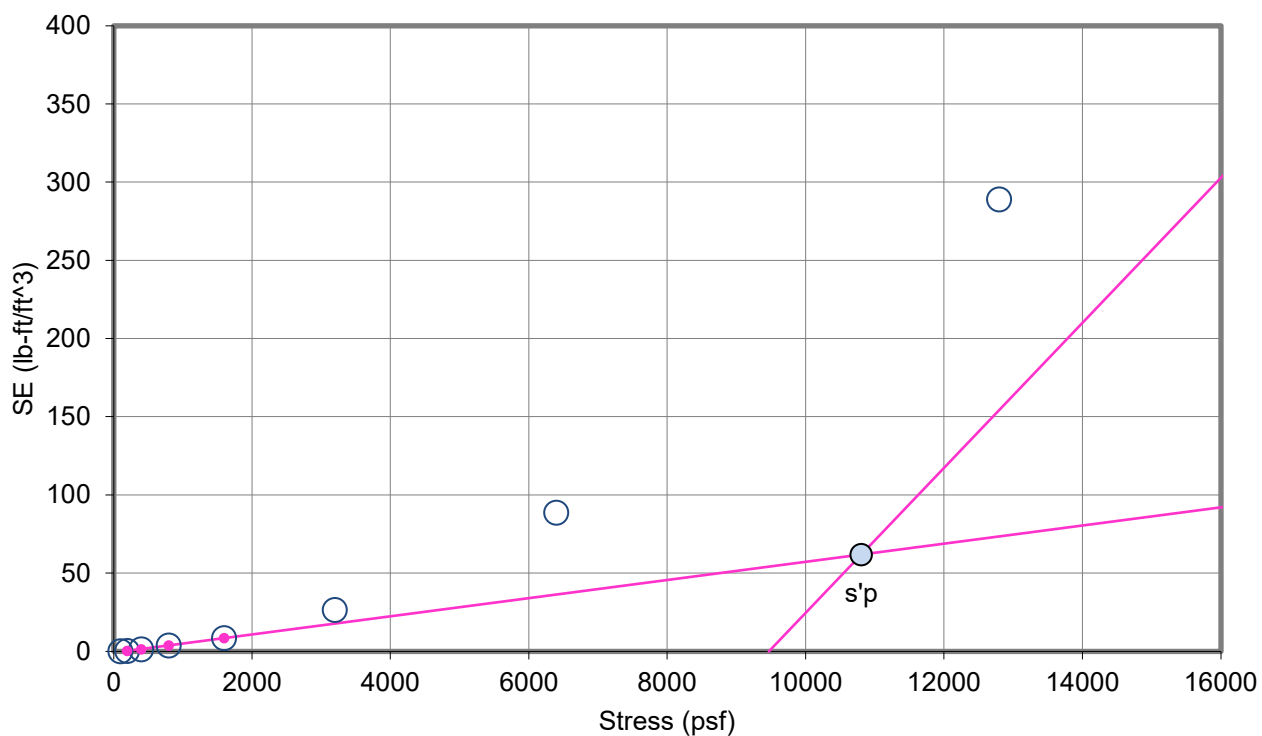
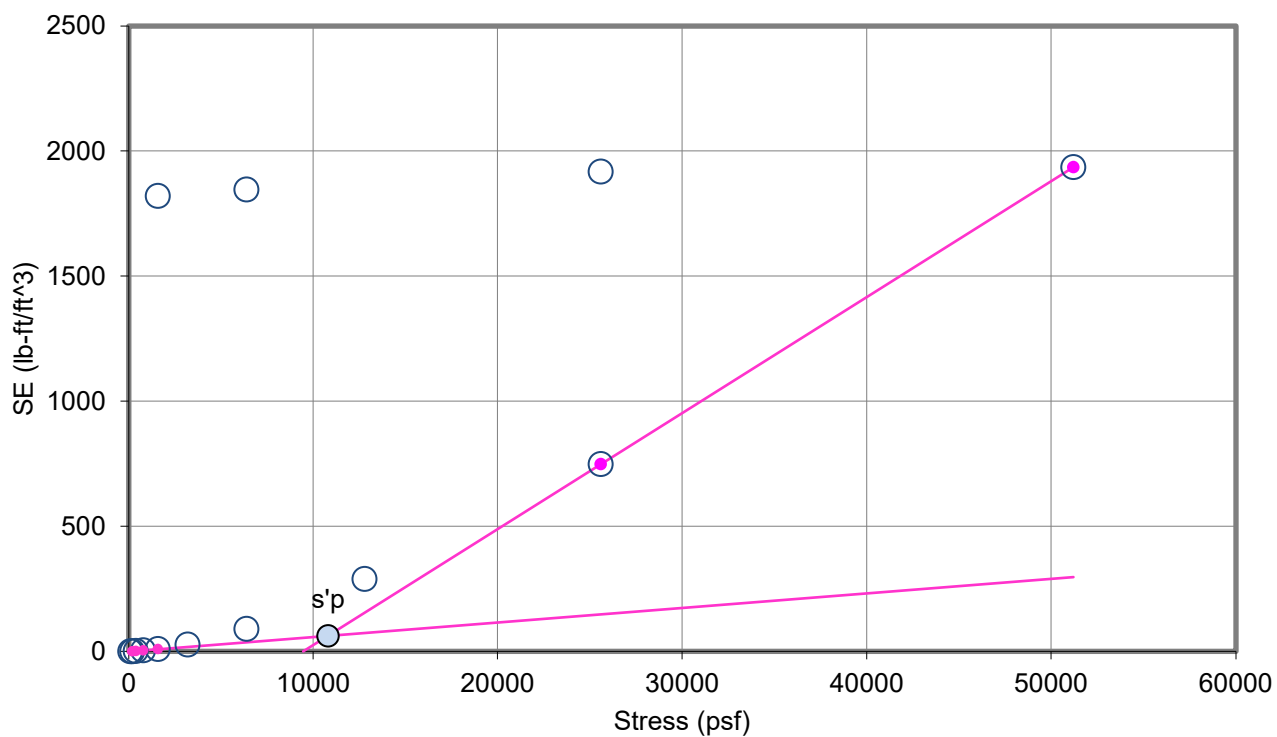
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **35-37 ft (~36.5 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 10,800

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 24-May-23

TH/TP/Sample: 23-TH-07
Depth: 45-47 ft (~46 ft)

Laboratory sample description: ol bn - gy clay
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): 354
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	0.996	-	Seating	0.0000	0.9980	0.0000	1.0595	0
Sample ht., 90°	1.000	-	354	0.0001	0.9979	0.0001	1.0593	33
H (in), 180°	0.996	-	800	0.0025	0.9955	0.0025	1.0544	48
H (in), 270°	1.000	-	1,600	0.0087	0.9893	0.0087	1.0416	41
Avg. height, Havg (in)	0.998	0.803	3,200	0.0194	0.9786	0.0195	1.0194	64
Avg height, Havg (cm)	2.535	2.039	6,400	0.0473	0.9507	0.0474	0.9618	253
Sample Dia., 0°	2.495	-	12,800	0.1095	0.8885	0.1097	0.8335	393
D (in), 90°	2.497	-	25,600	0.1710	0.8270	0.1714	0.7066	409
Avg dia., Davg (in)	2.496	2.496	51,200	0.2238	0.7742	0.2242	0.5977	136
Avg dia., Davg (cm)	6.340	6.340	25,600	0.2210	0.7770	0.2214	0.6034	8
Wt. rings + wet soil (g)	358.14	344.42	6,400	0.2103	0.7877	0.2107	0.6255	58
Wt. rings (g)	216.65	216.65	1,600	0.1953	0.8027	0.1956	0.6566	126
Wet soil + tare (g)	362.10	246.94						
Dry soil + tare (g)	317.01	218.16						
Tare (g)	196.49	119.26						
Moisture cont., w (%)	37.4	29.1						
Gs, assumed	2.65	2.65						
Mass total (g)	141.5	127.8						
Mass of solids (g)	103.0	103.0						
Volume (cm ³)	80.0	64.4						
Vol. of water (cm ³)	38.5	24.8						
Vol. of solids (cm ³)	38.9	38.9						
Vol. of voids (cm ³)	41.2	25.5						
Vol. of air (cm ³)	2.6	0.7						
Area, A (cm ²)	31.6	31.6						
Ht. solids, Hs (cm)	1.231	1.231						
Void ratio, e	1.059	0.657						
Porosity, n	0.514	0.396						
Vol. moisture, T	0.481	0.385						
Saturation, S (%)	94	97						
Dry density (gm/cm ³)	1.287	1.600						
Wet unit wt., gm (pcf)	110.4	128.9						
Dry unit wt., gd (pcf)	80.3	99.9						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 5,000
Compression ratio, CR 0.21
Recompression ratio, RR 0.021

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 4,900

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

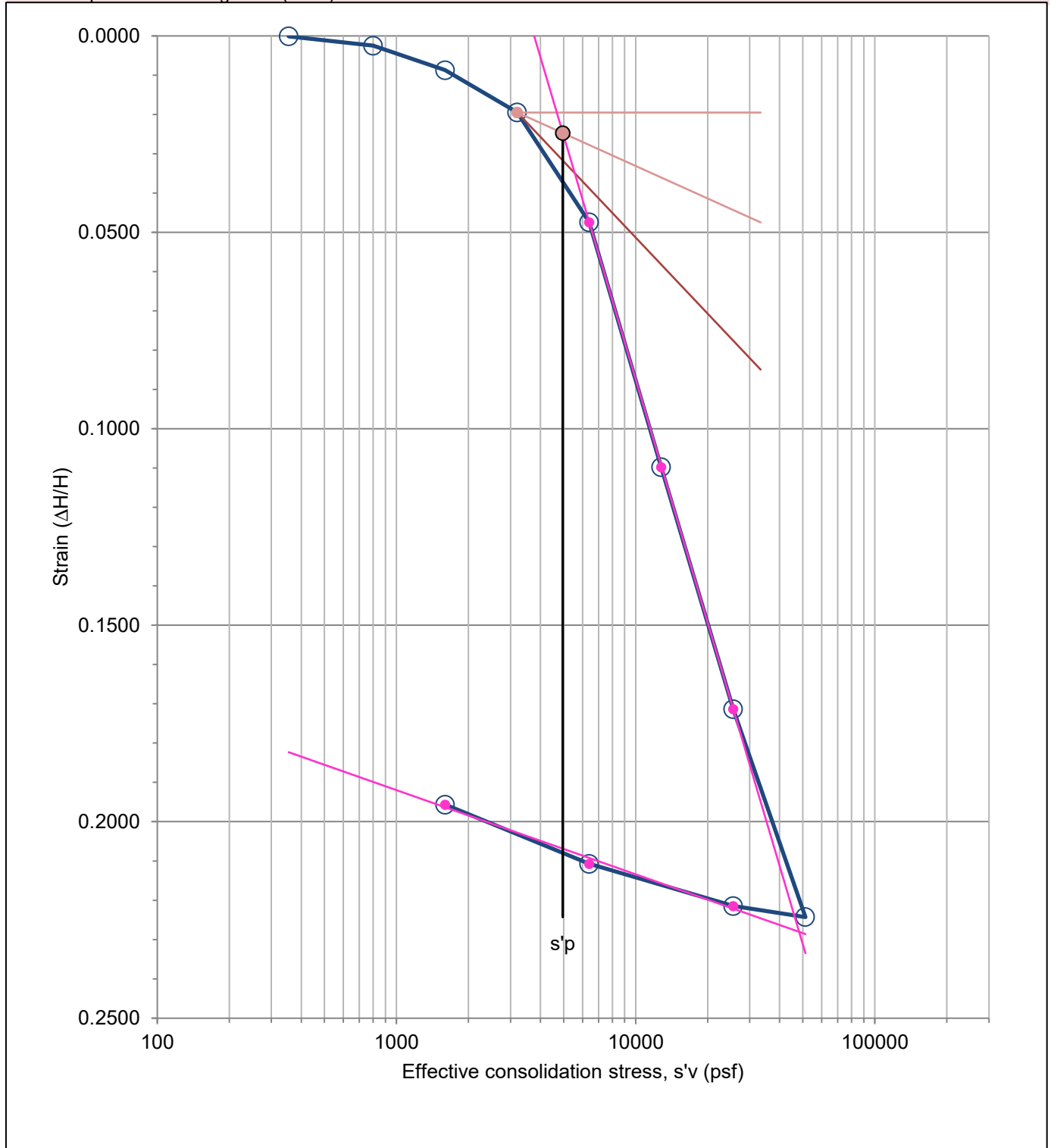
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **45-47 ft (~46 ft)**

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	5,000
Compression ratio, CR	0.21
Recompression ratio, RR	0.021

One-Dimensional Consolidation Properties of Soils

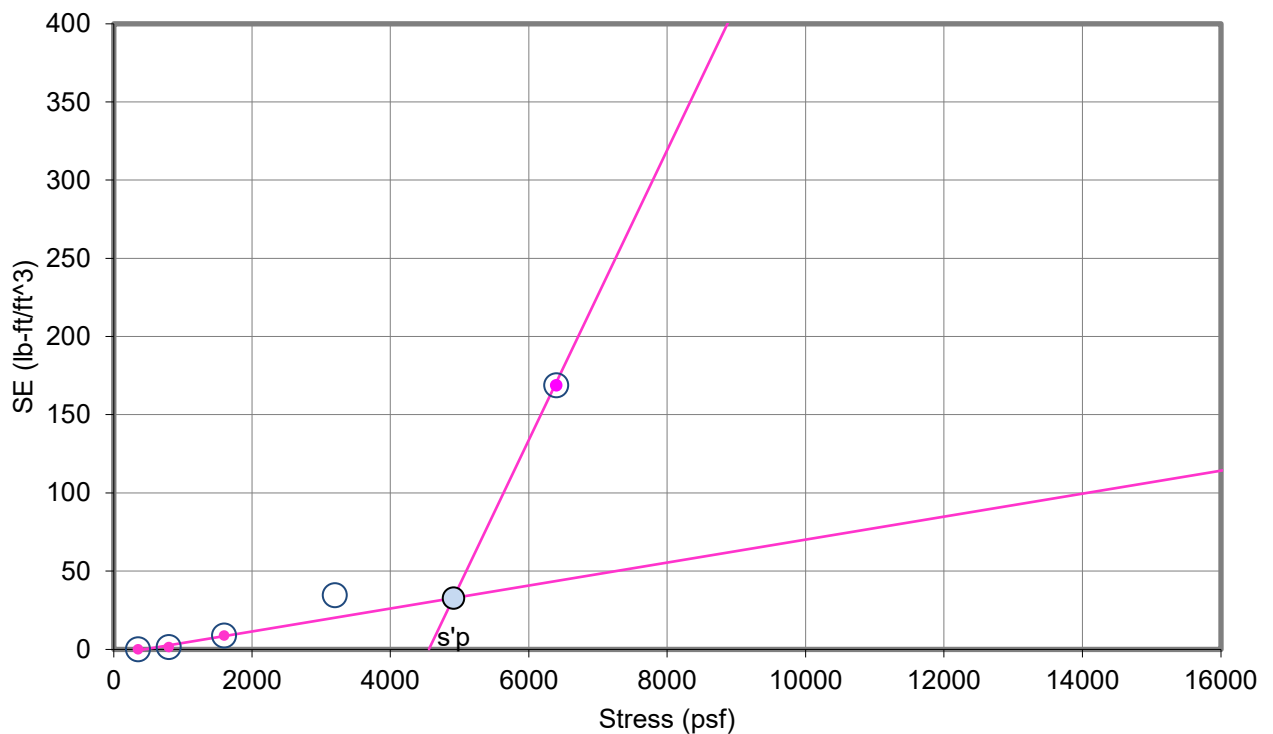
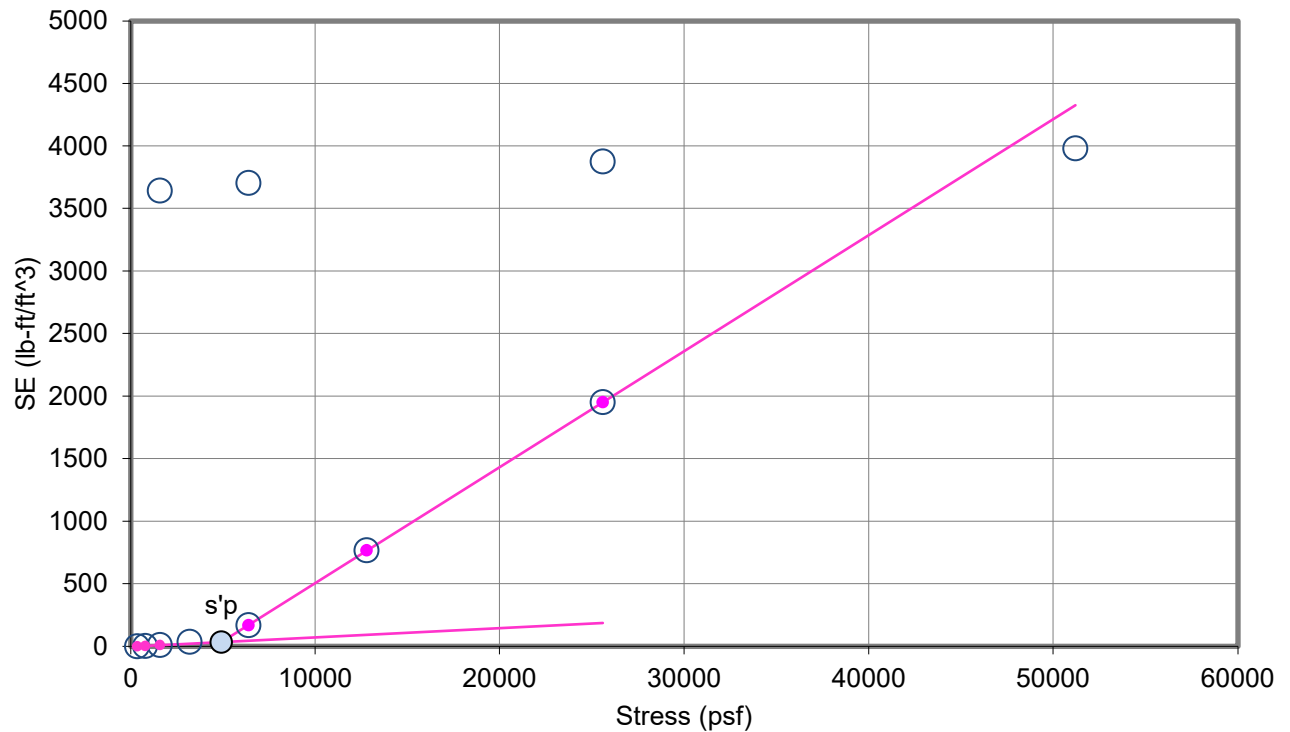
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-07**
Depth: **45-47 ft (~46 ft)**

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 4,900

One-Dimensional Consolidation Properties of Soils

After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 22-May-23

TH/TP/Sample: 23-TH-09
Depth: 15-17 ft (~16.5 ft)

Laboratory sample description: pr gy - lt gy clay
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: MGS
Comments:

Sample type: Rel. undisturbed, Shelby Tube
Inundation stress (psf): 100, completion
Swell pressure (psf): 216
Test method: B
Preparation procedure: trimmed

Phase Relationships			Vertical Stress - Deformation Results					
	Initial	Final	Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Sample ht., 0°	1.000	-	Seating	0.0000	1.0028	0.0000	0.7140	0
Sample ht., 90°	1.005	-	216	0.0001	1.0026	0.0001	0.7138	103
H (in), 180°	1.004	-	400	0.0022	1.0005	0.0022	0.7102	67
270°	1.002	-	800	0.0066	0.9962	0.0066	0.7028	66
Avg. height, Havg (in)	1.003	0.876	1,600	0.0136	0.9891	0.0136	0.6907	41
Avg height, Havg (cm)	2.547	2.226	3,200	0.0249	0.9778	0.0248	0.6714	79
Sample Dia., 0°	2.490	-	6,400	0.0387	0.9641	0.0386	0.6479	62
D (in), 90°	2.499	-	12,800	0.0597	0.9430	0.0596	0.6119	76
Avg dia., Davg (in)	2.495	2.495	25,600	0.0901	0.9126	0.0899	0.5599	480
Avg dia., Davg (cm)	6.336	6.336	51,200	0.1250	0.8777	0.1247	0.5003	469
Wt. rings + wet soil (g)	371.45	368.66	102,400	0.1629	0.8398	0.1625	0.4355	260
Wt. rings (g)	217.57	217.57	51,200	0.1593	0.8435	0.1588	0.4418	50
Wet soil + tare (g)	457.81	348.46	12,800	0.1448	0.8579	0.1444	0.4664	80
Dry soil + tare (g)	398.49	321.39	3,200	0.1265	0.8762	0.1262	0.4977	1062
Tare (g)	150.65	197.78						
Moisture cont., w (%)	23.9	21.9						
Gs, assumed	2.65	2.65						
Mass total (g)	153.9	151.1						
Mass of solids (g)	124.2	124.2						
Volume (cm ³)	80.3	70.2						
Vol. of water (cm ³)	29.7	26.9						
Vol. of solids (cm ³)	46.9	46.9						
Vol. of voids (cm ³)	33.5	23.3						
Vol. of air (cm ³)	3.7	-3.6						
Area, A (cm ²)	31.5	31.5						
Ht. solids, Hs (cm)	1.486	1.486						
Void ratio, e	0.714	0.498						
Porosity, n	0.417	0.332						
Vol. moisture, T	0.370	0.384						
Saturation, S (%)	89	115						
Dry density (gm/cm ³)	1.546	1.769						
Wet unit wt., gm (pcf)	119.6	134.7						
Dry unit wt., gd (pcf)	96.5	110.5						

Data Interpretation Summary

Casagrande (1936)

Preconsolidation stress, s_p (psf) 10,700
Compression ratio, CR 0.12
Recompression ratio, RR 0.027

Strain Energy Method (after Becker et al. 1987)

Preconsolidation stress, s_p (psf) 14,200

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

^b Hc = height at end of consolidation of each vert. stress

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One-Dimensional Consolidation Properties of Soils

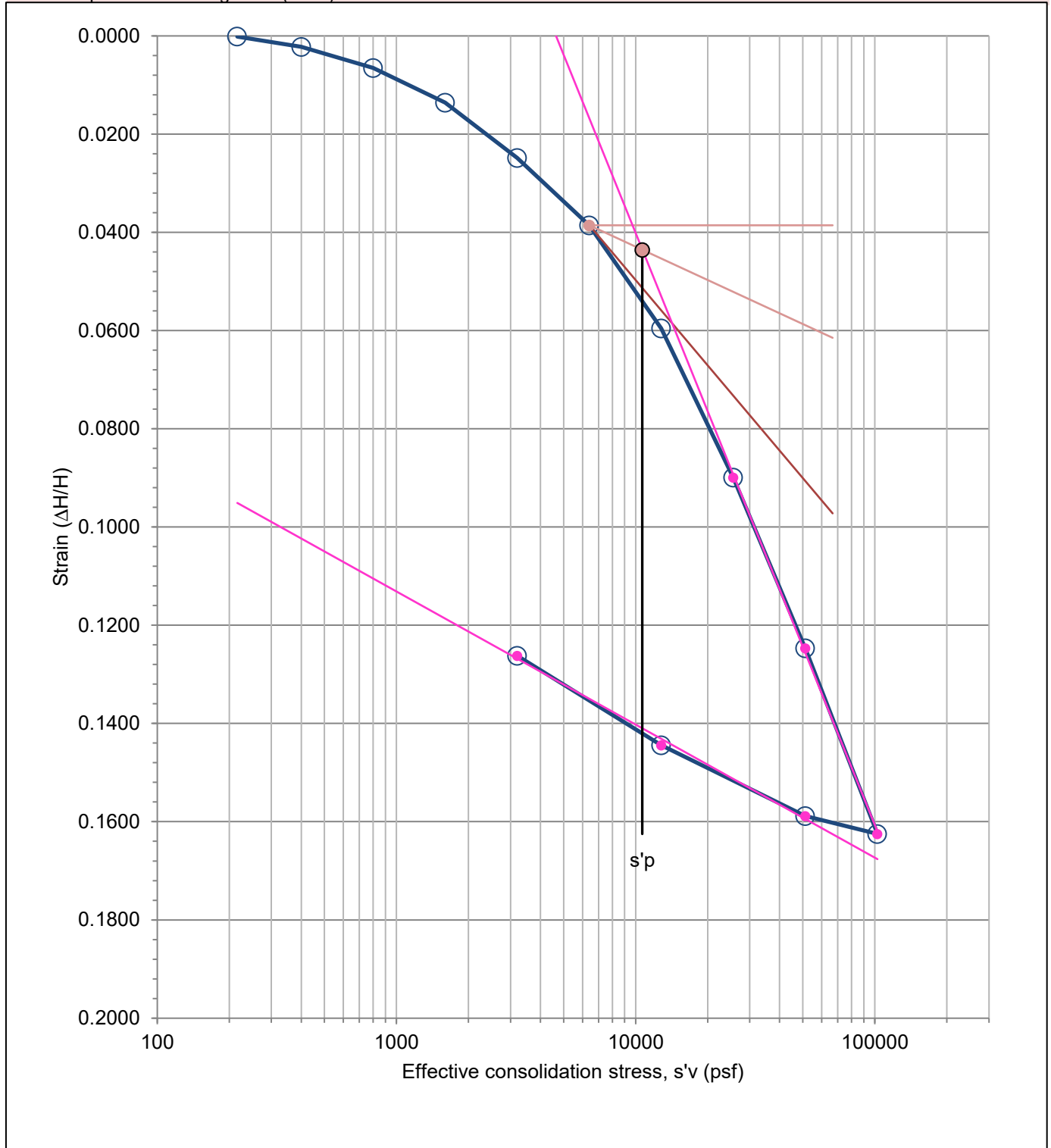
After ASTM D2435 and USBR 5700



Project: **Bear Lake Marina Expansion**
No: **22-1522**

TH/TP/Sample: **23-TH-09**
Depth: **15-17 ft (~16.5 ft)**

Data Interpretation - Casagrande (1936) Method



Preconsolidation stress, s'_p (psf)	10,700
Compression ratio, CR	0.12
Recompression ratio, RR	0.027

One-Dimensional Consolidation Properties of Soils

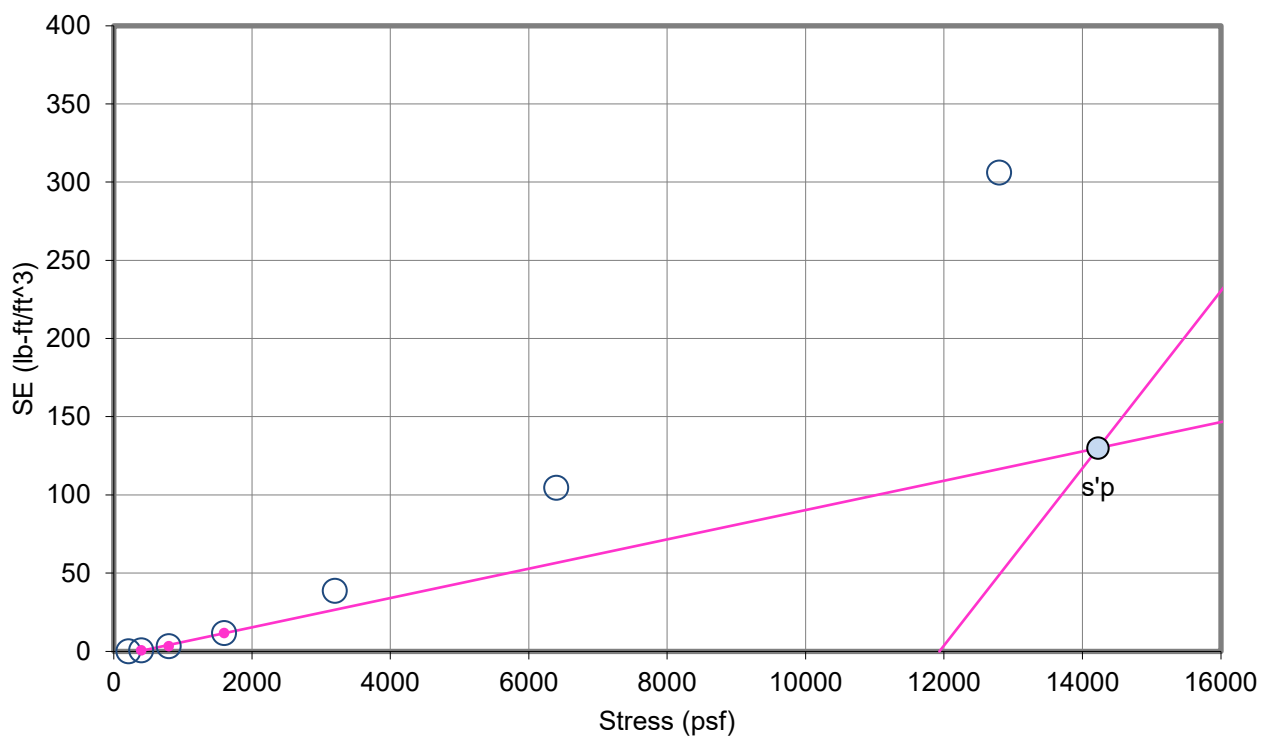
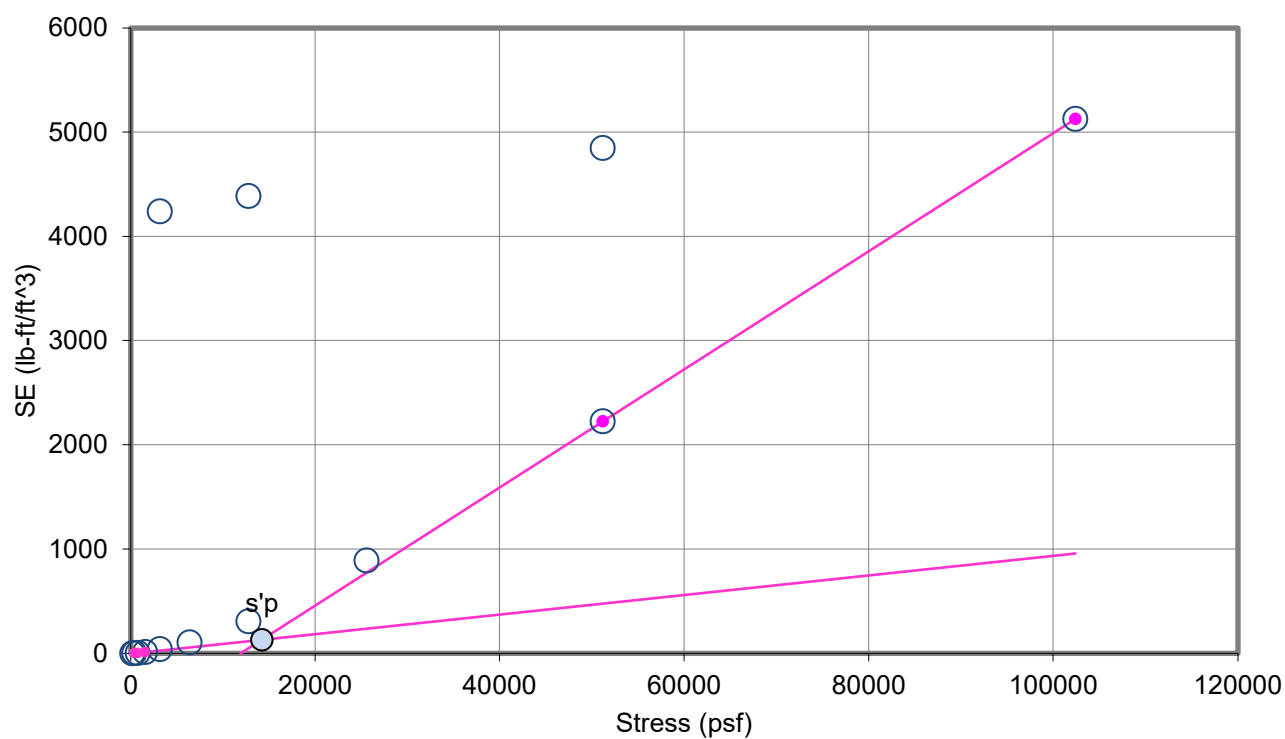
After ASTM D2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

TH/TP/Sample: 23-TH-09
Depth: 15-17 ft (~16.5 ft)

Data Interpretation - Strain Energy Method (after Becker et al. 1987)



Preconsolidation stress, s'p (psf) 14,200

One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah
Date: 07-Jul-23

TH/TP/Sample: 23-TH-04
Depth: 7.5-14.5 ft

Laboratory sample description: pl ol bn - tn clay
USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: AT
Comments:

Sample type: Remolded using moderate effort at ~OMC.
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: B
Preparation procedure: trimmed

Phase Relationships

	Initial	Final
Height, H (in)		
0°	0.986	-
90°	0.986	-
180°	0.985	-
270°	0.987	-
Avg Height, Havg (in)	0.986	1.006
Height, H (cm)	2.504	2.555
Dia., D (in)		
0°	2.496	-
90°	2.496	-
Avg Dia., Davg (in)	2.496	2.496
Dia., D (cm)	6.340	6.340
Wt. rings + wet soil (g)	368.27	371.53
Wt. rings (g)	214.28	214.28
Wet soil + tare (g)	471.32	299.89
Dry soil + tare (g)	408.30	264.91
Tare (g)	172.98	142.76
Moisture cont., w (%)	26.8	28.6
Gs, assumed	2.70	2.70
Mass total (g)	154.0	157.3
Mass of solids (g)	121.5	121.5
Volume (cm ³)	79.1	80.6
Vol. of water (cm ³)	32.5	35.8
Vol. of solids (cm ³)	45.0	45.0
Vol. of voids (cm ³)	34.1	35.7
Vol. of air (cm ³)	1.5	-0.1
Area, A (cm ²)	31.6	31.6
Ht. solids, Hs (cm)	1.425	1.425
Void ratio, e	0.757	0.793
Porosity, n	0.431	0.442
Vol. moisture, T	0.411	0.444
Saturation, S (%)	95	100
Dry density (gm/cm ³)	1.536	1.506
Wet unit wt., gm (pcf)	121.6	121.0
Dry unit wt., gd (pcf)	95.9	94.0

Notes:

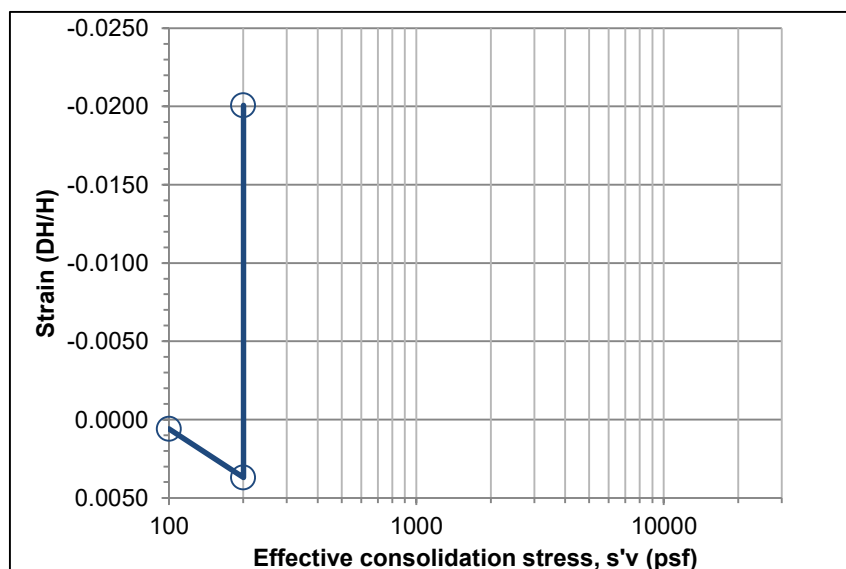
- ^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf) 200
Swell strain (%) -2.38

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9860	0.0000	0.7574	0
100	0.0006	0.9854	0.0006	0.7564	100
200	0.0036	0.9824	0.0037	0.7509	87
200	-0.0198	1.0058	-0.0201	0.7927	1259



One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah

Date: 07-Jul-23

TH/TP/Sample: 23-TH-05
Depth: 2.5-4.5 ft (~4 ft)

Laboratory sample description: bn - dk bn silt

USCS classification: not requested

Tested by: AT
Reduced by: JC
Checked by: AT
Comments:

Sample type: Remolded using moderate effort at ~OMC.
Inundation stress (psf): 200
Swell pressure (psf): N/A
Test method: B
Preparation procedure: trimmed

Phase Relationships

	Initial	Final
Height, H (in)	0° 0.993	-
	90° 0.992	-
	180° 0.989	-
	270° 0.997	-
Avg Height, Havg (in)	0.993	0.992
Height, H (cm)	2.522	2.520
Dia., D (in)	0° 2.497	-
	90° 2.490	-
Avg Dia., Davg (in)	2.494	2.494
Dia., D (cm)	6.333	6.333
Wt. rings + wet soil (g)	374.61	374.35
Wt. rings (g)	214.63	214.63
Wet soil + tare (g)	391.01	354.88
Dry soil + tare (g)	343.15	327.53
Tare (g)	118.30	195.47
Moisture cont., w (%)	21.3	20.7
Gs, assumed	2.70	2.70
Mass total (g)	160.0	159.7
Mass of solids (g)	131.9	131.9
Volume (cm^3)	79.4	79.4
Vol. of water (cm^3)	28.1	27.8
Vol. of solids (cm^3)	48.9	48.9
Vol. of voids (cm^3)	30.6	30.5
Vol. of air (cm^3)	2.5	2.7
Area, A (cm^2)	31.5	31.5
Ht. solids, Hs (cm)	1.551	1.551
Void ratio, e	0.626	0.625
Porosity, n	0.385	0.385
Vol. moisture, T	0.353	0.350
Saturation, S (%)	92	91
Dry density (gm/cm^3)	1.660	1.661
Wet unit wt., gm (pcf)	125.7	125.2
Dry unit wt., gd (pcf)	103.7	103.7

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

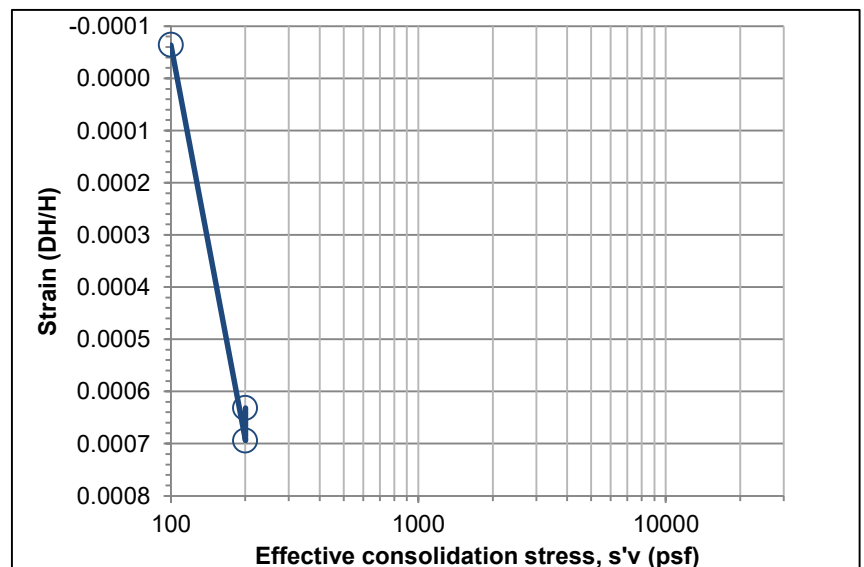
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf) 200
Swell strain (%) -0.01

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9928	0.0000	0.6261	0
100	-0.0001	0.9928	-0.0001	0.6262	100
200	0.0007	0.9921	0.0007	0.6250	93
200	0.0006	0.9921	0.0006	0.6251	1440



One-Dimensional Collapse / Swell Properties of Soils

After ASTM D4546, D5333, 2435 and USBR 5700



Project: Bear Lake Marina Expansion
No: 22-1522

Location: Rich County, Utah

Date: 07-Jul-23

TH/TP/Sample: 23-TH-05

Depth: 15-27 ft

Laboratory sample description: lt gn gy - pl ol bn clay

USCS classification: not requested

Tested by: AT

Reduced by: JC

Checked by: AT

Comments:

Sample type: Remolded using moderate effort at ~OMC.

Inundation stress (psf): 200

Swell pressure (psf): N/A

Test method: B

Preparation procedure: trimmed

Phase Relationships

	Initial	Final
Height, H (in)	0° 0.998	-
	90° 0.999	-
	180° 0.999	-
	270° 0.999	-
Avg Height, Havg (in)	0.999	1.018
Height, H (cm)	2.537	2.586
Dia., D (in)	0° 2.493	-
	90° 2.490	-
Avg Dia., Davg (in)	2.492	2.492
Dia., D (cm)	6.328	6.328
Wt. rings + wet soil (g)	362.97	365.84
Wt. rings (g)	216.56	216.56
Wet soil + tare (g)	438.82	267.01
Dry soil + tare (g)	373.70	225.79
Tare (g)	195.59	117.84
Moisture cont., w (%)	36.6	38.2
Gs, assumed	2.70	2.70
Mass total (g)	146.4	149.3
Mass of solids (g)	107.2	107.2
Volume (cm^3)	79.8	81.3
Vol. of water (cm^3)	39.2	42.1
Vol. of solids (cm^3)	39.7	39.7
Vol. of voids (cm^3)	40.1	41.6
Vol. of air (cm^3)	0.9	-0.4
Area, A (cm^2)	31.5	31.5
Ht. solids, Hs (cm)	1.262	1.262
Void ratio, e	1.010	1.048
Porosity, n	0.502	0.512
Vol. moisture, T	0.491	0.517
Saturation, S (%)	98	101
Dry density (gm/cm^3)	1.344	1.318
Wet unit wt., gm (pcf)	114.5	113.7
Dry unit wt., gd (pcf)	83.9	82.3

Notes:

^a Dfc = end of increment deformation corrected for machine, porous stone, and filter paper deformation

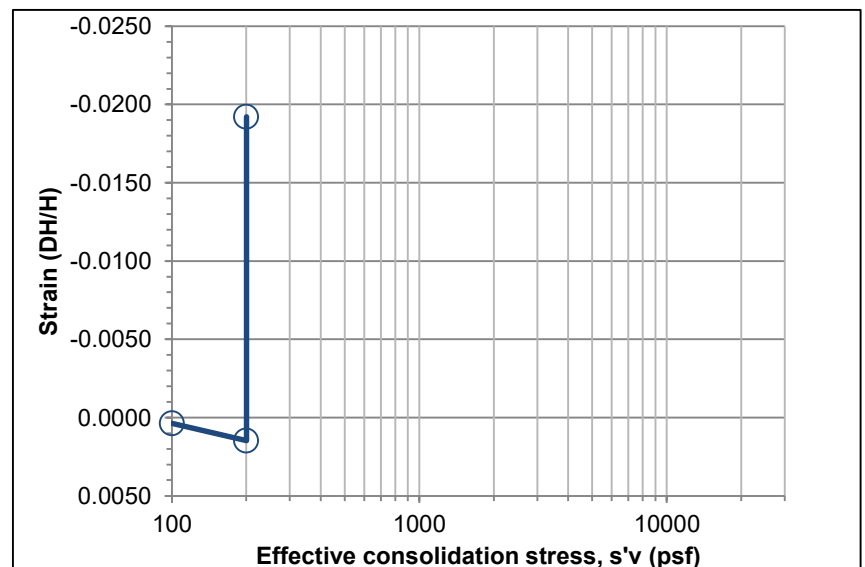
^b Hc = height at end of consolidation of each vert. stress

Test Results

Swell load (psf)	200
Swell strain (%)	-2.07

Vertical Stress - Deformation Results

Vert. stress (psf)	Corr. Dial, dfc ^a (in)	Hc ^b (in)	Vert. strain, ev	Void ratio, e	Load duration (min)
Seating	0.0000	0.9988	0.0000	1.0095	0
100	0.0004	0.9984	0.0004	1.0088	79
200	0.0015	0.9973	0.0015	1.0066	92
200	-0.0192	1.0179	-0.0192	1.0481	1464



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Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **23-May-23**

Tested by: **JC**

Reduced by: **JC**

Reviewed by: **MGS**

Comments:

TH/TP/Sample: **23-TH-07**

Depth: **7-12 ft**

Location: **Rich County, Utah**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 14.8

Maximum dry unit weight (pcf): 114.6

Laboratory sample description: **or - lt bn clay**

Engineering Classification: **Not requested**

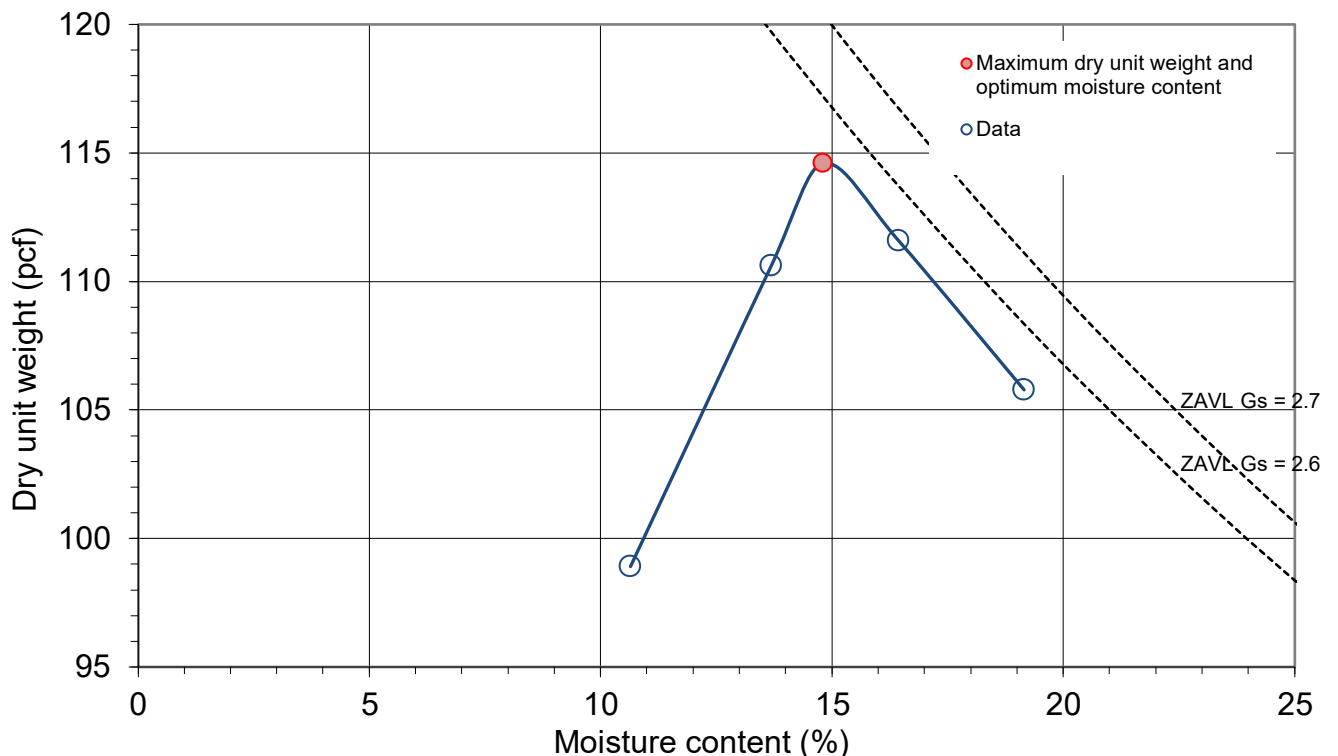
As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **No**

Point Number	+3	+6	+9	+12
Wt. mold + wet soil (g)	5887.7	6134.1	6197.5	6138.7
Wt. mold (g)	4232.8	4232.8	4232.8	4232.8
Moist unit wt., gd (pcf)	109.4	125.7	129.9	126.1
Wet soil + tare (g)	699.21	741.53	698.92	842.25
Dry soil + tare (g)	650.86	666.64	617.08	738.44
Tare (g)	196.69	119.22	119.20	196.32
Moisture content, w (%)	10.6	13.7	16.4	19.1
Dry unit wt., gd (pcf)	98.9	110.6	111.6	105.8



Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **16-May-23**

Tested by: **JCC**

Reduced by: **JCC**

Reviewed by: **AT**

TH/TP/Sample: **23-TH-11**

Depth: **0-10 ft**

Location: **Rich County, Utah**

Comments: **Asphalt and Glass present.**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Optimum moisture content (%): 17.3

Maximum dry unit weight (pcf): 104

Laboratory sample description: **dk bn - bn clay**

Engineering Classification: **Not requested**

As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **Yes**

Point Number	-6	-3	As-is	+3
Wt. mold + wet soil (g)	5779.6	6006.5	6061.8	6023.7
Wt. mold (g)	4234.0	4234.0	4234.0	4234.0
Moist unit wt., gd (pcf)	102.2	117.2	120.9	118.4
Wet soil + tare (g)	464.89	770.89	779.61	807.54
Dry soil + tare (g)	432.85	724.77	719.32	729.65
Tare (g)	195.50	440.89	421.41	416.39
Moisture content, w (%)	13.5	16.2	20.2	24.9
Dry unit wt., gd (pcf)	90.1	100.8	100.5	94.8

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Corrected moisture content (%): 15.9

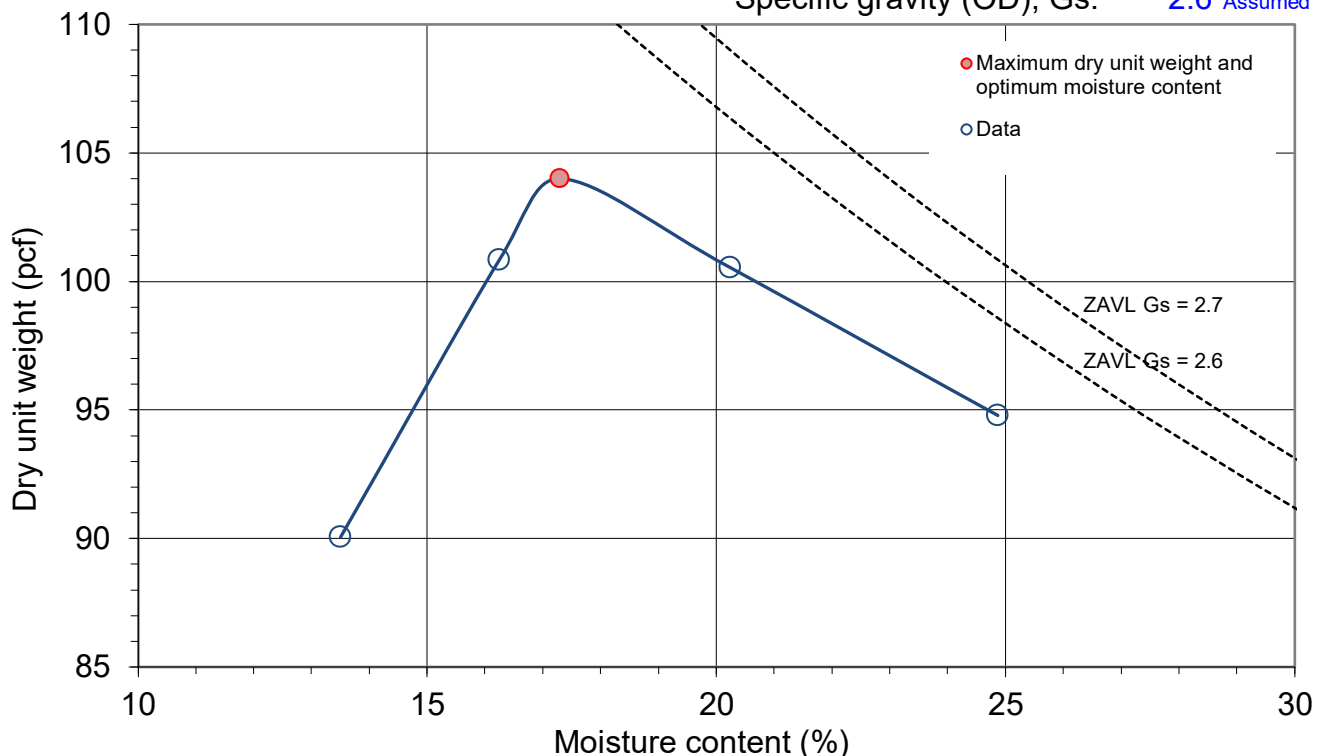
Corrected dry unit weight (pcf): 107.5

Oversized fraction, +3/8-in. (%): **9.0**

Moisture content, +3/8-in. (%): **2.2**

Sieve for oversized fraction: **3/8-in.**

Specific gravity (OD), Gs: **2.6 Assumed**



Laboratory Compaction Characteristics of Soil

after ASTM D698 / D1557



Project: **Bear Lake Marina Expansion**

No: **22-1522**

Date: **16-May-23**

Tested by: **JCC**

Reduced by: **JCC**

Reviewed by: **AT**

TH/TP/Sample: **23-TH-12**

Depth: **2.5-10 ft**

Location: **Rich County, Utah**

Comments: **Asphalt and Glass present.**

Test Summary

Method: **ASTM D698 B**

Mold volume (ft³): **0.0333**

Laboratory sample description: **lt ol bn - bn clay**

Engineering Classification: **Not requested**

As-received moisture content (%): **Not requested**

Preparation method: **Moist**

Rammer: **Manual**

Rock Correction: **Yes**

Optimum moisture content (%): 12.7

Maximum dry unit weight (pcf): 117.3

Point Number	-3	As-is	+3	+6	+9
Wt. mold + wet soil (g)	6063.9	6182.7	6228.7	6213.4	6189.0
Wt. mold (g)	4234.0	4234.0	4234.0	4234.0	4234.0
Moist unit wt., gd (pcf)	121.0	128.9	131.9	130.9	129.3
Wet soil + tare (g)	599.88	909.16	665.82	616.79	561.76
Dry soil + tare (g)	567.53	859.53	638.17	557.94	493.52
Tare (g)	196.77	422.23	441.30	194.07	117.24
Moisture content, w (%)	8.7	11.3	14.0	16.2	18.1
Dry unit wt., gd (pcf)	111.3	115.7	115.7	112.7	109.4

*Correction of Unit Weight and Water Content for Soils Containing Oversize Particles

(ASTM D4718)

Oversized fraction, +3/8-in. (%): **8.0**

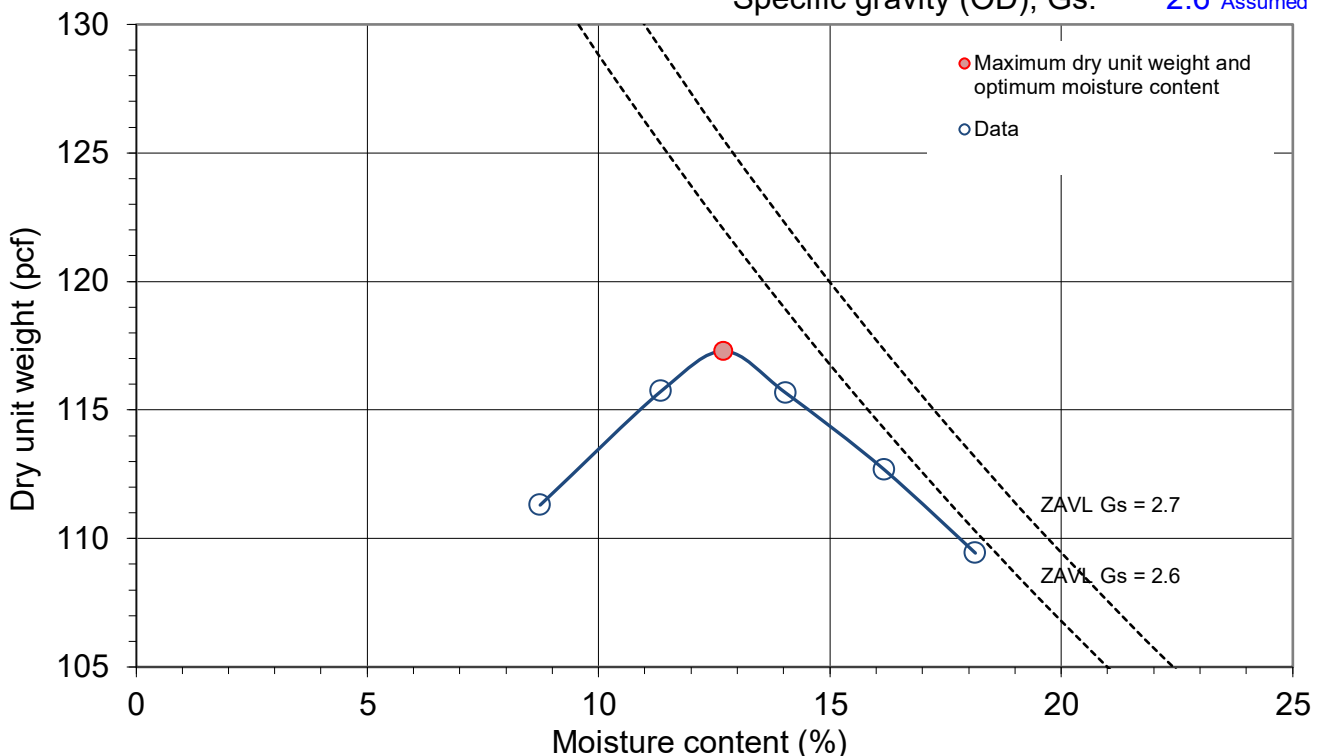
Corrected moisture content (%): 11.7

Moisture content, +3/8-in. (%): **0.6**

Corrected dry unit weight (pcf): 120.0

Sieve for oversized fraction: **3/8-in.**

Specific gravity (OD), Gs: **2.6 Assumed**



California Bearing Ratio*

(After ASTM D 1883 and AASHTO T193)

**Project: Bear Lake Marina Expansion****TH/TP/Sample: 23-TH-07****No: 22-1522****Depth: 7-12 ft**

Date: 24-May-23

Location: Rich County, Utah

Tested by: JC

Comments:

Reduced by: JC

Reviewed by: MGS

Test Summary

Maximum dry unit weight (pcf): 114.6

Reference method: ASTM D698 B

Optimum moisture content (%): 14.8

Eng. classification: Not requested

Relative compaction (%): 99.0

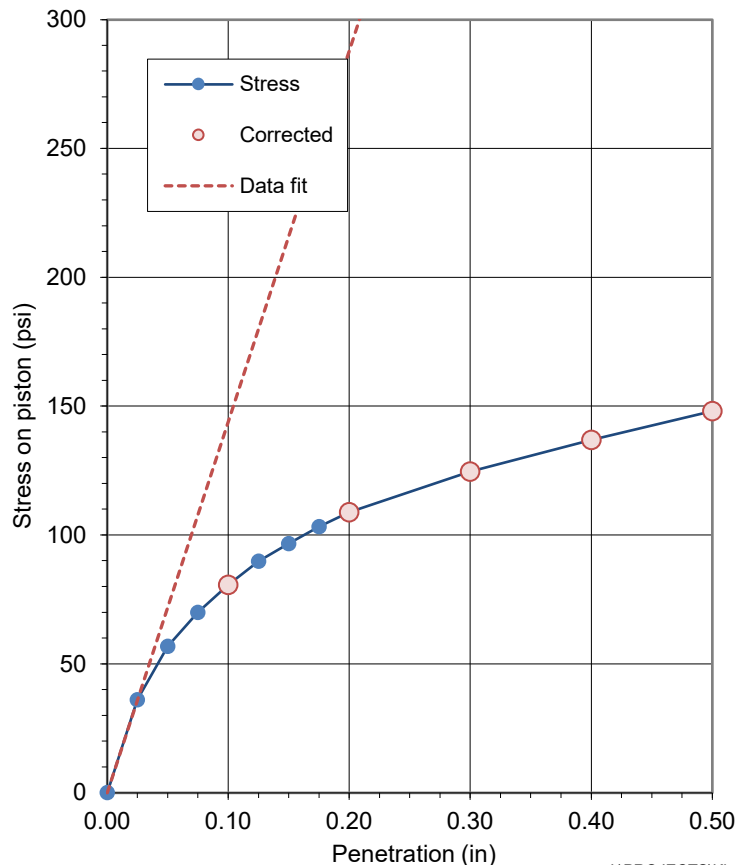
Condition of sample: Soaked

CBR at 0.1-in. (%): 8.1

Scalp and replace: No

CBR at 0.2-in. (%): 7.3**Compaction Data****Swell Data**

	As-Comp.	After Soak	Top 1-in.	Date	Time	Dial (in)
Wt. mold + moist soil (g)	12499.9	12539		5/26	12:47	0.168
Wt. mold (g)	8044.75	8044.75		5/30	14:16	0.180
Mold volume (ft^3)	0.0750	0.0752				
Moist unit wt., gm (pcf)	130.955	131.76		Soaking Period (hr)		98
Moist soil + tare (g)	812.88	462.03	405.47		Ho (in)	4.584
Dry soil + tare (g)	730.69	413.45	364.27		Hf (in)	4.596
Tare (g)	197.15	119.35	126.8		Swell (%)	0.26
Moisture content, w (%)	15.4	16.5	17.3		Surcharge (psf)	20
Dry unit wt., gd (pcf)	113.5	113.1				

Bearing Test Results

Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	0	0		
0.025	36	36		
0.05	57	57		
0.075	70	70		
0.1	81	81	1000	8.1
0.125	90	90	1125	8.0
0.15	97	97	1250	7.7
0.175	103	103	1375	7.5
0.2	109	109	1500	7.3
0.3	125	125	1900	6.6
0.4	137	137	2300	6.0
0.5	148		2600	5.7

California Bearing Ratio*

(After ASTM D 1883 and AASHTO T193)



Project: Bear Lake Marina Expansion

No: 22-1522

Date: 12-May-23

Tested by: JC

Comments: Asphalt present in sample.

Reduced by: JC

Reviewed by: AT

TH/TP/Sample: 23-TH-11

Depth: 0-10 ft

Location: Rich County, Utah

Test Summary

Maximum dry unit weight (pcf): 104.2

Optimum moisture content (%): 17.3

Relative compaction (%): 98.7

CBR at 0.1-in. (%): 6.4

CBR at 0.2-in. (%): 5.6

Reference method: ASTM D698 B

Eng. classification: Not requested

Condition of sample: Soaked

Scalp and replace: No

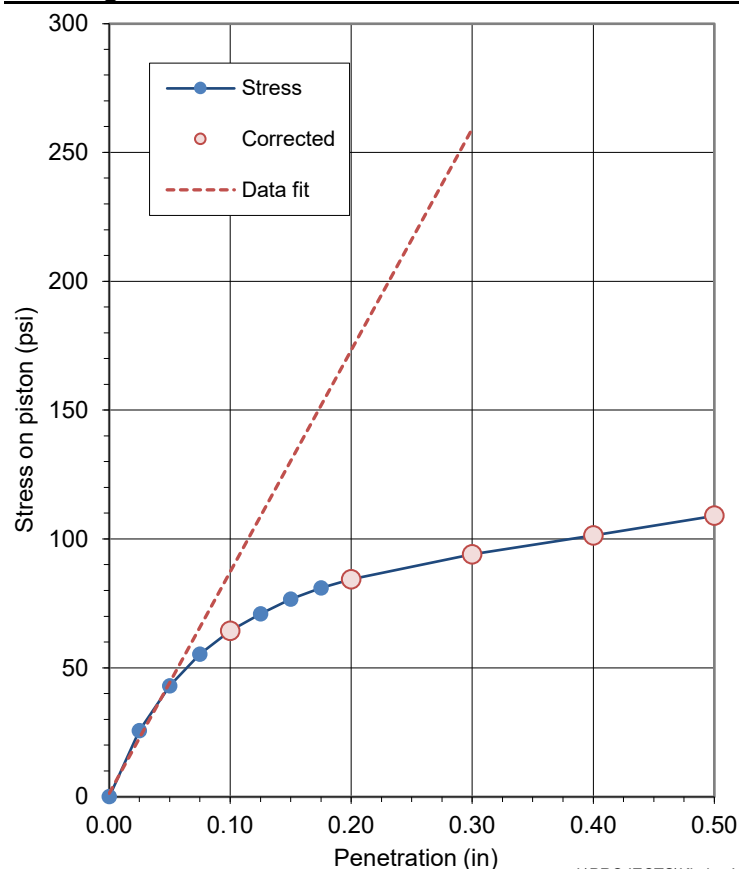
Compaction Data

	As-Comp.	After Soak	Top 1-in.
Wt. mold + moist soil (g)	12076.5	12165	
Wt. mold (g)	8000.2	8000.2	
Mold volume (ft^3)	0.0750	0.07605	
Moist unit wt., gm (pcf)	119.819	120.744	
Moist soil + tare (g)	764.36	688.5	590.86
Dry soil + tare (g)	720.28	586.7	503.28
Tare (g)	454.07	118.5	119.66
Moisture content, w (%)	16.6	21.7	22.8
Dry unit wt., gd (pcf)	102.8	99.2	

Swell Data

Date	Time	Dial (in)
5/18	14:00	0.153
5/22	13:10	0.217
Soaking Period (hr)		95
Ho (in)		4.584
Hf (in)		4.648
Swell (%)		1.40
Surcharge (psf)		50

Bearing Test Results



Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	0	0		
0.025	26	26		
0.05	43	43		
0.075	55	55		
0.1	64	64	1000	6.4
0.125	71	71	1125	6.3
0.15	77	77	1250	6.1
0.175	81	81	1375	5.9
0.2	84	84	1500	5.6
0.3	94	94	1900	4.9
0.4	101	101	2300	4.4
0.5	109		2600	4.2

California Bearing Ratio*

(After ASTM D 1883 and AASHTO T193)



Project: Bear Lake Marina Expansion

No: 22-1522

Date: 12-May-23

Tested by: JC

Reduced by: JC

Reviewed by: AT

Comments: Asphalt present in sample

TH/TP/Sample: 23-TH-12

Depth: 2.5-10 ft

Location: Rich County, Utah

Test Summary

Maximum dry unit weight (pcf): 117.3

Optimum moisture content (%): 12.8

Relative compaction (%): 97.3

CBR at 0.1-in. (%): 6.9

CBR at 0.2-in. (%): 6.8

Reference method: ASTM D698 B

Eng. classification: Not requested

Condition of sample: Soaked

Scalp and replace: No

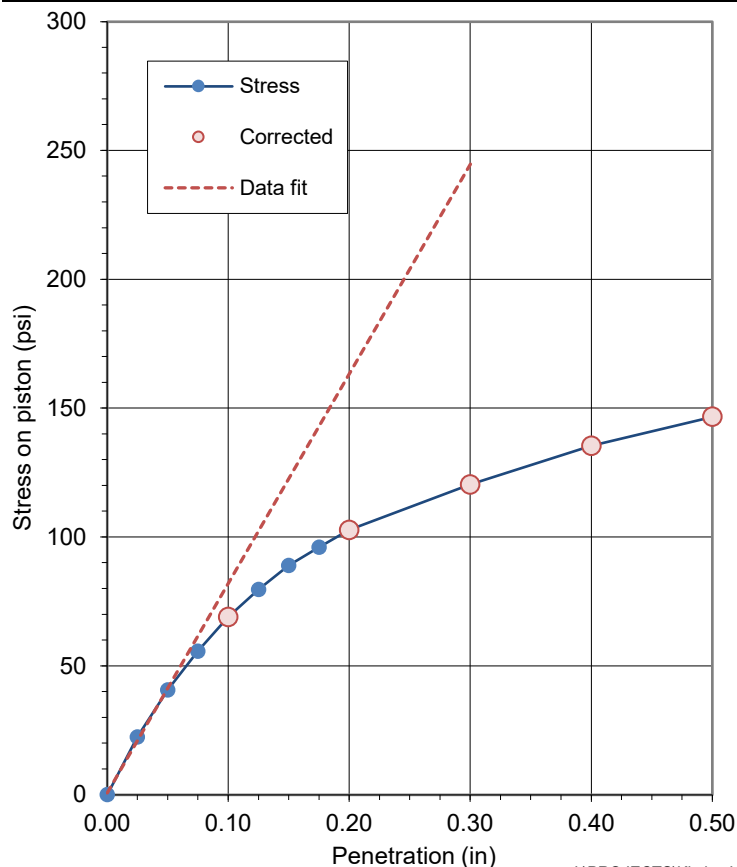
Compaction Data

	As-Comp.	After Soak	Top 1-in.
Wt. mold + moist soil (g)	12432	12531	
Wt. mold (g)	8044.75	8044.75	
Mold volume (ft^3)	0.0750	0.07585	
Moist unit wt., gm (pcf)	128.961	130.387	
Moist soil + tare (g)	860.91	923.62	490.08
Dry soil + tare (g)	810.24	832.96	440.02
Tare (g)	421.6	197.17	118.13
Moisture content, w (%)	13.0	14.3	15.6
Dry unit wt., gd (pcf)	114.1	114.1	

Swell Data

Date	Time	Dial (in)
5/19	13:55	0.155
5/23	12:26	0.207
Soaking Period (hr)		95
Ho (in)		4.584
Hf (in)		4.636
Swell (%)		1.13
Surcharge (psf)		50

Bearing Test Results



Penetration (in)	Meas. Stress (psi)	Corrected Str. (psi)	Standard Stress (psi)	Bearing Ratios
0	0	0		
0.025	22	22		
0.05	41	41		
0.075	56	56		
0.1	69	69	1000	6.9
0.125	80	80	1125	7.1
0.15	89	89	1250	7.1
0.175	96	96	1375	7.0
0.2	103	103	1500	6.8
0.3	120	120	1900	6.3
0.4	135	135	2300	5.9
0.5	147		2600	5.6

Minimum Laboratory Soil Resistivity*

After AASHTO T 288

Project: Bear Lake Marina Expansion

No: 22-1522

Location: Rich County, Utah



Sample Info.	Test Hole/Pit:	23-TH-01							
	Depth (ft):	5-7 ft							
	Date Sampled:	5/10/2023							
	Date Tested:	5/24/2023							
	Laboratory sample description:	lt tn - pl ol bn silt							
	Meter Serial Number	4777							
Soil Data	Wet soil + tare (g)	520.98							
	Air dry soil + tare (g)	468.59							
	Tare (g)	195.13							
	Moisture Content, w (%)	19.2							
	Dry Soil after #10 sieve (g)	220.85							
Moisture	Water for 10% initial MC (mL)	22.09							
	% / Step (%)	5							
	Water for % / Step (mL)	11.0							
Resistivity data		Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
	1	Initial	3,100						
	2	Initial +5	1,500						
	3	Initial +10	870						
	4	Initial +15	510						
	5	Initial +20	325						
	6	Initial +25	330						
	7	Initial +30	345						
	8								
	9								
	10								
	Minimum resistivity (Ω-cm)		325						
QC/QA	Tested By:	AW							
	Reduced By:	AT							
	Reviewed By:	WC							

Comments:

Minimum Laboratory Soil Resistivity*

After AASHTO T 288

Project: Bear Lake Marina Expansion

No: 22-1522

Location: Rich County, Utah



Sample Info.	Test Hole/Pit:	23-TH-05							
	Depth (ft):	12.5-14.5 ft							
	Date Sampled:	5/10/2023							
	Date Tested:	5/19/2023							
	Laboratory sample description:	lt bn - bn sand							
	Meter Serial Number	4777							
Soil Data	Wet soil + tare (g)	460.43							
	Air dry soil + tare (g)	387.25							
	Tare (g)	144.14							
	Moisture Content, w (%)	30.1							
	Dry Soil after #10 sieve (g)	225.89							
Moisture	Water for 10% initial MC (mL)	22.59							
	% / Step (%)	5							
	Water for % / Step (mL)	11.3							
Resistivity data		Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)	Soil condition (%)	Resistivity (Ω-cm)
	1	Initial	6,500						
	2	Initial +5	2,950						
	3	Initial +10	2,200						
	4	Initial +15	1,150						
	5	Initial +20	1,150						
	6	Initial +25	1,550						
	7								
	8								
	9								
	10								
	Minimum resistivity (Ω-cm)		1,150						
QC/QA	Tested By:	CJS							
	Reduced By:	JC							
	Reviewed By:	AT							

Comments:



5/19/2023

Work Order: 23E1149
Project: [none]

Gerhart Cole, Inc.
Attn: Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.



Approved By:

Reed Hendricks, Director of Operations



Chemtech-Ford Laboratories

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9632 South 500 West
Sandy, UT 84070
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www.ChemtechFord.com



Certificate of Analysis

Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: 5/12/23 12:40 @ 24.9 °C
Date Reported: 5/19/2023
Project Name: [none]

Sample ID: TH-01 @ 7.5 ft

Matrix: Solid

Lab ID: 23E1149-01

Date Sampled: 5/11/23 0:00

Sampled By:

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	79	mg/kg dry	18	EPA 300.0	5/15/23	5/16/23	
pH	8.3	pH Units	0.1	EPA 9045D	5/12/23	5/12/23	
Sulfate, Soluble (IC)	ND	mg/kg dry	18	EPA 300.0	5/15/23	5/16/23	
Total Solids	56.8	%	0.1	CTF8000	5/12/23	5/12/23	
Metals							
Sulfur, Total	59.0	mg/kg dry	0.27	EPA 6010B/C/D	5/15/23	5/16/23	



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Certificate of Analysis

Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: 5/12/23 12:40 @ 24.9 °C
Date Reported: 5/19/2023
Project Name: [none]

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).

1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.

1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.

1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.

On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.



6/1/2023

Work Order: 23E1980
Project: 22-1522

Gerhart Cole, Inc.
Attn: Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.



Approved By:

Reed Hendricks, Director of Operations



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Certificate of Analysis

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Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: 5/23/23 16:59 @ 26.4 °C
Date Reported: 6/1/2023
Project Name: 22-1522

Sample ID: TH-05/12.5-14.5 ft

Matrix: Solid

Lab ID: 23E1980-01

Date Sampled: 5/11/23 0:00

Sampled By: Client

	<u>Result</u>	<u>Units</u>	<u>Minimum Reporting Limit</u>	<u>Method</u>	<u>Preparation Date/Time</u>	<u>Analysis Date/Time</u>	<u>Flag(s)</u>
Inorganic							
Chloride, Soluble (IC)	15	mg/kg dry	12	EPA 300.0	5/24/23	5/24/23	
pH	8.4	pH Units	0.1	EPA 9045D	5/24/23	5/24/23	
Sulfate, Soluble (IC)	61	mg/kg dry	12	EPA 300.0	5/24/23	5/24/23	
Total Solids	81.1	%	0.1	CTF8000	5/25/23	5/26/23	
Metals							
Sulfur, Total	597	mg/kg dry	0.11	EPA 6010B/C/D	5/30/23	5/31/23	



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Certificate of Analysis

Gerhart Cole, Inc.
Zach Gibbs
7657 South Holden Street
Midvale, UT 84047

PO#:
Receipt: 5/23/23 16:59 @ 26.4 °C
Date Reported: 6/1/2023
Project Name: 22-1522

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).

1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.

1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.

1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.

On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

Triaxial Test - Isotropic Consolidated Sheared Undrained
Measuring Pore Pressure (CIU-PP) - After ASTM D4767 and USBR 5750



Project: Bear Lake Marina Expansion
No: 22-1522a

TH/TP/Sample: Combined Sample
Depth: -

Location: Rich County, Utah
 Date: 08-Jun-23

Laboratory sample description: or - rd sand
 USCS classification: not requested

Tested by: AT

Sample type: #REF!

PROJECTS\Kimley Horn\22-1522 Bear Lake Marina Expansion\Data\Lab\Test Results\Gun Range Quarry\[2023-06-05_TX_CU3pts.xlsx]SUM

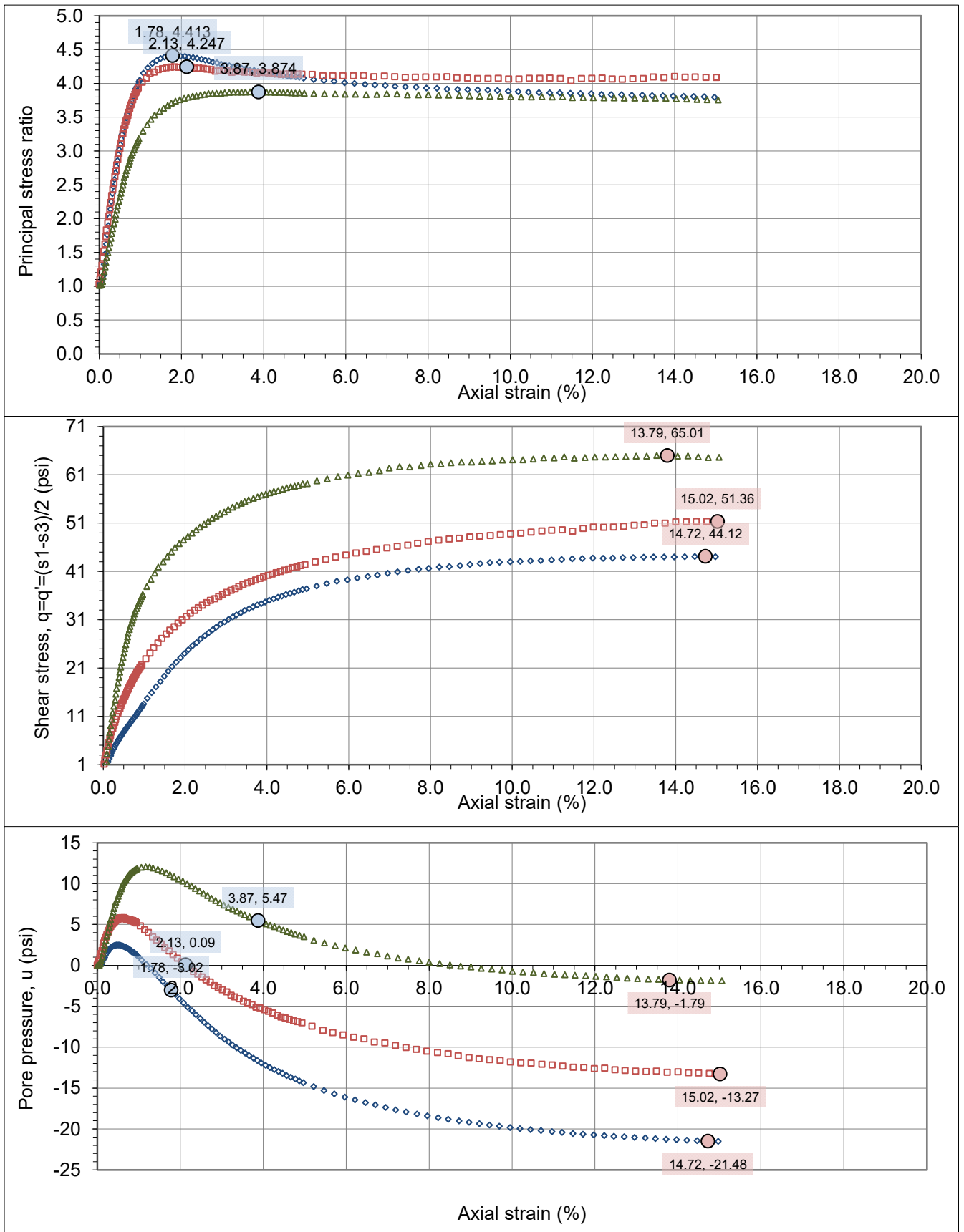
Test Number		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi
Test information	Total backpressure (psi)	55.0	65.0	55.0
	Skempton B	0.96	0.95	0.96
	t-90 (min)	1.4	1.4	1.1
	t-100 (min)	239.6	125.3	234.9
	t-50 (min)	0.3	0.3	0.3
	Strain rate (%/hr)	1.20	1.20	1.20
	Strain rate (%/min)	0.02	0.02	0.02
	Membrane correction	Yes	Yes	Yes
	Filter paper correction	No	No	No
Max principal stress ratio (s1/s3), failure criteria	Strain at failure, ef (%)	1.78	2.13	3.87
	Time to failure, tf (min)	89.1	106.4	193.6
	Obliquity, s'1/s'3	4.413	4.247	3.874
	Excess pore pressure, u (psi)	-3.02	0.09	5.47
	q = q' = (s1+s3)/2 (psi)	22.22	32.33	56.81
	p' = (s'1+s'3)/2 (psi)	35.23	52.24	96.33
	p = (s1+s3)/2 (psi)	32.22	52.33	101.81
	Effective major principal stress, s'1 (psi)	57.45	84.57	153.14
	Effective minor principal stress, s'3 (psi)	13.02	19.91	39.53
	Total major principal stress, s1 (psi)	54.43	84.66	158.61
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	-0.07	0.00	0.05
	Secant friction angle, phi-s (deg)	39.1	38.2	36.1
		Effective stress	Total stress	
	Friction angle, phi (deg)	34.3	29.8	
	Cohesion intercept, c (psi)	3.1	7.2	
Peak deviator stress (s1-s3), failure criteria	Strain at failure, ef (%)	14.72	15.02	13.79
	Time to failure, tf (min)	736.0	750.8	689.5
	Deviator stress, s1-s3 (psi)	88.24	102.72	130.02
	Excess pore pressure, u (psi)	-21.48	-13.27	-1.79
	q = q' = (s1+s3)/2 (psi)	44.12	51.36	65.01
	p' = (s'1+s'3)/2 (psi)	75.60	84.63	111.80
	p = (s1+s3)/2 (psi)	54.12	71.36	110.01
	Effective major principal stress, s'1 (psi)	119.72	135.98	176.81
	Effective minor principal stress, s'3 (psi)	31.48	33.27	46.79
	Total major principal stress, s1 (psi)	98.24	122.72	175.02
	Total minor principal stress, s3 (psi)	10.00	20.00	45.00
	Skempton A at failure, Af	-0.24	-0.13	-0.01
	Secant friction angle, phi-s (deg)	35.7	37.4	35.6
		Effective stress	Total stress	
	Friction angle, phi (deg)	34.0	21.7	
	Cohesion intercept, c (psi)	3.3	26.3	
Photo of sample after shearing		S1 at 10 psi	S2 at 20 psi	S3 at 45 psi

Comments:



Project: Bear Lake Marina Expansion
No: 22-1522a

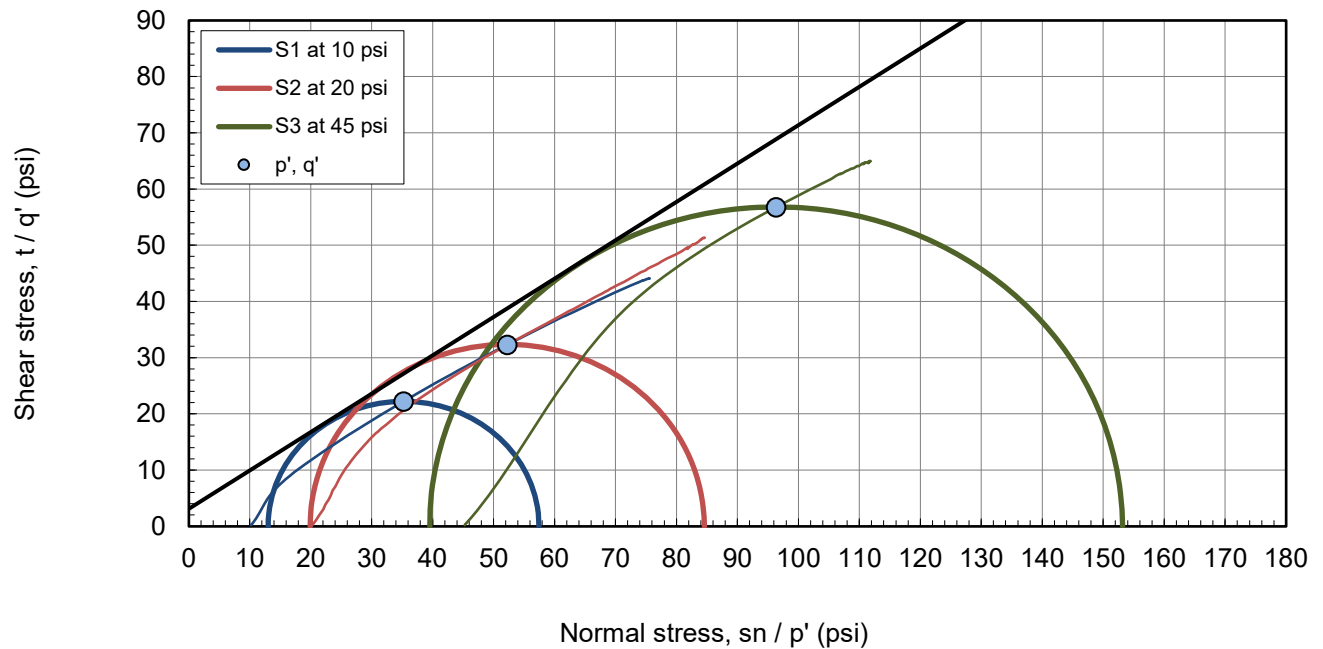
TH/TP/Sample: Combined Sample
Depth: -



Project: Bear Lake Marina Expansion
No: 22-1522a

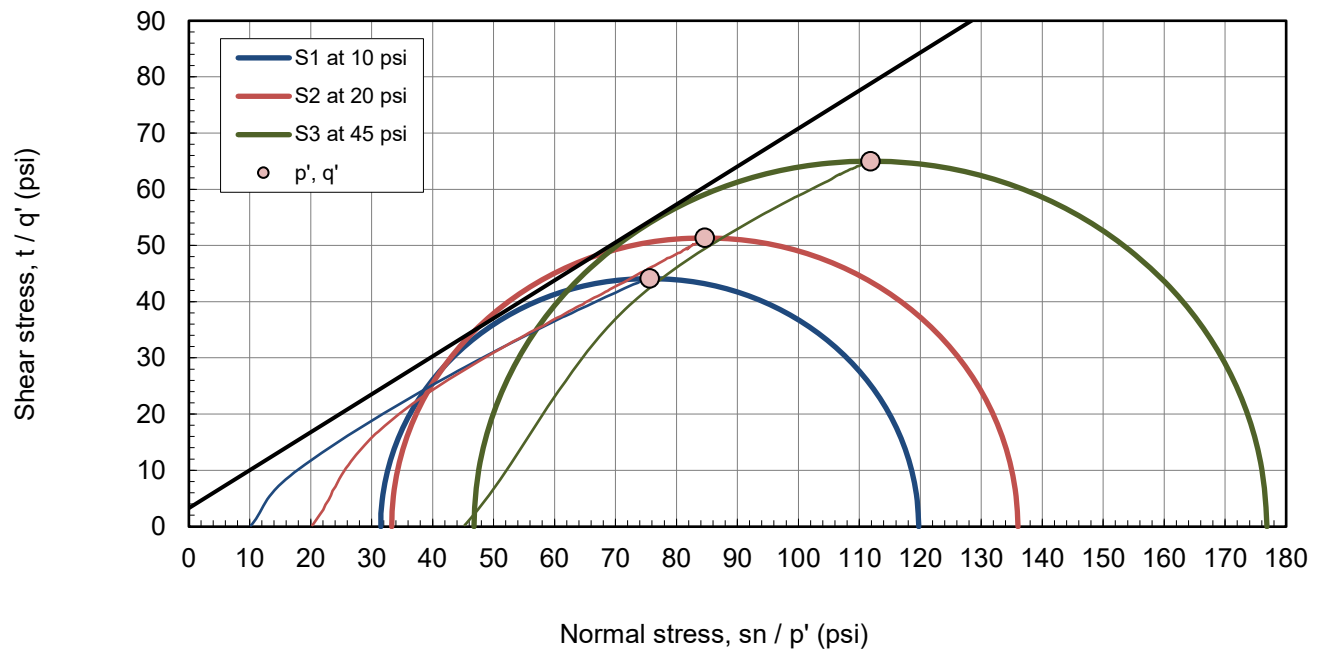
TH/TP/Sample: Combined Sample
Depth: -

Effective stress results



Max principal stress ratio (s'_1/s'_3), failure criteria Mohr and $p' - q'$ space plots

Effective stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and $p' - q'$ space plots

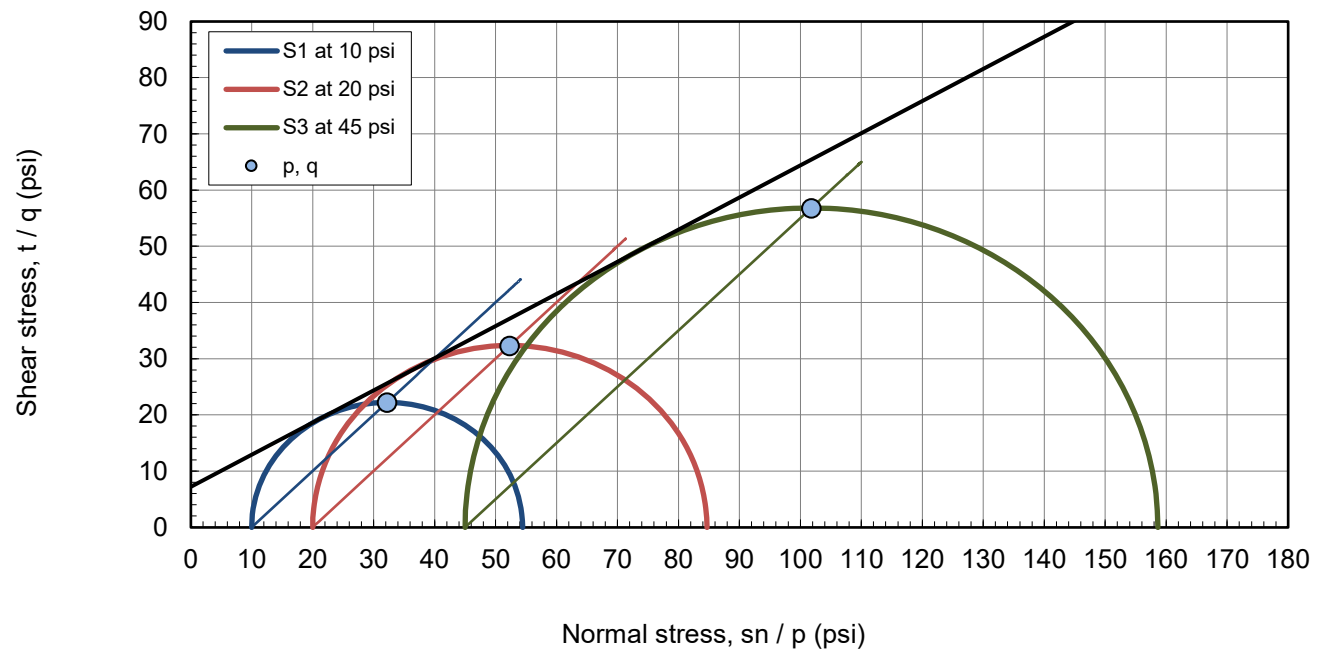
Project: Bear Lake Marina Expansion

TH/TP/Sample: Combined Sample

No: 22-1522a

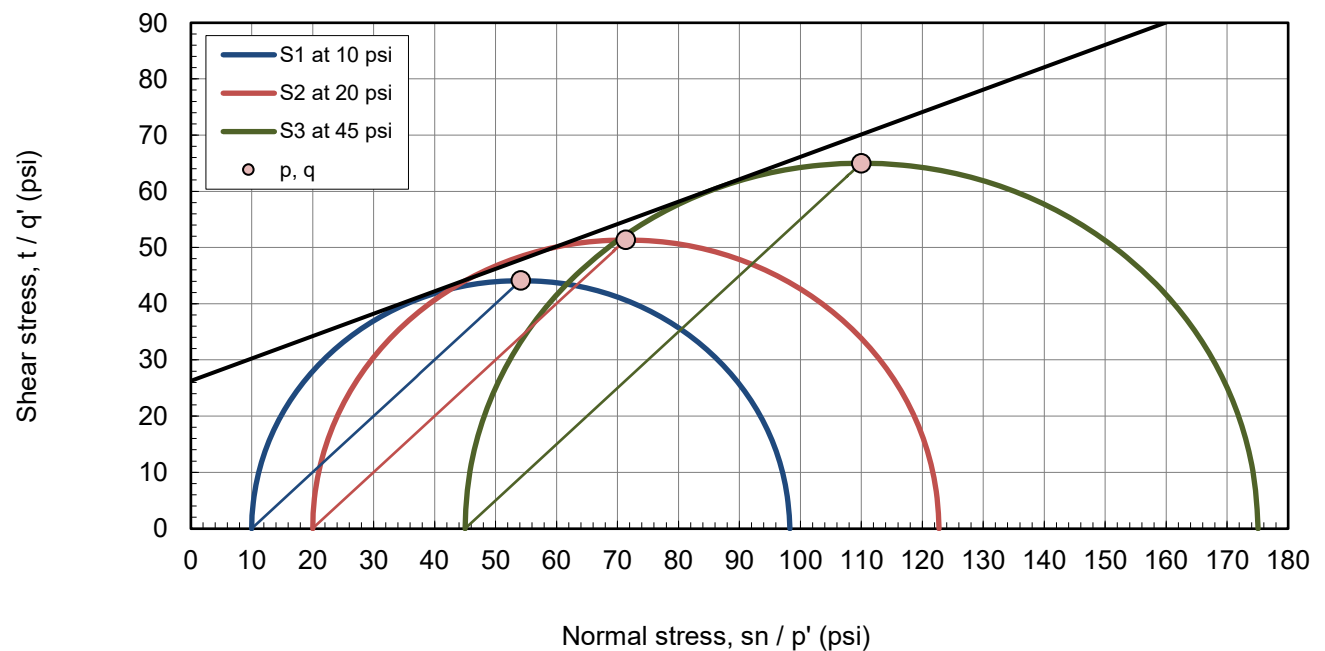
Depth: -

Total stress results



Max principal stress ratio (s_1/s_3), failure criteria Mohr and $p-q$ space plots - effective stress results

Total stress results



Peak deviator stress (s_1-s_3), failure criteria Mohr and $p-q$ space plots

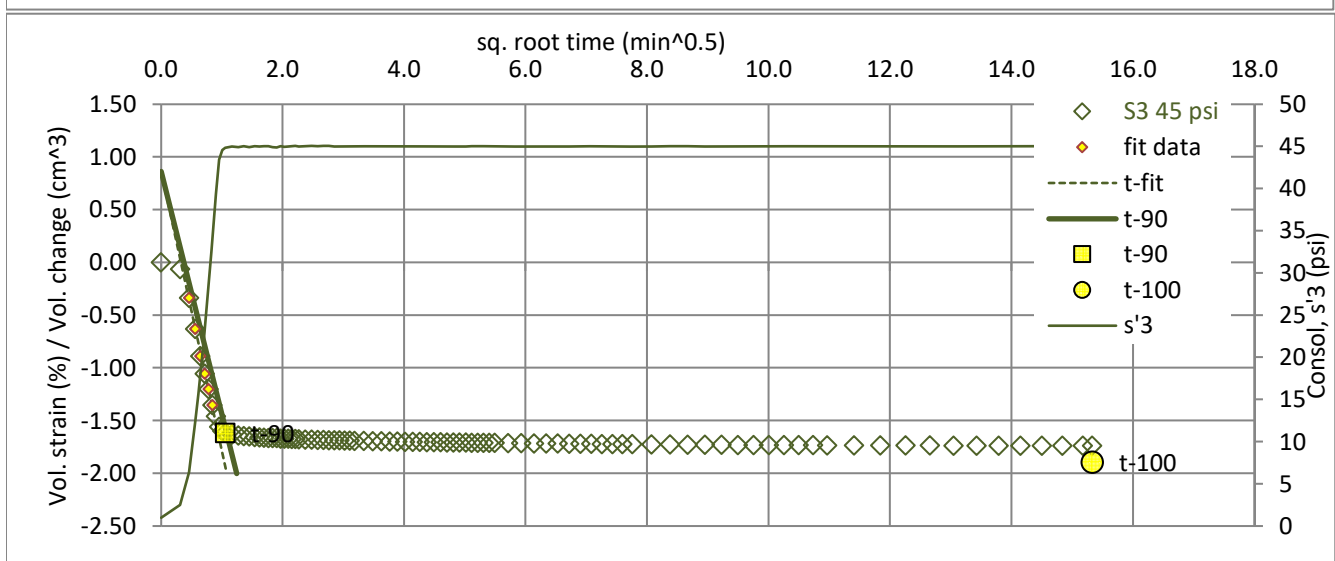
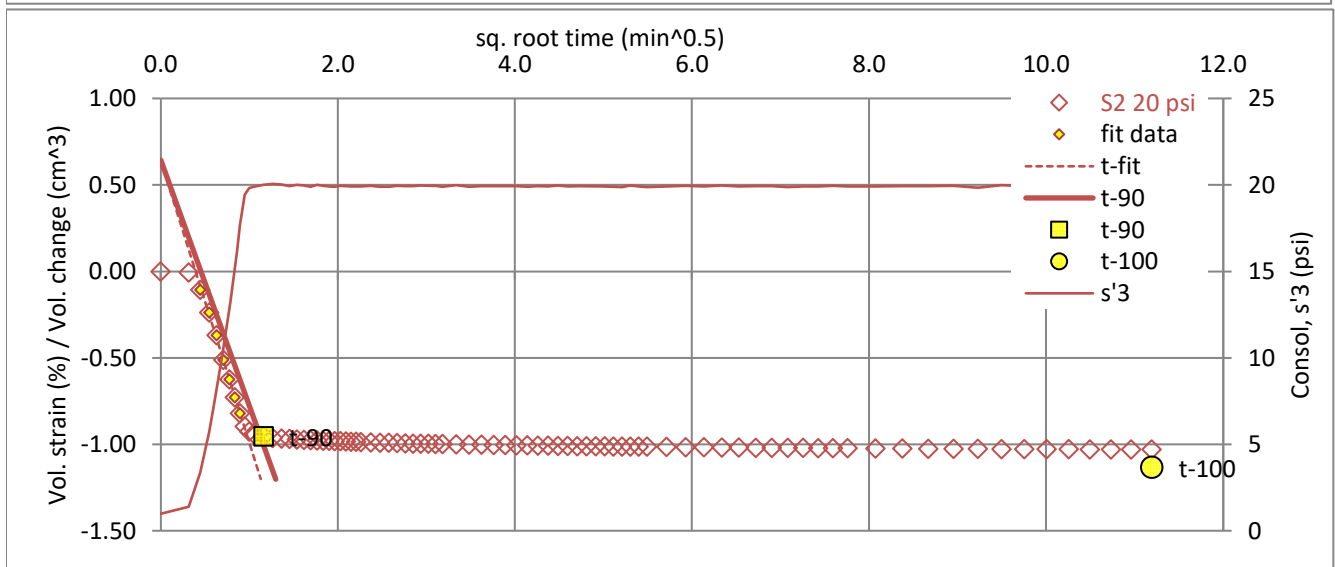
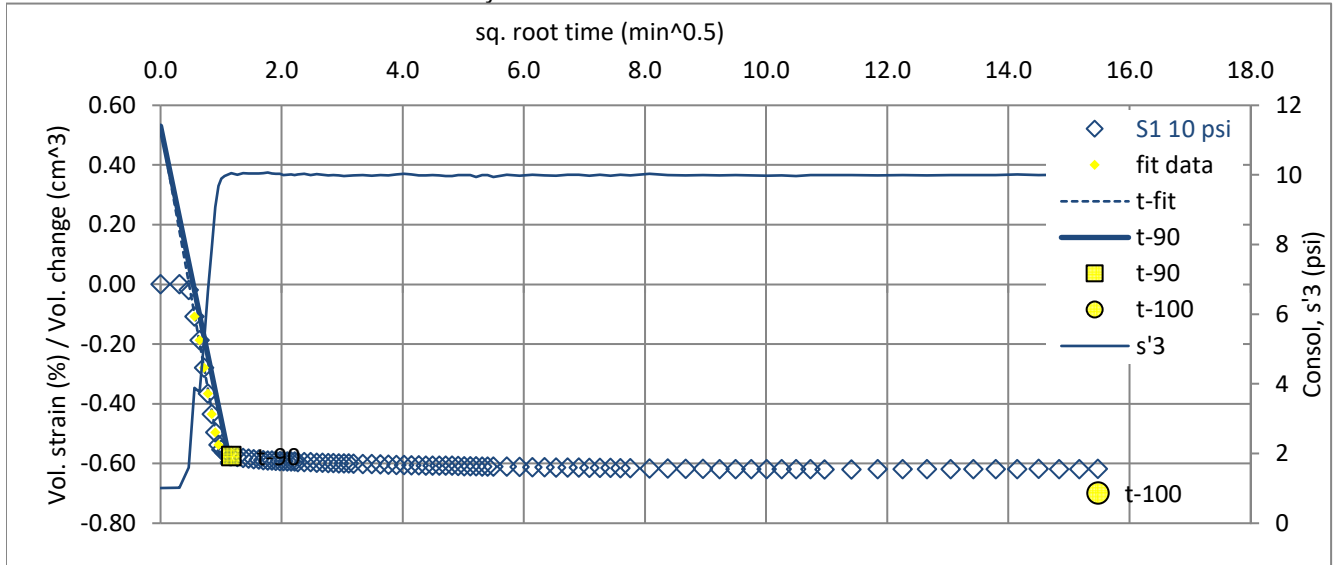
Project: Bear Lake Marina Expansion

TH/TP/Sample: Combined Sample

No: 22-1522a

Depth: -

Time rate of consolidation data and analysis

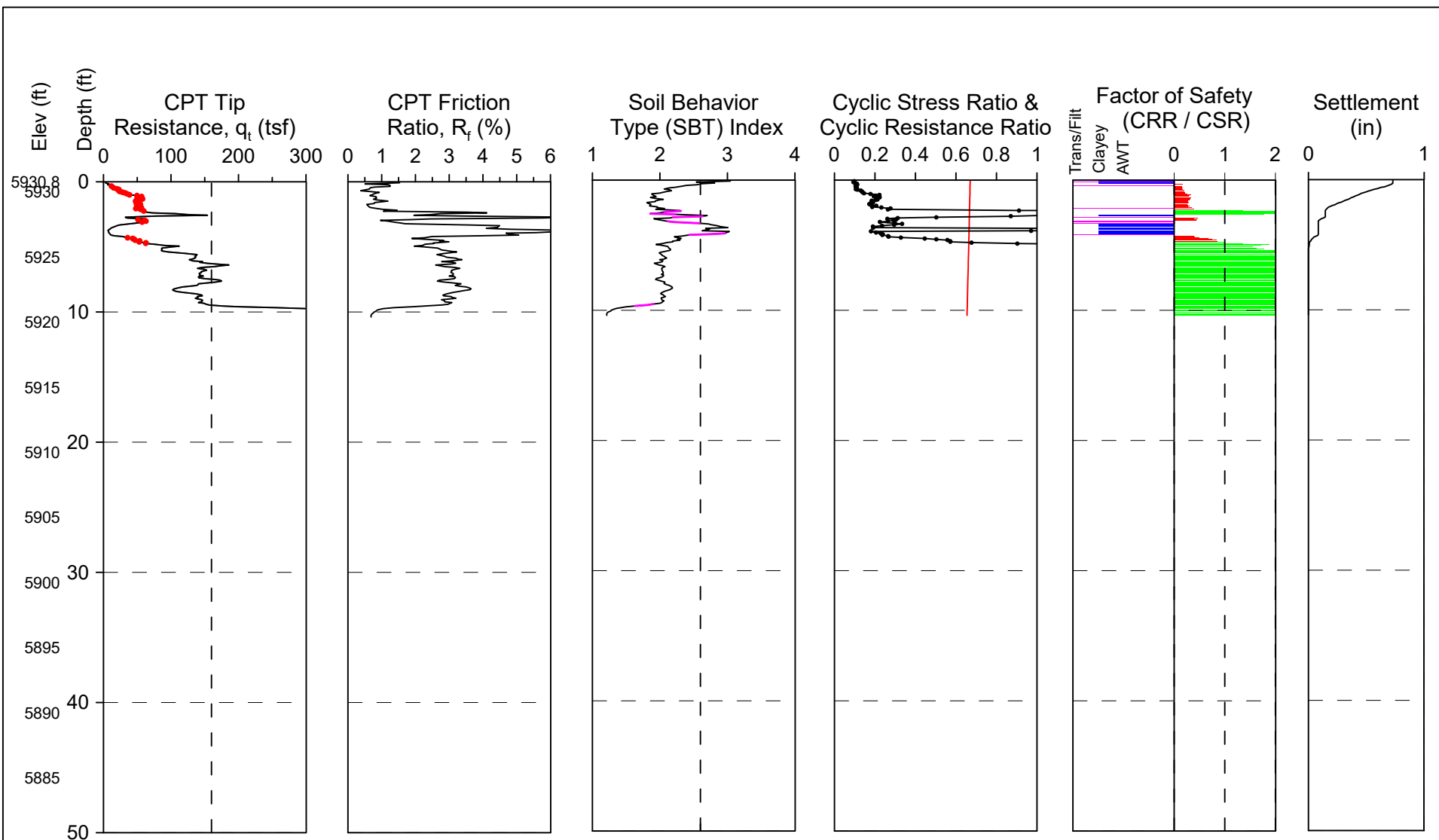




Appendix F

Liquefaction Results Bear Lake Marina Expansion Table of Contents

<u>Description</u>	<u>Page No.</u>
CPT Liquefaction Triggering & Settlement Analysis	F-1
Test Holes; Semi-Empirical Liquefaction Potential Evaluation	F-6



Data Source: 23-CPT-02

Seismic Parameters: PGA = 0.52g; M=7.11 [2500 year]

Analysis Method: Youd et al., 2001; Yoshimine et al., 2006

Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered

Settlement cutoff depth = 75ft

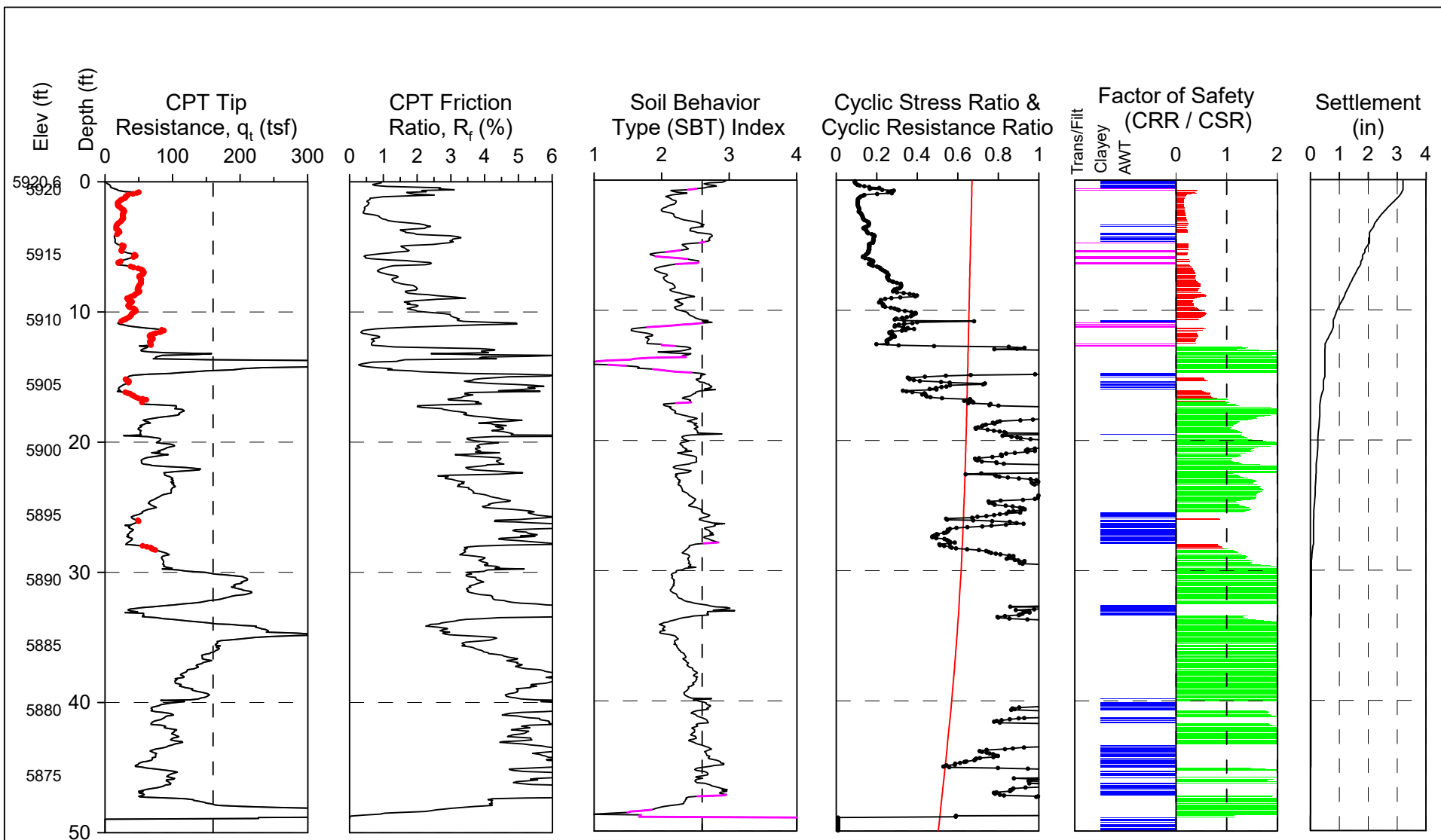


LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS

22-1522

Bear Lake Marina Expansion

Fig 23-CPT-02

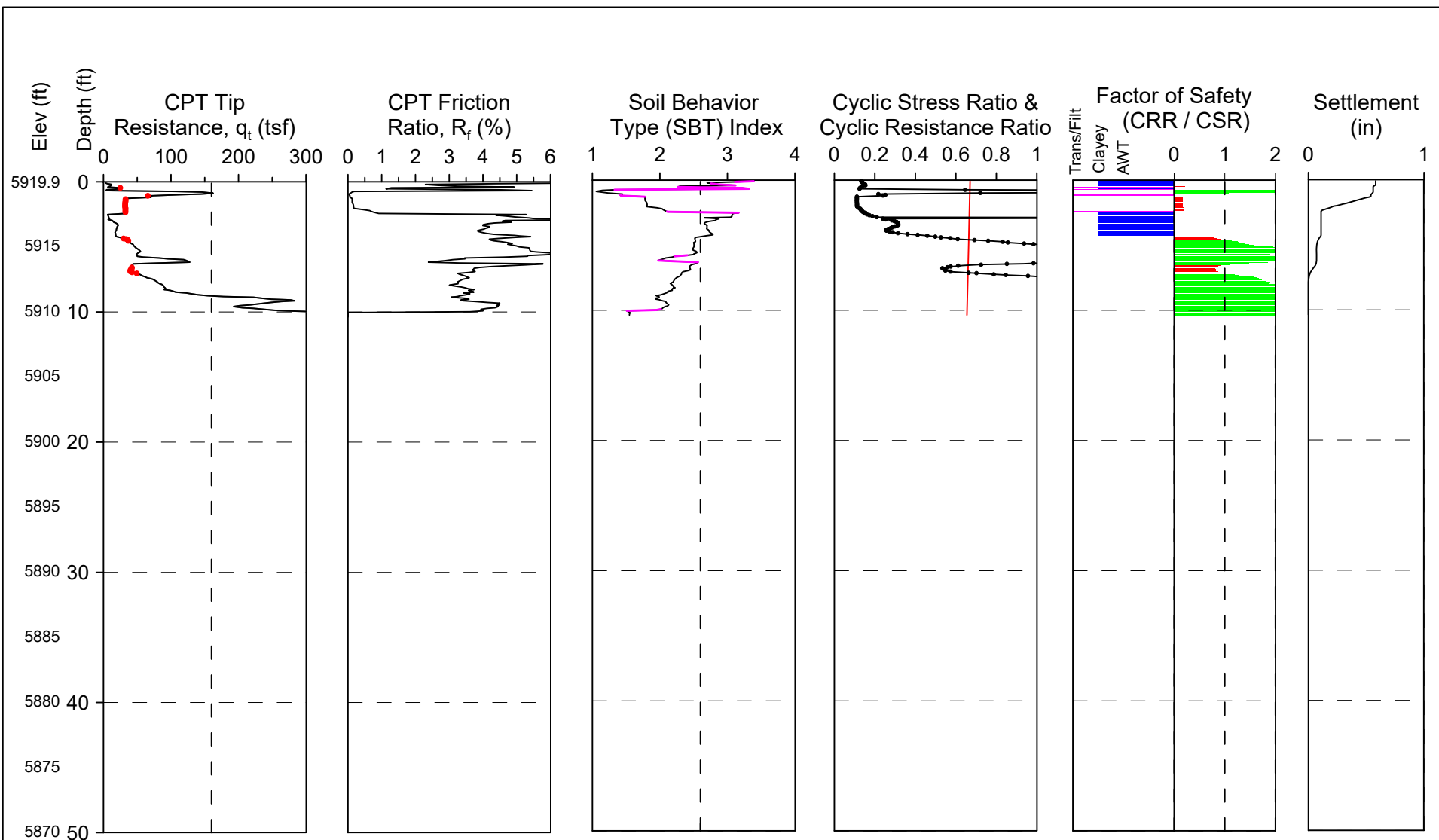


Data Source: 23-CPT-06

Seismic Parameters: PGA = 0.52g; M=7.11 [2500 year]

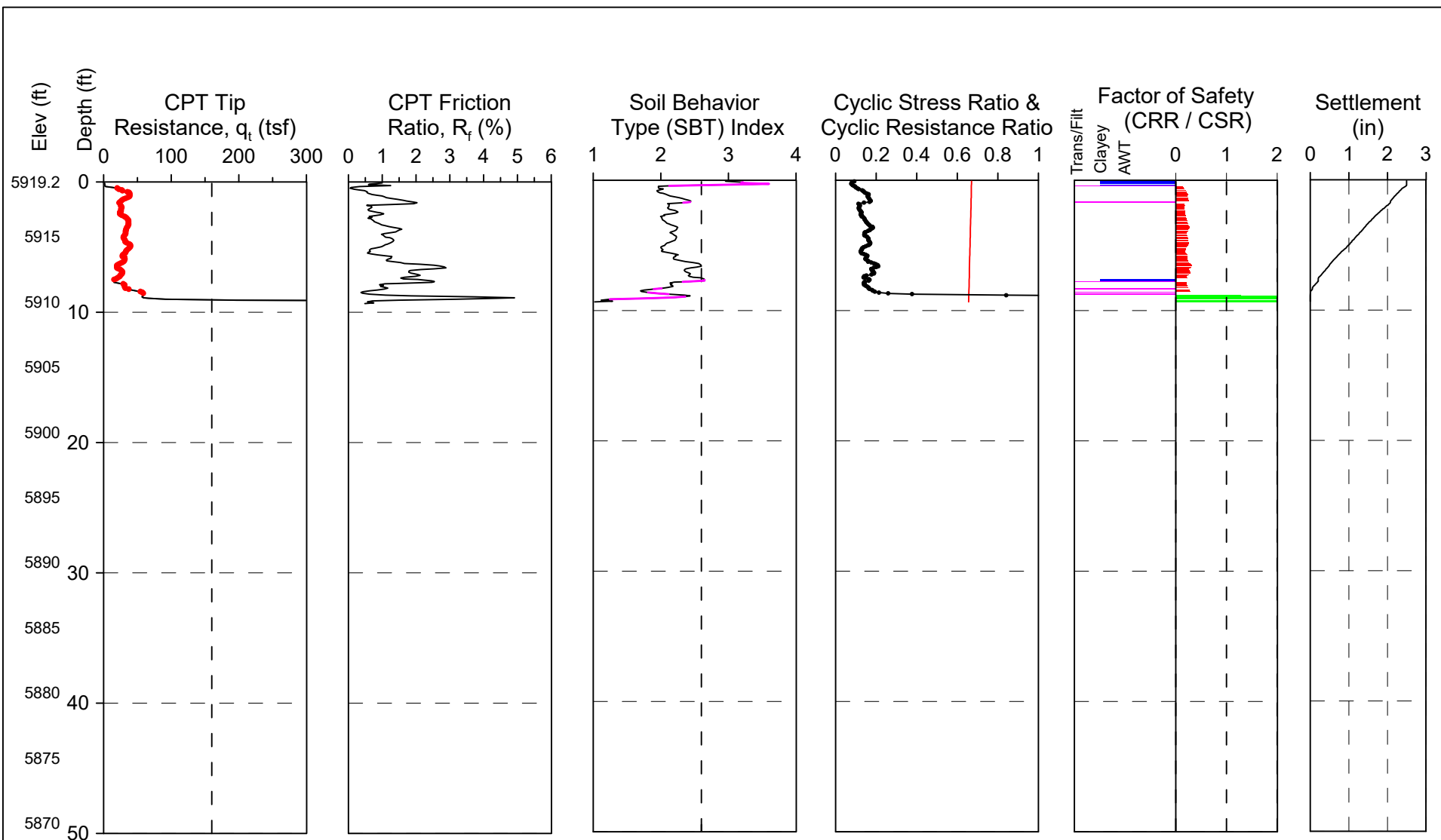
Analysis Method: Youd et al., 2001; Yoshimine et al., 2006

Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
Settlement cutoff depth = 75ft



Data Source: 23-CPT-08
 Seismic Parameters: PGA = 0.52g; M=7.11 [2500 year]
 Analysis Method: Youd et al., 2001; Yoshimine et al., 2006
 Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered
 Settlement cutoff depth = 75ft

	LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS	22-1522
	Bear Lake Marina Expansion	Fig 23-CPT-08



Data Source: 23-CPT-10b

Seismic Parameters: PGA = 0.52g; M=7.11 [2500 year]

Analysis Method: Youd et al., 2001; Yoshimine et al., 2006

Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered

Settlement cutoff depth = 75ft

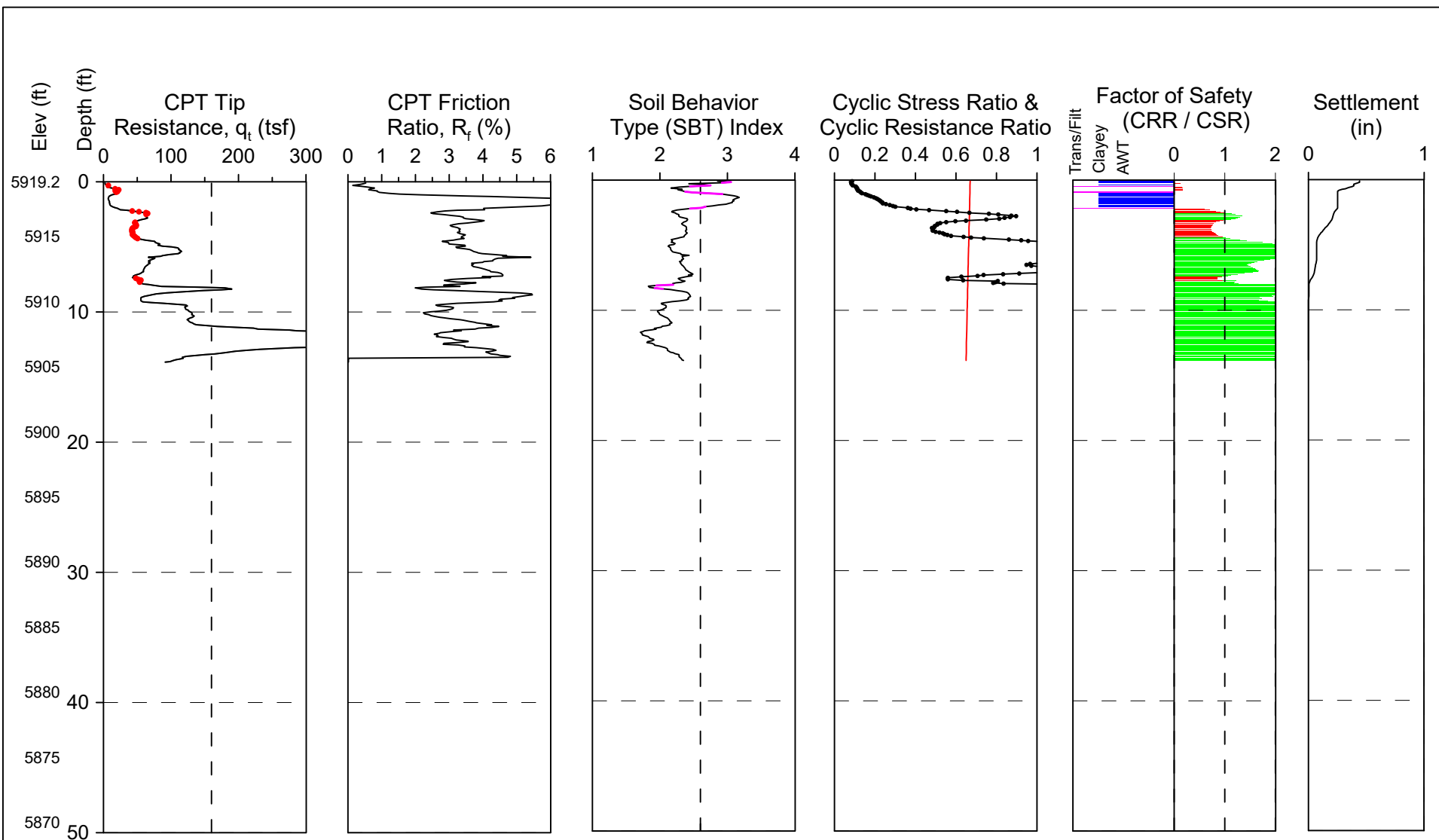


LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS

22-1522

Bear Lake Marina Expansion

Fig 23-CPT-10b



Data Source: 23-CPT-13

Seismic Parameters: $PGA = 0.52g$; $M=7.11$ [2500 year]

Analysis Method: Youd et al., 2001; Yoshimine et al., 2006

Notes: AWT = Above water table; Trans/Filt = Layer transition, filtered

Settlement cutoff depth = 75ft



LIQUEFACTION TRIGGERING & SETTLEMENT ANALYSIS

22-1522

Bear Lake Marina Expansion

Fig 23-CPT-13

Table X-X: Semi-Empirical Liquefaction Potential Evaluation
Project Bear Lake Marina Expansion (22-1522)



PGA (g) = 0.52

by: rrb

Test hole = 23-TH-04

Earthquake magnitude, M_R = 7.1

Date: 2/21

Ground surface elev. (ft) = 5920.1

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																SPT Liquefaction, Youd et al.														Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement											
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	total stress s _{vo} (psf)	Pore pressure, u (psf)	effective stress s' _{vo} (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M , σ' _{vc}	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) &B (2008)	Cyclic Resistance Ratio, CRR _{M=7.5, σ'_{vc}=1}	C _σ	Overburden correction factor, K _σ	Static shear stress corr. factor (sands), K _σ	Cyclic Resistance Ratio, CRR _M , σ' _{vc}	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, CRR _{7.5}	Relative Density, Dr (%) Skempton (86)	K _σ	Cyclic Resistance Ratio, CRR _M , σ' _v	F.S. Liquefaction	CSR _{M=7.5, σ'_{vc}=1} I&B	CSR _{M=7.5, σ'_{vc}=1} Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	γ _{lim}	F _α	γ _{max}	Volumetric Strain, ε _v - I&B approximation	F _{ult}	γ _{o,max}	Volumetric Strain, ε _v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	PI (%)	Filter (remove using "x")
SM	2.5	5	5917.6	313	156	157	15	18	1.00	0.67	1.70	1.24	1.00	0.75	Yes	1.30	30.7	0.00	30.7	34.8	87.0	1.06	0.26	1.10	1.00	1.30	1.92	0.99	0.671	1.7	30.7	35.98	No Liq	77.4	1.00	#####	#####	0.55	0.59	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.023	-0.419	0.002	0.000	0.074	#####	#####	1.00	0.02	0.00	0	
CL	7.5	10	5912.6	938	468	470	5	31	0.98	0.66	1.70	1.24	1.00	0.75	Yes	1.10	8.7	0.00	8.7	14.1	55.3	No Liq (Clayey)	0.11	1.10	1.00	#####	#####	0.98	0.663	1.547	7.9	13.93	No Liq (Clayey)	48.2	1.00	#####	#####	0.54	0.58	No Liq	No Liq	1.00	0.00	0.00	0.304	0.796	#####	#####	0.904	#####	#####	1.00	0.00	0.00	24	X
CL	12.5	2.5	5907.6	1563	780	783	21	80	0.97	0.65	1.37	1.24	1.00	0.80	Yes	1.30	37.0	0.00	37.0	42.5	96.1	No Liq (Clayey)	0.30	1.10	1.00	#####	#####	0.97	0.655	1.401	37.8	50.36	No Liq (Clayey)	91.6	1.00	#####	#####	0.53	0.57	No Liq	No Liq	1.00	0.00	0.00	0.005	-0.995	#####	#####	-0.698	#####	#####	1.00	0.00	0.00	20	X
CL	15.0	2.5	5905.1	1875	936	939	24	80	0.96	0.64	1.27	1.24	1.00	0.85	Yes	1.30	41.4	0.00	41.4	47.0	101.1	No Liq (Clayey)	0.30	1.10	1.00	#####	#####	0.97	0.651	1.338	43.8	57.6	No Liq (Clayey)	98.0	1.00	#####	#####	0.53	0.57	No Liq	No Liq	1.00	0.00	0.00	0.001	-1.346	#####	#####	-1.123	#####	#####	1.00	0.00	0.00	20	X
CL	17.5	2.5	5902.6	2188	1092	1096	100	80	0.94	0.64	0.94	1.24	1.00	0.85	Yes	1.30	128.8	0.00	128.8	134.4	170.9	No Liq (Clayey)	-0.09	0.94	1.00	#####	#####	0.96	0.647	1.281	174.8	214.7	No Liq (Clayey)	189.2	1.00	#####	#####	0.61	0.56	No Liq	No Liq	1.00	0.00	0.00	0.000	-9.461	#####	#####	#####	#####	1.00	0.00	0.00	20	X	
CL	20.0	2.5	5900.1	2500	1248	1252	33	80	0.93	0.63	1.12	1.24	1.00	0.95	Yes	1.30	56.2	0.00	56.2	61.7	115.8	No Liq (Clayey)	-0.89	0.54	1.00	#####	#####	0.95	0.643	1.228	61.8	79.16	No Liq (Clayey)	114.9	1.00	#####	#####	1.06	0.56	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.572	#####	#####	-2.486	#####	#####	1.00	0.00	0.00	20	X
																																															0.0 0.0		0.0 0.0							

Table X-X: Semi-Empirical Liquefaction Potential Evaluation
Project Bear Lake Marina Expansion (22-1522)



PGA (g) = 0.52

by: rrb

Test hole = 23-TH-05

Earthquake magnitude, M_R = 7.1

Date: 2/21

Ground surface elev. (ft) = 5920

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger														SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement																	
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	total stress s _{vo} (psf)	Pore pressure, u (psf)	effective stress s' _{vo} (psf)	SPT Blow count, N _m	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M , σ' _v /σ' _{vc}	Overburden, C _n	Energy ratio, C _e	Borehole, C _b	rod length, C _r	Unused room for liners in SPT?	Liner, C _s	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) &B (2008)	Cyclic Resistance Ratio, CRR _{M=7.5, σ'_v/σ'_{vc}=1}	C _σ	Overburden correction factor, K _σ	Static shear stress corr. factor (sands), K _σ	Cyclic Resistance Ratio, CRR _M , σ' _v /σ' _{vc}	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M	Overburden, C _n	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, CRR _{7.5}	Relative Density, Dr (%) Skempton (86)	K _σ	Cyclic Resistance Ratio, CRR _M , σ' _v /σ' _{vc}	F.S. Liquefaction	CSR _{M=7.5, σ'_v/σ'_{vc}=1} I&B	CSR _{M=7.5, σ'_v/σ'_{vc}=1} Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	y _{lim}	F _α	y _{max}	Volumetric Strain, ε _v - I&B approximation	F _{ult}	y _{o,max}	Volumetric Strain, ε _v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	P1 (%)	Filter (remove using "x")
ML	2.5	6	5917.5	313	156	157	2	55	1.00	0.67	1.70	1.24	1.00	0.75	Yes	1.10	3.5	0.00	3.5	9.1	44.4	0.11	0.09	1.10	1.00	0.14	0.20	0.99	0.671	1.7	3.5	9.157	0.11	39.1	1.00	0.12	0.18	0.55	0.59	0.028	0.028	1.00	2.02	2.02	0.524	0.936	0.524	0.039	0.952	10.0	0.045	1.00	2.84	3.25	0	
ML	7.5	3.75	5912.5	938	468	470	6	54	0.98	0.66	1.70	1.24	1.00	0.75	Yes	1.10	10.4	0.00	10.4	16.0	59.1	0.17	0.12	1.10	1.00	0.20	0.30	0.98	0.663	1.547	9.5	16.4	0.17	52.3	1.00	0.20	0.30	0.54	0.58	0.018	0.018	1.00	0.81	0.81	0.246	0.715	0.246	0.027	0.849	10.0	0.032	1.00	1.23	1.46	0	
SM	10.0	2.5	5910.0	1250	624	626	12	15	0.98	0.66	1.64	1.24	1.00	0.80	Yes	1.24	24.2	0.00	24.2	27.4	77.2	0.36	0.18	1.10	1.00	0.44	0.67	0.98	0.659	1.471	21.6	25.19	0.30	64.8	1.00	0.34	0.51	0.54	0.58	0.011	0.013	1.00	0.33	0.39	0.066	0.085	0.066	0.014	0.558	10.0	0.024	1.00	0.43	0.71		
SM	12.5	2.5	5907.5	1563	780	783	21	15	0.97	0.65	1.37	1.24	1.00	0.80	Yes	1.30	37.0	0.00	37.0	40.2	93.5	No Liq	0.30	1.10	1.00	#####	#####	0.97	0.655	1.401	37.8	42.12	No Liq	83.8	1.00	#####	#####	0.53	0.57	No Liq	No Liq	1.00	0.00	0.00	0.008	-0.820	#####	#####	-0.242	#####	#####	1.00	0.00	0.00		
CL	15.0	10	5905.0	1875	936	939	42	80	0.96	0.64	1.14	1.24	1.00	0.85	Yes	1.30	65.4	0.00	65.4	71.0	124.2	No Liq (Clayey)	-0.39	0.69	1.00	#####	#####	0.97	0.651	1.338	76.7	97.05	No Liq (Clayey)	127.2	1.00	#####	#####	0.85	0.57	No Liq	No Liq	1.00	0.00	0.00	0.000	-3.387	#####	#####	-3.696	#####	#####	1.00	0.00	0.00	22	X
CL	25.0	5	5895.0	3125	1560	1565	16	80	0.91	0.61	1.12	1.24	1.00	0.95	Yes	1.27	26.7	0.00	26.7	32.3	83.8	No Liq (Clayey)	0.23	1.07	1.00	#####	#####	0.94	0.636	1.134	27.0	37.38	No Liq (Clayey)	78.9	1.00	#####	#####	0.52	0.55	No Liq	No Liq	1.00	0.00	0.00	0.034	-0.241	#####	#####	0.004	#####	#####	1.00	0.00	0.00	22	X
CH	30.0	5	5890.0	3750	1872	1878	28	80	0.88	0.60	1.03	1.24	1.00	0.95	Yes	1.30	44.1	0.00	44.1	49.7	103.9	No Liq (Clayey)	0.30	1.04	1.00	#####	#####	0.93	0.628	1.054	45.0	59.01	No Liq (Clayey)	99.2	1.00	#####	#####	0.52	0.55	No Liq	No Liq	1.00	0.00	0.00	0.000	-1.563	#####	#####	-1.208	#####	#####	1.00	0.00	0.00	28	X
CH	35.0	5	5885.0	4375	2184	2191	80	80	0.86	0.58	1.00	1.24	1.00	1.00	Yes	1.30	128.8	0.00	128.8	134.4	170.9	No Liq (Clayey)	-0.09	1.00	1.00	#####	#####	0.89	0.6	0.984	126.4	156.7	No Liq (Clayey)	161.6	0.99	#####	#####	0.52	0.53	No Liq	No Liq	1.00	0.00	0.00	0.000	-9.462	#####	#####	-8.041	#####	#####	1.00	0.00	0.00	25	X
CH	40.0	5	5880.0	5000	2496	2504	59	80	0.83	0.56	0.99	1.24	1.00	1.00	Yes	1.30	94.1	0.00	94.1	99.6	147.2	No Liq (Clayey)	-0.15	1.03	1.00	#####	#####	0.85	0.573	0.923	87.4	109.9	No Liq (Clayey)	135.4	0.93	#####	#####	0.49	0.53	No Liq	No Liq	1.00	0.00	0.00	0.000	-6.048	#####	#####	-4.599	#####	#####	1.00	0.00	0.00	25	X
MH	45.0	5	5875.0	5625	2808	2817	22	80	0.80	0.54	0.90	1.24	1.00	1.00	Yes	1.30	32.0	0.00	32.0	37.5	90.3	No Liq (Clayey)	0.30	0.91	2.00	#####	#####	0.81	0.545	0.869	30.7	41.84	No Liq (Clayey)	83.5	0.89	#####	#####	0.54	0.53	No Liq	No Liq	2.00	0.00	0.00	0.014	-0.616	#####	#####	-0.227	#####	#####	2.00	0.00	0.00	30	X
MH	50.0	5	5870.0	6250	3120	3130	39	80	0.78	0.53	0.92	1.24	1.00	1.00	Yes	1.30	57.9	0.00	57.9	63.5	117.4	No Liq (Clayey)	-0.71	1.10	3.00	#####	#####	0.77	0.518	0.821	51.4	66.7	No Liq (Clayey)	105.4	0.86	#####	#####	0.43	0.53	No Liq	No Liq	3.00	0.00	0.00	0.000	-2.724	#####	#####	-1.682	#####	#####	3.00	0.00	0.00	30	X
																									3.2						3.2																4.5	5.4								

Table X-X: Semi-Empirical Liquefaction Potential Evaluation
Project Bear Lake Marina Expansion (22-1522)



PGA (g) = 0.52	by: rrb	Test hole = 23-TH-07
Earthquake magnitude, M _R = 7.1	Date: 2/21	Ground surface elev. (ft) = 5934.1
Liquefaction, MSF (Youd) = 1.15		
Liquefaction, MSF (Idriss & Boulanger) = 1.11		

Soil Layer									SPT Liquefaction, Idriss and Boulanger																				SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement																												
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	total stress s _{vo} (psf)	Pore pressure, u (psf)	effective stress s' _{vo} (psf)	SPT Blow count, N _m	Fines content (%)	Stress reduction coefficient, r _d	Cyclic stress ratio, CSR _{M=7.5, σ'_v=1}	Overburden, C _n	Energy ratio, C _e	Borehole, C _b	rod length, C _r	Unused room for liners in SPT?	liner, C _s	Calculated_(N1)60	(N1)60_Convergence Difference	Used_(N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) &B (2008)	Cyclic Resistance Ratio, CRR _{M=7.5, σ'_v=1}	C _g	Overburden correction factor, K _σ	Static shear stress corr. factor (lands), K _z	Cyclic Resistance Ratio, CRR _{M, σ'_v}	F.S. Liquefaction	Stress reduction coefficient, r _d	Cyclic stress ratio, CSR _M	Overburden, C _n	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, CRR _{7.5}	Relative Density, Dr (%) Skempton '96)	K _σ	Cyclic Resistance Ratio, CRR _{M, σ'_v}	F.S. Liquefaction	CSR _{M=7.5, σ'_v=1} &B	CSR _{M=7.5, σ'_v=1} - Youd	Volumetric Strain - &B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - &B CSR	Settlement (in) - Youd CSR	γ _{lim}	E _a	γ _{max}	Volumetric Strain, ε _v - &B approximation	E _{ult}	γ _{cs,max}	Volumetric Strain, ε _v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - &B	Settlement (in) - Youd	PI (%)	Filter (remove using "x")																	
CH	2.5	4.5	5931.6	313	0	313	8	70	1.00	0.34	1.70	1.24	1.00	0.75	Yes	1.14	14.4	0.00	14.4	20.0	65.9	No Liq (AWT)	0.13	1.10	1.00	#####	#####	0.99	0.336	1.632	13.8	21.61	No Liq (AWT)	60.0	1.00	#####	#####	0.28	0.29	No Liq	No Liq	1.00	0.00	0.00	0.159	0.523	#####	#####	0.692	#####	#####	1.00	0.00	0.00	19	X																	
CH	5.0	2.5	5929.1	625	56	569	11	70	0.99	0.37	1.70	1.24	1.00	0.75	Yes	1.21	20.9	0.00	20.9	26.5	75.9	No Liq (Clayey)	0.17	1.10	1.00	#####	#####	0.99	0.367	1.498	18.5	27.15	No Liq (Clayey)	67.3	1.00	#####	#####	0.30	0.32	No Liq	No Liq	1.00	0.00	0.00	0.073	0.141	#####	#####	0.479	#####	#####	1.00	0.00	0.00	19	X																	
CL	7.5	5	5926.6	938	212	725	7	70	0.98	0.43	1.70	1.24	1.00	0.75	Yes	1.12	12.4	0.00	12.4	18.0	62.5	No Liq (Clayey)	0.12	1.10	1.00	#####	#####	0.98	0.429	1.426	10.4	17.47	No Liq (Clayey)	54.0	1.00	#####	#####	0.35	0.37	No Liq	No Liq	1.00	0.00	0.00	0.199	0.626	#####	#####	0.821	#####	#####	1.00	0.00	0.00	19	X																	
CL	12.5	5	5921.6	1563	524	1038	7	70	0.97	0.49	1.46	1.24	1.00	0.80	Yes	1.11	11.2	0.00	11.2	16.8	60.4	No Liq (Clayey)	0.12	1.08	1.00	#####	#####	0.97	0.494	1.301	10.0	17.01	No Liq (Clayey)	53.2	1.00	#####	#####	0.41	0.43	No Liq	No Liq	1.00	0.00	0.00	0.227	0.683	#####	#####	0.834	#####	#####	1.00	0.00	0.00	19	X																	
CL	15.0	5	5919.1	1875	680	1195	7	70	0.96	0.51	1.35	1.24	1.00	0.85	Yes	1.11	11.0	0.00	11.0	16.6	60.1	No Liq (Clayey)	0.12	1.07	1.00	#####	#####	0.97	0.512	1.247	10.2	17.21	No Liq (Clayey)	53.6	1.00	#####	#####	0.43	0.45	No Liq	No Liq	1.00	0.00	0.00	0.231	0.690	#####	#####	0.828	#####	#####	1.00	0.00	0.00	19	X																	
SP-SM	25.0	3.5	5909.1	3125	1304	1821	11	9	0.91	0.53	1.07	1.24	1.00	0.95	Yes	1.16	16.1	0.00	16.1	16.8	60.5	0.17	0.12	1.02	1.00	0.19	0.37	0.94	0.546	1.068	16.0	16.83	0.18	53.0	1.00	0.21	0.38	0.47	0.48	0.017	0.017	1.00	0.71	0.71	0.226	0.681	0.226	0.026	0.838	10.0	0.032	1.00	1.11	1.34																			
SP-SM	30.0	10	5904.1	3750	1616	2134	11	10	0.88	0.53	1.00	1.24	1.00	0.95	Yes	1.15	14.7	0.00	14.7	15.9	58.8	0.16	0.11	1.00	1.00	0.18	0.35	0.93	0.552	0.996	14.8	15.94	0.17	51.5	1.00	0.19	0.35	0.47	0.48	0.018	0.018	1.00	2.16	2.16	0.250	0.721	0.250	0.028	0.860	10.0	0.033	1.00	3.31	3.97																			
ML	40.0	11.5	5894.1	5000	2240	2760	8	50	0.83	0.51	0.86	1.24	1.00	1.00	Yes	1.10	9.4	0.00	9.4	15.0	57.1	No Liq (Clayey)	0.11	0.97	1.00	#####	#####	0.85	0.52	0.878	9.5	16.46	No Liq (Clayey)	52.4	0.92	#####	#####	0.47	0.49	No Liq	No Liq	1.00	0.00	0.00	0.275	0.759	#####	#####	0.848	#####	#####	1.00	0.00	0.00	12	X																	
SM	50.0	3.5	5884.1	6250	2864	3386	25	45	0.78	0.49	0.85	1.24	1.00	1.00	Yes	1.30	34.3	0.00	34.3	39.9	93.1	4.01	0.30	0.86	1.00	3.82	7.87	0.77	0.479	0.786	31.5	42.84	No Liq	84.5	0.83	#####	#####	0.51	0.50	(N1)60cs>31	No Liq	1.00	0.00	0.00	0.009	-0.796	0.000	0.000	-0.281	#####	#####	1.00	0.00	0.00																			
SM	55.0	4.5	5879.1	6875	3176	3699	15	5	0.75	0.47	0.77	1.24	1.00	1.00	Yes	1.17	16.6	0.00	16.6	16.6	60.1	0.17	0.12	0.93	2.00	0.35	0.75	0.73	0.456	0.746	16.1	16.12	0.17	51.8	0.85	0.17	0.36	0.46	0.47	0.017	1.00	0.92	0.97	0.231	0.690	0.231	0.027	0.856	10.0	0.033	1.00	1.44	1.77																				
GM	65.0	5	5869.1	8125	3800	4325	100	10	0.70	0.45	1.24	1.24	1.00	1.00	Yes	1.30	198.8	0.00	198.8	199.9	208.5	No Liq	-0.06	1.04	3.00	#####	#####	0.65	0.41	0.678	108.9	112.1	No Liq	136.7	0.75	#####	#####	0.39	0.48	No Liq	No Liq	1.00	0.00	0.00	0.000	-16.247	#####	#####	-4.754	#####	#####	1.00	0.00	0.00																			
GM	70.0	5	5864.1	8750	4112	4638	100	10	0.68	0.43	1.28	1.24	1.00	1.00	Yes	1.30	206.2	0.00	206.2	207.3	212.3	No Liq	-0.06	1.04	4.00	#####	#####	0.60	0.385	0.649	104.1	107.3	No Liq	133.7	0.73	#####	#####	0.38	0.46	No Liq	No Liq	1.00	0.00	0.00	0.000	-17.033	#####	#####	-4.410	#####	#####	1.00	0.00	0.00																			
																																	3.8		3.8																																			5.9		7.1	

Table X-X: Semi-Empirical Liquefaction Potential Evaluation
Project Bear Lake Marina Expansion (22-1522)



PGA (g) = 0.52

by: rrb

Test hole = 23-TH-09

Earthquake magnitude, M_R = 7.1

Date: 2/21

Ground surface elev. (ft) = 5919.3

Liquefaction, MSF (Youd) = 1.15

Liquefaction, MSF (Idriss & Boulanger) = 1.11

Soil Layer									SPT Liquefaction, Idriss and Boulanger																SPT Liquefaction, Youd et al.										Tokimatsu & Seed (1987) Settlement						Ishihara & Yoshimine (1992) Settlement															
Soil layer	Depth (ft)	Layer Thickness (ft)	Elev. (ft)	total stress s _{vo} (psf)	Pore pressure, u (psf)	effective stress s' _{vo} (psf)	SPT Blow count, Nm	Fines content (%)	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M , σ' _{vc}	Overburden, Cn	Energy ratio, Ce	Borehole, Cb	rod length, Cr	Unused room for liners in SPT?	Liner, Cs	Calculated (N1)60	(N1)60 Convergence Difference	Used (N1)60	Clean sand, (N1)60cs	Relative Density, Dr (%) &B (2008)	Cyclic Resistance Ratio, CRR _{M=7.5, σ'_{vc}=1}	C _σ	Overburden correction factor, K _σ	Static shear stress corr. factor (sands), K _σ	Cyclic Resistance Ratio, CRR _M , σ' _{vc}	F.S. Liquefaction	Stress reduction coefficient, rd	Cyclic stress ratio, CSR _M	Overburden, Cn	(N1)60	Clean sand, (N1)60cs	Cyclic Resistance Ratio, CRR _{7.5}	Relative Density, Dr (%) Skempton (86)	K _σ	Cyclic Resistance Ratio, CRR _M , σ' _v	F.S. Liquefaction	CSR _{M=7.5, σ'_{vc}=1} I&B	CSR _{M=7.5, σ'_{vc}=1} Youd	Volumetric Strain - I&B CSR	Volumetric Strain - Youd CSR	Depth Weighting Factor	Settlement (in) - I&B CSR	Settlement (in) - Youd CSR	y _{lim}	F _α	y _{max}	Volumetric Strain, ε _v - I&B approximation	F _{ult}	y _{o,max}	Volumetric Strain, ε _v - Yoshimine (2006)	Depth Weighting Factor	Settlement (in) - I&B	Settlement (in) - Youd	P1 (%)	Filter (remove using "x")
SC-SM	2.5	4.75	5916.8	313	156	157	6	30	1.00	0.67	1.70	1.24	1.00	0.75	Yes	1.10	10.4	0.00	10.4	15.8	58.6	0.16	0.11	1.10	1.00	0.20	0.29	0.99	0.671	1.7	10.4	16.75	0.18	52.8	1.00	0.20	0.30	0.55	0.59	0.018	0.017	1.00	1.03	0.97	0.252	0.726	0.252	0.028	0.840	10.0	0.032	1.00	1.58	1.83	0	
SC-SM	5.0	2.25	5914.3	625	312	313	9	31	0.99	0.67	1.70	1.24	1.00	0.75	Yes	1.17	16.5	0.00	16.5	21.9	69.0	No Liq (Clayey)	0.14	1.10	1.00	#####	#####	0.99	0.667	1.632	15.9	23.2	No Liq (Clayey)	62.2	1.00	#####	#####	0.55	0.58	No Liq	No Liq	1.00	0.00	0.00	0.128	0.418	#####	#####	0.635	#####	#####	1.00	0.00	0.00	7	X
SW-SM	7.0	2.5	5912.3	875	437	438	42	8	0.99	0.67	1.29	1.24	1.00	0.75	Yes	1.30	65.4	0.00	65.4	65.7	119.5	No Liq	-0.56	0.11	1.00	#####	#####	0.98	0.664	1.564	79.1	80.37	No Liq	115.7	1.00	#####	#####	5.30	0.58	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.924	#####	#####	-2.565	#####	#####	1.00	0.00	0.00		
CL	10.0	2.5	5909.3	1250	624	626	8	80	0.98	0.66	1.70	1.24	1.00	0.80	Yes	1.16	15.5	0.00	15.5	21.1	67.7	No Liq (Clayey)	0.14	1.10	1.00	#####	#####	0.98	0.659	1.471	13.4	21.12	No Liq (Clayey)	59.3	1.00	#####	#####	0.54	0.58	No Liq	No Liq	1.00	0.00	0.00	0.141	0.465	#####	#####	0.709	#####	#####	1.00	0.00	0.00	23	X
CL	12.5	10	5906.8	1563	780	783	31	80	0.97	0.65	1.27	1.24	1.00	0.80	Yes	1.30	50.5	0.00	50.5	56.0	110.4	No Liq (Clayey)	-5.40	-4.37	1.00	#####	#####	0.97	0.655	1.401	55.8	71.96	No Liq (Clayey)	109.5	1.00	#####	#####	-0.13	0.57	No Liq	No Liq	1.00	0.00	0.00	0.000	-2.088	#####	#####	-2.017	#####	#####	1.00	0.00	0.00	20	X
CL	20.0	5	5899.3	2500	1248	1252	100	80	0.93	0.63	0.93	1.24	1.00	0.95	Yes	1.30	142.3	0.00	142.3	147.8	179.3	No Liq (Clayey)	-0.08	0.96	1.00	#####	#####	0.95	0.643	1.228	187.3	229.7	No Liq (Clayey)	195.7	1.00	#####	#####	0.59	0.56	No Liq	No Liq	1.00	0.00	0.00	0.000	-10.826	#####	#####	#####	#####	#####	1.00	0.00	0.00	20	X
CL	25.0	5	5894.3	3125	1560	1565	94	80	0.91	0.61	0.96	1.24	1.00	0.95	Yes	1.30	138.3	0.00	138.3	143.9	176.8	No Liq (Clayey)	-0.09	0.97	1.00	#####	#####	0.94	0.636	1.134	162.6	200.1	No Liq (Clayey)	182.6	1.00	#####	#####	0.57	0.55	No Liq	No Liq	1.00	0.00	0.00	0.000	-10.420	#####	#####	#####	#####	#####	1.00	0.00	0.00	22	X
CL	30.0	5	5889.3	3750	1872	1878	100	80	0.88	0.60	0.98	1.24	1.00	0.95	Yes	1.30	149.7	0.00	149.7	155.3	183.7	No Liq (Clayey)	-0.08	0.99	1.00	#####	#####	0.93	0.628	1.054	160.7	197.9	No Liq (Clayey)	181.6	1.00	#####	#####	0.54	0.55	No Liq	No Liq	1.00	0.00	0.00	0.000	-11.584	#####	#####	#####	#####	#####	1.00	0.00	0.00	20	X
CL	35.0	5	5884.3	4375	2184	2191	100	80	0.86	0.58	1.01	1.24	1.00	1.00	Yes	1.30	161.6	0.00	161.6	167.2	190.6	No Liq (Clayey)	-0.07	1.00	1.00	#####	#####	0.89	0.6	0.984	158.0	194.6	No Liq (Clayey)	180.1	0.99	#####	#####	0.52	0.53	No Liq	No Liq	1.00	0.00	0.00	0.000	-12.813	#####	#####	#####	#####	#####	1.00	0.00	0.00	20	X
CL	40.0	5	5879.3	5000	2496	2504	72	80	0.83	0.56	1.01	1.24	1.00	1.00	Yes	1.30	116.5	0.00	116.5	122.0	162.9	No Liq (Clayey)	-0.11	1.02	2.00	#####	#####	0.85	0.573	0.923	106.7	133	No Liq (Clayey)	148.9	0.93	#####	#####	0.50	0.53	No Liq	No Liq	2.00	0.00	0.00	0.000	-8.228	#####	#####	-6.274	#####	#####	2.00	0.00	0.00	20	X
																																								1.0	1.0			1.6	1.8											



Appendix G

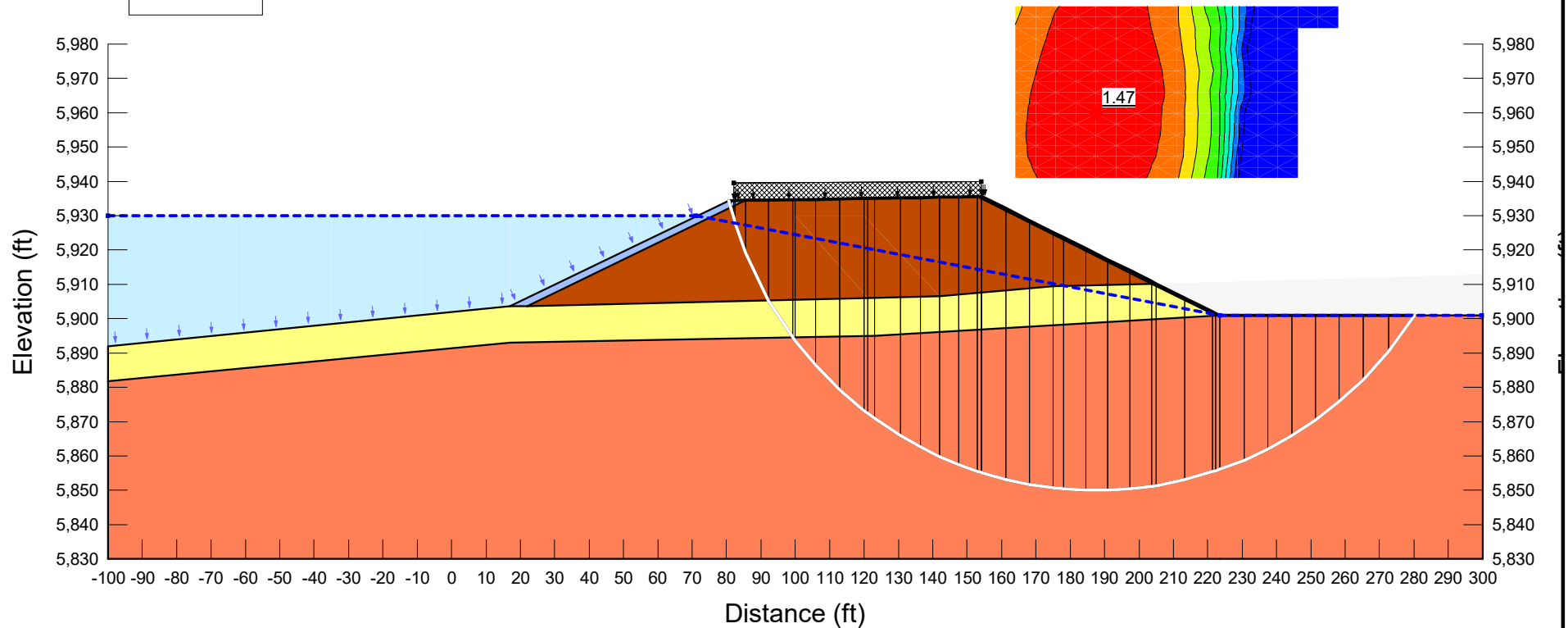
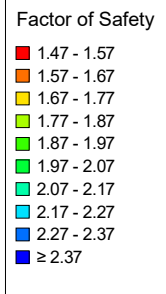
Stability Results – Breakwater Sections

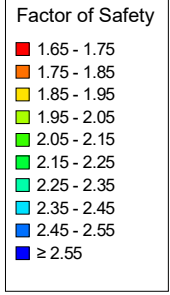
Bear Lake Marina Expansion

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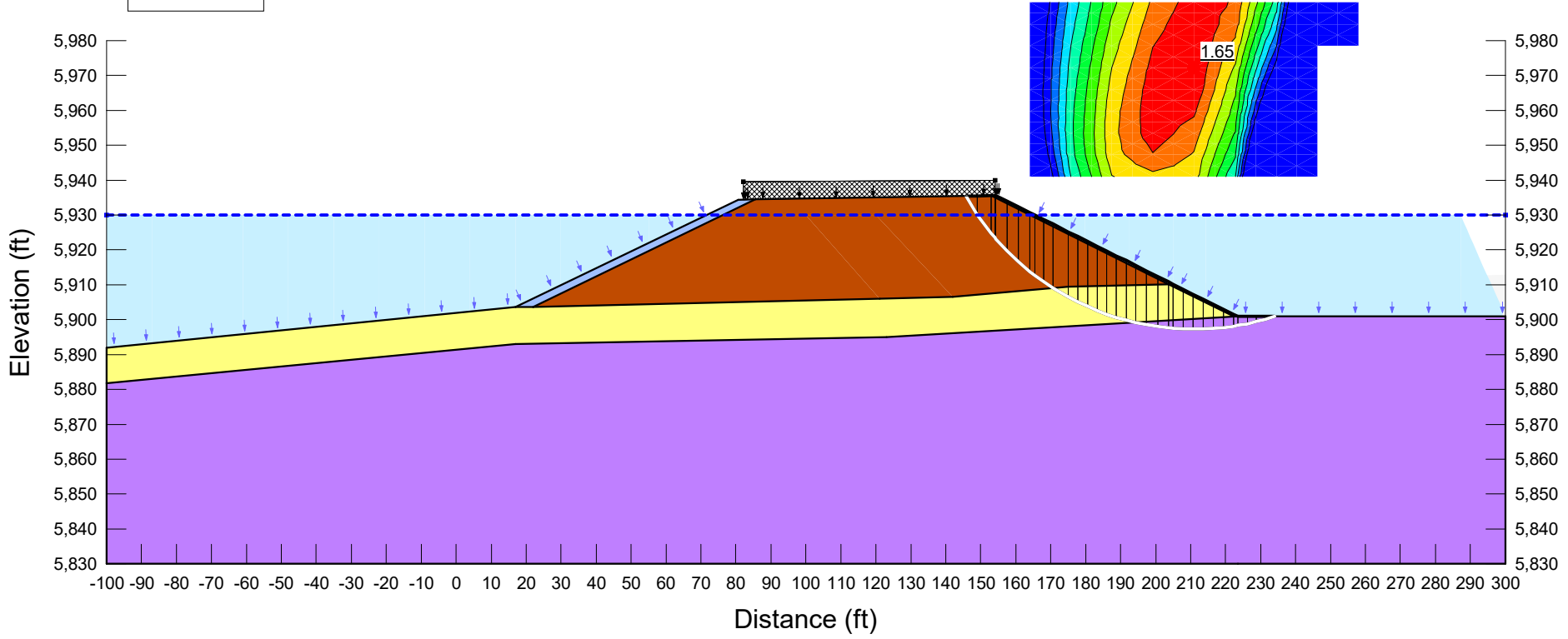
<u>Description</u>	<u>Page No.</u>
Section A-2 Stability Results	G-1
Section A-3 Stability Results	G-9
Section A-4 Stability Results	G-13
Breakwater Cross Sections (Provided by KH)	G-21

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Clayey Soil - Undrained	115	1,300	0
	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32

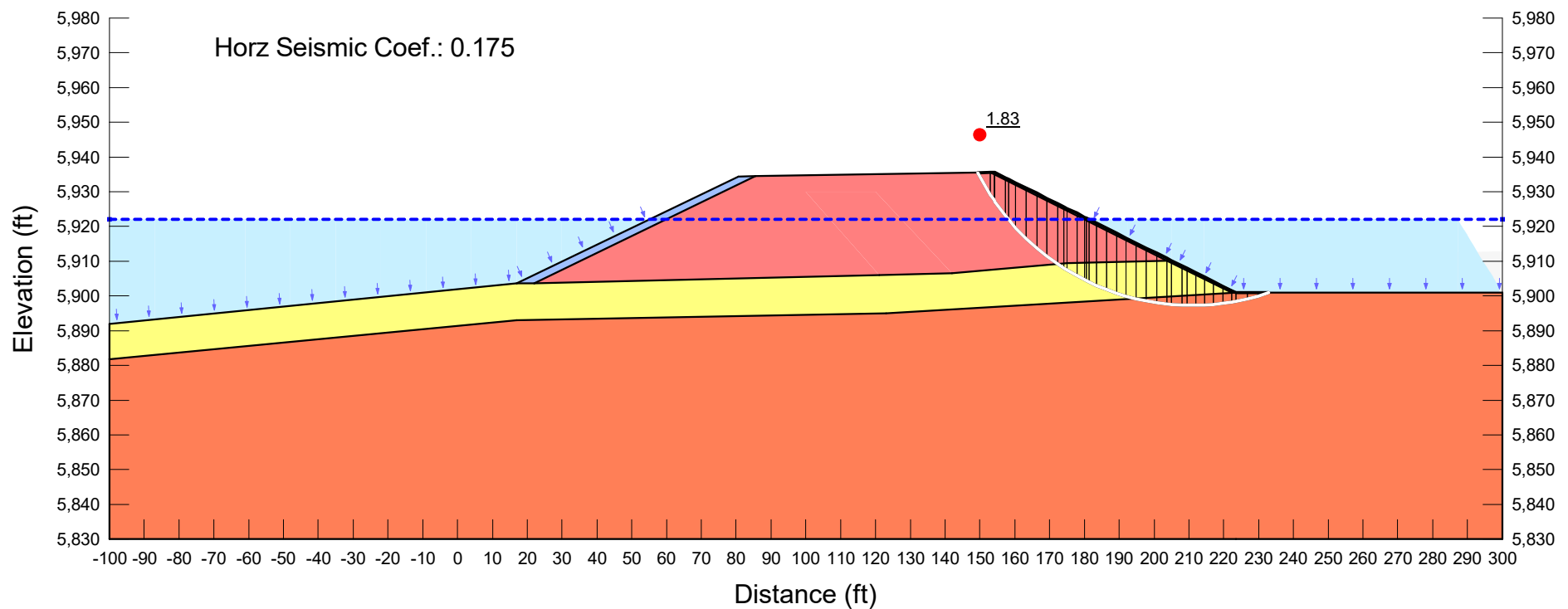
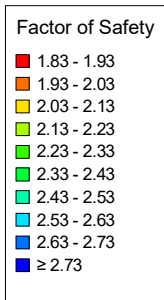




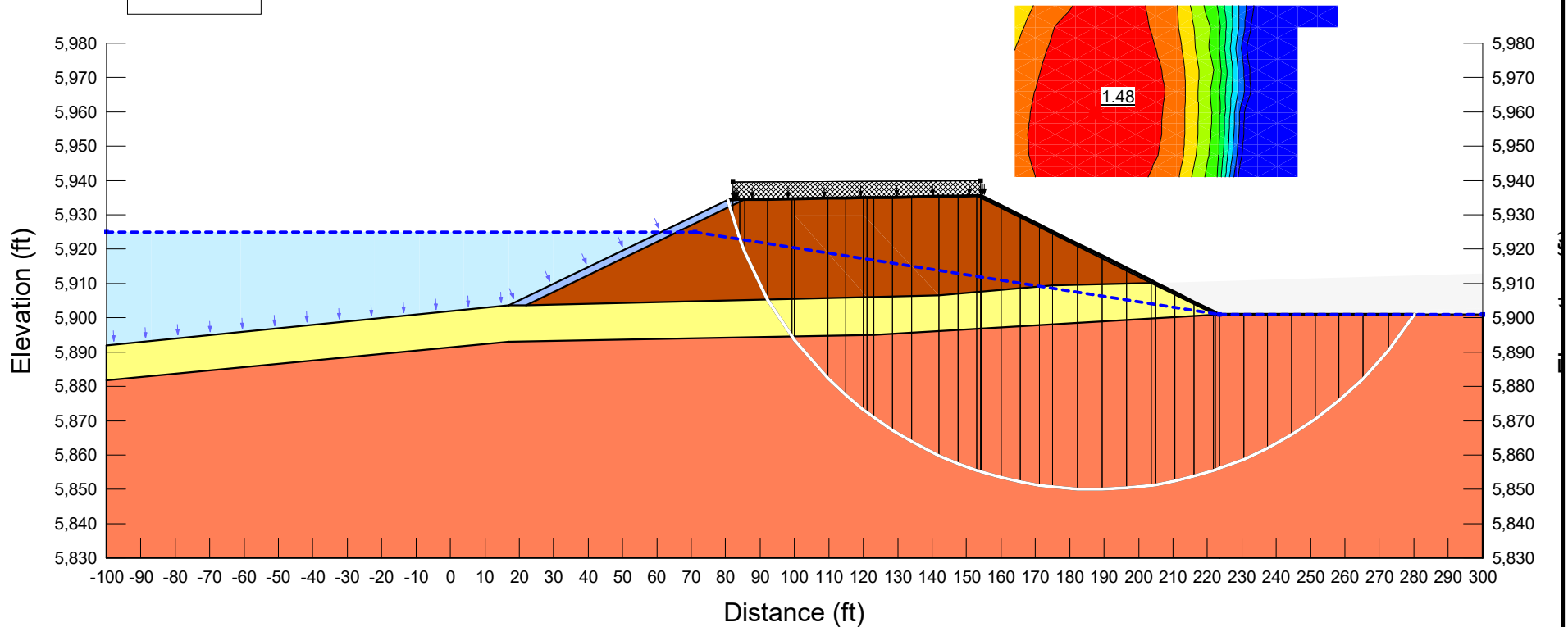
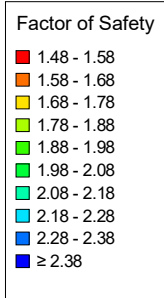
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	Clayey Soil - drained	115	100	28
	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32



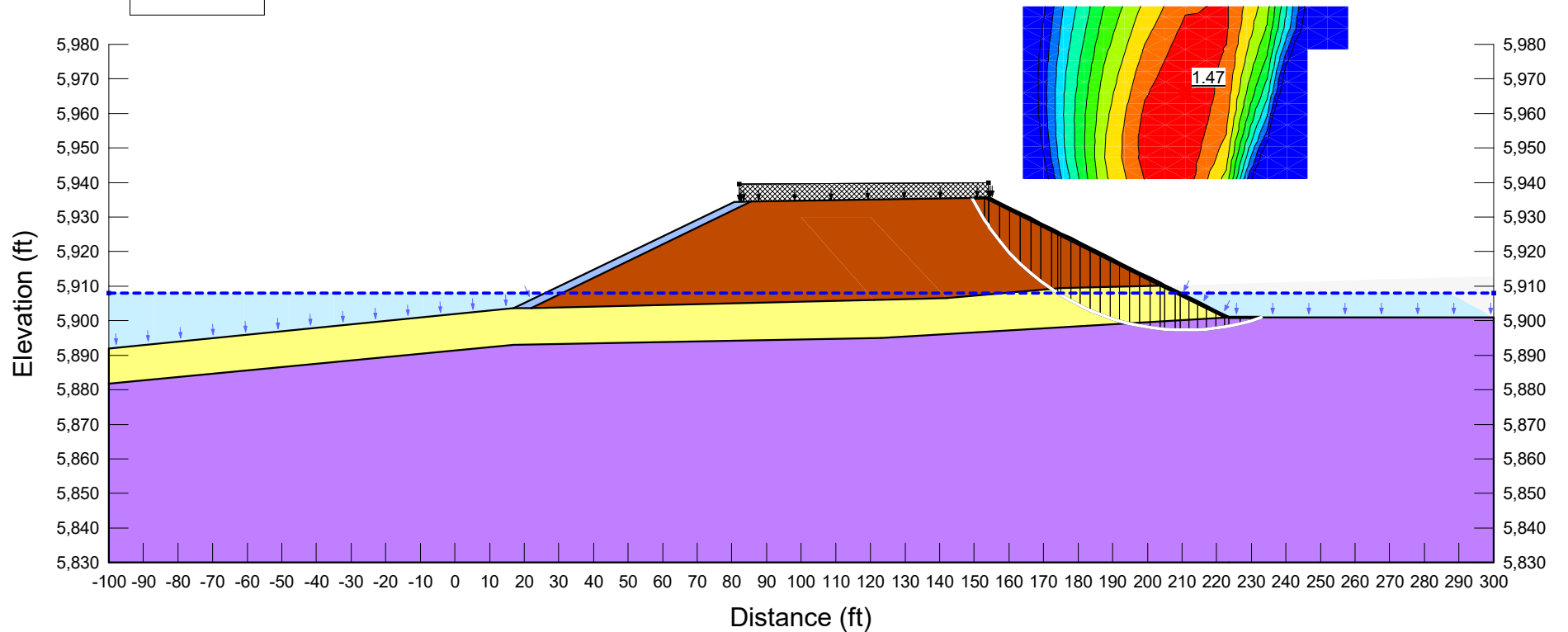
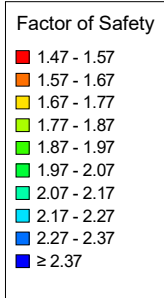
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	Clayey Soil - Undrained	115	1,300	0
	Dike Material (undrained_CU)	135	500	30
	Riprap	125	0	40
	Sand to sandy silt	115	0	32



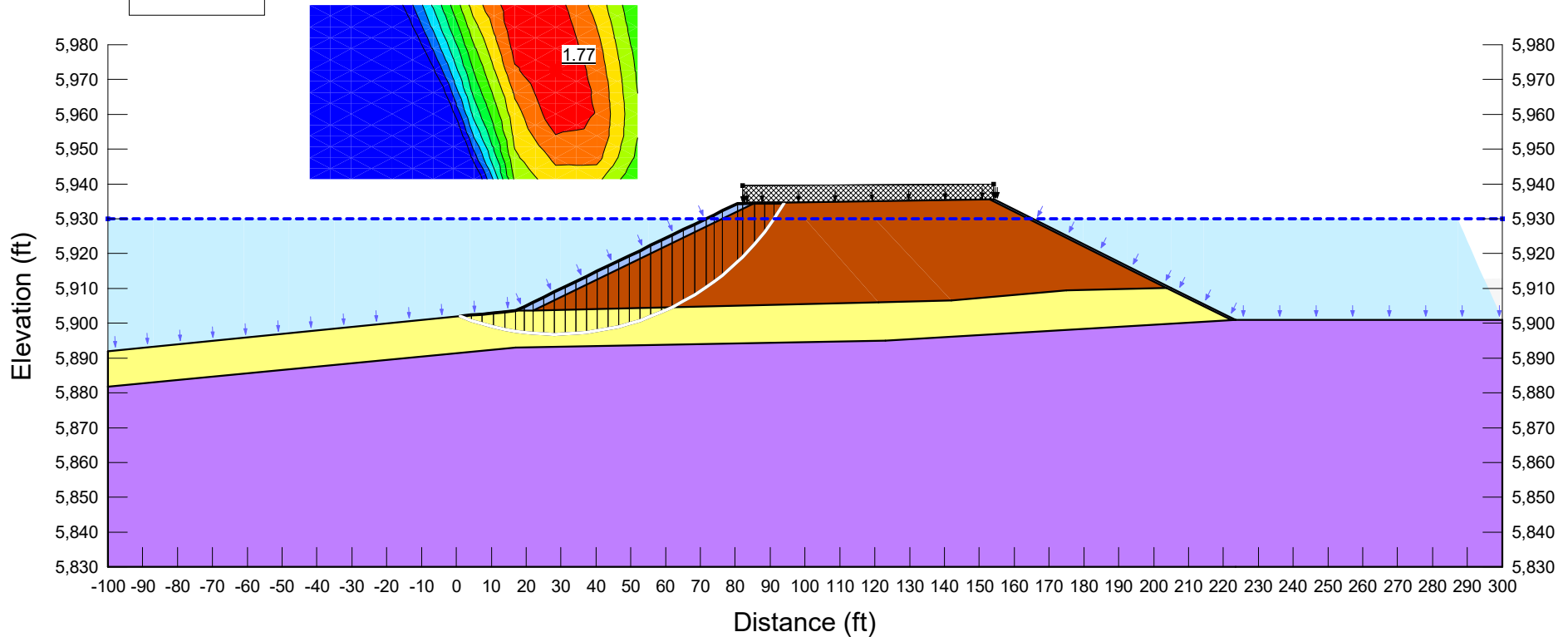
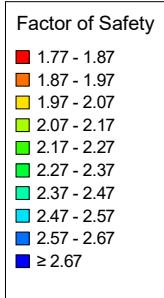
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	Clayey Soil - Undrained	115	1,300	0
	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32



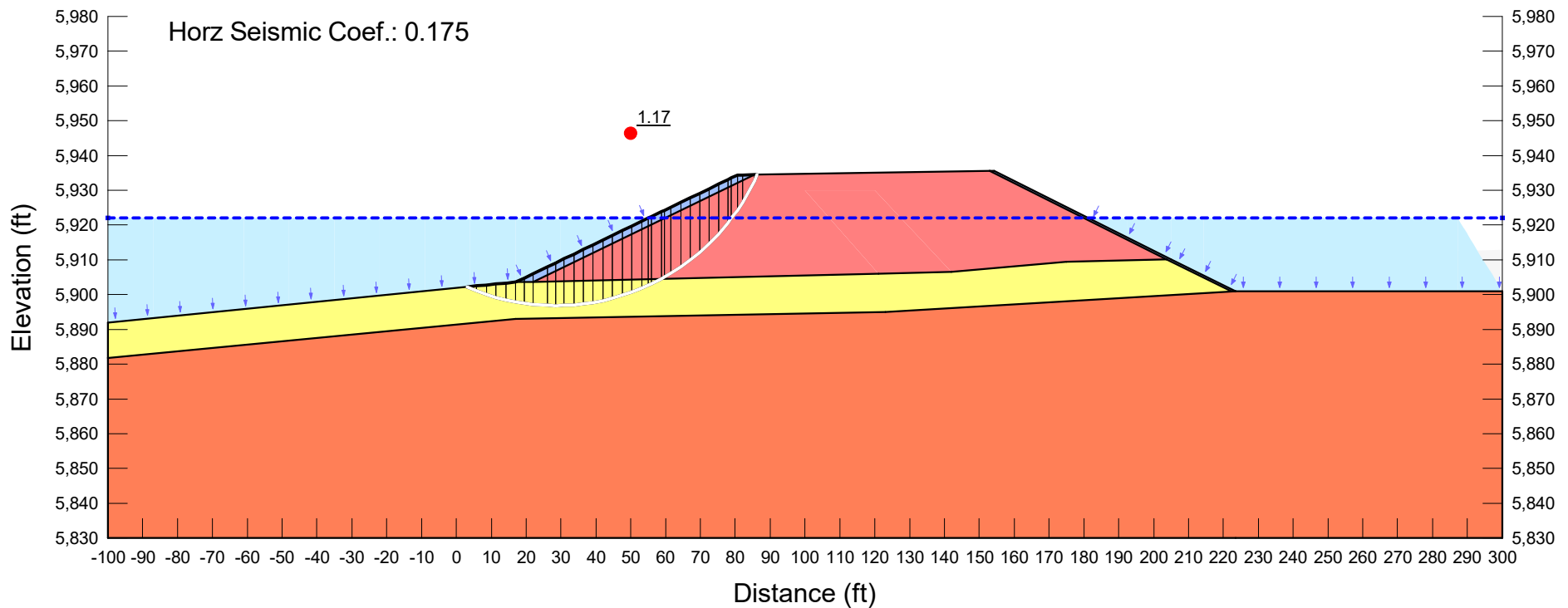
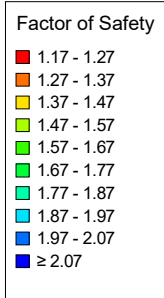
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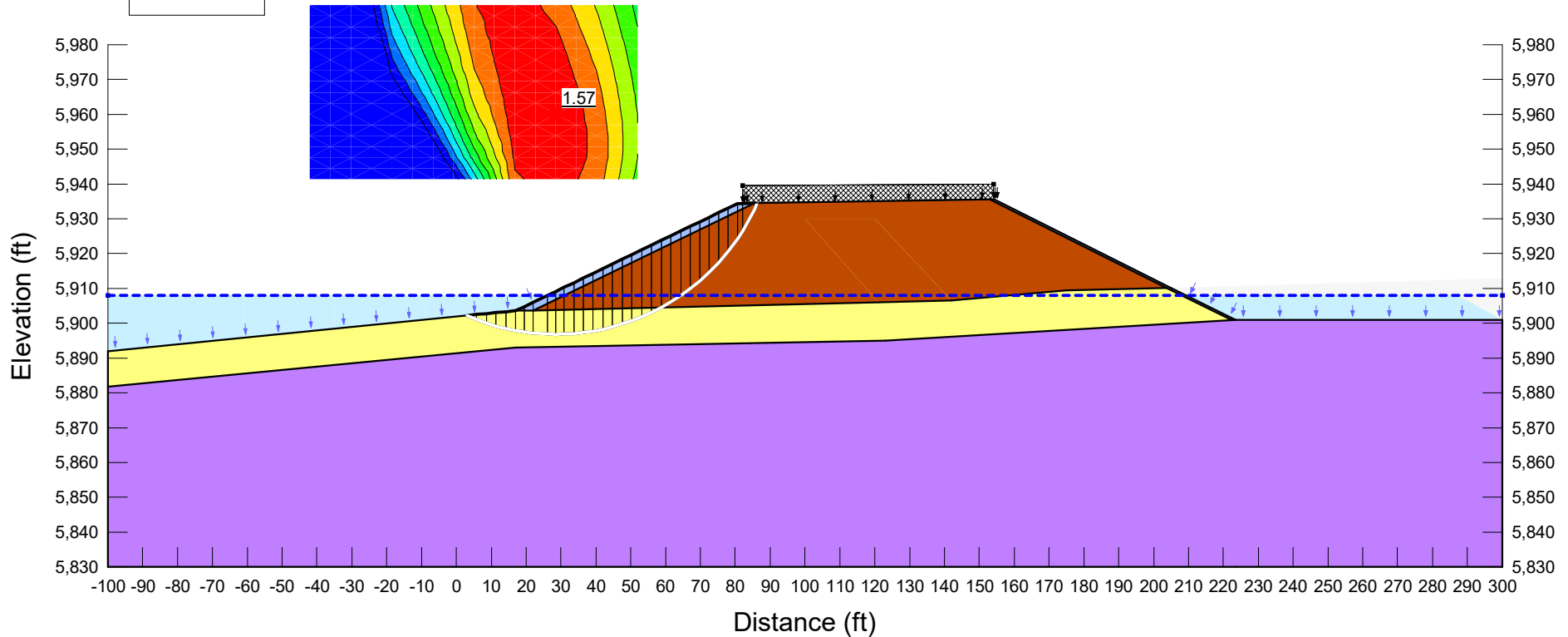
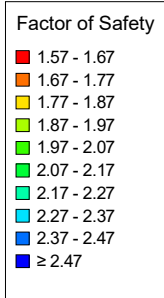
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	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32

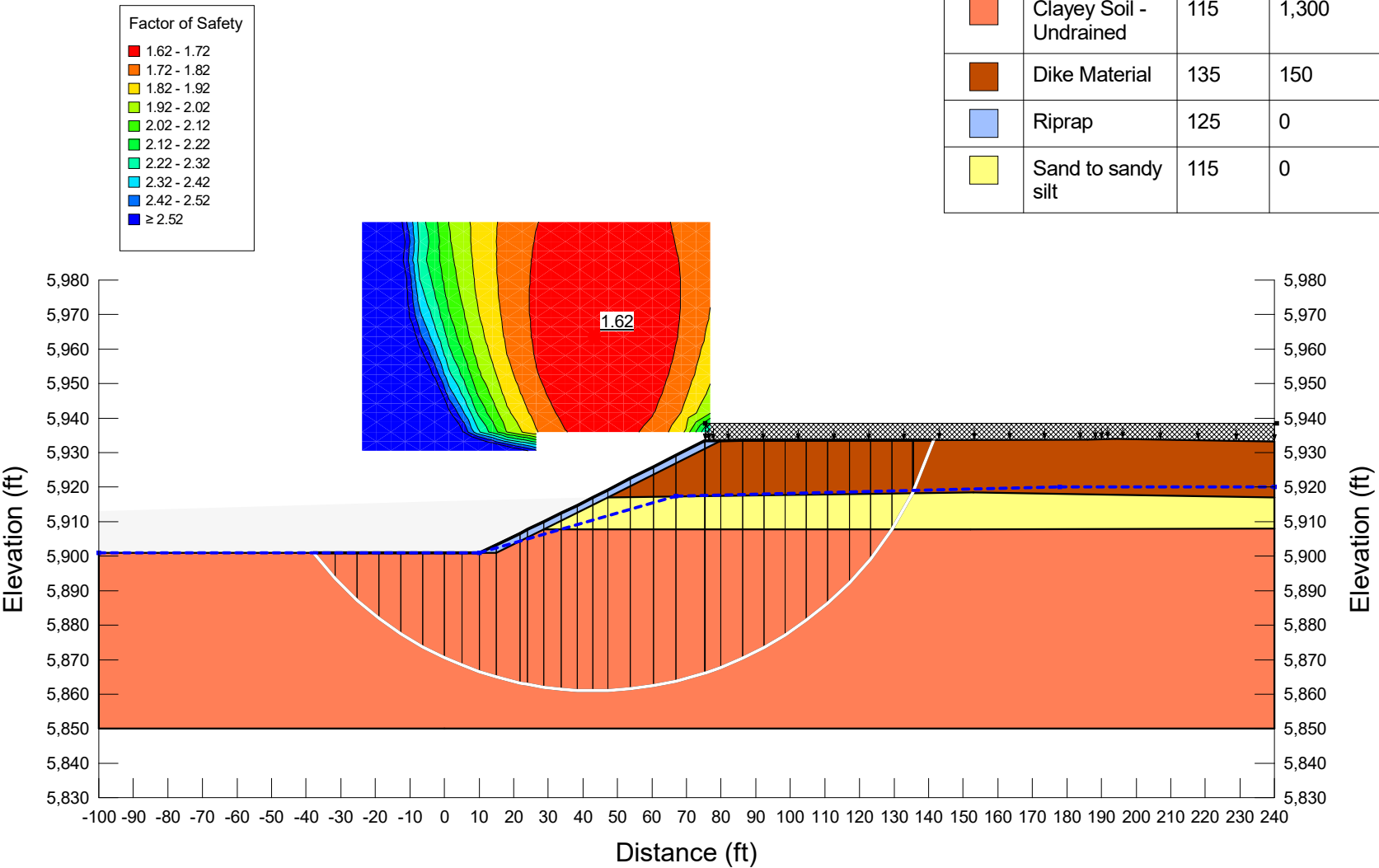


Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
■	Clayey Soil - Undrained	115	1,300	0
■	Dike Material (undrained_CU)	135	500	30
■	Riprap	125	0	40
■	Sand to sandy silt	115	0	32

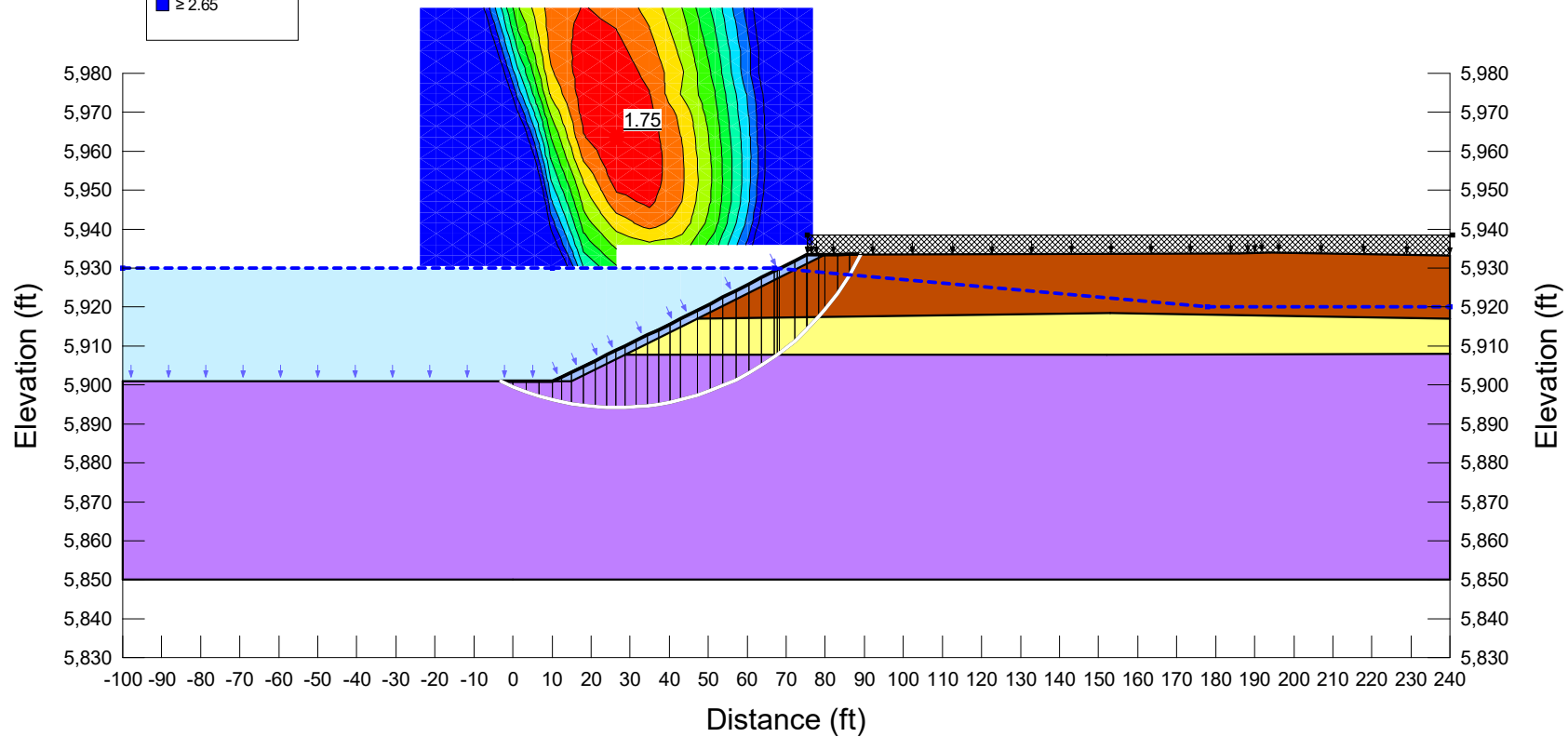
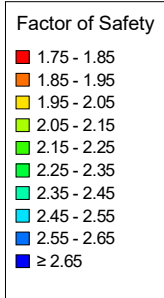


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	Clayey Soil - drained	115	100	28
	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32

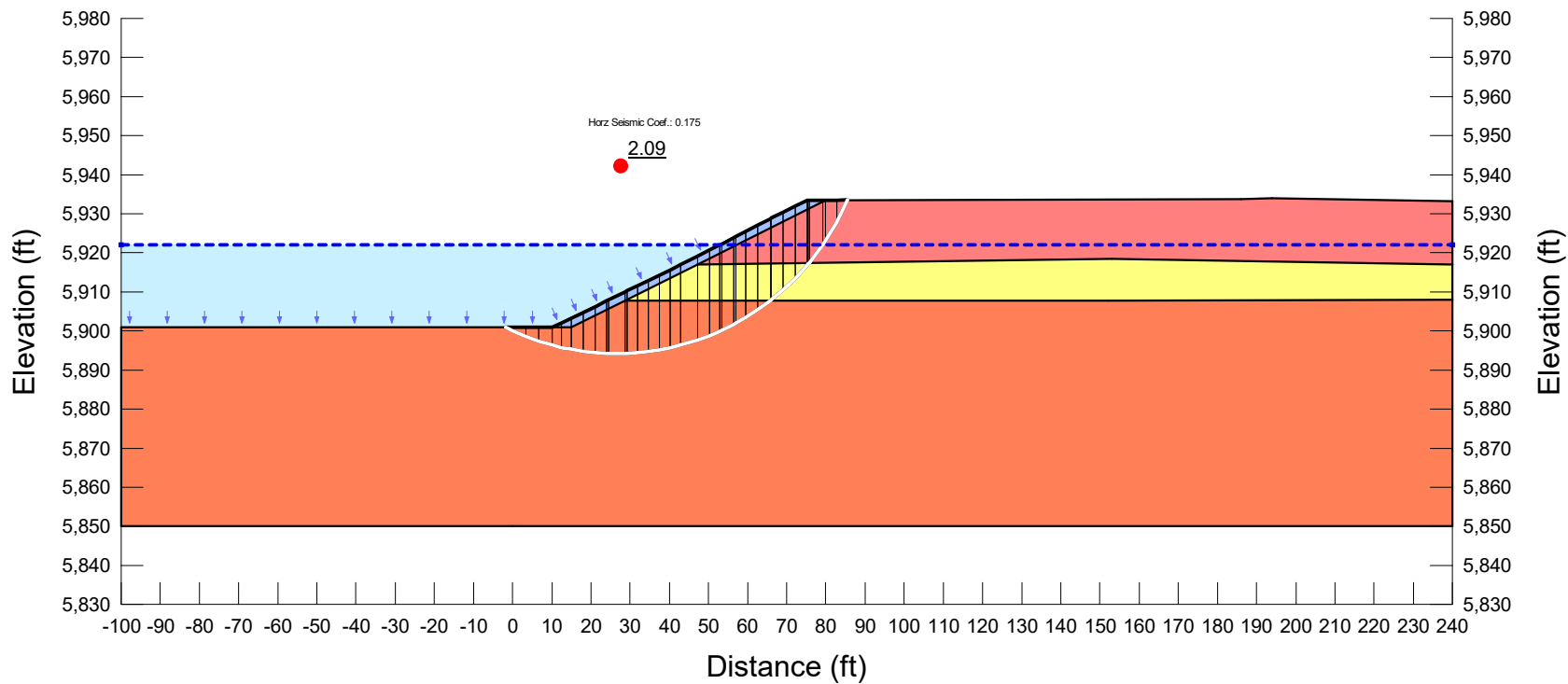
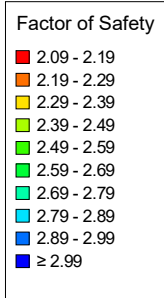




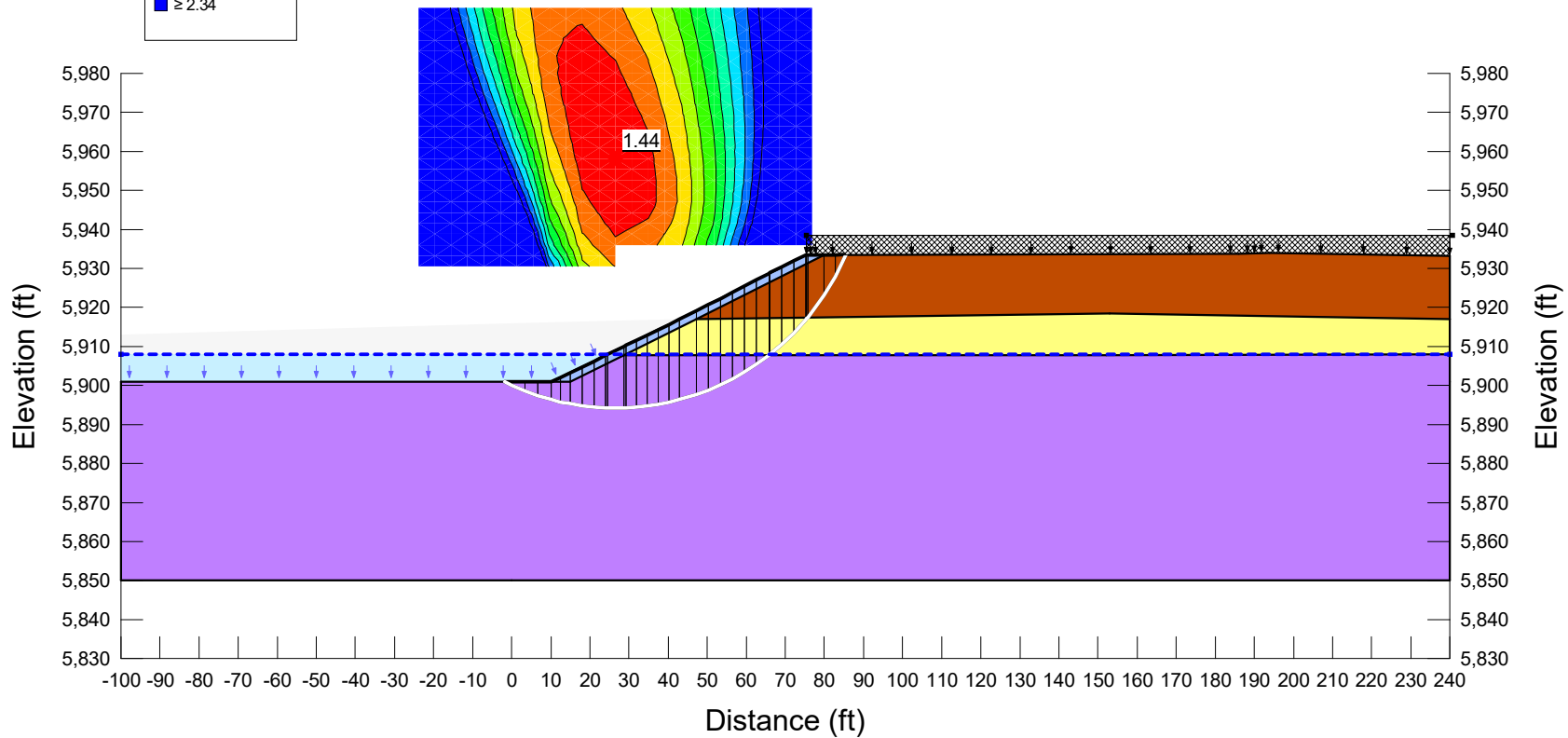
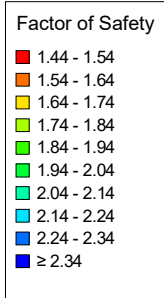
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	Dike Material	135	150	34
	Riprap	125	0	40
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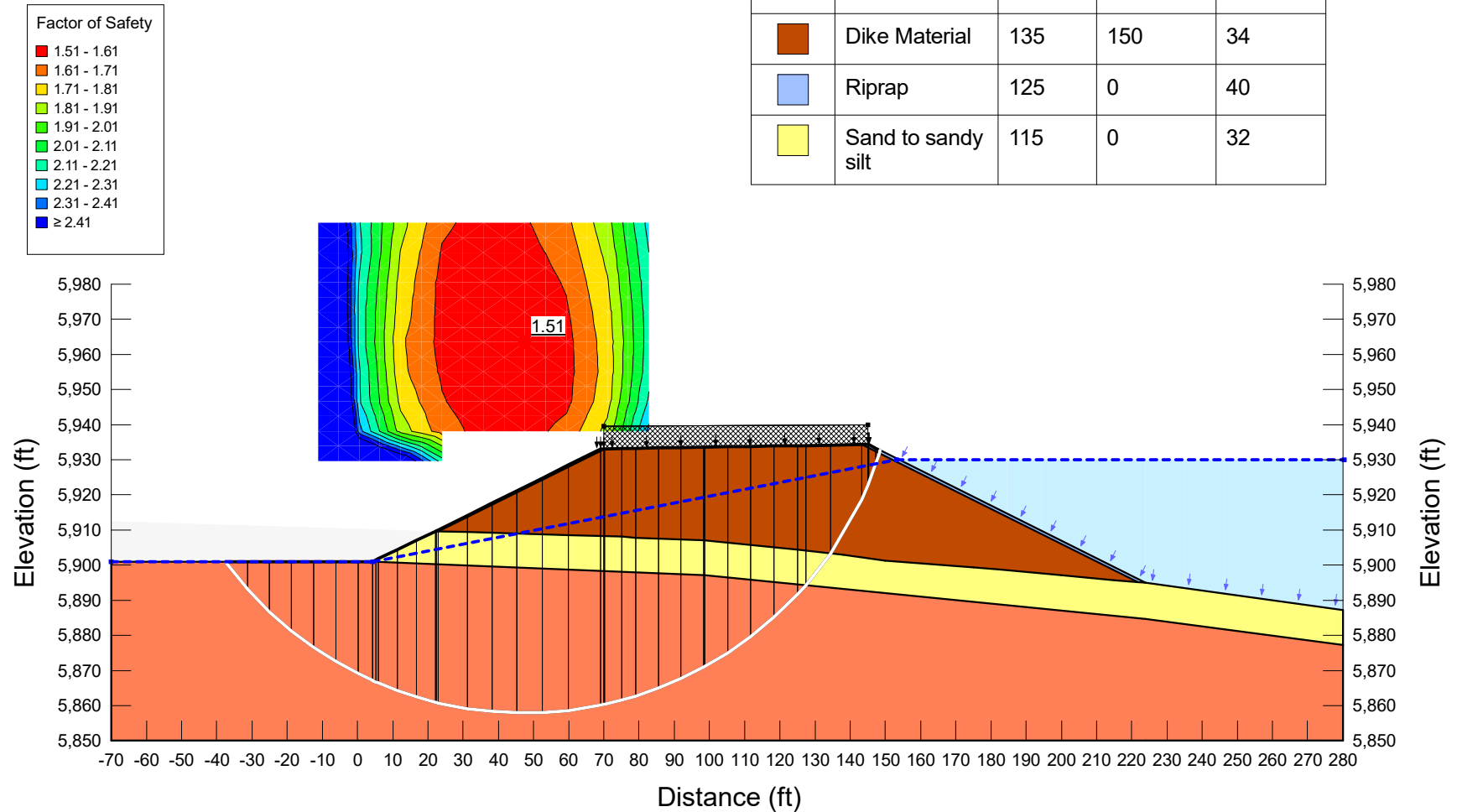
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	Clayey Soil - Undrained	115	1,300	0
	Dike Material (undrained_CU)	135	500	30
	Riprap	125	0	40
	Sand to sandy silt	115	0	32



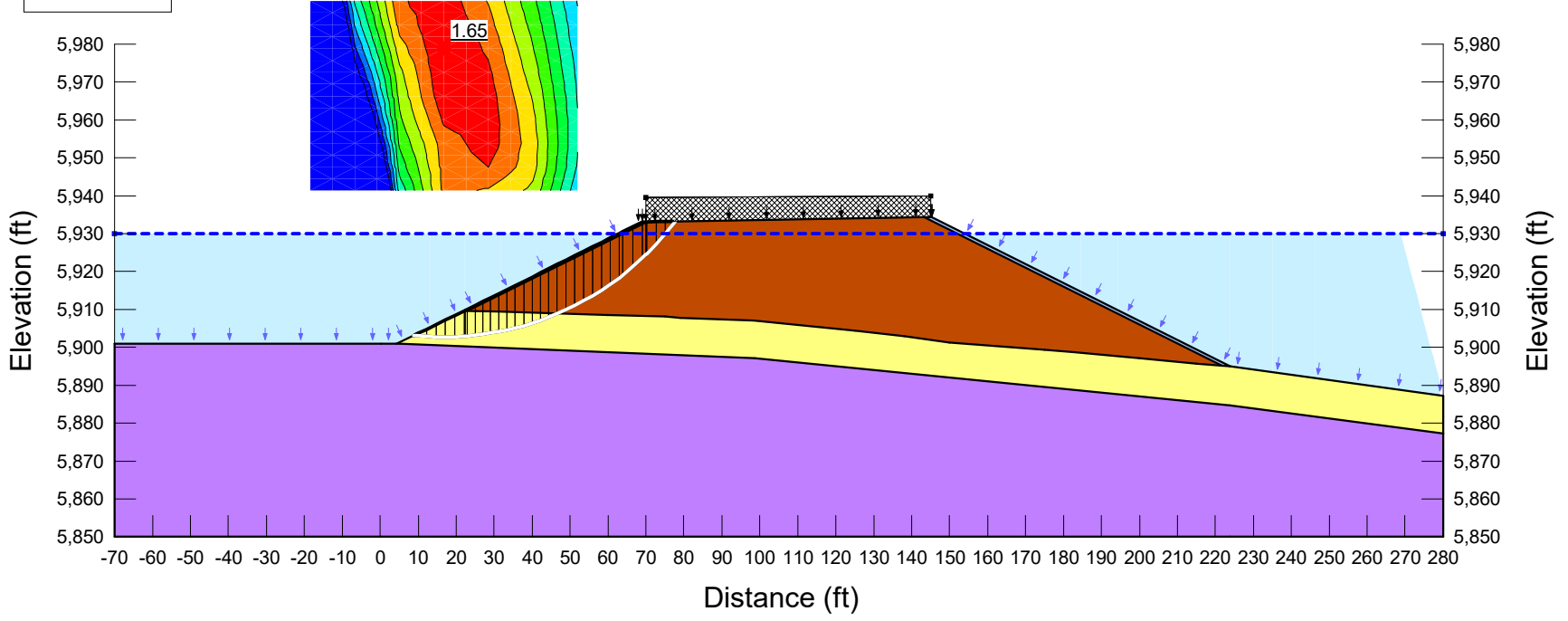
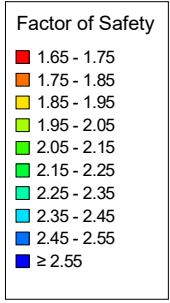
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	Clayey Soil - drained	115	100	28
	Dike Material	135	150	34
	Riprap	125	0	40
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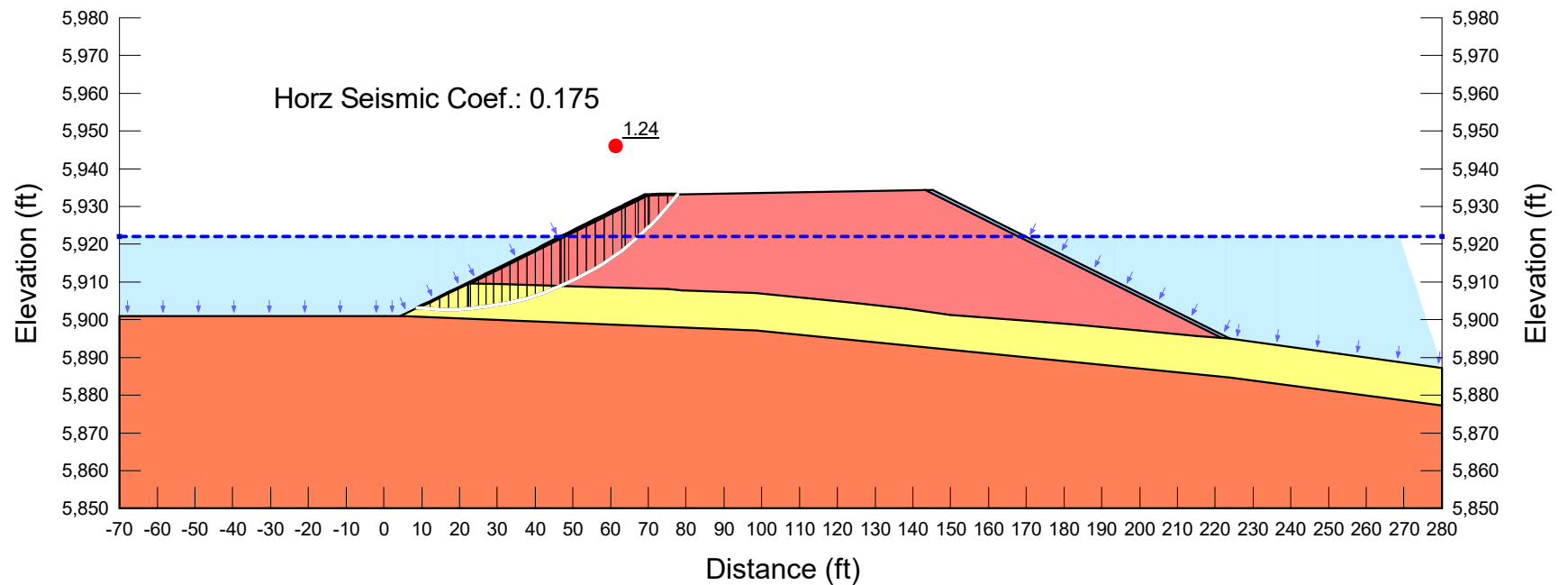
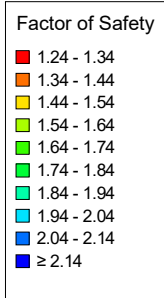
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	Clayey Soil - Undrained	115	1,300	0
	Dike Material	135	150	34
	Riprap	125	0	40
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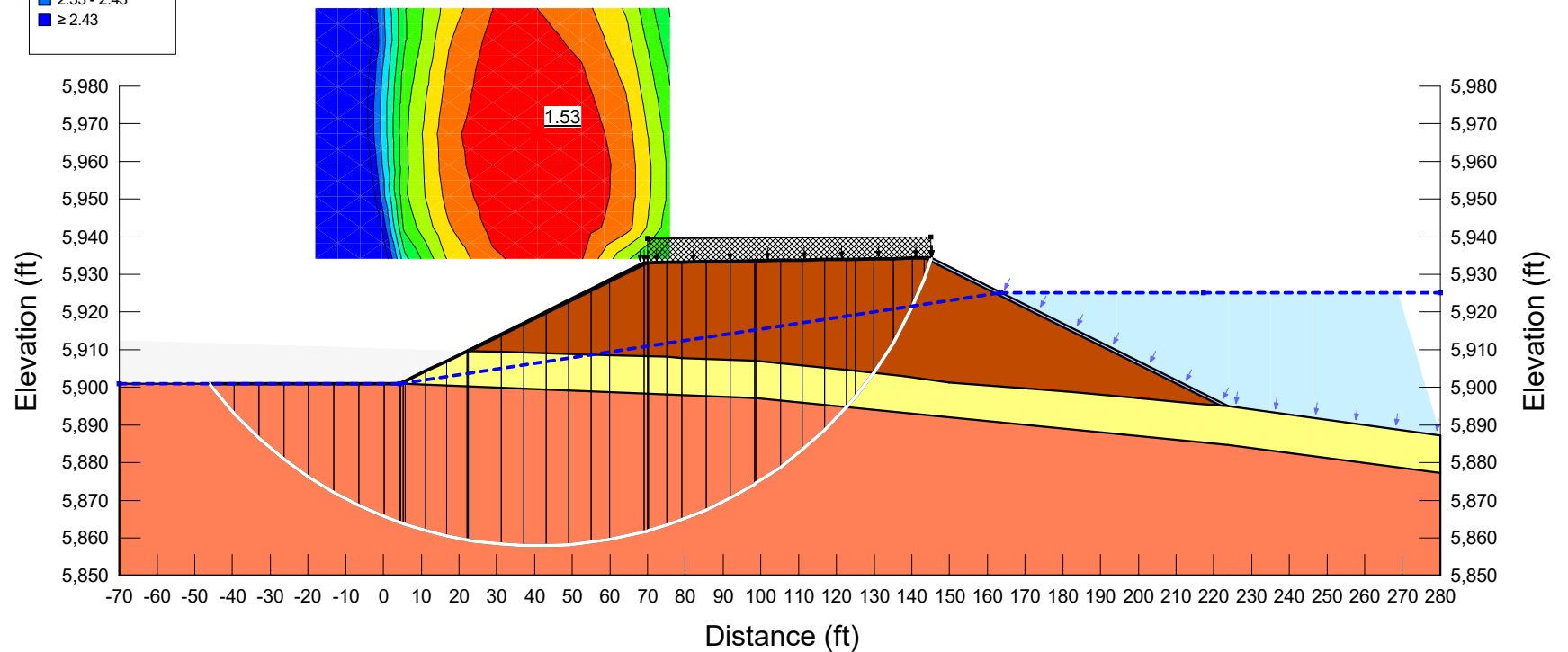
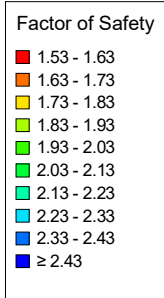
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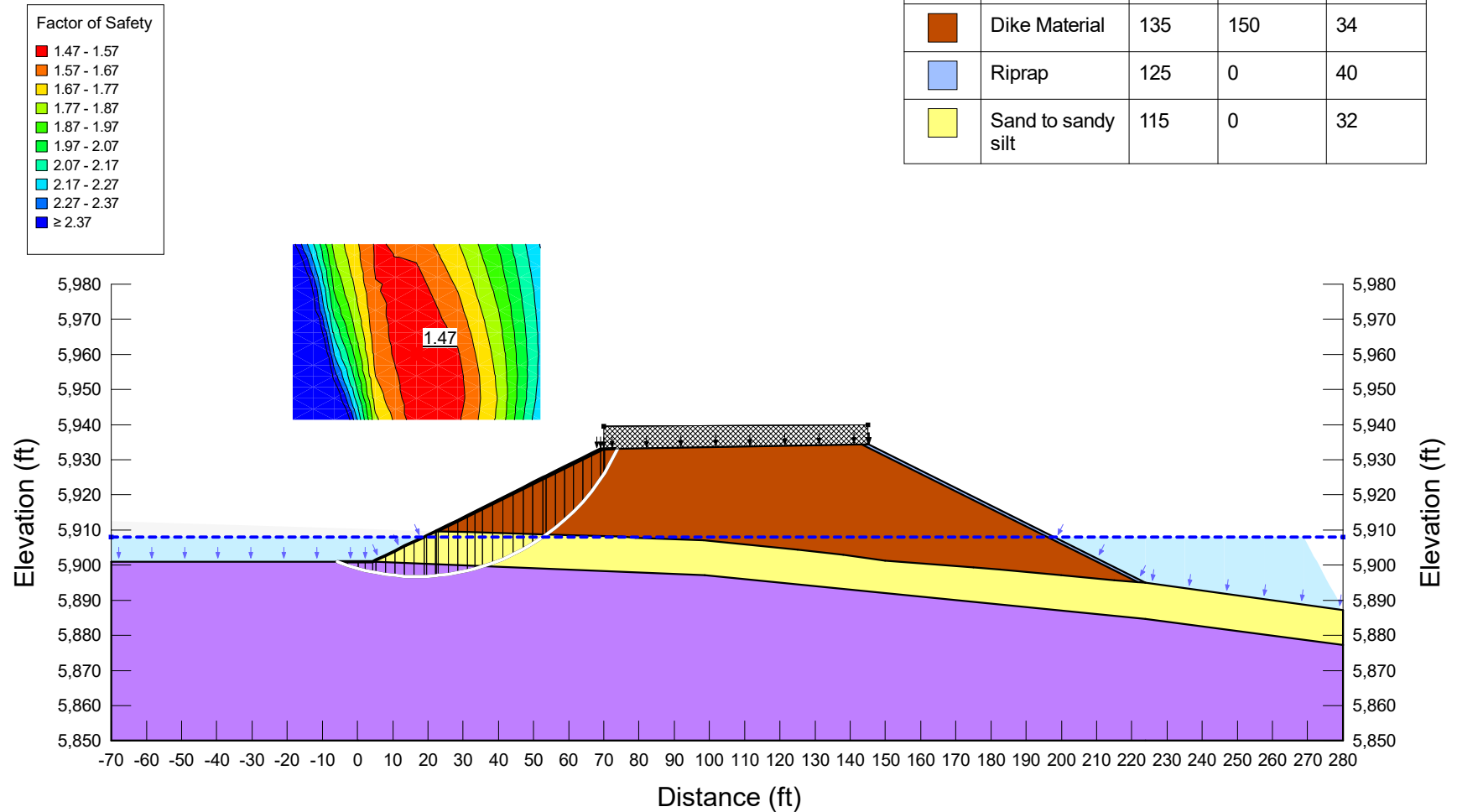
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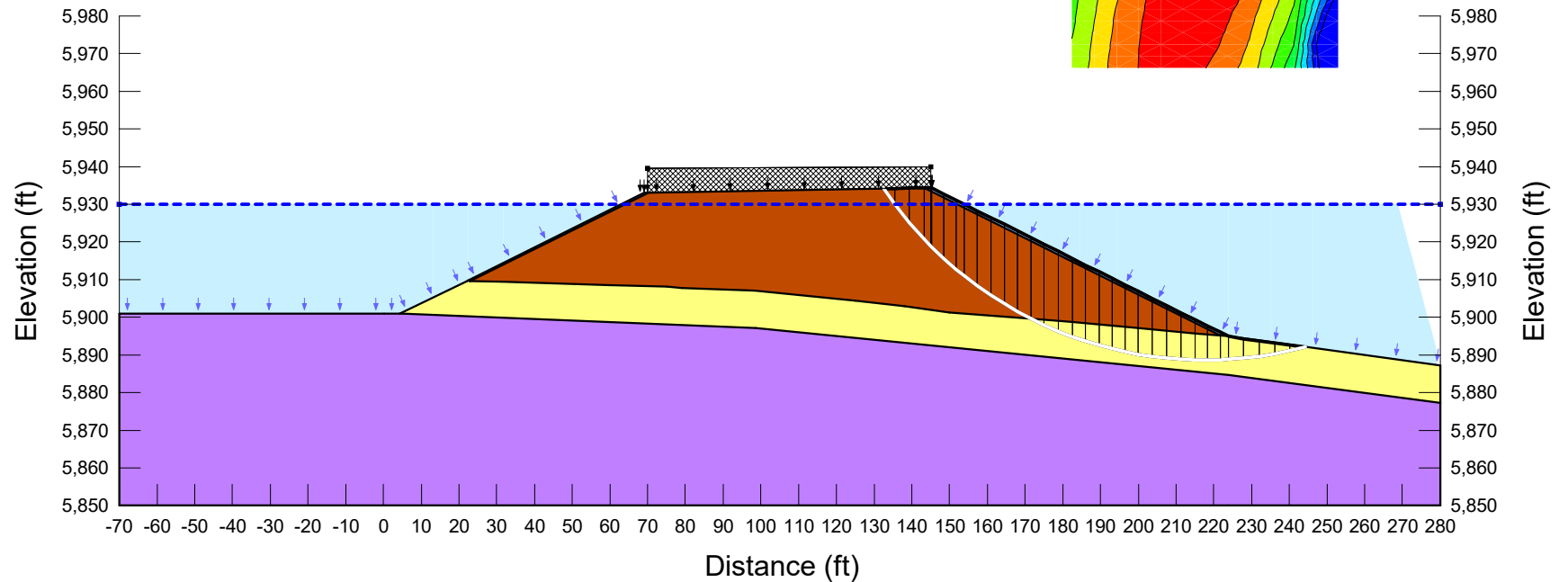
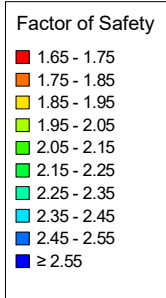
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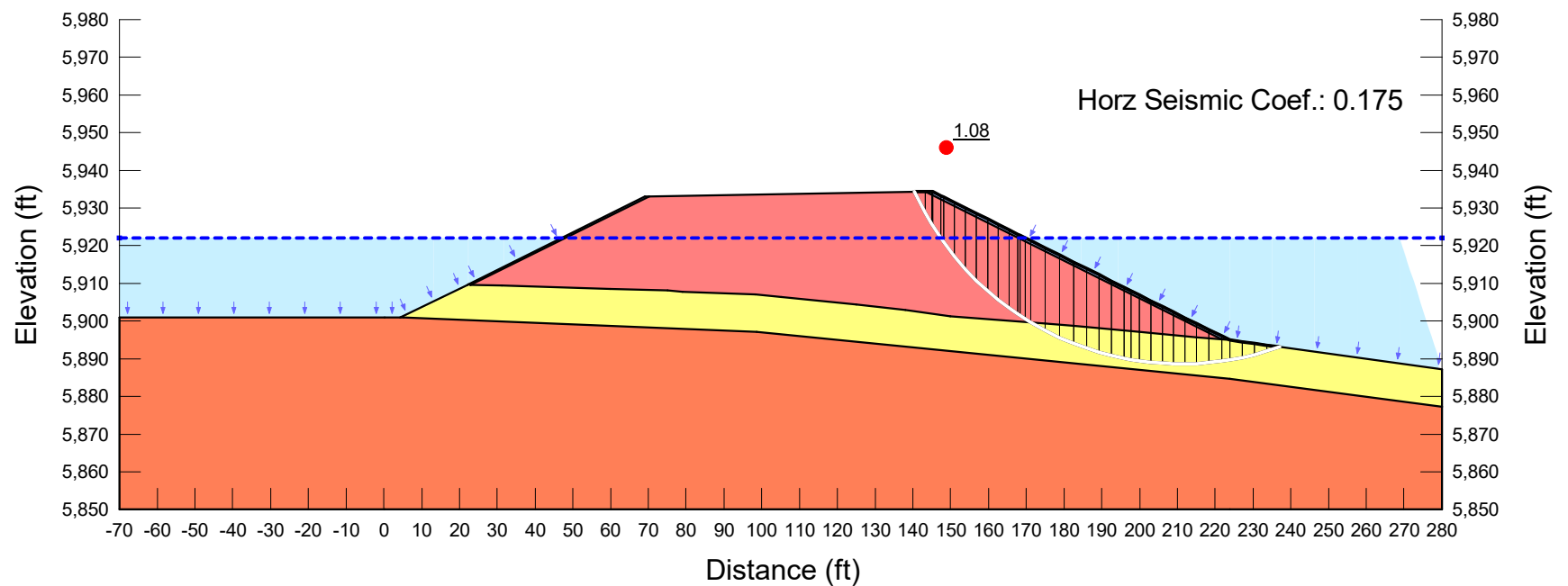
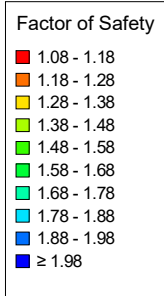
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	Clayey Soil - drained	115	100	28
	Dike Material	135	150	34
	Riprap	125	0	40
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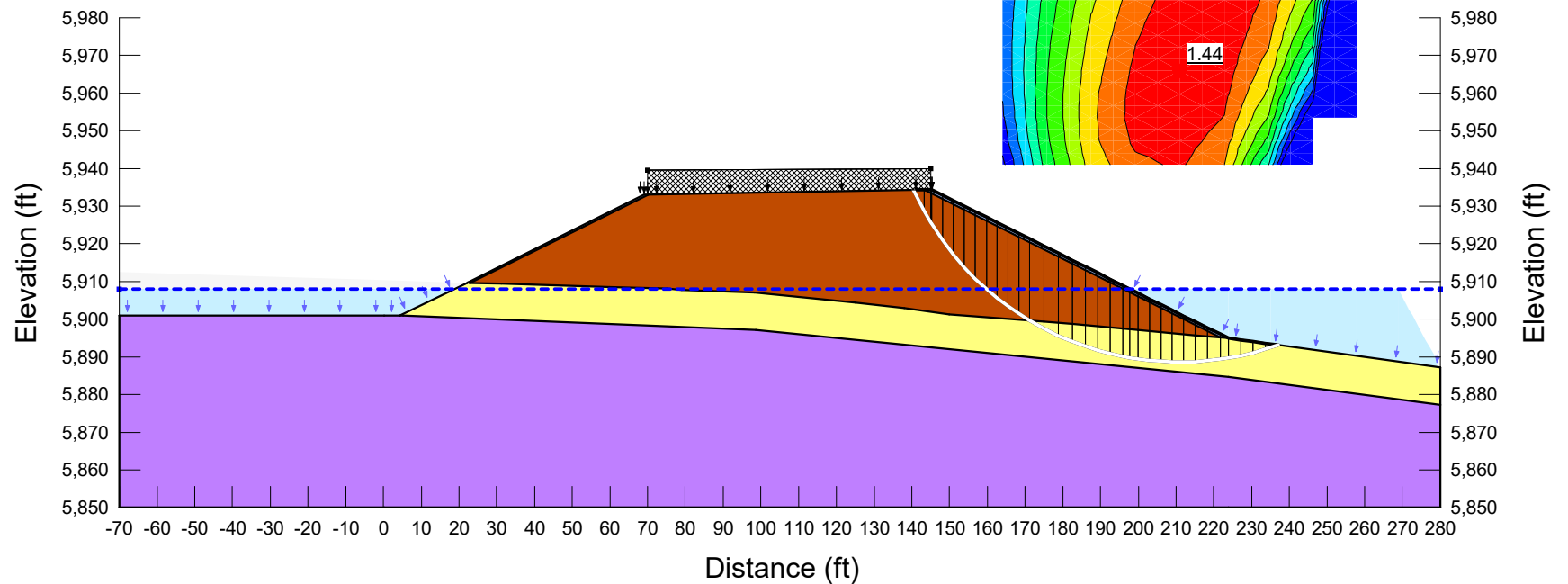
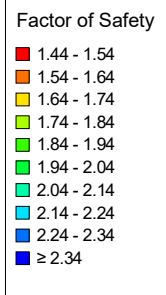
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	Dike Material	135	150	34
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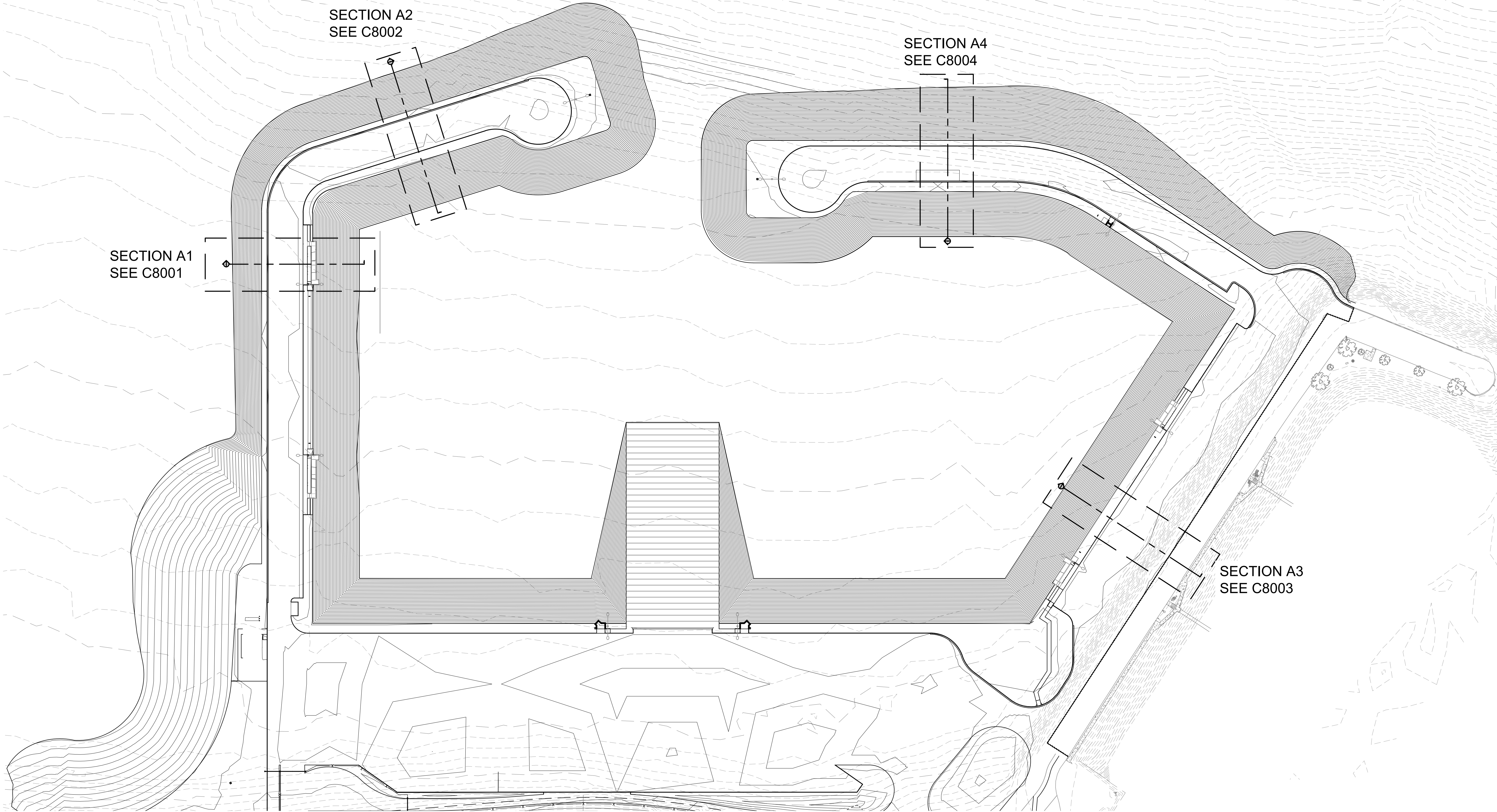


Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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	Sand to sandy silt	115	0	32

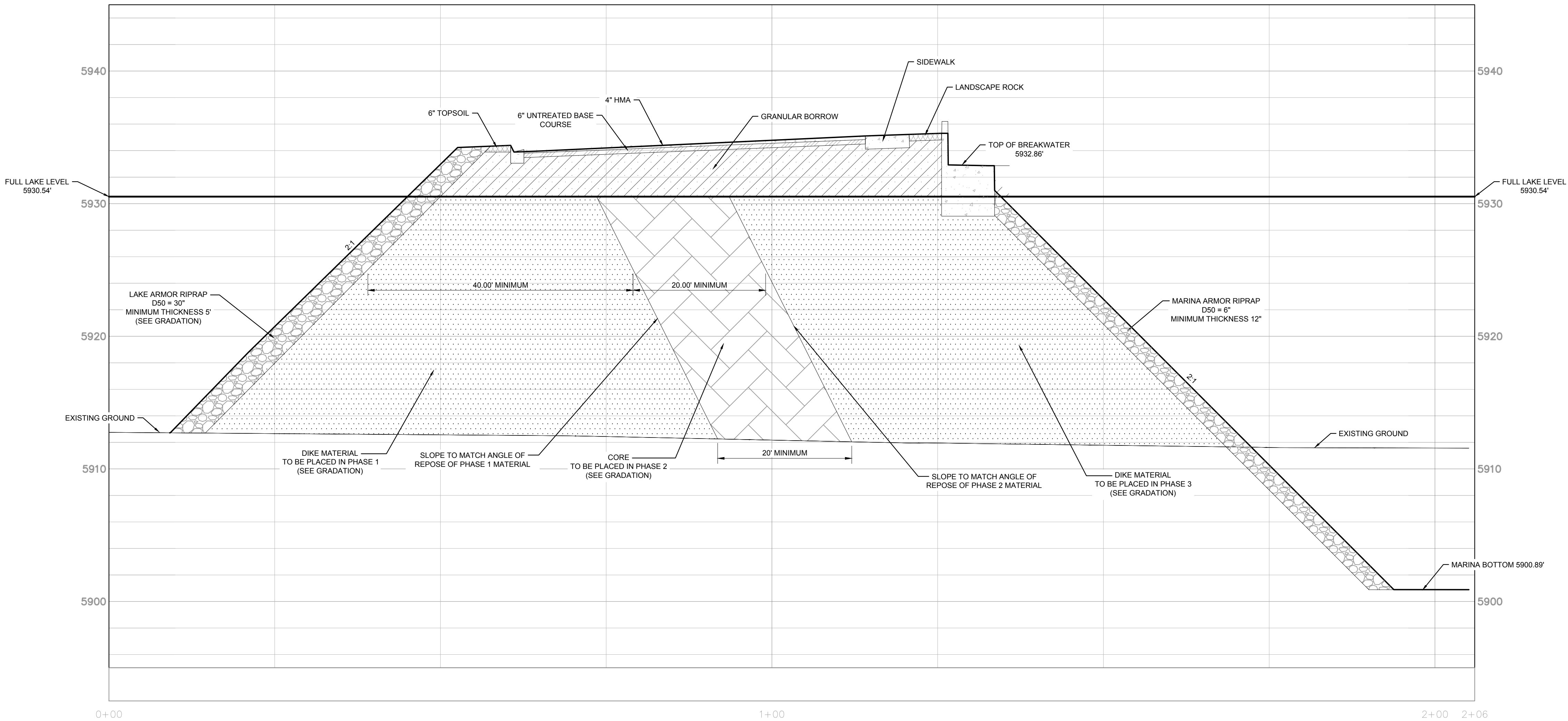
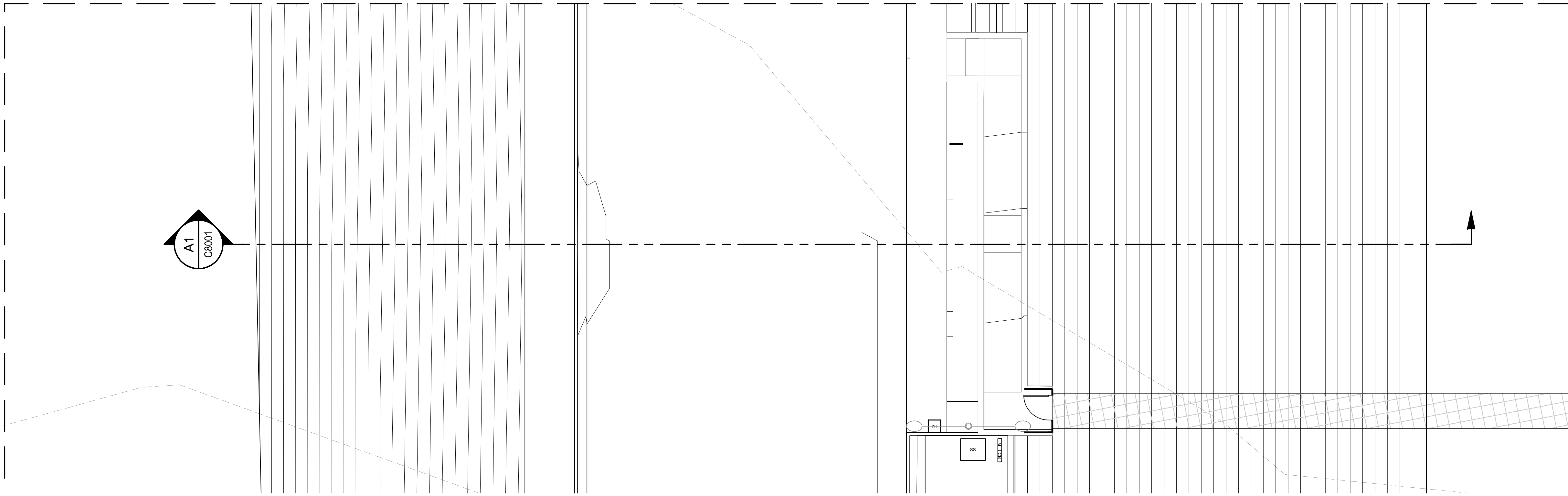


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	Dike Material	135	150	34
	Riprap	125	0	40
	Sand to sandy silt	115	0	32





				△		DATE	DESCRIPTION



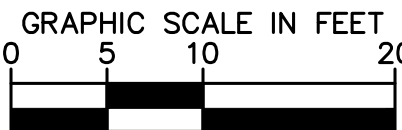
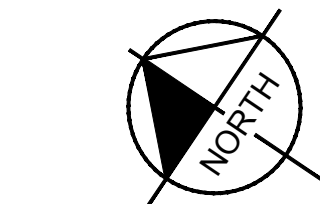
MATERIAL GRADATIONS

LAKE ARMOR RIPRAP	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
48	100
40	75-100
30	30-70
20	20-40
12	5-20
8 (MIN.)	0-5

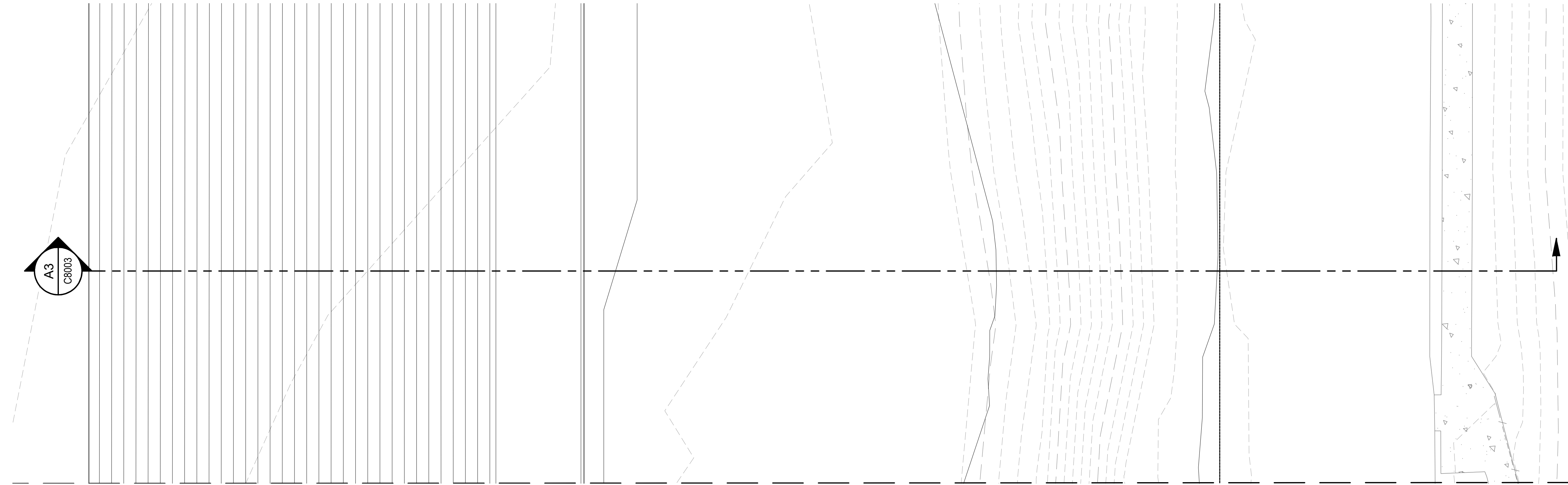
MARINA ARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	100
10	70-100
7	30-70
5	0-40
3 (MIN.)	0-5

DIKE MATERIAL / SUB-ARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	95
6	70-100
3	50-100
2	40-80
1	30-65
#4	15-50
#20	8-45
#200 (0.075MM)	0-20

CORE	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
3	100
#4	80-100
#20	70-100
#200 (0.075MM)	40-90



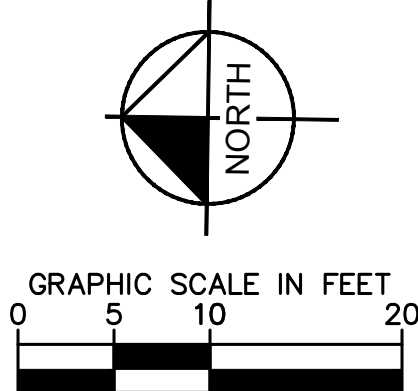
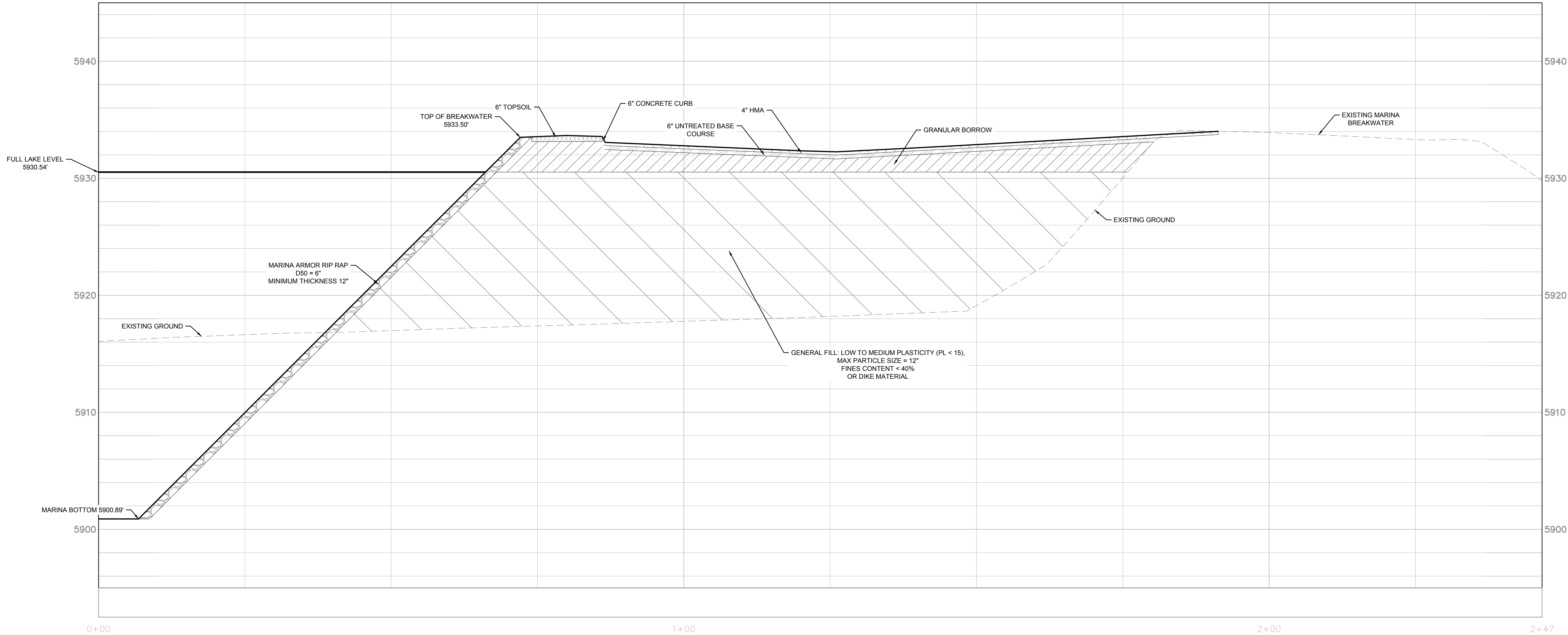
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DESIGNED BY: ITR/JRW		7/25/2024	
CHECKED BY: CHP		7/25/2024	
PROJECT No.: 23356510		7/25/2024	
SEAL			
NOT FOR CONSTRUCTION			
####			
PREPARED UNDER THE DIRECTION SUPERVISION OF CHRIS PRICE, P.E. UTAH REGISTRATION NO. XXXXXX FOR AND ON BEHALF OF KIMLEY-HORN AND ASSOCIATES, INC.			
SHEET C8001			



MATERIAL GRADATIONS	
MARINA ARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	100
10	70-100
7	30-70
5	0-40
3 (MIN.)	0-5

DIKE MATERIAL / SUBARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	95
6	70-100
3	50-100
2	40-80
1	30-65
#4	15-50
#20	8-45
#200 (0.075MM)	0-20

CORE	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
3	100
#4	80-100
#20	70-100
#200 (0.075MM)	40-90



DRAWN BY: ITR/JRW	DESIGNED BY: ITR/JRW	CHECKED BY: CHP	PROJECT No.: 23356510	7/25/2024	SEAL					
NOT FOR CONSTRUCTION										
####										
PREPARED UNDER THE DIRECTION SUPERVISION OF CHRIS PRICE, P.E. UTAH REGISTRATION NO. XXXXXX FOR AND ON BEHALF OF KIMLEY-HORN AND ASSOCIATES, INC.										
SHEET C8003										

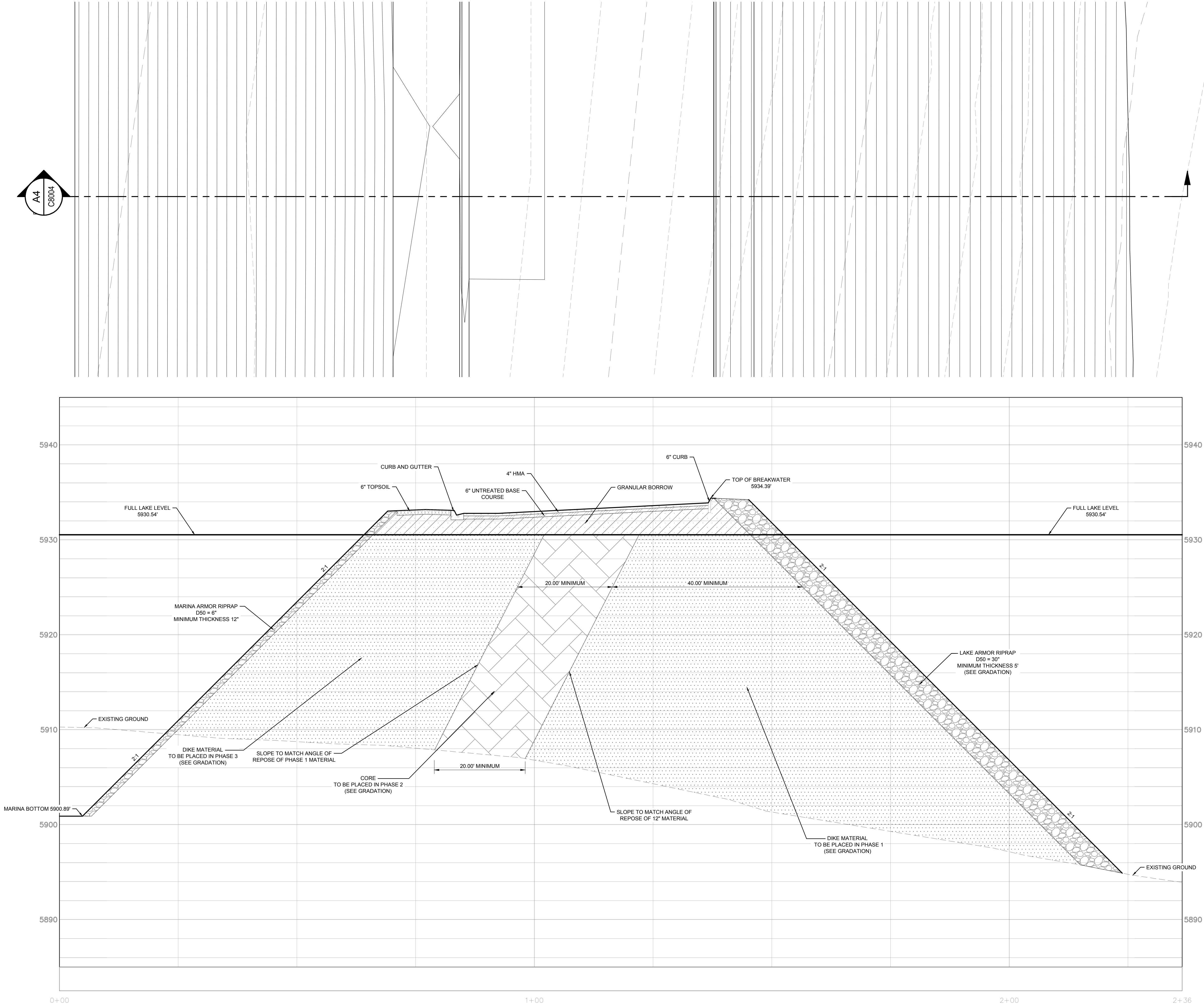
CROSS SECTION A3

BEAR LAKE MARINA EXPANSION
DFCM PROJECT #23356510
RICH COUNTY, UT

Kimley»Horn

111 East Broadway, Suite 600 | Salt Lake City, UT 84111 | Tel. No. (866) 212-3776

G-24



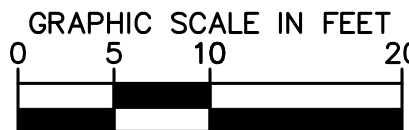
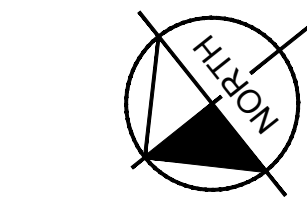
MATERIAL GRADATIONS

LAKE ARMOR RIPRAP	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
48	100
40	75-100
30	30-70
20	20-40
12	5-20
8 (MIN.)	0-5

MARINA ARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	100
10	70-100
7	30-70
5	0-40
3 (MIN.)	0-5

DIKE MATERIAL / SUB-ARMOR	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
12	95
6	70-100
3	50-100
2	40-80
1	30-65
#4	15-50
#20	8-45
#200 (0.075MM)	0-20

CORE	
NOMINAL DIAMETER (IN.)	PERCENT PASSING
3	100
#4	80-100
#20	70-100
#200 (0.075MM)	40-90



DRAWN BY: ITR/URW		DESIGNED BY: ITR/URW		CHECKED BY: CHP		PROJECT No.: 23356510							
7/25/2024		7/25/2024		7/25/2024		7/25/2024							
SEAL													
NOT FOR CONSTRUCTION													
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SHEET C8004													