APPENDIX C

Geotechnical Investigations

PRELIMINARY GEOTECHNICAL INVESTIGATION

SPECIES CONSERVATION HABITAT PROJECT
SALTON SEA, CALIFORNIA

Project No. 758.01
January 21, 2011

Prepared by

Hultgren – Tillis Engineers

A California Corporation
Specializing in Geotechnical Engineering

Hultgren-Tillis Engineers

January 21, 2011
Project No. 758.01

Cardno
701 University Avenue, Suite 200
Sacramento, California 95825

Attention: Mr. Paul Wisheropp

Preliminary Geotechnical Investigation
Species Conservation Habitat Project
Salton Sea, California

Dear Mr. Wisheropp:

We performed a geotechnical investigation for preliminary design of the Species Conservation Habitat Project along the southeast shoreline of the Salton Sea. Our services are part of Cardno Project Number 32676001-5000, Task 5 of the Salton Sea SCH Project. Our task number is HT-DWR-2010-01, dated July 22, 2010. The results of the investigation are presented in the attached report.

It was a pleasure working with you on this project and we look forward to working with you during design development and construction. If you have any questions, please call.

Sincerely,

Hultgren – Tillis Engineers

Edwin M. Hultgren
Geotechnical Engineer

WRC:SKT:EMH:db:la

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I. INTRODUCTION

This report presents the results of our preliminary geotechnical investigation for the proposed Salton Sea Species Conservation Habitat Project (SCH Project). The preliminary investigation is intended to provide a general characterization of on-site soil conditions and to provide geotechnical engineering criteria for preliminary design. The preliminary design will be the basis for the project description in the environmental impact documents. The findings and conclusions presented in this report are not intended for final design. A more detailed investigation should be conducted for the final berm alignment, berm configurations, borrow sources and anticipated construction methodologies.

II. PROJECT DESCRIPTION

The SCH Project will be located along the southeast shore of the Salton Sea. A Vicinity Map is presented on Plate 1. The project will consist of creating shallow ponds along the existing shoreline. The ponds will be located on both sides of the mouths of the New River and the Alamo River. The approximate boundaries of the ponds near New River and Alamo River are shown on the Exploration Site Plans, Plates 2 and 3, respectively.

In the area of the New River, the ponds will extend approximately 2.5 miles southwest and 1.5 miles east from the mouth of the river. In the area of the Alamo River, the ponds will extend between 1.5 miles south to about 2 miles northeast of the river mouth. Immediately adjacent to both river mouths, the berms will close off existing bays, and the berms will be approximately 1.5 to 2 miles off shore of the existing levees. Beyond the bays, the seaward-most berms will be approximately 0.5 to 1 mile beyond the existing levees. The total length of seaward berms will be up to approximately 5.5 miles in the vicinity of New River and approximately 3.5 miles in the Alamo River area. These estimates of berm lengths are preliminary as berm alignments continue to be evaluated.

The water depths within the ponds will typically be 6 feet or less. Ponds will contain water with varying degrees of salinity. Interior berms will subdivide the site into smaller ponds for individual salinity control. The target salinities are 20 parts per thousand (ppt) and 35 ppt. Water for the ponds will come from the New River and the Alamo River. Additional water for mixing various salinities in the ponds will come from the Salton Sea.

III. SCOPE OF SERVICES

For this preliminary investigation, our scope of services included reviewing the existing geotechnical data, exploring subsurface conditions at shallow depths along the berm alignments, assigning laboratory testing to be done by others, characterizing the materials encountered, and performing analyses and developing preliminary geotechnical conclusions and recommendations for constructing berms for the ponds.

IV. PREVIOUS INVESTIGATION

Two previous investigations contained geotechnical exploration and testing data.

The September 1972 Federal-State Feasibility Report, Salton Sea Project, California contain a summary of shallow probes drilled between the shoreline and five miles offshore. The thickness of sediment and the material type that refused further penetration are presented on Map 13, “Subaqueous Geology”, in the 1972 report. Map 14, titled “Subaqueous Structure Contours, Top of Foundation” provides bathymetry in 1972 and generalized elevation contours of the top of relatively firm foundation materials.

URS issued a report for the “Preliminary In-Sea Geotechnical Investigation, Salton Sea Restoration Project” in February 2004. One cone penetration test, CPT-13, and one boring, 14, were performed near the SCH Project. Conclusions reached in URS’s report regarding the engineering properties they observed in what they labeled “sea floor deposits” across the length of the sea were similar to our findings and conclusions regarding sea sediments (term used in our report) in the SCH Project area.

V. FIELD EXPLORATION

Methods for exploring subsurface conditions were dependent in part on site accessibility. On the playa (beach) above the water's edge, the site conditions are too soft to support conventional exploration equipment. This portion of the site was explored by hand-augering. At and beyond the water's edge (within the Sea), vibracore samples were taken from an airboat. At each exploration location, the insitu strength was characterized by hand-held vane shear apparatus (Geonor model H-60). Vane shear strength measurements were made at 0.5 foot intervals on the playa and at 1.0 foot intervals beneath the Sea. The vane was advanced between reading depths by pressing the vane further into the formation. In addition to the vane shear measurements taken by continuous advancement of the vane, hand-held vane shear strength measurements were also taken within the hand auger borings at approximately one foot intervals. A cone penetrometer test was conducted adjacent to each of the six hand auger borings. As the hand-held cone penetrometer (Durham model S-214) was pushed, the maximum and minimum penetration resistance was recorded for each 0.5 foot of penetration.

The locations of the exploration points are shown on the Exploration Site Plans, Plates 2 and 3. Logs of the hand auger borings and vibracores are presented on Plates 4 through 18. The key to the logs is presented on Plate 19. The hand-held vane shear tests performed adjacent to the hand auger and vibracore locations are summarized on Plate 20. (To better define the individual vane shear test results, the data points are shown vertically offset, in depth, by up to +/- 0.14 foot. The sole purpose of this arbitrary shift is to avoid having one data point masked by another.) The hand-held vane shear tests taken within the hand auger borings are presented on the logs of borings. Those shown on the logs of vibracores are from the continuous advancement of the vane adjacent to the vibracore. The hand-held cone penetrometer tests are presented on Plates 21 and 22.

VI. LABORATORY TESTING

Samples recovered from the hand augers and vibracores were delivered to the Moore Twining Associates, Inc. laboratory in Fresno, California. Laboratory testing on selected samples from the hand auger borings and vibracores consisted of 46 moisture content tests, 24 sieve analyses, and 18 Atterberg limits. Two bulk samples were collected from the playas near the New and Alamo Rivers (hand auger boring locations HA-1 and HA-4). Two laboratory compaction curves were performed on each bulk sample. One laboratory compaction test used "modified" Proctor compactive effort (ASTM Test D-1557) and the other "standard Proctor" (ASTM Test D-698).

To evaluate the dispersive characteristics of the on-site soils, six samples were selected for additional laboratory testing. They included the two bulk samples (HA-1 and HA-4) and four vibracore composite samples (VC-11, VC-16, VC-20 and VC-28). For each sample, the following laboratory tests were performed: gradation; Atterberg limits; organic content; crumb test; double hydrometer test; percent sodium in saturation extract; and pinhole test.

All of the laboratory testing was performed by Moore Twining Associates, Inc. except the pinhole tests. The pinhole tests were performed by the Department of Water Resources' Bryte Soils and Concrete Laboratory in West Sacramento.

The results of the laboratory testing are presented in Appendix A. A summary of the laboratory test results is presented in Table A-1 in Appendix A. Moisture contents and Atterberg limits are included in the logs of borings. A plot of the Atterberg limit tests and the corresponding in-situ moisture contents is presented on Plate 23. A combined plot of the four compaction tests is presented on Plate 24.

VII. SITE AND SUBSURFACE CONDITIONS

Several processes have gone into creating the feature now known as the Salton Sea. The Salton Sea basin is a northern extension of the Sea of Cortez, a down-dropped block created as Pacific Plate moved northwest and the Gulf of California spread open. The San Andreas Fault system forms a boundary between the low lying Salton Sea basin and mountain range further east. Some active faults may lie beneath the Alamo River portion of the SCH Project.

The Salton Sea basin is now isolated from the Sea of Cortez by an enormous alluvial fan created by the Colorado River. In the past, the Colorado River has flowed into the Salton Sea basin to heights well above those experienced in historic times. Upon European man's arrival in the Imperial Valley, the Salton Sea was a dry sink. Beginning in 1900, irrigation canals were constructed from the Colorado River into the Imperial Valley and northern Mexico. In 1905, control of the river was lost at one of the canal headworks, and the Colorado River flowed uncontrolled into the Salton Sea for one and a half years. The Sea as it is known today was reborn.

Over the subsequent century, the Sea has shrunk, swelled and now is again shrinking, all in response to the extent of irrigation and irrigation practices. Since the flood of 1905 – 1906, much of the site drainage and irrigation tail water has been collected by the New and Alamo Rivers and discharged into the Salton Sea. These waters are fairly high in dissolved solids, about 3 ppt. These rivers also bring suspended sediments. Upon reaching the high salinity of the Salton Sea (currently about 51 ppt), the finer grained sediments (clay size) flocculate and settle out on the floor of the Sea. The coarser grained sediments, including silt and fine sands, settle by normal gravity forces.

The Sea is now receding. On the exposed playa, the sediments are drying, creating a crust strong enough to walk on. However, as one approaches the shoreline, within one to two feet of elevation above the current sea level, the ground remains too soft to walk on in some areas. The surface of the playa is cracked in many areas as the sediments shrink from evaporation. At fairly shallow depths, the sediments remain nearly saturated over much of the playa.

In approximately half of the locations explored within the Sea, the mudline beneath the Sea is very soft and will not support a person wading. Grades are generally very flat.

The thicknesses of sea sediments nominally range from 3 to 8 feet in the areas we explored along and adjacent to the southeast shore of the Salton Sea. The thicknesses probably exceed this range in some areas. Most of these sediments likely accumulated within the last sixty years during the Sea's most recent rise above Elevation -240 feet. The sea sediments consist of very soft to medium stiff fat and lean clays, loose clayey and silty sands and soft to medium stiff silt. Red-brown lean clay, commonly medium stiff to stiff, was encountered below the sea sediment in many areas.

VIII. DISCUSSION OF FINDINGS

A. General

The most significant geotechnical issues for the project include the low strength of the sea sediments, the potential dispersive nature of the sediments and erosion from wave action. Compressibility, seepage and the expansion potential are also significant issues.

In some portions of the currently submerged areas, very flat slopes may be needed to safely construct the planned berms. Over a greater portion of the site, moderate slopes may be used but the ground is too weak to support traditional low-ground-pressure track-mounted construction equipment.

Sea sediments, including those beneath the playa, are predominantly fine grained soils. These soils will readily erode when exposed to even light wave action. The soils are also dispersive in fresh water. Their performance in brackish water is yet to be evaluated. If seepage developed through a berm and daylighted on the downstream slope, the dispersive nature of the soils could lead to fairly rapid development of a piping condition and loss of the embankment.

B. Settlement

The embankments for the berm will settle appreciatively during and following construction. To qualify the potential settlement, we performed one dimensional settlement analysis. This assumes that the loaded area is wide relative to the thickness of the compressible layer and ignores edge effects. We considered varying thicknesses of new fill, from two feet thick to 12 feet thick. The analyses were done for a range of compressible soil thicknesses from two feet to 12 feet. For the preliminary design, no undisturbed samples were taken from which to do consolidation testing. To assess potential settlement, we used estimated values of the compression ratio and coefficient of consolidation in our settlement analysis. We assumed that the sea sediments are normally consolidated and that the virgin compression ratio, C_{ce}, equals 0.3. The alluvial soil beneath the sea sediment over-consolidated relative to the weight of the planned berms and was assumed to be incompressible.

Results of the settlement analyses are summarized on Plate 25. To use this figure, select the thickness of fill along the bottom portion of the chart (for example: 10 feet thickness of fill), go vertically until intercepting the curved line representing the sediment thickness at that location (for example, 4 feet soft soil thickness), then find the estimate of ultimate settlement on the vertical axis (in this case 1.5 feet). For this example, placing 10 feet of fill causes 1.5 feet of settlement resulting in a final embankment height of 8.5 feet. Conceptual design consists of a berm whose crest will be eight feet above the toe of the berm after settlement has occurred. The diagonal line marked on the chart labeled “Fill for Net 8 Feet” shows the combinations of fill thicknesses and thicknesses of soft sediment that result in a berm crest 8 feet above the original ground surface after settlement is complete.

To estimate how quickly this settlement may occur, we ran analyses that assumed single drainage, meaning that the soils beneath the sea sediments are very low in permeability and are considered a impermeable boundary and the soils overlying sea sediments are sufficiently permeable to provide unrestricted drainage. Pore water trying to escape the sea sediments under the weight of the fill is assumed to travel vertically to the top of the sediment layer. Lateral drainage is ignored. These are simplifying assumptions. Fill that will be placed to create the berm will be of low permeability and will inhibit drainage at the surface. Some drainage will likely occur into the underlying alluvial formation and some lateral drainage will occur. For the purpose of these analyses, we have assumed that modeling single vertical drainage and ignoring lateral drainage is offset by ignoring the low permeability of the overlying fill.

In estimating the time rate of consolidation, we assumed a coefficient of consolidation (c_v) of 10 feet squared per year. The estimated time for 50 percent degree of consolidation is less than one to two months. The time requirement for 90 percent of the settlement to occur for varying thicknesses of soft soil sediments are presented on Table 1.

Table 1. Time for 90 Percent Consolidation

Thickness of Compressible Soils (feet)	Time required for 90 percent of Ultimate Settlement (months)
4	3
6	6
8	12
10	18
12	28

The above time rates of settlement as well as the estimated magnitudes of settlement were developed for assumed properties of the sea sediments. The presented results are intended to provide order of magnitude understanding for preliminary planning only.

C. Stability

The results of the vane shear tests at the fifteen exploration locations are summarized on Plate 20. In this plot, the vane shear data taken adjacent to hand auger borings on the exposed playa are shown in warm colors (pale yellow, orange, and brown tones). Those vane shear tests taken from the airboat on the Sea or at its shoreline are shown in cool (lavender and blue) colors. On average, the strength of the materials beneath the Sea are considerably weaker than those beneath the playa.

The strength plots shown on Plate 20 as well as the strengths taken within the hand auger borings are measures of peak strength. No residual strength tests were performed for the preliminary investigation. Because the sediments coming out of the New and Alamo Rivers were essentially coming from a fresh water environment and hitting a highly saline body of water, the clayey materials likely have a flocculated structure. Flocculated clays can be highly sensitive, meaning that the residual strength may be much less than the peak strength.

The strength of the foundation soils (sea sediment) will greatly influence the way in which the berms are constructed. Where the shear strength in the foundation soil is consistently greater than 300 pounds per square feet (psf), the foundation soil can support the berm fill with little risk of foundation failure. (We discuss ability of construction equipment to operate on weak foundation soil in a later section.) At strengths lower than 300 psf, the risk of shear failure in the foundation soils needs to be carefully considered.

There are several states of stress that are commonly considered when assessing the stability of a water retention embankment such as the planned berms. The “end of construction” condition assumes that the soils are undrained and that no consolidation (and corresponding strength gain) has occurred in the weak foundation soils. The “steady state seepage” (or “long-term”) condition assumes that the soils are fully consolidated and that the water level in the pond has been in place long enough for the embankment to become saturated up to a stable phreatic surface. “Sudden drawdown” occurs when the pool elevation in the pond is lowered quickly, faster than the embankment soils can drain. “Seismic loading” includes inertial lateral forces from earthquake shaking. Other seismic considerations are liquefaction in cohesionless soil, strength reduction in sensitive cohesive soils, and excessive deformations. The more critical cases for the berms at this site will be the end of construction condition and, for seismic considerations, liquefaction and strength reduction.

To check the capacity of the Salton Sea sediments to support fill for the berms, we performed a series of stability analyses for the end of construction condition. We considered three idealized strength profiles, various thicknesses of sediments, various thickness of berm fill and three slope inclinations.

For soil parameters, we assumed the densities of fill and underlying sea sediments were 110 and 100 pounds per cubic feet (pcf), respectively. Three models for shear strength for the foundation were used. To represent what we judge to be the weakest conditions, we assumed an undrained shear strength (S_u) of 100 psf at the mudline, increasing at 10 psf per foot of depth below the mud line. We note this as *S_u=100+10D psf* in our results summary (discussed below). Several vane shear measurements at one foot depth had strengths less than this “weakest” shear strength model. Under almost any method of fill placement, we concluded that this very weak surficial material will be displaced.

To characterize the mid-range of shear strengths in sea sediments beyond the shoreline, we used a shear strength profile of 200 psf at the mudline, increasing at 10 psf per foot of depth *(S_u=200+10D psf)*.

We used one additional strength profile of S_u*=300+10D psf*. This third profile is stronger than most strength measurements taken in the sea sediments beyond the current shoreline, but it was also weaker than essentially all of the vane shear strength data measured beneath the exposed playa. This strength profile was used as a lower bound strength for sediments beneath the playa.

We ran a suite of stability analyses using Spencers method for soft sea sediment thicknesses of 4, 8, and 12 feet. We evaluated three slope inclinations of 3 horizontal to 1 vertical (3H:1V), 5H:1V and 10H:1V. The factor of safety was computed for berm fill thicknesses of between 2 to 12 feet.

The results of stability analyses for the S_u=100+10D psf profile are summarized on Plate 26. Those for the S_u=200+10D psf strength profile are summarized on Plate 27. All of the computed factors of safety were greater than 2.0 for the S_u=300 + 10D psf strength profile and a plot of these results is not presented.

Using the findings of the settlement and stability analyses, we computed factors of safety for the end of construction condition for fill thicknesses that will result in an eight feet high berm after consolidation. The computed factors of safety for the two weaker soil profiles are presented in Table 2.

Table 2. Factor of safety for fills that will yield an eight feet high berm

Depth of Soft Sea Sediments (ft)	Shear Strength S_u=100+10D psf		Shear Strength S_u=200+10D psf	
	5H:1V Slope	10H:1V Slope	5H:1V Slope	10H:1V Slope
4	1.1	1.8	2.0	3.5
8	1.0	1.6	1.7	2.5
12	0.9	1.5	1.6	2.4

For most projects, the minimum factor of safety for an end of construction condition is commonly required to be at least 1.3. As discussed above, the sea sediments at this site are likely to be highly sensitive and may exhibit considerable strength loss once strained beyond their peak strength. To reduce the risk of overstressing the foundation soil and experiencing a strength reduction, a higher target should be set for the minimum end of construction factor of safety. The selection should be made during final design, when the sensitivity of the sea sediment is more fully assessed. We anticipate that the minimum recommended factor of safety may be on the order of 1.5 or higher.

For the steady state seepage (long term) conditions, we checked two profiles whose end of construction factors of safety were between 1.5 and 2.0. For effective stress parameters, we used an angle of internal friction of 27 degrees and zero cohesion. We assumed a phreatic surface that intercepts the toe of the berm. For eight feet high berms (post settlement), we computed factors of safety for the steady state seepage condition of 1.9 for a 5H:1V slope and 3.2 for a 10H:1V slope.

A pseudo-static stability analyses, using consolidated strengths, was not performed at the conceptual design phase. With long-term static factors of safety of 1.9 to 3.2, the application of an inertial force to represent seismic loading would indicate a factor of safety still greater than 1.0. However, during a large earthquake, we believe that some reduction in strength is likely within the foundation soils and that the embankment foundation may fail. This is discussed in the following section.

D. Seismic Performance

Sand, silty sand and sandy silt were encountered at some of the exploration locations. Standard penetration testing was not a part of the preliminary geotechnical investigation, so no definitive measure (SPT blow count) is available to classify the density of these cohesionless soils. The recent disposition history of these soils suggest that these are all loose deposits. With several seismic sources close by, most notably the San Andreas Fault, sandy materials with little to no cohesion are likely to liquefy during a large nearby earthquake. Lateral deformation and/or settlement is likely to occur if the foundation soils liquefy. Lateral deformation and/or settlement could lead to cracking of the berm, which could in turn lead to increased seepage, internal erosion and a piping failure through the berm. The berm settlement and deformation could also lead to overtopping of the berm.

Seismic shaking may strain some portions of cohesive foundation soils beyond their peak strength. If these soils are highly sensitive, the marked reduction in strength within these overstressed zones would put increased demands on adjacent zones, expanding the overstressed area and potentially leading to instability of the foundation.

A detailed risk analyses was not part of the preliminary geotechnical investigation. The consequences of berm failure are not likely to include property damage beyond that of the ponds, and chance of injury or death from berm failure is low. For the purpose of assessing the economic impact of a seismically-induced berm failure, an annual chance of occurrence of between 1 to 2 percent is reasonable. This applies to berms constructed over the sea sediments. If the sea sediments are excavated and the berms are constructed on the underlying alluvium, the risks decrease.

E. Plasticity and Expansion Potential

Half of the samples tested for Atterberg limits had a plasticity index (PI) greater than 30. More than two-thirds classify as fat clays. These classification tests indicate that these materials have a high potential for shrinking and swelling with changes in moisture content. During our field investigation, we had judged the materials to be lower plasticity, observing a more silt-like behavior than the classification tests indicate. The six bulk and composite samples indicated higher plasticity on average compared to the individual sample tests. The bulk/composite samples were for depth intervals of 3.6 to 5.3 feet. The individual samples from the hand auger borings commonly covered a 1.0 to 1.5 foot depth interval. The vibracore samples covered a 2.7 foot depth interval, though some samples were shorter. We suspect that high plasticity clay layers within the longer stratigraphic samples dominated the sample behavior, masking lower plasticity silts within the sample intervals.

As the Sea level falls and the sea sediments become exposed, cracking is observed on the surface of the playa. These cracks extend at least in the range of 1 to 2 feet deep; though no detailed assessment of the depths of the cracks was performed. Water can be seen within some of the cracks. Surface cracking is an indication of the expansive character of the soil. Though cracking was observed, the pervasiveness was not as extensive as one would expect from the Atterberg limit tests.

F. Dispersion

Dispersive clay soils are clays that disaggregate (or deflocculate and lose their cohesion) easily and rapidly in water of low-salt concentration and become susceptible to erosion and piping. Dispersive clay soils can be eroded by slow-moving water, at gradients that would not erode cohesionless fine sands and silts.

Dispersive clay soils cannot be identified by the usual laboratory index tests such as moisture and dry density measurements, grain size distribution or Atterberg limits. Other special laboratory tests (i.e. crumb test, double hydrometer test, percent sodium in saturation extract and pinhole test) were performed as mentioned earlier. Samples for the pinhole tests were compacted to near 95 percent relative compaction using Standard proctor (ASTM Test D-698) as the laboratory compaction reference. The moisture content was near optimum. This results in a moderately compacted clay. We chose this level of compaction to reflect our belief that higher degrees of compaction may not be readily achievable for the soft site conditions. A summary of the dispersion potential from the individual laboratory tests performed for this purpose is shown in Table 3. Each of these samples were logged as gray fat clay (CH). Detailed results of the dispersion tests are included in Appendix A.

Table 3. Summary of Dispersion Potential

Sample	Crumb Test (ATM Test D-6572)	Double Hydrometer Test (ASTM Test D-4221)	Percent Sodium in Saturation Extract (EPA 60103)	Pinhole Test (ASTM Test D-4647)
HA-1	Nondispersive	Nondispersive	Nondispersive	Dispersive
HA-4	Intermediate	Nondispersive	Nondispersive	Dispersive
VC-11	Dispersive	Dispersive	Nondispersive	Dispersive
VC-16	Intermediate	Nondispersive	Nondispersive	Dispersive
VC-20	Nondispersive	Nondispersive	Nondispersive	Dispersive
VC-28	Nondispersive	Nondispersive	Nondispersive	Dispersive

As shown, the results from the individual tests do not agree. Due to the very high TDS, the correlation with Percent Sodium in Solution Extract and dispersion potential were beyond the range used in the Bureau of Reclamation's chart of percent sodium versus total dissolved salts. Extrapolation of that chart suggests the non-dispersive classification. In general, the pinhole test is considered the most reliable since it is a direct physical test. Based on these considerations, it appears likely that the on-site soils would have a tendency to disperse in a fresh water environment. The validity of extending this finding to the SCH Project ponds, which will retain brackish to saline water, is not clear.

The tendency toward dispersive erosion in a dispersive clay depends on the chemistry of the water. The dispersion potential likely decreases with increasing salinity of the water. The ASTM standard for pinhole test uses distilled water. The retained water will have 20 ppt to 35 ppt TDS. These concentrations may not disperse the clays. To further assess the dispersion potential of the on-site soils, additional pinhole tests are being performed using water of various salt concentrations modeling the waters in the planned ponds.

When dispersive clay soils are used for construction of embankments without filters, piping and erosion may occur. Dispersive piping is usually initiated when water flows into small cracks and fissures caused by desiccation and/or differential settlement, particularly if the soils are placed dry of optimum or not well compacted. The water that flows through the cracks will remove the disaggregated particles, with the rate of removal increasing as the seepage velocity and size of opening increase.

The risk of a dispersive erosion induced failure is greatest in areas of higher seepage potential, such as around pipes through the embankments, adjacent to concrete structures, and at the foundation interface where compaction may have been less methodical. Deep gullies may also form on embankment slopes, where dispersive clay soils are exposed to rainwater run-off as well as water retained by the ponds. Severe dispersive erosion can lead to costly and difficult operation and maintenance.

G. Seepage

A wide range of permeabilities likely occurs within the sea sediments. In some hand auger holes, no apparent water seeped into the boring as it was drilled. In other hand auger borings where sandy silt layers were encountered, water percolated into the hole during drilling. Permeability in the undisturbed sea sediment is likely anisotropic. One slug test was performed in hand auger boring HA-4. The transmissivity was too low to develop reliable data from the sensors used. For purposes of estimating seepage through the soil matrix, the permeability correlations with material type and gradation presented in Table 4 may be used.

Table 4. Permeability Estimates for Conceptual Design

Material Type	Vertical Permeability cm/sec	Horizontal Permeability cm/sec
Sand	$1x10^{-4}$	$1x10^{-3}$
Silty Sand and Clayey Sand	$1x10^{-5}$	$1x10^{-4}$
Silt	$1x10^{-6}$	$1x10^{-5}$
Clay	$1x10^{-7}$	$1x10^{-6}$

Where shrinkage cracks have developed, structure of the soil will dominate seepage performance. The cracking will need to be considered when estimating seepage potential beneath the embankments. The tendency of the embankments themselves to develop shrinkage cracks will also need to be considered in evaluating seepage risks.

Seepage may occur through and beneath the berms. The fills used to construct the berms will be predominately fine grained soils of low permeability. Factors with the greatest potential for causing adverse seepage through the berms include less-than-rigorous placement and compaction methods, cracking due to settlement, shrinkage cracking, and dispersion potential. By “adverse seepage”, we refer to conditions that could potentially lead to internal erosion within the berm.

On the playa, the sea sediments have dried on the surface and shrinkage cracks extend at least a couple of feet. These cracks could become seepage paths beneath the berm fill. Having a pre-existing cracking pattern coupled with the dispersive character of the soil creates risk of piping beneath the berm. Leakage through these cracks can be limited by constructing a wide, shallow cutoff trench during site preparation, prior to placing berm fill. The trench will disrupt the interconnected cracks. Using a non-dispersive soil for the cutoff trench backfill would further reduce the risk of an under seepage failure.

Sand and silty sand within the foundation can be a seepage path beneath the berm. Though some water loss may occur at these locations, the sandy soils would not be dispersive, and the risk is low for a berm failure by under seepage in these soils. The magnitude of seepage through an underlying sand layer may be best controlled by an upstream blanket of lower permeability soil.

If local seepage is identified once the ponds are containing water, excavating a trench parallel to the berm's axis and remixing the soils can be an inexpensive method of disrupting a seepage path and controlling seepage.

IX. CONCLUSIONS

A. General

There are several major considerations in assessing what may be the more efficient methods for constructing the berms. Major considerations include:

- Will the toe of the berm be above the water level in the Sea and will the Sea be covering the site?
- What kind of equipment can access the site?
- Will the berm be supported on the existing weak sea sediments or will the berm fill be placed in such a manner as to intentionally displace (fail) the sediments?
- Will soft sea sediments be used to create the berm or will stiffer soils be used?

These and other issues are addressed in this section.

B. Berm Embankments

In much of the currently submerged areas, the sea sediments are quite weak. To avoid failing the ground, the berm embankments will need to have very flat slopes. In these areas, the ground is too weak to support construction equipment, and barge-mounted equipment will be needed. One method to construct berms in those conditions is to excavate sediment immediately adjacent to the berm's alignment and cast it up on the berm. The berm footprint would be quite wide, and it may be most practical to operate draglines (or similar barge-mounted equipment) on both sides of the berm alignment. The saturated soft berm fill material cannot be effectively compacted. Once the surface of the fill extends more than about one foot above the level of the Sea, the dragline bucket can be dropped on the fill as a means of providing some compactive effort.

This is likely the most cost-effective method for constructing some form of berm in these weak foundation areas. However, the berm fill would be weak and have a high moisture content, subject to shrinking and cracking as the fill dries.

The upper several feet of the fill will need to be moisture conditioned and compacted to provide support for service vehicles.

With a fill poorly compacted and having a high potential for shrinkage cracks, there is risk of seepage developing through the berm. If seepage is observed, it can be remediated by excavating a trench partially down through the center of the berm crest. Within the trench, the excavator bucket can be used to remold the soils at depth. Pre-mixing a thick bentonite slurry to the partially excavated trench can aid the remolding process. This technique would be useful for treating local seepage zones. If seepage over long sections develop, a traditional slurry trench cutoff wall may be needed.

An alternate approach for constructing a berm in submerged areas would be to create a berm using moisture conditioned fill. The fill material could be prepared on the higher portions of the site, above the Sea. In many areas, the sediments are only three to four feet thick. The underlying alluvial soils are stiff and can support track-mounted construction equipment. A pad could be developed for spreading the playa sediments in a thin lift (about one foot thick). The sediments could be moisture conditioned by discing and/or rototilling and kneaded until a moisture content suitable for compaction is developed. Another material source could be to excavate (mine) the alluvial soils beneath the sediments.

The stiff fills would be placed by end-dumping from the end of the berm alignment and advancing the berm as additional fill is placed. The fill can either be placed on the soft sediments or the sediments could be excavated to a firm bottom prior to placing the fill. Soft sediments will not support steeper sloped fills in many areas. The weight of the fill will create a “mud wave” as the displaced sediments are heaved up in front of and/or to the sides of the advancing fill. Creating mudwaves is a valid form of berm construction in very weak areas. One drawback is that the weak soils are displaced in a non-uniform manner and the final thickness of fill will vary along the berm alignment. Excavating the soft soil prior to placing the fill can develop a more uniform thickness fill.

Whether placed with mudwaves or in areas where soft soil is removed, the fills below the water will not be compacted. As the fill extends above the water surface, the fills can be compacted. However, in the mudwave case, the compacted fill will be dropping in irregular sections as the foundation soil becomes over-stressed from increasing fill thickness.

On the playa where sediments can support the fill, they still may not be able to support low ground pressure track-mounted construction equipment. Though the vane shear data indicate the shear strength is greater than 300 psf which would normally support low ground pressure equipment, the potential for strength loss when the soils are overloaded suggests to us that using tracked equipment directly on the playa surface would be risky. Dozing 18-inches to two feet of fill out in front of the tracked equipment and keeping this thickness beneath the tracks may spread the contact pressure enough to support light, low ground pressure equipment. (Note - This discussion is not directed toward suggesting to a contractor what it might take to work on the playa. Rather, it is aimed at providing a general understanding of what kinds of methods may need to be considered in preparing environmental documentation.)

The thick initial lift (bridging lift) will not be well compacted. It would likely only be track-walked by the low ground pressure dozer. A poorly compacted zone has increased potential for seepage. A bridging lift, as well as moisture-conditioned soil placed below water in the previously described method, would not be effectively compacted. An upstream blanket of sediment could be used to resist seepage. If seepage develops, a cutoff wall may be needed.

C. Treating Dispersion

Even if it is determined during the next stage of investigation that the majority of the on-site soils may be dispersive when retaining brackish water, there may be no economic alternative other than to use these soils for the construction of the embankments. Embankments can be constructed with dispersive clay soils provided certain precautionary measures are taken. Some of these precautionary measures are discussed below.

Erosion of dispersive clay soils through embankments can be controlled by properly designed and constructed filters. The filter may be part of a downstream seepage berm. Filter material should be placed around the downstream one-third portion of pipes through the embankments, regardless of whether the soils are dispersive or not.

Embankments constructed with dispersive clay soils should be properly compacted; especially if the soils are being placed around pipes, adjacent to concrete structures, at the foundation interface, and if no filters are being provided. Achieving a well-compacted embankment on the soft subgrade may not be feasible.

Risk of seepage induced failures, including those due to dispersive soils can be reduced somewhat by simply making a wider embankment.

Most dispersive clay soils can be rendered non-dispersive by the addition of lime. Lime modification of dispersive clay soils may be considered for the surface of the embankments to provide slope protection (discussed later). Lime-modified dispersive clay soils may also be considered for portions of the interface with rigid structures such as pipes through the embankments.

A cutoff wall to block seepage through the embankments may be considered to lower the risk of piping. The cutoff wall may consist of a soil-bentonite cutoff wall constructed by slurry trench methods and using non-dispersive clay for source fill. As an alternative, plastic sheetpiling may be considered, but would likely be more expensive than a soil-bentonite cut-off.

Impermeable liners placed on the waterside slopes of the ponds may also be considered to reduce seepage through the embankments. Liners may include plastic liners (such as a thick HDPE membrane) or a well-compacted clay blanket comprised of low-permeability non-dispersive soils.

Most of these schemes reduce the potential rate of dispersion, but the risk of an eventual piping failure may still remain.

D. Shoreline Protection

There are two shorelines for the ponds. The interior of each pond will have water lapping against the interior face of the berm. During construction and during the first several years of operation, the seaward-most berm will be exposed to wave action from the Salton Sea.

For the interior face of the berms, the wave height will be fetch-limited with maximum fetches of about two miles for some ponds. Berm faces derived from sediment fill sources will be highly erodible. Some form of shoreline protection will be needed on the interior faces of the berms. The protective facing will need to extend over the portion of slope face that will be exposed to wave action, including the estimated height of run-up.

The traditional scheme for erosion protection is riprap facing. Riprap would be quarried rock material with an angular to subangular shape. Riprap should be placed on slopes no steeper than 2H:1V. Steeper as opposed to flatter slopes will limit the square footage of berm face that needs to be protected with riprap. Riprap would be placed on a geotextile designed for riprap underlayment.

Soil cement can be used for erosion protection and often is a viable option when riprap is not available. Soil cement consists of mixing portland cement with a locally available source of sand or silty sand. For good quality control, it is preferable to mix the soil cement in a pugmill at a central location within the project site and deliver the soil cement by dump truck to the berm. Soil cement is most efficient when there is little to no clay or organic material in the sands to be treated. Identifying a suitable source of sand within the project site may be a challenge. The vibracores near the mouth of Alamo River (VC-22 and 24) indicated about one foot of silty sand over fat clay and silt. No other surficial sand deposits were identified. These thin layers would be difficult to mine. At present there is no readily available source of sand for soil cement.

A hard clay is erosion resistant, though not nearly to the extent of riprap or soil cement. A hard clay can be developed by lime treating on-site clays. Lime is mixed with the clays on the berm slope and compacted. The equipment can safely operate on a 6H:1V slope. A flatter slope may be more appropriate near the still water elevation where most of the erosion action might occur. This erosion method would have a limited service life, perhaps in the range of five years, before major reconstruction is needed.

Geomembrane facing has been used to line reservoirs. The service life of the linings vary considerably with the type of material used and its resistance to degradation under extended sunlight. A geomembrane would have the smoothest surface of the erosion protection systems addressed here, and for similar slope inclinations would have the highest run-up.

On the outward face of the seaward-most berm, waves from across the 40-mile fetch of the Salton Sea will attach the slope. Unprotected fill will readily erode. The installation of shore protection will be complicated by interfacing the berm embankment construction method selected.

As with the pond interiors, riprap would be our first choice. Depending on the embankment construction method used for the seaward berm, placing riprap can be reasonably efficient to quite inefficient. Some embankment construction methods will have flat slopes or heaved up sediments on the seaward side of the berm. These geometries will be inefficient to armor with riprap. Excavating the sediment in front of placing moisture-conditioned soil can develop reasonably steep slopes, likely in the range of 3H:1V to 5H:1V. These slopes allow reasonably efficient use of riprap.

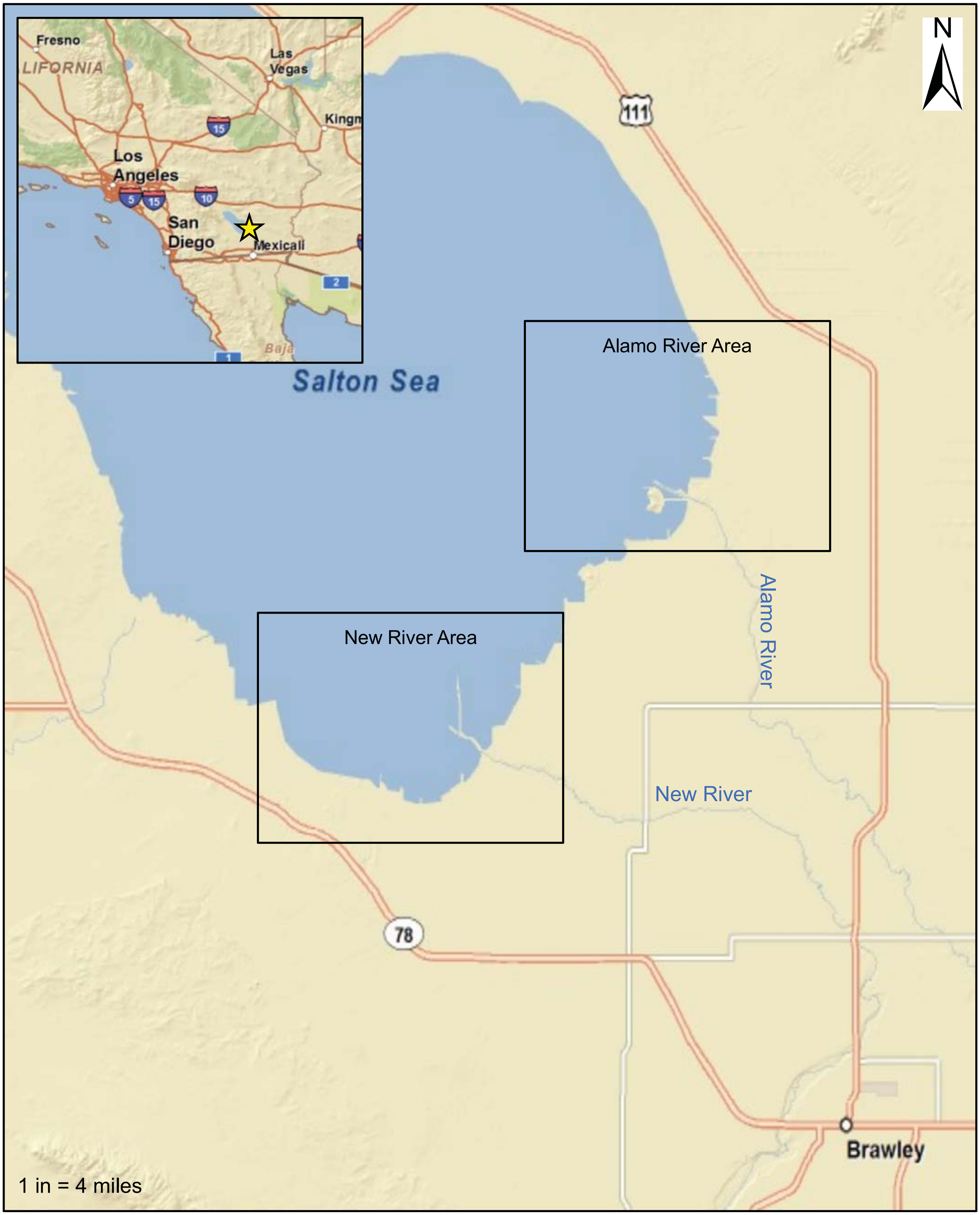
Riprap could be used to create an offshore breakwater, creating a fairly still water pool adjacent to the berm. After the level in the Sea has dropped, the riprap could be more easily salvaged for reuse on future projects if placed against the slope rather than as a separate offshore breakwater.

Other off shore breakwater systems could be considered, including a cable tire system. This system could be relocated further off shore as the Sea level drops.

A geomembrane could be used to wrap the face of fill. Though the material may have a limited service life, the period that sea waves may attack the berm of service would likely be shorter than the service life for many materials. We are not aware of an example of this scheme, suggesting that issues such as how to anchor the geomembrane and how to distribute stresses at anchorage points have not been satisfactorily resolved. Deployment may also be difficult.

A geotube is a large diameter geotextile tube (in the range of 20 to 30 feet in diameter), that is filled by pumping slurried soil into the tube, creating a gravity structure. The more common applications of geotubes include serving as groins to control onshore/offshore and longshore migration of beach sand and as containment structures for fine grained slurries to allow the slurries to drain. The geotube would become the seaward toe of the berm. A geotube would be compatible with the berm construction method of excavating adjacent sediments and casting them up on the landward side of the geotube. Fill for the geotube will need to be sand or silty sand. The material requirements of the sands would not be as strict as those for soil-cement. Material logged as clayey sand in the hand auger borings and vibracores would likely be suitable fill. This material was found in limited locations. Further exploration near the mouths of the New and Alamo Rivers may disclose additional sources of silty sand or sand.

PLATES



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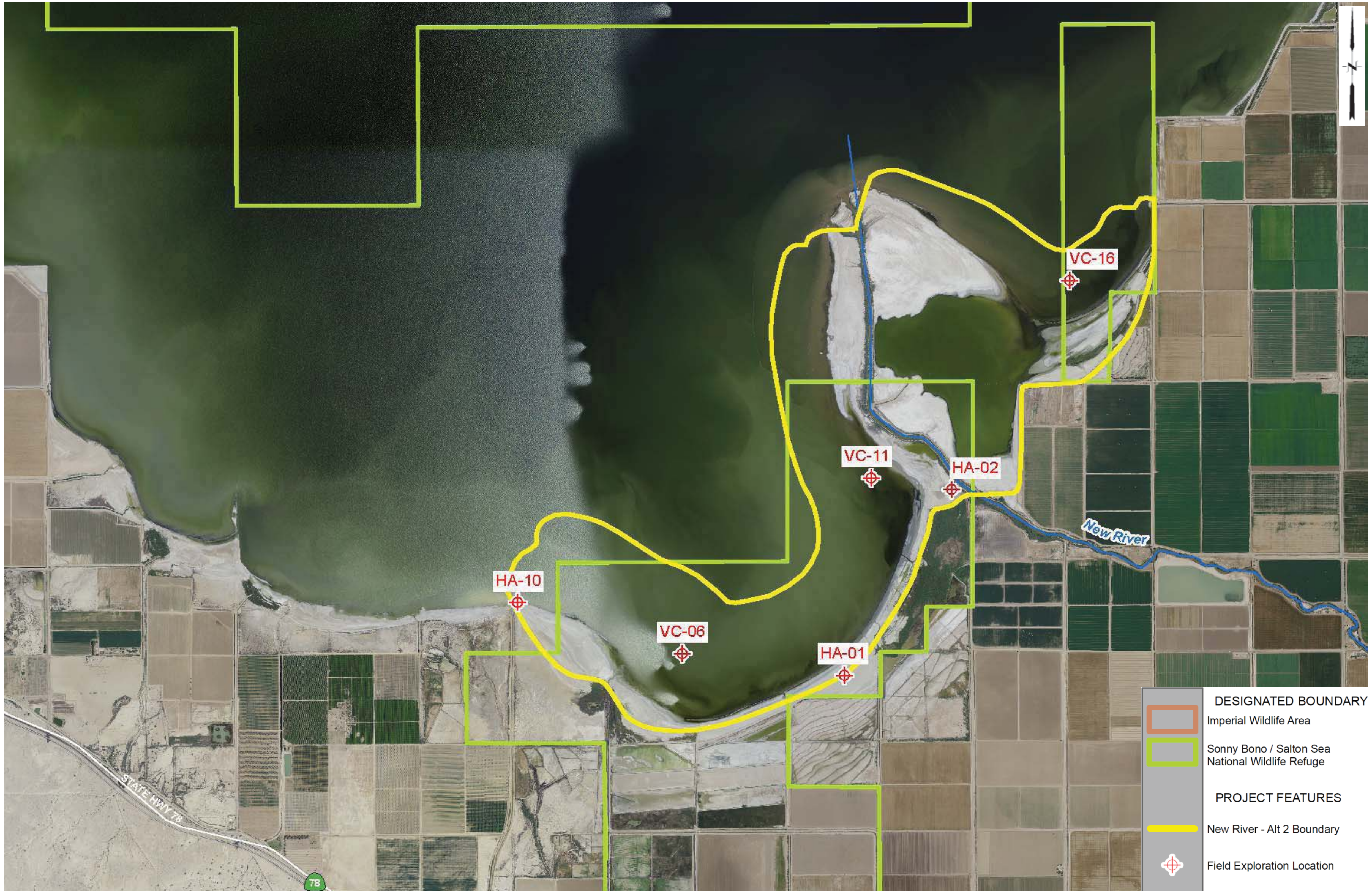
Vicinity Map

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 1



1 inch = 2,700 feet
Approximate Scale

Salton Sea SCH Project Salton Sea, California	**Exploration Site Plan** **New River**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 2

1 inch = 2,700 feet
Approximate Scale

Salton Sea SCH Project Salton Sea, California	**Exploration Site Plan Alamo River**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 3

Date : 9/15/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.0949
Longitude : -115.6957

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), olive gray, moist, medium stiff, with occassional sand partings			63*	44*	Full Suite**
	B							45			Sieve
1						Becoming wet					
							0.33				
				CH		Becoming dark gray					
2						Becoming saturated					
	B						0.33	65			Sieve
3						Lean Clay (CL), gray, saturated, medium stiff					
	B			CL			0.41	35			
						Lean Clay (CL), reddish brown, saturated, stiff					
4											
	B			CL			0.55	22	42	27	Sieve
5											

Bottom of boring at 5 feet
No groundwater encountered during drilling.
Refusal to vane shear device at 5.2 feet.
*Atterberg Limits measurements on bulk sample (0 - 3.6 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.6 feet).

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 4

Date	: 9/16/2010
Drilling Method	: Hand Auger
Elevation (Feet)	:
Latitude	: 33.1099
Longitude	: -115.6855

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Lean Clay (CL), tan brown, moist, medium stiff to soft, with some shell fragments					
	B										
1								31			
							0.32				
						Becoming dark gray, saturated					
2				CL	▽						
	B						0.24	45	43	24	Sieve
3											
							0.21				
	B							54			
4											
	B			ML		Silt (ML), reddish brown, saturated, medium stiff	0.40	41			

Bottom of boring at 4.3 feet
Groundwater encountered during drilling. Refusal to cone penetrometer at 4.3 feet.

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(Page 1 of 1)

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 5

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Hand Auger Elevation (Feet) : Latitude : 33.1939 Longitude : -115.6129 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Silt (ML), mottled olive brown, moist, stiff to medium stiff, low plasticity			56*	36*	Sieve* Full Suite**
1	B			ML				29			
2						Lean Clay (CL), gray, moist, soft to medium stiff, with some fine grained sand, low plasticity	0.22				
	B			CL		Becoming wet, with shell fragments		33			Sieve
3							0.24				
						Fat Clay (CH), dark gray, wet, soft to medium stiff					
4							0.21				
	B				▽			46			Sieve
5				CH							
							0.23				
6	B						0.26	47			
7						Bottom of boring at 7.0 feet	0.24				

Vane shear device used to measure undrained shear strength to a depth of 7.2 feet
Groundwater encountered during drilling.
*Atterberg Limits measurement and sieve analysis on bulk sample (0 - 5.3 feet).
**Full suite of laboratory tests on bulk sample (0 - 5.3 feet).

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 6

Date : 9/14/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1981
Longitude : -115.5979

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), mottled olive gray, moist, meduim stiff, trace of organics, rare salt crystals					
	B							44			
1											
							0.44				
						Becoming moist, thin shell bed at 1.5 feet					
2	B					Sand seams between 1.7 and 2 feet		49	52	28	Sieve
							0.31				
				CH		Becoming dark gray, saturated, soft to medium stiff, organic odor					
3											
						Soft zone between 3 and 3.5 feet					
	B						0.21	55			
4											
						Becoming gray	0.29				
	B							49			
5	B			SM	▽	Silty Sand (SM), dark gray, fine grained, saturated, loose	0.22	20			Sieve

Bottom of boring at 5.3 feet
Groundwater encountered during drilling. Refusal to cone penetrometer at 5.0 feet.

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 7

Date : 9/17/2010
Drilling Method : Hand Auger
Elevation (Feet) :
Latitude : 33.1836
Longitude : -115.6222

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Lean Clay (CL), mottled tan and dark gray, wet, medium stiff to soft, with shell fragments					
	B							44			
1				CL							
							0.21				
2											
	B			CL		Sandy Lean Clay (CL), wet, medium stiff, organic odor	0.33	44	31	15	Sieve
						Clayey Sand (SC), gray, saturated, medium dense					
3				SC			0.42				
	B							29			
				CL		Sandy Lean Clay (CL), gray, saturated, stiff					
4	B			CL		Lean Clay (CL), gray, saturated, stiff	0.68+	33			
	B			CL		Lean Clay (CL), reddish brown, saturated, stiff		31			
5							0.68+				

Bottom of boring at 5 feet
No groundwater enountered.
Refusal to vane shear device at 4.5 feet.
Refusal to cone penetrometer at 6 feet.

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 8

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/16/2010 Drilling Method : Hand Auger Elevation (Feet) : Latitude : 33.1009 Longitude : -115.7263 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	B			ML-CL		Clayey Silt (ML-CL), tan and gray, dry to moist, soft to medium stiff, with sand, abundant shell fragments		25	25	5	Sieve
1					∇	Becoming dark gray to black, saturated	0.29				
2	B			SC		Clayey Sand (SC), tan, saturated, loose to medium dense	0.28	21			Sieve
3	B						0.35	34			
4	B			CL		Sandy Lean Clay (CL), reddish brown, saturated, stiff	0.50	31			
5											

Bottom of boring at 5 feet
Groundwater encountered during drilling. Refusal to vane shear device at 3.3 feet.
Refusal to cone penetrometer at 5.3 feet.

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Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 9

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/17/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.0968 Longitude : -115.7109 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
1	V			ML		Silt (ML), gray, saturated, soft to stiff, with sand, organic odor	0.12	69	NP	NP	Sieve
2						No recovery below 1.3 feet	0.68+				

Bottom of boring at 2 feet
Water level approximately 2 feet above surface.
Refusal to vane shear device at 1.5 feet.

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 10

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Date : 9/17/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1109 Longitude : -115.6931					
	V					Fat Clay (CH), gray, saturated, very soft, organic odor		31	68*	47*	Sieve* Full Suite**
1							0.05				
2	V			CH			0.11	56			
3							0.11				
						No recovery below 3.6 feet					
4							0.14				
5						Bottom of boring at 5.0 feet	0.22				
6							0.36				
7							0.61				
8							0.68+				

Refusal to vane shear device at 8.5 feet
Vane Shear device used to measure undrained shear strength to a depth of 8.5 feet.
*Atterberg Limits measurements on bulk sample (0 - 3.6 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.6 feet).

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 11

Date : 9/17/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.1268
Longitude : -115.6743

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
0				CH		Fat Clay (CH), gray, saturated, very soft, organic odor			66*	46*	Sieve* Full Suite**
	V							43			
1							0.05				
2							0.13				
						Becoming soft					
	V							52			
3				CL		Lean Clay (CL), reddish brown, saturated, soft	0.17				
4						No recovery below 4.0 feet	0.12				
5							0.26				
							0.68+				
6											
7											

Bottom of boring at 7.5 feet
Water level approximately 2-feet above surface.
Refusal to vane shear device at 5.5 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0 - 3.9 feet).
**Full suite of laboratory tests on bulk sample (0 - 3.9 feet).

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 12

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			ML		Sandy Silt (ML), gray, saturated, medium stiff, organic odor		44	NP	NP	Sieve
1						Silt (ML), gray, saturated, soft to medium stiff, low plasticity	0.28				
2	V			ML			0.17	34			
3							0.39				
4						Fat Clay (CH), gray, saturated, soft to medium stiff, organic odor	0.25		58	37	
5	V			CH			0.29	38			Sieve
6						Becoming stiff at 6 feet	0.68+				
						No recovery below 6.2 feet					
7											

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.188
Longitude : -115.6184

Bottom of boring at 7.5 feet
Water level on the surface.
Refusal to vane shear device at 6 feet.

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 13

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1891 Longitude : -115.617 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), gray, saturated, medium stiff, organic odor			67*	49*	Sieve* Full Suite**
1	V						0.32	29			
2							0.27				
				CH							
3						Becoming soft	0.19				
	V							39			
4							0.17				
						No recovery below 4.7 feet					
5							0.45				
6							0.68+				

Bottom of boring at 6 feet
Water level approximately 1-foot above surface.
Refusal to vane shear device at 6 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0 - 4.7 feet).
**Full suite of laboratory tests on bulk sample (0 - 4.7 feet).

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Date : 9/14/2010 Drilling Method : Vibracore Elevation (Feet) : Latitude : 33.1901 Longitude : -115.6065 Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Fat Clay (CH), gray, saturated, very soft, organic odor					
1	V						0.04	56			
2							0.07				
				CH							
3							0.11				
	V							53	57	38	Sieve
4						Becoming soft to medium stiff	0.18				
5						No recovery below 4.8 feet	0.41				

Bottom of boring at 5.5 feet
Water level on the surface.
Refusal to vane shear device at 5.3 feet.

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 15

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.2018
Longitude : -115.6183

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
						Silty Sand (SM), gray, saturated, loose to medium dense, organic odor					
	V			SM				33			
1							0.11				
						Fat Clay (CH), gray, saturated, soft, with sand					
2							0.14				
	V			CH				32	60	41	Sieve
3							0.19				
4							0.20				
						No recovery below 4.0 feet					
5							0.20				
6							0.21				
7							0.31				

Bottom of boring at 7 feet
Water level approximately 1-foot above surface.
Refusal to vane shear device at 7.2 feet.

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Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 16

Field	Value
Date	9/14/2010
Drilling Method	Vibracore
Elevation (Feet)	
Latitude	33.2176
Longitude	-115.6115

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V			SM		Silty Sand (SM), gray, saturated, loose		28	NP	NP	Sieve
1							0.27				
						Silt (ML), gray, saturated, medium stiff to soft, organic odor, non-plastic					
2							0.17				
	V			ML				57			
3							0.18				
						Lean Clay (CL), gray, saturated, soft, organic odor					
4							0.16				
5	V			CL			0.20	42	26	10	Sieve
6							0.21				
						No recovery below 6.4 feet					
7							0.60				

Bottom of boring at 7.5 feet
Water level approximately 2-inches above surface.
Refusal to vane shear device at 7 feet.

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Log of VC-24
(Page 1 of 1)

Date : 9/14/2010
Drilling Method : Vibracore
Elevation (Feet) :
Latitude : 33.2274
Longitude : -115.5999

Depth in Feet	Samples Type/ Recovery	Blow Count	Graphic	USCS	Water Levels	Material Description	Vane Shear (tsf)	Moisture Content (%)	Liquid Limit (%)	Plasticity Index (%)	Other Laboratory Tests
	V					Fat Clay (CH), gray, saturated, very soft, organic odor		48	65*	47*	Sieve* Full Suite**
1							0.10				
	V							45			
2							0.10				
3				CH			0.12				
4							0.11				
	V							64			
5						Becoming soft	0.13				
						No recovery below 5.7 feet					
6							0.14				
7							0.22				

Bottom of boring at 7 feet
Water level approximately 1-foot above surface.
Refusal to vane shear device at 7.3 feet.
*Atterberg Limits measurements and sieve analysis on bulk sample (0.4 - 5.7 feet).
**Full suite of laboratory tests on bulk sample (0.4 - 5.7 feet).

Salton Sea
SCH Project
Salton Sea, California

Log of VC-28
(Page 1 of 1)

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 18

MAJOR DIVISIONS				GROUP NAMES	
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO. 200 SIEVE	**GRAVELS** MORE THAN 50% OF COARSE FRACTION IS RETAINED ON NO. 4 SIEVE	**CLEAN GRAVELS** WITH LESS THAN 5% FINES	GW		WELL GRADED GRAVEL
			GP		POORLY GRADED GRAVEL
		GRAVELS WITH OVER 12% FINES	GM		SILTY GRAVEL
			GC		CLAYEY GRAVEL
	SANDS 50% OR MORE OF COARSE FRACTION PASSES NO. 4 SIEVE	**CLEAN SANDS** WITH LESS THAN 5% FINES	SW		WELL GRADED SAND
			SP		POORLY GRADED SAND
		SANDS WITH OVER 12% FINES	SM		SILTY SAND
			SC		CLAYEY SAND
FINE GRAINED SOILS 50% OR MORE PASSES NO. 200 SIEVE	**SILTS AND CLAYS** LIQUID LIMIT LESS THAN 50		ML		SILT
			CL		LEAN CLAY
			OL		ORGANIC CLAY, ORGANIC SILT
	SILTS AND CLAYS LIQUID LIMIT 50 OR MORE		MH		ELASTIC SILT
			CH		FAT CLAY
			OH		ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			Pt		PEAT

UNIFIED SOIL CLASSIFICATION SYSTEM- ASTM D 2487

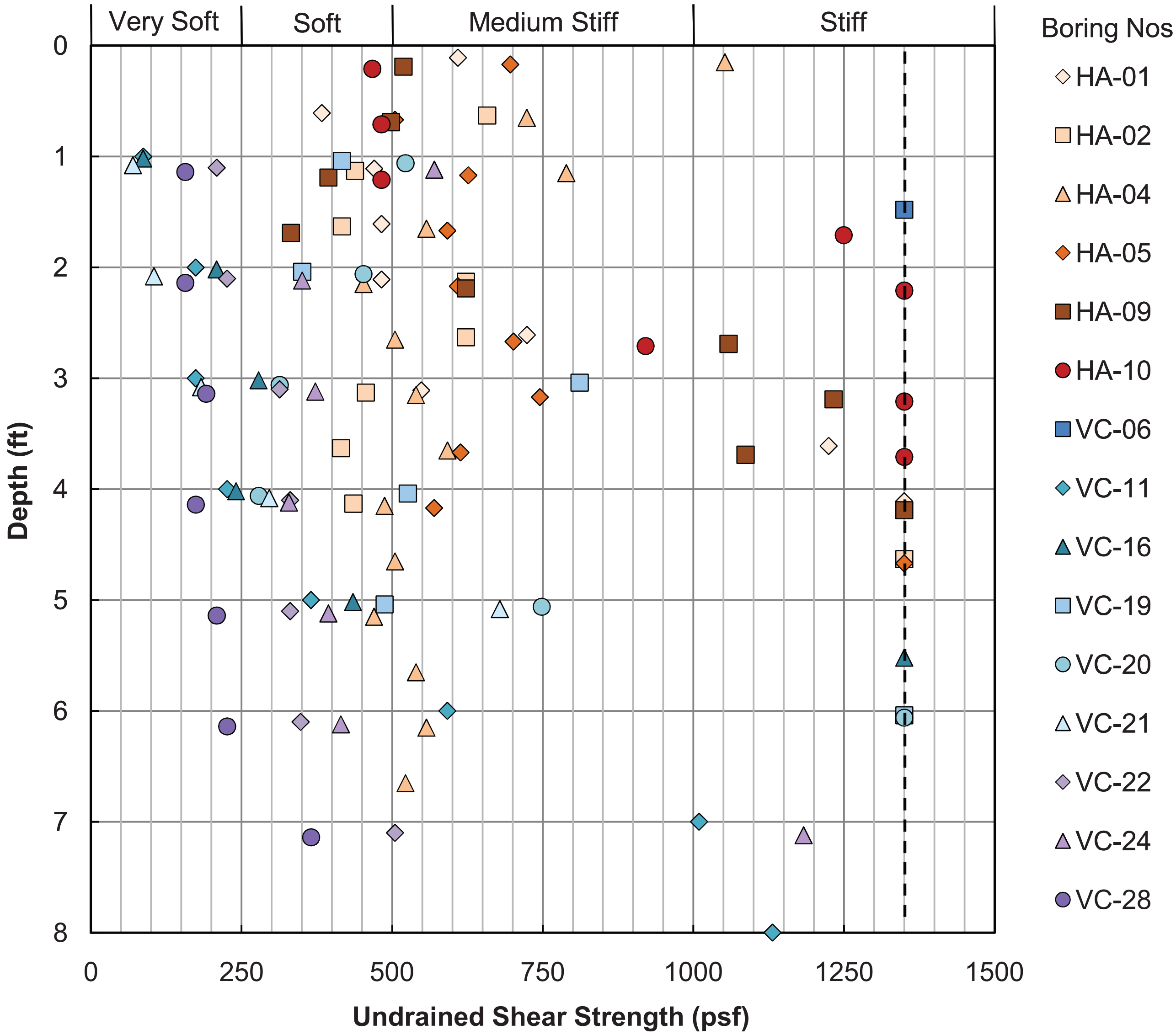
S	- SPT	▽	- Water Level at Time of Drilling	P	- Push
		▼	- Water Level after Drilling (with date measured)	Perm	- Permeability
V	- Vibracore	Consol	- Consolidation	Sieve	- Particle Size Analysis
		Gs	- Specific Gravity	-200	- % Passing No. 200 Sieve
C	- 3.0 inch	TxUU	- Shear Strength (psf) - Unconsolidated Undrained Triaxial Shear		
		TxCU	- Shear Strength (psf) - Consolidated Undrained Triaxial Shear		
T	- Shelby Tube	UC	- Compressive Strength (psf) - Unconfined Compression		
B	- Bag				

KEY TO TEST DATA

Salton Sea
SCH Project
Salton Sea, California

Soil Classification

Hultgren - Tillis Engineers | Project No. 758.01 | Plate No. 19



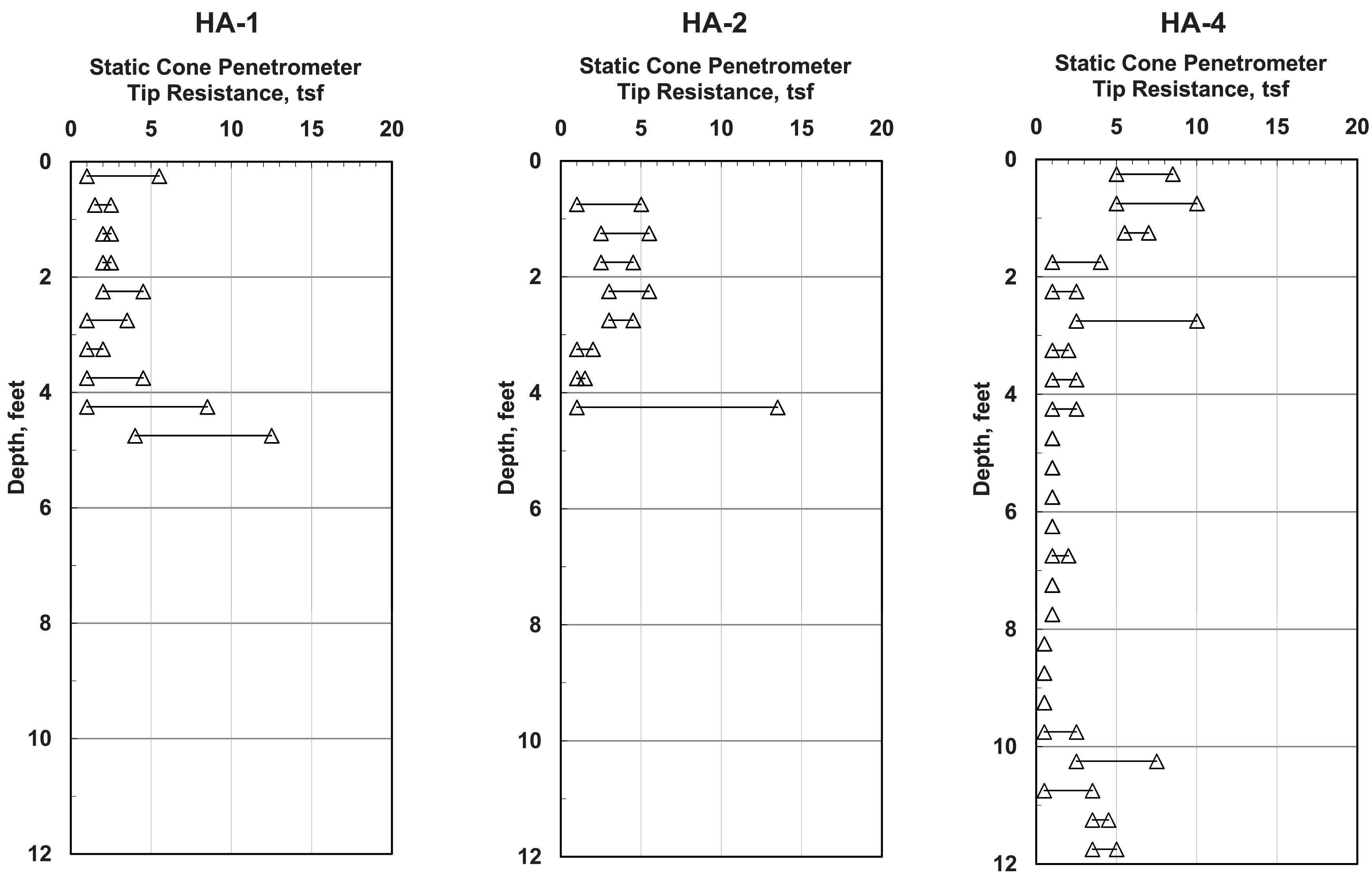
Notes:

1. Undrained shear strength was measured using hand held vane shear device (Model: Geonor H-60) manufactured by Geonor, Inc.
2. Undrained shear strength data shown in the plot above were modified by the Bjerrum's field vane correction factor (μ) in correlation with plastic index (PI).
3. Atterberg limits (LL and PI) measurements were conducted on selected samples only. PI's of soil samples without directly measurements were estimated by soil types accordingly .
4. The Hand Auger (HA) and Vibracore (VC) borings were presented using warm and cold colors, respectively.
5. Data points falling on the vertical dashed gridline indicate the soil samples have an undrained shear strength exceeding 1350 psf (65 kPa), the maximum value for the vane used.

Salton Sea
SCH Project
Salton Sea, California

Vane Shear Results

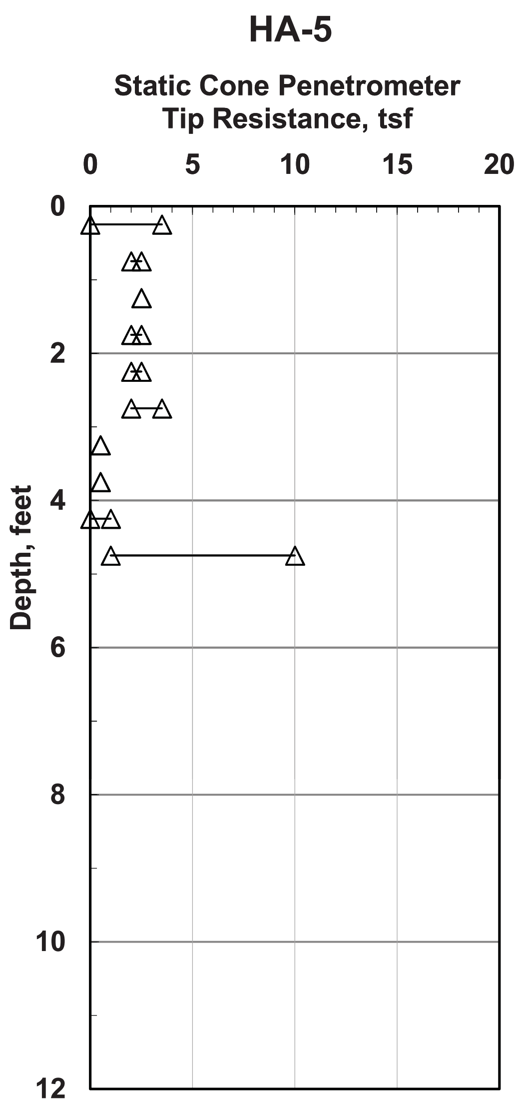
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 20

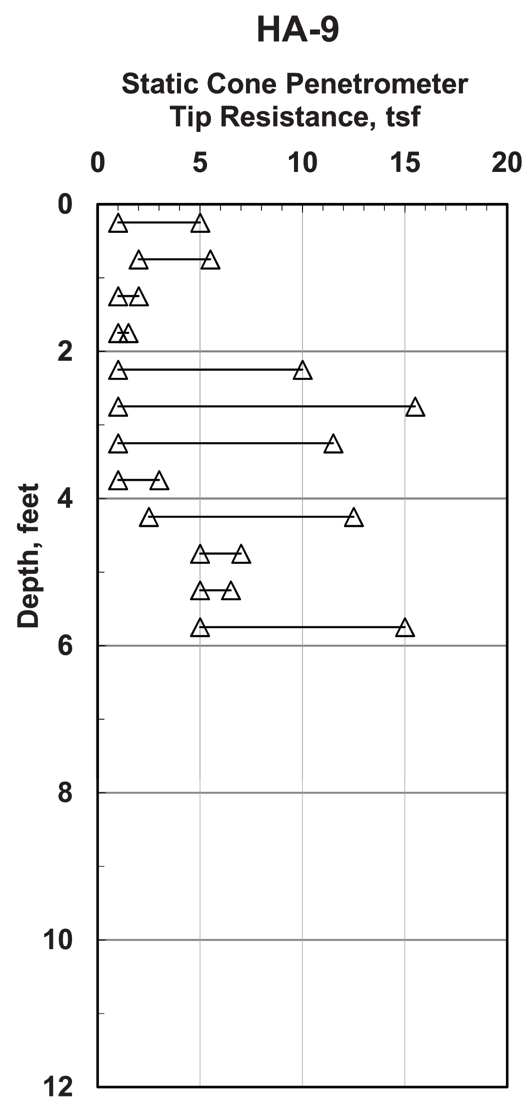


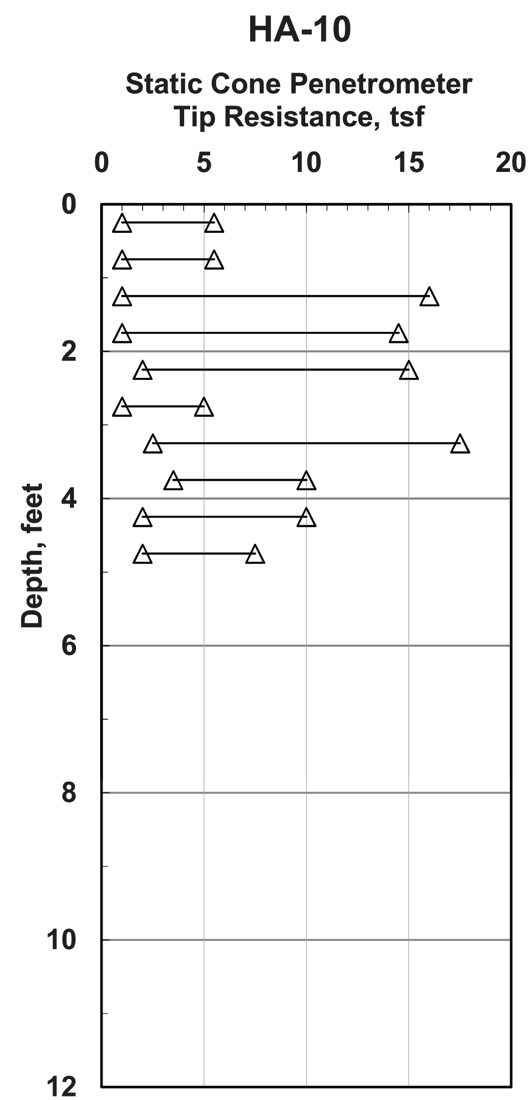
Note:

1. Portable Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214).
2. Range of penetration resistance (max and min) shown for 0.5 feet intervals.

Salton Sea SCH Project Salton Sea, California	**Penetrometer Results**	
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 21







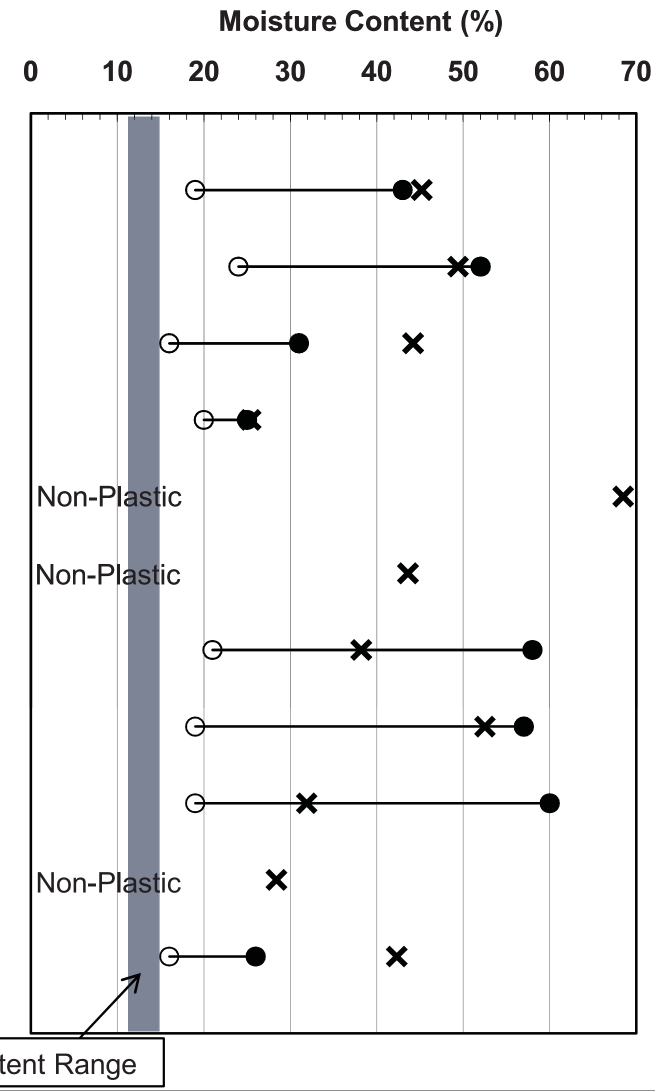
Note:

1. Portable Static Cone Penetrometer (Durham Geo Slope Indicator Model S-214).
2. Range of penetration resistance (max and min) shown for 0.5 feet intervals.

Salton Sea SCH Project Salton Sea, California	**Penetrometer Results**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 22

Sample Descriptions	Boring Nos. (Depth in feet)
Tan Brown Lean Clay (CL)	HA-2 (1.5 - 3.0)
Olive Gray Fat Clay (CH)	HA-5 (1.5 - 2.5)
Dark Gray Sandy Lean Clay (CL)	HA-9 (1.5 - 3.0)
Tan Gray Clayey Silt (CL_ML)	HA-10 (0.0 - 1.5)
Gray Silt (ML)	VC-6 (0.0 - 1.3)
Gray Sandy Silt (ML)	VC-19 (0.0 - 0.9)
Gray Fat Clay (CH)	VC-19 (3.5 - 6.2)
Gray Fat Clay (CH)	VC-21 (2.1 - 4.8)
Gray Fat Clay (CH)	VC-22 (1.3 - 4.0)
Gray Silty Sand (SM)	VC-24 (0.0 - 1.1)
Gray Lean Clay (CL)	VC-24 (3.7 - 6.4)



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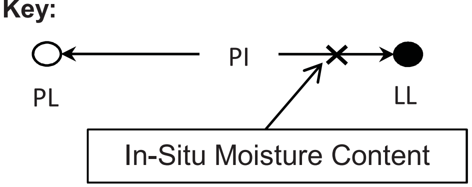
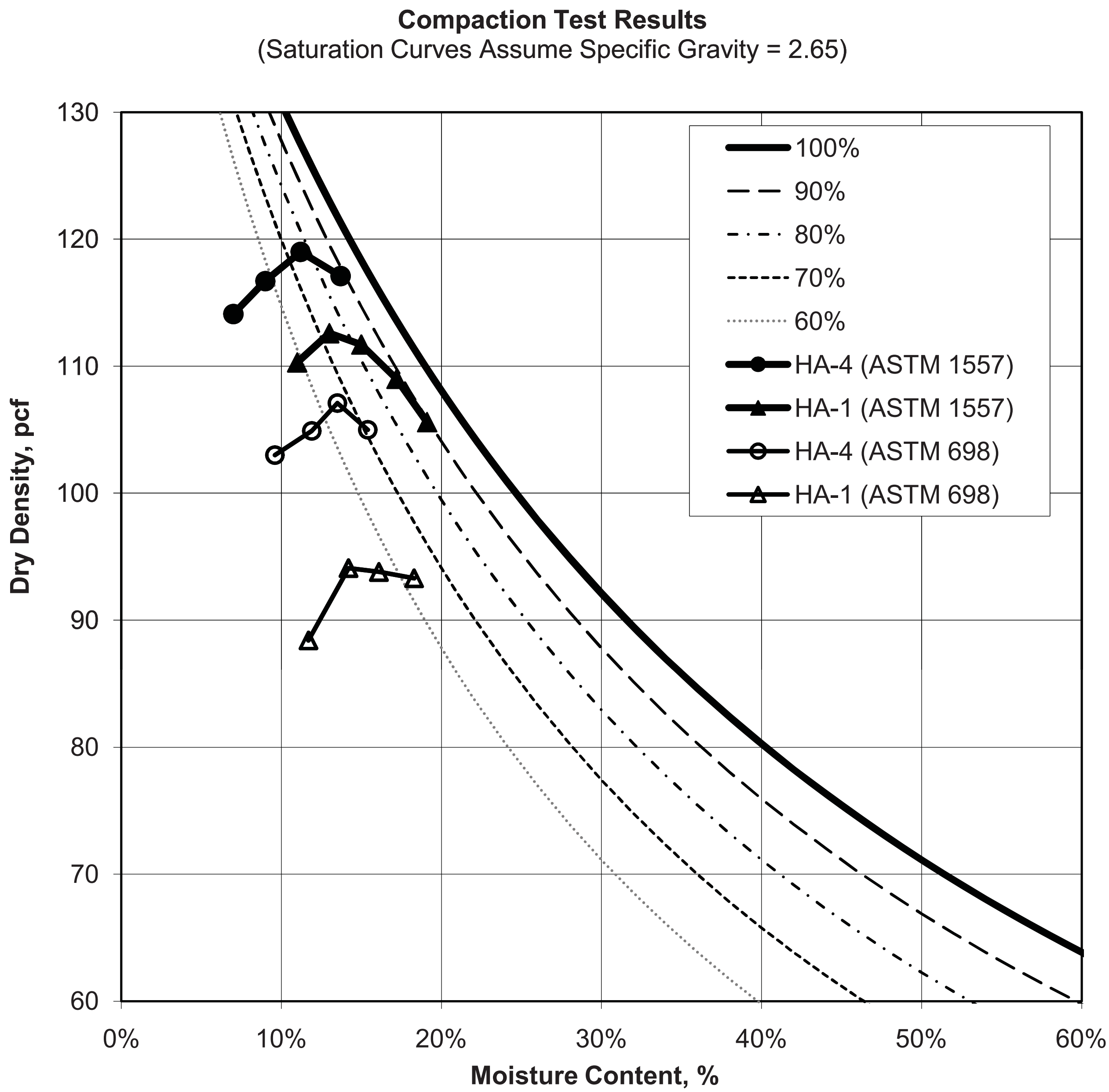


Salton Sea
SCH Project
Salton Sea, California

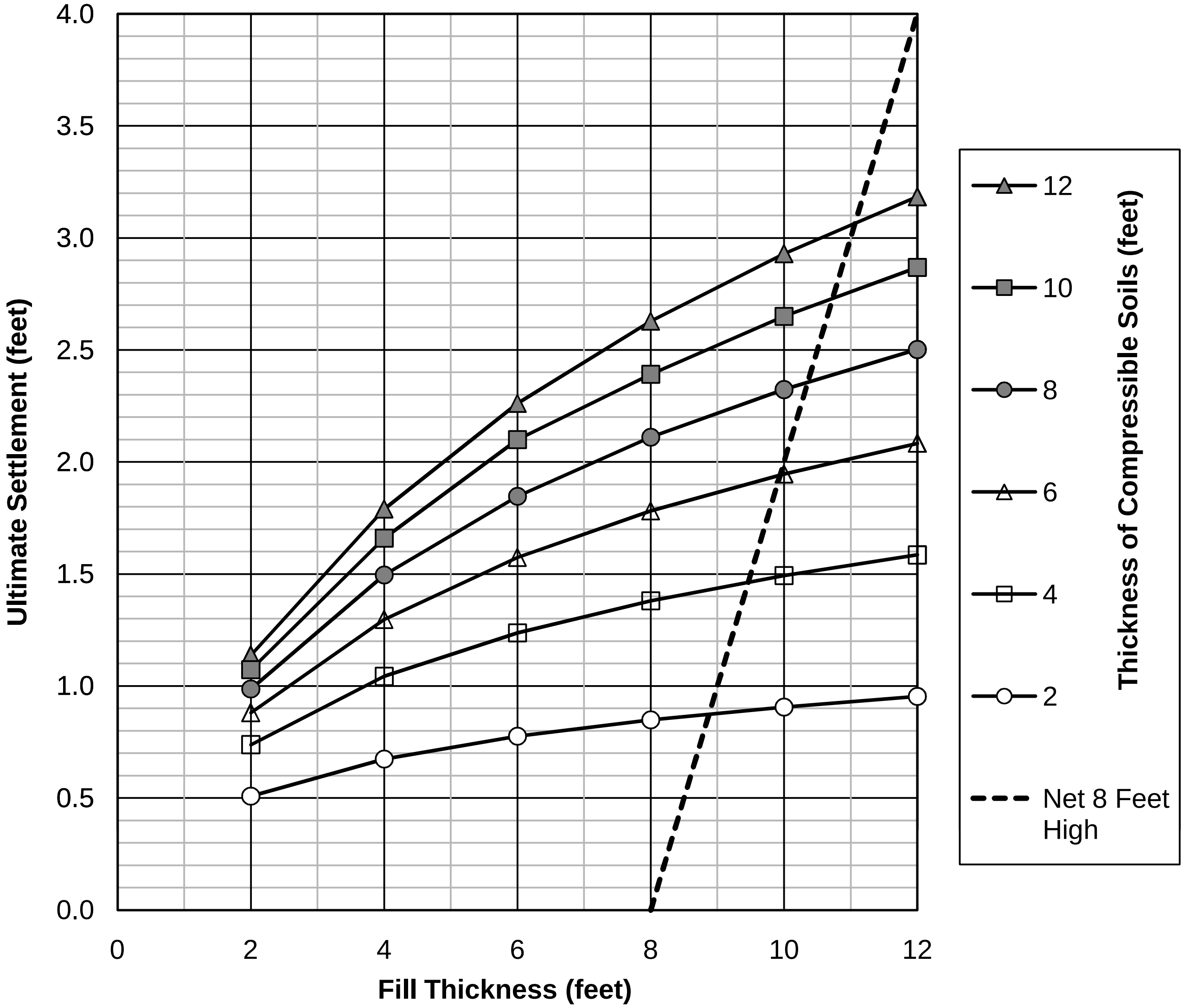
In-Situ Moisture Contents
Relative to Atterberg Limts
Sea Sediments

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 23



Salton Sea SCH Project Salton Sea, California	**Compaction Test Results**

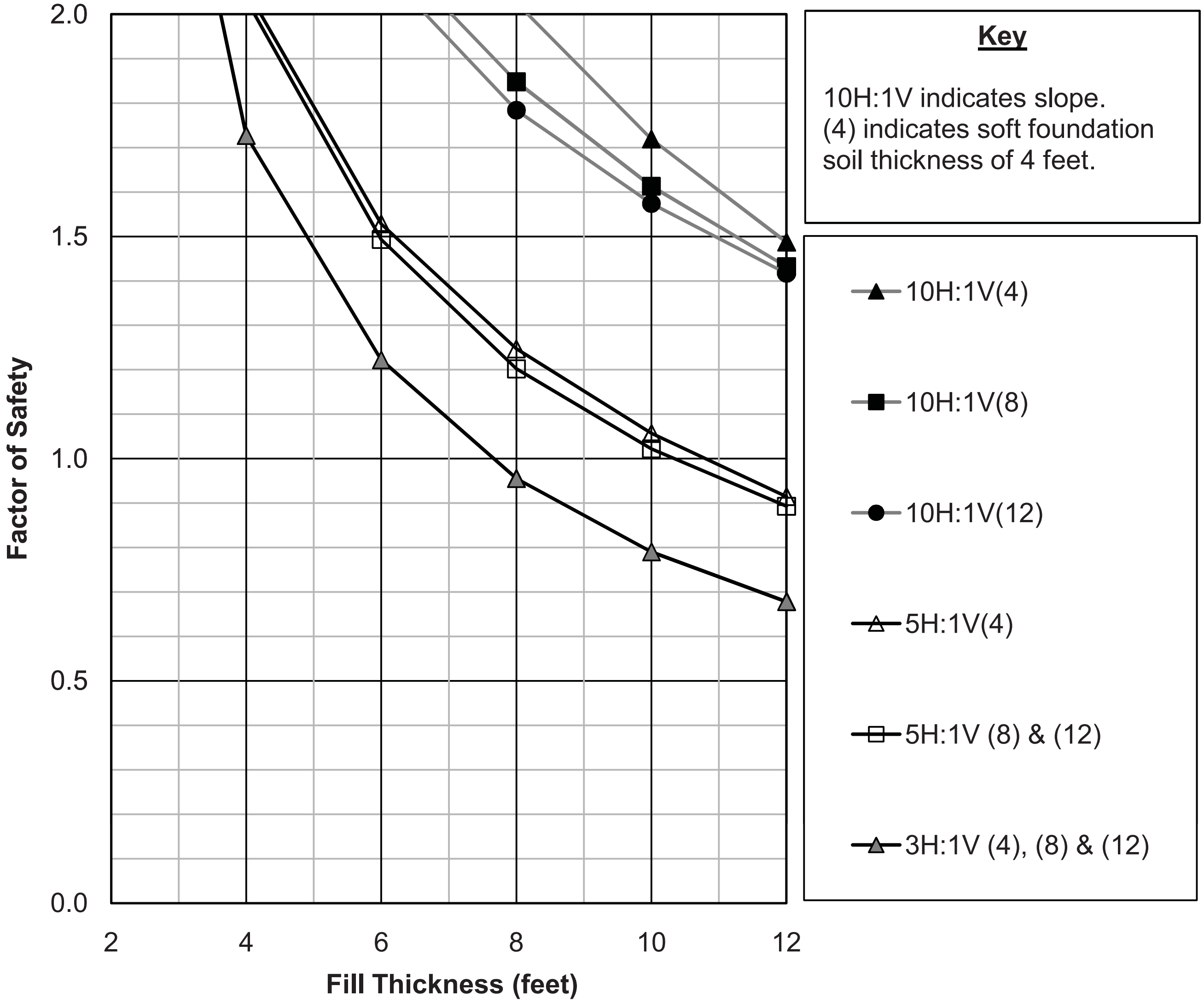
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 24



Notes:
1. Analyses based on uniform thickness fills placed on top of normally consolidated compressible soils with a thickness varying from 2 to 12 feet.
2. Analyses assume the ground water table at the top of compressible soils.
3. Analyses assume compressible soils with a coefficient of compressibility (C_{ce}) of 0.3 and an unit weight of 100 pcf, and fills with an unit weight of 110 pcf.
4. "Net 8 Feet High" line indicates the thickness of fill needed for final berm to be eight feet above original grade after settlement is complete.

Salton Sea SCH Project Salton Sea, California	**Ultimate Settlement vs Fill Thickness**

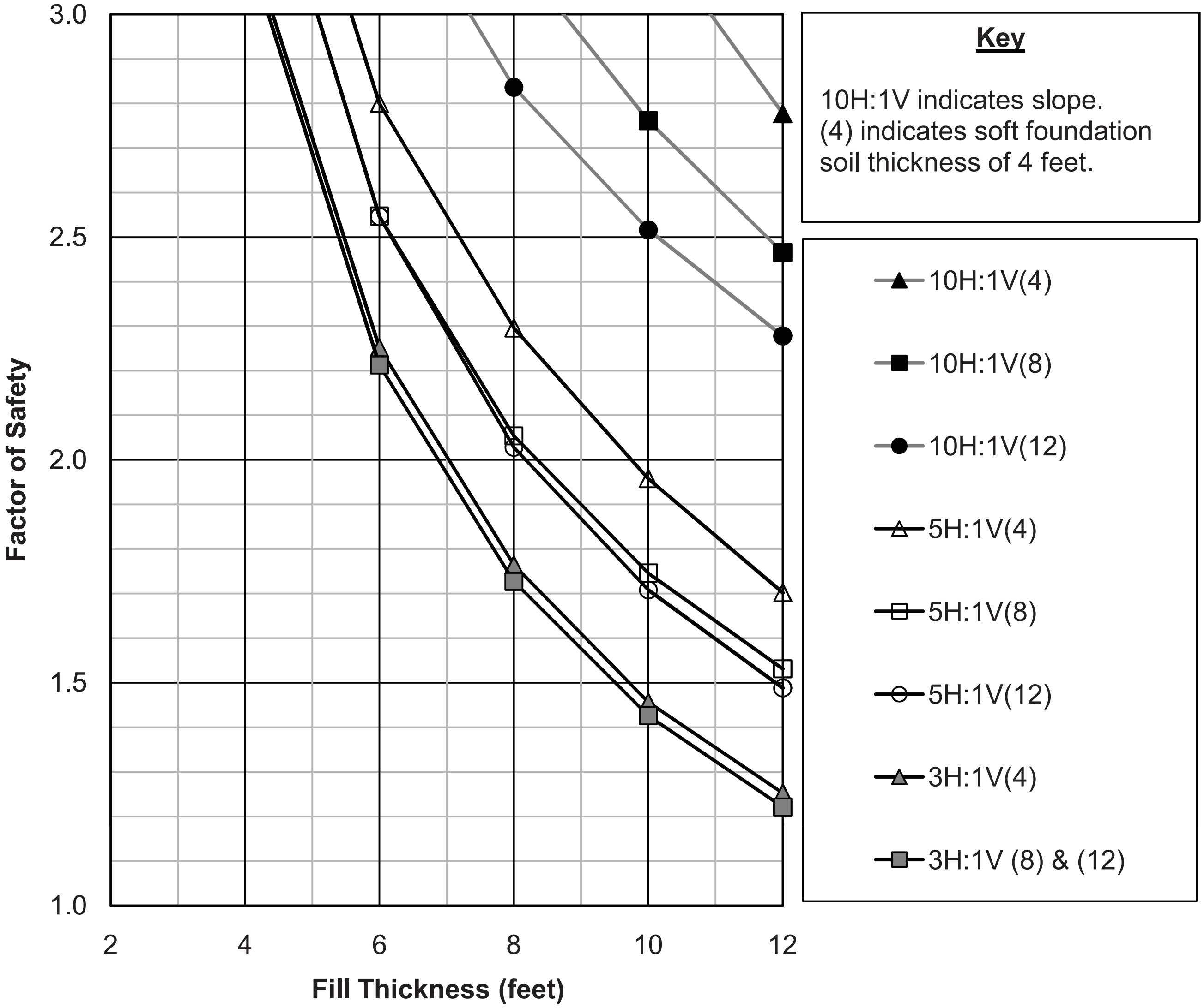
Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 25



Notes:
1. Factor of Safety represents the Immediately-After-Construction condition.
2. Analyses assume uniform slopes (3H:1V, 5H:1V and 10H:1V) with a maximum slope height varying form 2 to 12 feet, constructed on top of soft foundation soils of 4, 8, and 12 feet in thickness.
3. Analyses assume an undrained strength (Su) of 100 psf at top of the foundation soils and increase 10 psf per foot of depth. Strength Profile (foundation soils): Su = 100+10D (psf).
4. Analyses assume an undrained strength of 100 (psf) of fill.
5. Analyses assume the ground water table at the top of the foundation soils.

Salton Sea SCH Project Salton Sea, California	**Factor of Safety vs Fill Thickness** **Su = 100 + 10 D (psf)**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 26



Notes:

1. Factor of Safety represents the Immediately-After-Construction condition.
2. Analyses assume uniform slopes (3H:1V, 5H:1V and 10H:1V) with a maximum slope height varying form 2 to 12 feet, constructed on top of soft foundation soils of 4, 8, and 12 feet in thickness.
3. Analyses assume an undrained strength (Su) of 200 psf at top of the foundation soils and increase 10 psf per foot of depth. Strength Profile (foundation soils): Su = 200+10D (psf).
4. Analyses assume an undrained strength of 200 (psf) of fill.
5. Analyses assume the ground water table at the top of the foundation soils.

Salton Sea SCH Project Salton Sea, California	**Factor of Safety vs Fill Thickness** **Su = 200 + 10 D (psf)**

Hultgren - Tillis Engineers	Project No. 758.01	Plate No. 27

APPENDIX A

Laboratory Test Results

APPENDIX A
TABLE OF CONTENTS

Summary of Laboratory Test Results

Table A-1

Boring No.	Depth (ft.)	Unified Soil Classification/ Description	In-situ Moisture Content (%)	Soil Fines Passing No. 200 Sieve (%)	Atterberg Limits			Organic Content (%)	Compaction (Stand.)		Compaction (Mod.)		Anion Fracton				Cation				Double Hydrometer Dispersion (%)	Crumb Test (Grade)	Pinhole Test - Dispersive Classification
					LL	PL	PI		Max Dry Density (pcf)	Optimum Moisture Content (%)	Max Dry Density (pcf)	Optimum Moisture Content (%)	Bromide (mg/kg)	Chloride (mg/kg)	Nitrate (mg/kg)	Nitrite (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Potassium (mg/kg)	Sodium (mg/kg)			
HA-1	0.0 - 1.5	Olive Gray Fat Clay (CH)	45	94																			
HA-1	1.5 - 3.0	Olive Gray Fat Clay (CH)	65	91																			
HA-1	3.0 - 3.6	Gray Lean Clay (CL)	35																				
HA-1	3.6 - 5.0	Reddish Brown Lean Clay (CL)	22	97	42	15	27																
HA-1	0.0 - 3.6	Bulk Sample		89	63	19	44	Non-Organic	94	15	113	13	ND	29000	ND	ND	62000	11000	5900	18000	11	1 - Nondispersive	D1 - Dispersive
HA-2	0.0 - 1.5	Tan Brown Lean Clay (CL)	31																				
HA-2	1.5 - 3.0	Tan Brown Lean Clay (CL)	45	99	43	19	24																
HA-2	3.0 - 4.0	Dark Gray Lean Clay (CL)	54																				
HA-2	4.0 - 4.3	Reddish Brown Silt (ML)	41																				
HA-4	0.0 - 2.0	Olive Brown Silt (ML)	29																				
HA-4	2.0 - 3.5	Gray Lean Clay (CL)	33	85																			
HA-4	3.5 - 5.3	Dark Gray Fat Clay (CH)	46	93																			
HA-4	5.3 - 7.0	Dark Gray Fat Clay (CH)	47																				
HA-4	0.0 - 5.3	Bulk Sample		75	56	20	36	Non-Organic	107	14	119	11	ND	12000	ND	ND	48000	9000	3700	8500	17	2 - Intermediate	D1 - Dispersive
HA-5	0.0 - 1.5	Olive Gray Fat Clay (CH)	44																				
HA-5	1.5 - 2.5	Olive Gray Fat Clay (CH)	49	94	52	24	28																
HA-5	2.5 - 4.0	Dark Gray Fat Clay (CH)	55																				
HA-5	4.0 - 4.9	Gray Fat Clay (CH)	49																				
HA-5	4.9 - 5.3	Dark Gray Sandy Fat Clay (CH)	20	72																			
HA-9	0.0 - 1.5	Tan & Gray Lean Clay (CL)	44																				
HA-9	1.5 - 3.0	Dark Gray Sandy Lean Clay (CL)	44	62	31	16	15																
HA-9	3.0 - 4.0	Gray Clayey Sand (SC)	29																				
HA-9	4.0 - 4.5	Gray Lean Clay (CL)	33																				
HA-9	4.5 - 4.8	Reddish Brown Lean Clay (CL)	31																				
HA-10	0.0 - 1.5	Tan & Gray Clayey Silt (CL-ML)	25	78	25	20	5																
HA-10	1.5 - 3.0	Tan Clayey Sand (SC)	21	42																			
HA-10	3.0 - 4.0	Tan Sandy Lean Clay (CL)	34																				
HA-10	4.0 - 5.0	Reddish Brown Lean Clay (CL)	31																				
VC-6	0.0 - 1.3	Gray Silt (ML)	69	83	NV	NP	NP																
VC-11	0.0 - 0.8	Gray Fat Clay (CH)	31																				
VC-11	0.8 - 3.6	Gray Fat Clay (CH)	56																				
VC-11	0.0 - 3.6	Bulk Sample		90	68	21	47	Non-Organic					ND	5,500	ND	ND	41,000	8,000	3,700	6,400	61	3 - Dispersive	D2 - Dispersive
VC-16	0.0 - 1.3	Gray Fat Clay (CH)	43																				
VC-16	1.3 - 3.9	Gray Fat Clay (CH) & Reddish Brown Lean Clay (CL)	52																				
VC-16	0.0 - 3.9	Bulk Sample		95	66	20	46	Non-Organic					ND	6,900	ND	ND	36,000	7,500	3,500	6,700	9	2 - Intermediate	D1 - Dispersive
VC-19	0.0 - 0.9	Gray Sandy Silt (ML)	44	64	NV	NP	NP																
VC-19	0.9 - 3.5	Gray Silt (ML)	34																				
VC-19	3.5 - 6.2	Gray Fat Clay (CH)	38	93	58	21	37																
VC-20	0.0 - 2.0	Gray Fat Clay (CH)	29																				
VC-20	2.0 - 4.7	Gray Fat Clay (CH)	39																				
VC-20	0.0 - 4.7	Bulk Sample		89	67	18	49	Non-Organic					ND	4,600	ND	ND	40,000	7,600	2,000	4,600	13	1 - Nondispersive	D2 - Dispersive
VC-21	0.0 - 2.1	Gray Fat Clay (CH)	56																				
VC-21	2.1 - 4.8	Gray Fat Clay (CH)	53	98	57	19	38																
VC-22	0.0 - 1.3	Gray Silty Sand (SM)	33																				
VC-22	1.3 - 4.0	Gray Fat Clay (CH)	32	75	60	19	41																
VC-24	0.0 - 1.1	Gray Silty Sand (SM)	28	40	NV	NP	NP																
VC-24	1.1 - 3.7	Gray Silt (ML)	57																				
VC-24	3.7 - 6.4	Gray Lean Clay (CL)	42	89	26	16	10																
VC-28	0.0 - 0.4	Gray Fat Clay (CH)	48																				
VC-28	0.4 - 3.0	Gray Fat Clay (CH)	45																				
VC-28	3.0 - 5.7	Gray Fat Clay (CH)	64																				
VC-28	0.4 - 5.7	Bulk Sample		98	65	18	47	Non-Organic					ND	8,600	ND	ND	48,000	7,900	3,400	8,400	9	1 - Nondispersive	D2 - Dispersive

Note:

1. "Bulk Sample" indicates that lsample was recovered over a wide depth interval. Several additional hand auger borings were drilled immediately adjacent to the logged boring to recover a large quantity of soil for testing. The depth interval is noted.
2. "Composite sample" indicates that a sample that extends more than one 2.7-feet section of vibracore tubing. The depth interval is noted.
3. Abbreviations - NV: No Value, NP: Non Plastic, ND: Not Detected.

Tests on Individual Samples

DENSITY MOISTURE

PROJECT Hultgren - Tillis Engineers (Salton Sea) DATE 10/5/2010

PROJECT NUMBER 60 TECHNICIAN 997

BORING NO.	HA-1				HA-2				HA-4	
DEPTH, ft	0-1.5	1.5-3	3-3.6	3.6-5	0-1.5	1.5-3	3-4	4-4.3	0-2	2-3.5
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	423.1	357.9	400.2	454.4	421.1	465.6	432.3	406.9	609.7	609.4
DRY WT. (g)	291.4	216.7	297.6	371.7	322.6	320.6	281.7	289.6	473.4	457.4
WET DENSITY										
% MOISTURE	**45.2**	**65.2**	**34.5**	**22.2**	**30.5**	**45.2**	**53.5**	**40.5**	**28.8**	**33.2**
DRY DENSITY										

BORING NO.	HA-4		HA-5					HA-9		
DEPTH, ft	3.5-5.3	5.3-7	0-1.5	1.5-2.5	2.5-4	4-4.9	4.9-5.3	0-1.5	1.5-3	3-4
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	522.2	437.7	455.3	599.2	443	410.4	519.3	550.6	441.7	585.9
DRY WT. (g)	357.1	298.3	316.3	401.1	285.8	276.4	433.6	383.6	306.4	453.2
WET DENSITY										
% MOISTURE	**46.2**	**46.7**	**43.9**	**49.4**	**55.0**	**48.5**	**19.8**	**43.5**	**44.2**	**29.3**
DRY DENSITY										

DENSITY MOISTURE

PROJECT Hultgren - Tillis Engineers (Salton Sea) DATE 10/5/2010

PROJECT NUMBER 60 TECHNICIAN 997

BORING NO.	HA-9		HA-10				VC-6C	VC-11B	VC-11C	VC-16B
DEPTH, ft	4-4.5	4.5-4.8	0-1.5	1.5-3	3-4	4-5	0-1.3	0-0.8	0.8-3.6	0-1.3
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	518.9	252.4	578.9	583.5	557.8	562.2	442.2	288.8	471.4	480.9
DRY WT. (g)	389.6	192.2	461.7	483.1	416.5	430.4	262.4	220.9	302.9	336.6
WET DENSITY										
% MOISTURE	**33.2**	**31.3**	**25.4**	**20.8**	**33.9**	**30.6**	**68.5**	**30.7**	**55.6**	**42.9**
**							**14/1.5**	**8.5/0.5**	**33/0**	**13/0.5**

** Length of Solid column/Length of Water Column, Respectively, IN

BORING NO.	VC-16C	VC-19A	VC-19B	VC-19C	VC-20B	VC-20C	VC-21B	VC-21C	VC-22B	VC-22C
DEPTH, ft	1.3-3.9	0-0.9	0.9-3.5	3.5-6.2	0-2	2-4.7	0-2.1	2.1-4.8	0-1.3	1.3-4
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	345.6	220	496.3	325.9	481.7	317.8	523.9	439.8	336.6	482.1
DRY WT. (g)	227.4	153.2	370.1	235.9	374.2	228.7	336.5	288.4	253.3	365.6
WET DENSITY										
% MOISTURE	**52.0**	**43.6**	**34.1**	**38.2**	**28.7**	**39.0**	**55.7**	**52.5**	**32.9**	**31.9**
**	**33/0**	**7.5/0.5**	**32.0**	**33/0**	**21.5/1.0**	**33/0**	**21/2**	**33/0**	**8.5/0**	**31/0.5**

** Length of Solid column/Length of Water Column, Respectively, IN

DENSITY MOISTURE

PROJECT Hultgren - Tillis Engineers (Salton Sea) DATE 10/5/2010

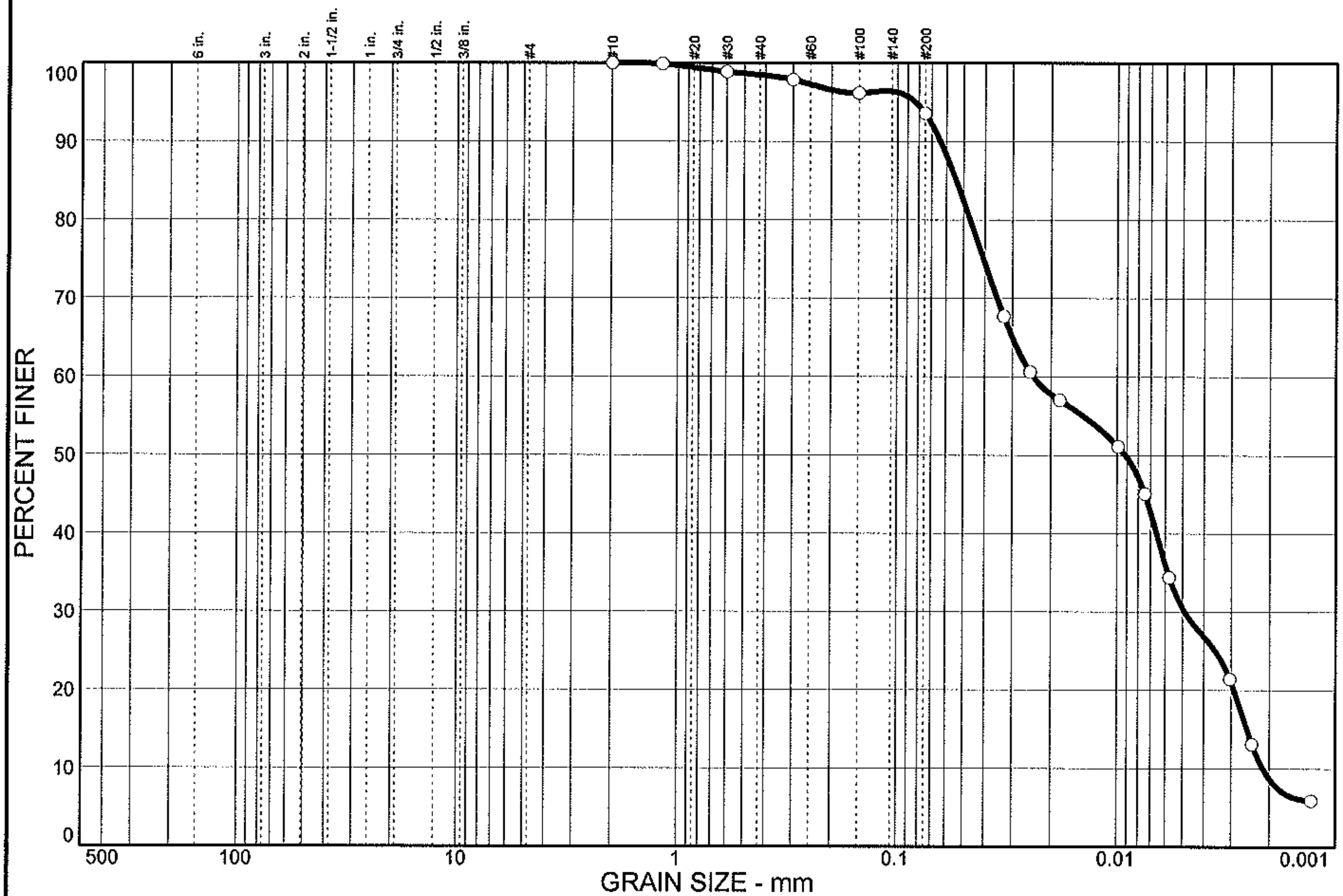
PROJECT NUMBER TECHNICIAN 997

BORING NO.	VC-24A	VC-24B	VC-24C	VC-28A	VC-28B	VC-28C				
DEPTH, ft	0-1.1	1.1-3.7	3.7-6.4	0-0.4	0.4-3	3-5.7				
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)	342.7	440	444.7	306.7	488.6	335.9				
DRY WT. (g)	266.9	280.9	312.4	207.3	337.9	205.5				
WET DENSITY										
% MOISTURE	**28.4**	**56.6**	**42.3**	**47.9**	**44.6**	**63.5**				
**	**10/1**	**31/0**	**32/0**	**3/6**	**32/0**	**28.5/0**				

** Length of Solid column/Length of Water Column, Respectively, IN

BORING NO.										
DEPTH, ft										
SAMPLE NO.										
LENGTH (IN.)										
TOTAL WT. (g)										
WET WT. (g)										
DRY WT. (g)										
WET DENSITY										
% MOISTURE										
DRY DENSITY										

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	1.5	4.9	63.1	30.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	98.9		
#50	97.9		
#100	96.2		
#200	93.6		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0540 D_{60}= 0.0241 D_{50}= 0.0091
D_{30}= 0.0049 D_{15}= 0.0025 D_{10}= 0.0021
C_u= 11.25 C_c= 0.46

Classification

USCS= AASHTO=

Remarks

F.M.=0.07

Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 0-1.5 Feet

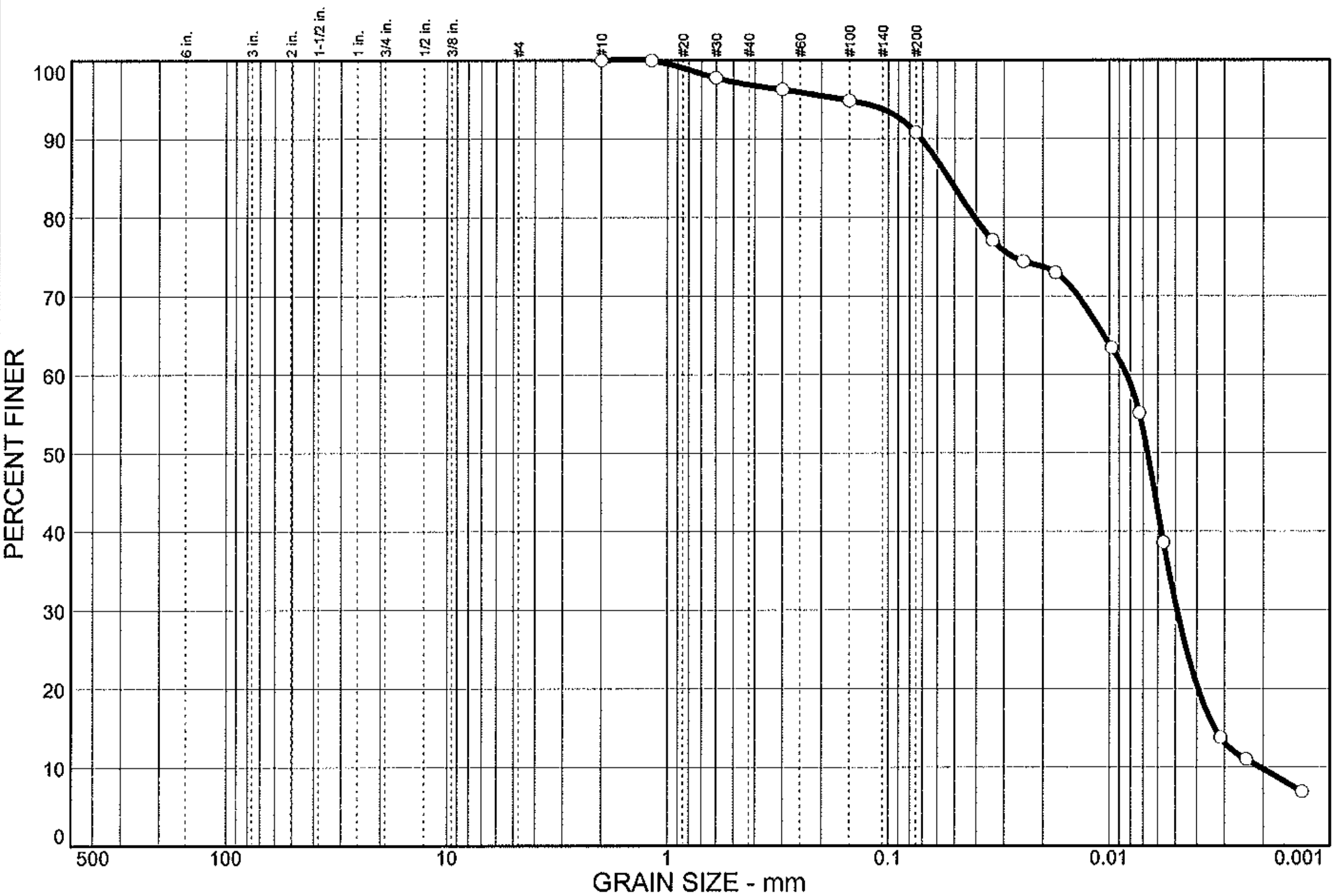
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	3.1	6.1	59.9	30.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	97.8		
#50	96.3		
#100	94.9		
#200	90.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0532 D_{60}= 0.0083 D_{50}= 0.0067
D_{30}= 0.0049 D_{15}= 0.0033 D_{10}= 0.0021
C_u= 4.02 C_c= 1.41

Classification

USCS= AASHTO=

Remarks

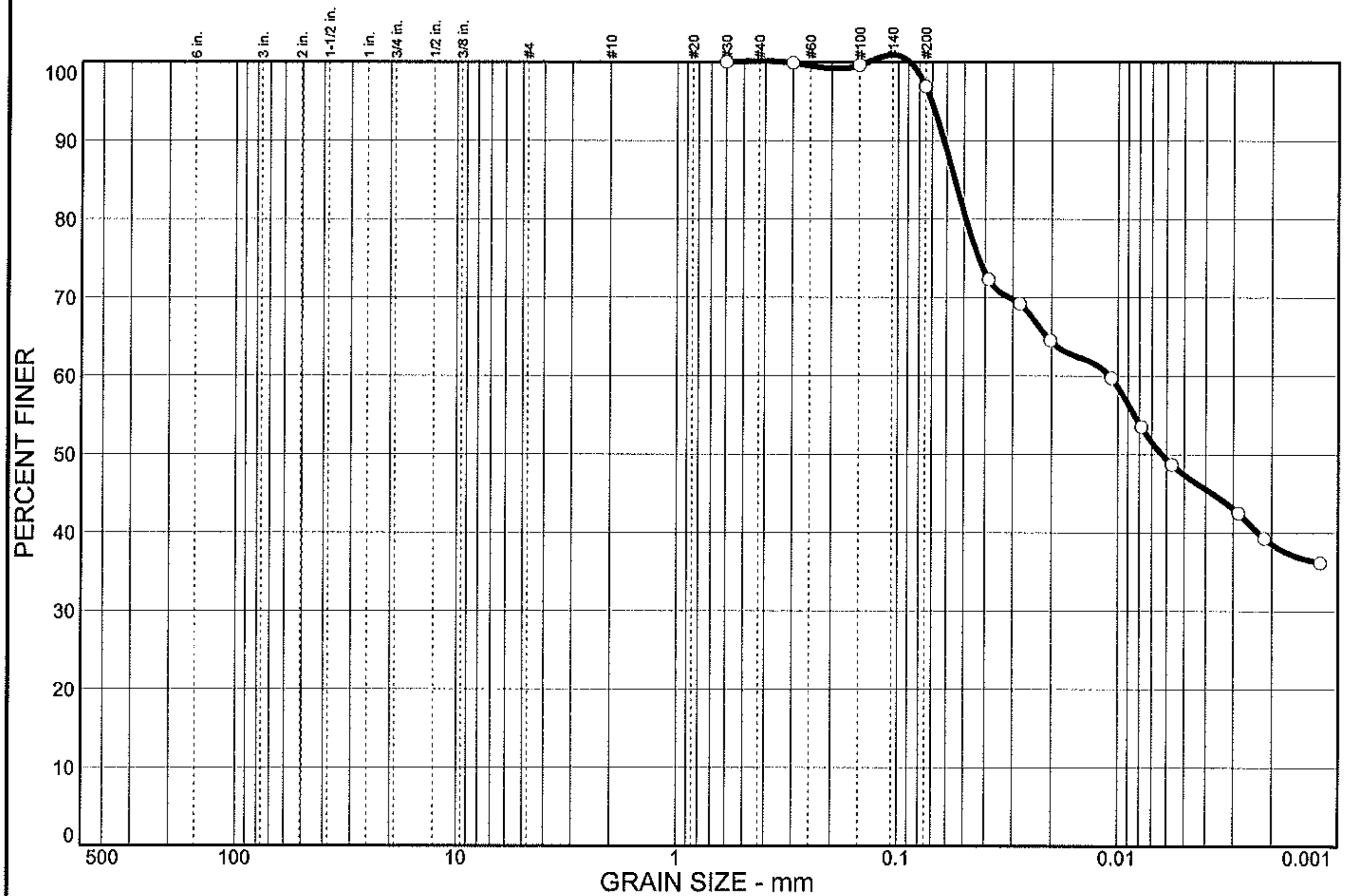
F.M.=0.11

Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

Moore Twining Associates, Inc.
Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		3.2	49.5	47.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#50	99.9		
#100	99.6		
#200	96.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0551 D_{60}= 0.0109 D_{50}= 0.0063
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

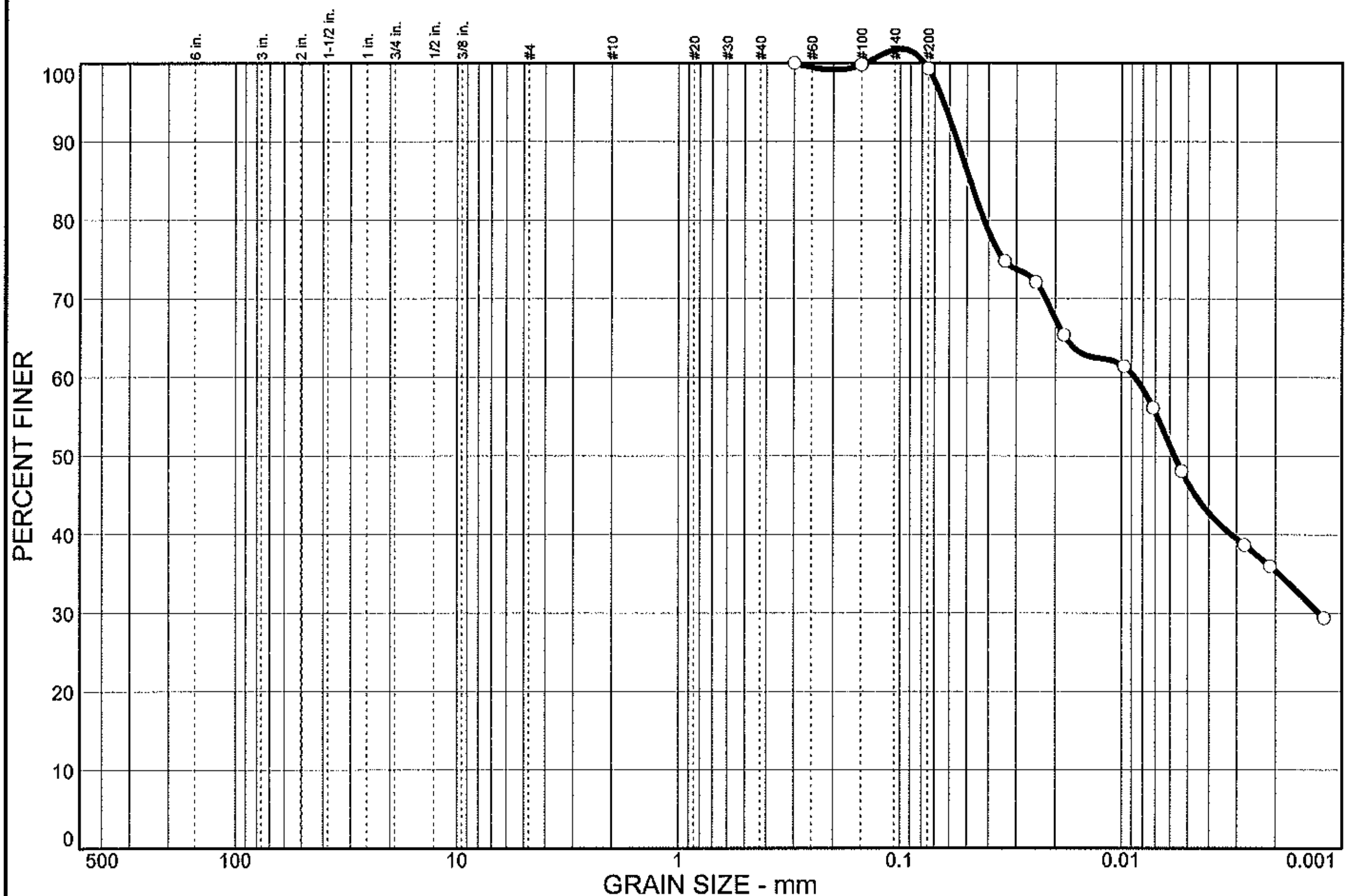
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 3.5-5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.0	0.7	52.6	46.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#50	100.0		
#100	99.8		
#200	99.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 43 PI= 24

Coefficients

D_{85}= 0.0485 D_{60}= 0.0087 D_{50}= 0.0057
D_{30}= 0.0013 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

Sample No.: HA-2 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

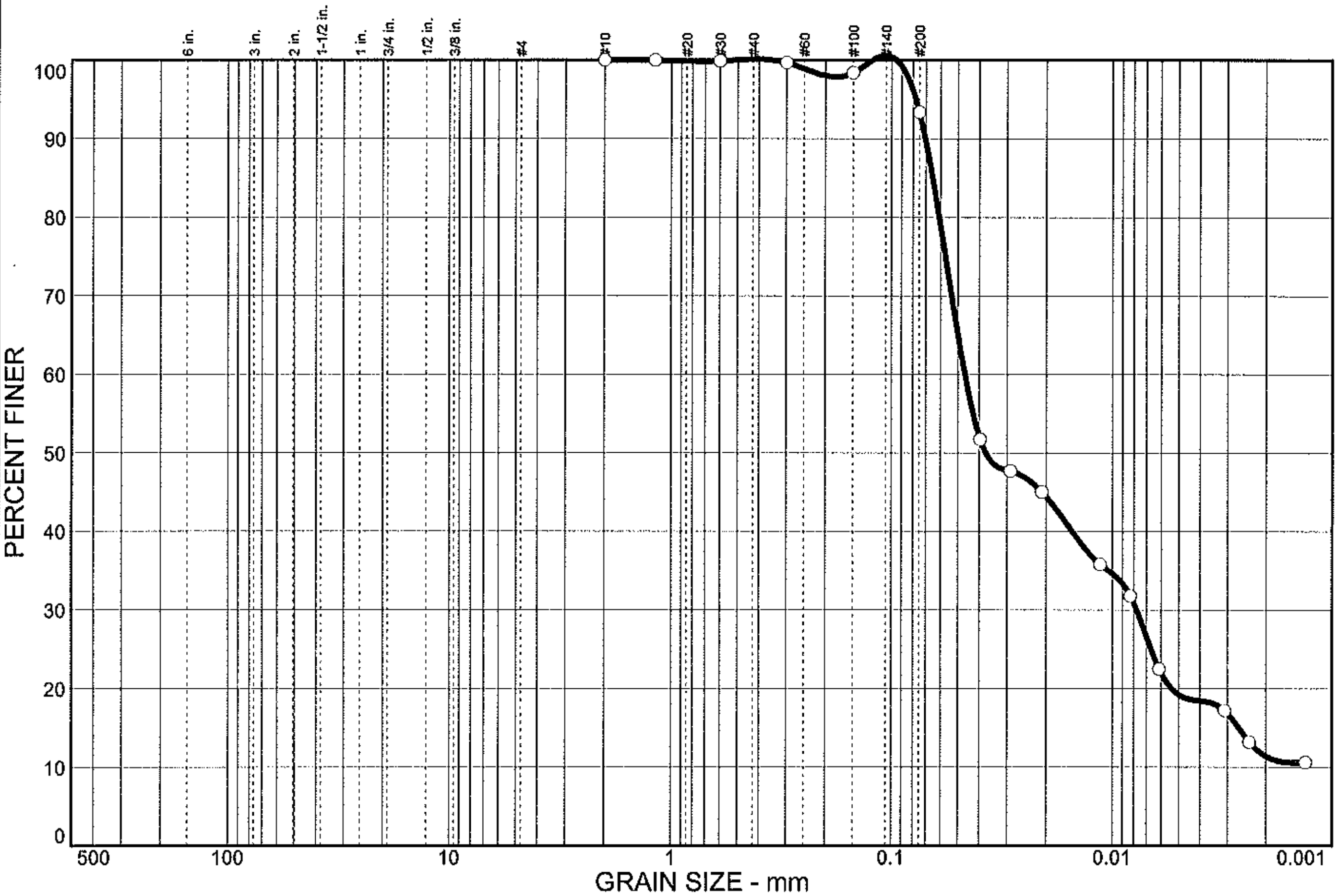
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		6.7	74.2	19.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.7		
#100	98.4		
#200	93.4		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0652 D_{60}= 0.0465 D_{50}= 0.0374
D_{30}= 0.0078 D_{15}= 0.0027 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 3.5-5.3 Feet

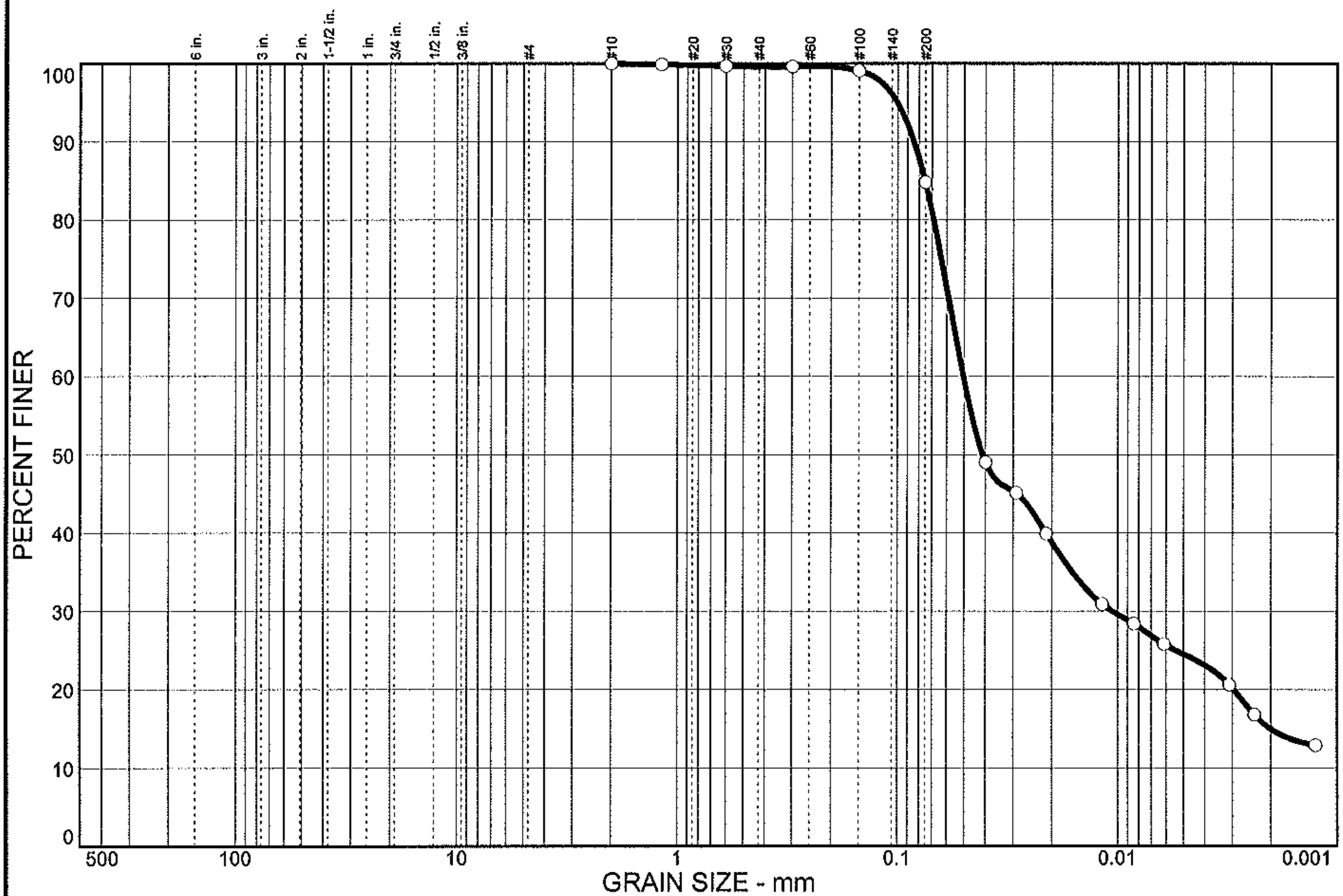
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	14.8	60.3	24.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.6		
#100	99.1		
#200	84.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.0753 D_{60}= 0.0505 D_{50}= 0.0412
D_{30}= 0.0105 D_{15}= 0.0020 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

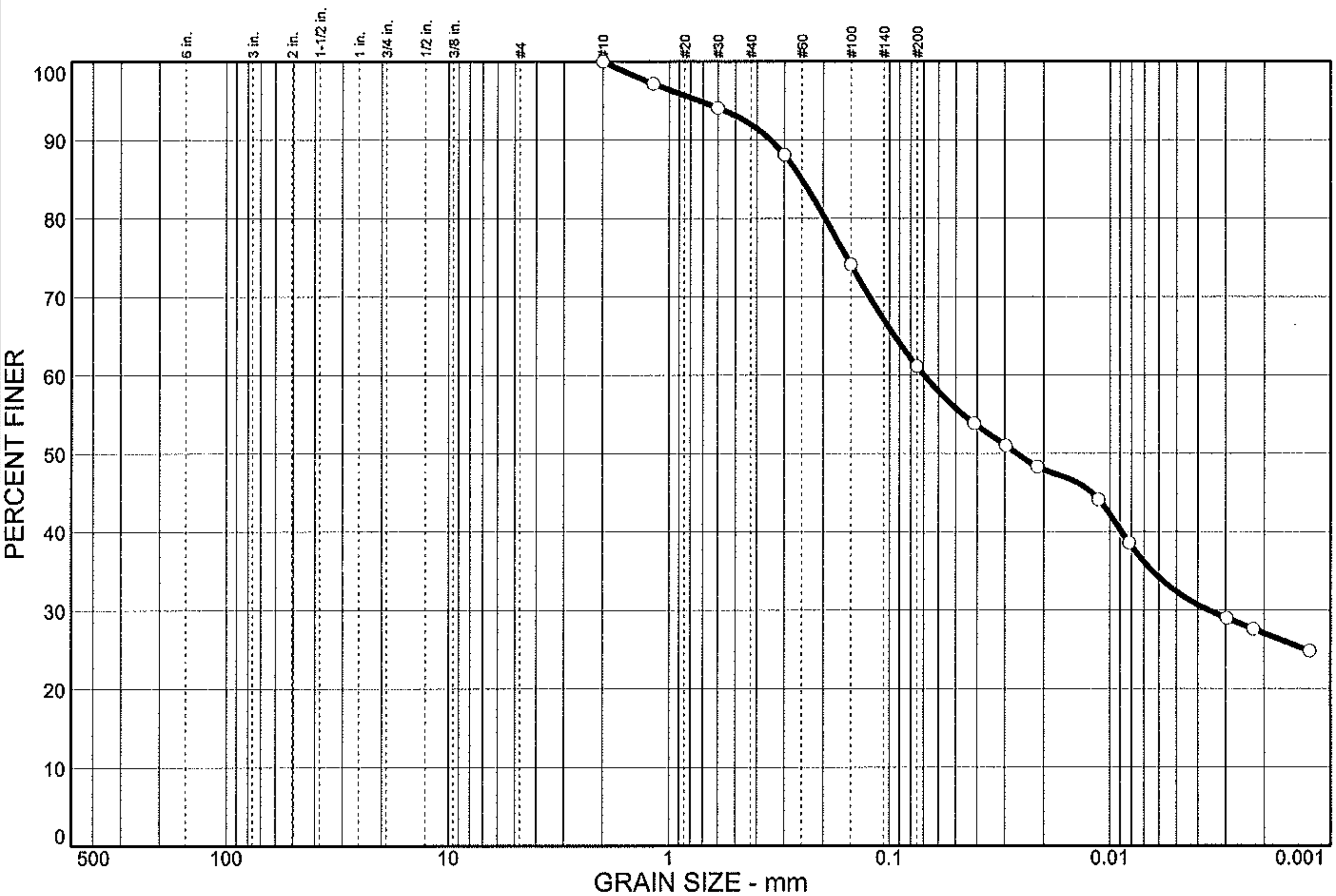
F.M.=0.02

Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 2-3.5 Feet

Moore Twining Associates, Inc.
Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	8.0	30.9	28.7	32.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	97.2		
#30	94.1		
#50	88.1		
#100	74.1		
#200	61.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= 16 LL= 31 PI= 15

Coefficients

D_{85}= 0.250 D_{60}= 0.0697 D_{50}= 0.0265
D_{30}= 0.0036 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.47

Sample No.: HA-9 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-3 Feet

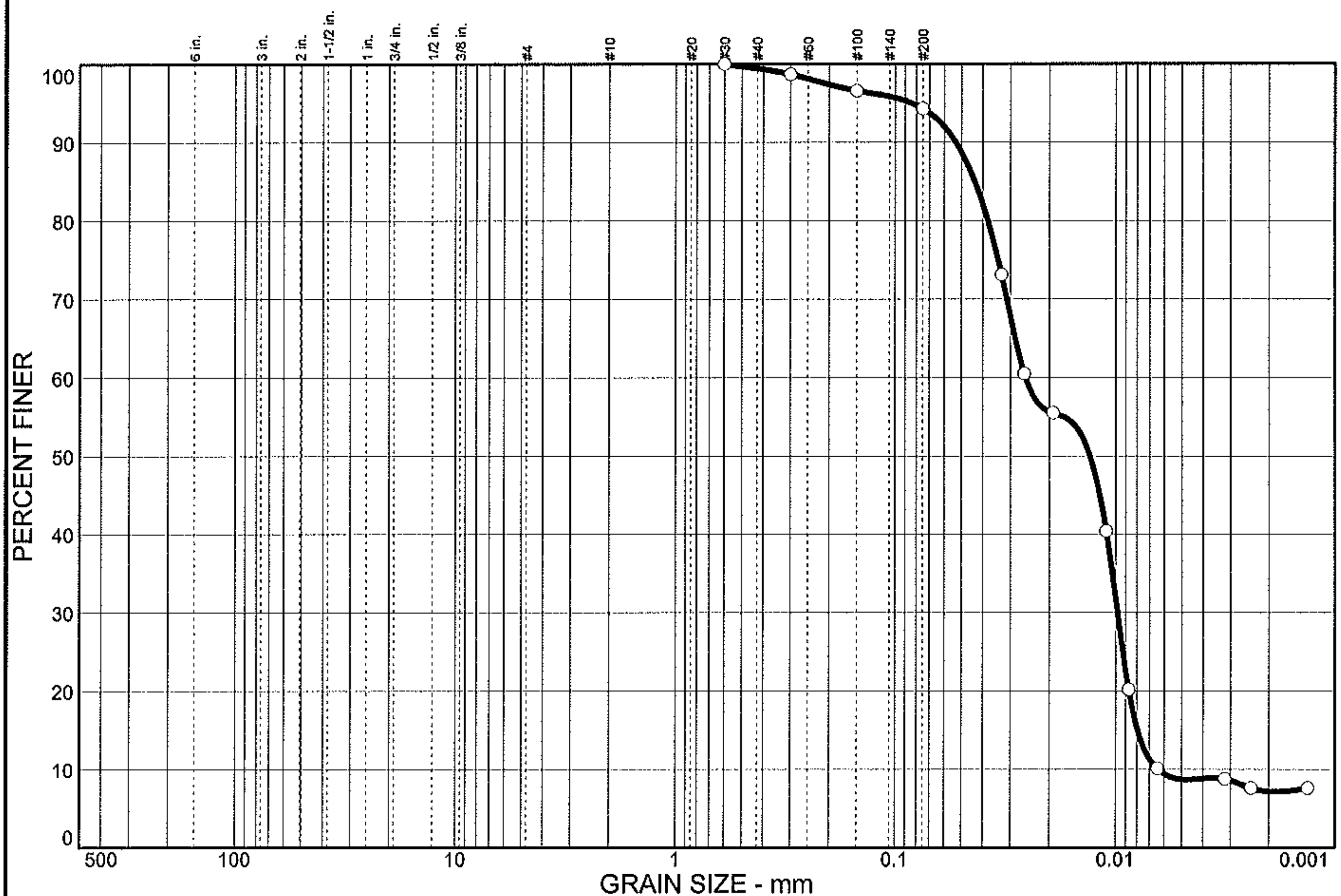
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.5	5.2	85.6	8.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#50	98.7		
#100	96.6		
#200	94.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= 24 LL= 52 PI= 28

Coefficients

D_{85}= 0.0436 D_{60}= 0.0256 D_{50}= 0.0131
D_{30}= 0.0098 D_{15}= 0.0079 D_{10}= 0.0064
C_u= 4.02 C_c= 0.59

Classification

USCS= AASHTO=

Remarks

F.M.=0.05

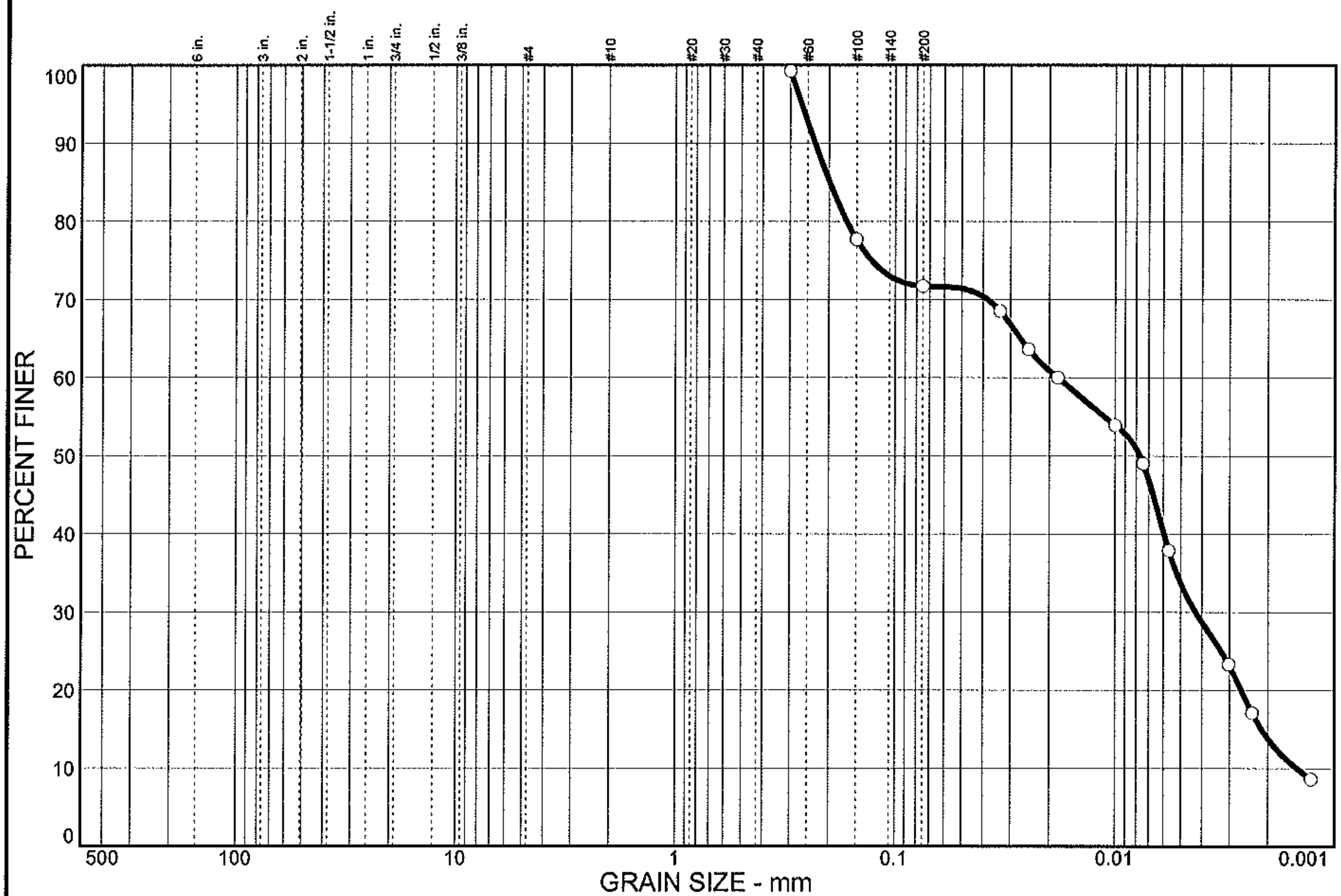
Sample No.: HA-5 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 1.5-2.5 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
						37.9	33.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#50	99.3		
#100	77.7		
#200	71.7		

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.198 D_{60}= 0.0183 D_{50}= 0.0077
D_{30}= 0.0043 D_{15}= 0.0021 D_{10}= 0.0015
C_u= 12.33 C_c= 0.67

Classification

USCS= AASHTO=

Remarks

F.M.=0.23

* (no specification provided)

Sample No.: HA-5 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:** 4.9-5.3 Feet

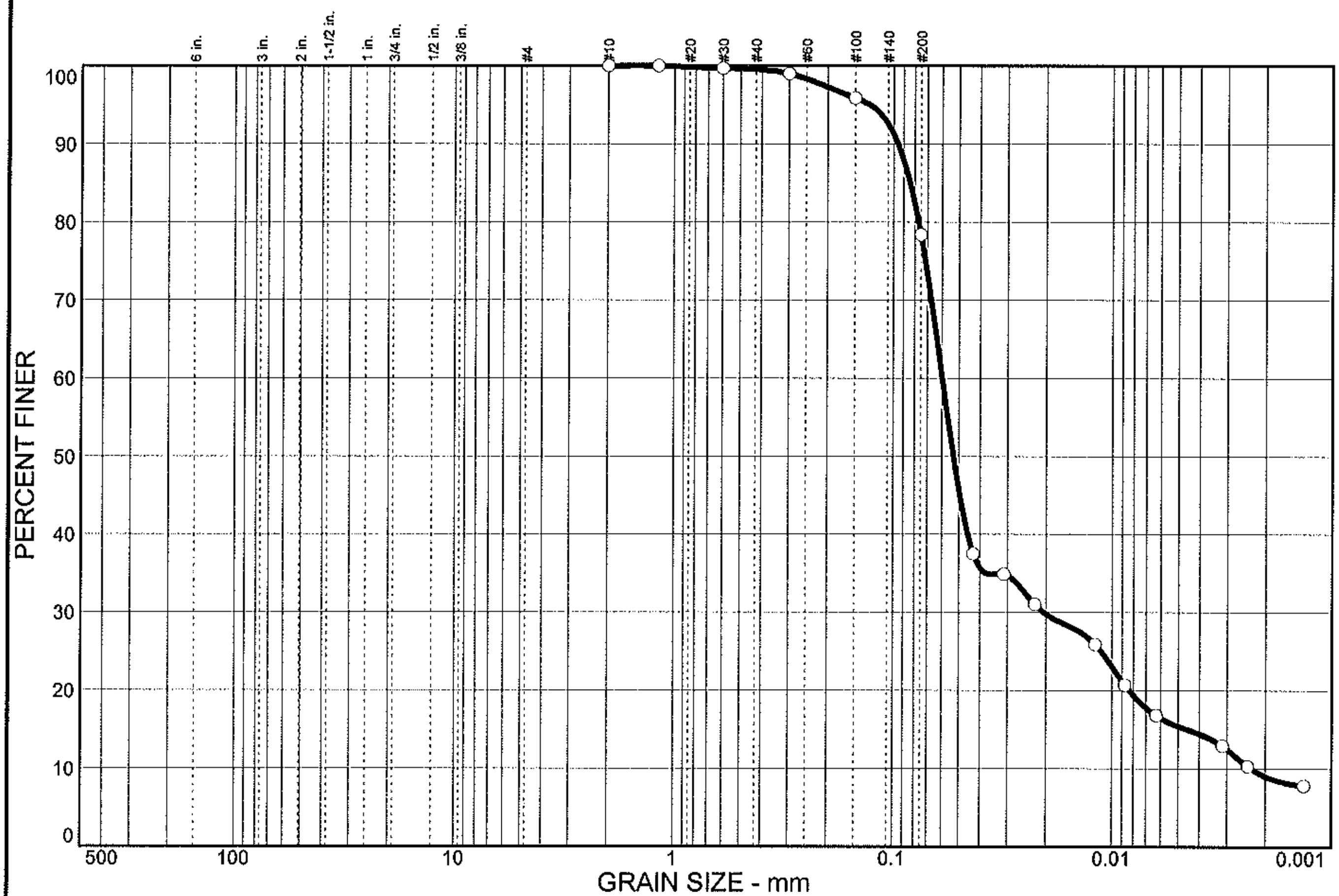
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	21.2	63.0	15.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.7		
#50	99.0		
#100	95.9		
#200	78.4		

* (no specification provided)

Material Description

*

Atterberg Limits

PL= 20 LL= 25 PI= 5

Coefficients

D_{85}= 0.0841 D_{60}= 0.0597 D_{50}= 0.0530
D_{30}= 0.0205 D_{15}= 0.0045 D_{10}= 0.0023
C_u= 25.70 C_c= 3.03

Classification

USCS= AASHTO=

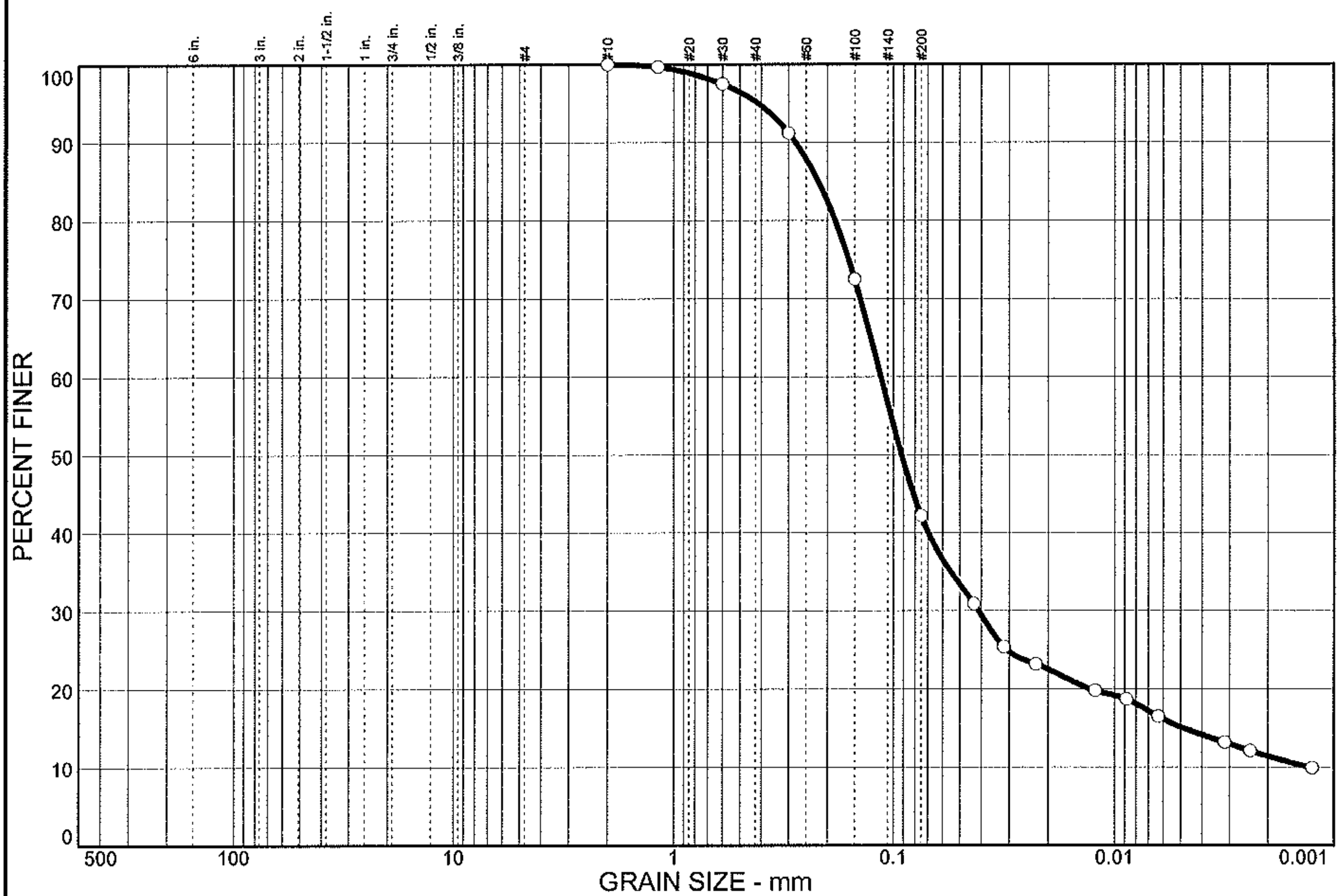
Remarks

F.M.=0.05

Sample No.: HA-10 **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-1.5 Feet

Moore Twining Associates, Inc. **Fresno, CA**	**Client:** Hultgren - Tillis Engineers **Project:** Salton Sea **Project No:** 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	4.7	53.1	27.0	15.2

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.7		
#30	97.5		
#50	91.2		
#100	72.5		
#200	42.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 0.220 D_{60}= 0.114 D_{50}= 0.0919
D_{30}= 0.0412 D_{15}= 0.0048 D_{10}= 0.0013
C_u= 87.63 C_c= 11.46

Classification

USCS= AASHTO=

Remarks

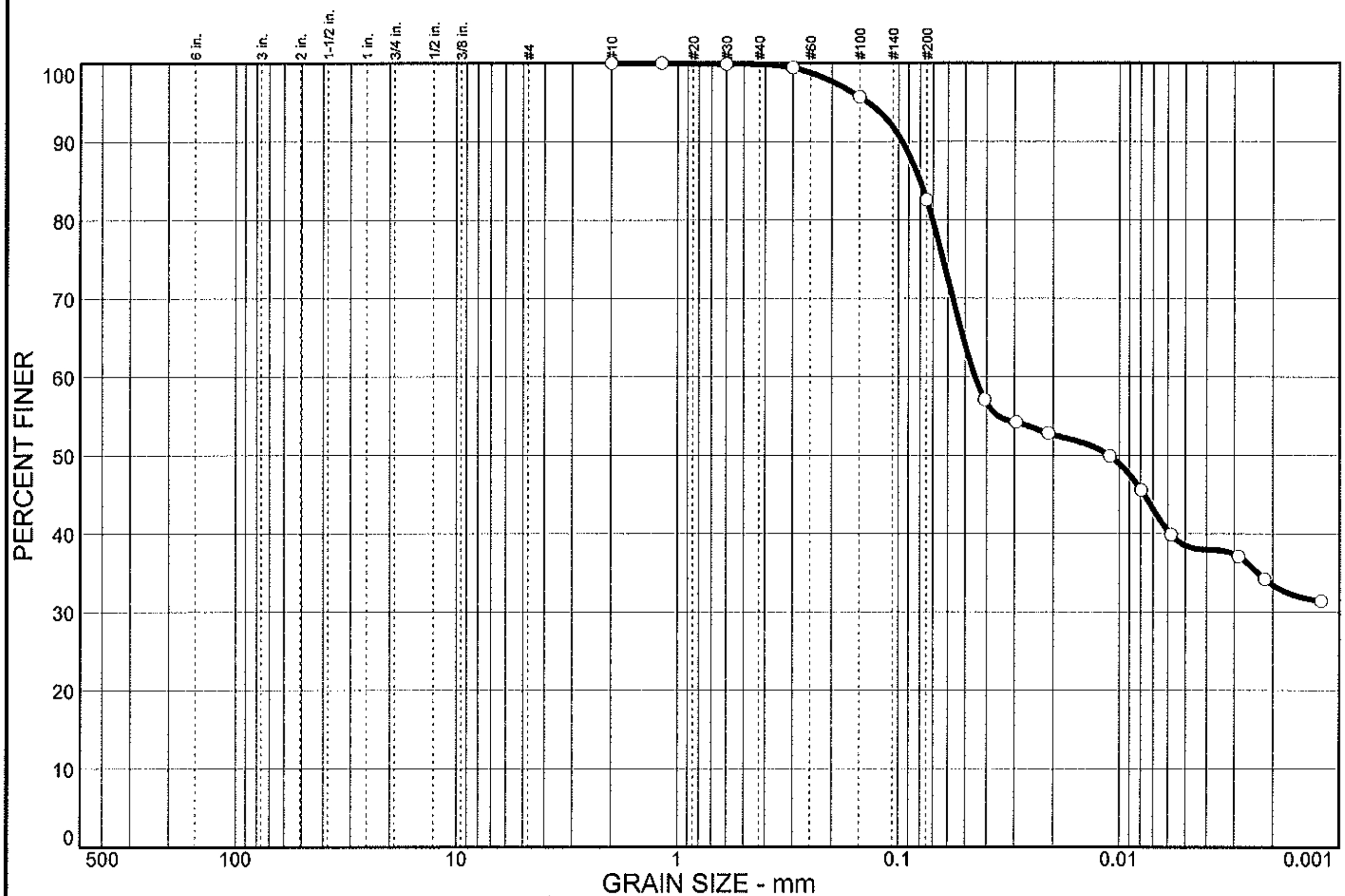
F.M.=0.39

Sample No.: HA-10 **Source of Sample:** **Date:** 12/13/10
Location: **Elev./Depth:** 1.3-3 Feet

Moore Twining Associates, Inc.
Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.1	17.3	44.1	38.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.4		
#100	95.7		
#200	82.6		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.0801 D_{60}= 0.0452 D_{50}= 0.0111
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.05

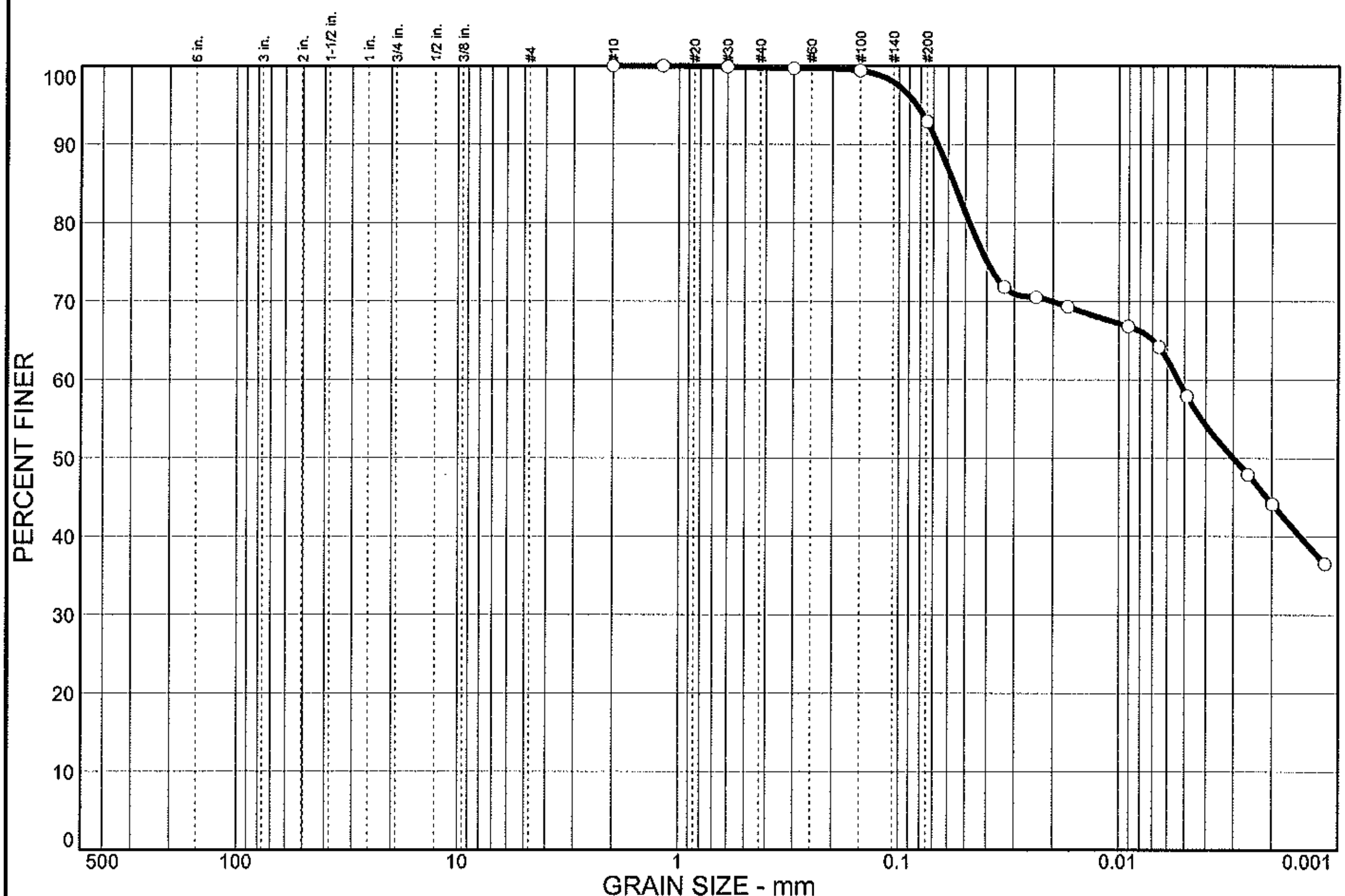
Sample No.: VC-6C **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-1.3 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	6.9	34.4	58.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.9		
#50	99.7		
#100	99.4		
#200	92.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 21 LL= 58 PI= 37

Coefficients

D_{85}= 0.0564 D_{60}= 0.0053 D_{50}= 0.0030
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

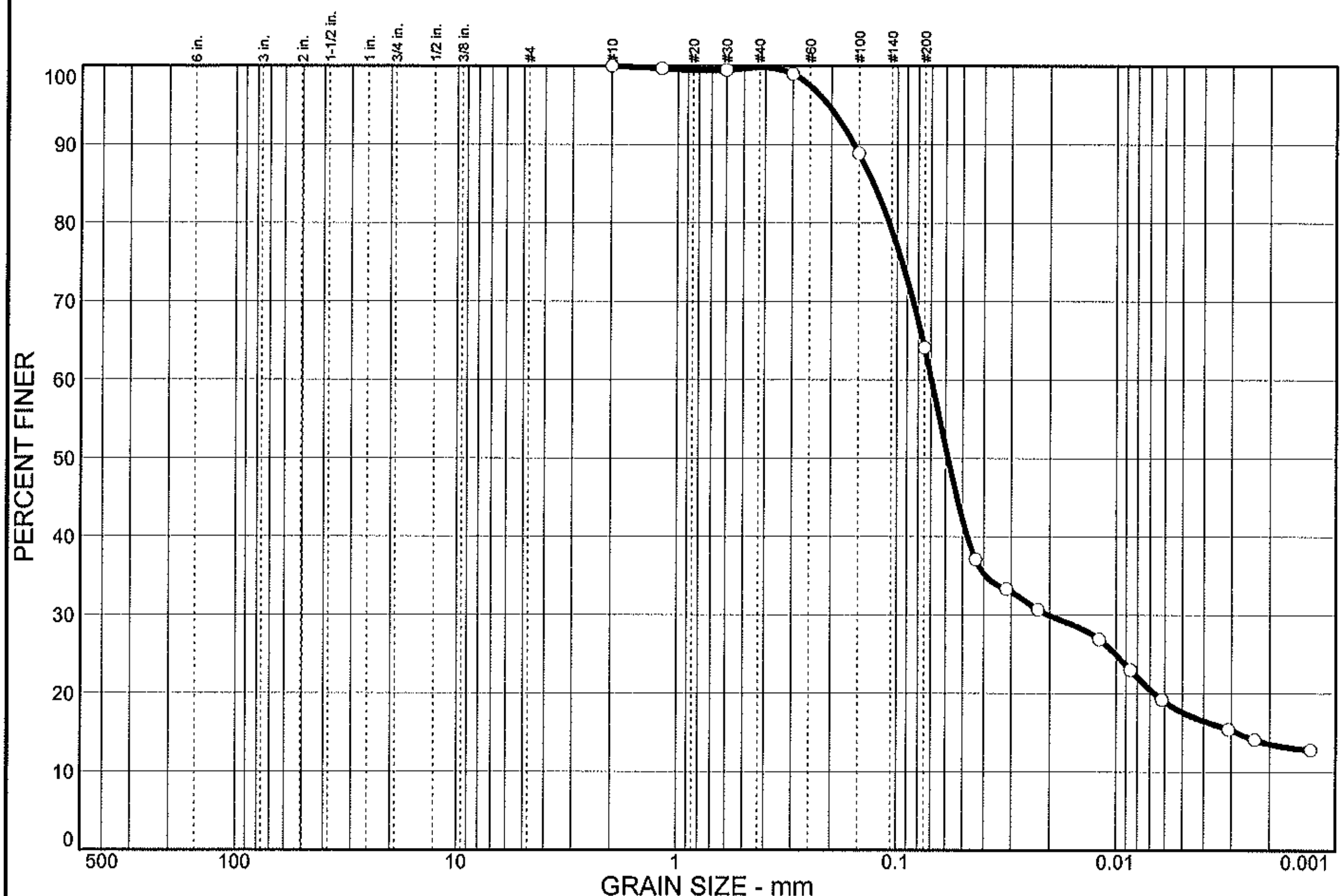
F.M.=0.01

Sample No.: VC-19C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 3.5-6.2 Feet

Moore Twining Associates, Inc.
Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	35.7	46.5	17.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.7		
#30	99.5		
#50	99.0		
#100	88.9		
#200	64.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.128 D_{60}= 0.0696 D_{50}= 0.0584
D_{30}= 0.0202 D_{15}= 0.0028 D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.13

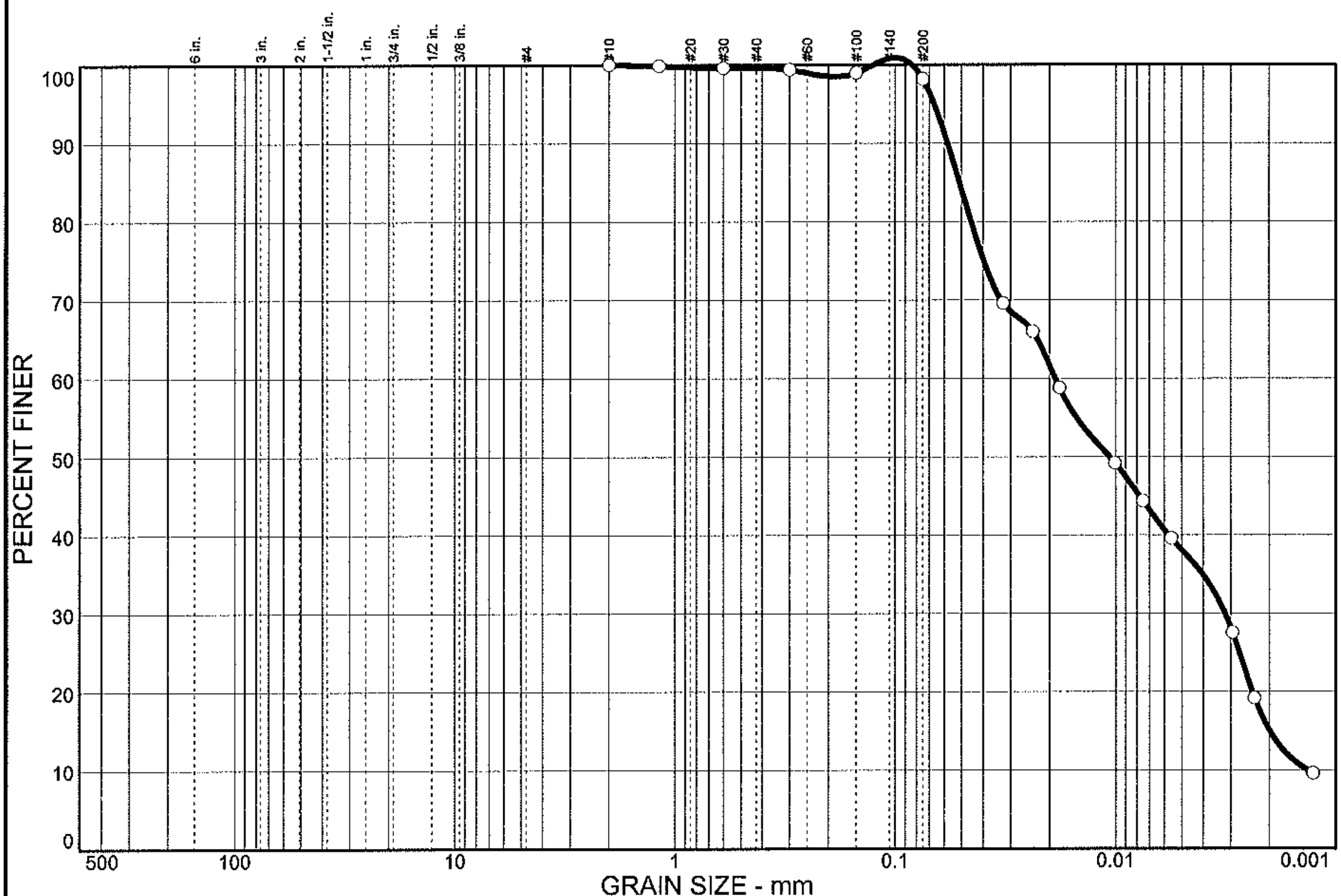
Sample No.: VC-19A **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-0.9 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.3	1.5	60.1	38.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.4		
#100	99.0		
#200	98.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 57 PI= 38

Coefficients

D_{85}= 0.0512 D_{60}= 0.0188 D_{50}= 0.0106
D_{30}= 0.0032 D_{15}= 0.0020 D_{10}= 0.0013
C_u= 14.06 C_c= 0.40

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

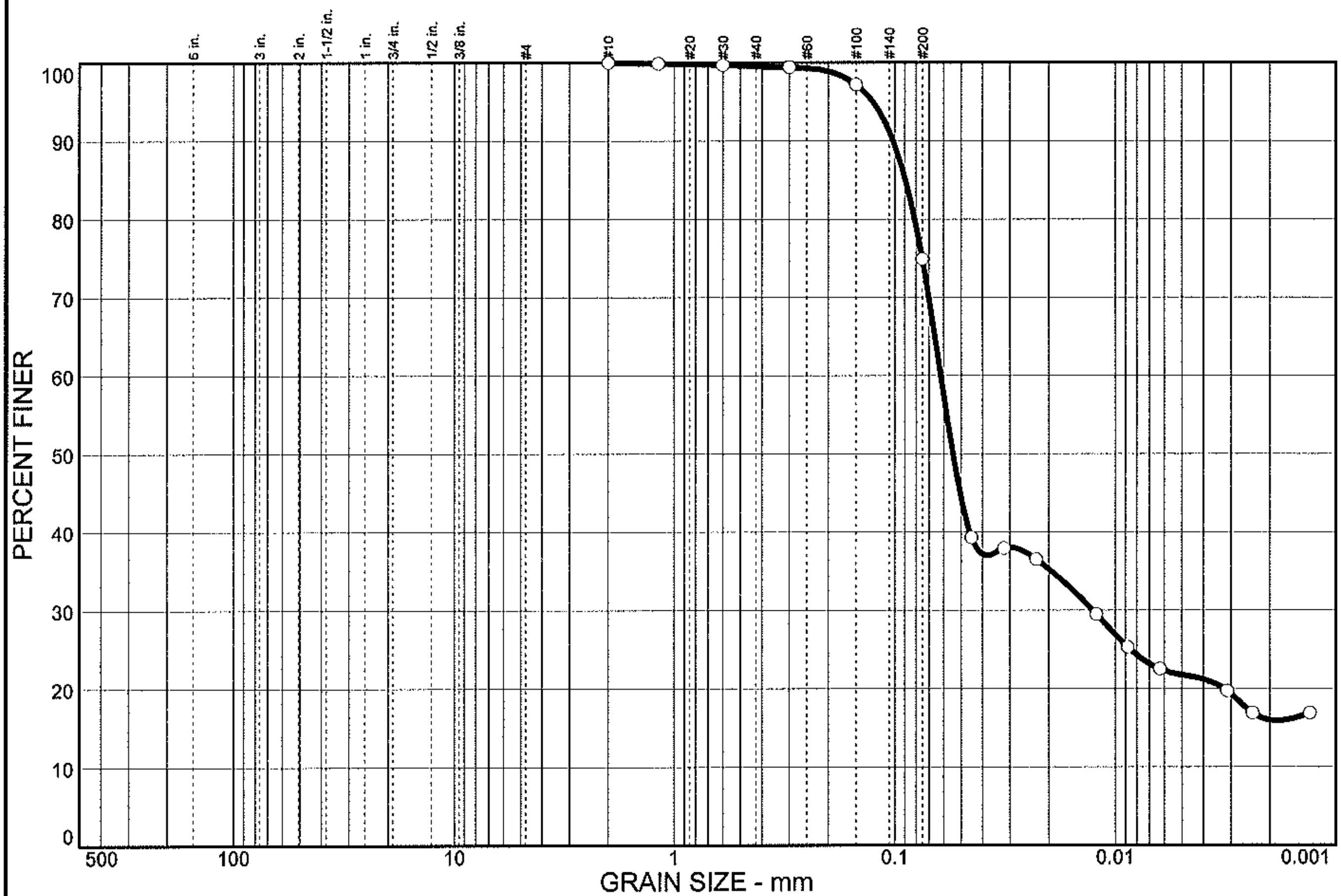
Sample No.: VC-21C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 2.1-4.8 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.5	24.6	53.2	21.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.4		
#100	97.2		
#200	74.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 60 PI= 41

Coefficients

D_{85}= 0.0896 D_{60}= 0.0619 D_{50}= 0.0545
D_{30}= 0.0126 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.04

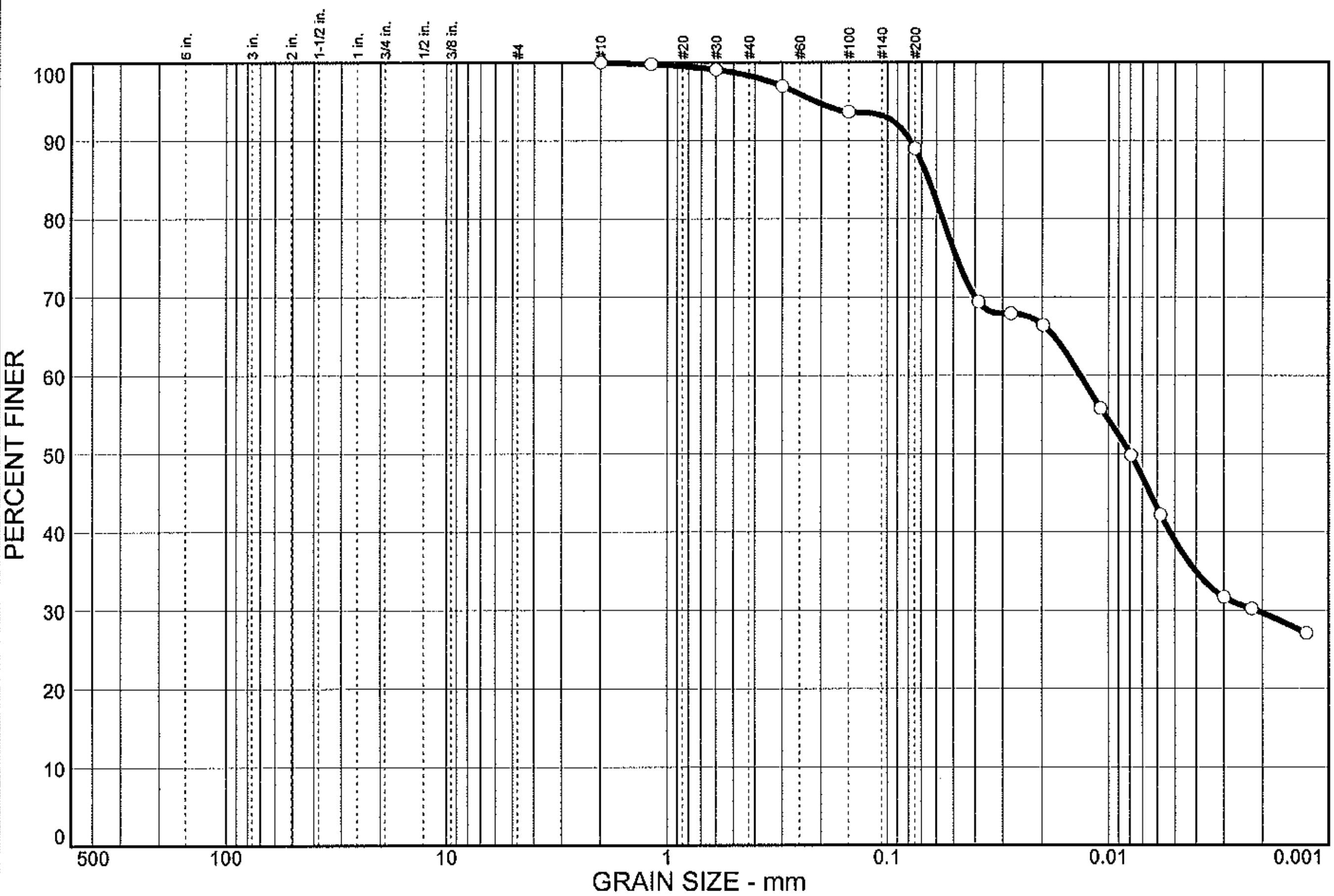
Sample No.: VC-22C **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 1.3-4 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	1.7	9.3	50.1	38.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.8		
#30	99.1		
#50	97.0		
#100	93.7		
#200	89.0		

* (no specification provided)

Material Description

Atterberg Limits

PL= 16 LL= 26 PI= 10

Coefficients

D_{85}= 0.0650 D_{60}= 0.0134 D_{50}= 0.0080

D_{30}= 0.0021 D_{15}= D_{10}=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.10

Sample No.: VC-24C **Source of Sample:** **Date:** 10/14/10

Location: **Elev./Depth:** 3.7-6.4 Feet

Moore Twining Associates, Inc.

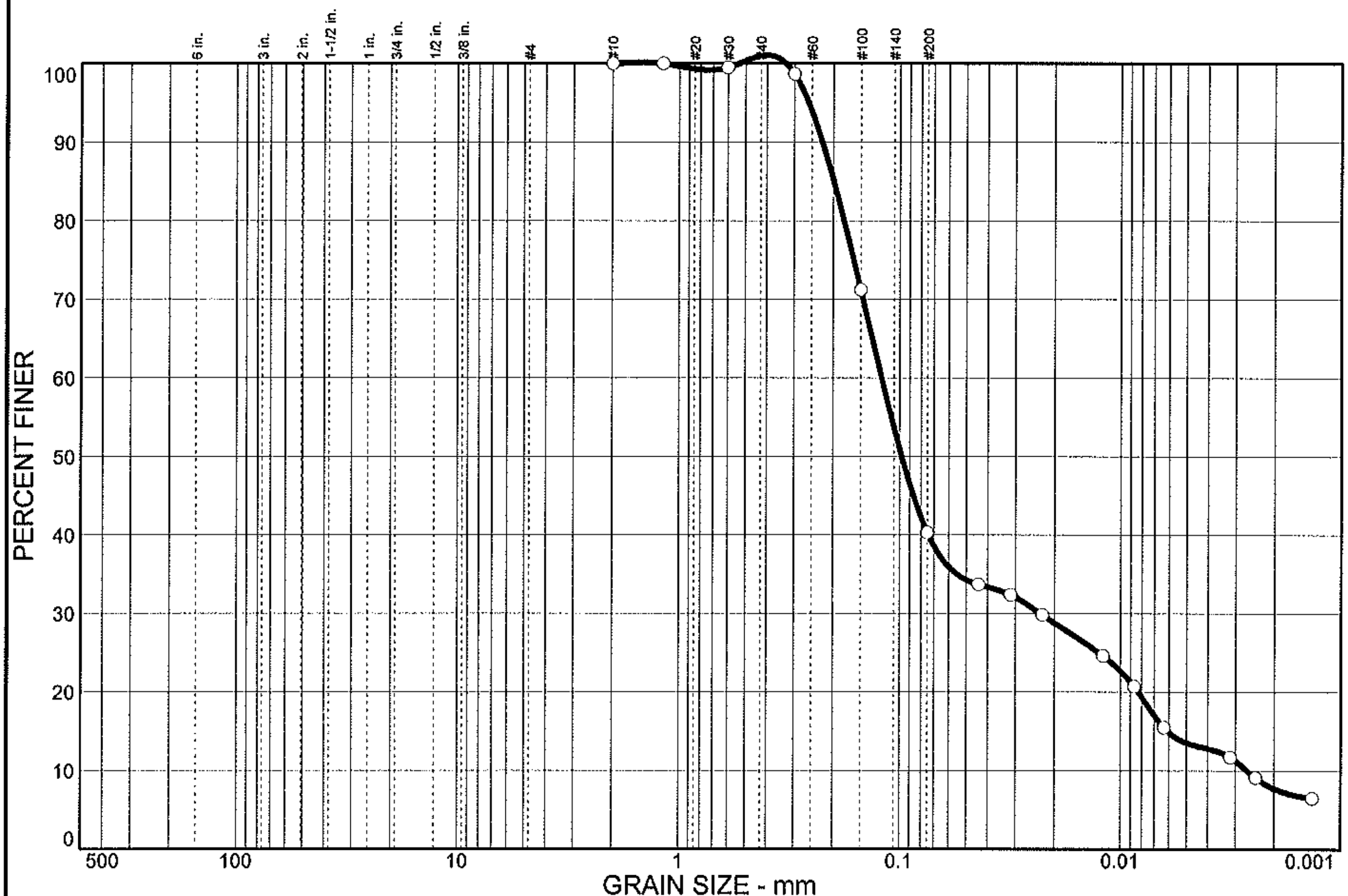
Fresno, CA

Client: Hultgren - Tillis Engineers

Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		60.7	26.7	13.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	99.5		
#50	98.7		
#100	71.2		
#200	40.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{85}= 0.199 D_{60}= 0.121 D_{50}= 0.0979
D_{30}= 0.0231 D_{15}= 0.0061 D_{10}= 0.0027
C_u= 45.57 C_c= 1.67

Classification

USCS= AASHTO=

Remarks

F.M.=0.31

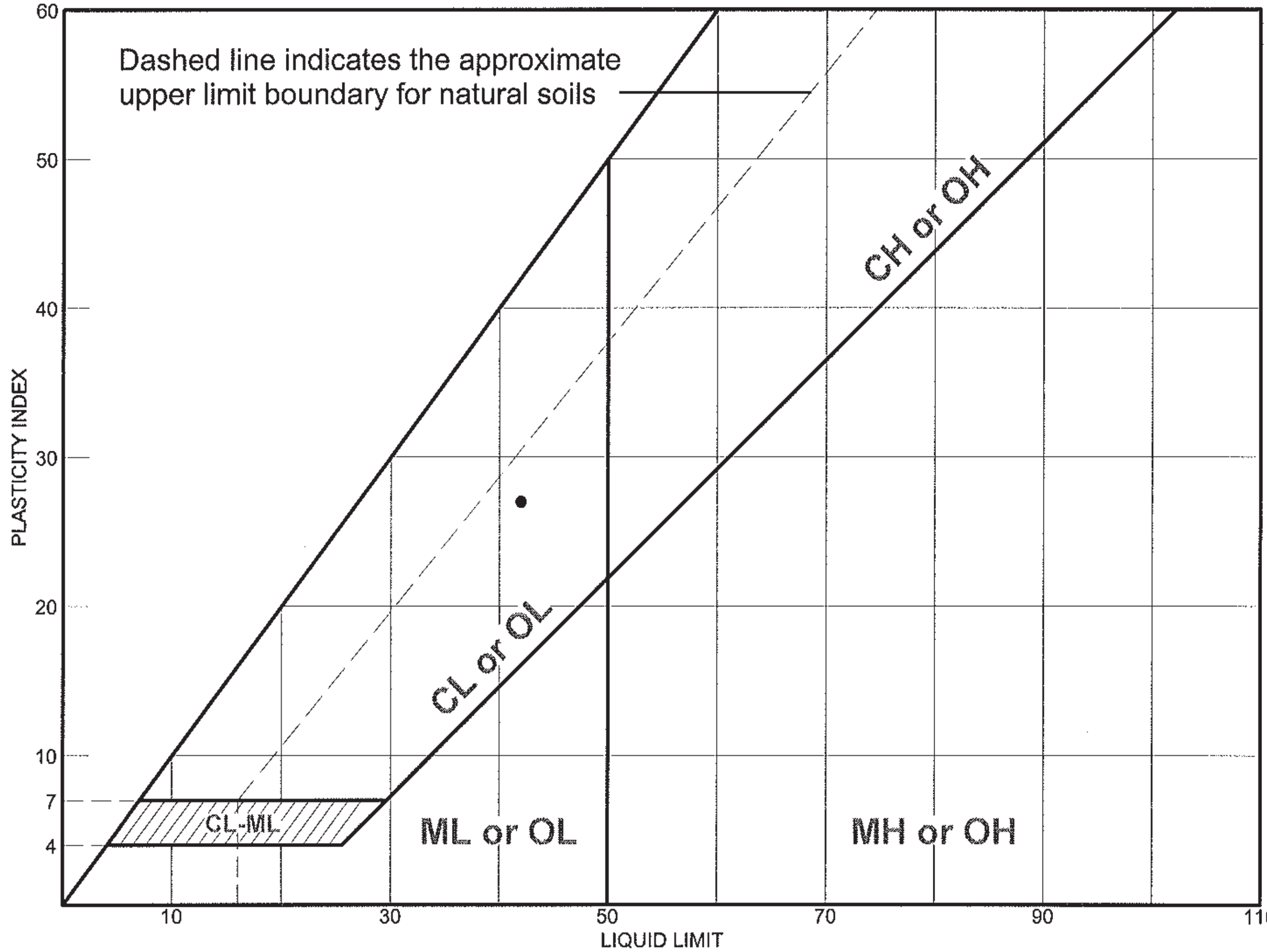
Sample No.: VC-24A **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-1.1 Feet

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		42	15	27			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-1 **Elev./Depth:** 3.6-5 Feet

Remarks:

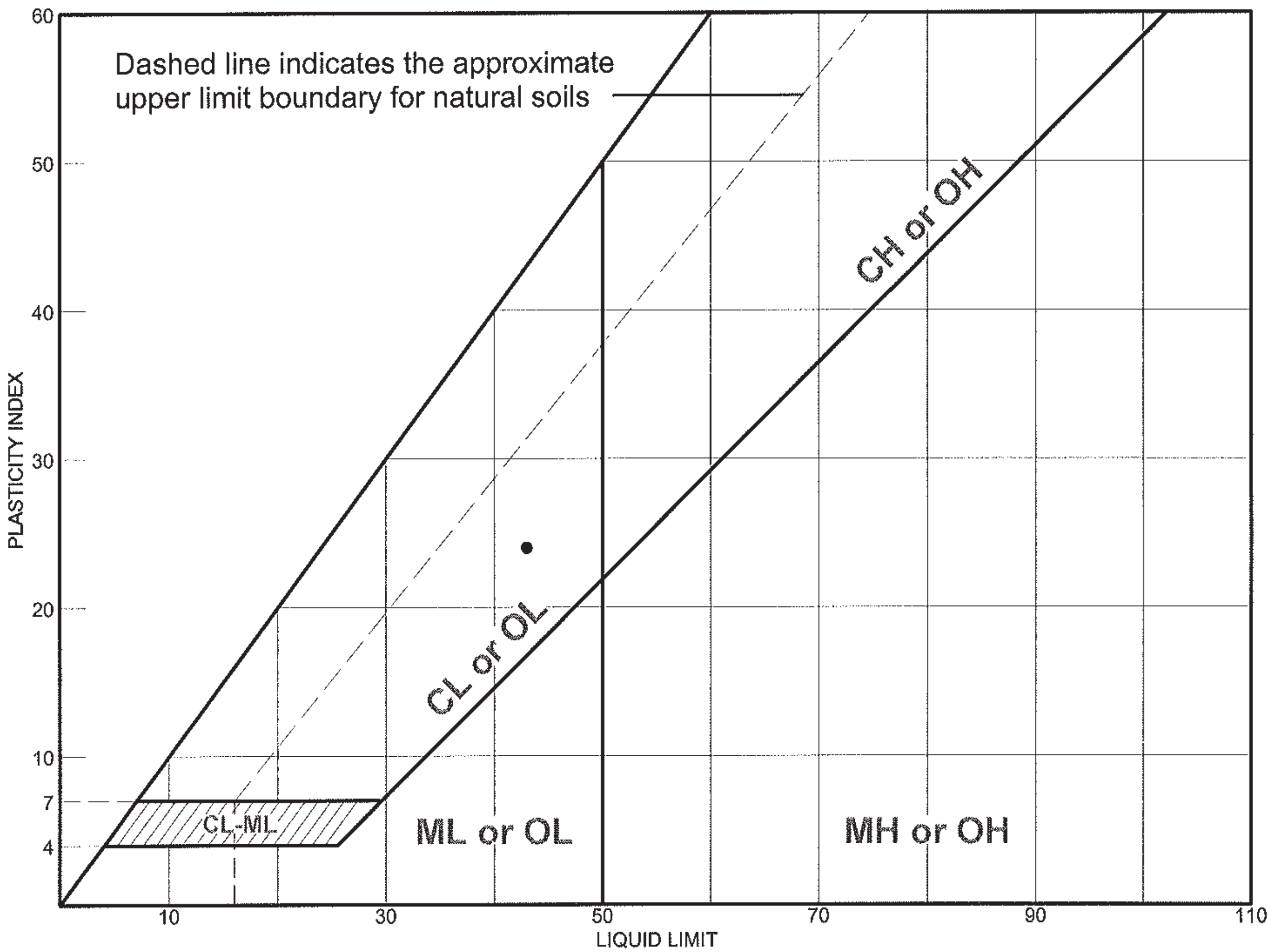
●

Moore Twining Associates, Inc.

Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		43	19	24			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-2 **Elev./Depth:** 1.5-3 Feet

Remarks:

●

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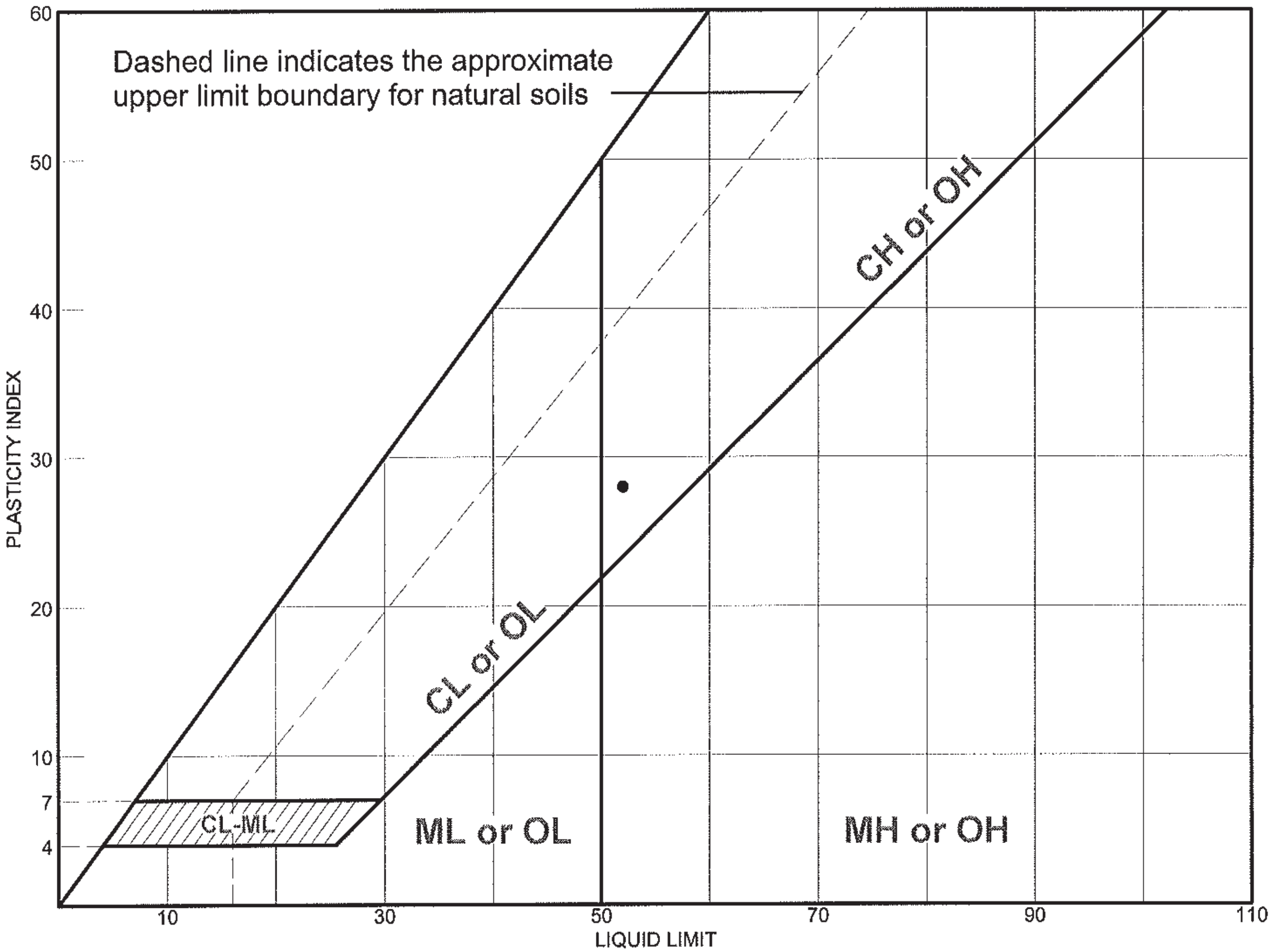
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		52	24	28			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-5 **Elev./Depth:** 1.5-2.5 Feet

Remarks:

●

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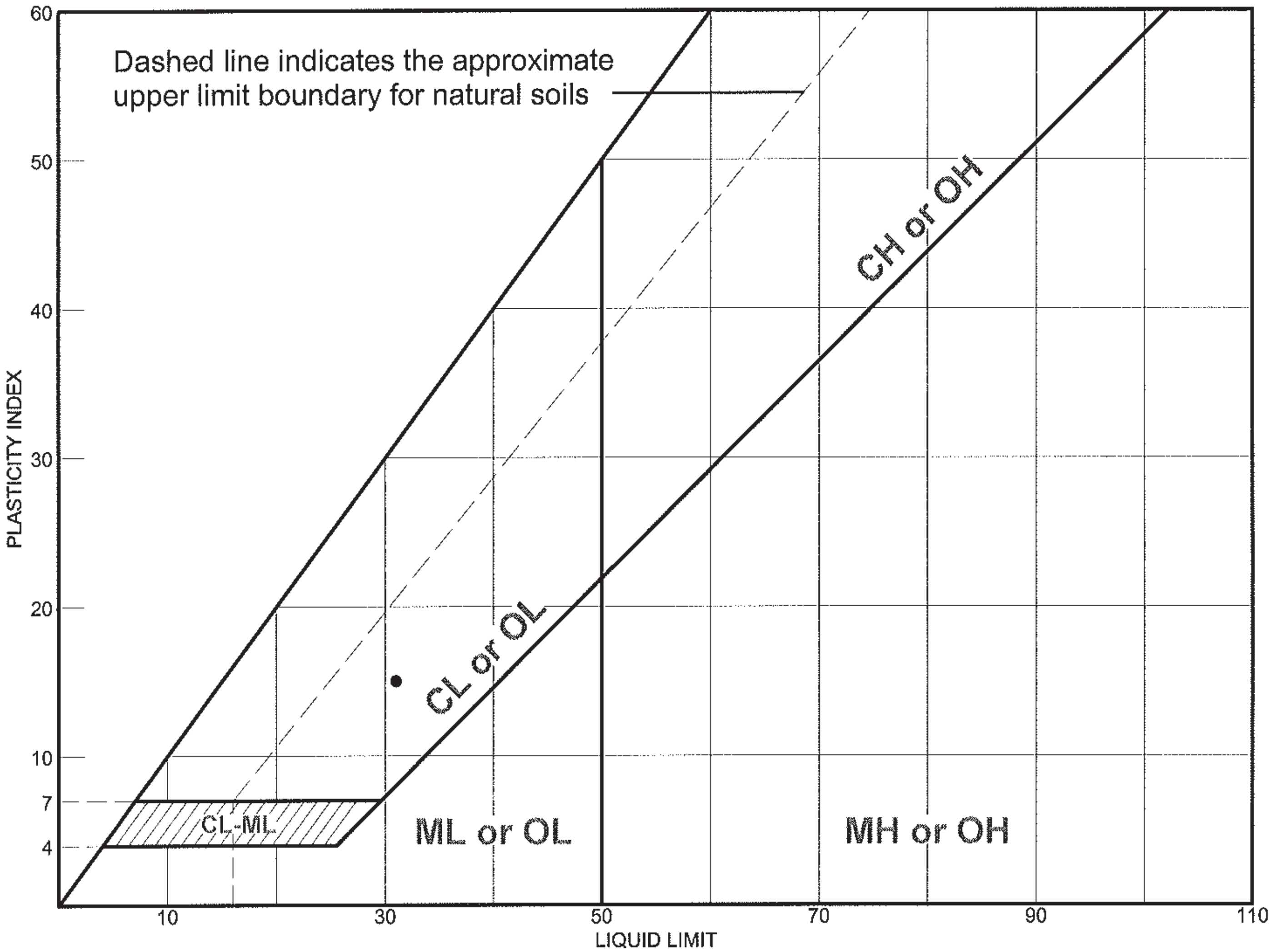
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		31	16	15			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-9 **Elev./Depth:** 1.5-3 Feet

Remarks:

●

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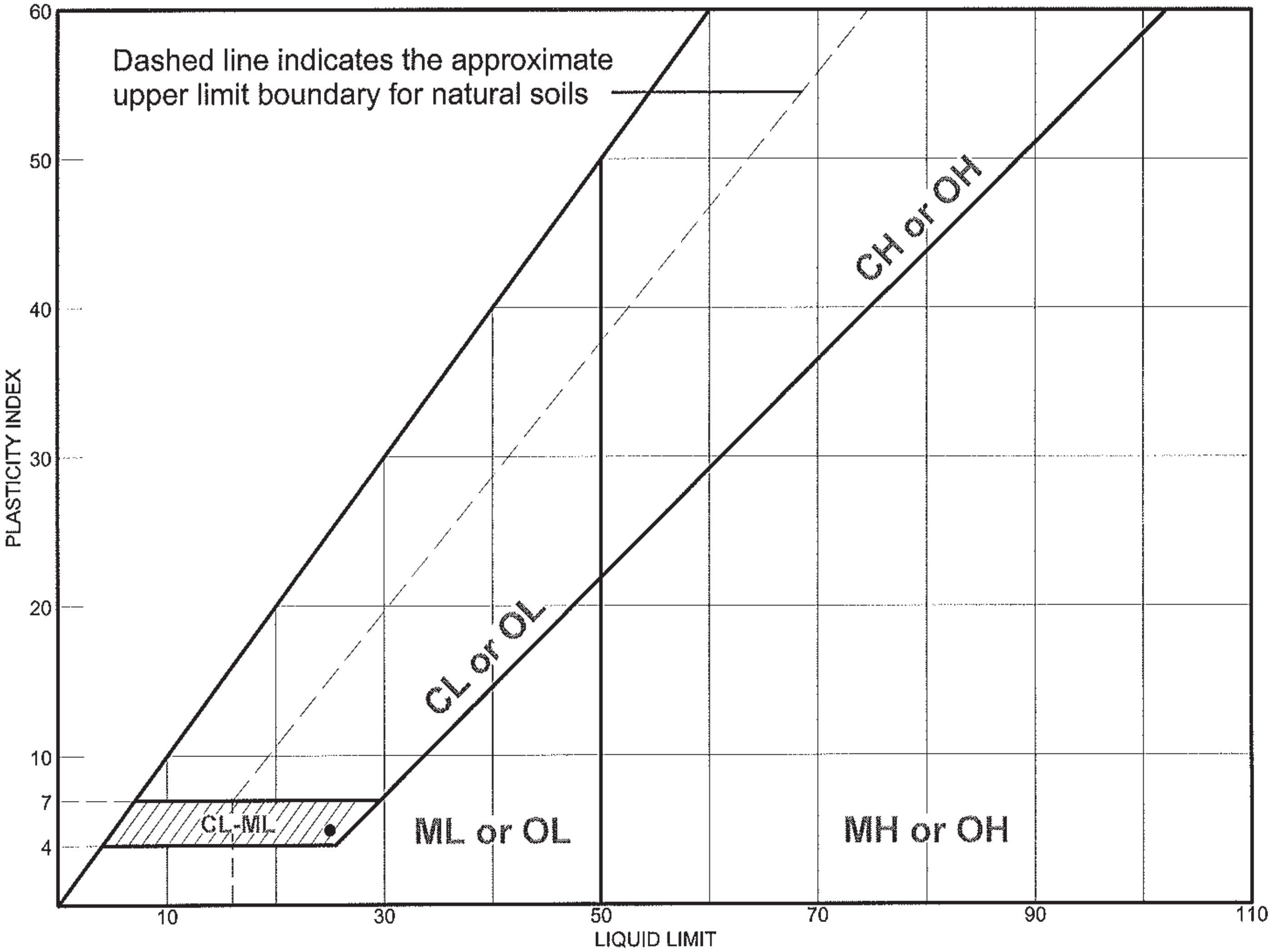
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		25	20	5			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-10 **Elev./Depth:** 0-1.5 Feet

Remarks:

●

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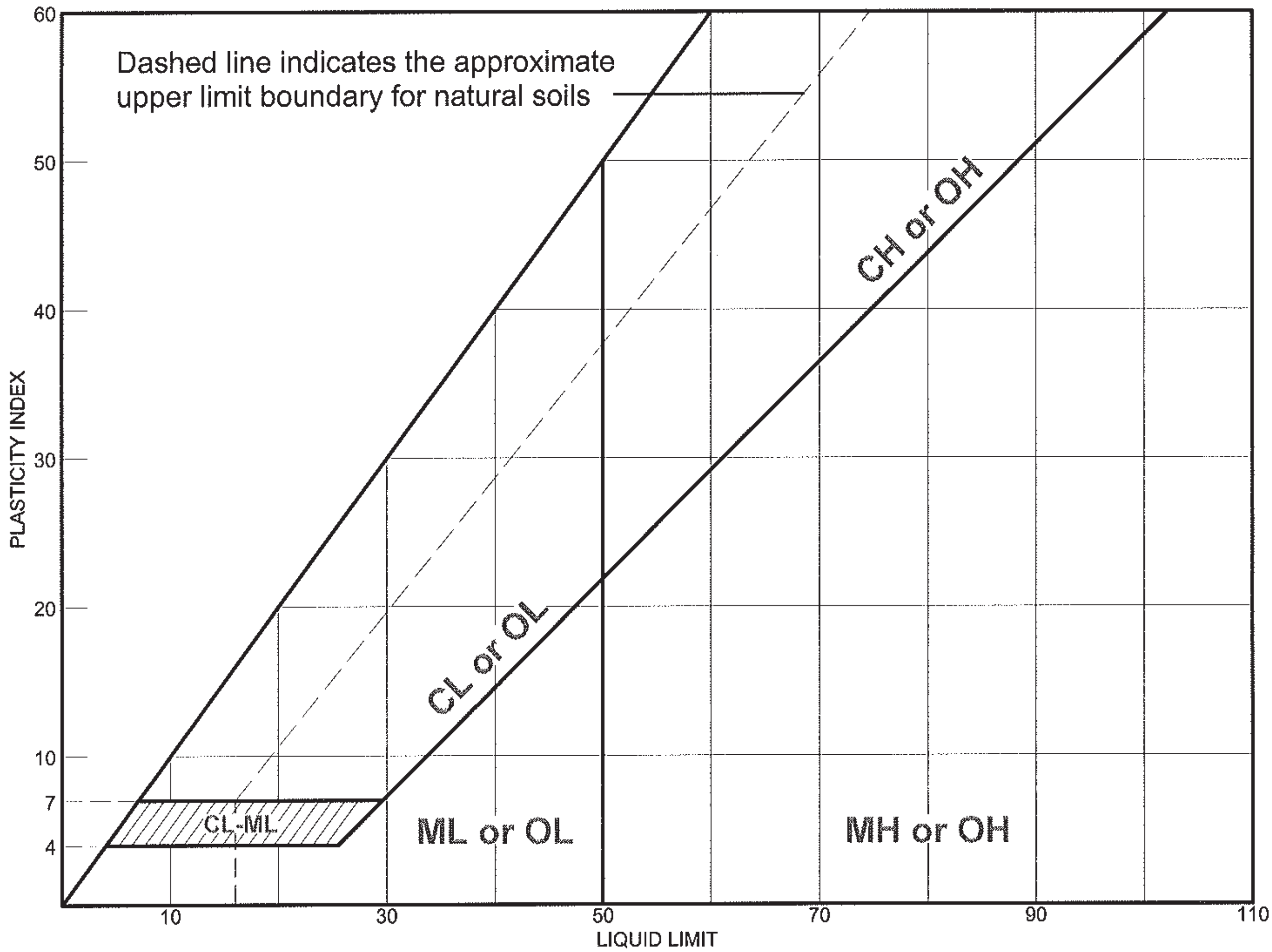
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-6C **Elev./Depth:** 0-1.3 Feet

Remarks:

●

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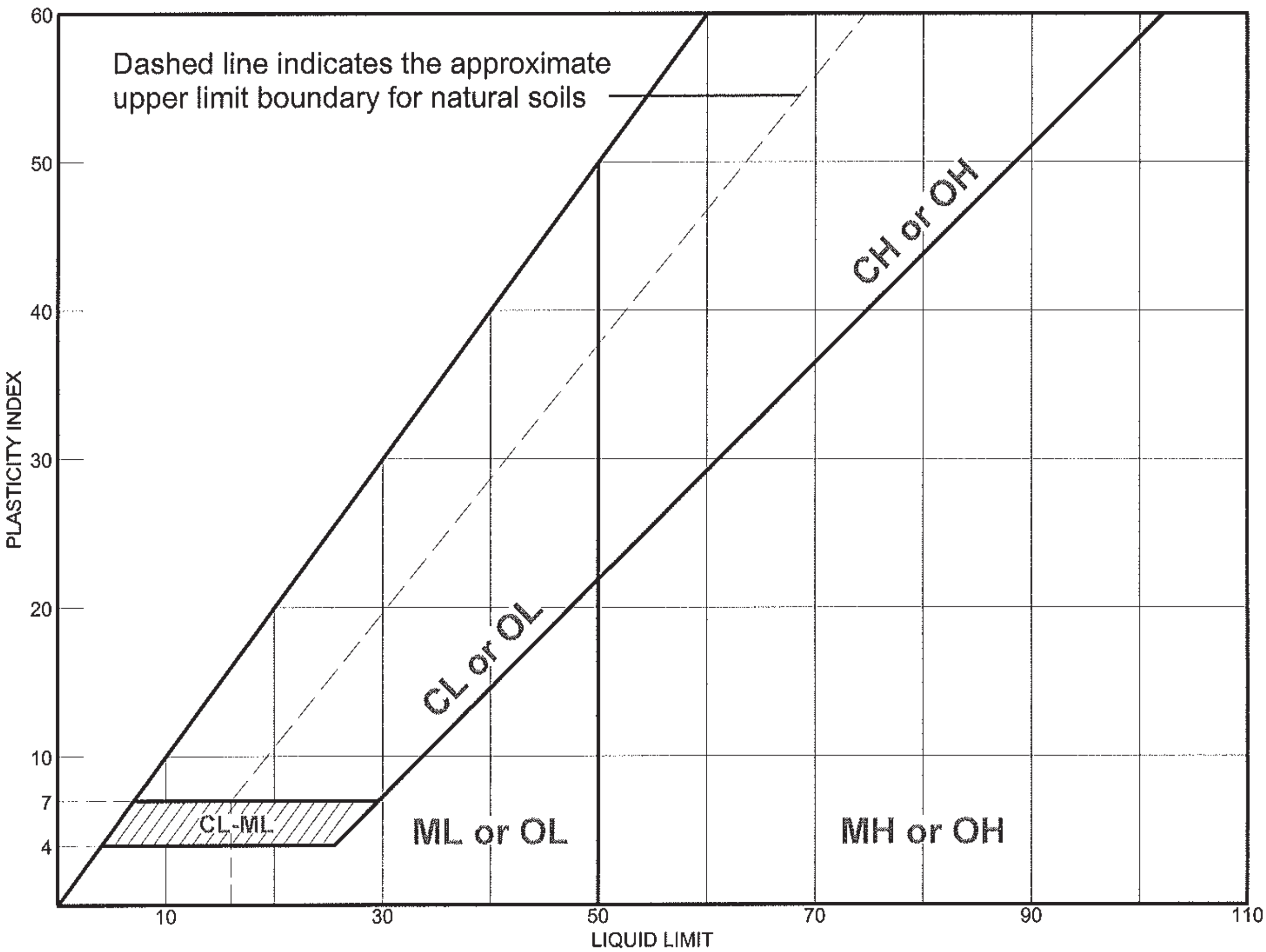
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-19A **Elev./Depth:** 0-0.9 Feet

Remarks:

●

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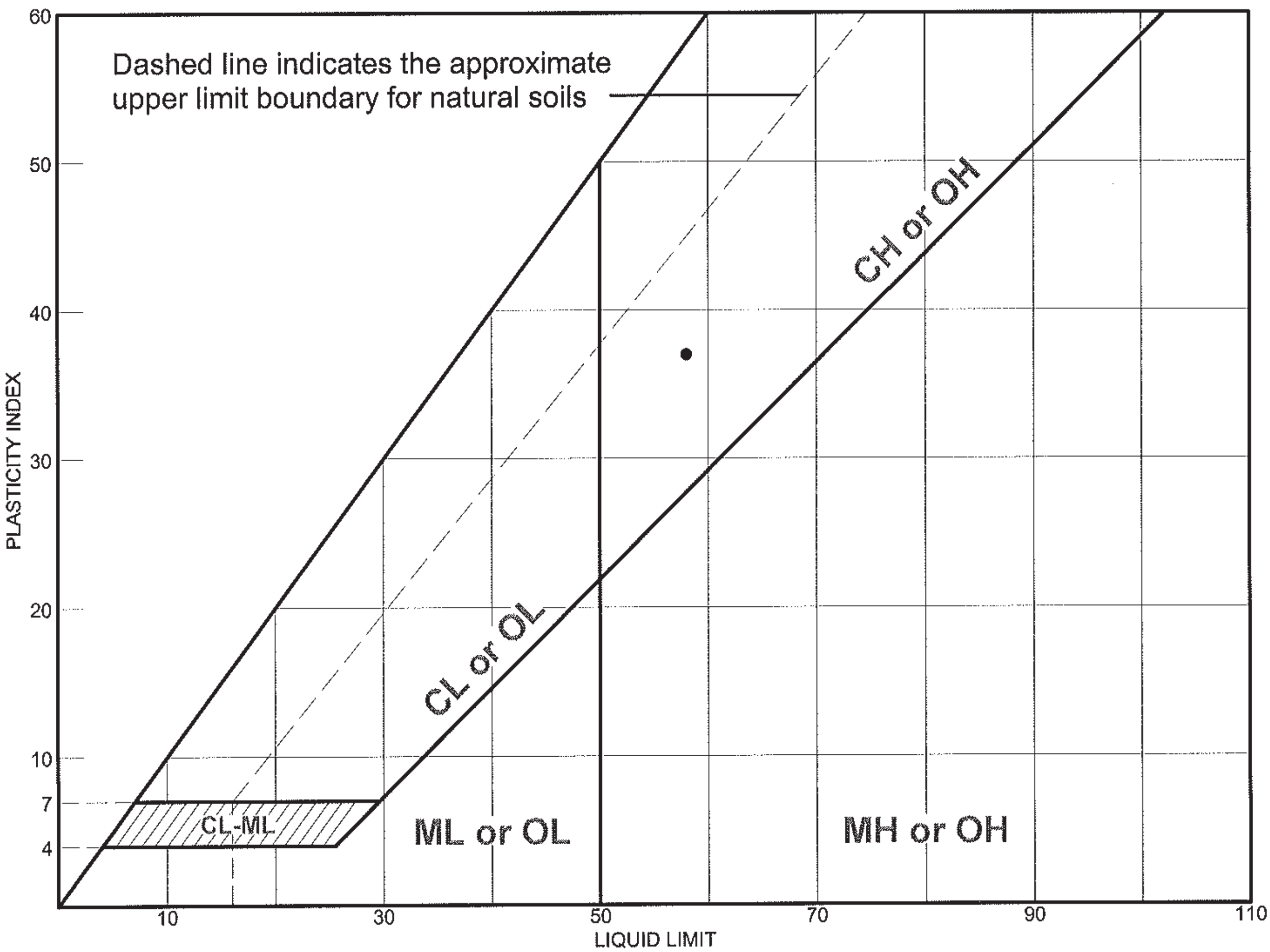
Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		58	21	37			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-19C **Elev./Depth:** 3.5-6.2 Feet

Remarks:

●

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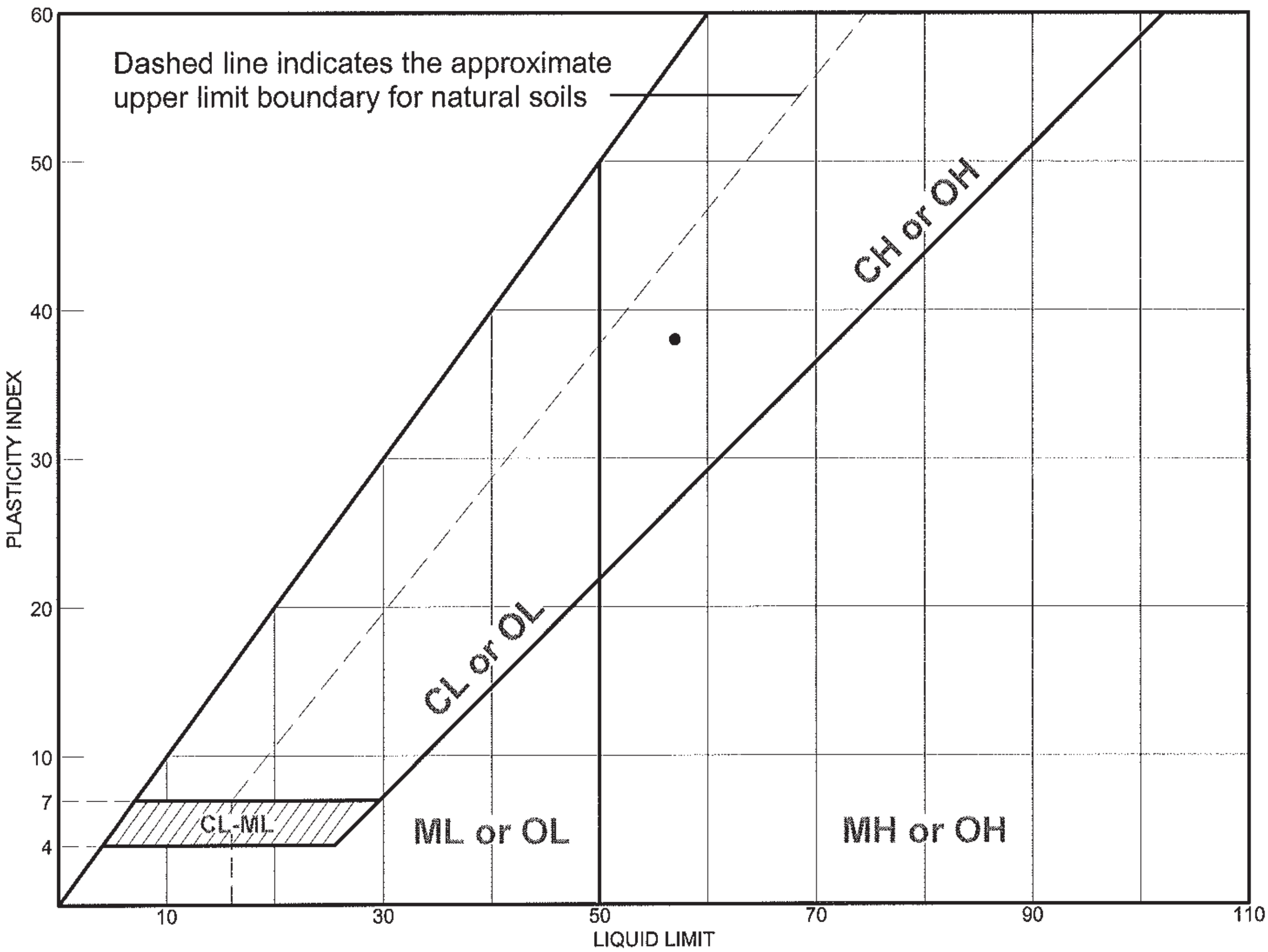
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		57	19	38			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-21C **Elev./Depth:** 2.1-4.8 Feet

Remarks:

●

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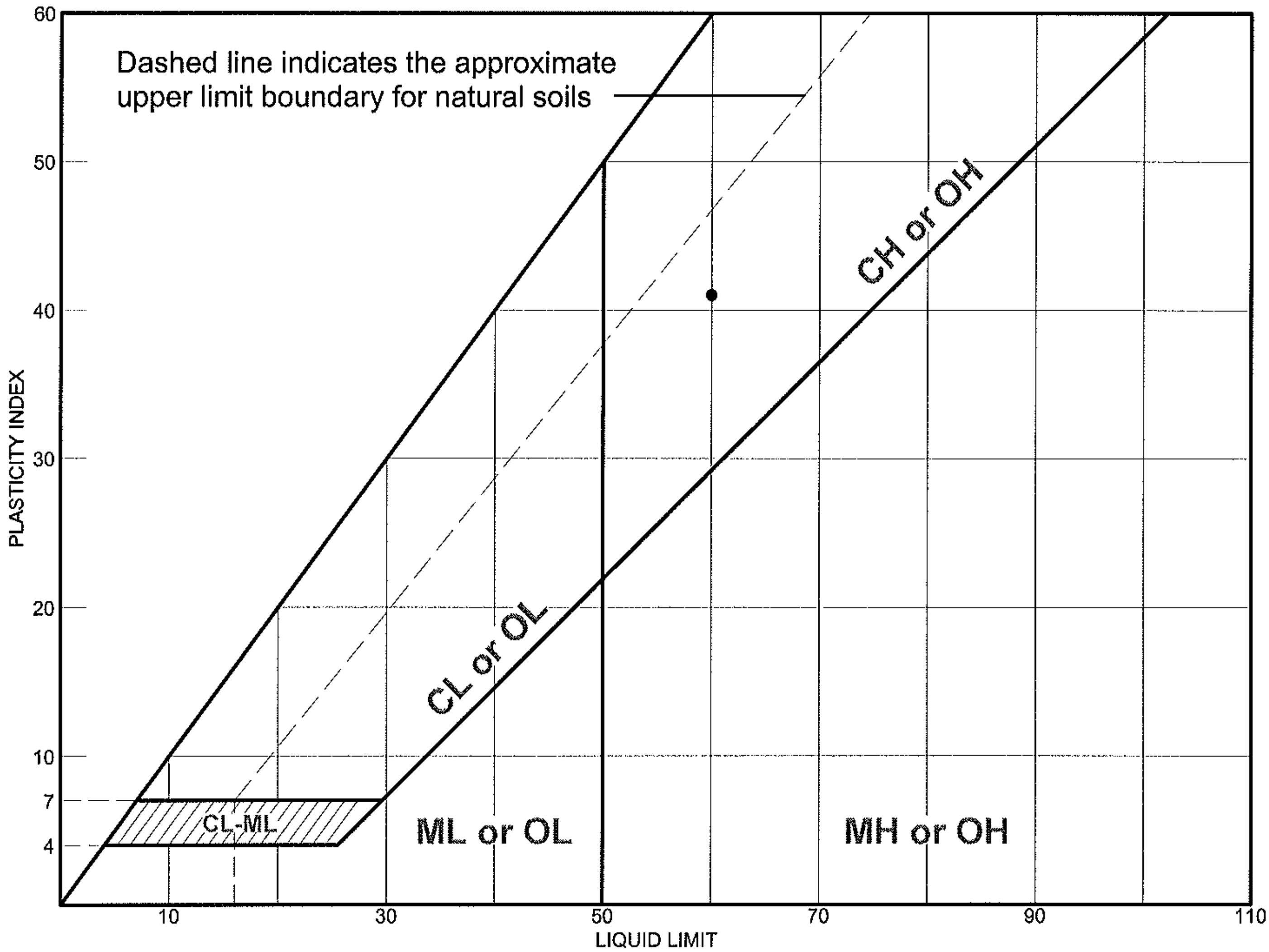
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		60	19	41			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-22C **Elev./Depth:** 1.3-4 Feet

Remarks:

●

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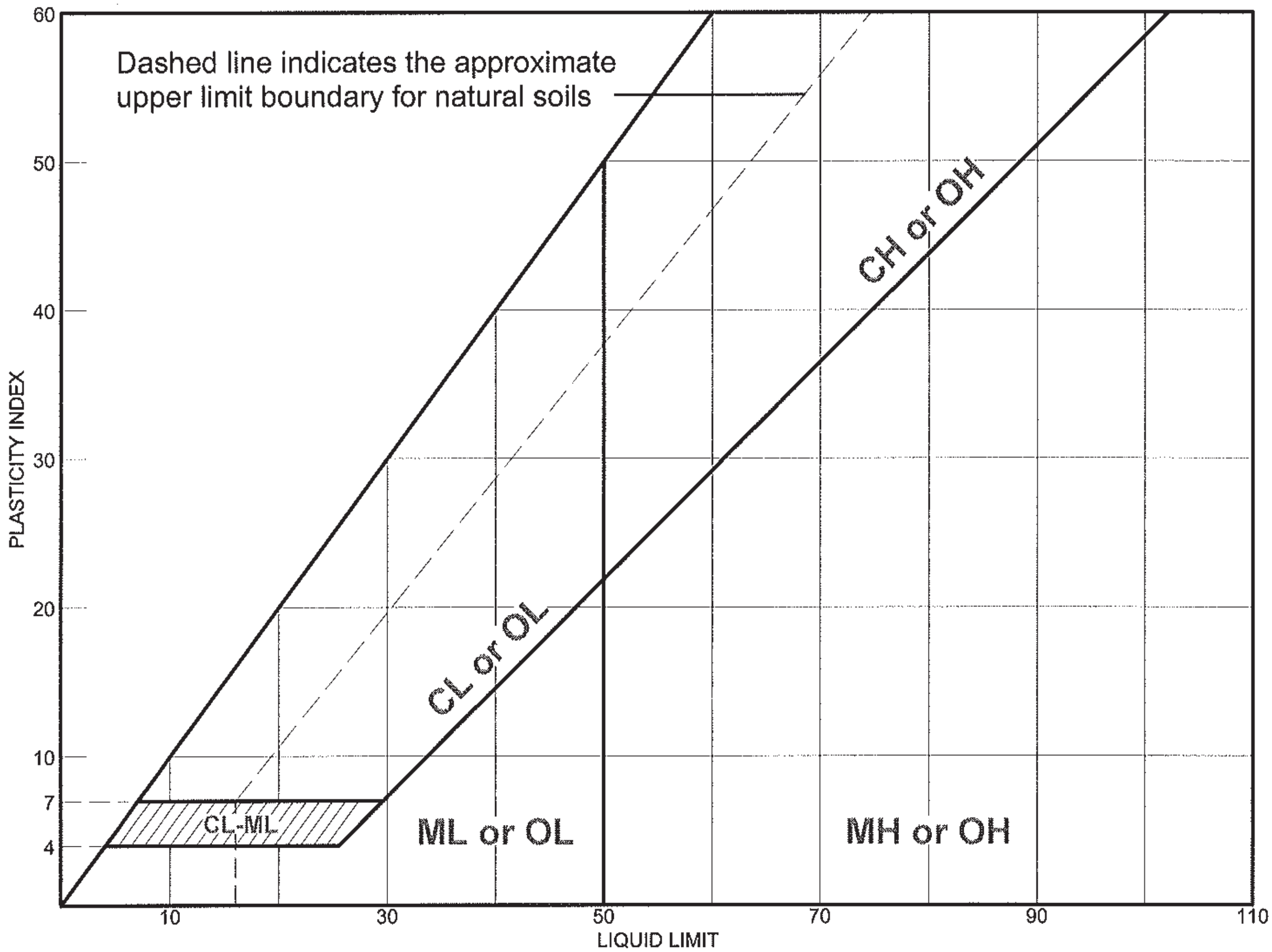
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		NV	NP	NP			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-24A **Elev./Depth:** 0-1.1 Feet

Remarks:

●

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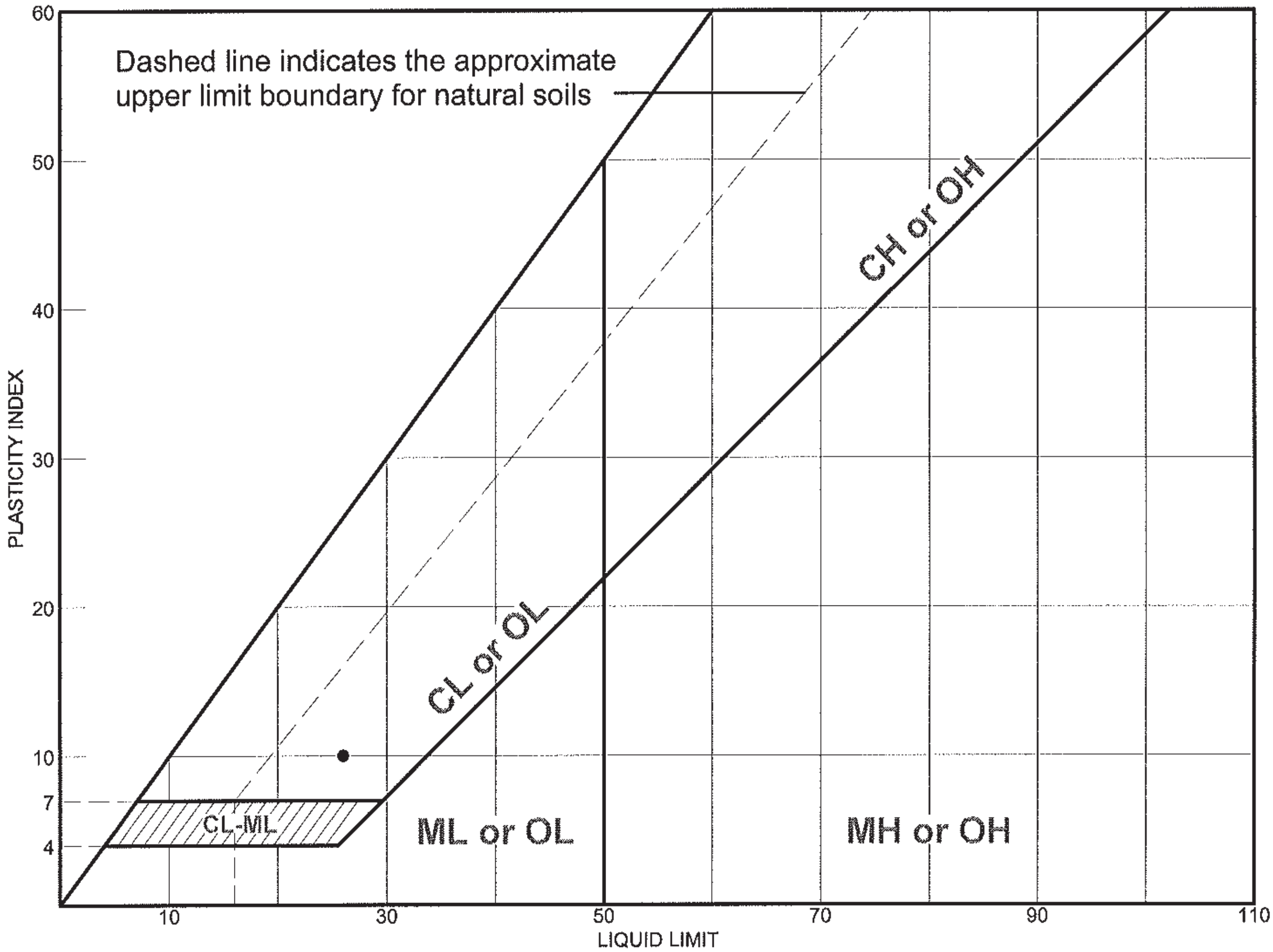
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		26	16	10			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-24C **Elev./Depth:** 3.7-6.4 Feet

Remarks:

●

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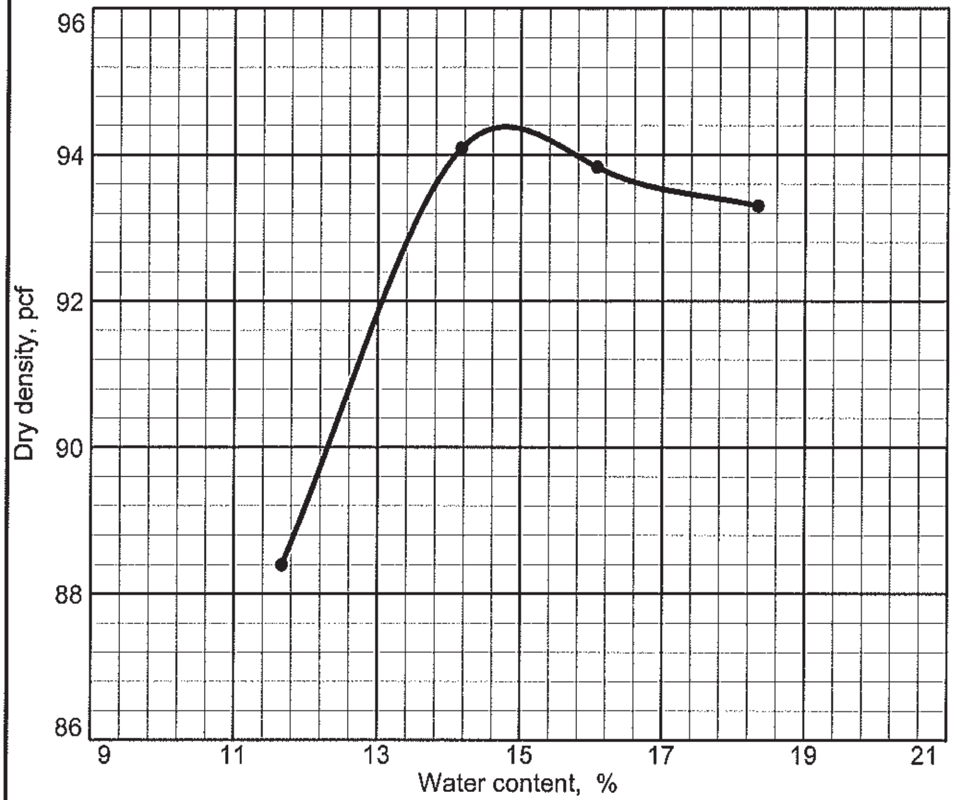
Figure

Test on Bulk and Composite Samples

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 698-07 Procedure A Standard

Hammer Wt.: 5.5 lb.
Hammer Drop: 12 in.
Number of Layers: three
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM ______ **Sp.G.** ______
LL ______ **PI** ______
%>No.4 ______ **%<#200** ______
USCS ______ **AASHTO** ______

TESTING DATA

	1	2	3	4	5	6
WM + WS	7.91	7.96	7.62	8.01		
WM	4.33	4.33	4.33	4.33		
WW + T #1	269.30	262.20	285.20	263.30		
WD + T #1	235.90	225.90	255.40	222.50		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	14.2	16.1	11.7	18.3		
DRY DENSITY	94.1	93.8	88.4	93.3		

TEST RESULTS	Material Description
Maximum dry density = 94.4 pcf Optimum moisture = 14.8 %	

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

● **Source:** **Sample No.:** HA-1

Remarks:

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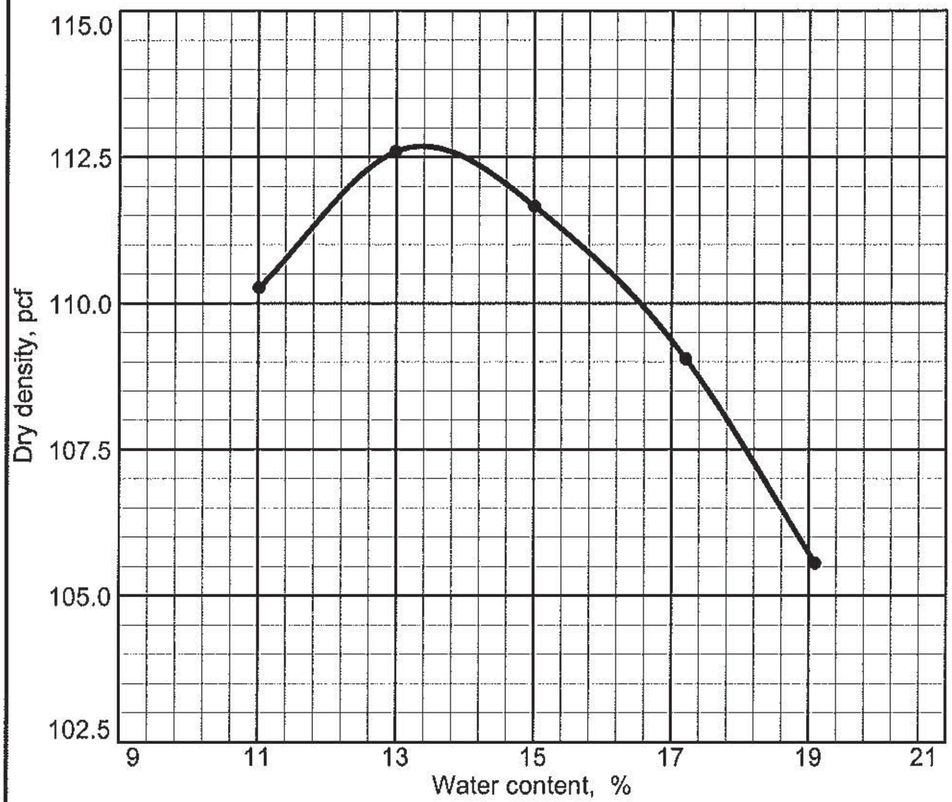
Fresno, CA

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-07 Method A Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM ____ **Sp.G.** ____
LL ____ **PI** ____
%>No.4 ____ **%<#200** ____
USCS ____ **AASHTO** ____

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.59	8.52	8.61	8.57	8.41	
WM	4.33	4.33	4.33	4.33	4.33	
WW + T #1	506.10	260.70	262.90	253.20	250.00	
WD + T #1	431.80	218.90	228.60	224.10	225.20	
TARE #1	0.00	0.00	0.00	0.00	0.00	
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	17.2	19.1	15.0	13.0	11.0	
DRY DENSITY	109.0	105.6	111.7	112.6	110.3	

TEST RESULTS

Maximum dry density = 112.7 pcf

Optimum moisture = 13.4 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

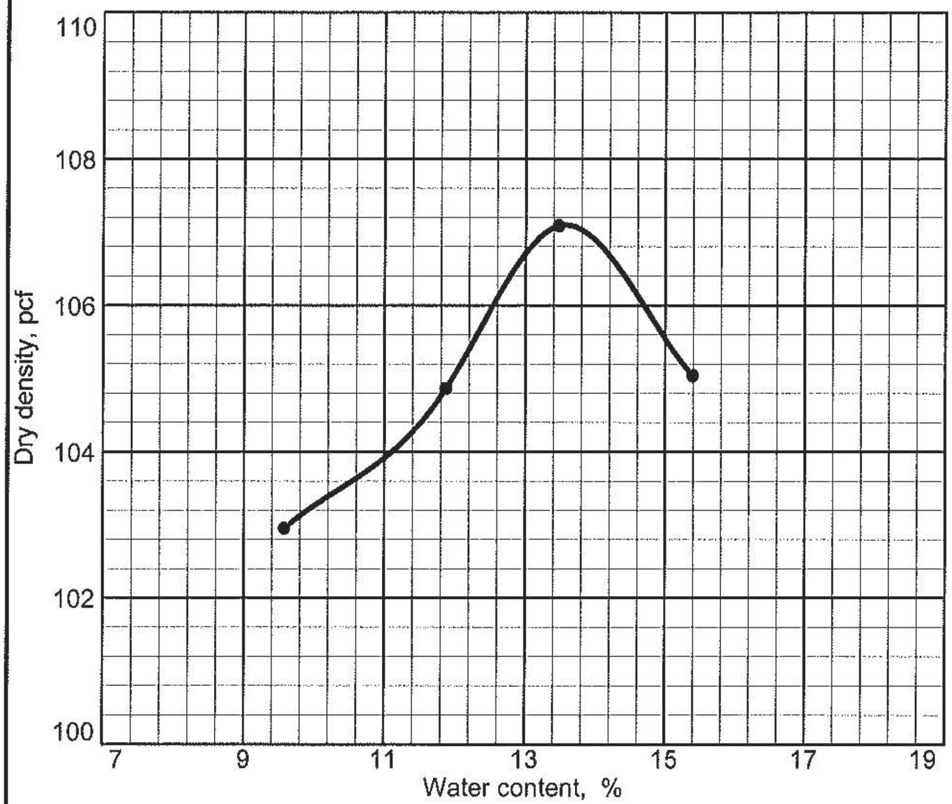
● **Source:** **Sample No.:** HA-1

Remarks:

Moore Twining Associates, Inc.
Fresno, CA

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 698-07 Procedure A Standard

Hammer Wt.: 5.5 lb.
Hammer Drop: 12 in.
Number of Layers: three
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		Sp.G.	
LL		PI	
%>No.4		%<#200	
USCS		AASHTO	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.24	8.38	8.09	8.37		
WM	4.33	4.33	4.33	4.33		
WW + T #1	279.90	274.60	273.50	268.40		
WD + T #1	250.20	242.00	249.60	232.60		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	11.9	13.5	9.6	15.4		
DRY DENSITY	104.9	107.1	103.0	105.0		

TEST RESULTS

Maximum dry density = 107.1 pcf

Optimum moisture = 13.6 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

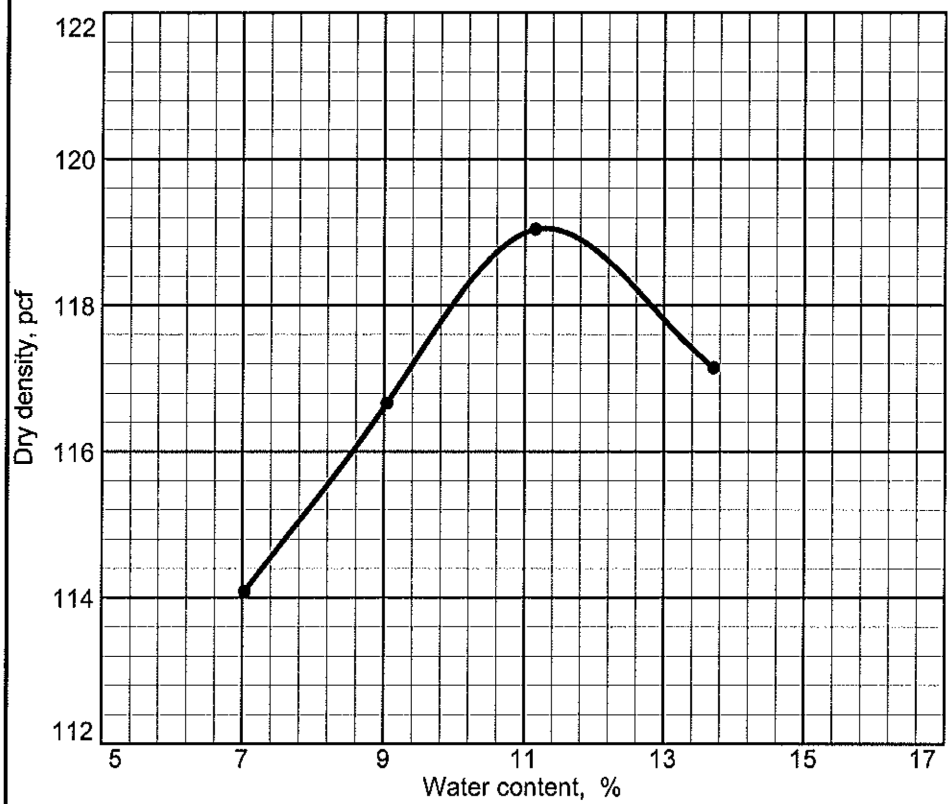
• **Source:** **Sample No.:** HA-4

Moore Twining Associates, Inc.
Fresno, CA

Remarks:

Figure

COMPACTION TEST REPORT



Curve No.

Test Specification:
ASTM D 1557-07 Method A Modified

Hammer Wt.: 10 lb.
Hammer Drop: 18 in.
Number of Layers: five
Blows per Layer: 25
Mold Size: .03333 cu.ft.
Test Performed on Material Passing No.4 **Sieve**

Soil Data

NM		Sp.G.	
LL		PI	
%>No.4		%<#200	
USCS		AASHTO	

TESTING DATA

	1	2	3	4	5	6
WM + WS	8.57	8.40	8.74	8.77		
WM	4.33	4.33	4.33	4.33		
WW + T #1	255.70	274.00	266.10	260.40		
WD + T #1	234.50	256.00	239.40	229.00		
TARE #1	0.00	0.00	0.00	0.00		
WW + T #2						
WD + T #2						
TARE #2						
MOISTURE	9.0	7.0	11.2	13.7		
DRY DENSITY	116.7	114.1	119.0	117.1		

TEST RESULTS

Maximum dry density = 119.1 pcf

Optimum moisture = 11.3 %

Material Description

Project No. 60 **Client:** Hultgren - Tillis Engineers
Project: Salton Sea

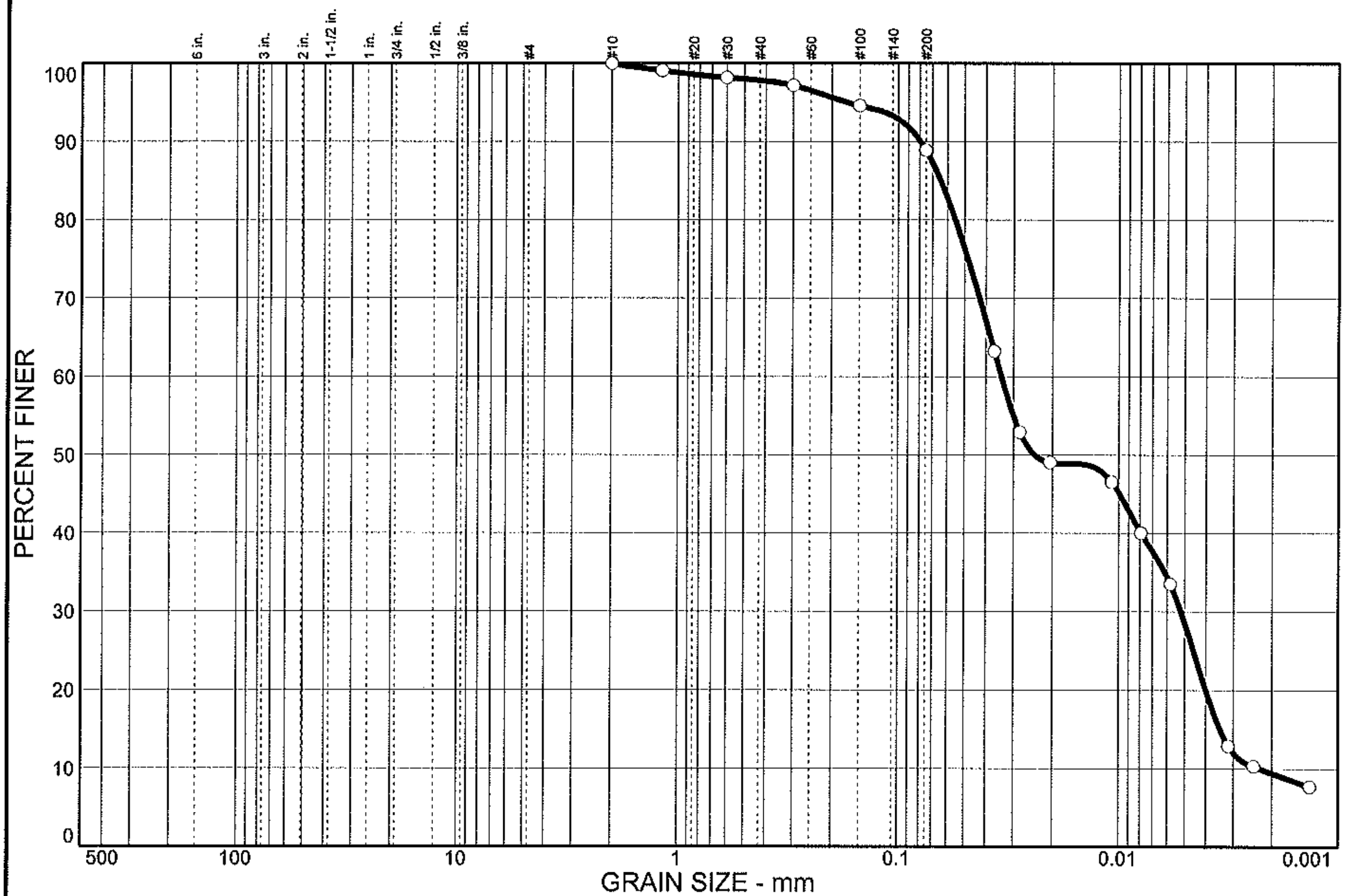
● **Source:** **Sample No.:** HA-4

Moore Twining Associates, Inc.
Fresno, CA

Remarks:

Figure

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	2.1	9.0	60.3	28.6

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.1		
#30	98.2		
#50	97.2		
#100	94.6		
#200	88.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 19 LL= 63 PI= 44

Coefficients

D_{85}= 0.0643 D_{60}= 0.0340 D_{50}= 0.0241
D_{30}= 0.0052 D_{15}= 0.0034 D_{10}= 0.0023
C_u= 15.00 C_c= 0.35

Classification

USCS= AASHTO=

Remarks

F.M.=0.11

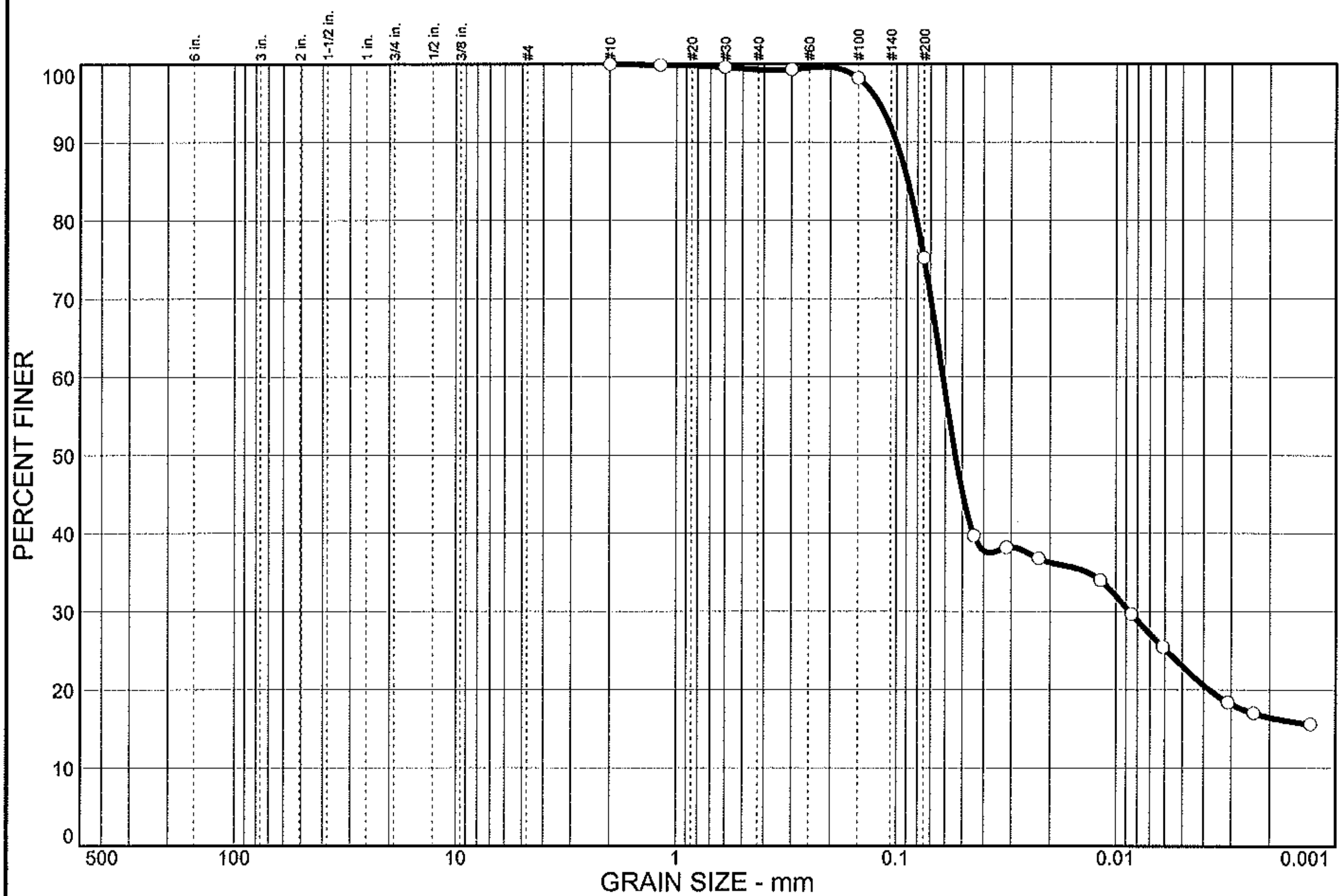
Sample No.: HA-1 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:**

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.7	24.1	52.2	23.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.3		
#100	98.2		
#200	75.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= 20 LL= 56 PI= 36

Coefficients

D_{85}= 0.0889 D_{60}= 0.0614 D_{50}= 0.0538
D_{30}= 0.0087 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.03

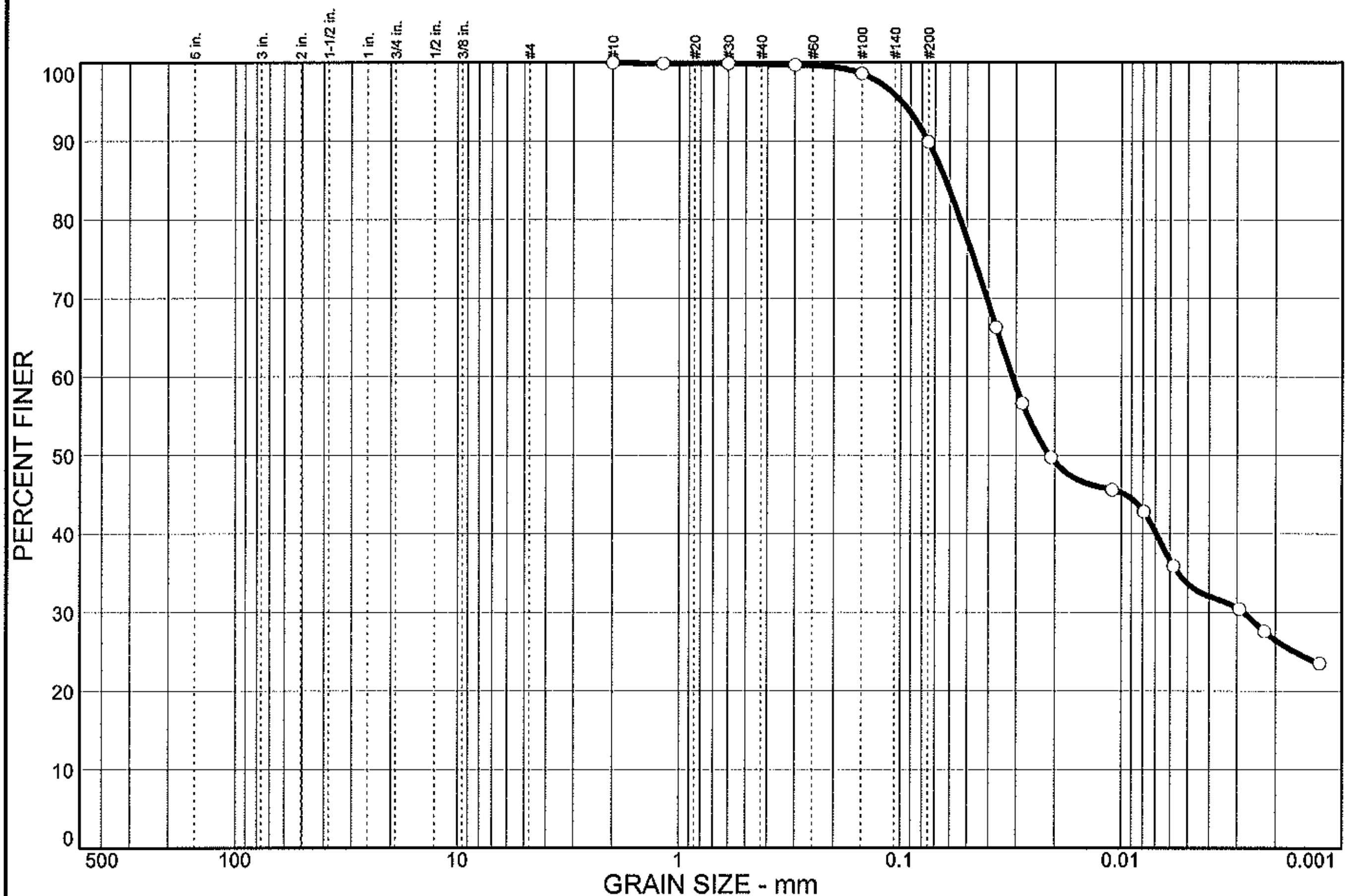
Sample No.: HA-4 **Source of Sample:** **Date:** 10/12/10
Location: **Elev./Depth:**

Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	9.9	56.2	33.7

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.9		
#50	99.7		
#100	98.6		
#200	89.9		

* (no specification provided)

Material Description

Atterberg Limits

PL= 21 LL= 68 PI= 47

Coefficients

D_{85}= 0.0627 D_{60}= 0.0311 D_{50}= 0.0211
D_{30}= 0.0028 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

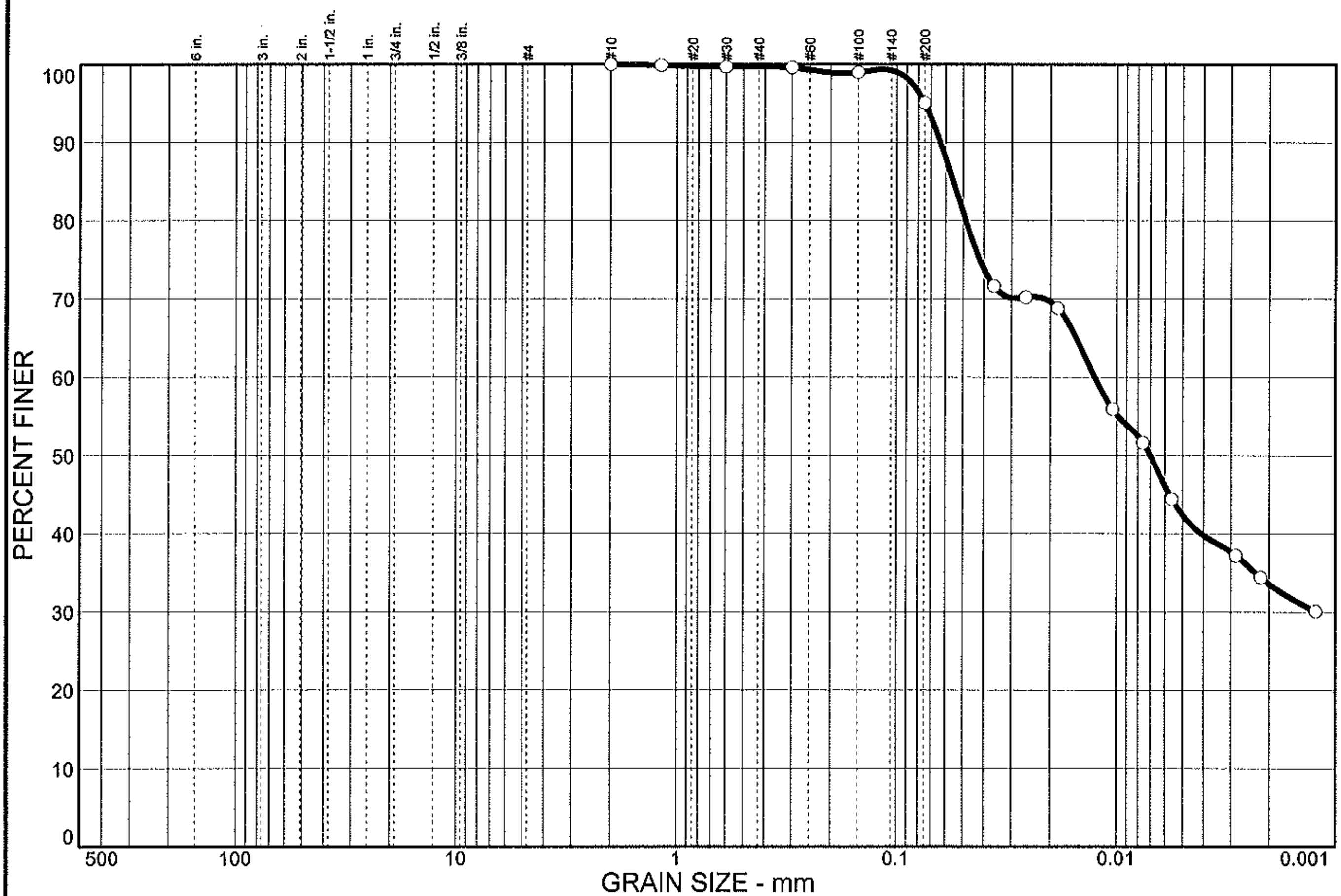
F.M.=0.02

Sample No.: VC-11 (B&C) **Source of Sample:** **Date:** 10/13/10
Location: **Elev./Depth:** 0-3.5 Feet

Moore Twining Associates, Inc.
Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea
Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.2	4.7	52.7	42.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.7		
#50	99.6		
#100	99.0		
#200	95.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= 20 LL= 66 PI= 46

Coefficients

D_{85}= 0.0554 D_{60}= 0.0126 D_{50}= 0.0070
D_{30}= D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.02

Sample No.: VC-16 (B&C) **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0-3.9 Feet

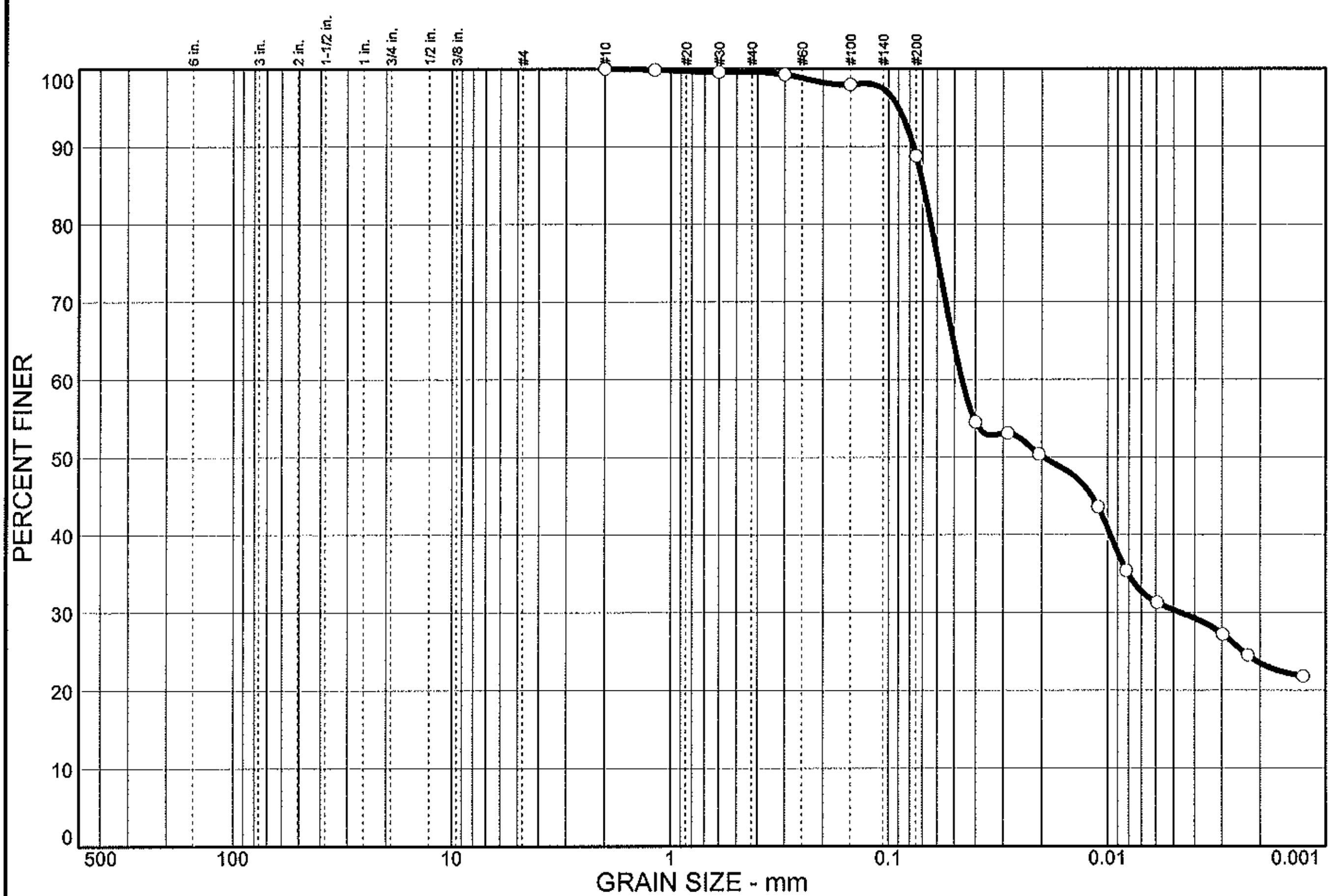
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0	0.4	10.8	58.5	30.3

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	99.9		
#30	99.6		
#50	99.3		
#100	98.0		
#200	88.8		

* (no specification provided)

Material Description

Atterberg Limits

PL= 18 LL= 67 PI= 49

Coefficients

D_{85}= 0.0696 D_{60}= 0.0463 D_{50}= 0.0196

D_{30}= 0.0047 D_{15}= D_{10}=

C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.03

Sample No.: VC-20 (B&C) **Source of Sample:** **Date:** 10/14/10

Location: **Elev./Depth:** 0-4.7 Feet

Moore Twining Associates, Inc.

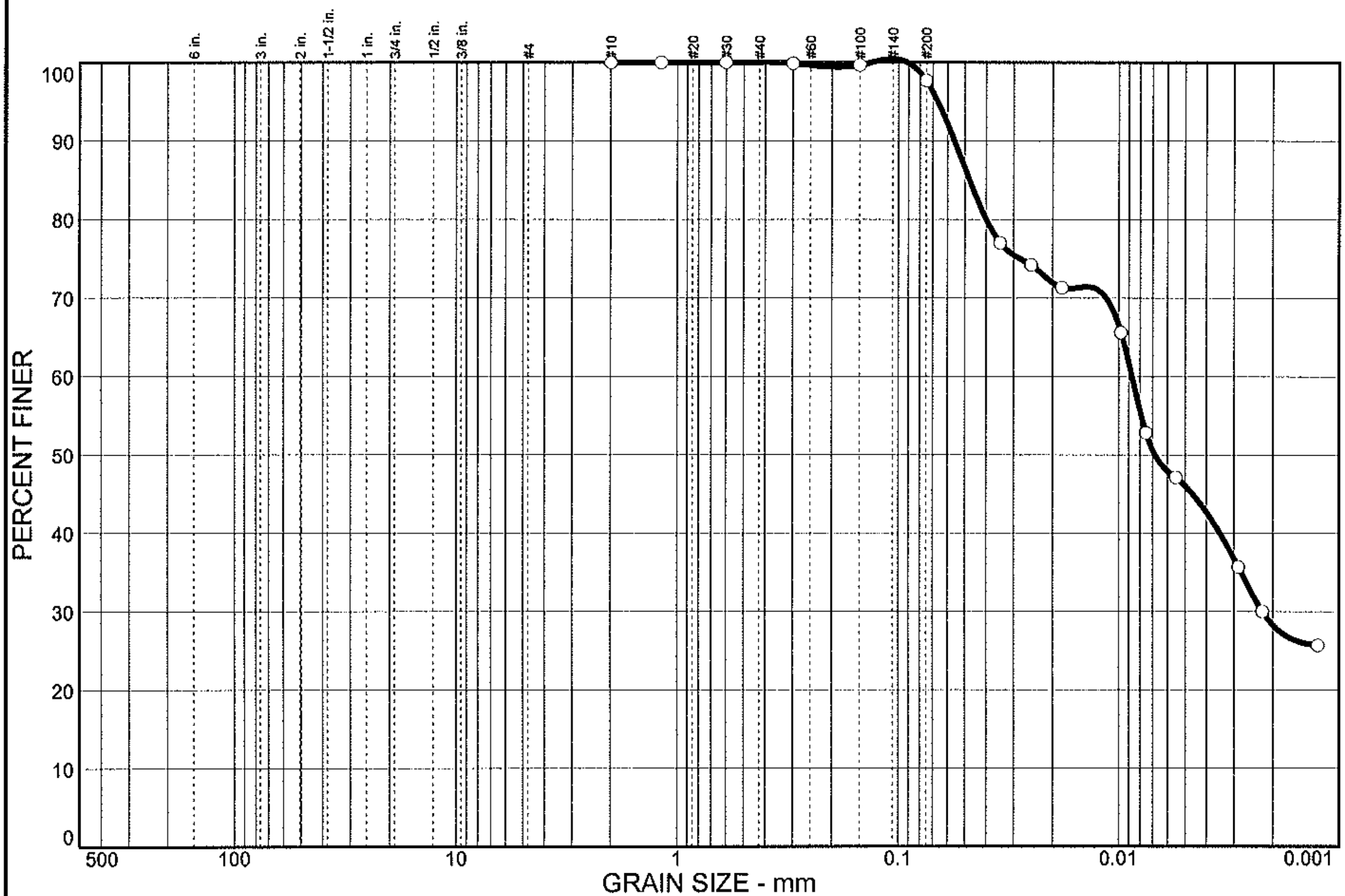
Fresno, CA

Client: Hultgren - Tillis Engineers

Project: Salton Sea

Project No: 60 **Figure**

Particle Size Distribution Report



% COBBLES	% GRAVEL		% SAND			% FINES	
	CRS.	FINE	CRS.	MEDIUM	FINE	SILT	CLAY
0.0	0.0	0.0	0.0		2.3	51.6	46.1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#16	100.0		
#30	100.0		
#50	99.9		
#100	99.7		
#200	97.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= 18 LL= 65 PI= 47

Coefficients

D_{85}= 0.0476 D_{60}= 0.0087 D_{50}= 0.0068
D_{30}= 0.0022 D_{15}= D_{10}=
C_u= C_c=

Classification

USCS= AASHTO=

Remarks

F.M.=0.00

Sample No.: VC-28 (B&C) **Source of Sample:** **Date:** 10/14/10
Location: **Elev./Depth:** 0.4-5.7 Feet

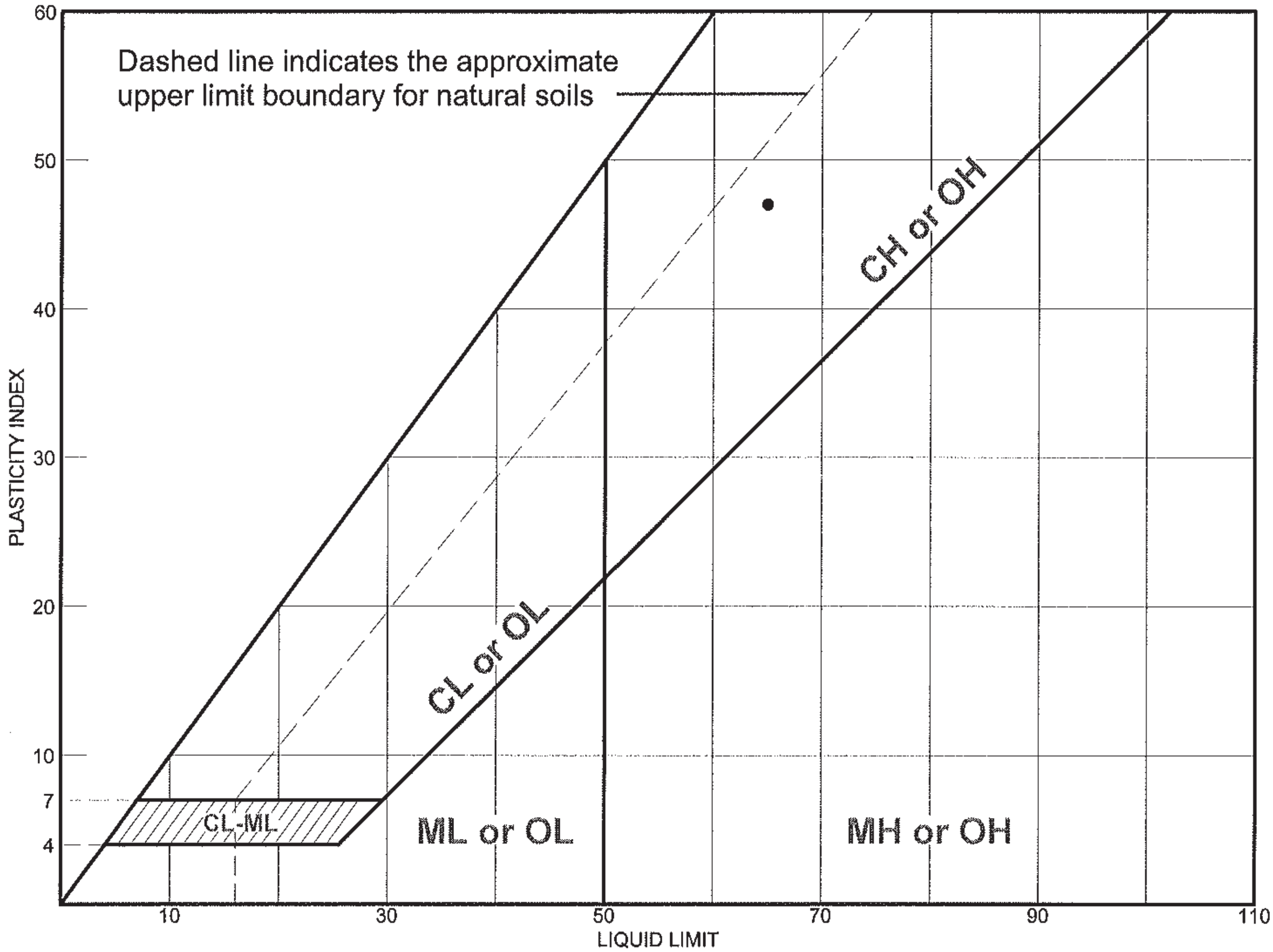
Moore Twining Associates, Inc.

Fresno, CA

Client: Hultgren - Tillis Engineers
Project: Salton Sea

Project No: 60 **Figure**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		65	18	47			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-28 (B&C)**Elev./Depth:** 0.4-5.7 Feet

Remarks:

● Material is considered Non-Organic

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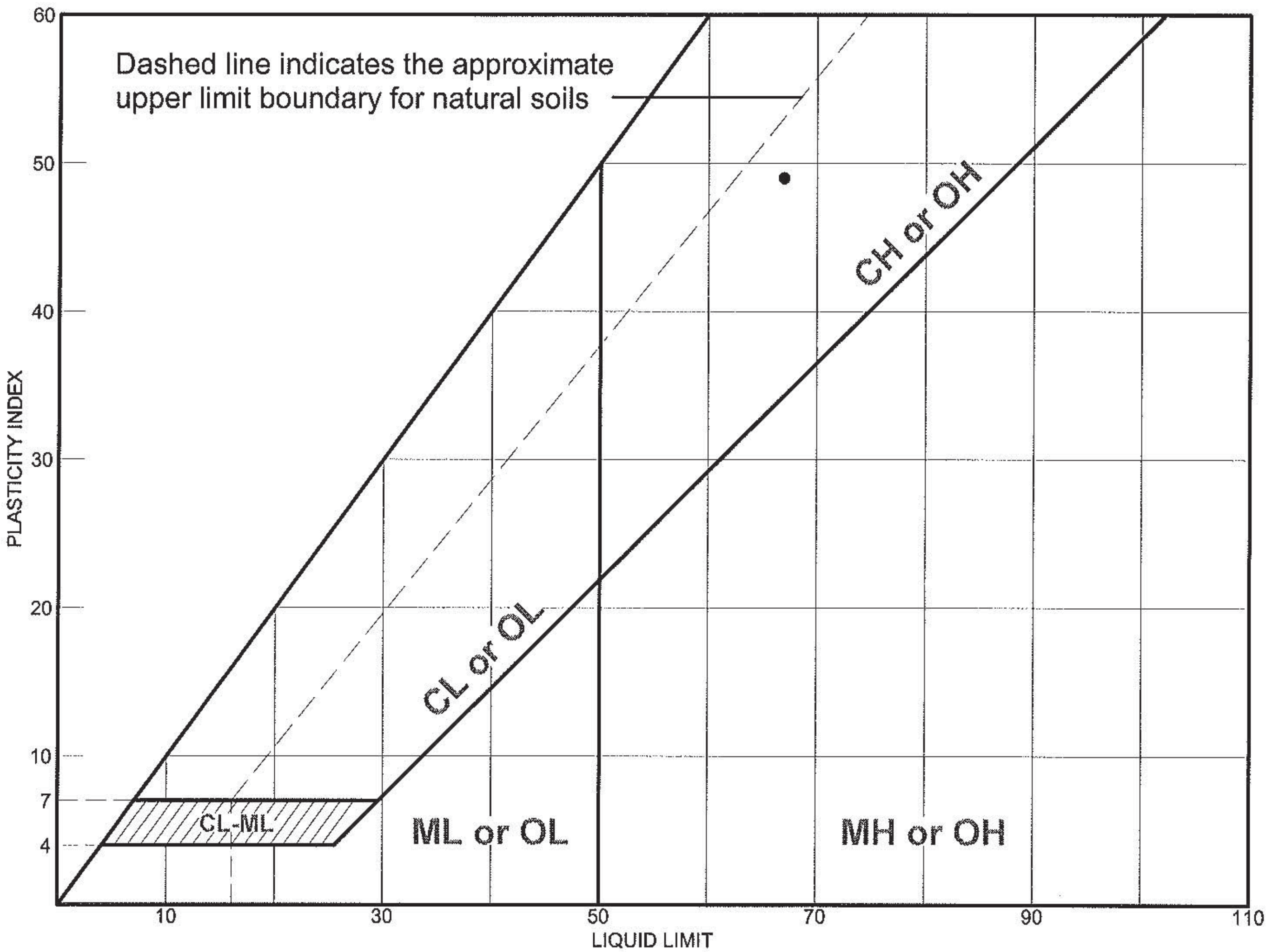
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		67	18	49			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-20 (B&C)**Elev./Depth:** 0-4.7 Feet

Remarks:

● Material is considered Non-Organic

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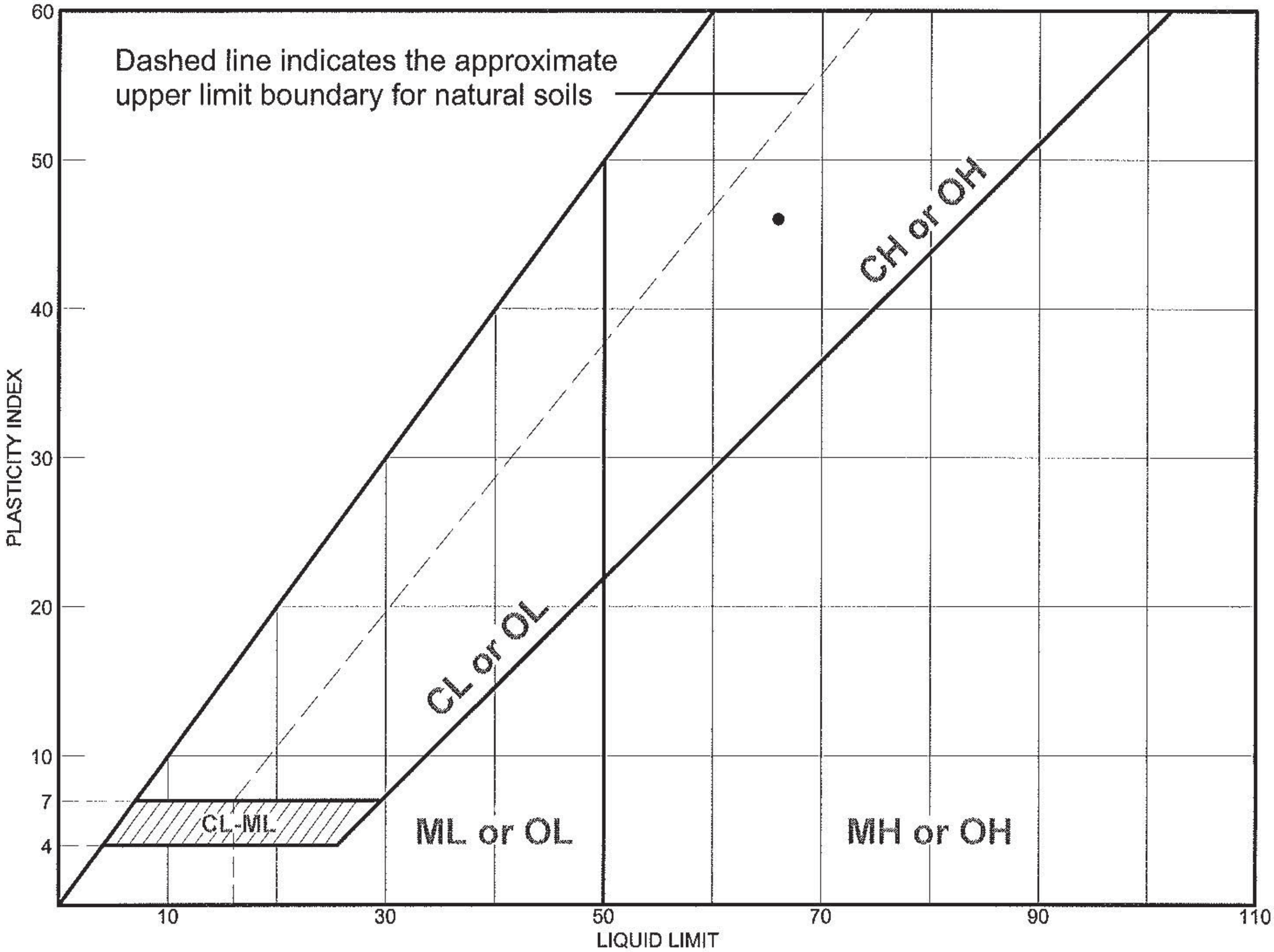
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		66	20	46			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-16 (B&C)**Elev./Depth:** 0-3.9 Feet

Remarks:

● Material is considered Non-Organic

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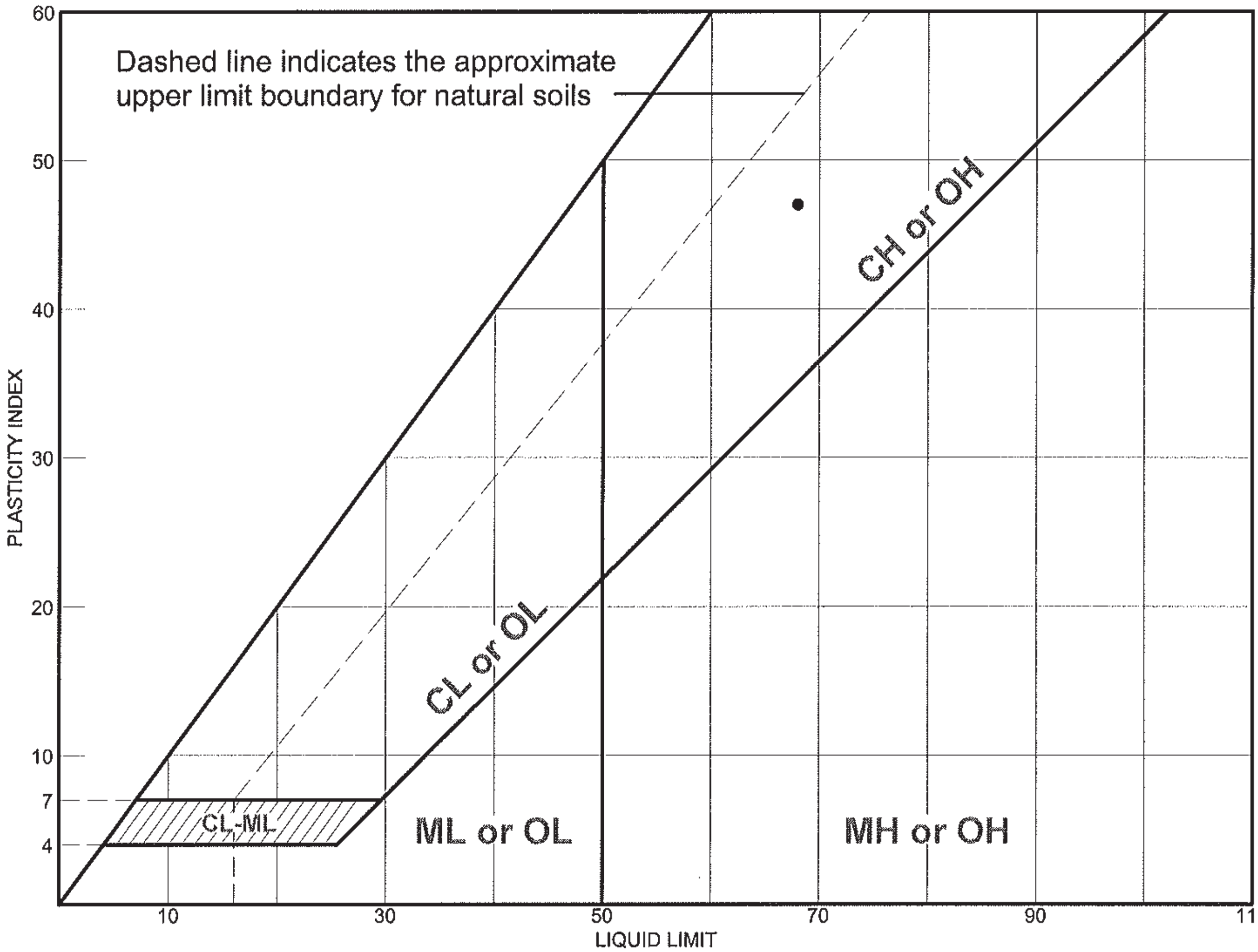
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		68	21	47			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** VC-11 (B&C) **Elev./Depth:** 0-3.5 Feet

Remarks:

● Material is considered Non-Organic

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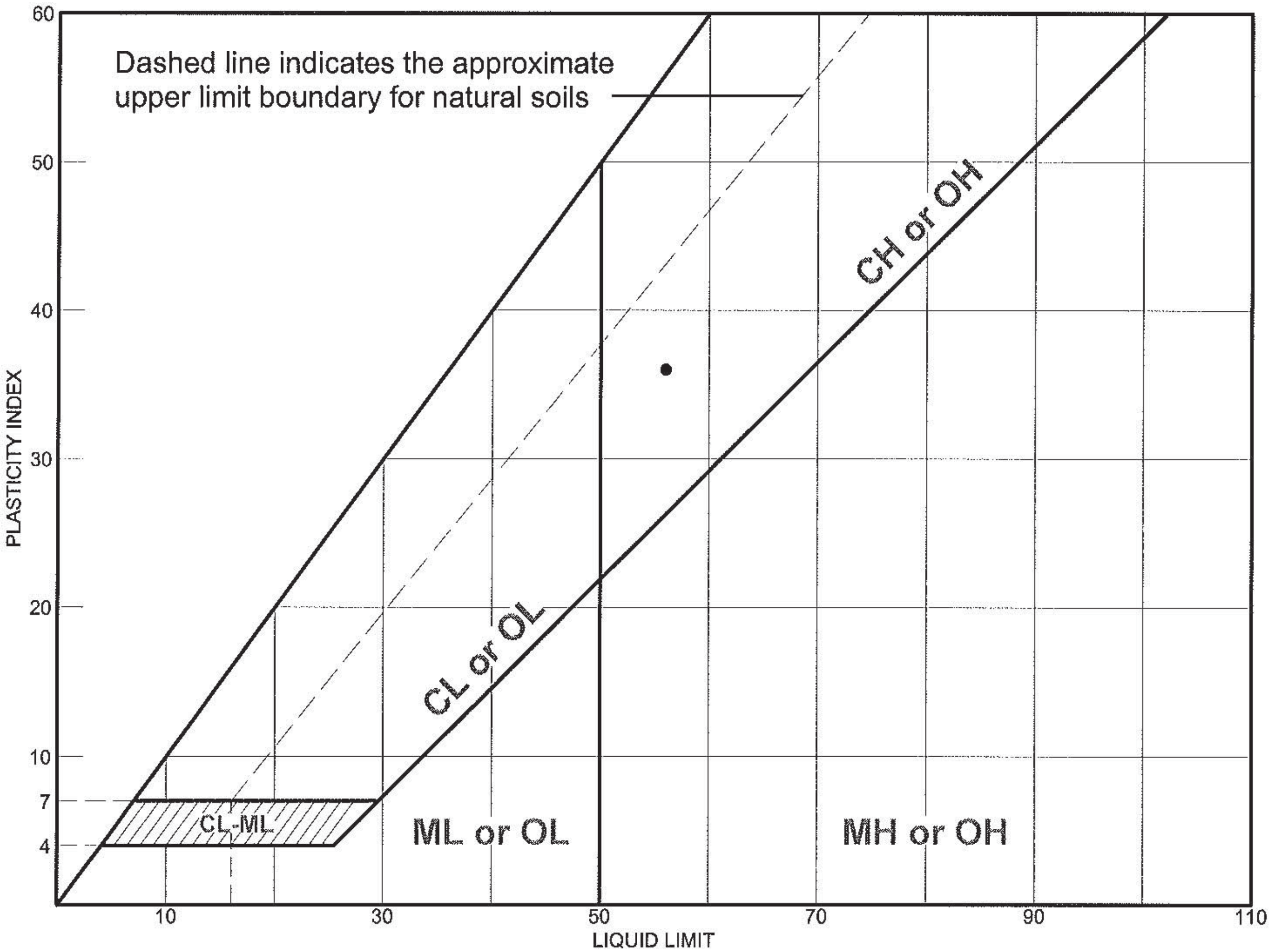
Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		56	20	36			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-4

Remarks:
● Material is considered Non-Organic

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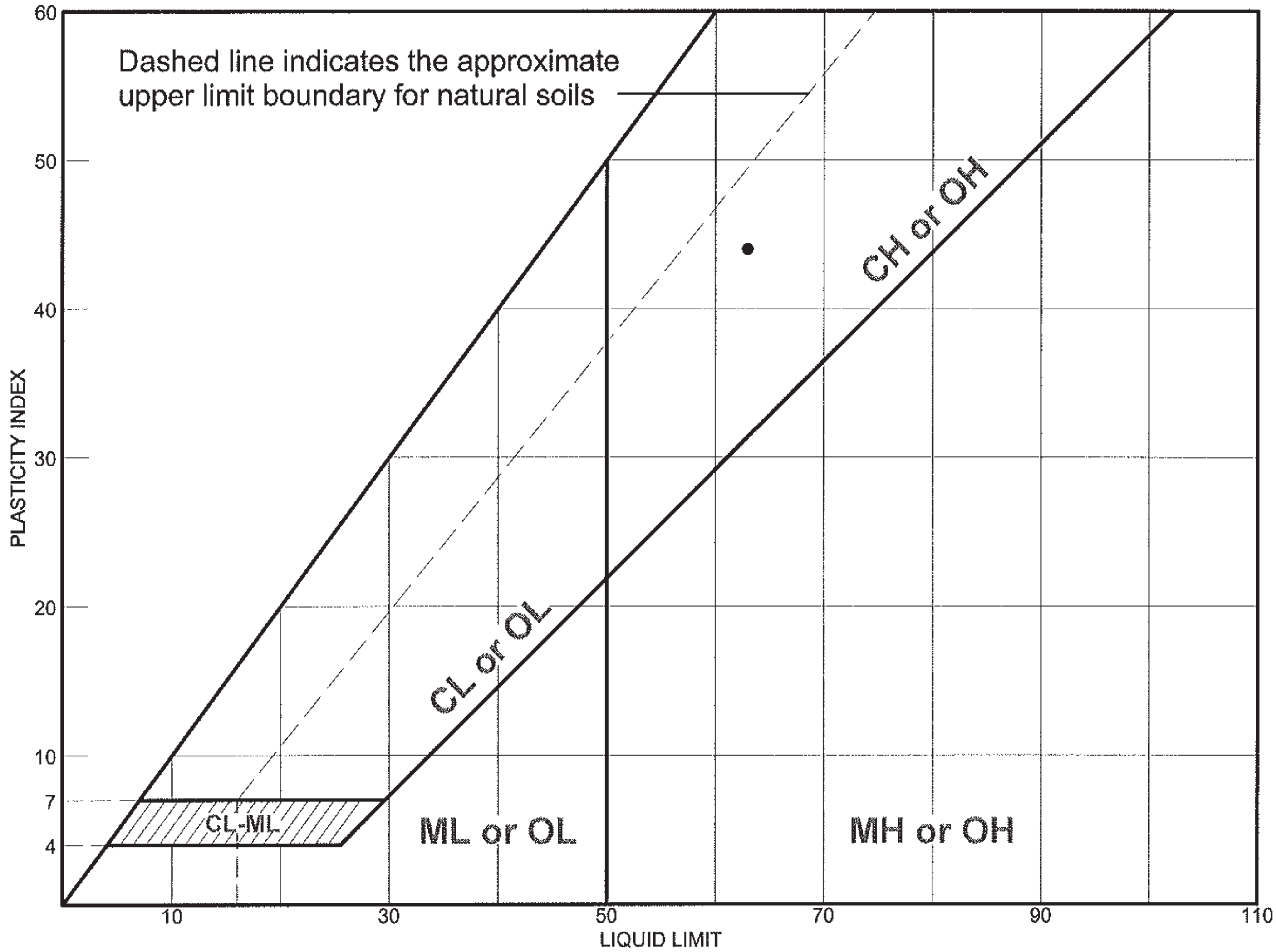
Fresno, CA

Figure

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●		63	19	44			

Project No. 60 **Client:** Hultgren - Tillis Engineers

Project: Salton Sea

● **Source:** **Sample No.:** HA-1

Remarks:

● Material is considered Non-Organic

Moore Twining Associates, Inc.

Fresno, CA

Figure

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California ELAP Certificate #1371

2527 Fresno Street
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October 22, 2010

Work Order #: 0I29061

Michael Shwiyhat
MTA Materials Division
2527 Fresno St.
Fresno, CA 93721

RE: Salton Sea Project

Enclosed are the analytical results for samples received by our laboratory on 09/29/10 . For your reference, these analyses have been assigned laboratory work order number 0I29061.

All analyses have been performed according to our laboratory's quality assurance program. All results are intended to be considered in their entirety, Moore Twining Associates, Inc. (MTA) is not responsible for use of less than complete reports. Results apply only to samples analyzed.

If you have any questions, please feel free to contact us at the number listed above.

Sincerely,

Moore Twining Associates, Inc.

for AG

Allen Glover
Director of Analytical Chemistry

MOORE TWINING ASSOCIATES, INC.

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
HA1 Bulk Comp.	0I29061-01	Soil	09/29/10 00:00	09/29/10 15:22
HA4 Bulk Comp.	0I29061-02	Soil	09/29/10 00:00	09/29/10 15:22
VC 11 (B+C)	0I29061-03	Soil	09/29/10 00:00	09/29/10 15:22
VC 16 (B+C)	0I29061-04	Soil	09/29/10 00:00	09/29/10 15:22
VC 20 (B+C)	0I29061-05	Soil	09/29/10 00:00	09/29/10 15:22
VC 28 (B+C)	0I29061-06	Soil	09/29/10 00:00	09/29/10 15:22

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

HA1 Bulk Comp.

0I29061-01 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**29000**	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
LOI (% Organic Matter)	**2.3**	0.10	%	1	T0J1123	10/11/10	10/13/10	ASTM D2974	
Nitrate as NO3	ND	4000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	2000	mg/kg	2000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**62000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**11000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**5900**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**18000**	200	mg/kg	50	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

HA4 Bulk Comp.

0I29061-02 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**12000**	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
LOI (% Organic Matter)	**0.80**	0.10	%	1	T0J1123	10/11/10	10/13/10	ASTM D2974	
Nitrate as NO3	ND	2000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	1000	mg/kg	1000	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**48000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**9000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3700**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**8500**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 11 (B+C)

0I29061-03 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**5500**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**41000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**8000**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3700**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**6400**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 16 (B+C)

0I29061-04 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**6900**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**36000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7500**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3500**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**6700**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 20 (B+C)
0I29061-05 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**4600**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**40000**	100	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7600**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**2000**	1000	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**4600**	40	mg/kg	10	T0J0514	10/05/10	10/12/10	EPA 6010B	

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MTA Materials Division 2527 Fresno St. Fresno CA, 93721	Project: Salton Sea Project Project Number: Salton Sea Project Project Manager: Michael Shwiyhat	**Reported:** 10/22/10

VC 28 (B+C)

0I29061-06 (Soil) Sampled:09/29/10 00:00

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Inorganics									
Bromide	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Chloride	**8600**	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrate as NO3	ND	1000	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Nitrite as NO2	ND	500	mg/kg	500	T0J1910	10/19/10	10/20/10	EPA 300.0	
Metals - Totals									
Calcium	**48000**	50	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Magnesium	**7900**	10	mg/kg	1	T0J0514	10/05/10	10/09/10	EPA 6010B	
Potassium	**3400**	500	mg/kg	5	T0J0514	10/05/10	10/12/10	EPA 6010B	
Sodium	**8400**	80	mg/kg	20	T0J0514	10/05/10	10/12/10	EPA 6010B	

Notes and Definitions

RPD	The RPD result exceeded the QC control limits. However, both percent recoveries were acceptable.
QM	The spike recovery for this QC sample is outside of established control limits due to matrix interference.
Q4	The spike recovery was outside of QC acceptance limits for the MS and/or MSD due to analyte concentration at 4 times or greater the spike concentration.
ug/L	micrograms per liter (parts per billion concentration units)
mg/L	milligrams per liter (parts per million concentration units)
mg/kg	milligrams per kilogram (parts per million concentration units)
ND	Analyte NOT DETECTED at or above the reporting limit
RPD	Relative Percent Difference

Quality Control Data Available Upon Request

Moore Twining Associates, Inc.
Allen Glover, Director of Analytical Chemistry
Jim Brownfield, Quality Assurance Manager

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: VC-28 @ 0.4-5.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	70.1	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	97.7	% Passing #200 Sieve	97.7
Hydrometer Reading @ 60 min	37	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	46	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\text{(\% Passing 5-µm(b))}}{\text{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{46.0} = 9\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: VC-28 @ 0.4-5.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 1 - Nondispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: VC-20 @ 0-4.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	73.4	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	88.8	% Passing #200 Sieve	88.8
Hydrometer Reading @ 60 min	27	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	30	% Passing 5-µm(b)	4

$$\textbf{\% Dispersion} = \frac{\textbf{(\% Passing 5-µm(b))}}{\textbf{(\% Passing 5-µm(a))}} * 100 \longrightarrow \frac{4.0\ (100)}{30.0} = 13\%$$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: VC-20 @ 0-4.7 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 1 - Nondispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location:	VC-16 @ 0-3.5 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	69.8	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	95.1	% Passing #200 Sieve	95.1
Hydrometer Reading @ 60 min	35	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	42.5	% Passing 5-µm(b)	4

% Dispersion = $\frac{\text{(\% Passing 5-µm(b))}}{\text{(\% Passing 5-µm(a))}}$ *** 100** → $\frac{4.0\ (100)}{42.5}$ = 9%

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location:	VC-16 @ 0-3.5 Feet		
Visual Classification:	Fat Clay		
Sampled By:	Client	Tested By:	TD
		Test Date:	10/9/2010

Test Results:
Grade: 2 - Intermediate

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/14/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: VC-11 @ 0-3.5 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	72.4	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	89.9	% Passing #200 Sieve	89.9
Hydrometer Reading @ 60 min	30	Hydrometer Reading @ 60 min	6
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-μm(a)	33	% Passing 5-μm(b)	20

% Dispersion = $\frac{\textbf{(\% Passing 5-μm(b))}}{\textbf{(\% Passing 5-μm(a))}}$ *** 100** → $\frac{20.0\ (100)}{33.0}$ = 61%

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: VC-11 @ 0-3.5 Feet
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 3 - Dispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/12/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: HA-4 (Bulk)
Visual Classification: Fat Clay W/Sand
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	70.6	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	75.2	% Passing #200 Sieve	75.2
Hydrometer Reading @ 60 min	22	Hydrometer Reading @ 60 min	1
Temperature, °C	21.4	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-µm(a)	23	% Passing 5-µm(b)	4

% Dispersion = $\frac{\text{(\% Passing 5-µm(b))}}{\text{(\% Passing 5-µm(a))}}$ *** 100** ⟶ $\frac{4.0\ (100)}{23.0}$ = 17%

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: HA-4 (Bulk)
Visual Classification: Fat Clay W/Sand
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 2 - Intermediate

(a) % by ASTM D422
(b) % by ASTM D4221

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Dispersive Characteristic of Clay Soil by Double Hydrometer
ASTM D4221

MTA Project Name:	Hultgren - Tillis Engineers	Report Date:	10/12/2010
	Salton Sea	Sample Date:	Sept. 20010
MTA Project Number	60	Sample I.D.:	

Sample Location: HA-1 (Bulk)
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

ASTM D422 Procedure		ASTM D4221 Procedure	
Dry Sample Wt., gm	77.5	Dry Sample Wt., gm	25
% Passing #10 Sieve	100	% Passing #10 Sieve	100
% Passing #200 Sieve	88.9	% Passing #200 Sieve	88.9
Hydrometer Reading @ 60 min	30	Hydrometer Reading @ 60 min	1
Temperature, °C	21.3	Temperature, °C	25.5
Hydrometer Correction	-4	Hydrometer Correction	0
% Passing 5-μm(a)	36	% Passing 5-μm(b)	4

% Dispersion = $\frac{\text{(\% Passing 5-μm(b))}}{\text{(\% Passing 5-μm(a))}} \times 100 \rightarrow \frac{4.0\ (100)}{36.0} = 11\%$

Dispersive Characteristic of Clay Soil by Crumb Test
ASTM D6572

Sample Location: HA-1 (Bulk)
Visual Classification: Fat Clay
Sampled By: Client
Tested By: TD
Test Date: 10/9/2010

Test Results:
Grade: 1 - Nondispersive

(a) % by ASTM D422
(b) % by ASTM D4221

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OFFICE MEMO

TO: Thang (Vic) Nguyen	**DATE:** December 29, 2010
	SUBJECT: Test Request No. 2010-29: Pin Hole Tests of Salton Sea Restoration Samples
FROM: Mike Driller	

Attached are the results of testing performed under Test Request No. 2010-29, "Pin Hole Tests of Salton Sea Restoration Soil Samples." Soil samples were received at the Bryte Laboratory on October 7, 2010 in six small plastic bags.

Pin Hole Tests were performed according to ASTM Test Designation D 4647 - 06, "Identification and Classification of Dispersive Clay Soils by the Pinhole Test." Results are listed below and on the attached Pin Hole Test Data Sheets.

The Method A procedure was used, and testing consisted of compacting the 38-mm (1.5-in.) long specimens into the pinhole test cylinder on top of the coarse sand and wire screen (see Figure 1). Samples were compacted to the density and moisture contents provided. The test method used distilled water flowing horizontally under a hydraulic head of 50 mm (2 in.) through a 1.0-mm (0.04-in.) diameter hole punched in the soil specimen. Pictures were taken before and after the Pinhole Test are attached.

<u>Pinhole Test Results</u>

The Pin Hole test is a direct, qualitative measurement of the dispersibility and erodibility of clay soils when subjected to water of low-salt concentration. The test is performed by passing water through a small hole punched in a specimen (see Figure 1). Flow from *dispersive* clays will be distinctly dark and the hole through the specimen will enlarge rapidly, with a resultant increase in the flow rate. Flow from slightly to *moderately dispersive* clays will be slightly dark with a constant hole size and flow rate. Flow from *nondispersive* clays will be completely clear with no measureable increase in the hole size. Classifications were determined using criteria from ASTM (see attached) based on the flow rate, turbidity, and hole size at the end of the test.

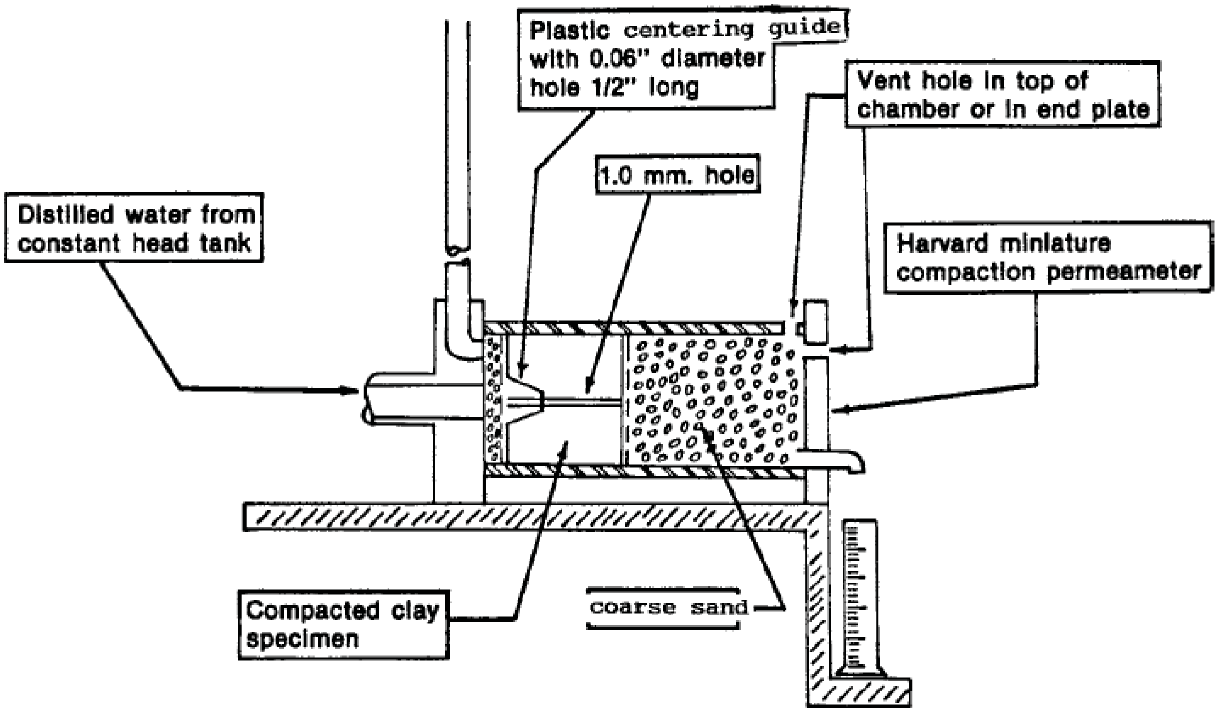

FIG. 1 Schematic Drawing of the Pinhole Test Equipment

Table 1: Results of pinhole tests

Hole No.	Bryte Lab No.	Dry Unit Weight	Moisture Content	Dispersive Classification	Remarks
HA-1	10-528	90 pcf	14.2	D1	Dispersive
HA-4	10-529	101 pcf	11.9	D1	Dispersive
VC-11	10-530	95 pcf	12.9	D2	Dispersive
VC-16	10-531	95 pcf	13.4	D1	Dispersive
VC-20	10-532	95 pcf	13.2	D2	Dispersive
VC-28	10-533	101 pcf	12.3	D2	Dispersive

Please call myself at 916-764-0277 or Doug Najima of my staff at 916-375-6012 if you have any questions.

PIN HOLE TEST DATA

Date: 12/11/2010

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Pin Hole Test No. 1

Sample No. 10-528 (HA-1)

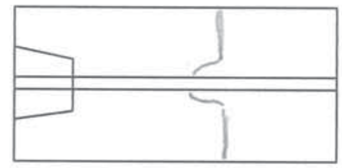
Compaction Characteristics good, firm, pliable

Water Content 14.2% @ 90pcf

Distilled water added x (yes) or ____ (no)

Curing time: 24 hrs.

Speciman after test:



Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1.33p	2"	25	31.1		x					x		0.80	
	2"	25	24.4		x					x		1.02	
	2"	25	20.2		x					x		1.24	
	2"	25	17.6		x					x		1.42	
1:38p	2"	25	17.5		x					x		1.43	<---stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with
													cloudy suspension of colloids in water.
													Pinhole after test was larger than the
													needle punch and expanded from 1.0mm
													to 3.58mm hole.
													Soil was air dried and moisturized to
													14.2%.

PIN HOLE TEST DATA

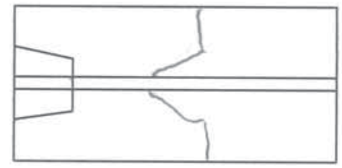
Date: 12/13/2010

Pin Hole Test No. 2

Page: 1

Sample No. 10-529 (HA-4)

Speciman after test:



Compaction Characteristics good, firm, pliable

Water Content 11.9% @ 101pcf

Distilled water added x (yes) or ____ (no)

Curing time: 48 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1:00p	2"	25	25	x						x		1.00	
	2"	25	20.1	x						x		1.24	
	2"	25	18.2	x						x		1.37	
	2"	25	17.9	x						x		1.40	
	2"	25	17.8	x						x		1.40	
1.05p	2"	25	17.6	x						x		1.42	<---stop test.
													Classification of test results:
													Method A: D1, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													8.89mm hole.
													Soil was air dried and moisturized to
													11.9%.

PIN HOLE TEST DATA

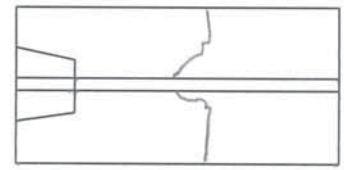
Date: 12/14/2010

Page: 1

Pin Hole Test No. 3

Sample No. 10-530 (VC-11)

Speciman after test:



Compaction Characteristics good, firm, pliable

Water Content 12.9% @ 95pcf

Distilled water added x (yes) or ____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy	ml / sec	
1:30p	2"	25	54		x					x		0.46	
	2"	25	52.5		x					x		0.48	
	2"	25	49.9		x					x		0.50	
	2"	25	49.8		x					x		0.50	
	2"	25	47.2		x					x		0.53	
	2"	25	32.8		x					x		0.76	
	2"	25	29.8		x					x		0.76	
	2"	25	27.1		x					x		0.92	
	2"	25	26.8		x					x		0.93	
	2"	25	26.5		x					x		0.94	
	2"	25	25.1		x					x		1.00	
1:41p	2"	25	24.9		x					x		1.004	<--- stop test
													Classification of test results:
													Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													9.5mm hole.
													Soil was air dried and moisturized to
													12.9%.

PIN HOLE TEST DATA

Date: 12/15/2010

Page: 1

Pin Hole Test No. 4

Sample No. 10-531 (VC-16)

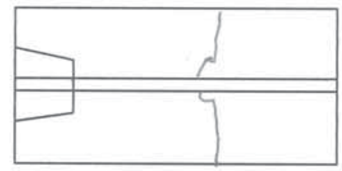
Compaction Characteristics good, firm, pliable

Water Content 13.4% @ 95pcf

Distilled water added x (yes) or ____ (no)

Curing time: 24 hrs.

Speciman after test:



Flow started on 1 trial.

Clock Time	Head	Flow Rate ml	Flow Rate sec	Color from Side: Dark	Color from Side: Slight to Medium	Color from Side: Barely Visible	Color from Side: Completely Clear	Completely Clear From Top	Particles Falling: None	Particles Falling: Few	Particles Falling: Heavy	Flow Rate ml / sec	Remarks
2:55p	2"	25	43.4		x					x		.058	
	2"	25	37.6		x					x		0.66	
	2"	25	31.9		x					x		0.78	
	2"	25	30.0		x					x		0.83	
	2"	25	25.6		x					x		0.98	
3:00p	2"	25	22.5		x					x		1.11	<--- stop test
													Classification of test results:
													Method A: D1, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													7.061mm hole.
													Soil was air dried and moisturized to
													13.4%.

PIN HOLE TEST DATA

Date: 12/16/2010

Page: 1

Pin Hole Test No. 5

Sample No. 10-532 (VC-20)

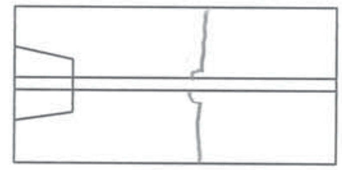
Compaction Characteristics good, firm, pliable

Water Content 13.2% @ 95pcf

Distilled water added x (yes) or ____ (no)

Curing time: 24 hrs.

Speciman after test:



Flow started on 1 trial.

Clock Time	Head	Flow Rate		Color from Side				Completely Clear From Top	Particles Falling			Flow Rate ml / sec	Remarks
		ml	sec	Dark	Slight to Medium	Barely Visible	Completely Clear		None	Few	Heavy		
2:09p	2"	25	53.8		x					x		0.46	
	2"	25	47.3		x					x		0.53	
	2"	25	40.8		x					x		0.61	
	2"	25	36.1		x					x		0.69	
	2"	25	35.8		x					x		0.70	
	2"	25	33.3		x					x		0.75	
	2"	25	32.5		x					x		0.77	
	2"	25	31.2		x					x		0.80	
	2"	25	29.7		x					x		0.84	
	2"	25	28.6		x					x		0.87	
	2"	25	27.8		x					x		0.90	
	2"	25	27.5		x					x		0.91	
	2"	25	26.3		x					x		0.95	
	2"	25	26.0		x					x		0.96	2:20p---stop test.
	2"	25	25.7		x					x		0.97	Classification of test results:
2:20p	2"	25	25.0		x					x		1.00	Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													5.105mm hole.
													Soil was air dried and moisturized to 13.2%.

PIN HOLE TEST DATA

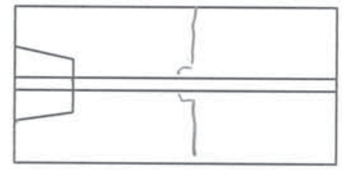
Date: 12/17/2010

Pin Hole Test No. 6

Page: 1

Sample No. 10-533 (VC-28)

Speciman after test:



Compaction Characteristics good, firm, pliable

Water Content 12.3% @ 101pcf

Distilled water added x (yes) or ____ (no)

Curing time: 24 hrs.

Flow started on 1 trial.

Clock Time	Head	Flow Rate ml	Flow Rate sec	Color from Side: Dark	Color from Side: Slight to Medium	Color from Side: Barely Visible	Color from Side: Completely Clear	Completely Clear From Top	Particles Falling: None	Particles Falling: Few	Particles Falling: Heavy	Flow Rate ml / sec	Remarks
2:06p	2"	25	49.5		x					x		0.51	
	2"	25	47.4		x					x		0.53	
	2"	25	41.8		x					x		0.60	
	2"	25	38.1		x					x		0.66	
	2"	25	37.9		x					x		0.66	
	2"	25	37.1		x					x		0.67	
	2"	25	36.2		x					x		0.69	
	2"	25	28.9		x					x		0.87	
	2"	25	27.1		x					x		0.92	
	2"	25	26.4		x					x		0.95	
	2"	25	24.7		x					x		1.01	
2:16p	2"	25	22.6		x					x		1.11	<--- stop test
													Classification of test results:
													Method A: D2, Dispersive clay with cloudy
													suspension of colloids in water.
													Pinhole after test was larger than the needle
													punch and expanded from 1.00mm to a
													5.029mm hole.
													Soil was air dried and moisturized to 12.3%.

Pinhole Test Pictures

Hole HA-1(Lab No. 10-528):

Hole HA-4(Lab No. 10-529):

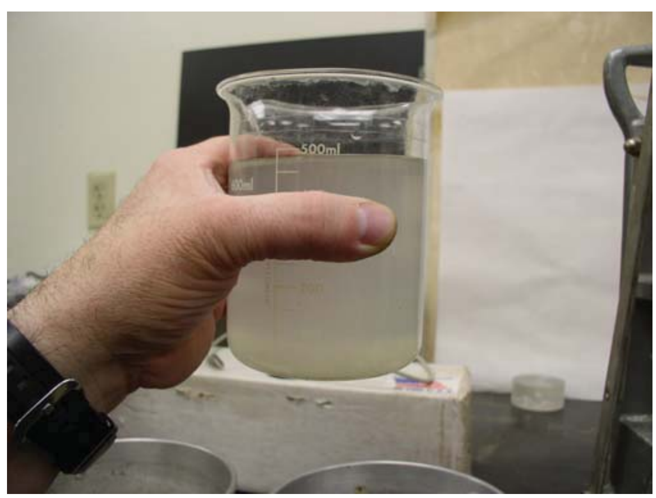
Hole VC-11(Lab No. 10-530):

Hole VC-16(Lab No. 10-531):

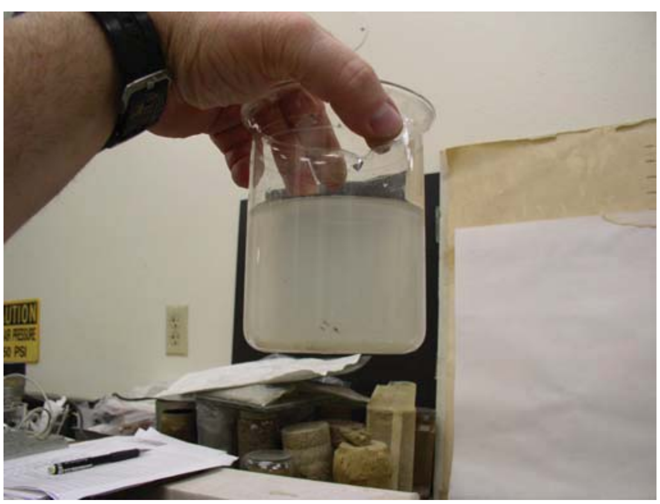


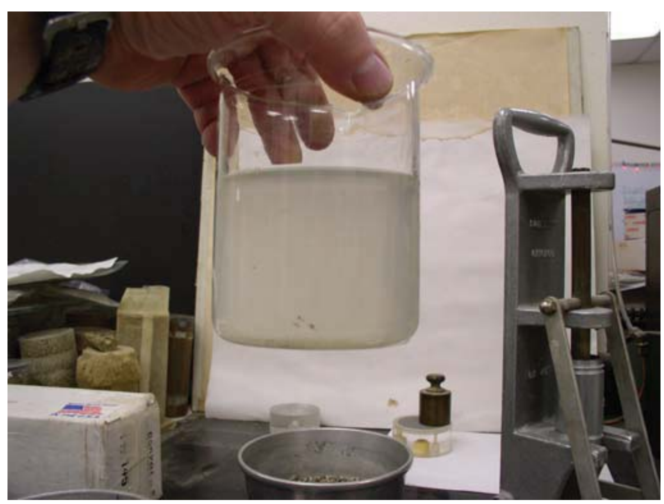



Hole VC-20(Lab No. 10-532):



Hole VC-28(Lab No. 10-533):





ASTM Criteria for interpreting results.

7. Classification

7.1 The observations of this test method provide the basis for classifying the soil specimen into a category of dispersiveness according to the following general criteria:

7.1.1 *Method A:*

D1, D2—Dispersive clays that fail rapidly under 50-mm (2-in.) head.

ND4, ND3—Slightly to moderately dispersive clays that erode slowly under 50-mm (2-in.) or 180-mm (7-in.) head.

ND2, ND1—Nondispersive clay with very slight to no colloidal erosion under 380-mm (15-in.) or 1020-mm (40-in.) head.

TABLE 1 Criteria for Evaluating Pinhole Test Results[A]

Dispersive Classification[B]	Head, mm	Test time for given head, min.	Final flow rate through specimen, mL/s	Cloudiness of flow at end of test		Hole size after test, mm
				from side	from top	
D1	50	5	1.0–1.4	dark	very dark	≥2.0
D2	50	10	1.0–1.4	moderately dark	dark	>1.5
ND4	50	10	0.8–1.0	slightly dark	moderately dark	≤1.5
ND3	180	5	1.4–2.7	barely visible	slightly dark	≥1.5
	380	5	1.8–3.2			
ND2	1020	5	>3.0	clear	barely	<1.5
ND1	1020	5	≤3.0	perfectly clear	perfectly clear	1.0