Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

35+ YEARS

August 18, 2023
Project No. 606752008

Mr. Paul Keesler
Town of Oro Valley
11000 North La Canada Drive
Oro Valley, Arizona 85737

Subject: Geotechnical Services
Valley Vista Subdivision Soil Evaluation
Oro Valley, Arizona

Dear Mr. Keesler:

In accordance with our proposal dated June 29, 2023, and your authorization, Ninyo & Moore has performed geotechnical services related at the above referenced site. This letter report presents the results of our evaluation and our findings, conclusions and recommendations regarding the project.

## SCOPE OF SERVICES

The scope of our services for this phase of the project generally included:

- Performing research of existing geotechnical reports, design and as-built documentation, and construction records related to the subsurface utilities within the affected areas.
- Conducting a visual reconnaissance of the pavement surface and marking out of the field test locations.
- Contacting Arizona 811 to evaluate underground utility locations prior to drilling.
- Coring the existing pavement at four locations along the affected roadway segments using an electronic coring machine.
- Drilling four exploratory borings, through the aforementioned core holes, to an approximate depth of 3 feet below ground surface (bgs) using hand auger techniques, and drilling, logging, and sampling two exploratory soil borings to an approximate depth of about 20 feet below ground surface (bgs). Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System and ASTM D2488 by observing cuttings and split-spoon samples. The boring logs are presented in Attachment A.
- Collecting bulk and relatively undisturbed ring samples of the soils in the borings for laboratory testing and analysis. The soil samples were transported to a Ninyo & Moore laboratory for testing.

- Conducting laboratory testing on subgrade soil samples generally included in-place moisture and dry density, gradation, Atterberg limits, consolidation, and laboratory maximum density characteristics. The laboratory test results are presented in Attachment B.

- Preparing this letter report.

Our scope of services did not include environmental consulting services such as hazardous waste sampling or analytical testing at the site. A detailed scope of services and estimated fee for such services can be provided upon request.

## PROJECT AND SITE DESCRIPTION

At the time of our study, the site occupied the easternmost portion of the Rancho Vistoso Valley Vista residential subdivision and encompassed southeastern segments of Kalalau Drive and Romsdalen Road, with single-family houses on both sides of the roadways. The roadways were two-lane asphaltic concrete paved facilities with a curb and gutter system and Portland cement concrete sidewalks. A Pima County pump station was located near the southeast corner of the site (the intersection of Kalalau Drive and Romsdalen Road) and was surrounded by a perimeter masonry wall.

The subdivision is situated near the western flank of Honey Bee Canyon within the Big Wash floodplain. Based on our field observations the site improvements associated with the subdivision were built partly in shallow cuts (west side) and on fill embankments (eastern side), with Federal Emergency Management Agency (FEMA) floodplain bank protection systems with relatively steep soil-cement paved embankments along the eastern and southeastern edges of the site. These embankment heights varied roughly between 6 and 12 feet and native floodplain land extended to the east.

We understand that Pima County Regional Water Reclamation Department (RWRD) performed video inspections of a sewer alignment in 2021 and 2023 within the subdivision. The inspections demonstrated sagging of the sewer pipeline near the pump station, but leaking was not noticed. There has also been reported surficial distress of the roadway and in common area asphalt pavement in the pump station proximity, near the pipe sagging area. Surface repairs have been made to the pavement since then. In addition, some residential properties located adjacent to the affected sewer line have reportedly developed various ground settlement caused distress. Lastly, the pump station has exhibited movement and cracking of its perimeter wall and some gate deformations.

Per the Town of Oro Valley (Town) request, the goal of this study was to explore the soils along the affected roadway segments and sewer line, and evaluate possible cause of the aforementioned pavement distress. We have also been asked to develop possible mitigation measures.

## BACKGROUND RESEARCH

We have performed background research for the project that included a review of the following documents and records:

- Topographic Map and Aerial photograph review (Google Earth™);
- ProTeX, 2018, Geotechnical Investigation, Rancho Vistoso Neighborhood 5 – Parcel X and W, Rancho Vistoso Boulevard and Moore Loop, Oro Valley, Arizona.
- The WLB Group, 2018. Public Sewer Improvement Plan for Moore Loop & Rancho Vistoso, Valley Vista, G-2018-091, AS-Built Sewer Plans dated 03/16/20;
- The WLB Group, 2019, Kalalau Drive Public Wastewater Pump Station, Moore Loop, Rancho Vistoso Valley Vista Lots 1 through 168 & Common Areas “A” & “B”, dated March;
- The WLB Group, 2019, Final Site Plan & Public Street Improvement and Grading Plan, Rancho Vistoso Velley Vista, dated March;
- ProTeX, Field Density Summary Reports for the Sewer Line Backfill along Kalalau Drive, Romsdalen Road, Danum Valley Drive, Gayser Valley Street, Harau Valley Road, and Sewer Easement, covering the period between June 11, 2019 and January 7, 2020;
- ProTeX, 2020, Letter of Final Compliance, 5X and 5W Lift Station @ Rancho Vistoso Valley Vista, dated June 18;
- ProTeX, 2020, Underground Improvements Package for: Rancho Vistoso Valley – 5X and 5W:
    - Phase 1A dated 3/2/2020;
    - Phase 1B dated 1/23/2020; and
    - Phase 1C dated 3/25/2020.
- ProTeX, 2020, Street Improvements Package for: Rancho Vistoso Valley Vista – 5X and 5W:
    - Phase 1A dated 4/7/2020;
    - Phase 1B dated 4/8/2020; and
    - Phase 1C dated 2/9/2020.
- ProTeX, 2019 and 2020, Building Pad-Post-Tension Foundation for 5X and 5W Mass Grading @ Rancho Vistoso Valley Vista:
    - Phase 1A dated 6/13/2019;
    - Phase 1B dated 1/8/2020; and
    - Phase 1C dated 3/18/2020.
- ProTeX, 2022, Geotechnical Investigation – Forensics, Rancho Vistoso Velley vista – Lot 19, 780 East Kalalau Drive, Oro Valley, Arizona, dated November 3, 2022.

The following sections summarize each of the documents and records reviewed.

## Topographic Map and Aerial Photograph Review

According to the Oro Valley, Pima County, 7.5-Minute United States Geological Survey (USGS) Topographic Quadrangle Map (2021) the average site elevation is approximately 2,720 feet relative to mean sea level (MSL). The topography of the site is relatively flat and slopes gently from west to east.

Several historical aerial photographs from Google Earth™ were reviewed for this project. Images dated 1992 through 2018 depicted the project area as undeveloped land with relatively dense vegetation. The Honey Bee Canyon with the Big Wash were located to the east of the site. Unpaved paths and trails were observed on the images from the late 1990's and later. Small drainages and washes traversed the site generally trending form northwest to southeast converging in the vicinity of what currently is the pump station. An image dated December 2020 depicted the roadways and the pump station in place. By 2020, many of the building pads were prepared with few houses built. Also, the FEMA floodplain bank protection system with soil-cement paved embankments was already constructed along the eastern and southeastern edges of the site. An image dated April 2023 depicted the project site as similar to its current condition.

## ProTeX Geotechnical Investigation Report (2018)

In 2018, ProTeX conducted a geotechnical exploration within the area generally west and north of the project site in support of the then proposed Rancho Vistoso Valley Vista residential subdivision development. A total of 10 borings (B1 to B10) were drilled to a depth of 15 feet below ground surface (bgs) for the purpose of evaluating subsurface conditions. Standard Penetration Tests (SPT) were performed in selected borings and at selected depths, where bulk and relatively undisturbed ring samples were also collected. The laboratory testing program included gradation, Atterberg limits, expansion index, R-value and chlorides and sulfates content.

Based on the field exploration and laboratory testing the subsurface profile consisted primarily of native alluvial sediments including silty sands, sandy silts and clayey sands with plasticity index ranging from 0 (non-plastic) to 12. Based on the field blow count testing (SPT N-values), ProTeX concluded that the subsurface soils were loose to medium dense and susceptible to hydro-collapse. These conditions were encountered in many areas of the site. ProTeX further indicated that the potential for hydro-consolidation of the subsurface soils should be mitigated. It was recommended that "*due to light to moderate vegetation and loose/soft surface conditions, the surface soils should be over-excavated a minimum depth of 1.0 foot below existing grade or 1.0 foot below finished pad grade elevation, whichever is deeper. After clearing and over-excavation, the exposed soils should*

*be scarified a minimum of 8 inches, moisture conditioned and compacted."*. This overexcavation recommendation was applicable to the building foundation pads.

The report provided compaction specifications for subgrade below post-tension and conventional foundations as evaluated based on the standard Proctor test (ASTM D698), as summarized below:

- Below conventional interior floors: 95 percent;
- Below conventional foundation level and post-tension slab-on-grade: 95 percent;
- Fills at depths 5 to 10 feet below finish grade: 98 percent; and
- Fills at depths 10 feet or greater below finish grade: 100 percent.

## WLB, 2018. Public Sewer Improvement Plans

These WLB plans present as-built information for the public 8-inch sewer and the 6-inch forcemain construction along the roadways within the subdivision (plan and profile sheets), including the pump station. For the sewer construction, the plans referenced the Pima County Regional Wastewater Reclamation Department (PCRWRD) Engineering Design Standards 2016 Edition and the Standard Specifications and Details for Construction (2016). The ProTeX 2018 report was referenced for the roadway pavement sections. The public gravity sewer slopes towards the pump station. In the wet well sewage is pumped into the forcemain and disposed of offsite. Due to the original ground configuration and the final grades, the profiles show mainly cut sections within the western portion of the subdivision and fill embankments towards the east. The Kalalau Drive and Romsdalen Road intersection area was constructed within a shallow (up to 4 feet deep) cut and on a low (up to 3 feet high) embankment. The pump station was constructed on an approximately 10 feet fill embankment.

## WLB, 2019, Kalalau Drive Public Wastewater Pump Station

These WLB plans present as-built information for the public wastewater pump station located near the Kalalau Drive and Romsdalen Road intersection including the 25-foot deep wetwell supported on a 12-inch thick concrete mat foundation and the containment structure with associated equipment and appurtenances. The perimeter masonry wall was supported on continuous spread footings. The gate track sections had 36-inch wide footings. Other improvements were supported on either slab on grade/pad foundations (containment structure, generator, motor control center) or extended footings (light poles, wetwell equipment rack). The General Notes sheet provides the following references:

- The General Sewer Notes in Note 3 reference the PCRWRD Engineering Design Standards 2016 Edition and the Standard Specifications and Details for Construction (2016).
- The General Notes in Note 1 reference the PCRWRD Standard Detail RWRD 001.
- The General Notes for the pump station in Note 5 state that *all earthwork shall be in accordance with the requirements of the geotechnical report, "Geotechnical Investigation, Rancho Vistoso Neighborhood 5 Parcels W & X," ProTeX, ProTeX job number 7466, February 20, 2018*.
- The General Notes for paving and grading state the following:
    - Note 4: Earthwork, except as modified by the soils report on record, shall conform to PAG SSPI, Section 203; and
    - Note 23: A report of soils investigations, including recommendations for grading procedures has been prepared by ProTeX, LLC, dated February 20, 2018, Project No.7466, all earthwork shall conform to the recommendations contained in said report and any amendments made thereto.

## WLB, 2019, Final Site Plan & Public Street Improvement and Grading Plan

These WLB plans present as-built information for the subdivision development. They generally reference relevant standards for the Pima County, Arizona Department of Transportation (ADOT) and the Town of Oro Valley. Specifically, the General Paving Notes state the following:

- Note 4: Earthwork, except as modified by the soils report on record, shall conform to PAG SSPI, Section 203; and
- Note 23: A report of soils investigations, including recommendations for grading procedures has been prepared by ProTeX, LLC, dated February 20, 2018, Project No.7466, all earthwork shall conform to the recommendations contained in said report and any amendments made thereto.

In addition, the typical street cross-sections referenced the 2018 ProTeX report.

## ProTeX 2019 - 2020, Field Density Summary Reports

These ProTeX reports provide the results of field density testing performed during construction for the sewer line trench backfill along Kalalau Drive, Romsdalen Road, Danum Valley Drive, Gayser Valley Street, Harau Valley Road, and Sewer Easement, for the lower zone (depths between 2 and 7 feet below final grade) and the upper zone (depths between 0 and 2 feet below final grade). Sewer manhole backfill testing was reported separately. The tests generally passed the minimum specified compaction. However, the reports contained incomplete information on the laboratory testing (index tests and standard Proctor) associated with the field tests.

## ProTeX, 2020, Letter of Final Compliance

This ProTeX letter of compliance provides construction inspection and testing results for the pump station and specifically:

- Construction observation services and grout compressive strength test results for the perimeter wall;
- Field density test results for the access drive and the sewer line and the manhole trench backfill; and
- Laboratory test results including five standard Proctors and concrete compressive strength for the electrical slab and the containment slab.

The letter stated compliance of the construction with the project plans and specifications.

## ProTeX, 2020, Underground Improvements Packages

Each of these ProTeX packages were prepared for a different project phase (A through C) and included:

- Field density test results for trench backfill for dry utilities, the sewer line, storm drain and water line;
- Asphaltic core density test results; and
- Respective laboratory test results for soils including the standard Proctor, asphaltic concrete and concrete (compressive strength tests for curbs and different drainage improvements).

The results were stated to be in substantial conformance with Pima County and the City of Tucson specifications and requirements.

## ProTeX, 2020, Street Improvements Packages

Each of these ProTeX packages were prepared for a different project phase (A through C) and included:

- Field density test results for curb subgrade, street subgrade and aggregate base course; and
- Respective laboratory test results including the standard Proctor and concrete compressive strength for a sewer manhole base (Phase 1B).

The results were stated to be in substantial conformance with Pima County and the City of Tucson specifications and requirements.

## ProTeX, 2019 and 2020, Building Pad-Post-Tension Foundation

Each of these ProTeX packages were prepared for a different project phase (A through C) and included:

- Field density summary reports for each lot at various depths between 7 feet bgs and the finished grade; and
- Respective laboratory test results including standard Proctor.

The packages included the following statement:

*Field observations were made to ensure that the site was cleared of all vegetation and structures, site was overexcavated to a depth of 1 foot and exposed subgrade soils were scarified. Testing was performed to confirm moisture conditioning and compaction efforts are in compliance with the recommendations of the aforementioned geotechnical report. Field Density tests are enclosed. Based on the observations, laboratory testing, and field density testing, a bearing value of 1250psf at finished grade bearing on 1 foot of engineered fill is assigned for post-tensioned foundation systems. Building Pads are certified for one year from the date of this letter.*

## ProTeX, 2022, Geotechnical Investigation – Forensics

ProTeX, conducted a forensic geotechnical investigation to evaluate the cause(s) of distress observed at residence Lot 19. The common area with the Pima County Pump Station located to the east of Lot 19 was also evaluated. A total of 23 borings were advanced to depth ranging between 25 and 71 feet bgs. The laboratory testing included index tests as well as consolidation (hydro-collapse potential). The field test results and observations indicated that the subsurface soils were very loose/soft with varying levels of moisture content with very damp to wet soils near the saturation level observed to substantial depths. Cracks in the roadway pavements an in the common area adjacent to the pump station were also observed.

In conclusions, ProTeX stated that the site soils are susceptible to progressive settlements and progressive displacement resulting in significant loss of soil support under certain foundation elements for the houses and site walls as well as underground utilities.

The recommendations included the following mitigation measures:

- Helical piers installed to competent material depths under foundations;
- Grouting compaction of subsurface soils around the houses and the pump station;
- Drainage evaluation to provide positive drainage away from foundation elements.

The depth of the above mitigation techniques was not defined and left to the remediation contractor/structural engineer judgement.

## GEOTECHNICAL FIELD EXPLORATION AND LABORATORY TESTING

On July 13 and 14, 2023, Ninyo & Moore conducted a geotechnical exploration in order to evaluate the subgrade conditions. Our exploration consisted of pavement coring at three locations and drilling of six exploratory borings to approximate depths of 3 to 20 feet bgs and collecting bulk and relatively undisturbed ring samples of the subgrade soils using hand hand-operated equipment and a truck mounted drill rig equipped with hollow stem augers.

Ninyo & Moore personnel logged the borings in general accordance with the Unified Soil Classification System (USCS) and American Society for Testing and Materials (ASTM) test method D 2488 by observing cuttings and drive samples. Collected ring samples were trimmed in the field, wrapped in plastic bags, and placed in cylindrical plastic containers to retain in-place moisture conditions. Similarly, Standard Penetration Test (SPT) and bulk samples were sealed in plastic bags to retain their approximate in-place moisture. Detailed descriptions of the soils encountered are presented on the boring logs in Attachment A.

The soil samples collected from our exploratory activities were transported to the Ninyo & Moore laboratory in Tucson, Arizona for geotechnical laboratory testing. The testing included in-place moisture and dry density, gradation, Atterberg limits, consolidation, and laboratory maximum dry density. The results of the in-situ moisture content and dry density testing are presented on the boring log in Attachment A and a description of each laboratory test method and the remainder of the test results is presented in Attachment B.

## GEOLOGY AND SUBSURFACE CONDITIONS

The following sections provide a discussion of the general site geology and description of the site subsurface conditions based on the results of our exploratory borings.

### Site Geology

The project site is located in the Sonoran Desert Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous, subparallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basin floors consist of alluvium with thickness extending to several thousands of feet.

The basins and surrounding mountains were formed approximately 18 million years ago during the mid- to late-Tertiary age. Extensional tectonics resulted in the formation of horsts (mountains) and

grabens (basins) with vertical displacement along high-angle normal faults. Intermittent volcanic activity also occurred during this time. The surrounding basins were filled with alluvium from the erosion of the surrounding mountains as well as from deposition from rivers. Coarser-grained alluvial material was deposited at the margins of the basins near the mountains.

The surficial geology of the site is described as being Holocene age (10,000 years or less) basin-fill deposits composed of active stream channels, low stream terraces, and relatively un-dissected alluvial fans (Pearthree, 1998). Our review of the United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) online Web Soil Survey, indicates that the soils at this site are described as the Anthony fine sandy loam complex associated with the Big Wash floodplain. This unit consists of fine sandy loam, stratified loamy sand to very fine sandy loam, gravelly loamy sand, and gravelly loamy coarse sand. Loam is an agricultural soil classification that refers to a soil comprised of a mixture of clay, silt, and sand.

## Subsurface Conditions

The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate, as the actual transition between soil types (strata) may be gradual. Detailed stratigraphic information and a key to the soil symbols and terms used on the boring logs are provided in Attachment A.

## Fill

Recent embankment fill soils associated with the site development were encountered at the surface of our borings, (except for boring B-2) and extended to a depth of 3 feet bgs. This fill was likely placed as part of the recent site development including the roadways and the sewer line construction. The fill soils consisted of medium dense to dense silty sand and silty clayey sand with variable percentages of gravel.

## Alluvium

Native alluvial deposits associated with the Big Wash floodplain were encountered below the fill and at the surface of our boring B-2 and extended to the boring termination depths. The alluvium in our borings consisted of very loose to medium dense silty clayey sand with variable percentages of gravel. In our borings the loose/very loose zone was sandwiched between the surficial and greater depth medium dense deposits.

### Groundwater

Groundwater was not encountered in our exploratory boring. Based on well data provided by the Arizona Department of Water Resources (ADWR), groundwater has been historically measured at a depth on the order of 100 feet bgs or greater. However, it should be noted that groundwater levels near the site can fluctuate due to seasonal variations, flows in the Big Wash, irrigation, groundwater withdrawal or injection, and other factors.

## DISCUSSION OF LABORATORY TEST RESULTS

As mentioned above, both fill and native alluvial soils were encountered in our borings and generally consisted of silty clayey sand in a medium dense to dense condition. For the fill soils, the in-situ moisture content varied between 4.7 and 6.6 percent and the in-situ dry densities ranged between 114.6 and 126.5 pounds per cubic foot (pcf). For the alluvium soils, the in-situ moisture content varied between 3 and 16.4 percent and the in-situ dry densities ranged between 101 and 116.3 pounds per cubic foot (pcf). The relative compaction of the fill was estimated to be approximately 91 to 100 percent of the maximum dry density as evaluated in accordance with ASTM D698.

The laboratory test results also show that both fill and native alluvial soils at our exploration locations are relatively consistent and include low plasticity silty sand and silty clayey sand. Based on the collected relatively undisturbed ring samples, the fill soils have generally higher dry densities and moisture content then the alluvial soils. The results of the consolidation tests indicate moderate to very severe collapse potential upon saturation:

- Approximately 4 to 5 percent for the fill material (moderate collapse potential); and
- Approximately 11 to 13.5 percent for the alluvial material (severe collapse potential).

## CONCLUSIONS

Based on the results of our work, we estimate that the utility trench backfill and general grade-raise fill soils exist along the affected segments of the two roadways. Even though not encountered in our borings, the trench/backfill depths could be as deep as 14 feet bgs.

Our work also indicates that loose alluvial soils exist below the trench backfill and general grade-raise fill soils. The borings advanced by ProTeX within or in close proximity of the current project indicated these same loose alluvial soils. ProTeX also indicated that these settlement prone soils extend to substantial depths, with elevated moisture conditions (close to saturation) observed in many soil samples.

Our field and laboratory test results indicate relatively consistent subsurface conditions along both project alignments with silty sand and silty clayey sand soils encountered. The native alluvial soils are generally more compressible under loading and/or saturation and are in a relatively loose condition. We conclude that this is the main factor affecting the observed pavement deformation/distress. Settlement related pavement distress may develop in other areas of the residential subdivision that do not currently shows signs of deformation/distress. Its time and extent cannot be accurately predicted.

## RECOMMENDATION

To help mitigate the affected roadway segments, we recommend the following steps:

1. Remove the existing asphalt and aggregate base pavement and overexcavate the subgrade soils to a depth of four (4) feet below the existing pavement (as measured form the bottom of the aggregate base course).

2. After the overexcavation described above is finished and prior to the placement of engineered fill, evaluate the exposed surface for the presence of soft, loose, or wet soils. Based on this evaluation, additional remediation may be needed.

3. Replacement the overexcavated zone with engineered fill. The engineered fill should be placed in up to 8-inch thick lifts in loose condition and compacted by mechanical means to 95 percent of the maximum dry density as evaluated in accordance with ASTM D698.

4. Place a geogrid layer (Tensar® BX 1200 or better) above the engineered fill used to backfill the overexcavated zone and under the pavement aggregate base layer.

5. Replace the asphalt and aggregate base pavement per the original plans and specs.

## LIMITATIONS

The recommendations presented in this report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the findings and recommendations presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this letter report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

Our results are based on testing performed at the indicated test locations. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this letter may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, opinions and recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

We appreciate the opportunity to be of service to you on this project.

Respectfully submitted,
**NINYO & MOORE**

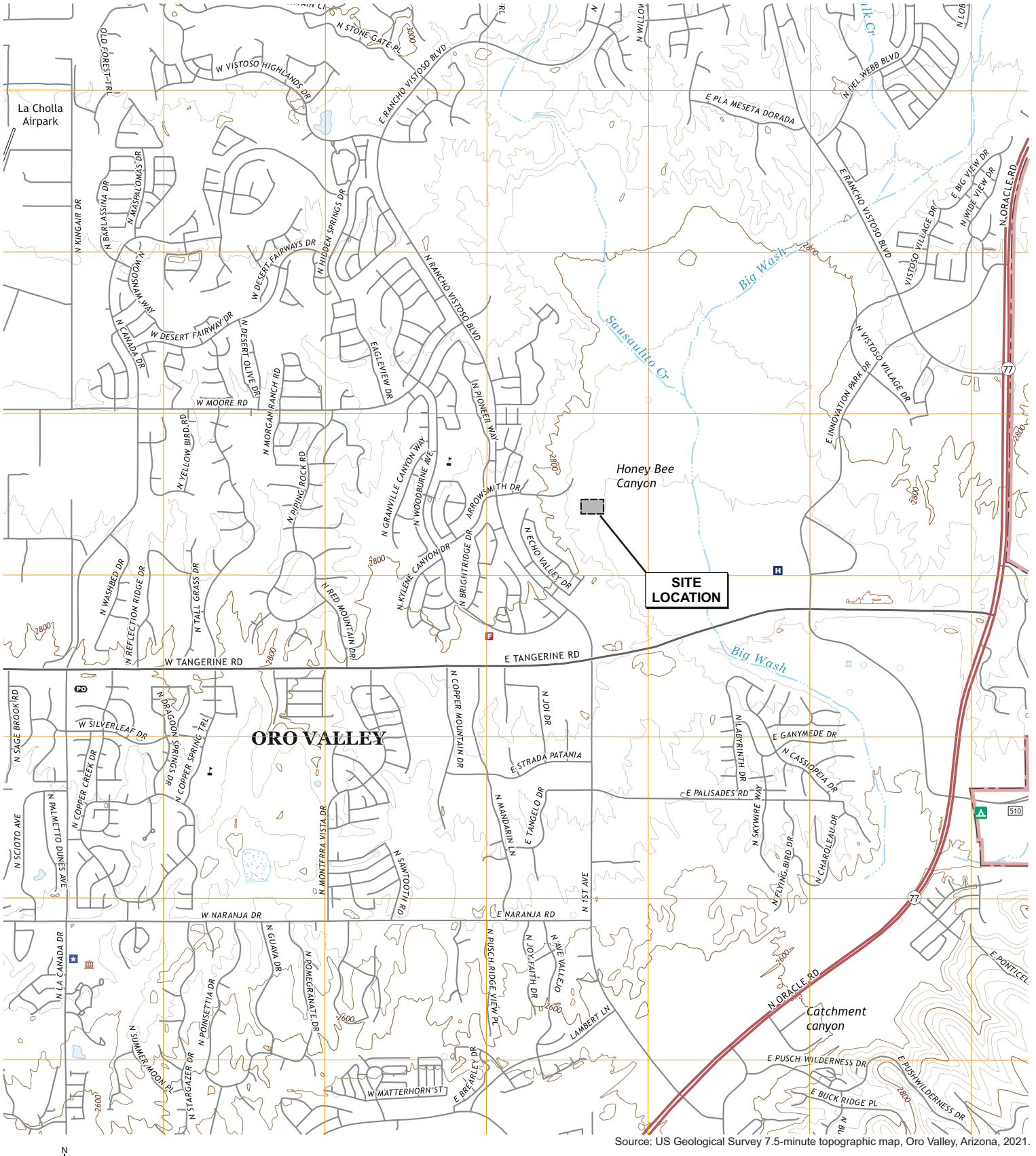

Marek J. Kasztalski, PE
Principal Engineer

Fred Narcaroti
Principal/Tucson Office Manager

MJK/FFN/SDN/jom

Attachments: Figure 1 - Site Location
Figures 2A and 2B - Boring Locations
Attachment A – Boring Logs
Attachment B – Laboratory Test Results

# FIGURES




Source: US Geological Survey 7.5-minute topographic map, Oro Valley, Arizona, 2021.

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NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

**FIGURE 1**

# SITE LOCATION

VALLEY VISTA SUBDIVISION SOILS EVALUATION
ORO VALLEY, ARIZONA

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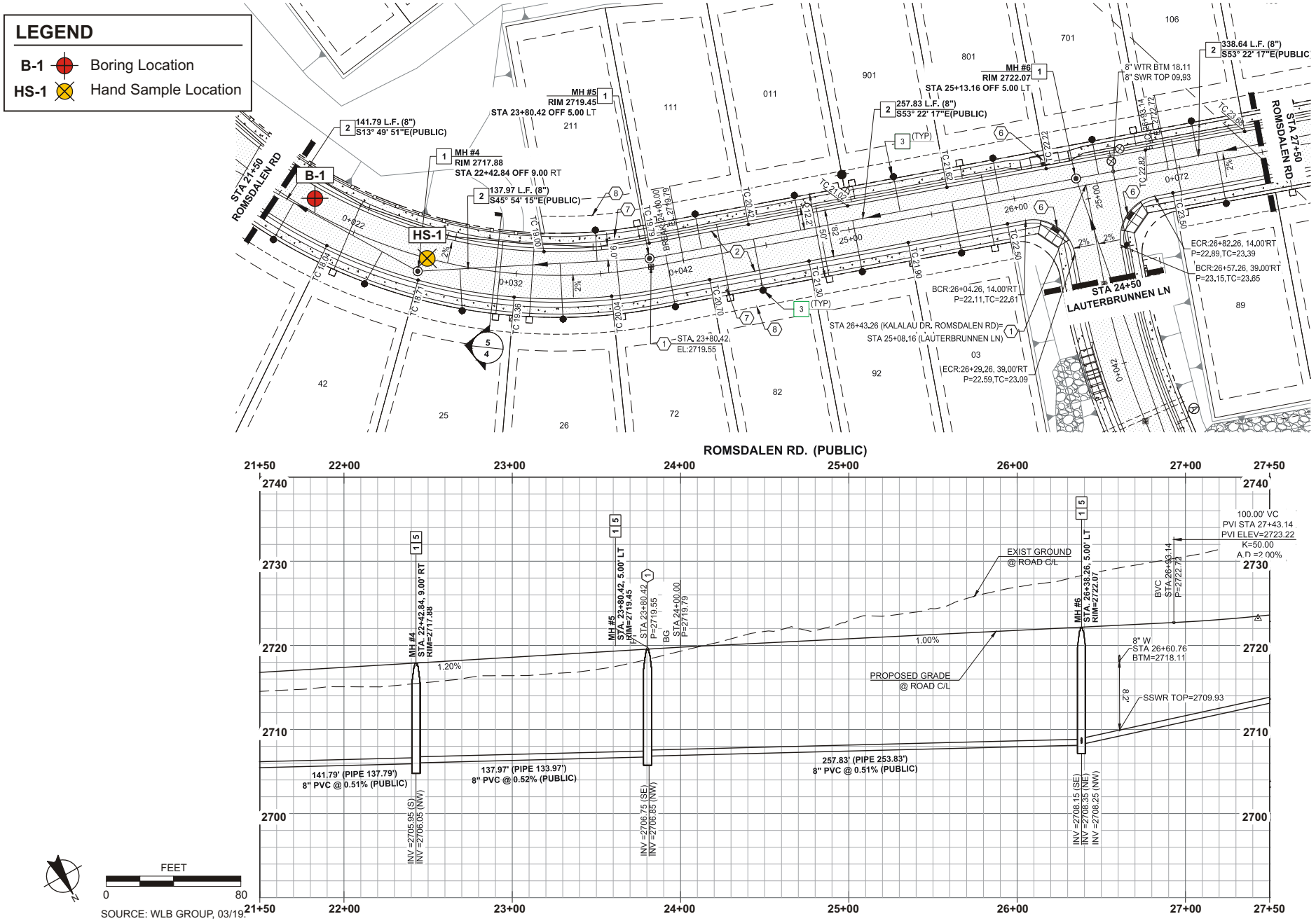
bsm file no: 6752vmap0723




SOURCE: WLB GROUP, 03/19.

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

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**FIGURE 2A**

# EXPLORATION LOCATIONS

VALLEY VISTA SUBDIVISION SOILS EVALUATION
ORO VALLEY, ARIZONA

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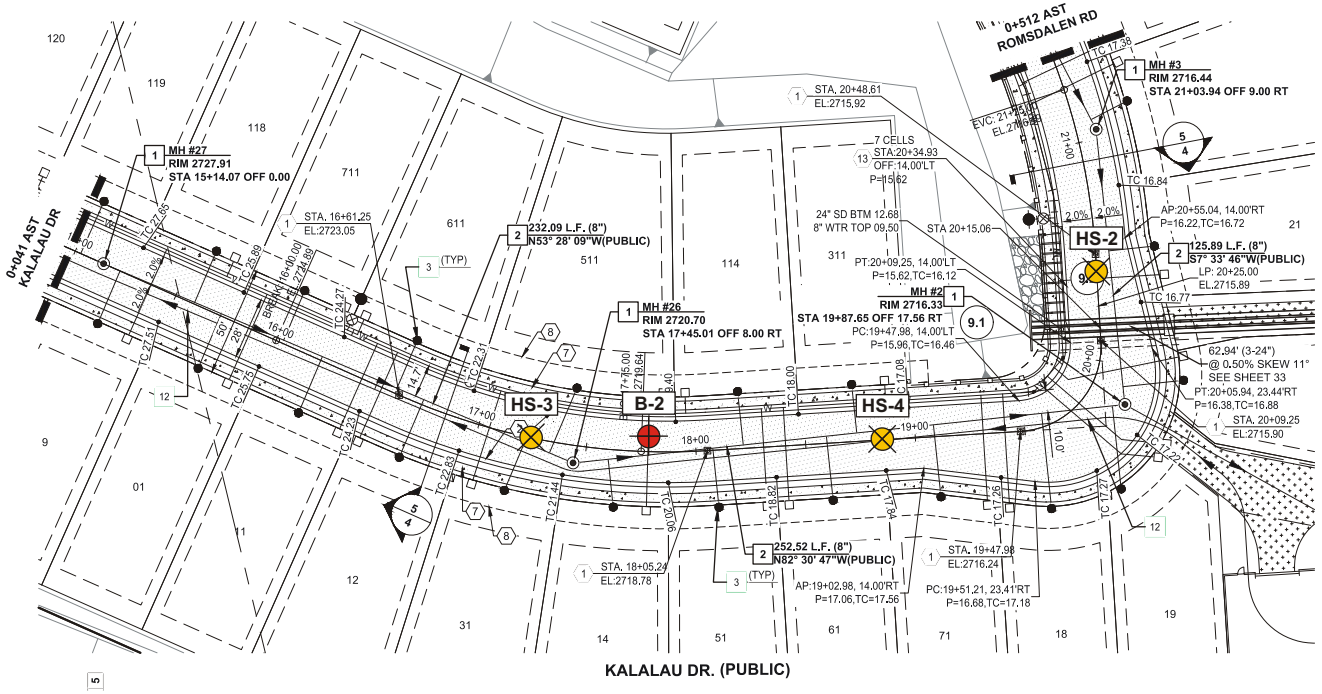
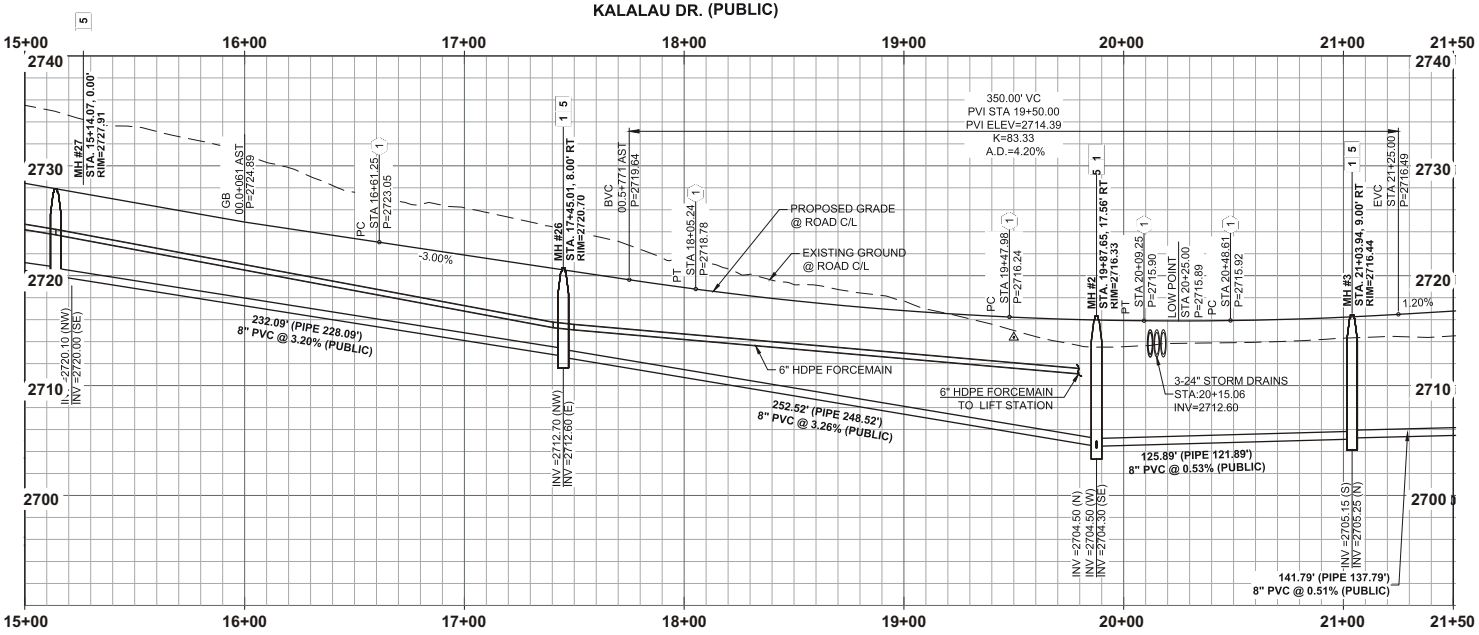
**LEGEND**

B-2 Boring Location

HS-4 Hand Sample Location

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SOURCE: WLB GROUP, 03/19.

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

bsm file no: 6752blm0723b

**FIGURE 2B**

# EXPLORATION LOCATIONS

VALLEY VISTA SUBDIVISION SOILS EVALUATION
ORO VALLEY, ARIZONA

606752008 | 8/23

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

# ATTACHMENT A

Boring Logs

# ATTACHMENT A

## BORING LOGS

**Field Procedure for the Collection of Disturbed Samples**
Disturbed soil samples were obtained in the field using the following methods.

**Bulk Samples**
Bulk samples of representative earth materials were obtained from the exploratory borings. The samples were bagged and transported to the laboratory for testing.

**The Standard Penetration Test (SPT) Sampler**
Disturbed drive samples of earth materials were obtained by means of a Standard Penetration Test sampler. The sampler is composed of a split barrel with an external diameter of 2 inches and an unlined internal diameter of 1-3/8 inches. The sampler was driven into the ground 12 to 18 inches with a 140-pound hammer falling freely from a height of 30 inches in general accordance with ASTM D 1586. The blow counts were recorded for every 6 inches of penetration; the blow counts reported on the log are those for the last 12 inches of penetration. Soil samples were observed and removed from the sampler, bagged, sealed and transported to the laboratory for testing.

**Field Procedure for the Collection of Relatively Undisturbed Samples**
Relatively undisturbed soil samples were obtained in the field using the following methods.

**The Modified Split-Barrel Drive Sampler**
The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sample barrel was driven into the ground with the weight of a hammer or the Kelly bar of the drill rig in general accordance with ASTM D 3550. The driving weight was permitted to fall freely. The approximate length of the fall, the weight of the hammer or bar, and the number of blows per foot of driving are presented on the boring log as an index to the relative resistance of the materials sampled. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

**The Split-Barrel Knocker Bar Sampler**
The sampler, with an external diameter of 3.0 inches, was lined with 1-inch long, thin brass rings with inside diameters of approximately 2.4 inches. The sampler was manually driven into the ground with a hammer weighing approximately 35 pounds. The samples were removed from the sample barrel in the brass rings, sealed, and transported to the laboratory for testing.

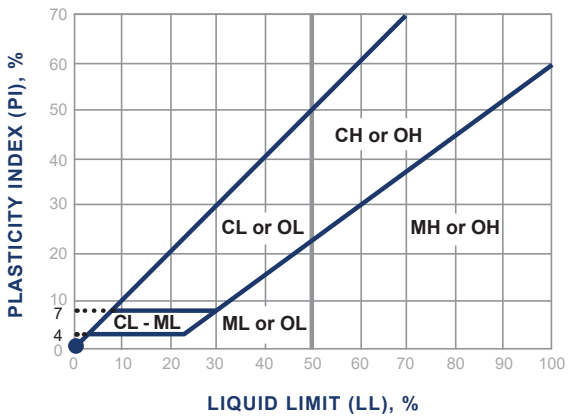
## Soil Classification Chart Per ASTM D 2488

| Primary Divisions | | | Secondary Divisions | |
|---|---|---|---|---|
| | | | Group Symbol | Group Name |
| **COARSE-GRAINED SOILS** more than 50% retained on No. 200 sieve | **GRAVEL** more than 50% of coarse fraction retained on No. 4 sieve | CLEAN GRAVEL less than 5% fines | GW | well-graded GRAVEL |
| | | | GP | poorly graded GRAVEL |
| | | GRAVEL with DUAL CLASSIFICATIONS 5% to 12% fines | GW-GM | well-graded GRAVEL with silt |
| | | | GP-GM | poorly graded GRAVEL with silt |
| | | | GW-GC | well-graded GRAVEL with clay |
| | | | GP-GC | poorly graded GRAVEL with |
| | | GRAVEL with FINES more than 12% fines | GM | silty GRAVEL |
| | | | GC | clayey GRAVEL |
| | | | GC-GM | silty, clayey GRAVEL |
| | **SAND** 50% or more of coarse fraction passes No. 4 sieve | CLEAN SAND less than 5% fines | SW | well-graded SAND |
| | | | SP | poorly graded SAND |
| | | SAND with DUAL CLASSIFICATIONS 5% to 12% fines | SW-SM | well-graded SAND with silt |
| | | | SP-SM | poorly graded SAND with silt |
| | | | SW-SC | well-graded SAND with clay |
| | | | SP-SC | poorly graded SAND with clay |
| | | SAND with FINES more than 12% fines | SM | silty SAND |
| | | | SC | clayey SAND |
| | | | SC-SM | silty, clayey SAND |
| **FINE-GRAINED SOILS** 50% or more passes No. 200 sieve | **SILT and CLAY** liquid limit less than 50% | INORGANIC | CL | lean CLAY |
| | | | ML | SILT |
| | | | CL-ML | silty CLAY |
| | | ORGANIC | OL (PI > 4) | organic CLAY |
| | | | OL (PI < 4) | organic SILT |
| | **SILT and CLAY** liquid limit 50% or more | INORGANIC | CH | fat CLAY |
| | | | MH | elastic SILT |
| | | ORGANIC | OH (plots on or above "A"-line) | organic CLAY |
| | | | OH (plots below "A"-line) | organic SILT |
| | Highly Organic Soils | | PT | Peat |

## Grain Size

| Description | | Sieve Size | Grain Size | Approximate Size |
|---|---|---|---|---|
| Boulders | | > 12" | > 12" | Larger than basketball-sized |
| Cobbles | | 3 - 12" | 3 - 12" | Fist-sized to basketball-sized |
| Gravel | Coarse | 3/4 - 3" | 3/4 - 3" | Thumb-sized to fist-sized |
| | Fine | #4 - 3/4" | 0.19 - 0.75" | Pea-sized to thumb-sized |
| Sand | Coarse | #10 - #4 | 0.079 - 0.19" | Rock-salt-sized to pea-sized |
| | Medium | #40 - #10 | 0.017 - 0.079" | Sugar-sized to rock-salt-sized |
| | Fine | #200 - #40 | 0.0029 - 0.017" | Flour-sized to sugar-sized |
| Fines | | Passing #200 | < 0.0029" | Flour-sized and smaller |

## Plasticity Chart




## Apparent Density - Coarse-Grained Soil

| Apparent Density | Spooling Cable or Cathead | | Automatic Trip Hammer | |
|---|---|---|---|---|
| | SPT (blows/foot) | Modified Split Barrel (blows/foot) | SPT (blows/foot) | Modified Split Barrel (blows/foot) |
| Very Loose | ≤ 4 | ≤ 8 | ≤ 3 | ≤ 5 |
| Loose | 5 - 10 | 9 - 21 | 4 - 7 | 6 - 14 |
| Medium Dense | 11 - 30 | 22 - 63 | 8 - 20 | 15 - 42 |
| Dense | 31 - 50 | 64 - 105 | 21 - 33 | 43 - 70 |
| Very Dense | > 50 | > 105 | > 33 | > 70 |

## Consistency - Fine-Grained Soil

| Consis-tency | Spooling Cable or Cathead | | Automatic Trip Hammer | |
|---|---|---|---|---|
| | SPT (blows/foot) | Modified Split Barrel (blows/foot) | SPT (blows/foot) | Modified Split Barrel (blows/foot) |
| Very Soft | < 2 | < 3 | < 1 | < 2 |
| Soft | 2 - 4 | 3 - 5 | 1 - 3 | 2 - 3 |
| Firm | 5 - 8 | 6 - 10 | 4 - 5 | 4 - 6 |
| Stiff | 9 - 15 | 11 - 20 | 6 - 10 | 7 - 13 |
| Very Stiff | 16 - 30 | 21 - 39 | 11 - 20 | 14 - 26 |
| Hard | > 30 | > 39 | > 20 | > 26 |

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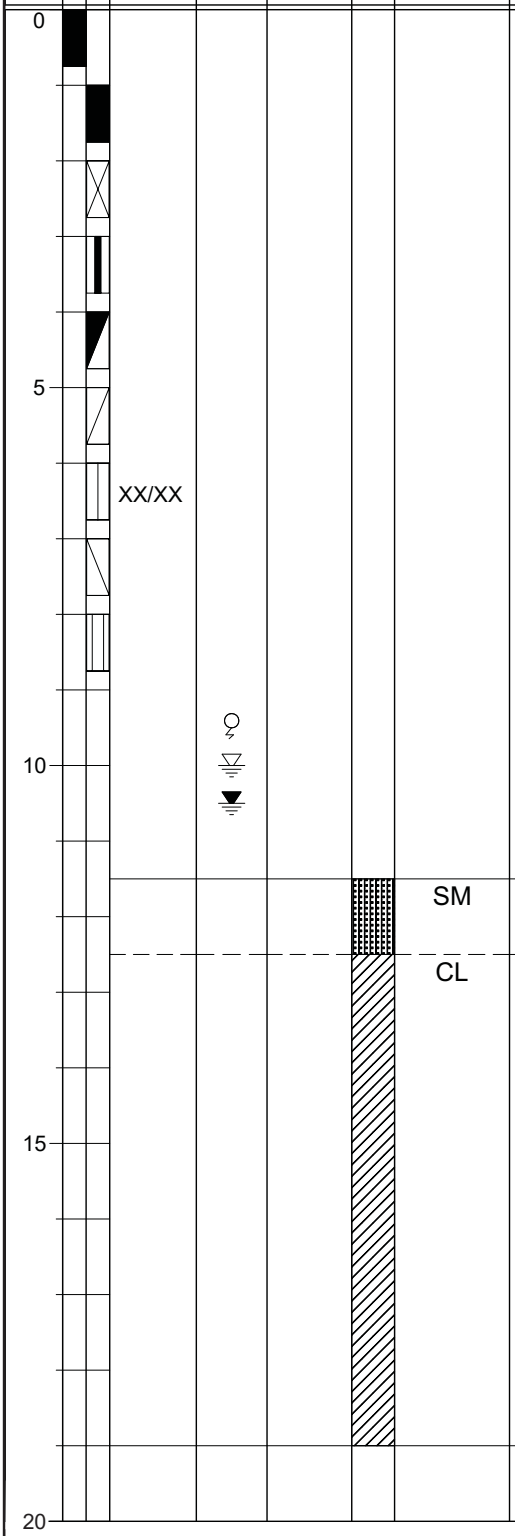
**USCS METHOD OF SOIL CLASSIFICATION**

# BORING LOG EXPLANATION SHEET




Bulk sample.

Modified split-barrel drive sampler.

No recovery with modified split-barrel drive sampler.

Sample retained by others.

Standard Penetration Test (SPT).

No recovery with a SPT.

Shelby tube sample. Distance pushed in inches/length of sample recovered in inches.

No recovery with Shelby tube sampler.

Continuous Push Sample.

Seepage.

Groundwater encountered during drilling.

Groundwater measured after drilling.

SM

MAJOR MATERIAL TYPE (SOIL):

Solid line denotes unit change.

CL

Dashed line denotes material change.

Attitudes: Strike/Dip
b: Bedding
c: Contact
j: Joint
f: Fracture
F: Fault
cs: Clay Seam
s: Shear
bss: Basal Slide Surface
sf: Shear Fracture
sz: Shear Zone
sbs: Shear Bedding Surface

The total depth line is a solid line that is drawn at the bottom of the boring.

DATE DRILLED 7/14/2023 BORING NO. B-1

GROUND ELEVATION 2,717' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)

DRIVE WEIGHT 40 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | | | | | SM | FILL: Brown, dry, dense, silty SAND; trace gravel. |
| | | 67 | 5.8 | 126.5 | | | |
| | | | | | | SC-SM | ALLUVIUM: Brown, dry, medium dense, silty clayey SAND; trace gravel. |
| | | 36 | 16.4 | 104.4 | | | |
| 5 | | | | | | | |
| | | 6 | 6.5 | 103.9 | | | Loose. |
| | | 9 | 5.1 | 101.0 | | | |
| 10 | | | | | | | |
| | | 15 | | | | | Medium dense. |
| 15 | | | | | | | |
| | | 28 | 3.1 | 114.8 | | | |
| 20 | | | | | | | |

FIGURE A -1

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VALLEY VISTA SUBDIVISION SOILS EVALUATION
ORO VALLEY, ARIZONA

606752008 | 8/23

DATE DRILLED 7/14/2023 BORING NO. B-1

GROUND ELEVATION 2,717' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)

DRIVE WEIGHT 40 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES: Bulk | SAMPLES: Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | | Total Depth = 20 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/14/23 shortly after completion of drilling.<br><br>Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 25 | | | | | | | | |
| 30 | | | | | | | | |
| 35 | | | | | | | | |
| 40 | | | | | | | | |

DATE DRILLED 7/14/2023 BORING NO. B-2

GROUND ELEVATION 2,722' ± (MSL) SHEET 1 OF 2

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)

DRIVE WEIGHT 14 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | | | | | SC-SM | ALLUVIUM: Brown, dry, medium dense, silty clayey SAND; trace gravel. |
| | | 17 | 4.3 | 116.3 | | | |
| | | 11 | 5.6 | 107.2 | | | Loose. |
| 5 | | | | | | | |
| | | 4 | 3.6 | 103.1 | | | Very loose. |
| | | 11 | | | | | Loose. |
| 10 | | | | | | | |
| | | 8 | | | | | Medium dense. |
| 15 | | | | | | | |
| | | 21 | 3.0 | 111.9 | | | |
| 20 | | | | | | | |

FIGURE A -3

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

VALLEY VISTA SUBDIVISION SOILS EVALUATION
ORO VALLEY, ARIZONA

DATE DRILLED 7/14/2023 BORING NO. B-2

GROUND ELEVATION 2,722' ± (MSL) SHEET 2 OF 2

METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)

DRIVE WEIGHT 14 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES: Bulk | SAMPLES: Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | | Total Depth = 20 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/14/23 shortly after completion of drilling.<br><br>Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 25 | | | | | | | | |
| 30 | | | | | | | | |
| 35 | | | | | | | | |
| 40 | | | | | | | | |

DATE DRILLED 7/13/2023 BORING NO. HS-1

GROUND ELEVATION 2,718' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING Hand Auger

DRIVE WEIGHT N/A DROP N/A

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | | 6.2 | 114.5 | | SM | FILL:<br>Brown, dry, medium dense, silty SAND; few to little gravel. |
| 5 | | | | | | | Total Depth = 3 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/13/23 shortly after completion of drilling.<br><br>Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 10 | | | | | | | |
| 15 | | | | | | | |
| 20 | | | | | | | |

**FIGURE A -5**

DATE DRILLED 7/13/2023 BORING NO. HS-2

GROUND ELEVATION 2,716' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING Hand Auger

DRIVE WEIGHT N/A DROP N/A

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | | 6.6 | 117.1 | | SC-SM | FILL:<br>Brown, dry, medium dense, silty clayey SAND; few gravel. |
| 5 | | | | | | | Total Depth = 3 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/13/23 shortly after completion of drilling.<br><br>Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 10 | | | | | | | |
| 15 | | | | | | | |
| 20 | | | | | | | |

**FIGURE A -6**

DATE DRILLED 7/13/2023 BORING NO. HS-3

GROUND ELEVATION 2,721' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING Hand Auger

DRIVE WEIGHT N/A DROP N/A

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | | | | | SM | FILL:<br>Brown, dry, medium dense, silty SAND; few to little gravel. |
| | | | | | | | Total Depth = 3 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/13/23 shortly after completion of drilling. |
| 5 | | | | | | | Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 10 | | | | | | | |
| 15 | | | | | | | |
| 20 | | | | | | | |

DATE DRILLED 7/13/2023 BORING NO. HS-4

GROUND ELEVATION 2,717' ± (MSL) SHEET 1 OF 1

METHOD OF DRILLING Hand Auger

DRIVE WEIGHT N/A DROP N/A

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DEPTH (feet) | SAMPLES (Bulk / Driven) | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | ASPHALT CONCRETE: Approximately 3 inches thick. |
| | | | | | | | AGGREGATE BASE: Approximately 5 inches thick. |
| | | 50/5" | | | | SM | FILL:<br>Brown, dry, medium dense, silty SAND; few to little gravel. |
| | | | | | | | Total Depth = 3 feet.<br>Groundwater not encountered during drilling.<br>Backfilled and asphalt concrete patched on 7/13/23 shortly after completion of drilling. |
| 5 | | | | | | | Notes:<br>Groundwater, though not encountered at the time of drilling, may rise to a higher level due to seasonal variations in precipitation and several other factors as discussed in the report.<br><br>The ground elevation shown above is an estimation only. It is based on our interpretations of published maps and other documents reviewed for the purposes of this evaluation. It is not sufficiently accurate for preparing construction bids and design documents. |
| 10 | | | | | | | |
| 15 | | | | | | | |
| 20 | | | | | | | |

**FIGURE A -8**

# ATTACHMENT B

Laboratory Test Results

# ATTACHMENT B

## LABORATORY TEST RESULTS

**Classification**
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488-00.

**In-Place Moisture and Density Tests**
The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were evaluated in general accordance with AASHTO T265. These test results are presented on the logs of the exploratory borings in Attachment A

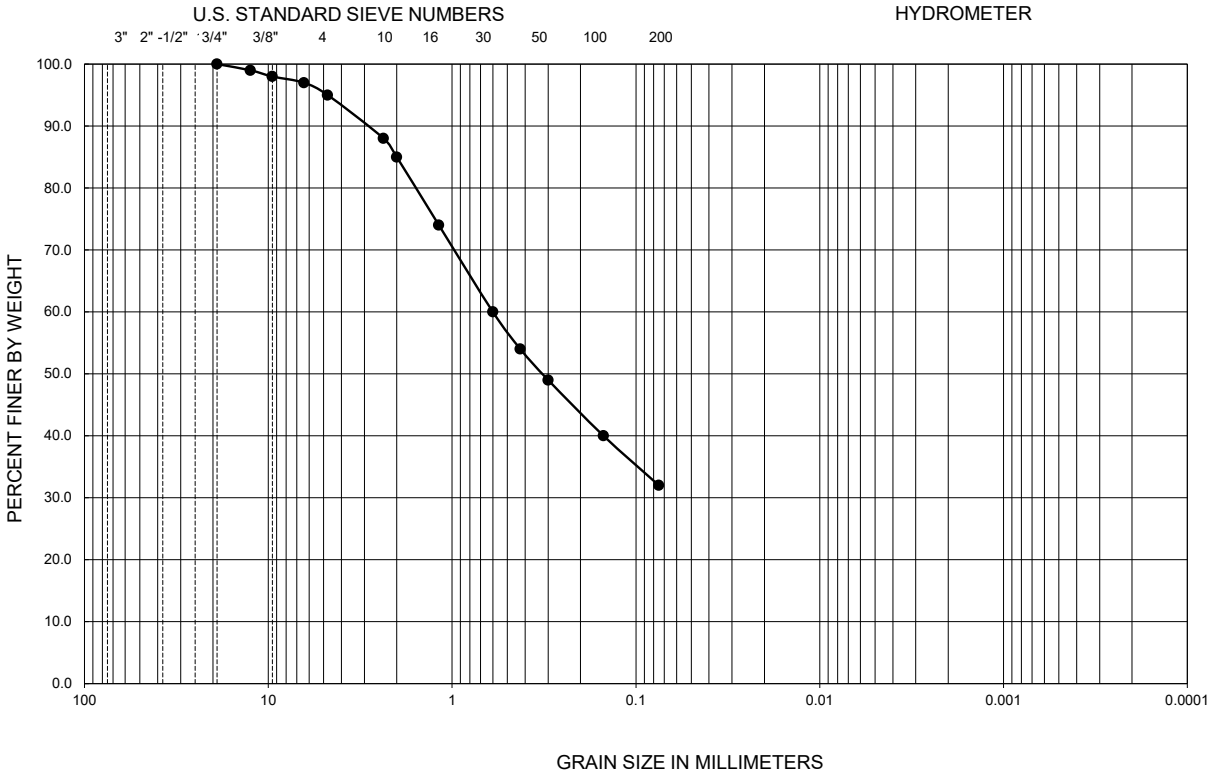
**Gradation Analysis**
Gradation analysis test was performed on selected representative soil samples in general accordance with ASTM D 422. The grain size distribution curves are shown on Figures B-1 through B-6. These test results were utilized in evaluating the soil classification in accordance with the USCS.

**Atterberg Limits**
Tests were performed on a selected representative soil samples to evaluate the liquid limit, plastic limit, and plasticity index in general accordance with ASTM D 4318. These test results were utilized to evaluate the soil classification in accordance with the USCS. The test results and classification are shown on Figure B-7.

**Consolidation Tests (Collapse Potential)**
Consolidation (collapse potential) tests were performed on selected relatively undisturbed soil samples in general accordance with ASTM D 2435. The samples were inundated during testing to represent adverse field conditions. The percent of consolidation for each load cycle was recorded as a ratio of the amount of vertical compression to the original height of the samples. The results of the tests are summarized on Figures B-8 through B-11.

**Maximum Dry Density and Optimum Moisture Content Tests**
The maximum dry density and optimum moisture content of a selected representative soil samples were evaluated in general accordance with ASTM D 698. The results of these tests are summarized on Figures B-12 and B-13.

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-1 | 0.7-3.0 | -- | -- | NP | -- | -- | 0.58 | -- | -- | 32.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-1**

**GRADATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA



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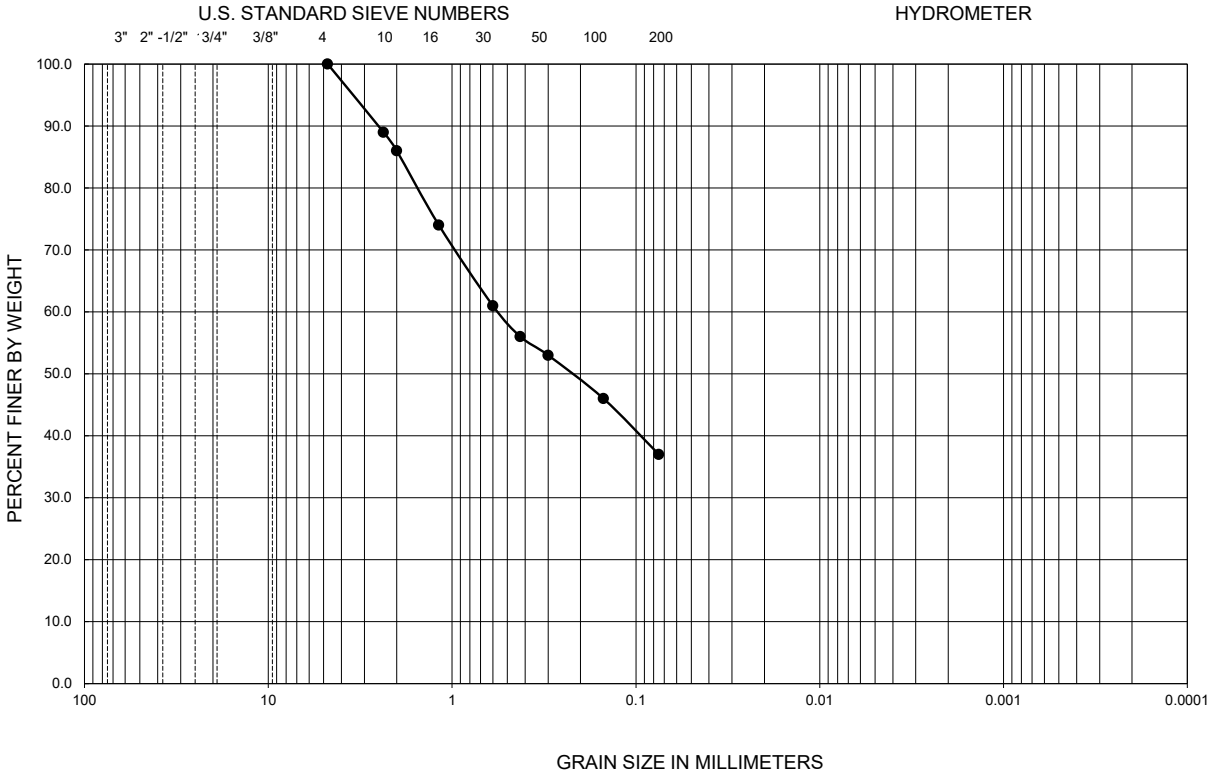
Geotechnical & Environmental Sciences Consultants

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-1 | 6.0-7.5 | 23 | 19 | 4 | -- | -- | 0.55 | -- | -- | 37.0 | SC-SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

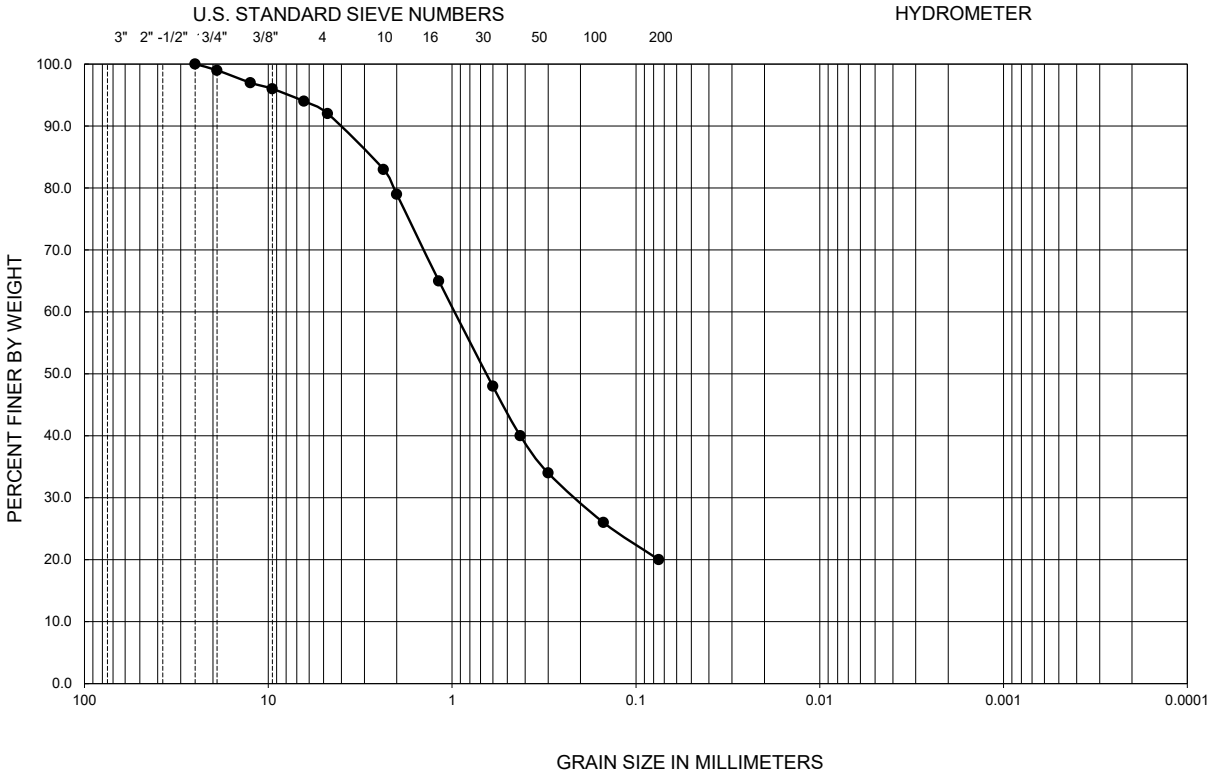
**FIGURE B-2**

**GRADATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-2 | 0.7-5.0 | 21 | 17 | 4 | -- | 0.214 | 0.97 | -- | -- | 20.0 | SC-SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-3**

**GRADATION TEST RESULTS**

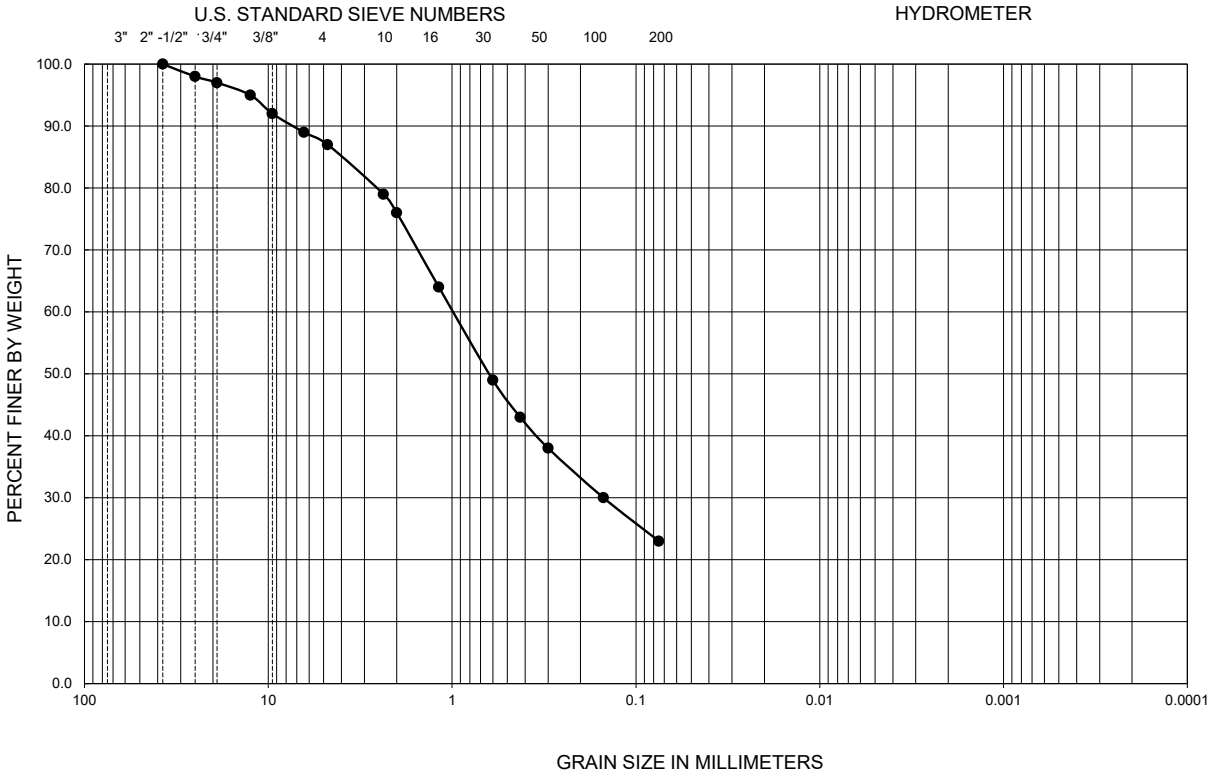
VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | HS-1 | 0.7-3.0 | -- | -- | NP | -- | 0.150 | 0.99 | -- | -- | 23.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

FIGURE B-4

**GRADATION TEST RESULTS**

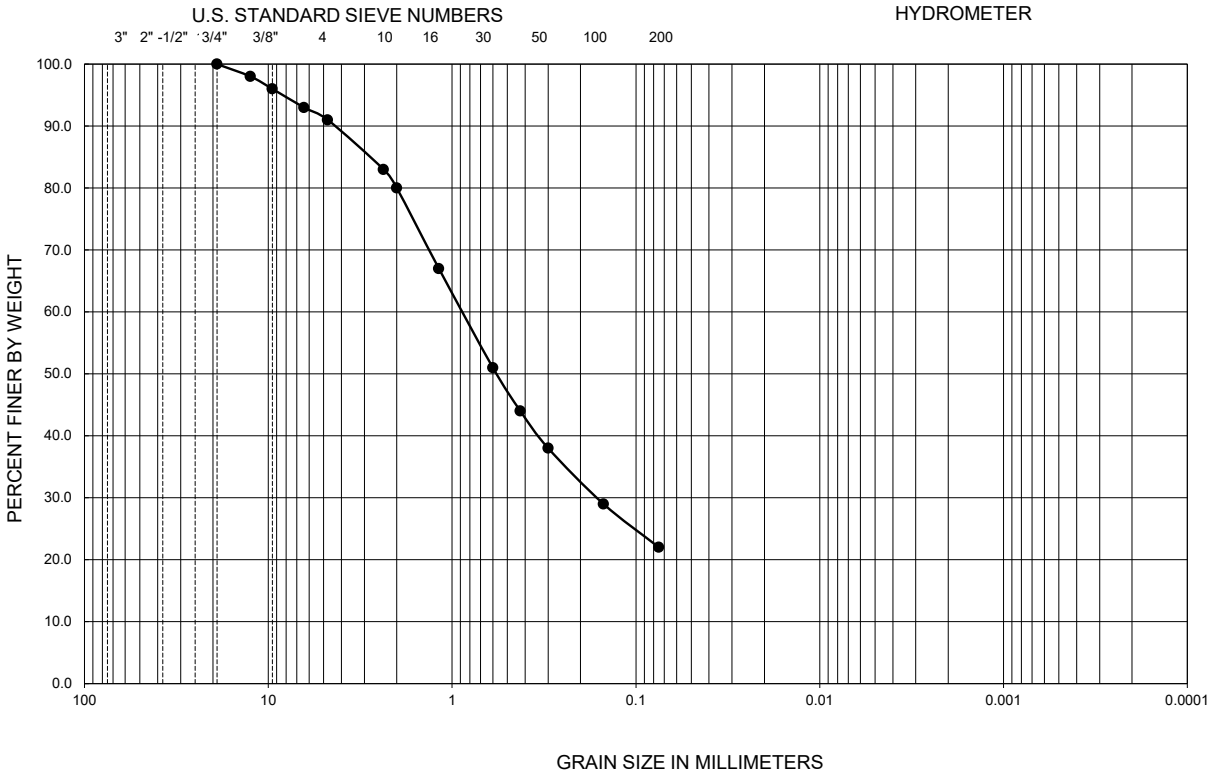
VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | HS-2 | 0.7-3.0 | 22 | 18 | 4 | -- | 0.162 | 0.87 | -- | -- | 22.0 | SC-SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

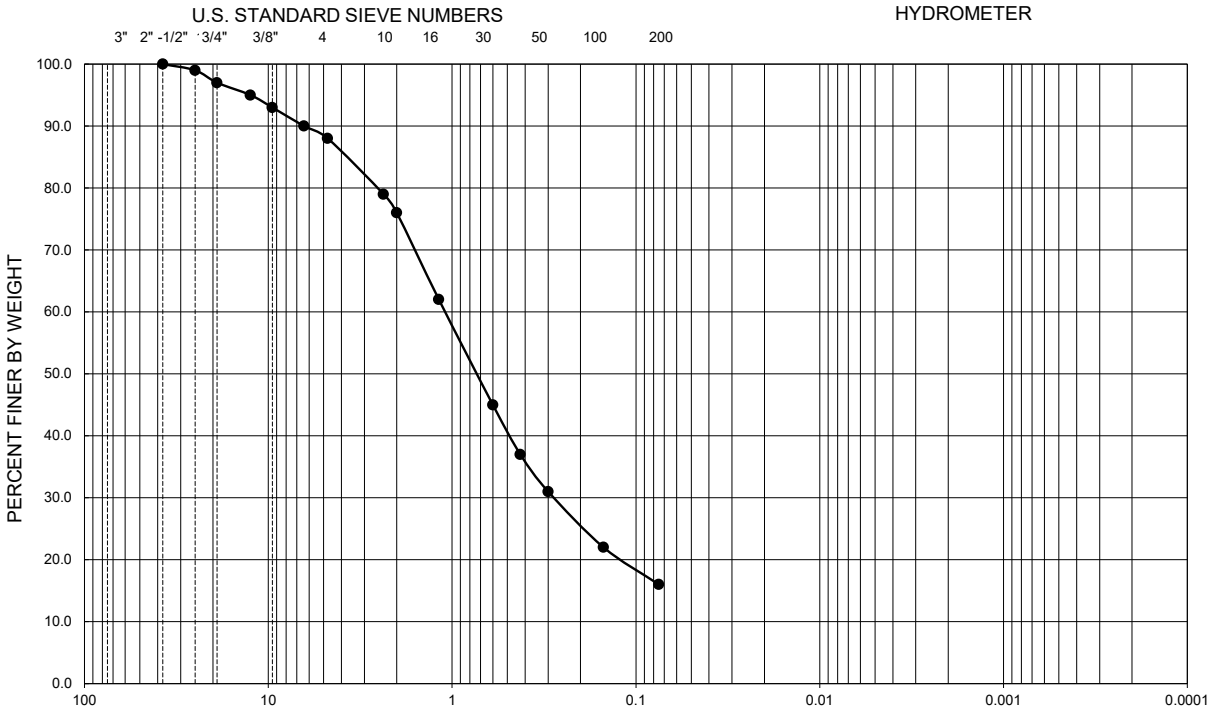
**FIGURE B-5**

**GRADATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| Coarse | Fine | Coarse | Medium | Fine | SILT | CLAY |




| Symbol | Sample Location | Depth (ft) | Liquid Limit | Plastic Limit | Plasticity Index | $D_{10}$ | $D_{30}$ | $D_{60}$ | $C_u$ | $C_c$ | Passing No. 200 (percent) | USCS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | HS-3 | 0.7-3.0 | -- | -- | NP | -- | 0.282 | 1.10 | -- | -- | 16.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

FIGURE B-6

**GRADATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

606752008 | 8/23

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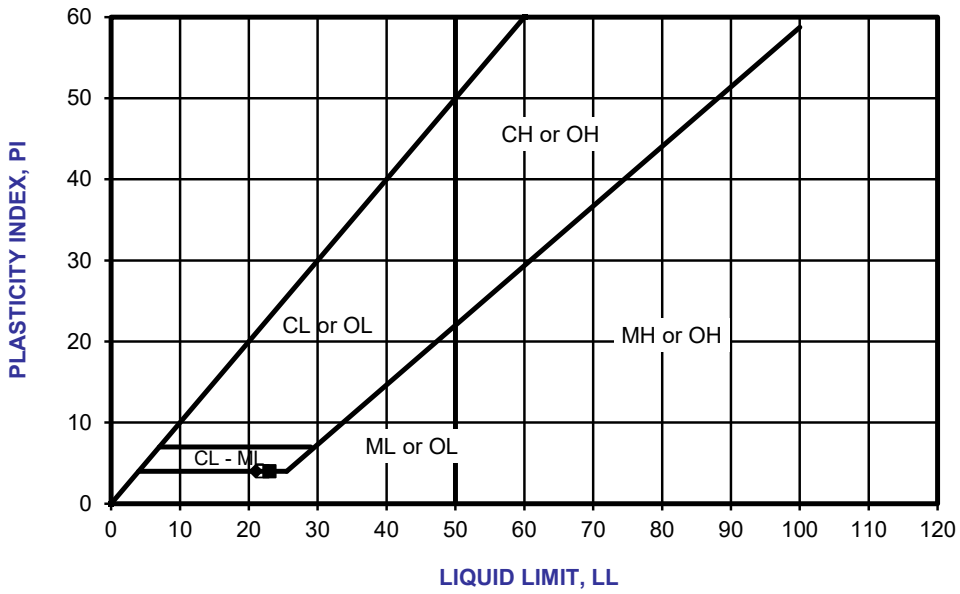
| SYMBOL | LOCATION | DEPTH (ft) | LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve) | USCS |
|---|---|---|---|---|---|---|---|
| ● | B-1 | 0.7-3.0 | -- | -- | NP | ML | SM |
| ■ | B-1 | 6.0-7.5 | 23 | 19 | 4 | CL-ML | SC-SM |
| ◆ | B-2 | 0.7-5.0 | 21 | 17 | 4 | CL-ML | SC-SM |
| ○ | HS-1 | 0.7-3.0 | -- | -- | NP | ML | SM |
| □ | HS-2 | 0.7-3.0 | 22 | 18 | 4 | CL-ML | SC-SM |
| △ | HS-3 | 0.7-3.0 | -- | -- | NP | ML | SM |

NP - INDICATES NON-PLASTIC



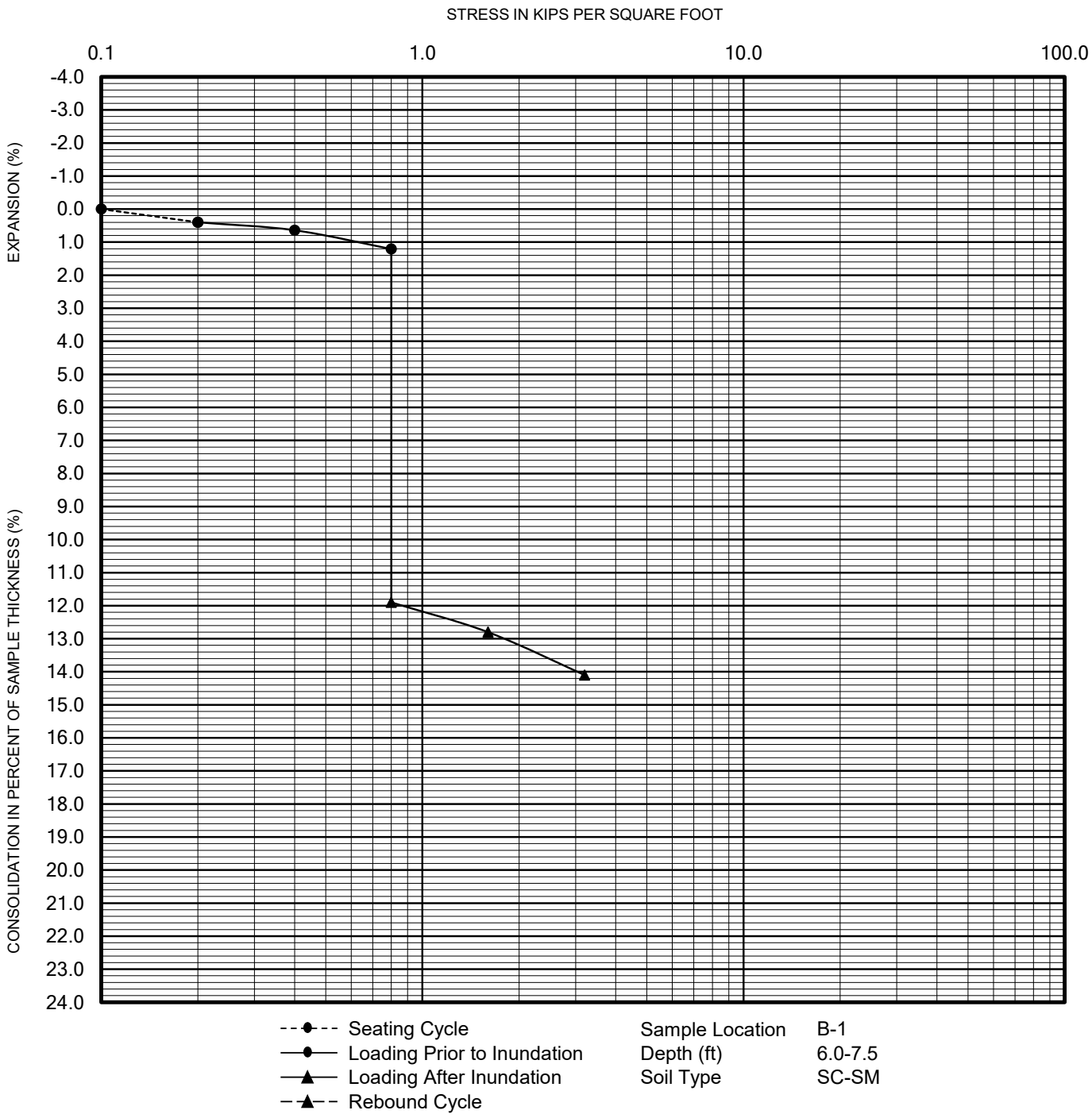

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-7

ATTERBERG LIMITS TEST RESULTS

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA




PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-8**

**CONSOLIDATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

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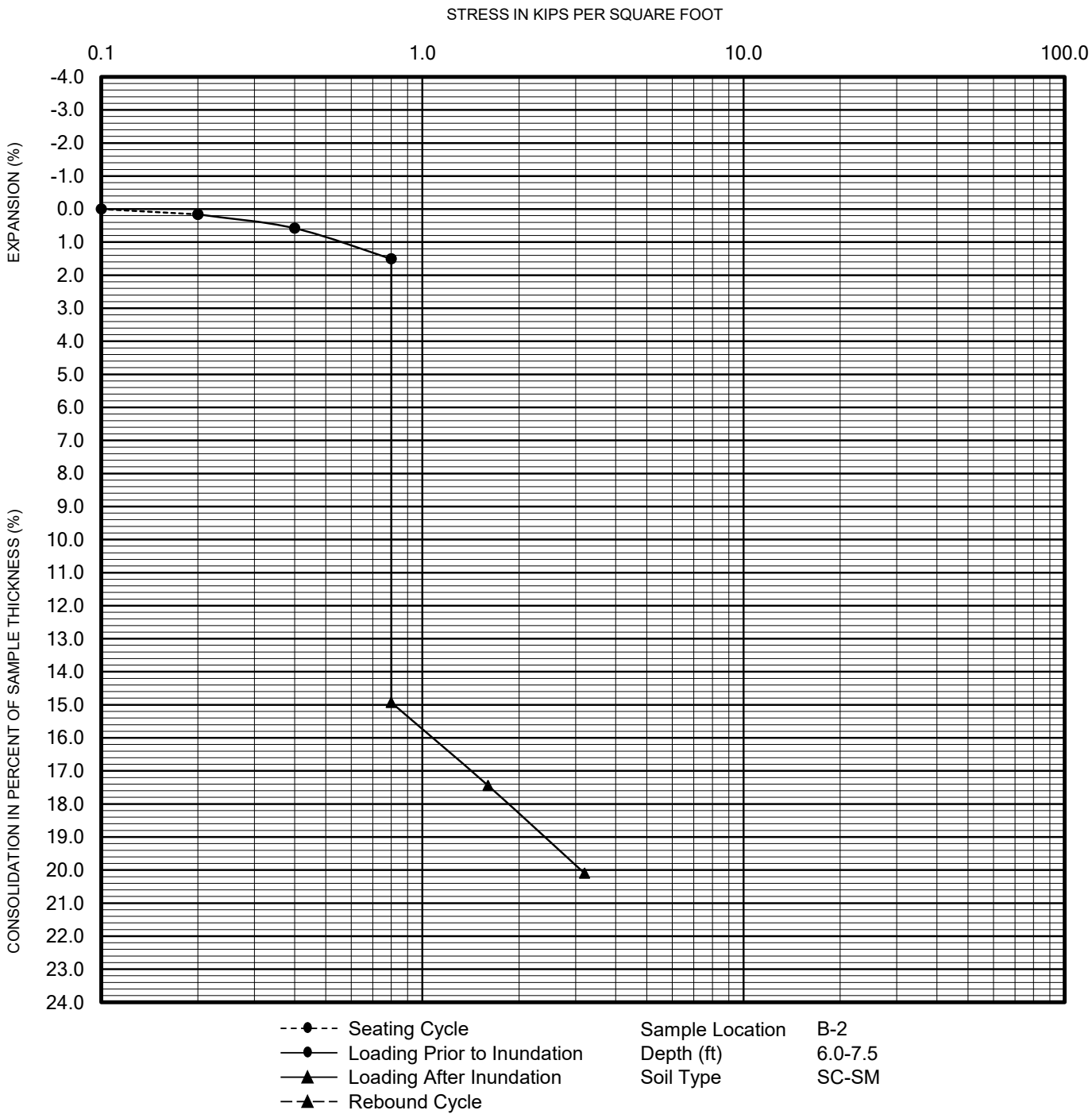


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-9**

**CONSOLIDATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

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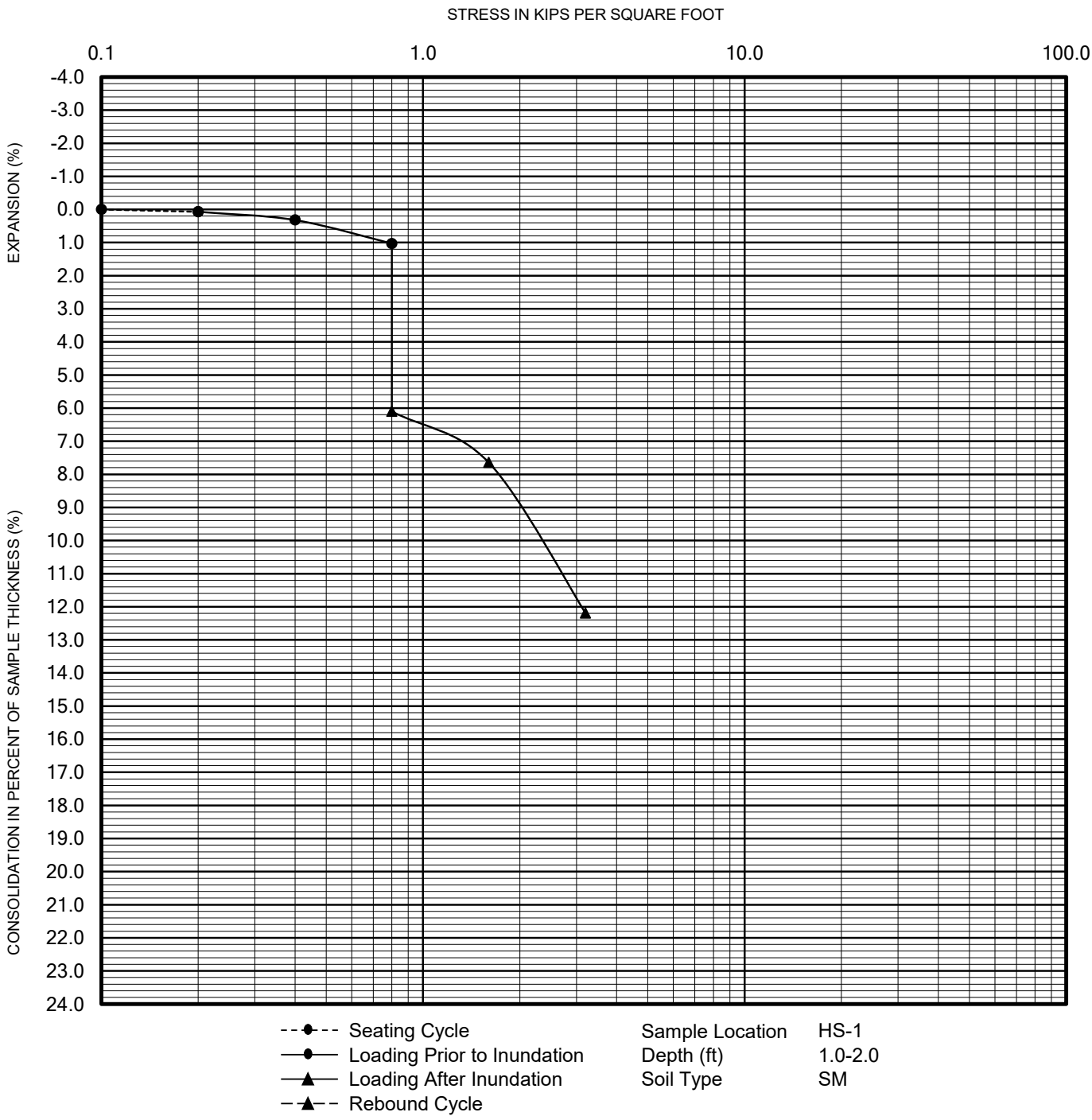


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-10**

**CONSOLIDATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

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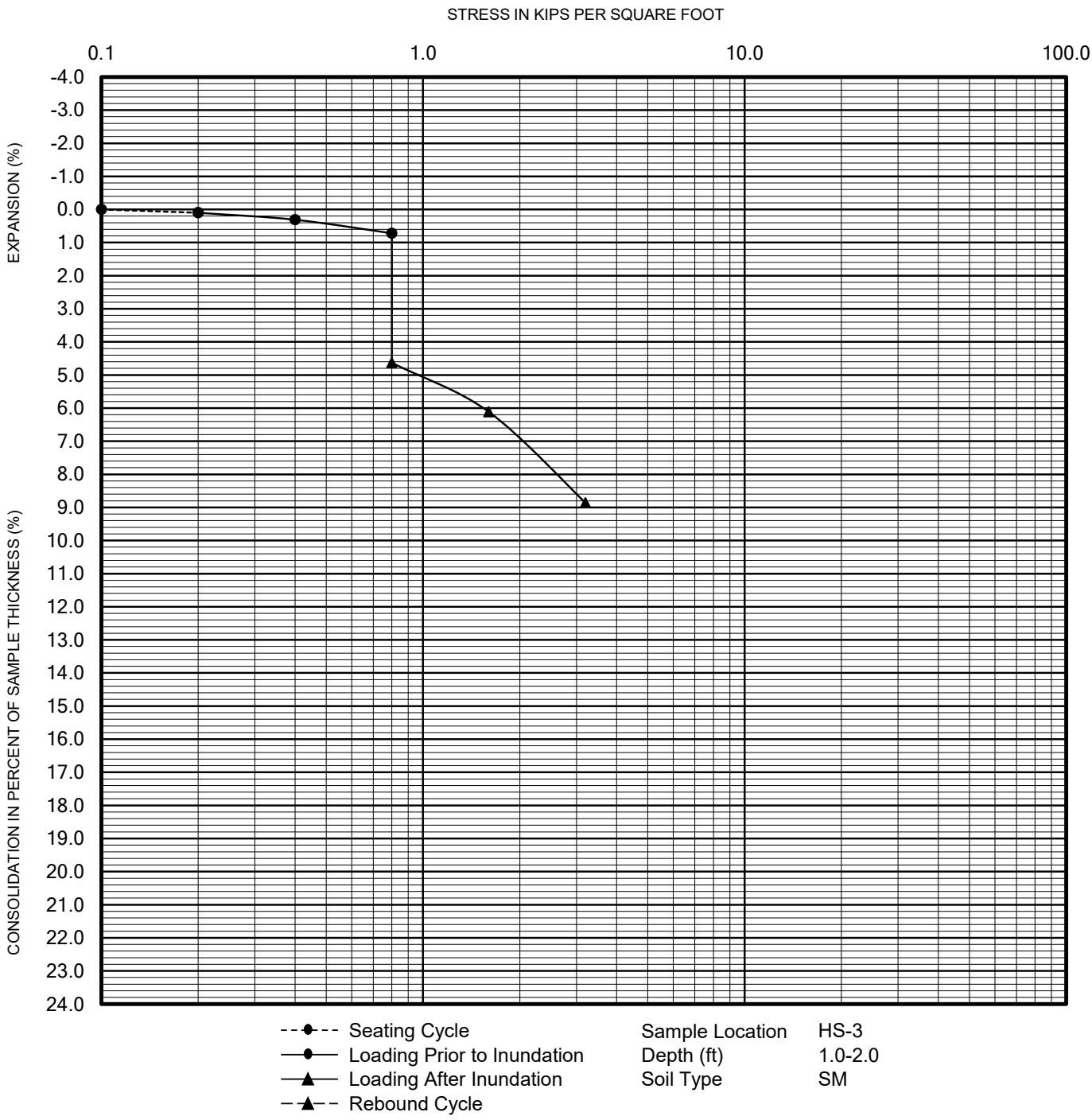


PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-11**

**CONSOLIDATION TEST RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY, ARIZONA

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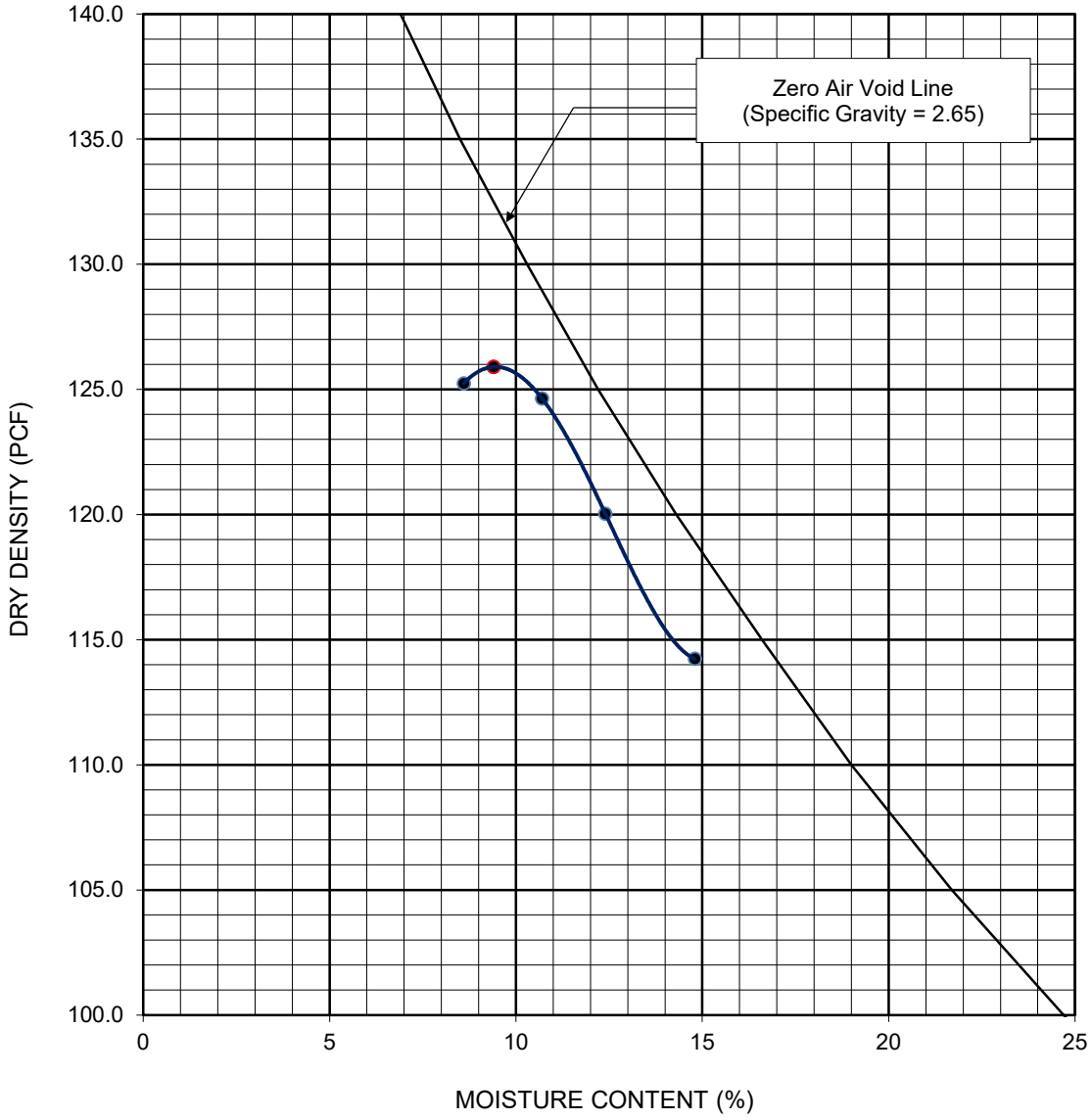


| Sample Location | Depth (ft) | Soil Description | Maximum Dry Density (pcf) | Optimum Moisture Content (percent) |
|---|---|---|---|---|
| B-1 | 0.0-3.0 | SM | 125.9 | 9.4 |
| Dry Density and Moisture Content Values Corrected for Oversize (ASTM D 4718) | | | 127.5 | 9 |

PERFORMED IN GENERAL ACCORDANCE WITH ☐ ASTM D 1557 ☑ ASTM D 698 METHOD ☑ A ☐ B ☐ C

**FIGURE B-12**

**MAXIMUM DENSITY RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY ARIZONA

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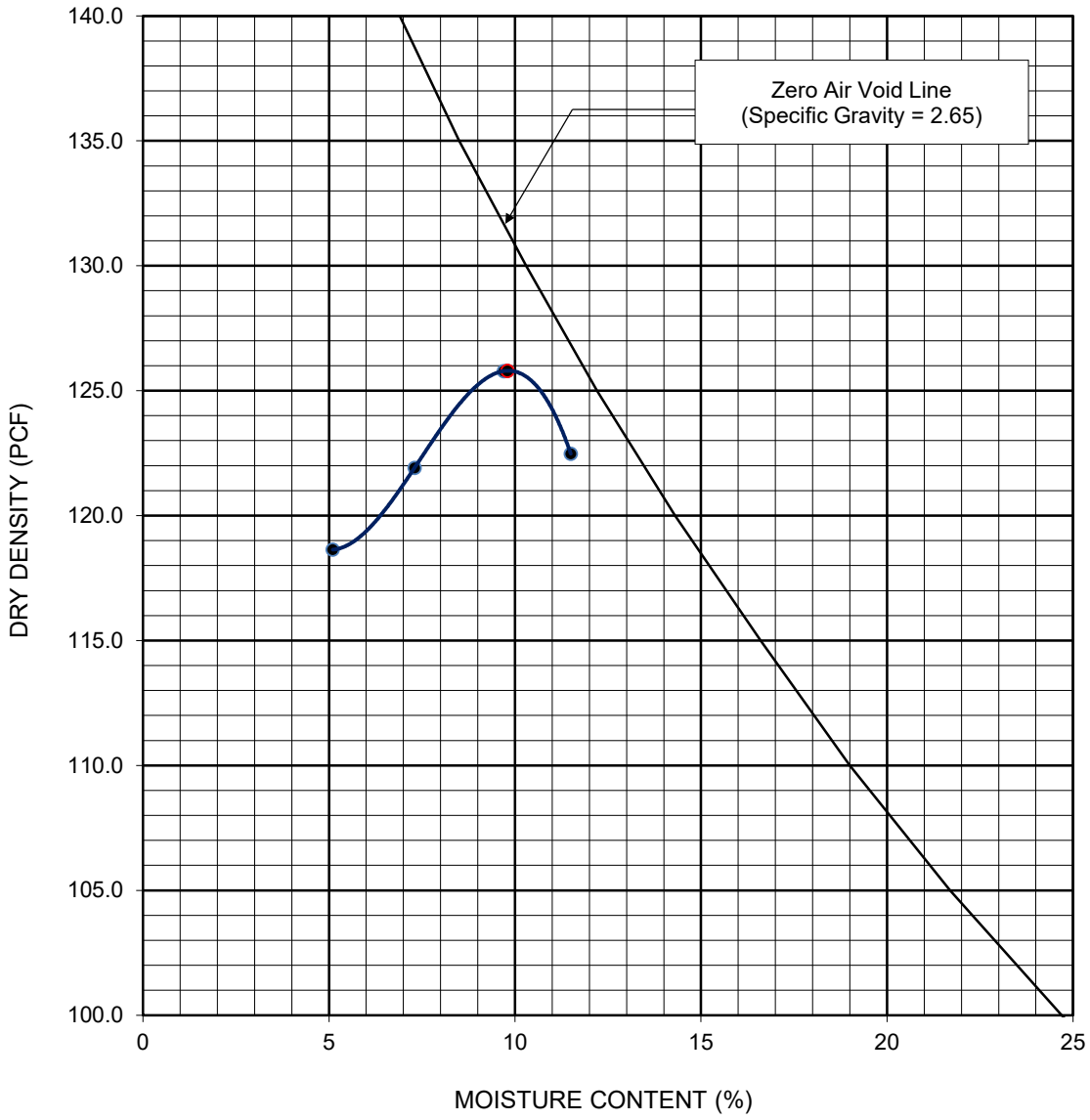


| Sample Location | Depth (ft) | Soil Description | Maximum Dry Density (pcf) | Optimum Moisture Content (percent) |
|---|---|---|---|---|
| HS-3 | 0.7-3.0 | SM | 125.8 | 9.8 |
| Dry Density and Moisture Content Values Corrected for Oversize (ASTM D 4718) | | | 129.5 | 8.5 |

PERFORMED IN GENERAL ACCORDANCE WITH ☐ ASTM D 1557 ☑ ASTM D 698 METHOD ☑ A ☐ B ☐ C

**FIGURE B-13**

**MAXIMUM DENSITY RESULTS**

VALLEY VISTA SUBDIVISION SOILS EVALUATION

ORO VALLEY ARIZONA

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