Preliminary Geotechnical Evaluation

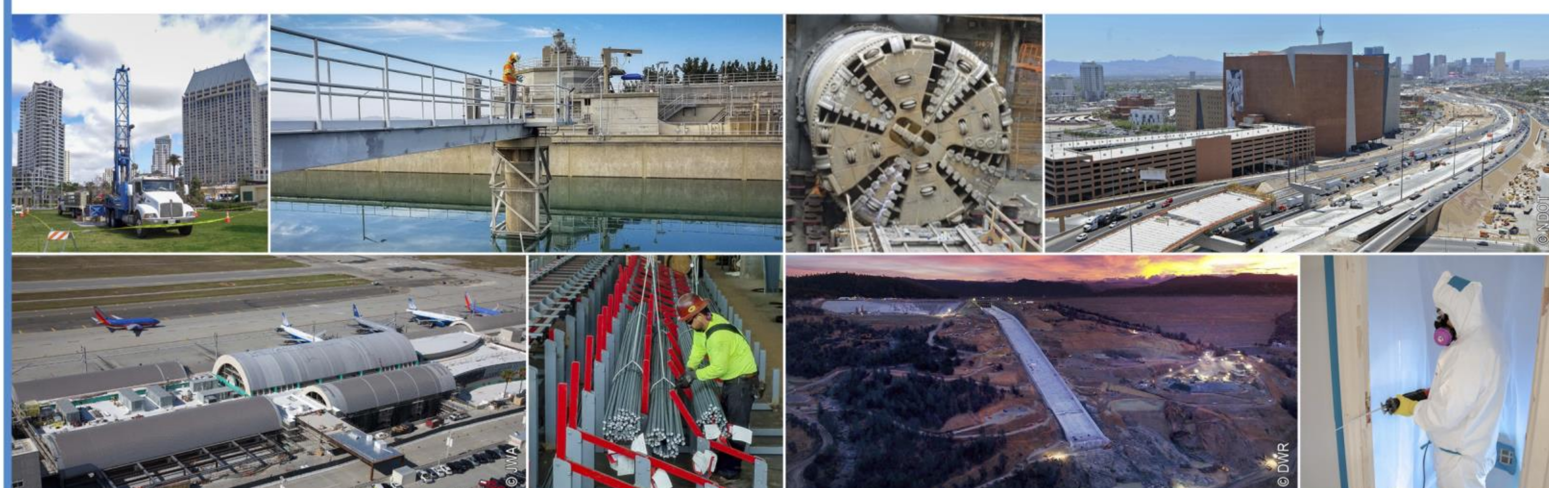
# Rancho Vistoso Parcel 5-R
# Planned Area Development Amendment

Oro Valley, Arizona

## Vistoso Partners, LLC

7117 East Rancho Vista Drive, Suite 6003 | Scottsdale, Arizona 85251

September 6, 2023 | Project No. 607834001



Geotechnical | Environmental | Construction Inspection & Testing | Forensic Engineering & Expert Witness

Geophysics | Engineering Geology | Laboratory Testing | Industrial Hygiene | Occupational Safety | Air Quality | GIS

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

35+ YEARS

Preliminary Geotechnical Evaluation

# Rancho Vistoso Parcel 5-R
# Planned Area Development Amendment

Oro Valley, Arizona

Mr. Mark Winkleman
Vistoso Partners, LLC
7117 East Rancho Vista Drive, Suite 6003 | Scottsdale, Arizona 85251

September 6, 2023 | Project No. 607834001

Registered Professional Engineer (Civil)
CERTIFICATE NO.
44704
MAREK J.
KASZTALSKI
Date Signed 9/6/23
ARIZONA U.S.A.

**Marek J. Kasztalski, PE**
Principal Engineer

**Fred F. Narcaroti**
Principal/Tucson Office Manager

MJK/SDN/FFN/jom

# CONTENTS

## TABLES



## FIGURES



## APPENDICES

# 1 INTRODUCTION

In accordance with our proposal dated July 28, 2023, and your authorization, we have performed a preliminary geotechnical evaluation for the design and construction of Rancho Vistoso Parcel 5-R Planned Area Development (PAD) Amendment in Oro Valley, Arizona (Figure 1). The purpose of our evaluation was to assess the subsurface conditions at the project site in order to provide preliminary geotechnical recommendations for design and construction. This report presents the results of our evaluation and our geotechnical preliminary conclusions and recommendations regarding the proposed construction.

A supplemental geotechnical study that will include additional soil borings, laboratory testing and analysis should be conducted for the project final design phase.

# 2 SCOPE OF SERVICES

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

- Reviewing available topographic information, soil surveys, geologic literature, historic geotechnical data, and aerial photographs of the project area.
- Conducting a visual reconnaissance of the project area and marking out the boring locations.
- Notifying Arizona 811 of the proposed exploration locations prior to conducting our field work.
- Drilling, logging, and sampling five exploratory soil borings to an approximate depth of 50 feet below ground surface (bgs). The boring logs are presented in Appendix A.
- Performing laboratory tests on selected samples collected from our borings to evaluate the in-situ moisture content and dry density, gradation, Atterberg limits, consolidation, and corrosivity characteristics (including pH, minimum electrical resistivity, and soluble sulfate and chloride contents). The results of the laboratory tests are included in Appendix B.
- Preparing this report presenting our findings, conclusions, and preliminary recommendations regarding the proposed design and construction.

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.

## 3 SITE DESCRIPTION

The project site, Parcel 5-R, is located within the southeastern and currently undeveloped parcel just south of Rancho Vistoso Valley Vista development, south in Moore Loop and Kalalau Drive, in Oro Valley, Arizona.

At the time of our evaluation, the project site was undeveloped land with sparse to dense desert vegetation with trails and paths, and small washes traversing the site in a generally west to east direction. The recently developed adjacent portion of the development, including residential properties and a Pima County pump station, is situated near the western flank of Honey Bee Canyon, is situated just north of the project site. The easterly portion of Parcel 5-R is located within the Big Wash floodplain.

## 4 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. An image dated December 2020 depicted the roadways of the Valley Vista residential subdivision and the pump station in place. By 2020, many of the building pads were prepared with few houses already built. Also, the FEMA floodplain bank protection system with soil-cement paved embankments was already constructed along the eastern and southeastern edges of the subdivision, just north of the project site. However, Parcel 5-R remained undeveloped during that time. An image dated April 2023 depicted the project site and adjacent areas as being similar to its current condition.

## 5 REVIEW OF HISTORIC GEOTECHNICAL REPORTS

We have reviewed the following existing geotechnical reports related to the Valley Vista development:

- ProTeX, 2018, Geotechnical Investigation, Rancho Vistoso Neighborhood 5 – Parcel X and W, Rancho Vistoso Boulevard and Moore Loop, Oro Valley, Arizona.
- ProTeX, 2022, Geotechnical Investigation – Forensics, Rancho Vistoso Velley vista – Lot 19, 780 East Kalalau Drive, Oro Valley, Arizona, dated November 3, 2022.
- Ninyo & Moore, 2023, Geotechnical Services, Valley Vista Subdivision Soil Evaluation, Oro Valley, Arizona, dated August 17; and
- Ninyo & Moore, 2023, Geotechnical Services, Valley Vista Sewer and Pump Station Evaluation, Oro Valley, Arizona, dated August 22.

## 5.1 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.

## 5.2 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.

## 5.3 Ninyo & Moore, 2023A

In 2023, Ninyo & Moore conducted a geotechnical exploration within the easternmost portion of the Rancho Vistoso Valley Vista residential subdivision that encompassed southeastern segments of Kalalau Drive and Romsdalen Road. Ninyo & Moore cored the existing pavement at four locations along the roadway segments using an electronic coring machine and drilled four exploratory borings, through the aforementioned core holes to approximate depths of 3 and 20 feet bgs using hand auger techniques, and a truck mounted drill rig equipped with hollow stem augers. The laboratory testing included in-place moisture and dry density, gradation, Atterberg limits, consolidation, and laboratory maximum dry density.

The results of the study indicated relatively consistent subsurface conditions along both project alignments with silty sand and silty clayey sand soils encountered. The native alluvial soils were generally more compressible under loading and/or saturation and were in a relatively loose condition.

## 5.4 Ninyo & Moore, 2023B

In 2023, Ninyo & Moore conducted a geotechnical exploration the Rancho Vistoso Valley Vista residential subdivision within the area of the existing pump station southeast of Kalalau Drive and Romsdalen Road intersection. Ninyo & Moore drilled, logged, and sampled three exploratory borings to approximate depths of 20 to 65 feet bgs using a truck mounted drill rig equipped with hollow-stem augers. Bulk and relatively undisturbed soil samples were collected at selected depth intervals in our borings. The laboratory testing included in-place moisture and dry density, gradation, Atterberg limits, consolidation, and laboratory maximum dry density.

The results of the study indicated relatively consistent subsurface conditions along both project alignments with silty sand and silty clayey sand soils encountered. The native alluvial soils were generally more compressible under loading and/or saturation and were in a relatively loose condition. The following were the findings of the study:

- The native alluvial soils exhibited relative densities that were generally lower than those for the fill material, especially at depths ranging between 10 and 25 feet bgs.
- The in-situ moisture contents and degrees of saturation were generally higher in the borings located closer to the pump station to approximate depths of 20 to 25 feet bgs.
- The collapse potential and compressibility measured from samples collected within the alluvial deposits were severe and higher than for the fill material.

## 5.5 Summary of Historic Geotechnical Report Review

Based on the review of the above reports, the native alluvial deposits in the study areas are associated with the Big Wash floodplain and consist of layers of non-plastic silty sand, sand with silt, and low plasticity clayey sand with variable percentages of gravel. Many of these soils are in relatively loose condition and exhibit moderate to severe hydro-collapse potential and elevated compressibility upon saturation.

## 6 PROPOSED CONSTRUCTION

We understand that Vistoso Partner, LLC (VP) is in the process of rezoning with the Town of Oro Valley (Town) for the site known as Rancho Vistoso Parcel 5-R PAD Amendment, that is located south of the Rancho Vistoso Valley Vista development in Oro Valley, Arizona. Ground settlements resulting in property damage haven recently been reported within the southeast portion of the recently developed Valley Vista Subdivision. Consequently, the Town has requested VP to conduct a third-party soil study to preliminarily evaluate the feasibility to development on this site.

Engineering plans for the future project were not available for our review. However, we assume that the new structures will be supported by shallow foundations and slabs on grade. We further assume that the new construction will involve moderate earthwork grading.

## 7 FIELD EXPLORATION AND LABORATORY TESTING

On August 24$^{th}$ and 25$^{th}$, 2023, Ninyo & Moore conducted a subsurface exploration at the site in order to evaluate the subsurface conditions and to collect soil samples for laboratory testing. Our evaluation consisted of drilling, logging, and sampling of five exploratory borings using a CME 75 truck mounted drill rig equipped with hollow-stem augers (Figure 2). The borings extended to an approximate depth of 50 feet below ground surface (bgs). Bulk and relatively undisturbed soil samples were collected at selected depth intervals in our borings.

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 log in Appendix 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-situ moisture content and dry density, gradation, Atterberg limits, consolidation, and corrosivity characteristics (including pH, minimum electrical resistivity, and soluble sulfate and chloride contents). The results of the in-situ moisture content and dry density testing are presented on the boring logs in Appendix A and a description of each laboratory test method and the remainder of the test results is presented in Appendix B.

# 8 GEOLOGY AND SUBSURFACE CONDITIONS

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).

According to the United States Department of Agriculture (USDA), Natural Resource Conservation Service (NRCS) online Web Soil Survey, the proposed alignment crosses areas of two main soil types as described in Table 1 below.

**Table 1 – NRCS Soil Units**

| Soil Map Unit Name | Description of Soil Units |
|---|---|
| Anthony fine sandy loam | Fine sandy loam, stratified loamy sand to very fine sandy loam, gravelly loamy sand, and gravelly loamy coarse sand |
| Pinaleno-Stagecoach-Palos Verdes | Very cobbly sandy loam, extremely cobbly sandy clay loam, extremely gravelly sandy clay loam |

**Notes:**
Loam is an agricultural soil classification that refers to a soil comprised of a mixture of clay, silt, and sand

## 8.1 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.

Native alluvial soil deposits primarily associated with the Big Wash floodplain were encountered at the surface of our borings and extended to the boring termination depths. The alluvium in our borings consisted of loose to very dense silty sand, well-graded sand with silt, and clayey sand with variable percentages of gravel. The soil relative densities measured by the SPT blow counts were generally increasing with depth. The general stratigraphy in terms of relative density is presented below:

- 0 to 10 feet: loose to medium dense condition:
- 10 to 25 feet: medium dense to dense condition;
- Below 25 feet: dense to very dense condition.

However, relatively low densities as evaluated by SPT blow counts with medium dense condition extending to approximately 35 feet bgs were encountered in boring B-4.

## 8.2 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 110 feet bgs. However, it should be noted that groundwater levels near the site can fluctuate due to seasonal variations, flows in nearby washes, irrigation, groundwater withdrawal or injection, and other factors.

# 9 GEOLOGIC HAZARDS

The following section provides a discussion regarding potential geologic hazards such as land subsidence, earth fissures, faulting and seismicity.

## 9.1 Land Subsidence and Earth Fissures

Groundwater depletion, due to groundwater pumping, has caused land subsidence and earth fissures in numerous alluvial basins in Arizona. It has been estimated that subsidence has affected more than 3,000 square miles and has caused damage to a variety of engineered structures and agricultural land. From 1948 to 1983, excessive groundwater withdrawal has been documented in several alluvial valleys where groundwater levels have been reportedly lowered by up to about 500 feet. With such large depletions of groundwater, the alluvium has undergone consolidation resulting in large areas of land subsidence (Schumann and Genualdi, 1986).

In Arizona, earth fissures are generally associated with land subsidence and pose an on-going geologic hazard. Earth fissures generally form near the margins of geomorphic basins where significant amounts of groundwater depletion have occurred. Reportedly, earth fissures have also formed due to tensional stress caused by differential subsidence of the unconsolidated alluvial materials over buried bedrock ridges and irregular bedrock surfaces (Schumann and Genualdi, 1986).

Based on our field reconnaissance and review of the referenced material, there are no known earth fissures at the surface of the subject site. Based on fissure maps published by the Arizona Geological Survey (AZGS), the closest reported unconfirmed earth fissures to the site are located approximately 16.5 miles to the west of the project site near the Town of Marana (Shipman, 2007).

Continued groundwater withdrawal in the area may result in subsidence and the formation of new fissures or the extension of existing fissures. While the future occurrence of land subsidence and earth fissures cannot accurately be predicted, these phenomena are not expected to be a constraint to the construction of this project.

## 9.2 Faulting and Seismicity

The site lies within the Sonoran zone, which is a relatively stable tectonic region located in southwestern Arizona, southeastern California, southern Nevada, and northern Mexico (Euge et al., 1992). This zone is characterized by sparse seismicity and few Quaternary faults. Based on our field observations and on our review of readily available published geologic maps and literature, there are no known active faults underlying the subject site or adjacent areas.

The closest known Quaternary fault to the site is the Santa Rita Fault Zone, located approximately 33.5 miles southeast of the site. The Santa Rita Fault Zone is situated along the western piedmont of the Santa Rita Mountains. The fault zone is a series of northeast-striking normal faults that dip to the northwest. The most recent movement along this fault was approximately 130,000 years ago during the Middle to Late Pleistocene epoch. The slip-rate category of this fault is less than 0.2 millimeters per year (Pearthree, 1998). Seismic parameters recommended for the design of the proposed improvements are presented in Section 10.2.

# 10 CONCLUSIONS

Based on the results of our subsurface evaluation, laboratory testing, and data analysis, the proposed construction is feasible from a geotechnical standpoint, provided the recommendations of this report are incorporated into the design of the project, as appropriate. Geotechnical considerations include the following:

- The site soils can generally be excavated or ripped using heavy-duty earthmoving or excavation equipment. However, zones of very dense, gravelly/cobbly materials should be anticipated, which may result in difficult and/or slower excavation rates.
- Soils of variable relative densities encountered in our borings exhibit significant collapse potential and increased compressibility upon saturation.
- Imported soils and soils generated from on-site excavation activities, that exhibit a relatively low plasticity index (PI) can generally be used for engineered fill. Based on the results of our study, many of the on-site soils are suitable for re-use as engineered fill.
- Groundwater was not observed in our borings. Based on ADWR well data, the regional groundwater table has been historically measured at depths on the order of 110 feet bgs. In general, groundwater is not expected to be a constraint to the design and construction of this project.
- No documented geologic hazards are present underlying or immediately adjacent to the site.

# 11 PRELIMINARY RECOMMENDATIONS

The following sections present our preliminary geotechnical recommendations for the project design and construction. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations. A supplemental geotechnical study that will include additional soil borings, laboratory testing and analysis should be conducted for the project final design phase.

## 11.1 Earthwork

The following sections provide our earthwork recommendations for this project. In general, the earthwork specifications contained in the *Pima Association of Governments (PAG) Standard Specifications for Public Improvements (Standard Specifications)* are expected to apply unless specifically noted.

### 11.1.1 Site Preparation

Construction areas should be cleared of deleterious materials, if any are present, construction debris, vegetation, and any other material that might interfere with the performance or progress of the work. These materials should be disposed of at a legal dumpsite. Existing features that call for relocation or removal and extend below finished grade, if present, should be removed, and the resulting excavations backfilled with compacted engineered fill as discussed in this report.

#### 11.1.2 Excavations

Our evaluation of the excavation characteristics of the on-site soils is based on the results of our exploratory borings, site observations, and experience with similar soils. The on-site soils include loose to very dense silty sand, well-graded sand with silt, and clayey sand which can generally be excavated or ripped using heavy-duty earthmoving or excavation equipment. However, very dense deposits of gravel and cobbles associated with the wash, although not observed in our borings, should also be anticipated, which could be more difficult to excavate and could slow the excavation rate.

Equipment and procedures should be used that do not cause significant disturbance to the excavation bottoms. Excavators and backhoes with buckets having large claws to loosen the soil should be avoided when excavating the last 6 to 12 inches. Such equipment will probably disturb the excavation bases. If wet or saturated soils are found at the excavation bases, these soils may soften under the action of light equipment and foot traffic. If the subgrade becomes disturbed, it should be compacted before placing the backfill material.

#### 11.1.3 Temporary Slopes

Sidewalls for temporary excavations should not be anticipated to stand near-vertical without sloughing. Therefore, the contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration (OSHA) regulations, for employees working in an excavation that may expose them to the danger of moving ground. For planning purposes and according to OSHA soil classifications, a "Type C" soil should be considered for this project. This corresponds to a temporary slope inclination no steeper than 1.5:1 (horizontal to vertical [H:V]) up to a height of 20 feet. During excavation, soil classification and excavation performance should be evaluated in the field by Ninyo & Moore in accordance with the OSHA regulations.

### 11.1.4 Permanent Slopes

A formal slope stability analysis was beyond the scope of this study; however, based on the subsurface conditions at the site we recommend that any permanent slopes have an inclination of 3:1 (Horizontal:Vertical), or flatter.

Exposed cut slopes may call for periodic maintenance due to sloughing and erosion. To reduce this potential for erosion, we recommend that erosion mitigation measures be placed on slopes. The establishment of long-term erosion mitigation measures is beneficial for aesthetics, reduces erosion by slowing runoff velocities, and protects soil from rainfall impact. Temporary measures may include, but not limited to, straw mulching or matting, and/or straw wattles. Long-term erosion control measures such as deep-rooted perennial vegetation, gravel mulch, riprap, geotextiles, gabion mats, concrete lining, or bio-reinforcement should be considered.

### 11.1.5 Fill Materials and Reuse of On-site Soils

On-site and imported soils that exhibit relatively low plasticity indices and very low to low expansive potential are generally suitable for re-use as engineered fill. Relatively low plasticity indices are defined as a PI value of 15, or less, as evaluated by ASTM D 4318. Based on laboratory test results, the on-site soils are generally non-plastic. As such, it is our opinion that many of the on-site soils will be suitable for re-use as engineered fill during construction. The Contractor should perform additional testing either prior to or during construction to better understand the soil conditions. Fill soils not suitable for re-use as engineered fill can be re-used in non-structural areas (e.g. landscaping, etc.).

In addition, suitable fill should not include organic material, construction debris, or other non-soil fill materials. Clay lumps and rock particles should not be larger than 4 inches in dimension. This material should be disposed of off-site or in non-structural areas.

Engineered fill materials in contact with ferrous metals should also have low corrosion potential (minimum resistivity more than 2,000 ohm-cm, chloride content less than 25 parts per million [ppm]). Engineered fill material in contact with concrete should have a soluble sulfate content of less than 0.1 percent.

### 11.1.6 Subgrade Preparation

As stated previously, our borings disclosed near-surface alluvial soils generally consisting of silty sand, well-graded sand with silt, and clayey sand. Based on the results of our explorations and laboratory testing, the on-site soils exhibit potential for volume changes upon inundation with water and may be compressible. Our laboratory measured collapse potential tested on relatively undisturbed specimens was on the order of 5 to 7 percent for the easterly borings B-3 through B-5 and on the order of 2 to 3 percent in the remaining (westerly located) borings. Accordingly, we recommend that the developer considers the following mitigation measures:

- Relatively light-weight improvements with column loads less than 100 thousand pounds (kips) and wall loads less than 4 kips/linear foot should be placed on a zone of engineered fil extending:
    - For shallow foundations (spread footings): 5 to 7 feet below existing grade:
    - For slab-on-grade, mat foundations, post tensioned slabs, flatwork and pavements: 2 to 4 feet below existing grade;
- Heavier-loaded, or settlement sensitive structures with column loads exceeding 100 kips and wall loads exceeding 4 kips/linear foot may need ground improvement techniques such as stone columns extending to 25 feet below existing grade or deep foundations (concrete drilled piers) extending to a competent layer generally below 40 feet depth.
- Deep structure foundations such as mat foundations below a depth of 10 feet: ground improvements should be designed on a case by case basis.
- For pipelines, the zone of engineered fill should extend 5 feet below the pipe bedding. Additional ground improvements involving geogrid layer installation may reduce the overexcavation depth and should be designed on a case by case basis.
- Fill embankments should be placed on prepared subgrade. The overexcavation depths will depend on the fill thickness and proposed development, and may vary between 1 and 3 feet.

The engineered fill placed in the subgrade improvement zone should be moisture-conditioned and compacted as discussed in Section 11.1.7. The fill thickness should be measured from the bottom of the foundation or the aggregate base (AB) layer, where applicable. This subgrade improvement should extend laterally 1 to 3 feet beyond the slab/pavement footprint.

After the overexcavation described above is finished and prior to the placement of engineered fill, exposed surfaces from excavations should be carefully evaluated by Ninyo & Moore for the presence of soft, loose, or wet soils that were not removed as part of the improvement process. This evaluation should consist of probing and visual observation of the excavation bottom. Based on this evaluation, additional remediation may be needed. This could include further scarification of the exposed surface. This additional remediation, if needed, should be addressed by the geotechnical consultant during the earthwork operations.

#### 11.1.7 Fill Placement and Compaction

Engineered fill soils should be moisture-conditioned within the moisture range shown below in Table 2 and mechanically compacted to the percent compaction shown. Engineered fill should generally be placed in 8-inch-thick loose lifts such that each lift is firm and non-yielding under the weight of construction equipment.

**Table 2 – Compaction Recommendations**

| Engineered Fill Description | Percent Compaction per ASTM D698 | Moisture Content |
|---|---|---|
| Below foundations, slab-on-grade, mat foundations, exterior flatwork, and pavement | 95 percent | ±2 percent of optimum |
| Aggregate Base (AB) | 100 percent | ±2 percent of optimum |
| Trench Backfill – within 2 feet below pavements | 100 percent | ±2 percent of optimum |
| Trench Backfill – deeper than 2 feet below pavement | 95 percent | ±2 percent of optimum |
| Pipe Bedding/Pipe Zone | 95 percent | ±2 percent of optimum |

An earthwork (shrinkage) factor of 10 to 20 percent is estimated. This shrinkage factor range represents an average of the material tested and assumes that materials excavated from the site will be placed as fill. Potential bidders should consider this in preparing estimates and should review the available data to make their own conclusions regarding excavation conditions.

## 11.2 Seismic Design Considerations

Design of the proposed improvements should be performed in accordance with the requirements of the governing jurisdictions and applicable building codes. Table 3 presents the seismic design parameters for the site in accordance with the International Building Code (IBC) guidelines and adjusted maximum considered earthquake (MCE) spectral response acceleration parameters evaluated using the California's Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps (web-based).

| Table 3 – International Building Code Seismic Design Criteria | |
|---|---|
| **Site Coefficients and Spectral Response Acceleration Parameters** | **Values** |
| Site Class | D |
| Site Coefficient, $F_a$ | 1.585 |
| Site Coefficient, $F_v$ | 2.40 |
| Mapped Spectral Response Acceleration at 0.2-second Period, $S_s$ | 0.269 g |
| Mapped Spectral Response Acceleration at 1.0-second Period, $S_1$ | 0.083 g |
| Spectral Response Acceleration at 0.2-second Period Adjusted for Site Class, $S_{MS}$ | 0.426 g |
| Spectral Response Acceleration at 1.0-second Period Adjusted for Site Class, $S_{M1}$ | 0.200 g |
| Design Spectral Response Acceleration at 0.2-second Period, $S_{DS}$ | 0.284 g |
| Design Spectral Response Acceleration at 1.0-second Period, $S_{D1}$ | 0.133 g |

## 11.3 Corrosion

The corrosion potential of the on-site materials was analyzed to evaluate its potential effect on the foundations and structures. Corrosion potential was evaluated using the results of laboratory testing of a soil sample obtained during our subsurface evaluation that was considered representative of soils at the subject site.

Laboratory testing consisted of pH, minimum electrical resistivity, and chloride and soluble sulfate contents. The pH and minimum electrical resistivity tests were performed in general accordance with Arizona Test 236c, while sulfate and chloride tests were performed in accordance with Arizona Test 733 and 736, respectively. The results of the corrosivity tests are presented in Appendix B.

The soil pH value of the tested samples ranged between 8.1 and 8.2, which is considered to be alkaline. The minimum electrical resistivity measured in the laboratory varied between 2,615 and 10,050 ohm-cm, which is considered to be non-corrosive to ferrous metals. The chloride content of the samples tested ranged between 10 and 17 parts per million (ppm), which is also considered to be non-corrosive environment to ferrous metals. The soluble sulfate content of the soil samples tested was 0.005 percent by weight, which is considered to represent negligible sulfate exposure for concrete.

The results of the laboratory testing indicate that the on-site materials are non-corrosive to ferrous materials. However, based on our experience in the project area, it is possible that soils with variable corrosivity characteristics may be encountered at the site and should be evaluated during construction. A corrosion specialist should be consulted for further recommendations.

### 11.4 Concrete

Laboratory chemical tests performed on soil samples indicated sulfate content of approximately 0.005 percent by weight. Based on American Concrete Institute (ACI), the on-site soils should be considered to represent negligible sulfate exposure to concrete.

We recommend the use of Type II cement for construction of concrete structures at this site. Due to potential uncertainties as to the use of reclaimed irrigation water, or topsoil that may contain higher sulfate contents, pozzolan or admixtures designed to increase sulfate resistance may be considered.

The concrete should have a water-cementitious materials ratio of no more than 0.50 by weight for normal weight aggregate concrete. The structural engineer should select the concrete design strength based on the project specific loading conditions. Higher strength concrete may be selected for increased durability and resistance to slab curling and shrinkage cracking.

We recommend that concrete cover over reinforcing steel for foundations be in accordance with the recommendations of the structural engineer. The structural engineer should be consulted for additional concrete specifications.

## 12 ADDITIONAL GEOTECHNICAL STUDY

We recommend that a detailed geotechnical study be conducted during the final design stage and prior to project construction to better evaluate the subsurface conditions in project sensitive areas, specifically, but not limited to, the eastern portion of the site (currently borings B-3 through B-5). Ninyo & Moore will be available to provide such services, if requested.

## 13 LIMITATIONS

The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical 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 conclusions, recommendations, and opinions 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 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 also 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.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. 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 report 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, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.

# 14 REFERENCES


American Concrete Institute, Guidelines for Concrete Floor and Slab Construction (ACI 302.1R).

American Concrete Institute, Guidelines for Residential Cast-in-Place Concrete Construction (ACI 332R).

Arizona Department of Water Resources, Well Registry Application, https://gisweb.azwater.gov/waterresourcedata/.

American Society for Testing and Materials (ASTM), Annual Book of ASTM Standards.

Arizona Geological Survey (AZGS), Natural Hazards in Arizona, on-line tool, https://uagis.maps.arcgis.com/apps/webappviewer/index.html?id=98729f76e4644f1093d1c2cd6dabb584.

Euge, K.M., Schell, B.A., and Lam, I.P., 1992, Development of Seismic Acceleration Contour Maps for Arizona: Arizona Department of Transportation Report No. AZ 92-344: dated September.

Google, Inc., Google Earth™ mapping service, http://earth.google.com.

International Code Council, 2018, International Building Code.

Nationwide Environmental Title Research (NETR), LLC, Historic Aerials by NETR Online, http://historicaerials.com/.

Ninyo & Moore, In-house proprietary information.

Ninyo & Moore, 2023, Geotechnical Services, Valley Vista Subdivision Soil Evaluation, Oro Valley, Arizona, dated August 17; and

Ninyo & Moore, 2023, Geotechnical Services, Valley Vista Sewer and Pump Station Evaluation, Oro Valley, Arizona, dated August 22

Occupational Safety and Health Administration (OSHA), Title 29 of the Code of Federal Regulations (CFR), Part No. 1926 - Safety and Health Regulations for Construction, Subpart P – Excavations.

Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps (web based) www.seismicmaps.org .

Pearthree, P.A., 1998, Quaternary Fault Data and Map for Arizona: Arizona Geological Survey, Open-File Report 98-24.

Pearthree, P.A., McKittrick, M.A., Jackson, G.W., and Demsey, K.A., 1988, Geologic Map of Quaternary and Upper Tertiary Deposits, Tucson 1 x 2 Degree Quadrangle, AZ: Arizona Geological Survey, Open-File Report 88-21, Scale 1:250,000.

Pima Association of Governments (PAG) Standard Specifications for Public Improvements.

Pima County Roadway Design Manual, 2013 Edition with June 2016 updates.

ProTeX, 2018, Geotechnical Investigation, Rancho Vistoso Neighborhood 5 – Parcel X and W, Rancho Vistoso Boulevard and Moore Loop, Oro Valley, Arizona.

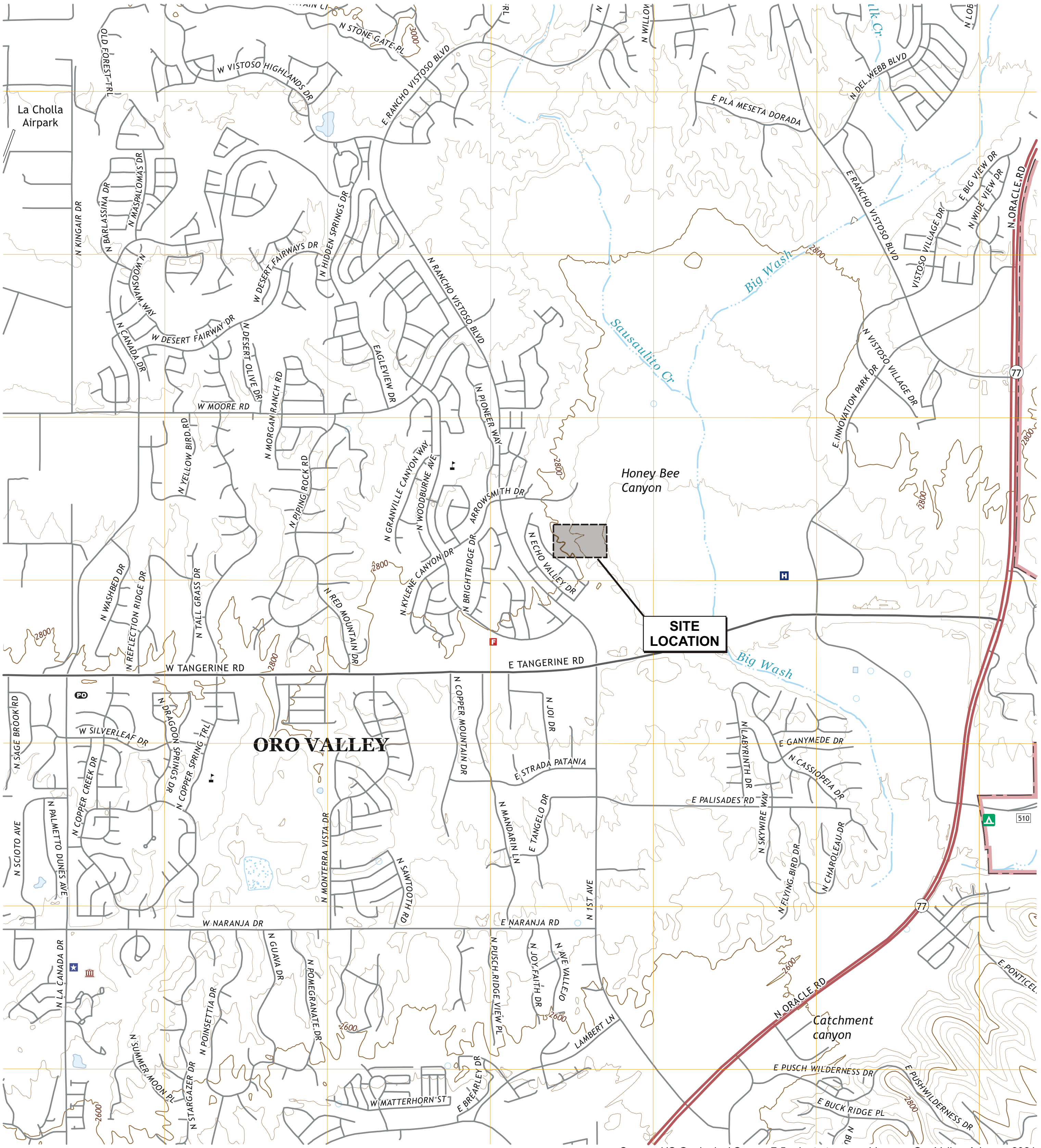
ProTeX, 2022, Geotechnical Investigation – Forensics, Rancho Vistoso Velley vista – Lot 19, 780 East Kalalau Drive, Oro Valley, Arizona, dated November 3, 2022.

Schumann, H.H. and Genualdi, R., 1986. Land Subsidence, Earth Fissures, and Water-level Changes in Southern Arizona: Arizona Geological Survey OFT 86-14. 1:500,000.

United States Department of Agriculture (USDA) Web Soil Survey, http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

United States Geological Survey, 2018, Oro Valley, Arizona, 7.5-Minute Topographic Quadrangle Map: Scale 1:24,000.

# FIGURES




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


NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

**FIGURE 1**

## SITE LOCATION

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

RANCHO VISTOSO PARCEL 5-R
ORO VALLEY, ARIZONA

607834001 | 9/23

bsm file no: 7834vmap0823


SOURCE: PARADIGM LAND DESIGN, 8/23.

NOTE: DIMENSIONS, DIRECTIONS AND LOCATIONS ARE APPROXIMATE.

bsm file no: 7834blm0823

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

**FIGURE 2**

# BORING LOCATIONS

RANCHO VISTOSO PARCEL 5-R
ORO VALLEY, ARIZONA

607834001 | 9/23

# APPENDIX A

Boring Logs

# APPENDIX 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.

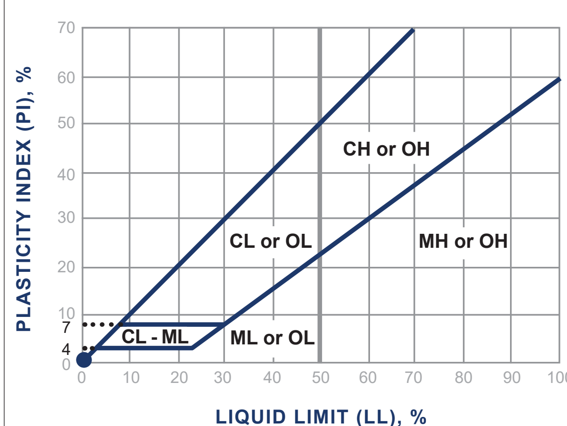
## Soil Classification Chart Per ASTM D 2488

| Primary 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: SPT (blows/foot) | Spooling Cable or Cathead: Modified Split Barrel (blows/foot) | Automatic Trip Hammer: SPT (blows/foot) | Automatic Trip Hammer: 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: SPT (blows/foot) | Spooling Cable or Cathead: Modified Split Barrel (blows/foot) | Automatic Trip Hammer: SPT (blows/foot) | Automatic Trip Hammer: 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 |

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

**USCS METHOD OF SOIL CLASSIFICATION**

# BORING LOG EXPLANATION SHEET

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | Bulk sample. |
| | | | | | | | | Modified split-barrel drive sampler. |
| | | | | | | | | No recovery with modified split-barrel drive sampler. |
| | | | | | | | | Sample retained by others. |
| | | | | | | | | Standard Penetration Test (SPT). |
| 5 | | | | | | | | No recovery with a SPT. |
| | | | XX/XX | | | | | Shelby tube sample. Distance pushed in inches/length of sample recovered in inches. |
| | | | | | | | | No recovery with Shelby tube sampler. |
| | | | | | | | | Continuous Push Sample. |
| | | | | | | | | Seepage. |
| 10 | | | | | | | | Groundwater encountered during drilling. |
| | | | | | | | | Groundwater measured after drilling. |
| | | | | | | | SM | MAJOR MATERIAL TYPE (SOIL):<br>Solid line denotes unit change. |
| | | | | | | | CL | Dashed line denotes material change. |
| 15 | | | | | | | | Attitudes: Strike/Dip<br>b: Bedding<br>c: Contact<br>j: Joint<br>f: Fracture<br>F: Fault<br>cs: Clay Seam<br>s: Shear<br>bss: Basal Slide Surface<br>sf: Shear Fracture<br>sz: Shear Zone<br>sbs: Shear Bedding Surface |
| 20 | | | | | | | | The total depth line is a solid line that is drawn at the bottom of the boring. |

DATE DRILLED 6/25/23 BORING NO. B-1

GROUND ELEVATION 2,763' ± (MSL) SHEET 1 OF 3

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

DRIVE WEIGHT 140 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 |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SW-SM | ALLUVIUM: Brown, dry, medium dense, well-graded SAND with silt; few gravel. |
| | | | 10 | | | | | |
| | | | 22 | 1.7 | 111.2 | | | |
| 5 | | | | | | | | |
| | | | 11 | | | | | |
| | | | 25 | 1.7 | 118.2 | | | Few to little gravel. |
| 10 | | | | | | | | |
| | | | | | | | SM | Brown, dry, dense, silty SAND; few gravel. |
| | | | 27 | | | | | |
| 15 | | | | | | | | |
| | | | 56 | | | | | |
| 20 | | | | | | | | |



Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

RANCHO VISTOSO PARCEL 5-R
ORO VALLEY, ARIZONA

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | SM | ALLUVIUM (Continued):<br>Brown, dry, dense, silty SAND; few gravel. |
| | | | 18 | | | | | Medium dense. |
| 25 | | | | | | | | |
| | | | 88/10" | | | | | Very dense. |
| 30 | | | | | | | | |
| | | | 46 | | | | | |
| 35 | | | | | | | | |
| | | | 50/3" | | | | | |
| 40 | | | | | | | | |

DATE DRILLED 6/25/23 BORING NO. B-1

GROUND ELEVATION 2,763' ± (MSL) SHEET 2 OF 3

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

DRIVE WEIGHT 140 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 |
|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | SM | ALLUVIUM (Continued): Brown, dry, very dense, silty SAND; few gravel. |
| | | ■ | 50/5" | | | | | |
| 45 | | | | | | | | |
| | | ■ | 50/4" | | | | | |
| | | | | | | | | Total Depth = 48.8 feet. Groundwater not encountered during drilling. Backfilled on 6/25/23 shortly after completion of drilling. |
| 50 | | | | | | | | Notes: 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. 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. |
| 55 | | | | | | | | |
| 60 | | | | | | | | |

DATE DRILLED 6/25/23 BORING NO. B-1

GROUND ELEVATION 2,763' ± (MSL) SHEET 3 OF 3

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

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

| DATE DRILLED | 6/25/23 | BORING NO. | B-2 |
|---|---|---|---|
| GROUND ELEVATION | 2,736' ± (MSL) | SHEET 1 OF 3 | |
| METHOD OF DRILLING | CME-75, 8" Diameter Hollow-Stem Auger (GSI) | | |
| DRIVE WEIGHT | 140 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 | | | | | | SM | ALLUVIUM: Brown, dry, medium dense, silty SAND; few gravel. |
| | | 16 | 1.0 | 111.4 | | | |
| | | 7 | | | | | Loose. |
| 5 | | | | | | | |
| | | 24 | 2.2 | 111.5 | | | Medium dense. |
| | | 8 | | | | | |
| 10 | | | | | | | |
| | | 41 | | | | | |
| 15 | | | | | | | |
| | | 21 | | | | | Dense. |
| 20 | | | | | | | |

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | SM | ALLUVIUM (Continued): Brown, dry, dense, silty SAND; few gravel. |
| | | | 34 | | | | | Medium dense. |
| 25 | | | | | | | | |
| | | | 32 | | | | | Dense. |
| 30 | | | | | | | | |
| | | | 48 | | | | | |
| 35 | | | | | | | | |
| | | | 53 | | | | | Very dense. |
| 40 | | | | | | | | |

DATE DRILLED 6/25/23 BORING NO. B-2
GROUND ELEVATION 2,736' ± (MSL) SHEET 2 OF 3
METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)
DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"
SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN



Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

DATE DRILLED 6/25/23 BORING NO. B-2

GROUND ELEVATION 2,736' ± (MSL) SHEET 3 OF 3

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

DRIVE WEIGHT 140 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 |
|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | SM | ALLUVIUM (Continued):<br>Brown, dry, very dense, silty SAND; few gravel. |
| | | | 58 | | | | | Dense. |
| 45 | | | | | | | | |
| | | | 49 | | | | | Very dense. |
| 50 | | | | | | | | Total Depth = 50 feet.<br>Groundwater not encountered during drilling.<br>Backfilled on 6/25/23 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. |
| 55 | | | | | | | | |
| 60 | | | | | | | | |

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SM | ALLUVIUM: Brown, dry, loose, silty SAND; few gravel. |
| | | | 10 | 2.8 | 94.9 | | | |
| | | | 7 | | | | | |
| 5 | | | | | | | | |
| | | | 15 | 3.7 | 100.4 | | | Medium dense. |
| | | | 13 | | | | | |
| 10 | | | | | | | | |
| | | | 21 | | | | | |
| 15 | | | | | | | | |
| | | | 9 | | | | | |
| 20 | | | | | | | | |

DATE DRILLED 6/24/23 BORING NO. B-3

GROUND ELEVATION 2,712' ± (MSL) SHEET 1 OF 3

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

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

**FIGURE A -7**

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

**RANCHO VISTOSO PARCEL 5-R**
**ORO VALLEY, ARIZONA**

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | SM | ALLUVIUM (Continued):<br>Brown, dry, medium dense, silty SAND; few gravel. |
| | | | 26 | | | | | |
| 25 | | | | | | | | |
| | | | 33 | | | | | Very dense. |
| 30 | | | | | | | | |
| | | | 50 | | | | | Dense. |
| 35 | | | | | | | | |
| | | | 45 | | | | | Very dense. |
| 40 | | | | | | | | |

DATE DRILLED 6/24/23 BORING NO. B-3

GROUND ELEVATION 2,712' ± (MSL) SHEET 2 OF 3

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

DRIVE WEIGHT 140 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. | DATE DRILLED 6/24/23 BORING NO. B-3<br>GROUND ELEVATION 2,712' ± (MSL) SHEET 3 OF 3<br>METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)<br>DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"<br>SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN<br>DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | SC | ALLUVIUM (Continued):<br>Brown, dry, very dense, clayey SAND; few gravel. |
| | | ■ | 59 | | | | | Dense. |
| 45 | | | | | | | | |
| | | | | | | | SM | Brown, dry, very dense, silty SAND. |
| | | ◣ | 58 | | | | | |
| 50 | | | | | | | | Total Depth = 50 feet.<br>Groundwater not encountered during drilling.<br>Backfilled on 6/24/23 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. |
| 55 | | | | | | | | |
| 60 | | | | | | | | |

| | | |
|---|---|---|
| DATE DRILLED 6/24/23 | BORING NO. B-4 | |
| GROUND ELEVATION 2,710' ± (MSL) | SHEET 1 OF 3 | |
| METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI) | | |
| DRIVE WEIGHT 140 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 |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | SM | ALLUVIUM: Brown, dry, loose, silty SAND; few gravel. |
| | | | 5 | | | | | |
| | | | 9 | 6.3 | 113.7 | | | |
| 5 | | | | | | | | |
| | | | 8 | | | | | Medium dense. |
| | | | 19 | 1.7 | 112.3 | | | |
| 10 | | | | | | | | |
| | | | 8 | | | | | |
| 15 | | | | | | | | |
| | | | 19 | | | | | |
| 20 | | | | | | | | |

FIGURE A -10

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

RANCHO VISTOSO PARCEL 5-R
ORO VALLEY, ARIZONA
607834001 | 9/23

DATE DRILLED 6/24/23 BORING NO. B-4

GROUND ELEVATION 2,710' ± (MSL) SHEET 2 OF 3

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

DRIVE WEIGHT 140 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 | | | | | | | SM | ALLUVIUM (Continued): Brown, dry, medium dense, silty SAND; few gravel. |
| | | ■ | 9 | | | | | |
| 25 | | | | | | | | |
| | | ■ | 31 | | | | | |
| 30 | | | | | | | | |
| | | ■ | 13 | | | | | |
| 35 | | | | | | | | |
| | | ■ | 46 | | | | | Dense. |
| 40 | | | | | | | | |

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DATE DRILLED 6/24/23 BORING NO. B-4<br>GROUND ELEVATION 2,710' ± (MSL) SHEET 3 OF 3<br>METHOD OF DRILLING CME-75, 8" Diameter Hollow-Stem Auger (GSI)<br>DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"<br>SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN<br>**DESCRIPTION/INTERPRETATION** |
|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | SM | <u>ALLUVIUM (Continued)</u>:<br>Brown, dry, dense, silty SAND; few gravel. |
| | | | 49 | | | | | Very dense. |
| 45 | | | | | | | | |
| | | | 58 | | | | | Dense. |
| 50 | | | | | | | | Total Depth = 50 feet.<br>Groundwater not encountered during drilling.<br>Backfilled on 6/24/23 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. |
| 55 | | | | | | | | |
| 60 | | | | | | | | |

DATE DRILLED 6/24/23 BORING NO. B-5

GROUND ELEVATION 2,708' ± (MSL) SHEET 1 OF 3

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

DRIVE WEIGHT 140 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 | | | | | | SM | ALLUVIUM:<br>Brown, dry, loose, silty SAND; few gravel. |
| | | 12 | | | | | |
| | | 10 | | | | | Medium dense. |
| 5 | | | | | | | |
| | | 10 | 2.9 | 101.4 | | | Loose. |
| | | 8 | | | | | Medium dense. |
| 10 | | | | | | | |
| | | 17 | 2.3 | 114.0 | | | |
| 15 | | | | | | | |
| | | 17 | | | | | |
| 20 | | | | | | | |



Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

| DEPTH (feet) | SAMPLES Bulk | SAMPLES Driven | BLOWS/FOOT | MOISTURE (%) | DRY DENSITY (PCF) | SYMBOL | CLASSIFICATION U.S.C.S. | DESCRIPTION/INTERPRETATION |
|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | SM | ALLUVIUM (Continued): Brown, dry, medium dense, silty SAND; few gravel. |
| | | | 40 | | | | | |
| 25 | | | | | | | | |
| | | | 23 | | | | | Dense. |
| 30 | | | | | | | | |
| | | | 71 | | | | | Light brown; very dense. |
| 35 | | | | | | | | |
| | | | 55 | | | | | |
| 40 | | | | | | | | |

DATE DRILLED 6/24/23 BORING NO. B-5

GROUND ELEVATION 2,708' ± (MSL) SHEET 2 OF 3

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

DRIVE WEIGHT 140 lbs. (Automatic) DROP 30"

SAMPLED BY MH LOGGED BY MH REVIEWED BY SDN

DATE DRILLED 6/24/23 BORING NO. B-5

GROUND ELEVATION 2,708' ± (MSL) SHEET 3 OF 3

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

DRIVE WEIGHT 140 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 |
|---|---|---|---|---|---|---|---|---|
| 40 | | | | | | | SM | ALLUVIUM (Continued): Light brown, dry, very dense, silty SAND; few gravel. |
| 45 | | ■ | 62 | | | | | Dense. |
| 50 | | ▲ | 58 | | | | | Very dense. |
| 50 | | | | | | | | Total Depth = 50 feet.<br>Groundwater not encountered during drilling.<br>Backfilled on 6/24/23 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. |
| 55 | | | | | | | | |
| 60 | | | | | | | | |

# APPENDIX B

## Laboratory Testing

# APPENDIX B

## LABORATORY TESTING

**Classification**
Soils were visually and texturally classified in accordance with the Unified Soil Classification System (USCS) in general accordance with ASTM D 2488. Soil classifications are indicated on the log of the exploratory borings in Appendix A.

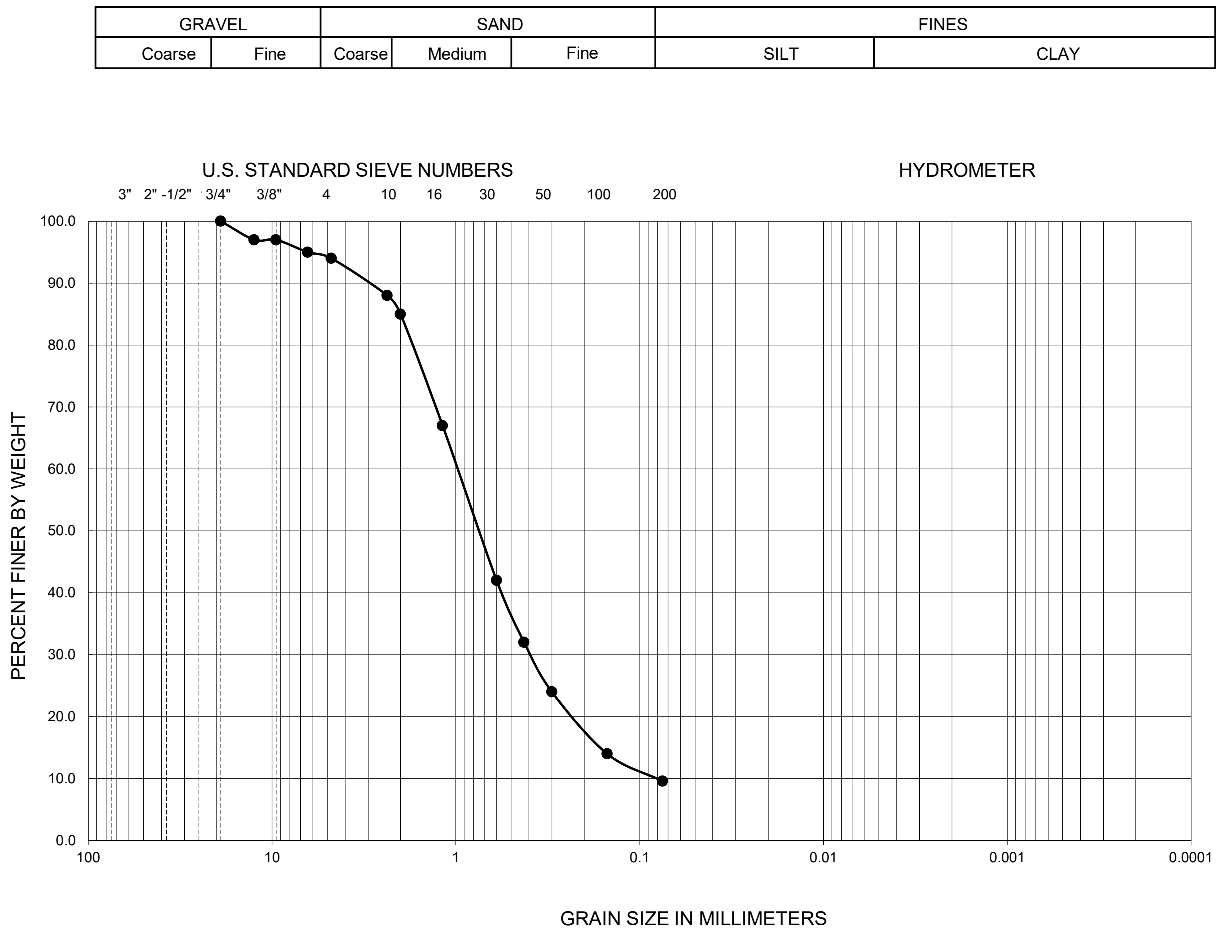
**In-Place Moisture and Density Tests**
The moisture content and dry density of relatively undisturbed samples obtained from the exploratory borings were evaluated in general accordance with ASTM D 2937. The test results are presented on the logs of the exploratory boring in Appendix A.

**Gradation Analysis**
Gradation analysis tests were 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-8. These test results were utilized in evaluating the soil classifications in accordance with the USCS.

**Atterberg Limits**
Tests were performed on selected representative fine-grained 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 classifications are shown on Figure B-9.

**Consolidation Tests**
Consolidation test was 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-10 through B-15.

**Soil Corrosivity Tests**
Soil pH and resistivity tests were performed on representative samples in general accordance with Arizona Test Method 236c. The soluble sulfate and chloride content of the samples were evaluated in general accordance with Arizona Test Method 733 and Arizona Test Method 736, respectively. The test results are presented on Figure B-16.




| 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 | 0.0-5.0 | -- | -- | NP | 0.079 | 0.396 | 0.98 | 12.4 | 2.0 | 9.6 | SW-SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-1**

## GRADATION TEST RESULTS

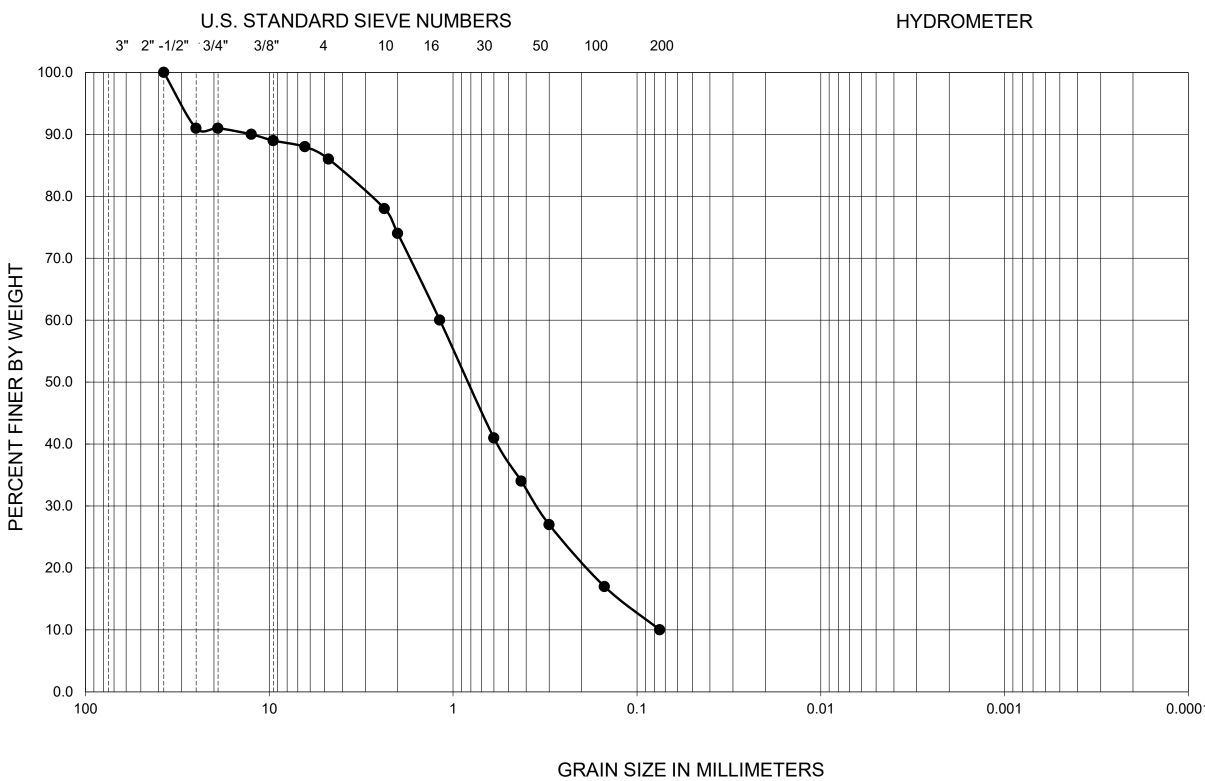
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23

| 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 | 8.5-10.0 | -- | -- | NP | 0.074 | 0.354 | 1.19 | 16.1 | 1.4 | 10.0 | SW-SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-2**

**GRADATION TEST RESULTS**

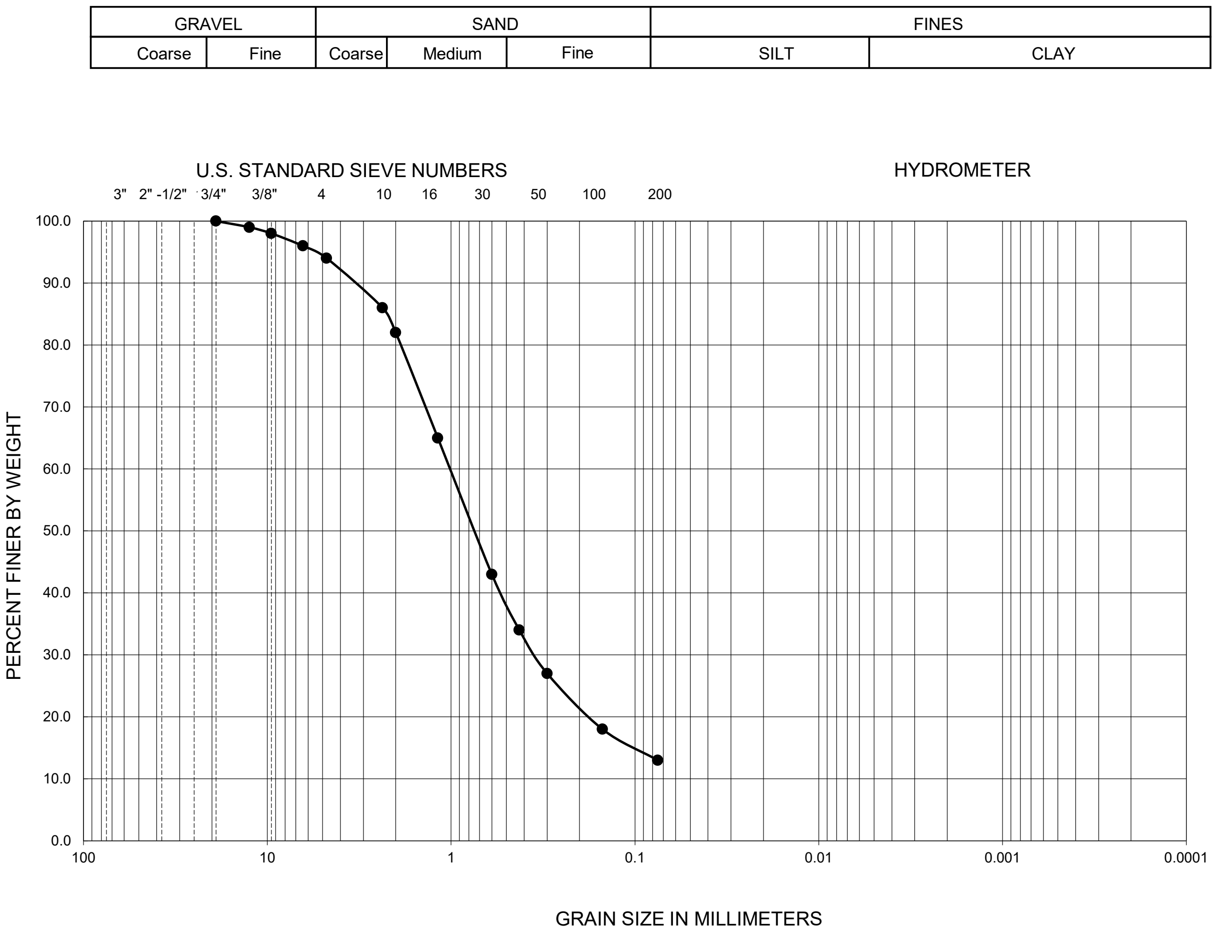
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

607834001 | 9/23

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants




| 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 | 0.0-5.0 | -- | -- | NP | -- | 0.354 | 1.02 | -- | -- | 13.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

FIGURE B-3

**GRADATION TEST RESULTS**

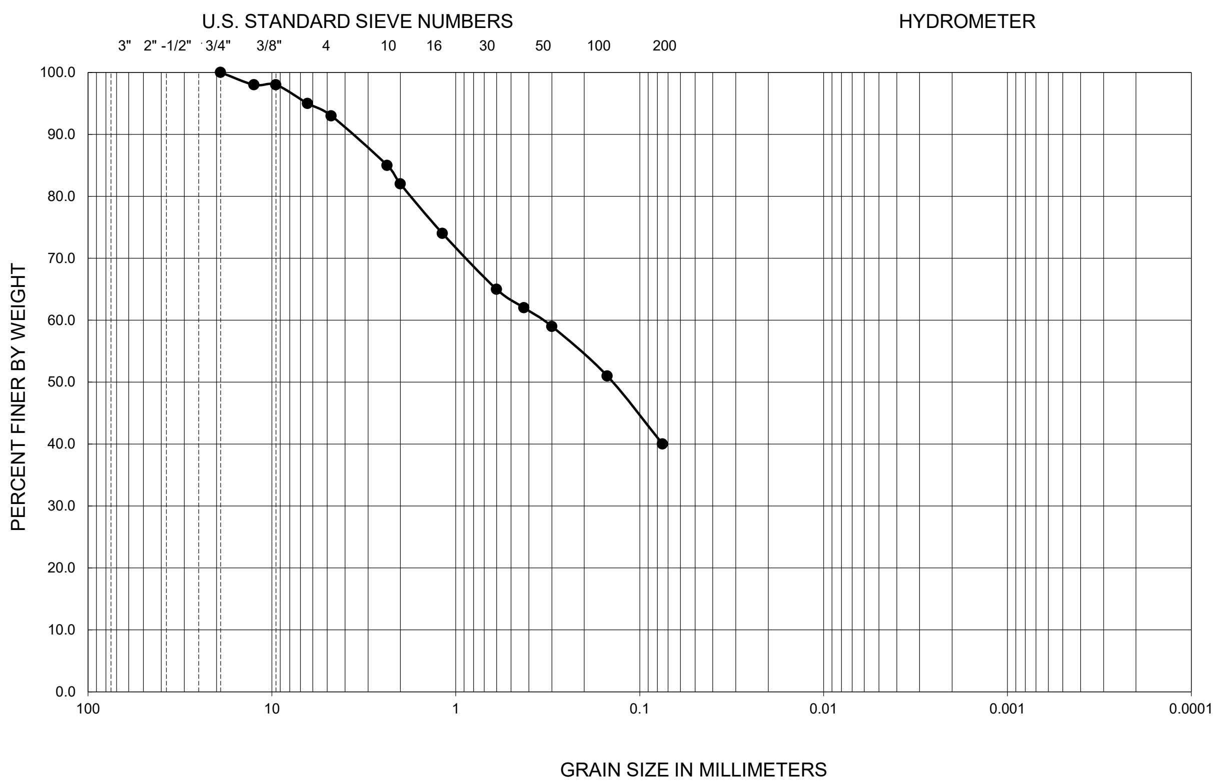
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23

| 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-3 | 0.0-5.0 | -- | -- | NP | -- | -- | 0.34 | -- | -- | 40.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

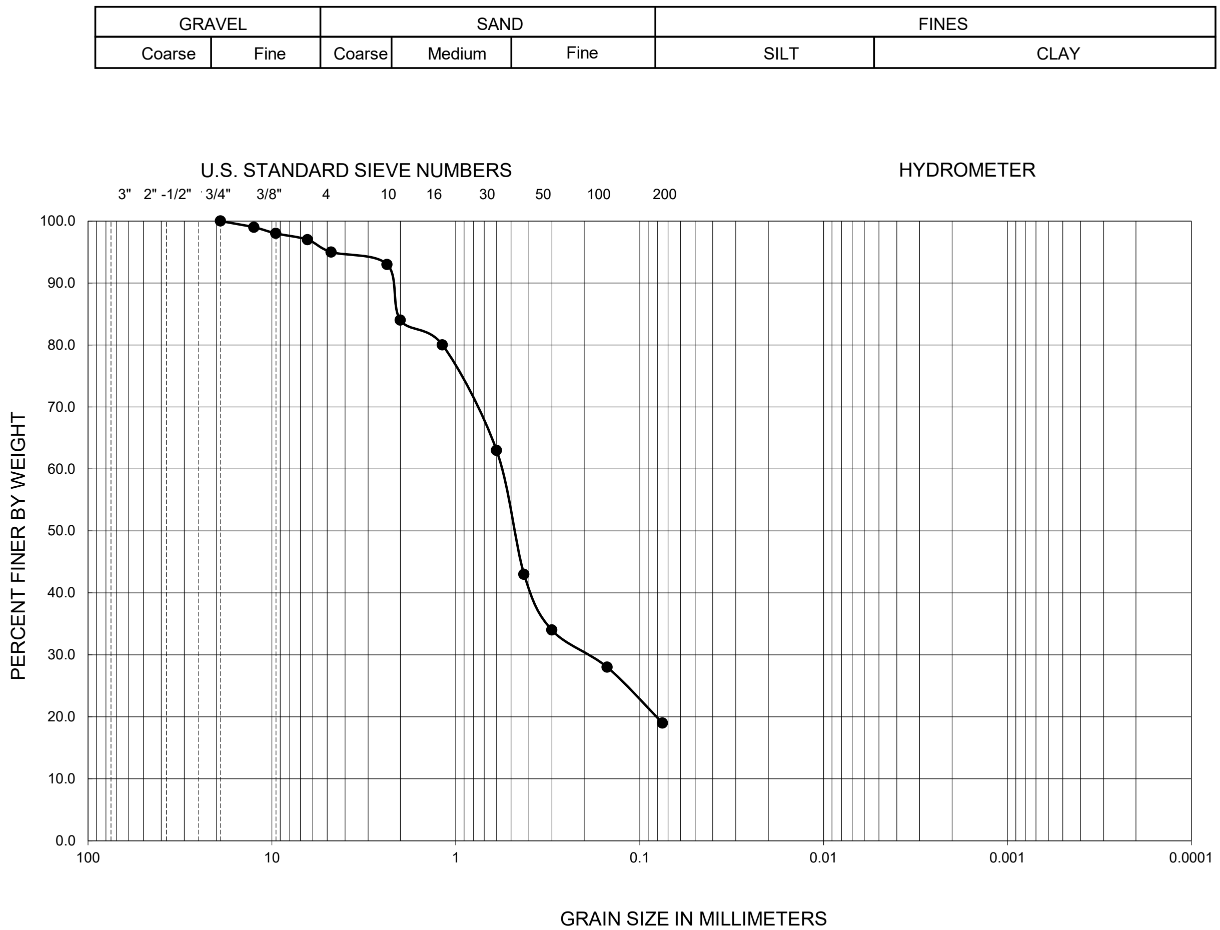
**FIGURE B-4**

**GRADATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants




| 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-3 | 18.0-25.0 | -- | -- | NP | -- | 0.342 | 1.07 | -- | -- | 14.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-5**

**GRADATION TEST RESULTS**

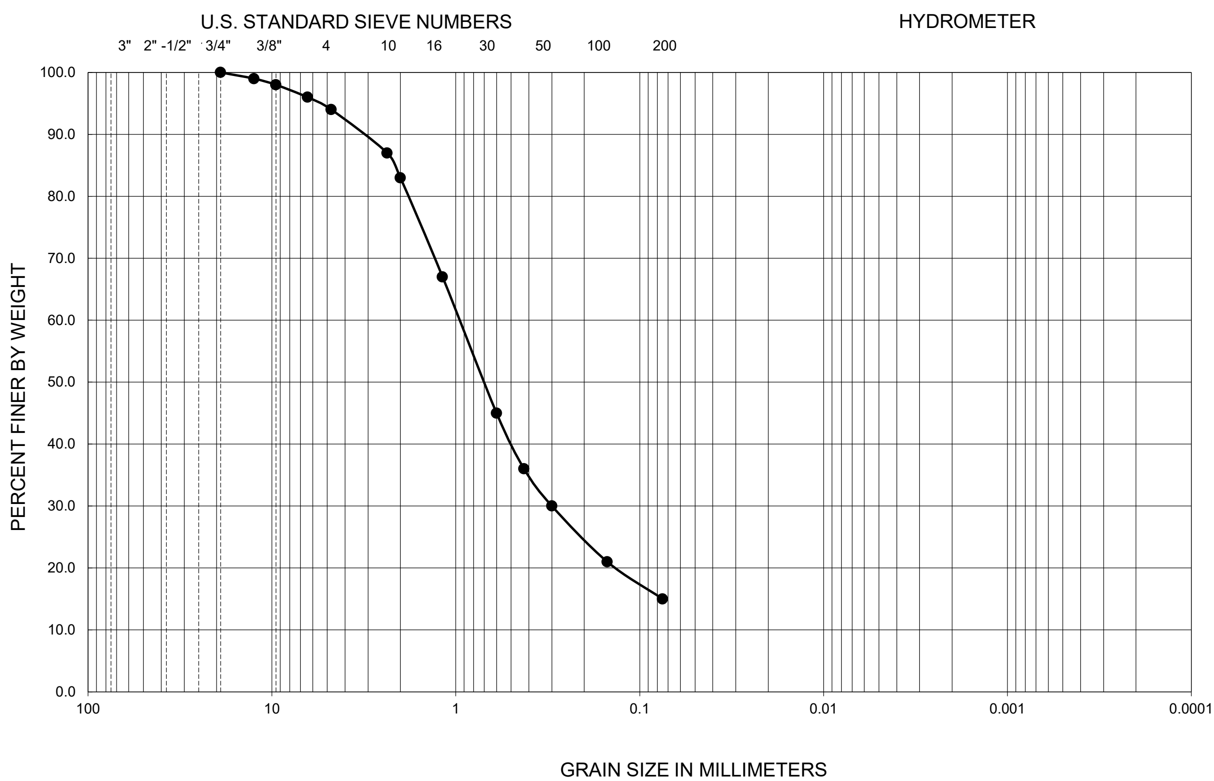
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23

| 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-4 | 0.0-5.0 | -- | -- | NP | -- | 0.305 | 0.95 | -- | -- | 15.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

FIGURE B-6

**GRADATION TEST RESULTS**

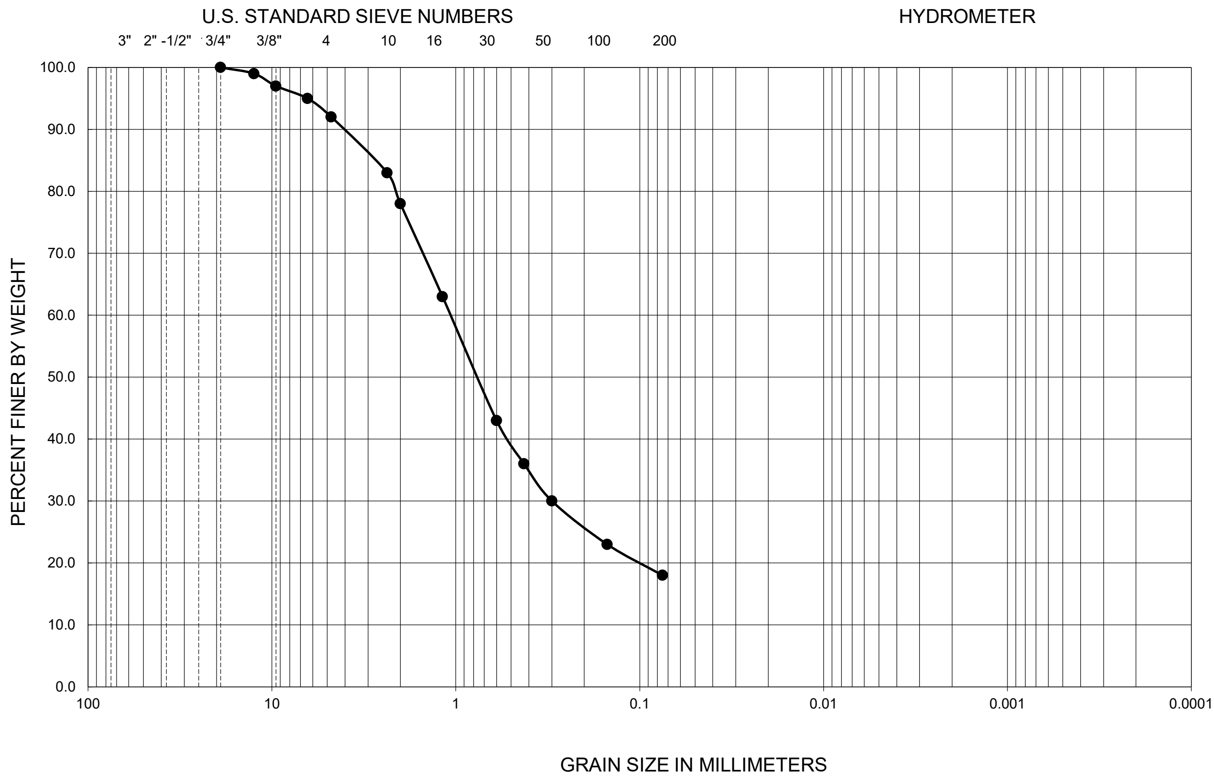
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

607834001 | 9/23

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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ● | B-5 | 0.0-5.0 | -- | -- | NP | -- | 0.305 | 1.07 | -- | -- | 18.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-7**

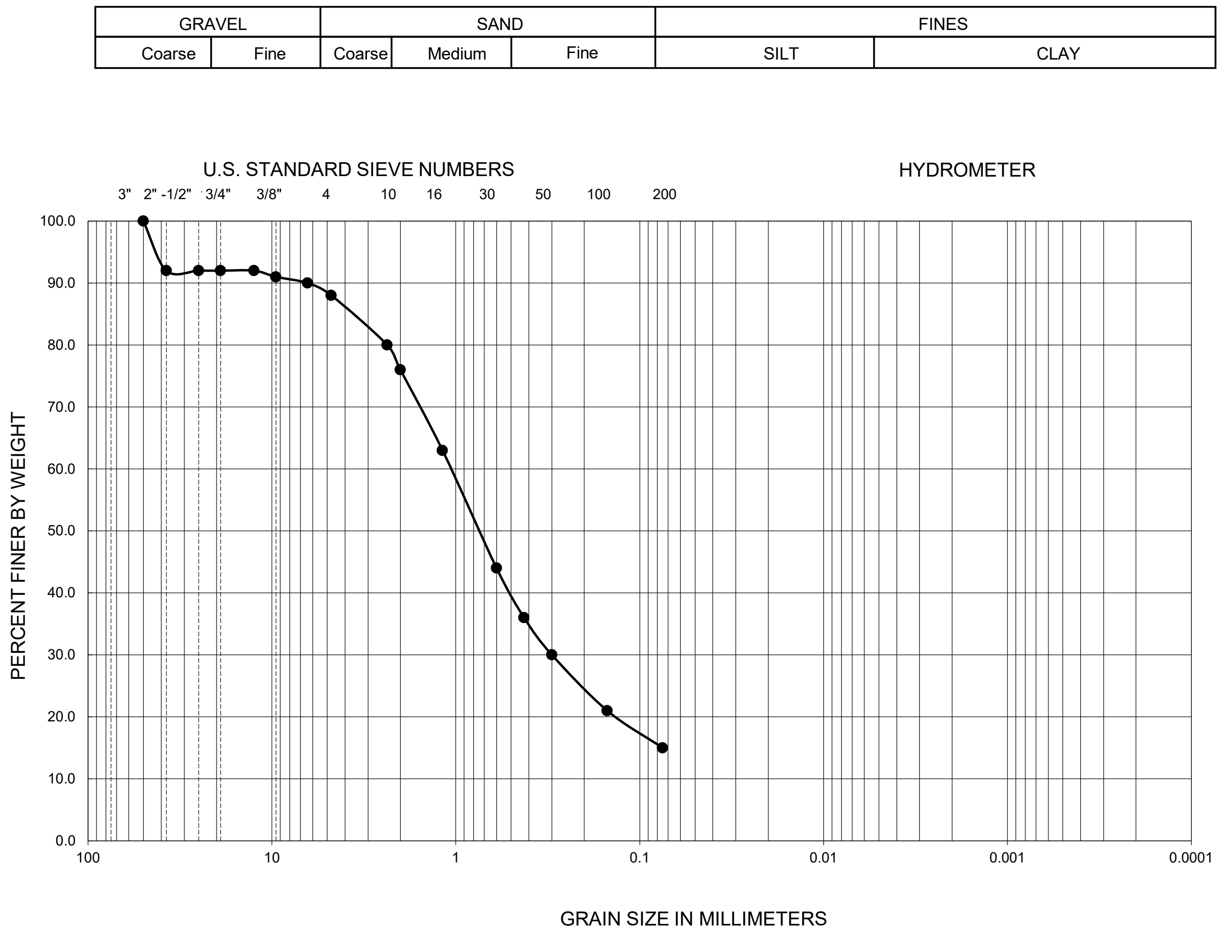
**GRADATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23




| 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-5 | 13.5-15.0 | -- | -- | NP | -- | 0.305 | 1.07 | -- | -- | 15.0 | SM |

NP - INDICATES NON-PLASTIC

PERFORMED IN GENERAL ACCORDANCE WITH ASTM C136 / D422

**FIGURE B-8**

**GRADATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

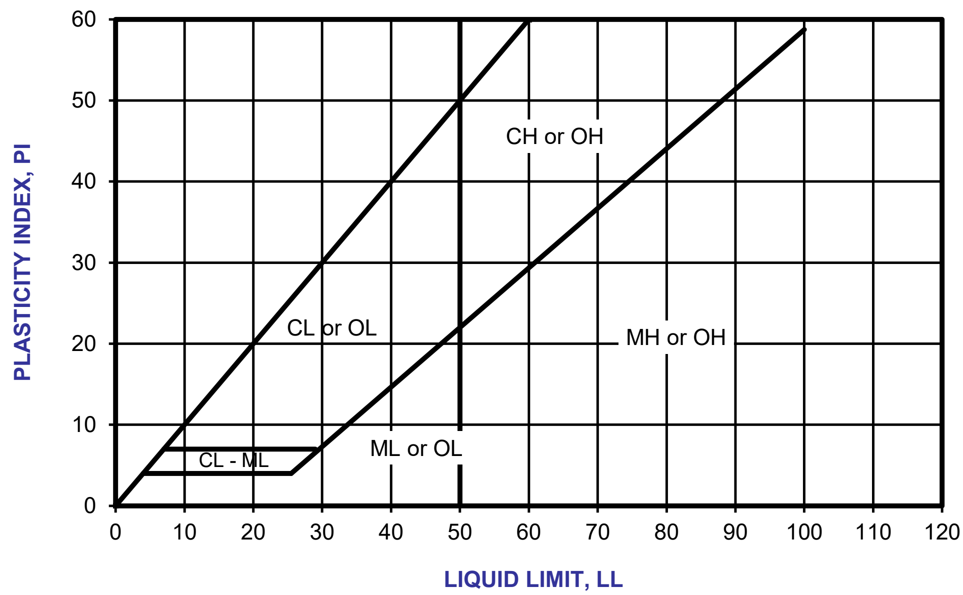
ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23

| SYMBOL | LOCATION | DEPTH (ft) | LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX | USCS CLASSIFICATION (Fraction Finer Than No. 40 Sieve) | USCS |
|---|---|---|---|---|---|---|---|
| ● | B-1 | 0.0-5.0 | -- | -- | NP | ML | SW-SM |
| ■ | B-1 | 8.5-10.0 | -- | -- | NP | ML | SW-SM |
| ◆ | B-2 | 0.0-5.0 | -- | -- | NP | ML | SM |
| ○ | B-3 | 0.0-5.0 | -- | -- | NP | ML | SM |
| □ | B-3 | 18.0-25.0 | -- | -- | NP | ML | SM |
| Δ | B-4 | 0.0-5.0 | -- | -- | NP | ML | SM |
| X | B-5 | 0.0-5.0 | -- | -- | NP | ML | SM |
| + | B-5 | 13.5-15.0 | -- | -- | NP | ML | SM |

NP - INDICATES NON-PLASTIC




PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 4318

FIGURE B-9

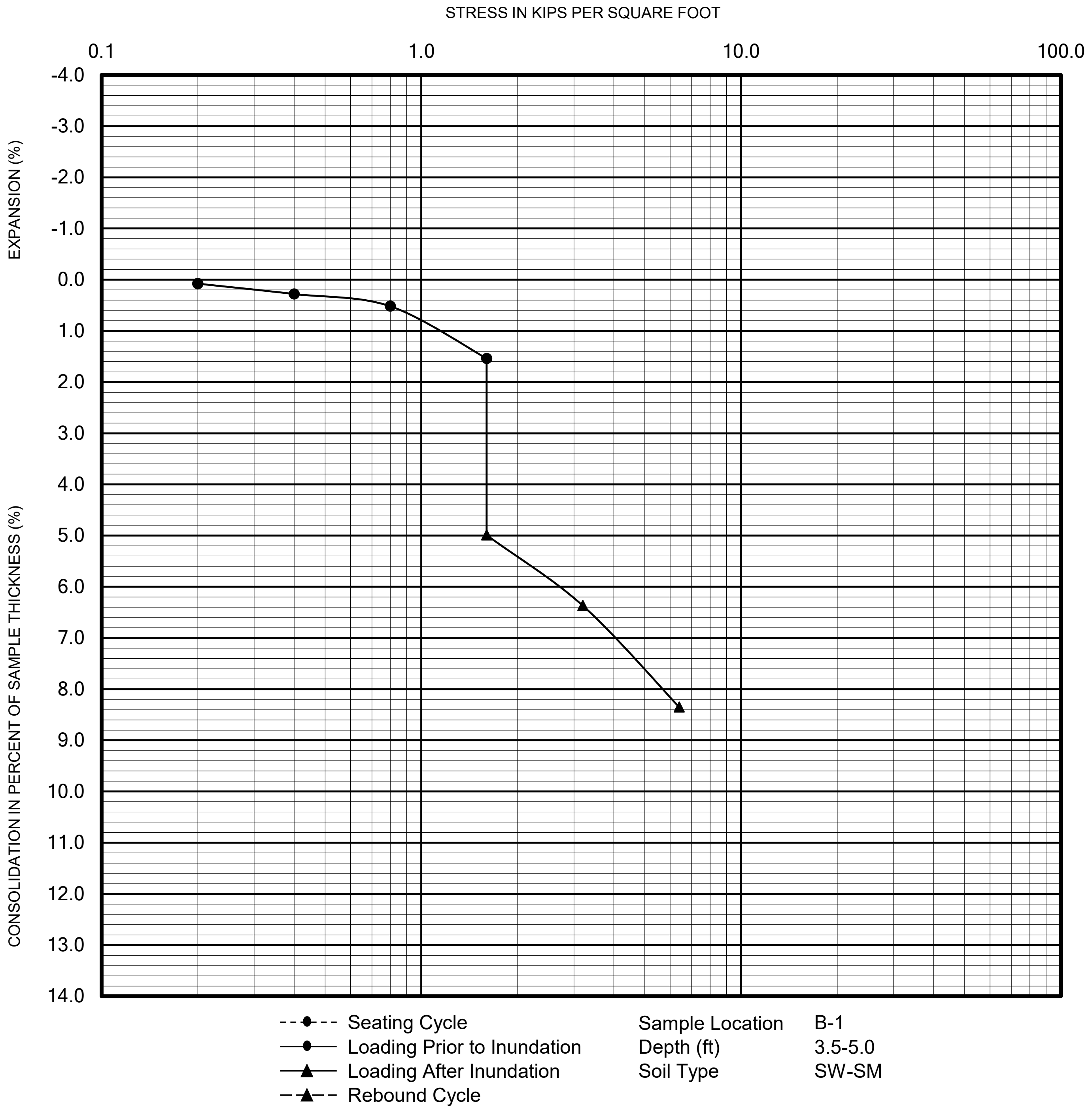
## ATTERBERG LIMITS TEST RESULTS

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA




Ninyo & Moore
Geotechnical & Environmental Sciences Consultants




| | |
|---|---|
| Sample Location | B-1 |
| Depth (ft) | 3.5-5.0 |
| Soil Type | SW-SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-10**

**CONSOLIDATION TEST RESULTS**

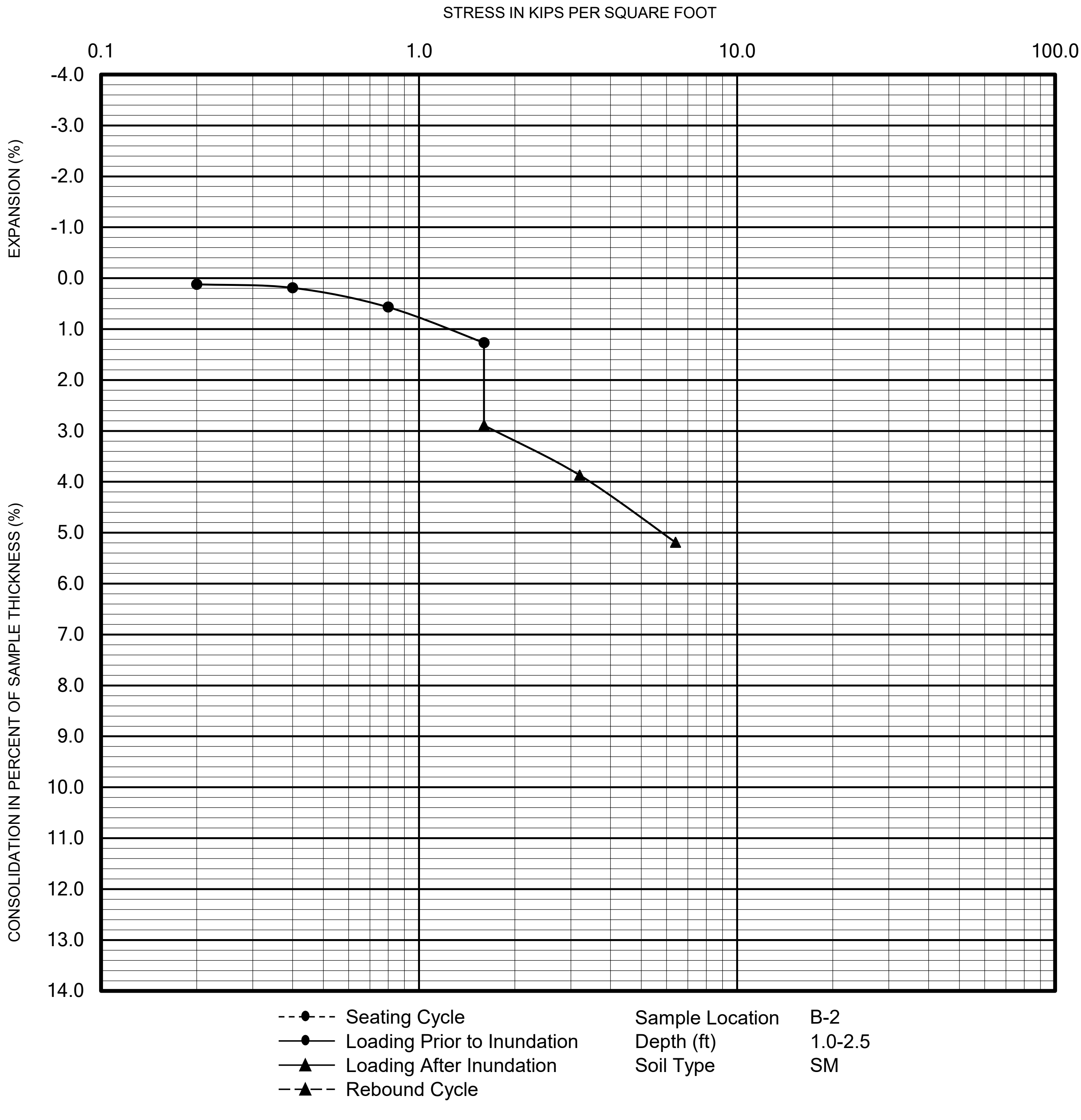
RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants

607834001 | 9/23




| | |
|---|---|
| Sample Location | B-2 |
| Depth (ft) | 1.0-2.5 |
| Soil Type | SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-11**

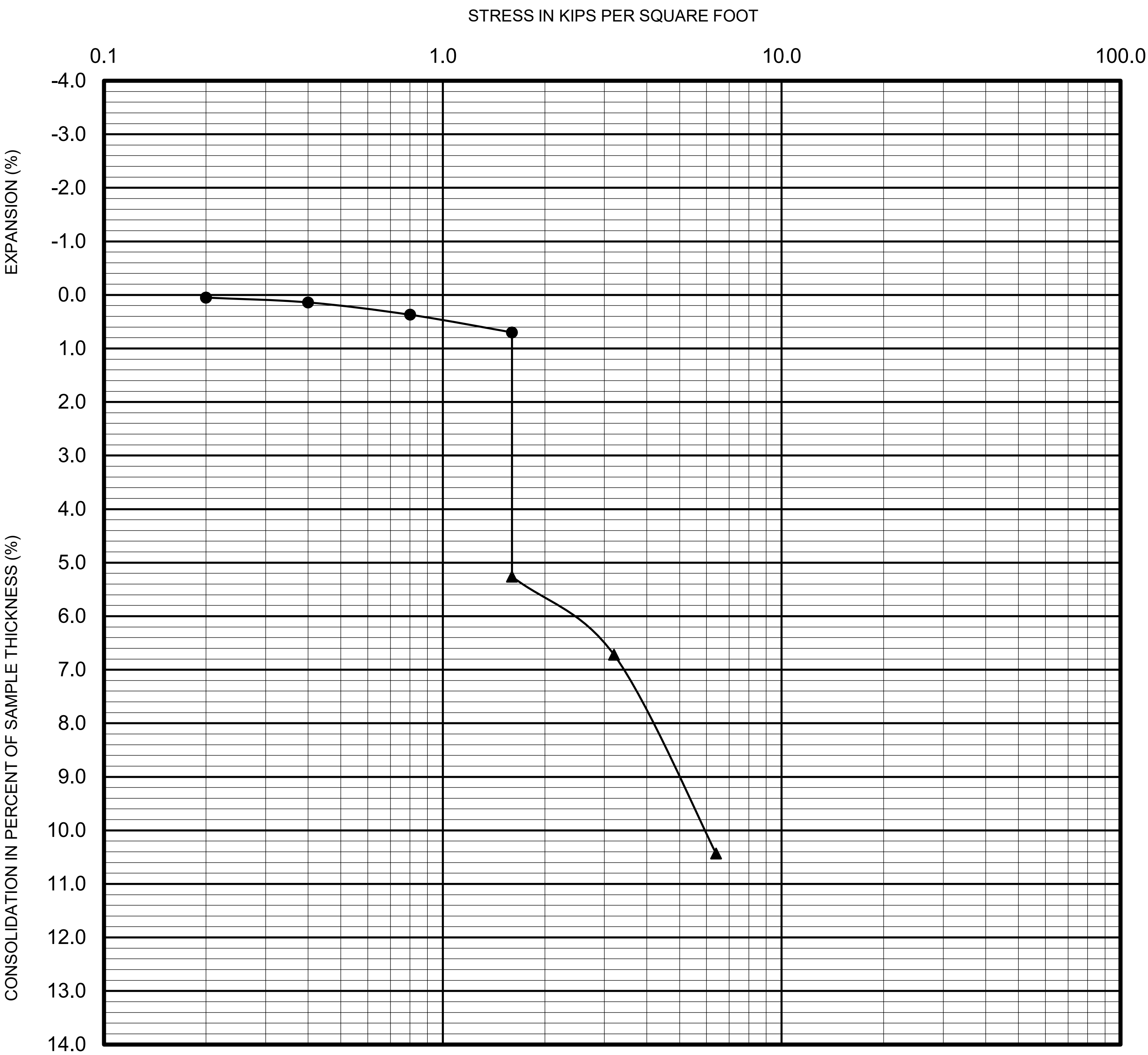
**CONSOLIDATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

607834001 | 9/23

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants




| | | | |
|---|---|---|---|
| - -●- - | Seating Cycle | Sample Location | B-3 |
| —●— | Loading Prior to Inundation | Depth (ft) | 1.0-2.5 |
| —▲— | Loading After Inundation | Soil Type | SM |
| - -▲- - | Rebound Cycle | | |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-12**

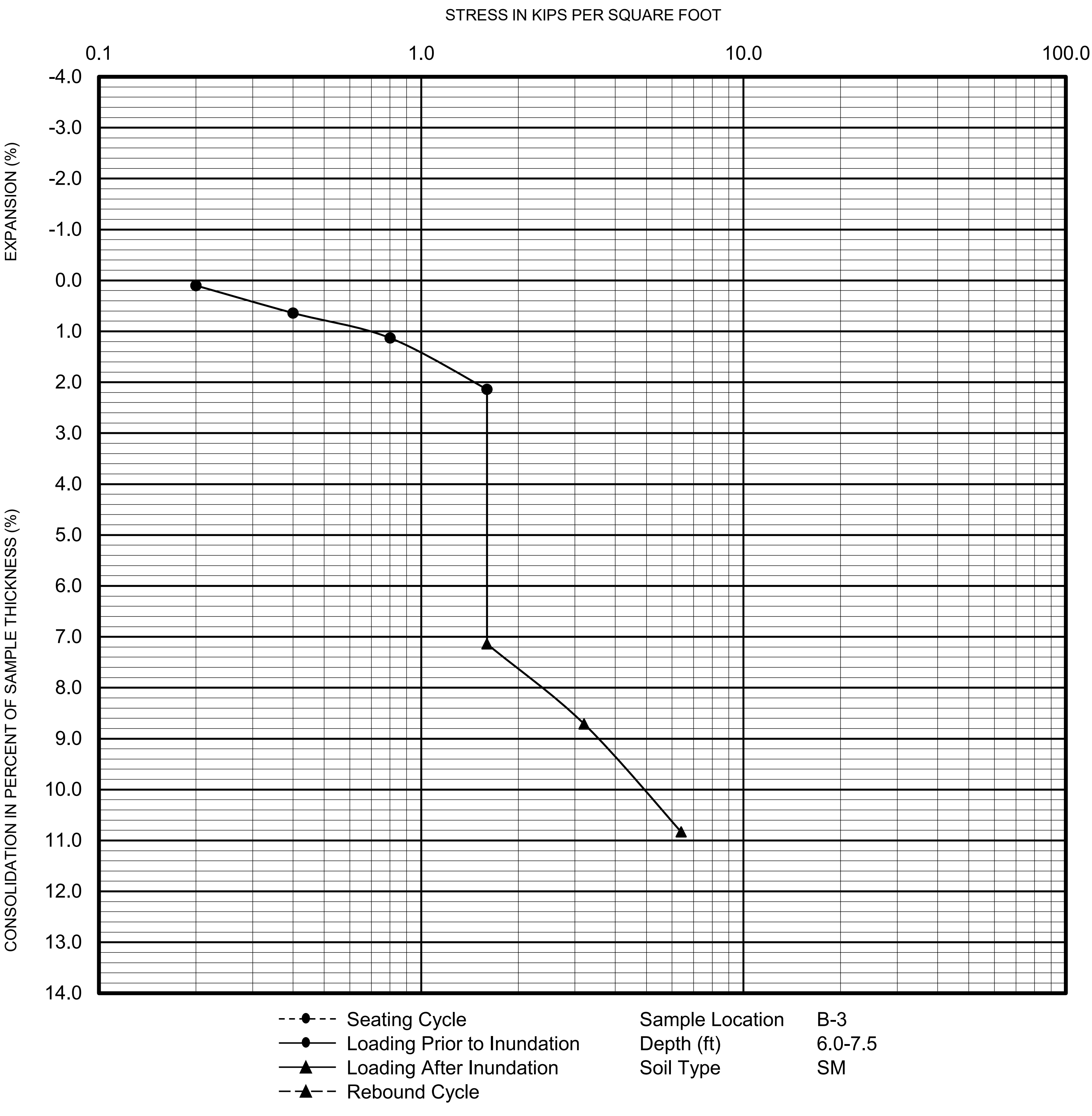
**CONSOLIDATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23




| | |
|---|---|
| Sample Location | B-3 |
| Depth (ft) | 6.0-7.5 |
| Soil Type | SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-13**

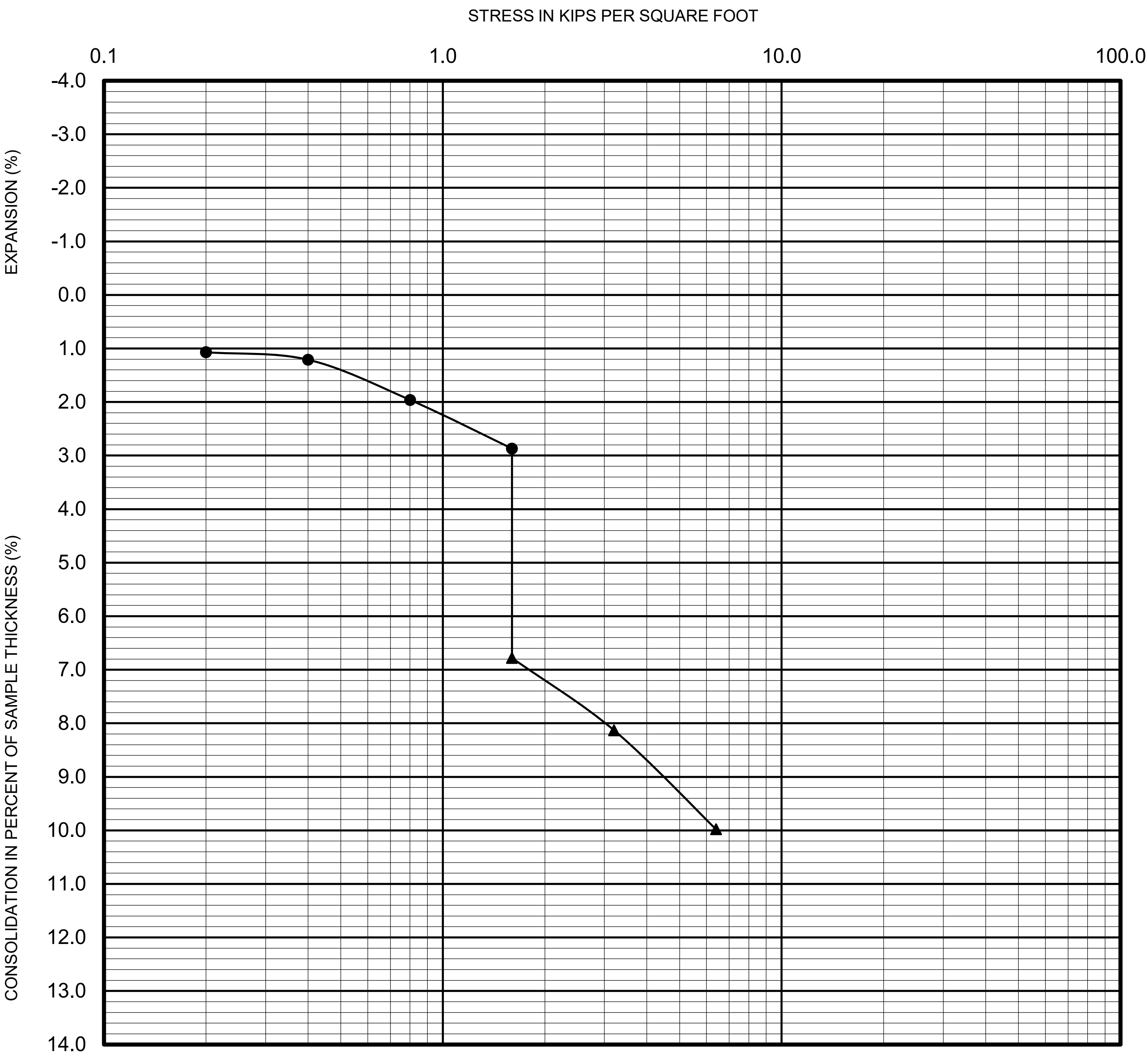
**CONSOLIDATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

607834001 | 9/23

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants




Seating Cycle
Loading Prior to Inundation
Loading After Inundation
Rebound Cycle

| | |
|---|---|
| Sample Location | B-4 |
| Depth (ft) | 3.5-5.0 |
| Soil Type | SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-14**

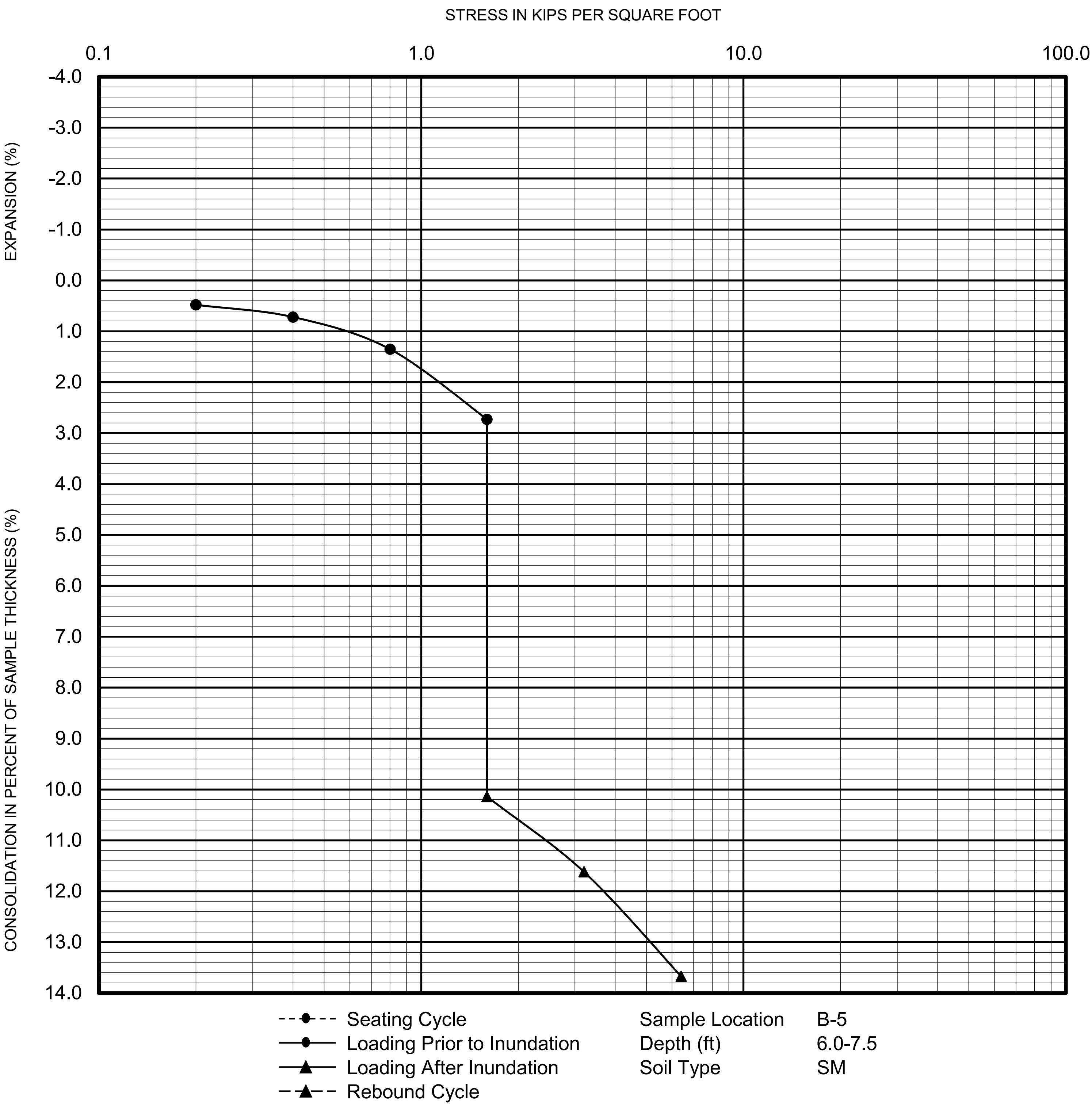
**CONSOLIDATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

607834001 | 9/23




| | |
|---|---|
| Sample Location | B-5 |
| Depth (ft) | 6.0-7.5 |
| Soil Type | SM |

PERFORMED IN GENERAL ACCORDANCE WITH ASTM D 2435

**FIGURE B-15**

**CONSOLIDATION TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R

ORO VALLEY, ARIZONA

607834001 | 9/23

Ninyo & Moore
Geotechnical & Environmental Sciences Consultants

| SAMPLE LOCATION | SAMPLE DEPTH (ft) | pH [1] | RESISTIVITY [1] (Ohm-cm) | SULFATE CONTENT [2] (ppm) | (%) | CHLORIDE CONTENT [3] (ppm) |
|---|---|---|---|---|---|---|
| B-1 | 0.0-5.0 | 8.2 | 10,050 | 50 | 0.005 | 10 |
| B-3 | 0.0-5.0 | 8.1 | 2,615 | 50 | 0.005 | 11 |
| B-5 | 0.0-5.0 | 8.1 | 6,030 | 50 | 0.005 | 17 |

[1] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 236c
[2] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 733
[3] PERFORMED IN GENERAL ACCORDANCE WITH ARIZONA TEST METHOD 736

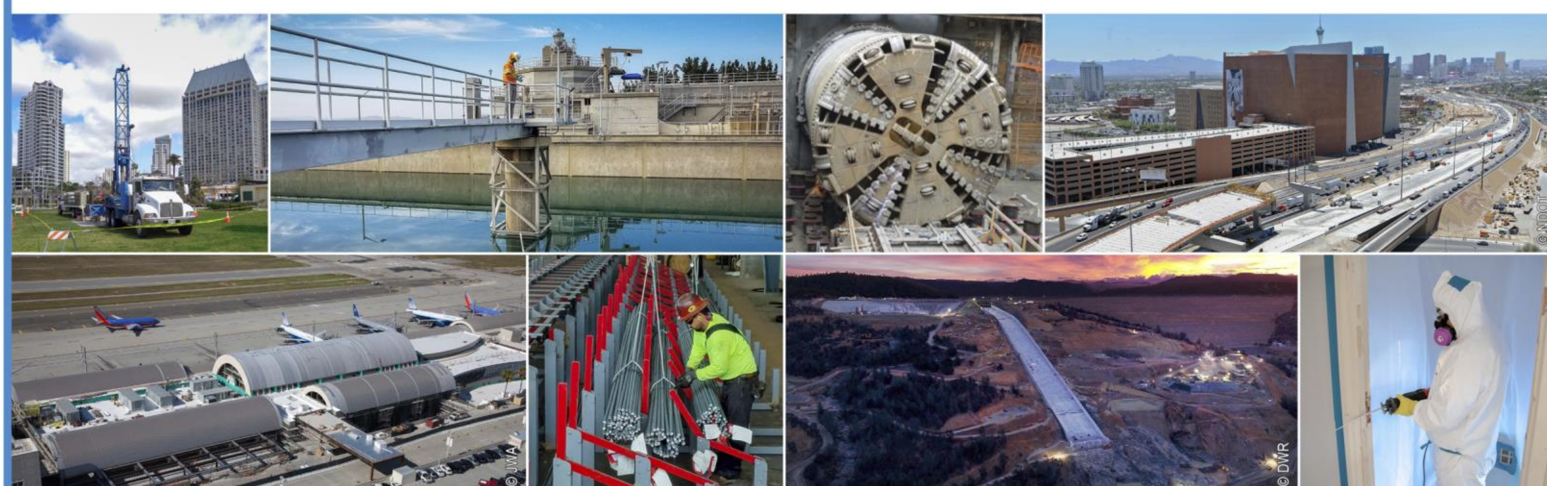


**CORROSIVITY TEST RESULTS**

RANCHO VISTOSO PARCEL 5-R
ORO VALLEY, ARIZONA



Ninyo & Moore
Geotechnical & Environmental Sciences Consultants




1991 East Ajo Way, Suite 145 | Tucson, Arizona 85713 | p. 520.577.7600

ARIZONA | CALIFORNIA | COLORADO | NEVADA | TEXAS | UTAH

www.ninyoandmoore.com

Ninyo & Moore

Geotechnical & Environmental Sciences Consultants