CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GEOTECHNICAL STUDY

Shoshana Ranch
Larimer County, Colorado

This report is not a guarantee of soil composition. Buyers to verify information and soil composition for the lot(s) purchased.

Report Prepared for:

Steve Smith, P.E.
Applegate Group, Inc.
1490 West 121st Avenue, #100
Denver, CO 80234

Project No. 21.3092
January 31, 2022

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Report Prepared by:

Jonathan A. Crystal, P.E.
Project Engineer

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COMMON ABBREVIATIONS AND ACRONYMS

AASHTO ..... **American Association of State Highway and Transportation Officials**
ABC ..... **aggregate base course**
ACI ..... **American Concrete Institute**
ADA ..... **Americans with Disabilities Act**
ADSC ..... **Association of Drilled Contractors**
AI ..... **Asphalt Institute**
APM ..... **asphalt paving material**
ASCE ..... **American Society of Civil Engineers**
ASTM ..... **American Society for Testing and Materials**
AWWA ..... **American Water Works Association**
bgs ..... **below ground surface**
CDOT ..... **Colorado Department of Transportation**
CBR ..... **California Bearing Ratio**
CFR ..... **Code of Federal Regulations**
CGS ..... **Colorado Geological Survey**
CKD ..... **cement of kiln dust stabilized subgrade**
CMT ..... **construction material testing**
CMU ..... **concrete masonry unit**
CTB ..... **cement treated base course**
deg ..... **degree**
EDLA ..... **equivalent daily load application**
e_m ..... **edge moisture variation distance**
EPS ..... **expanded polystyrene**
ESAL ..... **equivalent single axle loads**
f'c ..... **specified compressive strength of concrete at the age of 28 days**
F_a ..... **seismic site coefficient**
FHWA ..... **Federal Highway Administration**
FS ..... **factor of safety**
F_V ..... **seismic site coefficient**
GSA ..... **global stability analysis**
GVW ..... **gross vehicle weight**
IBC ..... **International Building Code**
ICC-ES ..... **International Code Council Evaluation Services, Inc.**
IRC ..... **International Residential Code**
kip ..... **1,000 pounds-force**
km ..... **kilometer**
LTS ..... **lime treated subgrade**
MDD ..... **maximum dry density**
mg/L ..... **milligrams per liter**
MGPEC ..... **Metropolitan Government Pavement Engineers Council**
mm ..... **millimeter**
Mr ..... **resilient modulus**
MSE ..... **mechanically stabilized earth**
mV ..... **millivolts**
NAPA ..... **National Asphalt Pavement Association**
N_{DESIGN} ..... **design gyrations**

OMC..... optimum moisture content
OSHA ..... Occupational Safety and Health Administration
OWTS ..... onsite wastewater treatment system
PCA..... Portland Cement Association
PCC..... portland cement concrete
pcf ..... pounds per cubic foot
pci..... pounds per cubic inch
pH..... power of hydrogen
psf ..... pounds per square foot
psi..... pounds per square inch
PT ..... post-tension
RAP..... recycled asphalt pavement
S_s ..... mapped spectral accelerations for short periods
UBC ..... Uniform Building Code
USGS ..... United States Geological Survey

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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1. PURPOSE

1.1 GENERAL

Cesare, Inc. (Cesare) performed a preliminary geotechnical study of Shoshana Ranch, a proposed residential development located about 12-1/2 miles west of Livermore, Colorado on Larimer County Road 74, also known as Red Feather Lakes Road, as shown in the vicinity map presented in Figure 1. The study was made to characterize existing subsurface conditions at the site and provide preliminary design criteria for planning and site development, with general discussion regarding foundation systems, interior floor systems, exterior flatwork, surface and subsurface drainage adjacent to structures, and other pertinent geotechnical issues. Information gathered during the field exploration and laboratory testing is summarized in Figure 1 and Appendices A through C. Cesare's opinions and recommendations presented in this report are based on data generated during this field exploration, laboratory testing, and its experience. Cesare's opinions and recommendations presented in this report are based on data generated during this field exploration, laboratory testing, and its experience.

Cesare also performed a preliminary pavement thickness design for a proposed roadway for the development. The appropriate time for pavement design is after the roadway is rough graded to within 1 foot of finished surface grade. "Larimer County Rural Area Road Standards" (Larimer Road Standards) requires a maximum boring spacing of 500 feet along the roadway alignment. A final pavement design should be performed for this project at that time as the exploration performed for this study was insufficient for Larimer Road Standards.

1.2 SCOPE OF SERVICES

The scope of services performed is detailed in Cesare's Proposal Agreement No. F211105 for which a work order was executed on December 21, 2021.

2. SUMMARY OF FINDINGS AND CONCLUSIONS

This section is intended as a summary only and does not include design details. The report should be read in its entirety and utilized for design.

- The soil encountered consisted of sand with clay to clayey and varying amount of gravel and gravel with clay and sand to depths of about 1/2 to 6 feet. Granite bedrock was encountered below the soil and outcropped in several areas. The bedrock refused backhoe bucket penetration in all cases.
- A geologic hazards study was performed for this project and reported under separate cover. Larimer County geologic hazard areas map indicates the majority of the ranch is in a low hazard classification with an area of moderate hazard north of the site. Geologic hazards of significance include radon potential, site grading induced landslides in steeper areas, rockfall in the Haystack Butte and northern boundary areas, low hazard of debris flow on and below steeper slopes, and potentially swelling soil. The subsurface conditions exhibit Seismic Site Classification A characteristics.
- Due to the presence of shallow bedrock, shallow foundations can provide structural support for the various buildings to be constructed. Any building should bear on a single material type, which should be bedrock at this site. Where a potential bearing condition would include soil at footing bearing depth, the footing should be extended deeper to

bear on rock. The alternative would be to excavate or place structural fill as necessary to provide at least 2 feet of soil below all footings.

- Good surface drainage should be established and positive drainage away from the pavement and other site improvements should be provided during construction and maintained throughout the life of the project.
- The preferred pavement section consists of full depth ABC. The full ABC should be at least 21-1/2 inches thick and placed on compacted subgrade.

3. SITE CONDITIONS

The site is about 800 acres in plan area located about 12-1/2 miles due west of Livermore, Colorado; north of Red Feather Lakes Road, as shown in the vicinity map presented in Figure 1. The site is currently undeveloped land, likely used historically for livestock grazing. The site is bounded by Red Feather Lakes Road on the south and surrounded by other largely undeveloped properties around the remainder of its perimeter, with the exception of isolated residences to the west. Topography of the site is gently sloping over most of its southern 3/4 and very steep over its northern 1/4. Bedrock outcrops in the middle of the southern 3/4 and practically the entire northern 1/4. The maximum elevation differential across the southern 3/4 is estimated to be about 370 feet and about 440 feet for the northern 1/4. Topography adjacent to the site is more consistently mountainous.

Vegetation onsite consists of a heavy growth of native grasses, weeds, and shrubs on the lower elevations and moderate to dense stands of coniferous trees on the steep areas. Gordon Creek is perennial and flows through the ranch from the ranch's northwestern corner and exiting the ranch near its southeastern corner. An unnamed pond, likely for livestock watering, is located in the creek alignment. Granite bedrock outcrops onsite in a topographic high area in the middle of the ranch and are predominant on the entire northern 1/4.

Photo 1. View looking northeast at Haystack Butte from Pit TP-1.

Photo 2. View looking southeast from Pit TP-3.

Photo 3. View looking northwest from Pit PT-6.

4. PROPOSED CONSTRUCTION

The project is currently proposed as a residential subdivision for individual residences on parcels averaging 33 acres in plan area. Cesare understands the subdivided lots will be sold and the individual parcel owners will be responsible for site preparation and building construction.. Cesare anticipates

the residences will be wood frame, up to two stories in height, possibly with basements. Onsite wastewater treatment systems (OWTS), commonly referred to as septic systems, are also anticipated. Foundation loads of 2 kips per lineal foot, or less, on walls are anticipated.

The developer will construct a roadway to provide primary access within the ranch, but the parcel owners will construct the final access from the primary roadway to their properties. The primary roadway will be paved with full depth ABC as the wear course. The primary roadway surface is intended to meet Larimer Road Standards structural requirements. The proposed roadway is estimated to be over 14,000 feet in length, or over 2-1/2 miles, of two-lane roadway. Cesare anticipates the roadway will follow existing contours, as much as possible, with cuts and fills of less than 3 feet and onsite soil will be used for fill.

5. PREVIOUS STUDIES

Cesare prepared a geologic hazards assessment[1] of the ranch as part of this project. This report was submitted under separate cover and will be referred to in this report.

6. GEOLOGIC CONDITIONS

The site geology was described in the geologic hazards report described previously. The following information was excerpted from that document.

The "Geologic Map of the Fort Collins 30' X 60' quadrangle, Larimer and Jackson Counties, Colorado, and Albany and Laramie Counties, Wyoming," by Jeremiah B Workman, et al.; USGS SIR 3399, 2018, indicates the bedrock on the site is granite of the Log Cabin batholith.

7. FIELD EXPLORATION

Subsurface conditions were explored on December 13, 2021 by excavating ten exploratory pits to depths of about 2 to 6-1/2 feet at the locations indicated in the exploratory pit location plan presented in Appendix B. Small bulk samples were recovered of major material types exposed. Graphical logs depicting the subsurface conditions observed, locations of sampling, and further explanation of the exploration are presented in Appendix A.

[1] Letter prepared by Cesare, Inc., Subject: Geologic Hazards Assessment, Shoshana Ranch, Larimer County, Colorado, Project No. 21.3092, dated January 6, 2022.

Photo 4. View looking north at Exploratory Pit TP-3.

8. LABORATORY TESTING

Cesare personnel returned samples obtained during field exploration to its laboratory where professional staff visually classified them and assigned testing to selected samples to evaluate pertinent engineering properties. Laboratory tests performed are listed in Table 8.1. Further discussion of laboratory testing, a summary of laboratory results, and the individual laboratory test results are presented in Appendix B.

TABLE 8.1. Laboratory Testing Performed

Laboratory Test	To Evaluate
Grain size analysis	Grain size distribution for classification purposes.
Atterberg limits	Soil plasticity for classification purposes.
Moisture/density relationship	Determine maximum density and optimum moisture content for compaction evaluation
R-value	Determine soil strength for pavement section design
Water soluble sulfate	Evaluate sulfate content for reaction potential with concrete

9. SUBSURFACE CONDITIONS

Cesare's exploratory pits encountered:

- Overburden soil consisting of sand with varying amounts of silt, clay, and gravel and gravel with clay and sand to depths of about 1/2 to 6 feet.
- Granite bedrock, which refused penetration by the backhoe bucket, below the soil at all locations.

Groundwater was not encountered to the maximum depth explored of 2 to 6-1/2 feet at the time of excavation. Pits were backfilled at the completion of excavation before leaving the location. A more complete description of the soil and groundwater conditions encountered is depicted in the

exploratory pit logs presented in Appendix A.

The subsurface conditions encountered in Cesare's borings are reasonably consistent with those described in Section **6. GEOLOGIC CONDITIONS**. These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations. Groundwater can be expected to fluctuate and can be influenced by variations in seasons, weather, precipitation, drainage, vegetation, landscaping, irrigation, leakage of water and/or wastewater systems, etc., both onsite and offsite. Discontinuous zones of perched water may exist or develop within the overburden material and/or upper zones of the bedrock. Cesare's field explorations were performed during the fall when groundwater levels are usually lowest. Groundwater levels may be higher in the spring and early summer.

10. GEOLOGIC HAZARDS

Cesare performed a geologic hazards assessment for this project, submitted under separate cover. The geologic hazards indicated in that report included swelling soil, radon, landslides, rockfall, and debris flow. The geologic hazards report should be reviewed for details.

11. GEOTECHNICAL CONSIDERATIONS

The ranch has a relatively thin veneer of soil ranging from about 1/2 foot to 6 feet overlying granite bedrock. The lesser veneer was found over the steeper slopes and greater veneer was found over the less mountainous portion of the ranch. The soil is granular, consisting primarily of sand with varying amounts of silt, clay, and gravel; with lesser amounts of gravel with clay and sand encountered. Sand classifications ranged from sand with fines to clayey sand. These conditions will allow using shallow spread foundations to support the residences.

The subsurface conditions encountered will require site specific geotechnical evaluations. Each building pad should be explored to evaluate the site specific soil cover and bedrock conditions. The conditions will likely impact building details, such as location and depth of basements, and construction methods more so than foundation design as very high bearing capacities are likely for the bedrock.

Cesare estimates most, if not all, parcels will require rock excavation for structures, particularly if basements are desired. Rock excavation will likely require blasting in most cases.

12. FOUNDATIONS AND RETAINING WALLS

12.1 SPREAD FOOTINGS

The proposed structures can bear on conventional spread footings or pad type footings bearing on either natural undisturbed soil and/or structural fill below frost depth, or on bedrock. Design should address the following:

a) Foundations for any structure should bear on a single material type, either bedrock or soil. At this location, considering the relatively shallow bedrock contact, soil exposed in footing excavations should be removed to an extent sufficient for the footing to bear entirely on rock. The rock bearing surface should be cut or stepped to provide a reasonably horizontal surface.

b) Frost does not affect granite bedrock; such that footing depths need be only 24 inches on bedrock. The soil encountered ranged from negligible to medium susceptibility to frost. Footings bearing in soil should have a minimum depth of 36 inches.
c) Allowable bearing pressures in rock can range from about 5,000 to 10,000 psf. Allowable bearing pressures in soil can range from 2,000 to 3,000 psf. These bearing pressures should consider dead load plus full live load.
d) Excavated rock will likely have a very rough exposed surface.
e) A Cesare representative should observe all footing excavations prior to concrete placement to evaluate if bearing conditions are consistent with those assumed and utilized in developing these recommendations.

12.2 RETAINING WALLS

Due to the grade changes across the ranch, retaining walls will likely be required. MSE walls will likely be used for exterior grading and should bear on granite bedrock. MSE wall design should address the following:

a) A design frost depth of 24 inches can be used for bedrock bearing and 36 inches should be used for soil bearing conditions.
b) The base of the wall should be designed for allowable bearing pressures of 5,000 to 10,000 psf for walls bearing on bedrock and 3,000 psf for walls bearing on soil and considering dead load plus full live load.
c) Excavated rock will likely have a very rough surface exposed. For MSE wall elements, a high strength flowable grout can be placed to smooth the excavated surface below the elements.
d) Walls bearing on soil should have all soft or loose soil beneath footing areas densified in place or removed and replaced with properly compacted structural fill.
e) A Cesare representative should observe all footing excavations prior to concrete placement to evaluate if bearing conditions are consistent with those assumed and utilized in developing these recommendations.

12.3 LATERAL EARTH PRESSURES

Lateral pressures on walls depend on the type of wall, hydrostatic pressure behind the wall, type of backfill material, and allowable wall movements. Cesare recommends drain systems be constructed behind walls to reduce the potential for hydrostatic pressures to develop. Where anticipated/permissible wall movements are greater than 0.5% of the wall height, lateral earth pressures can be estimated for an "active" condition. Where anticipated/permissible wall movement is less than approximately 0.5% of the wall height or wall movement is constrained, lateral earth pressures should be estimated for an "at rest" condition.

The backfill material should not be coarse and blocky, rather, it should have a maximum particle size of 2 inches as it will likely be placed with small walk behind compaction equipment. If little soil is available for backfill on the parcels in the more mountainous areas, import material may be required. The backfill should be free draining; however, provisions should be made for water to exit through weep holes in the wall or collected and discharged away from the wall to alleviate buildup of hydrostatic pressure.

13. CONCRETE SLAB-ON-GRADE: INTERIOR AND EXTERIOR

The natural granular soil is estimated to exhibit zero swell potential. Concrete slabs placed on this material or on properly placed structural fill comprised of this material do not require special considerations for accommodating movement as a result of expansive soil. If soil is imported for pad development, expansive soil should be avoided. Details regarding specific slab support will depend on the site specific conditions and should be evaluated on a case-by-case basis. Treatment of the soil recommended to reduce potential movement of interior floors is applicable to exterior flatwork.

Exterior flatwork supported on foundation wall backfill may settle and crack if the backfill is not properly moisture conditioned and compacted. Exterior flatwork should be isolated from the structures. Exterior flatwork should be expected to move due to foundation wall backfill consolidation, although measures can be incorporated into construction to limit the movement or effects of the movement. Cesare recommends flatwork not be doweled into structure foundations, but rather supported on a haunch to limit settlement. The haunch should extend the full length of the slab. To reduce potential movement, the soil below the planned flatwork can be moisture conditioned and compacted or replaced with flowable low strength grout..

14. EXCAVATIONS

Difficulty may be experienced in developing the individual residences due to the very hard granite bedrock. Shallow utility and footing trenches will likely encounter this very hard granite and will likely require at least jackhammering and probably blasting. Bearing material loosened by jackhammering or blasting should be compacted or removed.

Conventional earthmoving equipment should be adequate to excavate the onsite soil, although it is typically only a thin veneer. All excavations should be properly sloped and/or braced, and local and federal safety codes observed. Slopes and other areas void of vegetation should be protected against erosion.

It is the contractor's responsibility to provide safe working conditions and comply with the regulations in OSHA Standards-Excavations, 29 CFR Part 1926. The following guidelines are provided for planning purposes. Sloping and shoring requirements must be evaluated at the time of construction by the contractor's competent person as defined by OSHA. The geotechnical engineer is NOT the contractor's "competent person" by default or delegation. OSHA classifications for various material types and the steepest allowable slope configuration corresponding to those classifications are shown in Table 14.1.

TABLE 14.1. Allowable Slope Configuration for Onsite Material

Material Type	OSHA Classification	Steepest Allowable Slope Configuration*
Granite bedrock	Stable rock	Vertical
Shot rock, Coarse angular soil	Type B	1:1
Granular overburden soil	Type C	1-1/2:1

* Units horizontal to units vertical. The values shown apply to excavation less than 20 feet in height. Conditions can change and evaluation is the contractor's responsibility.

The preceding classifications and slope configurations assume that excavations are above the groundwater table, there is no standing water in the excavations, and there is no seepage from the slope into the excavations, unless otherwise specified. The preceding classifications and slope configurations assume that the material in the excavations is not fractured, adversely bedded, jointed, nor left open to desiccate, crack, or slough, and is protected from surface runoff. There are other considerations regarding allowable slope configurations that the contractor is responsible for, including proximity of equipment, stockpiles, and other surcharge loads to the excavation. The contractor's competent person is responsible for all decisions regarding slope configuration and safety conditions for excavations.

Permanent slopes depend on the material and should be individually evaluated and protected from erosion.

15. STRUCTURAL FILL

Structural fill for site grading will depend on the extent of fill required. If a building pad requires significant fill depth, greater than 5 feet, the lower portion of the fill can be rockfill with a maximum size particle of 3 feet in maximum dimension. Blasting patterns should be designed to create the appropriate size material. Rockfill can be placed and densified using a method specification based on the number of passes of compaction equipment over the fill surface to be verified with full-time observation by professional construction material staff. Sufficient finer grained fill should be placed in the upper few feet to allow footing and utility construction.

Pads requiring less than 5 feet should use finer grained fill with a 2 inch maximum particle size. Compaction requirements for finer grained fill should be developed for each parcel.

Finer grained fill from onsite sources and material imported for structural fill should be similar in quality. Fill material should be well graded, low permeable material meeting the example specifications in Table 15.1 or as otherwise tested and approved by the project geotechnical engineer.

TABLE 15.1. Import Fill Specifications

Soil Parameter	Specification
Maximum particle size	2 inch
Percent finer than No. 200 sieve	15% to 40%
Liquid limit	0% to 40%
Plasticity index	0% to 15%
Swell potential under anticipated loads	less than 1%*

* Upon inundation, when remolded to 97% maximum dry density at 1% below the optimum moisture content per ASTM D698 at a surcharge pressure of 100 psf.

16. SUBSURFACE DRAINAGE

Groundwater was not encountered during this study. Basement foundation systems; however, will be excavated into relatively impervious bedrock. This creates a depression around the structure backfilled with soil. Infiltration through the backfill from precipitation and runoff can collect in this depression and create a perched water condition that can cause foundation and floor slab problems, including water in the below grade areas.

Cesare recommends that the basement and/or crawlspace be provided with an exterior perimeter subsurface drainage system. The system shall be sloped to drain to a suitable gravity outlet or a sump. A pump must be installed if a sump is used. The drainage system shall consist of perforated, machine slotted, or equivalent rigid plastic pipe placed around the perimeter of the basement or crawlspace foundation. Pipes with a smooth interior are recommended. Pipes that are corrugated on the interior can become obstructed more easily than pipes with smooth interiors and may be more difficult to clean. A recommended drain schematic is shown in Figure 2.

17. SURFACE DRAINAGE

Good drainage and surface water management is important. Performance of site improvements, such as foundations, floors, hardscape, and pavement are often adversely affected by failing to establish and/or maintain good site drainage. Grades must be adjusted to provide positive drainage away from the structures, pavement, and other site improvements during construction and maintained throughout the life of the proposed facility.

18. PAVEMENT RECOMMENDATIONS

The appropriate time for pavement design is after the roadway is rough graded to within 1 foot of finished surface grade. Larimer Road Standards requires a maximum boring spacing of 500 feet along the roadway alignment centerline. A final pavement design should be performed for this project at that time as the exploration performed for this study was insufficient for Larimer Road Standards.

This pavement design analysis included evaluating engineering properties of the subgrade material over the lower lying areas of the ranch for preliminary design. Based on broad based exploration, subgrade strength correlations, roadway use, traffic, and loosely on Larimer Road Standards, preliminary pavement sections were determined. At the request of Applegate Group, Inc., the pavement section consists of full depth ABC. This pavement design analysis was not intended to strictly meet all criteria in the Larimer Road Standards.

Full depth ABC pavement section will likely require a high level of maintenance due to the lack of binding material in the material. ABC used for wear course would require modification by increasing the amount finer than the #200 screen, preferably clay, to hold the material together. Even with this, increased maintenance would be required.

Recycled asphalt pavement (RAP) has performed well as a wear course on low traffic roadways in Colorado due to the asphalt remaining in the material. Cesare recommends at minimum placing at least 4 inches of RAP on the roadway for a wear course. The pavement sections presented in following sections include using RAP as a wear course and full depth RAP as alternatives. RAP would still require maintenance, but not as much as ABC.

An attempt was made to obtain pricing for RAP and ABC to assist in evaluation; however, little pricing data was made available. What was obtained included the City of Fort Collins will sell stockpiled RAP for $10/ton and CDOT price data indicated ABC costs of about $35 to $40/ton, which likely delivered. A civil engineering consultant in Loveland indicated a cost of about $24/yd^3 delivered.

18.1 DESIGN CRITERIA

The pavement recommendations contained in this report are loosely based on Larimer Road Standards and the design parameters indicated in Table 18.1. Cesare's R-value test was not complete at the time of this writing. Cesare estimated an R-value of 25 for a preliminary pavement design, to be updated when the R-value results are available.

TABLE 18.1. Pavement Design Parameters

Design Parameter	Value
Design period (years)	20
Initial serviceability (ρ_s)	4.5
Terminal serviceability (ρ_t)	2
Serviceability loss (ρ_s-ρ_t)	2.5
Reliability, Z_r (%)	75
Overall standard deviation, S_o APM	0.44
Total 18 kip ESAL's/EDLA • Rural residential collector (FHWA)	100,000
Subgrade strength • R-value (estimated) • Resilient modulus, Mr (psi) (by correlation to R-value per CDOT)	 57 16,617
Structural layer coefficients for: a. RAP (R-value >90) b. ABC (R-value >69)	 0.19 0.11

Deviation from the preceding parameters will require a revision to the recommended pavement section thicknesses. If the subgrade becomes saturated, the pavement is not properly maintained, and/or the actual traffic is greater than the values used in the design, the design service life will be reduced.

18.2 PAVEMENT THICKNESSES

Most of the shallow subgrade soil consists of sand with clay and gravel and gravel with clay and sand. According to FHWA-RD-97-083 Design Pamphlet for the Determination of Design Subgrade in Support of the 1993 AASHTO Guide for the Design of Pavement Structures, dated September 1997, this material is considered good and good to excellent, respectively, for pavement subgrade. Localized areas of clayey sand were encountered, which are considered poor to fair. Recommended pavement sections are shown on Table 18.2.

TABLE 18.2. Recommended Pavement Section Thicknesses

Traffic Area	Alternate	Recycled Asphalt (in)	ABC (in)
Residential Collector	ABC	--	14.0
	Recycled asphalt+ABC	4	7.5
	Recycled asphalt	8.5	--

18.3 SPECIAL CONCERNS

18.3.1 Swell Potential

The predominant soil encountered on the ranch was sand with clay, the clay content for which varied from about 6% to 21%. Table 5.1 of the Larimer Road Standards indicates this soil has a low expansion classification, estimated to exhibit less than 1% swell upon wetting at a surcharge load of 150 psf. Larimer County does not require special treatment of subgrade with swell potential of less than 2%.

Table 5.1 of Larimer Road Standards indicates the clayey sands encountered are estimated to exhibit 1% to 5% swell under a 150 psf surcharge. The potentially swelling subgrade soil was encountered in Pits TP-3 and TP-10A. Larimer County requires the soil encountered in these areas require mitigation. The likely mitigation would be primarily excavating the native soil to a depth sufficient to provide at least 2 feet of moisture conditioned and properly compacted native soil below finished subgrade elevation. This must be verified prior to or during construction. An alternative mitigation is to remove the expansive material to 2 feet below finished subgrade elevation and replace it with non-expansive material from elsewhere on the ranch.

18.3.2 Frost Heave

The soil encountered onsite has low to high susceptibility to frost heave. The presence of water is required for frost heave to occur. Groundwater was not encountered during this study to refusal depths of 2 to 6 feet below existing grades. In Cesare's opinion, infiltration of surface water is the most likely source for moisture in the pavement section. Maintaining surface drainage will keep the potential for distress due to frost heave low and will help increase pavement longevity.

18.4 SUBGRADE PREPARATION AND PAVEMENT CONSTRUCTION

18.4.1 Excavation Below Pavement

Where encountered, the clayey sand subgrade should be excavated a minimum 2 feet below finished subgrade elevation. This excavation should extend the entire width of the roadway to 1 foot beyond the shoulders. The clayey sand subgrade can be reused by moisture conditioning and compacting it in the excavation from where it was removed. Backfill material should be placed in loose lifts and compacted to at least 95% of MDD at OMC ± 2%.

18.4.2 Pavement Subgrade

At least the top 12 inches of the subgrade should be uniformly moisture conditioned in accordance with the guidelines presented in Section **18.4.1 Excavation Below Pavement**. Blading, tilling, windrowing, watering, or drying shall be performed, as needed, to achieve the moisture/density specification to the required depth. It is Cesare's experience that scarifying to a depth of 12 inches in-place and attempting to compact 12 inches of scarified material in one lift is usually not successful in achieving a uniformly moisture conditioned and adequately compacted subgrade.

If RAP is used, prior to placing RAP, the entire subgrade should be proof rolled with a loaded 988 front end loader or similar heavy rubber tired vehicle having a GVW of 50,000 pounds with 18 kip per axle at tire pressures of 90 psi to detect any soft or loose areas. All areas exhibiting unstable subgrade conditions, such as rutting, pumping, or excessive movement should be excavated to a

firm soil layer or to a maximum depth of 2 feet, whichever is shallowest, and replaced with suitable compacted fill. If unstable subgrade conditions persist, Cesare should be contacted for consultation. Soft spots should be stabilized prior to placement of pavement sections. Positive drainage off paved surfaces should be provided.

18.4.3 Aggregate Base Course

ABC should meet the following requirements:

- ABC material should meet CDOT Standard Specifications for Road and Bridge Construction, Section 700, dated 2021 for Class 4 or 5 ABC, with the exception of the material finer than 75μm, or #200 screen, should range between 15% and 25%.
- ABC material should be approved prior to construction and should subsequently be tested as the material is being placed.
- ABC should have a minimum R-value of 69.
- ABC material should be compacted to a minimum of 95% of the MDD as determined by the modified Proctor test, ASTM D1557.

18.4.4 Recycled Asphalt

RAP construction shall be in accordance with the following recommendations and criteria:

- RAP shall meet the requirements in the CDOT specifications Table 703.3.
- RAP material should be approved prior to construction and should subsequently be tested as the material is being placed.
- RAP should have a minimum R-value of 90.
- RAP material should be compacted to a minimum of 95% of the MDD as determined by the modified Proctor test, ASTM D1557.

19. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical study. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical study should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to help the structure/pavement perform in a satisfactory manner based on the information generated during this study, training, and experience in working with these conditions.

20. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of Applegate Group, Inc. for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this study are valid as of the date its preparation. Changes in the conditions of a

property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether a result from legislation or the broadening of knowledge. Accordingly, the findings of this study may be invalidated wholly or partially by changes outside of Cesare's control, therefore, this study is subject to review and should not be relied upon without such review after a period of 3 years.

In the event that changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either confirms or modifies the conclusions of this report in writing.

Cesare should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this study were selected to obtain a reasonably accurate depiction of underground conditions for design purposes and these locations are often modified based on accessibility and the presence of underground or overhead utility conflicts. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to Cesare's design recommendations, therefore, Cesare should be retained to observe subsurface conditions, once exposed, to evaluate whether they are consistent with the conditions encountered during Cesare's exploration and that the recommendations of this study remain valid. If parties other than Cesare perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

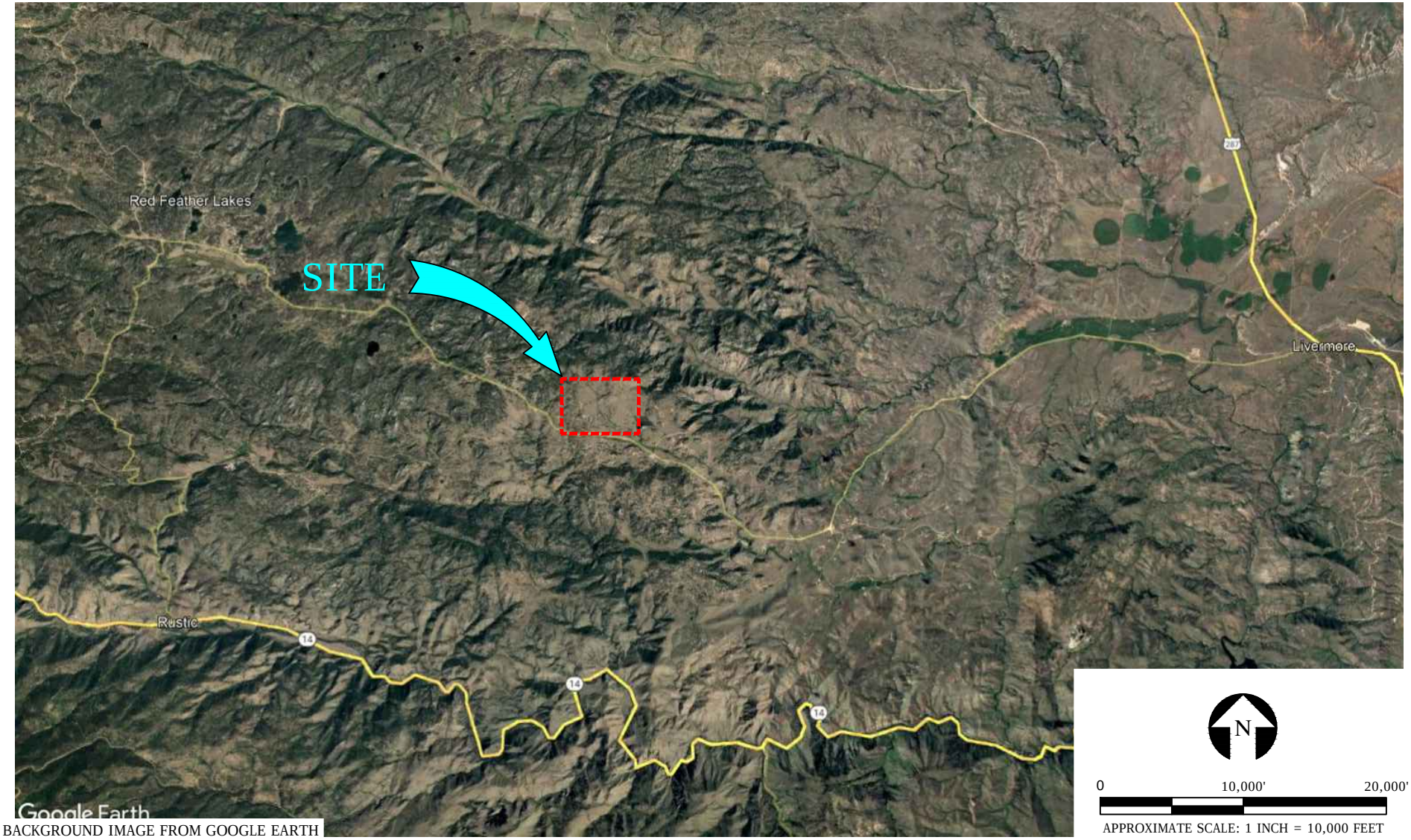
Cesare's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions. Additionally, none of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not, of itself, be enough to prevent mold from growing in or on the structures involved.

At a minimum, Cesare should be retained during construction to observe and/or test:

- placement and compaction of fill.
- proposed import or onsite fill material.
- placement and compaction of pavement subgrade, subbase, and base course.

Cesare offers many other construction observations, materials engineering, and testing services and can be contacted to discuss further.

W:\2021\Frederick\21.3092.A Shoshana Ranch\ACAD\Boring Location Map.dwg 1/17/2022 4:54 PM



BACKGROUND IMAGE FROM GOOGLE EARTH

PROJECT NO:	21.3092		
PROJECT NAME:	Shoshana Ranch		
DRAWN BY:	JBE	CHECKED BY:	JAC2
DWG DATE:	01.11.22	REV. DATE:	--

FIGURE 1
Vicinity Map

CESARE, INC.
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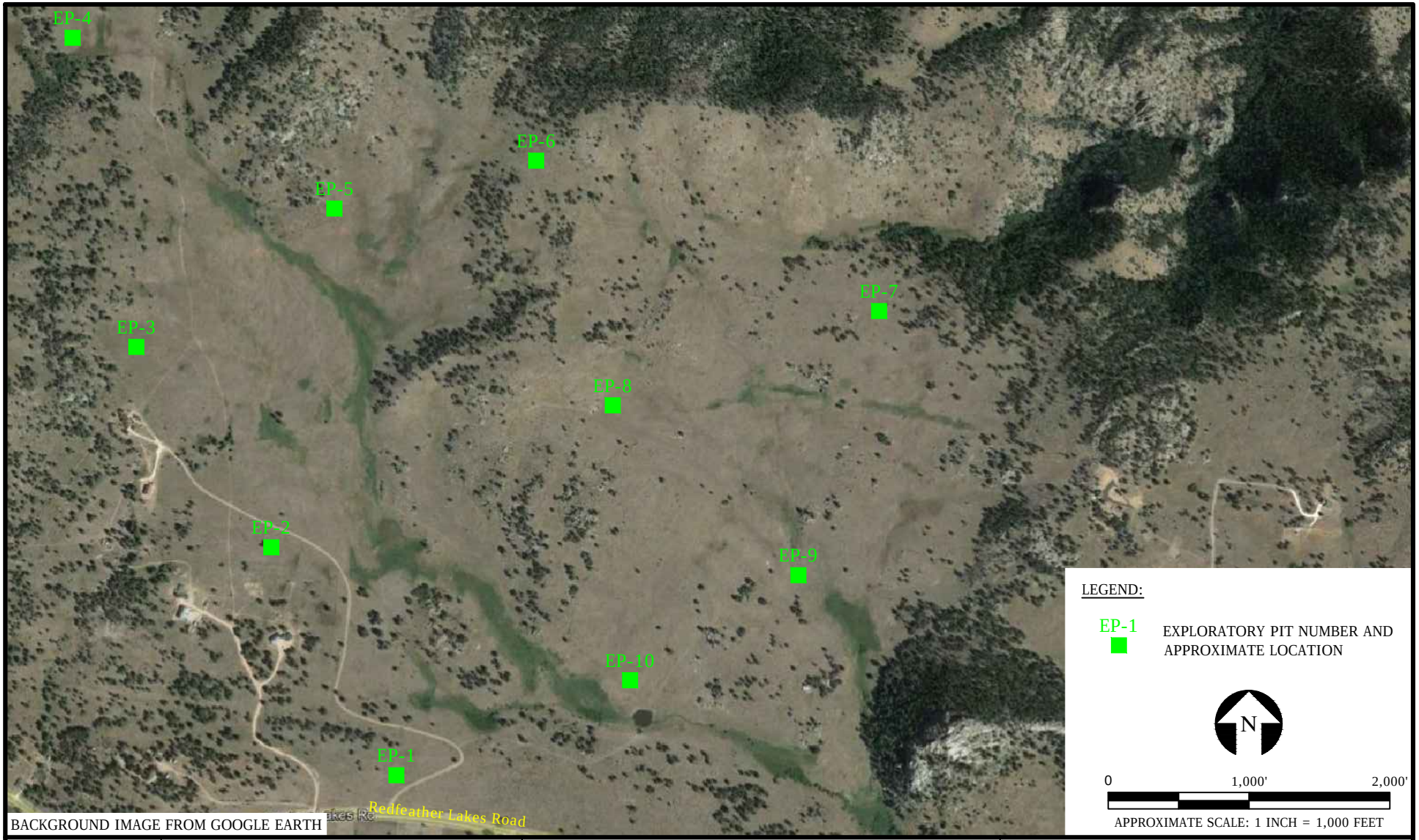
Geotechnical Engineers & Construction Materials Consultants

APPENDIX A

Field Exploration

W:\2021\Frederick\21.3092.A Shoshana Ranch\ACAD\Boring Location Map.dwg 1/17/2022 4:52 PM



BACKGROUND IMAGE FROM GOOGLE EARTH

PROJECT NO:	21.3092		
PROJECT NAME:	Shoshana Ranch		
DRAWN BY:	JBE	CHECKED BY:	JAC2
DWG DATE:	01.11.22	REV. DATE:	--

EXPLORATORY PIT LOCATION PLAN

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-1	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, with clay and gravel, decomposed granite, moist, red-brown.		0						
				4							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	4.5			5.5		30-14-16	10	
			Excavator refused at 4.5 feet								

LEGEND

WATER LEVEL AT TIME OF EXCAVATION

DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-2	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, with clay and gravel, decomposed granite, moist, red-brown.		0						
							3		25-15-10	10	
				4							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	4.5							
			Excavator refused at 4.5 feet								

LEGEND

WATER LEVEL AT TIME OF EXCAVATION

DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-3	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.		0						
							5.6		33-15-18	44	
				3							
			SAND, with clay and gravel, decomposed granite, moist, red to brown to pink.		5						
				6							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	6.5							
↑			Excavator refused at 6.5 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-4	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			GRAVEL, with clay and sand, decomposed granite, moist, red-brown.		0						
				1.5			2.3		29-15-14	11	
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	2							
↑			Excavator refused at 2 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-5	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	0.5	0						
			SAND, clayey, with gravel, decomposed granite, moist, red to brown to pink.	2			3.6		31-15-15	13	
↑			GRANITE, weathered, highly fractured, moist, red to pink to brown.	2.5							
			Excavator refused at 2.5 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

↑ DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-6	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	0.5	0						
			SAND, with silty clay and gravel, decomposed granite, moist, red to brown to pink.	1.5			0.7		25-19-6	9	
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	2							
			Excavator refused at 2 feet								

LEGEND

WATER LEVEL AT TIME OF EXCAVATION

DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-7	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	0.5	0						
			SAND, clayey, with gravel, decomposed granite, moist, red to brown to pink.				6.2		31-15-16	17	
				3							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	3.5							
↑			Excavator refused at 3.5 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-8	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	0.5	0						
			SAND, with clay, decomposed granite, moist, red to brown to pink.	2			2.5		30-16-14	6	
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	2.5							
↑			Excavator refused at 2.5 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-9	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	0.5	0						
			SAND, clayey, decomposed granite, moist, red to brown to pink.				3.7		31-15-16	21	
				3							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	4							
↑			Excavator refused at 4 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-10	Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.	
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan	
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating	
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe	
CO STATE PLANE				

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.		0						
				1.5							
			SAND, clayey, decomposed granite, moist, red to brown to pink.								
				3.5							
			GRANITE, weathered, highly fractured, moist, red to pink to brown.	4							
↑			Excavator refused at 4 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

BULK SAMPLE

↑ DEPTH OF REFUSAL

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

PROJECT NAME	Shoshana Ranch	EXPLORATORY PIT ID	EP-10A		Page 1 of 1
PROJECT NUMBER	21.3092	PIT ELEVATION	ft.		
CESARE REP.	J. Edwards	PIT LOCATION	See Exploratory Pit Location Plan		
DATE STARTED	12/13/2021	EXCAVATOR COMPANY	Chambers Excavating		
DATE COMPLETED	12/13/2021	TYPE OF EXCAVATOR	John Deere 60G Trackhoe		
CO STATE PLANE					

WATER LEVEL & CAVE DEPTH (ft)	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	DEPTH (ft)	SAMPLE	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	LL-PL-PI	FINES (%)	SWELL-CONSOL VOL CHANGE/SURCHARGE PRESSURE (psf)
			SAND, clayey, topsoil, moist, dark brown to black.	1.5	0						
			SAND, clayey, decomposed granite, moist, dark brown to black.	3.5			5.5		34-15-19	42	
			GRANITE, weathered, highly fractured, red to pink to brown.	4.5							
↑			Excavator refused 4.5 feet								

LEGEND

▼ WATER LEVEL AT TIME OF EXCAVATION

↑ DEPTH OF REFUSAL

BULK SAMPLE

CESARE, INC.
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Geotechnical Engineers & Construction Materials Consultants

APPENDIX A

Field Exploration

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

SUMMARY OF LABORATORY TEST RESULTS
Shoshana Ranch
Project No. 21.3092

Sample Location		Natural Moisture Content (%)	Water Soluble Sulfates (%)	R-value	Standard Proctor (ASTM D698)		Gradation			Atterberg Limits		Material Type
Test Pit	Depth (feet)				Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	
TP-1	2 to 3	5.5					15	75	10	30	16	SAND, well graded, with clay and gravel (SW-SC, A-2-6)
TP-2	1 to 3	3.0					23	67	10	25	10	SAND, well graded, with clay and gravel (SW-SC, A-2-4)
TP-3	1 to 3	5.6					3	53	44	33	18	SAND, clayey (A-6(4))
TP-4	0.5 to 2	2.3					51	38	11	29	14	GRAVEL, poorly graded, with clay and sand (GP-GC, A-2-6)
TP-5	1 to 3	3.6					25	62	13	31	15	SAND, clayey, with gravel (SC, A-2-6)
TP-6	0.5 to 2	0.7		57	125.5	10.8	41	50	9	25	6	SAND, well graded, with silty clay and gravel (SW-SC, A-1-a)
TP-7	1 to 3	6.2					22	61	17	31	16	SAND, clayey, with gravel (SC, A-2-6)
TP-8	1 to 2	2.5					10	84	6	30	14	SAND, well graded, with clay (SW-SC, A-2-6)
TP-9	1 to 3	3.7					7	72	21	31	16	SAND, clayey (SC, A-2-6)
TP-10A	1.5 to 3.5	5.5					5	53	42	34	19	SAND, clayey (SC, A-6(4))

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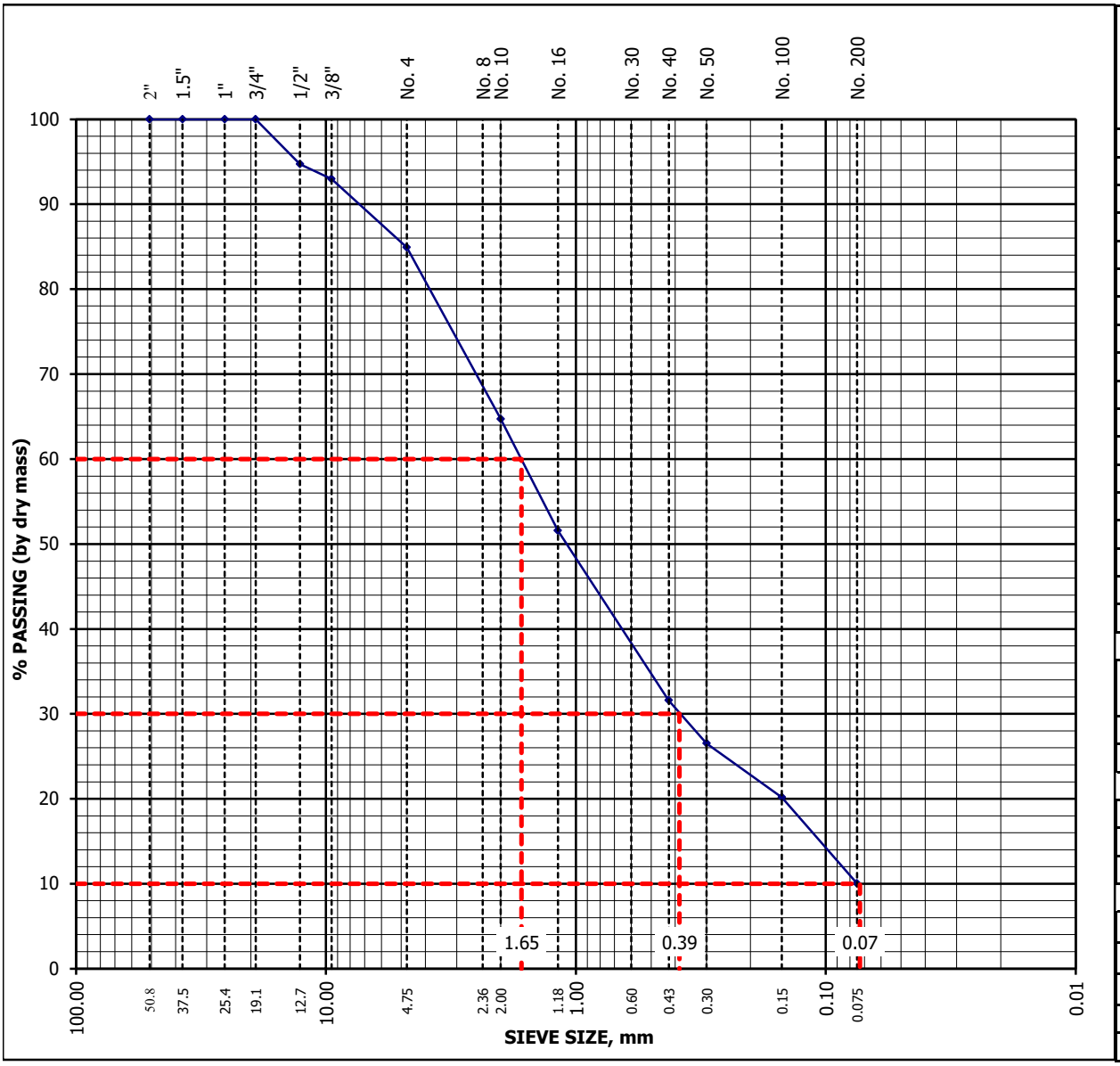
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121838	Reviewer:	G. Hoyos
Sample Location:	TP-1 at 2' to 3'		
Visual Description:	SAND, with clay, and gravel, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SW-SC) Well graded sand with clay and gravel**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	100
1/2"	95
3/8"	93
#4	85
#8	
#10	65
#16	52
#30	
#40	32
#50	27
#100	20
#200	10.0

Moisture (M) & Density (D)	
M, %:	5.5
D, pcf:	

LL	30
PL	14
PI	16

D_{60}	1.65
D_{30}	0.39
D_{10}	0.07
Cu	**22.60**
Cc	**1.23**

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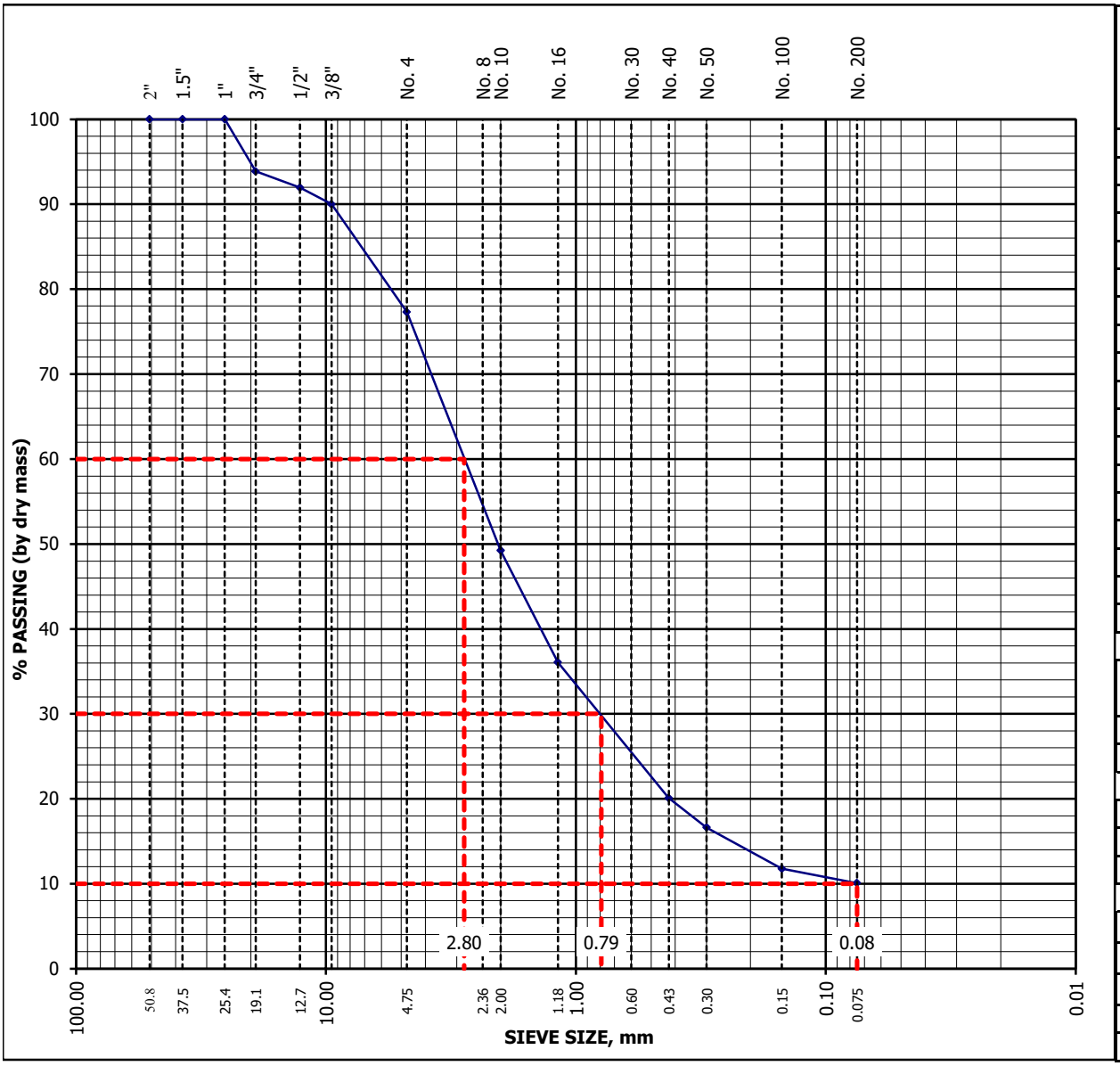
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121839	Reviewer:	G. Hoyos
Sample Location:	TP-2 at 1' to 3'		
Visual Description:	SAND, with clay, and gravel, brown		

AASHTO M 145 Classification: **A-2-4** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SW-SC) Well graded sand with clay and gravel**



Sieve Size	% Passing
2"	
1.5"	
1"	100
3/4"	94
1/2"	92
3/8"	90
#4	77
#8	
#10	49
#16	36
#30	
#40	20
#50	17
#100	12
#200	10.1

Moisture (M) & Density (D)	
M, %:	3.0
D, pcf:	

LL	25
PL	15
PI	10

D_{60}	2.80
D_{30}	0.79
D_{10}	0.08
Cu	**37.33**
Cc	**2.99**

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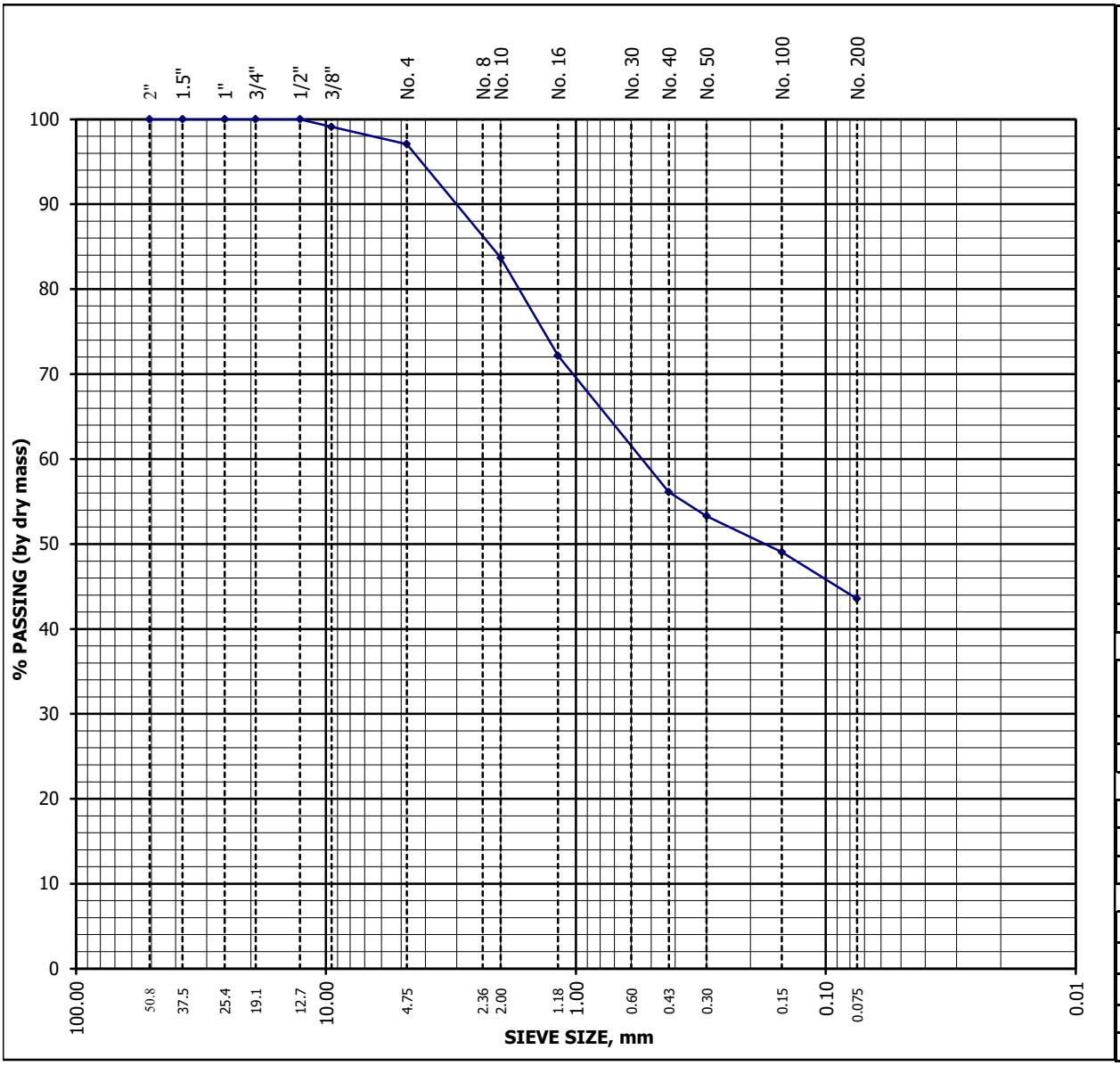
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121840	Reviewer:	G. Hoyos
Sample Location:	TP-3 at 1' to 3'		
Visual Description:	SAND, clayey, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **4**

Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	100
3/8"	99
#4	97
#8	
#10	84
#16	72
#30	
#40	56
#50	53
#100	49
#200	43.6

Moisture (M) & Density (D)	
M, %:	5.6
D, pcf:	

LL	33
PL	15
PI	18

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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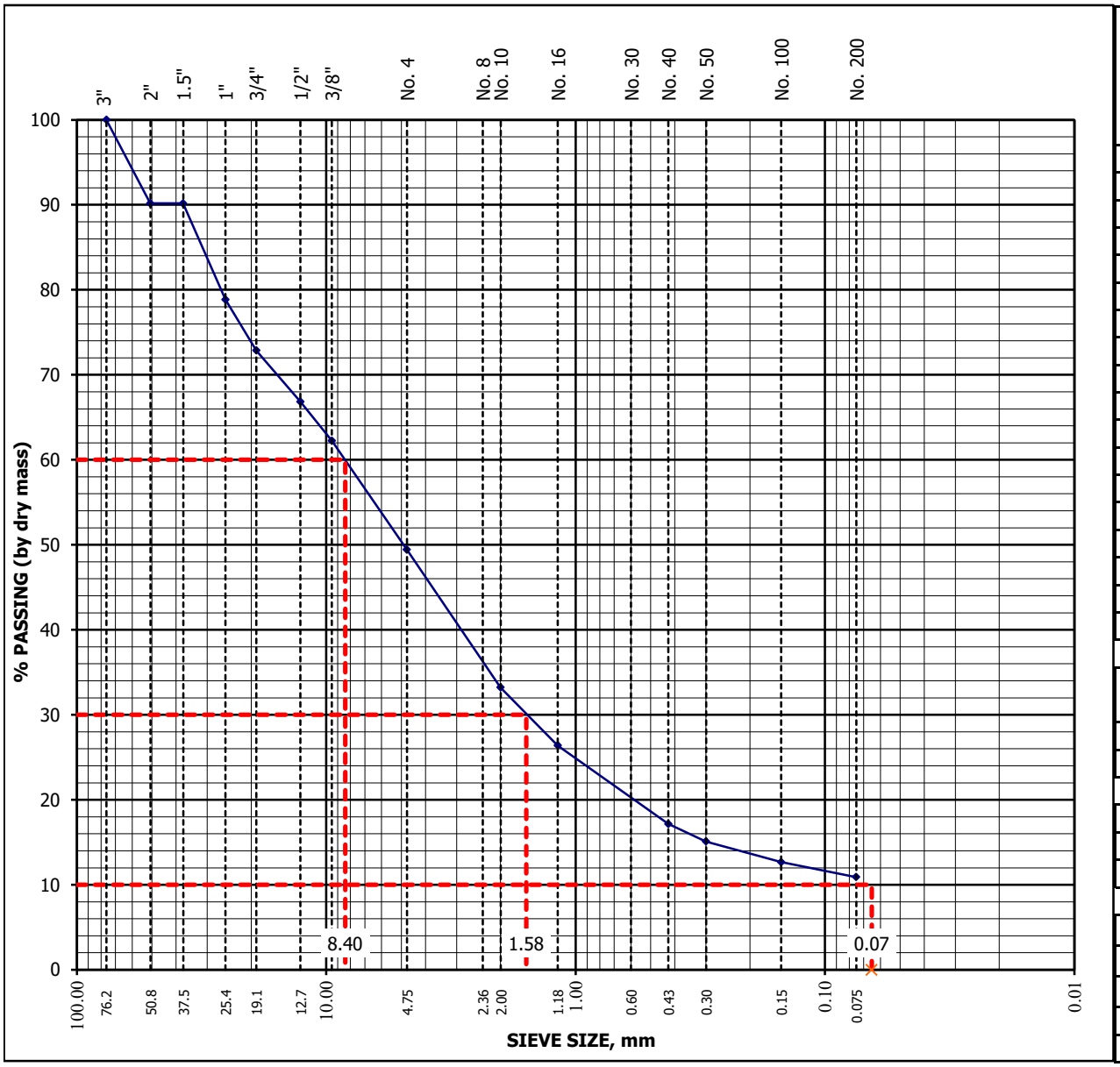
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121841	Reviewer:	G. Hoyos
Sample Location:	TP-4 at 0.5' to 2'		
Visual Description:	GRAVEL, with clay, and sand, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(GP-GC) Poorly graded gravel with clay and sand**



Sieve Size	% Passing
3"	
2"	90
1.5"	90
1"	79
3/4"	73
1/2"	67
3/8"	62
#4	49
#8	
#10	33
#16	26
#30	
#40	17
#50	15
#100	13
#200	10.9

Moisture (M) & Density (D)	
M, %:	2.3
D, pcf:	

LL	29
PL	15
PI	14

D_{60}	8.40
D_{30}	1.58
D_{10}	0.07
Cu	**129.23**
Cc	**4.57**

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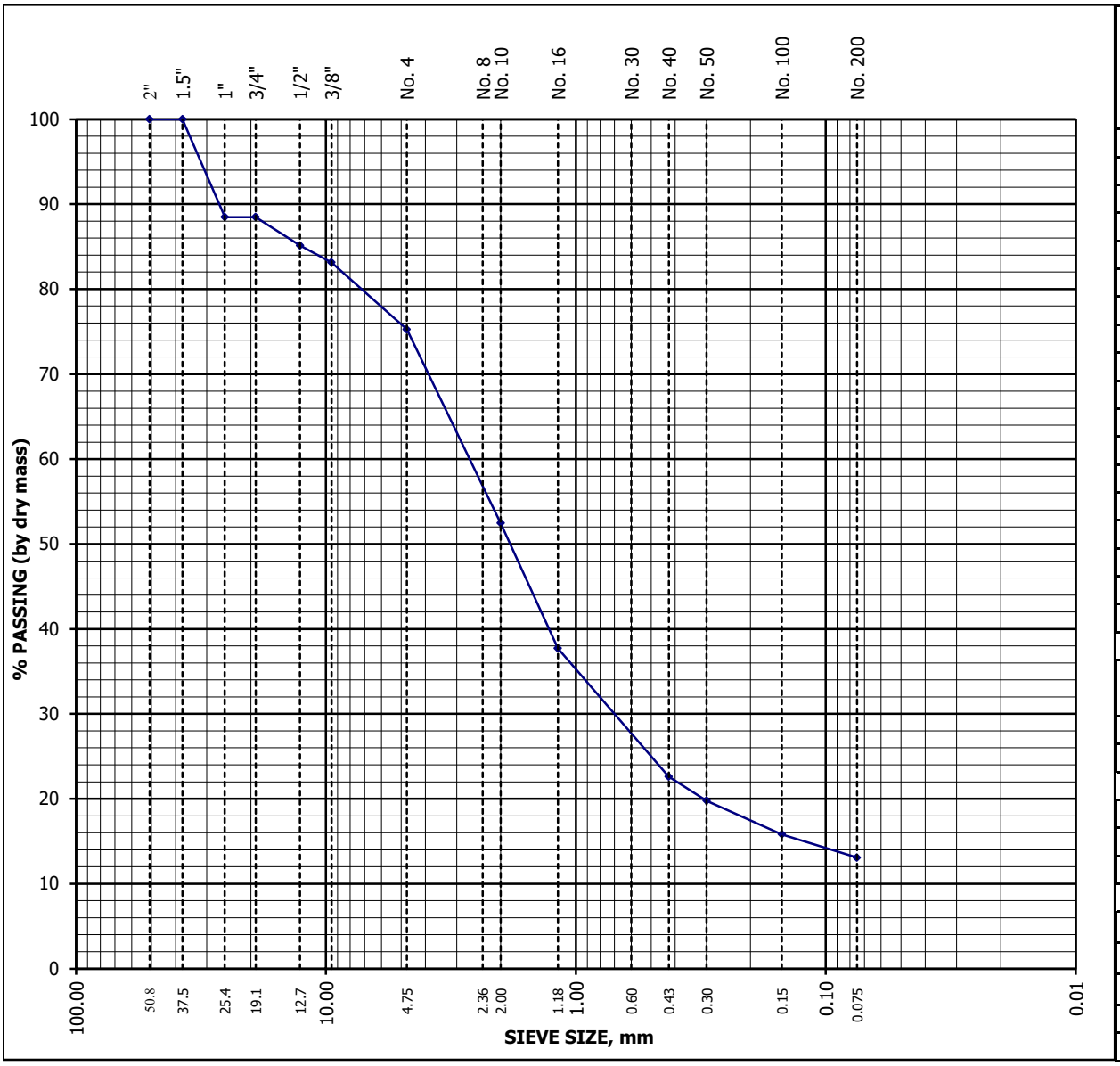
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121842	Reviewer:	G. Hoyos
Sample Location:	TP-5 at 1 to 3 feet		
Visual Description:	SAND, clayey, with gravel, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey sand with gravel**



Sieve Size	% Passing
2"	
1.5"	100
1"	88
3/4"	88
1/2"	85
3/8"	83
#4	75
#8	
#10	52
#16	38
#30	
#40	23
#50	20
#100	16
#200	13.1

Moisture (M) & Density (D)	
M, %:	3.6
D, pcf:	

LL	31
PL	16
PI	15

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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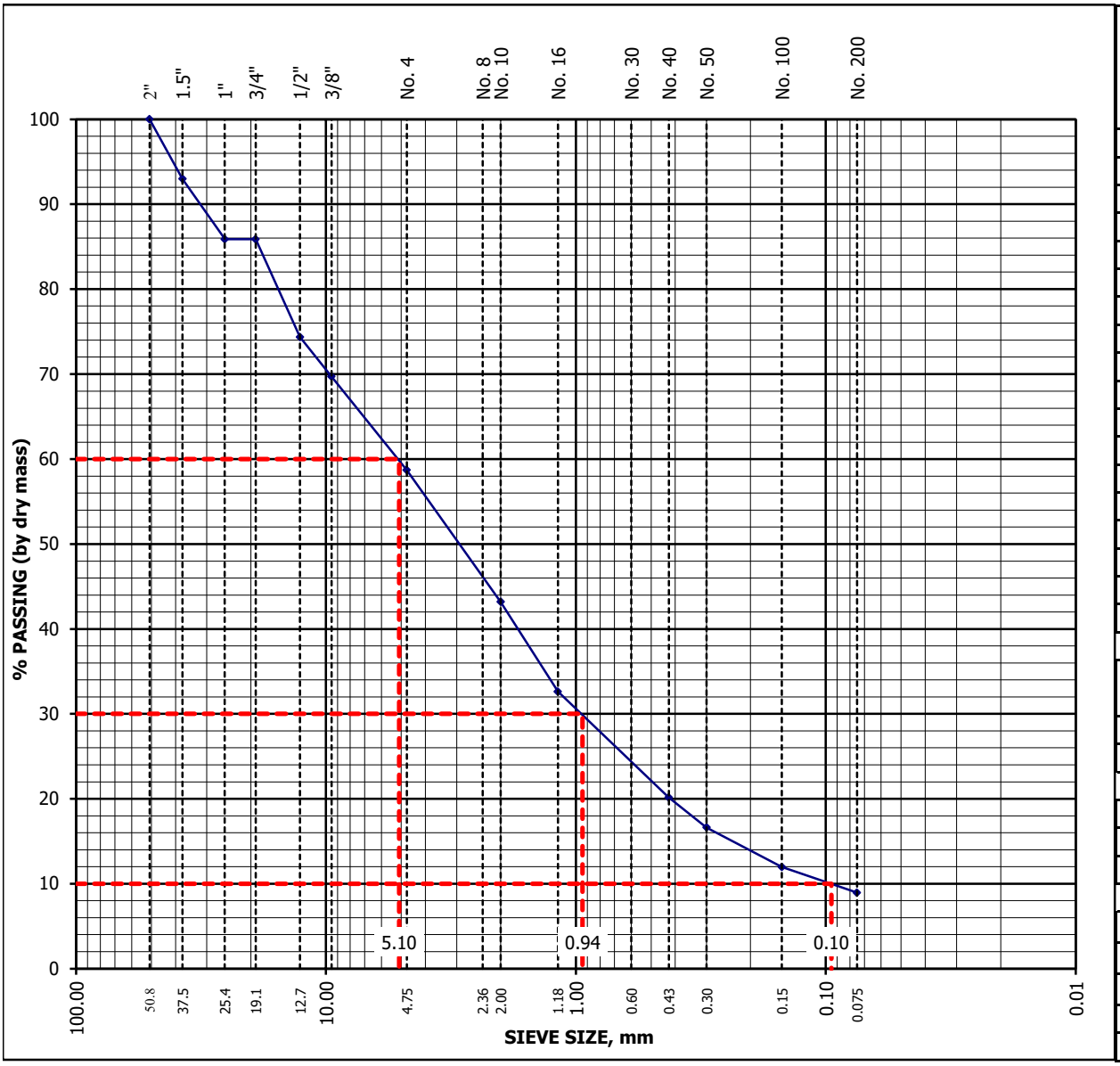
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121843	Reviewer:	G. Hoyos
Sample Location:	TP-6 at 0.5' to 2'		
Visual Description:	SAND, with silt, and clay, and gravel, brown		

AASHTO M 145 Classification: **A-1-a** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SW-SC) Well graded sand with silty clay and gravel**



Sieve Size	% Passing
2"	100
1.5"	93
1"	86
3/4"	86
1/2"	74
3/8"	70
#4	59
#8	
#10	43
#16	33
#30	
#40	20
#50	17
#100	12
#200	9.0

Moisture (M) & Density (D)	
M, %:	0.7
D, pcf:	

LL	25
PL	19
PI	6

D_{60}	5.10
D_{30}	0.94
D_{10}	0.10
Cu	**53.68**
Cc	**1.82**

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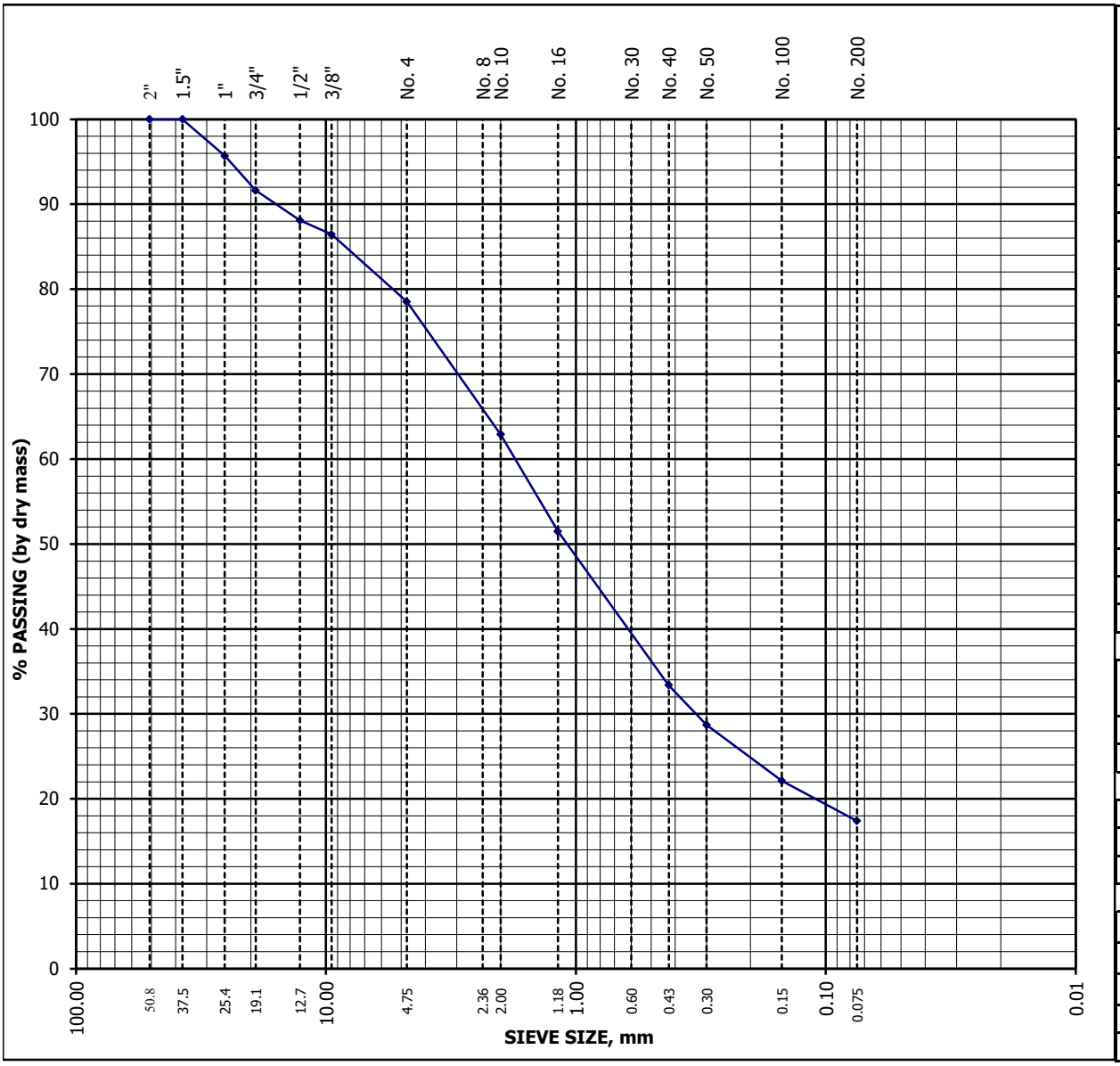
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121844	Reviewer:	G. Hoyos
Sample Location:	TP-7 at 1' to 3'		
Visual Description:	SAND, clayey, with gravel, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey sand with gravel**



Sieve Size	% Passing
2"	
1.5"	100
1"	96
3/4"	92
1/2"	88
3/8"	86
#4	79
#8	
#10	63
#16	51
#30	
#40	33
#50	29
#100	22
#200	17.4

Moisture (M) & Density (D)	
M, %:	6.2
D, pcf:	

LL	31
PL	15
PI	16

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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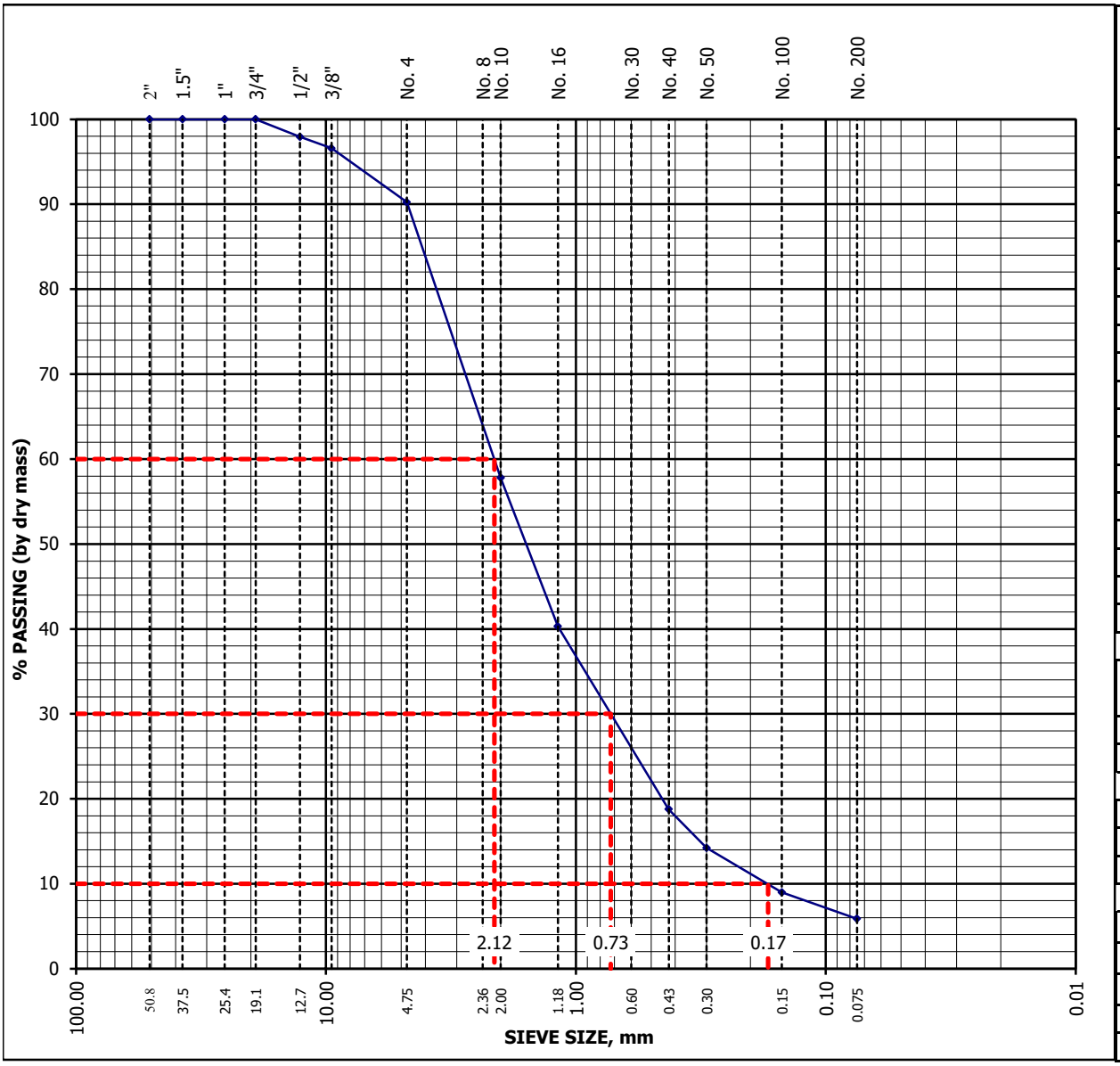
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121845	Reviewer:	G. Hoyos
Sample Location:	TP-8 at 1' to 2'		
Visual Description:	SAND, with clay, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SW-SC) Well graded sand with clay**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	100
1/2"	98
3/8"	97
#4	90
#8	
#10	58
#16	40
#30	
#40	19
#50	14
#100	9
#200	5.9

Moisture (M) & Density (D)	
M, %:	2.5
D, pcf:	

LL	30
PL	16
PI	14

D_{60}	2.12
D_{30}	0.73
D_{10}	0.17
Cu	**12.47**
Cc	**1.46**

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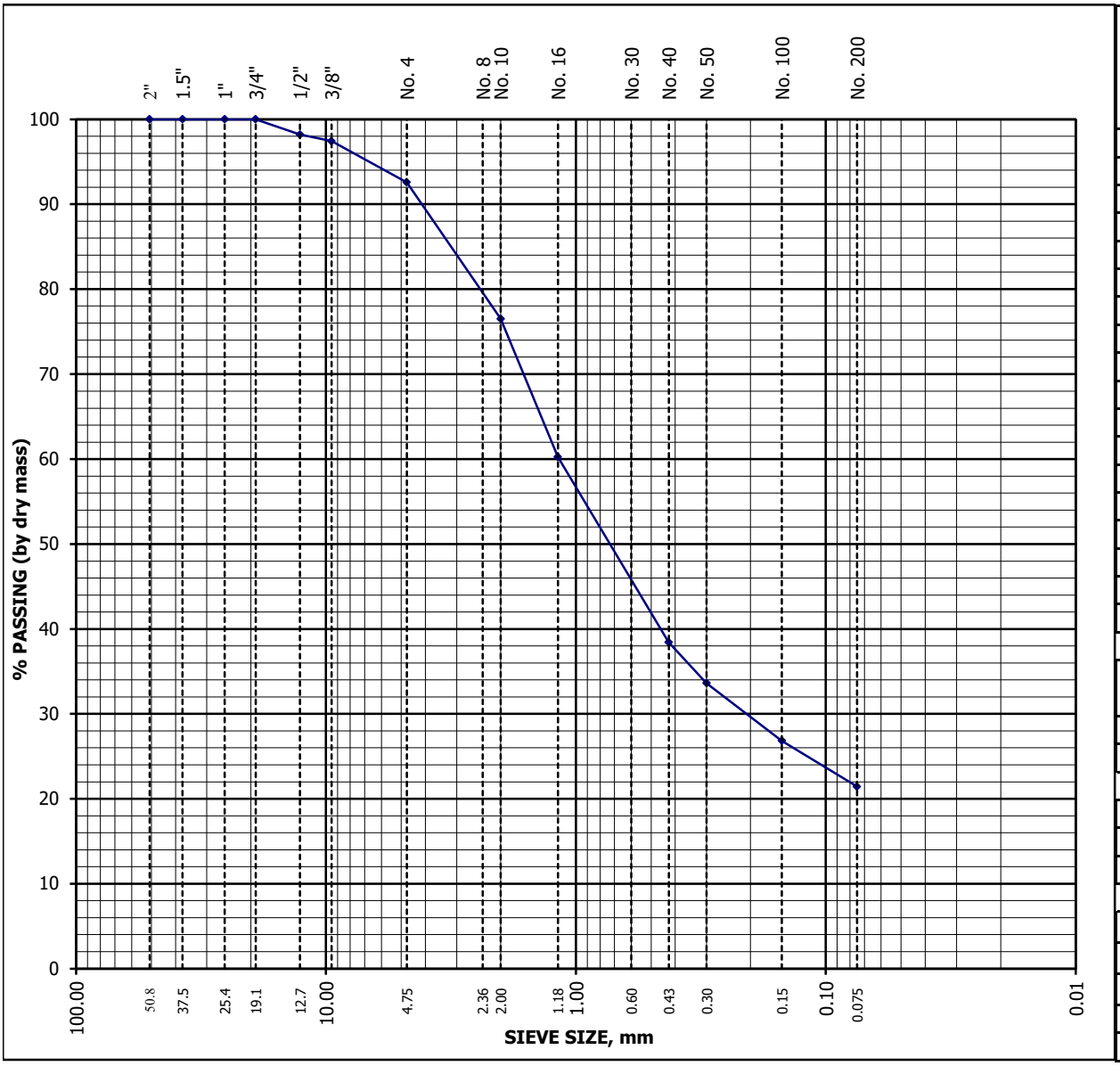
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121846	Reviewer:	G. Hoyos
Sample Location:	TP-9 at 1' to 3'		
Visual Description:	SAND, clayey, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**

Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	100
1/2"	98
3/8"	97
#4	93
#8	
#10	77
#16	60
#30	
#40	38
#50	34
#100	27
#200	21.4

Moisture (M) & Density (D)	
M, %:	3.7
D, pcf:	

LL	31
PL	15
PI	16

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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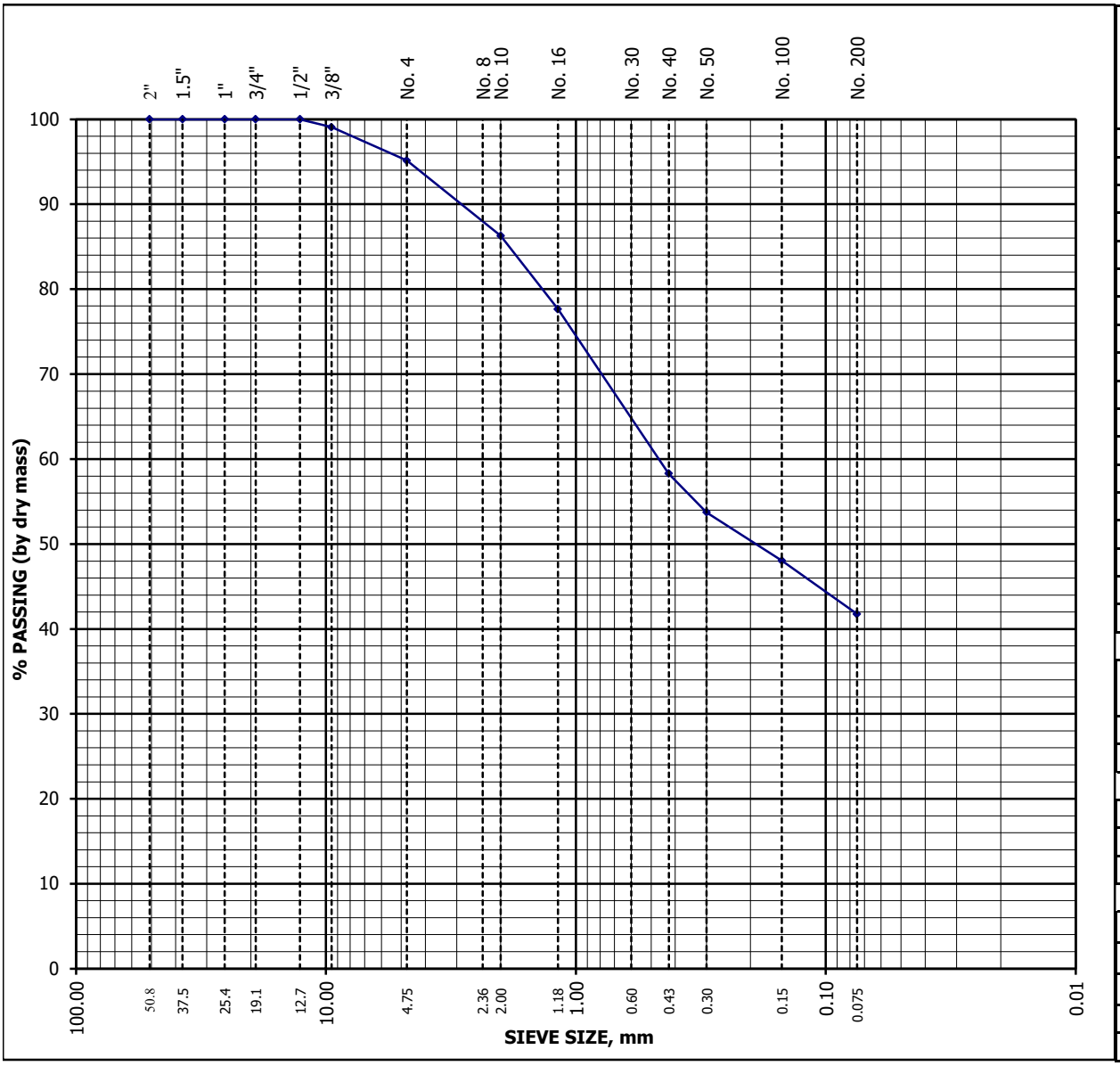
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	21.3092	Date:	4-Jan-22
Project Name:	Shoshana Ranch	Technician:	C. Kilcullen
Lab ID Number:	2121847	Reviewer:	G. Hoyos
Sample Location:	TP-10A at 1.5' to 3.5'		
Visual Description:	SAND, clayey, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **4**

Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	
1/2"	100
3/8"	99
#4	95
#8	
#10	86
#16	78
#30	
#40	58
#50	54
#100	48
#200	41.8

Moisture (M) & Density (D)	
M, %:	5.5
D, pcf:	

LL	34
PL	15
PI	19

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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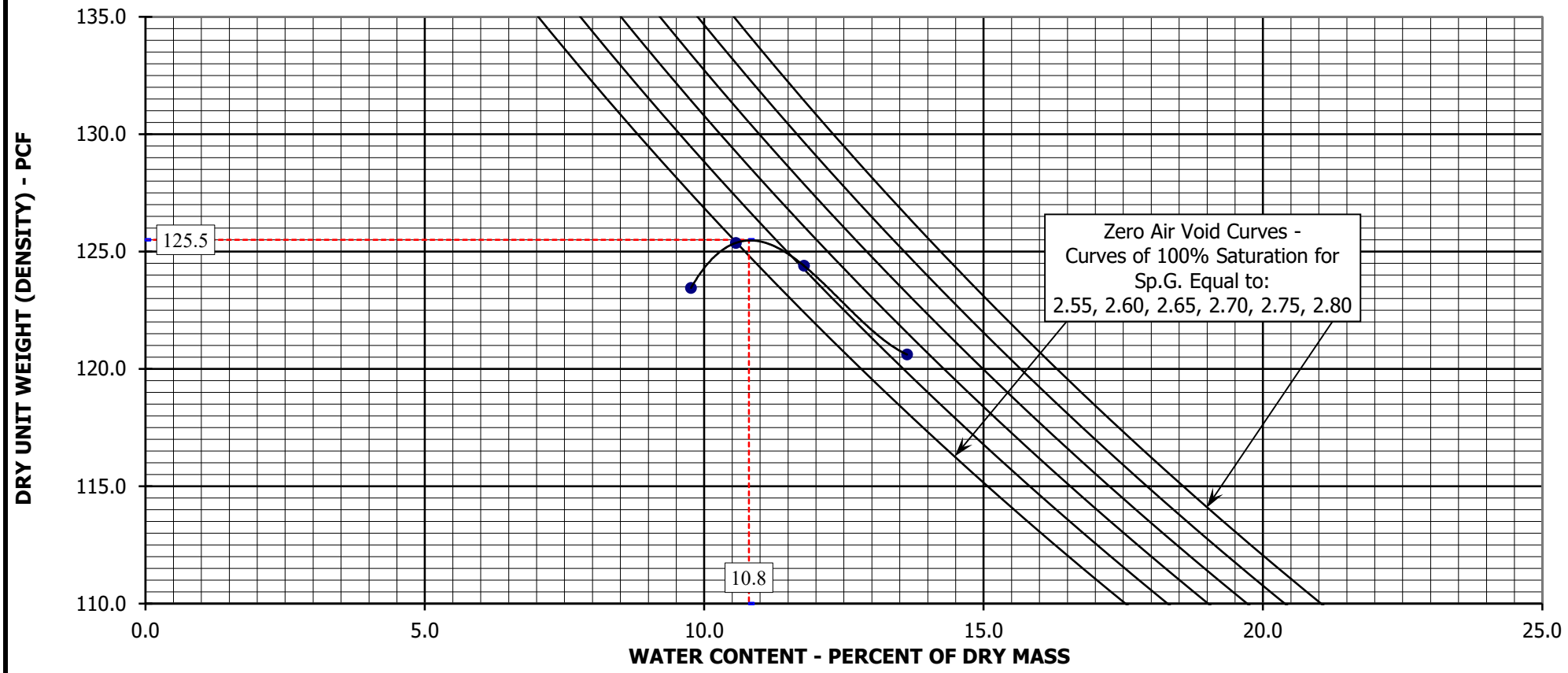
ASTM/AASHTO Compaction Test

Procedure Designation:	ASTM D698 (Standard)	
Method:	B	
	Rock Corrected Values	
Laboratory Maximum Dry Unit Weight (Density):	**125.5**	**pcf**
Laboratory Optimum Moisture Content (OMC):	**10.8**	**%**

Corrected for Bulk Specific Gravity (Dry) **30 % Gravel retained on Absorption (%)** **3/8" sieve per ASTM D4718**



Sample Location	Depth (ft)	LL	PL	PI	-#200 (%)	Soil Description/Classification	
TP-6	0.5 to 2	**25**	19	**6**	**9.0**	Visual:	SAND, clayey, with gravel, red brown
						AASHTO:	A-1-a (0)
						USCS:	(SW-SC) Well-graded sand with silty clay and gravel

Moisture/Density Relationship (Proctor) Test

Project Number	21.3092		
Project Name:	Shoshana Ranch		
Drawn By:	A. Wright	Tested by:	K. McNally
Checked By:	G. Hoyos	Date:	27-Jan-22
Date:	28-Jan-22	Lab ID Number:	222073

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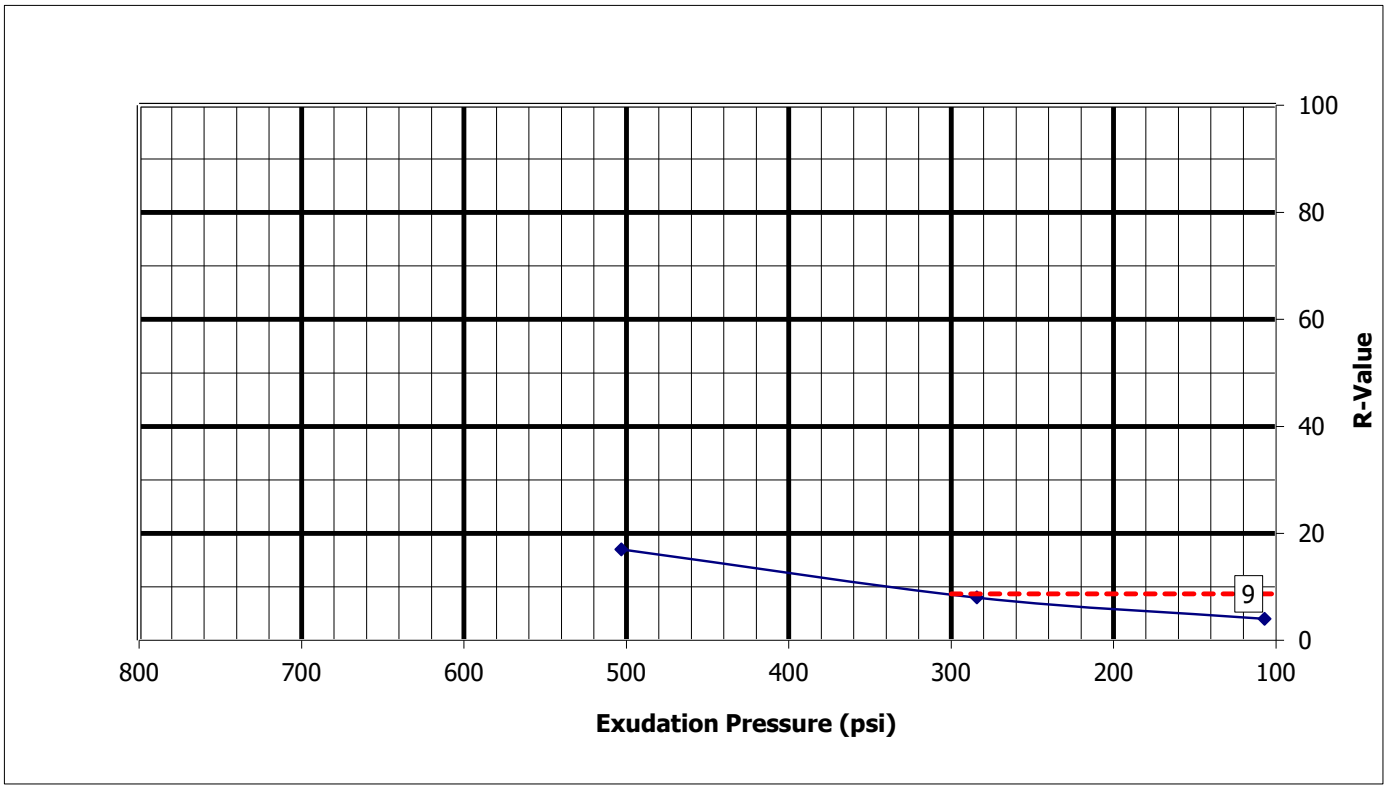
AASHTO ACCREDITED

R-VALUE TEST GRAPH (ASTM D2844)

Project Number:	21.3092	Date:	12-Jan-22
Project Name:	Shoshana Ranch	Technician:	J. De Los Santos
Lab ID Number:	222020	Reviewer:	G. Hoyos
Sample Location:	Composite: TP-3, TP-10, TP-10a at 1' to 3.5'		
Visual Description:	SAND, clayey, brown		



R-Value @ Exudation Pressure 300 psi: 9

Specification:

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 3.33**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 3,414**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	11.9	13.4	17.4
Expansion Pressure, psi:	0.30	0.12	-0.12
Dry Density, pcf:	125.9	120.0	111.3
R-Value:	17	8	4
Exudation Pressure, psi:	503	284	107

Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

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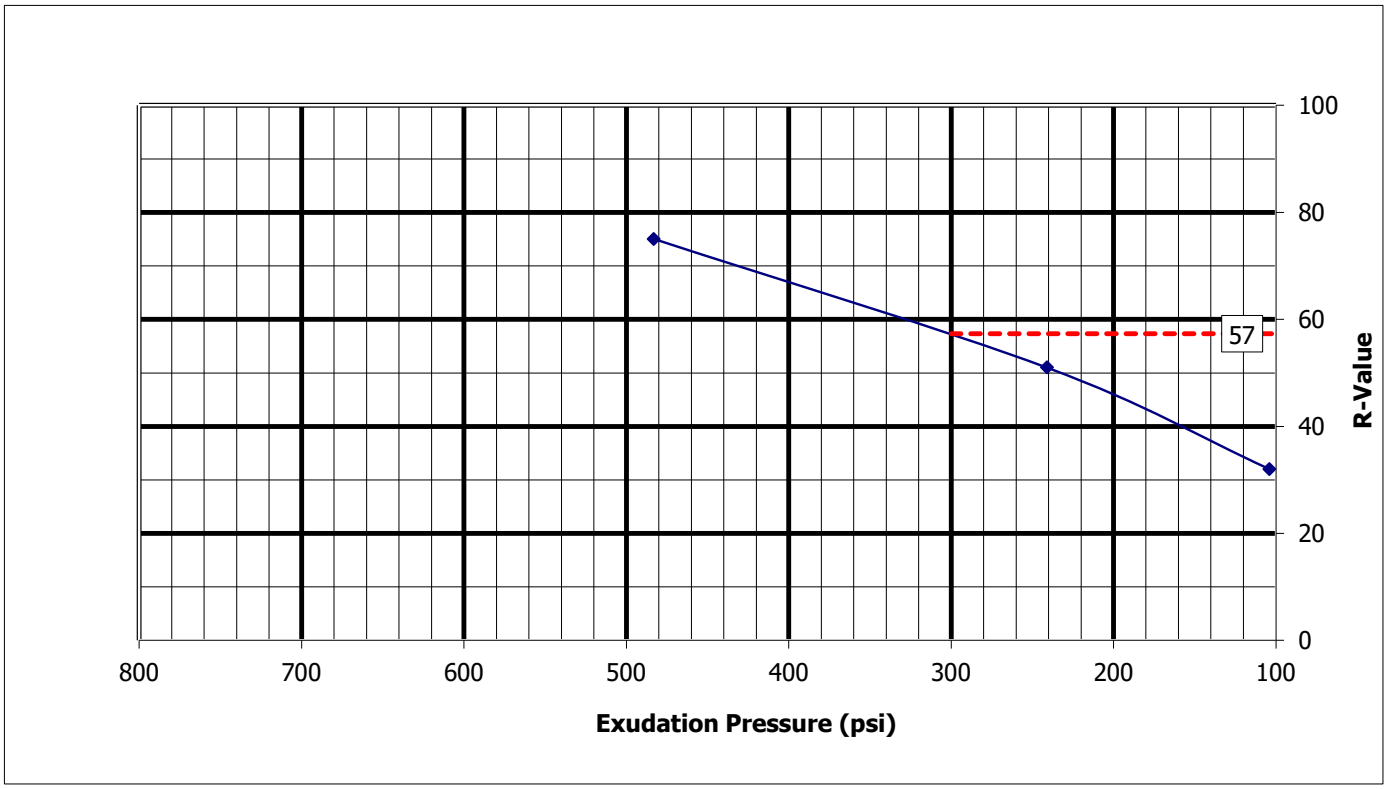
AASHTO ACCREDITED

R-VALUE TEST GRAPH (ASTM D2844)

Project Number:	21.3092	Date:	25-Jan-22
Project Name:	Shoshana Ranch	Technician:	J. Holiman
Lab ID Number:	222073	Reviewer:	G. Hoyos
Sample Location:	TP-6 at 0.5' to 2'		
Visual Description:	SAND, with silt, and clay, and gravel, brown		



R-Value @ Exudation Pressure 300 psi: 57
Specification:

CDOT Pavement Design Manual, 2011.
Eq. 2.1 & 2.2, page 2-3.

$S_1 = [(R-5)/11.29]+3$ **S_1= 7.63**

$M_R = 10^{[(S_1+18.72)/6.24]}$ **M_R= 16,716**

M_R = Resilient Modulus, psi

S_1 = the Soil Support Value

R = the R-Value obtained

Test Specimen:	1	2	3
Moisture Content, %:	10.0	10.6	11.3
Expansion Pressure, psi:	-0.03	-0.03	-0.09
Dry Density, pcf:	130.2	128.3	125.4
R-Value:	75	51	32
Exudation Pressure, psi:	483	241	104

Note: The R-Value is measured; the M_R is an approximation from correlation formulas.

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APPENDIX C

Pavement Section Analysis Reports

PaveXpress

Project Information

Scenario Name	Access Road - Rural residential collector
Scenario Description	Full Depth ABC
Estimated Completion Year	2022
State	Colorado
Roadway Classification	Residential/Collector
Pavement Type	New - Asphalt

Design Parameters

Design Period (Years)	20 years
Reliability Level (R)	75 Z_R=-0.674
Combined Standard Error (S0)	.44
Initial Serviceability Index (pi)	4.5
Terminal Serviceability Index (pt)	2
Change in Serviceability (ΔPSI)	2.5

Traffic Data

Total Design ESALs (W18)	100,000

Pavement Structure

Subgrade Resilient Modulus (MR)	16716 psi

Required minimum design SN: 1.54

Layer Thicknesses (in)

Surface: 14.00

Total SN: 1.54

PaveXpress

Project Information

Scenario Name	Access Road - Rural residential collector
Scenario Description	Full depth RAP
Estimated Completion Year	2022
State	Colorado
Roadway Classification	Residential/Collector
Pavement Type	New - Asphalt

Design Parameters

Design Period (Years)	20 years
Reliability Level (R)	75 Z_R=-0.674
Combined Standard Error (S0)	.44
Initial Serviceability Index (pi)	4.5
Terminal Serviceability Index (pt)	2
Change in Serviceability (ΔPSI)	2.5

Traffic Data

Total Design ESALs (W18)	100,000

Pavement Structure

Subgrade Resilient Modulus (MR)	16716 psi

Required minimum design SN: 1.54

Layer Thicknesses (in)

Surface: 8.50

Total SN: 1.61

PaveXpress

Project Information

Scenario Name	Access Road - Rural residential collector
Scenario Description	RAP over ABC
Estimated Completion Year	2022
State	Colorado
Roadway Classification	Residential/Collector
Pavement Type	New - Asphalt

Design Parameters

Design Period (Years)	20 years
Reliability Level (R)	75 Z_R=-0.674
Combined Standard Error (S0)	.44
Initial Serviceability Index (pi)	4.5
Terminal Serviceability Index (pt)	2
Change in Serviceability (ΔPSI)	2.5

Traffic Data

Total Design ESALs (W18)	100,000

Pavement Structure

Surface Lifts None

Base Layers

Type	Layer Coef	Drainage	Thickness
Aggregate Base	0.11	1	4

Subgrade Resilient Modulus (MR) 16716 psi

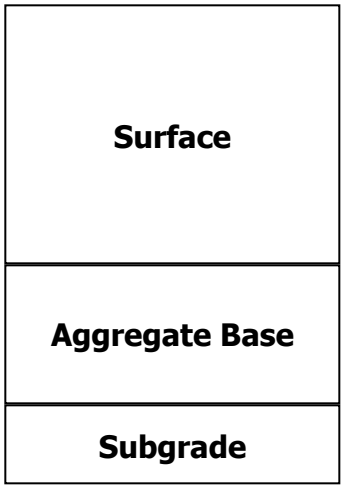
Required minimum design SN: 1.54

Layer Thicknesses (in)

Surface: 4.00

Aggregate Base: 7.50

Total SN: 1.59



Design Notes