SUBMITTED TO:
Jacobs
3721 Rutledge Road NE, Ste B1
Albuquerque, NM 97109

BY:
Shannon & Wilson
5900 W. 38th Avenue
Wheat Ridge, CO 80201

(303) 825-3800
www.shannonwilson.com

GEOTECHNICAL REPORT

NPS Bandelier National Monument Utility Rehabilitation

LOS ALAMOS & SANDOVAL COUNTIES, NEW MEXICO

SHANNON & WILSON

September 26, 2024

Shannon & Wilson No: 107523-002

Submitted To: Jacobs
3721 Rutledge Road NE, Ste B1
Albuquerque, NM 97109
Attn: Ms. Monica Quinones, PE

Subject: GEOTECHNICAL REPORT, NPS BANDELIER NATIONAL MONUMENT UTILITY REHABILITATION, LOS ALAMOS & SANDOVAL COUNTIES, NEW MEXICO

This geotechnical report presents the results of our geotechnical explorations performed during the Design Development phase of work along with updated geotechnical engineering recommendations for the Bandelier National Monument Utility Rehabilitation Project in Los Alamos & Sandoval Counties, New Mexico. Our work was completed in accordance with our signed Professional Services Task Order Number 148045033 with Jacobs Government Services Company (Jacobs), and Revision Number 01 to this task order dated February 20, 2024. Please note that the conclusions and recommendations in this report supersede those presented in our previous reports (Shannon & Wilson, 2022 and 2024).

We appreciate the opportunity to be of service to you on this project. If you have any questions or require further information, please contact me at 303-825-3800.

Sincerely,

SHANNON & WILSON

Margaret A. (Peggy) Ganse
Vice President

David A. Varathungarajan, PE
Vice President

BTM:CRC:MAG:DAV/ajg

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1 INTRODUCTION

This report presents the results of our geotechnical explorations and provides our geotechnical engineering recommendations in support of the Design Development (DD) phase of work for the Bandelier National Monument Utility Rehabilitation Project (the project) in Los Alamos and Sandoval Counties, New Mexico. Our work was completed in accordance with our signed Professional Services Task Order Number 148045033 with Jacobs Government Services Company (Jacobs) dated September 14, 2023, and Revision Number 01 to this task order dated February 20, 2024. Under this agreement we:

- Performed a subsurface investigation, including observation and logging of 37 borings, obtaining permits, completing utility locates, and coordinating traffic control;
- Completed geotechnical laboratory tests on selected soil and bedrock samples;
- Performed a visual condition assessment of asphalt pavement;
- Evaluated potential geologic hazards;
- Evaluated site subsurface conditions with respect to the proposed improvements;
- Provided recommendations for geotechnical aspects of the project; and
- Prepared this geotechnical report.

The scope of our services did not include any environmental assessment or evaluation regarding the presence or absence of wetlands or toxic materials in the soil, surface water, or air, on or below the site. If a service is not specifically indicated in this report, do not assume it was performed.

The conclusions and recommendations in this report supersede those presented in our previous reports (Shannon & Wilson, 2022 and 2024). The purpose of this report is to provide Jacobs with updated recommendations based on the results of the current investigation. The boring logs and laboratory data presented in the 2022 report were utilized in our analyses, along with the data collected during the current investigation, and are included in Appendix C of this report.

2 SITE AND PROJECT DESCRIPTION

The project is located in Los Alamos and Sandoval Counties, approximately 6 miles south of Los Alamos, New Mexico (Figure 1). Based on discussions with Jacobs, proposed project improvements include a new 24,000-gallon below-grade water tank with an adjacent mechanical building, new utility lines (water, gas, and electrical) constructed by open

trenching and trenchless methods, and a package lift station. In addition, sections of asphalt pavement are being evaluated for rehabilitation or replacement. Each of the proposed improvements is discussed below.

2.1 Below-Grade Water Tank and Maintenance Building

The below-grade cast-in-place (CIP) 24,000-gallon tank and adjacent mechanical building will be located near the intersection of the Entrance Road and the treatment pond access road (see Figure 2). The approximate plan dimensions of the tank are 20 feet by 29 feet with a foundation depth of approximately 15 feet below existing ground surface (bgs). The proposed mechanical building will be constructed at grade and will consist of precast/prefabricated concrete. The approximate plan dimensions of the mechanical building are 12 feet by 16 feet.

2.2 Utilities

New water and natural gas utilities will extend from the New Mexico Highway 4 (NM Hwy 4) blue water storage tank along the Entrance Road alignment to Bandelier Visitor Center. At this time, the inside diameter of the water and gas lines is expected to range from 2- to 10-inches. The utilities are expected to be buried a maximum of about 5 feet below ground surface (bgs). Water transmission pipelines will consist of polyvinyl chloride (PVC), except where paralleling existing force main within 10 feet of the alignment. In this case, waterlines will consist of fused PVC. Natural gas lines will consist of medium density polyethylene (MPDE). Most of the new utilities will be constructed using open trench methods along previously disturbed corridors such as paved or gravel roads. However, one section of waterline along the Entrance Road is planned for construction using trenchless methods where it crosses under NM Hwy 4.

2.3 Package Lift Station

The package lift station will be located along the Overflow Parking Road on the south side of Rios de los Frijoles. It is planned as a 6-foot diameter precast concrete manhole and may extend as much as 20 feet bgs (Figure 2).

2.4 Asphalt Pavement

Hot mix asphalt (HMA) pavement rehabilitation and/or replacement may be performed throughout the site in the 13 areas as described below:

- Entrance Road: A two lane, 3.2-mile-long road between NM Hwy 4 and the Visitors Center.

- Campground Road: Accessed approximately 0.2-mile from NM Hwy 4 along the Entrance Road and consists of a 0.4-mile, two-lane road that connects to Saltbrush Road, Paintbrush Road, Coopers Hawk Road and Field Operations Center, Juniper Campground Loops, Amphitheater parking, and bus stop parking.
- Saltbrush Road, Paintbrush Road, and Parking: Accessed approximately 0.1-mile from Entrance Road along the Campground Road and consists of two loop roadways approximately 0.2-mile long that vary in width from one to two lanes. This road also includes several parking spaces.
- Coopers Hawk Road and Field Operations Center Parking: Accessed at the turn off from Campground Road to Saltbrush and Paintbrush Roads and consists of a two-lane road approximately 0.2-mile long that ends at the Field Operations Center parking area.
- Juniper Campground: Accessed using the Campground Road and consists of three one-way loops (Abert Squirrel Loop, Black Bear Loop, and Coyote Loop) each approximately 0.2- to 0.4-mile long.
- Amphitheater Parking: Accessed using the Campground Road and consists of parking for approximately 20 cars.
- Bus Stop Parking: Accessed using the Campground Road and is adjacent to the Amphitheater parking and consists of parking for approximately 20 cars and 4 busses. (Some of the parking lot was under construction at the time of our 2023 exploration).
- Fire Tower Lane and Parking: Accessed approximately 1.3-miles from NM Hwy 4 along the Entrance Road and consists of a vehicle turn around loop adjacent to the Entrance Road, a one-lane road to the Fire Tower Lane parking, and a parking area for several cars.
- Agoyo Lane and Parking: Accessed approximately 2.9-miles from NM Hwy 4 along the Entrance Road and consists of a two-lane road approximately 0.1-mile long with parking at the end of the road for several vehicles.
- Stonehouse Road and Parking: Accessed from the Visitor Center parking area and consists of a one lane road approximately 0.1- to 0.2- mile long with several small parking areas suitable for one or two cars each. One of the parking lots is surfaced with gravel and the others are asphalt pavement.
- Frijoles Canyon Maintenance Parking: Accessed at the beginning of Stonehouse Road from the Visitor Center Main Parking and consists of parking for several maintenance vehicles.
- Visitor Center Main Parking: Accessed at the end of the Entrance Road and consists of a loop with parking for approximately 80 cars and a few busses.
- Overflow Parking Road: Accessed from the Entrance Road approximately 750 feet southeast of the Visitor Center Main Parking area and consists of a loop with parking for several vehicles.

3 FIELD EXPLORATIONS AND LABORATORY TESTING

3.1 Previous Investigation

Shannon & Wilson performed a subsurface investigation in December 2021 during the preliminary design phase of the project (Shannon & Wilson, 2022). This investigation included 14 borings (designated SW-01 through SW-14). Boring logs and laboratory test results are included in Appendix C of this report for reference. A summary of the borings is included in Table 1, and approximate boring locations are shown in Figure 2.

3.2 Current Investigation

During the DD phase of the project, Shannon & Wilson's field exploration program included 37 borings (designated SW-15 through SW-52) drilled during two mobilizations. The first mobilization was from November 2 to November 7, 2023, and consisted of drilling 28 borings. The second mobilization was from April 9 to April 11, 2024, and consisted of drilling nine borings. Boring SW-16 was not drilled due to utility clearing and permitting issues with the Los Alamos National Laboratory (LANL). Approximate boring locations are shown in Figure 2.

Appendix A describes the procedures used to complete the drilling and sampling of the geotechnical borings and presents the individual exploration logs along with an explanation of the symbols and terminology used on the logs.

We completed geotechnical laboratory testing to determine index and engineering properties of selected soil and rock samples retrieved from the borings. Laboratory tests included natural water content, Atterberg limits, grain-size distribution, corrosion testing, one-dimensional swell/collapse, R-Value, and proctor compaction. Laboratory test methods and results are provided in Appendix B. The natural water contents, Atterberg limits, and fines content are also indicated on the individual boring logs in Appendix A.

4 GEOLOGIC SETTING AND SUBSURFACE CONDITIONS

We based our understanding of the geology and subsurface conditions at the site on regional geologic maps, our field reconnaissance, and the results of our field exploration program.

4.1 Regional Geology

We reviewed a geologic map of the Frijoles quadrangle (Goff and others, 2002), the southern half of which includes Bandelier National Monument. The regional geology of the project site is characterized by relatively recent (Eocene-age and later) volcanism and tectonic activity. Surficial units mapped within the project area consist primarily of pyroclastic fall deposits overlying ash-flow tuff from volcanic activity within the past fifty thousand to two million years. The pyroclastic deposits form part of the Pajarito Plateau, which has since been deeply incised by stream water erosion, resulting in the distinctive canyons and finger mesas within Bandelier National Monument.

Based on the mapping by Goff and others (2002), the project traverses multiple geologic units as described below:

- Alluvium (Qal) – Holocene-age deposits of gravel, sand, and silt in canyon bottoms.
- Terrace gravel (Qt) – Holocene-age, slightly older alluvium along the margins of streams and basins that is currently undergoing erosion.
- El Cajete pyroclastic beds (Qvec) – Pleistocene-age (approximately 50- to 60-thousand-year-old) deposits of vesicular rhyolite rich in pumice.
- Bandelier Tuff, Tshirege Member (Qbt) – Pleistocene-age (approximately 1.25 million years old) rhyolitic ash-flow tuff.
- Mafic lava flows (Tcb) – Pliocene-age deposits of basalt exposed by erosion of overlying pyroclastic units.

Our observations of exposed rock slopes and subsurface samples from the borings along the project alignment are consistent with this mapping.

4.2 Subsurface Conditions

Subsurface conditions encountered in the explorations included asphalt pavement and aggregate base course, fill, alluvium, residual soil, and bedrock. A description of each of these units is provided in the sections below. Note that the boring logs included in Appendix C did not always identify the name of the geologic unit.

The explorations were completed to evaluate geotechnical soil and bedrock conditions at the site. Our observations are specific to the locations, depths, and times noted on the boring logs and may not be applicable to all areas of the project. No amount of explorations or testing can precisely predict the characteristics, quality, or distribution of subsurface and site conditions. Section 9 describes the limitations of our geotechnical report as it relates to the project and subsurface conditions.

4.2.1 Existing Pavement

The existing monument roadways and parking areas are paved with HMA pavement. The observed pavement thicknesses in the 31 borings ranged from 2-1/2 to 7 inches. Aggregate base course (ABC) was encountered in approximately 65% of our boring locations with thicknesses ranging from approximately 1 to 7 inches. A summary of observed pavement thicknesses is provided Table A-1 in Appendix A, along with photographs of pavement cores completed in our subsurface investigation.

4.2.2 Fill

Fill was observed in borings SW-05, SW-17, and SW-39 at the ground surface or below the asphalt pavement. The observed thickness of fill ranged from less than 1 foot to 8 feet. However, some of these borings terminated in fill; therefore, the actual thickness of this unit is unknown. As observed in the borings, fill consisted of medium dense to very dense, silty sand (SM).

4.2.3 Alluvium

Alluvium was observed in borings SW-13, SW-14, SW-23, SW-41, SW-43, SW-45 to SW-50, and SW-52 at the ground surface or below the asphalt pavement. The alluvium was generally located at the bottom of the canyon near the Visitor Center. The observed thickness of alluvium ranged from less than 1 foot to 21.5 feet. However, most of these borings terminated in alluvium; therefore, the actual thickness of this unit is unknown. As observed in the borings, alluvium consisted of interbedded layers of very loose to very dense sand and gravel with varying amounts of silt and clay (SM, SP-SM, SC, and SP). Boulders were observed in an adjacent slope at boring SW-14 and cobbles were inferred or observed in borings SW-43, S-46, SW-48, and SW-49. Very stiff to hard sandy silt (ML) was observed in a few locations.

4.2.4 Residual Soil

Most of the borings on top of the mesa above the Visitor Center encountered completely weathered rhyolite bedrock (including Cajete pyroclastic beds) or tuff bedrock at the ground surface (borings SW-01-SW-03, SW-06-SW-10, SW-15, SW-18-SW-22, SW-24-SW-33, SW-37, and SW-38). As described in Appendix A, the bedrock was logged as a soil in some areas with a dual rock description because the relatively weathered, low-strength bedrock (where encountered) may be considered more soil-like in engineering properties.

The completely weathered bedrock encountered at the surface was labeled as residual soil on the logs presented in Appendix A. The thickness of this material ranged from approximately 1 to 11 feet, varying by location. Locally, the residual soil layer may have

been reworked or disturbed by surficial erosional and depositional processes. As encountered in the borings, residual soil consisted of very loose to dense sand with varying amounts of silt, clay, and gravel (SM, SP-SM, and SC). Medium stiff sandy silt (ML) and stiff to hard lean clay with varying amounts of silt and sand (CL, CL-ML) was also observed in some locations.

4.2.5 Bedrock

Bedrock was encountered in most of the borings below the residuum and extended to the bottom of the explorations. As encountered in the borings, bedrock consisted of extremely weak to weak, moderately weathered to fresh rhyolite (El Cajete pyroclastic beds) and Upper Bandelier Tuff. Basalt bedrock was also encountered in boring SW-13. The basalt was described as medium strong to very strong, slightly weathered rock. Approximate bedrock depths encountered during our subsurface investigations are shown in Exhibit 4-1.

Exhibit 4-1: Approximate Bedrock Depths

Boring	Approx. Bedrock Depth (ft)	Bedrock Type
SW-03	2	Rhyolite
SW-02	0.2	Tuff
SW-13	0.2	Basalt
SW-17	9	Rhyolite
SW-23	7.3	Rhyolite
SW-25	6	Rhyolite
SW-29	7	Rhyolite
SW-30	3	Rhyolite
SW-31	2.5	Rhyolite
SW-32	4	Rhyolite
SW-33	10	Rhyolite
SW-34	0.2	Rhyolite
SW-35	0.2	Rhyolite
SW-36	0.6	Tuff
SW-37	4	Tuff
SW-38	1	Tuff

NOTE:
Approx. = Approximately; ft = feet

4.3 Groundwater

Groundwater was encountered in borings SW-12, SW-48, and SW-49 at depths of 8.5, 9.0, and 9.8 feet bgs, respectively, at the time of drilling. Groundwater fluctuations are possible and will depend on many factors, including seasonal variations, local precipitation, runoff, and snow melt.

4.4 Anticipated Subsurface Conditions at Proposed Improvements

4.4.1 Below-Ground Water Tank and Mechanical Building

Subsurface conditions near the proposed 24,000-gallon below-ground water tank are based on borings SW-09, SW-37, and SW-38, which were drilled to depths ranging from 5.5 to 50.5 feet bgs. These borings encountered 4 to 11.5 feet of residual soil (medium dense to very dense, silty sand with varying amounts of gravel) underlain by completely weathered to extremely weak, slightly weathered to fresh Upper Bandelier Tuff. Bedrock was able to be augered to the maximum boring depth of 50.5 feet. No groundwater was encountered.

4.4.2 Utilities

Subsurface conditions encountered along the proposed utility lines are varied and will include both overburden soils, completely weathered bedrock, extremely weak to weak, rhyolite and tuff bedrock, along with medium strong to very strong basalt near boring SW-13.

4.4.3 Package Lift Station

Subsurface conditions near the proposed package lift station are based on borings SW-14 and SW-52, which were drilled to depths ranging from 5 to 21.5 feet bgs. These borings encountered alluvium consisting of very loose to very dense sand with varying amounts of silt and gravel (SM, and SP-SM). Some of the silty sand graded to very stiff, sandy silt (ML). No groundwater was encountered.

4.4.4 Pavement Subgrade

Subsurface conditions below the existing pavements varied throughout the site. However, in general, pavement subgrade conditions can be divided into two types: clay or sand.

4.4.5 Clay Subgrade

Clay subgrade materials were primarily observed in the Juniper Campground and surrounding areas (Campground Road west of Saltbrush Road, Juniper Campground loops, Amphitheater Parking, and Bus Stop Parking). The clayey subgrade consisted of lean clay

with varying percentages of sand, silt with varying percentages of sand, and clayey sand [AASHTO soil classification A-4 and A-6]. The clay and silt varied from medium stiff to hard in consistency. Extremely weak to weak rhyolite bedrock was also encountered in the subgrade of some borings.

4.4.6 Sand Subgrade

Sand subgrade materials were observed throughout the rest of the site. The sandy subgrade consisted of sand with varying percentages of silt and clay [AASHTO soil classification A-1-a, A-1-b, A-2-4, A-3, A-4, and A-6]. Additionally, extremely weak to weak rhyolite or tuff bedrock was encountered in the subgrade of some borings.

5 GEOLOGIC HAZARD EVALUATION

5.1 Seismic Hazards

Based on geologic mapping, the nearest fault to the project site is the Pajarito Fault Zone, a late Quaternary-age normal fault that runs through Bandelier National Monument less than 5 miles west of the site (USGS, 2021 and McCalpin, 2005). The fault is not mapped as passing through the project site. The fault is primarily in Tertiary bedrock with a long-term average slip rate of 0.1 mm per year (McCalpin, 2005). National Park Service documents indicate that the most recent surface-rupturing earthquake within the fault zone occurred between 2,200 and 1,400 years ago, with no historic surface-rupturing earthquakes on record (KellerLynn, 2015). Most historic recorded earthquakes near the fault zone have been of magnitude 3.5 or lower (Gammans and others, 2017 and KellerLynn, 2015), with the most recent strong earthquake in the area recorded in 1918 in nearby Santa Fe County (estimated magnitude 6.0). The probability of an earthquake of magnitude 5.0 or greater occurring within the next 100 years affecting the area near the project site is estimated to be greater than 50 percent (KellerLynn, 2015).

Liquefaction can occur in loose, saturated, cohesionless soils when subjected to earthquake ground shaking. Based on the subsurface conditions at the site, it is our opinion that the risk of liquefaction is low.

Seismic compression may occur when loose, granular soils above the groundwater table are rearranged into a tighter packing configuration during seismic shaking, which can cause settlement. Based on subsurface conditions at the site, it is our opinion that the risk of settlement from seismic compression is generally low. However, looser alluvial soils as encountered in 11 borings (SW-11, SW-12, SW-14, SW-15, SW-19, SW-21, SW-22, SW-43, SW-

45, SW-46, SW-47, SW-50, and SW-52) could be anticipated to compress and settle under the design seismic event (see Section 7.2).

5.2 Corrosive Soil and Bedrock

The soil/rock encountered at the project site can be corrosive to substructure elements. To assist in estimating the corrosion potential at the site, selected samples were tested for pH, resistivity, water soluble sulfates, and chlorides. The results are summarized below in Exhibit 5-1.

Exhibit 5-1: Corrosion Testing Results

Boring	Depth (feet)	Material	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)
SW-01	2.5	CL	7.6	2,600	0.01	0.008
SW-07	5.0	SM	8.9	4,600	0.02	0.005
SW-14	12.5	ML	6.9	3,400	0.01	0.007
SW-17	2.5	SM	10.1	5,500	0.01	0.023
SW-18	4.0	SM	8.3	6,700	<0.01	0.023
SW-27	4.0	CL	7.1	1,900	0.01	0.030
SW-32	2.5	SM	7.6	4,600	0.02	0.020
SW-34	2.0	SM	8.7	32,000	<0.01	0.020
SW-38	4.5	SM	8.9	10,000	<0.01	0.020
SW-48	0.0	SM	9.4	8,000	<0.1	0.025

NOTES:

1 Water-soluble sulfate and chloride content values are shown as percent weight in dry soil.

ohm-cm = ohm-centimeter

The resistivity measured in the samples ranged from 1,900 to 32,000 ohm-centimeters. Based on correlations developed by Roberge (2012) as shown in Exhibit 5-2, these values suggest essentially noncorrosive to highly corrosive subsurface conditions for metallic pipe in contact with subsurface materials across the site. Only two of the 10 tests performed classified the soils as being essentially noncorrosive or mildly corrosive. The remaining tests classified the soils as being moderately to highly corrosive.

Exhibit 5-2: Corrosivity Ratings Based on Soil Resistivity

Soil Resistivity (ohm-cm)	Corrosivity Rating
>20,000	Essentially Noncorrosive
10,000-20,000	Mildly Corrosive
5,000-10,000	Moderately Corrosive
3,000-5,000	Corrosive
1,000-3,000	Highly Corrosive
<1,000	Extremely Corrosive

The concentration of water-soluble sulfates measured in the samples was <0.01% to 0.02% by weight. Based on classifications as defined by ACI-318-19 (ACI, 2019) as shown in Exhibit 5-3, these test results classified as Negligible (S0) for concrete exposed to site soils.

Exhibit 5-3: Corrosivity Ratings Based on Water Soluble Sulfate Exposure

Water Soluble Sulfate in Soil (Percent by Weight)	Sulfate Severity (Class)
<0.10	Negligible (S0)
0.10-<0.20	Moderate (S1)
0.20-2.00	Severe (S2)
>2.00	Very Severe (S3)

The test results and the above discussion are provided to assist the designer in the selection of project materials, concrete type, or other features with respect to corrosion. As appropriate, the designer should consider protective measures, such as coatings, upsizing for section loss, or using alternative materials to reduce the corrosion potential.

5.3 Swelling and Collapsing Soil and Bedrock

Many soil and rock formations are susceptible to volume change by swelling/collapsing. This geologic phenomenon has the potential to cause substantial damage to lightly loaded structures, such as pavements. To provide an indication of the swell/collapse potential of near surface soil and bedrock materials at the site, we performed eight swell/consolidation tests on soil samples encountered in our explorations. All of the tests were run with an inundation pressure of 200 pounds per square foot (psf). The results are presented below in Exhibit 5-4 and are included in Appendix B.

Exhibit 5-4: Swell Testing Results

Boring	Depth (feet)	Material	% Swell/Collapse
SW-18	4.0	Residual Soil	-0.4
SW-22	4.0	Residual Soil	-4.2
SW-25	2.0	Residual Soil	-0.8
SW-26	2.0	Residual Soil	1.1
SW-33	2.5	Residual Soil	-0.4
SW-36	2.0	Upper Bandelier Tuff	-0.2
SW-39	1.0	Fill	-0.3
SW-41	4.0	Alluvium	-0.7

The swell test result for boring SW-26 indicated a swell potential of 1.1%. The remaining tests indicted a collapse potential of less than 1%, except for the result from boring SW-22 which indicated a collapse potential of 4.2%. These results are indicative of a low swell and low to medium collapse potential. Swell/collapse mitigation recommendations for pavements are provided in Section 7.

6 PAVEMENT CONDITION ASSESSMENT

To evaluate the condition of the existing roadway pavement for potential rehabilitation options, Shannon & Wilson performed a visual pavement survey on October 25 and 26, 2023 to assess the general pavement condition and to identify areas of distress and typical crack patterns. We used the U.S. Fish and Wildlife Services (FWS) rating system to quantify levels of distress and to describe roadway conditions of asphalt pavements. Their five levels of pavement condition for asphalt are summarized below:

- Excellent: Recently constructed or overlaid road where construction or overlay was performed correctly. No maintenance required.
- Good: Low extent longitudinal and transverse cracks. All cracks are ¼ inch or less with little or no crack erosion. Patches are in good condition and applied correctly. Routine maintenance recommended.
- Fair: Roads are in good structural condition with little or no fatigue cracking. Longitudinal, transverse, and edge cracking is at medium extent and severity. Block cracking is extensive. Any patches are in good condition. Preventative maintenance recommended.
- Poor: Road beginning to show signs of structural distress. Fatigue cracking is medium to high extent and medium severity. Cracking is severe. Surface may have severe block

cracking and show. Patches are in fair to poor condition. There is moderate distortion or rutting and occasional potholes. Rehabilitation recommended.

- Failed: Road is severely deteriorated. Signs of structural failure appear along with severe and extensive fatigue cracking, distortion, potholes, or extensive patches in poor condition. Reconstruction recommended.

Observations made by Shannon & Wilson along the 13 roadway segments and parking areas indicate asphalt pavement conditions of poor, fair, and good. Photographs of pavement conditions are presented in Appendix D. Our classification of pavement conditions by segment are summarized below in Exhibit 6-1, and presented graphically in Figure D-1 in Appendix D.

Exhibit 6-1: Pavement Condition Assessment Results

Roadway	Poor Condition	Fair Condition	Good Condition	Comments
Entrance Road		X		Low to high extent and severity transverse cracking. Low extent and low to medium severity longitudinal cracking. Parking areas had low to high extent and severity block cracking. Juniper Campground loop roads had occasional areas with low to medium severity edge cracking.
Campground Road		X		
Saltbrush & Paintbrush Roads and Parking		X		
Coopers Hawk Road and Field Operations Center Parking		X		
Juniper Campground		X		
Amphitheater Parking		X		
Bus Stop Parking		X		
Fire Tower Lane and Parking	X	X		Medium to high extent and severity transverse and longitudinal cracking. Medium to high extent and severity block cracking.
Agoyo Lane and Parking	X	X		
Stonehouse Road and Parking	X	X		
Frijoles Canyon Maintenance Parking	X	X		
Visitor Center Main Parking		X		Low to high extent and severity transverse cracking. Low extent and low to medium severity longitudinal cracking. Parking areas had low to high extent and severity block cracking.
Overflow Parking Road			X	No to low extent and severity cracking observed.

7 GEOTECHNICAL ENGINEERING RECOMMENDATIONS

The recommendations presented in the following sections are based on our understanding of the project based on conversations with Jacobs and our subsurface exploration and laboratory testing program.

7.1 Pavement Design Recommendations

At the time of this report preparation, the scope of the monument's pavement rehabilitation and/or reconstruction has not been finalized including the specific roadways to be replaced, or rehabilitated. The following sections provide reconstruction design recommendations and provide a general discussion of rehabilitation alternatives.

7.1.1 Design Criteria

We understand that pavement rehabilitation and reconstruction areas are currently unknown. Our pavement design and results are based on the design procedures presented in the 1993 AASHTO Guide for the Design of Pavement Structures (AGDPS) with guidance from the New Mexico Department of Transportation (NMDOT) Design Manual (NMDOT, 2020). The following sections summarize our pavement analysis and design assumptions (pavement design inputs and calculations are presented in Appendix E).

7.1.2 Subgrade Design Strength

As discussed in Section 4.4, soils below the proposed pavement vary in the project area. The subgrade strength for the project was evaluated by R-value testing on samples of the subgrade material. R-value testing results are shown Exhibit 7-1.

Exhibit 7-1: R-value Testing Results

Boring	AASHTO Classification	R-value
SW-26	A-4	45
SW-36	A-2-4	68
SW-50	A-1-b	72

To estimate the design subgrade strength, a correlation from R-value to resilient modulus was utilized. Correlations from the AGDPS (AASHTO, 1993) are limited to R-values of 20 or less. No local NMDOT R-value correlations are available, but a City of Albuquerque

correlation is available from their Development Process Manual (2020). For our analysis, we assumed a design R-value of 45 and correlated this value to a design resilient modulus of 10,322 psi.

7.1.3 Swelling and Collapsing Soil and Bedrock Mitigation

As discussed in Section 5.3, all but one of the swell/consolidation test results indicated low collapse potential; the remaining sample from SW-22 indicated moderate swell potential. Considering the test results and that site development is not anticipated to significantly change the moisture regime at the site, we recommend moisture treating the upper 8 inches of subgrade material below the pavement section. See Section 8.3.3 for moisture treatment and compaction requirements for the pavement subgrade.

Our recommendation assumes surface drainage patterns don't change and wet utilities don't leak. At new structures, it is also important that proper surface drainage be designed and maintained to prevent ponding and reduce infiltration near pavements. Irrigation near pavements should not be performed.

7.1.4 Traffic Loading

Traffic loading was estimated using shuttle bus schedule information provided on the National Park Service website for Bandelier National Monument (US Department of the Interior, 2022), traffic counts provided by Jacobs, and guidance from the AGDPS (AASHTO, 1993). We assumed three types of vehicles contribute to traffic loading within the park: shuttle buses, garbage trucks, and passenger vehicles. We estimated the total annual one-way vehicle passes for each vehicle type. We projected the annual one-way vehicle passes for a pavement design life of 20 years using a growth rate of 2%, which was provided by Jacobs.

To estimate the passenger vehicle passes, we used average annual daily traffic (AADT) volumes from 2022 that were provided by Jacobs. The data showed AADT of 770 vehicles per day for the Entrance Road and less than 200 vehicles per day for the other roads. We assumed the traffic was one way and was for passenger vehicles. This traffic was projected forward using the 2% growth rate and assuming a paving year of 2025 and a design life of 20 years.

We assumed one garbage truck per week visits the park with an average weight of 54 kips.

The National Park Service website provided a shuttle bus schedule for Bandelier National Monument (US Department of the Interior, 2022). The website stated that buses run seven days a week from June to the middle of October (we assumed five total months). The

website also stated that buses start at 9:00AM each day and run every half hour on weekdays and every 20 minutes on weekends. We assumed buses stop running at 5:00PM. We assumed the average weight of a shuttle bus was 32 kips.

After determining the number of passes for each vehicle type, we then used axle load equivalency factors for flexible pavement provided in Appendix D of the AASHTO GDPS (AASHTO, 1993) to estimate the 18-kip equivalent single axle loading (ESAL) along the Entrance Road. We calculated a 20-year design value of approximately 81,000 ESALs for roadways where shuttle bus traffic is anticipated. See Appendix E for the traffic loading calculation.

The shuttle busses contribute the majority of the vehicular traffic loading. For our analysis, we provided pavement sections for the project shuttle bus routes as well as low volume roads (access roads without routine shuttle bus traffic). For the low volume road design, we used the AGDPS (AASHTO, 1993) minimum traffic loading of 50,000 ESALs.

7.1.5 Recommended HMA Pavement Section

Exhibit 7-2 summarizes our recommended pavement sections.

Exhibit 7-2: Recommended Pavement Sections

Roadway	Design Traffic Loading (ESALs)	Alt. 1	Alt. 2	Alt. 3
Shuttle Bus Routes	80,000	4-1/2 in. HMA	3-1/2 in. HMA 4 in. ABC	3 in. HMA 6 in. FDR
Low Volume Roads (3)	50,000	4 in. HMA	3 in. HMA 4 in. ABC	3 in. HMA 6 in. FDR

NOTE:

1 A Class 1 geotextile separator should be provided below ABC.

2 A 6-inch minimum existing pavement section is required for FDR. Where existing pavement is not thick enough, the underlying ABC (if present) or new ABC may be added to achieve the required thickness.

3 Low volume roads are all roads with average annual daily traffic less than 200 vehicles per day and that do not have routine shuttle bus traffic.

4 Refer to Appendix E for the pavement design analysis worksheets.

ABC = Aggregate Base Course; Alt. = Alternative; ABC = Aggregate Base Course; ESALs = 18-kip equivalent single axle loading; FDR = Full Depth Reclamation; HMA = Hot Mix Asphalt; in. = inches.

7.1.6 Recommended PCC Parking Pads

We understand that reinforced Portland Cement Concrete (PCC) pavement parking pads will be constructed at the visitor center parking lot. We recommend following standard plan sheet 501-1 from Federal Lands Highway (U.S. Department of Transportation, 2024) for the continuously reinforced PCC pavement parking pad. The details from sheet 501-1 call

for W6 x W6 welded wire mesh or no. 4 bars spaced 12 in. by 24 in. For the PCC pavement thickness, we recommend 6 inches.

7.1.7 Pavement Patches

When patching pavement, the patch should match the existing pavement section or follow the recommended pavement thicknesses in Section 7.1.5 if the existing pavement section is thinner than the recommended pavement sections.

In narrow pavement patches (e.g., adjacent to curb and gutter or for utility cuts), compaction of the HMA will be difficult and may require the use of narrow handheld equipment to compact the individual HMA lifts. The size of handheld equipment available may require enlarging the size of the pavement repair patch to utilize larger equipment.

Pavement patches to repair damaged pavements should be saw cut into rectangular areas. The longitudinal saw cuts (relative to the direction of traffic) should be located along the edge of the proposed lane or in the center of the lane. If necessary, we recommend widening the patch to relocate the saw cut from wheel paths for improved long-term performance of the patch.

7.2 Pavement Rehabilitation Alternatives

As described in Section 6, the majority of roadway and parking areas are considered to be in fair to good condition. Only four roadway segments were considered to be in fair to poor condition: Fire Tower Lane and Parking, Agoyo Lane and Parking, Frijoles Canyon Maintenance Parking, and Stonehouse Road and Parking. At this time, it is not known where and to what extent pavement rehabilitation may occur. At a minimum, we understand that in the areas where utility trenches are excavated in the roadway, half of the roadway will require replacement or repair. See Section 7.1.7 for pavement patching recommendations, Section 7.5 for recommendations for backfill of utility trenches, and Section 8.3 for pavement subgrade compaction recommendations.

High-severity fatigue or alligator cracking indicates the pavement section can no longer support traffic loading and rehabilitation is generally not possible. Refer to 2014 FHWA Distress Identification Manual for the definitions of crack pattern distress levels (FHWA, 2014). High-severity fatigue cracking typically looks like moderately or severely spalled interconnected cracks forming a complete pattern (see Exhibit 7-3). For pavement areas with high-severity fatigue cracking, we recommend replacing the pavement section before performing a rehabilitation on the adjacent pavement area.

Exhibit 7-3: High Severity Fatigue Cracking (FHWA, 2014)

When selecting pavement rehabilitation options, the project team should consider cost, size of rehabilitation area, length of traffic control lane closures and durations, effect on expected ride quality of pavement, and expected extension of pavement service life. Based on pavement subgrade conditions, our visual pavement condition assessment, and the existing pavement section thicknesses, we recommend the following six feasible pavement rehabilitation/reconstruction methods for consideration of the project team.

7.2.1 Full Depth Reclamation

Full Depth Reclamation (FDR) consists of pulverizing the existing pavement section in-place so that becomes the base of a new HMA pavement section. A new HMA surface layer is then paved over the FDR prepared roadway, typically resulting in an overall raise to the roadway grade. Utilizing FDR effectively provides a new pavement section and eliminates the potential for reflective cracking from the underlying pavement. Another benefit is that the existing pavement does not need to be hauled away as it is incorporated into the new pavement section.

One issue with completing FDR at the site is that shallow bedrock was observed underlying the pavement in many of the roadway segments. In these locations, there may be an

increased risk of damaging the machinery used to pulverize the existing pavement section. In our opinion, we anticipate this risk to be low due to the extremely weak rhyolite and tuff units encountered in the borings. However, boring SW-13 encountered medium strong to strong basalt bedrock at a depth of approximately 0.2 feet below the ground surface. In this area, there is a higher risk of the bedrock impacting the FDR machinery if encountered below the pavement section.

Also, due to the variability in pavement thicknesses observed, the contractor should verify the existing pavement section thickness prior to performing FDR to confirm that the required FDR thickness can be achieved from the existing pavement section. If the combined existing HMA and ABC thicknesses are insufficient, the contractor should be prepared to place additional ABC material to achieve the FDR thickness provided in Exhibit 7-2. The additional ABC should be placed prior to completing the FDR pulverization process. Table A-1 in Appendix A presents a summary of pavement section thicknesses observed during our subsurface investigations.

7.2.2 Functional Mill and Overlay

The functional mill and overlay approach is typically adequate for preventative maintenance and will increase ride quality. However, it will not provide a significant extension of the pavement service life. Furthermore, reflective cracking from wide cracks in the milled pavement is likely.

As previously described, the measured asphalt thickness varied from 2 1/2 to 7 inches thick but was typically on the order of 4 inches. The milling process removes the surface lift of HMA that typically oxidizes over time and can become brittle (resulting in a lower durability pavement). A minimum thickness of 3 inches of asphalt pavement should remain in place after milling to support construction equipment and reduce the risk of the un-milled pavement being cracked or completely removed. Based on the observed thicknesses of the existing pavement, there is a risk for the locations with thin HMA to be completely removed during the milling process. Further, if the entire HMA section is removed, the contractor will be responsible for reconditioning the underlying base course or subgrade and paving a thicker HMA section resulting in additional costs.

Typical mill and overlay thickness are 2 inches of mill with 2 inches of overlay. Therefore, this type of maintenance might not be appropriate for areas of the project where the asphalt pavement is thinner than 5 inches thick. As an alternative, the milling of the HMA thickness can either be reduced or omitted, resulting in a grade raise of the roadway profile. However, leaving the surface lift of HMA in place (typically removed by milling) could result in reduced durability, and could require a thicker overlay.

7.2.3 Patching

Saw cutting around wide transverse cracks and fatigue cracked areas and replacing the pavement section will extend pavement service life. This procedure will also reduce ride quality if differential settlement occurs between the patched area and the existing asphalt. We do not recommend this approach for the Entrance Road because based on the observed transverse crack spacing, patching would result in a network of closely spaced patches and poor ride quality.

7.2.4 Chip Seal

Chip seal provides a new wearing course and waterproofs low severity cracking with no pavement structure improvement. Installing a chip seal on existing asphalt pavement can extend the service life of the existing pavement section, but existing cacks will propagate through the chip seal. During our visual pavement assessment, we observed the Entrance Road pavement had been previously surfaced with a chip seal. Transverse cracks and occasional longitudinal cracks had propagated upwards through the chip seal in some areas. Other than these propagating cracks, the roadway was considered to be in good condition using the FWS rating system.

7.2.5 Crack Sealing and Crack Filling

Crack sealing and crack filling is generally a short-term treatment (typically less than 1-year) and is typically performed between pavement rehabilitations and will generally not improve ride quality. The FHWA manual of practice titled Materials and Procedures for Sealing and Filling Cracks in Asphalt-Surfaced Pavements (Smith and Romine, 1999) has the following definitions.

- Crack Sealing – The placement of specialized treatment materials above or into working cracks using unique configurations to prevent the intrusion of water and incompressibles into the crack.
- Crack Filling – The placement of ordinary treatment materials into non-working cracks to substantially reduce infiltration of water and to reinforce the adjacent pavement.

The difference between working and non-working cracks can be identified by measuring their horizontal movement over the duration of a year.

- Working Crack - 1/8 inch or greater
- Non-working Crack - less than 1/8 inch

Typically, high severity cracks, such as the ones observed throughout the project area, are caused by thermal expansion and contraction of the HMA pavement between day/night and

between the seasons. These are considered working cracks because they continue moving after the crack has formed and typically keep increasing in aperture with time. Therefore, it is generally difficult to achieve a lasting repair, and we recommend crack sealing or replacing the pavement section if cracks have an aperture of 1/8 inch or greater. Crack filling can be utilized for smaller cracks (less than 1/8 inch).

Available products for crack sealing are asphalt rubber, rubberized asphalt, low-modulus rubberized asphalt, and self-leveling silicone. Available products for crack filling are polymer-modified emulsion, fiberized asphalt, asphalt cement, and asphalt emulsion.

Regardless of how a crack is filled or sealed, annually maintenance should be expected between scheduled pavement rehabilitation. In accordance with Smith and Romine (1999), we recommend performing crack sealing during moderately cool temperatures (spring or fall) so the aperture of the cracks are in the middle of their working range.

7.2.6 Fog Seal

Fog seal is another short-term treatment between scheduled pavement rehabilitations. Fog seal typically involves applying a thin layer of asphalt emulsion to the existing HMA pavement to seal non-working cracks and slow the oxidization of the existing pavement surface. This short-term treatment method will generally extend pavement service life by one to two years, but will not seal working cracks or fatigue cracked pavement areas, nor will it improve ride quality.

7.3 Seismic Design Considerations

We understand that design ground motion parameters will be based on the requirements of the 2021 International Building Code (International Code Council, 2021), which has adopted the ASCE 7-16 design code for minimum design loads on buildings (ASCE, 2017). These design loads are in turn based on the USGS National Seismic Hazard Maps that were updated in 2008 (Petersen and others, 2008). The design ground motions are based on the risk-targeted maximum considered earthquake (MCE_R) as defined in ASCE 7-16. Based on encountered soil and rock conditions, the site can best be described as Site Class C at the proposed 24,000-gallon water tank locations and Site Class D at the proposed lift station location. The following exhibit provides seismic design parameters for the project.

Exhibit 7-4: Seismic Design Parameters

Design Parameter	Value	
Peak Ground Acceleration (PGAB)[1]	0.218 g	
Short-period Spectral Acceleration, SS	0.507 g	
Long-period Spectral Acceleration, S1	0.166 g	
Site Class	C	D
Site Factor, FPGA	1.2	1.38
Site Factor, Fa	1.3	1.39
Site Factor, Fv	1.5	2.27
Site Modified Peak Ground Acceleration, PGAm	0.262 g	0.301 g
Site Modified Spectral Acceleration (0.2 s), SMS	0.659 g	0.705 g
Site Modified Spectral Acceleration (1.0 s), SM1	0.249 g	0.377 g
Seismic Design Value (0.2 s), SDS	0.439 g	0.470 g
Seismic Design Value (1.0 s), SD1	0.166 g	0.251 g

NOTES:

1 PGAB refers to peak ground acceleration for a site underlain by Site Class B soil (rock).

g = gravity; sec. = seconds

7.4 Foundation Recommendations for Structures

We understand that the structures will be supported on shallow foundations (conventional spread footings or a mat). We recommend mat foundations for all of the structures based on current design plans (Jacobs, 2024), although spread footings are also feasible. Shallow foundation design is governed by the strength and settlement characteristics of the underlying soil/rock strata. The following sections provide our shallow foundation recommendations. Foundation excavations should extend below frost depth.

7.4.1 Below-Grade Water Tank Foundation

We understand that this structure will be fully compensated (i.e. the weight of the structure will be less than the excavated soil) and the foundation bearing elevation will be approximately 15 feet bgs. We recommend a net allowable bearing of 8 kips per square foot (ksf) for a mat foundation bearing on tuff bedrock. We anticipate less than one inch of settlement at the recommended net allowable bearing pressure with differential settlement of approximately half the total settlement over the length of the foundation.

We do not anticipate that bearing capacity will control design of a mat foundation. Instead, we anticipate that the design will be governed by soil-structure interaction and the evaluation of calculated mat settlement (deflections), shears, and moments. To design the

mat foundation, we recommend using a modulus of subgrade reaction (k) value ranging from 110 to 130 pounds per cubic inch (pci).

7.4.2 Mechanical Building Foundation

We understand the foundation bearing elevation for this structure will be at a maximum depth of 2 feet bgs. We recommend a net allowable bearing of 7 ksf for a mat foundation bearing on tuff bedrock for this structure. The allowable bearing pressure can be increased by 1/3 for short term loads such as wind and seismic. We anticipate less than one inch of settlement at the recommended net allowable bearing pressure with differential settlement of approximately half the total settlement over the length of the foundation. To design the mat foundation, we recommend using a modulus of subgrade reaction (k) value ranging from 90 to 110 pci.

7.4.3 Package Lift Station

We understand the foundation bearing elevation has not been chosen yet, but will be somewhere between 10 and 20 feet bgs. We understand that this structure will be fully compensated and recommend a net allowable bearing of 6 or 12 ksf for a mat foundation bearing on dense to very dense sand at 10 feet and 20 feet bgs, respectively. Linear interpolation for the net allowable bearing should be used if the bearing elevation is between 10 and 20 feet bgs. We anticipate less than one inch of settlement at the recommended net allowable bearing pressure with differential settlement of approximately half the total settlement over the length of the foundation.

To design the mat foundation, we recommend using a modulus of subgrade reaction (k) value ranging from 80 to 100 pci or 180 to 200 pci for a bearing elevation of 10 feet and 20 feet bgs, respectively. Linear interpolation for the k-value should be used if the bearing elevation is between 10 and 20 feet bgs.

7.4.4 Lateral Earth Pressures

The lateral earth pressures on structure walls depend on many factors, including surcharge loads, the soil type, and whether the top of the wall can yield or deflect laterally during and after excavation. If the top of the wall is free to yield a minimum of 0.1% of the wall height (i.e., 0.001 times the height [H]), the soil pressures will generally be lower (i.e., active condition), than if the wall is not able to yield this amount due to stiffness or resistance of the wall (i.e., at-rest condition). We anticipate that at-rest earth pressures will be appropriate for the structure. See Exhibit 7-5 for recommended lateral earth pressures values.

The lateral earth pressures assume the structure walls are backfilled with properly compacted granular material in a 1H:1V (horizontal to vertical) zone extending upward from the base of the structure from a point 1.5 feet behind the wall and that water does not accumulate in the backfill. These pressures also assume a vertical wall face and a flat backslope.

Seismic active lateral earth pressure coefficients were determined based on the Mononabe-Okabe method (AASHTO, 2020), and seismic at-rest earth pressure coefficients were determined based on methods developed by Zhang and others (1998). For both methods, we assumed the Site Class D site-adjusted peak ground accelerations to calculate the seismic earth pressure. Per AASHTO (2020), the pressure distribution shape for dynamic active earth pressures is triangular, with the resultant force (P_{AE}) acting at the lower third of the wall height (h/3). The parameters are provided in Exhibit 7-5.

Exhibit 7-5: Recommended Lateral Earth Pressures

Design Parameter	Coefficient	Equivalent Fluid Density (pcf)
Static At-Rest Earth Pressure Coefficient, K_0	0.44	59
Dynamic At-Rest Earth Pressure Coefficient, K_{oe}	0.66	89

NOTES:

1 Values assume a vertical face and flat backslope.

2 pcf = pounds per cubic foot

Surcharge loads from motor vehicles/traffic and construction equipment will induce additional lateral loads on structure walls. The pressures provided above do not account for surcharge loads. Lateral loads due to various types of surcharges may be calculated by using the at-rest earth pressure coefficient (K_0) and the diagrams provided in Figure 3.

7.4.5 Lateral Resistance

Lateral loads can be resisted by friction along the base of the foundation using an allowable coefficient of sliding resistance of 0.35 for concrete sliding on tuff or granular overburden. This allowable value for coefficient of sliding resistance includes a factor of safety of 1.5.

7.4.6 Uplift

Groundwater was not encountered near the location of the proposed 24,000-gallon tank (boring SW-09) or the lift station (boring SW-14). As such, groundwater is not anticipated to impact design of the structures. However, given the proximity of the lift station to the Frijoles Creek, we recommend that the depth of the proposed structures relative to the creek level be evaluated. If the creek level is anticipated to be above the base of the structure, design of the structure should consider uplift.

7.5 Pipelines

7.5.1 Loads on Pipes

The structural design of pipelines should consider the loads acting on the pipe. The earth load that will be imposed on a buried pipe depends on the subsurface soil and groundwater conditions, the type of backfill, the height of backfill above the pipe, the method of installation, the relative rigidity of the pipe, and the pipe dimensions.

PVC and MDPE pipe are proposed to be installed for water, sewer, and gas utility lines, primarily through open-cut construction methods. However, trenchless methods are also being considered in one location where the waterline will cross under New Mexico Highway 4 east of the existing above-ground water tank (see Section 8.5 for construction considerations). We anticipate that the loading will be transferred through the pipe and carried by the bedding and subgrade soils beneath the pipe.

Loads on flexible pipes, such as PVC and MDPE, are supported by the passive resistance of the soil as the pipe deflects and the sides move outward and downward into the soil. To estimate the potential settlement of flexible pipes under loading, a derivation of Spangler's equation (the Modified Iowa Formula) is typically used. The soil parameter required in this formula is the modulus of soil reaction (E'). Based on the explorations completed for this project and recommendations made in the PVC Pipe Design and Installation Manual (AWWA, 2002), we recommend using an E' value of 3,000 psi. This is based on a Type 5 laying condition as described in AWWA's manual. This E' value does not include a factor of safety.

7.5.2 Thrust Restraint

Thrust restraint for the pipelines may be provided through the use of restrained joints or thrust blocks. Thrust blocks bearing against the native soils and used to encase tee connections and bends may be designed using an allowable passive earth pressure of 250 pcf, with an average pressure over the face of the thrust block not to exceed 3,000 psf. For restrained joints, a coefficient of friction of 0.25 may be used between the pipe and pipe bedding material in combination with a soil unit weight of 125 pcf. These values include a factor of safety of 1.5 on ultimate soil strengths.

7.5.3 Pipe Bedding and Backfill

The thickness and gradation of materials to be used for pipe bedding depend on a number of factors, primarily the pipe diameter, pipe material, trench width, and constructability. Different jurisdictions typically have their own specifications for pipe bedding, as no uniform standard exists. Based on our experience, 4 to 6 inches of pipe bedding is

commonly placed in the trench prior to pipe installation and extends to at least the top of the pipe. In many cases, pipe embedment will extend a distance of 6 to 12 inches above the top of the pipe.

Pipe bedding typically consists of compacted granular material containing a relatively low percentage of fines or controlled low strength material (CLSM). We recommend that the pipe bedding and embedment material consist of one of the following materials: ASTM C33 (Gradation 67), graded gravel, uniformly graded pea gravel, or 3/8-inch crushed rock. Bedding should be clean, free draining, poorly graded, non-friable material containing no clay balls or organics. Given the data from our geotechnical explorations, we do not anticipate that native soils will be suitable for pipe bedding given the fines content. We have provided recommended gradations in Exhibit 7-6 for imported bedding. Alternately, flowfill could be utilized for bedding and embedment. See Section 8.3.2 for recommendations for subgrade preparation prior to bedding placement.

Exhibit 7-6: Recommended Pipe Bedding and Embedment Material Gradation

Material	Sieve Size (Percent Passing by Weight)[1]									
	1-Inch	¾ - Inch	½ - Inch	⅜-Inch	No. 4	No. 8	No. 16	No. 20	No. 100	No. 200
ASTM C33 (Gradation 67)	100	90-100	-	20-55	0-10	-	-	0	-	-
Graded Gravel	-	100	90-100	40-100	0-30	0-10	0-5	-	-	-
Uniformly Graded Pea Gravel	-	-	-	100	70-100	25-90	5-80	-	1-15	0-5
Crushed Rock	-	-	-	100	20	-	-	-	-	-

Most native soils are considered acceptable for reuse as trench backfill. Completely weathered to moderately weathered bedrock can be re-used as trench backfill above the embedment material, provided it is processed and re-worked to a soil-like material with the maximum particle size less than 6 inches. However, we do not recommend the use of clay soils as trench backfill under roadways or adjacent to any improved areas where post-construction settlement would be undesirable. However, this material is suitable in other areas where settlement is not a concern.

8 CONSTRUCTION CONSIDERATIONS

The applicability of the design recommendations provided in this report is contingent on good construction practice. Poor construction techniques may alter conditions from those on which our recommendations are based, resulting in reduced foundation capacity and

increased settlement. The following sections present construction considerations for this project.

8.1 Dewatering and Control of Water

Groundwater was encountered in borings SW-12, SW-48, and SW-49 at depths of 8.5, 9.0, and 9.8 feet bgs, respectively, at the time of drilling. We do not expect groundwater to be encountered during construction based on the proposed invert depths of the pipelines and structures. Surface water must be controlled and kept away from open portions of the excavation. If surface water runoff is unavoidable, we recommend using sumps within the excavation to control remove inflows.

8.2 Excavation and Support

8.2.1 Excavation

We understand that the depth to the proposed utilities will generally be less than 5 feet. Foundation depths of the structures is expected to be no more than 10 feet bgs. Based on our subsurface explorations, excavations will generally be performed within granular overburden and variably weathered bedrock predominantly consisting of extremely weak to weak tuff and rhyolite. Medium strong to very strong basalt was encountered in boring SW-13 at approximately 0.2 feet below the ground surface.

We anticipate that the overburden materials can be excavated with conventional construction equipment. Shallow bedrock was encountered in several of the borings and can be expected to be encountered throughout the alignment. We generally anticipate that the tuff/rhyolite can be excavated using conventional excavating equipment, such as a rubber-tired backhoe or a tracked hydraulic excavator with ripper attachments; however, production may be slower in comparatively stronger layers of the tuff/rhyolite which may require excavation with a hydraulic rock breaker. Excavation in the basalt encountered in SW-13 will be more challenging. Depending on the size of excavations in this material, techniques and equipment such as ripping, hydraulic rock breakers, and the use of percussive drilling to break up rock in narrow excavations for manholes and similar structures should be anticipated.

8.2.2 Utility Considerations

Based on preliminary plans and our experience coordinating utilities prior to our subsurface exploration program, numerous active underground utilities are present at the site. Excavation under and/or adjacent to existing utilities will be necessary based on the location of the proposed structures and new utility lines. Protection of these existing utilities during

excavation will be an important aspect of this project and will likely affect construction means and methods as well as sequencing and schedule. Recommendations related to excavation support and potential limitations or restrictions are provided in the following section.

8.2.3 Temporary Slopes and Shoring

8.2.3.1 Temporary Slopes

The safe slope for the excavation of subsurface materials depends on many factors, including: (a) the presence of groundwater; (b) the type, density, and shear strength of the subsurface materials; (c) the depth of excavation; (d) the presence of adjacent facilities; (e) surcharge loading adjacent to the excavation (including excavated material, existing dead or live loads, and construction equipment); and (f) time of construction. We recommend the temporary slopes be consistent with the Occupational Safety & Health Administration (OSHA) guidelines contained in 29 CFR 1926, Subpart P (OSHA, 1999). For cost estimating purposes only, we recommend assuming temporary slopes of 1H:1V (horizontal to vertical) to 1.5H:1V in weathered tuff/rhyolite and overburden, respectively. Steeper slopes may be feasible in less weathered zones of tuff/rhyolite.

Consistent with conventional practice, the contract documents should require the Contractor to be responsible for the actual temporary excavation slopes, including methods, sequence, and schedule of construction. The Contractor is able to observe the nature and conditions of the subsurface materials encountered and should evaluate the factors discussed above. If instability is observed, slopes should be flattened or shored. All excavations should be accomplished in accordance with local, state, and federal safety regulations.

To reduce the potential for horizontal ground disturbance caused by unsupported excavations, it is our understanding that shoring is the preferred method to support excavations where practical.

8.2.3.2 Shoring

Based on the proximity of the proposed structures to existing infrastructure and utilities and the required depth of excavation, the use of temporary slopes may not be possible; therefore, temporary shoring may be required (particularly for construction of the 24,000-gallon water tank and lift station). Where shored excavations of moderate depth are made in competent soils, our experience has been that temporary, flexible support systems used in conjunction with localized dewatering and/or groundwater control, as needed, are typically most economical. We anticipate that soldier pile and lagging and temporary soil nail

structures will be feasible alternatives based on subsurface conditions at the 24,000-gallon water tank and lift station. Due to the possibility of loose/clean sand and/or cobbles and boulders in the canyon bottom near the lift station, installation of temporary shoring may be more difficult, requiring specialized drilling methods and measures to reduce sloughing at the excavation face during shoring installation. Additionally, removal of boulders may result in an uneven excavation face, requiring additional shotcrete or other backfill.

Where shoring is required for localized pipeline construction, contractors typically use trench boxes for both pipeline and manhole construction. It should be understood, however, that trench boxes do not provide adequate support of the trench, but only provide for safety of workers within the trench. Because the trench box is placed after the excavation is dug and is not typically snug against the trench walls, a significant amount of soil movement is possible, especially in the presence of groundwater and in soft or loose soils. Where excavations will be near existing buried utilities or other sensitive facilities, this soil deformation may impose unacceptable loads and deflections. Therefore, trench boxes should be used with caution where adjacent ground movements would not be detrimental.

8.3 Earthwork

8.3.1 Site Preparation

We recommend that grass and other vegetation, including roots, be cleared from all areas to be improved. Any existing surficial organic topsoil and any soil containing organics also should be stripped and removed. The depth of this removal is anticipated to vary over the site. Topsoil and organic-rich soils are not considered suitable for reuse as fill and should be removed from the site or stockpiled for reuse in landscaping areas.

8.3.2 Structure Subgrades

The foundation soils anticipated at structure foundation elevations are expected to include primarily granular soils and bedrock with varying degrees of weathering. Based on our subsurface explorations, these materials will provide adequate foundation support for the buildings if maintained in an undisturbed condition free of water during construction.

Excavations for mat or shallow foundations should be observed by a geotechnical engineering representative familiar with the subsurface conditions to evaluate the adequacy of the bearing stratum and confirm that the subsurface conditions at and below the bearing elevations are consistent with design assumptions. For foundations and slabs constructed on granular soils, we recommend that the foundation subgrade be proof-rolled or probed to

determine its suitability. Any loose, soft, or yielding areas identified by proof-rolling should be over-excavated by 2 feet and recompacted.

The final subgrade surface of the structures should be sloped to promote positive drainage. Care should be taken during subgrade preparation to avoid disturbing subgrade soils and support soils that will remain in place, as they can rut and pump under repeated construction traffic. Subgrade excavations should be cleaned of all debris and loose/soft material prior to concrete placement.

Subgrade excavations should be cleaned of all undocumented fill, debris, or loose/soft material prior to concrete placement and should be kept free of water at all times. If any structures require dewatering to reach the base of excavation, it will be important to maintain the soil at the base of the excavation in a firm and undisturbed condition. If groundwater is flowing into the base of the excavation or is near the subgrade elevation it can loosen/soften the subgrade material. Therefore, we recommend that the groundwater level be maintained a minimum of 3 feet below the base of all excavations, and that surface water be directed away from excavations.

8.3.3 Pavement Subgrades

In pavement replacement areas, following the removal of the existing pavement and excavation to the proposed subgrade level, the exposed subgrade should be scarified to a depth of 8 inches, moisture treated, and recompacted. Clay subgrade soils (AASHTO soil classification A-6 and A-7) should be compacted between 0% and 2% above optimum moisture content and recompacted to at least 95% of the maximum dry density determined in accordance with AASHTO T99 (standard compaction effort). Additionally, we recommend that the subgrade be compacted to a firm and unyielding condition. If granular soils (AASHTO soil classification A-1 through A-5) are encountered, the subgrade should be moisture treated within 2% of the optimum moisture content and compacted to a dense and unyielding condition and at least 95% of maximum dry density determined in accordance with AASHTO T180 (modified compaction effort).

The compacted surface should then be proof rolled with a fully loaded, tandem-axle, 10-yard dump truck or equivalent. We recommend that the proof-rolling be observed by a representative of Shannon & Wilson. If areas are identified as being loose, soft, or yielding during proof-rolling, these areas of the subgrade should be improved by further compaction using a vibratory roller for sands or a sheep foot roller for clays. If the subgrade cannot be stabilized, we recommend a maximum overexcavation of two feet. If soft or yielding soils are encountered after overexcavating two feet, a geogrid (Tensar biaxial grid BX1200, triaxial grid TX-5, or equivalent) should be installed at the base of the excavation before backfilling with aggregate base course.

Care should be taken during proof rolling and subgrade preparation to avoid disturbing subgrade and supporting soil that will remain in place, as they can rut and pump under repeated construction traffic. At no point should the subgrade be allowed to either dry out or become overwetted and unworkable (i.e., exposure to surface runoff) after the completion of the moisture treatment processing. If treated soil becomes overwetted or dries below the criteria provided in this section, the Contractor should be responsible for returning the soil to an acceptable condition prior to additional fill placement or paving.

8.4 Fill Placement and Compaction

8.4.1 Structural Backfill

We recommend Granular Backfill for use in backfilling below grade structures and pipelines. Granular Fill should consist of native or imported well-graded sand and gravel with less than 12% fines (material passing the U.S. Standard No. 200 sieve). Imported material classified as GW, GW-GM, SW, or SW-SM according to the Unified Soil Classification System is suitable for Granular Fill, with the additional requirement that the maximum particle size should be 3 inches.

Fill materials should be placed in horizontal lifts, with the loose lift thickness not to exceed 8 inches for heavy equipment compactors and 4 inches for hand-operated compactors. Compaction of backfill adjacent to buried structures can result in higher lateral earth pressures. As such, only small equipment that is hand-operated should be used within a line extending upward from the base of the structure at 0.5H:1V, or at least 3 feet from the wall, whichever is greater. Unless the structural engineer indicates differently, we recommend that backfill around structures be brought up in uniform horizontal layers and not be unbalanced around the structure.

All fill materials should be compacted to a dense/firm and unyielding condition. Granular Fill should be compacted to a minimum of 95% of its Modified Proctor maximum dry density (ASTM D1557) with moisture content within ± 3% of the optimum moisture content.

8.4.2 Compaction of Bedrock-Derived Materials

We anticipate that the El Cajete pyroclastic beds (rhyolite) and Bandelier Tuff bedrock will break down into a mixture of silt, sand, and gravel in the course of excavation, hauling, placement, and recompaction. As such, it will be important to conduct grain-size analyses of the material before and after laboratory compaction tests, as well as before and after field compaction to determine if the laboratory tests are representative of the material being placed and compacted in the field. Large cobbles or boulders greater than 6 inches in diameter will need to be removed from the fill. Based on previous experience with tuff-

derived materials, we anticipate the material will have a low unit weight and may be moisture-sensitive, leading to difficult compaction conditions when it only slightly exceeds the optimum moisture content. As such, the recommended moisture range for this material is 3% under the optimum moisture content.

8.5 Trenchless Crossing

Based on discussions with Jacobs, we understand that trenchless methods will be used to construct a section of water, gas, and electric utilities under NM Hwy 4. The water and gas trenchless crossings will be approximately 400 feet southeast of the existing blue storage tank. The electric conduit trenchless crossing is approximately 400 feet northwest along NM Hwy from the Entrance Road. The final alignments are expected to be on the order of 150 to 175 feet in length.

Borings SW-04, SW-15, SW-16, and SW-17 were proposed to evaluate subsurface conditions near the proposed water and gas trenchless crossings. Boring SW-04 was drilled approximately 400 feet northwest of the proposed trenchless crossing. Boring SW-15 was terminated at 3.5 feet bgs due to a utility strike. Boring SW-16 was not drilled (see Section 3.2). SW-17 was drilled at the proposed trenchless crossing location on the south side of NM Hwy 4. Borings SW-04 and SW-17 encountered very weak, moderately to completely weathered tuff and medium dense to very dense silty sand fill material underlain by extremely weak, completely weathered to fresh rhyolite, respectively. These materials are considered suitable for utility pipe installation using trenchless methods.

Borings SW-17 and SW-18 are the closest borings to the proposed electric conduit trenchless crossing and are located approximately 800 feet northwest and 500 feet southwest from the proposed crossing, respectively. The subgrade for boring SW-17 was discussed in the previous paragraph and SW-18 encountered medium dense to dense silty sand residual soil. These materials are considered suitable for utility pipe installation using trenchless methods.

8.6 Paving Materials

8.6.1 Hot Mix Asphalt

HMA paving may consist of patching and reconstruction, and we assume that one HMA mix will be used for both applications. To determine the recommended binder, we used the FHWA Long Term Pavement Performance (LTPP) Bind (FHWA, 2008) with guidance from the NMDOT Design Manual (2020). LTPP Bind suggests using PG 64-22 for the surface lift and PG 58-16 for underlying lifts based on the minimum traffic speed of "slow", local weather station data, and the minimum traffic loading of "up to 3 million ESALs". The

NMDOT Design Manual (2020) provides criteria for binder selection based on geographic location, traffic speed, and ESALs. We assumed the geographic location was Los Alamos, the traffic speed was "standing" (below 15 miles per hour), and less than 300,000 ESALs. Using these assumptions, the NMDOT (2020) criteria recommend a PG 64-28 binder. NMDOT also recommends using the same PG for underlying lifts. We recommend following NMDOT guidance and using PG 64-28 for all HMA lifts.

The NMDOT Design Manual (2020) recommends using a gradation of either SP-III or SP-IV for the HMA. It also recommends using the same gradation for all lifts. The NMDOT Design Manual further recommends lift thicknesses of 2.5 to 3.5 inches and 1.5 to 3 inches for SP-III and SP-IV, respectively. For the 3-inch thick HMA pavement alternatives in Section 7.1.5, we recommend paving the HMA in one 3-inch-thick lift. A tack coat should be placed between subsequent lifts. The contractor may elect to place a prime coat on the subgrade or base course to protect the material during construction. HMA material and placement should conform to the requirements of the most recent NMDOT Standard Specifications for Highway and Bridge Construction.

8.6.2 Portland Cement Concrete Pavement

The PCC pavement mix design for pavements should be in accordance with the most recent NMDOT Standard Specifications for Highway and Bridge Construction for Class P concrete.

8.6.3 Aggregate Base Course

The Aggregate Base Course (ABC) material should conform to the requirements of Base Course from the most recent NMDOT Standard Specifications for Highway and Bridge Construction. ABC material should be placed in maximum 6-inch-thick lifts and compacted to a dense and unyielding condition and to at least 95% of the maximum dry density (AASHTO T180)

8.7 Construction Observation

We developed our geotechnical design recommendations based on a limited number of explorations and tests. Our recommendations may need to be adjusted in the field based on the conditions encountered during construction. We recommend that we be retained during the construction portion of this project to perform a construction observation and monitoring program related to the geotechnical aspects of this project. Monitoring would allow us to confirm that conditions encountered are consistent with those indicated by the explorations and provide expedient recommendations should conditions be revealed during construction that are different from those anticipated.

9 CLOSURE

This report was prepared for the exclusive use of the National Park Service and Jacobs for use in design of the project. Once the remaining borings have been completed, this interim report will be updated. It should be made available to prospective contractors for information on factual data only, and not as a warranty of subsurface conditions.

Our evaluations, analyses, conclusions, and recommendations are based on:

- The limitations of our approved scope, schedule, and budget described in our Professional Services Task Order.
- Our understanding of the project and information provided by Jacobs.

This report should not be used without our approval if any of the following occurs:

- Conditions change due to natural forces or human activity under, at, or adjacent to the site.
- Assumptions stated in this report have changed.
- Project details change or new information becomes available such that our analyses, conclusions, and recommendations may be affected.
- If the site ownership or land use has changed.
- More than 5 years has passed since the date of this report.

If any of these occur, we should be retained to review the applicability of our analyses, conclusions, and recommendations.

Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited boring and testing program. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

Within the limitations of scope, schedule, and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical and geological principles and practice in this area at the time this report was prepared. We make no other warranty, either express or implied.

Shannon & Wilson has prepared the attached document, "Important Information about Your Geotechnical and Environmental Report," to assist you and others in understanding the use and limitations of our reports.

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Table 1 - Summary of Borings

Design Phase	Boring Designation	Date Drilled	Boring Method	Purpose	Boring Depth (feet)
Preliminary/Schematic Design	SW-01	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-02	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-03	12/13/2021	Drill Rig	Utility Trench	10.4
	SW-04	12/15/2021	Drill Rig	Elevated Tank	31.5
	SW-05	12/14/2021	Drill Rig	Utility Trench	11.5
	SW-06	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-07	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-08	12/14/2021	Drill Rig	Utility Trench	11.5
	SW-09	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-10	12/14/2021	Drill Rig	Utility Trench	11.5
	SW-11	12/13/2021	Drill Rig	Utility Trench	11.5
	SW-12	12/14/2021	Drill Rig	Utility Trench	11.5
	SW-13	12/15/2021	Drill Rig	Utility Trench	20
	SW-14	12/13/2021	Drill Rig	Lift Station	21.5
Design Development	SW-15[4]	4/9/2024	Drill Rig	Elevated Tank	50 (terminated at 3.5)
	SW-16[1]	N/A	Drill Rig	Trenchless Utility	20 (not drilled)
	SW-17	4/9/2024	Drill Rig	Trenchless Utility	21
	SW-18	11/6/2023	Drill Rig	Pavement	5
	SW-19	11/3/2023	Drill Rig	Utility Trench	15
	SW-20	11/6/2023	Drill Rig	Pavement	5.5
	SW-21	11/6/2023	Drill Rig	Pavement	5.5
	SW-22	11/6/2023	Drill Rig	Pavement	5
	SW-23	11/3/2023	Drill Rig	Utility Trench	14.1
	SW-24	11/6/2023	Drill Rig	Pavement	5
	SW-25	11/6/2023	Drill Rig	Pavement and Utility Trench	14.3
	SW-26	11/6/2023	Drill Rig	Pavement	5.5
	SW-27	11/3/2023	Drill Rig	Pavement	5.5
	SW-28	11/6/2023	Drill Rig	Utility Trench	15
	SW-29	11/2/2023	Drill Rig	Utility Trench	14.3
	SW-30	11/3/2023	Drill Rig	Pavement	4.3
	SW-31	11/3/2023	Drill Rig	Utility Trench	29.3
	SW-32	11/3/2023	Drill Rig	Pavement	4.5
	SW-33	11/2/2023	Drill Rig	Utility Trench	15
	SW-34	11/7/2023	Drill Rig	Pavement	5
	SW-35	11/7/2023	Drill Rig	Pavement and Utility Trench	15.5
	SW-36	11/6/2023	Drill Rig	Pavement	5.5
	SW-37	11/7/2023	Drill Rig	Pavement	5.5
	SW-38	11/2/2023	Drill Rig	Buried Tank	50.5
	SW-39	4/10/2024	Drill Rig	Pavement	5.5

Table 1 - Summary of Borings

Design Phase	Boring Designation	Date Drilled	Boring Method	Purpose	Boring Depth (feet)
	SW-40[2]	4/10/2024	Hand Auger	Pavement	5 (refusal at 0.8)
	SW-41	11/7/2023	Drill Rig	Pavement	5
	SW-42[3]	4/10/2024	Hand Tools	Pavement	5 (refusal at 0.3)
	SW-43	11/7/2023	Drill Rig	Utility Trench	15.4
	SW-44[3]	4/10/2024	Hand Tools	Pavement	5 (refusal at 0.7)
Design Development	SW-45	11/7/2023	Drill Rig	Pavement	5
	SW-46	11/7/2023	Drill Rig	Pavement	5
	SW-47	11/7/2023	Drill Rig	Pavement	5.5
	SW-48	4/9/2024	Drill Rig	Trenchless Utility	20.3
	SW-49	4/11/2024	Drill Rig	Trenchless Utility	20
	SW-50	11/7/2023	Drill Rig	Pavement	5.5
	SW-51[2]	4/11/2024	Hand Auger	Pavement	5 (refusal at 0.8)
	SW-52	11/7/2023	Drill Rig	Pavement	5

NOTES:

1 Boring SW-16 was not drilled due to Los Alamos National Laboratory permit issues.

2 Due to the presence of unknown underground utilities, borings were advanced using a hand auger.

3 Due to the presence of unknown underground utilities and drill rig access issues, borings were advanced using a hand tools.

4 Boring SW-15 was terminated at 3.5 feet below ground surface due to an unmarked utility strike.

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Miles

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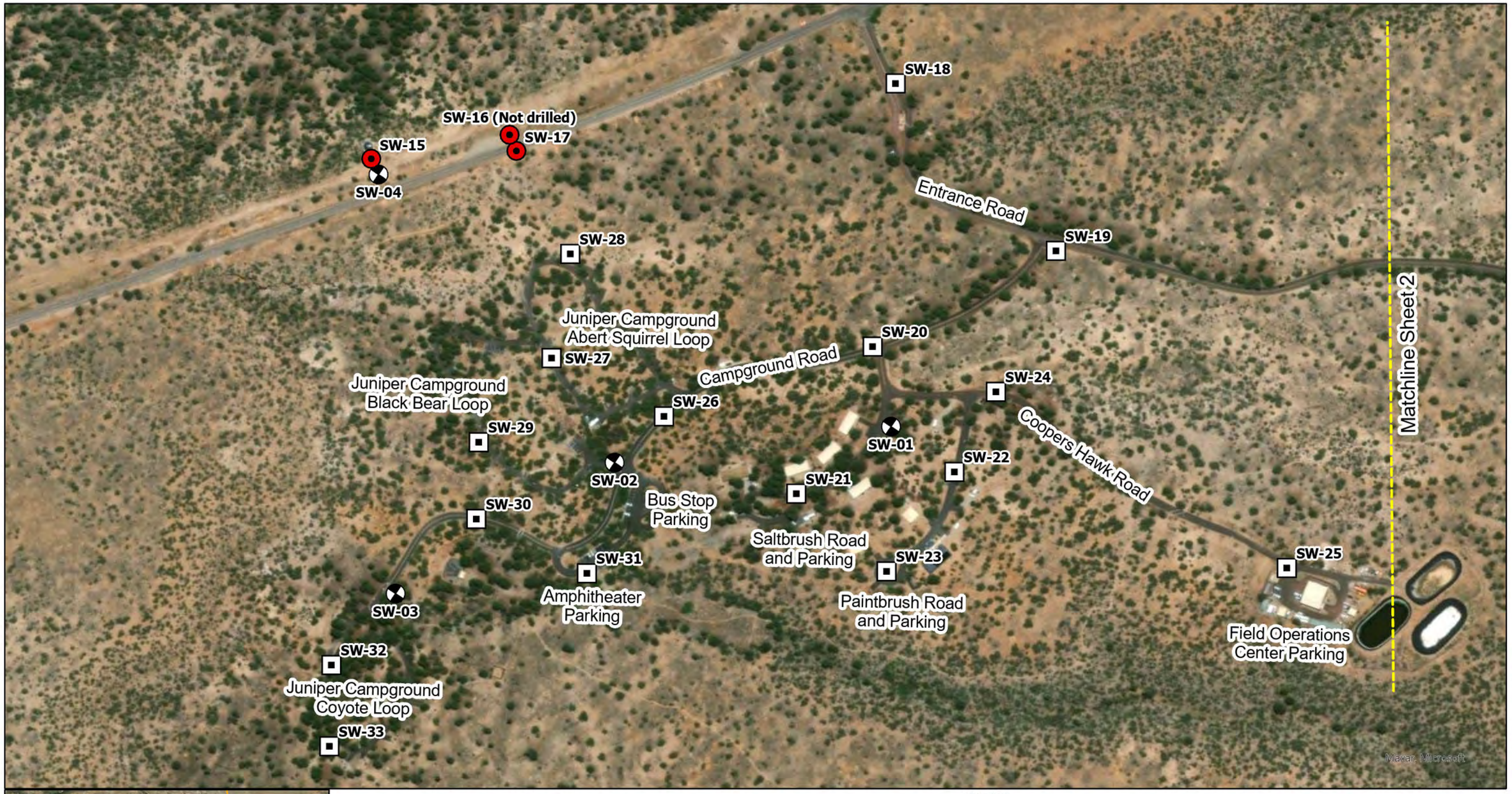
NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

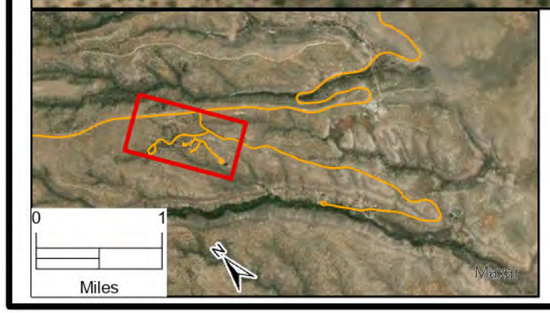
VICINITY MAP

September 2024 107523-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 1





LEGEND

SW-02	2022 Boring Designation and Approximate Location
SW-19	2023 Boring Designation and Approximate Location
SW-15	2024 Boring Designation and Approximate Location
	Matchline

NOTES

1. 2022 boring locations and location of boring SW-15 were estimated by Shannon & Wilson from existing site features as well as recreational grade GPS and should be considered approximate.

2. 2023 & 2024 boring locations are based on survey information provided by Jacobs.

0 300 600

Approximate Scale In Feet

N

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos County, New Mexico

SITE AND EXPLORATION PLAN

September 2024 107523-002

SHANNON & WILSON, INC.
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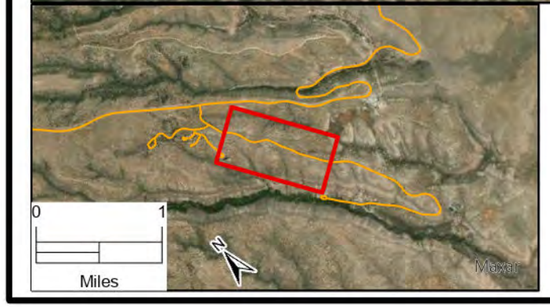
FIG. 2
Sheet 1 of 5



LEGEND

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Approximate Scale In Feet

N

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos County, New Mexico

SITE AND EXPLORATION PLAN

September 2024 107523-002

SHANNON & WILSON, INC.
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FIG. 2
Sheet 2 of 5

Matchline Sheet 2

Entrance Road

SW-36

SW-08

SW-07

SW-06

Fire Tower Lane and Parking

SW-35

Matchline Sheet 4

SW-39

SW-43

SW-44

SW-42

SW-40

SW-11

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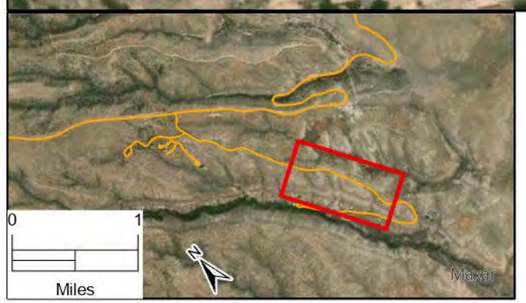

LEGEND

SW-02 2022 Boring Designation and Approximate Location

SW-19 2023 Boring Designation and Approximate Location

SW-15 2024 Boring Designation and Approximate Location

Matchline

NOTES

1. 2022 boring locations and location of boring SW-15 were estimated by Shannon & Wilson from existing site features as well as recreational grade GPS and should be considered approximate.

2. 2023 & 2024 boring locations are based on survey information provided by Jacobs.

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Approximate Scale In Feet

N

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos County, New Mexico

SITE AND EXPLORATION PLAN

September 2024 107523-002

SHANNON & WILSON, INC.
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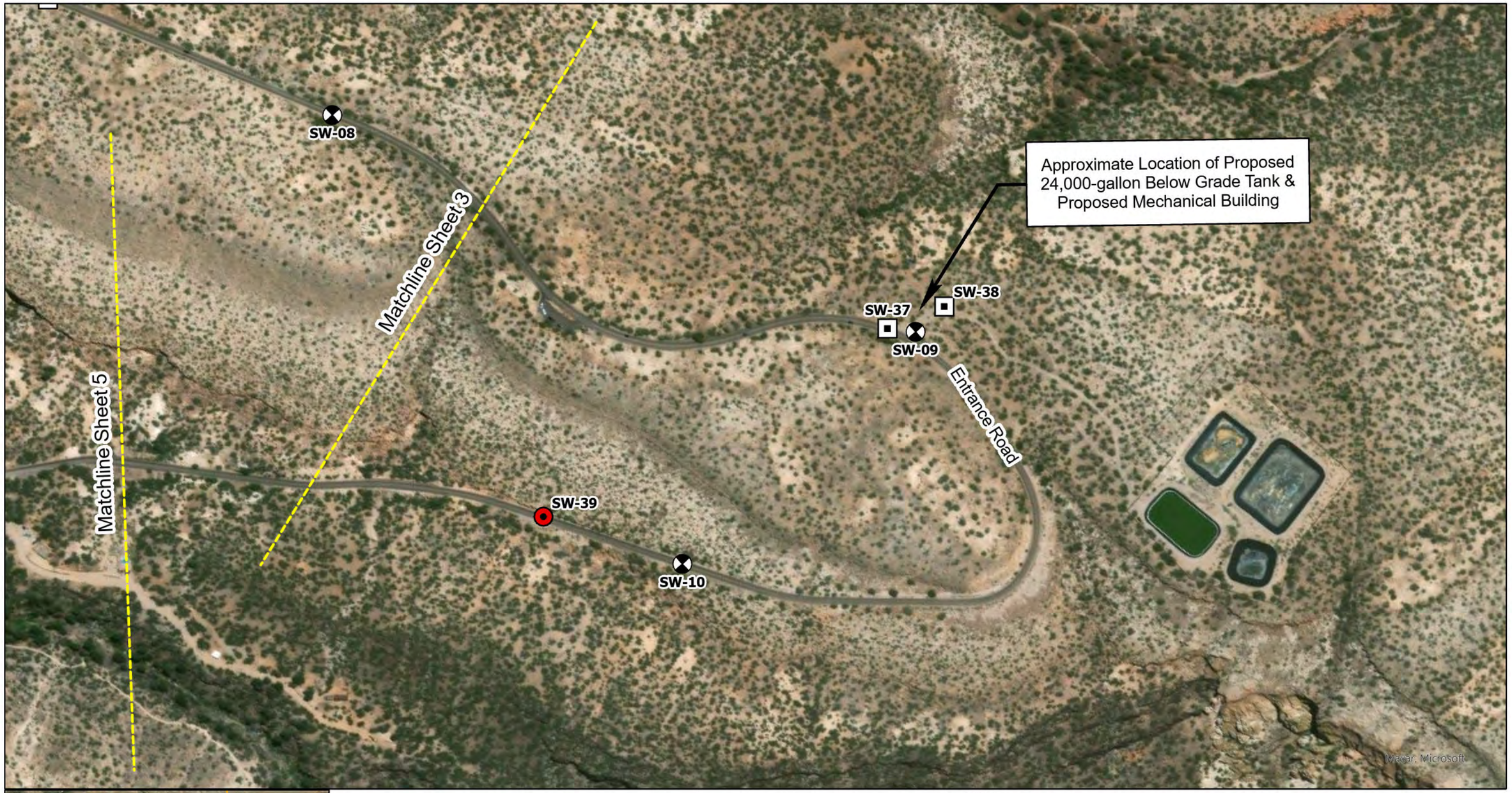
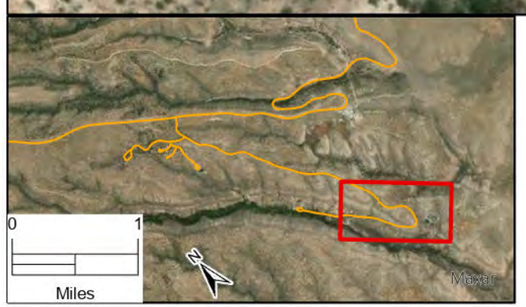
FIG. 2
Sheet 3 of 5





LEGEND

SW-02	2022 Boring Designation and Approximate Location
SW-19	2023 Boring Designation and Approximate Location
SW-15	2024 Boring Designation and Approximate Location
	Matchline

NOTES

1. 2022 boring locations and location of boring SW-15 were estimated by Shannon & Wilson from existing site features as well as recreational grade GPS and should be considered approximate.

2. 2023 & 2024 boring locations are based on survey information provided by Jacobs.

0 300 600

Approximate Scale In Feet

N

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SITE AND EXPLORATION PLAN

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FIG. 2
Sheet 4 of 5

Bandelier Visitors Center and Main Parking

Frijoles Canyon Maintenance Parking

Entrance Road

Agoyo Lane and Parking

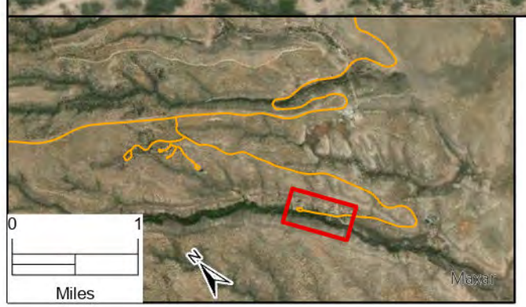
Overflow Parking Road

Matchline Sheet 4

SW-43
SW-44
SW-42
SW-40
SW-11
SW-45
SW-41
SW-46
SW-12
SW-13
SW-47
SW-48
SW-50
SW-49
SW-51
SW-52
SW-14

Approximate Location of Proposed Package Lift Station

Maxar, Microsoft



LEGEND

SW-02	2022 Boring Designation and Approximate Location
SW-19	2023 Boring Designation and Approximate Location
SW-15	2024 Boring Designation and Approximate Location
	Matchline

NOTES

1. 2022 boring locations and location of boring SW-15 were estimated by Shannon & Wilson from existing site features as well as recreational grade GPS and should be considered approximate.

2. 2023 & 2024 boring locations are based on survey information provided by Jacobs.

0 200 400

Approximate Scale In Feet

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FIG. 2
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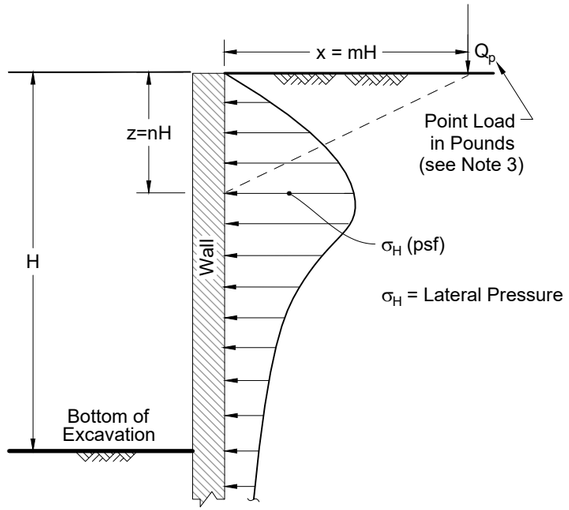
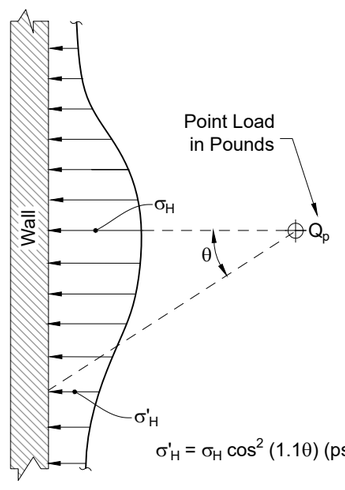


ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3}$ (psf) (see Note 3)

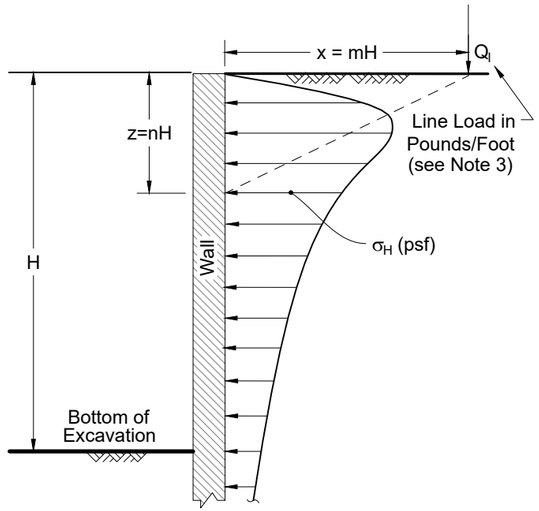
For m > 0.4: $\sigma_H = 1.77 \frac{Q_p}{H^2} \frac{m^2 n^2}{(m^2 + n^2)^3}$ (psf)



PLAN VIEW

A) LATERAL PRESSURE DUE TO POINT LOAD
i.e. SMALL ISOLATED FOOTING OR WHEEL LOAD

(NAVFAC DM 7.2, 1986)



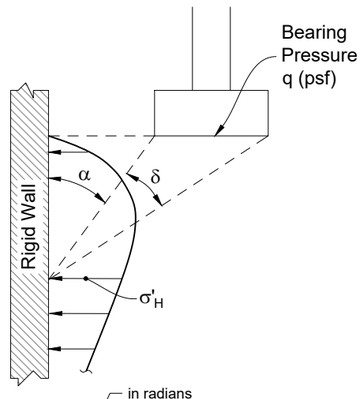
ELEVATION VIEW

For m ≤ 0.4: $\sigma_H = 0.20 \frac{Q_l}{H} \frac{n}{(0.16 + n^2)^2}$ (psf) (see Note 3)

For m > 0.4: $\sigma_H = 1.28 \frac{Q_l}{H} \frac{m^2 n}{(m^2 + n^2)^2}$ (psf)

B) LATERAL PRESSURE DUE TO LINE LOAD
i.e. NARROW CONTINUOUS FOOTING
PARALLEL TO WALL

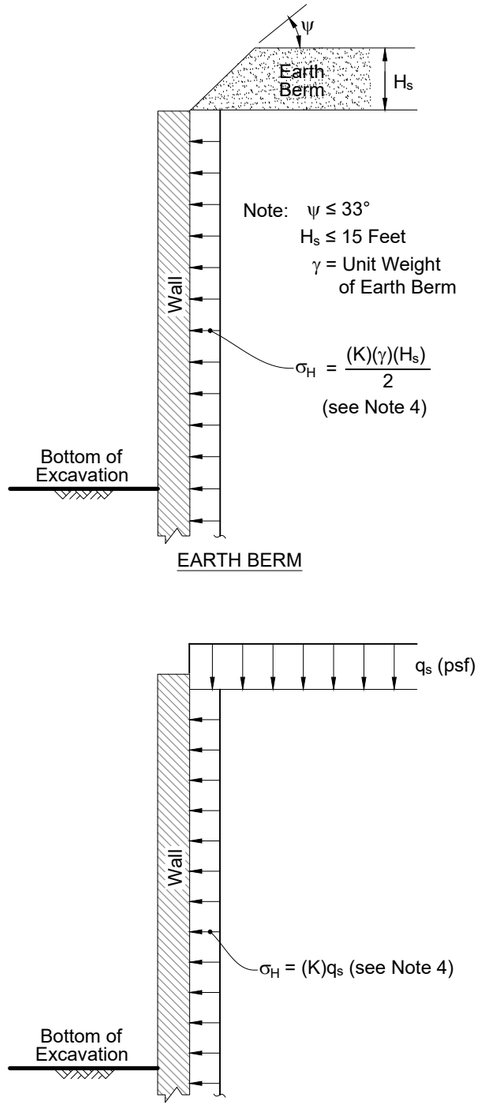
(NAVFAC DM 7.02, 1986)



$\sigma_H = \frac{2q}{\pi} (\delta - \sin\delta \cos(\delta + 2\alpha))$ (psf)

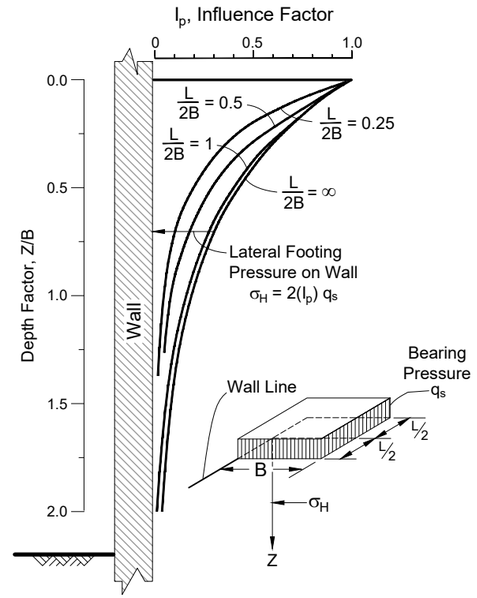
C) LATERAL PRESSURE DUE TO STRIP LOAD

(AASHTO LRFD Bridge Design Specifications, 2017)



D) LATERAL PRESSURE DUE TO EARTH BERM
OR UNIFORM SURCHARGE

(derived from Poulos and Davis, *Elastic Solutions for Soil and Rock Mechanics*, 1974; and Terzaghi and Peck, *Soil Mechanics in Engineering Practice*, 1967)



E) LATERAL PRESSURE DUE
TO ADJACENT FOOTING
(see Notes 5 and 6)

(derived from NAVFAC DM 7.02, 1986; and Sandhu, *Earth Pressure on Walls Due to Surcharge*, 1974)

NOTES

1. Figures are not drawn to scale.
2. Applicable surcharge pressures should be added to appropriate permanent wall lateral earth and water pressure.
3. If point or line loads are close to the back of the wall such that m ≤ 0.4, it may be more appropriate to model the actual load distribution (i.e., Detail E) or use more rigorous analysis methods.
4. See text for recommended K values.
5. The stress is estimated on the back of the wall at the center of the length, L, of loading.
6. The estimated stress is based on a Poisson's ratio of 0.5.

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RECOMMENDED SURCHARGE LOADING FOR TEMPORARY AND PERMANENT WALLS

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FIG. 3

File: J:\Support\library_Standard Figures\Surcharge Loading Temp-Perm Wall_Tabloid.dwg Date: 05-30-2019 Author: sac

Appendix A

Subsurface Explorations

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Boring Logs

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Exhibit A-2: Photograph of Boring SW-15 utility markings prior to drilling
Exhibit A-3: Photograph of Boring SW-15 with auger cuttings and orange utility marking tape
Exhibit A-4: Photograph of Boring SW-15 showing black cable wrapped around the auger

APPENDIX A: SUBSURFACE EXPLORATIONS

A.1 INTRODUCTION

During the DD phase of the project, Shannon & Wilson's field exploration program included 37 borings (designated SW-15 through SW-52) drilled during two mobilizations. The first mobilization was from November 2 to November 7, 2023, and consisted of drilling 28 borings. The second mobilization was from April 9 to April 11, 2024, and consisted of drilling nine borings. Boring SW-16 was not drilled due to utility clearing and permitting issues with the Los Alamos National Laboratory (LANL). Approximate boring locations are shown in Figure 2. The methods used to conduct the field exploration program are described below.

A.2 EXPLORATIONS

The borings were coordinated (including subcontractor coordination and traffic control) and observed by Shannon & Wilson. Individual boring logs are attached. These exploration logs represent our interpretation of the contents of the field logs and select results of laboratory testing. The borings were drilled by Vine Laboratories, Inc. (Vine) of Commerce City, Colorado (under subcontract to Shannon & Wilson) using a truck mounted CME-75 drill rig and a buggy mounted CME-750X drill rig during the first and second mobilizations, respectively. Pavement cores were completed on select borings using a portable electric-powered coring machine fitted with a 4-inch diameter core barrel. Pavement core photographs are included in Figure A-1.

Using the drill rig, borings were advanced to depths ranging from 3.5 to 50.5 feet below existing ground surface (bgs) using 6-inch outer diameter hollow-stem-auger and 4-inch diameter solid stem auger drilling techniques. Due to the presence of unknown underground utilities, borings SW-40 and SW-51 were advanced using a 4-inch diameter hand auger until auger refusal occurred at a depth of 0.8 feet bgs in both borings. Due to the presence of unknown underground utilities and drill rig access limitations caused by nearby trees, borings SW-42 and SW-44 were advanced using hand tools below the pavement until hand tool refusal occurred at depths of 0.3 and 0.7 feet bgs, respectively. Where groundwater was encountered, our field representative measured the approximate depth to groundwater using an electronic water level indicator. Groundwater was encountered in borings SW-48 and SW-49 at depths of approximately 9.0 and 9.8 feet bgs, respectively.

On completion of drilling, the borings in the roadway were backfilled with flow fill mixed on-site by Vine, and the existing pavement depth was matched using either Perma-Patch Permanent Pavement Repair cold-patch asphalt or hot mix asphalt. Borings completed off the roadway were backfilled with cuttings and excess cuttings spread to match the existing grade. The boring location was marked and a representative from Jacobs surveyed each boring location and provided latitude, longitude, and elevation for the borings except boring SW-15.

A.2.1 Soil and Rock Classification System

During the explorations, our representative collected samples and prepared field logs of the explorations. Soil classification for this project was based on ASTM International (ASTM) Designation: D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), and ASTM Designation: D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). The Unified Soil Classification System is summarized in the attached Log Key.

The Shannon & Wilson representative classified rock samples in general accordance with the International Society of Rock Mechanics (ISRM) classification method. According to this system, rocks are classified based on the stratigraphic structure, rock strength, degree of weathering, and other properties. The rock classification system is summarized in the attached Log Key. In some areas of the project, the bedrock was moderately to completely weathered and based on the relatively easy drilling conditions and the SPT sample penetration and recovery; these materials may be considered more soil like in behavior and properties. Therefore, for completeness, some boring logs included in Appendix A contain dual descriptions of the tuff and rhyolite bedrock using the Unified Soil Classification System and the ISRM classification system. In areas of the project where more competent bedrock was encountered, soil classification was not included in the description.

Exhibit A-1 presents a summary of the ISRM rock strength “R” grade.

Exhibit A-1: ISRM Rock Strength

Grade	Description	Approximate UCS (psi)
R0	Extremely Weak Rock	36 to 145
R1	Very Weak Rock	145 to 700
R2	Weak Rock	700 to 3,600
R3	Medium Strong Rock	3,600 to 7,200
R4	Strong Rock	7,200 to 14,500
R5	Very Strong Rock	14,500 to 36,250
R6	Extremely Strong Rock	> 36,250

NOTES:
psi = pounds per square inch; UCS = Unconfined Compressive Strength

A.2.2 Standard Penetration Test (SPT)

Disturbed samples were obtained in the borings in general accordance with the Standard Penetration Test (SPT) (ASTM Designation: D1586). The SPT consists of driving a 2-inch outside diameter, 1.375-inch inside diameter split-spoon sampler a distance of 18 inches with a 140-pound hammer free-falling a distance of 30 inches. An automatic hammer system was used to advance the samplers. During sampling, the Shannon & Wilson field representative recorded the number of blows for each 6-inch increment of penetration and summed the blow counts for the last two 6-inch increments. This sum is recorded as the penetration resistance number, or N-value. If high penetration resistance prevented driving the total length of the sampler, the Shannon & Wilson field representative recorded the partial penetration depth and blow count. The N-values provide a means for evaluating the relative density or compactness of cohesionless (granular) soils and consistency or stiffness of cohesive (fine-grained) soils (see attached Log Key). The raw N-values are shown on the individual boring logs. Representative portions of the split-spoon sample obtained in conjunction with the SPT were placed in a screw-top plastic jar and transported to our laboratory.

A.2.3 Modified California (MC) Test and Sampling

Samples were also obtained using a Modified California (MC) barrel sampler. The MC test procedure is similar to the SPT, except the sample barrel is larger (2½-inch O.D.) and lined with 2-inch-diameter brass tubing. The MC sampler is only driven 12 inches. During sampling, the Shannon & Wilson field representative recorded the number of blows for each 6-inch increment of penetration. As a result of the larger diameter, the MC sampler yields slightly higher raw blow count numbers when compared to SPT N-values for similar soils. However, this is counted by not ignoring a seating depth like is done for SPT. Because the

difference in blow counts does not significantly impact our evaluation, we used the field MC blow counts over the 12-inch increment to define the relative density and consistency/stiffness of the subsurface materials following SPT terminology. Representative samples were sealed in the brass liner tubes with plastic caps and transported to our laboratory for further testing.

A.2.4 Pocket Penetrometer

Select cohesive soil samples were also tested in the field using a pocket penetrometer. The penetrometer estimates the unconfined compressive strength of clay soil samples by penetrating the clay with a one-quarter-inch-diameter penetrometer and measuring the resistance (in units of tons per square foot [tsf]) with a calibrated spring. Measurements can be taken to the nearest 0.25 tsf increment. The field measurements from the pocket penetrometer are listed on the boring logs.

A.2.5 Bulk Sampling

Bulk soil samples were obtained from 26 borings by collecting drill cuttings. Approximately 20 to 30 pounds of cuttings from each boring were placed in a sealed plastic bag. For borings SW-40, SW-42, SW-44, and SW-51, the quantity of cuttings produced from excavation was small and the bulk samples were placed in a screw-top plastic jar. The samples were transported to our laboratory for further analysis.

A.3 UTILITY STRIKE AT BORING SW-15

Boring SW-15 was located on the east side of NM Hwy 4 on LANL property. This location was clear of buried utility markings prior to beginning drilling, as shown in Exhibit A-2.

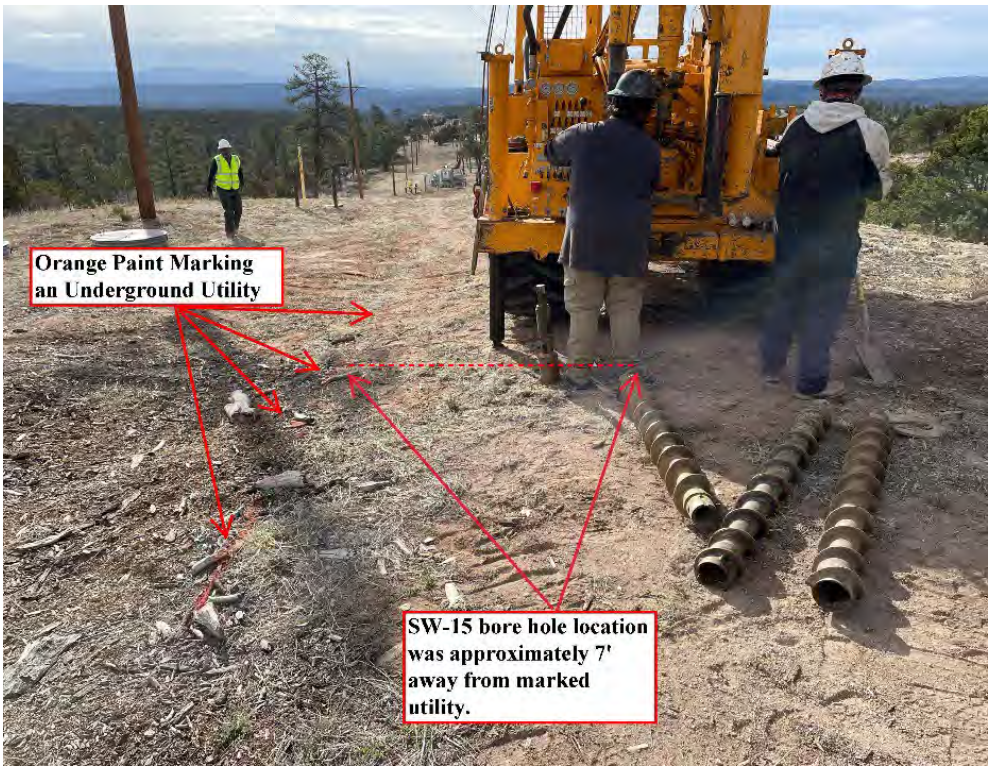


Exhibit A-2: Photograph of Boring SW-15 utility markings prior to drilling.

During drilling of boring SW-15, orange utility marking tape was observed in the auger cuttings when the drill bit was at a depth of approximately 2.5 feet below the ground surface (bgs) (see Exhibit A-3). Drilling excavation was terminated. When the auger was lifted out of the ground, black cable was observed wrapped around the auger (see Exhibit A-4). The drill rig was shut down, and Shannon & Wilson and Jacobs reported the utility strike to New Mexico 811 and LANL representatives. Jacobs, New Mexico 811, and LANL personnel worked to investigate and resolve the issue.

Because of the utility strike, drilling at boring SW-16 was not performed until utilities could be remarked by LANL. After utilities were remarked by LANL, sloping uneven terrain at the staked location for boring SW-16 prevented the drill rig from safely leveling out to perform drilling operations. The LANL permit did not allow for boring relocation outside of a 3-foot radius from the staked location for boring SW-16. For this reason, drilling was not performed at this location.

Exhibit A-3: Photograph of Boring SW-15 with auger cuttings and orange utility marking tape.

Exhibit A-3: Photograph of Boring SW-15 showing black cable wrapped around the auger.

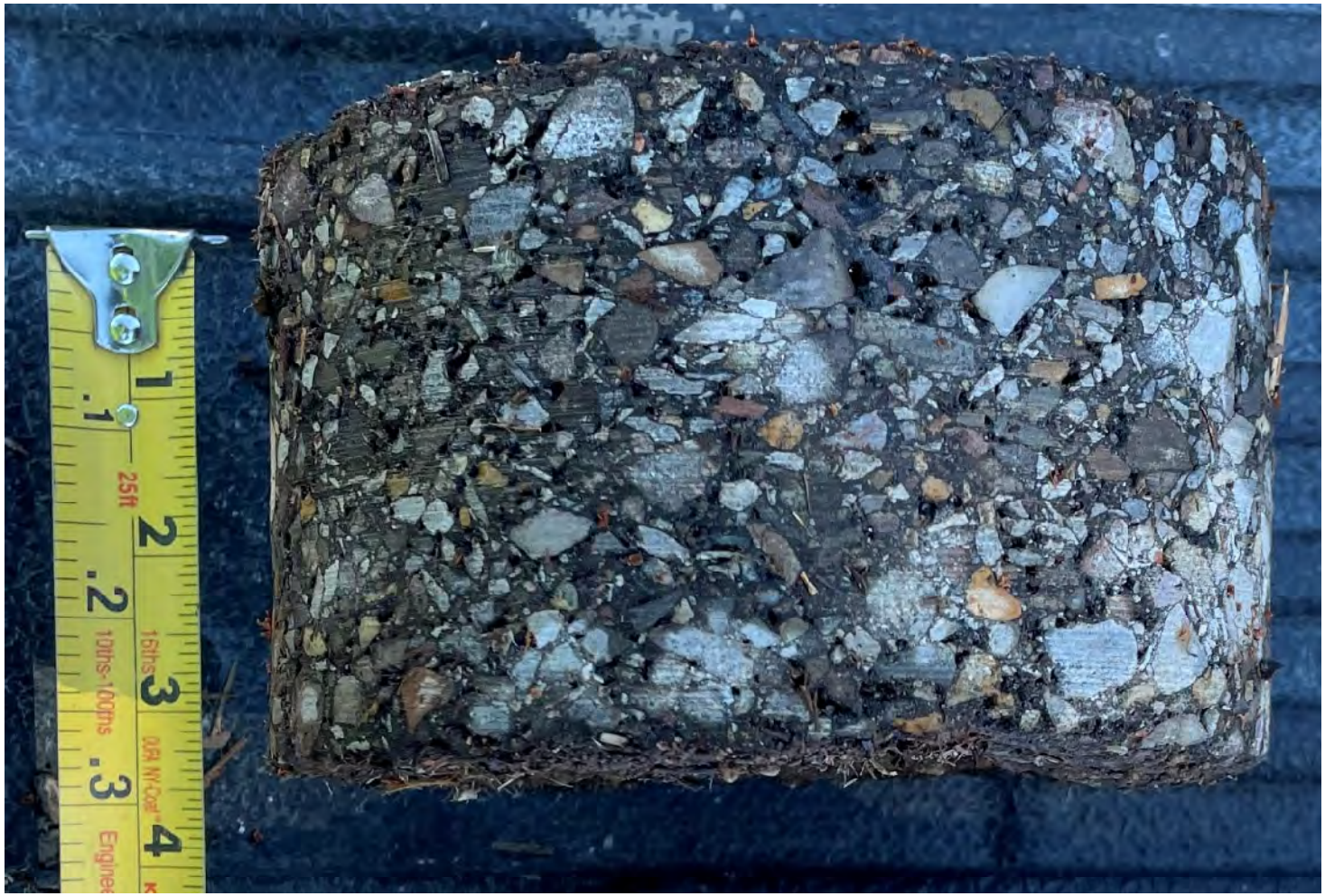
Table A-1 - Summary of Pavement Section Thickness

Boring/ Core Location	Approximate[1] Pavement Thickness (in.)	Approximate[1] Base Course Thickness (in.)
SW-05*	4	6
SW-08*	5	6
SW-10*	4	4
SW-11*	4	6
SW-12*	7	-
SW-18	5	1
SW-20	3-1/2	5-1/2
SW-21	5-1/2	-
SW-22	4-1/2	5
SW-24	3-1/4**	5
SW-25	4-1/2	6
SW-26	3-3/4**	7
SW-27	4	4
SW-30	4	3
SW-31	3	9
SW-32	3-1/4**	5
SW-34	2-1/2**	-
SW-35	2-1/2	-
SW-36	4-1/2	3
SW-37	4-1/2	-
SW-39	4-1/4**	6
SW-40	5-1/4	~ 3[4]
SW-41	5	-
SW-42	3**	~ 1[4]
SW-44	4**	~ 4[4]
SW-45	5	-
SW-46	4-1/2**	-
SW-47	5	-
SW-50	2-1/2**	-
SW-51	3-1/2	~ 6-1/2[4]
SW-52	2-1/4**	-

NOTES

1. Pavement section thickness measured from bore hole annulus.
2. Asterisk indicates measurements were recorded in December 2021.
3. Double asterisk indicated pavement core was collected.
4. Excavation refusal occurred before bottom of base course was encountered. The actual thickness of base course may be greater than reported.

in. = inches, "-" indicates not encountered



Pavement Core at Boring SW-24. 3-1/4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
Sheet 1 of 10

FIG. A-1
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Pavement Core at Boring SW-26. 3-3/4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-32. 3-1/4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-34. 2-1/2 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-39. 4-1/4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-42. 3 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-44. 4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-46. 4-1/2 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-50. 2-1/2 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
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FIG. A-1
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Pavement Core at Boring SW-52. 2-1/4 inches asphalt pavement.

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PAVEMENT CORE PHOTOGRAPHS

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FIG. A-1
Sheet 10 of 10

FIG. A-1
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SOIL CLASSIFICATION

Shannon & Wilson uses a soil identification system modified from the Unified Soil Classification System (USCS) as described on this Key. Soil descriptions are based on visual-manual procedures (ASTM D2488) and available laboratory index test results (ASTM D2487).

Exhibit A: Unified Soil Classification System (USCS)[1]

Major Divisions			Symbol	Graphic	Typical Identifications (USCS Group Names)[2,4]
COARSE-GRAINED SOILS *(> 50% of soil is retained on the No. 200 sieve[3])*	**GRAVELS** *(> 50% of coarse fraction retained on the No. 4 sieve[3])*	**Gravel** *(< 5% fines[3])*	GW		Well-graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(> 12% fines[3])*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	SANDS *(≥ 50% of coarse fraction passes the No. 4 sieve[3])*	**Sand** *(< 5% fines[3])*	SW		Well-graded Sand; Well-graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(> 12% fines[3])*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(≥ 50% of soil passes the No. 200 sieve[3])*	**SILTS AND CLAYS** *(liquid limit < 50)*	**Inorganic**	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly, Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
	SILTS AND CLAYS *(liquid limit ≥ 50)*	**Inorganic**	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly, Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly, Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly, Organic Silt or Clay
HIGHLY ORGANIC SOILS	*Primarily organic matter, dark in color, and organic odor*		PT		Peat or other Highly Organic Soils (see ASTM D4427)

NOTE: *For gravels and sands with 5 to 12% fines[3], the following are added to the Group Name:* with Silt and/or Clay or Silty Clay. *Dual Symbols are used:* GW-GM, GP-GM, SW-SM, SP-SM GW-GC, GP-GC, SW-SC, SP-SC

EXHIBIT A NOTES:
1. Adapted, with permission, from USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488.
2. Borderline symbols (symbols separated by a slash) indicate that the soil characteristics are close to the defining boundary between two groups (e.g., CL/ML = Lean Clay to Silt; SP-SM/SM = Sand with Silt to Silty Sand).
3. No. 4 size = 4.75 millimeters (mm) = 0.187 inch; No. 200 sieve size = 0.075 mm = 0.003 inch. Particles smaller 0.075 mm are termed "fines".
4. Poorly graded indicates a narrow range or missing grain sizes. Well-graded indicates a full-range and even distribution of grain sizes.
5. If cobbles and/or boulders are observed, "with cobbles" or "with boulders" or "with cobbles and boulders" is added to the Group Name.

Exhibit B-1: Standard Penetration Test (SPT)

Term	Description
Hammer	140-pound weight with a 30-inch free fall. Hammer types vary (e.g., automatic, rope and cathead). If available, the hammer type and energy ratio (E-ratio) is noted on the boring log.
Sampler	Barrel I.D. / O.D. = 1.5 inches / 2 inches (liner not used) Barrel Length = 30 inches; Shoe I.D. = 1.375 inches
N-Value (N)[1]	Sum of the count of hammer blows to penetrate the second and third 6-inch increments in blows per foot (bpf). **Refusal**: 50 blows for 6 inches or less or 10 blows for 0 inch.

EXHIBIT B NOTES:
1. N-values shown on boring logs are as recorded in the field and have not been corrected for hammer energy, overburden, or other factors. Where the hammer E-ratio is available, the N-value normalized to a ratio of 60% (N_{60}) is listed.
2. Based on ASTM Standard D1586. Relative densities/consistencies noted on the boring logs are based on uncorrected N-values.
3. PP = pocket penetrometer; TV = torvane, tsf = tons per square foot. Correlations based on experience and multiple published references.

Exhibit B-2: Relative Consistency of Cohesive Soils

Term	N[2] (bpf)	PP[3] (tsf)	TV[3] (tsf)
Very Soft	0 - 2	0 - 0.25	0 - 0.12
Soft	2 - 4	0.25 - 0.5	0.12 - 0.25
Medium Stiff	4 - 8	0.5 - 1	0.25 - 0.5
Stiff	8 - 15	1 - 2	0.5 - 1
Very Stiff	15 - 30	2 - 4	1 - 2
Hard	> 30	> 4	> 2

Exhibit B-3: Relative Density of Cohesionless Soils

Term	N[2] (bpf)
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

Exhibit C: Soil Structure[1]

Term	Description
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Fissured	Breaks along definite planes or fractures with little resistance.
Homogeneous	Same color and appearance throughout.
Interbedded	Alternating layers at least 1/4 inch thick of varying material or color. *Singular: bed*
Laminated	Alternating layers less than 1/4 inch thick of varying material or color. *Singular: lamination*
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.

EXHIBIT C NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit D: Soil Plasticity[1]

Term	Description
Nonplastic	Cannot roll a 1/8-inch thread at any water content.
Low Plasticity	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.
Medium Plasticity	A thread is easy to roll and not much time in rolling is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.
High Plasticity	It takes considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.

EXHIBIT D NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit E: Soil Moisture Content[1]

Term	Description
Dry	Absence of moisture, dusty, dry to the touch.
Moist	Damp but no visible water.
Wet	Visible free water, from below water table.

EXHIBIT E NOTE:
1. Adapted, with permission, from ASTM D2488 (Figure 2).

Exhibit F: Soil Cementation[1]

Term	Description
Weak	Crumbles or breaks with handling or slight finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

EXHIBIT F NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit G: Percentages

Term	Percent[1]
Trace	<5
Few	5 to 10
Little	15 to 25
Some	30 to 45
Mostly	>50

EXHIBIT G NOTE:
1. Percent estimated by weight for sand and gravel, and by volume for cobbles, organics, and other non-soil material (e.g., rubble, debris).

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SOIL CLASSIFICATION *(continued)*

See Page 1 for Soil Classification Exhibits A through G

Exhibit H: Particle Angularity and Shape[1]

Term	Description
Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width to thickness ratio > 3.
Elongated	Width to thickness ratio < 3.

EXHIBIT H NOTE:
1. Adapted, with permission, from ASTM D2488.

Exhibit I: Additional Descriptive Terms

Term	Description
Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling action.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

SOIL CLASSIFICATION REFERENCES:

ASTM International, [current edition], Annual book of standards, v. 04.08, soil and rock (I): D420 - D5876, available: www.astm.org.

U.S. Army Corps of Engineers, 1953, The unified soil classification system: Vicksburg, Miss., Waterways Experiment Station, Technical Memorandum 3-357, 2 v., March.

SYMBOLOGY AND GRAPHICS

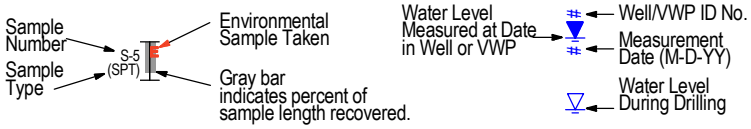
Exhibit J: Sample and Run Graphics

Graphic	Description	Graphic	Description	Graphic	Description
	SPT split spoon (2-inch OD)		Split spoon (SS) (diameters vary)		Core run (typically rock)
	Grab (GB) from cuttings or excavation		Modified California (MC) sampler		Sheath (SH) (used for geoprobes)
	Tube (TB) (e.g., Shelby, piston)		Sonic core (SC) run (typically soil)		

Exhibit K: Hole Backfill and Instrument Graphics

Graphic	Description	Graphic	Description	Graphic	Description
	Bentonite-cement grout		Surface cement seal		Blank pipe or instrument casing
	Bentonite grout		Sand filter pack		Perforated or slotted pipe
	Bentonite chips		Slough *(hole caved)*		VWP and electric lead

Exhibit L: Other Log Symbols



ROCK CLASSIFICATION

Shannon & Wilson uses a rock classification system modified from the system recommended by the International Society for Rock Mechanics (ISRM). Copyright limitations prevent us from reproducing summary tables from the ISRM system on this Key. General descriptions are provided in Exhibit M.

Exhibit M: General Rock Descriptive Terms - ISRM

Term	General Description
Strength	Ranges from extremely weak (q_u = 36 to 135 psi) to extremely strong (q_u > 36,250 psi), and is based on the ability to break the rock with a hammer or scrape the rock with a knife.
Weathering	Ranges from fresh (no visible signs of weathering) to completely weathered, based on observed degree of discoloration, decomposition, and/or disintegration. When the rock material has completely converted to soil, it is termed a residual soil.
Fabric	Describes the rock structure based on observed layering, tendency to break, and distribution of minerals (e.g., massive, bedded, foliated).
Roughness	For discontinuities: Includes rough, smooth, and slickensided, and includes other descriptive terms (e.g., stepped, undular, irregular, planar).
Spacing	For discontinuities: Ranges from extremely close (< 1 inch) to extremely wide (> 20 feet).
Persistence	For discontinuities: Ranges from very low to very high.
Other	Description of discontinuities (joints, fractures, bedding planes, etc.), observations of potential displacement, gouge, shear, etc.

REFERENCE: Brown, E. T., ed., 1981, Rock characterization, testing & monitoring: International Society of Rock Mechanics (ISRM) suggested methods: Oxford, Pergamon Press, 211 p.

Exhibit N: Rock Name Graphics

Graphic	Description	Graphic	Description
	Rhyolite		
	Tuff		

Exhibit O: Recovery and RQD Equations[1]

Term	Equation
Core Recovery (REC) in %	$100\% \times \frac{\text{Length of Core Recovered}}{\text{Length of Core Run}}$
Rock Quality Designation (RQD) in %	$100\% \times \frac{\text{Length of Core in Pieces} > 4 \text{ in}}{\text{Length of Core Run}}$

REFERENCE: Loehr, J. E.; Lutenegger, A.; Rosenblad, B.; and Boeckmann, A., 2016, Geotechnical site characterization: U.S. Federal Highway Administration Report FHWA NHI-16-072, Geotechnical Engineering Circular no. 5, 1 v.

ACRONYMS AND ABBREVIATIONS

ATD	at time of drilling	N	field (uncorrected) SPT N-value	REF	refusal
bpf	blows per foot	N_{60}	SPT N-value corrected for 60% ETR	RQD	rock quality designation (ASTM D6032)
dia, diam	diameter	NA, n/a	not applicable or not available	SC	sonic core
Elev.	elevation	NE	northeast	SE	southeast
ENV	environmental sample	NP	nonplastic	SPT	Standard Penetration Test (ASTM D1586)
ETR	energy transfer ratio (hammer)	NR	no recovery	SW	southwest
FC	fines content (< 0.075 mm)	NW	northwest	TP	test pit
FeO	iron oxide	OC	organic content	tsf	tons per square foot
ft or '	foot or feet	OD	outside diameter	TV	tor vane reading
gal	gallons	OW	observation well	UCS, q_u	unconfined compressive strength
GP	geoprobe	pcf	pounds per cubic foot	USCS	Unified Soil Classification System
GWT	groundwater table	PI	plasticity index	VST	vane shear test
HSA	hollow-stem auger	PID	photoionization detector	VWP	vibrating wire piezometer
ID	inside diameter or identification	PL	plastic limit	WC	natural water content
in or "	inch	PMT	pressuremeter test	WOH	weight of hammer
incl	inclinometer	PP	pocket penetrometer reading	WOR	weight of rods
ksf	kips per square foot	ppm	parts per million		
lbs	pounds	psi	pounds per square inch		
LL	liquid limit	PT	nonstandard penetration test N-value		
mm	millimeter	REC	recovery		

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*3.5 feet*
Top Elevation:	*n/a*
Vertical Datum:	*n/a*
Latitude:	*~ 35.7986 degrees*
Longitude:	*~ -106.2792 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 9, 2024*
Hole Finish Date:	*April 9, 2024*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
	Very loose, light brown to light gray, ***SILTY SAND*** (SM); dry to moist. [A-2-4] Residual Soil			*No Observed Groundwater* S-1 (MC12)	PT = 1,1	WC=4% FC=30% LL/PI=NP/NP		
3.5	*-Boring terminated at 3.5 feet due to unmarked utility strike.*		3.5					

BOTTOM OF HOLE AT 3.5 FEET

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-17

EXPLORATION INFORMATION

Total Depth:	*21.0 feet*
Top Elevation:	*6714.6 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7977360 degrees*
Longitude:	*-106.2782780 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 9, 2024*
Hole Finish Date:	*April 9, 2024*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6710 / 5	Medium dense to very dense, brown, ***SILTY SAND*** (SM); dry to moist. [A-4] Fill			*No Observed Groundwater*				
				S-1 (MC12)	PT = 30,24	WC=15%		
				S-2 (MC12)	PT = 5,16	WC=7% FC=41% LL/PI=21/1 DD=93 pcf		
	-Blow counts from drive S-3 are not representative and omitted from log. See note below for explanation.							
			8.0	S-3 (MC12)		WC=12%		
	White to light gray, ***SILTY SAND*** (SM); dry to moist. [RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds)]		9.0					
6705 / 10	***RHYOLITE***: extremely weak, white to light gray and light brown, slightly weathered to fresh. El Cajete pyroclastic beds			S-4 (MC12)	PT = 17,25	WC=5% FC=32% LL/PI=NP/NP DD=80 pcf		
				S-5 (MC12)	PT = 23,50	WC=8%		
6700 / 15				S-6 (MC12)	PT = 25,39	WC=6%		

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

NOTES:
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.
- The sample liners were deformed during sampling and blow counts are not considered accurate.

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Los Alamos & Sandoval Counties, New Mexico

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See Page 1 for Hole Information and Notes

Elev. (feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6695 / 20	***RHYOLITE***: extremely weak, white to light gray and light brown, slightly weathered to fresh. El Cajete pyroclastic beds *(starts on previous page)*			S-7 (MC12)	PT = 18,38	WC=7%		20
21	BOTTOM OF HOLE AT 21 FEET		21.0					

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	5.0 feet
Top Elevation:	6647.1 feet
Vertical Datum:	n/a
Latitude:	35.7953470 degrees
Longitude:	-106.2754930 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6645	0	**ASPHALT;** 5 inches.		0.4					0
		Dark brown, ***CLAYEY SAND WITH GRAVEL*** (SC); moist; 1 inch of aggregate base course.		0.5					
		Medium dense to dense, red-yellow, ***SILTY SAND*** (SM); dry to moist; calcareous. [A-2-4] Residual Soil			B-1 (GB)	N = 10,13,16	WC=5%		
					S-1 (SPT)				
					S-2 (MC12)	PT = 16,16 PP = 4.5 tsf	WC=5% FC=28% LL/PI=NP/NP DD=91 pcf		
	5			5.0					5

No Observed Groundwater

BOTTOM OF HOLE AT 5 FEET

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	15.0 feet
Top Elevation:	6645.5 feet
Vertical Datum:	n/a
Latitude:	35.7934350 degrees
Longitude:	-106.2760230 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 3, 2023
Hole Finish Date:	November 3, 2023

DRILLING INFORMATION

Drilling Method:	Solid Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	4 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6645	0	Very loose to dense, red-yellow, ***SILTY SAND*** (SM); dry to moist; calcareous, trace gravel. [A-2-4] Residual Soil			S-1 (MC12)	PT = 1,1	WC=7%		0
					S-2 (SPT)	N = 12,16,17	WC=4% FC=34% LL/PI=25/3	H	
6640	5				S-3 (MC12)	PT = 11,15	WC=3%		5
		Medium dense, white, ***SILTY SAND*** (SM); dry to moist. [RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds)]		8.5	S-4 (SPT)	N = 7,7,6	WC=1%		
6635	10				S-5 (MC12)	PT = 12,14	WC=2%		10
	15	BOTTOM OF HOLE AT 15 FEET		15.0					15

No Observed Groundwater

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6672.7 feet
Vertical Datum:	n/a
Latitude:	35.7942780 degrees
Longitude:	-106.2778270 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6670	0	**ASPHALT;** 3-1/2 inches.		0.3					
		Dark brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; 5-1/2 inches of aggregate base course.		0.8					
		Medium dense, light red, dark brown, white, and red-yellow, ***POORLY GRADED SAND WITH SILT*** (SP-SM); moist. [A-1-b] Residual Soil			B-1 (GB) S-1 (MC12)	PT = 6,7	WC=43% FC=10% LL/PI=NP/NP		
					No Observed Groundwater	N = 3,7,8	WC=15%		
	5	Stiff to very stiff, red-yellow, ***SANDY LEAN CLAY*** (CL); dry to moist. Residual Soil		4.8	S-2 (SPT)				5
	5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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BORING LOG

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EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6669.5 feet
Vertical Datum:	n/a
Latitude:	35.7941470 degrees
Longitude:	-106.2796060 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
	ASPHALT; 5-1/2 inches.							
	Loose to medium dense, red-yellow to white, ***POORLY GRADED SAND*** (SP); dry to moist. [A-3] Residual Soil		0.5	B-1 (GB) S-1 (MC12) S-2 (SPT) *No Observed Groundwater*	PT = 5,5 N = 5,6,7	WC=4% WC=2% FC=4% LL/PI=NP/NP		
6665								
5								5
5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-22
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	5.0 feet
Top Elevation:	6663.7 feet
Vertical Datum:	n/a
Latitude:	35.7931590 degrees
Longitude:	-106.2784410 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6660	0	**ASPHALT;** 4-1/2 inches.		0.4					0
		Red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist; 5 inches aggregate base course.		0.8					
		Medium dense to loose, red-yellow to light gray-brown, ***CLAYEY SAND*** (SC); dry to moist. [A-4] Residual Soil			B-1 (GB)	N = 9,8,3	WC=7% FC=36% LL/PI=28/9	▲ ◇	
					S-1 (SPT)				
					S-2 (MC12)	PT = 5,5	WC=3% DD=86 pcf	▼ ●	
5	5			5.0					5

No Observed Groundwater

BOTTOM OF HOLE AT 5 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-23
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*14.1 feet*
Top Elevation:	*6648.5 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7931600 degrees*
Longitude:	*-106.2797700 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 3, 2023*
Hole Finish Date:	*November 3, 2023*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		Red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist. Alluvium							
		Medium dense to very dense, red-yellow to light gray, ***SILTY SAND*** (SM); dry to moist. [A-4] [RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds)]		1.0					
6645	5				S-1 (MC12)	PT = 7,9	WC=3%		5
					S-2 (SPT)	N = 13,16,18	WC=9% FC=37% LL/PI=NP/NP		
		RHYOLITE: extremely weak to weak, white to light gray and light brown, slightly weathered to fresh. El Cajete pyroclastic beds		7.3	S-3 (MC12)	PT = 22,37	WC=6%		
6640	10				S-4 (SPT)	N = 50/4"	WC=5%	>>	10
6635	14.1	BOTTOM OF HOLE AT 14.1 FEET		14.1	S-5 (SPT)	N = 50/1"	WC=1%	>>	

No Observed Groundwater

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-24
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*5.0 feet*
Top Elevation:	*6672.7 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7932130 degrees*
Longitude:	*-106.2775370 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 6, 2023*
Hole Finish Date:	*November 6, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6670	0	***ASPHALT;*** 3-1/4 inches.		0.3					
		Red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist; 5 inches aggregate base course.		0.7					
		Dense to medium dense, white, ***SILTY SAND*** (SM); dry to moist. [A-2-4] Residual Soil			*No Observed Groundwater* B-1 (GB) S-1 (SPT) S-2 (MC12)	N = 12,15,18 PT = 11,17	WC=1% FC=33% LL/PI=NP/NP WC=1%		
5		BOTTOM OF HOLE AT 5 FEET		5.0					5

NOTES:
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- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-25
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*14.3 feet*
Top Elevation:	*6627.2 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7903300 degrees*
Longitude:	*-106.2773600 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 6, 2023*
Hole Finish Date:	*November 6, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6625	0	***ASPHALT;*** 4-1/2 inches.		0.4					
		CLAYEY SAND WITH GRAVEL (SC); moist; 6 inches aggregate base course.		0.9					
		Medium stiff, red-yellow, ***SANDY SILT*** (ML); moist. [A-4] Residual Soil			B-1 (GB)				
					S-1 (MC12)	PT = 2,3	WC=13% FC=58% LL/PI=NP/NP DD=86 pcf		
				4.0					
	5	Medium dense, red-yellow to white and light-red, ***SILTY SAND*** (SM); dry to moist. Residual Soil			S-2 (SPT)	N = 8,11,16	WC=10%		5
				6.0					
6620		***RHYOLITE***: extremely weak to weak, light red white, slightly weathered to fresh. El Cajete pyroclastic beds			S-3 (MC12)	PT = 50/5"	WC=6%	>>	
					S-4 (SPT)	N = 50/4"	WC=4%	>>	
	10								10
6615									
14.3				14.3	S-5 (SPT)	N = 50/3"	WC=2%	>>	

No Observed Groundwater

BOTTOM OF HOLE AT 14.3 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-26
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6675.9 feet
Vertical Datum:	n/a
Latitude:	35.7954220 degrees
Longitude:	-106.2796400 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
6675		***ASPHALT;*** 3-3/4 inches.		0.3			WC=8% FC=75% LL/PI=27/9 R-value=45	0 50 100	
		Dark brown, ***CLAYEY SAND WITH GRAVEL*** (SC); dry to moist; 7 inches of aggregate base course.		0.9					
		Hard, red-yellow, ***LEAN CLAY WITH SAND*** (CL); dry to moist; calcareous. [A-4 / A-6] Residual Soil			*No Observed Groundwater* B-1 (GB) S-1 (MC12)	PT = 13,24	WC=9% FC=72% LL/PI=30/15 DD=103 pcf		
					S-2 (SPT)	N = 16,19,24	WC=6%		
5									5
5.5		BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-27
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6681.1 feet
Vertical Datum:	n/a
Latitude:	35.7964740 degrees
Longitude:	-106.2798710 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 3, 2023
Hole Finish Date:	November 3, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6680		***ASPHALT;*** 4 inches.		0.3					
		Dark brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; 4 inches of aggregate base course.		0.7					
		Medium stiff to very stiff, red-yellow, ***LEAN CLAY WITH SAND*** (CL); dry to moist; trace gravel.. [A-6] Residual Soil			*No Observed Groundwater* B-1 (GB) S-1 (MC12)	PT = 2,4	WC=9%		
5					S-2 (SPT)	N = 10,10,10 PP = 4.5 tsf	WC=9% FC=82% LL/PI=29/11		5
5.5		BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-28
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	15.0 feet
Top Elevation:	6690.3 feet
Vertical Datum:	n/a
Latitude:	35.7968670 degrees
Longitude:	-106.2788710 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Solid Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data
6690	0	Red-yellow, ***SILTY SAND*** (SM); dry to moist. Residual Soil		1.0			
		Very stiff, red-yellow, ***SANDY LEAN CLAY*** (CL); dry to moist; calcareous. Residual Soil			S-1 (MC12)	PT = 12,16 PP = 4.5 tsf	WC=8%
				4.0	S-2 (SPT)	N = 10,14,16	WC=5% FC=61% LL/PI=29/7
6685	5	Very stiff to hard, red-yellow, ***SANDY SILTY CLAY*** (CL-ML); dry to moist. [A-4] Residual Soil			S-3 (MC12)	PT = 21,28	WC=5%
				9.0	S-4 (SPT)	N = 8,8,9	WC=2%
6680	10	Medium dense to dense, white and light red, ***SILTY SAND*** (SM); dry. [RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds)]			S-5 (MC12)	PT = 18,30	WC=1%
	15	BOTTOM OF HOLE AT 15 FEET		15.0			

No Observed Groundwater

Multiple Items Plotted *(see bottom legend on Page 1)*
0 — 50 — 100

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-29
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*14.3 feet*
Top Elevation:	*6670.7 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7966420 degrees*
Longitude:	*-106.2809380 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 2, 2023*
Hole Finish Date:	*November 2, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6670	0	Red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist. Residual Soil		0.5					
		Very dense, red-yellow, ***CLAYEY SAND*** (SC); dry to moist; calcareous. [A-6] Residual Soil			S-1 (SPT)	N = 17,24,26	WC=6% FC=48% LL/PI=32/15		
		Dense, red-yellow, ***CLAYEY SAND*** (SC); dry to moist; calcareous. Residual Soil		4.0	S-2 (MC12)	PT = 19,24 PP = 4.5 tsf	WC=6%		
6665	5								5
		RHYOLITE: extremely weak to weak, white, moderately weathered to fresh. El Cajete pyroclastic beds		7.0	S-3 (SPT)	N = 11,14,16	WC=1%		
					S-4 (MC12)	PT = 13,19	WC=2%		
6660	10								10
14.3		BOTTOM OF HOLE AT 14.3 FEET		14.3	S-5 (SPT)	N = 50/3"	WC=0%	>>	

No Observed Groundwater

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-30

EXPLORATION INFORMATION

Total Depth:	*4.3 feet*
Top Elevation:	*6661.9 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7962380 degrees*
Longitude:	*-106.2816410 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 3, 2023*
Hole Finish Date:	*November 3, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6660	0	***ASPHALT;*** 4 inches.		0.3	No Observed Groundwater				
		Dark brown, ***CLAYEY SAND WITH GRAVEL*** (SC); moist; 3 inches of aggregate base course.		0.6					
		Hard, red-yellow, ***SANDY SILT*** (ML); dry to moist. [A-4] Residual Soil			B-1 (GB)				
					S-1 (SPT)	N = 36,50/5"	WC=7% FC=60% LL/PI=NP/NP	>>	
		RHYOLITE: extremely weak to weak, white, slightly weathered to fresh. El Cajete pyroclastic beds		3.0					
4.3					S-2 (MC12)	PT = 50/3"	WC=2%	>>	
		BOTTOM OF HOLE AT 4.3 FEET		4.3					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

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Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-31

EXPLORATION INFORMATION

Total Depth:	*29.3 feet*
Top Elevation:	*6655.4 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7952580 degrees*
Longitude:	*-106.2814860 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 3, 2023*
Hole Finish Date:	*November 3, 2023*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6655		***ASPHALT;*** 3 inches.		0.3					
		Dark brown, ***CLAYEY SAND WITH GRAVEL*** (SC); moist; 9 inches of aggregate base course.		1.0					
		Very dense, red-yellow, ***CLAYEY SAND*** (SC); moist. Residual Soil		2.5	*No Observed Groundwater*				
		RHYOLITE: extremely weak to weak, white, slightly weathered to fresh. El Cajete pyroclastic beds			S-1 (SPT)	N = 21,50/2"	WC=1%	>>	
					S-2 (MC12)	PT = 50/2"	WC=1%	>>	
6650	5				S-3 (SPT)	N = 50/2"	WC=2%	>>	5
					S-4 (SPT)	N = 50/1"	WC=1%	>>	
6645	10								10
					S-5 (SPT)	N = 50/2"	WC=1%	>>	
6640	15								15

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-31
Page 2 of 2

See Page 1 for Hole Information and Notes

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		RHYOLITE: extremely weak to weak, white, slightly weathered to fresh. El Cajete pyroclastic beds *(starts on previous page)*							
6635	20				S-6 (SPT)	N = 50/3"	WC=3% FC=64%		20
6630	25				S-7 (SPT)	N = 50/2"	WC=1% LL/PI=NP/NP		25
	29.3			29.3	S-8 (SPT)	N = 50/3"	WC=1%		

BOTTOM OF HOLE AT 29.3 FEET

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*4.5 feet*
Top Elevation:	*6670.3 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7965980 degrees*
Longitude:	*-106.2837570 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 3, 2023*
Hole Finish Date:	*November 3, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6670	0	***ASPHALT;*** 3-1/4 inches.		0.2					
		Dark brown, ***CLAYEY SAND WITH GRAVEL*** (SC); moist; 5 inches of aggregate base course.		0.7					
		Medium dense, red-yellow, ***SILTY SAND*** (SM); dry to moist. [A-2-4] Residual Soil			*No Observed Groundwater* B-1 (GB)		WC=5% FC=33% LL/PI=NP/NP		
					S-1 (MC12)	PT = 13,15			
4.5		***RHYOLITE***: extremely weak to weak, white to light gray, slightly weathered to fresh. El Cajete pyroclastic beds		4.0	S-2 (SPT)	N = 50/6"	WC=1%		
		BOTTOM OF HOLE AT 4.5 FEET		4.5					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-33
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EXPLORATION INFORMATION

Total Depth:	*15.0 feet*
Top Elevation:	*6688.7 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7961180 degrees*
Longitude:	*-106.2844970 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 2, 2023*
Hole Finish Date:	*November 2, 2023*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		Red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist. Residual Soil		0.3					
		Very stiff to hard, red-yellow, ***LEAN CLAY WITH SAND*** (CL); dry to moist; few gravel. [A-6] Residual Soil			*No Observed Groundwater*				
6685	5				S-1 (MC12)	PT = 9,12 PP = 4.5 tsf	WC=8% FC=78% LL/PI=31/17 DD=93 pcf		5
					S-2 (SPT)	N = 17,17,14 PP = 4.5 tsf	WC=6%		
6680	10				S-3 (MC12)	PT = 9,20 PP = 4.5 tsf	WC=11%		10
					S-4 (SPT)	N = 14,19,20	WC=6%		
		RHYOLITE: extremely weak, white to red-yellow, slightly weathered to fresh. El Cajete pyroclastic beds		10.0					
6675	15				S-5 (MC12)	PT = 20,42	WC=7%		15
		BOTTOM OF HOLE AT 15 FEET		15.0					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-34
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EXPLORATION INFORMATION

Total Depth:	5.0 feet
Top Elevation:	6614.3 feet
Vertical Datum:	n/a
Latitude:	35.7881540 degrees
Longitude:	-106.2714450 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6610	5	***ASPHALT;*** 2-1/2 inches. ***RHYOLITE***: extremely weak, white, moderately weathered to fresh. El Cajete pyroclastic beds		0.2 5.0	*No Observed Groundwater* B-1 (GB) S-1 (SPT) S-2 (MC12)	N = 11,22,31 PT = 21,23	WC=2% FC=34% LL/PI=NP/NP WC=2%		5

BOTTOM OF HOLE AT 5 FEET

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-35
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*15.5 feet*
Top Elevation:	*6537.5 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7796060 degrees*
Longitude:	*-106.2658230 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 7, 2023*
Hole Finish Date:	*November 7, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6535	0	***ASPHALT;*** 2-1/2 inches.		0.2	B-1 (GB)				0
		RHYOLITE: extremely weak, white, moderately weathered to fresh. El Cajete pyroclastic beds			S-1 (MC12)	PT = 12,26	WC=2%		
					No Observed Groundwater				
	5				S-2 (SPT)	N = 10,18,22	WC=2% FC=36% LL/PI=NP/NP		5
6530					S-3 (MC12)	PT = 8,19	WC=3%		
	10				S-4 (SPT)	N = 12,24,24	WC=3%		10
6525									
	15				S-5 (SPT)	N = 11,15,18	WC=4%		15
	15.5	BOTTOM OF HOLE AT 15.5 FEET		15.5					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-36
Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6521.0 feet
Vertical Datum:	n/a
Latitude:	35.7776880 degrees
Longitude:	-106.2629950 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 6, 2023
Hole Finish Date:	November 6, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6520	0	***ASPHALT;*** 4-1/2 inches.		0.4			WC=6% FC=34% LL/PI=NP/NP R-value=68		
		Dark brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; 3 inches of aggregate base course.		0.6					
		TUFF: extremely weak, white, moderately weathered to fresh. Upper Bandelier Tuff			B-1 (GB) S-1 (MC12) *No Observed Groundwater*	PT = 21,26	WC=9% FC=68% LL/PI=NP/NP DD=75 pcf		
	5				S-2 (SPT)	N = 11,15,16	WC=7%		5
	5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-37
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EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6428.0 feet
Vertical Datum:	n/a
Latitude:	35.7708330 degrees
Longitude:	-106.2588610 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6425	0	***ASPHALT;*** 4-1/2 inches.		0.4	B-1 (GB)				
		Medium dense, red-yellow, ***SILTY SAND*** (SM); dry to moist; few gravel.. [A-2-4] Residual Soil			S-1 (MC12)	PT = 5,7	WC=3% FC=30% LL/PI=NP/NP		
					No Observed Groundwater				
		TUFF: extremely weak, white, slightly weathered to fresh. Upper Bandelier Tuff		4.0	S-2 (SPT)	N = 18,21,23	WC=1%		
5	5								5
5.5		BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-38

EXPLORATION INFORMATION

Total Depth:	50.5 feet
Top Elevation:	6431.9 feet
Vertical Datum:	n/a
Latitude:	35.7706740 degrees
Longitude:	-106.2582550 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 2, 2023
Hole Finish Date:	November 2, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6430	0	Light red, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist. Residual Soil		1.0					0
		TUFF: extremely weak to weak, white to light gray, slightly weathered to fresh. Upper Bandelier Tuff			*No Observed Groundwater* S-1 (MC12)	PT = 13,21	WC=0%		
	5				S-2 (SPT)	N = 19,20,24	WC=1% FC=39% LL/PI=NP/NP		5
6425					S-3 (MC12)	PT = 18,28	WC=2%		
	10				S-4 (SPT)	N = 15,21,24	WC=2%		10
6420									
	15				S-5 (MC12)	PT = 25,37	WC=2%		15

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-38
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See Page 1 for Hole Information and Notes

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6415		***TUFF***: extremely weak to weak, white to light gray, slightly weathered to fresh. Upper Bandelier Tuff *(starts on previous page)*	Y						
	20				S-6 (SPT)	N = 21,26,29	WC=2%		20
6410									
	25				S-7 (MC12)	PT = 50/4"	WC=2%	>>	25
6405									
	30				S-8 (SPT)	N = 50/5"	WC=1%	>>	30
6400									
	35				S-9 (SPT)	N = 50/5"	WC=1%	>>	35
6395									
	40				S-10 (SPT)	N = 47,50/2"	WC=0%	>>	40

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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See Page 1 for Hole Information and Notes

Elev. (feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6390	***TUFF***: extremely weak to weak, white to light gray, slightly weathered to fresh. Upper Bandelier Tuff *(starts on previous page)*							
45				S-11 (SPT)	N = 37,50/5"	WC=1%	>>	45
6385								
50				S-12 (SPT)	N = 39,37,36	WC=0%		50
50.5	BOTTOM OF HOLE AT 50.5 FEET		50.5					

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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Page 1 of 1

EXPLORATION INFORMATION

Total Depth:	*5.5 feet*
Top Elevation:	*6245.2 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7716370 degrees*
Longitude:	*-106.2628180 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 10, 2024*
Hole Finish Date:	*April 10, 2024*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6245		***ASPHALT;*** 4-1/4 inches.		0.3					
		Dark brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; 6 inches of aggregate base course.		0.8					
		Dense, red yellow to light brown, ***SILTY SAND*** (SM); dry to moist. [A-2-4] Fill			S-1 (MC12)	PT = 17,28	WC=12% FC=33% LL/PI=NP/NP DD=71 pcf	● ◇ ▼	
					No Observed Groundwater				
6240	5				S-2 (SPT)	N = 10,15,17	WC=9%	● ▲	5
	5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-40

EXPLORATION INFORMATION

Total Depth:	*0.8 feet*
Top Elevation:	*6097.5 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7752260 degrees*
Longitude:	*-106.2670870 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 10, 2024*
Hole Finish Date:	*April 10, 2024*

DRILLING INFORMATION

Drilling Method:	*Hand Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		ASPHALT; 5-1/4 inches.		0.4					
	0.8	Dark brown, ***WELL-GRADED SAND WITH SILT AND GRAVEL*** (SW-SM); moist; 3 inches of aggregate base course.		0.8	B-1 (GB)		WC=1% FC=11% LL/PI=NP/NP	◇ ●	
		-Hand auger refusal at 0.8 feet. BOTTOM OF HOLE AT 0.8 FEET							

No Observed Groundwater

NOTES:
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.
- Due to unknown underground utilities in the bore hole vicinity, Vine used the drill rig with 4" diameter solid stem auger to drill through the pavement. A 4" diameter hand auger was used to advance the boring below the pavement.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	*5.0 feet*
Top Elevation:	*6059.8 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7766830 degrees*
Longitude:	*-106.2685250 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 7, 2023*
Hole Finish Date:	*November 7, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6055	5	***ASPHALT;*** 5 inches. Very stiff to hard, red-yellow and dark brown, ***SANDY SILT*** (ML); dry to moist; calcareous, rootlets at 4 feet. [A-4] Alluvium		0.4 5.0	*No Observed Groundwater* B-1 (GB) S-1 (SPT) S-2 (MC12)	N = 12,12,10 PT = 14,16	WC=13% WC=8% FC=63% LL/PI=NP/NP DD=80 pcf		5

BOTTOM OF HOLE AT 5 FEET

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	*0.3 feet*
Top Elevation:	*6073.9 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7771940 degrees*
Longitude:	*-106.2686840 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 10, 2024*
Hole Finish Date:	*April 10, 2024*

DRILLING INFORMATION

Drilling Method:	*Hand Tools*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
	0.3	***ASPHALT;*** 3 inches.		0.2	B-1 (GB)		WC=11%	●	
		Dark brown, ***SILTY SAND WITH GRAVEL*** (SM); moist; at least 1 inches of aggregate base course.		0.3					
		-Hand tool refusal at 0.3 feet. BOTTOM OF HOLE AT 0.3 FEET							

No Observed Groundwater

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.
- Due to unknown underground utilities in the bore hole vicinity, Vine used a pavement core rig to core through the pavement. Hand tools were used to advance the boring below the pavement.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC%

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	*15.4 feet*
Top Elevation:	*6079.1 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7779590 degrees*
Longitude:	*-106.2689140 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 7, 2023*
Hole Finish Date:	*November 7, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
		light gray, **Gravel**; 4 inches.		0.4				0 50 100	
6075	5	Loose, red-yellow, ***SILTY SAND WITH GRAVEL AND COBBLES*** (SM); dry to moist; calcareous, rootlets at 4 feet. [A-1-b] Alluvium			*No Observed Groundwater* S-1 (SPT)	N = 3,3,2	WC=5% FC=21% LL/PI=NP/NP		5
					S-2 (MC12)	PT = 3,3	WC=3%		
		Dense, red-yellow and dark brown, ***CLAYEY SAND WITH GRAVEL AND COBBLES*** (SC); dry to moist. Alluvium		7.0	S-3 (SPT)	N = 18,19,13	WC=10%		
6070	10	Very dense, red-yellow, ***CLAYEY SAND*** (SC); moist. Alluvium		9.0	S-4 (MC12)	PT = 16,41	WC=12%		10
6065	15				S-5 (SPT)	N = 24,32,50/5"	WC=17%	>>	15
	15.4	BOTTOM OF HOLE AT 15.4 FEET		15.4					

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	*0.7 feet*
Top Elevation:	*6073.0 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7782270 degrees*
Longitude:	*-106.2694740 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 10, 2024*
Hole Finish Date:	*April 10, 2024*

DRILLING INFORMATION

Drilling Method:	*Hand Tools*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev.(feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		ASPHALT; 4 inches.		0.3					
	0.7	Dark brown, ***SILTY GRAVEL WITH SAND*** (GM); moist; at least 4 inches of aggregate base course.		0.7	B-1 (GB)		WC=9% FC=14% LL/PI=NP/NP	◇ ●	
		-Hand tool refusal at 0.7 feet. BOTTOM OF HOLE AT 0.7 FEET							

No Observed Groundwater

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.
- Due to unknown underground utilities in the bore hole vicinity, Vine used a pavement core rig to core through the pavement. Hand tools were used to advance the boring below the pavement.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	*5.0 feet*
Top Elevation:	*6066.9 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7786050 degrees*
Longitude:	*-106.2700470 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*November 7, 2023*
Hole Finish Date:	*November 7, 2023*

DRILLING INFORMATION

Drilling Method:	*Hollow Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-75*
Hole Size:	*6 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6065	0	***ASPHALT;*** 5 inches.		0.4					0
		Very loose to loose, red-yellow to dark brown, ***SILTY SAND*** (SM); dry to moist; rootlets at 4 feet. [A-2-4] Alluvium			B-1 (GB)	N = 3,2,2	WC=3% FC=21% LL/PI=NP/NP		
					S-1 (SPT)				
					No Observed Groundwater				
					S-2 (MC12)	PT = 1,2	WC=7%		
5	5	BOTTOM OF HOLE AT 5 FEET		5.0					5

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	5.0 feet
Top Elevation:	6060.9 feet
Vertical Datum:	n/a
Latitude:	35.7784330 degrees
Longitude:	-106.2703500 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6060	**ASPHALT;** 4-1/2 inches.		0.4					
	Loose to dense, red-yellow to dark-brown, ***SILTY SAND WITH GRAVEL AND COBBLES*** (SM); dry to moist. [A-1-b] Alluvium			B-1 (GB)	PT = 4,3	WC=6%	● ▼	
				S-1 (MC12)	No Recovery			
				S-2 (SPT)	N = 6,8,12		▼	
				No Observed Groundwater				
				S-3 (MC12)	PT = 8,22	WC=7% FC=13% LL/PI=NP/NP DD=103 pcf	● ◇	
5			5.0					5

BOTTOM OF HOLE AT 5 FEET

NOTES:
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▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

Logged by:	BTM
Review by:	KCR
Version:	1

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

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EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6067.8 feet
Vertical Datum:	n/a
Latitude:	35.7788570 degrees
Longitude:	-106.2707700 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6065	**ASPHALT;** 5 inches.		0.4					
	Loose, red-yellow and dark brown, ***SILTY SAND*** (SM); dry to moist; few gravel. [A-1-b] Alluvium			B-1 (GB)	PT = 5,3	WC=11% FC=16% LL/PI=NP/NP		
				S-1 (MC12)				
				No Observed Groundwater	N = 3,4,5	WC=12%		
5				S-2 (SPT)				5
5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5					

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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Version:	1

Job#: 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Rpt: BORING LOG | Library: SW GINT LIBRARY.GLB | Date: 9/24/24

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-48

EXPLORATION INFORMATION

Total Depth:	*20.3 feet*
Top Elevation:	*6066.1 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7786900 degrees*
Longitude:	*-106.2711430 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 9, 2024*
Hole Finish Date:	*April 9, 2024*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
6065	0	Medium dense to very dense, dark brown, ***SILTY SAND WITH GRAVEL WITH COBBLES*** (SM); moist to wet; rootlets from 0' to 5'.. [A-2-4 / A-4] Alluvium			B-1 (GB) S-1 (MC12)	PT = 5,10	WC=12% FC=29% LL/PI=NP/NP	0 50 100	0
							WC=14% FC=47% LL/PI=33/4	H	
					S-2 (MC12)	PT = 4,6	WC=15% DD=69 pcf		
6060	5								5
					S-3 (MC12)	PT = 38,48	WC=6%		
				4-9-24	S-4 (MC12)	PT = 10,22	WC=28% FC=43% LL/PI=NP/NP		
6055	10								10
					S-5 (MC12)	PT = 12,15	WC=28%		
					S-6 (MC12)	PT = 31,50/4"	WC=25% FC=13% LL/PI=NP/NP	>>	
	15	Very dense, yellow-brown, ***POORLY GRADED SAND*** (SP); wet. Alluvium		15.0					15

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-48
Page 2 of 2

See Page 1 for Hole Information and Notes

Elev. (feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
	Very dense, yellow-brown, ***POORLY GRADED SAND*** (SP); wet; interbedded with **CLAYEY SAND** (SC). Alluvium		17.0	S-7 (SPT)	N = 28,28,50/3"	WC=17%	>>	
20 / 20.3	BOTTOM OF HOLE AT 20.3 FEET		20.3					20

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-49

EXPLORATION INFORMATION

Total Depth:	*20.0 feet*
Top Elevation:	*6068.0 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7785750 degrees*
Longitude:	*-106.2713730 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 11, 2024*
Hole Finish Date:	*April 11, 2024*

DRILLING INFORMATION

Drilling Method:	*Solid Stem Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*
Rod Type/Dia.:	*AWJ 1.75 inch*
Hammer Wt. / Drop:	*140 lbs/30 inches*
Hammer ETR:	*n/a*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)*	Depth (feet)
6065	0	Medium dense to very dense, dark brown to red-yellow and light brown, ***SILTY SAND WITH GRAVEL*** (SM); moist to wet; cobbles from 6' to 9.5'. [A-1-b / A-4] Alluvium		0	S-1 (MC12)	PT = 9,9	FC=19% LL/PI=NP/NP	0 50 100	0
							WC=8%		
					S-2 (MC12)	PT = 10,20	WC=5% FC=42% LL/PI=NP/NP		
6060	5			5	B-1 (GB)				5
					S-3 (MC12)	PT = 26,36	WC=5% DD=105 pcf		
					S-4 (MC12)	PT = 10,12	WC=4% FC=48% LL/PI=NP/NP DD=97 pcf		
6055	10			10	4-11-24				10
					S-5 (MC12)	PT = 25,38	WC=21%		
					S-6 (MC12)	PT = 15,20	WC=30% FC=48% LL/PI=NP/NP		
	15			15					15

NOTES:
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-49
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See Page 1 for Hole Information and Notes

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6050		Medium dense to very dense, dark brown to red-yellow and light brown, ***SILTY SAND WITH GRAVEL*** (SM); moist to wet; cobbles from 6' to 9.5'. [A-1-b / A-4] Alluvium *(starts on previous page)*							
		Very dense, red-yellow and light brown, ***CLAYEY SAND WITH GRAVEL*** (SC); wet; cobbles from 18' to 20'. Alluvium		18.0	S-7 (MC12)	PT = 42,50/1"	WC=26%	>>	
20		BOTTOM OF HOLE AT 20 FEET		20.0					20

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-50
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EXPLORATION INFORMATION

Total Depth:	5.5 feet
Top Elevation:	6063.8 feet
Vertical Datum:	n/a
Latitude:	35.7781220 degrees
Longitude:	-106.2708040 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev.(feet) / Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted (see bottom legend on Page 1) 0 50 100	Depth (feet)
6060	***ASPHALT;*** 2-1/2 inches.		0.2			WC=2% FC=23% LL/PI=NP/NP R-value=72		
	Loose to medium dense, dark brown to red-yellow, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist; calcareous, rootlets at 2 feet. [A-1-b / A-2-4] Alluvium			B-1 (GB) S-1 (MC12) *No Observed Groundwater*	PT = 4,3	WC=7% FC=32% LL/PI=NP/NP		
5					N = 7,8,9	WC=8%		5
5.5	BOTTOM OF HOLE AT 5.5 FEET		5.5	S-2 (SPT)				

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
- Groundwater level, if indicated above, is for the date specified and may vary.
- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-51
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EXPLORATION INFORMATION

Total Depth:	*0.8 feet*
Top Elevation:	*6067.6 feet*
Vertical Datum:	*n/a*
Latitude:	*35.7783940 degrees*
Longitude:	*-106.2712060 degrees*
Horizontal Datum:	*WGS [GCS1984]*
Hole Start Date:	*April 11, 2024*
Hole Finish Date:	*April 11, 2024*

DRILLING INFORMATION

Drilling Method:	*Hand Auger*
Drilling Company:	*Vine*
Drill Rig Equipment:	*CME-750X*
Hole Size:	*4 inch*

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type → S-5 (SPT) ← Gray bar indicates percent of sample length recovered.

Water Level During Drilling →

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
		ASPHALT; 3-1/2 inches.		0.3					
	0.8	Dark brown, ***WELL-GRADED GRAVEL WITH SILT AND SAND*** (GW-GM); moist; at least 6-1/2 inches of aggregate base course.		0.8	B-1 (GB)		WC=4% FC=11% LL/PI=NP/NP		
		-Hand auger refusal at 0.8 feet. BOTTOM OF HOLE AT 0.8 FEET							

No Observed Groundwater

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Group symbol is based on visual-manual identification and selected lab testing.
- Report text contains limitations and information needed to contextually understand this log.
- Due to unknown underground utilities in the bore hole vicinity, Vine used the drill rig with 4" diameter solid stem auger to drill through the pavement. A 4" diameter hand auger was used to advance the boring below the pavement.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

FINAL

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BORING LOG

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-52

EXPLORATION INFORMATION

Total Depth:	5.0 feet
Top Elevation:	6072.0 feet
Vertical Datum:	n/a
Latitude:	35.7790440 degrees
Longitude:	-106.2718530 degrees
Horizontal Datum:	WGS [GCS1984]
Hole Start Date:	November 7, 2023
Hole Finish Date:	November 7, 2023

DRILLING INFORMATION

Drilling Method:	Hollow Stem Auger
Drilling Company:	Vine
Drill Rig Equipment:	CME-75
Hole Size:	6 inch
Rod Type/Dia.:	AWJ 1.75 inch
Hammer Wt. / Drop:	140 lbs/30 inches
Hammer ETR:	n/a

BASIC LEGEND

(See separate LOG KEY for additional symbols, acronyms, and definitions)

Abbreviations

N	Standard Penetration Test (SPT) blows per 6-inch increment
PT	Penetration test (not SPT) blows per 6-inch increment
bpf	Blows per foot for penetration test
WC	Natural water content (%)
FC	Fines content (% grains smaller than 0.075 mm)
PI	Plasticity index (Atterberg Limits)

Symbols

Sample Number / Sample Type: S-5 (SPT) — Gray bar indicates percent of sample length recovered.

Water Level During Drilling

Elev. (feet)	Depth (feet)	Material Description and Other Observations	Graphic	Depth (feet)	Samples	Field Data	Lab Data	Multiple Items Plotted *(see bottom legend on Page 1)* 0 50 100	Depth (feet)
6070	0	***ASPHALT;*** 2-1/4 inches.		0.2					
		Loose to medium dense, red-yellow, red, and light brown, ***SILTY SAND WITH GRAVEL*** (SM); dry to moist. [A-1-b] Alluvium			B-1 (GB)	N = 2,3,6	WC=3% FC=15% LL/PI=NP/NP		
					S-1 (SPT)				
					No Observed Groundwater	PT = 8,16	WC=3%		
5	5			5.0	S-2 (MC12)				5

BOTTOM OF HOLE AT 5 FEET

NOTES:
- Refer to LOG KEY for explanation of symbols, codes, abbreviations, and definitions.
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- Report text contains limitations and information needed to contextually understand this log.

▲ Uncorrected N-value, bpf
▼ Uncorrected, Penetration N-value, bpf
● = WC% ◇ = FC%
Plastic Limit — Liquid Limit

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APPENDIX B: LABORATORY TEST RESULTS

Appendix B

Laboratory Test Results

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APPENDIX B: LABORATORY TEST RESULTS

Figure B-11: R-Value Test Report, Boring SW-50, Sample B-1
Figure B-12: Moisture-Density Test, Boring SW-49, Sample B-1

APPENDIX B: LABORATORY TEST RESULTS

B.1 INTRODUCTION

Laboratory tests were completed on soil and bedrock samples retrieved from the borings in general accordance with American Association of State Highway and Transportation Officials (AASHTO) test methods, American Society of Testing and Materials International (ASTM) and Colorado Department of Transportation (CDOT) Colorado Procedure - Laboratory (CP-L) testing methods. The laboratory testing program was performed to classify the materials into similar geologic groups and provide data that can be used for design of the project. The geotechnical laboratory testing was performed at our in-house laboratory in Denver, Colorado, at Vivid Engineering Group (Vivid) in Denver, Colorado, and at Vine Laboratories, Inc. in Commerce City, Colorado. A summary of the laboratory test results is presented in Table B-1. The following sections describe the laboratory testing procedures.

B.2 GEOTECHNICAL INDEX TESTS

B.2.1 Water Content

Water content was determined for selected samples in general accordance with AASHTO T265, Laboratory Determination of Moisture Content in Soils. To perform this test, a sample was weighed before and after oven-drying, and the water content was calculated. Water content determinations are shown graphically on the boring logs and are also summarized in Table B-1.

B.2.2 Grain Size Analysis

The grain size distribution of selected samples was determined in general accordance with AASHTO T311, Standard Method of Test for Grain-Size Analysis of Granular Soil Materials. Results of these analyses are attached as grain size distribution curves and summarized in Table B-1.

Selected samples were tested for the percentage of material passing the No. 200 sieve in general accordance with ASTM D1140, Standard Test Method for Amount of Material in Soils Finer than the No. 200 (75-µm) Sieve. The percent fines (silt- and clay-sized particles passing the No. 200 sieve) are shown graphically on the boring logs in Appendix A and are also summarized in Table B-1.

B.2.3 Atterberg Limits

Soil plasticity was determined by performing Atterberg limits tests on selected fine-grained samples. The tests were completed in general accordance with AASHTO T89, Standard Test Method for Determining the Liquid Limit of Soils and AASHTO T90, Standard Test Method for Determining the Plastic Limit and Plasticity Index of Soils. The Atterberg limits include liquid limit (LL), plastic limit (PL), and plasticity index (PI equals LL minus PL) and are generally used to assist in classification of soils, to indicate soil consistency (when compared to natural water content), and to provide correlation to soil properties. The results of the Atterberg limits tests are plotted on the attached plasticity chart, shown graphically on the boring logs in Appendix A, and summarized in Table B-1.

B.3 GEOTECHNICAL ENGINEERING PROPERTY TESTS

B.3.1 One-Dimensional Swell/Collapse

One-dimensional swell/consolidation tests were performed in general accordance with ASTM D4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils. The samples were loaded at field moisture conditions in a fixed-ring consolidometer that measures vertical changes in volume for different loading conditions. During loading, the sample's pore pressures are allowed to drain from both the top and bottom of the sample. At a specified pressure, the sample is inundated with distilled water and then allowed to reach equilibrium. The vertical volume change caused from the inundation of water (expressed in percent strain) is then determined. The results of the swell tests are included as Figures 1 through 8 and summarized in Table B-1.

B.3.2 Corrosion

Corrosion testing of select samples was performed for pH, resistivity, sulfate content, and chloride content. Testing for pH and resistivity were done in general accordance with AASHTO T289, Standard Method of Test for Determining pH of Soil for Use in Corrosion Testing and ASTM G57, Standard Method of Test for Determining Minimum Laboratory Soil Resistivity, respectively. Sulfate and chloride content testing were done in accordance with CP-L 2103, Sulfate Ion Content in Soil and CP-L 2014, Determining the Chloride Ion Content in Water or Water-Soluble Chloride Ion Content in Soil, respectively. Test results for sulfate and chloride content are given in units of percent by weight. The test results are summarized in Table B-1.

B.3.3 R-Value

Hveem Stabilometer (R-value) testing was completed on selected bulk subgrade samples. The tests were completed in general accordance with ASTM D 2844, Standard Test Method for Resistance R-Value and Expansion Pressure of Compacted Soils. The R-value test results are presented in Figures B-9 through B-11 and summarized in Table B-1.

B.3.4 Standard Proctor

The moisture-density relationship (compaction) for a bulk sample was tested in general accordance with AASHTO T99, Standard Method of Test for Moisture–Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop. The test results (optimum moisture content [OMC] and maximum dry density) are presented as a moisture-density curve in Figure B-12 and summarized in Table B-1.

Table B-1 - Summary of Laboratory Test Results

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS			CORROSION				SWELL/COLLAPSE			COMPACTION[3]	
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Soil Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)	Swell(+) Collapse (-) (%)	Inundation Pressure (psf)	R-Value	Optimum Moisture Content (%)	Max. Dry Density (pcf)
SW-15	S-1	2.5	3.5	SM	A-2-4 (0)	3.8		13	57	30	NP	NP	NP									
SW-17	S-1	2.5	3.5			14.9								10.1	5,500	0.01	0.023					
	S-2	4.0	5.0	SM	A-4 (0)	7.2	100	2	57	41	21	20	1									
	S-3	7.5	8.4			11.6																
	S-4	10.0	11.0	SM	A-2-4 (0)	5.5	85	1	67	32	NP	NP	NP									
	S-5	12.5	13.5			7.8																
	S-6	15.0	16.0			5.9																
	S-7	20.0	21.0			6.7																
SW-18	S-1	2.0	3.5			5.0																
	S-2	4.0	5.0	SM	A-2-4 (0)	5.3	96			28	NP	NP	NP	8.3	6,700	<0.01	0.023	-0.4	200			
SW-19	S-1	2.5	3.5			7.5																
	S-2	4.0	5.5	SM	A-2-4 (0)	4.2			66	34	25	22	3									
	S-3	7.0	8.0			3.4																
	S-4	9.0	10.5			0.7																
	S-5	14.0	15.0			2.0																
SW-20	S-1	2.0	3.0	SP-SM	A-1-b (0)	43.5		12	77	11	NP	NP	NP									
	S-2	4.0	5.5			15.1																
SW-21	S-1	2.0	3.0			3.9																
	S-2	4.0	5.5		A-3 (0)	1.6				4	NP	NP	NP									
SW-22	S-1	2.0	3.5	SC	A-4 (0)	6.6				36	28	19	9									
	S-2	4.0	5.0			3.4	89											-4.2	200			
SW-23	S-1	2.0	3.0			2.7																
	S-2	4.0	5.5	SM	A-4 (0)	9.1		1	62	37	NP	NP	NP									
	S-3	7.0	8.0			5.7																
	S-4	9.0	9.3			5.1																
	S-5	14.0	14.1			0.6																
SW-24	S-1	2.0	3.0	SM	A-2-4 (0)	1.3				33	NP	NP	NP									
	S-2	4.0	5.0			0.9																

Table B-1 - Summary of Laboratory Test Results

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS			CORROSION				SWELL/COLLAPSE			COMPACTION[3]	
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Soil Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)	Swell(+) Collapse (-) (%)	Inundation Pressure (psf)	R-Value	Optimum Moisture Content (%)	Max. Dry Density (pcf)
SW-25	S-1	2.0	3.0	ML	A-4 (0)	13.4	98			58	NP	NP	NP					-0.8	200			
	S-2	4.0	5.5			10.1																
	S-3	7.0	7.4			6.1																
	S-4	9.0	9.3			4.0																
	S-5	14.0	14.3			2.0																
SW-26	B-1	0.0	4.0	CL	A-4 (5)	7.7		4	21	75	27	18	9							45.4		
	S-1	2.0	3.0	CL	A-6 (8)	8.9	112			72	30	15	15					1.1	200			
	S-2	4.0	5.5			6.3																
SW-27	S-1	2.0	3.0			8.7																
	S-2	4.0	5.5	CL	A-6 (7)	8.9				82	29	18	11	7.1	1,900	0.01	0.030					
SW-28	S-1	2.0	3.0			8.0																
	S-2	4.0	5.5	CL-ML	A-4 (2)	5.1			39	61	29	22	7									
	S-3	7.0	8.0			4.6																
	S-4	9.0	10.5			2.3																
	S-5	14.0	15.0			1.2																
SW-29	S-1	2.5	4.0	SC	A-6 (4)	5.6		1	51	48	33	17	16									
	S-2	4.5	5.5			6.5																
	S-3	7.5	9.0			1.1																
	S-4	9.0	10.0			2.1																
	S-5	14.0	14.3																			
SW-30	S-1	2.5	3.8	ML	A-4 (0)	6.7				60	NP	NP	NP									
	S-2	4.0	4.3			1.7																

Table B-1 - Summary of Laboratory Test Results

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS			CORROSION				SWELL/COLLAPSE			COMPACTION[3]	
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Soil Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)	Swell(+) Collapse (-) (%)	Inundation Pressure (psf)	R-Value	Optimum Moisture Content (%)	Max. Dry Density (pcf)
SW-31	S-1	2.0	2.7			1.0																
	S-2	4.0	4.2			1.0																
	S-3	7.0	7.2			1.7																
	S-4	9.0	9.1			0.5																
	S-5	14.0	14.2			0.6																
	S-6	19.0	19.3			3.4				64												
	S-7	24.0	24.2			1.1					NP	NP	NP									
	S-8	29.0	29.3			1.3																
SW-32	S-1	2.5	3.5	SM	A-2-4 (0)	4.5				33	NP	NP	NP	7.6	4,600	0.02	0.020					
	S-2	4.0	4.5			1.5																
SW-33	S-1	2.5	3.5	CL	A-6 (11)	7.6	100			78	31	14	17					-0.4	200			
	S-2	4.5	6.0			6.2																
	S-3	7.5	8.5			10.9																
	S-4	9.0	10.5			5.8																
	S-5	14.0	15.0			6.7																
SW-34	S-1	2.0	3.5	SM	A-2-4 (0)	1.6				34	NP	NP	NP	8.7	32,000	<0.01	0.020					
	S-2	4.0	5.0			2.2																
SW-35	S-1	2.0	3.0			2.3																
	S-2	4.0	5.5	SM	A-4 (0)	1.7				36	NP	NP	NP									
	S-3	7.0	8.0			3.1																
	S-4	9.0	10.5			3.1																
	S-5	14.0	15.5			4.1																
SW-36	B-1	0.0	4.0	SM	A-2-4 (0)	6.1		5	61	34	NP	NP	NP							68.2		
	S-1	2.0	3.0	ML	A-4 (0)	9.0	82			68	NP	NP	NP					-0.2	200			
	S-2	4.0	5.5			7.4																
SW-37	S-1	2.0	3.0	SM	A-2-4 (0)	2.6				30	NP	NP	NP									
	S-2	4.0	5.5			1.5																

Table B-1 - Summary of Laboratory Test Results

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS			CORROSION				SWELL/COLLAPSE			COMPACTION[3]	
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Soil Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)	Swell(+) Collapse (-) (%)	Inundation Pressure (psf)	R-Value	Optimum Moisture Content (%)	Max. Dry Density (pcf)
SW-38	S-1	2.5	3.5			0.2																
	S-2	4.5	6.0	SM	A-4 (0)	0.7		2	59	39	NP	NP	NP	8.9	10,000	<0.01	0.020					
	S-3	7.5	8.5			2.0																
	S-4	9.0	10.5			2.3																
	S-5	14.0	15.0			2.2																
	S-6	19.0	20.5			2.2																
	S-7	24.0	24.3			1.6																
	S-8	29.0	29.4			0.6																
	S-9	34.0	34.4			0.7																
	S-10	39.0	39.7			0.5																
	S-11	44.0	44.4			0.8																
	S-12	49.0	50.5			0.4																
SW-39	S-1	1.0	2.0	SM	A-2-4 (0)	12.3	80	2	65	33	NP	NP	NP					-0.3	200			
	S-2	4.0	5.5			9.4																
SW-40	B-1	0.4	0.7	SW-SM	A-1-a (0)	1.4		40	49	11	NP	NP	NP									
SW-41	S-1	2.0	3.5			12.7																
	S-2	4.0	5.0	ML	A-4 (0)	8.0	86			63	NP	NP	NP					-0.7	200			
SW-42	B-1	0.2	0.3			10.8																
SW-43	S-1	2.0	3.5	SM	A-1-b (0)	5.0		28	50	22	NP	NP	NP									
	S-2	4.0	5.0			3.4																
	S-3	7.0	8.5			10.1																
	S-4	9.0	10.0			11.7																
	S-5	14.0	15.4			16.8																
SW-44	B-1	0.3	0.7	GM	A-1-a (0)	9.4		58	28	14	NP	NP	NP									
SW-45	S-1	2.0	3.5	SM	A-2-4 (0)	3.3		3	76	21	NP	NP	NP									
	S-2	4.0	5.0			6.9																
SW-46	S-1	2.0	3.0			6.1																
	S-3	4.0	5.0	SM	A-1-b (0)	7.0	110	30	57	13	NP	NP	NP									

Table B-1 - Summary of Laboratory Test Results

SAMPLE DATA								GRAIN-SIZE ANALYSES[2]			ATTERBERG LIMITS			CORROSION				SWELL/COLLAPSE			COMPACTION[3]	
Boring	Sample	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	AASHTO Soil Classification	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	LL (%)	PL (%)	PI (%)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)	Swell(+) Collapse (-) (%)	Inundation Pressure (psf)	R-Value	Optimum Moisture Content (%)	Max. Dry Density (pcf)
SW-47	S-1	2.0	3.0	SM	A-1-b (0)	11.2		14	70	16	NP	NP	NP									
	S-2	4.0	5.5			12.4																
SW-48	B-1	0.0	5.0	SM	A-2-4 (0)	11.8		9	62	29	NP	NP	NP	9.4	8,000	<0.01	0.025					
	S-1	2.5	3.5	SM	A-4 (0)	14.3		13	40	47	33	29	4									
	S-2	4.0	5.0			15.3	80															
	S-3	7.5	8.5			6.1																
	S-4	9.0	10.0	SM	A-4 (0)	27.9		22	35	43	NP	NP	NP									
	S-5	12.5	13.5			28.0																
	S-6	14.0	14.8	SM	A-1-b (0)	24.8		6	81	13	NP	NP	NP									
	S-7	19.0	20.3			17.5																
SW-49	B-1	0.0	10.0	SM	A-1-b (0)			29	52	19	NP	NP	NP								10.6	121.7
	S-1	2.5	3.5			7.8																
	S-2	4.0	5.0	SM	A-4 (0)	5.0		7	51	42	NP	NP	NP									
	S-3	7.5	8.5			4.6	110															
	S-4	9.0	10.0	SM	A-4 (0)	4.2	101	6	45	49	NP	NP	NP									
	S-5	12.5	13.5			20.8																
	S-6	14.0	15.0	SM	A-4 (0)	30.0		22	30	48	NP	NP	NP									
	S-7	19.0	20.0			25.9																
SW-50	B-1	0.0	4.0	SM	A-1-b (0)	1.7		16	62	22	NP	NP	NP								72.1	
	S-1	2.0	3.0	SM	A-2-4 (0)	7.1		7	61	32	NP	NP	NP									
	S-2	4.0	5.5			7.6																
SW-51	B-1	0.3	0.8	GW-GM	A-1-a (0)	4.0		47	42	11	NP	NP	NP									
SW-52	S-1	2.0	3.5	SM	A-1-b (0)	2.9		25	60	15	NP	NP	NP									
	S-2	4.0	5.0			2.6																

NOTES:

1 Refer to Appendix A, Figure A-1 for definitions.

2 Gravel defined as particles larger than the No. 4 sieve size, Sand as particles between the No. 4 and No. 200 sieve sizes, and Fines as particles passing the No. 200 sieve.

3 Compaction test method is AASHTO T99 method A. Reported maximum dry density and optimum moisture content are corrected for oversized material.

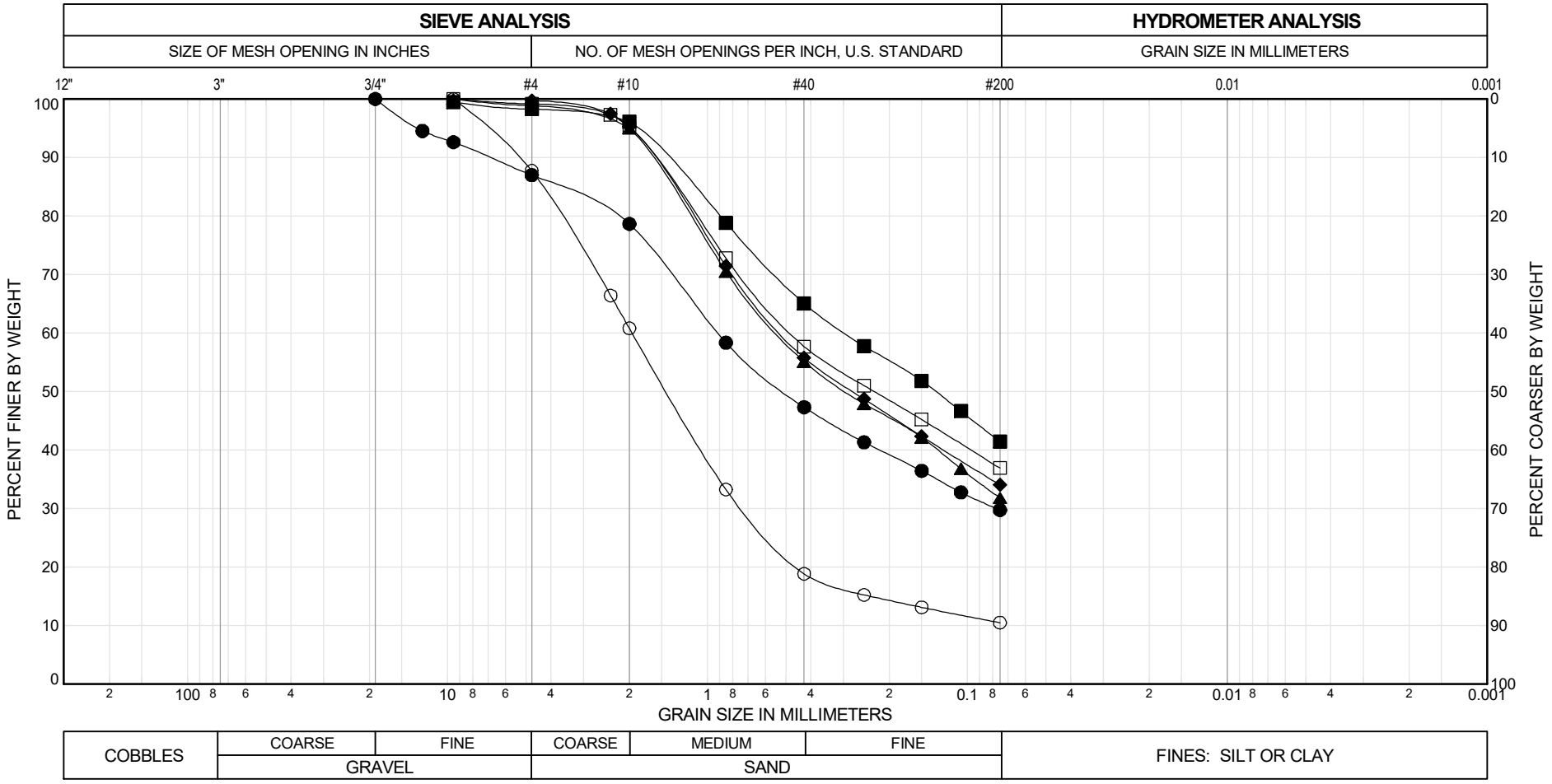
LL = Liquid Limit; Max. = Maximum; NP = Non-Plastic; PI = Plasticity Index; PL = Plastic Limit; psi = pounds per square inch; psf = pounds per square foot; pcf = pounds per cubic foot

SHANNON & WILSON

GRAIN SIZE DISTRIBUTION TEST RESULTS

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-15, SW-17, SW-19, SW-20, SW-23



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-15, S-1	2.5	SILTY SAND	SM	13	57	30	3.8	ATY ZAB	T311	
■ SW-17, S-2	4.0	SILTY SAND	SM	2	57	41	7.2	ATY AJG	T311	
▲ SW-17, S-4	10.0	SILTY SAND	SM	1	67	32	5.5	ATY ZAB	T311	
◆ SW-19, S-2	4.0	SILTY SAND	SM		66	34	4.2	VIVID	T311/D1140	
○ SW-20, S-1	2.0	POORLY GRADED SAND with SILT	SP-SM	12	77	10	43.5	VIVID	T311/D1140	
□ SW-23, S-2	4.0	SILTY SAND	SM	1	62	37	9.1	VIVID	T311/D1140	

* Sample was assumed to be nonplastic based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the grain size distribution only.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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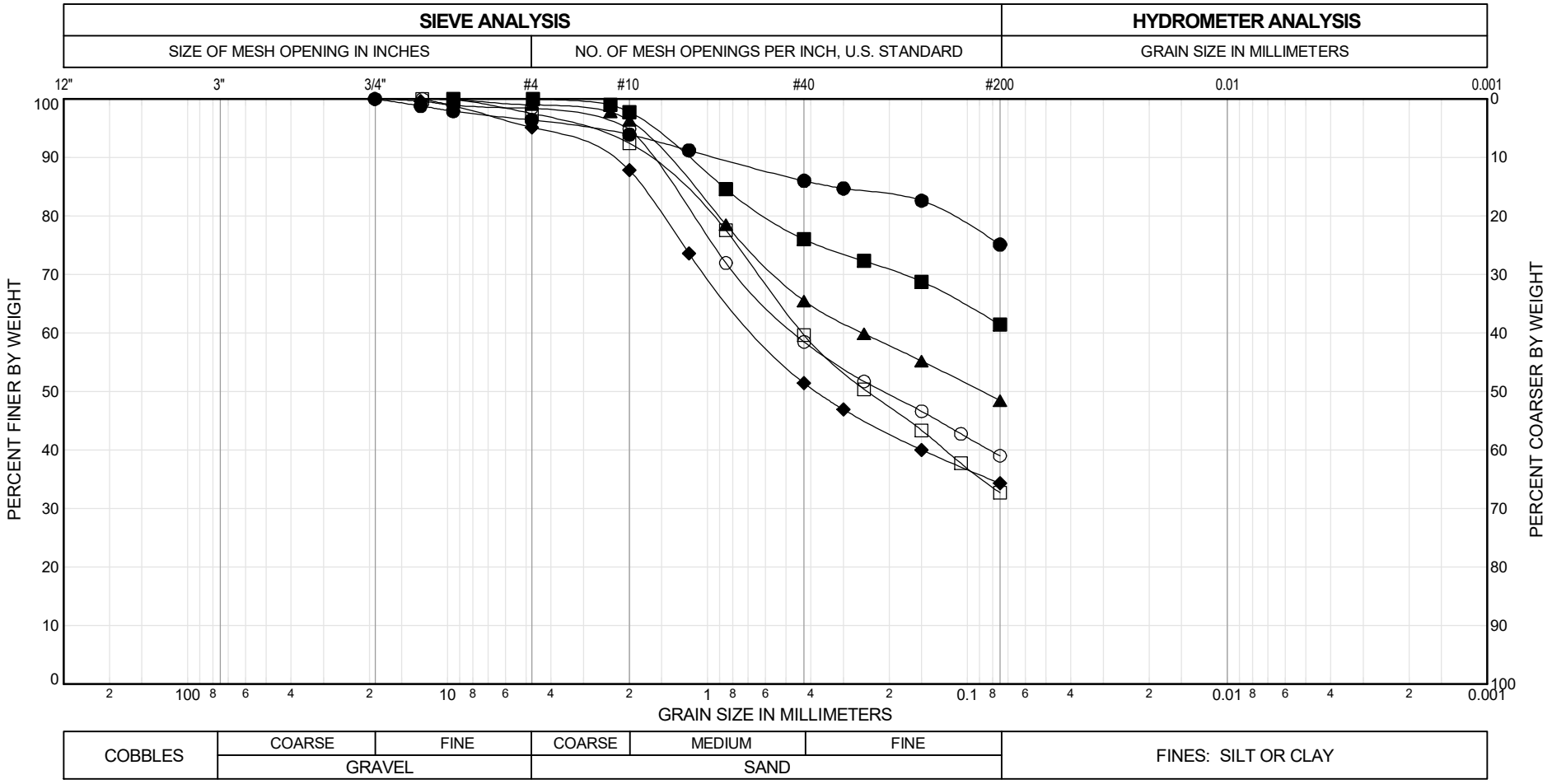
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-26, SW-28, SW-29, SW-36, SW-38, SW-39



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-26, B-1	0.0	LEAN CLAY with SAND	CL	4	21	75	7.7	VINE	T311/D1140	
■ SW-28, S-2	4.0	SANDY SILTY CLAY	CL-ML		39	61	5.1	VIVID	T311/D1140	
▲ SW-29, S-1	2.5	CLAYEY SAND	SC	1	51	48	5.6	VIVID	T311/D1140	
◆ SW-36, B-1	0.0	SILTY SAND	SM	5	61	34	6.1	VINE	T311/D1140	
○ SW-38, S-2	4.5	SILTY SAND	SM	2	59	39	0.7	JYS BTM	T311/D1140	
□ SW-39, S-1	1.0	SILTY SAND	SM	2	65	33	12.3	ATY ZAB	T311	

* Sample was assumed to be nonplastic based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the grain size distribution only.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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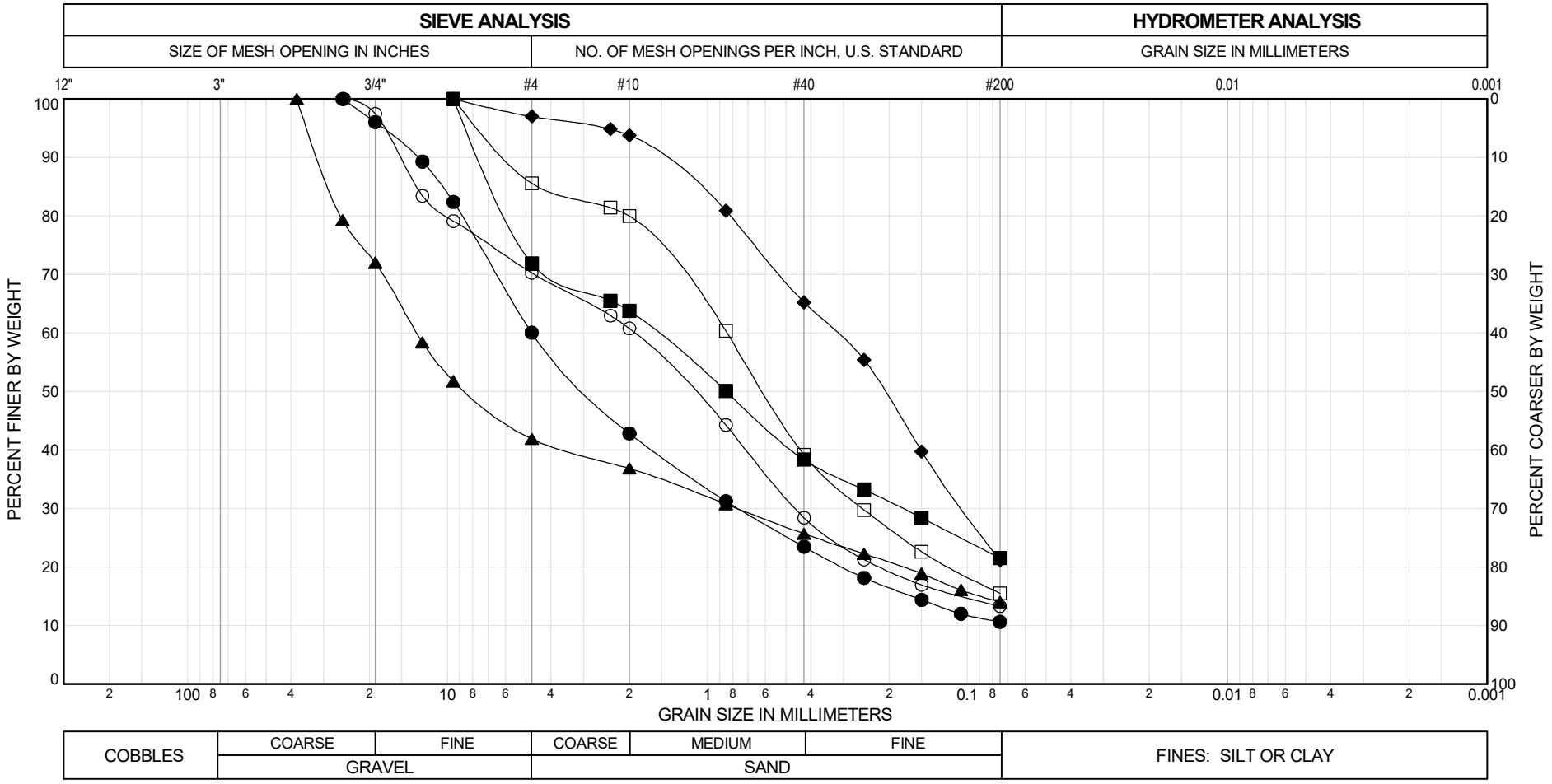
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-40, SW-43, SW-44, SW-45, SW-46, SW-47



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-40, B-1	0.4	WELL-GRADED SAND with SILT and GRAVEL	SW-SM	40	49	11	1.4	ATY ZAB	T311	
■ SW-43, S-1	2.0	SILTY SAND with GRAVEL	SM	28	50	21	5.0	VIVID	T311/D1140	
▲ SW-44, B-1	0.3	SILTY GRAVEL with SAND	GM	58	28	14	9.4	ATY ZAB	T311	
◆ SW-45, S-1	2.0	SILTY SAND	SM	3	76	21	3.3	VIVID	T311/D1140	
○ SW-46, S-3	4.0	SILTY SAND with GRAVEL	SM	30	57	13	7.0	VIVID	T311/D1140	
□ SW-47, S-1	2.0	SILTY SAND	SM	14	70	16	11.2	VIVID	T311/D1140	

* Sample was assumed to be nonplastic based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the grain size distribution only.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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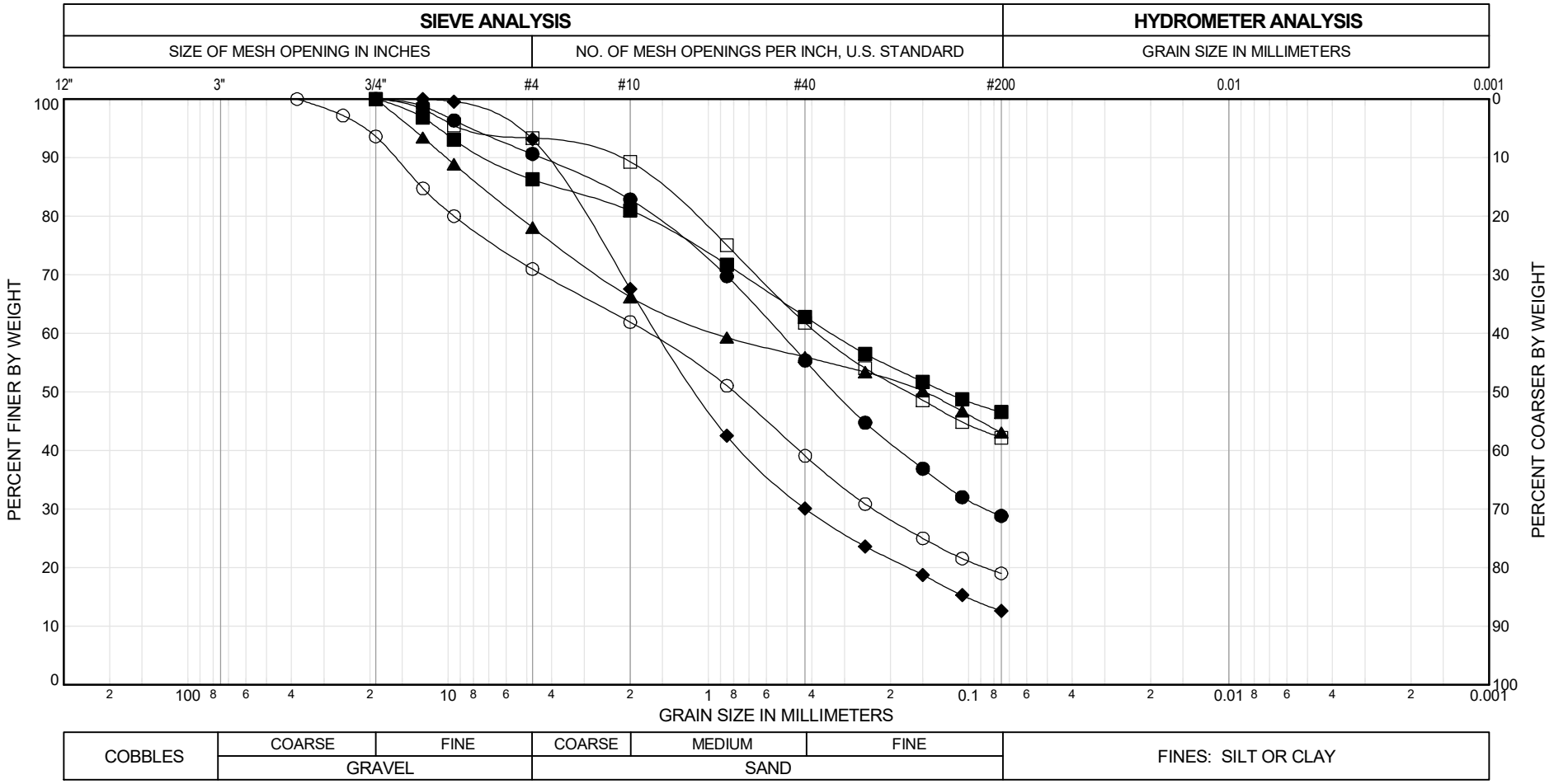
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-48, SW-49



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-48, B-1	0.0	SILTY SAND	SM	9	62	29	11.8	ATY ZAB	T311	
■ SW-48, S-1	2.5	SILTY SAND	SM	13	40	47	14.3	ATY ZAB	T311	
▲ SW-48, S-4	9.0	SILTY SAND with GRAVEL	SM	22	35	43	27.9	ATY ZAB	T311	
◆ SW-48, S-6	14.0	SILTY SAND	SM	6	81	13	24.8	ATY ZAB	T311	
○ SW-49, B-1	0.0	SILTY SAND with GRAVEL	SM	29	52	19		JYS ASW	T311	
□ SW-49, S-2	4.0	SILTY SAND	SM	7	51	42	5.0	ATY ZAB	T311	

* Sample was assumed to be nonplastic based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the grain size distribution only.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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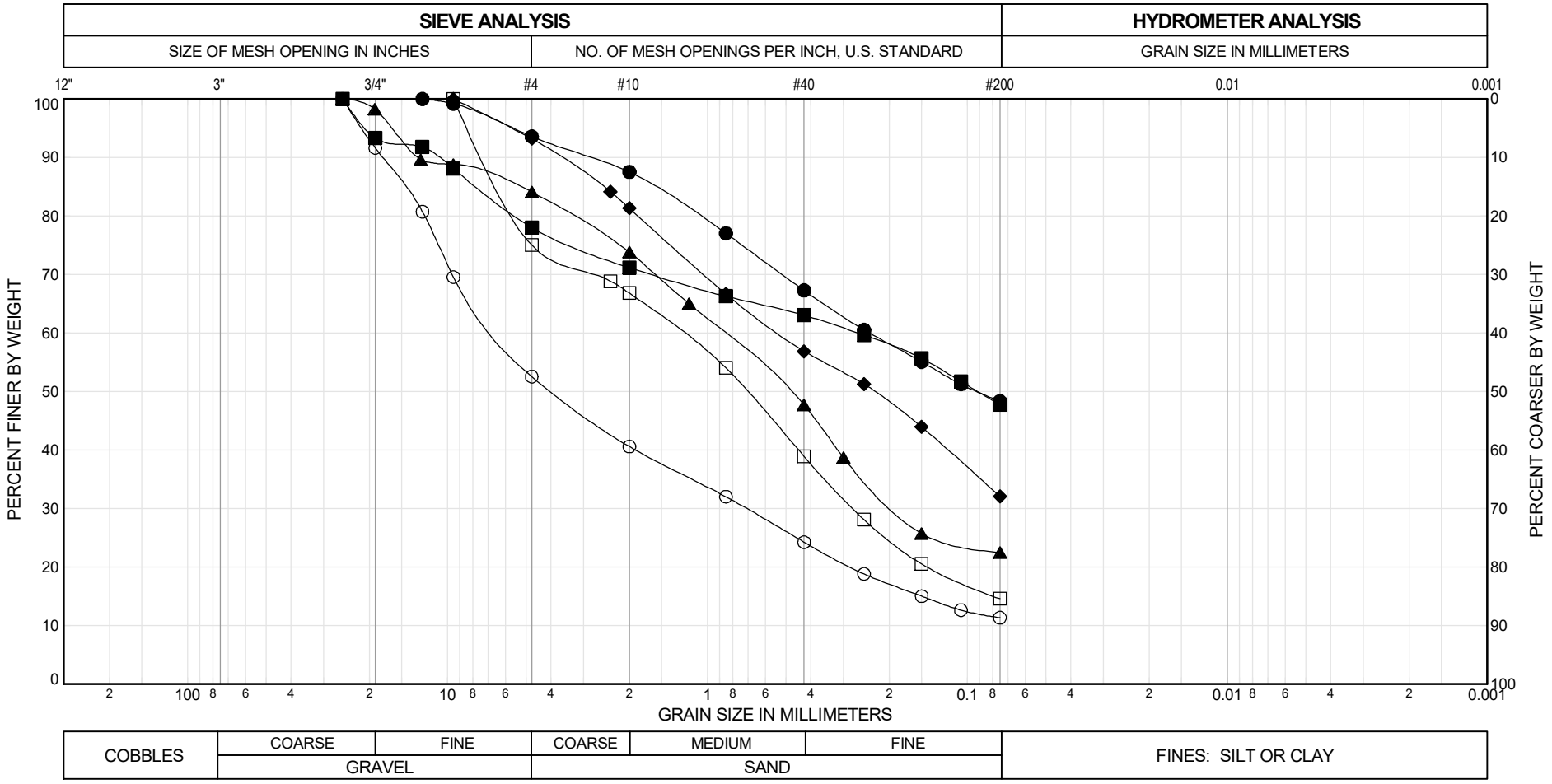
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-49, SW-50, SW-51, SW-52



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	GRAVEL %	SAND %	FINES %	NAT WC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-49, S-4	9.0	SILTY SAND	SM	6	45	48	4.2	ATY ZAB	T311	
■ SW-49, S-6	14.0	SILTY SAND with GRAVEL	SM	22	30	48	30.0	ATY ZAB	T311	
▲ SW-50, B-1	0.0	SILTY SAND with GRAVEL	SM	16	62	23	1.7	VINE	T311/D1140	
◆ SW-50, S-1	2.0	SILTY SAND	SM	7	61	32	7.1	VIVID	T311/D1140	
○ SW-51, B-1	0.3	WELL-GRADED GRAVEL with SILT and SAND	GW-GM	47	41	11	4.0	ATY ZAB	T311	
□ SW-52, S-1	2.0	SILTY SAND with GRAVEL	SM	25	60	15	2.9	VIVID	T311/D1140	

* Sample was assumed to be nonplastic based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the grain size distribution only.
ABBREVIATIONS: NAT WC = natural moisture content; RVW = reviewed by; STD = Standard; USCS = Unified Soil Classification System code; ~ = approximately (used when measured but not greater than 0.5%)

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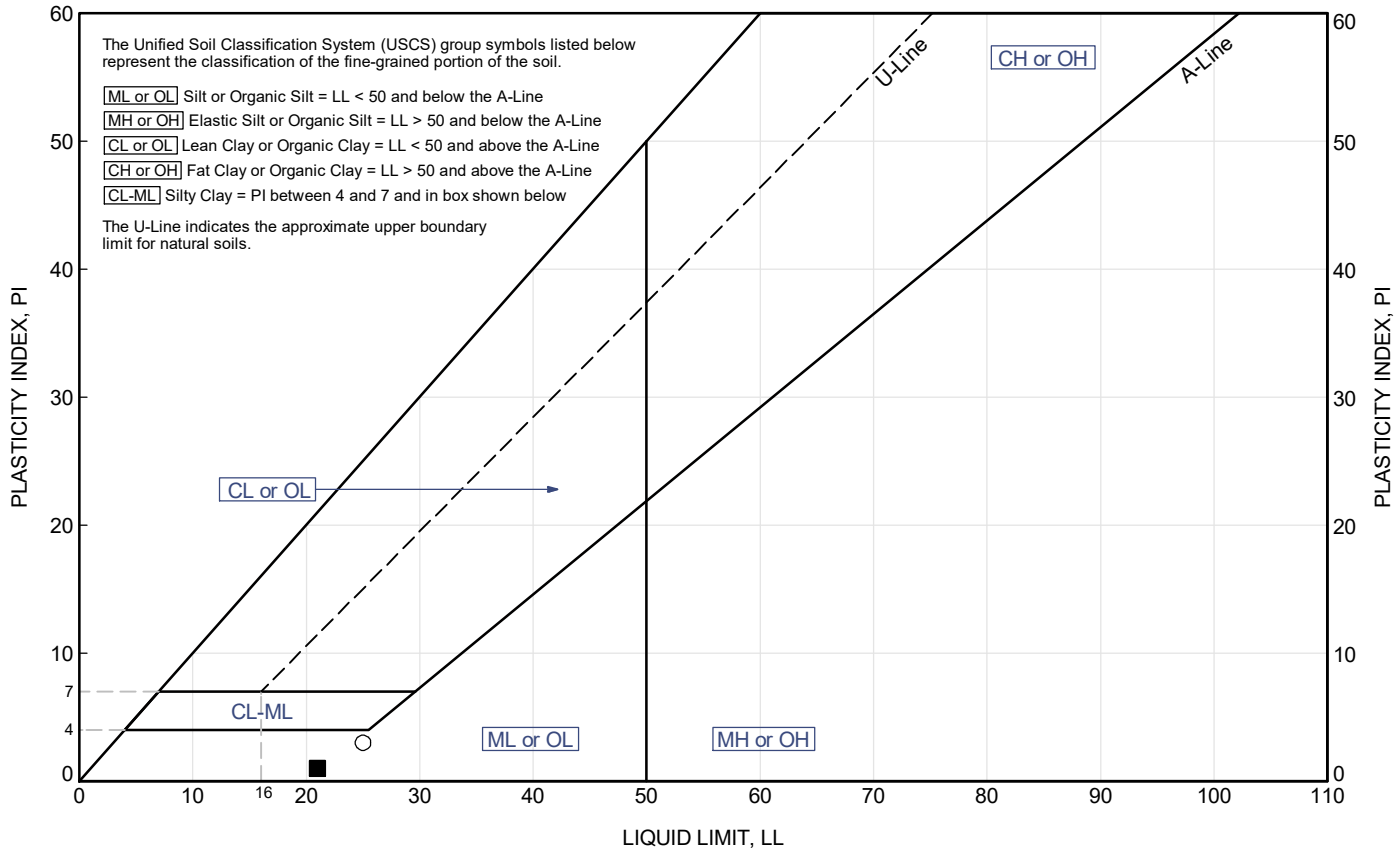
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-15, SW-17, SW-18, SW-19, SW-20, SW-21



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
SW-15, S-1	2.5	SILTY SAND	SM	*NP*	NP	*NP*	30	3.8	JDT ZAB	T89,T90	
■ SW-17, S-2	4.0	SILTY SAND	SM	21	20	1	41	7.2	ATY AJG	T89,T90	
SW-17, S-4	10.0	SILTY SAND	SM	*NP*	NP	*NP*	32	5.5	JDT ZAB	T89,T90	
SW-18, S-2	4.0	SILTY SAND	SM	*NP*	NP	*NP*	28	5.3	JYS BTM	T89,T90	
○ SW-19, S-2	4.0	SILTY SAND	SM	25	22	3	34	4.2	VIVID	T89,T90	
SW-20, S-1	2.0	POORLY GRADED SAND with SILT	SP-SM	*NP*	NP	*NP*	10	43.5	VIVID	T89,T90	
SW-21, S-2	4.0	*Atterberg Limits only - no sieve analysis: Group Name not estimated*		*NP*	NP	*NP*	4	1.6	VIVID	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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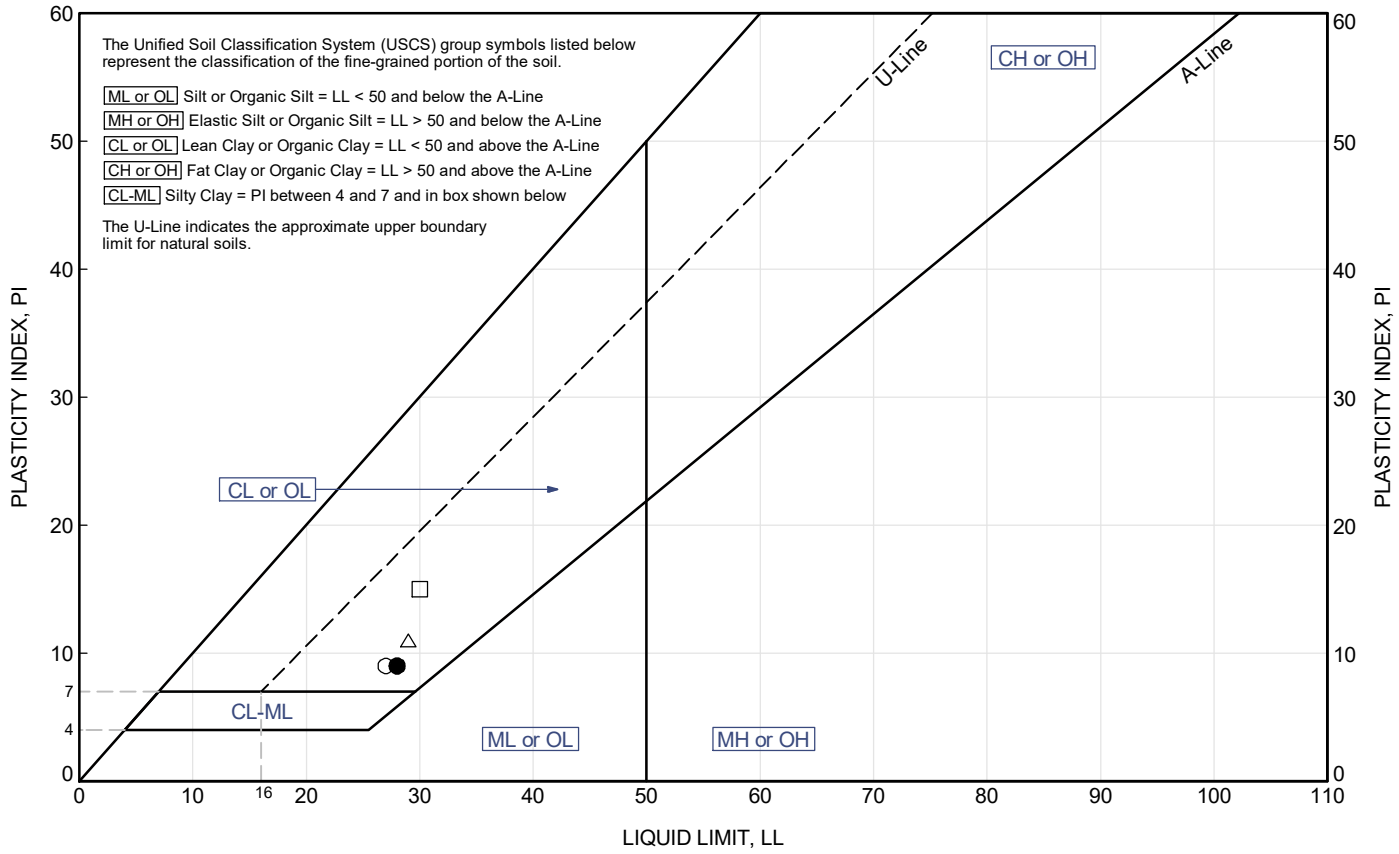
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-22, SW-23, SW-24, SW-25, SW-26, SW-27



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-22, S-1	2.0	CLAYEY SAND	SC	28	19	9	36	6.6	VIVID	T89,T90	
SW-23, S-2	4.0	SILTY SAND	SM	*NP*	NP	*NP*	37	9.1	VIVID	T89,T90	
SW-24, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	33	1.3	VIVID	T89,T90	
SW-25, S-1	2.0	SANDY SILT	ML	*NP*	NP	*NP*	58	13.4	VIVID	T89,T90	
○ SW-26, B-1	0.0	LEAN CLAY with SAND	CL	27	18	9	75	7.7	VINE	T89,T90	
□ SW-26, S-1	2.0	LEAN CLAY with SAND	CL	30	15	15	72	8.9	VIVID	T89,T90	
△ SW-27, S-2	4.0	LEAN CLAY with SAND	CL	29	18	11	82	8.9	ASW BTM	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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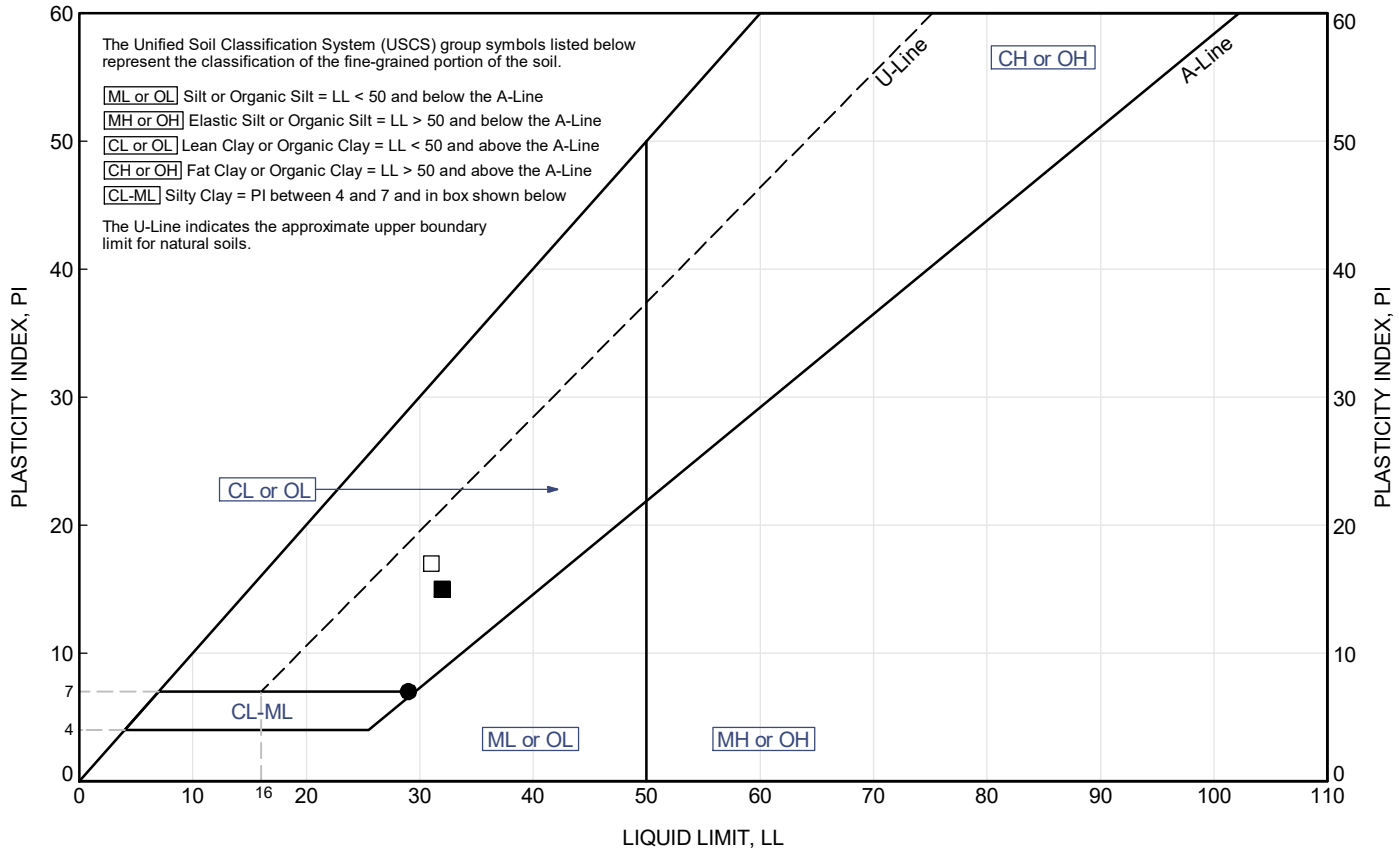
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-28, SW-29, SW-30, SW-31, SW-32, SW-33



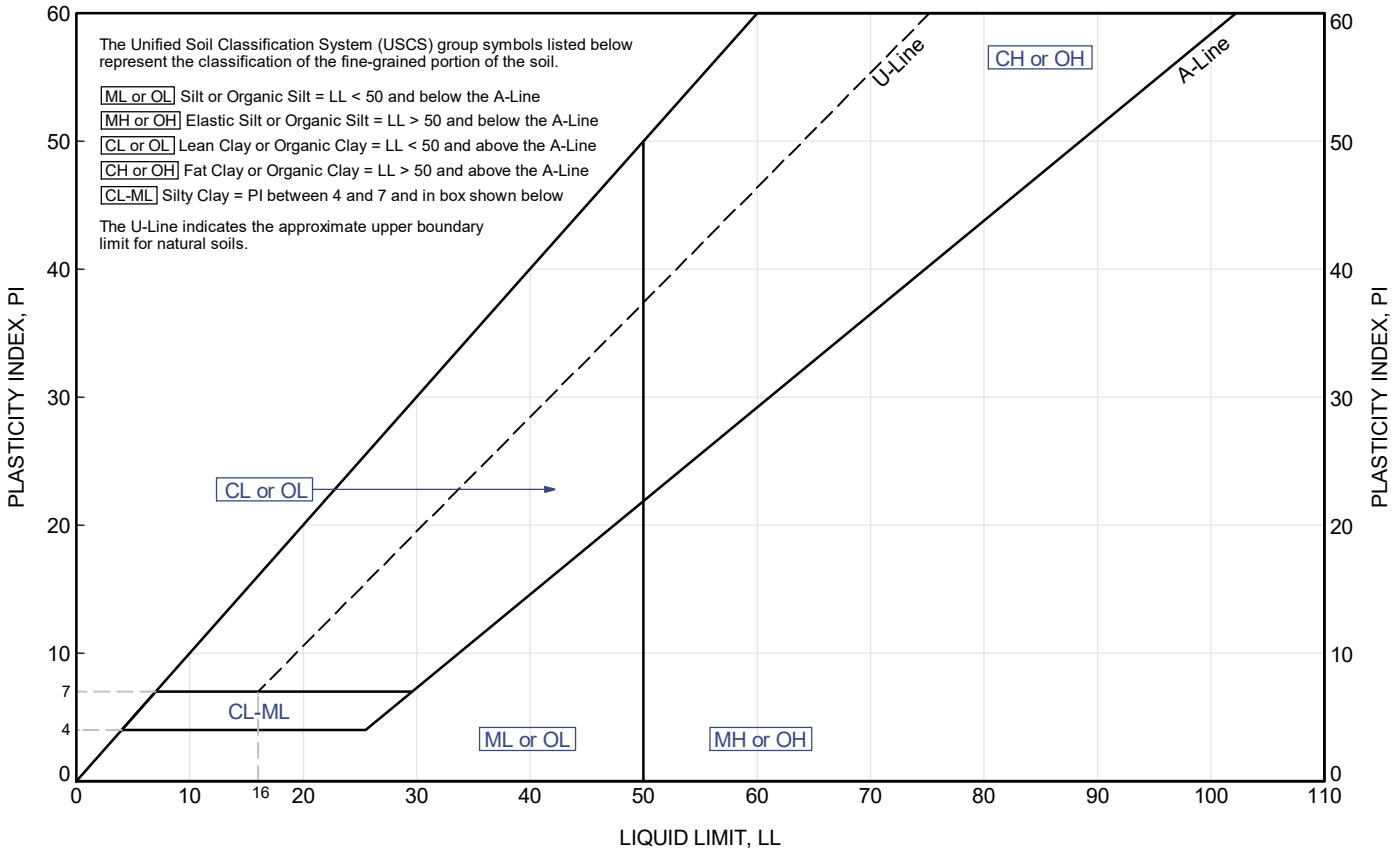
EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
● SW-28, S-2	4.0	SANDY SILTY CLAY	CL-ML	29	22	7	61	5.1	VIVID	T89,T90	
■ SW-29, S-1	2.5	CLAYEY SAND	SC	33	17	16	48	5.6	VIVID	T89,T90	
SW-30, S-1	2.5	SANDY SILT	ML	*NP*	NP	*NP*	60	6.7	VIVID	T89,T90	
SW-31, S-7	24.0	*Atterberg Limits only - no sieve analysis: Group Name not estimated*		*NP*	NP	*NP*		1.1	VIVID	T89,T90	
SW-32, S-1	2.5	SILTY SAND	SM	*NP*	NP	*NP*	33	4.5	JYS BTM	T89,T90	
□ SW-33, S-1	2.5	LEAN CLAY with SAND	CL	31	14	17	78	7.6	VIVID	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

Job# 107523-002 | Template Ver:1 | File: 107523-002.GPJ | Library: SW.GINT LIBRARY.GLB | Date: 5/21/24

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-34, SW-35, SW-36, SW-37, SW-38



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
SW-34, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	34	1.6	JYS BTM	T89,T90	
SW-35, S-2	4.0	SILTY SAND	SM	*NP*	NP	*NP*	36	1.7	VIVID	T89,T90	
SW-36, B-1	0.0	SILTY SAND	SM	*NP*	NP	*NP*	34	6.1	VINE	T89,T90	
SW-36, S-1	2.0	SANDY SILT	ML	*NP*	NP	*NP*	68	9.0	VIVID	T89,T90	
SW-37, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	30	2.6	VIVID	T89,T90	
SW-38, S-2	4.5	SILTY SAND	SM	*NP*	NP	*NP*	39	0.7	JYS BTM	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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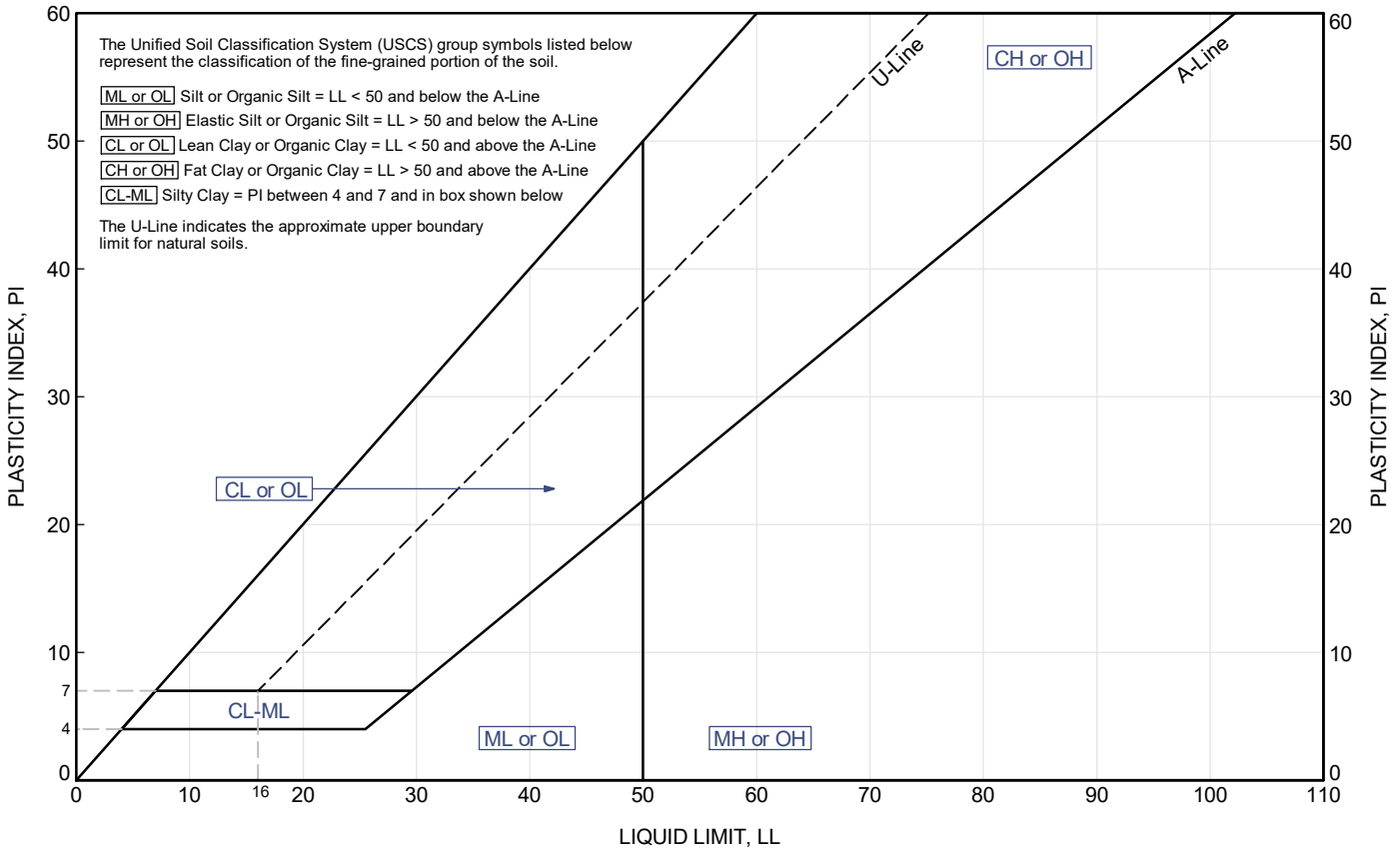
NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-39, SW-40, SW-41, SW-43, SW-44, SW-45

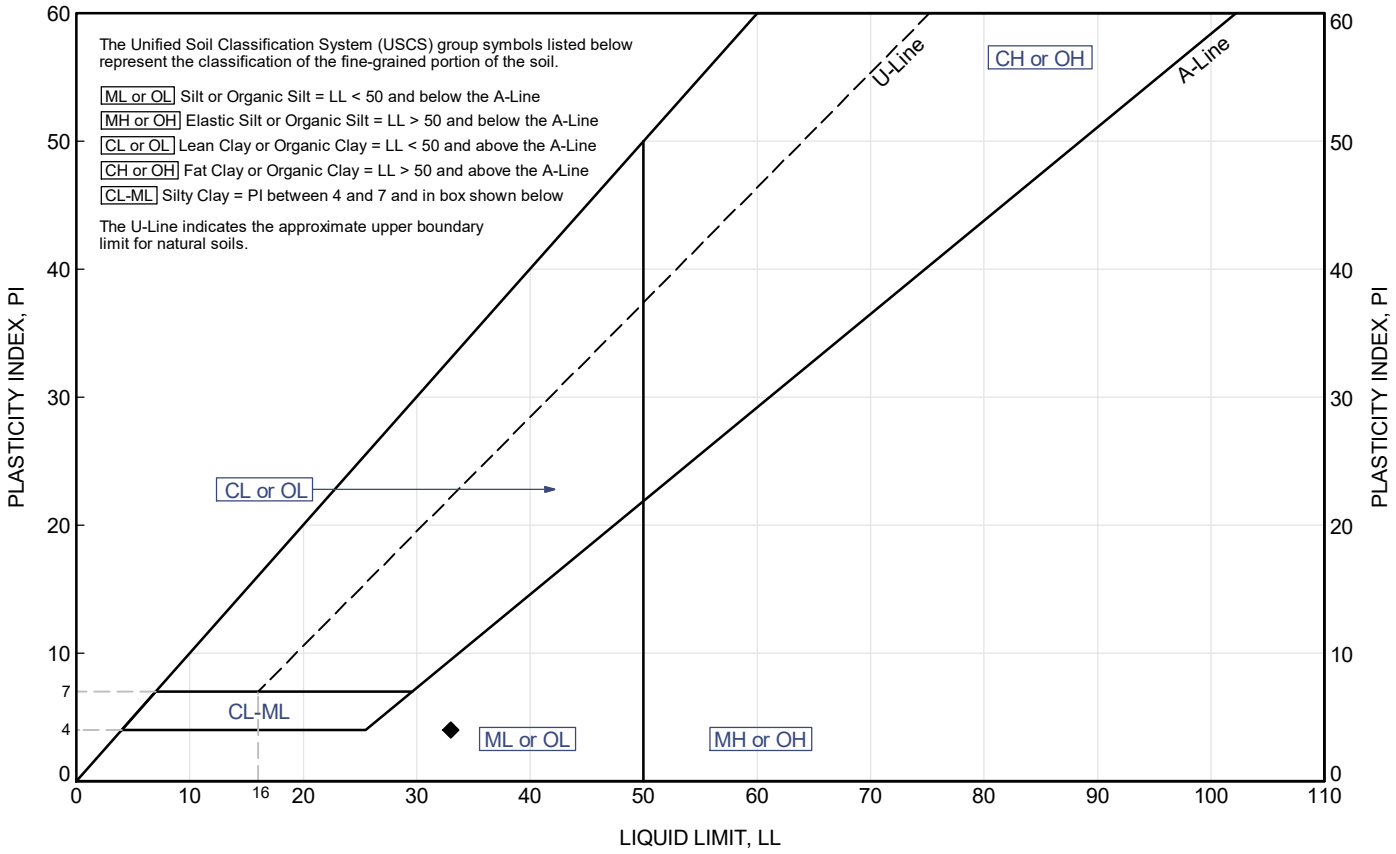


EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
SW-39, S-1	1.0	SILTY SAND	SM	*NP*	NP	*NP*	33	12.3	ATY KMK	T89,T90	
SW-40, B-1	0.4	WELL-GRADED SAND with SILT and GRAVEL	SW-SM	*NP*	NP	*NP*	11	1.4	JDT ZAB	T89,T90	
SW-41, S-2	4.0	SANDY SILT	ML	*NP*	NP	*NP*	63	8.0	VIVID	T89,T90	
SW-43, S-1	2.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	21	5.0	VIVID	T89,T90	
SW-44, B-1	0.3	SILTY GRAVEL with SAND	GM	*NP*	NP	*NP*	14	9.4	JDT ZAB	T89,T90	
SW-45, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	21	3.3	VIVID	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-46, SW-47, SW-48, SW-49

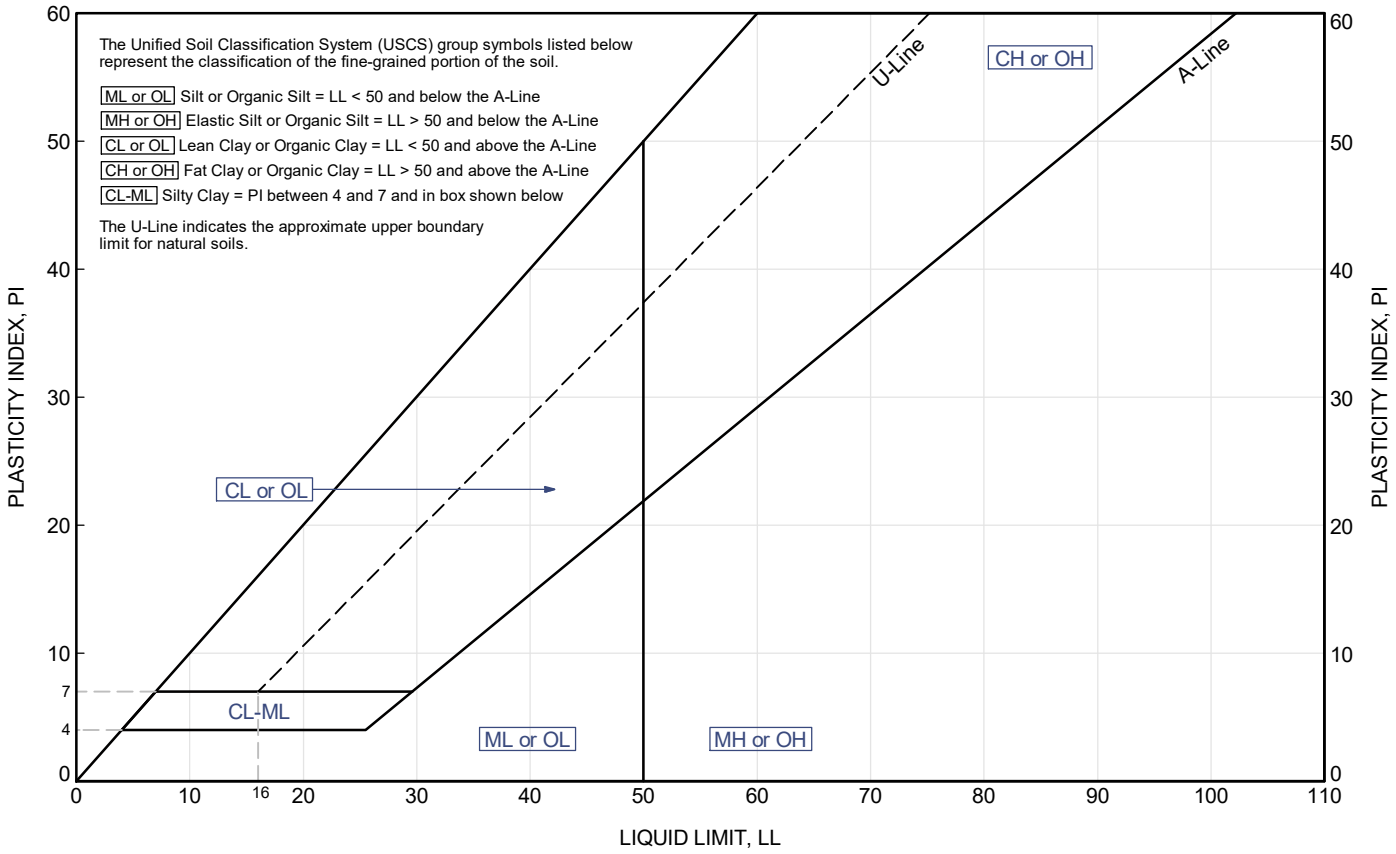


EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
SW-46, S-3	4.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	13	7.0	VIVID	T89,T90	
SW-47, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	16	11.2	VIVID	T89,T90	
SW-48, B-1	0.0	SILTY SAND	SM	*NP*	NP	*NP*	29	11.8	JYS ZAB	T89,T90	
◆ SW-48, S-1	2.5	SILTY SAND	SM	33	29	4	47	14.3	ZAB ZAB	T89,T90	
SW-48, S-4	9.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	43	27.9	ZAB ZAB	T89,T90	
SW-48, S-6	14.0	SILTY SAND	SM	*NP*	NP	*NP*	13	24.8	JDT ZAB	T89,T90	
SW-49, B-1	0.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	19		JYS ASW	T89,T90	
SW-49, S-2	4.0	SILTY SAND	SM	*NP*	NP	*NP*	42	5.0	JDT ZAB	T89,T90	
SW-49, S-4	9.0	SILTY SAND	SM	*NP*	NP	*NP*	48	4.2	JYS ZAB	T89,T90	
SW-49, S-6	14.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	48	30.0	ZAB ZAB	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

NPS Bandelier National Monument Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SW-50, SW-51, SW-52



EXPLORATION AND SAMPLE NUMBER	DEPTH (feet)	UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) GROUP NAME	USCS SYMBOL	LL	PL	PI	FINES (%)	NAT MC %	TEST BY/RVW	TEST STD	TEST NOTE
SW-50, B-1	0.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	23	1.7	VINE	T89,T90	
SW-50, S-1	2.0	SILTY SAND	SM	*NP*	NP	*NP*	32	7.1	VIVID	T89,T90	
SW-51, B-1	0.3	WELL-GRADED GRAVEL with SILT and SAND	GW-GM	*NP*	NP	*NP*	11	4.0	JDT ZAB	T89,T90	
SW-52, S-1	2.0	SILTY SAND with GRAVEL	SM	*NP*	NP	*NP*	15	2.9	VIVID	T89,T90	

* Sample was assumed to have less than 15% sand/gravel based on visual-manual examination procedures. Therefore, the USCS Group Name is estimated based on the Atterberg Limits only.
ABBREVIATIONS: LL = liquid limit; NAT MC = natural moisture content; n/a = test attempted; NP = nonplastic; PI = plasticity index; PL = plastic limit; STD = standard; RVW = reviewed by; USCS = Unified Soil Classification System symbol

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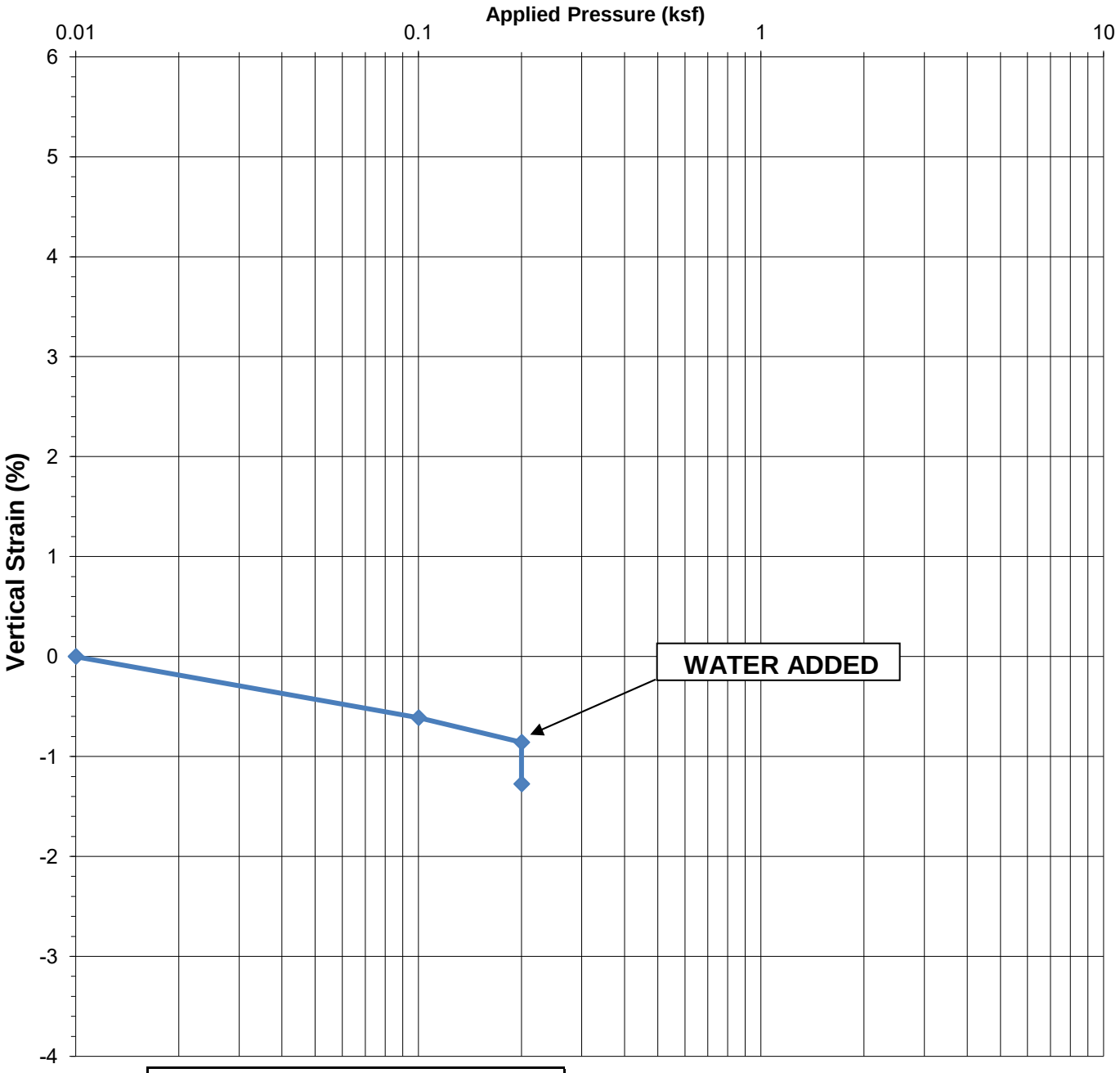
SWELL/COLLAPSE TEST REPORT
Boring SW-18 Sample S-2, 4 to 5 ft



Swell Pressure =	-	psf
Swell =	-0.4	%
Inundation Pressure =	200	psf
Initial Moisture Content =	5.3	%
Final Moisture Content =	32.9	%
Moist Unit Weight =	95.5	pcf

NOTES:

1. The swell pressure is the applied pressure required to compress the sample to its height immediately prior to inundation.
2. Testing was done in general accordance with Method B (an intact specimen obtained from a natural deposit) of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SWELL/COLLAPSE TEST REPORT
BORING SW-18, SAMPLE S-2

September 2024 107523-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

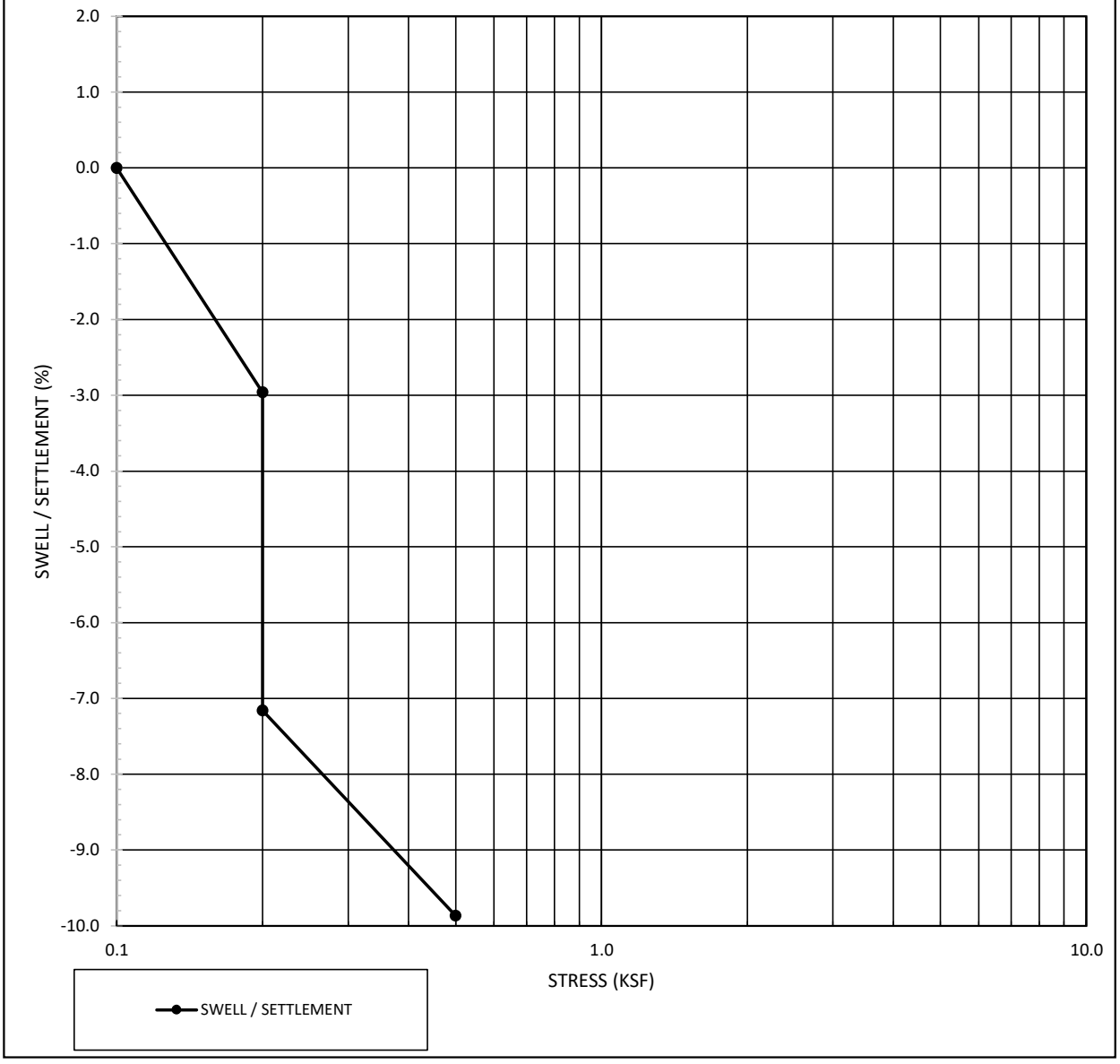
FIG. B-1

Project Name: NPS Banddelier NM **Date** 12/21/2023
Project No.: D23-1-408

Boring ID.: SW-22 **Sample Depth (ft)** 4

Sample Description: Silty SAND, light brown, dry

	%
Compression @ Wetting Weight:	**-4.2**

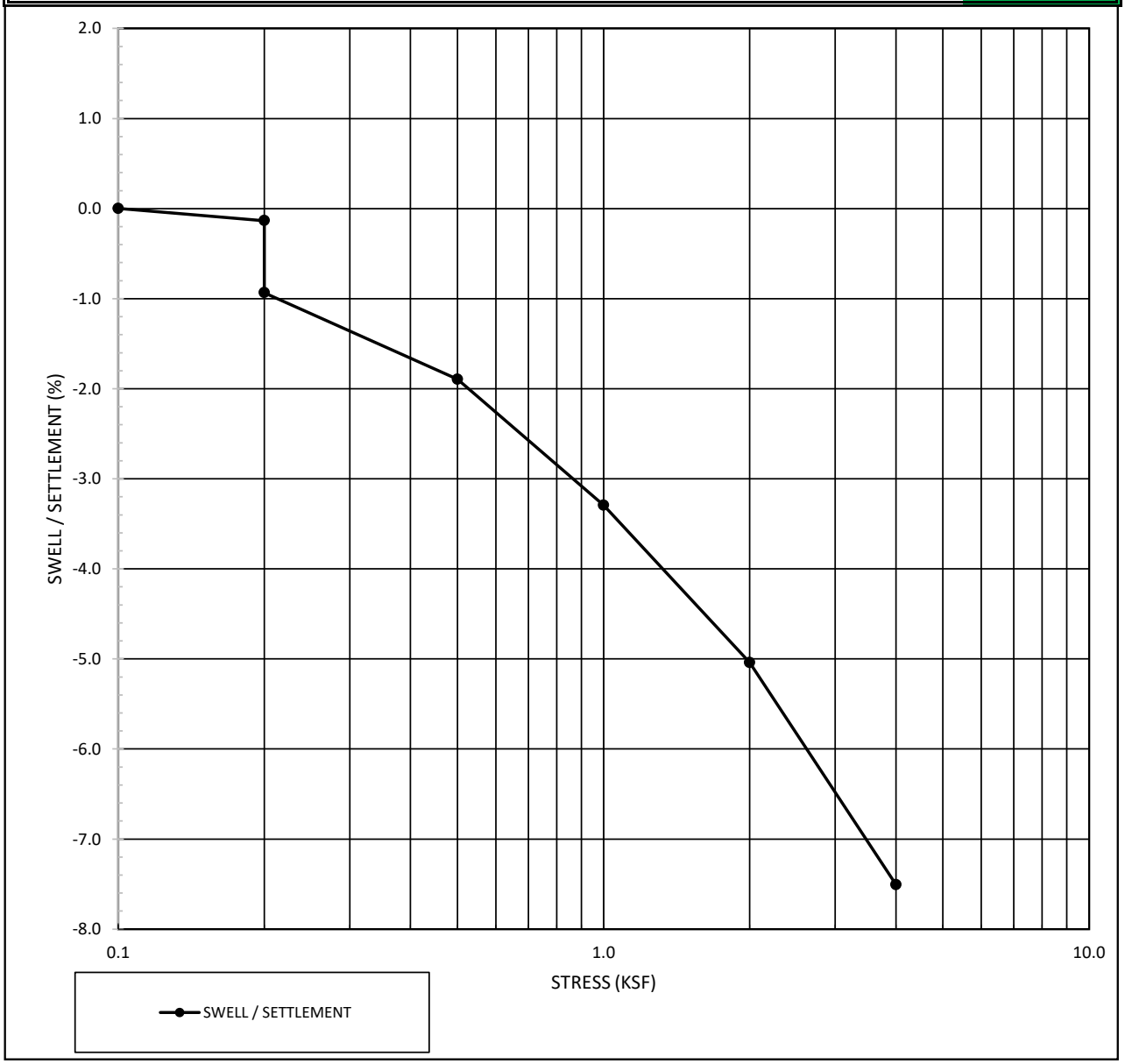


Initial Condition	
Moisture Content %	**3.4**
Dry Density (pcf)	**86.0**
Post-Swell Condition	
Moisture Content %	**20.3**

FIG. B-2

Project Name:	NPS Banddelier NM	**Date**	12/14/2024
Project No.:	D23-1-408		
Boring ID.:	SW-25	**Sample Depth (ft)**	2
Sample Description:	Silty SAND, brown, moist		

	%
Compression @ Wetting Weight:	**-0.8**

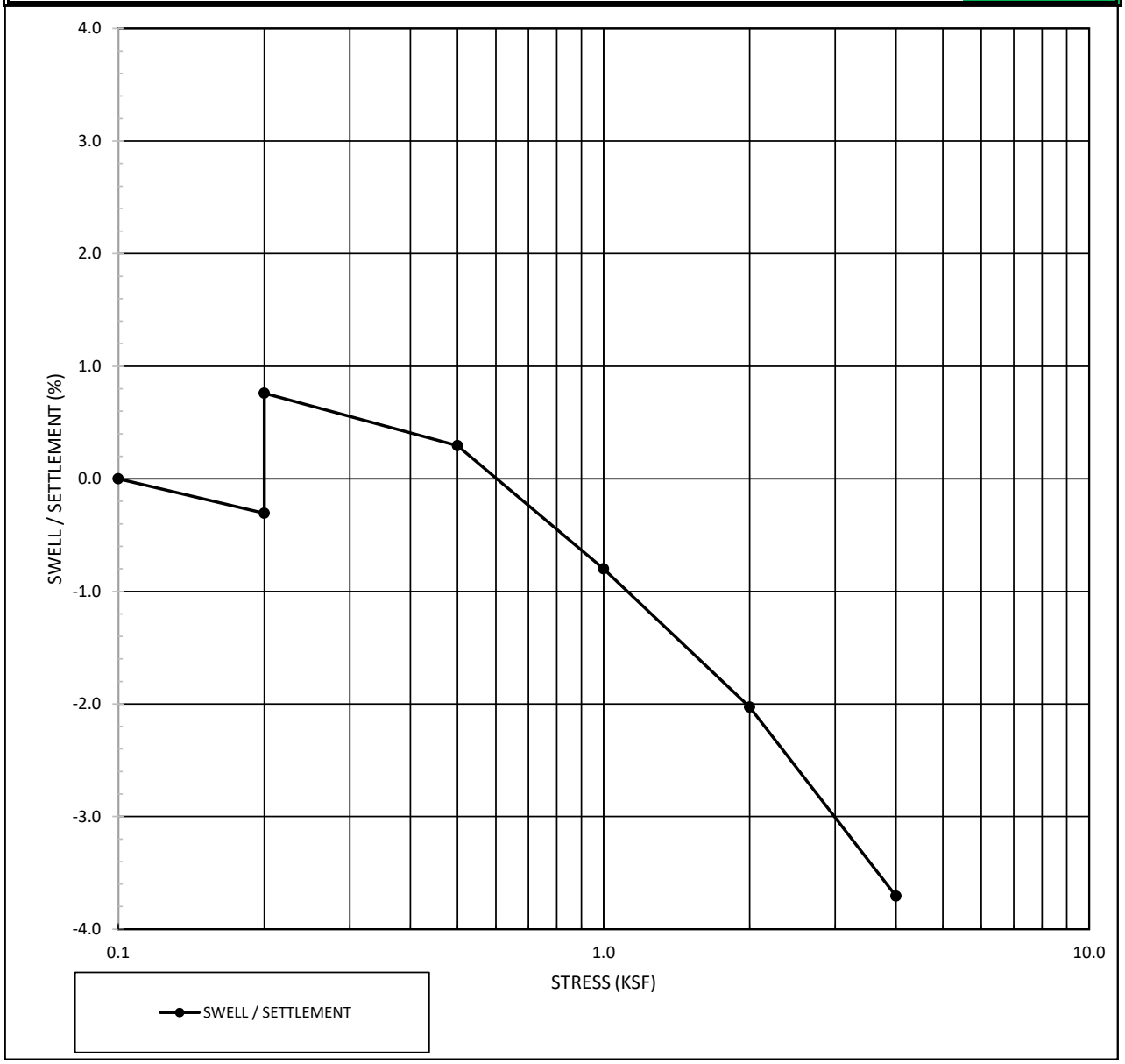


Initial Condition	
Moisture Content %	**13.4**
Dry Density (pcf)	**86.2**
Post-Swell Condition	
Moisture Content %	**26.5**

FIG. B-3

Project Name:	NPS Banddelier NM	**Date**	12/21/2023
Project No.:	D23-1-408		
Boring ID.:	SW-26	**Sample Depth (ft)**	2
Sample Description:	Silty CLAY, brown, slightly moist		

	%
Swell @ Wetting Weight:	**1.1**

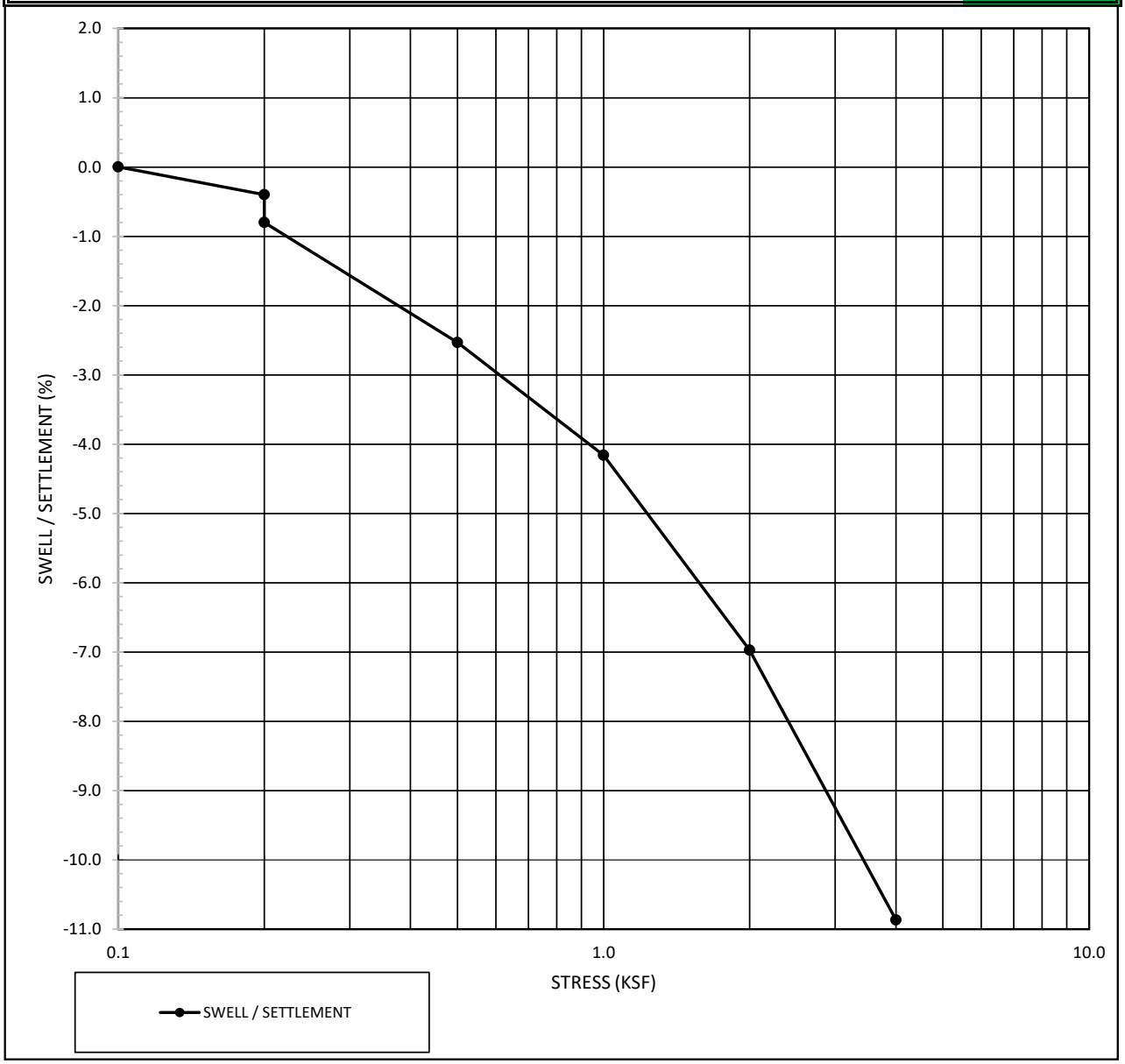


Initial Condition	
Moisture Content %	**8.9**
Dry Density (pcf)	**103.3**
Post-Swell Condition	
Moisture Content %	**20.6**

FIG. B-4

Project Name:	NPS Banddelier NM	**Date**	12/21/2023
Project No.:	D23-1-408		
Boring ID.:	SW-33	**Sample Depth (ft)**	2.5
Sample Description:	Clayey SAND, brown, moist		

	%
Compression @ Wetting Weight:	**-0.4**



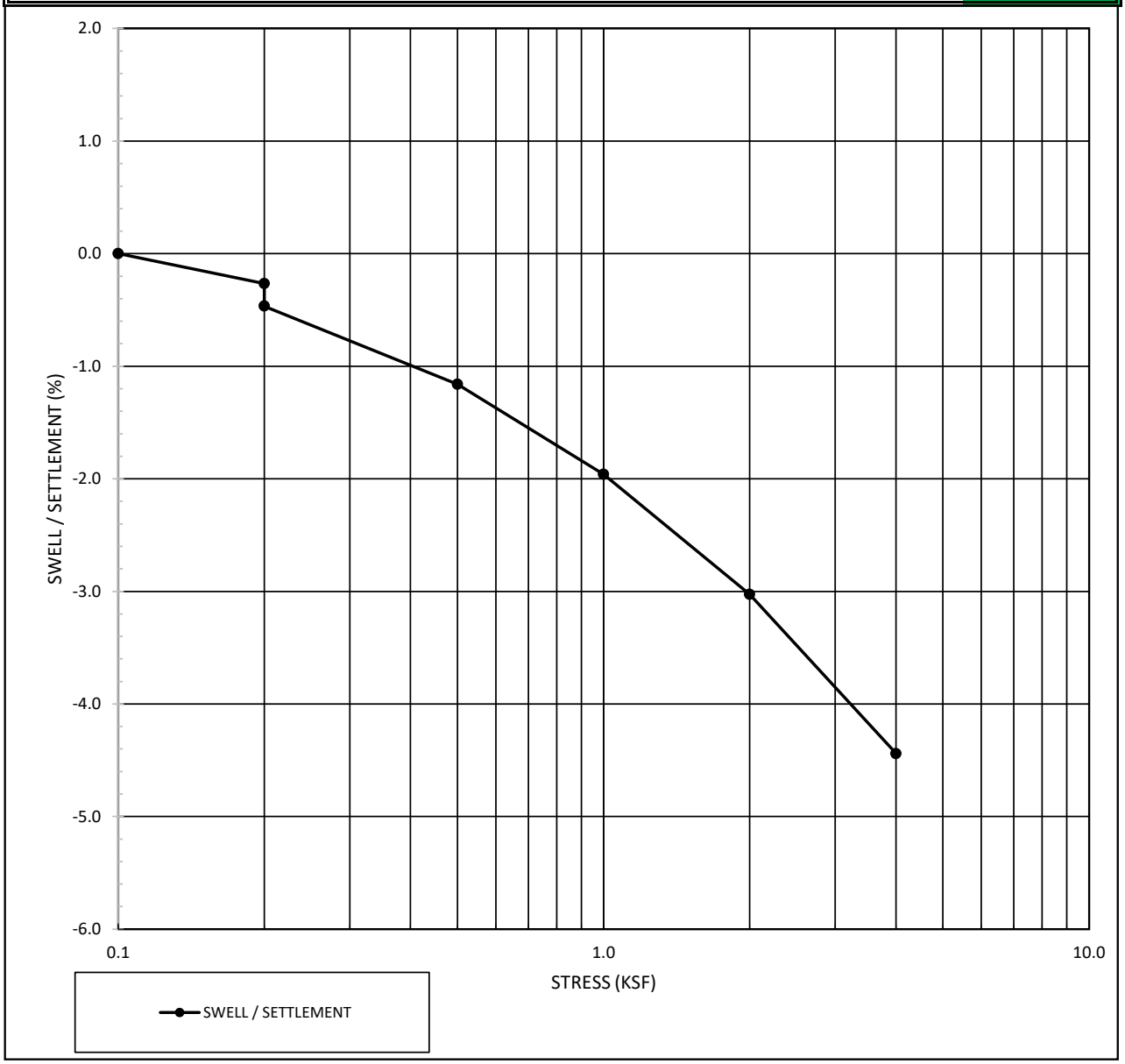
Initial Condition	
Moisture Content %	**7.6**
Dry Density (pcf)	**92.8**
Post-Swell Condition	
Moisture Content %	**23.1**

FIG. B-5

VIVID Engineering Group, Inc.

Project Name:	NPS Banddelier NM	**Date**	12/21/2023
Project No.:	D23-1-408		
Boring ID.:	SW-36	**Sample Depth (ft)**	2
Sample Description:	Poorly Graded Sand with Silt, light gray, slightly moist		

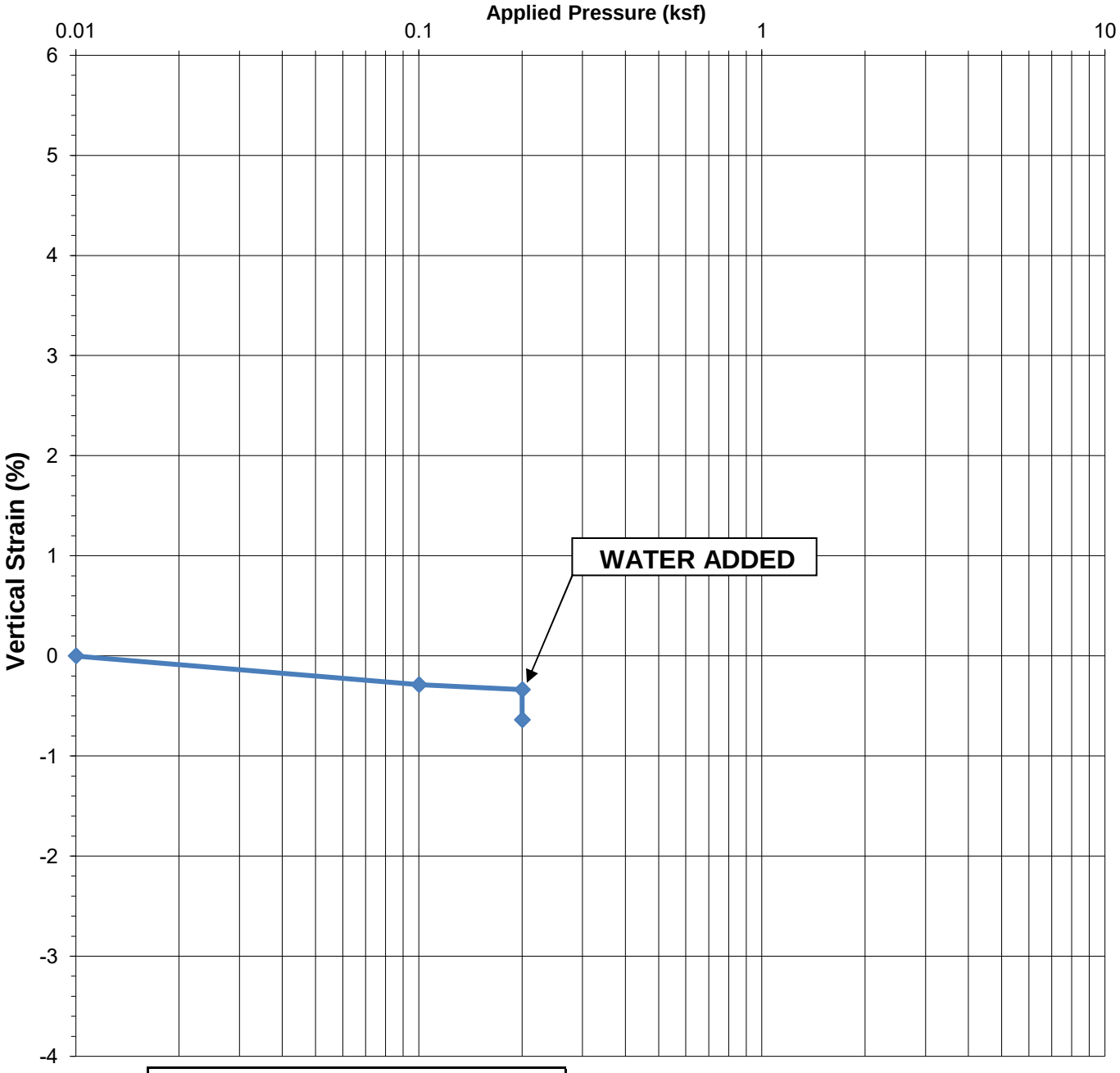
	%
Compression @ Wetting Weight:	**-0.2**



Initial Condition	
Moisture Content %	**9.0**
Dry Density (pcf)	**75.0**
Post-Swell Condition	
Moisture Content %	**39.2**

FIG. B-6

SWELL/COLLAPSE TEST REPORT
Boring SW-39 Sample S-1, 1 to 2 ft



Swell Pressure =	-	psf
Swell =	-0.3	%
Inundation Pressure =	200	psf
Initial Moisture Content =	11.4	%
Final Moisture Content =	46.2	%
Moist Unit Weight =	79.5	pcf

NOTES:

1. The swell pressure is the applied pressure required to compress the sample to its height immediately prior to inundation.
2. Testing was done in general accordance with Method B (an intact specimen obtained from a natural deposit) of ASTM D 4546, Standard Test Methods for One-Dimensional Swell or Collapse of Soils.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SWELL/COLLAPSE TEST REPORT
BORING SW-39, SAMPLE S-1

September 2024 107523-002

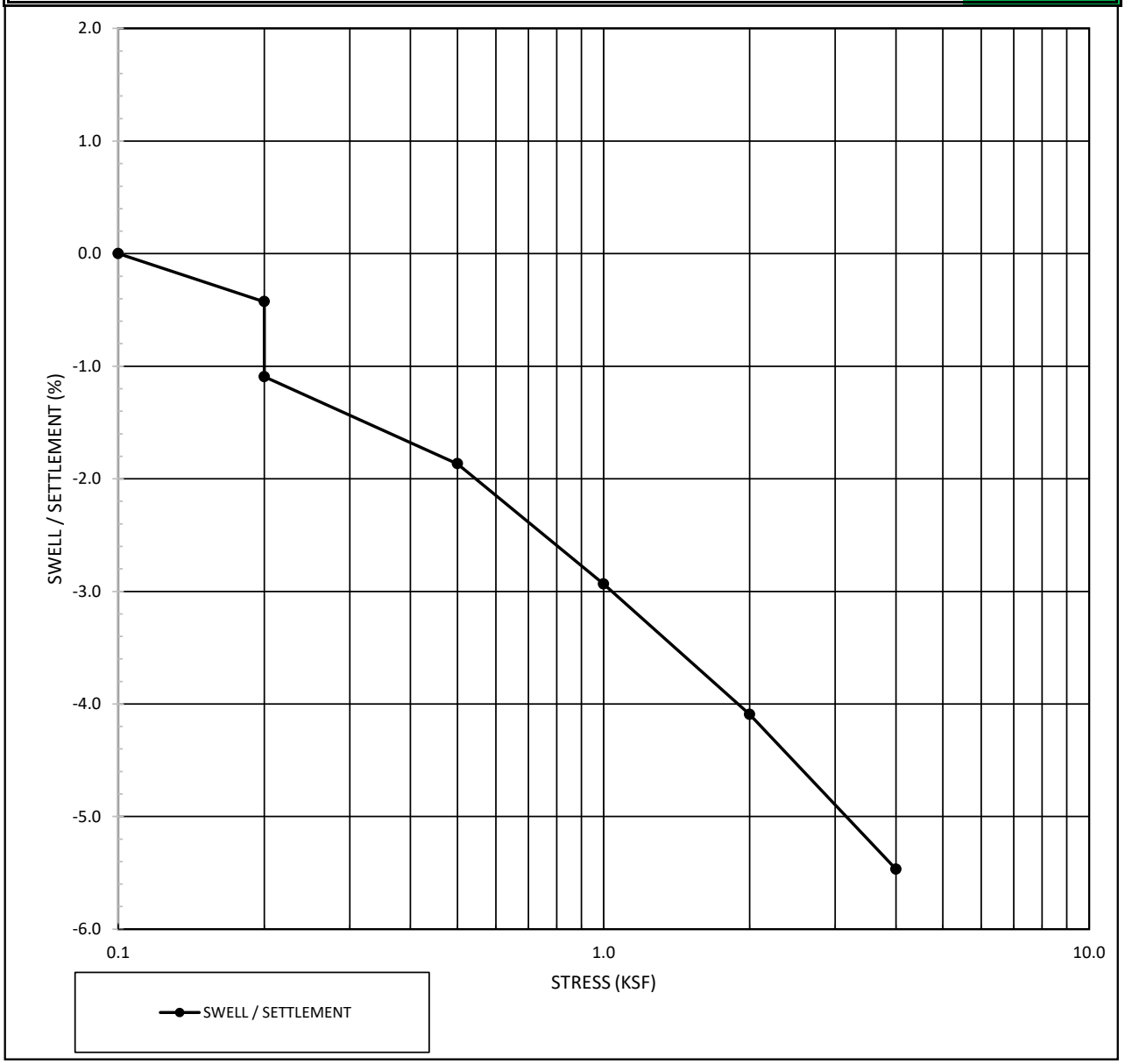
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-7

VIVID Engineering Group, Inc.

Project Name:	NPS Banddelier NM	**Date**	12/21/2023
Project No.:	D23-1-408		
Boring ID.:	SW-41	**Sample Depth (ft)**	4
Sample Description:	Sandy SILT, brown, moist		

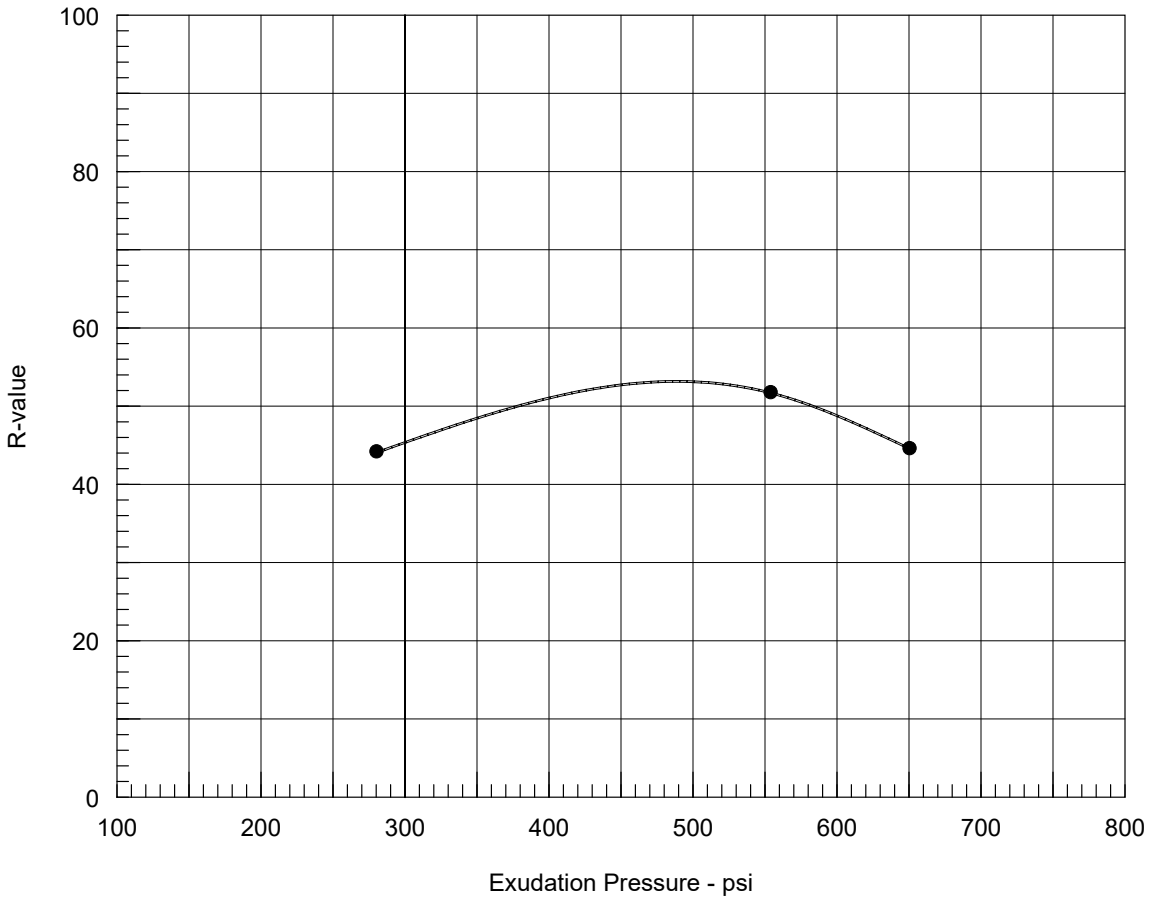
	%
Compression @ Wetting Weight:	**-0.7**



Initial Condition	
Moisture Content %	**8.0**
Dry Density (pcf)	**79.5**
Post-Swell Condition	
Moisture Content %	**34.3**

FIG. B-8

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - ASTM D2844

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	80	112.2	14.3	0.00	56	2.40	555	54.3	51.7
2	80	112.6	14.4	0.00	60	2.40	651	47.2	44.5
3	80	112.5	15.2	0.00	60	2.50	281	44.1	44.1

Test Results	Material Description
R-value at 300 psi exudation pressure = 45.4	SW-26 B-1 Bulk

Project No.: 24-5007 (10523-002)
Project: NPS Bandelier NM
Location: SW-26 B-1
Sample Number: S6997 **Depth:** 0' to 4'
Date: 2/27/2024

Tested by: Stacy Schulz
Checked by: Darrell Evig P.E.
Remarks:

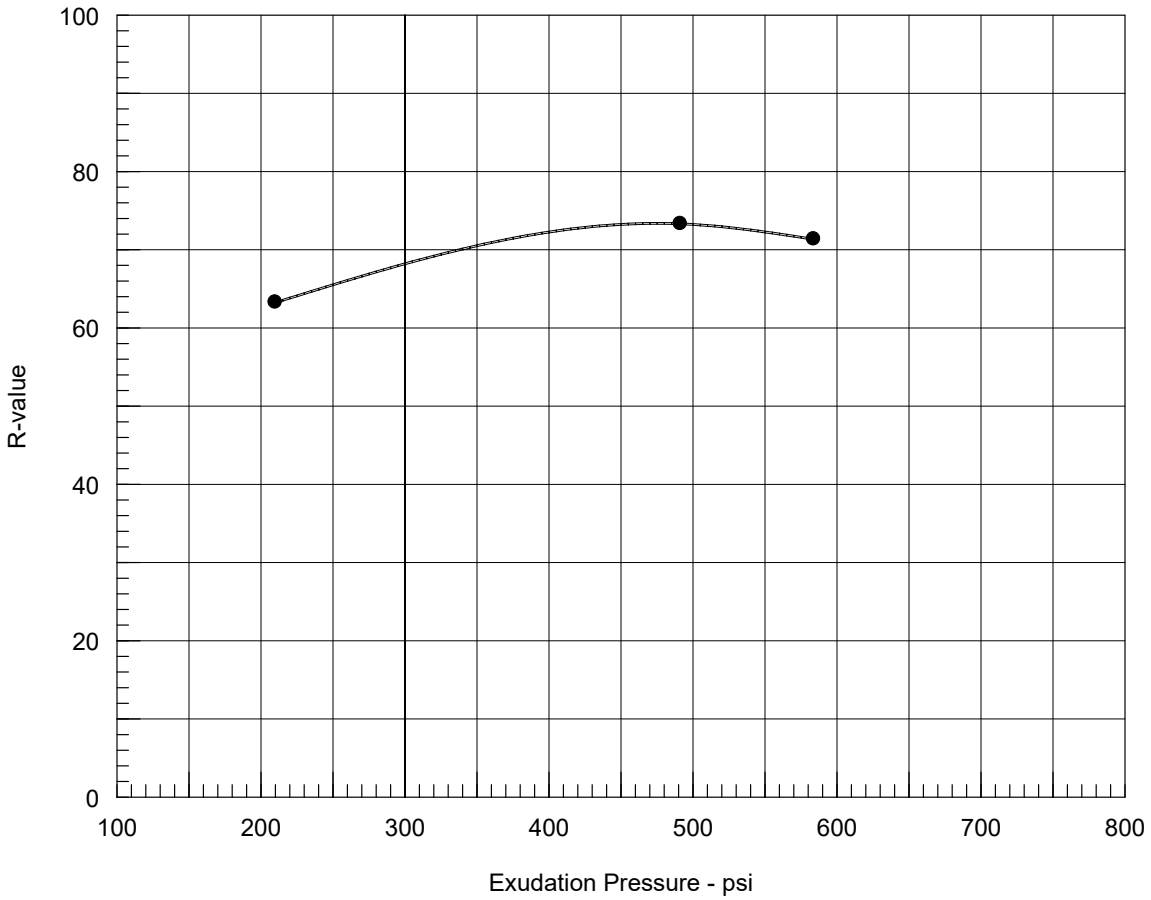
R-VALUE TEST REPORT

Vine Laboratories

Figure S6997

FIG. B-9

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - ASTM D2844

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	100	106.8	16.7	0.00	38	2.70	210	58.2	63.3
2	120	104.4	16.6	0.00	29	2.60	584	69.3	71.3
3	120	102.2	16.5	0.00	27	2.70	491	69.2	73.3

Test Results	Material Description
R-value at 300 psi exudation pressure = 68.2	SW-36 B-1 Bulk

Project No.: 24-5007 (10523-002)
Project: NPS Bandelier NM
Location: SW-36 B-1
Sample Number: S6998 **Depth:** 0' to 4'
Date: 2/27/2024

Tested by: Stacy Schulz
Checked by: Darrell Evig P.E.
Remarks:

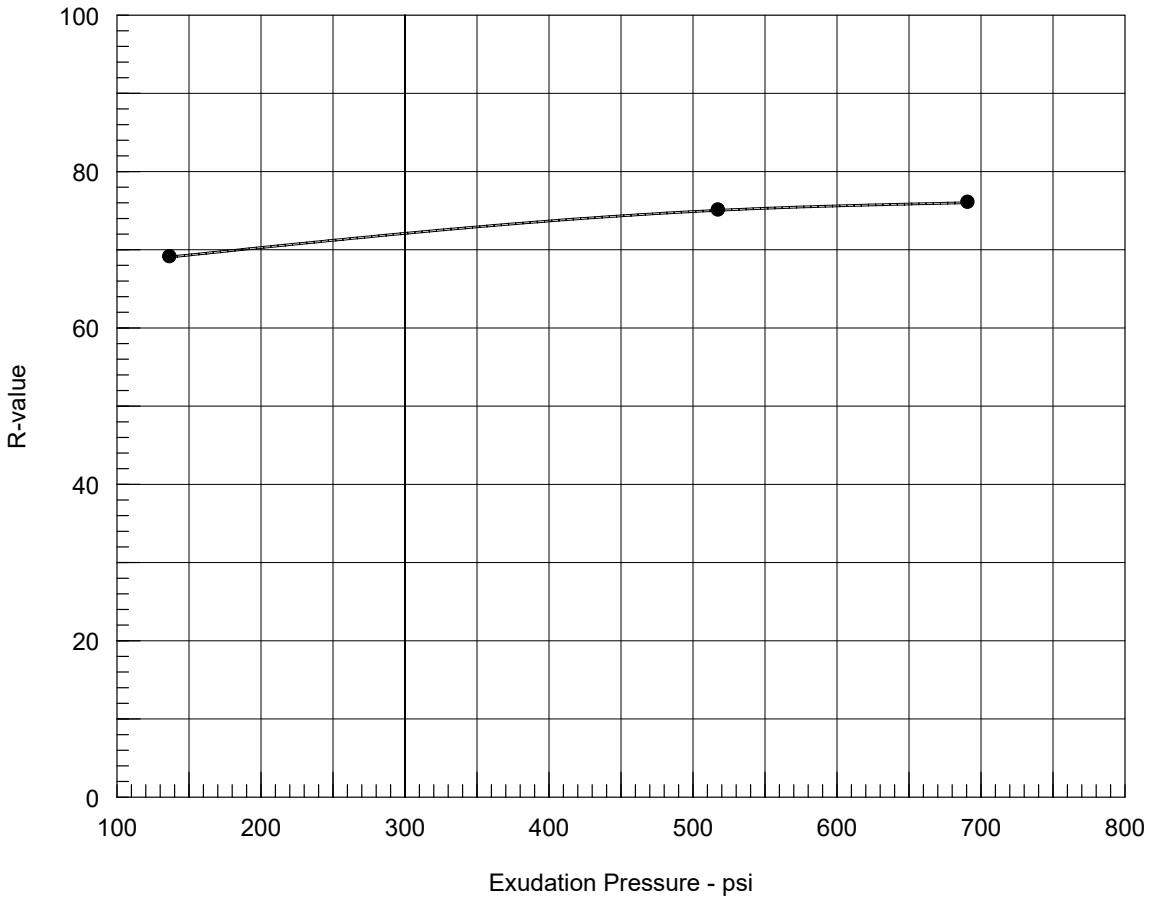
R-VALUE TEST REPORT

Vine Laboratories

Figure S6998

FIG. B-10

R-VALUE TEST REPORT



Resistance R-Value and Expansion Pressure - ASTM D2844

No.	Compact. Pressure psi	Density pcf	Moist. %	Expansion Pressure psi	Horizontal Press. psi @ 160 psi	Sample Height in.	Exud. Pressure psi	R Value	R Value Corr.
1	80	128.4	10.3	0.00	25	2.50	691	76.0	76.0
2	90	120.9	10.4	0.00	36	2.70	137	64.4	69.1
3	100	121.6	10.6	0.00	24	2.70	518	71.1	75.0

Test Results	Material Description
R-value at 300 psi exudation pressure = 72.1	SW-50 B-1 Bulk

Project No.: 24-5007 (10523-002)
Project: NPS Bandelier NM
Location: SW-50 B-1
Sample Number: S6999 **Depth:** 0' to 4'
Date: 2/27/2024

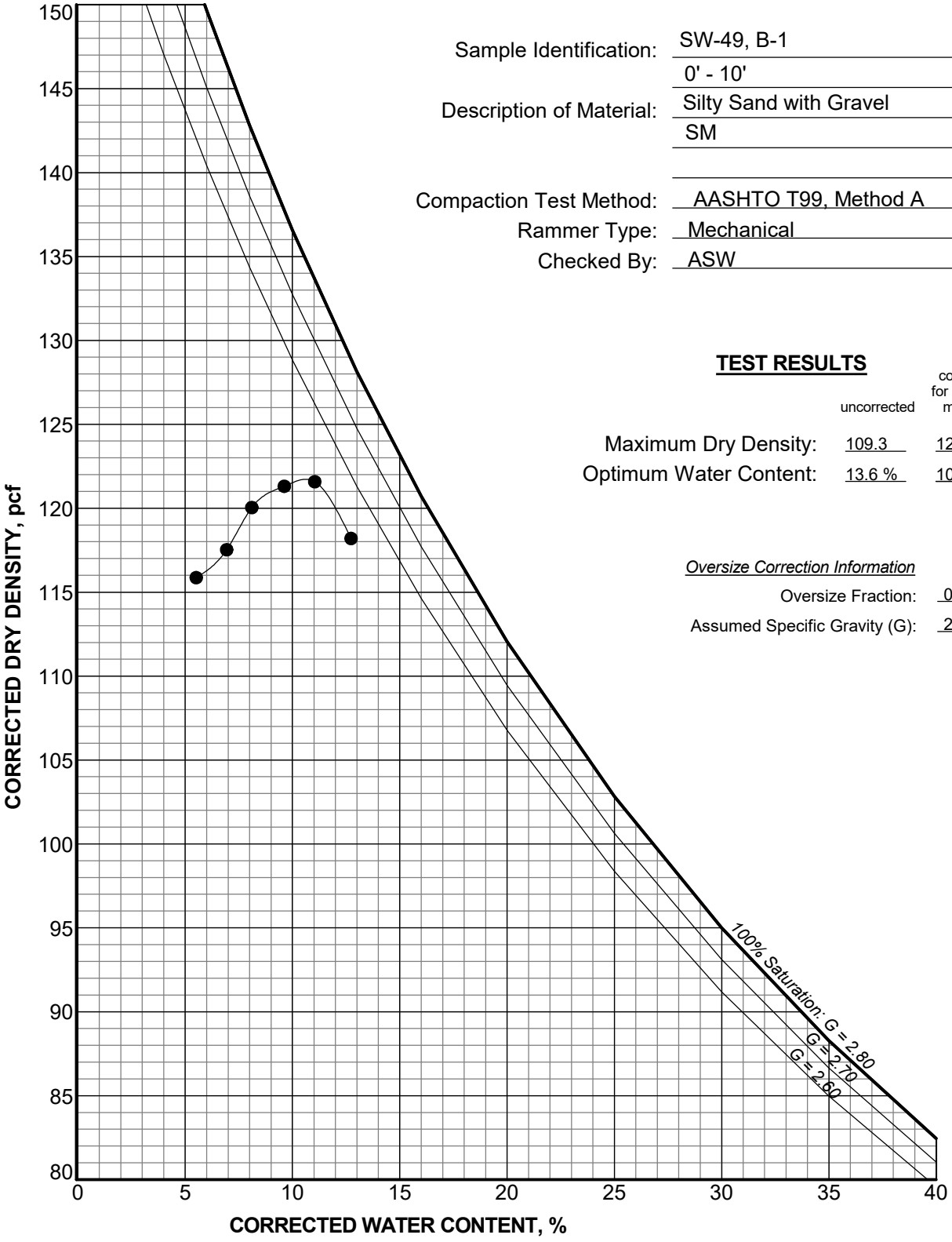
Tested by: Stacy Schulz
Checked by: Darrell Evig P.E.
Remarks:

R-VALUE TEST REPORT

Vine Laboratories

Figure S6999

FIG. B-11



Sample Identification: SW-49, B-1
0' - 10'

Description of Material: Silty Sand with Gravel
SM

Compaction Test Method: AASHTO T99, Method A
Rammer Type: Mechanical
Checked By: ASW

TEST RESULTS

	uncorrected	corrected for oversize material
Maximum Dry Density:	109.3	121.7
Optimum Water Content:	13.6 %	10.6 %

Oversize Correction Information

Oversize Fraction: 0.29
Assumed Specific Gravity (G): 2.7

OTHER TEST RESULTS

GRAIN SIZE ANALYSES:	% Gravel:	29.0
	% Sand:	52.0
	% Fines:	19.0
ATTERBERG LIMITS:	Liquid Limit:	NP
	Plastic Limit:	NP
	Plasticity Index:	NP

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

MOISTURE-DENSITY TEST

September 2024 107523-002

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. B-12

APPENDIX C: PREVIOUS GEOTECHNICAL LOGS AND LABORATORY DATA

Appendix C

Previous Geotechnical Logs and Laboratory Data

Attachments

Attachment D-1: Boring logs and asphalt core photos from Shannon & Wilson, 2022, Preliminary Geotechnical Report, NPS Bandelier National Monument Utility Rehabilitation, Los Alamos & Sandoval Counties, New Mexico, Project No. 107523.

Attachment D-2: Laboratory data from Shannon & Wilson, 2022, Preliminary Geotechnical Report, NPS Bandelier National Monument Utility Rehabilitation, Los Alamos & Sandoval Counties, New Mexico, Project No. 107523.

Shannon & Wilson, Inc. (S&W), uses a soil identification system modified from the Unified Soil Classification System (USCS). Elements of the USCS and other definitions are provided on this and the following pages. Soil descriptions are based on visual-manual procedures (ASTM D2488) and laboratory testing procedures (ASTM D2487), if performed.

S&W INORGANIC SOIL CONSTITUENT DEFINITIONS

CONSTITUENT[2]	FINE-GRAINED SOILS (50% or more fines)[1]	COARSE-GRAINED SOILS (less than 50% fines)[1]
Major	***Silt, Lean Clay, Elastic Silt,*** or ***Fat Clay***[3]	***Sand*** or ***Gravel***[4]
Modifying (Secondary) Precedes major constituent	30% or more coarse-grained: ***Sandy*** or ***Gravelly***[4]	More than 12% fine-grained: ***Silty*** or ***Clayey***[3]
Minor Follows major constituent	15% to 30% coarse-grained: ***with Sand*** or ***with Gravel***[4]	5% to 12% fine-grained: ***with Silt*** or ***with Clay***[3]
	30% or more total coarse-grained *and* lesser coarse-grained constituent is 15% or more: ***with Sand*** or ***with Gravel***[5]	15% or more of a second coarse-grained constituent: ***with Sand*** or ***with Gravel***[5]

[1]All percentages are by weight of total specimen passing a 3-inch sieve.
[2]The order of terms is: *Modifying Major with Minor*.
[3]Determined based on behavior.
[4]Determined based on which constituent comprises a larger percentage.
[5]Whichever is the lesser constituent.

MOISTURE CONTENT TERMS

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

STANDARD PENETRATION TEST (SPT) SPECIFICATIONS

Hammer:	140 pounds with a 30-inch free fall. Rope on 6- to 10-inch-diam. cathead 2-1/4 rope turns, > 100 rpm NOTE: If automatic hammers are used, blow counts shown on boring logs should be adjusted to account for efficiency of hammer.
Sampler:	10 to 30 inches long Shoe I.D. = 1.375 inches Barrel I.D. = 1.5 inches Barrel O.D. = 2 inches
N-Value:	Sum blow counts for second and third 6-inch increments. Refusal: 50 blows for 6 inches or less; 10 blows for 0 inches.

NOTE: Penetration resistances (N-values) shown on boring logs are as recorded in the field and have not been corrected for hammer efficiency, overburden, or other factors.

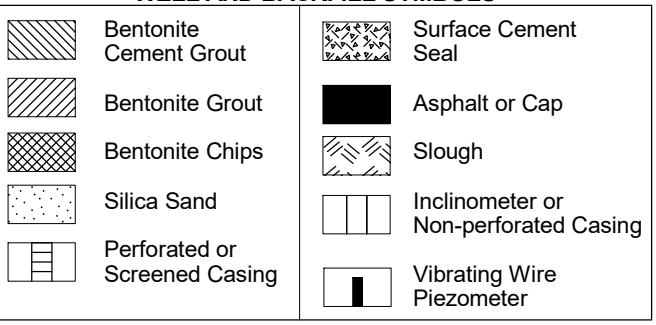
PARTICLE SIZE DEFINITIONS

DESCRIPTION	SIEVE NUMBER AND/OR APPROXIMATE SIZE
FINES	< #200 (0.075 mm = 0.003 in.)
SAND	
Fine	#200 to #40 (0.075 to 0.4 mm; 0.003 to 0.02 in.)
Medium	#40 to #10 (0.4 to 2 mm; 0.02 to 0.08 in.)
Coarse	#10 to #4 (2 to 4.75 mm; 0.08 to 0.187 in.)
GRAVEL	
Fine	#4 to 3/4 in. (4.75 to 19 mm; 0.187 to 0.75 in.)
Coarse	3/4 to 3 in. (19 to 76 mm)
COBBLES	3 to 12 in. (76 to 305 mm)
BOULDERS	> 12 in. (305 mm)

RELATIVE DENSITY / CONSISTENCY

COHESIONLESS SOILS		COHESIVE SOILS	
N, SPT, BLOWS/FT.	RELATIVE DENSITY	N, SPT, BLOWS/FT.	RELATIVE CONSISTENCY
< 4	Very loose	< 2	Very soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium dense	4 - 8	Medium stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very dense	15 - 30	Very stiff
		> 30	Hard

WELL AND BACKFILL SYMBOLS



PERCENTAGES TERMS [1, 2]

Trace	< 5%
Few	5 to 10%
Little	15 to 25%
Some	30 to 45%
Mostly	50 to 100%

[1]Gravel, sand, and fines estimated by mass. Other constituents, such as organics, cobbles, and boulders, estimated by volume.

[2]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

SOIL CLASSIFICATION AND LOG KEY

February 2022 107523-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-1
Sheet 1 of 3

2013 BORING CLASS1 107523-001 BANDELIER NM.GPJ SWNEW.GDT 1/4/22

UNIFIED SOIL CLASSIFICATION SYSTEM (USCS)
(Modified From USACE Tech Memo 3-357, ASTM D2487, and ASTM D2488)

MAJOR DIVISIONS			GROUP/GRAPHIC SYMBOL		TYPICAL IDENTIFICATIONS
COARSE-GRAINED SOILS *(more than 50% retained on No. 200 sieve)*	Gravels *(more than 50% of coarse fraction retained on No. 4 sieve)*	Gravel *(less than 5% fines)*	GW		Well-Graded Gravel; Well-Graded Gravel with Sand
			GP		Poorly Graded Gravel; Poorly Graded Gravel with Sand
		Silty or Clayey Gravel *(more than 12% fines)*	GM		Silty Gravel; Silty Gravel with Sand
			GC		Clayey Gravel; Clayey Gravel with Sand
	Sands *(50% or more of coarse fraction passes the No. 4 sieve)*	Sand *(less than 5% fines)*	SW		Well-Graded Sand; Well-Graded Sand with Gravel
			SP		Poorly Graded Sand; Poorly Graded Sand with Gravel
		Silty or Clayey Sand *(more than 12% fines)*	SM		Silty Sand; Silty Sand with Gravel
			SC		Clayey Sand; Clayey Sand with Gravel
FINE-GRAINED SOILS *(50% or more passes the No. 200 sieve)*	Silts and Clays *(liquid limit less than 50)*	Inorganic	ML		Silt; Silt with Sand or Gravel; Sandy or Gravelly Silt
			CL		Lean Clay; Lean Clay with Sand or Gravel; Sandy or Gravelly Lean Clay
		Organic	OL		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
	Silts and Clays *(liquid limit 50 or more)*	Inorganic	MH		Elastic Silt; Elastic Silt with Sand or Gravel; Sandy or Gravelly Elastic Silt
			CH		Fat Clay; Fat Clay with Sand or Gravel; Sandy or Gravelly Fat Clay
		Organic	OH		Organic Silt or Clay; Organic Silt or Clay with Sand or Gravel; Sandy or Gravelly Organic Silt or Clay
HIGHLY-ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT		Peat or other highly organic soils (see ASTM D4427)

NOTE: No. 4 size = 4.75 mm = 0.187 in.; No. 200 size = 0.075 mm = 0.003 in.

NOTES

1. Dual symbols *(symbols separated by a hyphen, i.e., SP-SM, Sand with Silt)* are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart. Graphics shown on the logs for these soil types are a combination of the two graphic symbols (e.g., SP and SM).

2. Borderline symbols *(symbols separated by a slash, i.e., CL/ML, Lean Clay to Silt; SP-SM/SM, Sand with Silt to Silty Sand)* indicate that the soil properties are close to the defining boundary between two groups.

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SOIL CLASSIFICATION AND LOG KEY

February 2022 107523-001

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FIG. A-1
Sheet 2 of 3

2013_BORING_CLASS2_107523-001_BANDELIER NM.GPJ_SWNEW.GDT 1/4/22

GRADATION TERMS

Poorly Graded	Narrow range of grain sizes present or, within the range of grain sizes present, one or more sizes are missing (Gap Graded). Meets criteria in ASTM D2487, if tested.
Well-Graded	Full range and even distribution of grain sizes present. Meets criteria in ASTM D2487, if tested.

CEMENTATION TERMS[1]

Weak	Crumbles or breaks with handling or slight finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

PLASTICITY[2]

DESCRIPTION	VISUAL-MANUAL CRITERIA	APPROX. PLASITICTY INDEX RANGE
Nonplastic	A 1/8-in. thread cannot be rolled at any water content.	< 4
Low	A thread can barely be rolled and a lump cannot be formed when drier than the plastic limit.	4 to 10
Medium	A thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. A lump crumbles when drier than the plastic limit.	10 to 20
High	It take considerable time rolling and kneading to reach the plastic limit. A thread can be rerolled several times after reaching the plastic limit. A lump can be formed without crumbling when drier than the plastic limit.	> 20

ADDITIONAL TERMS

Mottled	Irregular patches of different colors.
Bioturbated	Soil disturbance or mixing by plants or animals.
Diamict	Nonsorted sediment; sand and gravel in silt and/or clay matrix.
Cuttings	Material brought to surface by drilling.
Slough	Material that caved from sides of borehole.
Sheared	Disturbed texture, mix of strengths.

PARTICLE ANGULARITY AND SHAPE TERMS[1]

Angular	Sharp edges and unpolished planar surfaces.
Subangular	Similar to angular, but with rounded edges.
Subrounded	Nearly planar sides with well-rounded edges.
Rounded	Smoothly curved sides with no edges.
Flat	Width/thickness ratio > 3.
Elongated	Length/width ratio > 3.

ACRONYMS AND ABBREVIATIONS

ATD	At Time of Drilling
Diam.	Diameter
Elev.	Elevation
ft.	Feet
FeO	Iron Oxide
gal.	Gallons
Horiz.	Horizontal
HSA	Hollow Stem Auger
I.D.	Inside Diameter
in.	Inches
lbs.	Pounds
MgO	Magnesium Oxide
mm	Millimeter
MnO	Manganese Oxide
NA	Not Applicable or Not Available
NP	Nonplastic
O.D.	Outside Diameter
OW	Observation Well
pcf	Pounds per Cubic Foot
PID	Photo-Ionization Detector
PMT	Pressuremeter Test
ppm	Parts per Million
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
rpm	Rotations per Minute
SPT	Standard Penetration Test
USCS	Unified Soil Classification System
q_u	Unconfined Compressive Strength
VWP	Vibrating Wire Piezometer
Vert.	Vertical
WOH	Weight of Hammer
WOR	Weight of Rods
Wt.	Weight

STRUCTURE TERMS[1]

Interbedded	Alternating layers of varying material or color with layers at least 1/4-inch thick; singular: bed.
Laminated	Alternating layers of varying material or color with layers less than 1/4-inch thick; singular: lamination.
Fissured	Breaks along definite planes or fractures with little resistance.
Slickensided	Fracture planes appear polished or glossy; sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps that resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay.
Homogeneous	Same color and appearance throughout.

[1]Reprinted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.
[2]Adapted, with permission, from ASTM D2488 - 09a Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International, www.astm.org.

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Los Alamos & Sandoval Counties, New Mexico

SOIL CLASSIFICATION AND LOG KEY

February 2022 107523-001

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FIG. A-1
Sheet 3 of 3

2013 BORING CLASS3 107523-001 BANDELIER NM.GPJ SWNEW.GDT 1/4/22

WEATHERING

TERM	DESCRIPTION
Fresh	No visible sign of rock material weathering
Slightly Weathered	Slight discoloration on surface
Moderately Weathered	Discoloring evident; Less than half of the rock material is decomposed
Highly Weathered	Entire rock mass discolored; More than half of the rock material is decomposed
Completely Weathered	Rock reduced to a soil with relict rock texture
Residual Soil	All rock material is converted to soil

STRENGTH

GRADE	DESCRIPTION	APPROX. UCS (psi)
R0	Extremely Weak Rock	36 to 145
R1	Very Weak Rock	145 to 700
R2	Weak Rock	700 to 3,600
R3	Medium Strong Rock	3,600 to 7,200
R4	Strong Rock	7,200 to 14,500
R5	Very Strong Rock	14,500 to 36,250
R6	Extremely Strong Rock	>36,250

JOINT ROUGHNESS COEFFICIENT (JRC)

COEFFICIENT	DESCRIPTION
14 to 20	VERY ROUGH: Near vertical edges evident
10 to 14	ROUGH: Smooth ridges, surface abrasion
6 to 10	SLIGHTLY ROUGH: Asperities on surface can be felt
2 to 6	SMOOTH: Appears and feels smooth
0 to 2	SLICKENSIDED: Visible polishing, striated surface

DISCONTINUITY DATA

SPACING	
DESCRIPTION	SPACING
Extremely Close	< 1 in
Very Close	1 to 2.5 in
Close	2.5 to 8 in
Moderate	8 to 24 in
Wide	24 in to 6 ft
Very Wide	6 to 20 ft
Extremely Wide	> 20 ft

DISCONTINUITY TERMS

FRACTURE - Collective term for any natural break excluding shears, shear zones, and faults

JOINT (JT) - Planar break with little or no displacement

FOLIATION JOINT (FJ) or BEDDING JOINT (BJ) - Joint along foliation or bedding

INCIPIENT JOINT (IJ) or INCIPIENT FRACTURE (IF) - Joint or fracture not evident until wetted and dried; breaks along existing surface

RANDOM FRACTURE (RF) - Natural, very irregular fracture that does not belong to a set

BEDDING PLANE SEPARATION or PARTING - A separation along bedding after extraction from stress relief or slaking

FRACTURE ZONE (FZ) - Planar zone of broken rock without gouge

MECHANICAL BREAK (MB) - Breaks due to drilling or handling; drilling break (DB), hammer break (HB)

SHEAR (SH) - Surface of differential movement evident by presence of slickensides, striations, or polishing

SHEAR ZONE (SZ) - Zone of gouge and rock fragments bounded by planar shear surfaces

FAULT (FT) - Shear zone of significant extent; differentiation from shear zone may be site-specific

APERTURE WIDTH	
TERM	SPACING
Very Tight	<0.1mm
Tight	0.1 to 0.25mm
Partly Open	0.25 to 0.5mm
Open	0.5 to 2.5mm
Moderately Wide	2.5 to 10mm
Wide	10mm to 1cm
Very Wide	1 to 10cm
Extremely Wide	10 to 100cm
Cavernous	>1m

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ROCK CLASSIFICATION AND LOG KEY

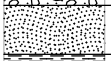
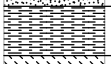
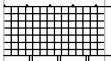
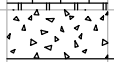
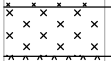
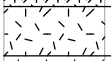
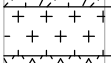
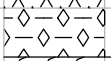
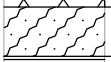
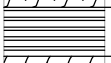
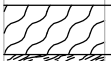
February 2022 107523-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 1 of 2

ROCK CLASS KEY - P1 (NEW STRENGTHS) 107523-001 BANDELIER NM.GPJ SHAN_WIL.GDT 1/4/22

ROCK CLASSIFICATION SYMBOLS

BEDROCK TYPE	GRAPHIC SYMBOL	ROCK NAME
Clastic Sedimentary Rocks		Breccia
		Conglomerate
		Sandstone
		Siltstone
		Claystone
		Shale
		Coal
Carbonate Sedimentary Rocks		Limestone
		Dolomite
		Coral
Evaporite Rocks		Gypsum
		Halite
		Calcite
Extrusive Igneous Rocks		Tuff
		Rhyolite
		Dacite
		Andesite
		Basalt
Intrusive Igneous Rocks		Granite
		Grano-diorite
		Diorite
		Gabbro
Metamorphic Rocks		Marble
		Quartzite
		Slate
		Phyllite
		Schist
		Gneiss

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ROCK CLASSIFICATION AND LOG KEY

February 2022 107523-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-2
Sheet 2 of 2

ROCK CLASS KEY - P2 107523-001 BANDELIER NM.GPJ SHAN_WIL.GDT 1/4/22

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.7938°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6674 ft.*	Longitude:	*~ -106.27847°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Hard, brown, *Sandy Lean Clay (CL);* moist.

5.5

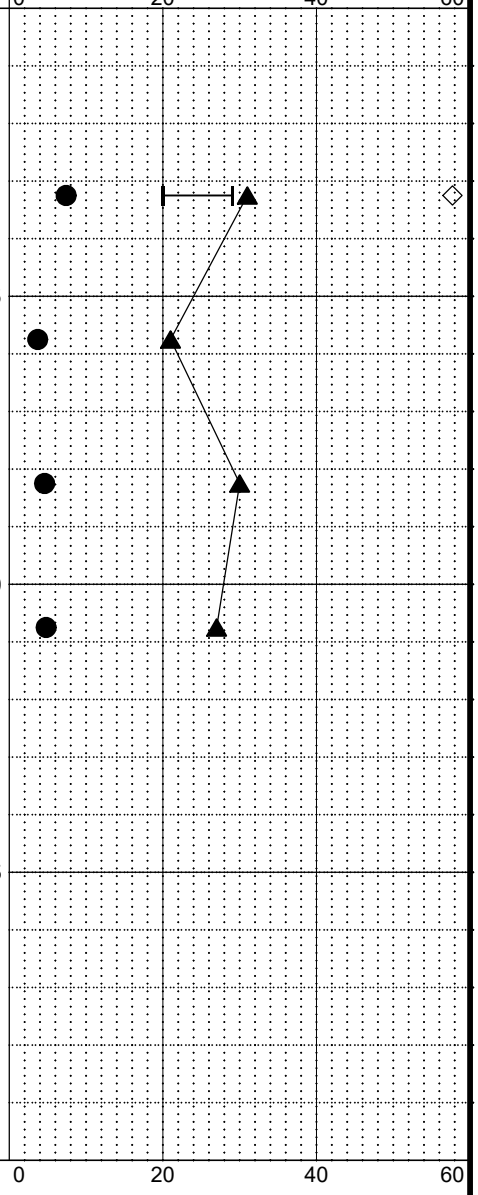
Medium dense to dense, reddish gray, *Silty Sand (SM);* moist.
[RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds).]

11.5

BOTTOM OF BORING
COMPLETED ON 12/13/2021

Depth, ft. | Symbol | Samples (S-1, S-2, S-3, S-4) | Ground Water Depth, ft. (Water Not Encountered During Drilling)

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND
* Sample Not Recovered
⊥ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

LOG OF BORING SW-01

February 2022 | 107523-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-3

MASTER LOG E_POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.79557°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6665 ft.*	Longitude:	*~ -106.28039°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense to medium dense, brown, *Silty Sand (SM);* moist; trace gravel.

6.0

Medium dense to dense, gray, *Silty Sand (SM);* moist.
[RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds).]

11.5

BOTTOM OF BORING
COMPLETED ON 12/13/2021

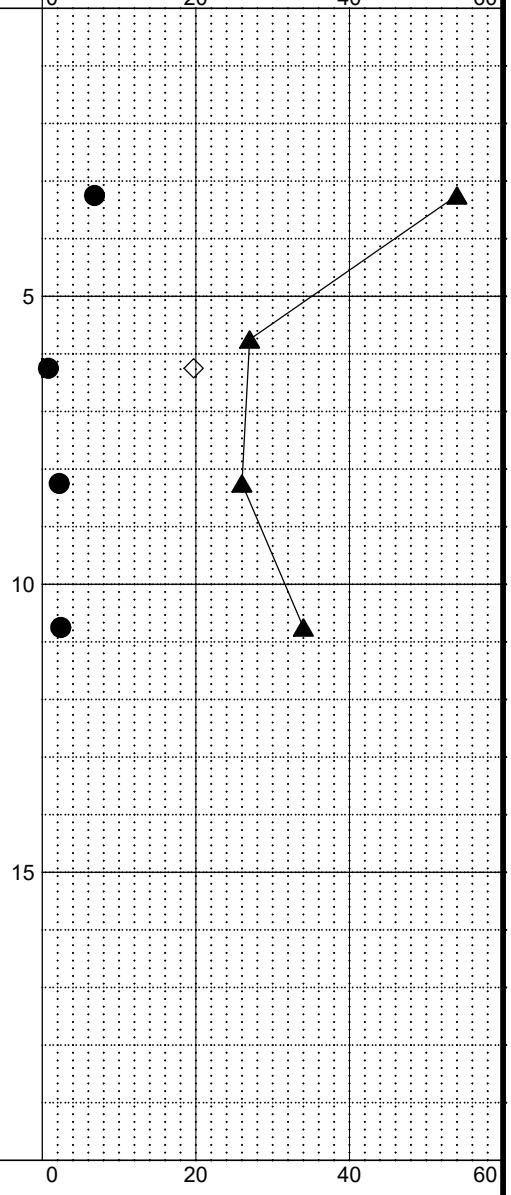
Depth, ft. | Symbol | Samples | Ground Water Depth, ft.

Samples: S-1, S-2, S-3, S-4

Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

LOG OF BORING SW-02

February 2022 | 107523-001

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FIG. A-4

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.79648°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6671 ft.*	Longitude:	*~ -106.28279°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Silty Sand (SM);* moist; trace gravel.

2.0

RHYOLITE: very weak, brown; moderately cemented; highly to moderately weathered (El Cajete pyroclastic beds).
[Very dense, *Silty Sand (SM);* moist.]

10.4

BOTTOM OF BORING
COMPLETED ON 12/13/2021

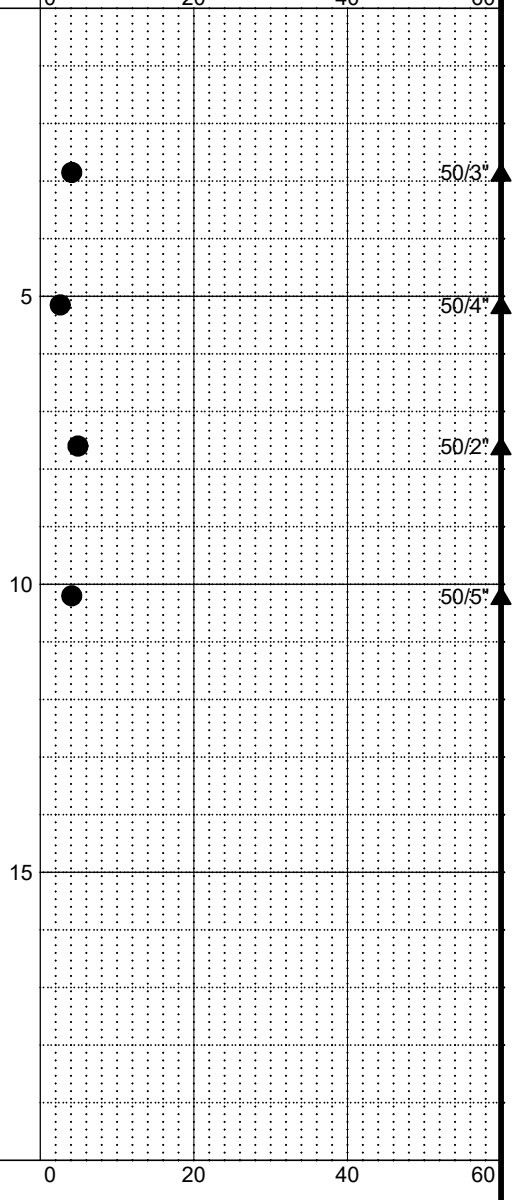
Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

Samples: S-1, S-2, S-3, S-4

Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-03

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FIG. A-5

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*31.5 ft.*	Latitude:	*~ 35.79859°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6652 ft.*	Longitude:	*~ -106.27928°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:	*HSA to NQ2 Core @ 20 feet*		

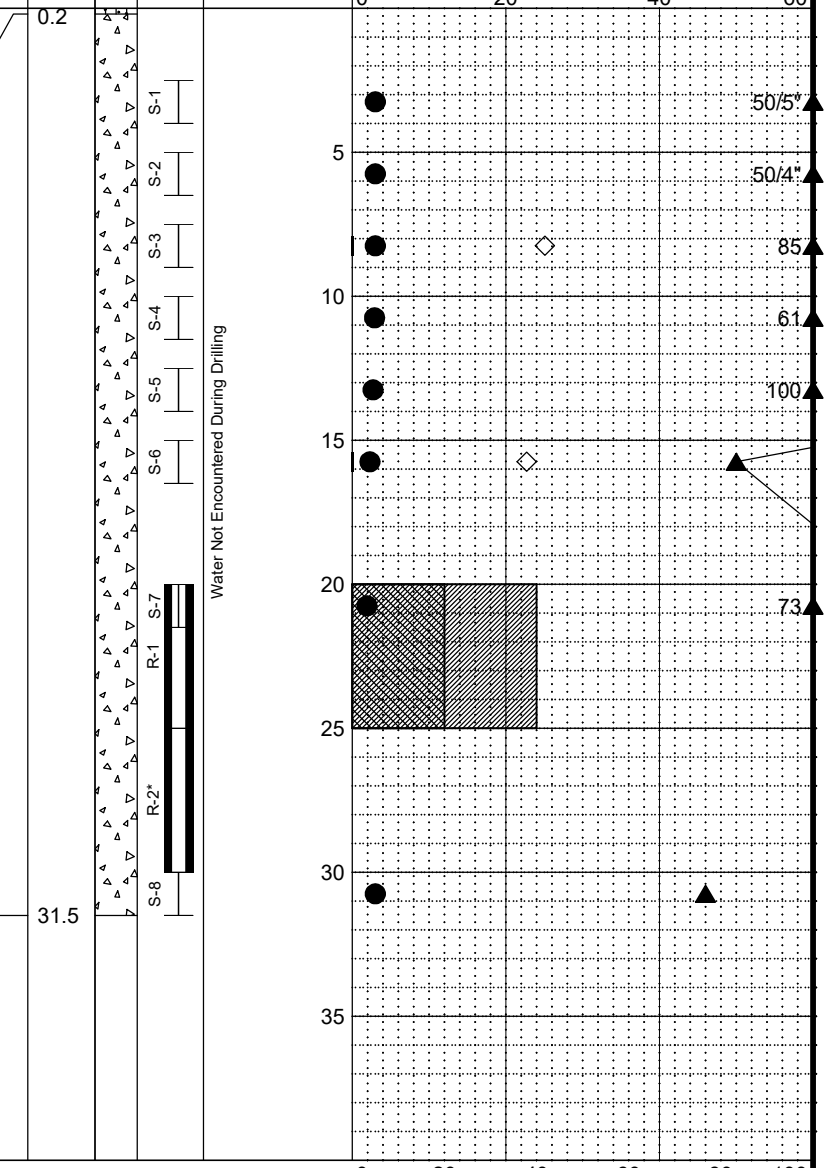
SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Silty Sand (SM);* moist.

TUFF: very weak, pinkish gray; moderately to completely weathered (Upper Bandelier Tuff). [Dense to very dense, *Silty Sand (SM);* moist; few gravel.]

BOTTOM OF BORING
COMPLETED ON 12/15/2021



LEGEND

* Sample Not Recovered
Standard Penetration Test
Rock Core

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-04

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FIG. A-6

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.78708°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6588 ft.*	Longitude:	*~ -106.27061°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

	Depth, ft.
4 inches of asphalt pavement.	0.3
6 inches of aggregate base course.	0.8
Brown, *Silty Sand (SM);* moist. Fill	1.5
Medium dense to dense, gray to pinkish gray, *Silty Sand (SM);* moist; trace gravel. [RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds).]	
BOTTOM OF BORING COMPLETED ON 12/14/2021	11.5

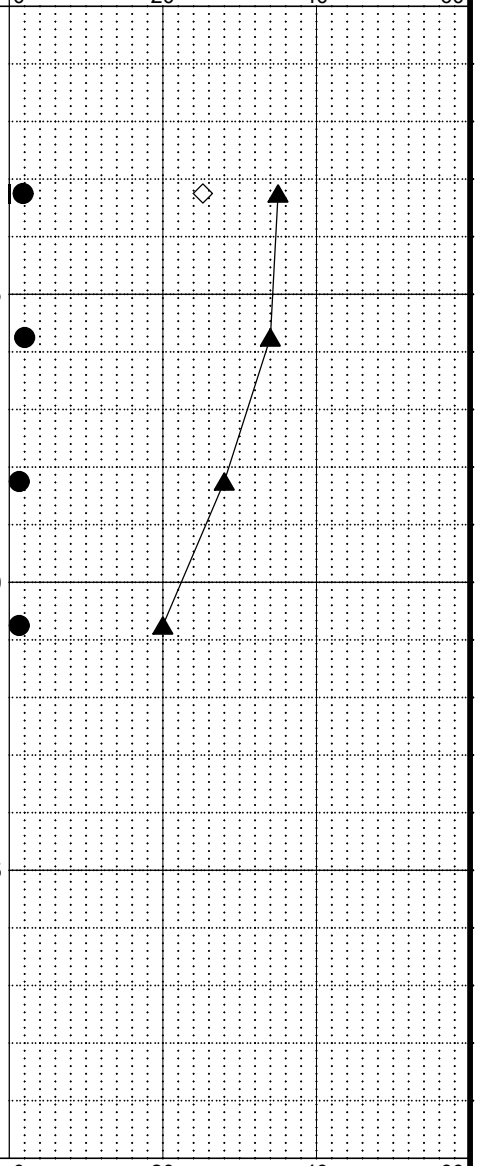
Symbol

Samples: S-1, S-2, S-3, S-4

Ground Water Depth, ft.: Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-05

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FIG. A-7

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.7821°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6541 ft.*	Longitude:	*~ -106.26735°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Silty Sand (SM);* moist; few gravel.

0.5

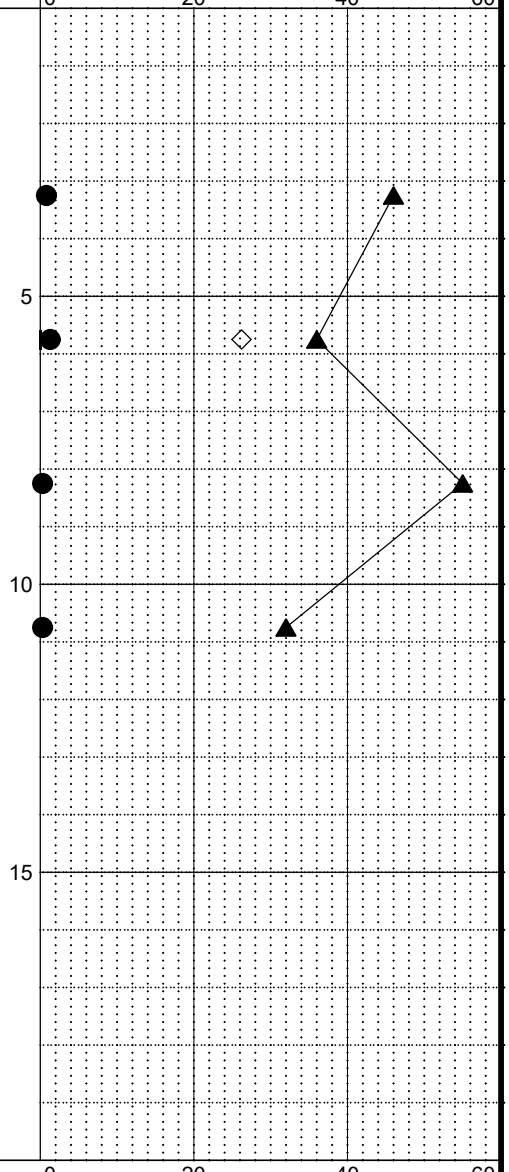
Dense to very dense, gray, *Silty Sand (SM) with Gravel;* moist.
[RHYOLITE: extremely weak; completely weathered (El Cajete pyroclastic beds).]

11.5

BOTTOM OF BORING
COMPLETED ON 12/13/2021

Depth, ft. | Symbol | Samples (S-1, S-2, S-3, S-4) | Ground Water Depth, ft. (Water Not Encountered During Drilling)

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND
* Sample Not Recovered
⊥ Standard Penetration Test

NOTES
1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-06

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FIG. A-8

MASTER LOG E_POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.78076°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6528 ft.*	Longitude:	*~ -106.26592°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Medium dense to dense, gray, *Silty Sand (SM);* moist; trace gravel.
[TUFF: extremely weak; completely weathered (Upper Bandelier Tuff).]

BOTTOM OF BORING
COMPLETED ON 12/13/2021

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

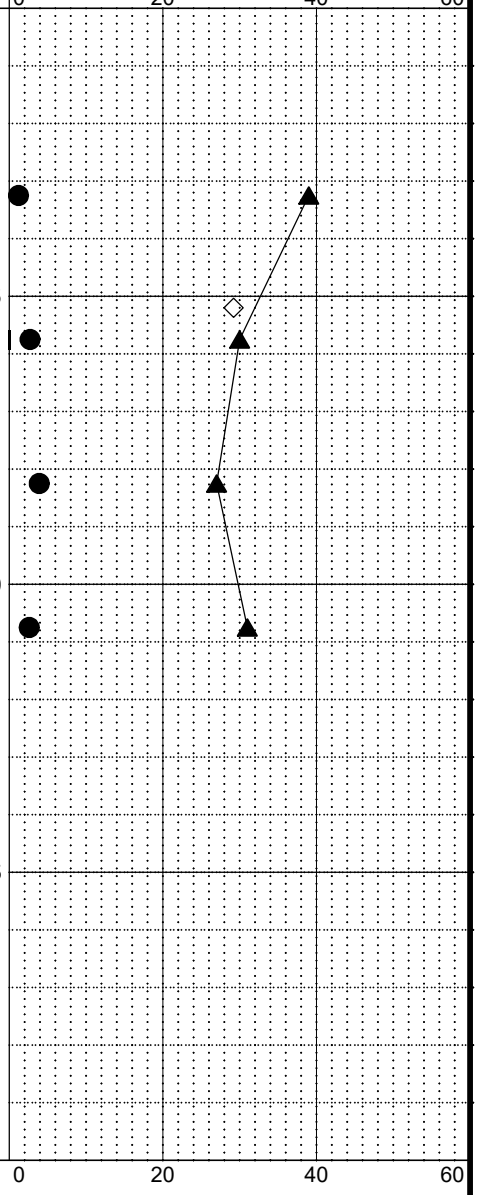
11.5

S-1 | S-2 | S-3 | S-4

Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⊥ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-07

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FIG. A-9

MASTER LOG E_POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.77536°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6469 ft.*	Longitude:	*~ -106.26164°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft.	Soil Description
0.4	5 inches of asphalt pavement.
0.9	6 inches of aggregate base course.
	Dense, gray to pinkish gray, *Silty Sand (SM);* moist; trace gravel. [TUFF: extremely weak; completely weathered (Upper Bandelier Tuff).]
11.5	BOTTOM OF BORING COMPLETED ON 12/14/2021

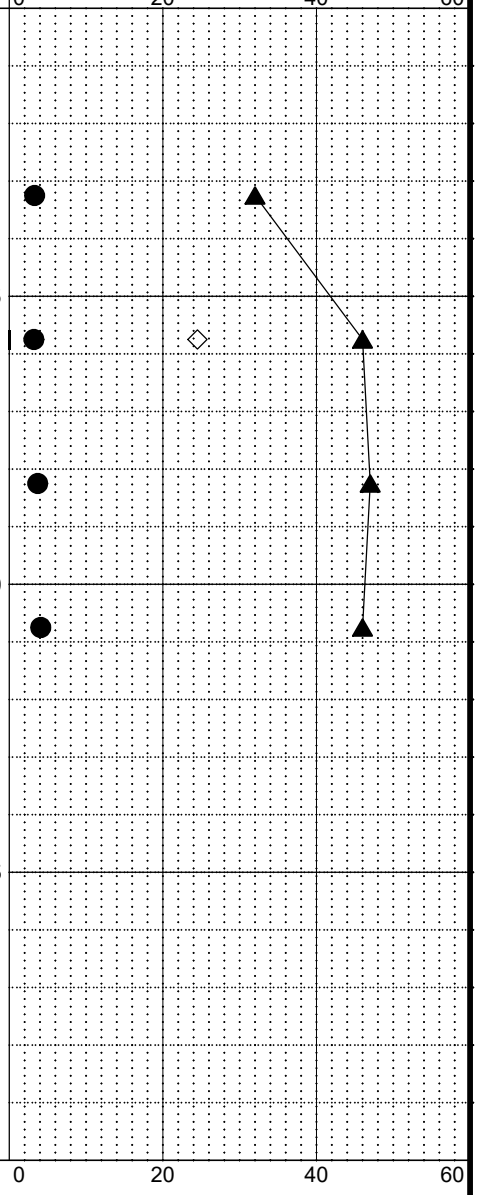
Symbol

Samples: S-1, S-2, S-3, S-4

Ground Water Depth, ft.: Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

LEGEND

* Sample Not Recovered

⌶ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-08

February 2022 107523-001

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FIG. A-10

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.77068°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6428 ft.*	Longitude:	*~ -106.25866°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very dense, gray to pinkish red, *Silty Sand (SM);* moist; few gravel.
[TUFF: extremely weak; completely weathered (Upper Bandelier Tuff).]

BOTTOM OF BORING
COMPLETED ON 12/13/2021

Depth, ft. | Symbol | Samples | Ground Water Depth, ft.

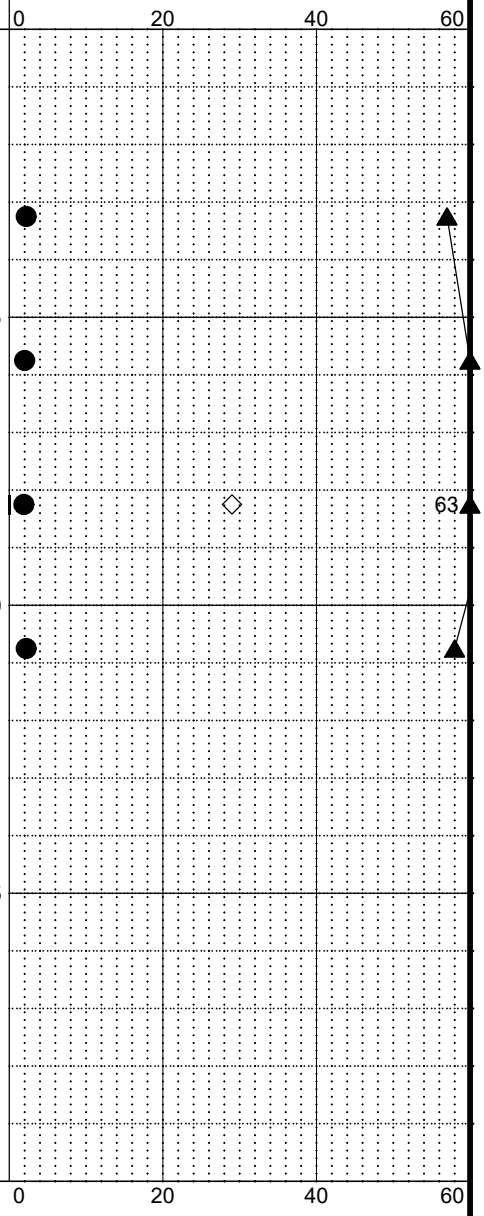
11.5

S-1 | S-2 | S-3 | S-4

Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⊥ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-09

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FIG. A-11

MASTER LOG E_POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.77055°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6281 ft.*	Longitude:	*~ -106.26208°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*

0 | 20 | 40 | 60

4 inches of asphalt pavement. — 0.3

4 inches of aggregate base course. — 0.6

Dense to very dense, brown to reddish brown, *Silty Sand (SM);* moist; few to little gravel. [TUFF: extremely weak; completely weathered (Upper Bandelier Tuff).]

S-1, S-2, S-3, S-4

Water Not Encountered During Drilling

50/6"

70

89

5

10

15

11.5

BOTTOM OF BORING
COMPLETED ON 12/14/2021

0 | 20 | 40 | 60

LEGEND

* Sample Not Recovered

Standard Penetration Test

◇ % Fines (<0.075mm)

● % Water Content

Plastic Limit ⊢●⊣ Liquid Limit

Natural Water Content

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-10

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FIG. A-12

MASTER LOG E_POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

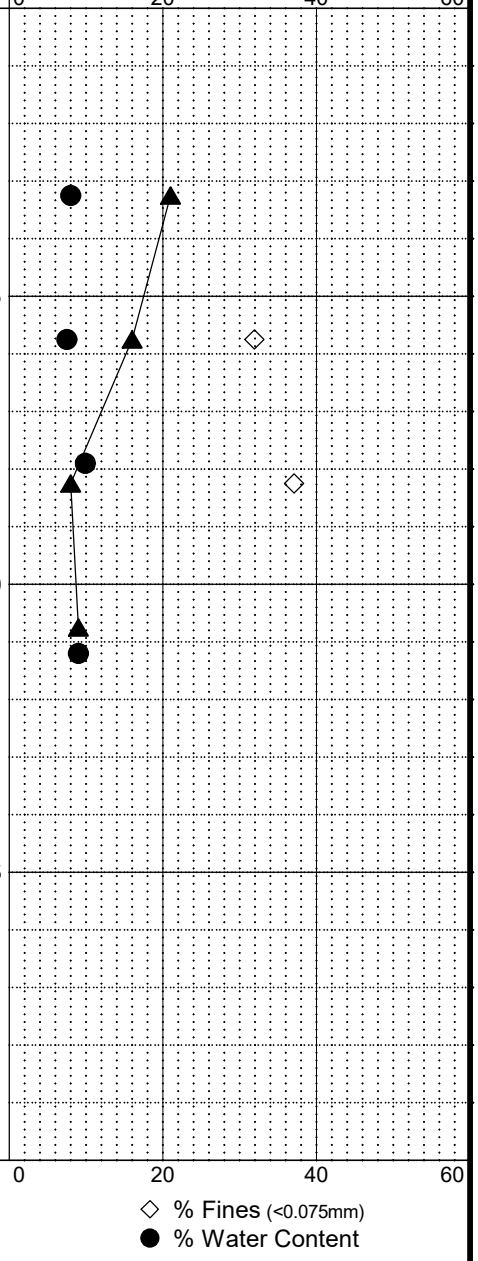
Total Depth:	*11.5 ft.*	Latitude:	*~ 35.77516°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6099 ft.*	Longitude:	*~ -106.26712°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION	Depth, ft.
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.	
4 inches of asphalt pavement.	0.3
6 inches of aggregate base course.	0.8
Medium dense, brown, *Silty Sand (SM);* moist; trace to few gravel. Fill	
Loose, brown, *Silty Sand (SM);* moist; few gravel. Alluvium	7.0
BOTTOM OF BORING COMPLETED ON 12/13/2021	11.5

Symbol; Samples: S-1, S-2, S-3, S-4; Ground Water Depth, ft.: Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

⊥ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

LOG OF BORING SW-11

February 2022 107523-001

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. A-13

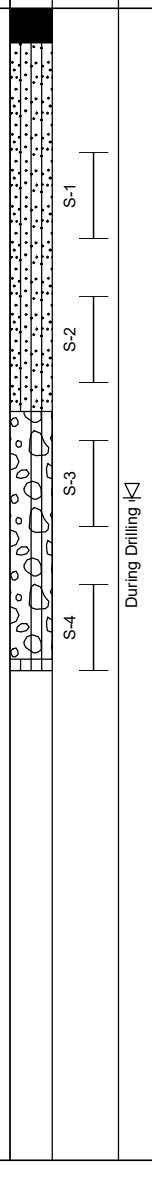
MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*11.5 ft.*	Latitude:	*~ 35.77812°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6059 ft.*	Longitude:	*~ -106.26996°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

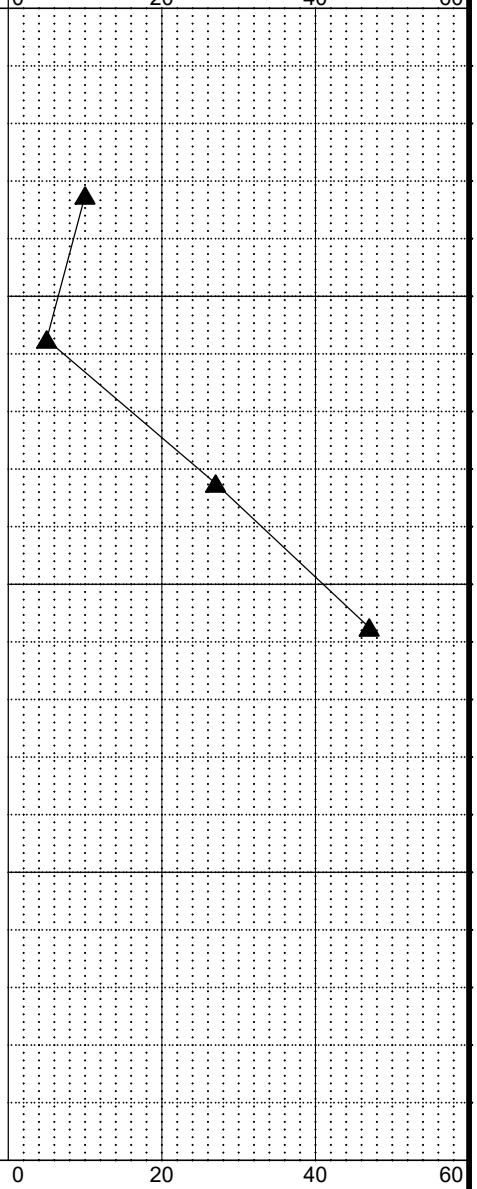
SOIL DESCRIPTION	Depth, ft.
Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.	
7 inches asphalt pavement.	
Loose to medium dense, brown, *Silty Sand (SM)* to *Poorly Graded Sand with Silt (SP-SM);* moist; trace gravel. Alluvium	0.6
Medium dense to dense, brown, *Poorly Graded Gravel with Silt and Sand (GP-GM);* moist to wet. Alluvium	7.0
Dense, red-brown, *Sandy Silt (ML);* moist. Alluvium	11.3
BOTTOM OF BORING COMPLETED ON 12/14/2021	11.5

Symbol, Samples, Ground Water Depth, ft.



PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered

Standard Penetration Test

Ground Water Level ATD

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

LOG OF BORING SW-12

February 2022 107523-001

SHANNON & WILSON, INC.
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FIG. A-14

QCL 3

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

Total Depth:	*20 ft.*	Latitude:	*~ 35.77729°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6058 ft.*	Longitude:	*~ -106.26931°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:	*HSA to NQ2 Core @ 4 feet*		

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Brown, *Poorly Graded Gravel with Silt and Sand (GP-GM);* moist.
Alluvium

0.2

BASALT: inferred from cuttings and drill action (Mafic lava flows).

4.0

BASALT: medium strong to very strong, black to gray; moderate to wide spaced, 45 to 65 degree joints, smooth, planar; moderately to slightly vesicular; slightly weathered (Mafic lava flows).

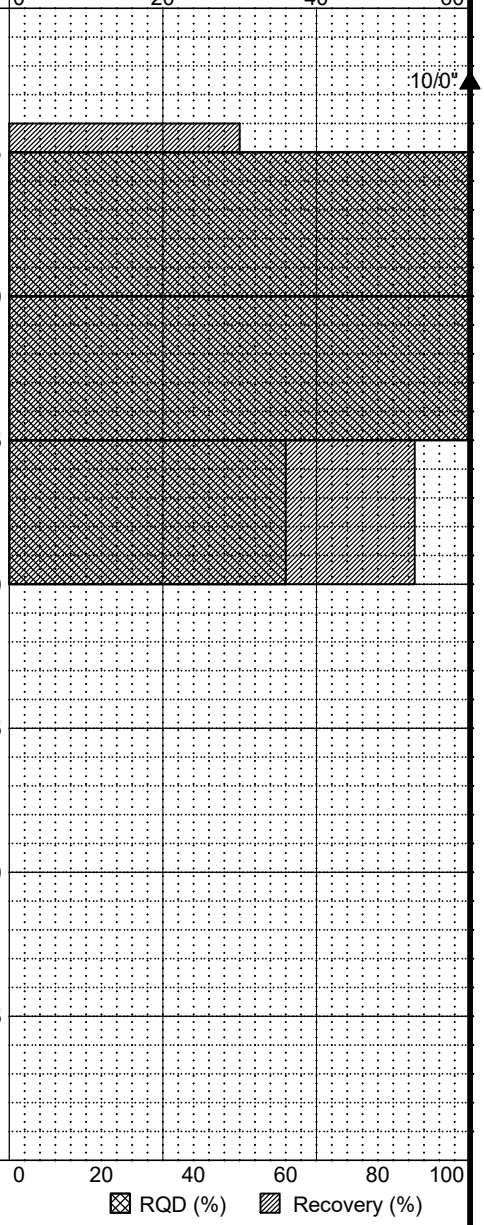
- Moderately vesicular from 4.0 to 5.5 feet and slightly vesicular from 5.5 to 17.0 feet.
- Core loss from 16.2 to 16.8 feet.
- Red to gray from 16.8 to 20.0 feet.
- Highly vesicular to scoraceous from 17.0 to 20.0 feet.
- Close to very close spaced joints from 16.7 to 18.0 and 19.1 to 19.6 feet with highly weathered joint faces and sandy clay infill.

20.0

BOTTOM OF BORING
COMPLETED ON 12/15/2021

Depth, ft. | Symbol | Samples (S-1, R-1, R-2, R-3, R-4) | Ground Water Depth, ft. (Water Not Encountered During Drilling)

PENETRATION RESISTANCE (blows/foot)
▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



LEGEND

* Sample Not Recovered
Rock Core

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
3. The discussion in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
4. Groundwater level, if indicated above, is for the date specified and may vary.
5. USCS designation is based on visual-manual classification and selected lab testing.
6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

LOG OF BORING SW-13

February 2022 | 107523-001

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FIG. A-15

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Total Depth:	*21.5 ft.*	Latitude:	*~ 35.7789°*	Drilling Method:	*Hollow-Stem Auger*	Hole Diam.:	*8 in.*
Top Elevation:	*~ 6073 ft.*	Longitude:	*~ -106.27198°*	Drilling Company:	*Enviro Drill*	Rod Type.:	*AWJ*
Vert. Datum:		Station:	~	Drill Rig Equipment:	*CME 75*	Hammer Type:	*Automatic*
Horiz. Datum:		Offset:	~	Other Comments:			

SOIL DESCRIPTION

Refer to the report text for a proper understanding of the subsurface materials and drilling methods. The stratification lines indicated below represent the approximate boundaries between material types, and the transition may be gradual.

Very loose to loose, brown, *Silty Sand with Gravel (SM)* to *Poorly Graded Sand with Silt and Gravel (SP-SM);* moist.
Alluvium
- 1 to 6 foot diameter boulders observed in adjacent slope.

7.0

Dense to very dense, red-brown, *Silty Sand (SM)* to *Sandy Silt (ML);* moist; trace to few gravel.
Alluvium

18.0

Very dense, red-brown, *Poorly Graded Sand with Silt and Gravel (SP-SM);* moist.
Alluvium

21.5

BOTTOM OF BORING
COMPLETED ON 12/13/2021

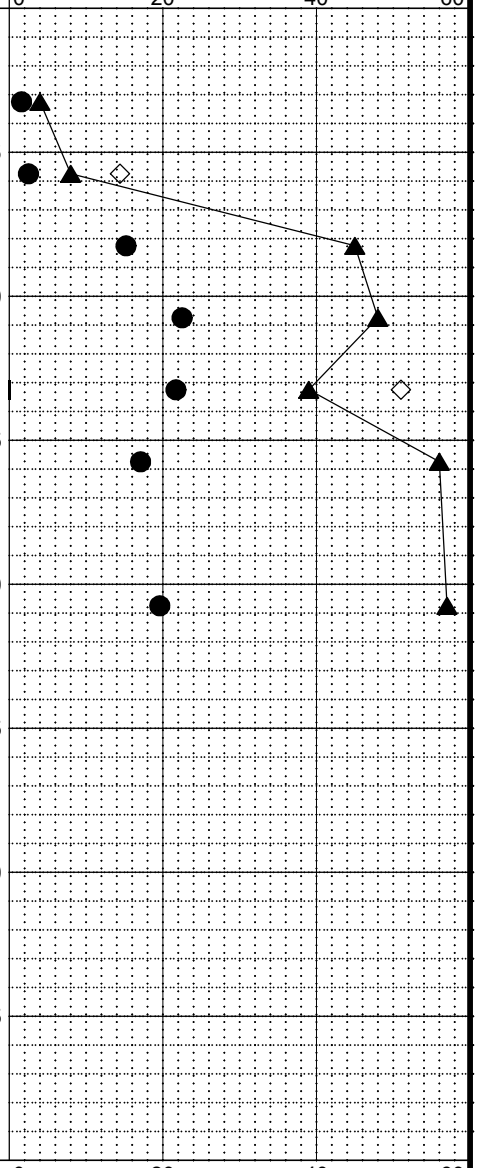
Depth, ft. | Symbol | Samples | Ground Water | Depth, ft.

Samples: S-1, S-2, S-3, S-4, S-5, S-6, S-7

Water Not Encountered During Drilling

PENETRATION RESISTANCE (blows/foot)

▲ Hammer Wt. & Drop: *140 lbs / 30 inches*



◇ % Fines (<0.075mm)
● % Water Content
Plastic Limit ⊢●⊣ Liquid Limit
Natural Water Content

LEGEND

* Sample Not Recovered
⊥ Standard Penetration Test

NOTES

1. Refer to Figures A-1 and A-2 for explanation of symbols, codes, abbreviations and definitions.
2. The stratification lines represent the approximate boundaries between soil types, and the transition may be gradual.
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4. Groundwater level, if indicated above, is for the date specified and may vary.
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6. Boring latitude and longitude are approximate, and were measured using a handheld GPS device. Boring top elevation is approximate and was not surveyed. Top elevation was estimated using topographic contours in Jacobs files D3167640_Bandelier_Master.dwg and D3167640_Bandelier_Surface.xml, dated 11/30/21.

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LOG OF BORING SW-14

February 2022 107523-001

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FIG. A-16

MASTER LOG E POCKETPEN LAT&LONG LOS 107523-001 BANDELIER NM.GPJ 2/17/22

QCL 3

Top of Core

Run 1: 20.0 – 25.0 feet

Run	Top (feet)	Bottom (feet)	Recovery (%)	RQD (%)
R-1	20.0	25.0	40	20

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ROCK CORE PHOTOGRAPHS
BORING SW-04

February 2022 107523-001

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FIG. A-17

FIG. A-17

Top of Core

Run 1: 4.0 – 5.0 feet

Top of Core

Photo Match Line

Photo Match Line

Run 2: 5.0 – 10.0 feet

Run	Top (feet)	Bottom (feet)	Recovery (%)	RQD (%)
R-1	4.0	5.0	50	0
R-2	5.0	10.0	100	100

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ROCK CORE PHOTOGRAPHS
BORING SW-13

February 2022 107523-001

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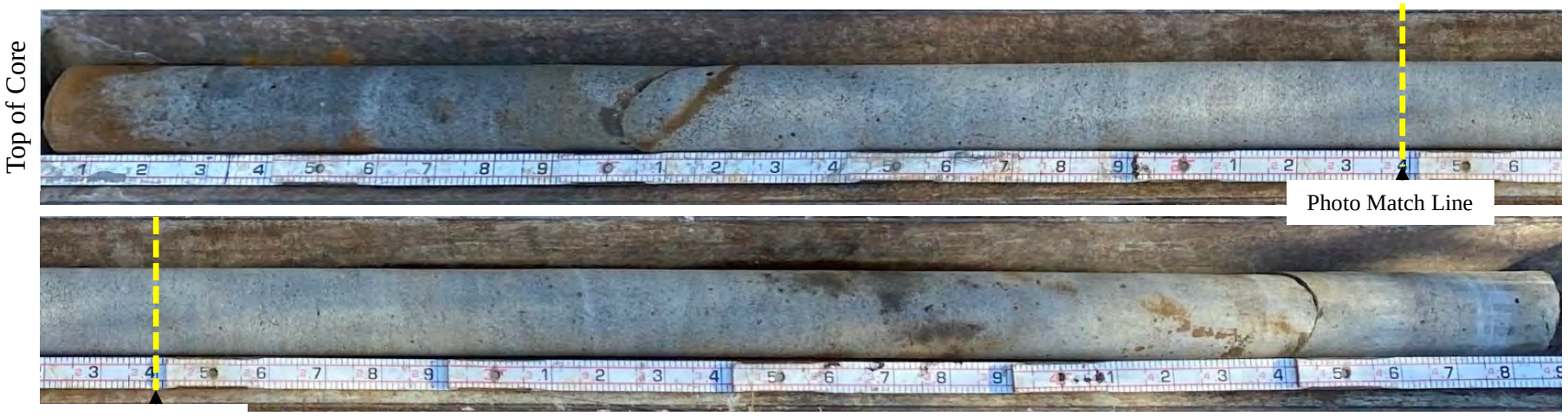
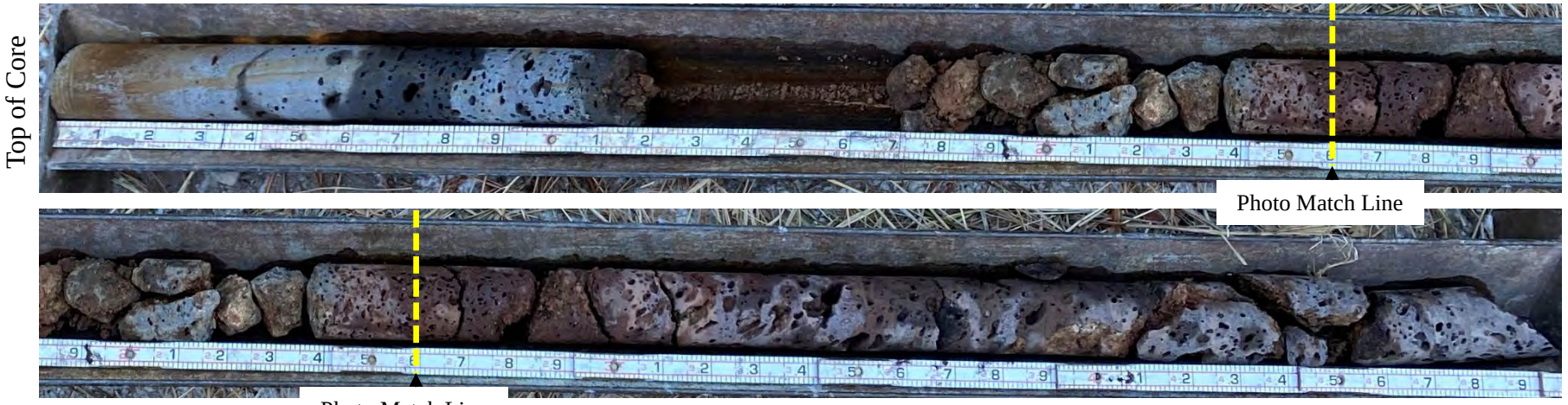
FIG. A-18
Sheet 1 of 2

FIG. A-18
Sheet 1 of 2



Run 3: 10.0 – 15.0 feet



Run 4: 15.0 – 20.0 feet

Run	Top (feet)	Bottom (feet)	Recovery (%)	RQD (%)
R-3	10.0	15.0	100	100
R-4	15.0	20.0	88	60

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ROCK CORE PHOTOGRAPHS
BORING SW-13

February 2022 107523-001

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FIG. A-18
Sheet 2 of 2

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA						GRAIN-SIZE ANALYSES			ATTERBERG LIMITS				CORROSION			
Boring	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	Natural Moisture Content (%)	Moist Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Unconfined Compressive Strength (psi)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)
SW-01	2.5	4.0	CL	7.4				58	29	20	9		7.55	2,600	0.01	0.008
	5.0	6.5		3.7												
	7.5	9.0		4.6												
	10.0	11.5		4.8												
SW-02	2.5	4.0		6.8												
	6.0	6.5	SM	0.8				20	NV	NP	NP					
	7.5	9.0		2.2												
	10.0	11.5		2.4												
SW-03	2.5	3.2		4.1												
	5.0	5.3		2.6												
	7.5	7.7		4.9												
	10.0	10.4		4.1												
SW-04	2.5	4.0		3.0												
	5.0	6.5		3.0												
	7.5	9.0	SM	3.0		19	56	25	NV	NP	NP					
	10.0	11.5		2.9												
	12.5	14.0		2.7												
	15.0	16.5	SM	2.3				23	NV	NP	NP					
	20.0	21.5		1.9												
	24.2	24.8			87.7							244				
	30.0	31.5		3.0												
SW-05	2.5	4.0	SM	1.8				25	NV	NP	NP					
	5.0	6.5		2.0												
	10.0	11.5		1.3												

Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA				Natural	Moist	GRAIN-SIZE ANALYSES			ATTERBERG LIMITS			Unconfined	CORROSION			
Boring	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	Moisture Content (%)	Unit Weight (pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Compressive Strength (psi)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)
SW-06	2.5	4.0		0.8												
	5.0	6.5	SM	1.3		16	58	26	NV	NP	NP					
	7.5	9.0		0.3												
	10.0	11.5		0.3												
SW-07	2.5	4.0		1.2												
	5.0	6.5	SM	2.7				29	NV	NP	NP		8.88	4,600	0.02	0.005
	7.5	9.0		3.9												
	10.0	11.5		2.6												
SW-08	2.5	4.0		3.3												
	5.0	6.5	SM	3.2				25	NV	NP	NP					
	7.5	9.0		3.7												
	10.0	11.5		4.1												
SW-09	2.5	4.0		2.2												
	5.0	6.5		2.0												
	7.5	9.0	SM	1.9		10	61	29	NV	NP	NP					
	10.0	11.5		2.2												
SW-10	2.5	3.0		11.4												
	5.0	6.5	SM	5.9				13	NV	NP	NP					
	7.5	9.0		6.5												
	10.0	11.5		6.7												
SW-11	5.0	6.5	SM	7.5		15	53	32								
	7.5	9.0	SM	9.9		9	54	37								
	10.0	11.5		9.0												
SW-13	7.6	8.1			174.5							24,455				
	18.2	18.7			129.0							3,911				

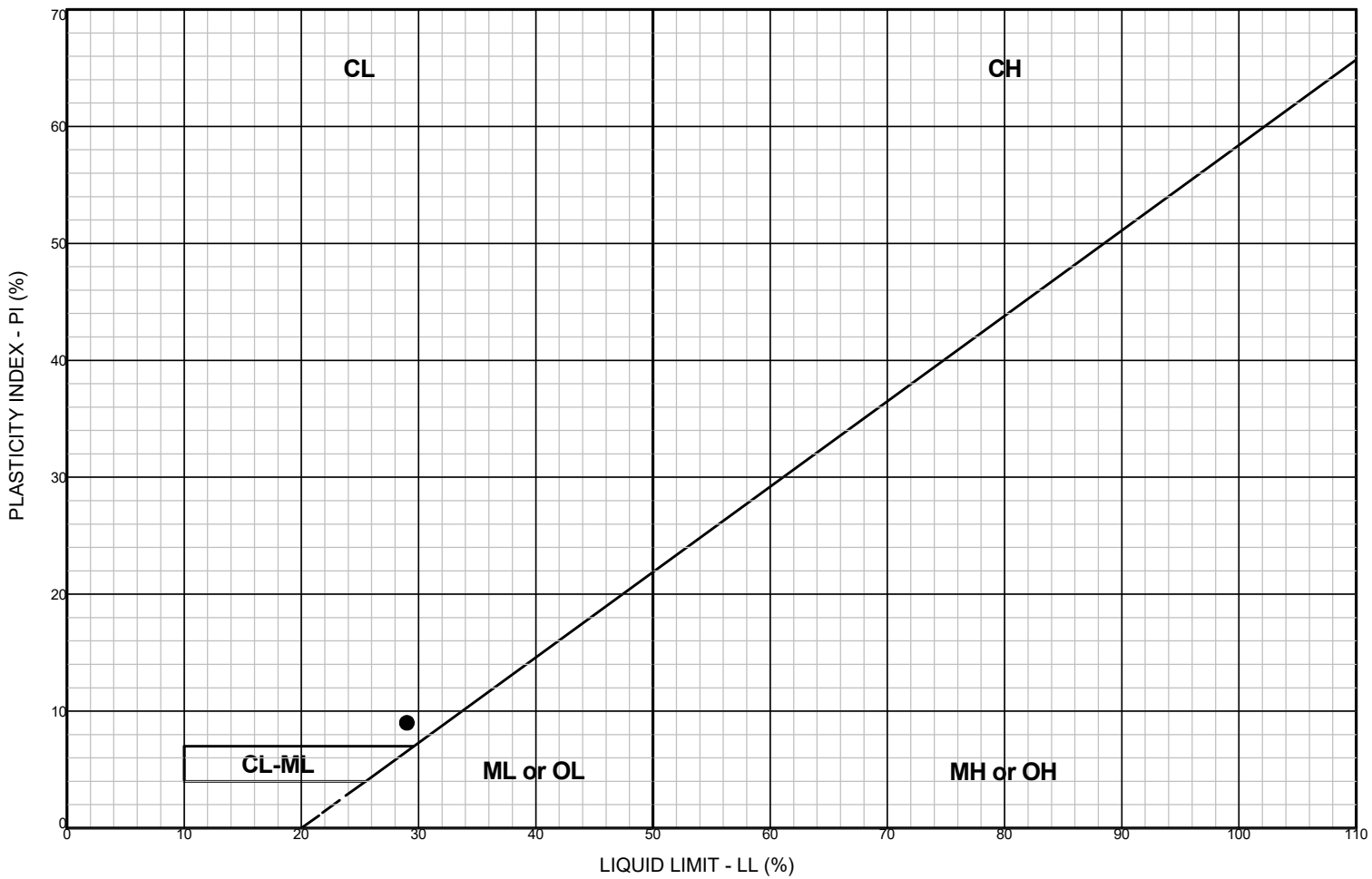
Table B-1 - Summary of Laboratory Test Results by Boring

SAMPLE DATA				Natural Moisture Content	Moist Unit Weight	GRAIN-SIZE ANALYSES			ATTERBERG LIMITS			Unconfined Compressive Strength	CORROSION			
Boring	Depth (feet) Top	Depth (feet) Bottom	USCS Symbol[1]	(%)	(pcf)	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	(psi)	pH	Resistivity (ohm-cm)	Sulfate Content (%)	Chloride Content (%)
SW-14	2.5	4.0		1.6												
	5.0	6.5	SM	2.5		23	63	14								
	7.5	9.0		15.2												
	10.0	11.5		22.5												
	12.5	14.0	ML	21.7		11	38	51	NV	NP	NP		6.91	3,400	0.01	0.007
	15.0	16.5		17.1												
	20.0	21.5		19.6												

NOTES:

1 Refer to Appendix A, Figure A-1 for definitions.

ohm-cm = ohm centimeters; psf = pounds per square foot; pcf = pounds per cubic foot; ppm = parts per million



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
● SW-01, S-1	2.5	CL	Sandy Lean Clay	29	20	9	7.4	57.7
SW-02, S-2	6.0	SM	Silty Sand	NV	NP	NP	0.8	19.7
SW-04, S-3	7.5	SM	Silty Sand	NV	NP	NP	3.0	25.1
SW-04, S-6	15.0	SM	Silty Sand	NV	NP	NP	2.3	22.7
SW-05, S-1	2.5	SM	Silty Sand	NV	NP	NP	1.8	25.2
SW-06, S-2	5.0	SM	Silty Sand	NV	NP	NP	1.3	26.2
SW-07, S-2	5.0	SM	Silty Sand	NV	NP	NP	2.7	29.2

NPS Bandelier National Monument
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Los Alamos & Sandoval Counties, New Mexico

PLASTICITY CHART

February 2022 107523-001

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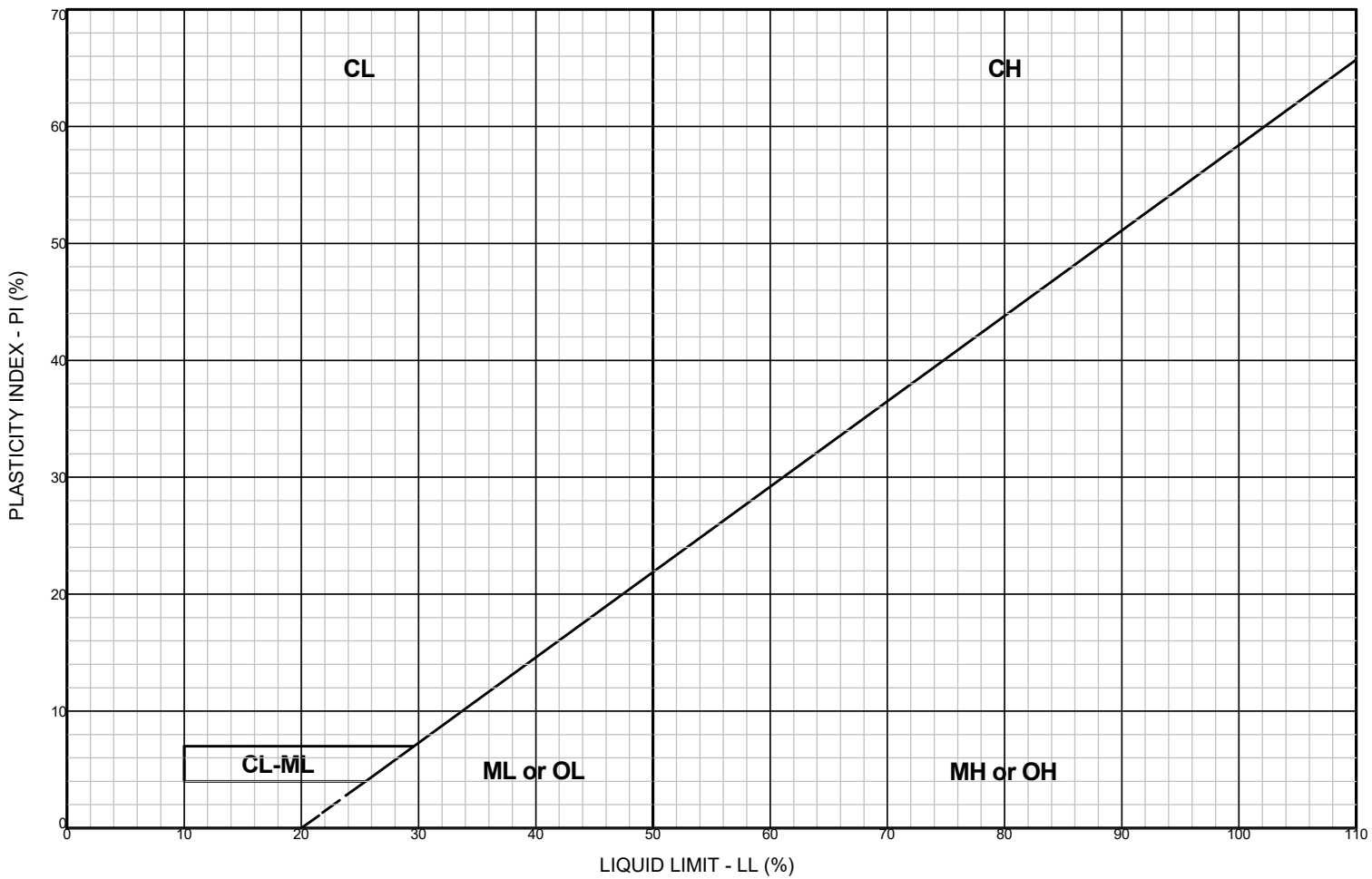
FIG. B-1
Sheet 1 of 2

FIG. B-1
Sheet 1 of 2

ATT. MAIN 107523-001 BANDELIER NM.GPJ 1/26/22



LEGEND

CL: Low plasticity inorganic clays; sandy and silty clays

CH: High plasticity inorganic clays

ML or OL: Inorganic and organic silts and clayey silts of low plasticity

MH or OH: Inorganic and organic silts and clayey silts of high plasticity

CL-ML: Silty clays and clayey silts

SAMPLE ID	DEPTH (feet)	U.S.C.S. SYMBOL	SOIL CLASSIFICATION	LL %	PL %	PI %	NAT. W.C. %	PASS. #200, %
SW-08, S-2	5.0	SM	Silty Sand	NV	NP	NP	3.2	24.5
SW-09, S-3	7.5	SM	Silty Sand	NV	NP	NP	1.9	29.0
SW-10, S-2	5.0	SM	SIlty Sand	NV	NP	NP	5.9	12.7
SW-14, S-5	12.5	ML	Sandy Silt	NV	NP	NP	21.7	51.0

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos & Sandoval Counties, New Mexico

PLASTICITY CHART

February 2022 107523-001

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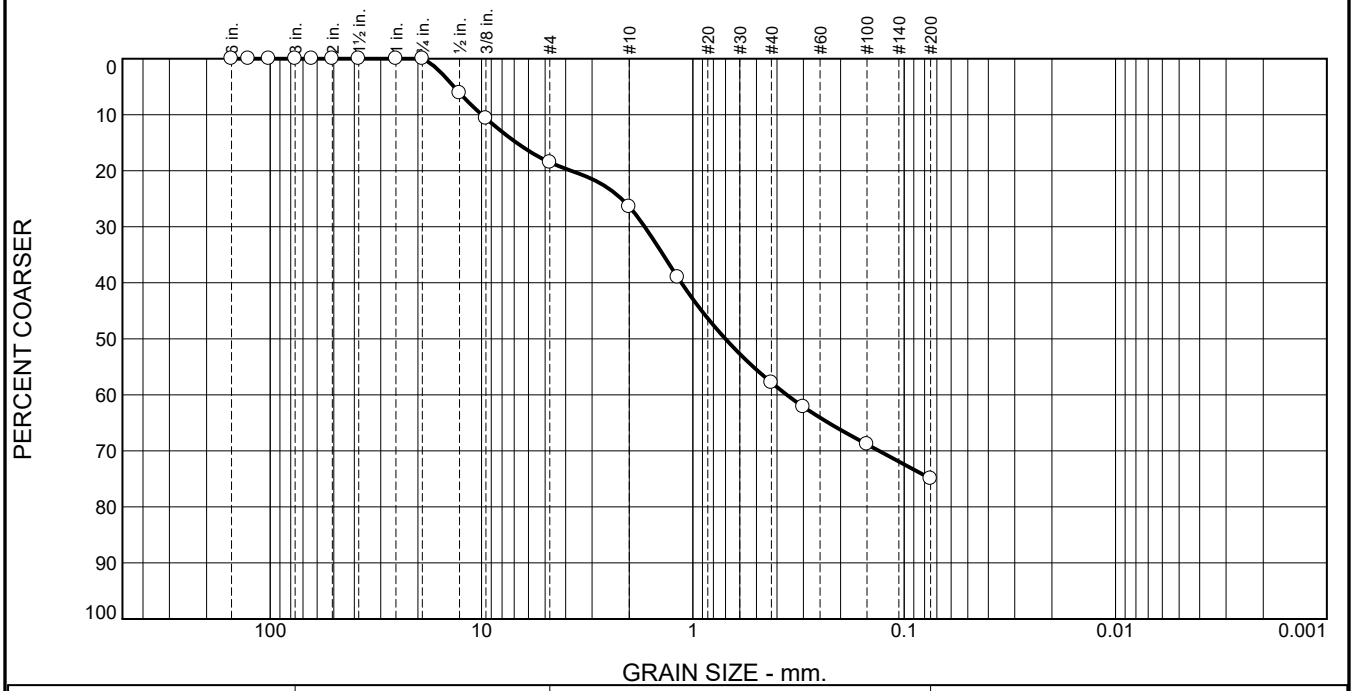
Geotechnical and Environmental Consultants

FIG. B-1
Sheet 2 of 2

FIG. B-1
Sheet 2 of 2

ATT. MAIN 107523-001 BANDELIER NM.GPJ 1/26/22

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	18.5	7.9	31.4	17.1	25.1	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	93.9		
.375	89.3		
#4	81.5		
#10	73.6		
#16	61.0		
#40	42.2		
#50	37.9		
#100	31.2		
#200	25.1		

* (no specification provided)

Material Description

SW-04 / S-3 / SPT / 7.5-9.0'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-1-b

Coefficients

D_{90}= 9.9650 D_{85}= 6.8333 D_{60}= 1.1339
D_{50}= 0.7015 D_{30}= 0.1314 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-04 / S-3 / SPT / 7.5-9.0' **Date Sampled:** 1/14/22
Sample Number: S3227 **Depth:** 7.5-9.0'

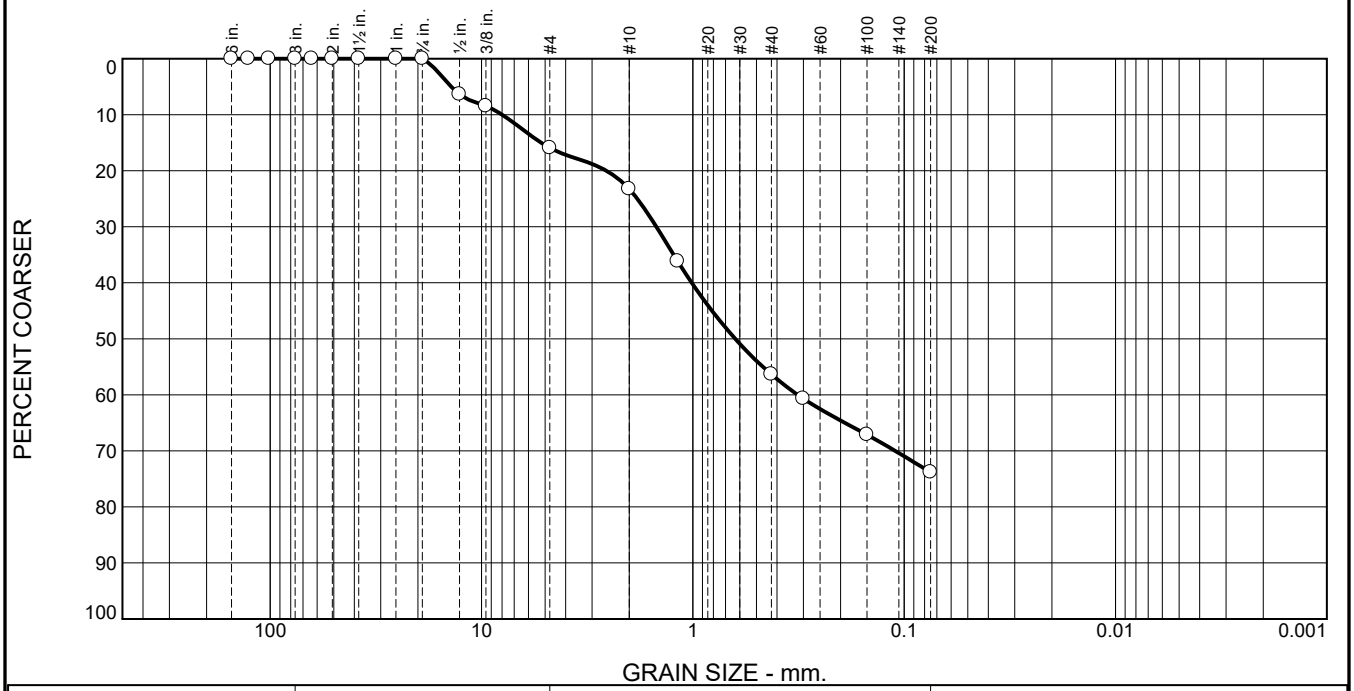
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	15.9	7.4	33.1	17.4	26.2	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	93.6		
.375	91.6		
#4	84.1		
#10	76.7		
#16	63.8		
#40	43.6		
#50	39.3		
#100	32.9		
#200	26.2		

* (no specification provided)

Material Description

SW-06 / S-2 / SPT / 5.0-6.5'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 7.9850 D_{85}= 5.2211 D_{60}= 1.0123
D_{50}= 0.6300 D_{30}= 0.1103 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-06 / S-2 / SPT / 5.0-6.5'
Sample Number: S3238 **Depth:** 5.0-6.5'

Date Sampled: 1/14/22

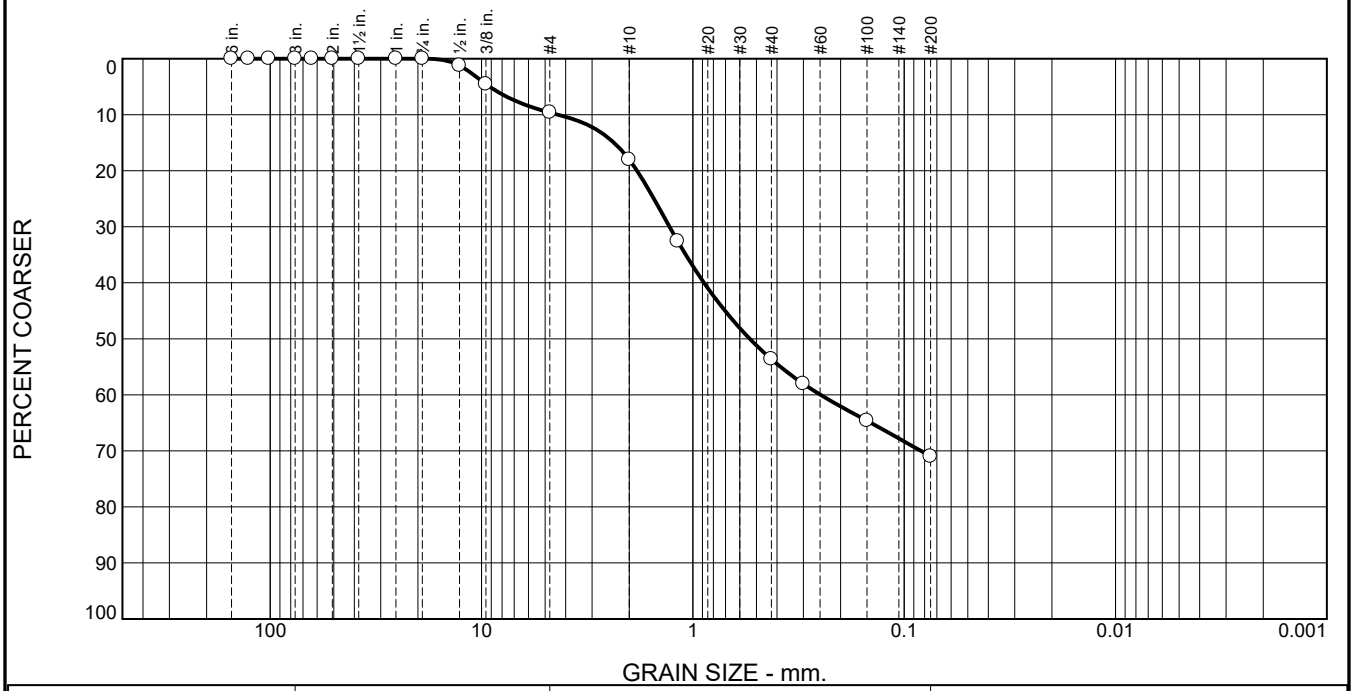
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.6	8.4	35.6	17.4	29.0	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	98.8		
.375	95.5		
#4	90.4		
#10	82.0		
#16	67.4		
#40	46.4		
#50	42.0		
#100	35.4		
#200	29.0		

* (no specification provided)

Material Description

SW-09 / S-3 / 7.5-9.0'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= SM **AASHTO (M 145)=** A-2-4(0)

Coefficients

D_{90}= 4.3589 D_{85}= 2.3605 D_{60}= 0.8856
D_{50}= 0.5375 D_{30}= 0.0834 D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-09 / S-3 / 7.5-9.0' **Date Sampled:** 1/14/22
Sample Number: S3251 **Depth:** 7.5-9.0'

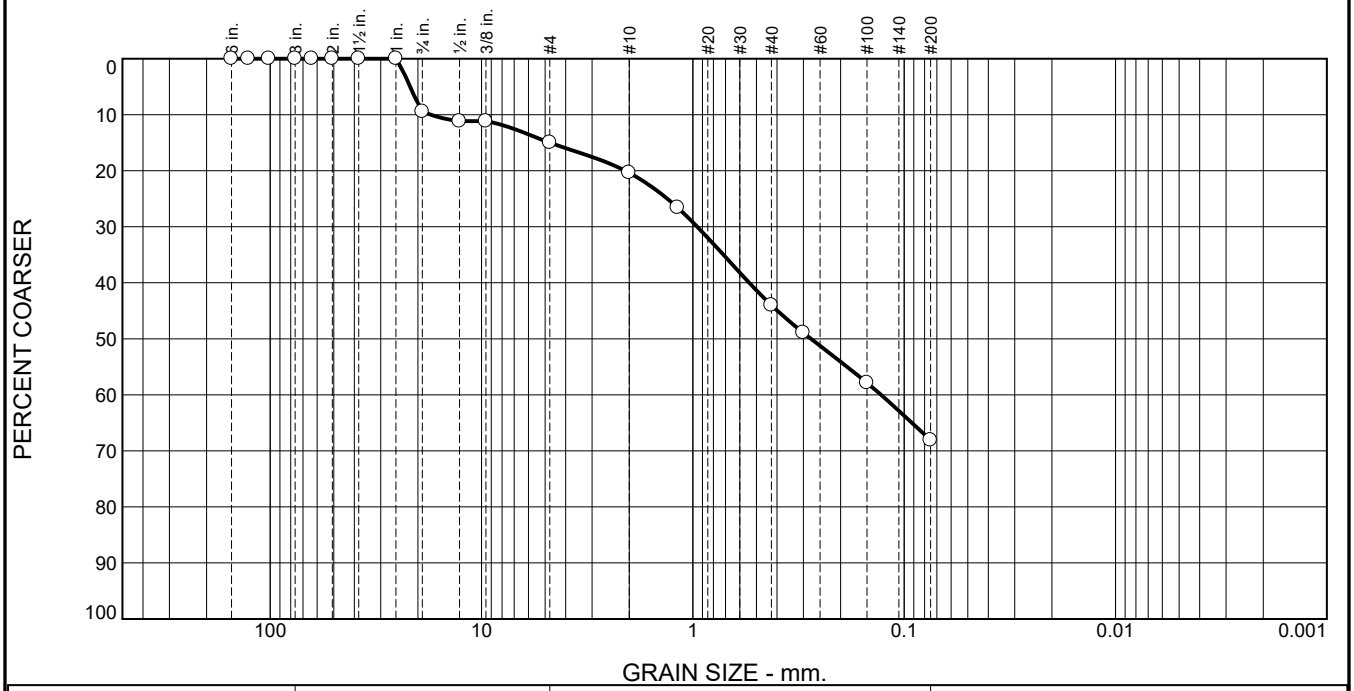
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	9.4	5.6	5.4	23.6	24.1	31.9	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	90.6		
.5	88.8		
.375	88.8		
#4	85.0		
#10	79.6		
#16	73.4		
#40	56.0		
#50	51.1		
#100	42.1		
#200	31.9		

* (no specification provided)

Material Description

SW-11 / S-2 / SPT / 5.0-6.5'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 17.3927 D_{85}= 4.7464 D_{60}= 0.5410
D_{50}= 0.2760 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-11 / S-2 / SPT / 5.0-6.5'
Sample Number: S3258 **Depth:** 5.0-6.5'

Date Sampled: 1/14/22

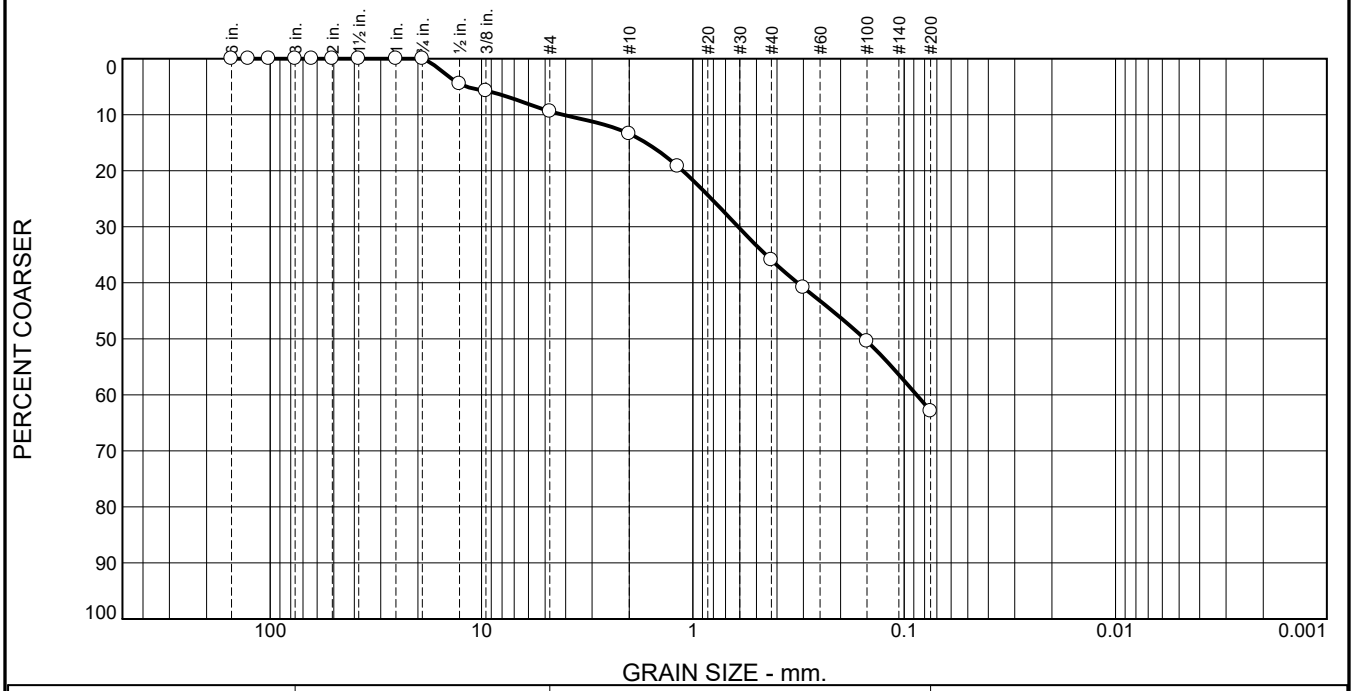
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	9.4	4.0	22.5	27.0	37.1	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	95.5		
.375	94.2		
#4	90.6		
#10	86.6		
#16	80.8		
#40	64.1		
#50	59.2		
#100	49.6		
#200	37.1		

* (no specification provided)

Material Description

SW-11 / S-3 / SPT / 7.5-9.0'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 4.1380 D_{85}= 1.6675 D_{60}= 0.3196
D_{50}= 0.1541 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-11 / S-3 / SPT / 7.5-9.0'
Sample Number: S3259 **Depth:** 7.5-9.0'

Date Sampled: 1/14/22

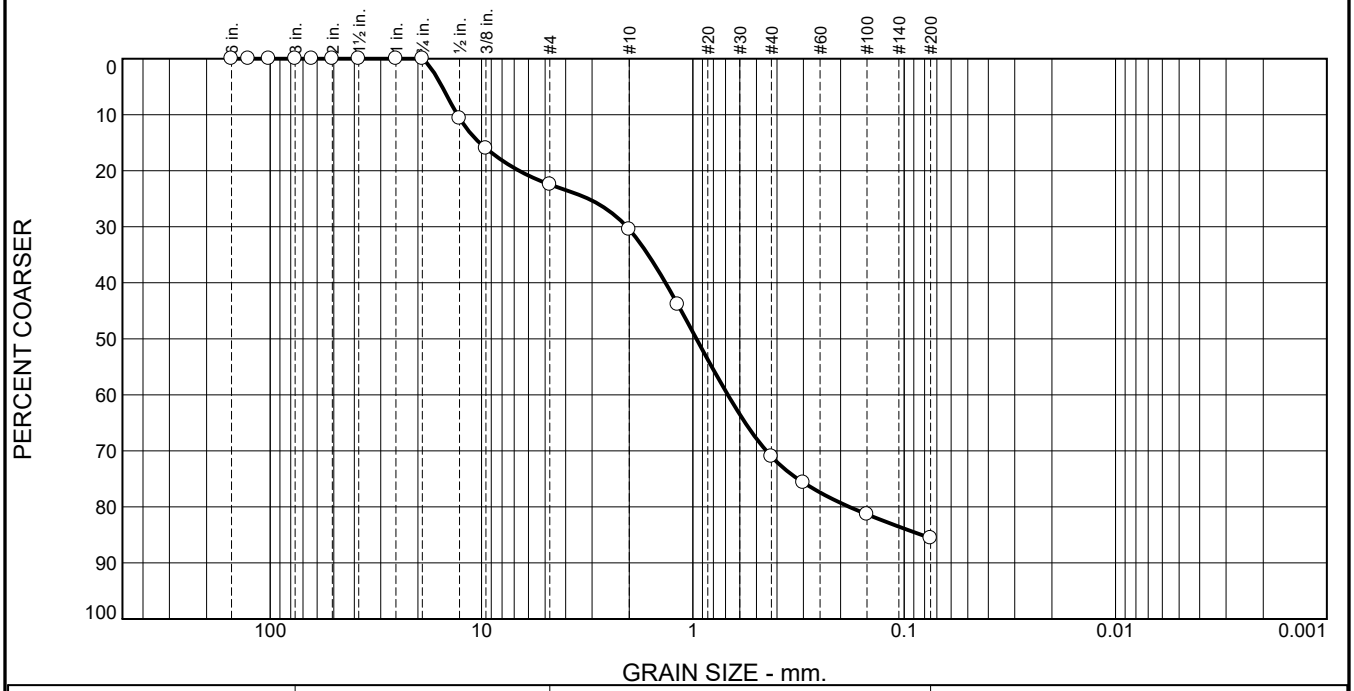
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	22.5	8.0	40.5	14.6	14.4	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	89.3		
.375	84.0		
#4	77.5		
#10	69.5		
#16	56.1		
#40	29.0		
#50	24.3		
#100	18.7		
#200	14.4		

* (no specification provided)

Material Description

SW-14 / S-2 / SPT / 5.0-6.5'

Atterberg Limits (ASTM D 4318)

PL= **LL=** **PI=**

Classification

USCS (D 2487)= **AASHTO (M 145)=**

Coefficients

D_{90}= 13.0175 D_{85}= 10.2141 D_{60}= 1.3475
D_{50}= 0.9613 D_{30}= 0.4493 D_{15}= 0.0828
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-14 / S-2 / SPT / 5.0-6.5'
Sample Number: S3262 **Depth:** 5.0-6.5'

Date Sampled: 1/14/22

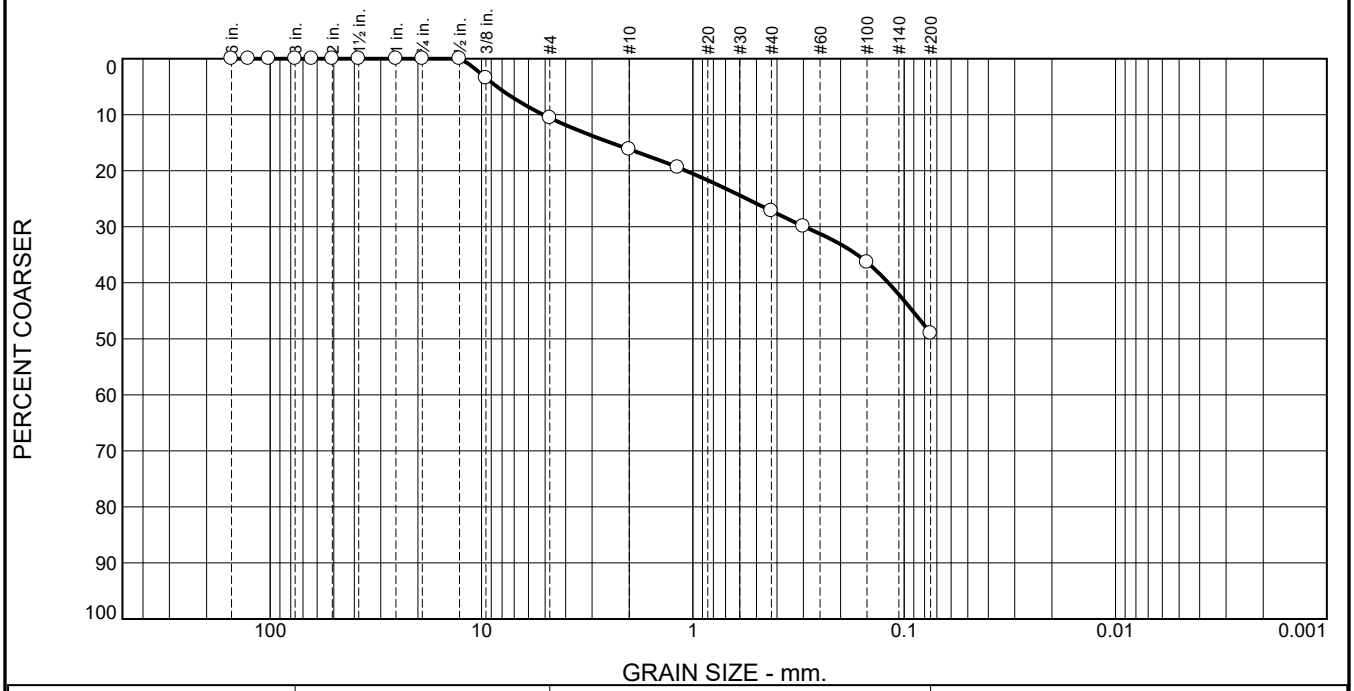
Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	10.6	5.6	11.0	21.8	51.0	

Test Results (ASTM D 422 & ASTM D 1140)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
6	100.0		
5	100.0		
4	100.0		
3	100.0		
2.5	100.0		
2	100.0		
1.5	100.0		
1	100.0		
.75	100.0		
.5	100.0		
.375	96.6		
#4	89.4		
#10	83.8		
#16	80.6		
#40	72.8		
#50	70.1		
#100	63.7		
#200	51.0		

* (no specification provided)

Material Description

SW-14 / S-5 / SPT / 12.5-14.0'

Atterberg Limits (ASTM D 4318)

PL= NP **LL=** NV **PI=** NP

Classification

USCS (D 2487)= ML **AASHTO (M 145)=** A-4(0)

Coefficients

D_{90}= 5.1052 D_{85}= 2.4453 D_{60}= 0.1188
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Remarks

Date Received: 1/14/22 **Date Tested:** 1/21/22

Tested By: Juan Romero

Checked By: Clay Hollowell

Title: PE

Location: SW-14 / S-5 / SPT / 12.5-14.0'
Sample Number: S3265 **Depth:** 12.5-14.0'

Date Sampled: 1/14/22

Vine Laboratories

Denver, Colorado

Client: Shannon & Wilson
Project: Bandelier NM

Project No: 107523-001 **Figure**

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson			JOB NO.	2481-304
PROJECT	Bandelier NM			LOCATION	Bandelier, NM
PROJECT NO.	107523-001				
BORING NO.		SW-04	SW-13	SW-13	
DEPTH		24.2-24.8	7.6-8.1	18.2-18.7	
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED		01/11/22	01/11/22	01/11/22	
TECHNICIAN		CL	CL	CL	
ROCK TYPE					
Diameter (in):		1.828	1.858	1.859	
Height (in):		3.700	3.630	3.522	
Mass of Wet Rock (g):		223.50	450.90	323.80	
Wet Density (lbs/ft³):		87.7	174.5	129.0	
Wet Density (g/cm³):		1.405	2.796	2.067	
Peak Load (lbs):		640	66493	10686	
Compressive Strength (psi)		244	*24455	*3911	
Compressive Strength (MPa)		1.7	*169	*27	
Failure Type:		Fracture / Bedding	Fracture / Bedding	Fracture / Bedding	
BORING NO.					
DEPTH					
SAMPLE NO.					
DATE SAMPLED					
DATE TESTED					
TECHNICIAN					
ROCK TYPE					
Diameter (in):					
Height (in):					
Mass of Wet Rock (g):					
Wet Density (lbs/ft³):					
Wet Density (g/cm³):					
Peak Load (lbs):					
Compressive Strength (psi)					
Compressive Strength (MPa)					
Failure Type:					
NOTES		* Despite the ASTM recommendation, due to sample dimensions a correction is applied with the equation CF= 1/(0.88+0.24(D/H))			

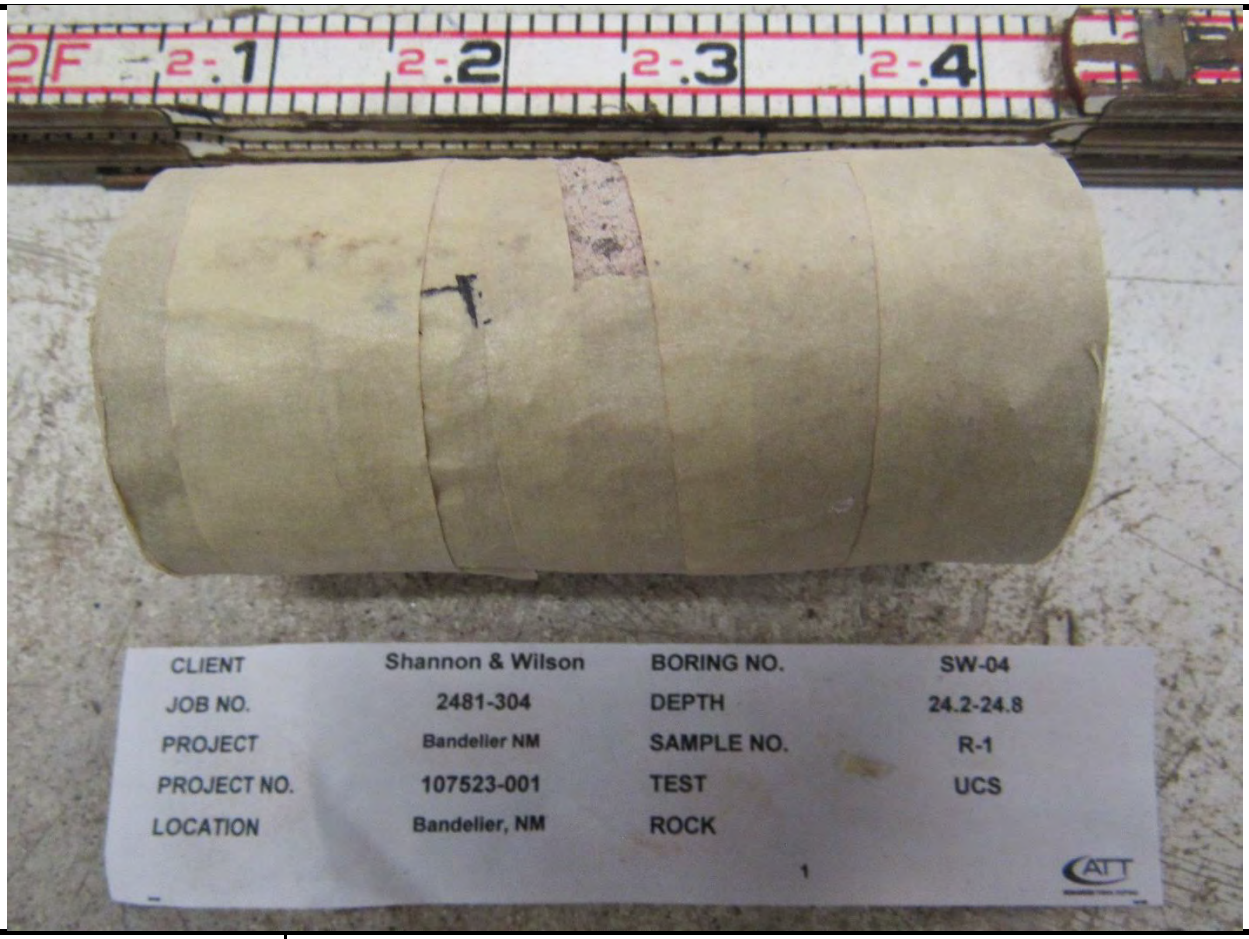
Data entry by:	CL	Date: 01/11/22
Checked by:	HN	Date: 01/12/22
File name:	2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm	

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-04
JOB NO.	2481-304	DEPTH	24.2-24.8
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

Before Picture



NOTES

Picture File: 1.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-04
JOB NO.	2481-304	DEPTH	24.2-24.8
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

After Picture

NOTES

Picture File: 1a.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-13
JOB NO.	2481-304	DEPTH	7.6-8.1
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

Before Picture

NOTES

Picture File: 2.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-13
JOB NO.	2481-304	DEPTH	7.6-8.1
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

After Picture

NOTES

Picture File: 2a.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-13
JOB NO.	2481-304	DEPTH	18.2-18.7
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

Before Picture

NOTES

Picture File: 3.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

ADVANCED TERRA TESTING

Unconfined Compressive Strength
ASTM D7012 Method C

CLIENT	Shannon & Wilson	BORING NO.	SW-13
JOB NO.	2481-304	DEPTH	18.2-18.7
PROJECT	Bandelier NM	SAMPLE NO.	
PROJECT NO.	107523-001	DATE SAMPLED	
LOCATION	Bandelier, NM	DATE TESTED	01/11/22
		TECHNICIAN	CL
		ROCK TYPE	

After Picture

NOTES

Picture File: 3a.JPG
File name: 2481304__Rock UCS-TCS ASTM D7012 Method A and C_0.xlsm

APPENDIX D: PAVEMENT PHOTOGRAPHS

Appendix D

Pavement Photographs

FIGURES

Figure D-1: Site and Pavement Condition Survey
Figure D-2: Pavement Photographs, Entrance Road
Figure D-3: Pavement Photographs, Campground Road
Figure D-4: Pavement Photographs, Saltbrush Road and Paintbrush Road
Figure D-5: Pavement Photographs, Coopers Hawk Road and Field Operations Center
Figure D-6: Pavement Photographs, Juniper Campground
Figure D-7: Pavement Photographs, Amphitheater Parking
Figure D-8: Pavement Photographs, Fire Tower Lane Parking
Figure D-9: Pavement Photographs, Agoyo Lane
Figure D-10: Pavement Photographs, Stonehouse Road
Figure D-11: Pavement Photographs, Visitor Center Parking
Figure D-12: Pavement Photographs, Overflow Parking Road
Figure D-13: Pavement Photographs, Frijoles Canyon Maintenance Parking

NOTES

1. Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth ™ Mapping Service.
2. Generalized pavement condition rating is based on the U.S. Fish and Wildlife Services visual rating system for asphalt pavement. The pavement condition assessment was conducted in October 2023.

LEGEND

FIG. D-2, Ph-1 — Photograph Designation, Approximate Location and Direction

Generalized Pavement Condition Rating

- Good
- Fair
- Fair to Poor

0 800 1600

Scale in Feet

N

NPS Bandelier National Monument
Utility Rehabilitation
Los Alamos and Sandoval Counties, New Mexico

SITE AND PAVEMENT CONDITION SURVEY

September 2024 107523-002

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FIG. D-1

Photo 1: Entrance Road at entrance to national monument. Low extent and medium severity transverse and longitudinal cracking. Photo looking southwest.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
ENTRANCE ROAD

September 2024 107523-002

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FIG. D-2
Sheet 1 of 5

FIG. D-2
Sheet 1 of 5

Photo 2: Entrance Road, approximately ½ of a mile south of Campground Road. Medium extent and low severity transverse cracking. Photo looking southeast.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
ENTRANCE ROAD

September 2024 107523-002

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FIG. D-2
Sheet 2 of 5

FIG. D-2
Sheet 2 of 5

Photo 3: Entrance Road, approximately ¾ of a mile south of Fire Tower Lane. Medium extent and severity transverse cracking. Low extent and low to medium severity transverse cracking. Photo looking south.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
ENTRANCE ROAD

September 2024 107523-002

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FIG. D-2
Sheet 3 of 5

FIG. D-2
Sheet 3 of 5

Photo 4: Entrance Road at the intersection with Agoyo Lane. Low to medium extent and severity transverse cracking. Photo looking north.

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Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
ENTRANCE ROAD

September 2024 107523-002

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FIG. D-2
Sheet 4 of 5

FIG. D-2
Sheet 4 of 5

Photo 5: Entrance Road, approximately 1/8 of a mile southeast of Visitor Center. Medium extent and low to medium severity transverse and longitudinal cracking. Photo looking southeast.

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Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
ENTRANCE ROAD

September 2024 107523-002

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FIG. D-2
Sheet 5 of 5

FIG. D-2
Sheet 5 of 5

Photo 1: Campground Road near intersection with Saltbrush Road. Low extent and medium severity transverse cracking. Low extent and severity longitudinal cracking. Photo looking southeast.

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Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
CAMPGROUND ROAD

September 2024 107523-002

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FIG. D-3
Sheet 1 of 1

FIG. D-3
Sheet 1 of 1

Photo 1: Saltbrush Road. Low extent and high severity transverse cracking. Photo looking northwest.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
SALTBRUSH ROAD

September 2024 107523-002

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FIG. D-4
Sheet 1 of 2

FIG. D-4
Sheet 1 of 2

Photo 2: Paintbrush Road. Low extent and medium severity transverse cracking. Photo looking west.

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Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
PAINTBRUSH ROAD

September 2024 107523-002

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FIG. D-4
Sheet 2 of 2

FIG. D-4
Sheet 2 of 2

Photo 1: Coopers Hawk Road near intersection with Paintbrush Road. Low extent and low to medium severity transverse cracking. Photo looking north.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
COOPERS HAWK ROAD

September 2024 107523-002

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FIG. D-5
Sheet 1 of 2

FIG. D-5
Sheet 1 of 2

Photo 2: Field Operations Center parking at the end of Coopers Hawk Road. Low extent and medium to high severity block cracking. Photo looking west.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
COOPERS HAWK ROAD,
FIELD OPERATIONS CENTER

September 2024 107523-002

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FIG. D-5
Sheet 2 of 2

FIG. D-5
Sheet 2 of 2

Photo 1: Juniper Campground, Abert Squirrel Loop. Low extent and high severity transverse cracking. Photo looking north.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
JUNIPER CAMPGROUND,
ABERT SQUIRREL LOOP

September 2024 107523-002

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FIG. D-6
Sheet 1 of 3

FIG. D-6
Sheet 1 of 3

Photo 2: Juniper Campground, Black Bear Loop. Low extent and high severity transverse cracking. Low to medium severity edge cracking. Photo looking south.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
JUNIPER CAMPGROUND,
BLACK BEAR LOOP

September 2024 107523-002

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FIG. D-6
Sheet 2 of 3

FIG. D-6
Sheet 2 of 3

Photo 3: Juniper Campground, Coyote Loop. High extent and medium to high severity transverse cracking. Photo looking north.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
JUNIPER CAMPGROUND,
COYOTE LOOP

September 2024 107523-002

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FIG. D-6
Sheet 3 of 3

FIG. D-6
Sheet 3 of 3

Photo 1: Amphitheater parking. Low extent and low to medium severity block cracking. Photo looking east.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
AMPHITHEATER PARKING

September 2024 107523-002

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FIG. D-7
Sheet 1 of 1

FIG. D-7
Sheet 1 of 1

Photo 1: Fire Tower Lane parking. High extent and medium to high severity block cracking. Photo looking north.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
FIRE TOWER LANE PARKING

September 2024 107523-002

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FIG. D-8
Sheet 1 of 1

FIG. D-8
Sheet 1 of 1

Photo 1: Agoyo Lane at the intersection with Entrance Road. High extent and low to high severity block cracking. Photo looking south.

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PAVEMENT PHOTOGRAPHS
AGOYO LANE

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FIG. D-9
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FIG. D-9
Sheet 1 of 1

Photo 1: Stonehouse Road, approximately 150 feet southeast of Visitor Center parking and adjacent to Frijoles Canyon maintenance parking. High extent and low to high severity block cracking. Photo looking southeast.

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Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
STONEHOUSE ROAD

September 2024 107523-002

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FIG. D-10
Sheet 1 of 1

FIG. D-10
Sheet 1 of 1

Photo 1: Visitor Center parking. Low to high extent and severity block cracking. Photo looking northeast.

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PAVEMENT PHOTOGRAPHS
VISITOR CENTER PARKING

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FIG. D-11
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FIG. D-11
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Photo 1: Overflow Parking Road located to the west of Visitor Center. No visible pavement distress. Photo looking northwest.

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Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
OVERFLOW PARKING ROAD

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FIG. D-12
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FIG. D-12
Sheet 1 of 1

Photo 1: Frijoles Canyon Maintenance Parking. Medium to high extent and severity block cracking. Photo looking west.

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Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
FRIJOLES CANYON
MAINTENANCE PARKING

September 2024 107523-002

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FIG. D-13
Sheet 1 of 2

FIG. D-13
Sheet 1 of 2

Photo 2: Frijoles Canyon Maintenance Parking. Medium to high extent and severity block cracking. Photo looking southwest.

NPS Bandelier National Monument
Geotechnical Report
Los Alamos and Sandoval Counties, NM

PAVEMENT PHOTOGRAPHS
FRIJOLES CANYON
MAINTENANCE PARKING

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FIG. D-13
Sheet 2 of 2

FIG. D-13
Sheet 2 of 2

APPENDIX E: PAVEMENT DESIGN CALCULATIONS

Appendix E

Pavement Design Calculations

Exhibits

Exhibit E-1: Flexible Pavement 18-kip ESAL Worksheet
Exhibit E-2: Flexible Pavement Design Worksheets

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GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

JOB NAME	NPS Bandelier NM Utility Rehabilitation		JOB NO.	107523-002	
SUBJECT	ESAL Calc		DATE	9/24/2024	
BY	BTM	CHK'D DAA	PAGE	1	OF 1

Shuttle Bus

Assume Total Load = 32 kips

16 kips 16 kips

Flexible Pavement Equivalency Factor (from 1993 AASHTO GDPS, Appendix D)
Say: SN = 2.0, Pt = 2.0
Front and Rear Axle, 15 kips each = **0.598 ESAL per single axle pass**

Shuttle Bus Passes
According to Bandelier NPS website, busses run from June through Oct. (5 months (mo.) of the year)
Assume 16 bus passes per weekday (wk day) and 24 passes on weekends (wkend day)
(busses come every half hr. on wk day & every 20 mins on wkends)
Annual bus passes =
5 mo. x 4 wk/mo. x (16 passes/wk day x 5 wk day/wk + 24 passes/wkend dy x 2 wkend day
= **2,560 bus passes per year**

For 20 year design life with an annual growth rate of 2%, Growth Factor = **24.3**
(growth factor = [(1+r/100)^t-1]/(r/100) where t = traffic projection years and r = growth rate)

Total bus passes for the 20 year pavement design life =
growth factor x bus passes/yr = **62,201 passes**

Shuttle Bus Traffic Loading
= total bus passes x ESAL per single axle pass x number of single axles = **74,393 ESALs**

Garbage Truck

Assume Total Load = 54 kips

20 kips 34 kips

Flexible Pavement Equivalency Factor (from 1993 AASHTO GDPS, Appendix D)
Say: SN = 2.0, Pt = 2.0
Front Single Axle, 20 kips = **1.59 ESAL per single axle pass**
Rear Tandem Axle, 34 kips = **1.07 ESAL per tandem axle pass**

Garbage Truck Passes
Assume one garbage truck pass per week for the entire year

Annual garbage truck passes =
52 wk/yr x 1 pass/wk = **52 garbage truck passes per year**

For 20 year design life with an annual growth rate of 2%, Growth Factor = **24.3**
Total garbage truck passes for the 20 year pavement design life =
growth factor x garbage truck passes/yr = **1,263 passes**

Garbage Truck Loading
= total garbage truck passes x (ESAL per single axle pass x number of single axles +ESAL per tandem axle pass x number of tandem axles) = **3,361 ESALs**

Passenger Vehicles

Flexible Pavement Equivalency Factor (from 1993 AASHTO GDPS, Appendix D)
Say: SN = 2.0, Pt = 2.0
Front and Rear Axle, 2 kips each = **0.0002 ESAL per single axle pass**

Passenger Vehicle Passes
Traffic counts provided by Jacobs. An average annual traffic was calculated for 2022 = **281,050 Vehicles per year**
For 20 year design life with an annual growth rate of 2% starting in 2022 Growth Factor = **24.3**
(growth factor = [(1+r/100)^t-1]/(r/100) where t = traffic projection years and r = growth rate)
t = 20 year design life
Total Vehicle Passes = vehicles per year x growth factor = **6,828,776 passes**
Passenger Vehicle Loading
= total passenger vehicle passes x ESAL per single axle pass x number of axles = **2,732 ESALs**

Total Roadway Loading

Total Roadway Loading = Shuttle Bus Loading + Gargabe Truck Loading + Passenger Vehicle Loading
= 80,485 ESALs
Use 81,000 ESALs for 20 year pavement life

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures (GDPS)
Low volume roadway - Alt. 1, Full Depth Hot Mix Asphalt (HMA)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) — 20.0 years

2. Traffic Loading (W_{18}): ESALs: 50,000 per lane

3. Serviceability:
   - p_0: 4.2 (NMDOT Section 620.7.3)
   - p_t: 2.0 (NMDOT Section 620.7.3)
   - ΔPSI: 2.2

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 — M_R: 10,322 psi

5. Reliability:
   - R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) — Z_R: -0.674

6. Design Standard Deviation (S_o):
   - S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R	
10,322	SN_1: **1.675**
-NA-	SN_2: **-NA-**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2				
3				

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	4.0 inches	1.760	1.675
2		inches		
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures
Low volume roadway - Alt. 2, Hot Mix Asphalt (HMA) over Aggregate Base Course (ABC)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) — 20.0 years

2. Traffic Loading (W_{18}): — ESALs: 50,000 per lane

3. Serviceability:
   - p_0: 4.2 (NMDOT Section 620.7.3)
   - p_t: 2.0 (NMDOT Section 620.7.3)
   - ΔPSI: 2.2

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 — M_R: 10,322 psi

5. Reliability:
   - R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) — Z_R: -0.674

6. Design Standard Deviation (S_o):
   - S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R		
25,000	SN_1:	**1.144**
10,322	SN_2:	**1.675**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients		Drainage Coefficients		Layer Modulus (psi)
1	HMA	a_1:	0.44	-		-
2	ABC	a_2:	0.11	m_2:	1.00	25,000
3		a_3:		m_3:		

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	3.0 inches	1.320	1.144
2	ABC	4.0 inches	1.760	1.675
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures
Low volume roadway - Alt. 3, Hot Mix Asphalt (HMA) over Full Depth Reclamation (FDR)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) — 20.0 years

2. Traffic Loading (W_{18}): ESALs: 50,000 per lane

3. Serviceability:
   - p_0: 4.2 (NMDOT Section 620.7.3)
   - p_t: 2.0 (NMDOT Section 620.7.3)
   - ΔPSI: 2.2

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 — M_R: 10,322 psi

5. Reliability:
   - R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) — Z_R: -0.674

6. Design Standard Deviation (S_o):
   - S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R		
30,000	SN_1:	**1.049**
10,322	SN_2:	**1.675**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	FDR	a_2: 0.11	m_2: 1.00	30,000
3		a_3:	m_3:	

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	3.0 inches	1.320	1.049
2	FDR	5.0 inches	1.870	1.675
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures (GDPS)
Alt. 1, Full Depth Hot Mix Asphalt (HMA)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) 20.0 years

2. Traffic Loading (W_{18}): ESALs: 81,000 per lane

3. Serviceability:
   p_0: 4.2 (NMDOT Section 620.7.3) ΔPSI: 2.2
   p_t: 2.0 (NMDOT Section 620.7.3)

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 M_R: 10,322 psi

5. Reliability:
   R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) Z_R: -0.674

6. Design Standard Deviation (S_o):
   S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R		
10,322	SN_1:	**1.827**
-NA-	SN_2:	**-NA-**
-NA-	SN_3:	**-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2				
3				

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	4.5 inches	1.980	1.827
2		inches		
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures
Alt. 2, Hot Mix Asphalt (HMA) over Aggregate Base Course (ABC)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) 20.0 years

2. Traffic Loading (W_{18}): ESALs: 81,000 per lane

3. Serviceability:
   p_0: 4.2 (NMDOT Section 620.7.3)
   p_t: 2.0 (NMDOT Section 620.7.3)
   ΔPSI: 2.2

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 M_R: 10,322 psi

5. Reliability:
   R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) Z_R: -0.674

6. Design Standard Deviation (S_o):
   S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R	
25,000	SN_1: **1.264**
10,322	SN_2: **1.827**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	ABC	a_2: 0.11	m_2: 1.00	25,000
3		a_3:	m_3:	

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	3.5 inches	1.540	1.264
2	ABC	4.0 inches	1.980	1.827
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

Flexible Pavement Design Worksheet

Job No.: 107523-002

Location: Bandelier National Monument, New Mexico

Comment: Analysis follows design procedures form 1993 AASHTO Guide for Design of Pavement Structures
Alt. 3, Hot Mix Asphalt (HMA) over Full Depth Reclamation (FDR)

1. Pavement Design Life: (NMDOT Exhibit 620-3, Reconstruction) 20.0 years

2. Traffic Loading (W_{18}): ESALs: 81,000 per lane

3. Serviceability:
   p_0: 4.2 (NMDOT Section 620.7.3)
   p_t: 2.0 (NMDOT Section 620.7.3)
   ΔPSI: 2.2

4. Subgrade Resilient Modulus (M_R):

City of Albequerque Development Process Manual (2020) - M_R Correlation (Table 7.4.49)

R-value 45.0 M_R: 10,322 psi

5. Reliability:
   R: 75 % (NMDOT Section 620-4, National Highway System w/ <15% Trucks) Z_R: -0.674

6. Design Standard Deviation (S_o):
   S_o: 0.49 (1993 AASHTO GDPS)

7. Required Structural Numbers (SN_i):

Analysis M_R	
30,000	SN_1: **1.163**
10,322	SN_2: **1.827**
-NA-	SN_3: **-NA-**

$$\log_{10}(W_{18}) = Z_R\ S_o + 9.36\ \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left[\frac{\Delta PSI}{4.2-1.5}\right]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32\ \log_{10}(M_R) - 8.07$$

Layer Analysis

8. Pavement Materials Characterization:

Layer	Material	Structural Layer Coefficients	Drainage Coefficients	Layer Modulus (psi)
1	HMA	a_1: 0.44	-	-
2	FDR	a_2: 0.11	m_2: 1.00	30,000
3		a_3:	m_3:	

9. Solutions for Thicknesses: [Figure 3.2, Part II of 1993 AASHTO]

$SN^*_1 = a_1D^*_1 >= SN_1$

$SN^*_2 = a_1D^*_1 + a_2D^*_2m_2 >= SN_2$

$SN^*_3 = a_1D^*_1 + a_2D^*_2m_2 + a_3D^*_3m_3 >= SN_3$

Recommended Thicknesses				
Layer	Material	Thickness (D^*_i)	SN^*_i	SN_i
1	HMA	3.0 inches	1.320	1.163
2	FDR	6.0 inches	1.980	1.827
3		inches		

Note: Required SN <= Pavement SN, Design is Acceptable

IMPORTANT INFORMATION

Important Information

About Your Geotechnical Report

IMPORTANT INFORMATION

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors that were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining

IMPORTANT INFORMATION

your consultant to observe subsurface construction operations can be particularly beneficial in this respect.

A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary, because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims

being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports, and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland