# GEOTECHNICAL INVESTIGATION

## US-50 & WARRIOR WAY SIGNAL POLE FOUNDATION
## ZEPHYR COVE, NEVADA

EA 74194

JULY 2021


| **NEVADA DEPARTMENT OF TRANSPORTATION** | MATERIALS DIVISION |
| GEOTECHNICAL SECTION | 1263 STEWART ST, CARSON CITY, NEVADA 89712 |

# STATE OF NEVADA

# DEPARTMENT OF TRANSPORTATION

## MATERIALS DIVISION

## GEOTECHNICAL SECTION

**GEOTECHNICAL INVESTIGATION**

**US-50 AND WARRIOR WAY SIGNAL POLE FOUNDATION**

**ZEPHYR COVE, NEVADA**

**JULY 2021**

**EA 74194**


Prepared by: George Helgerson

George Helgerson, P.E.
Geotechnical Engineer

Reviewed by: _____

Kyle Jermstad, P.E.
Principal Geotechnical Engineer

Reviewed by: _____

Mike Griswold, P.E.
Chief Geotechnical Engineer

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# 1. Introduction

The Nevada Department of Transportation (NDOT) plans to place a signal pole at the intersection of US-50 and Warrior Way. This report presents the findings and recommendations developed from our geotechnical engineering investigation for the proposed signal pole drilled shaft foundation. The investigation was conducted in accordance with American Association of State Highway and Traffic Administration (AASHTO) and Federal Highway Administration (FHWA) guidelines.

## 1.1 Project Description

It is our understanding that this project consists of placing a non-standard signal pole in the Northwest corner of US-50 and Warrior Way intersection. This signal pole will have a drilled shaft foundation.

The project Vicinity Map and Exploration Map are shown in Appendix A on Figures A-1 and A-2, respectively.

## 1.2 Purpose and Scope of Work

The purpose of this investigation was to evaluate the suitability of the project site from a geotechnical perspective, for the proposed drilled shaft. The main objectives of the investigation were to characterize the subsurface materials, perform engineering analyses, develop geotechnical recommendations for design and construction, and document our findings, and recommendations in this report.

The scope of our geotechnical investigation includes the following:

- A review of published geologic and geotechnical information pertaining to the site vicinity;
- A field exploration consisting of drilling one boring to a maximum depth of 44½ feet below ground surface (bgs) to obtain information to evaluate the subsurface conditions;
- Perform geotechnical laboratory testing on select soil samples collected from the borings;
- Perform engineering analyses to develop geotechnical design criteria and recommendations for the proposed project; and
- Preparation of this report.

## 1.3 Limitations

This report has been prepared by Nevada Department of Transportation (NDOT) Geotechnical Section under the supervision of those whose signatures appear herein. The interpretation of data, findings, and recommendations presented in this report were developed from our geotechnical investigation.

If the proposed project is modified or relocated, or if the subsurface conditions found during construction differ from those described in this report, NDOT Geotechnical Section should be contacted immediately to assess the new information or changed conditions and determine if additional recommendations are required.

# 2. Field Exploration and Laboratory Testing

## 2.1 Field Exploration

The boring was drilled on June 2, 2021 at the approximate locations shown on Figure A-2. The boring was advanced to a depth of approximately 44½ feet bgs utilizing a truck-mounted Diedrich D-120 (NDOT 1627) drill rig. Drilling method used was mud rotary utilizing a 3-inch tri-cone bit. Samples were collected using Modified California (3-inch outer diameter) and Standard Penetration Test samplers driven by an automatic hammer with a weight of 140 pounds and a drop of 30 inches.

The number of blows required to drive the sampler 6-inches were recorded for the 18-inch drive and are presented in the boring log. The blow counts presented in the log are uncorrected and are shown as they were recorded in the field. Normalizing the blow counts for use in analysis was performed utilizing corrections for sampler type, rod length, auger diameter, hammer efficiency, and overburden stress. The samples were visually classified in the field based on the Unified Soil Classification System (USCS) in general accordance with ASTM D2488.

The boring log was prepared based on the field logging and the results of laboratory testing in general accordance with ASTM D2487. The boring log and key are presented in Appendix B.

## 2.2 Geotechnical Laboratory Testing

Laboratory testing was conducted on select soil samples recovered during the field exploration. Tests conducted include the following:

- Method of Test Sieve Analysis of Coarse and Fine Aggregate (Nev. T206);
- Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil (AASHTO T265);
- Standard Method of Test for Direct Shear Test of Soils under Consolidated Drained Conditions (AASHTO T236)
- Standard Test Methods for Laboratory Determination of Density (ASTM D7263);
- Method of Test for Determining The Liquid Limit, Plastic Limit, and Plasticity Index of Soil (Nev. T210, T211, and T212);

Geotechnical laboratory test results are presented in Appendix C.

# 3. Site and Subsurface Conditions

## 3.1 Site Conditions

The intersection of US-50 and Warrior Way is located in Zephyr Cove, Nevada. The site consists of an unsignalized intersection of a five-lane highway (US-50 running North/South) and two-lane local county road (Warrior Way to the East). Currently, Warrior Way does not continue to the West side of US-50, although an approach into Zephyr Cove will be constructed across from Warrior Way.

The site topography generally slopes from the mountain to the East, down to Lake Tahoe on the West. At the time of our exploration, there is forested land with brush on the West and Southeast sides of the intersection. A fire station lies on the Northeast corner of the intersection. There is a small drainage retention basin on the Northwest corner. Overhead utilities were observed and multiple underground utilities were located at the site during our subsurface investigation.

## 3.2 Subsurface Conditions

### 3.2.1 General Geology and Faulting

The site is located in the Sierra Nevada Mountain range, which starts the western portion of the Basin and Range geomorphic province. The site area in the western part of Douglas County is mapped as Felsic phaneritic intrusive rocks being comprised of Granodiorite, granite and related rocks.

There are no active faults mapped within the project vicinity. The latest Quaternary (last 15,000 years) fault is the Genoa fault location 5 miles to the east. The East Tahoe Fault, an undifferentiated quaternary (1.6 million years) fault, lies .4 miles to the east. Other Quaternary faults lie within the Lake Tahoe basin, including the West Tahoe-Dollar Point fault and North Tahoe fault, which are 7 miles to the West and 8 Miles to the Northwest, respectively.

### 3.2.2 Subsurface Materials

The results of our field exploration and laboratory analyses indicate approximately 7 feet of loose clayey sand (SC) beneath the roadbed section. Soil becomes medium dense to dense, silty sand (SM) below 7 feet and continues down to the final depth of the boring. Decomposed granite makes up the majority of the material, with the exception of some plastic fines and trace organics near the top. The soil profile generally becomes more dense with depth, indicating the granite becomes less decomposed.

### 3.2.3 Groundwater Conditions

The drilling method used, along with time constraints, did not allow for a clear assessment of groundwater. Groundwater was anticipated approximately 15 feet deep based on existing well data. Samples collected were moist, but not saturated. This could be due to the absence of groundwater or the decomposed granite in this area is too dense to be permeable by the fluctuating ground water. Due to near by well data, construction methods should consider the possibility of seeping groundwater.

# 4. Recommendations

It is our understanding that the proposed signal pole is to be supported by a 48-inch diameter drilled shaft foundation. Based on the results of this exploration, the site is suitable for the proposed improvements. Provided herein are the recommendations for use in design and construction of the drilled shaft foundations.

## 4.1 Drilled Shaft Foundations

Soil parameters used in the analysis of axial and lateral resistance of the drilled shaft foundations were developed considering the materials encountered in the boring and are presented below in Table 1.

**Table 1 Soil Parameters**

| Layer | | Parameters | |
|---|---|---|---|
| Classification | Depth | Unit Weight (pcf) | Internal Friction Angle Φ (º) |
| Loose Sand (SC) | 0’ – 7.5’ | 124 | 33 |
| Medium Dense Sand (SM) | 7.5’ – 15’ | 130 | 35 |
| Dense Sand (SM) | 15’ – 44.5’ | 133 | 38 |

Design loads were provided by the structural engineer for use in analysis. The loads applied at the head of the drilled shaft are summarized below in Table 2.

**Table 2 Design Loads**

| Axial (lbs) | Moment (ft-lbs) | Shear (lbs) | Torque (ft-lbs) |
|---|---|---|---|
| 6,450 | 191,630 | 5,470 | 165,580 |

The axial resistance of the drilled shaft foundation soils were analyzed in accordance with the 2017 AASHTO LRFD Bridge Design Specifications (AASHTO 2017), using the computer program SHAFT (Ensoft, 2017). The results of the axial resistance analysis are presented in Appendix D. Due to the relatively small axial load and dense cohesionless soils, the estimated settlement is negligible.

Torsional resistance was considered and analyzed with two methods outlined by Colorado and Florida DOT’s. These results are presented in Appendix D along with the axial resistance.

Lateral resistance of the drilled shaft foundation soils were analyzed in accordance with AASHTO 2017, using the computer program LPILE (Ensoft, 2018). The minimum depth to satisfy lateral demands was determined considering methods presented FHWA-HIF-18-031, and NDOT Structures Manual Revision 2019-2. Resistance to posting of short drilled shafts was analyzed utilizing Broms Method as detailed in FHWA-NHI-18-024. The results of the lateral resistance analysis are presented in Appendix E.

Based on the results of our analysis, it is recommended that a 48-inch diameter drilled shaft with a minimum depth of 26 feet be incorporated into the design of the signal pole foundation. Presented below in Table 3 are the recommendations for the drilled shaft foundations.

**Table 3 Drilled Shaft Summary**

| Shaft Diameter (in.) | Minimum Shaft Length to Satisfy Lateral Demands (ft.) | Minimum Shaft Length to Satisfy Axial Demands (ft) | Design Shaft Length (ft.) |
|---|---|---|---|
| 48 | 26 | 6 | 32 |

### 4.1.1 Drilled Shaft Construction

Construction of the drilled shafts should follow the NDOT Standard Specifications for Road and Bridge Construction (Silver Book) section 509.

## 4.2 Seismic Design

The seismic design criteria for the site (39.011734°N, 119.947504°W) were developed utilizing the USGS seismic hazards tool in accordance with AASHTO 2017, considering the site location, and the subsurface information obtained from our geotechnical investigation. Minimum seismic criteria for use in design are listed by county in the NDOT Structures Manual and supersede the USGS mapped values presented below.

**Table 4 Seismic Design Criteria**

| Parameter | USGS Mapped Value | NDOT Structures Manual Value |
|---|---|---|
| Site Class | C | C |
| Peak ground acceleration (PGA) | 0.478 g | 0.5 g |
| Mapped horizontal response spectral response at short period ($S_S$) | 1.162 g | 1.25 g |
| Mapped horizontal response spectral response at 1sec period ($S_1$) | 0.421 g | 0.50 g |
| Peak ground acceleration coefficient ($F_{PGA}$) | 1 | 1 |
| Site coefficient (Fa) | 1 | 1 |
| Site coefficient ($F_V$) | 1.379 | 1.3 |
| Mapped MCE peak ground acceleration ($A_S$) | 0.478 g | 0.5 g |
| Design Spectral Acceleration for short period ($S_{DS}$) | 1.162 g | 1.25 g |
| Design Spectral Acceleration for 1 sec period ($S_{D1}$) | 0.581 g | 0.65 g |

# 5. References


American Association of State Highway and Transportation Officials (AASHTO), 2017, “LRFD Bridge Design Specifications, 8th Edition”

Brown, Dan, et al, 2018, “FHWA-NHI-18-024 Drilled Shafts”

Colorado Department of Transportation Research Branch, 2004, “Drilled Shaft Design For Sound Barrier Walls, Signs, and Signals”

Crafford, A.E.J., 2007, “Geologic Map of Nevada: Geological Survey Data Series 249”

Division of Water Resources, June 23, 2021, Nevada Hydrology Data, http://water.nv.gov/mapping.aspx

Loehr, Erik, et al, 2016, “FHWA NHI-16-072 Geotechnical Site Characterization”

Mayne, W. Paul, et al, 2002, “FHWA-NHI-01-031 Subsurface Investigation Manual”

Nevada Department of Transportation (NDOT), 2008, “Structures Manual”

Nevada Department of Transportation (NDOT), 2019, “Structures Manual Revision”

Nevada Department of Transportation (NDOT), 2014, “Standard Specifications for Road and Bridge Construction”

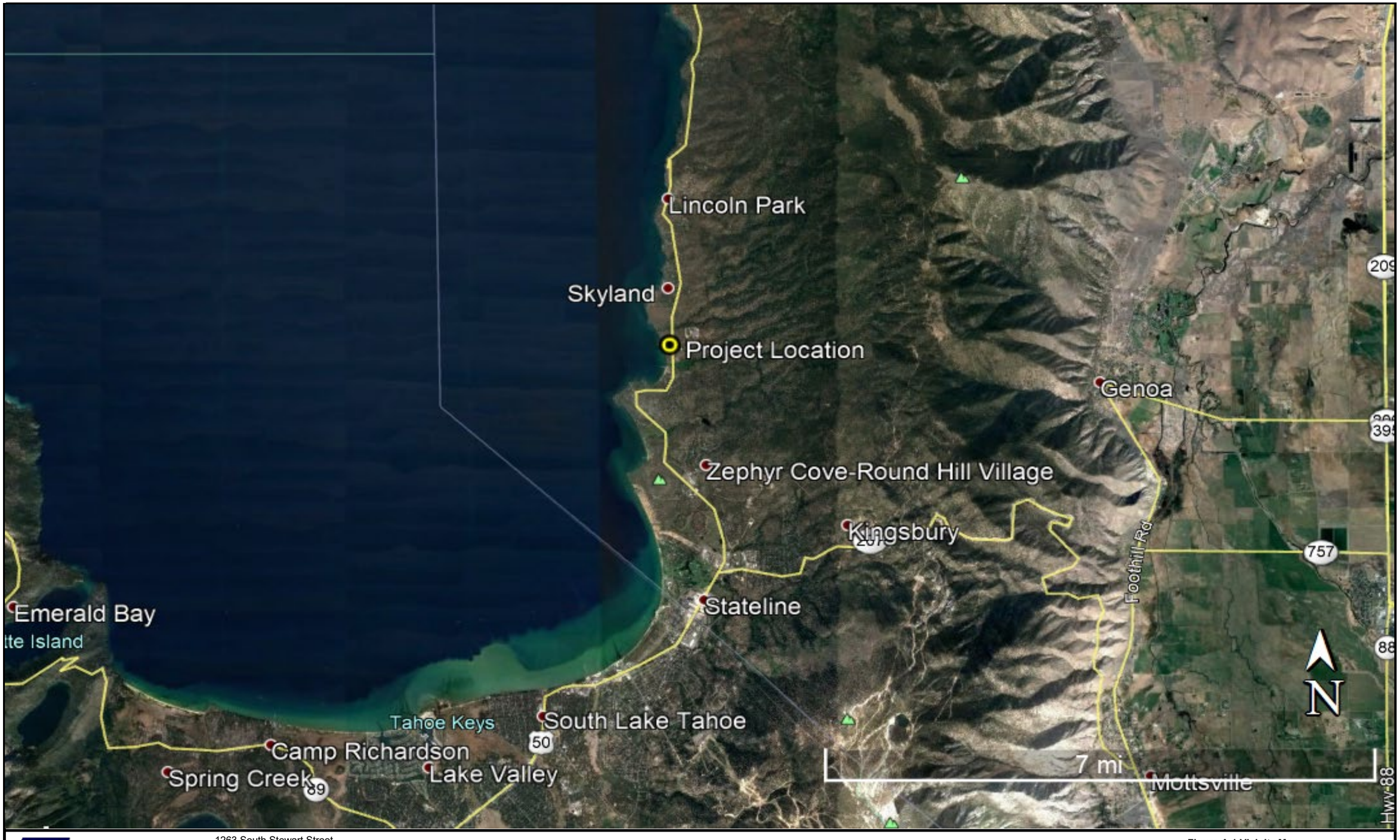
Parkes, James, et al, 2018, “FHWA-HIF-18-031 Design, Analysis, and Testing of Laterally Loaded Deep Foundations that Support Transportation Facilities”

Sabatini, P.J., et al, 2002, “FHWA-IF-02-034 Evaluation of Soil and Rock Properties”

Stewart, John H., and Carlson, John E., 1978, “Geologic map of Nevada, Nevada Bureau of Mines and Geology, scale 1:500,00.”

U.S. Geologic Survey, June 23, 2021, U.S. Seismic Design Maps, https://earthquake.usgs.gov/ws/designmaps/aashto-2009.json?latitude=39.011734&longitude=-119.947504&siteClass=C&title=Warrior%20Way%20

# Appendix A
# Figures





NEVADA DOT

1263 South Stewart Street

Carson City, Nevada 89712

Phone: (775) 888-7440

Fax: (775) 888-7201


**Figure A-1 Vicinity Map**

Location: Zephyr Cove, NV

Project Name: US50 & Warrior Way

EA Number: 74194


NEVADA DOT
1263 South Stewart Street
Carson City, Nevada 89712
Phone: (775) 888-7440
Fax: (775) 888-7201

**Figure A-2 Exploration Map**

Location: Zephyr Cove, NV

Project Name: US50 & Warrior Way

EA Number: 74194

# Appendix B
# Logs of Borings

# KEY TO BORING LOGS

| PARTICLE SIZE LIMITS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CLAY | SILT | SAND | | | GRAVEL | | COBBLES | BOULDERS |
| | | FINE | MEDIUM | COARSE | FINE | COARSE | | |
| .002 mm | | #200 | #40 | #10 | #4 | ¾ inch | 3 inch | 12 inch |

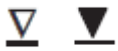
| USCS GROUP | TYPICAL SOIL DESCRIPTION |
|---|---|
| GW | Well graded gravels, gravel-sand mixtures, little or no fines |
| GP | Poorly graded gravels, gravel-sand mixtures, little or no fines |
| GC | Clayey gravels, poorly graded gravel-sand-clay mixtures |
| SW | Well graded sands, gravelly sands, little or no fines |
| SP | Poorly graded sands, gravelly sands, little or no fines |
| SM | Silty sands, poorly graded sand-silt mixtures |
| SC | Clayey sands, poorly graded sand-clay mixtures |
| ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity |
| CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays |
| OL | Organic silts and organic silt-clays of low plasticity |
| MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts |
| CH | Inorganic clays of high plasticity, fat clays |
| OH | Organic clays of medium to high plasticity |
| CS | Claystone/Siltstone |
| PT | Peat and other highly organic soils |

**MOISTURE CONDITION CRITERIA**

| Description | Criteria |
|---|---|
| Dry | Absence of moisture, dusty, dry to touch. |
| Moist | Damp, no visible free water. |
| Wet | Visible free water, usually below groundwater table. |

**SOIL CEMENTATION CRITERIA**

| Description | Criteria |
|---|---|
| Weak | Crumbles or breaks with handling or little finger pressure. |
| Moderate | Crumbles or breaks with considerable finger pressure |
| Strong | Won't break or crumble w/finger pressure |



Groundwater Elevation Symbols

| STANDARD PENETRATION CLASSIFICATION* | | | |
|---|---|---|---|
| GRANULAR SOIL | | CLAYEY SOIL | |
| BLOWS/FT | DENSITY | BLOWS/FT | CONSISTENCY |
| 0 - 4 | VERY LOOSE | 0 - 1 | VERY SOFT |
| 5 – 10 | LOOSE | 2 - 4 | SOFT |
| 11 - 30 | MEDIUM DENSE | 5 - 8 | MEDIUM STIFF |
| 31 - 50 | DENSE | 9 - 15 | STIFF |
| OVER 50 | VERY DENSE | 16 - 30 | VERY STIFF |
| | | 31 - 60 | HARD |
| | | OVER 60 | VERY HARD |

*Standard Penetration Test (N) 140 lb hammer
30-inch free fall on 2-inch O.D. x 1.4 inch I.D. sampler.

Blow counts on Calif. Modified Sampler ($N_{CMS}$) can be converted to $N_{SPT}$ by:

$(N_{CMS})(0.62) = N_{SPT}$

Automatic Hammer Engergy:
Rig # 1627: 82.5%
Rig # 1082: 84%

## TEST ABBREVIATIONS

CD CONSOLIDATED DRAINED
CH CHEMICAL (CORROSIVENESS)
CM COMPACTION
CU CONSOLIDATED UNDRAINED
D DISPERSIVE SOILS
DS DIRECT SHEAR
E EXPANSIVE SOIL
G SPECIFIC GRAVITY
H HYDROMETER
HC HYDRO-COLLAPSE
K PERMEABILITY
O ORGANIC CONTENT
OC CONSOLIDATION
PI PLASTICITY INDEX
RQD ROCK QUALITY DESIGNATION
RV R-VALUE
S SIEVE ANALYSIS
SL SHRINKAGE LIMIT
U UNCONFINED COMPRESSION
UU UNCONSOLIDATED UNDRAINED
UW UNIT WEIGHT
W MOISTURE CONTENT

SOIL COLOR DESIGNATIONS ARE FROM THE MUNSELL SOIL COLOR CHART.
EXAMPLE: (7.5 YR 5/3) BROWN

## SAMPLER NOTATION

CMS CALIF. MODIFIED SAMPLER[1]
CPT CONE PENETRATION TEST
CS CONTINUOUS SAMPLER[2]
CSS CALIFORNIA SPLIT SPOON
P PUSHED (NOT DRIVEN)
PB PITCHER BARREL
RC ROCK CORE[3]
SH SHELBY TUBE[4]
SPT STANDARD PENETRATION TEST
TP TEST PIT

1- I.D.= 2.421 inch
2- I.D.=3.228 inch with tube; 3.50 inch w/o tube
3- NXB I.D.= 1.875 inch
4- I.D.= 2.875 inch

Revised June 2018

# BORING LOG



Materials Division
Geotechnical Section
1263 S. Stewart St
Carson City, NV 89712

| | | | |
|---|---|---|---|
| START DATE | 6/2/21 | LATITUDE | 39.011734 |
| END DATE | 6/2/21 | LONGITUDE | 119.947504 |
| PROJECT | US-50 and Warrior Way Signal Boring | ENGINEER | G. Helgerson |
| LOCATION | Zephyr Cove, NV | OPERATOR | W. Marshall |
| E.A. # | 74194 | DRILL RIG | Diedrich D-120 (1627) |
| BORING | B-1 | METHOD | Mud Rotary |
| GROUND ELEV. ft | 6266.0 | HAMMER | Automatic |
| TOTAL DEPTH ft | 44.5 | BACKFILLED | Yes DATE 6/2/2021 |

| GROUNDWATER LEVEL | | | |
|---|---|---|---|
| DATE | TIME | DEPTH ft | ELEV. ft |
| | | | |
| | | | |

| ELEV. (ft) | DEPTH (ft) | SAMPLE NO. | TYPE | BLOWS / 6" | Uncorrected N Value | Recovery (%) | MOISTURE CONTENT (%) | DRY DENSITY (pcf) | % PASSING NO.4 | % PASSING NO.200 | LIQUID LIMIT | PLASTICITY INDEX | GRAPHIC LOG | MATERIAL DESCRIPTION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6265.0 | 1 | | | | | | | | | | | | AC | Approx. 8" Asphalt | |
| | | | | | | | | | | | | | AB | Approx. 6" Aggregate Base | |
| 6264.0 | 2 | | | | | | | | | | | | | Dark brown clayey SAND (SW), fine-to coarse-grained, trace sub-rounded fine gravel, slight plasticity, moist, loose | |
| 6263.0 | 3 | | | | | | | | | | | | | | |
| 6262.0 | 4 | | | | | | | | | | | | SC | | |
| 6261.0 | 5 | 1 | | 6<br>4<br>4 | 8 | 72 | 17 | | 99 | 31 | 26 | 9 | | | |
| 6260.0 | 6 | | | | | | | | | | | | | | |
| 6259.0 | 7 | | | | | | | | | | | | | | |
| 6258.0 | 8 | 2 | | 11<br>15<br>19 | 34 | 100 | 16.8<br>11.9 | 106.4<br>107.9 | 99 | 21 | 29 | 4 | | Brown silty SAND (SC), fine-to coarse-grained, moist, dense | |
| 6257.0 | 9 | | | | | | | | | | | | | | |
| 6256.0 | 10 | 3 | | 7<br>8<br>9 | 17 | 78 | 16 | | 99 | 25 | 28 | 5 | | Slight mottling, color includes redish brown, becomes medium dense | |
| 6255.0 | 11 | | | | | | | | | | | | | | |
| 6254.0 | 12 | | | | | | | | | | | | SM | | |
| 6253.0 | 13 | | | | | | | | | | | | | | |
| 6252.0 | 14 | | | | | | | | | | | | | | |
| 6251.0 | 15 | 4 | | 21<br>42<br>Refusal | | 100 | 12.1<br>10.8<br>8.1 | 120.3<br>122.9 | 100<br>99.2 | 16.6<br>15.8 | 24 | NP | | Less fines, becomes gray and brown with some red mottling, becomes very dense | |

Standard Penetration Test | Modified California Sampler | Ashpalt | Aggregate Base | USCS Clayey Sand | USCS Silty Sand

SMART SOIL LOG 74194 WARRIOR WAY.GPJ NDOT SMART LOG 2018.10.10.GDT 6/28/21

# BORING LOG

Materials Division
Geotechnical Section
1263 S. Stewart St
Carson City, NV 89712

| | | | |
|---|---|---|---|
| START DATE | 6/2/21 | LATITUDE | 39.011734 |
| END DATE | 6/2/21 | LONGITUDE | 119.947504 |
| PROJECT | US-50 and Warrior Way Signal Boring | ENGINEER | G. Helgerson |
| LOCATION | Zephyr Cove, NV | OPERATOR | W. Marshall |
| E.A. # | 74194 | DRILL RIG | Diedrich D-120 (1627) |
| BORING | B-1 | METHOD | Mud Rotary |
| GROUND ELEV. ft | 6266.0 | HAMMER | Automatic |
| TOTAL DEPTH ft | 44.5 | BACKFILLED | Yes DATE 6/2/2021 |

| GROUNDWATER LEVEL | | | |
|---|---|---|---|
| DATE | TIME | DEPTH ft | ELEV. ft |
| | | | |
| | | | |

| ELEV. (ft) | DEPTH (ft) | SAMPLE NO. | TYPE | BLOWS / 6" | Uncorrected N Value | Recovery (%) | MOISTURE CONTENT (%) | DRY DENSITY (pcf) | % PASSING NO.4 | % PASSING NO.200 | LIQUID LIMIT | PLASTICITY INDEX | GRAPHIC LOG | MATERIAL DESCRIPTION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6249.0 | 17 | | | | | | | | | | | | | Grayish brown silty SAND (SC), fine-to coarse-grained, moist, dense, some mottling | 400 psi drill pressure |
| 6248.0 | 18 | | | | | | | | | | | | | | 500 psi drill pressure for the rest of the boring |
| 6247.0 | 19 | | | | | | | | | | | | | | |
| 6246.0 | 20 | 5 | | 49<br>52<br>54 | 106 | 83 | 8 | | 99 | 17 | | | | Color becomes white and black with brown, trace mottling | |
| 6245.0 | 21 | | | | | | | | | | | | | | |
| 6244.0 | 22 | | | | | | | | | | | | | | |
| 6243.0 | 23 | | | | | | | | | | | | | | |
| 6242.0 | 24 | | | | | | | | | | | | SM | | |
| | | 6A | | Refusal | | 100 | 9 | | 99 | 19 | | | | CM refusal, chased with SPT | |
| 6241.0 | 25 | 6B | | Refusal | | 100 | | | | | | | | | |
| 6240.0 | 26 | | | | | | | | | | | | | | |
| 6239.0 | 27 | | | | | | | | | | | | | | |
| 6238.0 | 28 | | | | | | | | | | | | | | |
| 6237.0 | 29 | | | | | | | | | | | | | | |
| 6236.0 | 30 | 7 | | Refusal | | 100 | 12 | | | | | | | More white and black coloring | |
| 6235.0 | 31 | | | | | | | | | | | | | | |

Standard Penetration Test | Modified California Sampler | Ashpalt | Aggregate Base | USCS Clayey Sand | USCS Silty Sand

SMART SOIL LOG 74194 WARRIOR WAY.GPJ NDOT SMART LOG 2018.10.10.GDT 6/28/21

# BORING LOG

Materials Division
Geotechnical Section
1263 S. Stewart St
Carson City, NV 89712

| | |
|---|---|
| START DATE | 6/2/21 |
| END DATE | 6/2/21 |
| PROJECT | US-50 and Warrior Way Signal Boring |
| LOCATION | Zephyr Cove, NV |
| E.A. # | 74194 |
| BORING | B-1 |
| GROUND ELEV. ft | 6266.0 |
| TOTAL DEPTH ft | 44.5 |

| GROUNDWATER LEVEL | | | |
|---|---|---|---|
| DATE | TIME | DEPTH ft | ELEV. ft |
| | | | |
| | | | |

| | |
|---|---|
| LATITUDE | 39.011734 |
| LONGITUDE | 119.947504 |
| ENGINEER | G. Helgerson |
| OPERATOR | W. Marshall |
| DRILL RIG | Diedrich D-120 (1627) |
| METHOD | Mud Rotary |
| HAMMER | Automatic |
| BACKFILLED | Yes DATE 6/2/2021 |

| ELEV. (ft) | DEPTH (ft) | SAMPLE NO. | TYPE | BLOWS / 6" | Uncorrected N Value | Recovery (%) | MOISTURE CONTENT (%) | DRY DENSITY (pcf) | % PASSING NO.4 | % PASSING NO.200 | LIQUID LIMIT | PLASTICITY INDEX | GRAPHIC LOG | MATERIAL DESCRIPTION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6233.0 | 33 | | | | | | | | | | | | | White to black silty SAND (SC), fine-to coarse-grained, moist, dense | |
| 6232.0 | 34 | | | | | | | | | | | | | | Some rig chatter |
| | | 8 | | Refusal | | 100 | 11 | | | | | | | | |
| 6231.0 | 35 | | | | | | | | | | | | | | |
| 6230.0 | 36 | | | | | | | | | | | | | | Approx. 2 min/ft drill rate |
| 6229.0 | 37 | | | | | | | | | | | | | | |
| 6228.0 | 38 | | | | | | | | | | | | SM | | |
| 6227.0 | 39 | | | | | | | | | | | | | | |
| | | 9 | | Refusal | | 100 | 10 | | | | | | | | |
| 6226.0 | 40 | | | | | | | | | | | | | | |
| 6225.0 | 41 | | | | | | | | | | | | | | Approx. 4 min/ft drill rate |
| 6224.0 | 42 | | | | | | | | | | | | | | |
| 6223.0 | 43 | | | | | | | | | | | | | | |
| 6222.0 | 44 | | | | | | | | | | | | | | |
| | | 10 | | Refusal | | 0 | | | | | | | | Boring terminated at 44.5 feet. Groundwater level not measured due to drilling fluid. | |
| 6221.0 | 45 | | | | | | | | | | | | | | |
| 6220.0 | 46 | | | | | | | | | | | | | | |
| 6219.0 | 47 | | | | | | | | | | | | | | |

Standard Penetration Test | Modified California Sampler | Ashpalt | Aggregate Base | USCS Clayey Sand | USCS Silty Sand

SMART SOIL LOG 74194 WARRIOR WAY.GPJ NDOT SMART LOG 2018.10.10.GDT 6/28/21

# Appendix C
# Laboratory Test Results

# SUMMARY OF RESULTS
# N.D.O.T. GEOTECHNICAL SECTION

**EA/Cont #** 74194 **Job Description** US 50& Warrior Way Signal Foundation Boring

**Boring No.** B1 **Elevation (ft)** 6265 **Station** **Date** 6/2/2021

| SAMPLE NO. | SAMPLE DEPTH (ft) | SAMP-LER TYPE | N BLOWS per ft. | SOIL GROUP | W% | DRY UW pcf | % PASS #200 | LL % | PL % | PI % | STRENGTH TEST | | | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | TEST TYPE | Φ deg. (Peak) | C psi (Peak) | Φ deg. (Residual) | C psi (Residual) | |
| 1 | 4.5 - 6.0 | SPT | 8 | SC | 16.5 | | 30.6 | 26 | 17 | 9 | | | | | | |
| 2B | 8.0 - 8.5 | CMS | 34 | | 16.8 | 106.4 | | 29 | 25 | 4 | DS | 45 | 2.2 | 35 | 0.9 | |
| 2C | 8.5 - 9.0 | CMS | | SM | 11.9 | 107.9 | 20.6 | 27 | 23 | 4 | | | | | | |
| 3 | 9.5 - 11.0 | SPT | 17 | SM | 15.5 | | 25.0 | 28 | 23 | 5 | | | | | | |
| 4B | 15.0 - 15.5 | CMS | R | | 12.1 | 120.3 | 16.6 | | | | DS | 43 | 8.5 | 38 | 2.2 | |
| 4C | 15.5 - 16.0 | CMS | | SM | 10.8 | 122.9 | 15.8 | 17 | NP | NP | | | | | | |
| 4S | 19.5 - 21.0 | SPT | 106 | | 8.1 | | | 24 | NP | NP | | | | | | |
| 5 | 19.5 - 21.0 | SPT | R | | 7.7 | | 16.5 | | | | | | | | | |
| 6 | 24.5 - 25.0 | SPT | R | | 8.8 | | 18.9 | | | | | | | | | |
| 7 | 29.5 - 29.7 | SPT | R | | 12.0 | | | | | | | | | | | |
| 8 | 34.5 - 34.7 | SPT | R | | 11.3 | | | | | | | | | | | |
| 9 | 39.5 - 39.7 | SPT | R | | 9.6 | | | | | | | | | | | |

CMS = California Modified Sampler 2.42" ID
SPT = Standard Penetration 1.38" ID
CS = Continuous Sample 3.23" ID
RC = Rock Core
PB = Pitcher Barrel
CSS = Calif. Split Spoon 2.42" ID
CPT = Cone Penetration Test
TP = Test Pit
P = Pushed, not driven
R = Refusal
Sh = Shelby Tube 2.87" ID

U = Unconfined Compressive
UU = Unconsolidated Undrained
CD = Consolidated Drained
CU = Consolidated Undrained
DS = Direct Shear
Φ = Friction
C = Cohesion
N = No. of blows per ft., sampler

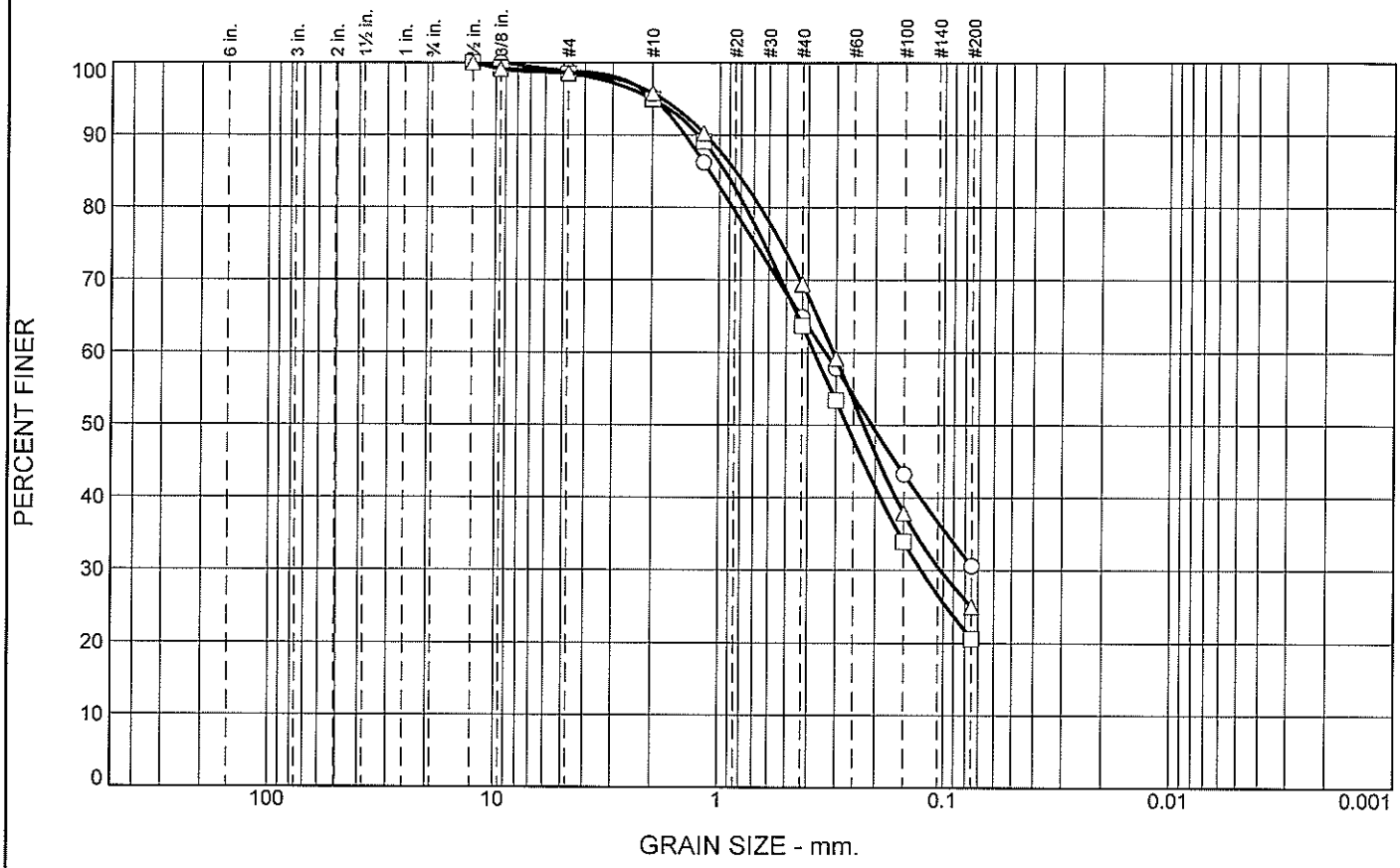
N = Field SPT $N = (N_{css})(0.62)$

H = Hydrometer
S = Sieve
G = Specific Gravity
PI = Plasticity Index
LL = Liquid Limit
PL = Plastic Limit
NP = Non-Plastic
OC = Consolidation
Ch = Chemical
RV = R - Value
MD = Moisture Density

CM = Compaction
E = Swell/Pressure on Expansive Soils
SL = Shrinkage Limit
UW= Unit Weight
W = Moisture Content
K = Permeability
O = Organic Content
D = Dispersive
RQD = Rock Quality Designation
X = X-Ray Defraction
HCpot = Hydro-Collapse Potential

*** = Average of subsamples**

# Particle Size Distribution Report




| | +3" | % GRAVEL | % SAND | % SILT | % CLAY | USCS | AASHTO | PL | LL |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 0.0 | 1.1 | 68.3 | 30.6 | | SC | A-2-4(0) | 17 | 26 |
| □ | 0.0 | 1.5 | 77.9 | 20.6 | | SM | A-2-4(0) | 23 | 27 |
| △ | 0.0 | 1.4 | 73.6 | 25.0 | | SM | A-2-4(0) | 23 | 28 |

| SIEVE inches size | PERCENT FINER ○ | □ | △ |
|---|---|---|---|
| 1/2" | | 100.0 | 100.0 |
| 3/8" | 100.0 | 99.3 | 99.1 |
| | GRAIN SIZE | | |
| $D_{60}$ | 0.3335 | 0.3746 | 0.3078 |
| $D_{30}$ | | 0.1253 | 0.1025 |
| $D_{10}$ | | | |
| | COEFFICIENTS | | |
| $C_c$ | | | |
| $C_u$ | | | |

| SIEVE number size | PERCENT FINER ○ | □ | △ |
|---|---|---|---|
| #4 | 98.9 | 98.5 | 98.6 |
| #10 | 95.2 | 94.9 | 95.8 |
| #16 | 86.2 | 89.1 | 90.3 |
| #40 | 64.9 | 63.7 | 69.5 |
| #50 | 57.8 | 53.4 | 59.2 |
| #100 | 43.3 | 34.0 | 37.9 |
| #200 | 30.6 | 20.6 | 25.0 |

Material Description
○ clayey sand
□ silty sand
△ silty sand

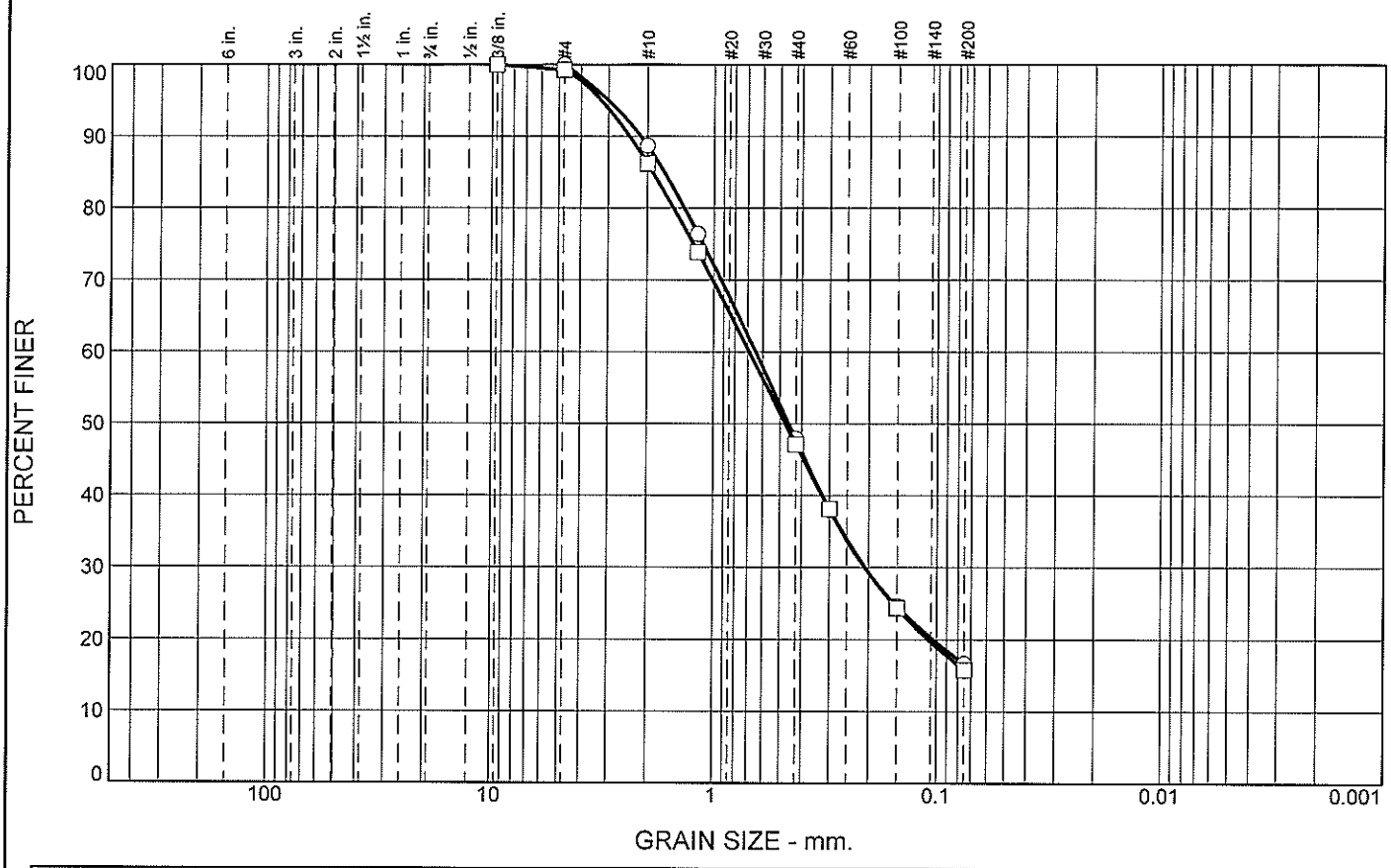
REMARKS:
○
□
△

○ Source of Sample: B1 Depth: 4.5' - 6.0' Sample Number: 1
□ Source of Sample: B1 Depth: 8.5' - 9.0' Sample Number: 2C
△ Source of Sample: B1 Depth: 9.5' - 11.0' Sample Number: 3

**NEVADA DEPARTMENT OF TRANSPORTATION**

Client: G. Helgerson
Project: US 50 & Warrior Way Signal Foundation
Project No.: EA 74194
Figure

# Particle Size Distribution Report




| | +3" | % GRAVEL | % SAND | % SILT | % CLAY | USCS | AASHTO | PL | LL |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 0.0 | 0.0 | 83.4 | 16.6 | | | | | |
| □ | 0.0 | 0.8 | 83.4 | 15.8 | | SM | A-1-b | NP | 17 |
| | | | | | | | | | |

| SIEVE inches size | PERCENT FINER ○ | □ | |
|---|---|---|---|
| 3/8" | | 100.0 | |
| | GRAIN SIZE | | |
| $D_{60}$ | 0.6460 | 0.6893 | |
| $D_{30}$ | 0.2084 | 0.2070 | |
| $D_{10}$ | | | |
| | COEFFICIENTS | | |
| $C_c$ | | | |
| $C_u$ | | | |

| SIEVE number size | PERCENT FINER ○ | □ | |
|---|---|---|---|
| #4 | 100.0 | 99.2 | |
| #10 | 88.7 | 86.2 | |
| #16 | 76.4 | 73.9 | |
| #40 | 47.9 | 47.1 | |
| #50 | 38.1 | 38.1 | |
| #100 | 24.6 | 24.4 | |
| #200 | 16.6 | 15.8 | |

Material Description

○

□ silty sand

REMARKS:

○

□

○ Source of Sample: B1 Depth: 15.0' - 15.5' Sample Number: 4B

□ Source of Sample: B1 Depth: 15.5' - 16.0' Sample Number: 4C

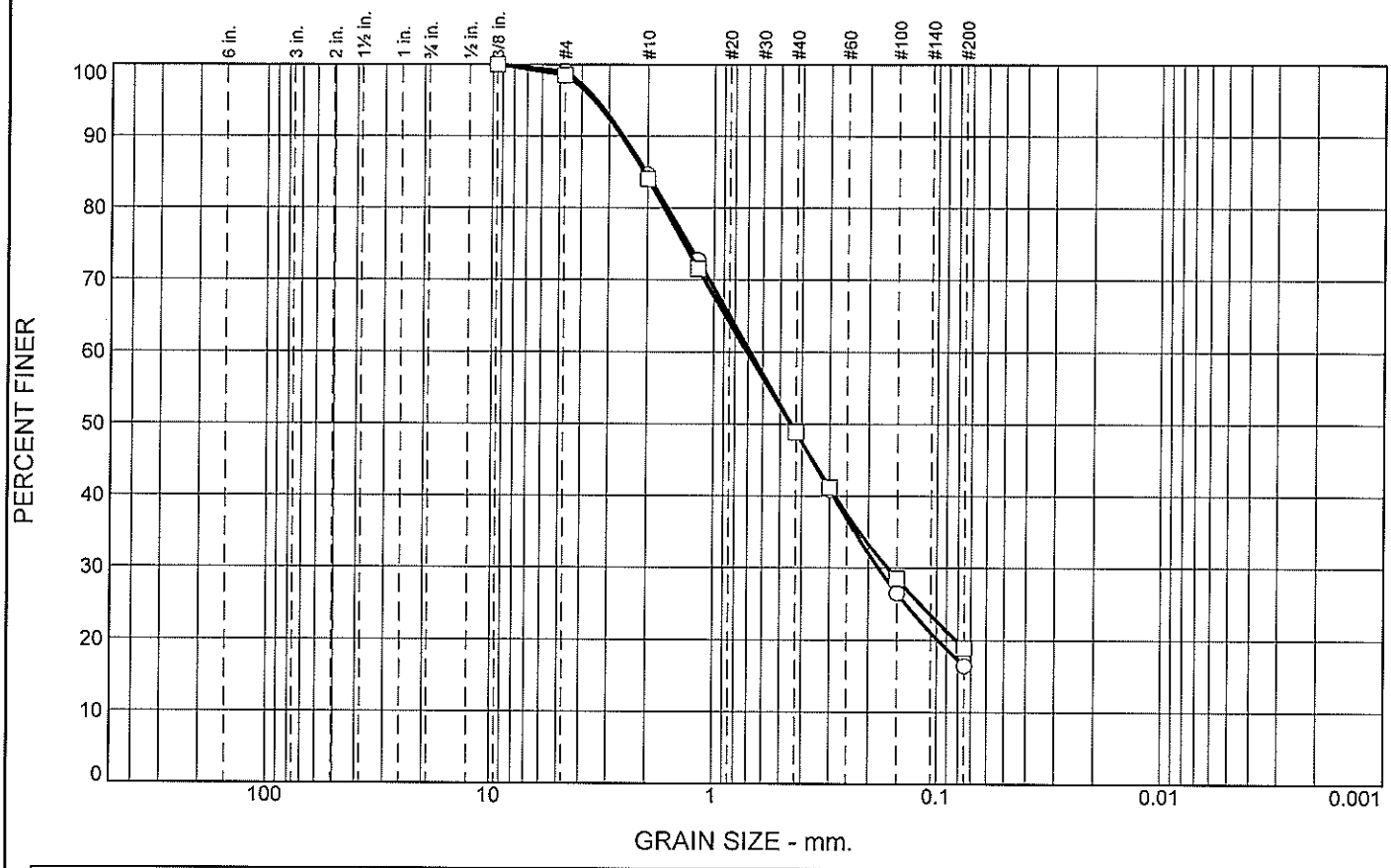
**NEVADA DEPARTMENT OF TRANSPORTATION**

Client: G. Helgerson

Project: US 50 & Warrior Way Signal Foundation

Project No.: EA 74194 Figure

# Particle Size Distribution Report




| | +3" | % GRAVEL | % SAND | % SILT | % CLAY | USCS | AASHTO | PL | LL |
|---|---|---|---|---|---|---|---|---|---|
| ○ | 0.0 | 1.0 | 82.5 | 16.5 | | | | | |
| □ | 0.0 | 1.5 | 79.6 | 18.9 | | | | | |
| | | | | | | | | | |

| SIEVE inches size | PERCENT FINER ○ | PERCENT FINER □ |
|---|---|---|
| 3/8" | 100.0 | 100.0 |
| GRAIN SIZE | | |
| $D_{60}$ | 0.6831 | 0.7074 |
| $D_{30}$ | 0.1809 | 0.1645 |
| $D_{10}$ | | |
| COEFFICIENTS | | |
| $C_c$ | | |
| $C_u$ | | |

| SIEVE number size | PERCENT FINER ○ | PERCENT FINER □ |
|---|---|---|
| #4 | 99.0 | 98.5 |
| #10 | 84.6 | 84.1 |
| #16 | 72.7 | 71.5 |
| #40 | 48.9 | 48.9 |
| #50 | 40.9 | 41.2 |
| #100 | 26.5 | 28.5 |
| #200 | 16.5 | 18.9 |

Material Description

○

□

REMARKS:

○

□

○ Source of Sample: B1 Depth: 19.5' - 21.0' Sample Number: 5

□ Source of Sample: B1 Depth: 24.5' - 25.0' Sample Number: 6

**NEVADA DEPARTMENT OF TRANSPORTATION**

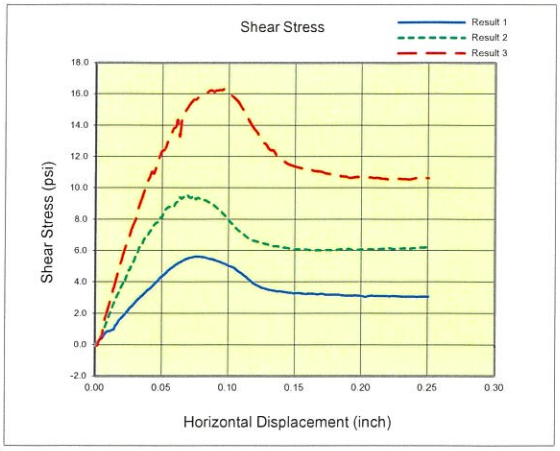
Client: G. Helgerson

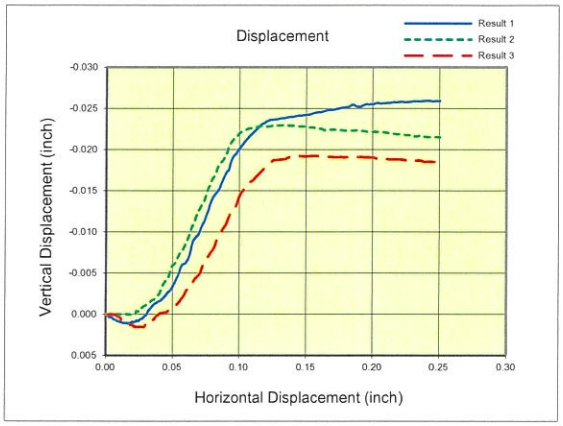
Project: US 50 & Warrior Way Signal Foundation

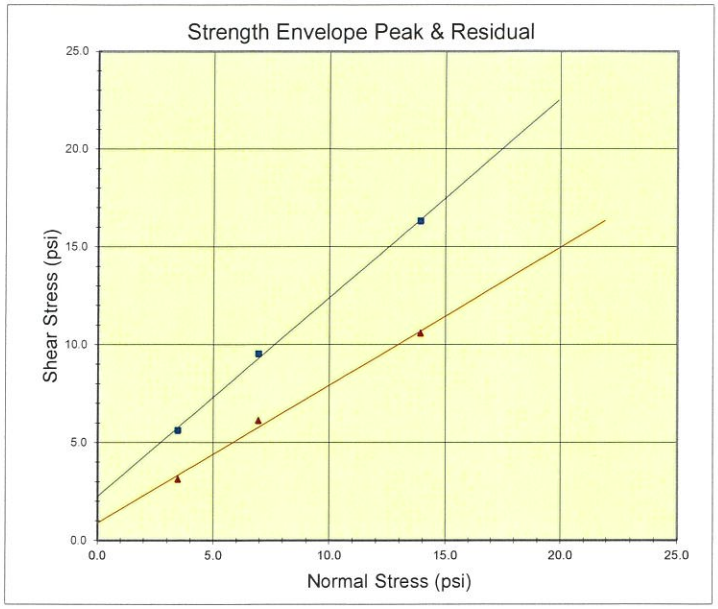
Project No.: EA 74194

Figure

# DIRECT SHEAR TEST REPORT




**Strength Parameters**

| | Peak | | Residual |
|---|---|---|---|
| Friction Angle = | 45 | degrees | 35 |
| Cohesion = | 2.24 | psi | 0.90 |

Project: FL-3-21 Boring: B1 Sample: 2B

| | Result 1 | Result 2 | Result 3 |
|---|---|---|---|
| Specimen: | a | b | c |
| Date Tested | 6/15/2021 | 6/15/2021 | 6/15/2021 |
| Diameter (inch): | 2.42 | 2.42 | 2.42 |
| Height (inch): | 1.00 | 1.00 | 1.00 |
| Depth (ft): | 8.00 | 8.00 | 8.00 |
| Moisture (%) | 17.8 | 15.7 | 14.0 |
| Dry Unit Wt (pcf) | 108.3 | 113.1 | 117.1 |
| SHEAR | | | |
| Displacement Rate($^{in}/_{min}$) | 0.0030 | 0.0030 | 0.0030 |
| Normal Stress (psi) | 3.47 | 6.94 | 13.92 |
| **Peak** Shear Stress(psi) | 5.62 | 9.52 | 16.33 |
| **Residual** Shear Stress(psi) | 3.1 | 6.1 | 10.6 |
| Residual Point Picked @(in) | 0.224 | 0.224 | 0.224 |
| Time @ Peak Failure (min) | 25.6 | 23.1 | 32.1 |

Specimen Comments

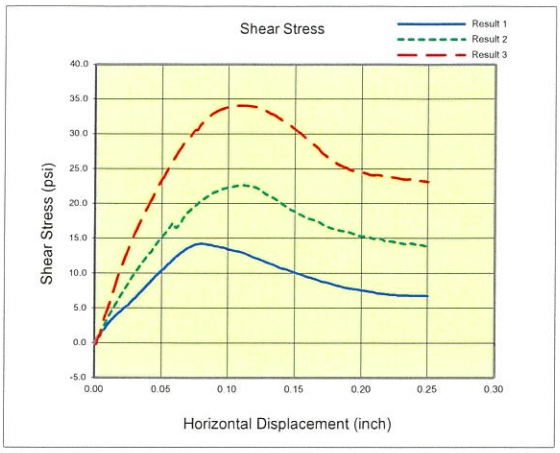
a Sheared at 500 psf
b Sheared at 1,000 psf
c Sheared at 2,000 psf

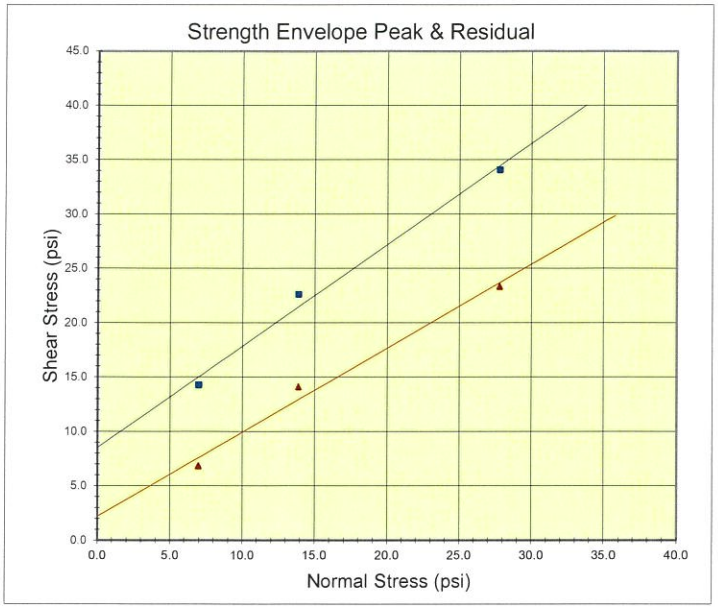
Geotechnical Section

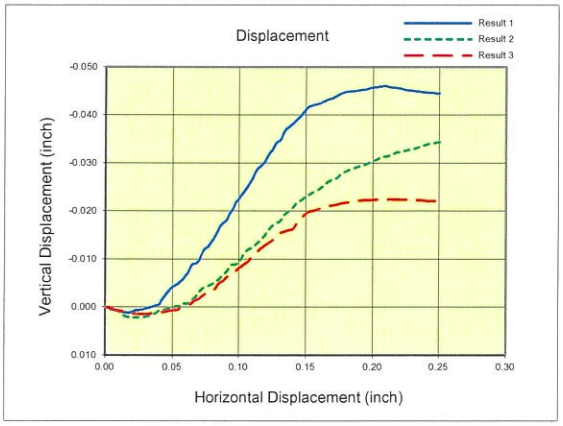
NEVADA DOT

DigiShear Report v4b __ FL-3-21 B1-2B

# DIRECT SHEAR TEST REPORT




Strength Parameters

| | Peak | | Residual |
|---|---|---|---|
| Friction Angle = | 43 | degrees | 38 |
| Cohesion = | 8.53 | psi | 2.21 |

Project: FL-3-21 Boring: B1 Sample: 4B

| | Result 1 | Result 2 | Result 3 |
|---|---|---|---|
| Specimen: | a | b | c |
| Date Tested | 6/16/2021 | 6/16/2021 | 6/16/2021 |
| Diameter (inch): | 2.42 | 2.42 | 2.42 |
| Height (inch): | 1.00 | 1.00 | 1.00 |
| Depth (ft): | 15.00 | 15.00 | 15.00 |
| Moisture (%) | 13.8 | 14.9 | 15.0 |
| Dry Unit Wt (pcf) | 117.8 | 116.7 | 115.5 |
| SHEAR | | | |
| Displacement Rate($^{in}/_{min}$) | 0.0030 | 0.0030 | 0.0030 |
| Normal Stress (psi) | 6.95 | 13.88 | 27.78 |
| **Peak** Shear Stress(psi) | 14.27 | 22.61 | 34.08 |
| **Residual** Shear Stress(psi) | 6.8 | 14.1 | 23.3 |
| Residual Point Picked @(in) | 0.242 | 0.242 | 0.242 |
| Time @ Peak Failure (min) | 26.6 | 36.6 | 37.6 |

Specimen Comments

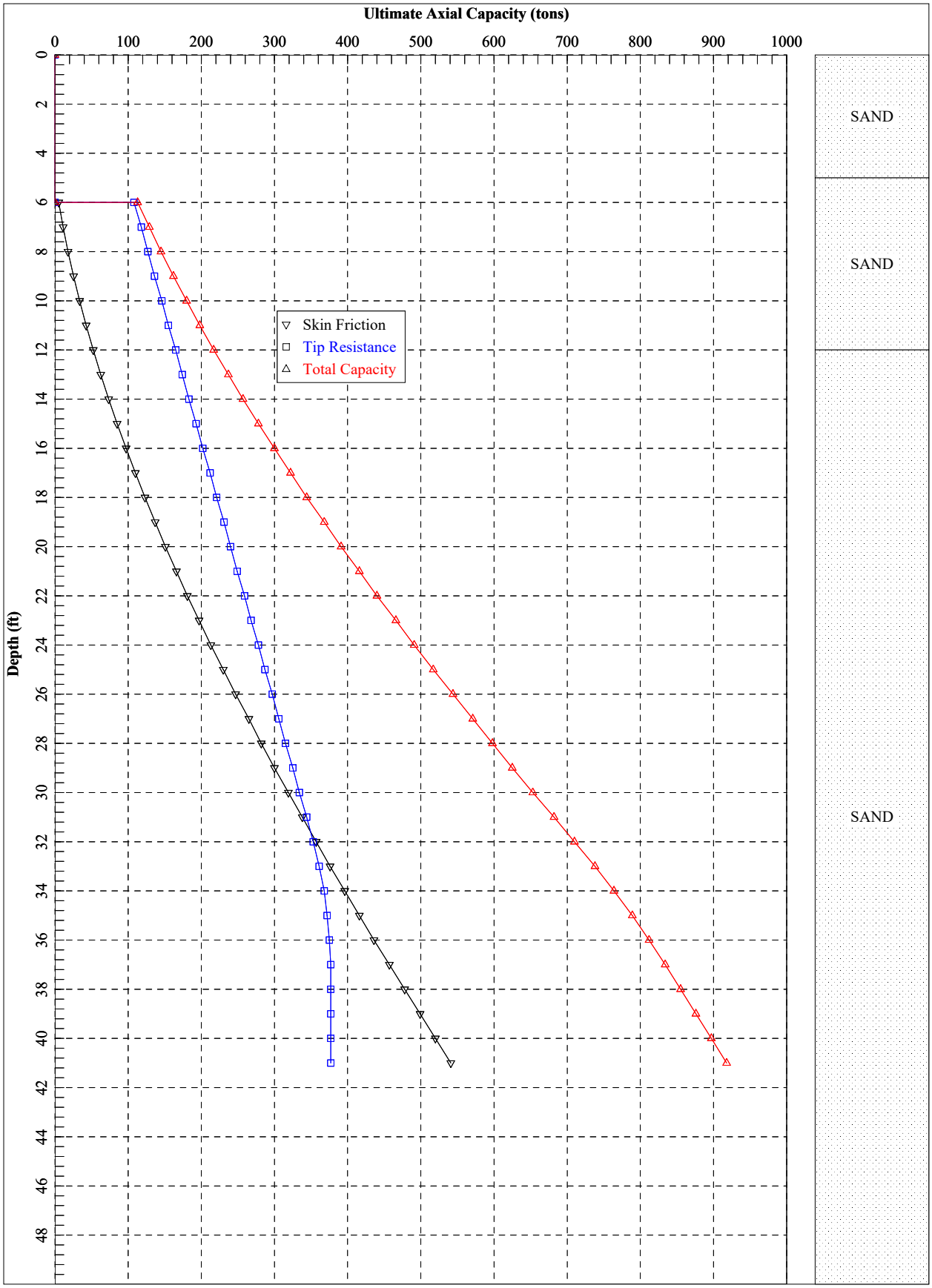
a Sheared at 1,000 psf
b Sheared at 2,000 psf
c Sheared at 4,000 psf

Geotechnical Section

NEVADA DOT

DigiShear Report v4b __ FL-3-21 B1-4B

# Appendix D
# Axial and Torsional Resistance Analysis


Ultimate Axial Capacity (tons)
0
100
200
300
400
500
600
700
800
900
1000
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
Skin Friction
Tip Resistance
Total Capacity
SAND
SAND
SAND

| Colorado DOT Sand Ultimate Torsion Calc | | |
|---|---|---|
| L= | 26 | ft |
| D= | 4 | ft |
| gamma= | 125 | lbs/ft^3 |
| phi | 35 | |
| m= | 0.70 | |
| volume= | 326.73 | ft^3 |
| n= | 4.33 | |
| k= | 1.85 | |
| **T=** | **1,439,249.95** | ft-lbs |

Therefore, the total torsion capacity of drilled shaft in sand contributed from side resistance and base resistance, can be given by:

$$T_{sand} = (K\gamma \frac{L}{2})(L)(\pi D)\mu(\frac{D}{2}) + w\mu(\frac{D}{3}) \qquad \text{(C-50)}$$

in which, $K = \eta(1-\sin\varphi)$, $\eta = 2L/(3D)$ for circular drilled shaft, $\mu = \tan\delta$, $\delta$ = soil friction angle $\varphi$ if the side contact between shaft and soil is very rough, w = the weight of shaft. A 1.25 safety factor for the torsional design of drilled shafts in cohesionless soils was used to keep torsion from controlling the shaft depth.

| Florida DOT Ultimate Torsion Calc | | |
|---|---|---|
| L= | 26 | ft |
| D= | 4 | ft |
| K= | 0.44 | |
| gamma= | 125 | lbs/ft^3 |
| phi | 35 | |
| | | |
| **T=** | **315,138.31** | ft-lbs |

shaft, the method can also be applied to stratified soil. For cohesionless soil the method can be applied as follows:

$$T_s = \left(K_0 \cdot \gamma \cdot 0.5L^2\right) \cdot \pi \cdot D \cdot \tan\delta \cdot 0.5D \qquad \text{(C-41)}$$

in which $T_s$ = side torsional resistance, ft-kips,

$K_0$ = at rest lateral earth pressure coefficient,

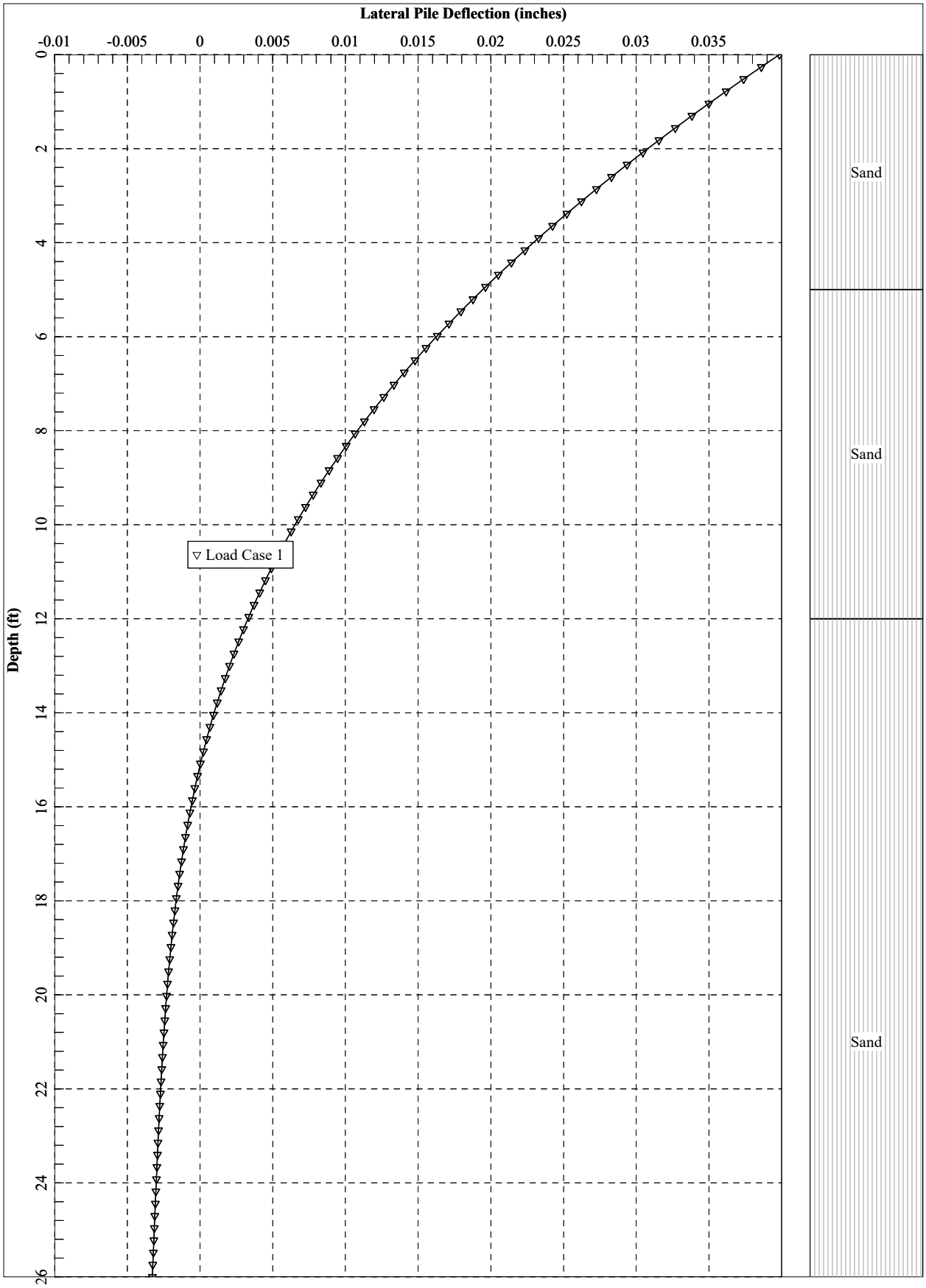
$\gamma$ = effective soil unit weight, $lb/ft^3$,

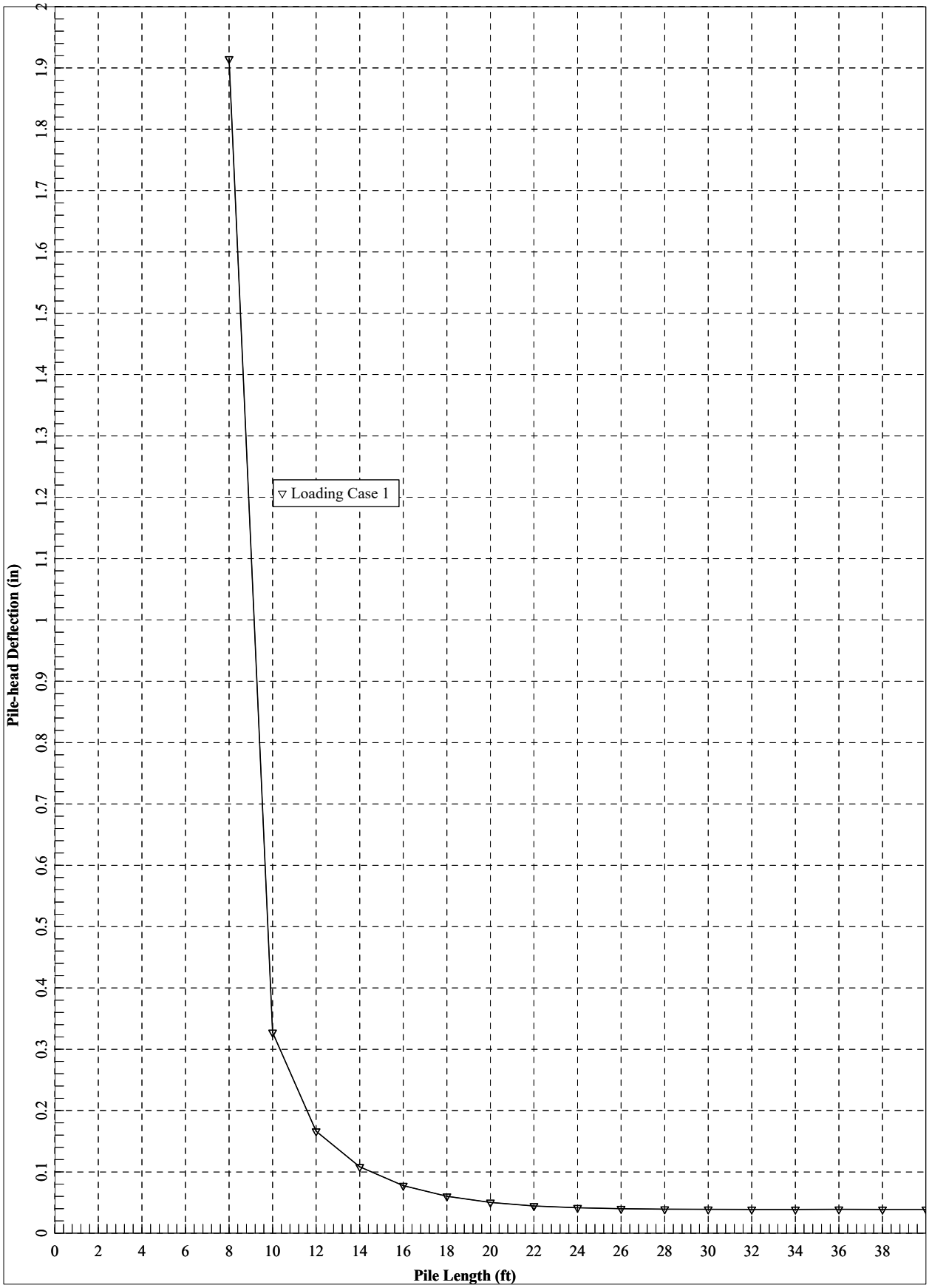
L = length of drilled shaft foundation, ft,

D = diameter of drilled shaft foundation, ft,

$\delta$ = friction angle at the soil-concrete interface, in the case of drilled foundations, it is equal to the internal friction angle of the soil, $\varphi$ of embedded soil.

# Appendix E
# Lateral Resistance Analysis


Lateral Pile Deflection (inches)
-0.01
-0.005
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
Load Case 1
Sand
Sand
Sand


Pile-head Deflection (in)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2
Loading Case 1
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
Pile Length (ft)

**NEVADA DEPARTMENT OF TRANSPORTATION**

Materials Division
Geotechnical Section
1263 Stewart St, Carson City, NV 89712