SAN BERNARDINO COUNTY

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Appendix B

2019 Geotechnical Report

SNOWDROP ROAD PROJECT

FOR

Assessment District 2018-1
UNINCOPORATED RANCHO CUCAMONGA, CALIFORNIA

PROJECT NO.: 30.30.0009

Converse Consultants
Geotechnical Engineering
Environmental & Groundwater Science
Inspection & Testing Services

GEOTECHNICAL INVESTIGATION REPORT

SNOWDROP ROAD IMPROVEMENT PROJECT

SAN BERNARDINO COUNTY, CALIFORNIA

CONVERSE PROJECT NO. 18-81-316-01

Prepared For:

SAN BERNARDINO COUNTY
SPECIAL DISTRICTS DEPARTMENT
Ms. Erin Opliger
157 West Third Street, Second Floor
San Bernardino, CA 92415

Presented By:

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January 22, 2019

Converse Consultants
Geotechnical Engineering, Environmental & Groundwater Science, Inspection & Testing Services

January 22, 2019

Ms. Erin Opliger
District Planner
San Bernardino County Special Districts Department
157 West Third Street, Second Floor
San Bernardino, CA 92415

Subject: **GEOTECHNICAL INVESTIGATION REPORT**
Snowdrop Road Improvement Project
0.4 Miles West of Haven Avenue
San Bernardino County, California
Converse Project No. 18-81-316-01

Dear Ms. Opliger:

Converse Consultants (Converse) is pleased to submit this geotechnical investigation report to assist with the design and construction of the proposed improvements along Snowdrop Road, located in San Bernardino County, California. This report was prepared in accordance with our proposal dated December 10, 2018 and your Work Oder No. 18407-904, dated December 12, 2018.

Based upon our field investigation, laboratory data, and analyses, the proposed improvements are considered feasible from a geotechnical standpoint, provided the recommendations presented in this report are incorporated into the design and construction of the project.

We appreciate the opportunity to be of service to San Bernardino County Special Districts Department (SBCSDD). Should you have any questions, please do not hesitate to contact us at 909-796-0544.

CONVERSE CONSULTANTS

Hashmi S. E. Quazi, PhD, GE, PE
Principal Engineer

Dist.: 4/Addressee
WB/JB/HSQ/kvg

PROFESSIONAL CERTIFICATION

This report has been prepared by the individuals whose seals and signatures appear herein.

The findings, recommendations, specifications, or professional opinions contained in this report were prepared in accordance with generally accepted professional engineering, engineering geologic principles, and practice in this area of Southern California. There is no warranty, either expressed or implied.

Hashmi S. E. Quazi, PhD, PE, GE
Principal Engineer

James Burnham, PG
Project Geologist

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1.0 INTRODUCTION

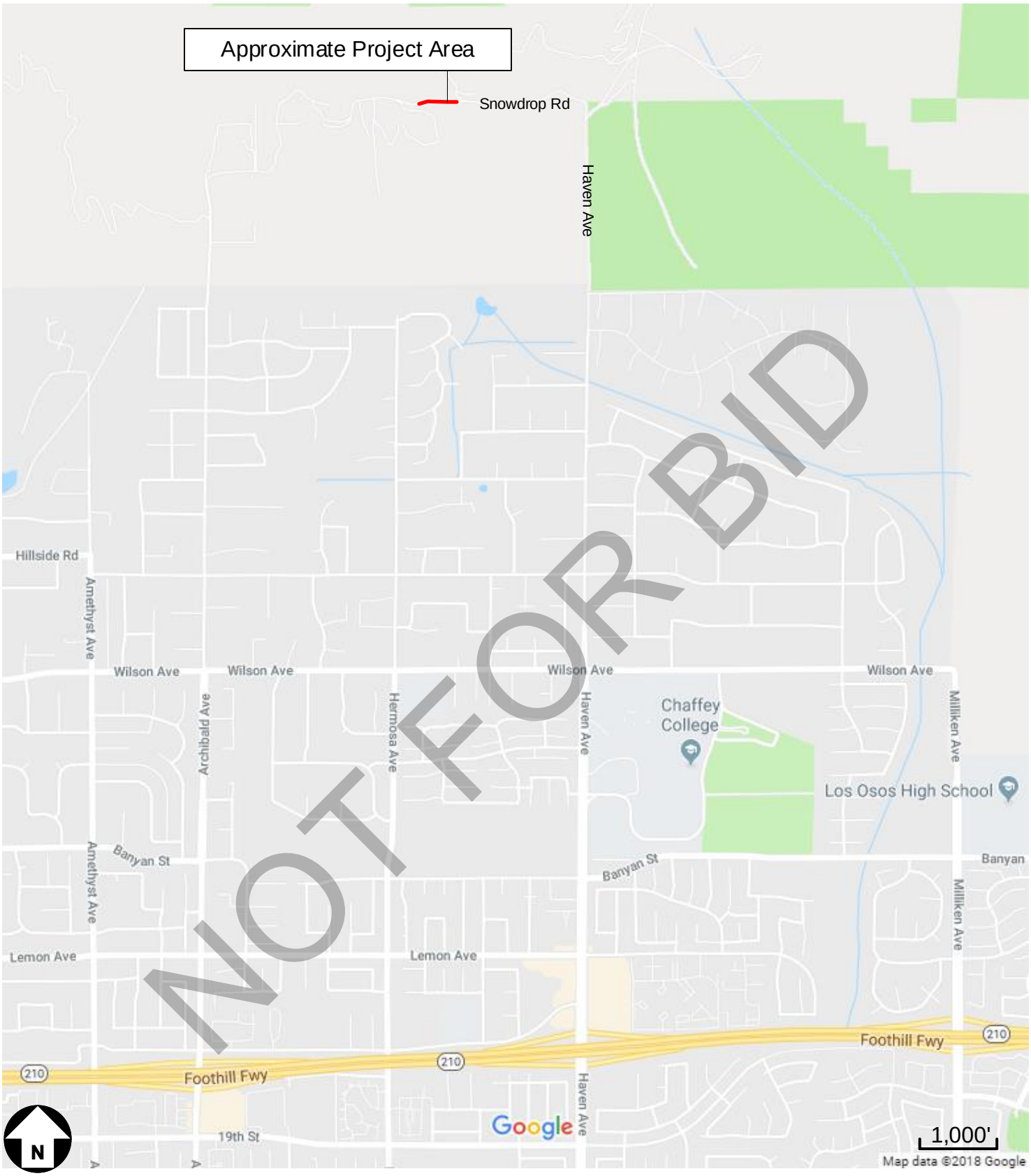
This report contains the findings of our geotechnical investigation performed for the design and construction of the proposed improvements along snowdrop road, located approximate 0.4 miles west of Haven Avenue in San Bernardino County, California. The approximate location of the proposed street improvements is shown in Figure No. 1, *Approximate Project Area Map.*

The purposes of this investigation were to evaluate the nature and pertinent engineering properties of the subsurface materials along the project limit and to provide recommendations regarding general site grading, flexible pavement design, and construction.

This report is prepared for the project site described herein and is intended for use solely by San Bernardino County Special Districts Department and their designated project team. If provided to other parties, this report be used for information on factual data only. Other parties should be responsible for making their own interpretations of the data contained in this report.

2.0 SITE AND PROJECT DESCRIPTION

The project consists of design and construction of approximately 300 feet of paved roadway beginning approximately 0.4 miles west of the northern termination of Haven Avenue and continuing to the west. At present the roadway is unpaved. The roadway is bounded on both sides by vacant land with trees and shrubs. We understand that undocumented fill has been placed to rebuild the roadway over time. The current site and roadway conditions are shown in photographs on the following page.



Approximate Project Area Map

Project: Snowdrop Road Improvement Project
Location: 0.4 Miles West of Haven Avenue
San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No
18-81-316-01

Converse Consultants

FIGURE NO.
1

Photo No. 1: Current roadway conditions, facing west.

Photo No. 2: Current roadway conditions, facing east.

3.0 SCOPE OF WORK

The scope of Converse's investigation included the tasks described in the following sections.

3.1 Project Set-Up

The project set-up consisted of the following tasks.

- Conducted a site reconnaissance with you and ensured that drill rig access to all boring locations was available.
- Notified Underground Service Alert (USA) at least 48 hours prior to drilling to clear the boring locations of conflict with underground utilities.
- Engaged a California-licensed driller to drill exploratory borings.

3.2 Subsurface Exploration

Four exploratory borings (BH-01 through BH-04) were drilled on December 21, 2018 to investigate the subsurface conditions along the proposed street section to be improved. The borings were drilled to depths between 11.0 and 16.5 feet below the existing ground surface (bgs). Boring BH-03 was terminated at 11.0 feet bgs due to refusal, likely on bedrock.

The approximate locations of the borings are shown on Figure No. 2, *Approximate Boring Locations Map*. A detailed discussion of the subsurface exploration is presented in Appendix A, *Field Exploration*.

3.3 Laboratory Testing

Representative samples of the site soils were tested in the laboratory to aid in the soils classification, and to evaluate relevant engineering properties of the site soils. These tests included the following.

- *In-situ* moisture content and dry densities (ASTM D2216 and D7263)
- Expansion Index (ASTM D4829)
- Soil corrosivity (California Test Methods 643, 422, and 417)
- R-value (ASTM D2844)
- Collapse (ASTM D5333)
- Grain size distribution (ASTM D422)
- Maximum dry density and optimum-moisture content (ASTM D1557)

For *in-situ* moisture and dry density data, see the Logs of Borings in Appendix A, *Field Exploration*. For a description of the laboratory test methods and test results, see Appendix B, *Laboratory Testing Program.*

Approximate Boring Locations Map

Project: Snowdrop Road Improvement Project
Location: 0.4 Miles West of Haven Avenue
San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No.
18-81-316-01

Converse Consultants

Figure No.
2

3.4 Analyses and Report

Data obtained from the exploratory fieldwork and the laboratory-testing program were evaluated. The geotechnical analyses were compiled, and this report was prepared to present our findings and recommendations.

4.0 SUBSURFACE CONDITIONS

The various elements of the subsurface condition are presented below.

4.1 Subsurface Profile

Based on the exploratory borings and laboratory test results, the subsurface soil at the site consisted of artificial fill, native alluvium, and bedrock with approximate thicknesses as shown in the following table.

Table No. 1, Subsurface Profile

	BH-01	BH-02	BH-03	BH-04
Asphalt Concrete / Aggregate Base	Not Encountered	Not Encountered	Not Encountered	3.0” AC / No AB
Artificial Fill	Surface to 2.5’	Surface to 7.5’	Surface to 6.0’	0.25’ to 2.5’
Alluvium	2.5’ to 10.0’	7.5’ to 15.0’	6.0’ to 11’	2.5’ to 16.5’
Bedrock	10.0’ to 15.4’	15.0’ to 15.9’	Refusal at 11’ on Bedrock	Not Encountered

For a detailed description of the subsurface materials encountered in the exploratory borings, see Drawing Nos. A-2 through A-5, *Log of Borings*, in Appendix A, Field Exploration.

4.2 Subsurface Variations

Based on the results of our subsurface exploration, variations in the continuity and nature of subsurface conditions should be anticipated. Due to the variations in the nature and depositional characteristics of earth materials, care should be exercised in extrapolating or interpolating subsurface soil conditions between or beyond the exploration location.

4.3 Groundwater

Groundwater was not encountered during the field investigation up to the depth explored. Regional databases were reviewed to estimate expected groundwater conditions in the vicinity of the project site. No relevant groundwater data was found in either the Geotracker (SWRCB, 2019) or National Water Information System (USGS, 2019) databases.

The site is located on a hillside with shallow bedrock. Groundwater is not expected to be encountered during construction of the proposed addition of the building. Shallow perched groundwater may be present locally, particularly following precipitation.

4.4 Excavatability

The artificial fill and native alluvial soils along the project are expected to be excavatable by conventional heavy-duty earth moving equipment such as excavators, scrapers, and trenching machines.

The bedrock encountered along the project may require specialized equipment such as hydraulic hammers ("breakers"), jackhammers, blasting, or other specialized techniques used to excavate hard earth materials. Selection of an appropriate excavation equipment models should be done by an experienced earthwork contractor.

5.0 LABORATORY TEST RESULTS

Laboratory testing was performed to determine the physical and chemical characteristics and engineering properties of the subsurface soils. Tests results are included in Appendix A, *Field Exploration* and Appendix B, *Laboratory Testing Program*. Discussions of the various test results are presented below.

5.1 Physical Test Results (Artificial Fill)

- *In-situ* Moisture and Dry Density – *In-situ* dry density and moisture content of the artificial fill soils were determined in accordance to ASTM Standard D2216. Dry densities ranged from 108 to 119 pcf with moisture contents of 4.0 to 7.0 percent. Results are presented in the log of borings in Appendix A, *Field Exploration*.
- Expansion Index – One representative bulk sample of the artificial fill soil was tested to evaluate expansion potential of soils in accordance with the ASTM D4829 test method. The test result indicated and expansion index of 0, corresponding to very low expansion potential.
- Collapse Potential – One relatively undisturbed representative sample collected from the upper 5 feet of artificial fill soils was tested in accordance with the ASTM Standard D4546 test method. The collapse potential was measured under a vertical stress of 2.0 kips per square foot (ksf). The test result showed a collapse potential of 8.9 percent, indicating moderately severe collapse potential.
- R-Value – One representative bulk sample of artificial fill soil was tested in accordance with Caltrans Test Method 301. The result of the R-value test was 65.
- Grain Size Analysis – One representative sample of artificial fill soil was tested to determine relative grain size distributions in accordance with the ASTM Standard D422. Test results are graphically presented in Drawing No. B-1, *Grain Size Distribution Results.*

- Maximum Dry Density and Optimum Moisture Content – One typical moisture-density relationship of representative fill soil was tested, according to ASTM Standard D1557, with the result presented in Drawing No. B-2, *Moisture-Density Relationship Results*, in Appendix B, *Laboratory Testing Program.* The laboratory maximum dry density with rock correction was 138.8 pounds per cubic feet (pcf), with optimum an optimum moisture contents of 7.2 percent.

5.2 Physical Test Results (Native Alluvium)

- *In-situ* Moisture and Dry Density – *In-situ* dry density and moisture content of the native alluvial soils were determined in accordance to ASTM Standard D2216. Dry densities ranged from 94 to 124 pcf with moisture contents of 4.0 to 9.0 percent. Results are presented in the log of borings in Appendix A, *Field Exploration*.
- Expansion Index – One representative bulk sample of the native alluvial soil was tested to evaluate expansion potential of soils in accordance with the ASTM D4829 test method. The test result indicated and expansion index of 8, corresponding to very low expansion potential.
- Collapse Potential – One relatively undisturbed representative sample collected from the native alluvial soil was tested in accordance with the ASTM Standard D4546 test method. The collapse potential was measured under a vertical stress of 2.0 kips per square foot (ksf). The test result showed a collapse potential of 3.3 percent, indicating moderate collapse potential.
- R-Value – One representative bulk sample of native alluvial soil was tested in accordance with Caltrans Test Method 301. The result of the R-value test was 41.
- Grain Size Analysis – One representative sample of native alluvial soil was tested to determine relative grain size distributions in accordance with the ASTM Standard D422. Test results are graphically presented in Drawing No. B-1, *Grain Size Distribution Results.*
- Maximum Dry Density and Optimum Moisture Content – One typical moisture-density relationship of representative native alluvial soil was tested, according to ASTM Standard D1557, with the result presented in Drawing No. B-2, *Moisture-Density Relationship Results*, in Appendix B, *Laboratory Testing Program.* The laboratory maximum dry density with rock correction was 131.2 pounds per cubic feet (pcf), with optimum an optimum moisture contents of 7.9 percent.

5.3 Physical Test Results (Bedrock)

- *In-situ* Moisture and Dry Density – *In-situ* dry density and moisture content of approximately the upper 1 to 5 feet of bedrock were determined in accordance to ASTM Standard D2216. Dry densities ranged from 112 to 128 pcf with moisture contents of 3.0 to 9.0 percent. Results are presented in the log of borings in Appendix A, *Field Exploration*.

5.4 Chemical Testing - Corrosivity Evaluation

One representative sample of the artificial fill soil was tested to determine minimum electrical resistivity, pH, and chemical content, including soluble sulfate and chloride concentrations. The purpose of these tests was to determine the corrosion potential of site soils when placed in contact with common ferrous materials. These tests were performed by AP Engineering and Testing, Inc. in accordance with California Test Methods 643, 422, and 417. The test results are presented in Appendix B, *Laboratory Testing Program and are discussed in section 7.5 soil corrosivity* and summarized below.

- The pH measurement of the sample was 7.3.
- The soluble sulfate content of the sample was 57 ppm.
- The chloride concentration of the sample was 49 ppm.
- The minimum electrical resistivity of the sample when saturated was 2,712 ohm-cm.

6.0 EARTHWORK RECOMMENDATIONS

Recommendations for earthwork associated are presented in the following subsections.

6.1 General

This section contains our general recommendations regarding earthwork for the proposed street improvement. These recommendations are based on the results of our field exploration, laboratory tests, our experience with similar projects, and data evaluation as presented in the preceding sections. These recommendations may require modification by the geotechnical consultant based on observation of the actual field conditions during grading.

Prior to the start of construction, all underground existing utilities and appurtenances, if any, should be located within the limit. Such utilities should either be protected in-place or removed and replaced during construction as required by the project specifications. All excavations should be conducted in such a manner as not to cause loss of bearing and/or lateral support of existing structures or utilities.

Based on laboratory testing, undocumented artificial fill along the project area exhibits moderately severe collapse potential and is considered unsuitable for the support of the proposed improvements.

All debris, surface vegetation, deleterious material, existing undocumented artificial fill, and surficial soils containing roots and perishable materials should be stripped and removed from the site. Deleterious material, including organics, concrete, and debris generated during excavation, should not be placed as fill.

The final bottom surfaces of all excavations should be observed and approved by the project geotechnical consultant prior to placing any fill. Based on these observations, localized areas may require remedial grading deeper than indicated herein. Therefore, some variations in the depth and lateral extent of excavation recommended in this report should be anticipated.

6.2 Overexcavation

In general, the undocumented artificial fills are considered collapsible. In areas receiving asphalt concrete, the existing artificial fill soils should be excavated. Such over-excavation should extend at least 2 feet beyond the pavement edges. Based on the materials encountered in the soil borings, the depth of overexcavation will vary from approximately 2.5 to 7.5 feet bgs.

6.3 Fill Materials

No fill or aggregate base should be placed until excavations and/or natural ground preparation have been observed by the geotechnical consultant. The soils encountered within the project site are generally considered suitable for re-use as compacted fill. Excavated soils should be processed, including cleaning roots and debris, removal of oversized particles, mixing, and moisture conditioning, before placing as compacted fill. On-site soils used as fill should meet the following criteria.

- No particles larger than 6 inches in largest dimension.
- Rocks larger than 1 inch should not be placed within the upper 12 inches of subgrade soils.
- Free of all organic matter, debris, or other deleterious material.
- Expansion index of 30 or less.
- Contain less than 30 percent by weight retained in 3/4-inch sieve.
- Contain less than 40 percent fines (passing #200 sieve).

Any imported fills should be tested and approved by geotechnical representative prior to delivery to the site. Imported materials, if required, should meet the above criteria prior to being used as compacted fill.

All surfaces to receive structural fills should be scarified to a depth of 12 inches. The soil should be moisture conditioned to within ±3 percent of optimum moisture content for coarse soils and 0 to 2 percent above optimum moisture content for fine soils. The scarified soils should be recompacted to at least 90 percent of the laboratory maximum dry density. The upper 12 inches of subgrade soils underneath pavements intended to support vehicle loads should be scarified, moisture conditioned, and compacted to at least 95 percent of the laboratory maximum dry density.

6.4 Compacted Fill Placement

Fill soils should be thoroughly mixed and moisture conditioned to within ±3 percent of optimum moisture content for coarse soils and 0 to 2 percent above optimum moisture content for fine soils. Fill soils should be evenly spread in horizontal lifts not exceeding 8 inches in uncompacted thickness.

All fill placed at the site should be compacted to at least 90 percent of the laboratory maximum dry densities as determined by ASTM Standard D1557 test method, unless a higher compaction is specified herein. At least the upper 12 inches of subgrade soils underneath pavements intended to support vehicle loads should be scarified, moisture conditioned, and compacted to at least 95 percent of the laboratory maximum dry density.

Fill materials should not be placed, spread or compacted during unfavorable weather conditions. When site grading is interrupted by heavy rain, filling operations should not resume until the geotechnical consultant approves the moisture and density conditions of the previously placed fill.

7.0 STRUCTURAL PAVEMENT RECOMMENDATIONS

These following recommendations are based on the results of our field exploration, laboratory testing, our experience with similar projects, and data evaluation as presented in the preceding sections. These recommendations may need to be modified based on observation of the actual field conditions during construction.

7.1 Structural Pavement Design

Two representative soil samples were tested to determine the R-value of the subgrade soils. The tested R-values were 41 and 65. The R-value of 65 corresponded to undocumented artificial fill soils. For pavement design, we have utilized an R-value of 41. A design traffic index of 6 was provided for the project. Recommended asphalt concrete (AC) and aggregate base (AB) thickness were determined using the *CALTRANS Highway Design Manual*, Chapter 630 and the *San Bernardino County Department of Public Works: General Permit Conditions and Trench Specifications,* Section 9.3.1 with a safety factor of 0.2. The recommended flexible pavement structural sections are presented in the following table.

Table No. 2, Recommended Flexible Pavement Structural Sections

Design Subgrade R-value	Design TI	Composite Structural Sections	
		AC (inches)	AB (inches)
41	6	3.0	6.0

At or near the completion of grading, subsurface samples should be tested to evaluate the actual subgrade R-value for final pavement design.

Aggregate base materials should be moisture conditioned as needed to near optimum moisture content, and compacted to at least 95 percent of the laboratory maximum dry density (ASTM D1557) for support of new pavement sections.

Base materials should conform to Section 200-2 of the Greenbook, or as required by the County of San Bernardino, and should be placed in accordance with Section 301-2 of the Greenbook.

In order to lengthen the life span of the pavement, the top portion of HMA surface layer may be replaced with equivalent gap-graded Rubberized Hot Mix Asphalt (RHMA-G) and/or a rubberized stress absorbing membrane interlayer (SAMI-R) may be placed below the RHMA-G surface layer. The RHMA-G thickness should have a minimum of 0.1 feet and a maximum of 0.2 feet. (Caltrans HDM, Topic 631). The RHMA-G and SAMI-R will reduce the occurrence of reflective cracking of the pavement surface.

Asphalt concrete materials should conform to Section 203 of the Greenbook and should be placed in accordance with Section 302.5 of the Greenbook, or as required by the City of San Bernardino.

Positive drainage should be provided away from all pavement areas to prevent seepage of surface and/or subsurface water into the pavement base and/or subgrade.

7.2 Soil Corrosivity

The results of chemical testing of representative samples of site soils were evaluated for corrosivity evaluation with respect to common construction materials such as concrete and steel. The test results are presented in Appendix B, *Laboratory Testing Program* in Table No. B-2, *Summary of Corrosivity Test Results*, and are discussed below.

The sulfate content of the soils tested correspond to American Concrete Institute (ACI) exposure category S0 for this sulfate concentration (ACI 318-11, Table 4.2.1). ACI recommends a minimum compressive strength of 2,500 psi for exposure category S0 in ACI 318-11, Table 4.3.1. No concrete type restrictions are specified.

We anticipate that concrete structures will be exposed to moisture from precipitation and irrigation. Based on the project location and the results of chloride testing of the site soils, we do not anticipate that concrete structures will be exposed to external sources of chlorides, such as deicing chemicals, salt, brackish water, or seawater. ACI specifies exposure category C1 where concrete is exposed to moisture, but not to external sources of chlorides (ACI 318-11, Table 4.2.1). ACI provides concrete design recommendations

in ACI 318-11, Table 4.3.1, including a minimum compressive strength of 2,500 psi, and a maximum chloride content of 0.3 percent.

The measured value of the minimum electrical resistivity when saturated was 2,712 Ohm-cm. This indicates that the soils tested are moderately corrosive to ferrous metals in contact with the soil (Romanoff, 1957). Converse does not practice in the area of corrosion consulting. A qualified corrosion consultant should provide appropriate corrosion mitigation measures for ferrous metals in contact with the site soils.

8.0 GEOTECHNICAL SERVICES DURING CONSTRUCTION

The project geotechnical consultant should review plans and specifications as the project design progresses. Such review is necessary to identify design elements, assumptions, or new conditions which require revisions or additions to our geotechnical recommendations.

The project geotechnical consultant should be present to observe conditions during construction. Geotechnical observation and testing should be performed as needed to verify compliance with project specifications. Additional geotechnical recommendations may be required based on subsurface conditions encountered during construction.

9.0 CLOSURE

This report is prepared for the project described herein and is intended for use solely by San Bernardino County Special Districts Department and their authorized agents, to assist in the design and construction of the proposed project. Our findings and recommendations were obtained in accordance with generally accepted professional principles practiced in geotechnical engineering. We make no other warranty, either expressed or implied.

Converse Consultants is not responsible or liable for any claims or damages associated with interpretation of available information provided to others. Site exploration identifies actual soil conditions only at those points where samples are taken, when they are taken. Data derived through sampling and laboratory testing is extrapolated by Converse employees who render an opinion about the overall soil conditions. Actual conditions in areas not sampled may differ. In the event that changes to the project occur, or additional, relevant information about the project is brought to our attention, the recommendations contained in this report may not be valid unless these changes and additional relevant information are reviewed and the recommendations of this report are modified or verified in writing. In addition, the recommendations can only be finalized by observing actual subsurface conditions revealed during construction. Converse cannot be held responsible for misinterpretation or changes to our recommendations made by others during construction.

As the project evolves, continued consultation and construction monitoring by a qualified geotechnical consultant should be considered an extension of geotechnical investigation services performed to date. The geotechnical consultant should review plans and specifications to verify that the recommendations presented herein have been appropriately interpreted, and that the design assumptions used in this report are valid. Where significant design changes occur, Converse may be required to augment or modify the recommendations presented herein. Subsurface conditions may differ in some locations from those encountered in the explorations, and may require additional analyses and, possibly, modified recommendations.

Design recommendations given in this report are based on the assumption that the recommendations contained in this report are implemented. Additional consultation may be prudent to interpret Converse's findings for contractors, or to possibly refine these recommendations based upon the review of the actual site conditions encountered during construction. If the scope of the project changes, if project completion is to be delayed, or if the report is to be used for another purpose, this office should be consulted.

10.0 REFERENCES

ASTM INTERNATIONAL, Annual Book of ASTM Standards, Current.

CALIFORNIA DEPARTMENT OF TRANSPORTATION (2015), *"Highway Design Manual"*, Department of Transportation, State of California.

CALIFORNIA DEPARTMENT OF TRANSPORTATION (2015), Standard Specifications, dated 2015.

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD (SWRCB), 2019, GeoTracker database (http://geotracker.waterboards.ca.gov/), accessed January, 2019.

ROMANOFF, MELVIN, 1957, Underground Corrosion, National Bureau of Standards Circular 579, dated April, 1957.

SAN BERNARDINO COUNTY DEPARTMENT OF PUBLIC WORKS (SBCDPW), 2017, General Permit Conditions and Trench Specifications: Web Interface (http://cms.sbcounty.gov/Portals/50/operations/permits/Trench%20Specs%20revised%2007112017.pdf?ver=2017-07-20-153104-720), accessed January, 2019.

STANDARD SPECIFICATIONS FOR PUBLIC WORKS CONSTRUCTION (SSPWC, 2015), 2015 Edition, Public Works Standards, Inc.

U.S. GEOLOGICAL SURVEY (USGS), 2019, National Water Information System: Web Interface (http://nwis.waterdata.usga.gov/nwis/gwlevels), accessed January, 2019.

Appendix A

Field Exploration

APPENDIX A

FIELD EXPLORATION

Our field investigation included site reconnaissance and a subsurface exploration program consisting of drilling soil borings. During the site reconnaissance, the surface conditions were noted and the borings were marked at intervals suggested by SBCSDD using nearby landmarks as a guide. The boring locations should be considered accurate only to the degree implied by the method used to mark them in the field.

Four exploratory borings (BH-01 through BH-04) were drilled on December 21, 2018 to a maximum depth of 16.5 feet below existing ground surface (bgs). BH-03 was terminated at 11.0 feet bgs due to refusal on bedrock.

The borings were advanced using a truck-mounted drill rig equipped with 6-inch diameter hollow-stem augers for soil sampling. Encountered earth materials were continuously logged by a Converse geologist and visually classified in the field in accordance with the Unified Soil Classification System. Where appropriate, field descriptions and classifications have been modified to reflect laboratory test results.

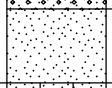
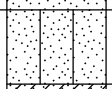
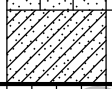
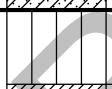
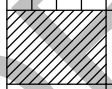
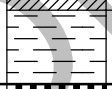
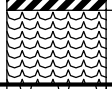
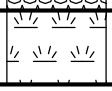
Relatively undisturbed samples were obtained using California Modified Samplers (2.4 inches inside diameter and 3 inches outside diameter) lined with thin sample rings. The steel ring sampler was driven into the bottom of the borehole with successive drops of a 140-pound driving weight falling 30 inches. Blow counts at each sample interval are presented on the boring logs. Samples were retained in brass rings (2.4-inches inside diameter and 1 inch in height) and carefully sealed in waterproof plastic containers for shipment to the Converse laboratory. Bulk samples of typical soil types were also obtained.

The exact depths at which material changes occur cannot always be established accurately. Unless a more precise depth can be established by other means, changes in material conditions that occur between driven samples are indicated in the log at the top of the next drive sample.

Following the completion of logging and sampling, all borings were backfilled with soil cuttings and surface patched with cold asphalt concrete. The surface may settle over time. If construction is delayed, we recommend the owner monitor the boring locations and backfill any depressions that might occur, or provide protection around the boring locations to prevent trip and fall injuries from occurring near the area of any potential settlement.

For a key to soil symbols and terminology used in the boring logs, refer to Drawing No. A-1, *Unified Soil Classification and Key to Boring Log Symbols*. Logs of the exploratory borings are presented in Drawings No. A-2 through A-5, *Logs of Borings.*

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE)	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS (MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE)	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

BORING LOG SYMBOLS

SAMPLE TYPE

STANDARD PENETRATION TEST
Split barrel sampler in accordance with ASTM D-1586-84 Standard Test Method

DRIVE SAMPLE 2.42" I.D. sampler (CMS).

DRIVE SAMPLE No recovery

BULK SAMPLE

GROUNDWATER WHILE DRILLING

GROUNDWATER AFTER DRILLING

LABORATORY TESTING ABBREVIATIONS			
TEST TYPE (Results shown in Appendix B)		STRENGTH	
		Pocket Penetrometer	p
		Direct Shear	ds
		Direct Shear (single point)	ds*
		Unconfined Compression	uc
CLASSIFICATION		Triaxial Compression	tx
Plasticity	pi	Vane Shear	vs
Grain Size Analysis	ma	Consolidation	c
Passing No. 200 Sieve	wa	Collapse Test	col
Sand Equivalent	se	Resistance (R) Value	r
Expansion Index	ei	Chemical Analysis	ca
Compaction Curve	max	Electrical Resistivity	er
Hydrometer	h	Permeability	perm
Disturb	Dist.	Soil Cement	sc

Apparant Density	Very Loose	Loose	Medium	Dense	Very Dense
SPT (N)	< 4	4 - 11	11 - 30	31 - 50	> 50
CA Sampler	< 5	5 - 12	13 - 35	36 - 60	> 60
Relative Density (%)	< 20	20 - 40	40 - 60	60 - 80	> 80

Consistency	Very Soft	Soft	Medium	Stiff	Very Stiff	Hard
SPT (N)	< 2	2-4	5-8	9-15	16-30	> 30
CA Sampler	< 3	3-6	7-12	13-25	26-50	> 50

UNIFIED SOIL CLASSIFICATION AND KEY TO BORING LOG SYMBOLS

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. **18-81-316-01**

Drawing No. **A-1**

Log of Boring No. BH-01

Dates Drilled: 12/21/2018 Logged by: William Buckley Checked By: James Burnham

Equipment: 6" HOLLOW STEM AUGER Driving Weight and Drop: 140 lbs / 30 in

Ground Surface Elevation (ft): 2698 Depth to Water (ft): NOT ENCOUNTERED

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.	SAMPLES: DRIVE	SAMPLES: BULK	BLOWS	MOISTURE	DRY UNIT WT. (pcf)	OTHER
		ARTIFICIAL FILL **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel and cobbles up to 5" in largest dimension, light reddish-brown.						
5		**ALLUVIUM** **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel up to 2" in largest dimension, reddish-brown.	■	▨	25/12/12	9	94	ei,ma,max col
			■	▨	43/50-4"	6	112	
10		**BEDROCK: DECOMPOSED GRANITE (Dg):** severely to completely weathered, no apparent bedding, orangish-brown.	■		4/31/50	5	123	
15			■		50-5"	9	115	
		End of boring at 15.4 feet bgs. No groundwater encountered. Borehole backfilled with soil cuttings and tamped on 12/21/2018.						

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. 18-81-316-01

Drawing No. A-2

Log of Boring No. BH-02

Dates Drilled: 12/21/2018 Logged by: William Buckley Checked By: James Burnham

Equipment: 6" HOLLOW STEM AUGER Driving Weight and Drop: 140 lbs / 30 in

Ground Surface Elevation (ft): 2673 Depth to Water (ft): NOT ENCOUNTERED

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES: DRIVE	SAMPLES: BULK	BLOWS	MOISTURE	DRY UNIT WT. (pcf)	OTHER
		This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.						
		ARTIFICIAL FILL **SILTY SAND (SM):** fine to coarse-grained, gravel and cobbles up to 5" in largest dimension, light reddish-brown.						
5			■		15-50-5.5"	5	112	r
		ALLUVIUM **SILTY SAND (SM):** fine to coarse-grained, gravel up to 2" in largest dimension, light brown.			50-4"			NR
10			■		50/28/22	5	115	
15		**BEDROCK: DECOMPOSED GRANITE (Dg):** severely to completely weathered, no apparent bedding, orangish-brown.	■		35/50-5.5"	3	128	
		End of boring at 15.9 feet bgs. No groundwater encountered. Borehole backfilled with soil cuttings and tamped on 12/21/2018.						

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. 18-81-316-01

Drawing No. A-3

Log of Boring No. BH-03

Dates Drilled: 12/21/2018 Logged by: William Buckley Checked By: James Burnham

Equipment: 6" HOLLOW STEM AUGER Driving Weight and Drop: 140 lbs / 30 in

Ground Surface Elevation (ft): 2666 Depth to Water (ft): NOT ENCOUNTERED

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES: DRIVE	SAMPLES: BULK	BLOWS	MOISTURE	DRY UNIT WT. (pcf)	OTHER
		This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.						
		ARTIFICIAL FILL **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel and cobbles up to 5" in largest dimension, brown.						ei,r,ca,er, ma,max
			■		32/50-4.5"	5	108	dist.
5			■		37/8/10	7	110	col
		ALLUVIUM **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel up to 2" in largest dimension, brown.						
10			■		50-4"	5	112	
		BEDROCK: DECOMPOSED GRANITE (Dg): severely to completely weathered, no apparent bedding, orangish-brown.						
		End of boring at 11.0 feet bgs due to refusal on bedrock. No groundwater encountered. Borehole backfilled with soil cuttings and tamped on 12/21/2018.						

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
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For: San Bernardino County Special Districts Department

Project No. 18-81-316-01

Drawing No. A-4

Log of Boring No. BH-04

Dates Drilled: 12/21/2018 Logged by: William Buckley Checked By: James Burnham

Equipment: 6" HOLLOW STEM AUGER Driving Weight and Drop: 140 lbs / 30 in

Ground Surface Elevation (ft): 2667 Depth to Water (ft): NOT ENCOUNTERED

Depth (ft)	Graphic Log	SUMMARY OF SUBSURFACE CONDITIONS	SAMPLES: DRIVE	SAMPLES: BULK	BLOWS	MOISTURE	DRY UNIT WT. (pcf)	OTHER
		This log is part of the report prepared by Converse for this project and should be read together with the report. This summary applies only at the location of the boring and at the time of drilling. Subsurface conditions may differ at other locations and may change at this location with the passage of time. The data presented is a simplification of actual conditions encountered.						
		3" ASPHALT CONCRETE / NO AGGREGATE BASE						
		ARTIFICIAL FILL **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel up to 2" in largest dimension, light reddish-brown.	■		36/28/40	4	119	
5		**ALLUVIUM** **SILTY SAND with GRAVEL (SM):** fine to coarse-grained, gravel up to 3" in largest dimension, brown.	■		28/50-5.5"	8	116	
			■		20/21/28	6	124	
10		- orangish-brown	■		23/23/13	4	123	
15			■		6/6/7	8	95	
		End of boring at 16.5 feet bgs. No groundwater encountered. Borehole backfilled with soil cuttings, tamped and surface patched with cold asphalt concrete on 12/21/2018.						

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. 18-81-316-01

Drawing No. A-5

Appendix B

Laboratory Testing Program

APPENDIX B

LABORATORY TESTING PROGRAM

Tests were conducted in our laboratory on representative soil samples for the purpose of classification and evaluation of their physical properties and engineering characteristics. The amount and selection of tests were based on the geotechnical parameters required for this project. Test results are presented herein and on the Logs of Borings in Appendix A, *Field Exploration*. The following is a summary of the various laboratory tests conducted for this project.

Moisture Content and Dry Density

Results of moisture content and dry density tests performed on relatively undisturbed ring samples tested in accordance with ASTM Standard D2216 were used to aid in the classification of the soils and to provide quantitative measurements of the *in situ* dry density. This test also provides qualitative information on strength and compressibility characteristics of site soils. For test results, see the Logs of Borings in Appendix A, *Field Exploration*.

Expansion Index Tests

Two representative bulk samples were tested in accordance with ASTM Standard D4829 to evaluate the expansion potential. The test results are presented in the following table.

Table No. B-1, Expansion Index Test Results

Boring No.	Depth (feet)	Soil Description	Expansion Index	Expansion Potential
BH-01	5-10	Silty Sand with Gravel (SM)	8	Very Low
BH-03	0-5	Silty Sand with Gravel (SM)	0	Very Low

Soil Corrosivity

One representative soil sample was tested by AP Engineering in accordance with California Test Methods 643, 422, and 417, to determine minimum electrical resistivity, pH, and chemical content, including soluble sulfate and chloride concentrations. Test results are presented on the following table.

Table No. B-2, Summary of Corrosivity Test Results

Boring No.	Depth (feet)	pH	Soluble Sulfates (CA 417) (ppm)	Soluble Chlorides (CA 422) (ppm)	Min. Resistivity (CA 643) (Ohm-cm)
BH-03	0-5	7.3	57	49	2712

Collapse Tests

To evaluate the moisture sensitivity (collapse/swell potential) of the encountered soils, two collapse tests were performed in accordance with the ASTM Standard D5333 laboratory procedure. The samples were loaded to approximately 2 kips per square foot (ksf), allowed to stabilize under load, and then submerged. The test results are presented in the following table.

Table No. B-3, Collapse Test Results

Boring No.	Depth (feet)	Soil Classification	Percent Swell + Percent Collapse -	Collapse Potential
BH-01	5.0-6.5	Silty Sand with Gravel (SM)	3.3	Moderate
BH-03	5.0-6.5	Silty Sand with Gravel (SM)	8.9	Moderately severe

R-value

Two representative bulk soil samples were tested for resistance value (R-value) in accordance with California Test Method CT301. This test is designed to provide a relative measure of soil strength for use in pavement design. The test results are shown in the following table.

Table No. B-4, R-Value Test Results

Boring No.	Depth (feet)	Soil Classification	Measured R-value
BH-02	5-10	Silty Sand with Gravel (SM)	41
BH-03	0-5	Silty Sand with Gravel (SM)	65

Grain-Size Analysis

To assist in classification of soils, two mechanical grain-size analyses were performed on selected samples in general accordance with the ASTM Standard D422 method. Grain-size curves are shown in Drawing No. B-1, *Grain Size Distribution Results*.

Maximum Dry Density and Optimum Moisture Content Tests

Laboratory maximum dry density and optimum moisture content relationship tests were performed on two representative bulk samples. The tests were conducted in accordance with the ASTM Standard D1557 method. Test result is presented on Drawing No. B-2, *Moisture-Density Relationship Results,* and summarized in the following table.

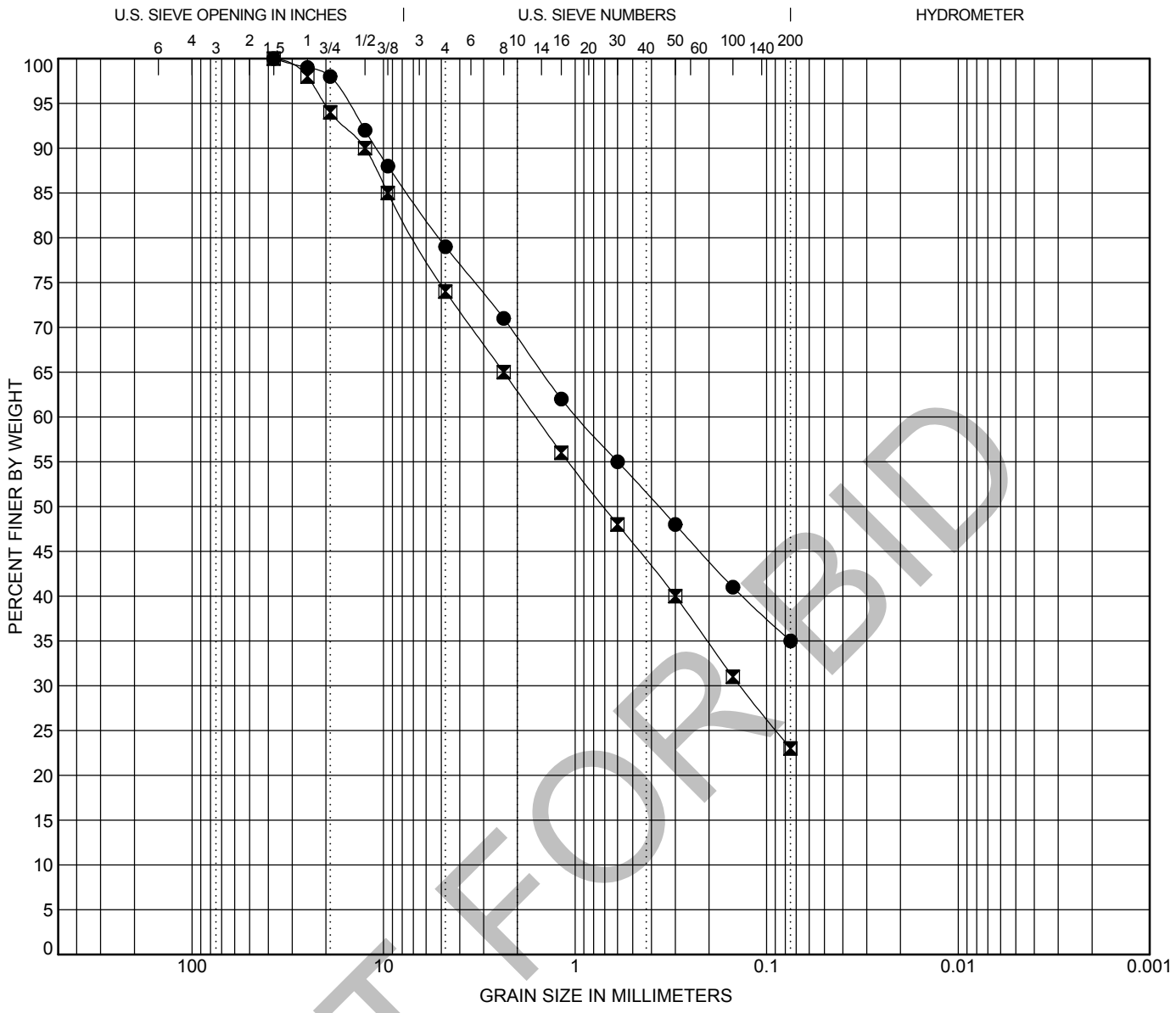
Table No. B-5, Laboratory Maximum Density Test Results

Boring No.	Depth (feet)	Soil Description	Maximum Dry Density (pcf)	Optimum Moisture (%)
*BH-01	5-10	Silty Sand with Gravel (SM), reddish-brown	131.2	7.9
*BH-03	0-5	Silty Sand with Gravel (SM), brown	138.8	7.2

(* = rock correction; BH-01 = 11.43% rock and BH-03 = 19.01% rock)

Sample Storage

Soil samples presently stored in our laboratory will be discarded 30 days after the date of this report, unless this office receives a specific request to retain the samples for a longer period.



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Boring No.	Depth (ft)	Description	LL	PL	PI	Cc	Cu
●	**BH-01**	**5-10**	**SILTY SAND WITH GRAVEL (SM)**					
⊠	**BH-03**	**0-5**	**SILTY SAND WITH GRAVEL (SM)**					

	Boring No.	Depth (ft)	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**BH-01**	**5-10**	**37.5**	**0.973**			**21.0**	**44.0**	**35.0**	
⊠	**BH-03**	**0-5**	**37.5**	**1.606**	**0.138**		**26.0**	**51.0**	**23.0**	

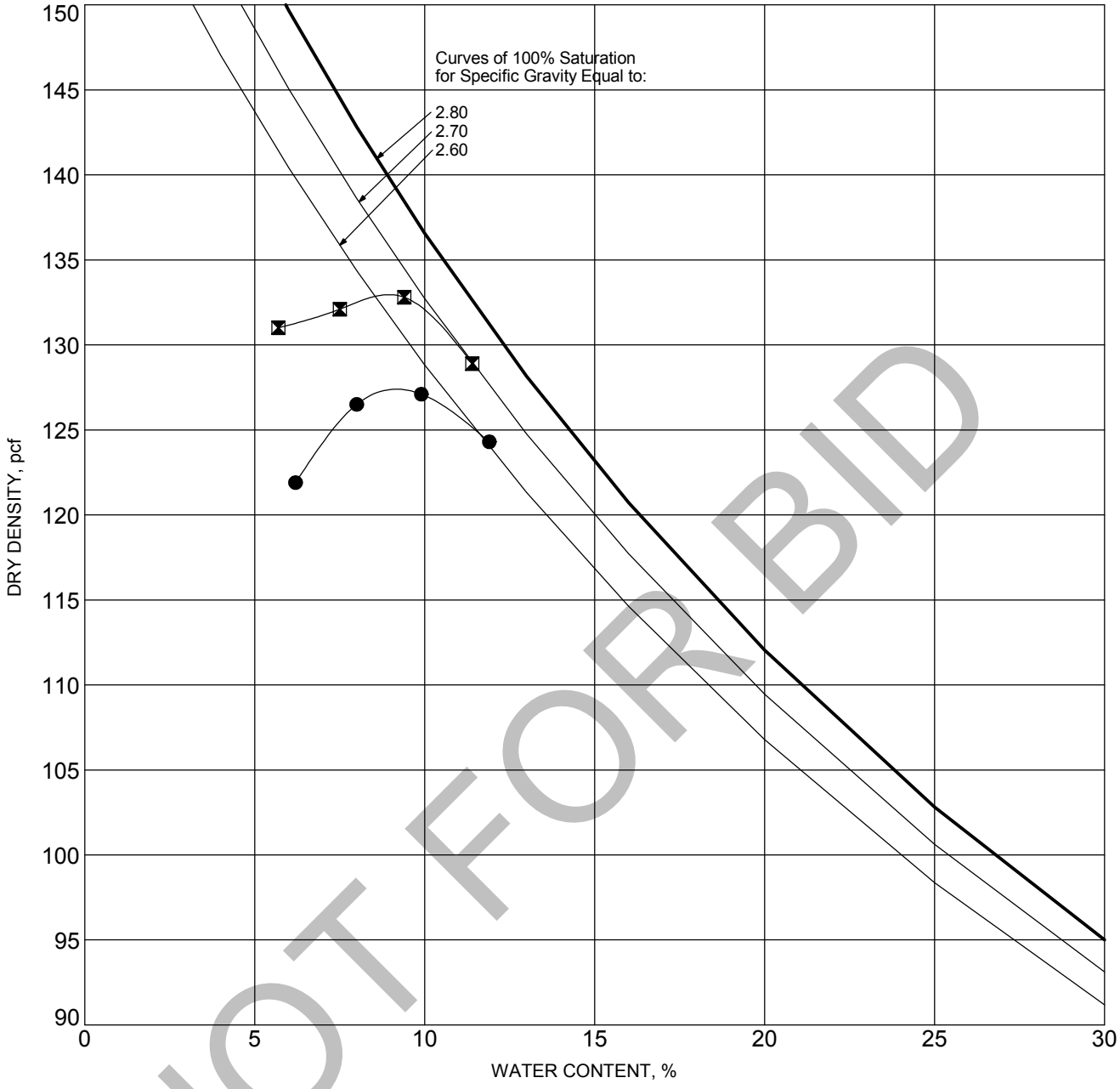
GRAIN SIZE DISTRIBUTION RESULTS

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. **18-81-316-01**

Drawing No. **B-1**



SYMBOL	BORING NO.	DEPTH (ft)	DESCRIPTION	ASTM TEST METHOD	OPTIMUM WATER, %	MAXIMUM DRY DENSITY, pcf
●	***BH-01**	**5-10**	**SILTY SAND WITH GRAVEL (SM), REDDISH-BROWN**	**D1557 - B**	**7.9**	**131.2**
⊠	***BH-03**	**0-5**	**SILTY SAND WITH GRAVEL (SM), BROWN**	**D1557 - B**	**7.2**	**138.8**

(* = rock correction; BH-01 = 11.43% rock and BH-03 = 19.01% rock)

MOISTURE-DENSITY RELATIONSHIP RESULTS

Converse Consultants

Snowdrop Road Improvement Project
Snowdrop Road, 0.4 Miles West of Haven Avenue
City of Rancho Cucamonga, San Bernardino County, California
For: San Bernardino County Special Districts Department

Project No. **18-81-316-01**

Drawing No. **B-2**