Geotechnical Engineering Report

N5001(1) Toadlena to Two Grey Hills
Newcomb, New Mexico
Project # 19-517-00006

Prepared for:

Wilson & Company, Inc., Engineers and Architects
4401 Masthead St. NE #150, Albuquerque, New Mexico 87109

4/5/2019

Wood Environment and Infrastructure Solutions, Inc.
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4/5/2019

Amended 6/3/19
Project No. 19-517-00006

Wilson & Company, Inc., Engineers and Architects
4404 Masthead St. NE #150
Albuquerque, NM 87109

Attention: Mr. Stephen M. Lujan, PE

Subject: **Geotechnical Engineering Report**
N5001(1) Toadlena to Two Grey Hills
Newcomb, New Mexico

Dear Mr. Lujan:

Wood Environment and Infrastructure Solutions, Inc. (Wood E&I), is pleased to submit this *amended* report describing our geotechnical engineering investigations and evaluation for the N5001(1) Toadlena to Two Grey Hills project. *This report is amended to provide resistivity test results, which were not previously available. Amendments are shown in italics.* The purpose of our evaluation was to provide supplementary data to complete available geotechnical resources in accordance with the project Development and Design Manual (PDDM) of the U.S. Department of Transportation Federal Highway Administration.

Our scope of work included field exploration, laboratory testing, and geotechnical engineering analyses. This report has been prepared for the exclusive use of Wilson & Company, Inc., Engineers and Architects and their consultants, for specific application to this project, in accordance with generally accepted geotechnical engineering practice.

We appreciate the opportunity to be of service on this project. If you have any questions regarding this report, or any aspects of the project, please feel free to contact our office.

Sincerely,

Wood Environment and Infrastructure Solutions, Inc.

Jacob S. Hays, P.E.
Senior Geotechnical Engineer

Geotechnical Engineering Report

N5001(1) Toadlena to Two Grey Hills
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T: 505-821-1801

4/5/2019

Copyright and non-disclosure notice

Third-party disclaimer

Summary

The following summary of project geotechnical considerations is presented for introductory purposes and should be used only in conjunction with the full text of this report.

Project Description: The project calls for providing test results to supplement existing geotechnical reports from previous studies for two bridge sites, N214 and GRS-IBS that exist along N5001(1) Toadlena to Two Grey Hills. Wood E&I evaluated surface and subsurface soil conditions and provided data which may be utilized for bridge design recommendations.

Exploratory Methods: We explored subsurface conditions by means of two (2) borings, advanced at strategic locations at the two bridge sites, one (1) per site. The target depths for sampling soils based on review of existing reports was 25 feet below existing grades. Due to large Cobble and Sandstone in the vicinity of our boring locations, the two borings were advanced to depths of 5.5 and 10.5 feet (Auger Refusal). Soils were field classified and logged, and Standard Penetration Test (SPT) were performed to evaluate consistency of native fills.

Soil Conditions: Soils in the site vicinity are mapped as Holocene-aged and/or Pleistocene-aged Quaternary alluvial and eolian deposits, and Upper Cretaceous-aged sandstone. The Quaternary deposits are comprised of alluvial deposits and windblown silt and sand deposits. The native soils encountered during the subsurface exploration at the bridge sites consist primarily of coarse-grained soil mixtures of clay, silt, sand, gravel and occasional cobbles overlaying bedrock. The sandstone typically is fine-grained and gray with lamination.

Groundwater Conditions: At the time of drilling (February 27, 2019), none of our explorations encountered groundwater.

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1.0 Project Description

This Geotechnical Engineering Report provides supplemental test results supporting existing studies for the improvement of N5001(1) Toadlena to Two Grey Hills project in Newcomb, New Mexico.

Ralph E. Crockett, P.E. of Wood Environment & Infrastructure Solutions, Inc. (Wood) conducted an assessment of the available geotechnical reports in July of 2018. Mr. Crockett reviewed geotechnical reports furnished for the project by Western Technologies (WTI), Terracon, and Amec Foster Wheeler. WTI drilled at the original Bridge 214 site. The original location of the proposed N214 bridge was relocated, and Amec Foster Wheeler evaluated the new proposed location of Bridge 214 along with the proposed GRS-IBS Bridge. The Terracon report provided geotechnical engineering recommendations for the proposed Box Culvert (Bridge 241).

The report performed by Terracon for the proposed Box Culvert (Bridge 241) provided sufficient information for foundation design. Amec Foster Wheeler originally drilled 2 borings at each for the Bridge 214 and the GRS-IBS bridge sites in 2017. The report was determined to be complete for foundation review except that there was no sulfate, chloride, or pH testing performed. For this reason, two borings were recommended to supplement the original Amec Foster Wheeler report to collect representative samples for performing these tests.

The supplemental study involved the following to support the design effort performed on February 27, 2019 by Wood Environment & Infrastructure Solutions:

- A review of published geologic maps and literature.
- Field reconnaissance, and sampling
- Sulphate, Chlorides, and pH. Resistivity was performed in the field;

2.0 Exploratory Methods

Wood E&I explored surface and subsurface conditions at the project site on February 27, 2019. Figure 1 is a site vicinity map showing the boring locations. Our exploration and testing program is comprised of the following elements:

- A visual surface reconnaissance of the site;
- Two (2) borings (designated B-01 and B-2), advanced at strategic locations;
- Standard Penetration Test (SPT) at each boring location;

The specific number, locations, and depths of our explorations were selected to be in the vicinity of Bridge 214 and the GRS-IBS bridge sites. Actual locations were selected with Wilson & Company, Inc., Engineers and Architects , and field-adjusted based on existing site features, under the constraints of surface access, underground utility locations, and budget considerations.

The target depths for each boring were 25'. However, due to large cobbles (greater than 6") and shallow sandstone present in the areas, B-1 was advanced 5' below the ground surface, and B-2 was advanced 10' below ground surface before auger refusal. After review of the existing reports, borings from the original studies in the vicinity of B-01 and B-02 for this supplemental study are available. The borings advanced in the previous study were logged in the field and show similar results to the logging performed for this study, and are fairly uniform though the surficial soils deposits to bedrock. The soils that were sampled for this study will adequately represent the deposits shown in the original study to depths of 25'.

3.0 SITE CONDITIONS

The following sections of text present our observations, measurements, and interpretations regarding surface, soil, and groundwater conditions at the project site.

3.1 Surface Conditions

N5001(1) Toadlena to Two Grey Hills project is located near Toadlena in San Juan County, New Mexico. The roadway alignment comprising this project is a gravel road and the conditions of the bridge were generally considered to be fair to poor, with obvious erosional/scouring problems.

3.2 Geologic Review

According to published geologic maps, soil and rock conditions in the site vicinity are characterized by Holocene-aged and/or Pleistocene-aged Quaternary alluvial and eolian deposit, and Upper Cretaceous-aged sandstone The Quaternary deposits are comprised of alluvial deposits and windblown silt and sand deposits. The native soils encountered during the subsurface exploration at the bridge sites consist primarily of coarse-grained soil mixtures of clay, silt, sand, gravel and occasional cobbles overlaying bedrock. The sandstone typically is fine-grained and gray with lamination. The exploration logs (enclosed in Appendix A) provide a detailed description of the soil strata encountered in our subsurface explorations.

3.3 Groundwater Conditions

At the time of drilling (February 27, 2018), none of our explorations encountered groundwater. Groundwater fluctuations may exist depending on seasonal fluctuations in rainfall. Temporary perched groundwater conditions may occur at spot locations during periods of increased rainfall.

4.0 RESULTS AND RECOMMENDATIONS

Our geotechnical laboratory tests result of selected soil samples are summarized in Table 1. The tests performed for this study included pH (AASHTO T289), Sulfate Content (AASTHO T290), and Chloride Content (AASHTO T291) as per The Federal Highway Administration's Geotechnical Technical Guidance Memo. The soil classification was determined in the field using visual classification procedures. *Resistivity testing was performed in the field and provided to complete out scope in this amended report. The resistivity test results ranged between 3,832 Ohm-cm and 18,193 Ohm-cm.*

Table 1 Laboratory Test Results

Boring	Soil Type	Sample Depth, ft	pH (S.U.)	Sulfate Content (ppm)	Chloride Content (ppm)
B-01	Silty Sand With Cobbles, GM-SM	2.5-4.0	9.2	11	10
B-02	Sand, SM	5.0-6.5'	8.2	1605	11
B-02	Clayey Sands With Cobbles, SC-GC	2.5'-5.0' & 10.0'-10.5'	8.4	2400	31

S.U. = Standard Unit; ppm = part per million

The sulfate test result for the sample representing soils at Bridge 241 (B-01) was 11 ppm, and indicates that the Exposure Class has "Negligible" potential for sulfate reaction with the concrete. However, the samples collected at the location for the proposed GRS-IBS Bridge (B-02) were 1,605 and 2,400 ppm. Both samples collected from the GRS-IBS site classify as having "Severe" exposure potential as both

values fall between 1,500 and 10,000 ppm. The cement type required for "Severe" Exposure Class is ASTM C150 Type V Cement. Even though only soils located at B-02 (GRS-IBS bridge) exhibit high potential for sulfate attack of concrete, it is recommended that ASTM C150 Type V Cement be used for all concrete on and below grade at both bridge sites to reduce the potential for sulfate reaction.

Laboratory test results indicate that the onsite soils for both Bridge 214 and the GRS-IBS Bridge have pH values ranging from 8.2 to 9.2 and Chloride content between 10 and 31 ppm.

Corrosion of metals is an electrochemical process which involves oxidation and reduction reactions on metal surfaces. For metals in soils and water, corrosion is typically a result of contact with soluble salts or an acidic (pH of 4.5 or less) environment. Per FHWA recommendations, the maximum range for the "Moderately Corrosive Range" (Resistivity from 5000 to 2000 ohm-cm) is 100 ppm for chloride ions and 200 ppm for sulfates. The tested chloride content (10-31 ppm) in all samples is lower than the recommended limit, but the sulfates (11 – 2400) are much higher than FHWA limits. The measurement of pH on the soil samples shows that the soils are alkaline. Very strong alkalinity soils (pH greater than 10) are generally associated with significant corrosion rates. None of the pH tests for Bridge 214 and the GRS-IBS Bridge have pH values greater than 10.

Given all of the corrosivity data available, it is our opinion that the soils present at the project are potentially corrosive given the sulfate content and pH level. *Resistivity testing was conducted and the FHWA Aggressiveness category for the sites falls within the range of "Moderately Corrosive."*

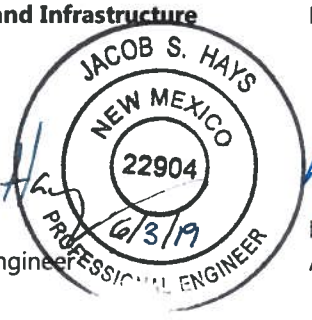
5.0 CLOSURE

The conclusions and recommendations presented in this report are based, in part, on the explorations Wood E&I performed and used for this study; therefore, if variations in the subgrade conditions are observed at a later time, we may need to modify this report to reflect those changes. In addition, because the future performance and integrity of the foundations depend largely on proper initial subgrade preparation, and backfilling procedures, monitoring and testing by experienced geotechnical personnel should be considered an integral part of the construction process. Wood E&I is available to provide geotechnical monitoring, soils testing, and other services throughout construction upon request.

We appreciate the opportunity to be of service on this project. If you have any questions regarding this report, or any aspects of the project, please feel free to contact our office.

Sincerely,

Wood Environment and Infrastructure Solutions, Inc.



Jacob S. Hays, P.E.
Senior Geotechnical Engineer

Reviewed By:

Ralph E. Crockett, P.E.
Associate Geotechnical Engineer

References

Amec Foster Wheeler, 2017. Final Geotechnical and Foundation Recommendation Report, BIA Project N5001(1)1,2&4, Toadlena, NM (Navajo Nation). Project Number 17-2017-4057. November 2017.

Federal Highway Administration (FHWA), 2009. Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes. Federal Highway Administration, U.S. Department of Transportation. November 2009

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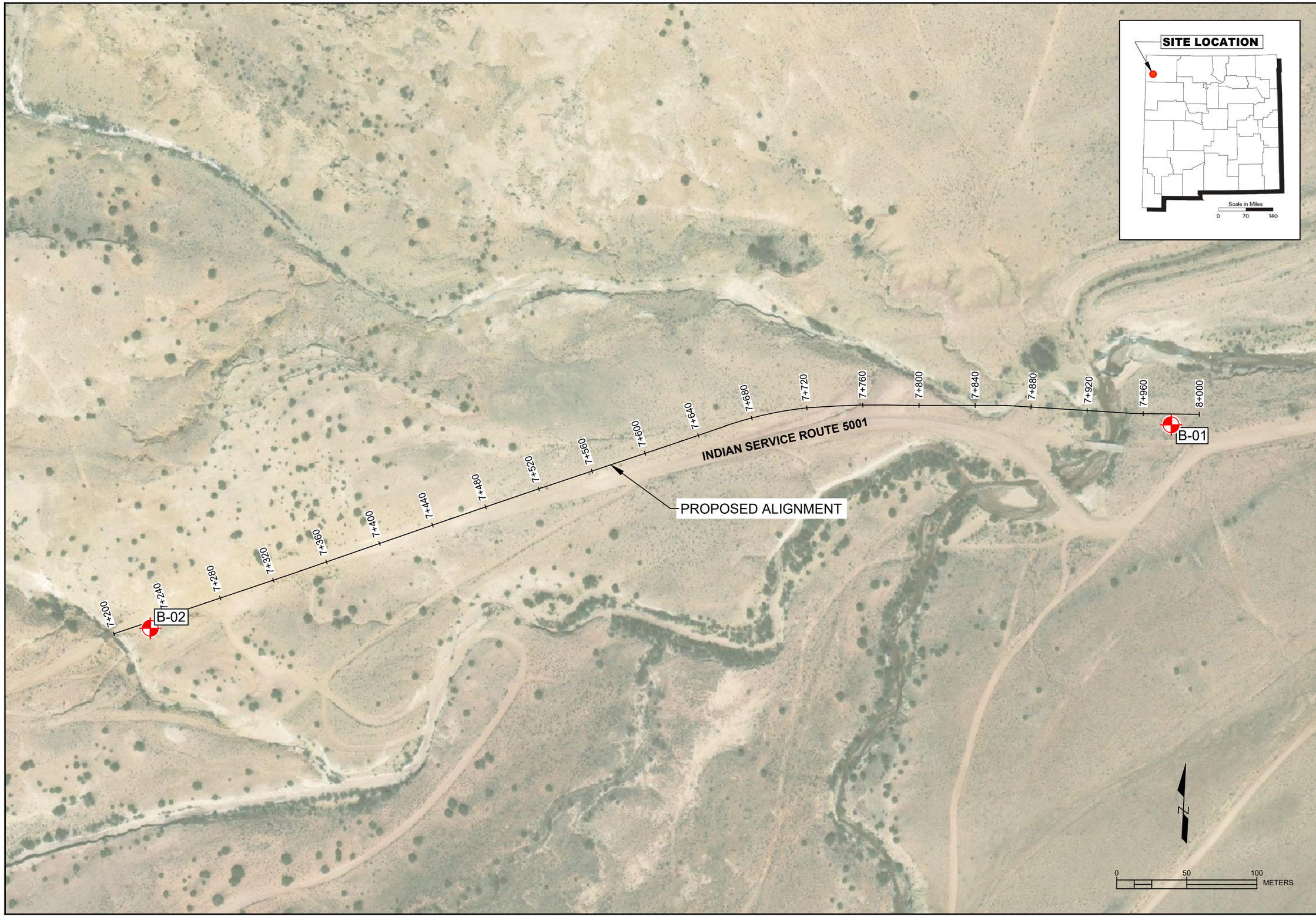
Zieglar, D.L., 1955. Preliminary Geologic Map of the Toadlena Quadrangle, San Juan County, New Mexico. U.S. Geological Society, Coal Investigations Map C-30.

Limitations

1. The work performed in the preparation of this report and the conclusions presented are subject to the following:
    a. The Standard Terms and Conditions which form a part of our Master Services Contract with Wilson & Company;
    b. The Scope of Services;
    c. Time and Budgetary limitations as described in our Contract; and
    d. The Limitations stated herein.
2. No other warranties or representations, either expressed or implied, are made as to the professional services provided under the terms of our Contract, or the conclusions presented.
3. The conclusions presented in this report were based, in part, on visual observations of the Site and subsurface explorations. Our conclusions cannot and are not extended to include those portions of the Site, which are not reasonably available, in Wood's opinion, for direct observation.
4. The Site history research included obtaining information from third parties. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.
5. Where testing was performed, it was carried out in accordance with the terms of our contract providing for testing. Other substances, or different quantities of substances testing for, may be present on-site and may be revealed by different or other testing not provided for in our contract.
6. Because of the limitations referred to above, different environmental conditions from those stated in our report may exist. Should such different conditions be encountered, Wood must be notified in order that it may determine if modifications to the conclusions in the report are necessary.
7. The utilization of Wood's services during the implementation of any remedial measures will allow Wood to observe compliance with the conclusions and recommendations contained in the report. Wood's involvement will also allow for changes to be made as necessary to suit field conditions as they are encountered.
8. This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or the part, or any reliance thereon or decisions made based on any information or conclusions in the report is the sole responsibility of such third party. Wood accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.
9. This report is not to be given over to any third party for any purpose whatsoever without the written permission of Wood.
10. Provided that the report is still reliable, and less than 12 months old, Wood will issue a third-party reliance letter to parties that the client identifies in writing, upon payment of the then current fee for such letters. All third parties relying on Wood's report, by such reliance agree to be bound by our proposal and Wood's standard reliance letter. Wood's standard reliance letter indicates that in no event shall Wood be liable for any damages, howsoever arising, relating to third-party reliance on Wood's report. No reliance by any party is permitted without such agreement.

FIGURES



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PROJECT:

TOADLENA TO TWO GREY HILLS
Newcomb,
New Mexico

TITLE:

SITE AND EXPLORATION PLAN

DWN BY: JT

CHK'D BY: JH

DATUM: N/A

PROJECTION: N/A

SCALE: AS SHOWN

LEGEND

B-01 Boring Number & Approximate Location

CLIENT:

Wilson & Company, Inc.

wood.

Environment and Infrastructure Solutions, Inc.
8519 Jefferson, N.E.
Albuquerque, NM 87113

REV. NO.:

DATE: 1/25/2019

PROJECT NO: 18-517-00006

CONTRACT NO: N/A

FIGURE NO: **1**

Appendix A

Field Exploration Procedures and Logs

APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS

The following paragraphs describe our procedures associated with the field explorations and field tests Wood E&I, conducted for this project. Descriptive logs of our explorations are enclosed in this appendix.

Auger Boring Procedures

Our exploratory borings were advanced with a solid-stem auger, using a trailer-mounted drill rig operated by Wood E&I personnel. A Wood E&I engineer continuously observed the borings, logged the subsurface conditions, and collected representative soil samples. All samples were stored in watertight containers and later transported to our laboratory for further visual examination and testing. After each boring was completed, the borehole was backfilled with a mixture of bentonite chips and soil cuttings, and the surface was patched with asphalt or concrete (where appropriate).

The enclosed Boring Logs describe the vertical sequence of soils and materials encountered in each boring, based primarily on our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the borings, as well as any laboratory tests performed on these soil samples. If any groundwater was encountered in a borehole, the approximate groundwater depth is depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted.

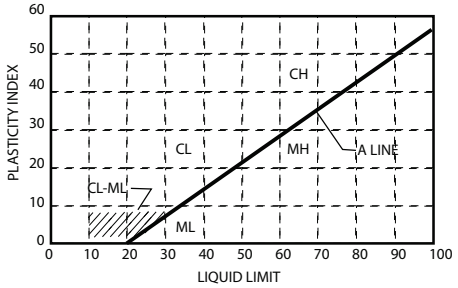
UNIFIED CLASSIFICATION SYSTEM FOR SOILS

Soils are visually classified by the Unified Soil Classification System on the boring logs presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see "The Unified Soil Classification System" ASTM Designation: D2487.

MAJOR DIVISION				GRAPH SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE-GRAINED SOILS (Less than 50% passes No. 200 sieve)	GRAVELS (50% or less of coarse fraction passes No. 4 sieve)	CLEAN GRAVELS (Less than 5% passes No. 200 sieve)			GW	Well graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
					GP	Poorly graded gravels, gravel-sand mixtures, or sand-gravel-cobble mixtures.
		GRAVELS WITH FINES (More than 12% passes No. 200 sieve)	Limits plot below "A" line & hatched zone on plasticity chart		GM	Silty gravels, gravel-sand-silt mixtures.
			Limits plot below "A" line & hatched zone on plasticity chart		GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (More than 50% of coarse fraction passes No. 4 sieve)	CLEAN SANDS (Less than 5% passes No. 200 sieve)			SW	Well graded sands, gravelly sands.
					SP	Poorly graded sands, gravelly sands.
		SANDS WITH FINES	Limits plot below "A" line & hatched zone on plasticity chart		SM	Silty sands, sand-silt mixtures.
			Limits plot below "A" line & hatched zone on plasticity chart		SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (50% or more passes No. 200 sieve)	SILTS (LIMITS PLOT BELOW "A" LINE & HATCH ZONE ON PLACTICITY CHART)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)			ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)			MH	Inorganic silts, clayey silts with slight plasticity.
	CLAYS (LIMITS PLOT ABOVE "A" LINE & HATCH ZONE ON PLACTICITY CHART)	CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)			CH	Inorganic clays of high plasticity, fat clays, silty and sandy clays of high plasticity.

NOTE: Coarse-grained soils with between 5% & 12% passing the No. 200 sieve and fine-grained soils with limits plotting in the hatched zone on the plasticity chart to have dual symbol.

PLASTICITY CHART



DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Boulders	Above 300 mm (12in.)
Cobbles	300mm to 75mm (12in. to 3in.)
Gravel	75mm (3in.) to No. 4 sieve
Coarse gravel	75mm to 19mm (3in. to 3/4in.)
Fine gravel	19mm (3/4in.) to No. 4 sieve
Sand	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 to No. 200
Fines (silt or clay)	Below No. 200 sieve

PROJECT Toadlena to Two Grey Hills
Newcomb, New Mexico
DATE 2/27/19
WOOD E & IS PROJECT NO. 19-517-00006

wood.

BORING NO. B-01

LOCATION See Site Plan
DRILLING CO.
RIG TYPE CME-45
BORING TYPE Split Spoon/Open Flight Auger
SURFACE ELEV.

Depth in Feet	Relative Drilling Resistance	Graphical Log	Sample	Sample Type	Blows/ft. 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SM-GM	dense	**SILTY SAND** with gravel, trace cobble up to 6" diameter, light brown, nonplastic, slightly moist
				S	50/7"					
5				S	50/6"				no sample recovered	Cobbles causing auger refusal @ 5.5'
10										
15										
20										
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	none		
▼			

SAMPLE TYPE
A-Auger Cuttings; NR-No Recovery
BS-Bulk Sample
S-2" O.D., 1.38" I.D. tube sample
U-3" O.D. 2.42" I.D. tube sample
T-3" O.D. thin walled Shelby tube

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PROJECT Toadlena to Two Grey Hills
Newcomb, New Mexico
DATE 2/27/19
WOOD E & IS PROJECT NO. 19-517-00006

wood.

 BORING NO. B-02

LOCATION See Site Plan
DRILLING CO.
RIG TYPE CME-45
BORING TYPE Split Spoon/Open Flight Auger
SURFACE ELEV.

Depth in Feet	Relative Drilling Resistance	Graphical Log	Sample	Sample Type	Blows/ft. 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								SC-GC		**CLAYEY SAND** trace cobbles up to 6", yellowish with trace lenses of brown clay, low to medium plasticity, slightly moist
				S	50/6"					
5				S	18			SM		**SAND** trace white streaks, light brown to yellow, moist to damp
10				S	50/4"					Cobbles caused refusal @ 10.5'
15										
20										
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	none		
▼			

SAMPLE TYPE
A-Auger Cuttings; NR-No Recovery
BS-Bulk Sample
S-2" O.D., 1.38" I.D. tube sample
U-3" O.D. 2.42" I.D. tube sample
T-3" O.D. thin walled Shelby tube

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Appendix B

Laboratory Testing Procedures and Results

APPENDIX B

LABORATORY TESTING PROCEDURES AND RESULTS

The following paragraphs describe our procedures associated with the laboratory tests Wood E&I conducted for this project. Graphical results of certain laboratory tests are enclosed in this appendix.

Visual Classification Procedures

Visual soil classifications were conducted on all samples in the field and on selected samples in our laboratory. All soils were classified in general accordance with the United Soil Classification System, which includes color, relative moisture content, primary soil type (based on grain size), and any accessory soil types. The resulting soil classifications are presented on the exploration logs contained in Appendix A.

MOTZZ LABORATORY, INC.

Soil Analysis Report

Wood
Jesse Boam
8519 Jefferson NE
Albuquerque, NM 87114

Project: Toadlena to Two Grey Hills
Date Received: 3/14/2019
Date Reported: 3/15/2019
PO Number: 195170000619

Lab Number: 927887-1 **19-0100-01 B-01 (2.5-4.0)**

AASHTO Methods	Method	Result	Units	Levels
pH	AASHTO T289	9.2	SU	
Sulfate, SO4	AASHTO T290	11	ppm	
Chloride, Cl	AASHTO T291	10	ppm	

Lab Number: 927887-2 **19-0100-02 B-02 (5.0-6.5)**

AASHTO Methods	Method	Result	Units	Levels
pH	AASHTO T289	8.2	SU	
Sulfate, SO4	AASHTO T290	1605	ppm	
Chloride, Cl	AASHTO T291	11	ppm	

Lab Number: 927887-3 **19-0100-03 B-02 (2.5-5.0 & 10.0-11.5)**

AASHTO Methods	Method	Result	Units	Levels
pH	AASHTO T289	8.4	SU	
Sulfate, SO4	AASHTO T290	2400	ppm	
Chloride, Cl	AASHTO T291	31	ppm	