wood.

Geotechnical Memo

To: Derek Meier, P.E., Senior Project Manager, Wilson & Company, Inc., Engineers & Architects

From: Brandi L. Butts, P.E., Senior Geotechnical Engineer, Wood.
John C. Lommler, Ph.D., P.E., D.GE, Principal Geotechnical Engineer, Wood

CC: Audra Gallegos, P.E., Civil Engineer, Wilson & Company, Inc., Engineers & Architects

Ref: NDOT N7054- Rock Cut Excavation Recommendations

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PROFESSIONAL ENGINEER

Wood previously performed an initial geotechnical site inspection to visually inspect the rock cut for the proposed alignment of N7054 and recommended further testing with geophysics to evaluate the characteristics of the rocks and the overburden material. As a result, Wilson & Company authorized Wood to subcontract Geolines LLC to perform a geophysical survey (shear wave velocity study) using microtremor methodology to evaluate subsurface strata and determine potential rippability of the rock outcropping along the alignment of the proposed road. This geotechnical memo summarizes the results of the geophysical investigation and provides recommendations for the rock excavation and related earthwork.

SUBSURFACE FIELD INVESTIGATION

Geolines LLC conducted subsurface investigation using refraction microtremor (ReMi) technique. The ReMi consisted of a 24, 10-Hz geophone array was situated at the crest of the hill. The results of geophysical investigation are provided as an attachment to this memo.

ROCK EXCAVATION OVERVIEW

Determining the excavatability of rock used in or encountered in construction projects can be accurately established using physical properties obtained either in the field or in the laboratory. One method is by conducting near surface geophysical profiling to estimate seismic compression wave velocity (i.e. P-wave velocity) of the rock. Based on the estimated compression wave velocity and the geology of the site (type of rock), published seismic velocity verses rippability charts can be used to determine if a given rock is rippable or will require blasting to achieve grade.

The 2019 Edition of the New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction *Section 203.2.1.1: Rock Excavation* classifies Rock Excavation as material that meets one (1) of the following field test criteria:

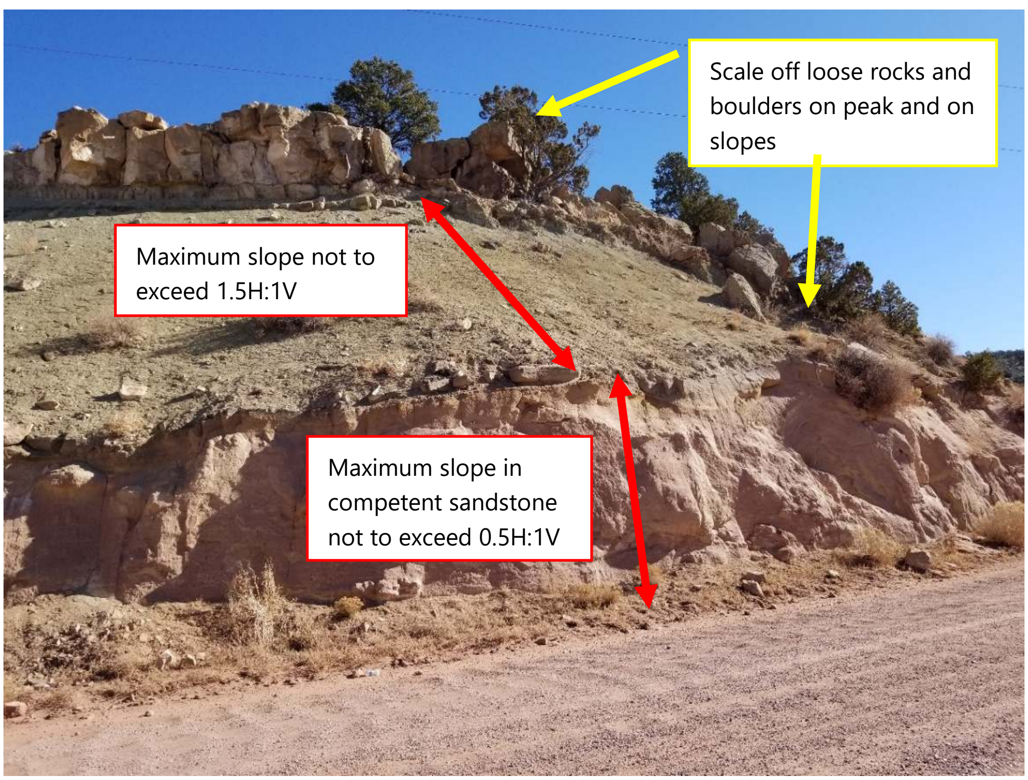
1. **Ripping Test.** Material that cannot be broken down with two passes parallel to construction centerline with a single tooth ripper mounted on a crawler-type tractor in low gear with a minimum net flywheel power rating of 255 hp.
2. **Seismic Test.** Material that has a seismic P-wave velocity greater than 6,000 ft/s. The Contractor shall submit the qualifications of the individual performing and interpreting the seismic testing to the Project Manager for approval and a minimum of 14 Days prior to testing. Perform the Ripping Test to resolve differences in Material classification if seismic velocities fall below 6,000 ft/s; or
3. **Handling Test.** Boulders or detached stones having a volume greater than one (1) yd^3 that cannot be readily broken down with excavation Equipment.

The rock cut was evaluated by a seismic line situated at the crest of the hill. The results showed shear wave velocities (P-wave velocity ~ 2 times S-wave velocity) ranging of approximately 500 ft/sec within the top five feet, and velocities ranging from approximately 750 ft/sec to 1,100 ft/sec within the limits of the proposed excavation, indicating hard soil consistency or soft rock. Based on the results of the geophysical testing, blasting will not be required to excavate the rock mass.

RECOMMENDATIONS

Based on the results of the geophysical investigation and our field reconnaissance, below is a summary of the findings and recommendations regarding the rock excavation:

- The existing slope cut consists of slightly to highly weathered sandstone with widely spaced narrow fractures and sub-vertical to vertical slope faces overlain by severely weathered sandstone.
- Based on the results of the geophysical testing, blasting will not be required. In our experience, conventional heavy duty excavation equipment such as trackhoes equipped with rock teeth, hydraulic rock breakers, or bulldozers equipped with ripping attachments can typically excavate bedrock materials that do not classify as hard rock
- Cuts in the highly to severely weathered sandstone/overburden material should not exceed 1.5H:1V
- Rock cuts in the more competent sandstone near the bottom of slope should not exceed 0.5H:1V
- Rock scaling should be performed to remove the boulders at the top of the slope as well as the loose rocks/boulders on the slopes
- At a minimum, concrete barrier walls (CWB) should be placed at the bottom of the new cut as a rock catchment method. The CWBs should be placed such that there is sufficient room for routine maintenance equipment to access the area and remove fallen rocks
- Although the rock is considered to be rippable and will not require blasting, Wood recommends a Rock Excavation bid item with a quantity of up to 20% of total excavation volume be established for the project as it may still classify based on the handling test as defined in the previous section.



SOIL FILL EMBANKMENTS

NMDOT Specifications Section 203, Excavation, Borrow, and Embankment specifies embankment materials within the roadway prism must be compacted to a minimum of 95 percent maximum density as determined by AASHTO T 180 (Modified Proctor), Method A or D (TTCP Modified). Granular and low-plasticity soils used for engineered fill shall be uniformly mixed and moisture conditioned to within -5 and +0 percent of the optimum moisture content, placed in horizontal lifts less than 8-inches in loose thickness, and compacted to at least 95 percent relative compaction. For soils with a Plasticity Index of 15 or greater, the moisture content of the soil at the time of compaction shall be -1 to +4 percent of the optimum moisture content; moisture conditioning and processing may be required to reach the specified moisture content for such soils encountered on the alignment.

The sandstone material generated from the rock cut appears to be suitable for use as embankment fill provided is placed as recommended in this memo. Roadway embankments constructed primarily of rock material, which is defined at least 65 percent retained on the No. 4 sieve, do not require moisture and density control per NMDOT Specifications Section 203.

ROCK FILL EMBANKMENTS

It is possible a portion of the fill embankments will be constructed with rock fill, which will be a soil-rock mixture containing rock excavated from road cuts. Per NMDOT Specifications Section 203, fill containing more than 25 percent of 6-inch plus rock fragments that cannot be broken down into standard lift sizes is considered rock fill. The maximum lift size (and maximum particle size) will not exceed 36 inches except where individual oversized rock fragments are placed such that the interstices are filled to provide a dense compact rock fill mass. Rock fragments that may be moisture sensitive or degrade with time, such as gypsum, claystone, or mudstone, will not be permitted as rock fill within the roadway prism.

Per NMDOT requirements, if the interstices of larger rock fragments cannot be filled with smaller sized rock and soil particles, a separation geotextile (per NMDOT Specifications Section 604) will be placed over the rock fill, followed by 1 to 3 feet of compacted soil fill. Additional layers of separation geotextile and soil fill may be required to provide adequate separation; the geotechnical and civil engineer shall determine the need for additional geotextile layers at the time of construction.

Wood recommends a bid item for a separation geotextile be established for the project.

EXCAVATION CONSIDERATIONS

All earthwork and grading should be performed in accordance with NMDOT 2019 Standard Specifications. Excavated soils along cut slopes will consist mainly of colluvium and alluvium. All soils and rock should be rippable with moderate to heavy effort using heavy-duty grading equipment. Local zones of moderate to strong cementation may be encountered within these soil deposits. The project corridor also includes zones of weathered sandstone that may be rippable using conventional construction equipment.

The cut slopes in soils, as well as weathered sedimentary rock, will be susceptible to erosion if exposed to surface runoff. Slope protection and maintenance (where the slope inclination is flat enough) should include planting with deep-rooted, lightweight, and drought resistant vegetation. Where feasible, surface drainage should be controlled along the top of slope to prevent water run-off entering excavations or fill slopes and eroding the slope face.

Attached: Results of Geophysical Investigations

SUPPLEMENTAL SUBSURFACE SITE CHARACTERIZATION

N7054 Pinedale West Rock Cut Analysis
McKinley County
Pinedale, New Mexico
Geolines Project No. NM-210014

Prepared for:

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Wood Project No. 21-517-00008

SUBSURFACE SITE CHARACTERIZATION

N7054 Pinedale West Rock Cut Analysis
McKinley County
Pinedale, New Mexico
Geolines Project No. NM-210014

INTRODUCTION

Background

This Subsurface Site Characterization is intended to provide engineering properties of subsurface materials to Wood Environment and Infrastructure Solutions, Inc. Geolines LLC collected surface wave data to provide calculated shear wave velocity profiles at one (1) array location.

SURFACE SESMIC EXPLORATION

Refraction Microtremor (ReMi) methods were used to calculate the average velocity of shear waves in materials underlying geophone array locations. ReMi analysis was used to provide calculated average shear wave velocities over segments of the arrays and approximate vertical profiles of shear wave velocities v. depth for subsurface materials.

Shear Wave Velocity Profiles

Refraction Microtremor (ReMi) techniques are routinely used to establish calculated average shear wave velocity of subsurface profiles to 100 feet depth for seismic design. ReMi is used to explore subsurface conditions to more than 1000 feet in oil and mineral exploration (Faster Better Shear Wave Velocity to 100 Meters Depth from Refraction Microtremor Arrays: John N. Louie, Seismological Laboratory and Department of Geological Sciences, Mackay School of Mines, University of Nevada, Reno, Feb 27, 2001). The method can generally estimate shear wave velocities to within 20 per cent of measurements by direct methods such as down-hole surveys. The total depth of investigation varies with material type and seismic velocities. Two-dimensional cross sections are presented to 55 feet below existing grades. For most site conditions, resolution for bed thickness is usually 0.3 to 1 times the geophone spacing. In this exploration the geophone spacing, or distance between geophones, was ten feet.

Fieldwork

Surface wave measurements for ReMi analysis were obtained at one geophone array location using a Seismic Source DAQ III Data Acquisition Link seismograph. The geophone array consisted of 24, 10-Hz (nominal) Geospace Technologies p-wave geophones. Digital samples of surface waves under passive and active conditions were recorded at two millisecond intervals for events of 30 second duration for ReMi analysis. After setting up each geophone array, about five, 30 second events were recorded to obtain surface wave measurements. After ambient conditions were recorded, about five, 30 second active source recordings were obtained while striking the ground with a 12-pound sledgehammer about twice per second for about three seconds. The data collected from each array was reduced, processed and stacked. Useable data collected under active and passive conditions at each geophone array location are stacked, as some readings emphasize different portions of the total frequency spectrum available for analysis. Approximate array locations are shown with array beginnings and endings (Geophone 1 and 24) on Plate 1, *Site Map* in Attachment 1.

Data Reduction and Results

Data collected from the overlapping segments of each array were analyzed to provide one-dimensional profiles of calculated shear wave velocities for materials underlying the geophone locations. The analytical segments included eight geophone spacings for each array. The analytical segments overlapped adjacent segments. In this investigation the overall geophone arrays consisted of 24 geophones. The one-dimensional profile developed for each array segment averages the calculated shear wave velocity of underlying materials over the length and depth of each segment.

The one-dimensional shear wave velocity profile and average shear wave velocities were modeled for each array data set using Optim Software's SeisOpt® ReMi™v4.0 software. The field data were reduced and processed by the software to produce a velocity spectrum by slowness-frequency (p-f) transformation of the records. Using the processed data, the software produces a p-f image and the normal-mode dispersion trend is identified. Frequency-velocity pairs comprising the dispersion curve are picked at the lower bounds of the trend of the high spectral ratio band identified in the p-f image.

To draw two-dimensional cross sections of shear wave velocities in materials underlying a geophone array, the one-dimensional profile from each segment is applied to the overall array length at the center of the analyzed segment. Two-dimensional cross sections showing the averaged results of shear wave velocity profiles developed as described are presented on Plate 3. One-dimensional profiles of shear wave velocities for analytical segments used to construct the cross sections are presented below the images shown on the plates.

Limitations of Refraction Microtremor Techniques and Assumptions

The ReMi analytical method presents solutions that are not necessarily unique. Application of averages over overlapping segments and inherent uncertainties from non-unique solutions suggest that indicated depths where velocity changes occur, and the calculated velocities shown should be considered approximate. The software used to evaluate surface wave measurements as presented in this report used some assumptions to facilitate the analysis. The bulk density of soils was assumed at 2 g/cc and a Poisson's Ratio of 0.3 is inherent in the calculations.

Closure

The information provided in this report is the result of remote sensing instruments and techniques. Data provided are approximate and should be considered supplemental to the overall characterization efforts performed by others.

Professional services for this project were performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical engineers practicing in this or similar localities. No warranties, express or implied, are intended or made.

Respectfully Submitted:

Zachary J. Rockhold
Project Manager

Reviewed By:

Otto C. Holmquist, PE
Principal Engineer

Attachment 1:
Plates

SUBSURFACE SITE CHARACTERIZATION

N7054 Pinedale West Rock Cut Analysis
McKinley County
Pinedale, New Mexico
Geolines Project No. NM-210014

Prepared for:

Wood Environment and Infrastructure Solutions, Inc.
8519 Jefferson Street NE
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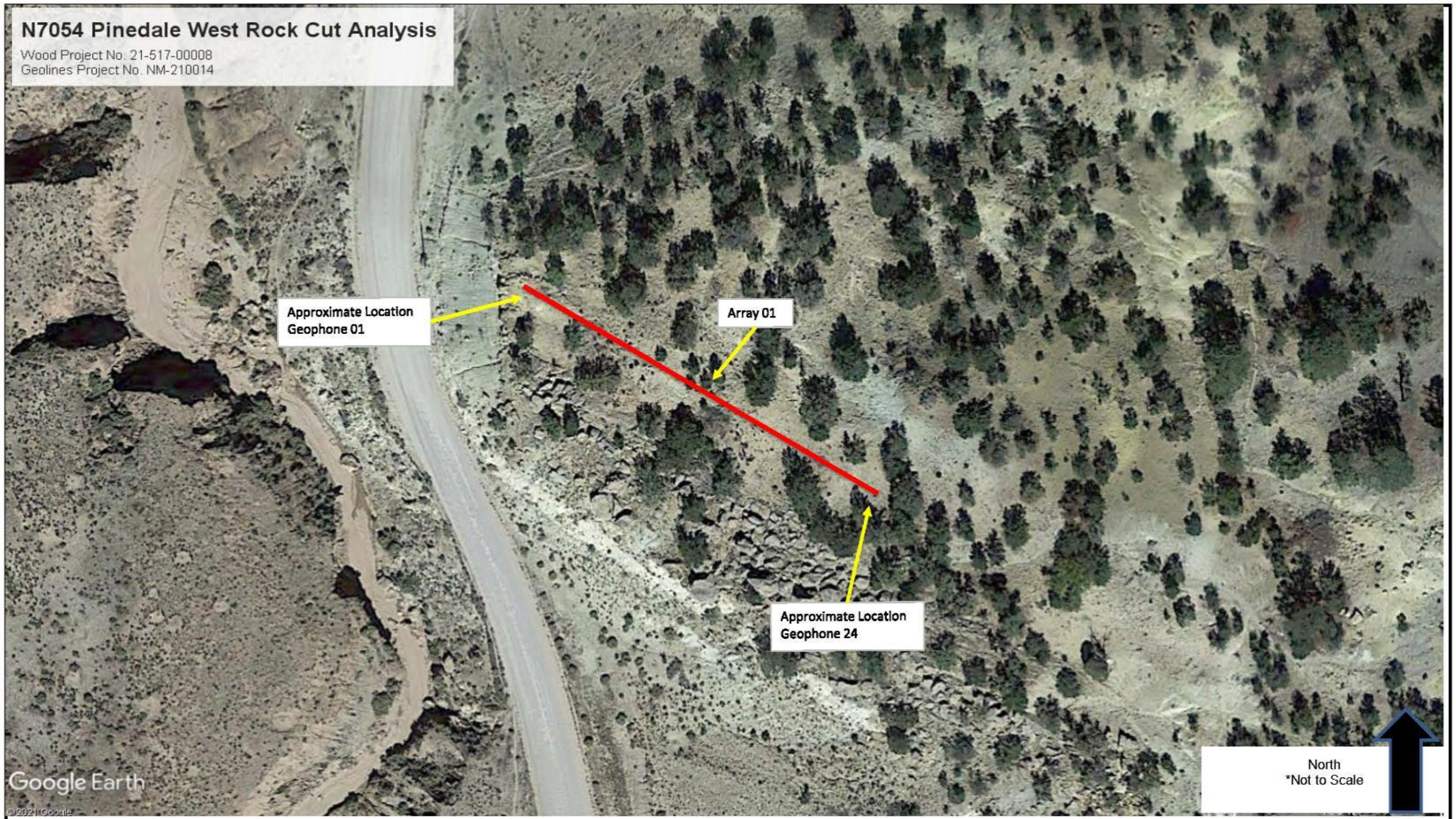
Wood Project No. 21-517-00008



MAP LEGEND	GEOLINES	Wood Environment and Infrastructure Solutions, Inc.	SITE MAP	
Array Location	Wood Project No. 21-517-00008	N7054 Pinedale West Rock Cut Analysis McKinley County Pinedale, New Mexico	PROJECT NO.:	PLATE NO.
			NM-210014	1

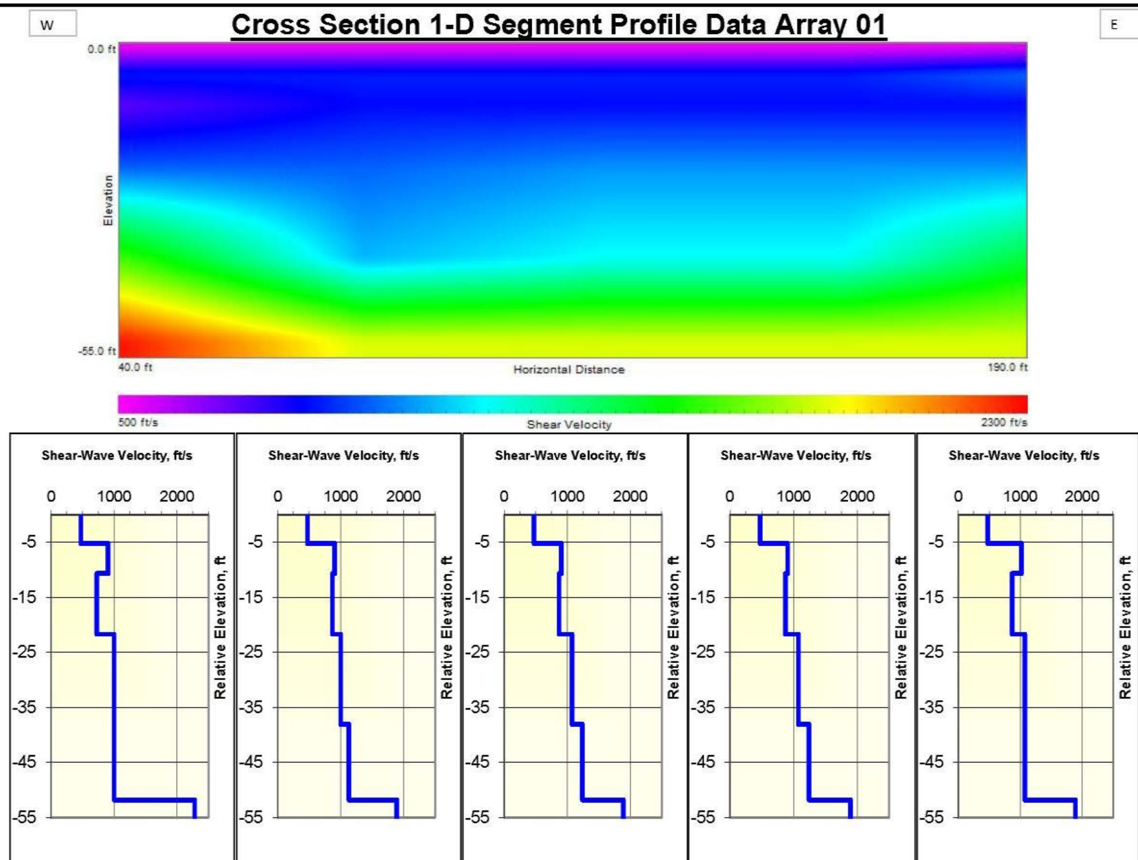
Global Positioning System Coordinates for Seismic Arrays

Project No.:	NM-210014
Project:	N7054 Pinedale West Rock Cut Analysis McKinley County Pinedale, New Mexico
Date:	Thursday 04/15/2021
Comments:	General investigation area location provided by Wood. Acutal loactions of seismic lines adjusted based on field conditions. Endpoint coordinates provided by Geode Sub-Meter GPS manufractured from Juniper Systems, and map datum WGS84 was used.

Array Name	Array Orentation Geophone 1-24	Geophone Spacing (ft)	Number of Geophones	Array Length (ft)	Location Latitude/Longitude: Latitude (Degrees)	Location Latitude/Longitude: Longitude (Degrees)	Comments
Array 01	W to E	10.00	24	230.00	35.597681°	-108.475470°	Geophone 01
					35.597522°	-108.475153°	Geophone 12
					35.597360°	-108.474817°	Geophone 24

GEOLINES	Wood Environment and Infrastructure Solutions, Inc.	GPS Data
Wood Project No. 21-517-00008	N7054 Pinedale West Rock Cut Analysis McKinley County Pinedale, New Mexico	PROJECT NO.: NM-210014 PLATE NO. 2

Cross Section 1-D Segment Profile Data Array 01



GEOLINES	Wood Environment and Infrastructure Solutions, Inc.	Cross Section 1-D Segment Profile Data Array 01	
Wood Project No. 21-517-00008	N7054 Pinedale West Rock Cut Analysis McKinley County Pinedale, New Mexico	PROJECT NO.:	PLATE NO.
		NM-210014	3