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MEMORANDUM

19 August 2020
File No. 130458-002

TO: Maine Department of Transportation
Kate Maguire, P.E.

FROM: Haley & Aldrich, Inc.
Erin A. Force, P.E., Wayne A. Chadbourne, P.E.

SUBJECT: Seismic Refraction Survey
Route 26 Improvements
MaineDOT WIN 018767.00

Pursuant to the work scope outlined in our proposal dated, 15 May 2020, a seismic refraction survey was conducted by Northeast Geophysical Services on the slope located to the northeast (uphill) of the existing roadway, where the proposed soil nail retaining wall is planned to be constructed. The survey was completed under the direction of Haley & Aldrich on 20 and 21 May 2020 and included two seismic refraction lines. Seismic Line 1 was extended to the existing roadway in the vicinity of test boring HB-WOOD-209 so that the seismic refraction data could be "ground truthed" with the top of rock elevation encountered in the boring. Seismic Line 2 was conducted approximately 15 ft farther upslope.

Haley & Aldrich reviewed the results of the seismic refraction survey and compared it to the limited test boring data located nearby (HB-WOOD-209). Test borings were not able to be conducted on the slope due to the steep/mountainous terrain. The estimated top of rock at the end of Seismic Line 1 was El. 714, which was comparable to the top of rock encountered at El. 714.5 in the boring.

Top of rock elevations from borings and interpreted top of rock information from the seismic refraction surveys were included on the cross section plan sheets in the vicinity of the proposed retaining wall, from Sta. 57+00 to Sta. 61+00. Refer to contract documents for this information.

Refer to the attached report by Northeast Geophysical Services for a description of the equipment and means/methods used to conduct the survey as well as a summary of the results of the survey.

Please do not hesitate to call if you have any questions or comments.

Attachments:

"Seismic Refraction Survey, Route 26 Highway Rehabilitation Site, Woodstock, Maine," prepared by Northeast Geophysical Services, dated June 2020 (11 pages)

SEISMIC REFRACTION SURVEY
ROUTE 26 HIGHWAY REHABILITATION SITE
WOODSTOCK, MAINE
For:
Haley & Aldrich Inc.
June, 2020

Northeast Geophysical Services
Division of NGS, Inc.
4 Union Street
Bangor, Maine

SEISMIC REFRACTION SURVEY
ROUTE 26 HIGHWAY
REHABILITATION SITE
WOODSTOCK, MAINE

INTRODUCTION

At the request of Haley & Aldrich, Inc., a seismic refraction survey was completed at the Route 26 Highway Rehabilitation Site located in Woodstock, Maine. The objective of this survey was to determine the bedrock depth and configuration beneath the survey area. The field survey was undertaken on May 20-21, 2020. Two seismic lines were surveyed. This report describes the equipment and methods used and the results of the survey, and includes profiles of the interpreted seismic lines.

LOCATION AND SITE CONDITIONS

The survey lines are located along the northeast side of Route 26 in Woodstock, Maine. The approximate locations of the seismic lines with respect to Route 26 are shown on the Seismic Line Location map (following page). Soil surface conditions along the lines were generally loose, rocky soil. Both survey lines traversed a steep slope making walking and geophone planting very difficult.

SUMMARY OF RESULTS

The seismic refraction results are attached as profiles of each survey line. The seismic results show the seismically interpreted depths to bedrock and configurations. The seismically calculated bedrock depths range from approximately 10 feet to 30 feet deep over the survey area.

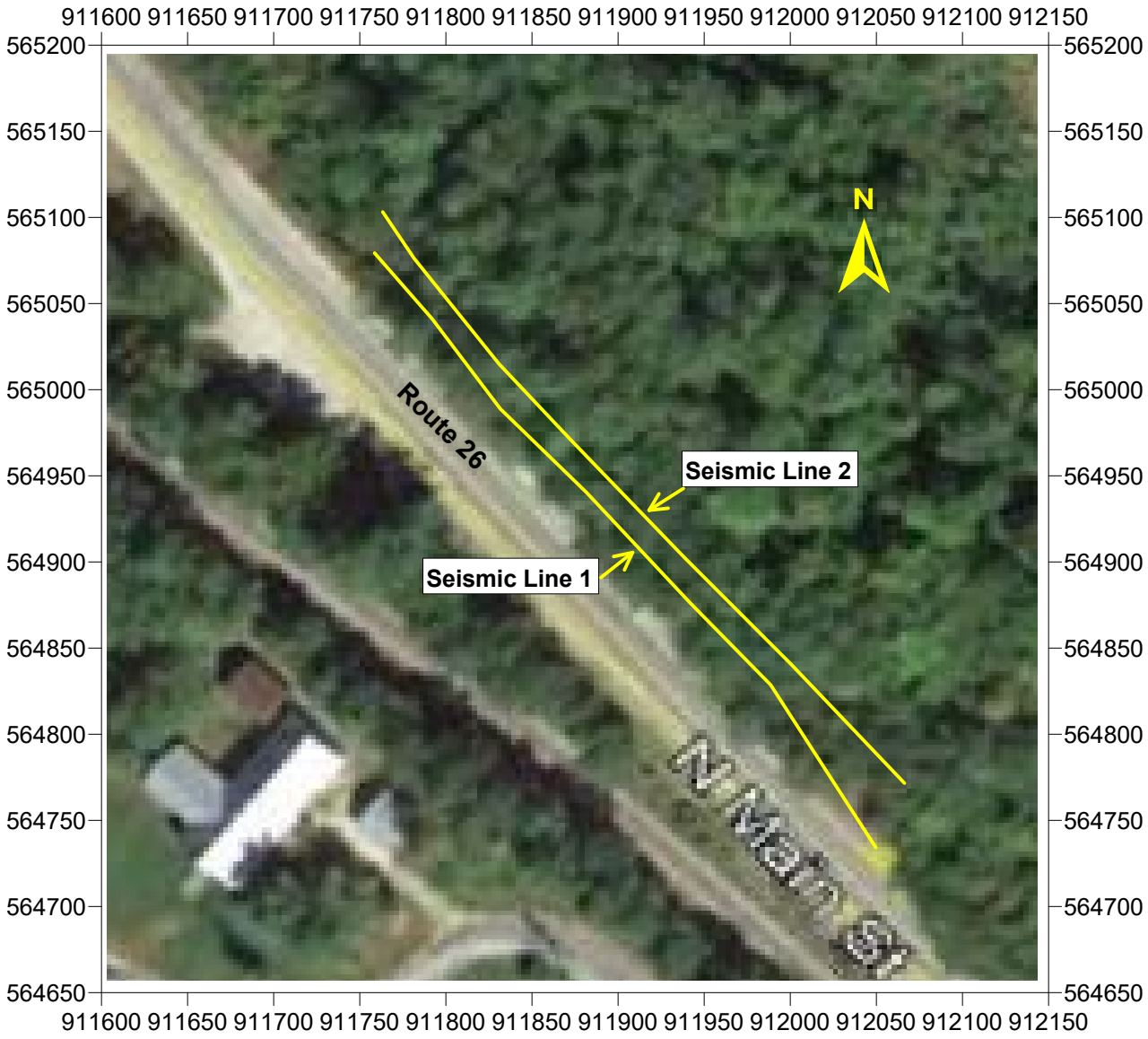
SEISMIC METHODS AND INSTRUMENTATION

The seismic refraction method relies on travel times of sound waves, measured in milliseconds, traveling through and refracting from subsurface layers with contrasting densities. The seismic refraction lines were surveyed using a Geometrics Geode, 24-channel seismograph. Surface elevations were obtained from the Maine DOT survey crew.

Each survey line was 445 feet long and consisted of four, 115-foot segments with each segment containing 24 geophones that were spaced 5 feet apart. Each segment was tested with six to seven shots. The general shot configuration consisted of one shot at either end of the segment, one off each end about 50 feet, and two or more within the segment. The energy source consisted of a 16-lb hammer or a small explosive charge buried about 3 feet.

The seismic data were processed and interpreted using the Seisimager 2D seismic interpretation program by Geometrics. This program calculates seismic velocities by regression and by Hobson-Overton method, and solves for layer thicknesses using the delay-time method and iterative ray tracing modeling. The data was also interpreted using tomographic analysis (also by SeisImager). Tomography better accommodates horizontal velocity variations.

Seismic Refraction Line Locations
Route 26 Highway Rehabilitation Site
Woodstock, Maine



These Line locations are approximate. The Maine DOT has acurate survey locations.

SEISMIC SURVEY RESULTS

Profiles of the two lines showing the seismically interpreted bedrock depths and configurations and tabulated data are attached.

The survey identified three velocity layers. The Layer 1 velocity for the survey was about 1,100 feet per second (fps) and is interpreted to represent dry, loose soil. The Layer 2 velocity was about 2,900 to 3,300 fps and is interpreted to represent dense soil – possibly till. The Layer 3 velocity was about 16,500 fps and is interpreted to represent bedrock.

DISCUSSION OF SEISMIC RESULTS

In order for the seismic refraction method to accurately estimate velocity layer depths, certain natural conditions should exist:

a.) Layers should increase in velocity and in thickness with depth. A typical example would be ten feet of unsaturated soil at 1,100 fps overlying 50 feet of saturated soil at 5,000 fps that overlies bedrock at 15,000 fps.

b.) There should be a sufficient velocity contrast between different layers. Ideally, each velocity layer would be 2 to 3 times faster than the overlying layer.

c.) The velocity within a layer should be relatively constant throughout that layer (lateral homogeneity).

At the Woodstock site these conditions were generally met, however, it is suspected that there are some lateral velocity variations in the Layer 1 and 2 velocities which may have affected the models. If velocities are used in the model that are lower than the actual velocities traveling through the subsurface, the depth to bedrock would be underestimated. And, conversely, if higher velocities are used in the model, the depth to bedrock would be overestimated.

In addition to these conditions, it is also important that there be a low level of background noise at the site. Background noise was troublesome because of traffic but we tried to collect data during lulls in the traffic. It is also very helpful if there is some ground truth data, such as borehole data, to compare and calibrate the seismic information. At the Woodstock site there was a borehole (Wood-209) at the southern end of Line 1. The modeled bedrock depth matched the known bedrock depth fairly closely at this end of Line 1.

Under favorable conditions seismic refraction results can be fairly precise, within +/- 10 percent or within 5 feet. The conditions at the Woodstock site were challenging because the loose, rocky soil did not transmit sound energy very well. Ideally the ground would be firm and homogeneous. In general, the poorest data quality on the survey lines was near the middle of the lines.

As with any indirect method it is possible that the seismically interpreted depths may not be accurate, however, it is believed that the seismic survey at the Woodstock site fairly accurately depicts the bedrock configuration.

ATTACHMENTS
SEISMIC REFRACTION PROFILES
AND TABULATED DATA

Seismic Line 1

Southeast

Northwest

on road near HB-209

Elevation in feet

Distance in feet

Line 1 Seismically Estimated depths - Woodstock, Maine			
X distance	Surface elevation	Bedrock elevation	Estimated depth to bedrock
0	733.1	714	20
5	733.3	714	19
10	733.5	714	19
15	733.6	714	19
20	733.8	715	19
25	734.0	716	18
30	734.3	717	17
35	734.5	718	16
40	734.8	719	15
45	735.1	720	15
47	735.2	720	15
50	735.5	721	15
55	736.1	722	15
60	736.3	722	14
65	737.1	723	14
70	737.5	724	13
75	738.6	726	13
80	739.5	727	13
82.5	738.9	727	12
85	740.2	728	12
90	741.3	728	13
95	742.0	728	14
100	743.1	728	15
105	743.6	728	15
110	745.1	729	16
115	746.3	729	17
120	747.0	729	18
125	746.1	729	17
130	746.1	729	17
135	746.7	729	18
140	747.3	730	18
145	747.3	730	17
150	748.1	731	17
155	749.4	731	18
160	749.4	732	17
165	749.7	732	18
170	749.7	732	18
175	750.4	732	18
180	750.7	732	19
185	751.2	732	19
190	751.8	732	20
195	753.7	732	21
200	754.0	733	21
205	753.3	733	21
210	752.4	733	20
215	752.5	733	20
220	752.8	733	20
225	752.7	733	20
230	752.9	735	18

Line 1 Seismically Estimated depths - Woodstock, Maine			
X distance	Surface elevation	Bedrock elevation	Estimated depth to bedrock
235	754.7	736	18
240	755.8	737	19
245	755.3	738	18
250	754.8	738	17
251.5	756.0	737	19
255	755.1	736	19
260	755.4	736	20
265	755.6	735	20
270	754.9	735	20
275	753.7	736	18
276.5	754.8	736	19
280	754.0	737	17
285	753.6	737	16
290	753.6	737	16
295	752.5	737	15
300	752.8	737	16
305	752.5	737	15
310	752.3	737	16
315	751.8	736	15
320	751.4	736	15
325	751.4	735	16
330	751.5	734	18
335	751.5	733	18
340	750.9	732	18
345	750.9	733	18
350	750.7	734	17
355	750.8	735	16
360	751.5	736	16
365	751.6	736	15
370	751.2	736	15
375	750.8	737	14
380	751.6	737	15
382.5	752.3	737	16
385	751.8	736	16
390	751.9	735	17
395	751.6	733	19
400	750.7	731	20
405	750.6	729	22
410	750.1	728	22
415	750.0	728	22
420	749.9	727	22
425	749.4	727	22
430	748.7	727	22
435	747.7	727	21
440	747.4	727	21
445	747.2	726	21

Seismic Line 2

Southeast

Northwest

Elevation in feet

Distance in feet

Line 2 Seismically Estimated depths - Woodstock, Maine			
X distance	Surface elevation	Bedrock elevation	Estimated depth to bedrock
0	747.8	720	28
5	748.8	719	29
10	749.9	719	30
15	750.6	720	31
20	751.0	720	31
25	751.3	721	30
30	751.6	722	30
35	752.3	724	28
40	753.4	727	27
45	754.4	730	25
50	754.8	732	23
55	755.9	733	23
60	755.7	733	23
65	755.2	733	23
70	755.2	732	23
75	755.2	732	23
80	754.4	733	22
85	754.8	733	22
90	755.3	733	22
95	755.2	733	22
100	755.7	734	22
105	756.0	735	21
110	756.3	736	21
115	756.9	736	21
120	757.5	736	21
125	757.0	736	21
130	757.1	737	20
135	757.2	737	21
140	757.0	736	21
145	757.1	736	21
150	758.0	735	23
155	758.2	735	23
160	758.5	735	23
165	758.8	736	23
170	759.8	738	22
175	759.9	740	20
180	760.0	742	18
185	760.0	743	17
190	760.0	743	17
195	761.1	743	18
200	761.8	743	18
205	762.3	744	18
210	763.1	745	18
215	763.3	746	17
220	763.9	747	17
225	763.6	747	17
230	763.8	746	18
235	764.6	744	20

Line 2 Seismically Estimated depths - Woodstock, Maine			
X distance	Surface elevation	Bedrock elevation	Estimated depth to bedrock
240	764.7	743	22
245	764.4	743	22
250	764.8	743	22
255	765.6	744	22
260	766.1	745	21
265	765.8	745	21
270	765.3	744	21
275	765.0	744	21
280	764.7	744	21
285	764.3	744	20
290	764.2	745	20
295	764.1	746	18
300	764.2	747	17
305	763.7	748	15
310	763.7	749	14
315	763.2	750	13
320	763.1	750	13
325	762.1	751	11
330	762.0	751	11
335	761.8	750	12
340	761.6	749	13
345	761.3	747	14
350	761.6	746	16
355	761.4	745	17
360	760.9	744	17
365	760.2	744	16
370	760.4	744	16
375	760.4	744	16
380	759.5	744	15
385	759.5	745	15
385	759.5	745	15
390	759.3	745	15
395	759.3	745	15
400	759.4	744	15
405	759.0	743	16
408.5	758.5	743	16
410	758.0	742	16
415	758.2	741	17
420	758.5	740	18
425	757.9	739	18
430	757.4	739	19
435	757.2	738	19
440	757.5	738	19
445	757.1	738	19