Boy Scouts of America, Beaumont Scout Reservation
Seismic Investigation

Date: 2 November, 2006 **OGS File Number**: 340079000324

Survey Type: Compressional (P) and Shear (S) wave seismic refraction
Survey Crew: Glenn Larsen, E. Mac Swinford, and Douglas Shrake.

Site Location: 2,275 feet south of Latimer Road and 4,625 feet west of SR 45 on the sports field in the area of the Reservation known as "Cub Scout World"
County: Ashtabula **Township:** Morgan **USGS 7½' Quadrangle:** Jefferson
Latitude: N 41º 41' 06.30" **Longitude:** W 80º 52' 09.72" **Reference Datum:** NAD83
Ohio State Plane, X: 2,413,889 ft. **Y:** 739,541 ft. **Zone:** North
Line Direction: N 79° E
Note: Coordinates were determined at location of geophone no. 1, line direction measured from geophone no.1.

Purpose: The Ohio Division of Geological Survey (OGS) is mapping the glacial deposits throughout the state of Ohio. One major goal in this effort is to map the three-dimensional glacial geology of the state in order to characterize the extent, vertical succession, and thickness of the glacial materials from the surface down to and including the uppermost bedrock unit. However, many areas in the state are remote and subsurface information on the geology and thickness of the glacial deposits does not exist. The OGS has been using the seismic refraction technique as a cost effective tool to acquire subsurface information in these problem areas. The specific objective of the seismic refraction survey was to acquire P- and S-wave velocities to determine the depth to bedrock, as well as, the thicknesses and in-situ elastic properties of the unconsolidated sediments overlying the bedrock. This data will be used in the OGS' long-term project of mapping the glacial deposits throughout the state of Ohio.

Geologic Overview: The site lies within the Grand River Finger-Lake Plain Region of the Glaciated Allegheny Plateaus Section within the Appalachian Plateaus Province (Brockman, 1998). The general surficial geology of the surrounding area is Wisconsinan-age lacustrine silty clay and clay overlying the Devonian-age Ohio Shale (Brockman, 1998; Larsen, 1996; Milliron, Prebonick, and Svoboda, 2003; White and Totten, 1979).

Seismic Refraction Survey: The seismic refraction survey was laid out along a straight, southwest to northeast, line 460 feet in length. P- and S-wave refraction data were collected from a linear array of 24 geophones with distances of 20 feet between geophones. The P- and S-wave data were collected from seven shot gathers, two shot gathers were acquired 50 feet off each end of the line and five shot gathers were acquired along the line. The seismic data were stacked 5 times at each shot gather to increase the signal-to-noise ratio to overcome any background noise affecting the survey

Seismic energy for the P-wave survey was generated by striking a small hardened aluminum plate with a 20-pound sledgehammer. The P-waves were detected by geophones that were sensitive to vertical ground motion, and had a natural frequency of 14 Hz. Seismic energy for the S-wave survey was generated striking a 70 pound I-beam plate with a 20-pound sledgehammer on one side (perpendicular to the line) to generate S-waves with one polarity. Then the source was struck on the opposite side (again, perpendicular to the line) to generate S-waves with a reversed polarity. The S-waves were detected by geophones that were sensitive to horizontal ground motion, and had a natural frequency of 28 Hz

The digitally recorded data were stored in the SEG-2 format (Subcommittee of the SEG Engineering and Groundwater Geophysics Committee, 1990). Relative elevation for each geophone was determined using a stadia rod and a handlevel. The reference datum for the

elevation data was set at the location of the first geophone. Location coordinates for the seismic survey were obtained with a Garmin handheld GPS unit.

Results: The seismic refraction survey detected two refractive boundaries which occurred at the top of the water table and at the top of the bedrock surface. The interpreted data was correlated to a water well (ODNR, Division of Well Log No. 544886) that was located 99 feet east of geophone 24. The geologic interpretation of the P-wave velocity data from spread 1 contains three velocity layers. The upper 1,186 ft/s velocity layer represents 4-8 feet of unsaturated lacustrine silty clay and clay overlying the water table. The middle 5,151 ft/s velocity layer represents 34-45 feet of saturated lacustrine silty clay and clay underlying the water table. The average thickness of the lacustrine sediment is 42 feet. The lower 11,224 ft/s layer is the shale bedrock.

S-waves are not influenced by the presence of ground water, thus, S-wave surveys will not detect refractions from the water table. A two velocity layer model was interpreted from the S-wave velocity data for spread 2. The model is essentially the same as the P-wave, with an upper 523 ft/s velocity layer represents lacustrine silty clay and clay and the lower 6,429 ft/s velocity layer represents the shale bedrock. Comparing the results of the P- and S-wave interpretations, the uncertainty of the predicted depths to bedrock are around ± 5 feet.

NEHRP Site Class Assessment and Spectral Accelerations: This site fits the Site Class D definition, as defined by NEHRP (Building Seismic Safety Council, 2004). The site class is based upon the average shear-wave velocity of the upper 100 feet of the soil profile measured along the seismic refraction line.

Seismic Design Parameters

Site Classification and Parameter	Value
Average Shear Wave Velocity (from S-wave refraction data)	1110 ft/s
	338 m/s
Site Classification	D
Amplification Rating	Moderate
0.2 sec. Spectral Response Acceleration, S_s	0.209
1.0 sec. Spectral Response Acceleration, S_1	0.052
Site Coefficient, F_a	1.60
Site Coefficient, F_v	2.40
Maximum Considered Earthquake Spectral Response Acceleration (0.2 sec), S_{MS}	0.335
Maximum Considered Earthquake Spectral Response Acceleration (1 sec.), S_{M1}	0.124
5% Damped Design Spectral Response Acceleration (0.2 sec.), S_{DS}	0.223
5% Damped Design Spectral Response Acceleration (1 sec.), S_{D1}	0.083

Ground motion parameters were calculated using the USGS Earthquake Ground Motion Parameter Calculator - Version 5.0.9

References

Brockman, C.S., 1998, Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map.

Larsen, G. E., 1996 Reconnaissance bedrock geology map of the Jefferson, Ohio, Quadrangle: Ohio Department of Natural Resources, Division of Geological Survey, Open-file map BG-D1F7.

Milliron, E. L., Prebonick, S. T., and Svoboda, J. R., 2003, Soil survey of Ashtabula County, Ohio: United States Department of Agriculture, Soil Conservation Service, 443 p.

Subcommittee of the SEG Engineering and Groundwater Geophysics Committee, Pullan, S.E., Chairman, 1990, Recommended standard for seismic (/radar) files in the personal computer environment: Geophysics, vol. 55, no. 9, p. 1260-1271.

White, G. W. and Totten, S. M., 1979, Glacial geology of Ashtabula County, Ohio: Ohio Survey, Report of Investigations No. 112, 48 p.

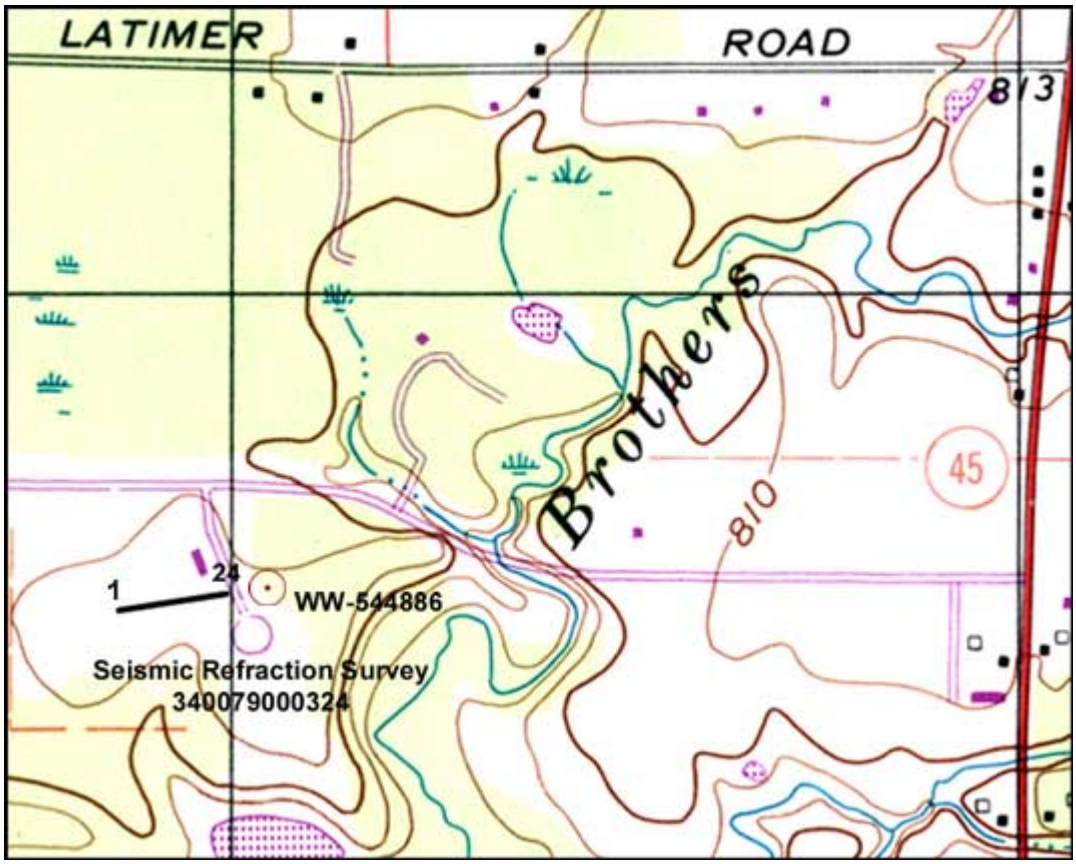

Figure 1. Map showing the location of seismic refraction survey 340079000324 on the Boy Scouts of America, Beaumont Scout Reservation. Numbers at each end of the line indicates the location of geophones 1 and 24. WW-544886 is the location of the water well used as a control point for geologic interpretation of the seismic refraction data. The water well I.D. number is the ODNR, Division of Water well log file number.

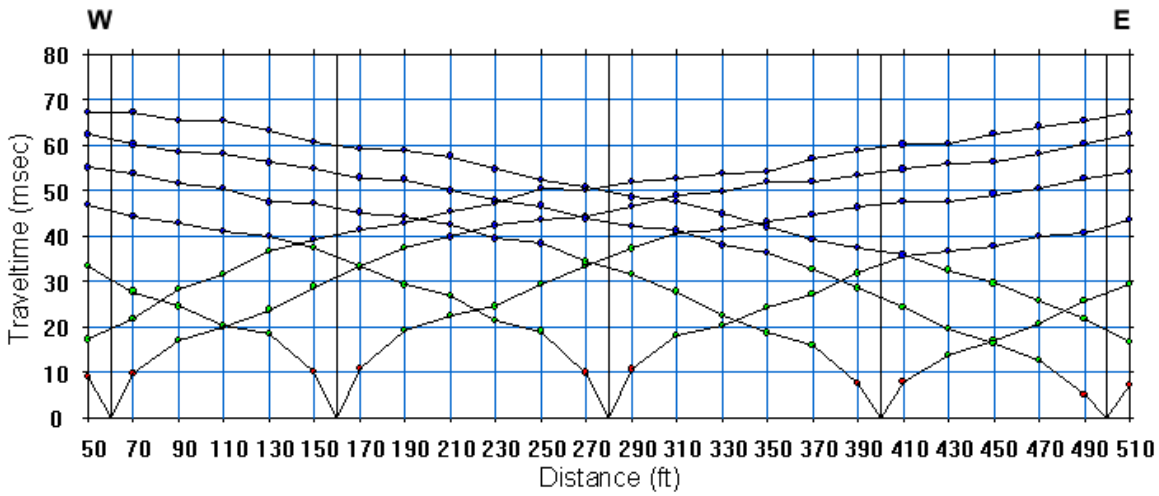

Figure 2. Travel time versus distance plot from the seven shot gathers of the P-wave survey.

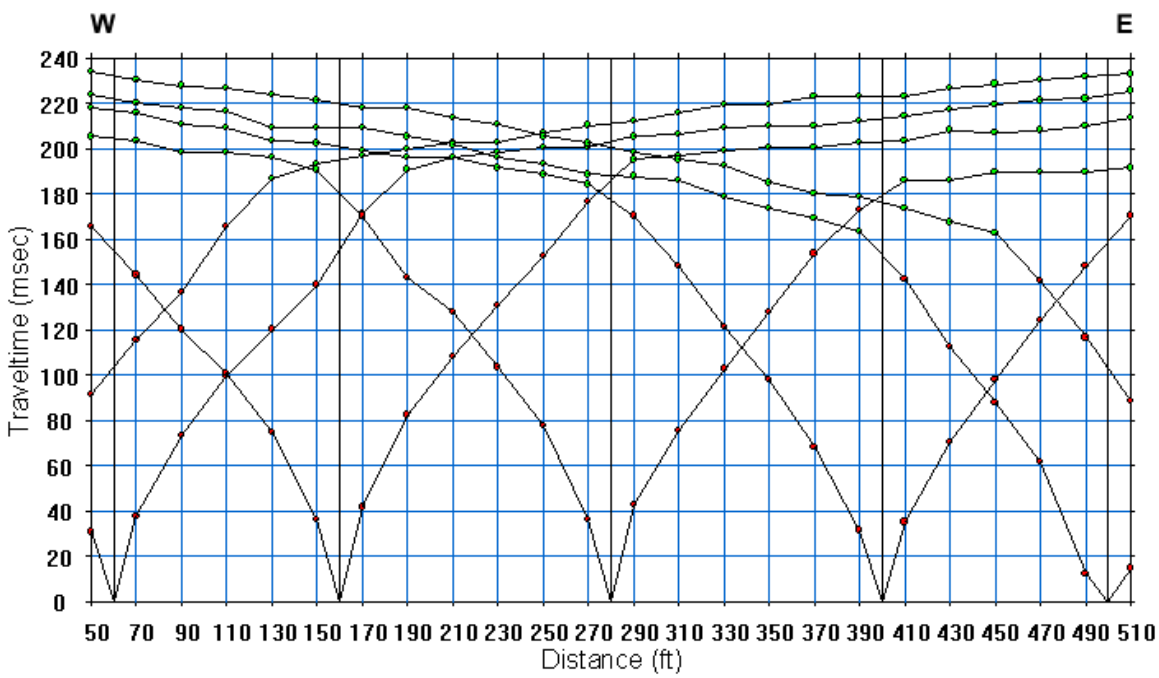

Figure 3. Travel time versus distance plot from the seven shot gathers of the S-wave survey.

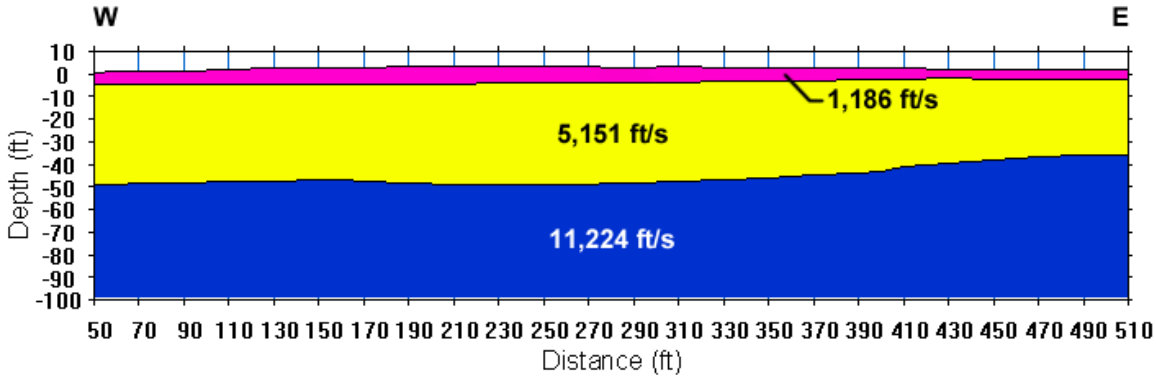

Figure 4. The velocity model of P-wave seismic refraction data, above, was constructed using the time-term inversion method. Three velocity layers were recorded and modeled. The 1,186 ft/s velocity layer represents unsaturated lacustrine silty clay and clay overlying the water table. The 5,151 ft/s velocity layer is saturated lacustrine silty clay and clay the water table. The lower 11,224 ft/s velocity layer is the shale bedrock.

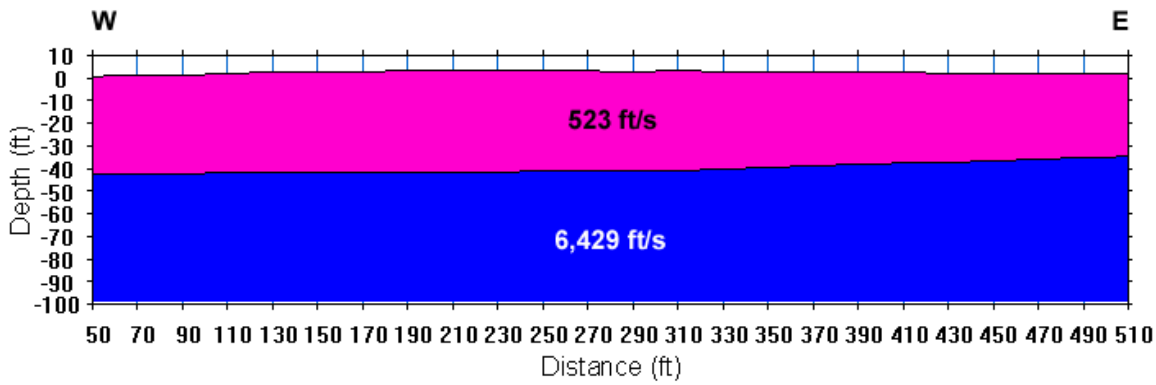

Figure 5. The velocity model of S-wave seismic refraction data, above, was constructed using the time-term inversion method. Two velocity layers were recorded and modeled. The 523 ft/s velocity layer represents lacustrine silty clay and clay overlying bedrock. The 6,429 ft/s velocity layer is the shale bedrock..

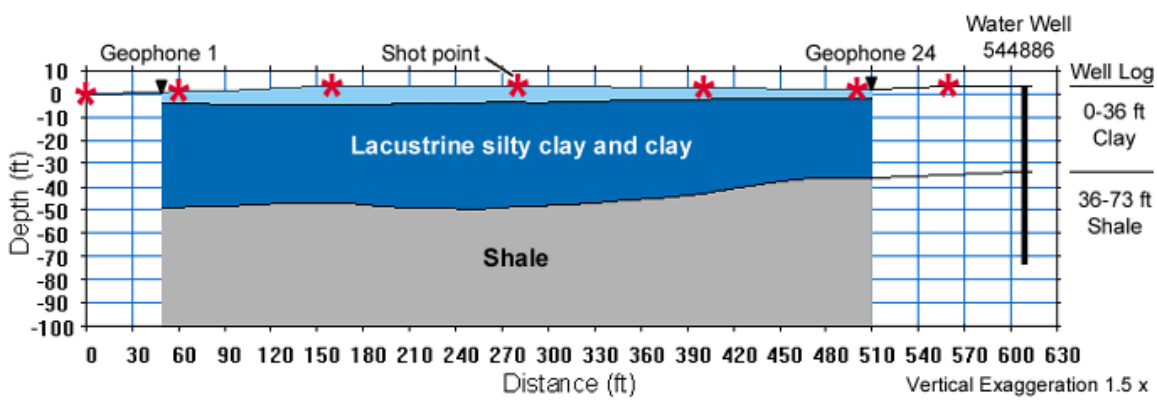

Figure 6. Geologic interpretation of the P- and S-wave data collected on the Boy Scouts of America, Beaumont Scout Reservation. Two refractive boundaries were detected. The P-wave survey detected refractions from the groundwater table and the top of the shale bedrock. The S-wave survey detected refractions from the top the bedrock.

APPENDIX A

Acquisition and Modeling Data

Geophone Location Data

Line No: 340079000324 **Date:** 2 November, 2006

Location: Scouts of America, Beaumont Scout Reservation

Group Interval: 20 ft. P-wave **Group Interval:** 20 ft. S-wave

First Geophone No: 1 **X-Loc:** 50.0 **First Geophone No:** 1 **X-Loc:** 50.0

Geophone Number	X-Location	Δ Elev.	Elevation
1	50.0	0.9	811.9
2	70.0	1.3	812.3
3	90.0	1.5	812.5
4	110.0	1.9	812.9
5	130.0	2.4	813.4
6	150.0	2.9	813.9
7	170.0	3.0	814.0
8	190.0	3.3	814.3
9	210.0	3.3	814.3
10	230.0	3.3	814.3
11	250.0	3.3	814.3
12	270.0	3.2	814.2
13	290.0	3.1	814.1
14	310.0	3.2	814.2
15	330.0	2.9	813.9
16	350.0	2.8	813.8
17	370.0	2.6	813.6
18	390.0	2.6	813.6
19	410.0	2.5	813.5
20	430.0	2.3	813.3
21	450.0	2.1	813.1
22	470.0	2.0	813.0
23	490.0	2.1	813.1
24	510.0	1.9	812.9

Geophone Number	X-Location	Δ Elev.	Elevation
1	50.0	0.9	811.9
2	70.0	1.3	812.3
3	90.0	1.5	812.5
4	110.0	1.9	812.9
5	130.0	2.4	813.4
6	150.0	2.9	813.9
7	170.0	3.0	814.0
8	190.0	3.3	814.3
9	210.0	3.3	814.3
10	230.0	3.3	814.3
11	250.0	3.3	814.3
12	270.0	3.2	814.2
13	290.0	3.1	814.1
14	310.0	3.2	814.2
15	330.0	2.9	813.9
16	350.0	2.8	813.8
17	370.0	2.6	813.6
18	390.0	2.6	813.6
19	410.0	2.5	813.5
20	430.0	2.3	813.3
21	450.0	2.1	813.1
22	470.0	2.0	813.0
23	490.0	2.1	813.1
24	510.0	1.9	812.9

Horizontal and vertical measurements in U.S. Survey Feet

Δ Elev. is the difference in elevation relative to the lowest geophone or shot point elevation.

Elevation Data of Geophones

Inst. Height: 5.00 ft. **Lowest Δ H:** 0.00 **Ref. Elev:** 811 ft. topo est.

Station	Rod Height (R.H.)			Δ R.H.	Δ H	Δ Elev.	Comments
	Feet	Inches	Dec. Ft.				
SP-1	5	0	5.00	0.00	0.00	0.0	
1	4	1	4.08	0.92	0.92	0.9	
SP-2	4	11	4.92	0.08	1.00	1.0	
2	4	9	4.75	0.25	1.25	1.3	
3	4	9	4.75	0.25	1.50	1.5	
4	4	7	4.58	0.42	1.92	1.9	
5	4	6	4.50	0.50	2.42	2.4	
6	4	6	4.50	0.50	2.92	2.9	
SP-3	4	11	4.92	0.08	3.00	3.0	
7	5	0	5.00	0.00	3.00	3.0	
8	4	9	4.75	0.25	3.25	3.3	
9	5	0	5.00	0.00	3.25	3.3	
10	5	0	5.00	0.00	3.25	3.3	
11	4	11	4.92	0.08	3.33	3.3	
12	5	2	5.17	-0.17	3.17	3.2	
SP-4	5	2	5.17	-0.17	3.00	3.0	
13	4	11	4.92	0.08	3.08	3.1	
14	4	11	4.92	0.08	3.17	3.2	
15	5	3	5.25	-0.25	2.92	2.9	
16	5	2	5.17	-0.17	2.75	2.8	
17	5	2	5.17	-0.17	2.58	2.6	
18	5	0	5.00	0.00	2.58	2.6	
SP-5	5	1	5.08	-0.08	2.50	2.5	
19	5	0	5.00	0.00	2.50	2.5	
20	5	2	5.17	-0.17	2.33	2.3	
21	5	3	5.25	-0.25	2.08	2.1	
22	5	1	5.08	-0.08	2.00	2.0	
23	4	10	4.83	0.17	2.17	2.2	
SP-6	5	1	5.08	-0.08	2.08	2.1	
24	5	2	5.17	-0.17	1.92	1.9	99 ft. west of water well
SP-7	3	8	3.67	1.33	3.25	3.3	

Vertical measurements in U.S. Survey Feet

Δ R.H. = Inst. Height - Rod Height (R.H.)

Δ H is the difference in height relative to the starting point of the survey, for this survey shot point SP-1.

Δ Elev. is the difference in elevation relative to the lowest geophone or shot point height (Lowest ΔH). This value is used because the modeling software requires positive elevation values.

1, 2, 3,... = geophone no.

Data Acquisition Parameters

Survey Type	P-Wave	S-wave
Recording System	Geometrics Geode	Geometrics Geode
Data Format	SEG-2	SEG-2
Acquisition	24 channel	24 channel
Source	20 lb sledgehammer	20 lb sledgehammer
Geophones	14 Hz Vertical	28 Hz Horizontal
Geophone Array	Linear	Linear
Line length	460 ft	460 ft.
Geophone spacing	20 ft.	20 ft.
Source Offset	2-50 ft. offend plus 5 inline	2-50 ft. offend plus 5 inline
Sampling Interval	0.125 msec	0.500 msec
Record Length	0.100 sec	0.300 sec
Preamp Gains	All geophones 36dB	All geophones 36 dB
Filters	None	None

P-wave Velocity Model Data

Geophone Location and Elevation Data			Velocity Layer Depth (Top)[1]		Velocity Layer Depth (Top)[2]		Velocity Layer Thickness	
Geo.	X-Loc.	Δ Elev.	2	3	2	3	1	2
1	50.0	0.9	-4.6	-48.9	-5.5	-49.8	5.5	44.3
2	70.0	1.3	-4.4	-48.8	-5.7	-50.1	5.7	44.4
3	90.0	1.5	-4.7	-48.4	-6.2	-49.9	6.2	43.7
4	110.0	1.9	-4.8	-47.8	-6.7	-49.7	6.7	43.1
5	130.0	2.4	-4.8	-47.3	-7.2	-49.7	7.2	42.5
6	150.0	2.9	-4.8	-46.9	-7.7	-49.8	7.7	42.1
7	170.0	3.0	-4.8	-47.3	-7.8	-50.3	7.8	42.5
8	190.0	3.3	-4.9	-48.1	-8.2	-51.4	8.2	43.2
9	210.0	3.3	-4.6	-48.9	-7.9	-52.2	7.9	44.3
10	230.0	3.3	-4.2	-49.3	-7.5	-52.6	7.5	45.2
11	250.0	3.3	-4.1	-49.4	-7.4	-52.7	7.4	45.3
12	270.0	3.2	-3.8	-49.1	-7.0	-52.3	7.0	45.3
13	290.0	3.1	-4.1	-48.3	-7.2	-51.4	7.2	44.3
14	310.0	3.2	-3.8	-47.8	-7.0	-51.0	7.0	44.0
15	330.0	2.9	-3.3	-46.9	-6.2	-49.8	6.2	43.6
16	350.0	2.8	-3.2	-45.9	-6.0	-48.7	6.0	42.7
17	370.0	2.6	-3.1	-45.0	-5.7	-47.6	5.7	41.9
18	390.0	2.6	-2.9	-44.1	-5.5	-46.7	5.5	41.2
19	410.0	2.5	-2.4	-41.6	-4.9	-44.1	4.9	39.2
20	430.0	2.3	-2.1	-39.8	-4.4	-42.1	4.4	37.6
21	450.0	2.1	-2.2	-38.0	-4.3	-40.1	4.3	35.8
22	470.0	2.0	-2.4	-36.7	-4.4	-38.7	4.4	34.3
23	490.0	2.1	-2.5	-36.1	-4.6	-38.2	4.6	33.6
24	510.0	1.9	-2.3	-36.3	-4.2	-38.2	4.2	34.0

[1] Datum 0.00 feet [2] Below surface (geophone elevation)

Horizontal and vertical measurements in U.S. Survey Feet.

Δ Elev. is the difference in elevation relative to the lowest geophone or shot point elevation.

S-wave Velocity Model Data

Geophone Location and Elevation Data			Velocity Layer Depth (Top)[1]		Velocity Layer Depth (Top)[2]		Velocity Layer Thickness	
Geo.	X-Loc.	Δ Elev.	2	3	2	3	1	2
1	50.0	0.9	-42.8		-43.7		43.7	
2	70.0	1.3	-42.5		-43.8		43.8	
3	90.0	1.5	-42.3		-43.8		43.8	
4	110.0	1.9	-42.1		-44.0		44.0	
5	130.0	2.4	-41.7		-44.1		44.1	
6	150.0	2.9	-41.6		-44.5		44.5	
7	170.0	3.0	-41.9		-44.9		44.9	
8	190.0	3.3	-42.0		-45.3		45.3	
9	210.0	3.3	-42.0		-45.3		45.3	
10	230.0	3.3	-41.7		-45.0		45.0	
11	250.0	3.3	-41.4		-44.7		44.7	
12	270.0	3.2	-41.2		-44.4		44.4	
13	290.0	3.1	-41.2		-44.3		44.3	
14	310.0	3.2	-41.0		-44.2		44.2	
15	330.0	2.9	-40.5		-43.4		43.4	
16	350.0	2.8	-39.8		-42.6		42.6	
17	370.0	2.6	-39.0		-41.6		41.6	
18	390.0	2.6	-38.5		-41.1		41.1	
19	410.0	2.5	-37.8		-40.3		40.3	
20	430.0	2.3	-37.4		-39.7		39.7	
21	450.0	2.1	-36.9		-39.0		39.0	
22	470.0	2.0	-36.1		-38.1		38.1	
23	490.0	2.1	-35.3		-37.4		37.4	
24	510.0	1.9	-34.8		-36.7		36.7	

[1] Datum 0.00 feet [2] Below surface (geophone elevation)
Horizontal and vertical measurements in U.S. Survey Feet.
Δ Elev. is the difference in elevation relative to the lowest geophone.

Difference Between V_P and V_S Refraction Depth to Bedrock Models

Geophone Number	X-Dist. (ft)	V_P Model Bedrock Depth (ft)	V_S Model Bedrock Depth (ft)	Difference Between Models (ft)
1	50	49.8	43.7	6.11
2	70	50.1	43.8	6.29
3	90	49.9	43.8	6.07
4	110	49.7	44.0	5.73
5	130	49.7	44.1	5.54
6	150	49.8	44.5	5.28
7	170	50.3	44.9	5.45
8	190	51.4	45.3	6.06
9	210	52.2	45.3	6.89
10	230	52.6	45.0	7.63
11	250	52.7	44.7	8.00
12	270	52.3	44.4	7.95
13	290	51.4	44.3	7.18
14	310	51.0	44.2	6.76
15	330	49.8	43.4	6.36
16	350	48.7	42.6	6.12
17	370	47.6	41.6	5.95
18	390	46.7	41.1	5.65
19	410	44.1	40.3	3.78
20	430	42.1	39.7	2.36
21	450	40.1	39.0	1.14
22	470	38.7	38.1	0.64
23	490	38.2	37.4	0.77
24	510	38.2	36.7	1.57

Average Diff. (ft)	5.22
Standard Dev. (± ft)	2.26
Minimum (ft)	0.64
Maximum (ft)	8.00

In-Situ Elastic and Seismic Properties of the Subsurface
Calculated from V_P and V_S Data at Mid-Station (280 feet)

Seismic Refraction P-wave and S-wave Velocity Model Data							
Velocity Layer	Strata Type	P-wave Velocity		S-wave Velocity		Ave. Thickness	
		V_p (ft/s)	V_p (m/s)	V_s (ft/s)	V_s (m/s)	(ft)	(m)
1	Silty clay	1,186	361	523	159	7.1	2.2
2	Silty clay	5,151	1,570	523	159	37.2	11.3
3	Shale	11,224	3,421	6,429	1,960		

Derived In-Situ Elastic Properties							
Velocity Layer	Vp/Vs	Density ρ (g/cm³)	σ	*G* (MPa)	*K* (MPa)	*E* (MPa)	λ (MPa)
1	2.27	1.35	0.38	0.03	0.13	0.09	0.11
2	9.85	1.95	0.49	0.05	4.74	0.15	4.70
3	1.75	2.37	0.26	9.09	15.59	22.83	9.53

Derived Seismic Properties From S-wave Model Data							
Period of Soil T_s (s)	Freq. (Hz)	Wave length		V_{s100} (ft/s)	V_{s30} (m/s)	NEHRP Site Class	Amp. Rating
		(ft)	(m)				
0.34	2.95	177.2	54.0	1,071	326	D	Moderate

V_{S100} from S-wave Refraction Data

Geophone Number	X-Dist. (ft)	Vs_{100} (ft/s)	Vs_{30} (m/s)	NEHRP Site Class.
1	50	1,083	330	D
2	70	1,081	329	D
3	90	1,081	329	D
4	110	1,077	328	D
5	130	1,075	328	D
6	150	1,067	325	D
7	170	1,059	323	D
8	190	1,051	320	D
9	210	1,051	320	D
10	230	1,057	322	D
11	250	1,063	324	D
12	270	1,069	326	D
13	290	1,071	326	D
14	310	1,073	327	D
15	330	1,089	332	D
16	350	1,106	337	D
17	370	1,128	344	D
18	390	1,140	347	D
19	410	1,158	353	D
20	430	1,173	358	D
21	450	1,190	363	C
22	470	1,212	369	C
23	490	1,231	375	C
24	510	1,250	381	C

Average Vs_{100} (ft/s)	1,110
Standard Dev. (± ft/s)	61
Minimum Vs_{100} (ft/s)	1,051
Maximum Vs_{100} (ft/s)	1,250

Definitions of Elastic Properties of Soil and Rock

Constants	Expression	Units	Comments
Bulk Density	$\rho = \alpha V_p^{0.25}$	g/cm^3	where α=0.23 if V_p is in ft/s, α=0.31 if V_p is in m/s
Poisson's Ratio	$\sigma = \frac{(V_p/V_s)^2 - 2}{2(V_p/V_s)^2 - 2}$		Measures the compressibility of material perpendicular to applied stress, or the ratio of latitudinal to longitudinal strain. Poisson's ratio is a dimensionless number ranging from 0.0 to 0.5. Compressible materials (e.g. Cork) will have a ratio of 0 and incompressible materials (e.g. rubber) will have a ratio of 5.
Shear Modulus	$G = V_s^2\rho$	Pascals (Pa)	Rigidity modulus, 2nd Lamé constant, used for estimation of settlement from static loads. Density (ρ) is in kg/m^3 and V_s is in m/s.
Bulk Modulus	$K = \rho(V_p^2 - 4/3V_s^2)$	Pascals (Pa)	Incompressibility modulus, used to determine how much a material will compress under a given amount of external pressure. Density (ρ) is in kg/m^3, V_s and V_p are in m/s.
Young's Modulus	$E = 2G(1+\sigma)$	Pascals (Pa)	Elasticity modulus, used to measure a materials resistance to elastic deformation.
1st Lamé Constant	$\lambda = K - 2G/3$	Pascals (Pa)	The Lamé constants are material properties that are related to the elastic modulus and Poisson ratio. The second Lamé constant is identical to the shear modulus (G).

The elastic properties, Poisson's ratio, shear modulus, bulk modulus, Young's modulus, and Lamé modulus, defines the properties of soil and rock that undergoes stress, deforms, and then recovers and returns to its original shape after the stress ceases.

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1997 NEHRP Soil Hazard Classification

Soil Class	Soil Description	Shear-wave Velocity (ft/s)	Shear-wave Velocity (m/s)	Susceptibility to Amplification Rating
A	Hard rock	> 5,000	> 1,500	Nil
B	Firm to hard rock	2500 - 5,000	760 - 1,500	Very low
C	Dense soil and soft rock	1200 - 2,500	360 - 760	Low
D	Stiff soil	600 - 1,200	180 - 360	Moderate
E	Soft soil	< 600	< 180	High
F	Peat or highly organic clay	Special soils requiring site specific evaluation		Very high

The 1997 National Earthquake Hazards Reduction Program (NEHRP) soil-classification to determine the potential for shallow soils to amplify ground motion is based on an averaged shear-wave velocity to a depth of 100 feet (V_{s100}), or 30 meters (V_{s30}). This classification is then used to calculate the amplification factors for use in engineering design.

According to NEHERP guidelines the averaged shear-wave velocity can be calculated by:

$$V_{s100} = \frac{100\ \text{ft}}{\sum(d_i / V_{si})}$$

where d_i = depth of layer i, and V_{si} = s-wave velocity of layer i.

$$V_{s30} = \frac{30\ \text{m}}{\sum(d_i / V_{si})}$$

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Ohio Department of Natural Resources
Division of Geological Survey

Seismic Investigations

Explanation of Contents

The reports, analyses, documents, and data in this document were compiled as part of seismic investigations done in the state of Ohio by the Ohio Department of Natural Resources (ODNR), Division of Geological Survey. The seismic investigations measured compressional-wave (P-wave) and shear-wave (S-wave) velocities and surface wave phase velocities to produce depth models characterizing the subsurface geology of the buried bedrock surface and the overlying sediments. The data collected were also used to determine the in situ elastic and seismic properties of soils and bedrock.

The file numbering scheme used for these investigations follow an API code format:

File 341419000724

34 = API state code (Ohio in this example)
141 = API county code (Ross County in this example)
9 = blank
0007 = code for survey number (survey no. 7 in this example)
24 = code for refraction and MASW surveys

History

The seismic equipment was purchased in 2001 by the ODNR Division of Geological Survey, Geologic Mapping Group with grant monies from Central Great Lakes Geologic Mapping Coalition (CGLGMC). This equipment provides a rapid and inexpensive means of determining the depth to bedrock and characterizing the stratigraphy of surficial materials in geologically complex areas. The equipment is portable, can be used in a wide range of situations, requires no dedicated vehicle, and can be used with minimal personnel and travel expense. The ODNR Division of Geological Survey started using the seismic system July 2002

Data Set Credit

The seismic data was acquired for the Statewide Surficial Mapping Project, funded by STATEMAP Geologic Mapping Program, Central Great Lakes Geologic Mapping Coalition (CGLGMC), and Ohio Seismic Network (OhioSeis).

Use Constraints

This product of the ODNR Division of Geological Survey is intended to provide general geologic information only and should not be used for any other purpose. It is not intended for resale or to replace site-specific investigations. These data were compiled by the ODNR Division of Geological Survey, which reserves the publication rights to this material. If these data are used in the compilation of other data sets or maps for distribution or publication, this source must be referenced.

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