SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

ALASKA
CALIFORNIA
COLORADO
FLORIDA
MISSOURI
OREGON
WASHINGTON

October 10, 2012

Mr. Bryan Thorp
Benton County Department of Public Works
PO Box 1001
Prosser, Washington 99350-0954

RE: GEOTECHNICAL ENGINEERING SERVICES ON-CALL CONTRACT; TASK ORDER 2012 -009, TRAVIS ROAD ROCK IDENTIFICATION STUDY; BENTON COUNTY, WASHINGTON

Dear Mr. Thorp:

At your request, Shannon & Wilson, Inc. conducted a limited subsurface assessment on Travis Road in the Horse Heaven Hills area of Benton County. This letter summarizes our findings and provides an opinion regarding the presence of rock within the proposed cut sections.

BACKGROUND

Travis Road connects the newly improved Webber Canyon Road to Sellards Road in the Horse Heaven Hills area of Benton County. Since Webber Canyon Road was improved in 2009, truck traffic has increased significantly. The proposed project will improve the horizontal and vertical alignment, and reconstruct the roadway section. Most of the new alignment will include relatively minor adjustments to the current vertical alignment. An approximately 700-foot section between Cemetery Road and Swanson Road will include 5- to 10-foot cuts. The soil exposed along the roadside in this area contains significant quantities of very dense cemented soil (caliche) that is often found just above the basalt bedrock.

EXPLORATIONS

Subsurface explorations included conducting seismic refraction soundings and excavating test pits to confirm the conditions indicated by the seismic refraction.

303 WELLSIAN WAY • P.O. BOX 967
RICHLAND, WASHINGTON 99352
509•946•6309 FAX 509•946•6580
TDD: 1-800-833-6388

The seismic refraction survey was conducted by our subcontractor, Geophysical Survey LLC, using a Geometrics Geode seismograph with 30 Hz geophones. Geophones were spaced 20 feet apart and data was collected at seven surficial shots on each 24 geophone spread. A 40 kilogram propelled energy generator was used as an energy source. The investigation depth was approximately 60 feet.

Data was collected along two seismic lines extending from Roadway Station 125+00 to Station 133+00. The seismic refraction lines were located on the shoulders of the current roadway. A Global Positioning System (<10cm) with VRS corrections was used to map seismic line positions and elevations. Seismic data was processed using SeisImager from Geometrics. A copy of the Geophysical Survey LLC report is enclosed.

After reviewing the seismic refraction data, our engineer excavated four test pits at selected locations. The locations at Stations 131+00 Left and Right, 132+00 Right, and 133+00 Right, were selected based on the profiles provided for the new vertical alignment. These locations seem to correspond to the areas with the highest likelihood of encountering the dense caliche or rock in the excavations.

The enclosed logs illustrate the subsurface conditions exposed in the test pits. Test pits TP-2 and TP-3 encountered refusal on caliche at 3.5 and 9.5 feet, respectively. The other test pits encountered sandy silt to the full exploration depths of 12 and 13 feet. Caliche fragments were exposed in TP-1.

CONCLUSIONS

Based on the seismic refraction and test pit explorations, it is our opinion that very dense caliche will be encountered within the proposed cut limits between Station 132+00 and 133+00. The proposed roadway surface elevation in that area is approximately 1,515 feet. The top of the caliche is approximately elevation 1,516 feet. The penetration depth into the caliche will depend on the pavement section thickness including base gravel used for the subject area.

The compression wave velocity can be used as an indicator of rippability. The following Figure 1 is from The Caterpillar Company Handbook of Ripping. Figure 1 shows the rippability of various rock types for different seismic velocities using a D9 Caterpillar tractor.

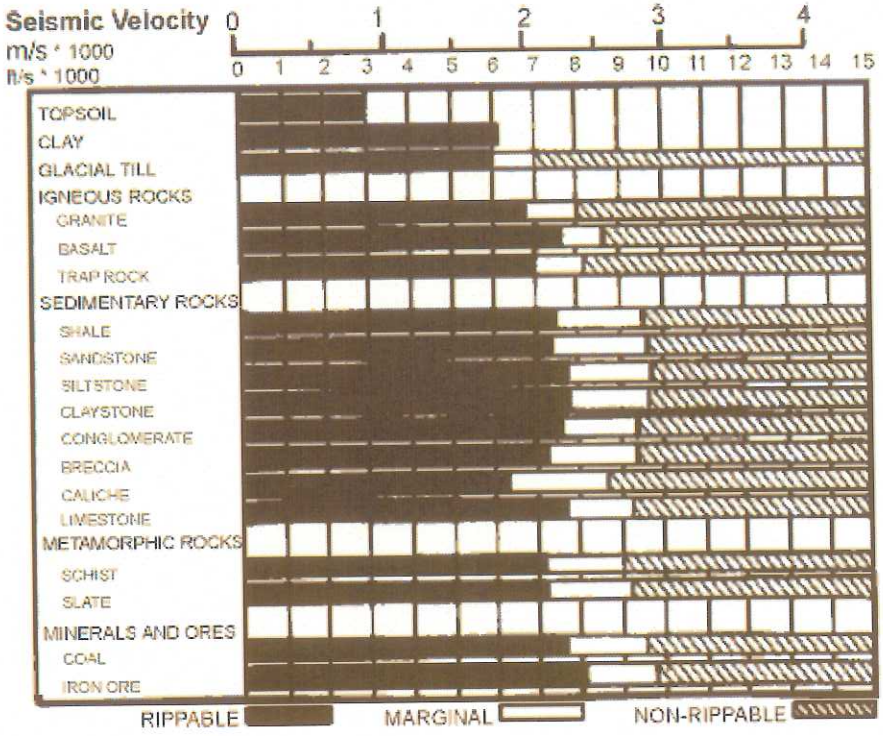


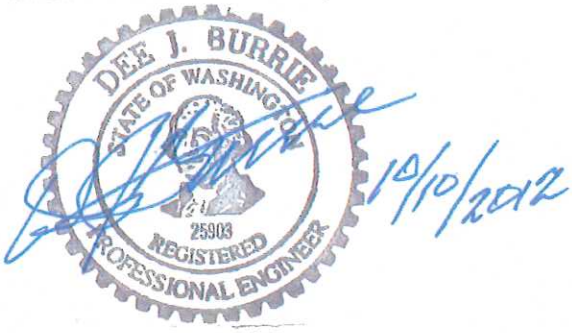
Figure 1. Rippability versus seismic velocity. (Caterpillar. Handbook of Ripping, 8th Edition)

The compression wave velocity measured for the caliche is well within the range considered rippable. We anticipate the excavations may be completed using standard heavy equipment. However, the small backhoe we used to excavate the test pits was unable to excavate the caliche.

We appreciate the opportunity to work with you on this Task. If you have any questions, please contact our office.

Sincerely,

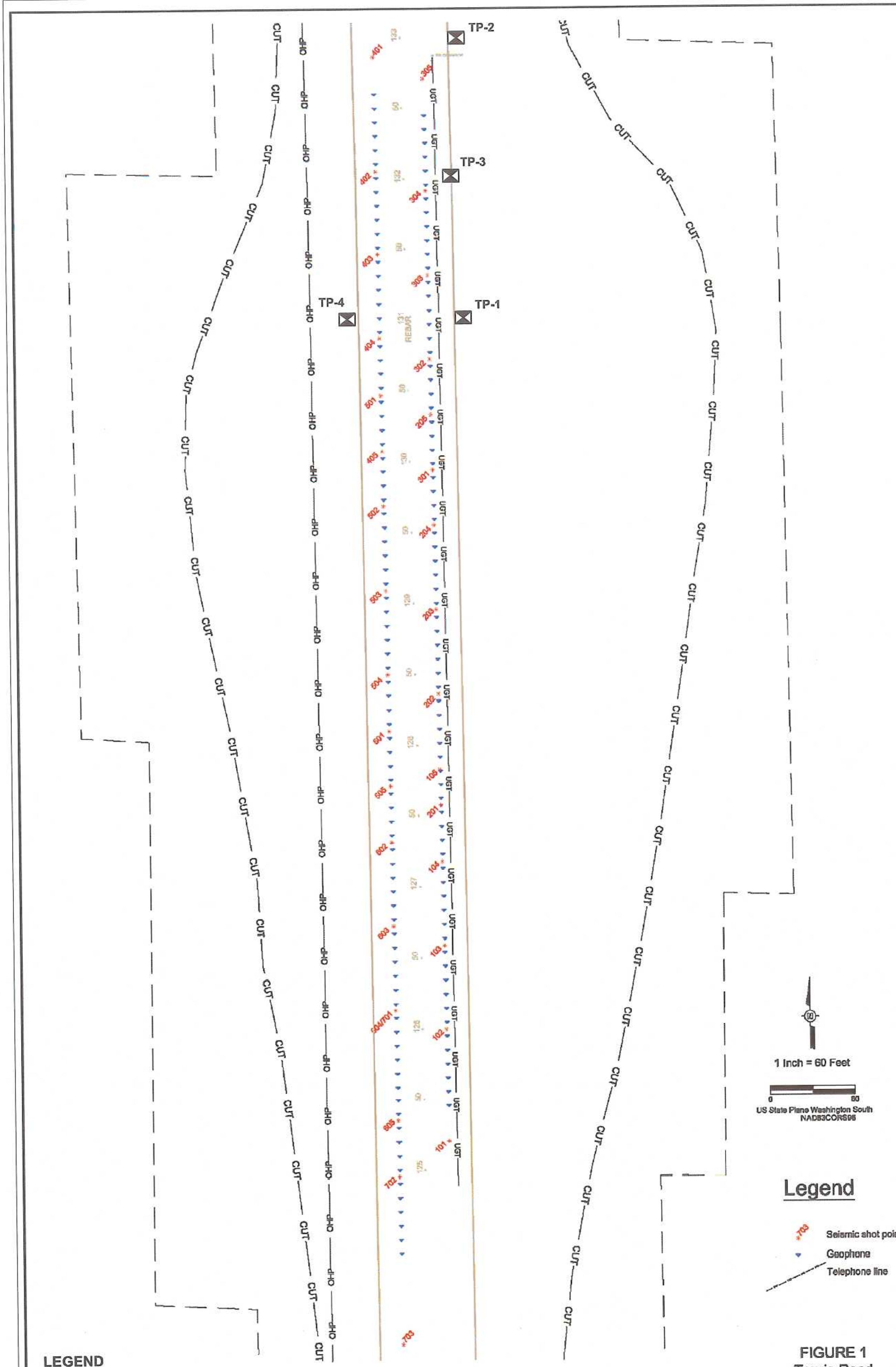
SHANNON & WILSON, INC.



Dee J. Burrie, P.E.
Vice President

DJB:LJR/djb

Enclosures: Figure 1 - Site and Exploration Plan
Figure 2 - Soil Classification and Log Key
Figure 3 – Log of Test Pit TP-1
Figure 4 – Log of Test Pit TP-2
Figure 5 – Log of Test Pit TP-3
Figure 6 – Log of Test Pit TP-4
Geophysical Consultants LLC Report



LEGEND

TP-1 Approximate Test Pit Location

FIGURE 1
Travis Road
Benton County, WA

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

USCS LEGEND 9/1/89

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

NOTES

1. Duel Symbols (symbols separated by a hyphen, i.e., SP-SM, slightly silty fine SAND) are used for soils with between 5% and 12% fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart
2. Borderline symbols (Symbols separated by a slash, i.e., CL/ML, silty CLAY/clayey SILT; GW/SW, sandy GRAVEL/gravelly SAND) indicates that the soil may fall into one of the two possible basic groups.

Travis Road Rock Estimate
Benton County, Washington

SOIL CLASSIFICATION AND LOG KEY

October 2012 22-1-02932-009

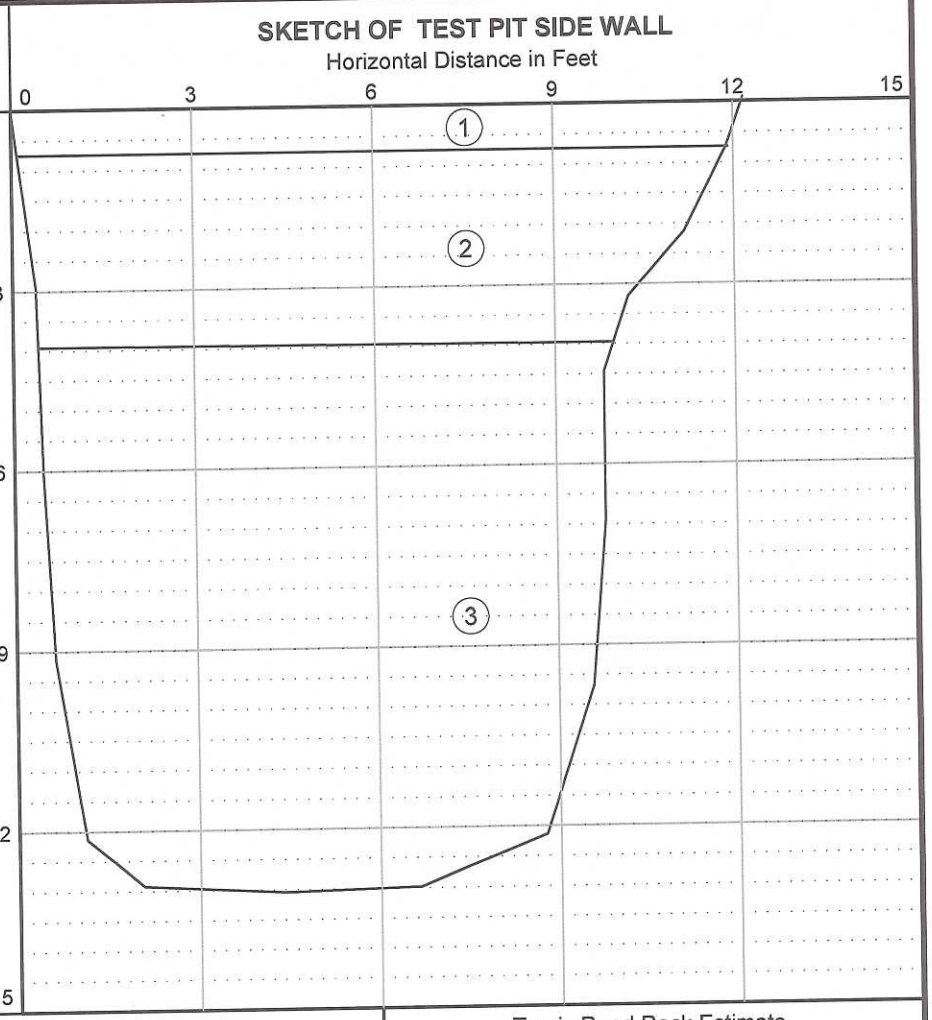
SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 2

TEST_PIT_LOG 22-1-02932-009 TEST PITS.GPJ SHAN_WIL.GDT 10/5/12

Fld: LJR Int: DJB Chk: CVM

SOIL PROFILE DESCRIPTION	Average Depth (ft)	Symbol	Samples	Water Content (%)	Ground Water	NOTES
1: Loose, tan, sandy SILT with roots; dry; non-plastic; (ML).	0.8					
2: Loose, tan, sandy SILT, trace rootlets; dry; non-plastic; (ML).			S-1			6-6-7
	4.0		S-2			6-50+
3: Very dense, tan, sandy SILT; dry to moist; non-plastic; (ML).			S-3		Not Encountered	
Trace caliche fragments.						
	13.0		S-4			
Bottom of Test Pit 13 ft. No groundwater encountered.						



NOTES

1. The description in the text of this report is necessary for a proper understanding of the nature of the subsurface materials.
2. Refer to Soil Classification and Log Key for explanation of "Symbols" and Definitions.
3. USCS designation is based on visual-manual classification.
4. Where possible, a 1/2-inch-diameter, steel T-bar probe was used to estimate the density of soil.

LEGEND

- Roots
- Seepage
- Cobble or Boulder
- Log

Travis Road Rock Estimate
Benton County, Washington

LOG OF TEST PIT TP-1

October 2012 22-1-02932-009

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

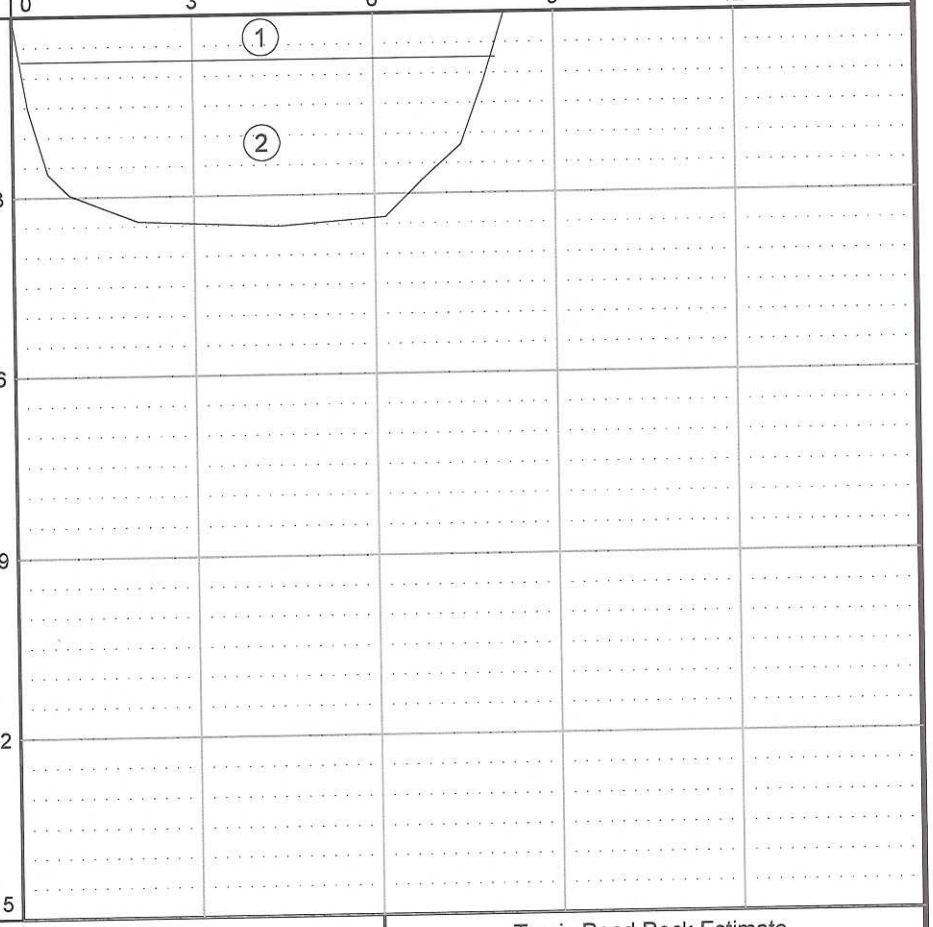
FIG. 3

FIG. 3

TEST_PIT_LOG 22-1-02932-009 TEST PITS.GPJ SHAN_WIL.GDT 10/5/12

Fld: LJR Int: DJB Chk: CVM

SOIL PROFILE DESCRIPTION	Average Depth (ft)	Symbol	Samples	Water Content (%)	Ground Water	NOTES
1: Loose, tan, sandy SILT with roots; dry; (ML).	0.8					
2: Loose to medium dense, tan, sandy SILT; dry; non-plastic; (ML). Trace caliche fragments.			S-1		Not Encountered	8-17
Refusal at 3.5 ft. on caliche. No groundwater encountered.	3.5					



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LEGEND

- Roots
- Seepage
- Cobble or Boulder
- Log

Travis Road Rock Estimate
Benton County, Washington

LOG OF TEST PIT TP-2

October 2012 22-1-02932-009

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FIG. 4

FIG. 4

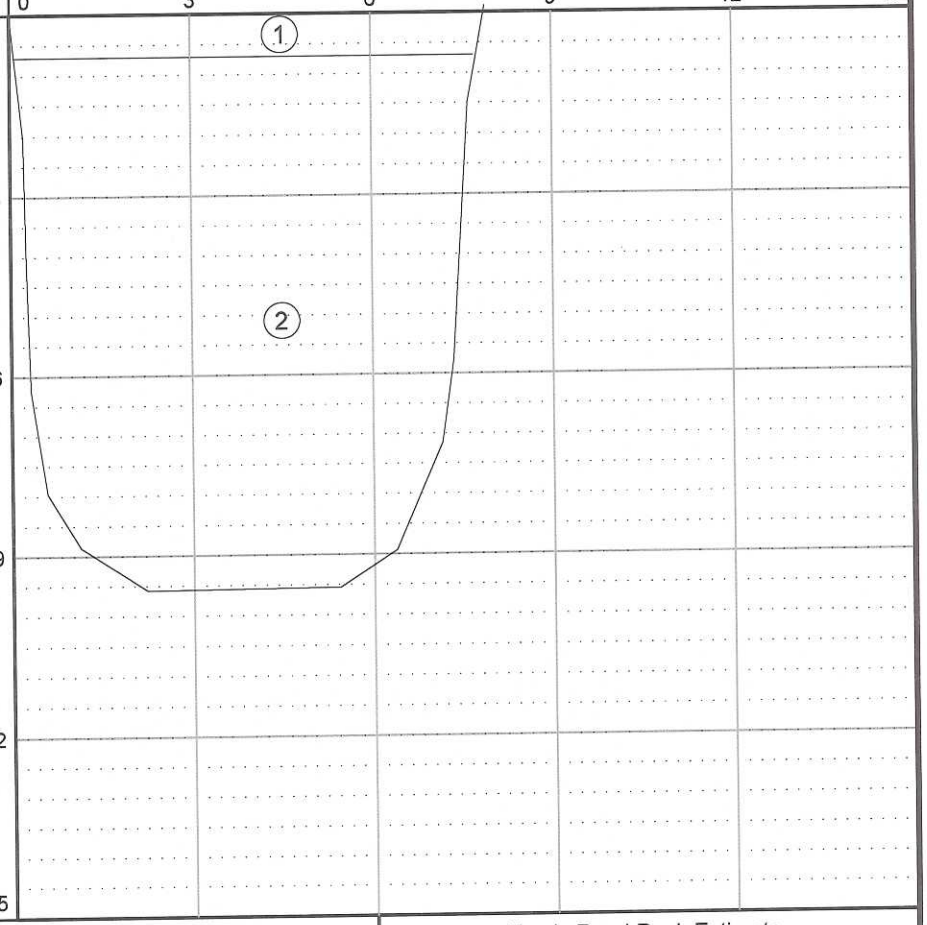
TEST_PIT_LOG 22-1-02932-009 TEST PITS.GPJ SHAN_WIL.GDT 10/5/12

Fld: LJR Int: DJB Chk: CVM

SOIL PROFILE DESCRIPTION	Average Depth (ft)	Symbol	Samples	Water Content (%)	Ground Water	NOTES	Depth (ft)
1: Loose, tan, sandy SILT with roots; dry; (ML).	0.8						
2: Loose to medium dense, tan, sandy SILT; dry; non-plastic; (ML).			S-1		Not Encountered	7-8-10	3
			S-2			6-7-9	6
Caliche fragments, grades dense to very dense.			S-3				9
	9.5		S-4				12
Bottom of Test Pit 9.5 ft. Practical refusal on cemented soils. No groundwater encountered.							15

SKETCH OF TEST PIT SIDE WALL

Horizontal Distance in Feet



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LEGEND

Roots

Seepage

Cobble or Boulder

Log

Travis Road Rock Estimate
Benton County, Washington

LOG OF TEST PIT TP-3

October 2012 22-1-02932-009

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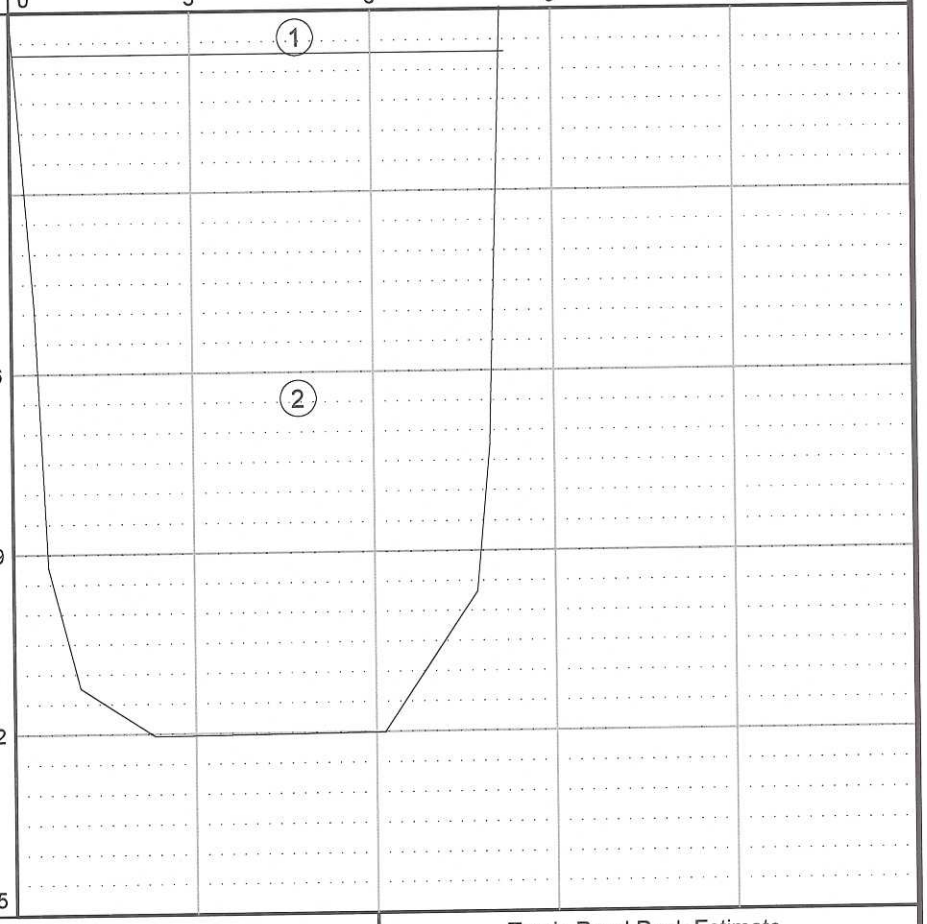
FIG. 5

FIG. 5

TEST_PIT_LOG 22-1-02932-009 TEST PITS.GPJ SHAN_WIL.GDT 10/5/12

Fld: LJR Int: DJB Chk: CVM

SOIL PROFILE DESCRIPTION	Average Depth (ft)	Symbol	Samples	Water Content (%)	Ground Water	NOTES	Depth (ft)
1: Loose, tan, sandy SILT with roots; dry; (ML).	0.8						
2: Loose, tan, sandy SILT; dry; non-plastic; (ML).			S-1			6-5-8	
Grades moist, medium dense.					Not Encountered		3
							6
Grades dense.			S-2				9
	12.0						12
Bottom of Test Pit 12 ft. No groundwater encountered.							15



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3. USCS designation is based on visual-manual classification.
4. Where possible, a 1/2-inch-diameter, steel T-bar probe was used to estimate the density of soil.

LEGEND

- Roots
- Seepage
- Cobble or Boulder
- Log

Travis Road Rock Estimate
Benton County, Washington

LOG OF TEST PIT TP-4

October 2012 22-1-02932-009

SHANNON & WILSON, INC.
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FIG. 6

FIG. 6

Geophysical Survey LLC
2200 W 8th Place
Kennewick, Washington 99336

October 2, 2012

Dee Burrie
Shannon & Wilson Inc.
303 Wellsian Way
Richland, WA

Re: ***Seismic Refraction Survey***
Travis Road
Benton County, Washington

Mr. Burrie:

Geophysical Survey LLC conducted a seismic refraction survey on Travis Road in Benton County, Washington on September 18, 2012. Two lines of seismic refraction data were collected. The objective of the survey was to detect the top of bedrock.

Methodology

Seismic Refraction

The seismic refraction method is based on the measurement of the travel time of seismic waves refracted at the interfaces between subsurface layers of different velocity. Seismic energy is provided by a source ('shot') located on the surface. The source of the seismic energy is a 16 lb. sledgehammer.

Energy radiates out from the shot point, either travelling directly through the upper layer (direct arrivals), or travelling down to and then laterally along higher velocity layers (refracted arrivals) before returning to the surface. This energy is detected on surface using a linear array (or spread) of geophones spaced at regular intervals. Beyond a certain distance from the shot point, known as the cross-over distance, the refracted signal is observed as a first-arrival signal at the geophones (arriving before the direct arrival). Observation of the travel-times of the direct and refracted signals provides information on the depth profile of the refractor.

Shots are deployed beyond both ends of the geophone spread in order to acquire refracted energy as first arrivals at each geophone position. Additional shots are deployed throughout the geophone spread.

Data are recorded on a seismograph and later downloaded to computer for analysis of the first-arrival times to the geophones from each shot position. Travel-time versus distance

graphs are then constructed and velocities calculated for the overburden and refractor layers through analysis of the direct arrival and T-minus graph gradients. Depth profiles for each refractor are produced by an analytical procedure based on consideration of shot and receiver geometry and the measured travel-times and calculated velocities. The final output comprises a depth profile of the refractor layers and a velocity model of the subsurface.

FIELD SURVEY

Mapping Control

Line shotpoints were mapped with a DGPS (differential global positioning system) with decimeter accuracy (<10cm).

Seismic Refraction Data Acquisition

Seismic data were recorded on twenty four 30Hz geophones spaced 10 feet apart using a Geometrics Geode seismic controller. Five shotpoints per 24 geophone spread were collected and digitally recorded on a laptop computer.

Seismic data was interpreted using SeisImager 2D software V4.2 from Geometrics. A layered earth model was created using a time term inversion. The time term model was used as an initial model for tomographic analysis which iteratively traces rays through the model with the goal of minimizing the RMS error between the observed and calculated traveltimes. Results for both models are presented in Figures 2 & 3.

RESULTS AND INTERPRETATION

Figure 1 show the location of each seismic shot point in relation to the geotechnical borings, overlaid on aerial imagery. Tomographic velocity contours are shown on Figures 2 & 3.

Seismic lines 1 and 2 have a second layer (3000feet per second) which is corresponds to the cemented silts/caliche found in test pits. Test pit data is shown classed by soil type on Figures 1 & 2.

Seismic Velocity	Interpretation
1000-2000 feet/second	Unconsolidated soil
3000 feet/second	Cemented silts/caliche

CLOSURE

Geophysical surveys performed as part of this survey may or may not successfully detect or delineate any or all subsurface objects or features present. Locations, depths and scale of buried objects or subsurface features mapped as a result of this survey are a result of geophysical interpretation only, and should be considered as confirmed, actual, or accurate only where recovered by excavation or drilling.

Geophysical Survey LLC performed this work in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No warranty, express or implied, beyond exercise of reasonable care and professional diligence, is made. This report is intended for use only in accordance with the purposes of the study described within.

Thank you for the opportunity to work with Shannon & Wilson. Please feel free to call if you have questions or need additional information.

Respectfully,

Geophysical Survey LLC

Mark Villa L.G.
Geophysicist

References: Redpath, Bruce B., (1973) . "Seismic Refraction Exploration for Engineering Site Applications." *Tech Report E-73-4*, U.S. Army Engineer Waterways Experiment Station Explosive Excavation Research Laboratory

Seismic Refraction Survey

Travis Road

Benton County, Washington

LIST OF FIGURES

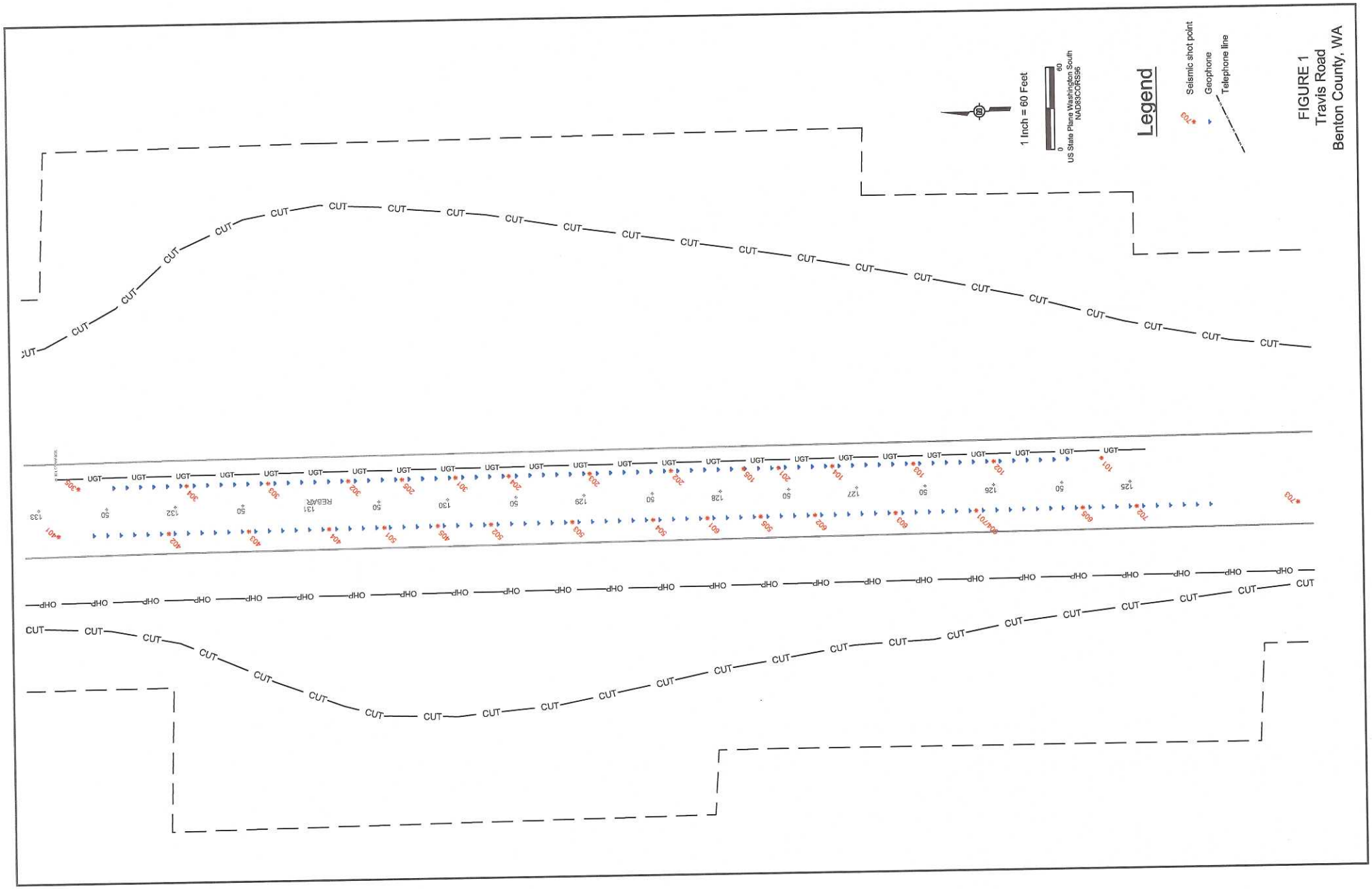
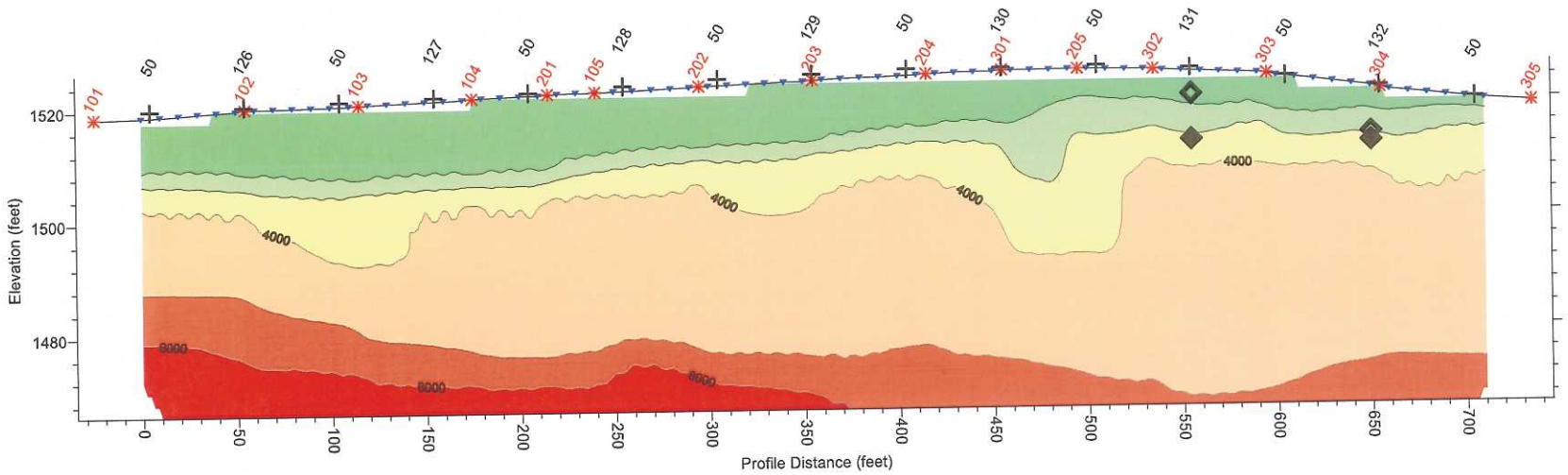


FIGURE 1
Travis Road
Benton County, WA
Legend
Seismic shot point
Geophone
Telephone line
1 Inch = 60 Feet
0
60
US State Plane Washington South
NAD83CORS96
CUT
UGT
OHP
REDAR



LEGEND

- Shot Point
- Geophone
- Dense silts from test pit
- Cemented silts/Caliche from test pit

Compression Wave Velocity (feet/second)

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000

1 Inch = 60 Feet

0 30 60

Note: 3:1 vertical exaggeration

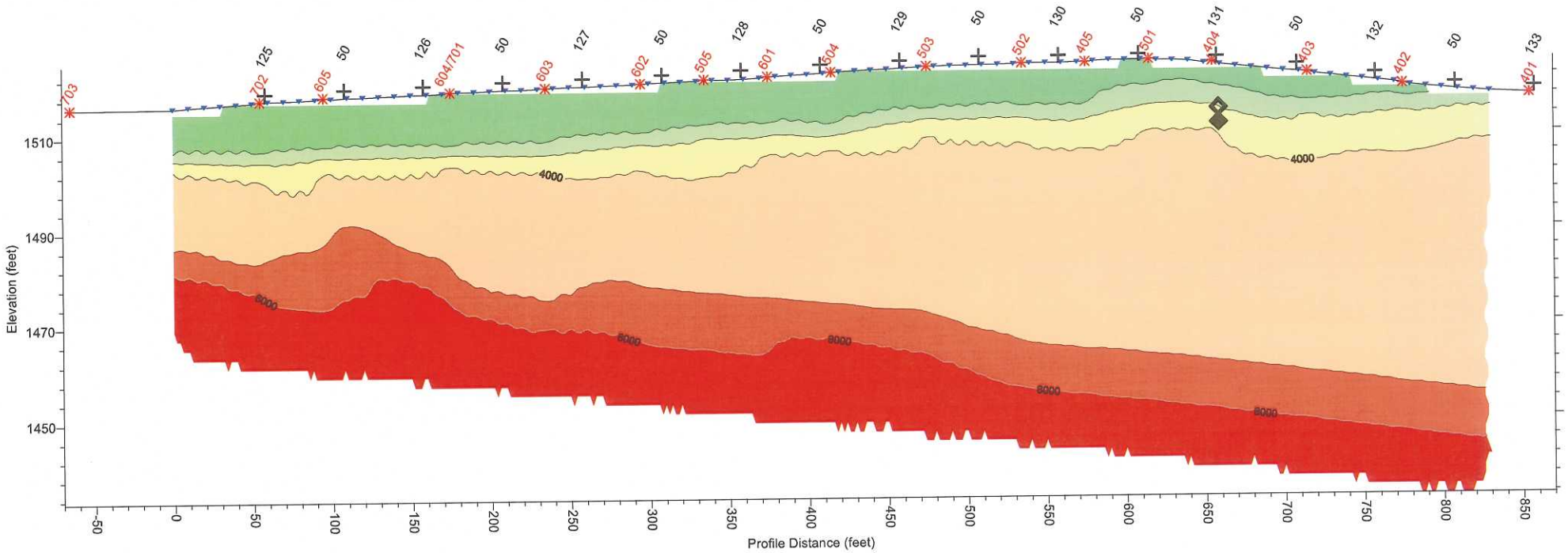
Prepared by:

GEOPHYSICAL SURVEY LLC

Prepared for:

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIGURE 2
Seismic Velocity Contours
Line 1
Travis Road
Benton County, WA



LEGEND

- Shot Point
- Geophone
- Dense silts from test pit
- Cemented silts/Caliche from test pit

Compression Wave Velocity (feet/second)

1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000

1 Inch = 60 Feet

0 30 60

Note : Vertical exaggeration 3:1

Prepared by:

GEOPHYSICAL SURVEY LLC

Prepared for:

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIGURE 3
Seismic Velocity Contours
Line 2
Travis Road
Benton County, WA