Seismic Refraction Surveys
For the Bell Bend Site Characterization

Final Report on Seismic Refraction Survey

May 29, 2008

Prepared for

Paul C. Rizzo Associates, Inc.
ExpoMart, Suite 270-E
105 Mall Boulevard
Monroeville, PA 15146-2288

By

Weston Geophysical Engineers, Inc.
20 Main Street
Acton, MA 01720
(978) 263-3600

Table of Contents

Section **Page**

1.0 Executive Summary 3

2.0 Seismic Refraction Survey 3
2.1 Refraction Test Coverage of the Site 3
2.2 Seismic Refraction Method 4
2.3 Field Procedures 6
2.4 Refraction Data Interpretation 9
2.5 Refraction Test Results 11

3.0 **References 13**

Figures

Appendix A – Critical Distance – Velocity Tabulation

Appendix B – WGE CSS 1 – Critical Distance Calculation Method

WGE P2 Seismic Refraction Survey Procedure

WGE P4 Hand Level Survey Procedure

WGE P7 Field Seismograph System Calibration Procedure

List of Figures

Figure Number	Description
1	Seismic Refraction Survey Profile Line Locations
2	Refraction Spread Geometry, Travel-Time Plot and Velocity Profile
3	24-Channel Refraction Record Section – Line B - Spread 3
4	Travel-Time Plot for Line B - Spread 3
5	Calculated Velocity Contours and Interpreted Velocity Structure – Line B – Spread 3
6	Seismic Velocity Contours – Lines 1 through 3 and A through C using SeisOpt Calculations
7	Refraction Profile – Line 1
8	Refraction Profile – Line 2
9	Refraction Profile – Line 3
10	Refraction Profile – Line A
11	Refraction Profile – Line B
12	Refraction Profile – Line C
13	Ground Surface Elevation Contour Map
14	Subsurface Elevation Contour Map – Top of Weathered/Till P-velocity > 6,000 ft/sec
15	Bedrock Elevation Contour Map – Top of Hard Bedrock P-velocity > 14,000 ft/sec

1.0 Executive Summary

Seismic refraction tests were performed to support site characterization studies for the Bell Bend project located in Berwick, Pennsylvania. Seismic refraction surveys were operated along 6 profile lines totaling 4,000 linear feet of coverage. Seismic refraction field data were collected during the period from January 7th, 2008 through January 10th, 2008 using approved quality assurance procedures.

Following is a summary of observations and foundation material descriptions derived from the geophysical investigations. These observations are reported for a specific location at an elevation of approximately 638 feet (mean sea level) in the area of the containment structure at the intersections of refraction Line 2 and Line B. At this location, this elevation datum corresponds to the bottom elevation of the common basemat and is approximately 36 feet below the proposed plant grade ground surface elevation (674 feet).

Interpretations of seismic refraction data across the site support the following observations.

- P-wave velocity at top of bedrock across the site was measured in range of 11,000 to 16,000 ft/sec and increased to greater than 16,000 ft/sec at depths of 10 feet below top of bedrock.
- The predominant top of bedrock velocity is approximately 14,000 ft/sec.
- The general trend of the bedrock depth is shallower on the northern portion of the site, with a fairly level bedrock depth from west to east across the site.
- Only minor lateral changes in seismic P-wave velocity were observed along refraction profile lines.

2.0 Seismic Refraction Surveys – Land Surveys

Seismic refraction surveys were performed at the Bell Bend site located in Berwick, Pennsylvania during a one week period beginning on January 7th, 2008. Field work commenced with a demonstration of the refraction test method to representatives of the facility who monitored compliance of field activities with procedures approved for the project. Acquisition of the seismic refraction data was completed on January 10th, 2008. The refraction survey covered the footprint of the proposed structures. A total of 4,000 linear feet of seismic refraction profile data were collected.

2.1 Refraction Test Coverage of the Site

Distribution of seismic refraction profile lines across the site is illustrated on Figure 1. The base map includes recent images of the site area obtained from Paul C Rizzo Associates, Inc. Figure 1 is displayed relative to the known borings and other uniquely identifiable features, the map units are in feet.

Lay-out of refraction spreads across the site was initially governed by locations of predetermined staked locations every 250 feet. The site area ultimately was covered by a series of intersecting refraction lines spaced approximately every 250 feet apart. The final distribution of refraction profile line coverage of the site is shown on Figure 1. The refraction study was conducted using 24-channel data acquisition with geophone spacing of 10 feet. An individual refraction spread covered 250 linear feet and seven "shot points" were operated for each spread. Seismic energy at the shot points was delivered by a sledge hammer striking a metal plate. All geophone and shot locations are shown on Figure 1. Longer refraction profiles consisted of five 250-foot spread segments (Lines B and C). The three south-to-north profiles, numbered as Lines 1 through 3, provided refraction data at the western and eastern limits of the site as well as one profile (Line 2) through the center of the proposed containment location. The three west-to-east profiles, lettered as Lines A through C, provided refraction data at the southern and northern limits of the site as well as one profile (Line B) through the center of the proposed containment location.

2.2 Seismic Refraction Method

The land-based seismic refraction survey method is a seismic test operated entirely at ground surface to determine the depths to refracting horizons and thicknesses of geologic strata that share a common average seismic velocity. A refracting boundary is established in all cases when a material with seismic velocity, v1, is underlain by a material with higher velocity, v2. Section 3.0 includes several references that describe the theory and field application of the refraction method.

Refraction tests can be conducted at local scales using small, portable energy sources and short "spreads" of geophones, as well as at regional scales to map crustal geologic velocity structure to considerable depths below ground surface (Note: the configuration of shot points and linear array of receivers typically is referred to as a "refraction spread"). Depths to which seismic refraction data are acquired are functions of magnitude of the seismic energy source and overall refraction spread lengths. Seismic velocities measured by this technique are used to calculate the mechanical properties of subsurface materials (moduli values), as well as for material identification and for assisting in stratigraphic correlations. Interpretations are made from travel times representing the time required for a compressional seismic wave to travel from an energy source location to each of an array of vibration sensitive geophones. Geophones are located at pre-determined intervals along the ground surface with spacing between individual geophones selected to be appropriate for the intended depth of the investigation.

The elastic wave measured in the seismic refraction method, the "P-wave" or compressional wave, is the first arrival of energy from the seismic source at each receiver, or geophone. This elastic wave travels from the energy source in a path causing adjacent solid particles to oscillate in the direction of wave propagation. At shorter distances between source and geophone the first arriving waves will be direct waves that travel near the ground surface through the lower velocity material. At greater distance, the first arrival at the geophone will be a refracted wave that has taken an indirect path through the two layers. The

refracted wave will arrive before the direct wave at a greater distance along the spread because the time gained in travel through the higher-speed material compensates for the longer path. For all configurations of seismic sources and receivers, P-wave energy will arrive at a given geophone location in the shortest possible time as required by Fermat's Principal (Dobrin, 1976). This principal was utilized to develop several analytical methods for calculating seismic velocity structure versus depth using only first arrival times of seismic P-wave energy measured along arrays of geophones deployed at ground surface.

Depth computations are based on the ratio of the layer velocities and the horizontal distance from the energy source to the point at which the refracted wave overtakes the direct wave; this distance is referred to as the critical distance, or cross-over distance. Key references on seismic refraction theory, the performance of seismic refraction field tests, and common methods for refraction data interpretation are listed in Section 3.0.

Generally, seismic refraction interpretation is made by one or more of several methods including ray-tracing, wave front methods, delay time, intercept time, critical distance, and forward modeling. More detailed methods include either a forward or inverse interpretation which requires using computer programs. Since successful refraction interpretation is based on experience, all interpretation of refraction data is performed or thoroughly reviewed by a senior staff geophysicist. Refraction data acquired for this land-based study of the Bell Bend site area were analyzed using two alternative methods to confirm accuracy of interpreted seismic velocity profiles. The first refraction interpretation method is the Critical Distance Method (ASTM, D 5777, 2000; Sjogren, 1984; Dobrin, 1976), a traditional analytical method developed more than a century ago and which is supported by many decades of successful interpretations of refraction data starting with oil prospecting as early as 1928 (Dobrin, 1976). The second interpretation method employed refraction interpretation software named SeisOpt @2D™ which was developed by Optim LLC, Inc.

The SeisOpt @2D™ velocity optimization software represents a modern, computer-intensive approach to refraction interpretation and is described by the developers to *" achieve a globally optimized velocity model using only first arrival travel time data and array geometry as input. SeisOpt requires no prior assumptions of subsurface structure, or any other subjective data, as input. SeisOpt technology is now being used throughout the world for geotechnical, mining and petroleum applications. The technology is based on a nonlinear optimization method called generalized simulated annealing. The algorithm performs repeated forward modeling, where new models are conditionally accepted or rejected based on a probability criterion. This criterion allows the algorithm to escape from non-unique, local, travel time minima to achieve a unique, globally optimized model of subsurface velocity structure. The algorithm makes no assumptions on the orientation of the subsurface velocity gradient, and can therefore reveal vertical structures and strong lateral gradients, if present. The method is therefore ideal in areas characterized by strong lateral velocity gradients, and in areas with extreme topography or complex near-surface structure where the user has little or no prior knowledge of subsurface structure."*

All refraction data acquired for the Bell Bend site area were interpreted using both methods discussed above and subsurface velocity profiles determined by these methods are described below. Calculations for the Critical Distance Method are included in a calculation summary (CSS 1), to be submitted under a separate transmittal. Unlike the traditional Critical Distance Method, the forward modeling method used by SeisOpt @2D™ cannot be reproduced by alternate calculations. Typical SeisOpt @2D™ processing times by advanced workstation computers range from 4 to 6 hours for each refraction profile. On the basis that the SeisOpt @2D™ results cannot be reasonably confirmed by other calculations, these result of forward modeling are used to complement the preferred interpretations of velocity profiles calculated using the Critical Distance Method. Calculations of velocity profiles made using the Critical Distance Method are provided in CSS 1 as EXCEL spreadsheets.

2.3 Field Procedures

All field data acquisition and data logging activities were performed in accordance with procedures documented in WGE-P2 Seismic Refraction Survey Procedure. This approved procedure is based on many years of experience, current WGE standard operating procedures, and additional guidelines listed in the ASTM Standard Guide for Using Seismic Refraction Method for Subsurface Investigation (D 5777 – 00). All field instruments were calibrated in accordance with WGE P7, Field Seismograph System Calibration. Field tests were performed over a grid of 6 intersecting refraction lines producing 9 common points at which interpreted velocity profiles could be compared for interpretation consistencies. Individual refraction spreads included 24 vertical component 40 Hz geophones that were fixed to the ground with predetermined 10-foot sensor spacing. Refraction cables mobilized for the project included pre-measured sensor hookups spaced at 10-foot intervals. Geophone spacing of 10 feet was verified prior to data collection using measuring tapes. The resulting 24-channel geophone array with 10-foot spacing resulted in 250-foot long refraction spreads.

Most refraction lines were built from linking or overlapping two, three, and five 250-feet long spreads to attain line lengths of about 500, 750, and 1,250 feet.

Installation of each sensor in the 24-geophone array was made manually by pressing the geophone's 3-inch spike anchor into the ground to establish a firm contact with the surrounding earth material; this assured a good coupling to the ground for direct transfer of seismic energy from the ground to the geophone. Each geophone was connected via a multi-channel data cable to a digital data recorder (Geometrics Strataview Seismograph). Confirmation of the proper placement of the geophones and correct orientation of the communication cable was made by performing a tap tests on geophone # 12 and then on geophone #13 while observing the signal strength display on the display screen on the recording unit. The recording unit was then set to record a number of seismic "shot" impacts at various points along the 250 foot long refraction spread.

Seismic refraction data were recorded for seismic energy generated at a number of points along each 250-foot spread to determine seismic energy transit times across multiple travel directions and locations. The procedure was designed to record 7 seismic source locations for every spread (note: seismic source locations is also commonly called "shot location" in reference to earlier common practice of using explosives as a seismic source). Layouts of individual spreads were set up to determine the velocities in both a forward and reverse direction. Figure 2 shows a sketch of a representative layout of the geophone array as well as the locations of the "shot" or seismic energy points. The 7 locations "shot" are described as follows:

- Low Offset – This "shot" location is typically 2 or more geophone spacings beyond the anticipated depth to rock. In this case 50 feet from the first geophone was used. This "shot" location provides the most information about the bedrock since the first energy arrivals are not from the velocities associated with the overburden material.

- Low End – This location is 10 feet before the first geophone (1); referred to as the 0-foot point of the profile and provides data for the overburden as well as any weathered rock and bedrock. The velocities determined from this seismic energy indicate what the velocity is as the energy moves from the low end to the high end of the profile section.

- Low Quarter – This location is midpoint between the 6^{th} and 7^{th} geophone, in this case 65 feet from the Low End point. The quarter point provides information on the overburden in addition to intermediate velocities for either weather or fractured rock on top of the competent bedrock.

- Center – The center "shot" point between the 12^{th} and 13^{th} geophone, in this case 125 feet from Low End point, provides a method for evaluating the possible lateral changes in the depth to rock in conjunction with information on the overburden and intermediate velocities for weathered of fractured rock.

- High Quarter – This location is midpoint between the 18^{th} and 19^{th} geophone, in this case 185 feet from the Low End point. The quarter point provides information on the overburden in addition to intermediate velocities for either weathered or fractured rock on top of the competent bedrock. The data for the quarter point is compared to evaluate lateral changes in the depth of bedrock along the profile section

- High End - This location is 10 feet after the last geophone (24); referred to as the 250 foot point of the profile and provides data for the overburden as well as the weather rock and bedrock. The velocities determined from this seismic "shot" point indicate what the velocity is as the energy moves from the high end to the low end of the profile section.

- High Offset – This location is typically 2 or more geophone spacings beyond the anticipated depth to rock. In this case 50 feet past the last geophone was used. This "shot" location

provides the most information about the bedrock since the first energy arrivals are not from the velocities associated with the overburden material.

Multiple impacts at each "shot" point, called signal stacking, was used to increase the signal to noise ratio by continued summation of the data for each of the impacts. The practice of using multiple impacts, or stacks, applies the fact that the generated seismic energy represents a coherent, repetitive signal that is enhanced by a mathematical signal summing algorithm relative the random background vibrations whose amplitudes are typically reduced by the signal summing procedure. The net result of "stacking" is recording of higher quality data from which arrival times of seismic signals can be more accurately measured. Locations of profile sections relative to external sources of vibration (e.g. operating drill rigs, roads, etc.) were evaluated for determining how many "stacks" were used to obtain acceptable data. The digital recording unit allows for the redisplay of the enhanced stacked data and the operator has the ability to evaluate when the signal to noise ratio is maximized at which point the data are stored for that "shot" location, as described in WGE P2.

The seismic source was manual operation of a 16 pound sledge hammer by the geophysicist by striking a metal plate placed at the "shot" locations. This seismic source provides sufficient energy levels across the relatively short 250-foot array of geophones. The sledge hammer utilizes a signal triggering method of a contact closure switch mounted on the hammer that transmitted a signal to the Strataview seismograph to begin data recording. This reliable timing mechanism allowed for repeatable time initiation on the recordings which allowed enhancement of the signal using multiple impacts at each "shot" location. Typically, 5 to 10 impacts were required for the manually operated sledge hammer to obtain the acceptable results.

During the data stacking procedure, the geophysicist visually reviewed the resulting travel time records on the Strataview seismograph display screen, which were also printed on strip charts to provide further visual verification of record acceptance. Once the data were accepted as valid and easily interpretable based on the acceptance criteria in the WGE P2 Procedure, the data file containing all of the recording parameters and the 24 traces of recorded data were stored on the Strataview digital seismograph. The "shot" location and other parameters were hand written on the Seismic Refraction Field Note. At the completion of the recording at a given "shot" location the energy source was moved to the next "shot" location for that spread. This procedure was continued to acquire refraction data for each of the 7 "shot" locations for each 250-foot spread. Following data acquisition for a given 250-foot spread, the geophone array was re-deployed to the next spread on a refraction line, or to the starting point of a new refraction line.

At the completion of each 250-foot spread, notes on intersection points with other lines, descriptive annotation of line layout and topographic elevation changes were written of the Seismic Refraction Field Note. The approximate elevation along the profile was determined in accordance with the WGE-P4 Hand Level Survey Procedure and results included in the Refraction Field Note.

Field procedures were repeated until refraction data were acquired along the entire length of each spread. The end point of each spread became the starting point for the next spread section. For example, at the completion of Line 1 spread 1 from 0 to 250 feet, the measuring tapes were laid out from 250 to 500 feet and geophones and communication data and "shot" trigger cables were moved to the 250 to 500 foot section. Similar spacing of the "shot" points was used for the second spread section with the High End "shot" for the first spread section becoming the Low End "shot" location for the second spread section. This method of linking refraction spreads was used to obtain data for each of the longer refraction lines built of 2, 3, or 5 individual spreads. All geophysical data acquired by the land refraction study and all field records that document the daily progress of work (WGE P2, WGE P4) were digitally archived.

2.4 Refraction Data Interpretation

Seismic refraction data were interpreted for this study to assist in characterizing the local subsurface geologic materials according to overburden thickness, depths to glacial till, weathered or fractured bedrock, and depths to competent bedrock. Classification of subsurface material is based on information obtained from seismic velocity profiles interpreted for each of the 6 refraction lines (Line 1 – 3, Lines A –C), and from available boring logs.

Earth materials exhibit a characteristic wave propagation velocity, thus they can be classified simply in terms of their seismic velocity, for both P-wave and S-wave propagation velocities. Shown below in Table 1 (ASTM D 5777-0, 2000) are compressional wave (P-wave) velocities that are typically measured for various types of earth materials.

TABLE 1 Range of Velocities For Compressional Waves in Soil and Rock (4)

Materials	Velocity	
Natural Soil and Rock	ft/s	m/s
Weathered surface material	800 to 2000	240 to 610
Gravel or dry sand	1500 to 3000	460 to 915
Sand (saturated)	4000 to 6000	1220 to 1830
Clay (saturated)	3000 to 9000	915 to 2750
Water[A]	4700 to 5500	1430 to 1665
Sea water[A]	4800 to 5000	1460 to 1525
Sandstone	6000 to 13000	1830 to 3960
Shale	9000 to 14000	2750 to 4270
Chalk	6000 to 13000	1830 to 3960
Limestone	7000 to 20 000	2134 to 6100
Granite	15000 to 19000	4575 to 5800
Metamorphic rock	10000 to 23000	3050 to 7000

The methodology used to interpret seismic refraction data included a sequence of steps to prepare the acquired field data for analysis with either hand calculations using the Critical Distance Method, or by velocity modeling using SeisOpt @2D. The first step was to transfer the digitally recorded data from the field seismograph to a computer for determining the arrival times at each of the 24 geophones for each of the 7 "shot" locations for each profile spread section. The signal or "trace" for each geophone was displayed on the computer and enhanced using signal amplification, if required. Once displayed at the appropriate scale, a cross-hair cursor was moved to the point of the first arrival of the compressional seismic wave for each of the 24 traces. The traces can be scaled up or down to evaluate the selected first arrivals ("first break picks"). Figure 3 shows an example of the first break picks selected for Line B for the interior profile spread section from 250 to 500 feet, e.g. Spread 2. Shown on Figure 3 are 24-channel seismograms for the High- and Low-Offset "shot" locations, and the Center "shot" location for Line B – Spread 2. Time picks for first arrivals of compressional (P-wave) energy for each geophone location are shown as horizontal 'red' lines. Time picks were recorded to "first-break" pick files which were then stored for velocity calculations using both the Critical Distance Method and the SeisOpt @2D forward modeling interpretation method.

The 24 first-break picks for each of the seven "shot" points per spread for each refraction line were then stored electronically to provide input for calculation of seismic velocity structures. The printed output of the first break picks were plotted on graph paper to present a time versus distance plot, which were manually interpreted using the Critical Distance Method. Refraction interpretations using this method are included in Calculation Summary Sheet 1 (WGE CSS 1). Figure 4 shows a representative computer generated travel time versus distance plot indicating the correlation of the forward and reverse impact points as wells as selected average 'best-fit' velocity lines for refraction Line B, spread section 3, between distances of 500 to 750 feet from the start of Line B. Shown on Figure 4 are "first-break" times at each of the 24 geophone locations measured for each of the 7 "shot" points. Solid black lines on Figure 4 illustrate linear best fit models through the "first-break" times shown as red points connected by red line segments. Inverse of the slopes of the best fit linear models (black lines) equal the apparent seismic velocities measured along various trends. Apparent velocities include 14,000 ft/sec determined for the Low-offset "shot", and 14,000 ft/sec determined for the High-offset shot. Differences in apparent seismic velocity most often result from sloping bedrock surfaces in which case a higher apparent velocity is measured up-dip of the bedrock slope, for this case towards the High-offset shot. Information contained on Figure 4 including apparent seismic velocities and cross-over distances (e.g. distances along the spread corresponding to changes in slopes of the travel-time data) were used to determine velocity structures using the Critical Distance Method. It is noted that the Critical Distance Method provides depth information only for locations near the 7 "shot" points, and that lateral and vertical variations in velocity beneath the bedrock refractor layer are not determined by the method.

More detailed methods than the Critical Distance Method are available that provide velocity structure information continuously along a spread, rather than just at the several "shot" points. SeisOpt @2D modeling software was used to achieve more detailed interpretations including determinations of

lateral and vertical velocity changes, if present, which cannot be interpreted using the traditional Critical Distance refraction interpretation method. But as noted above, SeisOpt @2D results are not able to be confirmed by alternate calculations, thus are shown to provide a complementary velocity structure for depths below those determined using the Critical Distance Method.

Figure 5 illustrates a comparison of refraction profiles calculated by the Critical Distance Method and modeled by SeisOpt @2D. Shown on Figure 5(a) is the velocity structure for Line B Spread 3 (i.e. from 500 to 750 feet along Line B) calculated by the Critical Distance Method. Figure 5(a) illustrates a velocity cross-section that includes 3 geologic layers. The top layer is a loose soil material with P-wave velocity in the range of 1,300 to 1,500 feet/sec. The underlying layer, characterized by a P-wave velocity near 5,500 to 6,200 feet/sec is interpreted to be a dense soil layer grading into a dense glacial till, or less likely weathered, or highly fractured bedrock. The third layer, characterized by P-wave velocity >14,000 feet/sec is interpreted to be the top of hard and unweathered bedrock.

Figure 5(b) illustrates the P-wave velocity model processed by SeisOpt @2D for the third spread of Line B (500 to 750 feet). These forward modeling results illustrate velocity gradients in both the vertical and horizontal directions. The SeisOpt model doesn't fit the calculated elevation of either the 6,000 or 14,000 ft/sec layers. Available boring logs (B-301, B-308, and B-311) indicate top of bedrock to be at an elevation of 626 feet at B-301 on Line B and the presence of several feet of glacial till with lower RQD values at the top of the bedrock layer. The Critical Distance Method interpretation places the top of hard bedrock (Vp > 14,000 ft/sec) at a consistent elevation near 630 feet. The SeisOpt @2D interpretation determines a lower velocity near 12,000 ft/sec at the confirmed top of bedrock while determining the elevation of higher velocity bedrock of 14,000 ft/sec to be near 620 feet, or about 8 feet deeper than confirmed by borings. Elevations to velocities greater than 14,000 ft/sec are determined by SeisOpt @2D to range from 620 feet to 596 feet. It is determined as an outcome of dual processing of the same refraction datasets that SeisOpt @2D systematically places higher velocity layers at depths deeper than calculated by the Critical Distance Method and deeper than confirmed by borings where available.

2.5 Refraction Test Results

Results of seismic refraction data interpretations are presented using graphical formats illustrated on Figure 5, as described above for the third spread of Line B. Colorized velocity profile sections contoured from SeisOpt gridded seismic velocity outputs are grouped into west to east profiles (Lines A – C) and into south to north profiles (Lines 1 – 3). It is noted that line orientations (northerly vs. westerly) indicate direction of data acquisition along refraction lines. For example, the 0+00 station of Line 1 is at the south end of Line 1, and the 0+00 station of Line A is at the west end of Line A. Calculated seismic P-wave velocity contours for Lines 1 through 3 and A through C are illustrated on Figure 6. Seismic velocity contours shown on this figure are plotted in a real world scale with equal vertical and horizontal distance scales measured in feet. The vertical scale is true elevation in feet. When viewed in the real world scale on

Figure 6, interpreted velocity profiles indicate a generally flat lying bedrock surface overlain by a variably thin veneer of overburden material. SeisOpt velocity profiles are used to illustrate vertical and lateral variations is measured seismic velocity. For the reason described above of SeisOpt @2D biasing downwards the depths to higher velocity, these profiles are not used to determine the absolute elevation of sound bedrock. The SeisOpt @2D velocity models however depict bedrock at the Bell Bend site to be nearly flat lying west to east and sloping upward from south to north and attain a P-wave velocity greater than 14,000 feet/sec at elevation of 620 feet across the site.

Seismic refraction velocity profiles were calculated using the Critical Distance Method for each of the 6 refraction lines. As discussed above, results of this traditional refraction interpretation method provide close correlations to top of rock determinations from available boring logs. Calculations are described in CSS 1. Geologic layer interfaces determined by this traditional method are illustrated corresponding to ground elevation (feet), elevation of the top of weathered/fractured rock or glacial till (≈ 6,000 – 8,000 feet/sec), and elevation of the top of hard bedrock (≥ 14,000 feet/sec). Geologic profiles for south-to-north Lines 1 through 3 are illustrated on Figures 7 through 9. Profiles for west-to-east Lines A through C are plotted on Figures 10 through 12. As noted above, associations of seismic P-wave velocities with geologic stratigraphic horizons was based on published correlations (ASTM D 5777-00, Table 1), and on inspection of geotechnical boring logs.

Seismic refraction data were acquired with sufficient aerial coverage to support preparation of contoured elevation maps for the following features;

1. Ground surface elevation
2. Elevation of dense soils, glacial till and/or weathered or fractured bedrock (top of the 6,000 feet/sec horizon)
3. Elevation of unweathered bedrock (top of 14,000 feet/sec horizon)

Contour maps of the ground surface elevation, elevation of the top of the 6,000 feet/sec intermediate velocity, and elevation of the top of the >14,000 feet/sec sound bedrock velocity are provided on Figures 13 through 15 respectively. Contour maps were prepared using the contouring program Surfer-8 created by Golden Software.

Results of detailed seismic refraction study of the Bell Bend site show the site to be underlain by competent bedrock that is characterized by P-wave velocity near 14,000 feet/sec at top of rock and increases to greater than 17,000 feet/sec typically at depth of 10 to 20 feet below the top of bedrock.

Seismic refraction interpretation results based on semi-automated calculations for all refraction Lines 1 – 3 and Lines A – C are compiled in Appendix A.

3.0 References

ASTM, May 2000. *Standard Guide for Using the Seismic Refraction Method for Subsurface Investigation*, Designation D 5777-00, 13p.

Birch, F., 1966. *Compressibility; Elastic Constants*, in Clark, S. P., Jr., editor (1966) Handbook of Physical Constants, GSA Memoir 97, Revised Edition, The Geological Society of America, New York, NY, pp. 97-173.

Bowles, J. E., 1977. *Foundation Analysis and Design*, Second Edition, McGraw-Hill Book Company, New York, NY, 750p.

Bullen, K. E., 1959. *An Introduction to the Theory of Seismology*, Second Edition, Cambridge University Press, 296p.

Carmichael, R. S., ed., 1984. *Handbook of Physical Properties of Rocks*, CRC Press, Boca Raton, FL, 340p.

CRC, 2003. *Standard Mathematical Tables and Formulae*, D. Zwillinger, 31th Edition, 910p.

Dobrin, M. B., and C. H. Sawl, 1988. *Introduction to Geophysical Prospecting,* Fourth Edition, McGraw-Hill, New York.

Dobrin, M. B., 1976. *Introduction to Geophysical Prospecting*, McGraw-Hill, Inc., ISBN 0-07-017195-5, 630p.

Korn, G.A. and T.M. Korn, 1968. *Mathematical Handbook for Scientists and Engineers, Definitions, Theorems, and Formulas for Reference and Review*, Dover Publications, Inc., New York, NY, 1130p.

Musgrave, A.W., ed., 1967. *Seismic Refraction Prospecting*, The Society of Exploration Geophysicists, Tulsa, OK, George Banta Company, Inc., 604p.

Palmer, D., 1991. *The Resolution of Narrow Low Velocity Zones with the Generalized Reciprocal Method*, Geophysical Prospecting, Vol. 39, 1991, pp. 1031–1060.

Palmer, D., 1990. *The GRM an Integrated Approach to Shallow Refraction Seismology*, Exploration Geophysics, Bulletin of the Australian Society of Exploration Geophysics, Vol. 21, 1990.

Palmer, D., 1988. *Refraction Seismics, the Lateral Resolution of Structure and Seismic Velocity*, Handbook of Geophysical Exploration Vol. 13, Section 1, Seismic Refraction, K. Helbig and S. Tredel (eds.), Geophysical Press, London, 1988.

Palmer, D., 1980. *The Generalized Reciprocal Method of Seismic Refraction Interpretation,* Society of Exploration Geophysicists, Tulsa, Oklahoma, 1980.

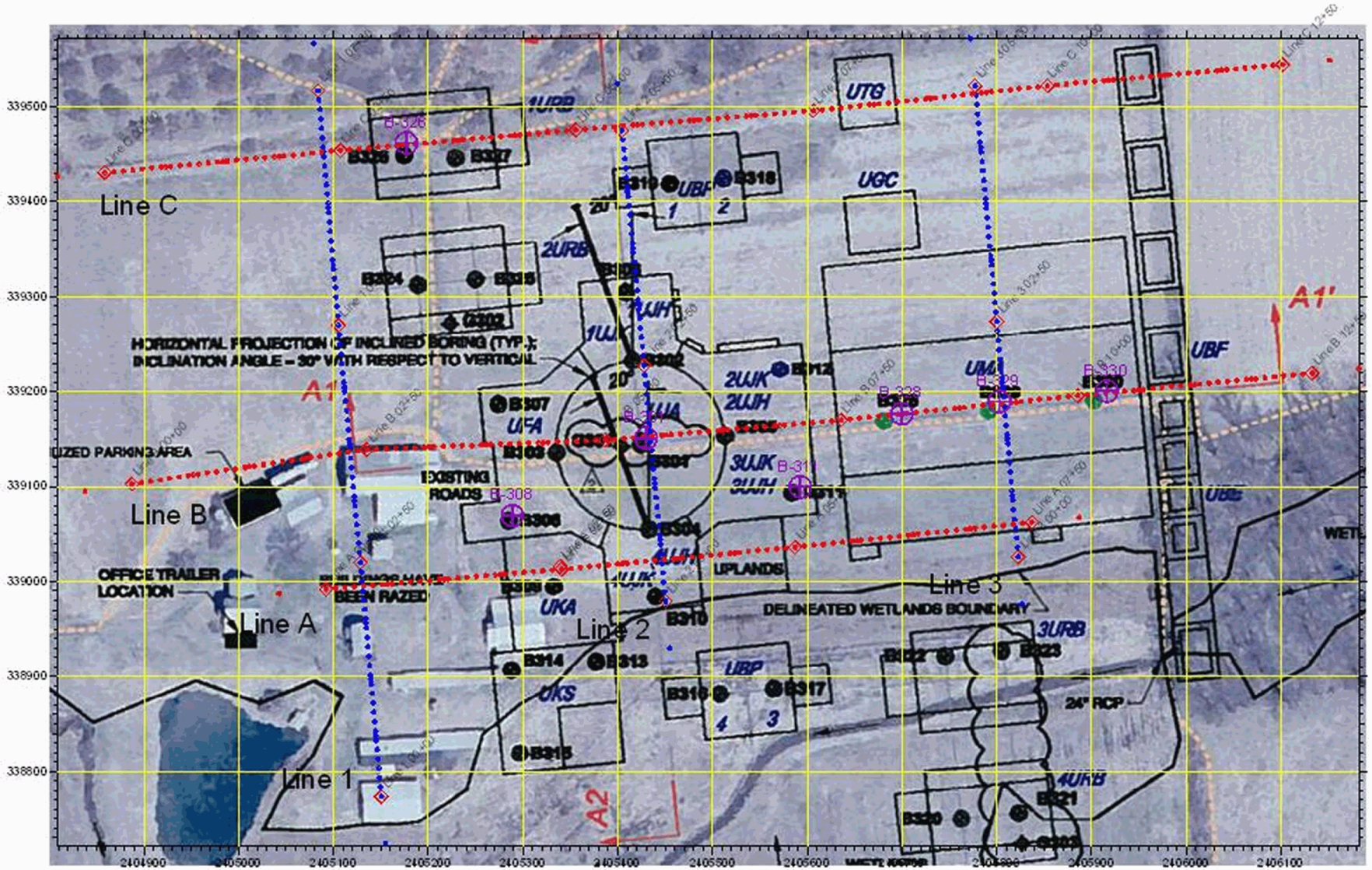
Redpath, B. B., 1973. *Seismic Refraction Exploration for Engineering Site Investigations: Technical Report E-73-4,* U.S. Army Engineering Waterways Experiment Station, Explosive Excavation Research Lab., Livermore, California.

Sjögren, B,, 1984. *Shallow Refraction Seismics*, Cambridge University Press, ISBN 0 412 24210 9, 270p.

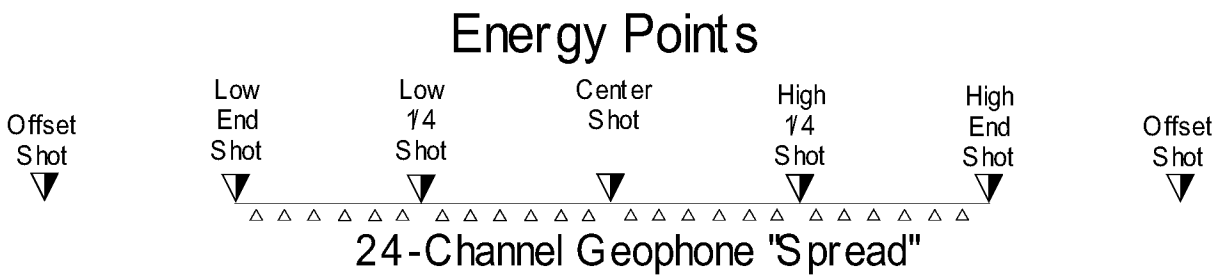
Telford, W. M., L. P. Geldart and R. E. Sheriff, 1990. *Applied Geophysics – Second Edition*, Cambridge University Press, ISBN 0-521-32693-1, 770p.

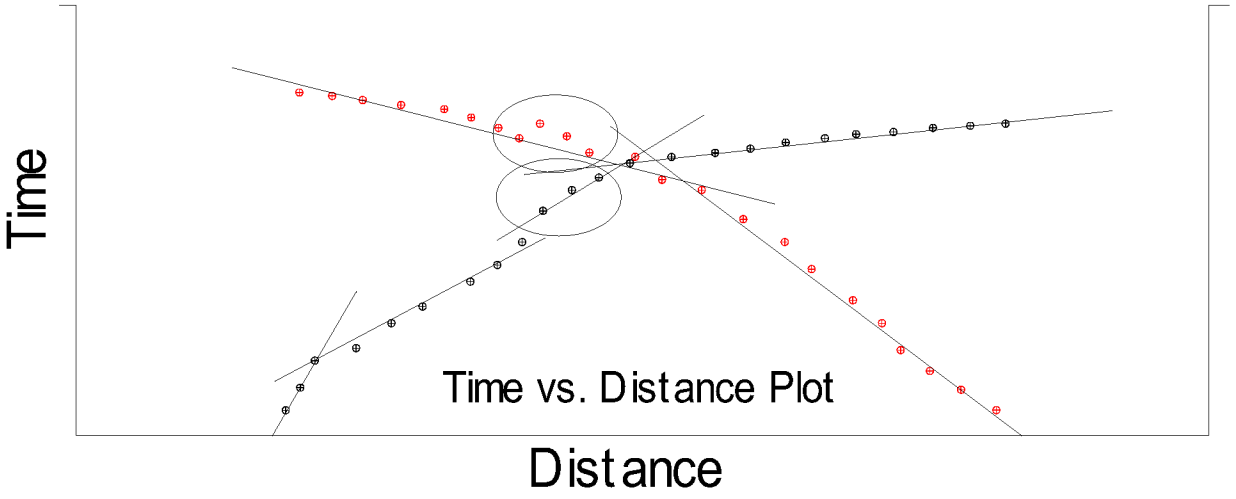
Vucetic, M. and Dobry, R., 1991. Effect of soils plasticity on cyclic response, Journal of Geotechnical Engineering, ASCE 117 (1), pp. 898-907.

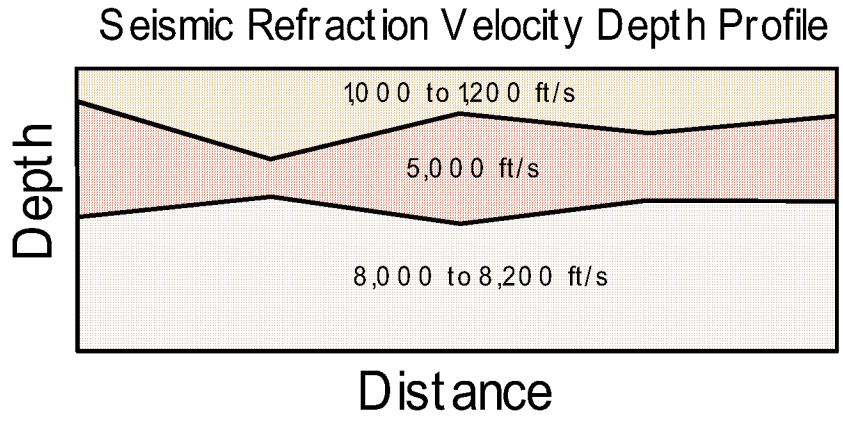
Woods, R. D., 1978. *Measurement of Dynamic Soil Properties*, Proceedings of the ASCE Geotechnical Engineering Division Specialty Conference on Earthquake Engineering and Soil Dynamics, ASCE, Vol. I, 19–21 June 1978, pp. 91–178.



Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Seismic Refraction Survey**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	**Profile Line Locations**	
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 1**







Refraction Spread:

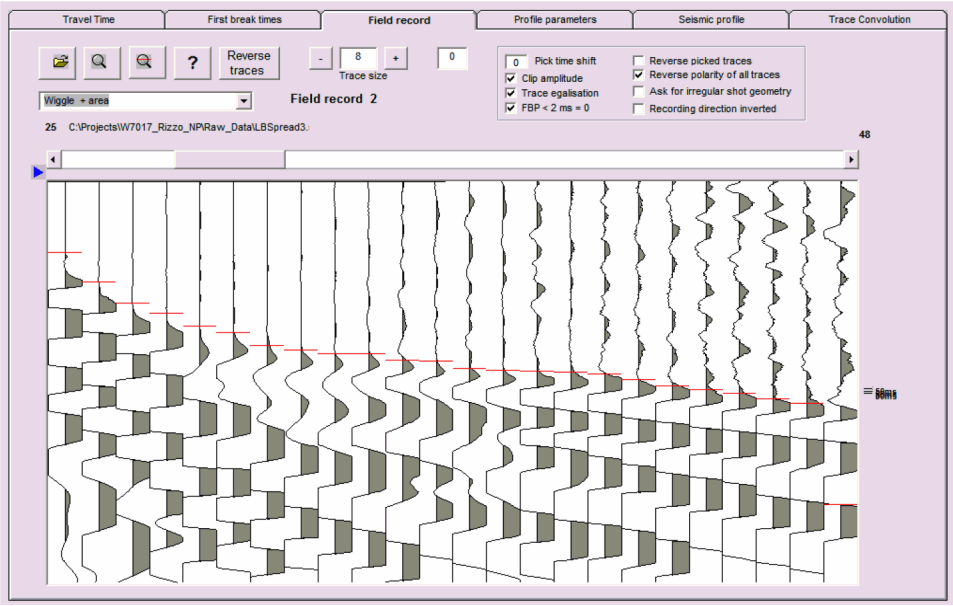
24-channel geophone array with uniform spacing of 10 feet between geophone locations. Energy ("shot") points include:

-50	feet	low offset
0	feet	low end
65	feet	low quarter
125	feet	center
185	feet	high quarter
250	feet	high end
300	feet	high offset

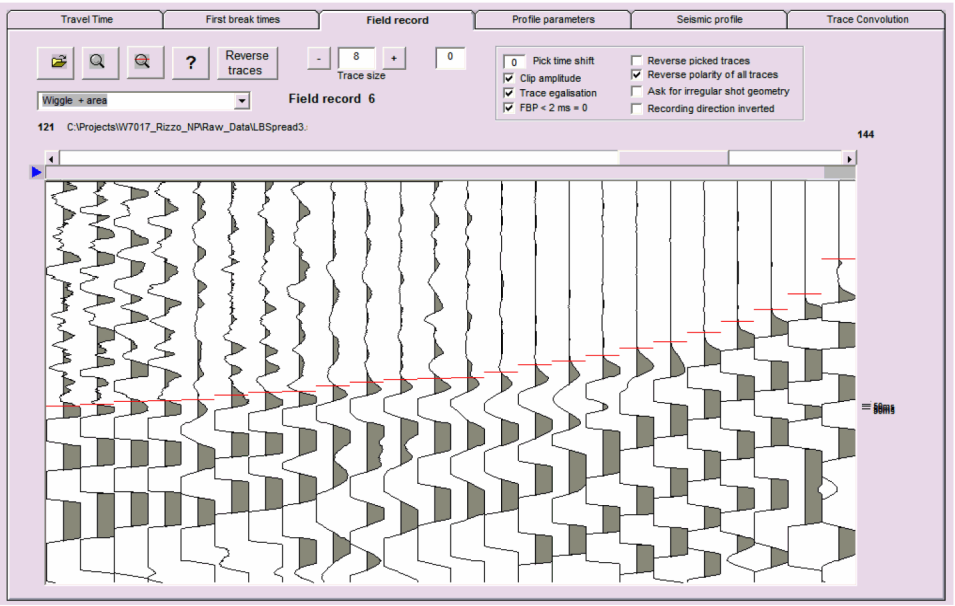
Example of Time vs. Distance Plot for 2 shot locations. Low end shot (black), high end (red). Data points are times measured at geophone location for arrival of compressional (P-wave) energy.

Example of Seismic P-wave Velocity Profile determined using one of several refraction interpretation methods.

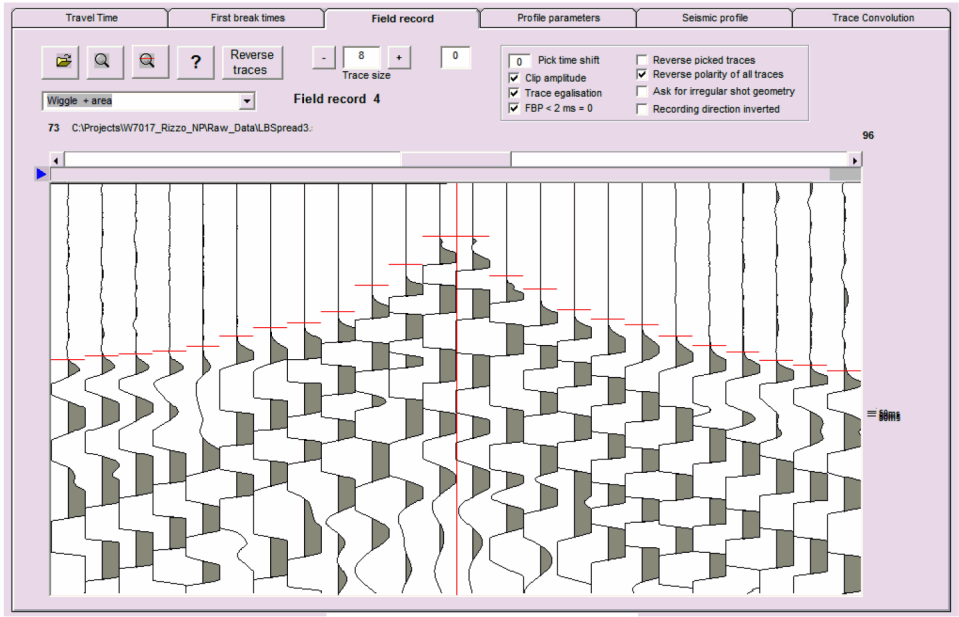
Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Spread Geometry Travel-Time Plot and Velocity Profile**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization **FIGURE 2**



Low End Shot (0 feet)



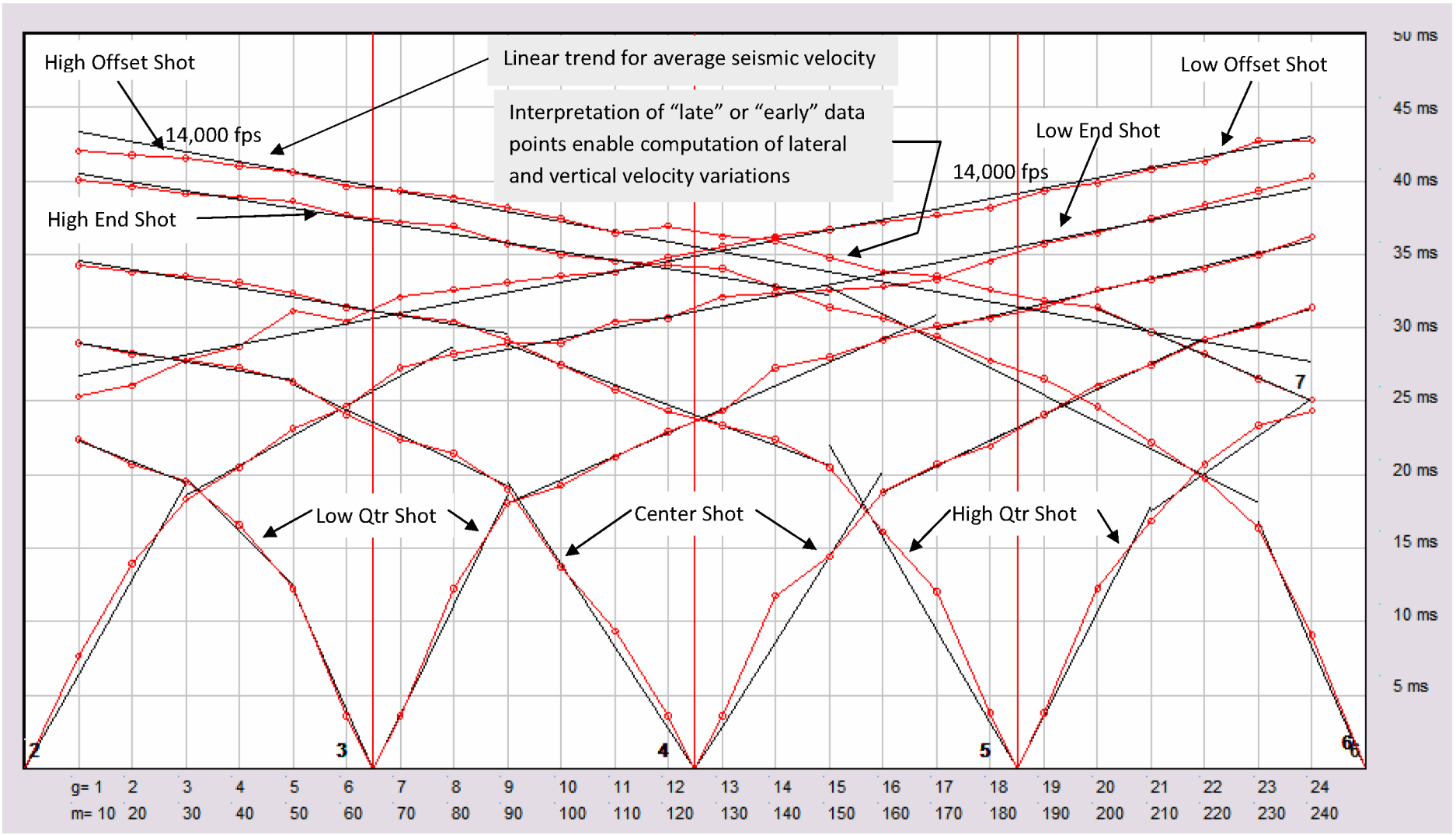
High End Shot (250 feet)



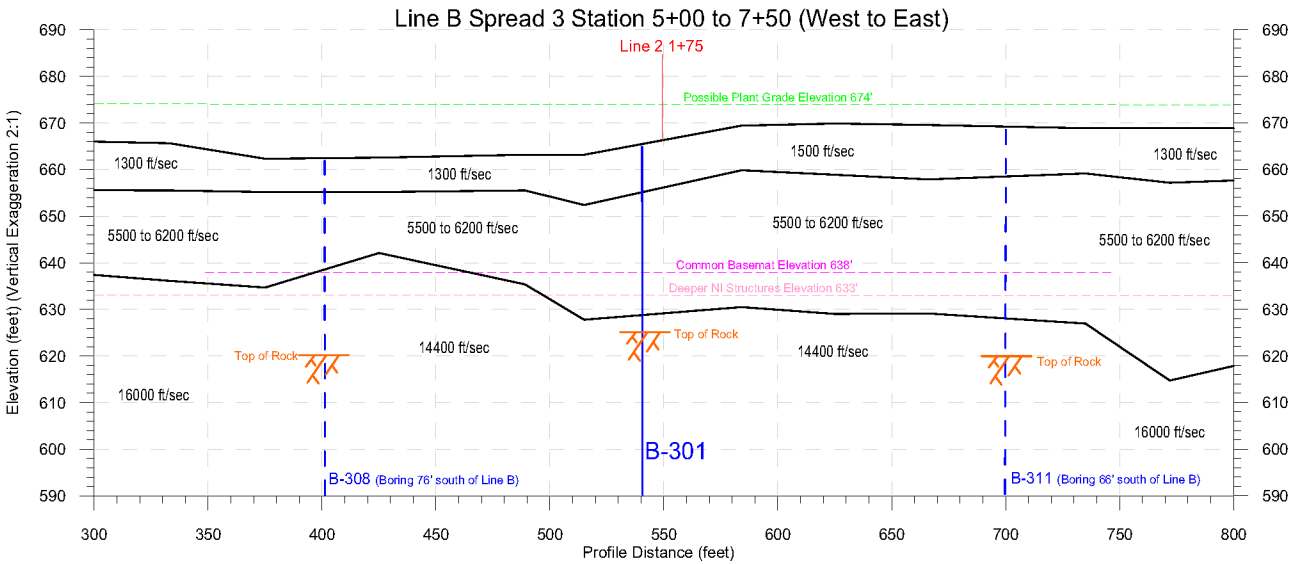
Center Shot (125 feet)

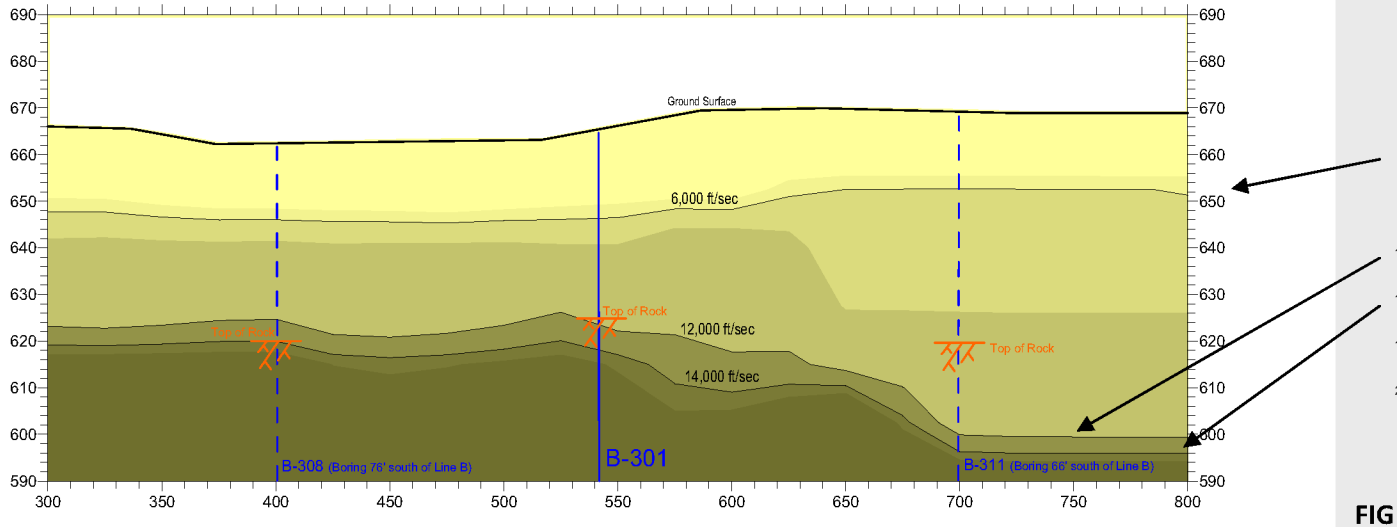
Red Lines indicate "time picks" for first arrival of seismic compressional wave (P-wave) energy across the 24-channel geophone spread

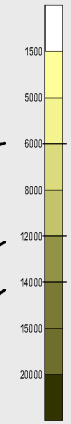
Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**24-Channel Refraction Record Section Line B – Spread 3**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.		
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 3**



Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Travel Time Plot for Line B – Spread 3**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.		
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 4**







Interpreted Seismic Velocity Interfaces corresponding to:

Overburden material (< 6,000 ft/sec)

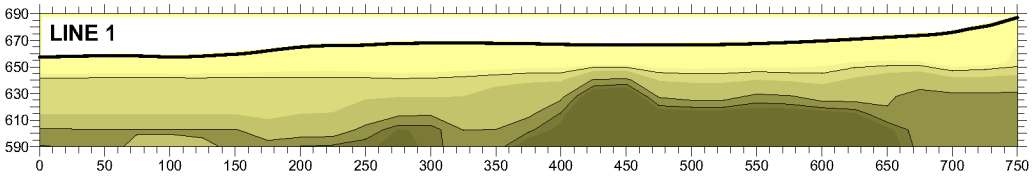
Variably glacial till and/or weathered/fractured bedrock (6,000 -14,000 ft/sec)

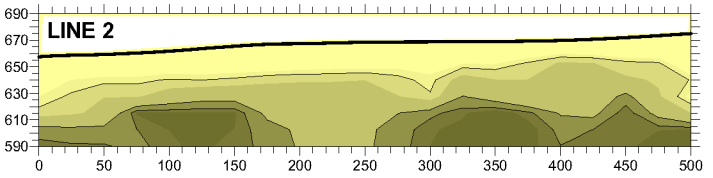
Hard, unweathered bedrock (>14,000 ft/sec)

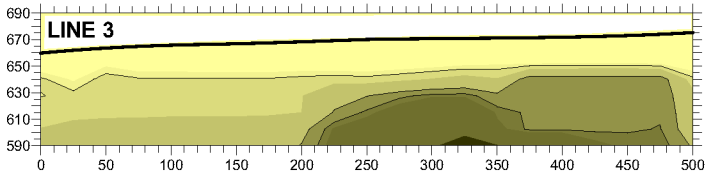
FIGURE 5(a) Refraction Line B –Spread 3

FIGURE 5(b) Seismic Velocity Contours determined from SeisOpt forward modeling.

Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Calculated Velocity Contours and Interpreted Velocity Structure–Line C-S2**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.		
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 5**





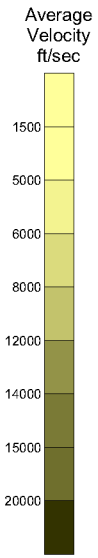


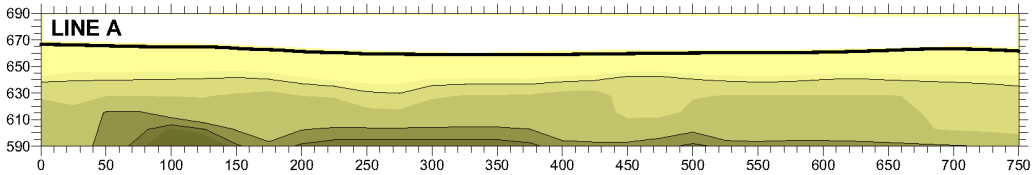
Vertical Scale = Elevation (feet)

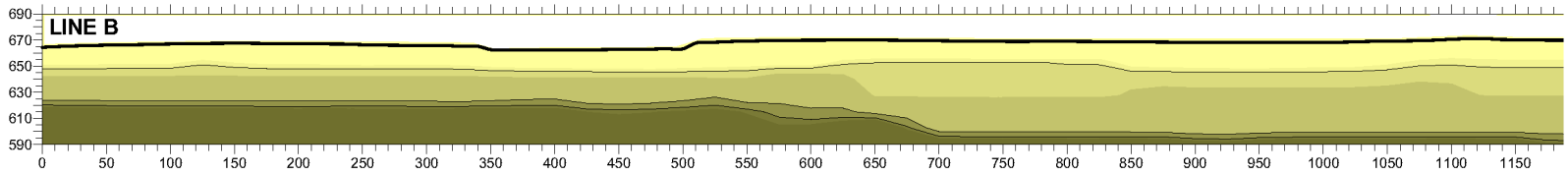
Horizontal Scale = Profile Distance (feet)

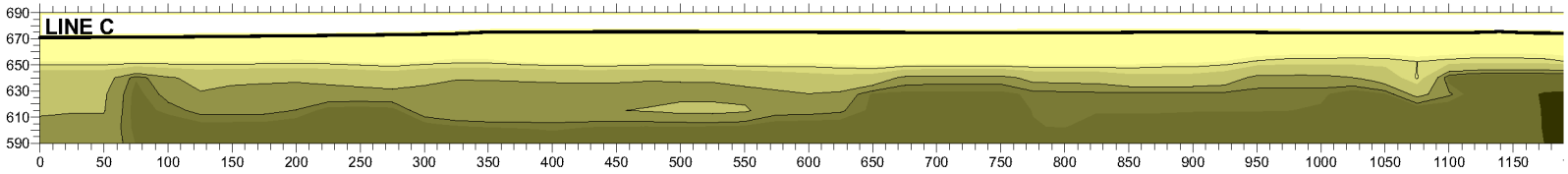
No vertical exaggeration

Ground surface, Layer 1 (6,000 fps), and Layer 2 (14,000 fps) are shown as heavy lines

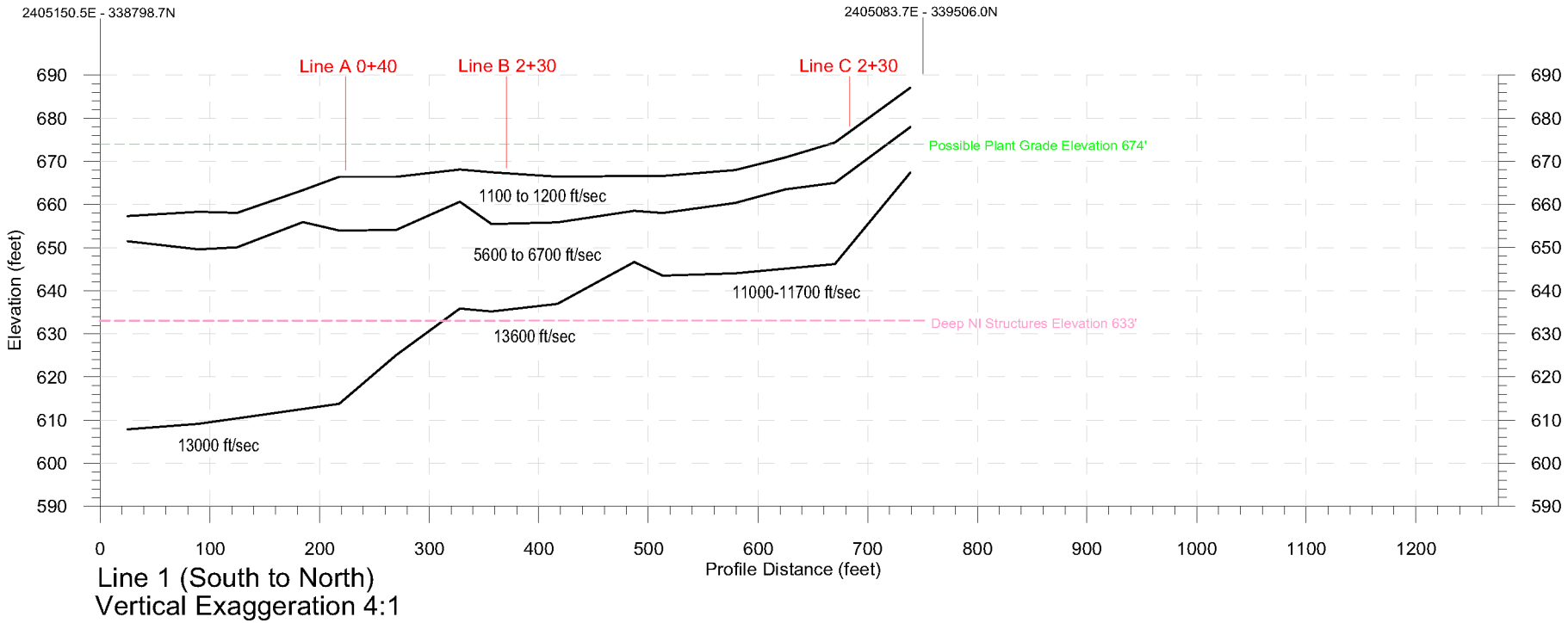






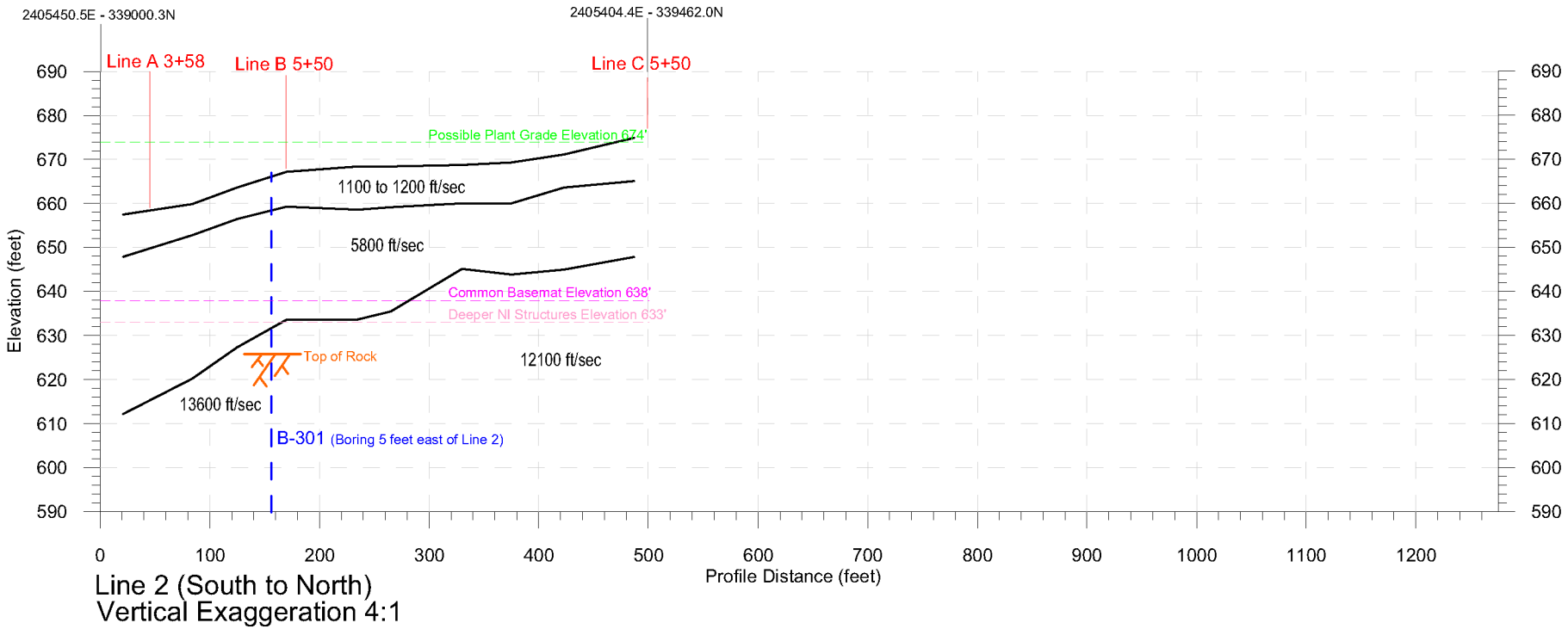


Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Seismic Velocity Contours, Lines 1 through 3 and A through C using SeisOpt Calculations**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization — **FIGURE 6**

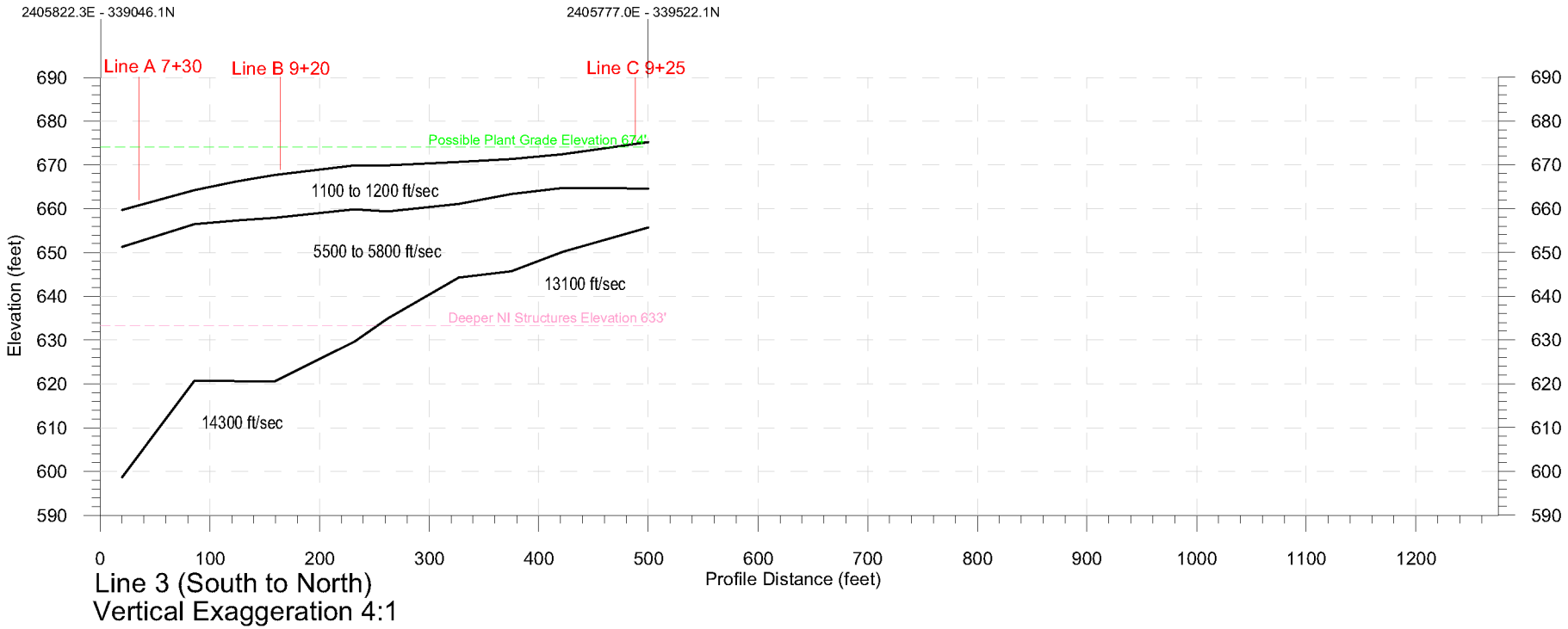


Line 1 (South to North)
Vertical Exaggeration 4:1

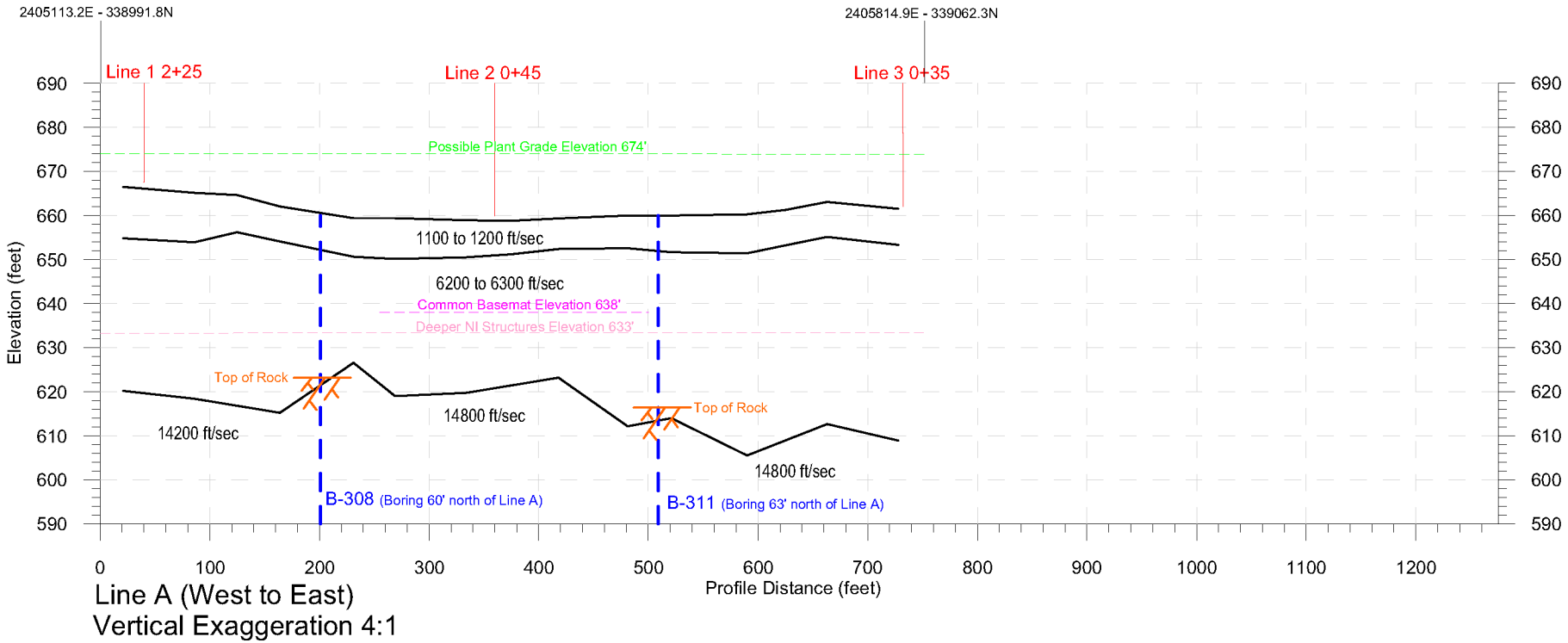
Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line 1**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.		
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 7**



Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line 2**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization — **FIGURE 8**

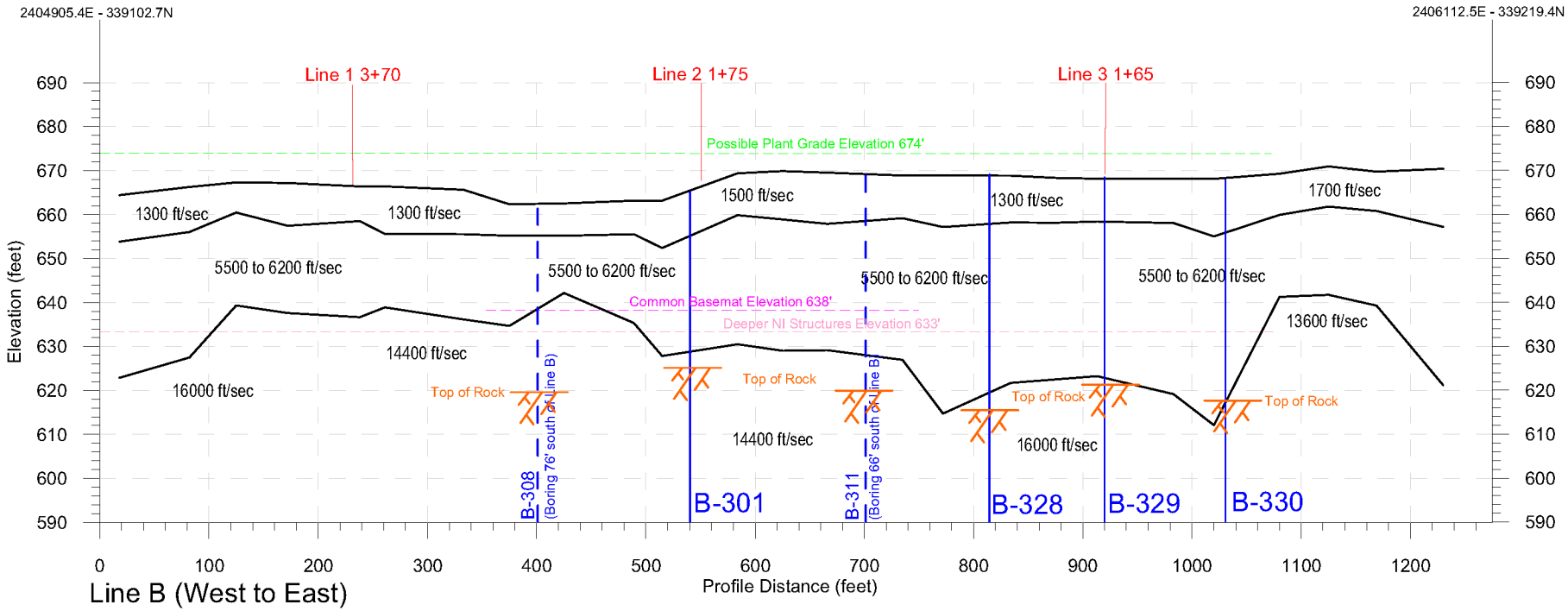


Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line 3**	
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.		
Project: W7017				March 24, 2008	Bell Bend Characterization	**FIGURE 9**



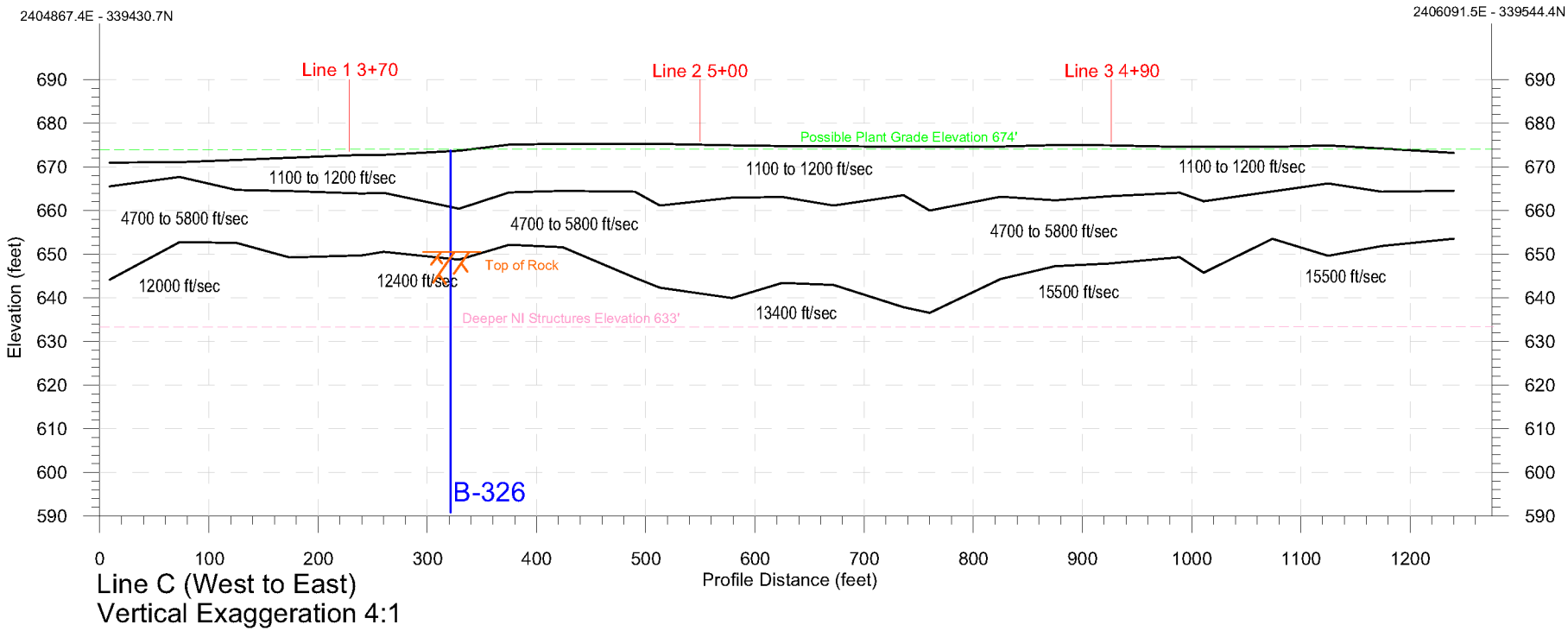
Line A (West to East)
Vertical Exaggeration 4:1

Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line A**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization **FIGURE 10**



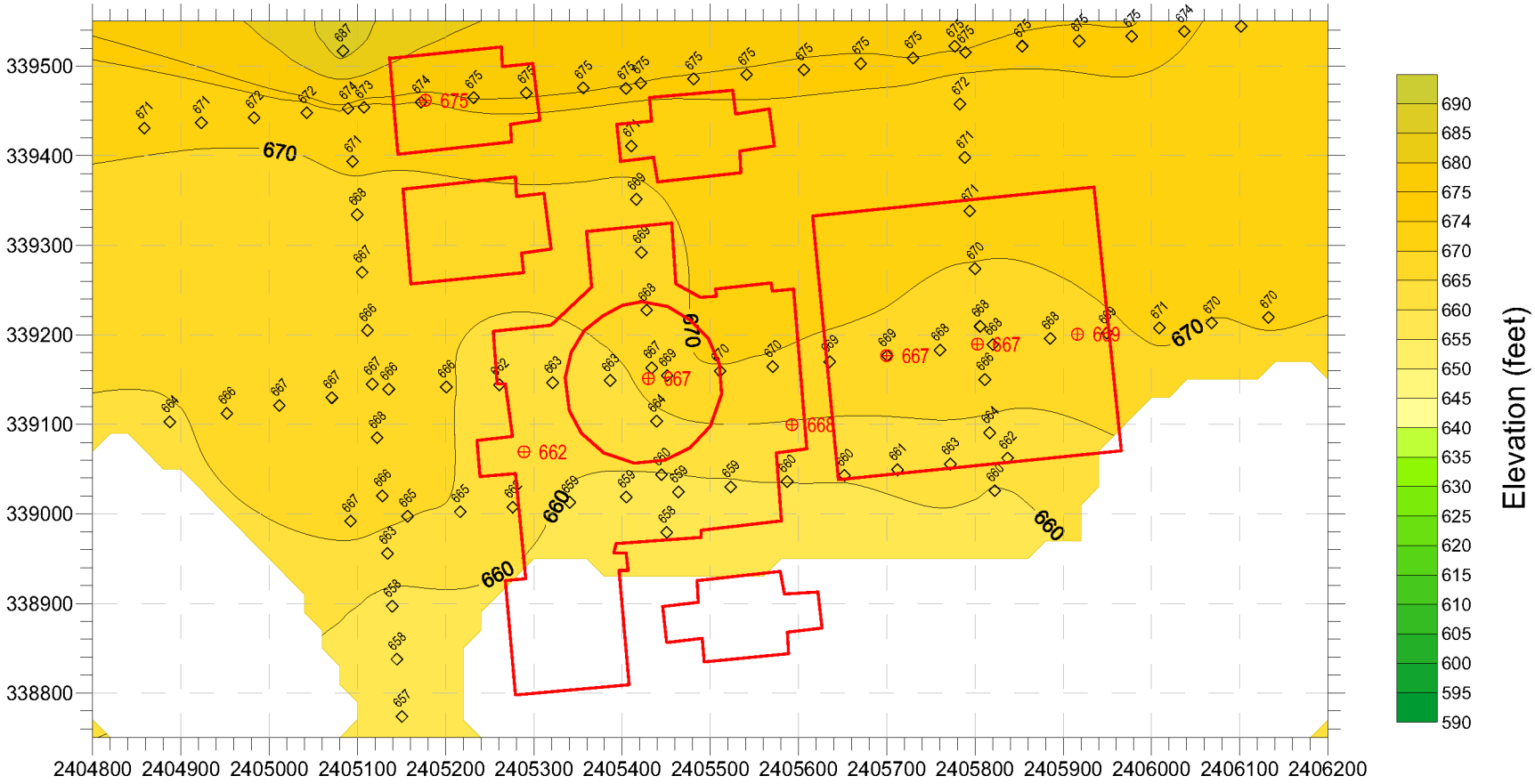
Line B (West to East)
Vertical Exaggeration 4:1

Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line B**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization **FIGURE 11**

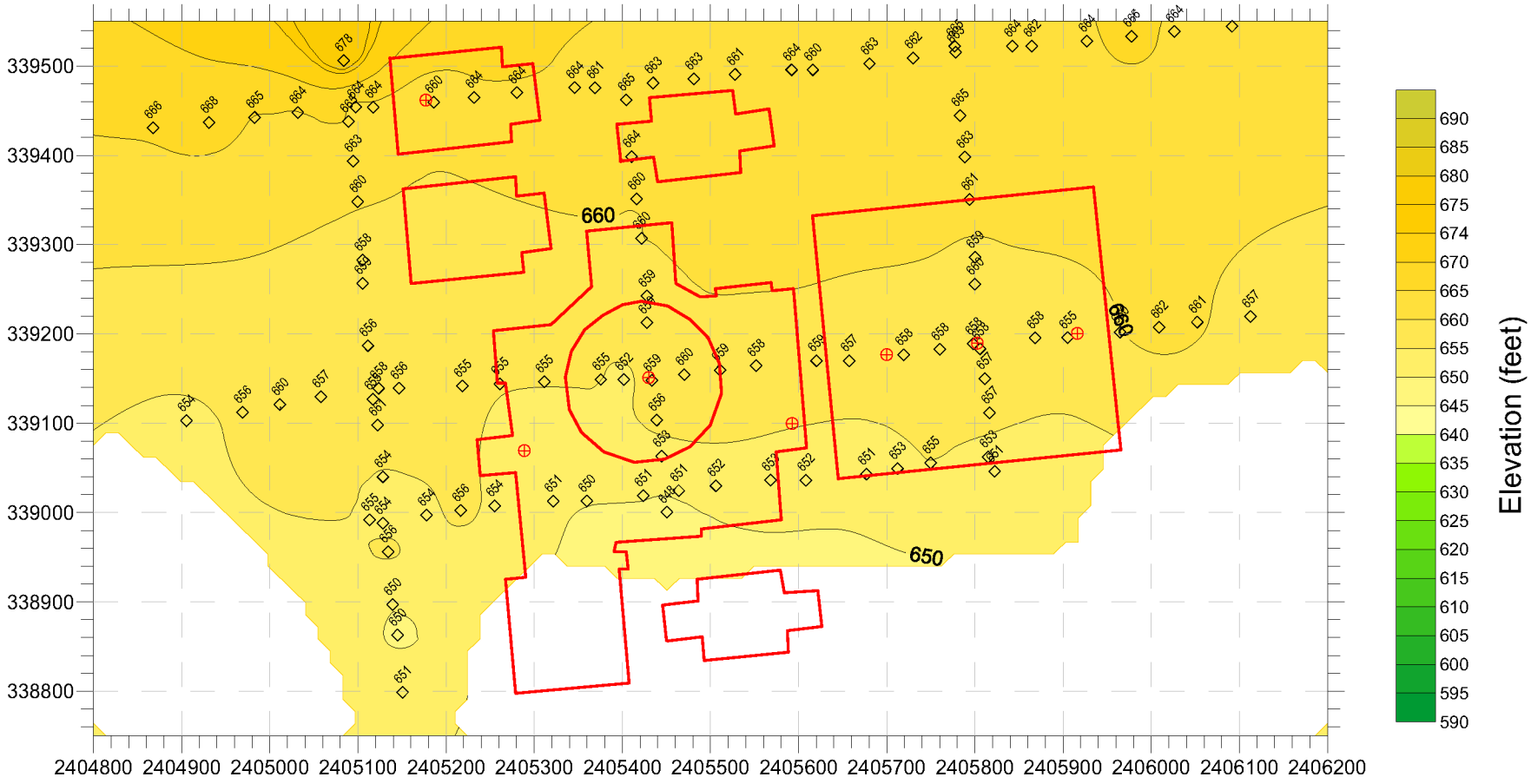


Line C (West to East)
Vertical Exaggeration 4:1

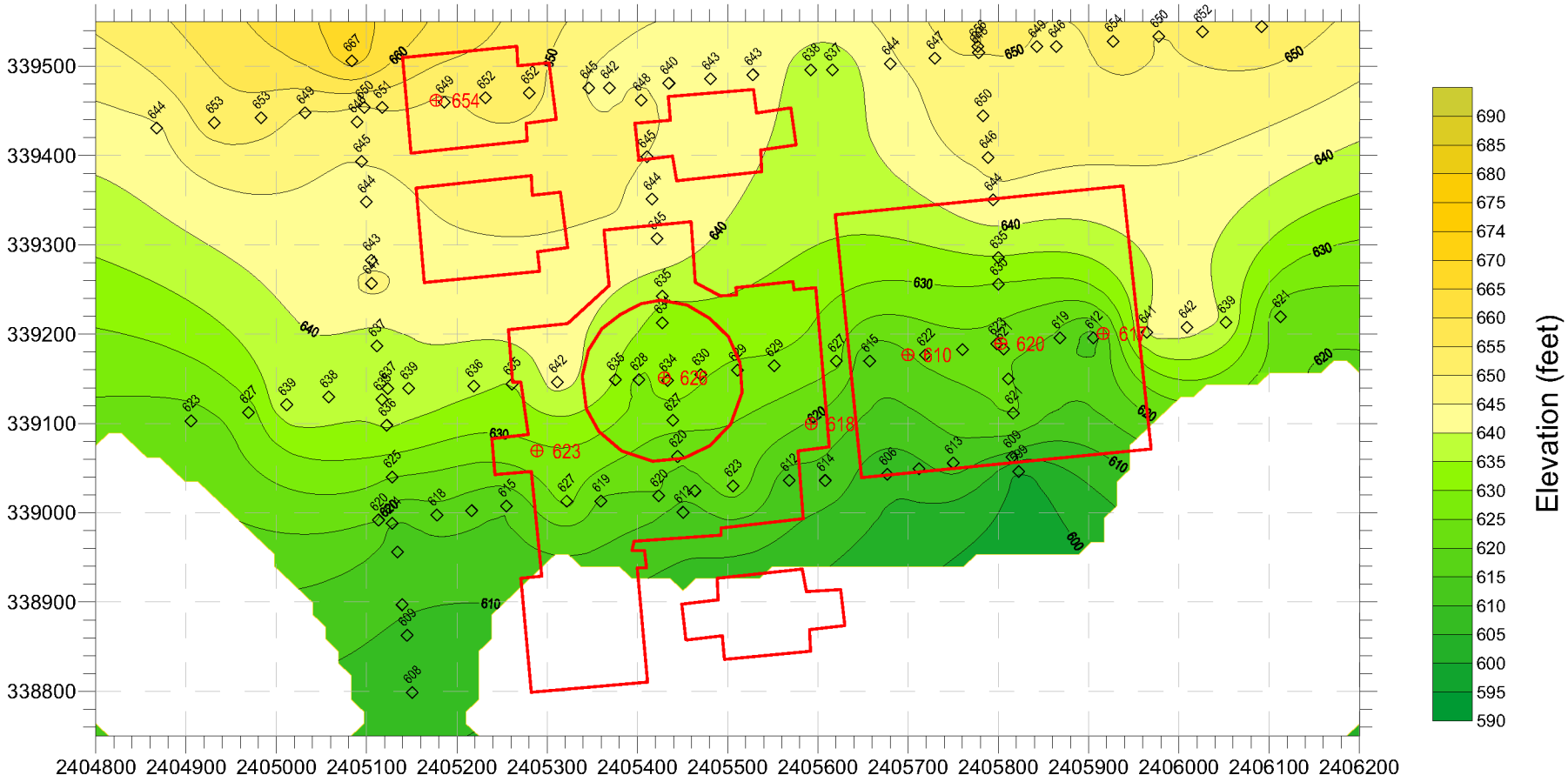
Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Refraction Profile – Line C**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization — **FIGURE 12**



Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Ground Surface Elevation Contour Map**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization — **FIGURE 13**



Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Top of Till Elevation Contour Map P-Wave Velocity > 6,000fps**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization — **FIGURE 14**

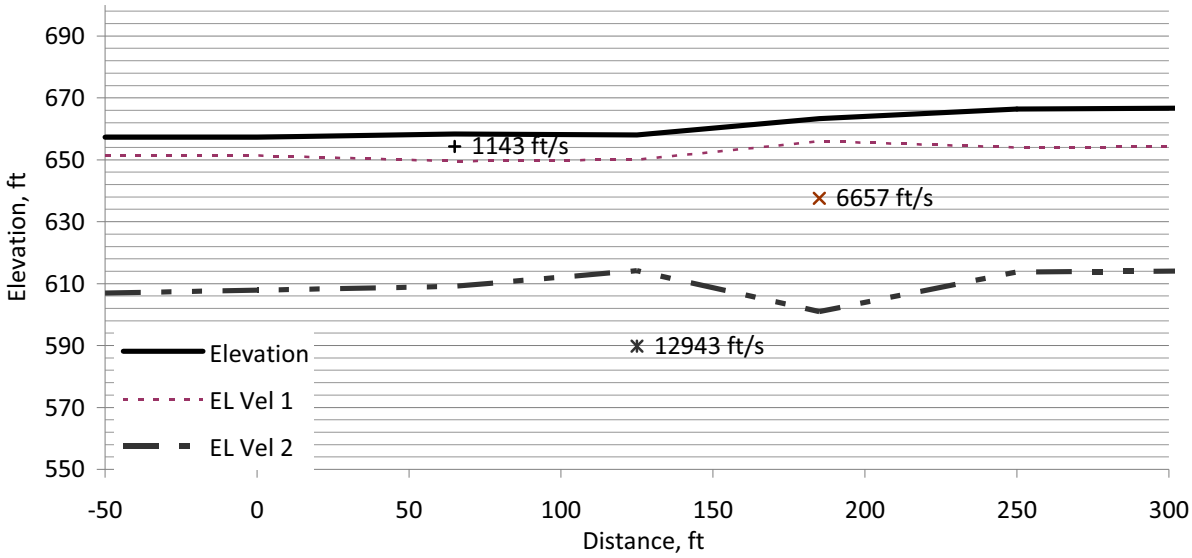


Weston Geophysical Engineers	Rev.	Prepared by: Date:	Approved by: Date:	Prepared for:	**Bedrock Elevation Contour Map P-Wave Velocity > 14,000fps**
20 Main St., Acton, MA 01720				Paul C. Rizzo Assoc.	
Project: W7017				March 24, 2008	Bell Bend Characterization **FIGURE 15**

Appendix A – Critical Distance – Velocity Tabulations

Prepared by:	_____	Date:	_____
Reviewed by:	_____	Date:	_____
Approved by:	_____	Date:	_____

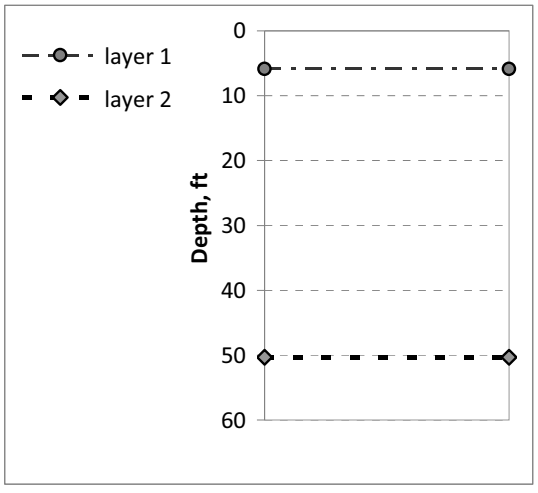
The following pages of the appendix were all prepared, reviewed, and approved under the signatures and on the days noted. The 160 pages are all verified as correct by the signatures shown on this cover sheet

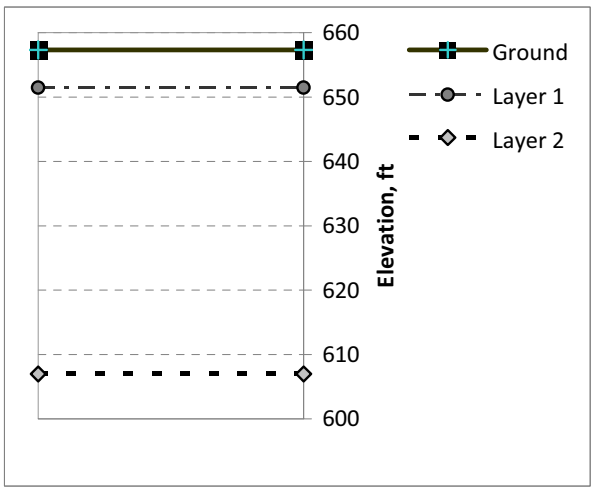

690
670
650
630
610
590
570
550
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
1143 ft/s
6657 ft/s
12943 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	1	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	657.3		
NAD1983	Coordinates:	**Easting:**	2405154.9		
PA State Plane	Eastern	**Northing:**	338724.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.178
X_critical 1 ------->		14.0			
Layer 1 thickness			5.9		
V1, Layer 2 -------->	6200.0			"V0_2	0.085
X_critical 2 -------->		151.0			0.836
Layer 2 thickness			44.5		
V2, Layer 3 -------->	13000.0			"V1_2	0.497
				k 0.461	0.595

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	5.9	651.4
Layer 3 ---------->	50.3	607.0





Prepared by: _____ Date: _____

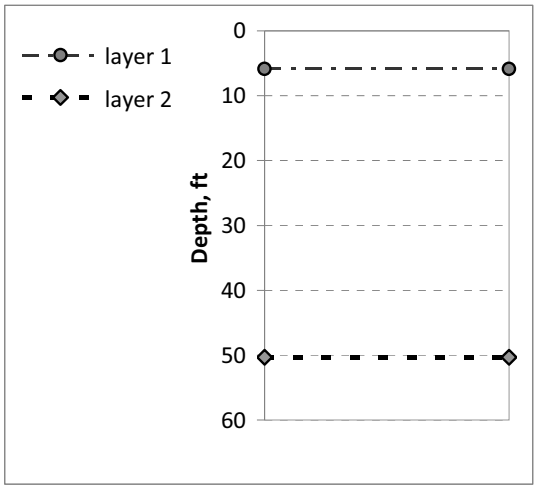
Reviewed by: _____ Date: _____

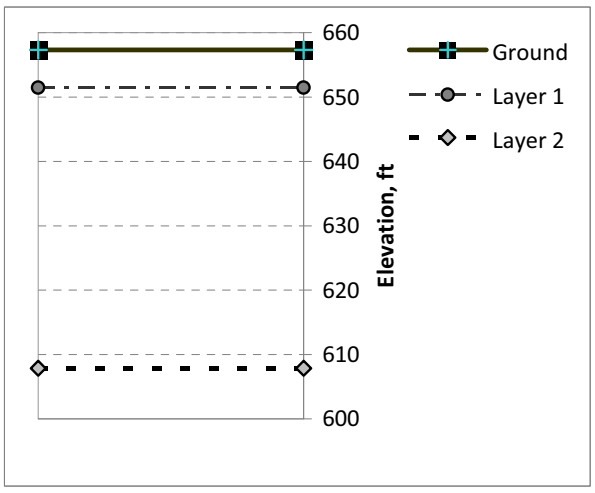
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	25		
		Elevation, ft:	657.3		
NAD1983	Coordinates:	**Easting:**	2405150.5		
PA State Plane	Eastern	**Northing:**	338773.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.178
X_critical 1 ------->		14.0			
Layer 1 thickness			5.9		
V1, Layer 2 -------->	6200.0			"V0_2	0.087
X_critical 2 -------->		151.0			0.836
Layer 2 thickness			43.6		
V2, Layer 3 -------->	12600.0			"V1_2	0.514
				k 0.456	0.583

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	5.9	651.4
Layer 3 ---------->	49.4	607.9





Prepared by: _____ Date: _____

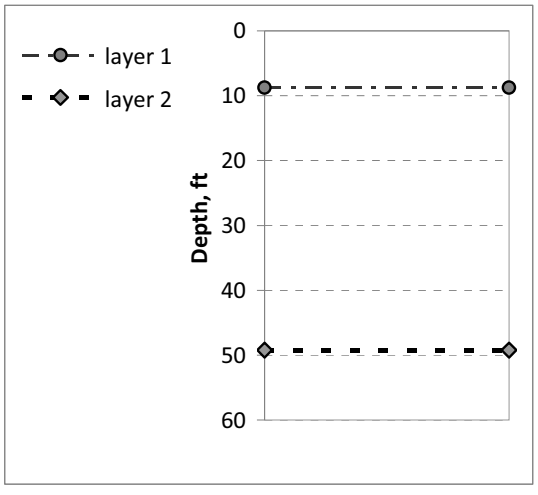
Reviewed by: _____ Date: _____

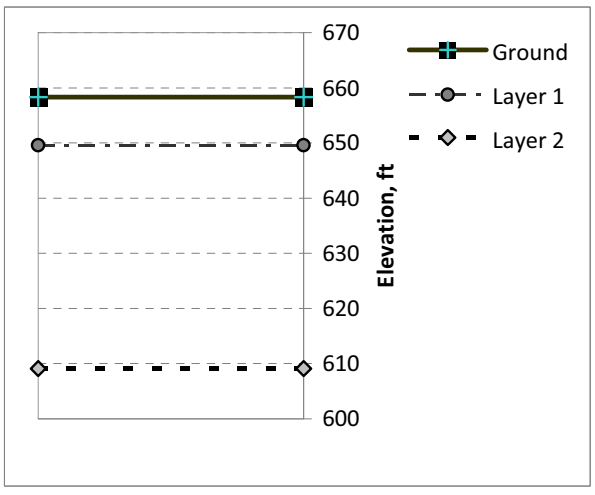
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	25		
		Elevation, ft:	658.3		
NAD1983	Coordinates:	**Easting:**	2405144.7		
PA State Plane	Eastern	**Northing:**	338837.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.181
X_critical 1 ------->		21.0			
Layer 1 thickness			8.8		
V1, Layer 2 -------->	6100.0			"V0_2	0.085
X_critical 2 -------->		137.0			0.833
Layer 2 thickness			40.5		
V2, Layer 3 -------->	13000.0			"V1_2	0.488
				k 0.704	0.601

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.8	649.6
Layer 3 ---------->	49.2	609.1





Prepared by: _____ Date: _____

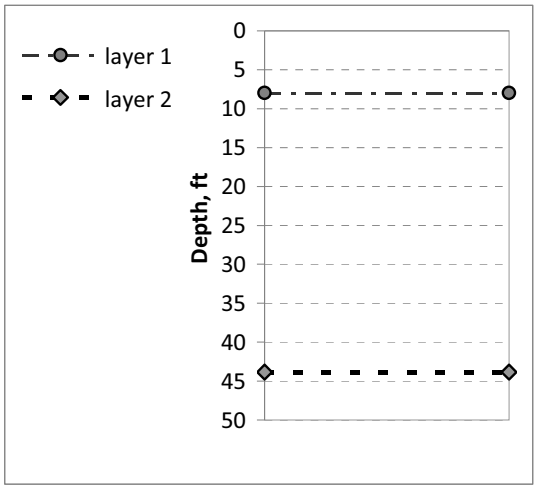
Reviewed by: _____ Date: _____

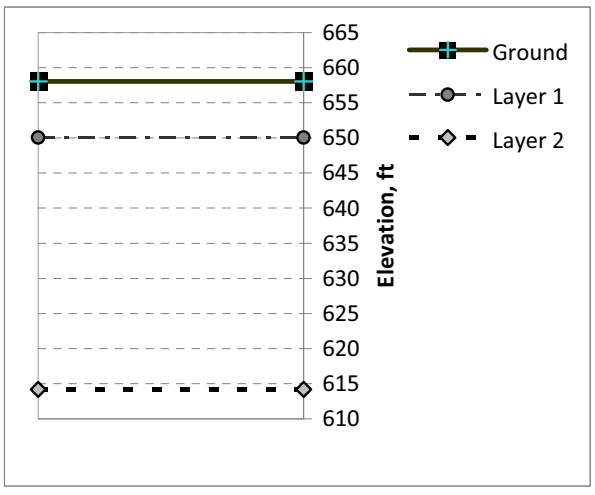
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	658.1		
NAD1983	Coordinates:	**Easting:**	2405139.4		
PA State Plane	Eastern	**Northing:**	338896.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.173
X_critical 1 ------->		19.0			
Layer 1 thickness			8.0		
V1, Layer 2 -------->	6400.0			"V0_2	0.085
X_critical 2 -------->		125.0			0.841
Layer 2 thickness			35.9		
V2, Layer 3 -------->	13000.0			"V1_2	0.515
				k 0.603	0.583

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	8.0	650.1	
Layer 3 ---------->	43.8	614.2	





Prepared by: _____ Date: _____

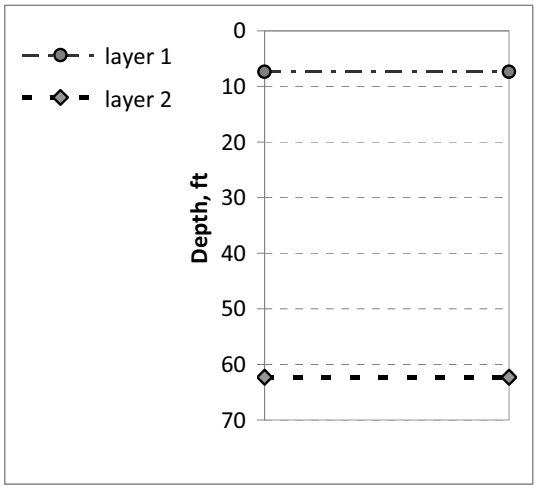
Reviewed by: _____ Date: _____

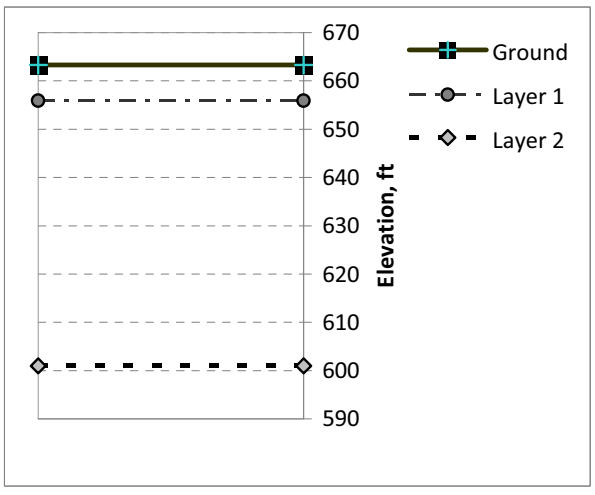
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	663.3		
NAD1983	Coordinates:	**Easting:**	2405134.0		
PA State Plane	Eastern	**Northing:**	338956.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.198
X_critical 1 ------->		18.0			
Layer 1 thickness			7.4		
V1, Layer 2 -------->	6100.0			"V0_2	0.092
X_critical 2 -------->		185.0			0.819
Layer 2 thickness			54.9		
V2, Layer 3 -------->	13000.0			"V1_2	0.488
				k 0.648	0.601

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.4	655.9
Layer 3 ---------->	62.3	601.0





Prepared by: _____ Date: _____

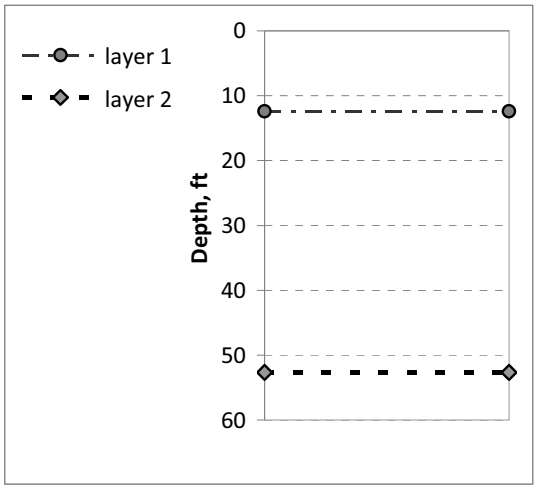
Reviewed by: _____ Date: _____

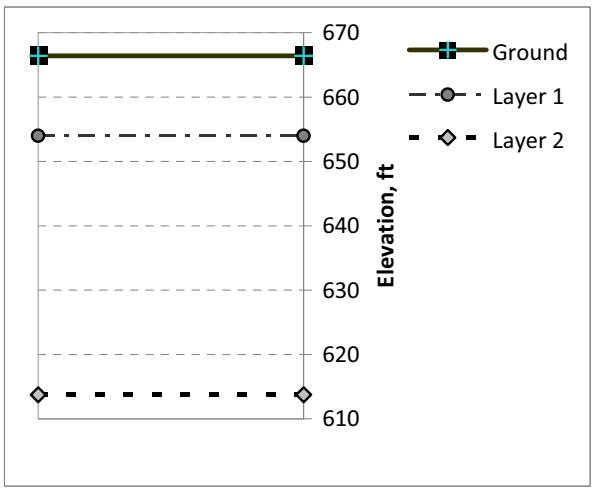
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-32		
		Elevation, ft:	666.4		
NAD1983	Coordinates:	**Easting:**	2405128.3		
PA State Plane	Eastern	**Northing:**	339020.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.154
X_critical 1 ------->		29.0			
Layer 1 thickness			12.4		
V1, Layer 2 -------->	7800.0			"V0_2	0.092
X_critical 2 -------->		164.0			0.856
Layer 2 thickness			40.2		
V2, Layer 3 -------->	13000.0			"V1_2	0.644
				k 0.770	0.500

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	12.4	654.0
Layer 3 ---------->	52.6	613.8





Prepared by: _____ Date: _____

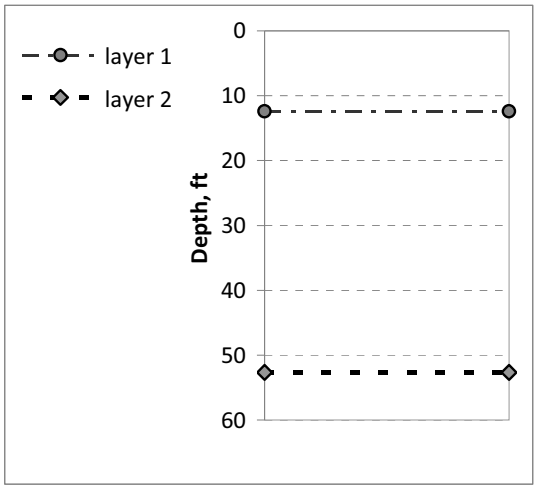
Reviewed by: _____ Date: _____

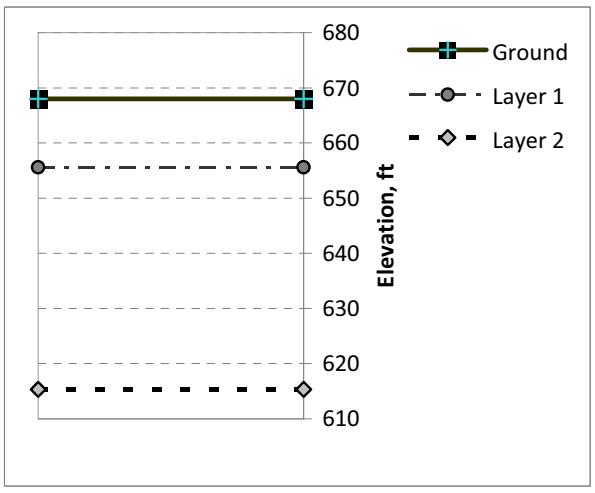
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.0		
NAD1983	Coordinates:	**Easting:**	2405123.7		
PA State Plane	Eastern	**Northing:**	339069.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.154
X_critical 1 ------->		29.0			
Layer 1 thickness			**12.4**		
V1, Layer 2 -------->	7800.0			"V0_2	0.092
X_critical 2 -------->		164.0			0.856
Layer 2 thickness			**40.2**		
V2, Layer 3 -------->	13000.0			"V1_2	0.644
				k 0.770	0.500

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ----------->	**12.4**	**655.6**
Layer 3 ----------->	**52.6**	**615.4**

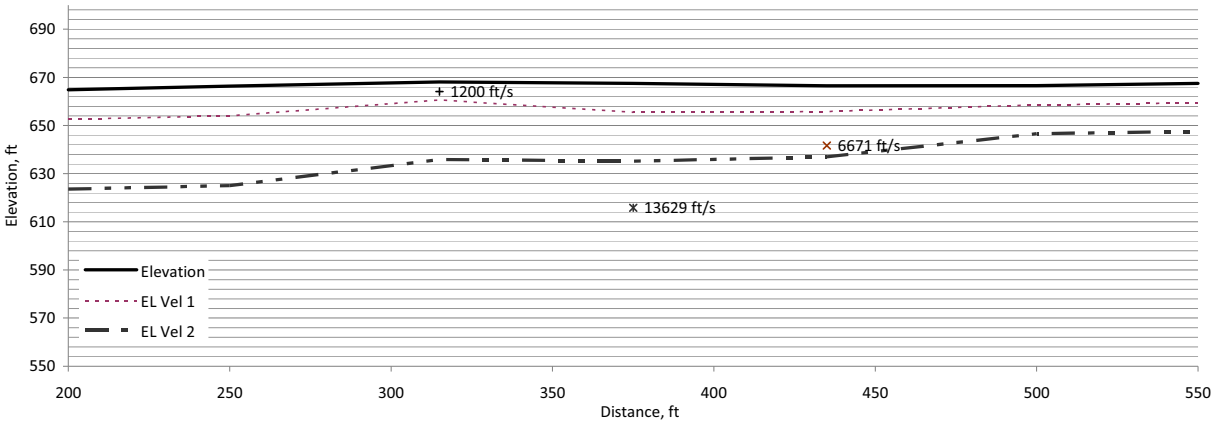




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

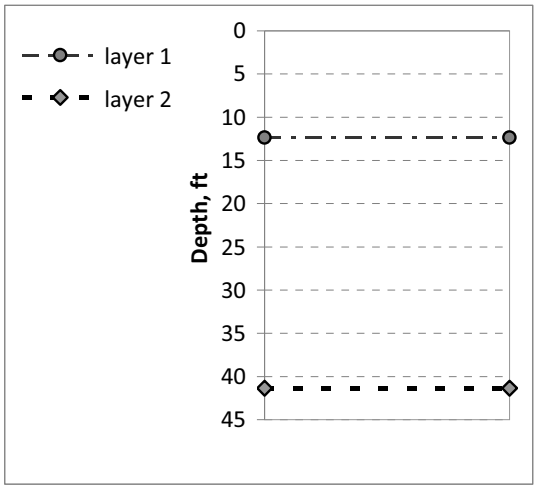
Approved by: _____ Date: _____

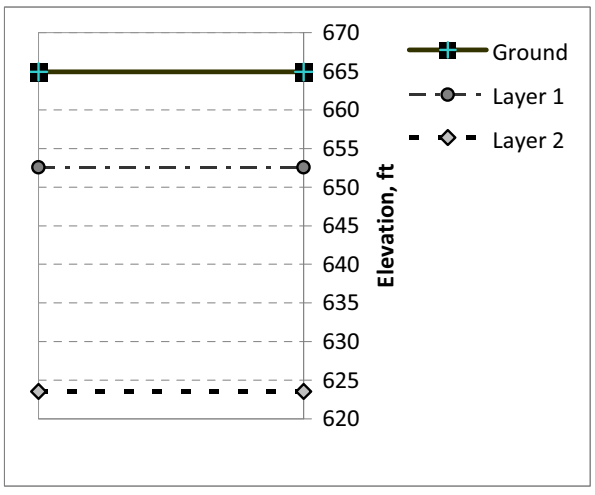

690
670
650
630
610
590
570
550
Elevation, ft
200
250
300
350
400
450
500
550
Distance, ft
1200 ft/s
6671 ft/s
13629 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	1	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	664.9		
NAD1983	Coordinates:	**Easting:**	2405132.7		
PA State Plane	Eastern	**Northing:**	338970.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.161
X_critical 1 ------->		29.0			
Layer 1 thickness			**12.3**		
V1, Layer 2 -------->	7500.0			"V0_2	0.068
X_critical 2 -------->		94.0			0.851
Layer 2 thickness			**29.0**		
V2, Layer 3 -------->	17700.0			"V1_2	0.438
				k 0.901	0.636

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**12.3**	**652.6**
Layer 3 ----------->	**41.3**	**623.6**





Prepared by: _____ Date: _____

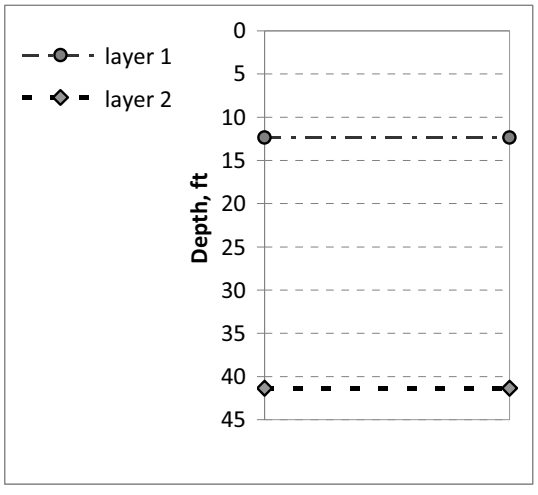
Reviewed by: _____ Date: _____

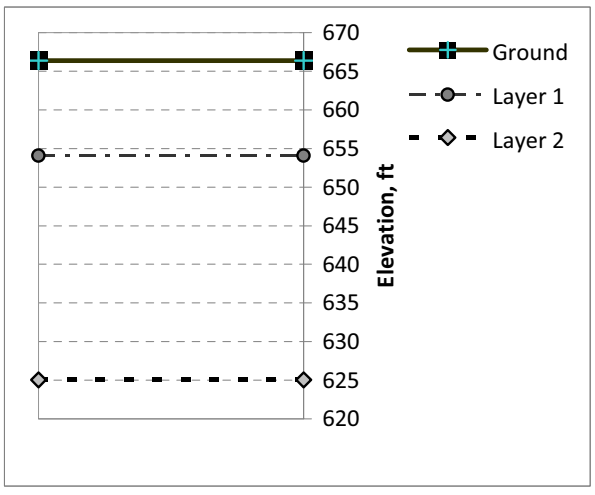
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	20		
		Elevation, ft:	666.4		
NAD1983	Coordinates:	**Easting:**	2405128.3		
PA State Plane	Eastern	**Northing:**	339020.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.161
X_critical 1 ------->		29.0			
Layer 1 thickness			12.3		
V1, Layer 2 -------->	7500.0			"V0_2	0.068
X_critical 2 -------->		94.0			0.851
Layer 2 thickness			29.0		
V2, Layer 3 -------->	17700.0			"V1_2	0.438
				k 0.901	0.636

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	12.3	654.1	
Layer 3 ---------->	41.3	625.1	





Prepared by: _____ Date: _____

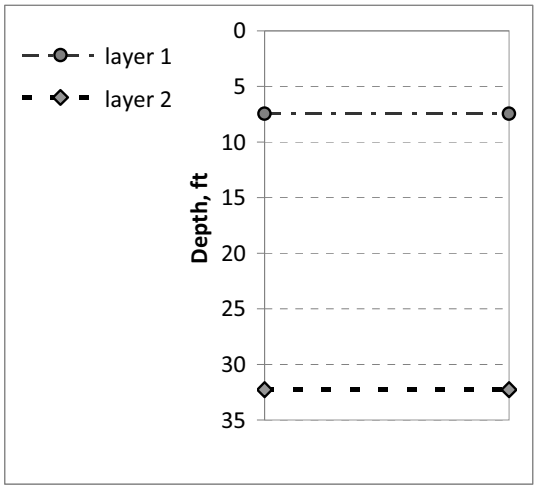
Reviewed by: _____ Date: _____

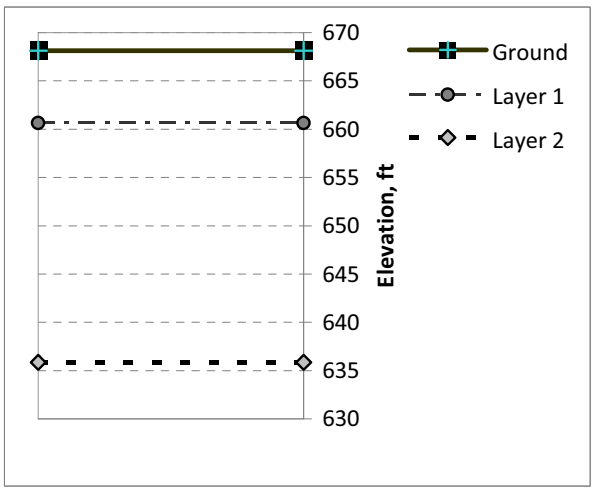
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	13		
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405122.3		
PA State Plane	Eastern	**Northing:**	339084.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.186
X_critical 1 ------->		18.0			
Layer 1 thickness			7.5		
V1, Layer 2 -------->	6500.0			"V0_2	0.068
X_critical 2 -------->		75.0			0.830
Layer 2 thickness			24.8		
V2, Layer 3 -------->	17600.0			"V1_2	0.378
				k 0.647	0.679

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.5	660.6	
Layer 3 ---------->	32.3	635.8	





Prepared by: _____ Date: _____

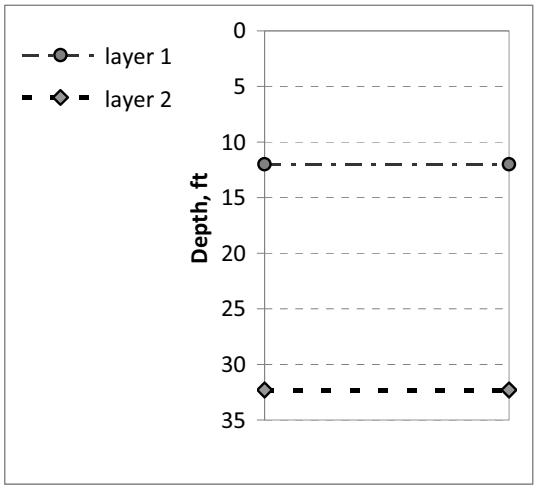
Reviewed by: _____ Date: _____

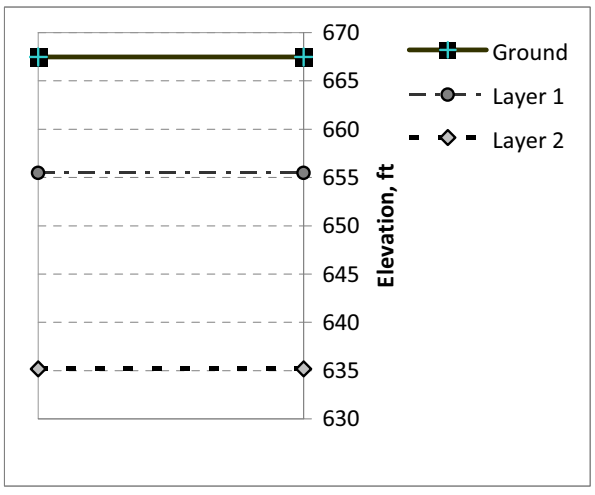
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:	-18		
		Elevation, ft:	667.5		
NAD1983	Coordinates:	**Easting:**	2405116.8		
PA State Plane	Eastern	**Northing:**	339144.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.253
X_critical 1 ------->		31.0			
Layer 1 thickness			12.0		
V1, Layer 2 -------->	5600.0			"V0_2	0.138
X_critical 2 -------->		80.0			0.775
Layer 2 thickness			20.3		
V2, Layer 3 -------->	10200.0			"V1_2	0.581
				k 1.281	0.540

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	12.0	655.5
Layer 3 ---------->	32.3	635.2





Prepared by: _____ Date: _____

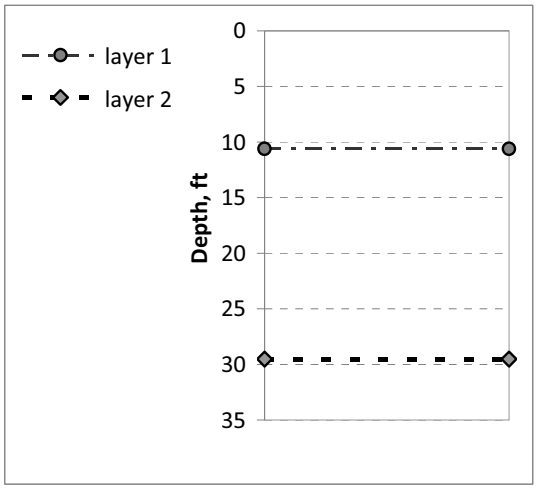
Reviewed by: _____ Date: _____

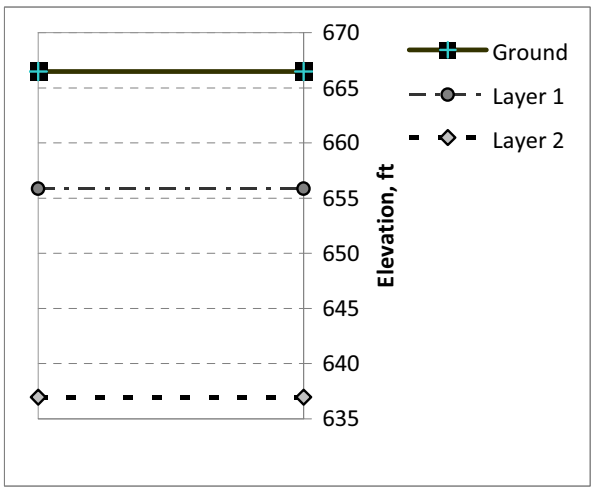
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-18		
		Elevation, ft:	666.5		
NAD1983	Coordinates:	**Easting:**	2405111.3		
PA State Plane	Eastern	**Northing:**	339204.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.201
X_critical 1 ------->		26.0			
Layer 1 thickness			10.6		
V1, Layer 2 -------->	6000.0			"V0_2	0.109
X_critical 2 -------->		73.0			0.816
Layer 2 thickness			18.9		
V2, Layer 3 -------->	11000.0			"V1_2	0.577
				k 0.901	0.542

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.6	655.9
Layer 3 ---------->	29.5	637.0





Prepared by: _____ Date: _____

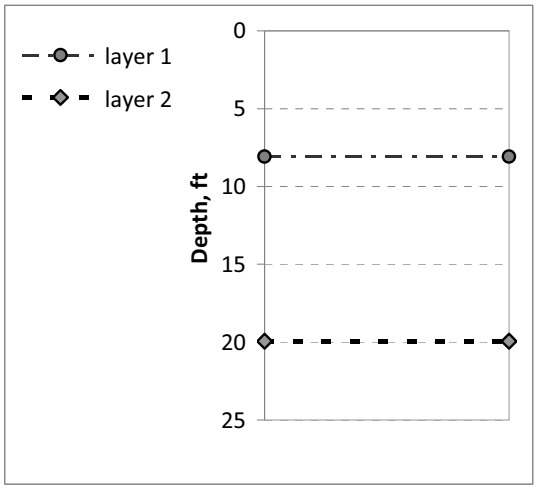
Reviewed by: _____ Date: _____

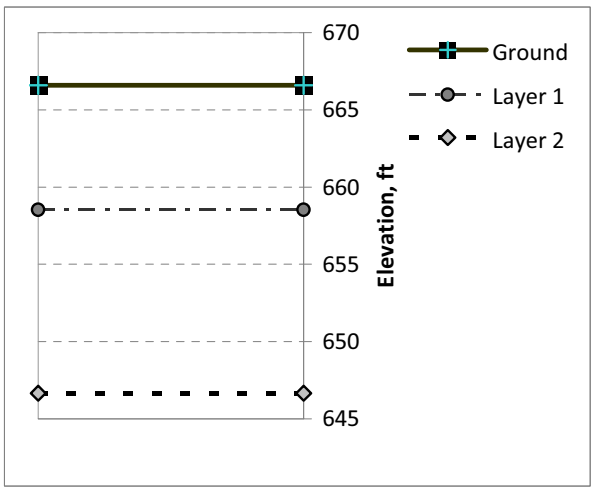
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	666.6		
NAD1983	Coordinates:	**Easting:**	2405105.3		
PA State Plane	Eastern	**Northing:**	339269.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.162
X_critical 1 ------->		19.0			
Layer 1 thickness			8.1		
V1, Layer 2 -------->	6800.0			"V0_2	0.104
X_critical 2 -------->		53.0			0.849
Layer 2 thickness			11.9		
V2, Layer 3 -------->	10600.0			"V1_2	0.696
				k 0.505	0.467

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.1	658.5
Layer 3 ---------->	19.9	646.7





Prepared by: _____ Date: _____

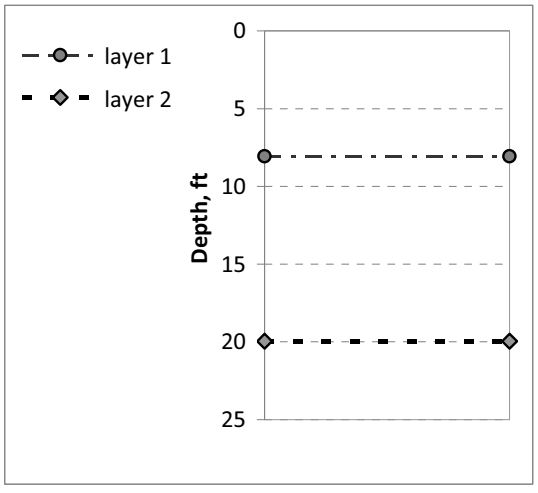
Reviewed by: _____ Date: _____

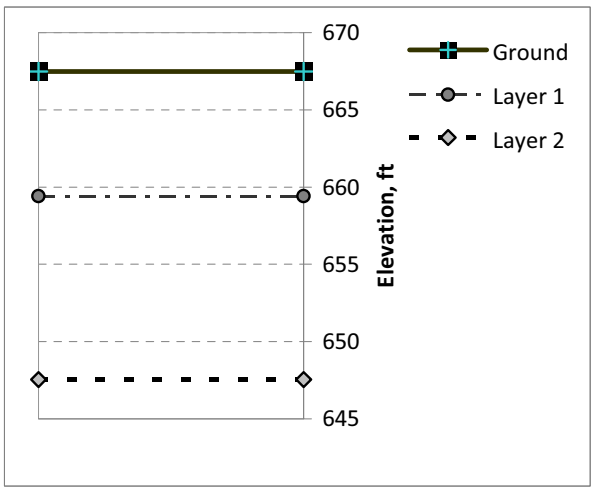
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	667.5		
NAD1983	Coordinates:	**Easting:**	2405101.0		
PA State Plane	Eastern	**Northing:**	339319.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.162
X_critical 1 ------->		19.0			
Layer 1 thickness			8.1		
V1, Layer 2 -------->	6800.0			"V0_2	0.104
X_critical 2 -------->		53.0			0.849
Layer 2 thickness			11.9		
V2, Layer 3 -------->	10600.0			"V1_2	0.696
				k 0.505	0.467

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.1	659.4
Layer 3 ---------->	19.9	647.5

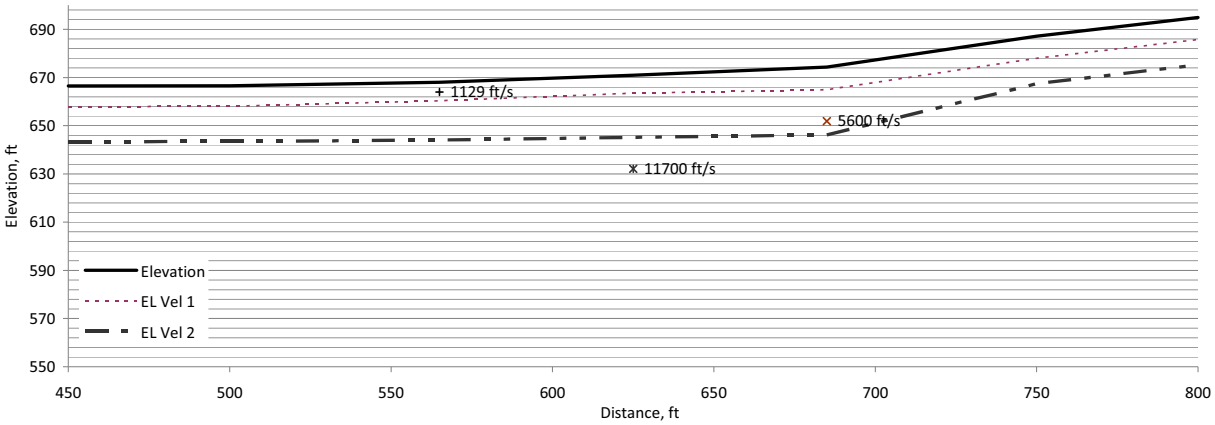




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

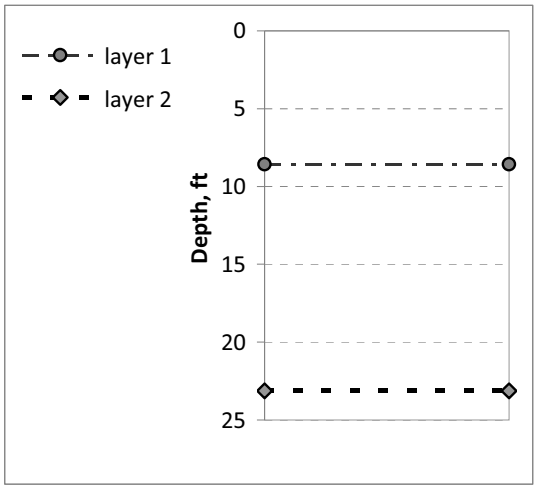
Approved by: _____ Date: _____

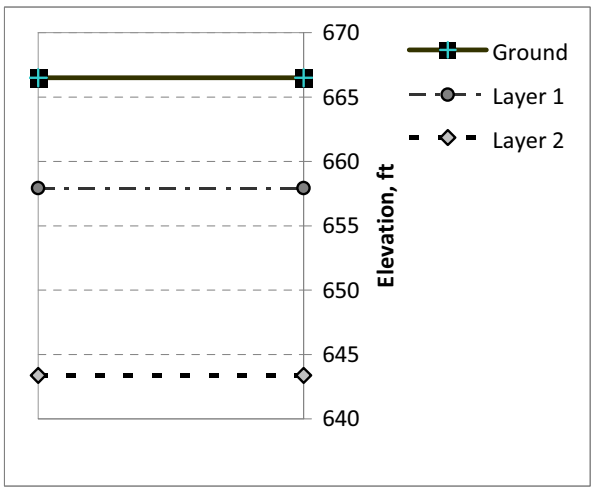

690
670
650
630
610
590
570
550
450
500
550
600
650
700
750
800
Elevation, ft
Distance, ft
1129 ft/s
5600 ft/s
11700 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	1	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	450	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	666.5		
NAD1983	Coordinates:	**Easting:**	2405109.9		
PA State Plane	Eastern	**Northing:**	339219.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.201
X_critical 1 ------->		21.0			
Layer 1 thickness			8.6		
V1, Layer 2 -------->	5500.0			"V0_2	0.100
X_critical 2 -------->		53.0			0.816
Layer 2 thickness			14.5		
V2, Layer 3 -------->	11000.0			"V1_2	0.524
				k 0.752	0.577

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.6	657.9
Layer 3 ---------->	23.1	643.4





Prepared by: _____ Date: _____

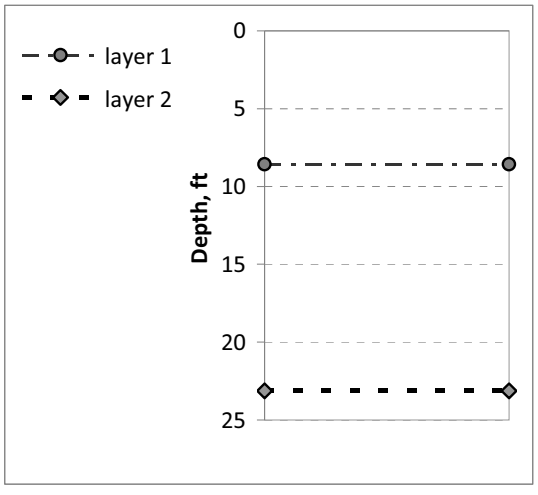
Reviewed by: _____ Date: _____

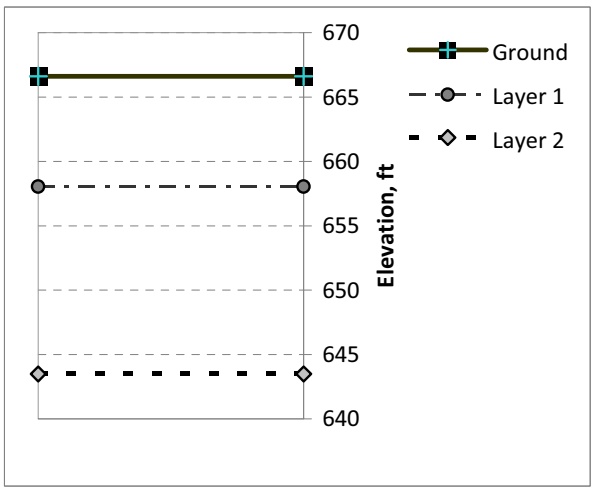
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	13		
		Elevation, ft:	666.6		
NAD1983	Coordinates:	**Easting:**	2405105.3		
PA State Plane	Eastern	**Northing:**	339269.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.201
X_critical 1 ------->		21.0			
Layer 1 thickness			8.6		
V1, Layer 2 -------->	5500.0			"V0_2	0.100
X_critical 2 -------->		53.0			0.816
Layer 2 thickness			14.5		
V2, Layer 3 -------->	11000.0			"V1_2	0.524
				k 0.752	0.577

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.6	658.0
Layer 3 ---------->	23.1	643.5





Prepared by: _____ Date: _____

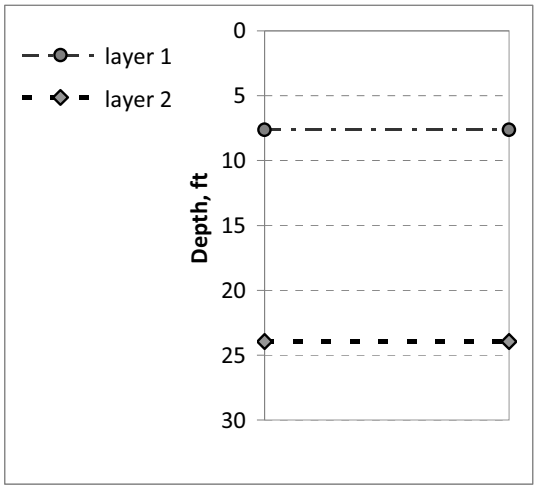
Reviewed by: _____ Date: _____

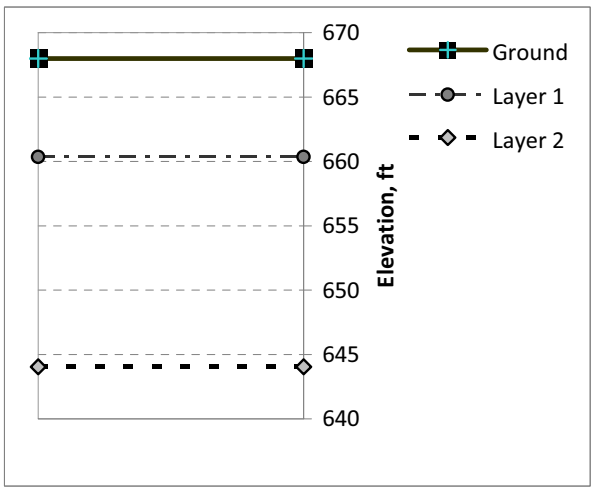
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	565	**Location:**	Berwick
		Depth Offset, ft:	14		
		Elevation, ft:	668.0		
NAD1983	Coordinates:	**Easting:**	2405099.7		
PA State Plane	Eastern	**Northing:**	339334.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		19.0			
Layer 1 thickness			7.6		
V1, Layer 2 -------->	5600.0			"V0_2	0.120
X_critical 2 -------->		64.0			0.804
Layer 2 thickness			16.3		
V2, Layer 3 -------->	10000.0			"V1_2	0.594
				k 0.689	0.531

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.6	660.3
Layer 3 ---------->	23.9	644.0





Prepared by: _____ Date: _____

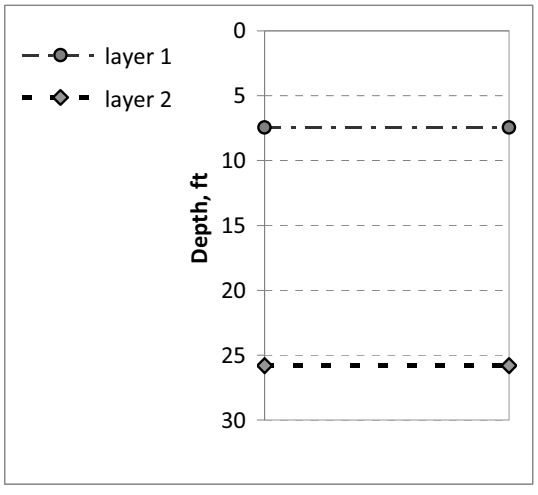
Reviewed by: _____ Date: _____

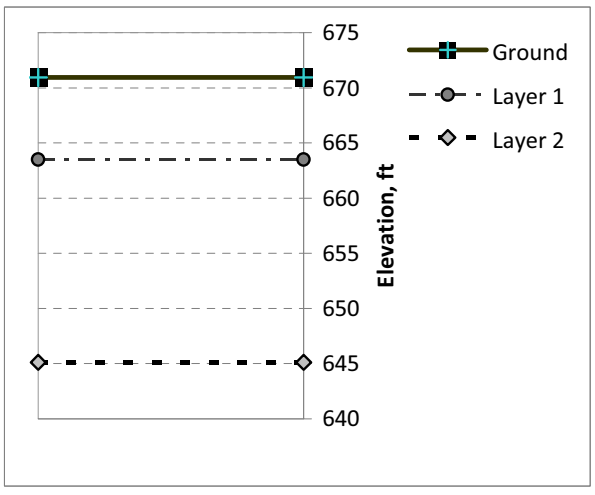
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	625	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	670.9		
NAD1983	Coordinates:	**Easting:**	2405094.5		
PA State Plane	Eastern	**Northing:**	339393.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.241
X_critical 1 ------->		19.0			
Layer 1 thickness			7.4		
V1, Layer 2 -------->	4600.0			"V0_2	0.092
X_critical 2 -------->		57.5			0.784
Layer 2 thickness			18.4		
V2, Layer 3 -------->	12000.0			"V1_2	0.393
				k 0.836	0.668

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.4	663.5	
Layer 3 ---------->	25.8	645.1	





Prepared by: _____ Date: _____

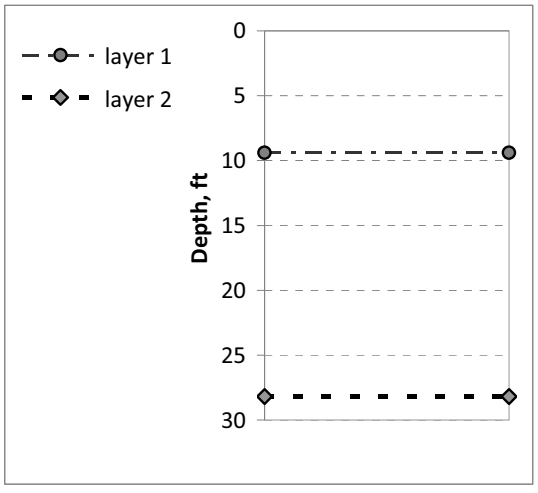
Reviewed by: _____ Date: _____

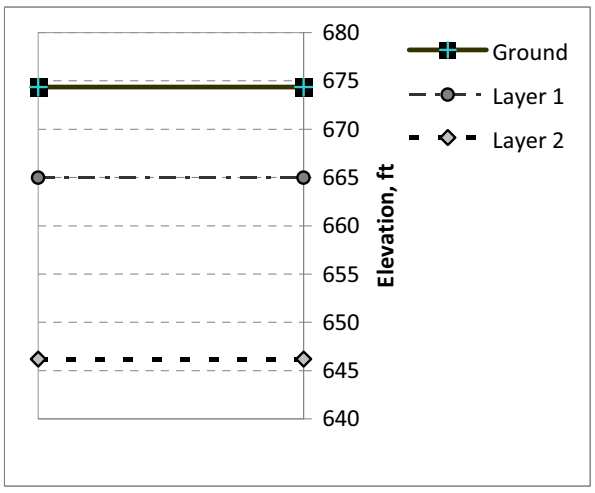
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	685	**Location:**	Berwick
		Depth Offset, ft:	-15		
		Elevation, ft:	674.4		
NAD1983	Coordinates:	**Easting:**	2405089.3		
PA State Plane	Eastern	**Northing:**	339452.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.201
X_critical 1 ------->		23.0			
Layer 1 thickness			9.4		
V1, Layer 2 -------->	6000.0			"V0_2	0.093
X_critical 2 -------->		65.0			0.816
Layer 2 thickness			18.8		
V2, Layer 3 -------->	12900.0			"V1_2	0.484
				k 0.842	0.604

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.4	665.0
Layer 3 ---------->	28.2	646.2





Prepared by: _____ Date: _____

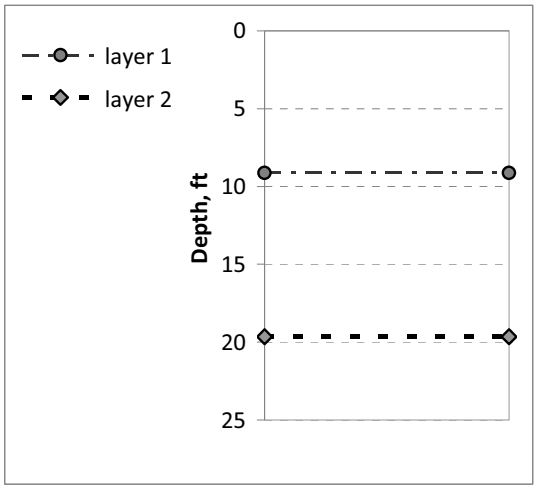
Reviewed by: _____ Date: _____

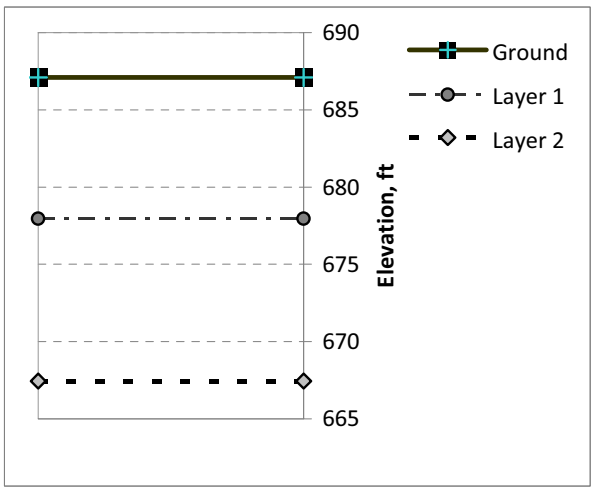
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	687.1		
NAD1983	Coordinates:	**Easting:**	2405083.7		
PA State Plane	Eastern	**Northing:**	339517.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		22.0			
Layer 1 thickness			9.1		
V1, Layer 2 -------->	6000.0			"V0_2	0.088
X_critical 2 -------->		38.0			0.831
Layer 2 thickness			10.5		
V2, Layer 3 -------->	12500.0			"V1_2	0.501
				k 0.743	0.593

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.1	678.0
Layer 3 ---------->	19.7	667.4





Prepared by: _____ Date: _____

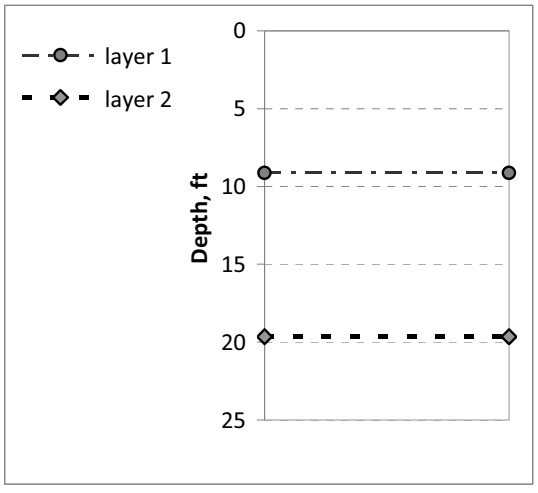
Reviewed by: _____ Date: _____

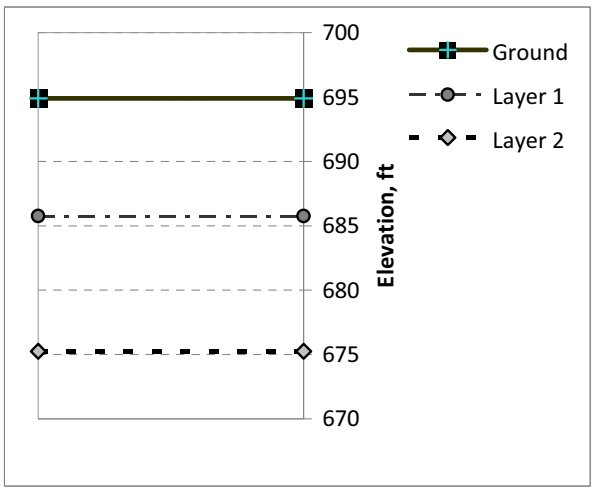
Approved by: _____ Date: _____

Line No.:	1	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	800	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	694.9		
NAD1983	Coordinates:	**Easting:**	2405079.3		
PA State Plane	Eastern	**Northing:**	339566.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		22.0			
Layer 1 thickness			9.1		
V1, Layer 2 -------->	6000.0			"V0_2	0.088
X_critical 2 -------->		38.0			0.831
Layer 2 thickness			10.5		
V2, Layer 3 -------->	12500.0			"V1_2	0.501
				k 0.743	0.593

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.1	685.8
Layer 3 ---------->	19.7	675.2

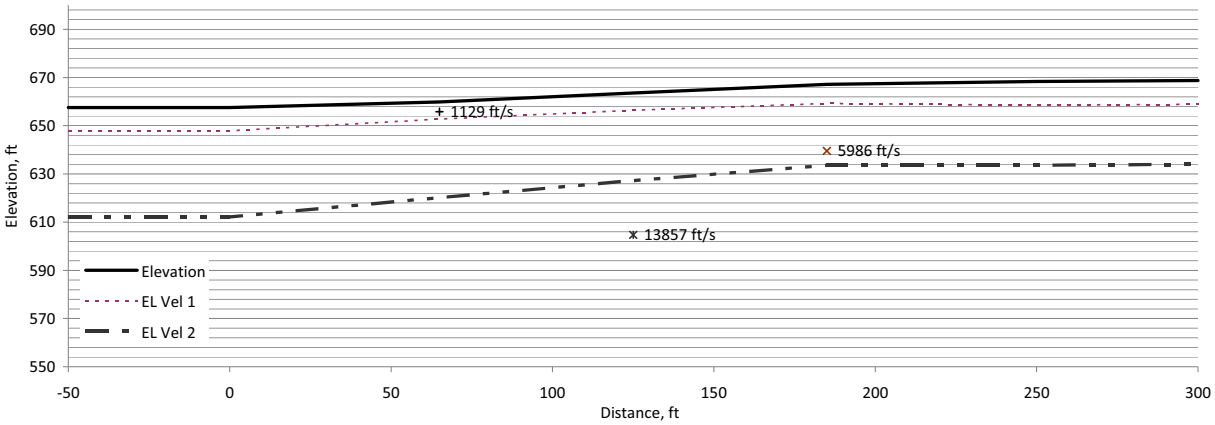




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

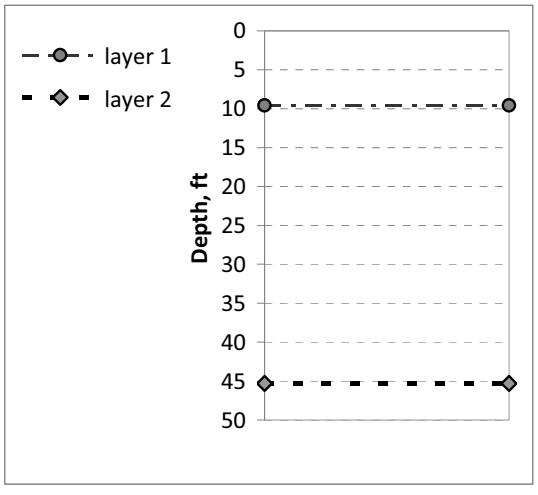
Approved by: _____ Date: _____

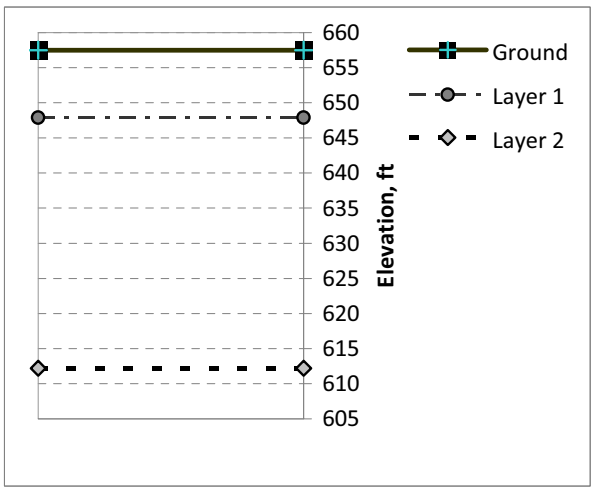

690
670
650
630
610
590
570
550
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
1129 ft/s
5986 ft/s
13857 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	2	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	657.5		
NAD1983	Coordinates:	**Easting:**	2405455.0		
PA State Plane	Eastern	**Northing:**	338929.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		23.0			
Layer 1 thickness			9.6		
V1, Layer 2 -------->	6700.0			"V0_2	0.080
X_critical 2 -------->		118.0			0.834
Layer 2 thickness			35.7		
V2, Layer 3 -------->	15000.0			"V1_2	0.463
				k 0.776	0.618

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.6	647.9
Layer 3 ---------->	45.3	612.2





Prepared by: _____ Date: _____

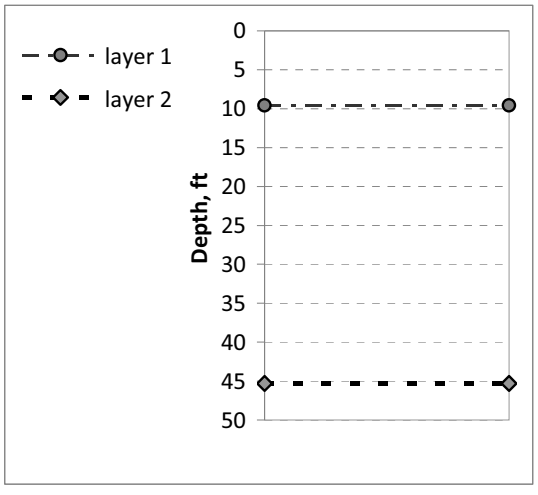
Reviewed by: _____ Date: _____

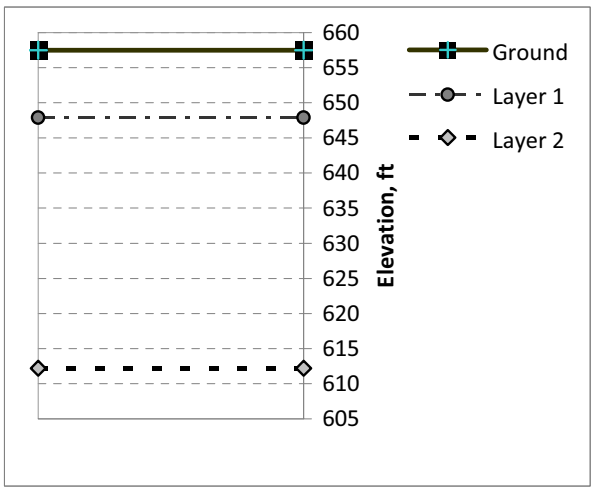
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	21		
		Elevation, ft:	657.5		
NAD1983	Coordinates:	**Easting:**	2405450.5		
PA State Plane	Eastern	**Northing:**	338979.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		23.0			
Layer 1 thickness			9.6		
V1, Layer 2 -------->	6700.0			"V0_2	0.080
X_critical 2 -------->		118.0			0.834
Layer 2 thickness			35.7		
V2, Layer 3 -------->	15000.0			"V1_2	0.463
				k 0.776	0.618

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.6	647.9
Layer 3 ---------->	45.3	612.2





Prepared by: _____ Date: _____

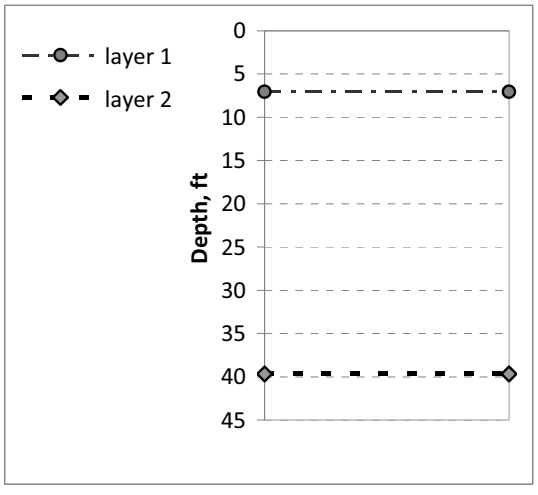
Reviewed by: _____ Date: _____

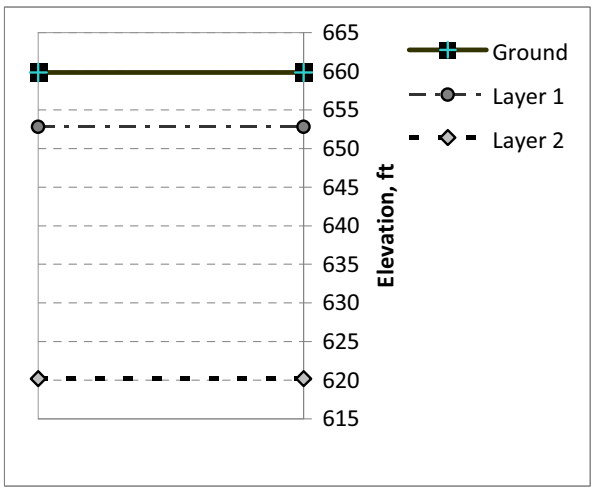
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	19		
		Elevation, ft:	659.9		
NAD1983	Coordinates:	**Easting:**	2405444.5		
PA State Plane	Eastern	**Northing:**	339043.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		17.0			
Layer 1 thickness			7.1		
V1, Layer 2 -------->	6000.0			"V0_2	0.079
X_critical 2 -------->		105.0			0.831
Layer 2 thickness			32.6		
V2, Layer 3 -------->	14000.0			"V1_2	0.443
				k 0.591	0.632

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.1	652.8
Layer 3 ---------->	39.7	620.2





Prepared by: _____ Date: _____

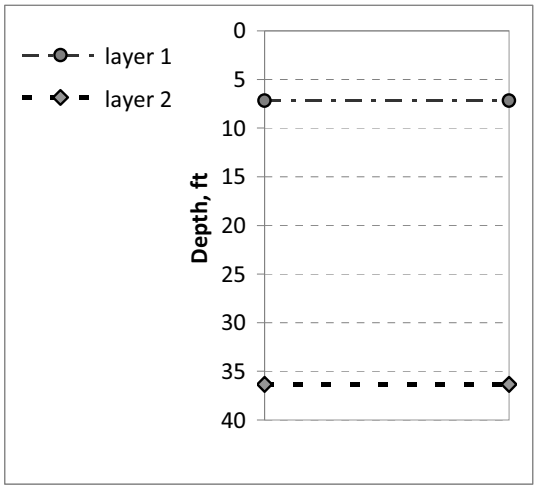
Reviewed by: _____ Date: _____

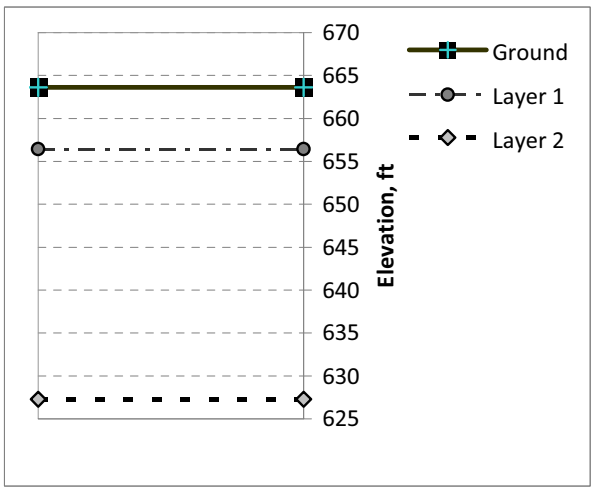
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	663.6		
NAD1983	Coordinates:	**Easting:**	2405439.1		
PA State Plane	Eastern	**Northing:**	339103.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.222
X_critical 1 ------->		18.0			
Layer 1 thickness			7.2		
V1, Layer 2 -------->	5000.0			"V0_2	0.083
X_critical 2 -------->		89.0			0.800
Layer 2 thickness			29.1		
V2, Layer 3 -------->	13200.0			"V1_2	0.388
				k 0.743	0.671

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.2	656.4	
Layer 3 ---------->	36.3	627.3	





Prepared by: _____ Date: _____

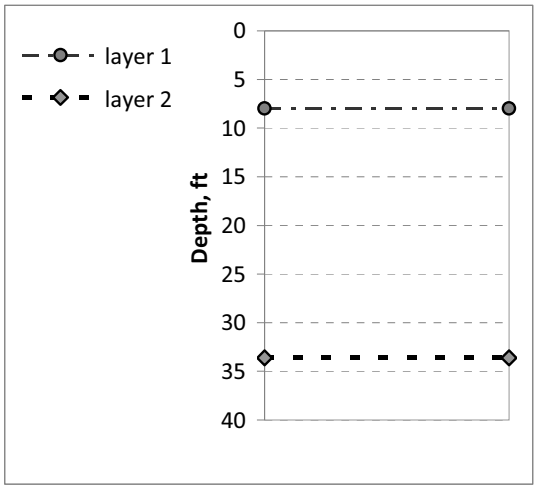
Reviewed by: _____ Date: _____

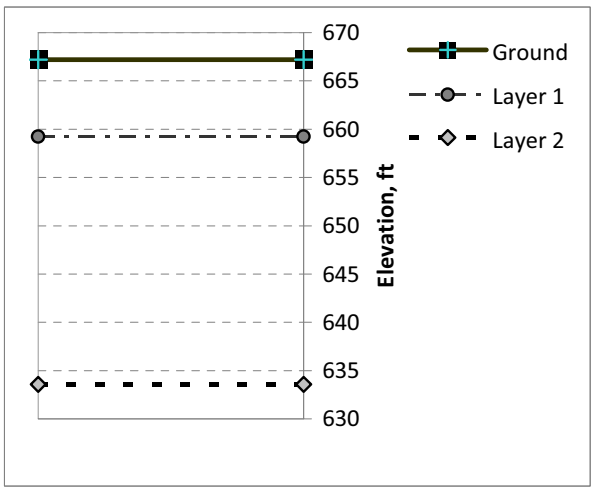
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:	-15		
		Elevation, ft:	667.2		
NAD1983	Coordinates:	**Easting:**	2405433.6		
PA State Plane	Eastern	**Northing:**	339163.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.176
X_critical 1 ------->		19.0			
Layer 1 thickness			8.0		
V1, Layer 2 -------->	6300.0			"V0_2	0.087
X_critical 2 -------->		91.0			0.838
Layer 2 thickness			25.7		
V2, Layer 3 -------->	12600.0			"V1_2	0.524
				k 0.608	0.577

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.0	659.2
Layer 3 ---------->	33.6	633.6





Prepared by: _____ Date: _____

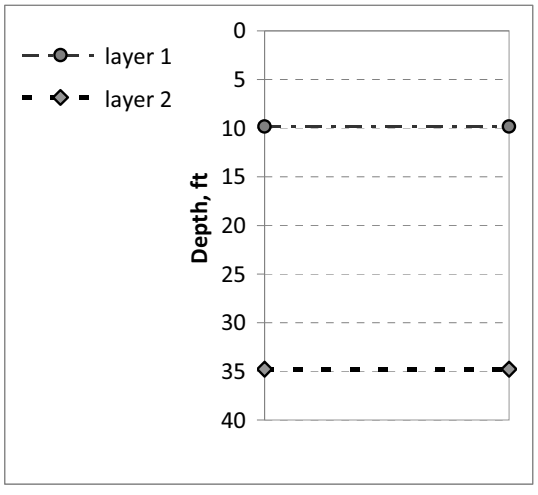
Reviewed by: _____ Date: _____

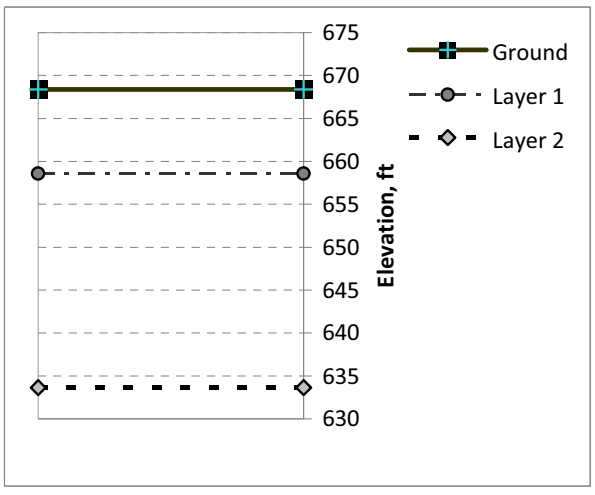
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-15		
		Elevation, ft:	668.4		
NAD1983	Coordinates:	**Easting:**	2405427.7		
PA State Plane	Eastern	**Northing:**	339227.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		24.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	5600.0			"V0_2	0.081
X_critical 2 -------->		80.0			0.820
Layer 2 thickness			24.9		
V2, Layer 3 -------->	13600.0			"V1_2	0.424
				k 0.890	0.645

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.8	658.6
Layer 3 ---------->	34.8	633.6





Prepared by: _____ Date: _____

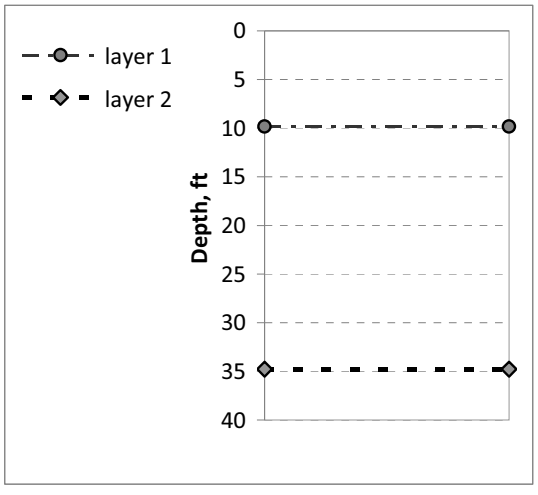
Reviewed by: _____ Date: _____

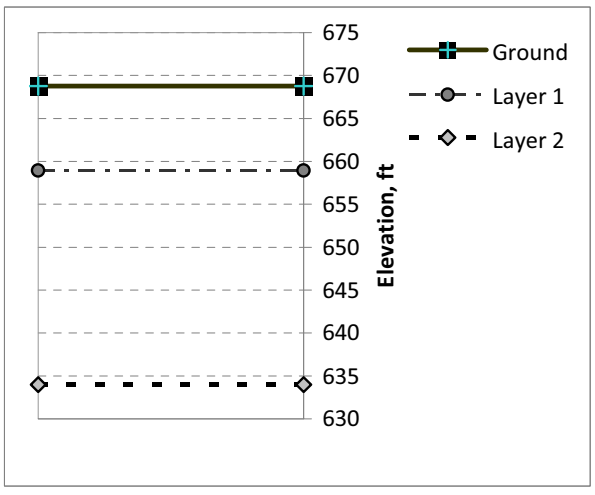
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	300	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.8		
NAD1983	Coordinates:	**Easting:**	2405423.1		
PA State Plane	Eastern	**Northing:**	339277.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		24.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	5600.0			"V0_2	0.081
X_critical 2 -------->		80.0			0.820
Layer 2 thickness			24.9		
V2, Layer 3 -------->	13600.0			"V1_2	0.424
				k 0.890	0.645

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.8	658.9
Layer 3 ---------->	34.8	634.0

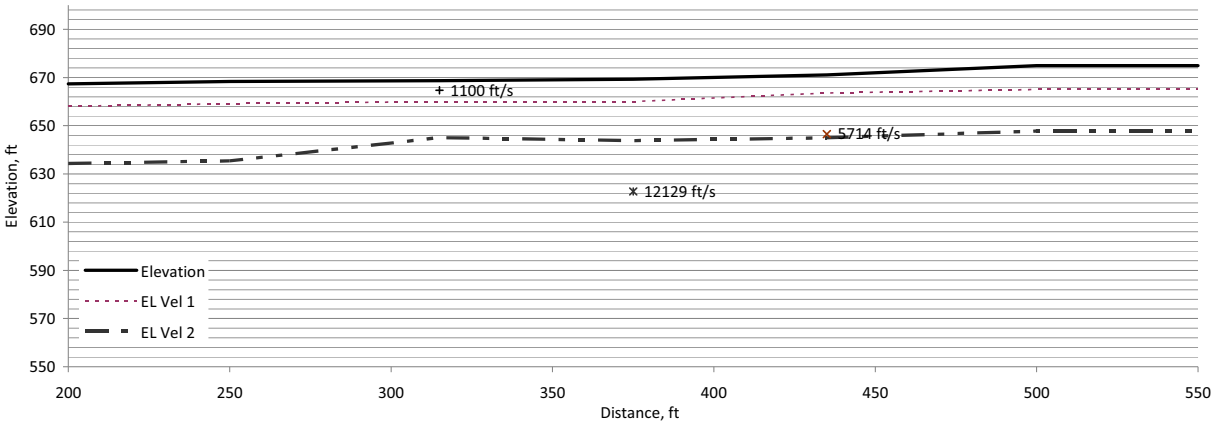




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

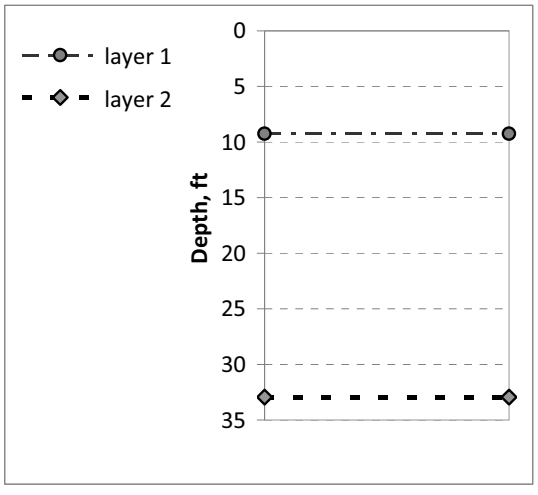
Approved by: _____ Date: _____

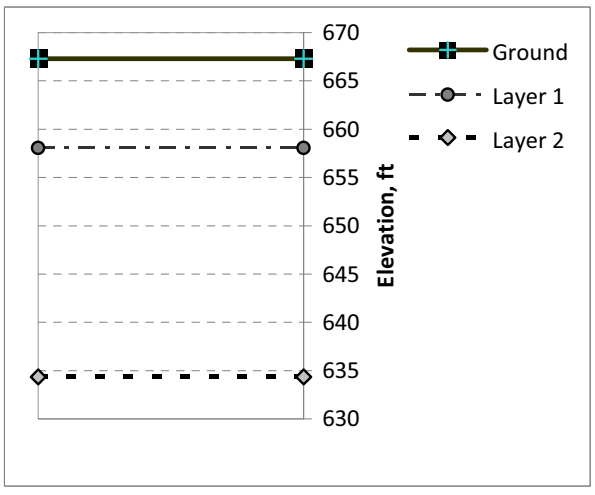

690
670
650
630
610
590
570
550
Elevation, ft
200
250
300
350
400
450
500
550
Distance, ft
1100 ft/s
5714 ft/s
12129 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	2	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	667.3		
NAD1983	Coordinates:	**Easting:**	2405432.3		
PA State Plane	Eastern	**Northing:**	339177.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.173
X_critical 1 ------->		22.0			
Layer 1 thickness			9.2		
V1, Layer 2 -------->	6400.0			"V0_2	0.079
X_critical 2 -------->		80.0			0.841
Layer 2 thickness			23.7		
V2, Layer 3 -------->	14000.0			"V1_2	0.475
				k 0.713	0.610

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.2	658.1
Layer 3 ---------->	32.9	634.4





Prepared by: _____ Date: _____

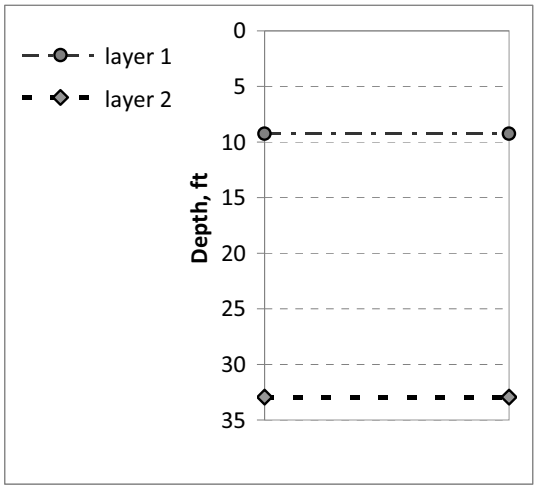
Reviewed by: _____ Date: _____

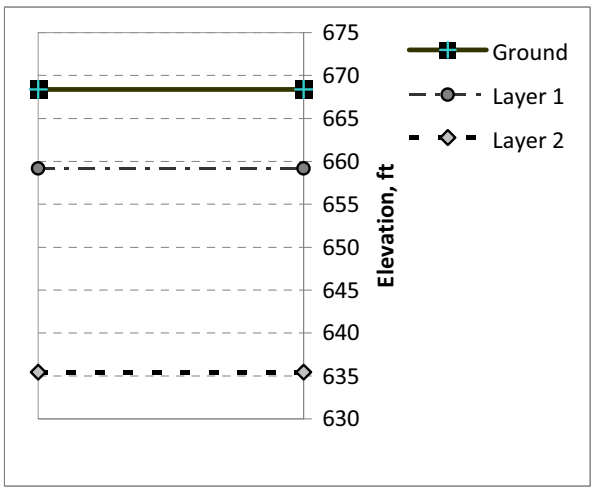
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	15		
		Elevation, ft:	668.4		
NAD1983	Coordinates:	**Easting:**	2405427.7		
PA State Plane	Eastern	**Northing:**	339227.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.173
X_critical 1 ------->		22.0			
Layer 1 thickness			9.2		
V1, Layer 2 -------->	6400.0			"V0_2	0.079
X_critical 2 -------->		80.0			0.841
Layer 2 thickness			23.7		
V2, Layer 3 -------->	14000.0			"V1_2	0.475
				k 0.713	0.610

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	9.2	659.2	
Layer 3 ---------->	32.9	635.5	





Prepared by: _____ Date: _____

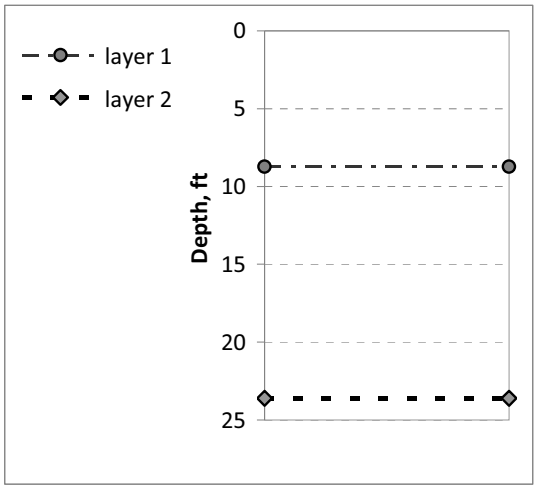
Reviewed by: _____ Date: _____

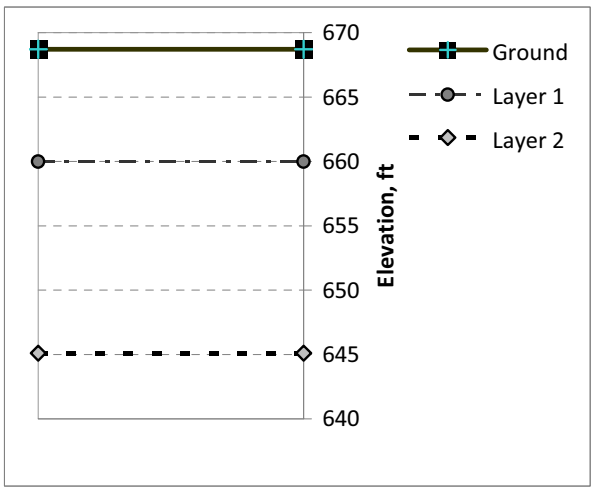
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	15		
		Elevation, ft:	668.7		
NAD1983	Coordinates:	**Easting:**	2405421.7		
PA State Plane	Eastern	**Northing:**	339291.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		21.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	6000.0			"V0_2	0.106
X_critical 2 -------->		60.0			0.831
Layer 2 thickness			14.9		
V2, Layer 3 -------->	10400.0			"V1_2	0.615
				k 0.661	0.518

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.7	660.0
Layer 3 ---------->	23.6	645.1





Prepared by: _____ Date: _____

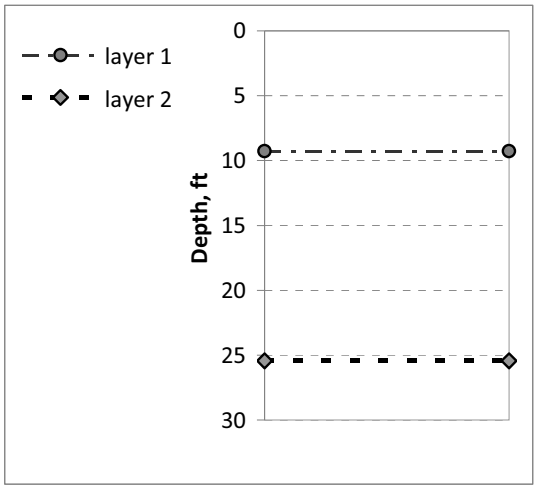
Reviewed by: _____ Date: _____

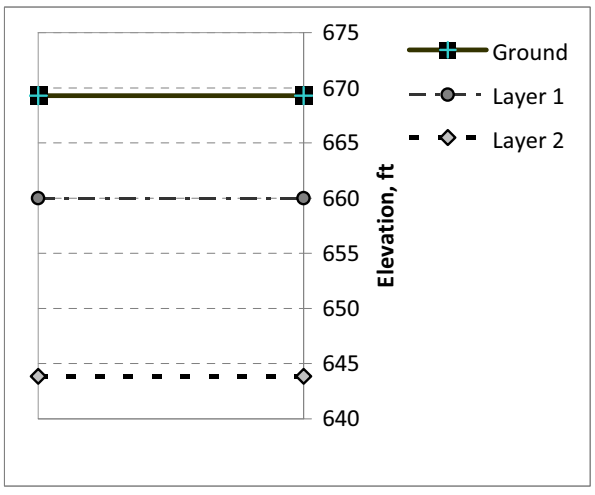
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	669.3		
NAD1983	Coordinates:	**Easting:**	2405416.0		
PA State Plane	Eastern	**Northing:**	339351.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		23.0			
Layer 1 thickness			9.3		
V1, Layer 2 -------->	5200.0			"V0_2	0.096
X_critical 2 -------->		55.5			0.807
Layer 2 thickness			16.2		
V2, Layer 3 -------->	11500.0			"V1_2	0.469
				k 0.887	0.614

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.3	660.0
Layer 3 ---------->	25.4	643.8





Prepared by: _____ Date: _____

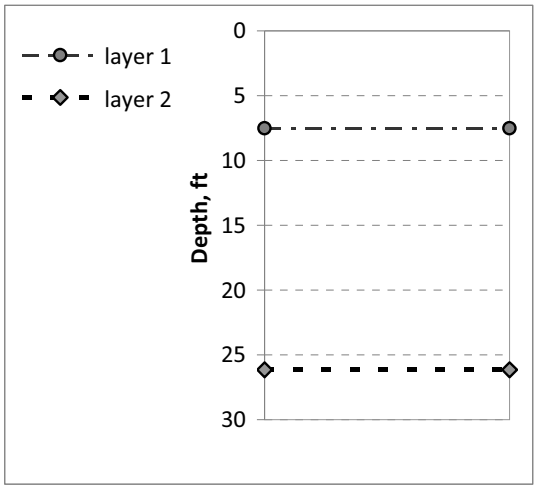
Reviewed by: _____ Date: _____

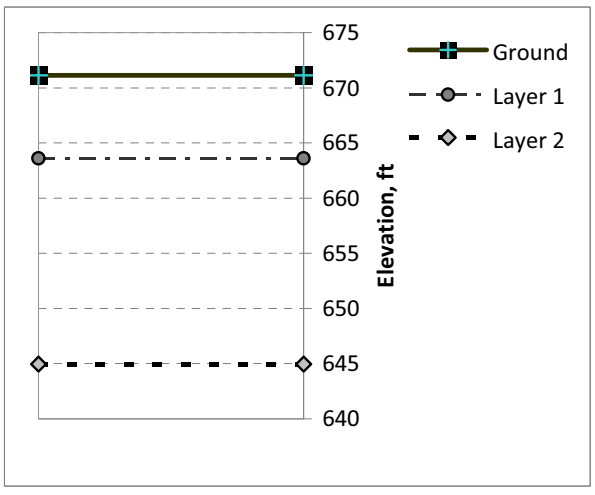
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-12		
		Elevation, ft:	671.1		
NAD1983	Coordinates:	**Easting:**	2405410.4		
PA State Plane	Eastern	**Northing:**	339410.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.231
X_critical 1 ------->		19.0			
Layer 1 thickness			7.5		
V1, Layer 2 -------->	4800.0			"V0_2	0.100
X_critical 2 -------->		62.0			0.792
Layer 2 thickness			18.6		
V2, Layer 3 -------->	11000.0			"V1_2	0.452
				k 0.788	0.626

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.5	663.6
Layer 3 ---------->	26.2	645.0





Prepared by: _____ Date: _____

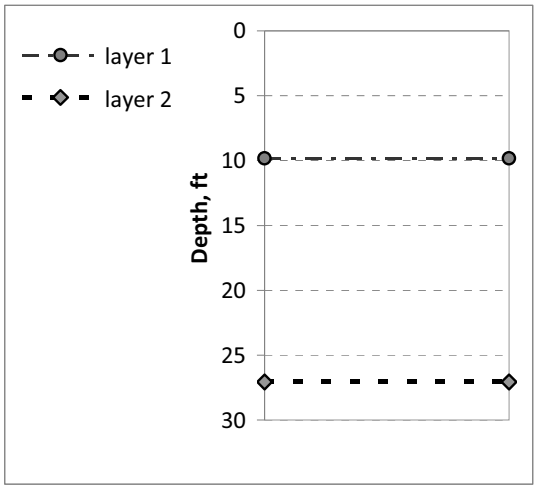
Reviewed by: _____ Date: _____

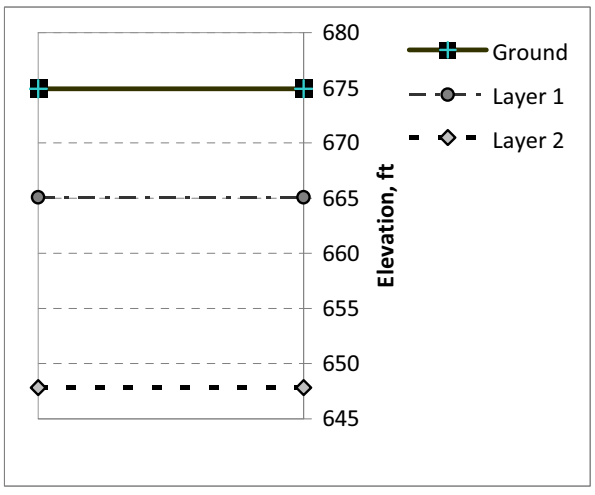
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	674.9		
NAD1983	Coordinates:	**Easting:**	2405404.3		
PA State Plane	Eastern	**Northing:**	339475.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		24.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	5600.0			"V0_2	0.092
X_critical 2 -------->		60.0			0.820
Layer 2 thickness			17.2		
V2, Layer 3 -------->	12000.0			"V1_2	0.486
				k 0.865	0.603

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.8	665.1
Layer 3 ---------->	27.1	647.8





Prepared by: _____ Date: _____

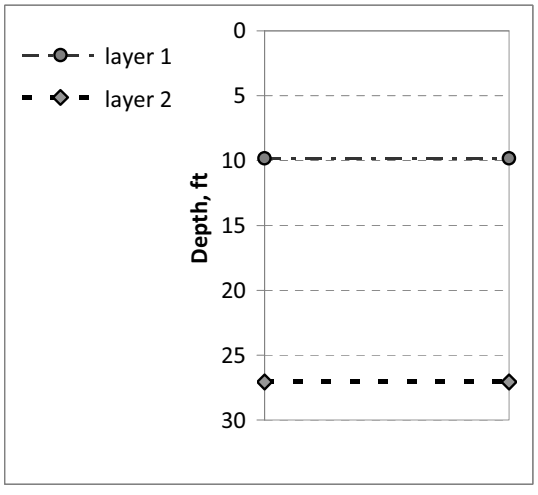
Reviewed by: _____ Date: _____

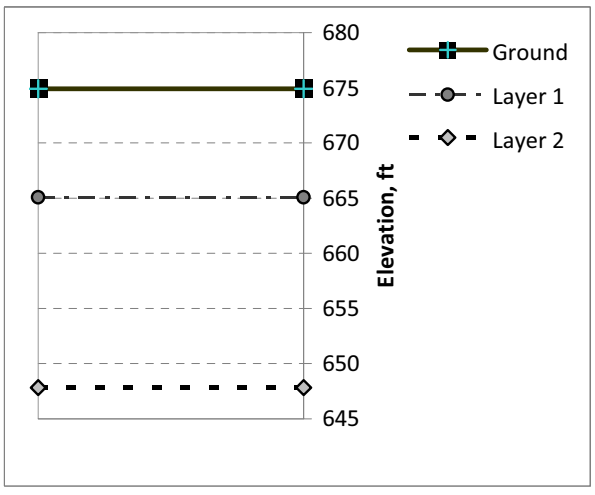
Approved by: _____ Date: _____

Line No.:	2	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	674.9		
NAD1983	Coordinates:	**Easting:**	2405404.3		
PA State Plane	Eastern	**Northing:**	339475.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		24.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	5600.0			"V0_2	0.092
X_critical 2 -------->		60.0			0.820
Layer 2 thickness			17.2		
V2, Layer 3 -------->	12000.0			"V1_2	0.486
				k 0.865	0.603

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.8	665.1
Layer 3 ---------->	27.1	647.8

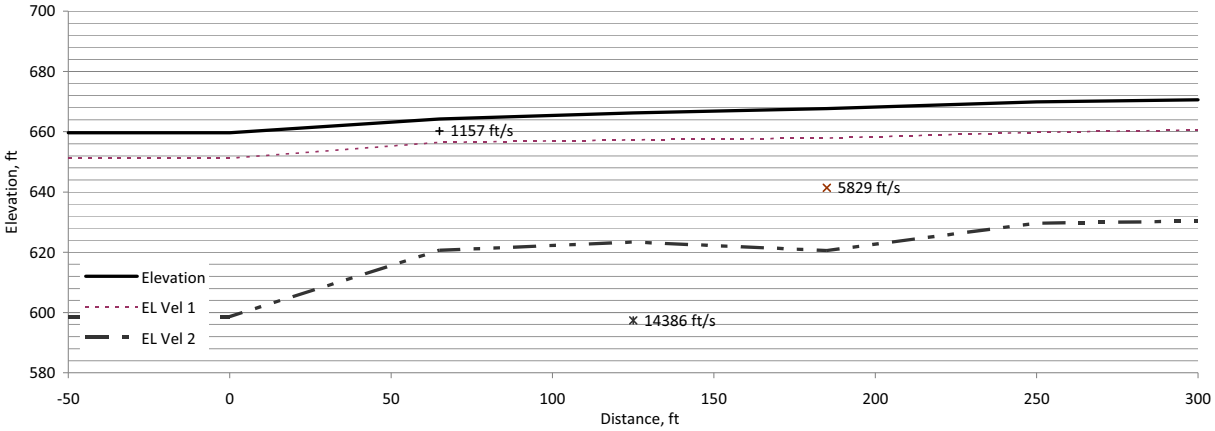




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

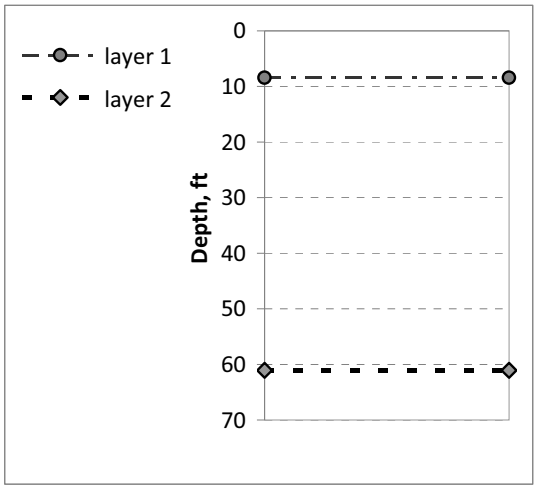
Approved by: _____ Date: _____

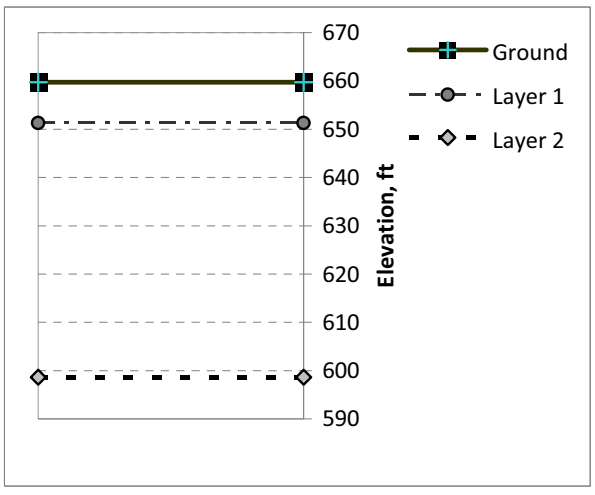

700
680
660
640
620
600
580
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
Elevation
EL Vel 1
EL Vel 2
1157 ft/s
5829 ft/s
14386 ft/s

Line No.:	3	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	659.7		
NAD1983	Coordinates:	**Easting:**	2405826.8		
PA State Plane	Eastern	**Northing:**	338976.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		21.0			
Layer 1 thickness			8.4		
V1, Layer 2 -------->	5600.0			"V0_2	0.065
X_critical 2 -------->		146.0			0.804
Layer 2 thickness			52.6		
V2, Layer 3 -------->	18600.0			"V1_2	0.306
				k 0.874	0.733

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.4	651.3
Layer 3 ---------->	61.1	598.6





Prepared by: _____ Date: _____

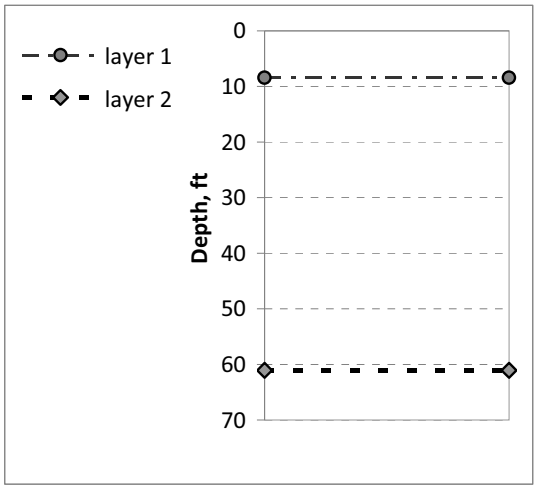
Reviewed by: _____ Date: _____

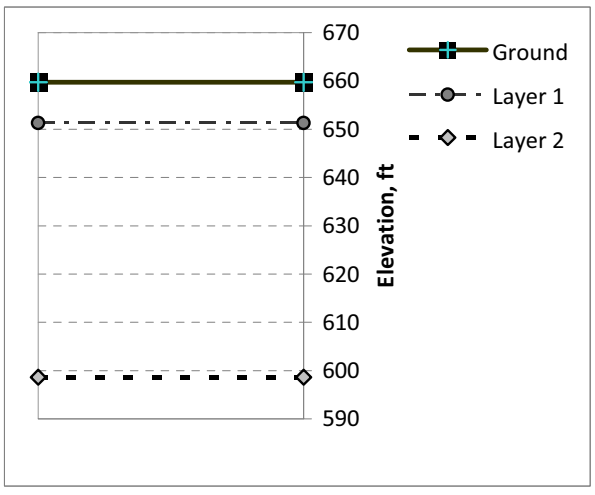
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	20		
		Elevation, ft:	659.7		
NAD1983	Coordinates:	**Easting:**	2405822.3		
PA State Plane	Eastern	**Northing:**	339026.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		21.0			
Layer 1 thickness			8.4		
V1, Layer 2 -------->	5600.0			"V0_2	0.065
X_critical 2 -------->		146.0			0.804
Layer 2 thickness			52.6		
V2, Layer 3 -------->	18600.0			"V1_2	0.306
				k 0.874	0.733

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.4	651.3
Layer 3 ---------->	61.1	598.6





Prepared by: _____ Date: _____

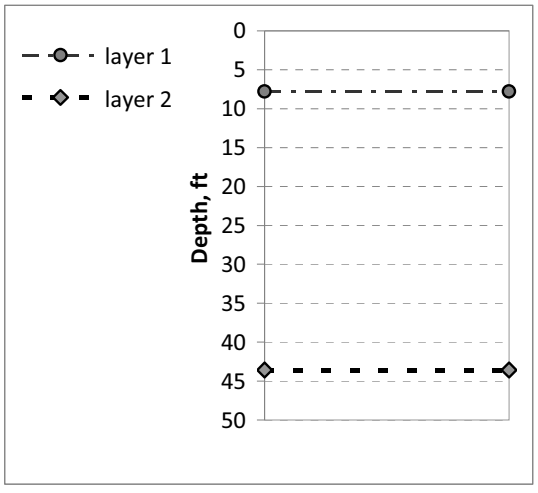
Reviewed by: _____ Date: _____

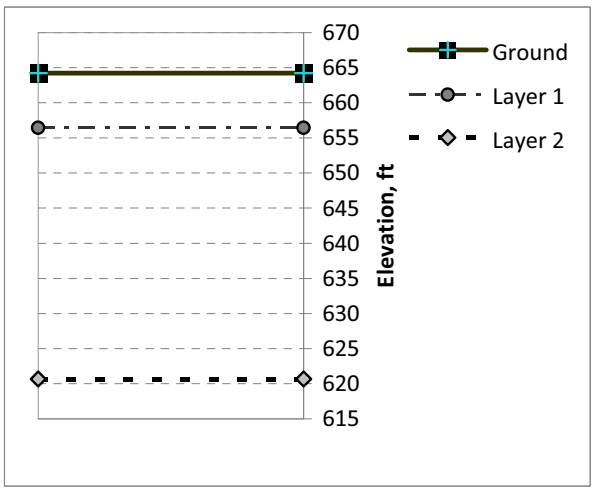
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	21		
		Elevation, ft:	664.3		
NAD1983	Coordinates:	**Easting:**	2405816.5		
PA State Plane	Eastern	**Northing:**	339090.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		19.0			
Layer 1 thickness			**7.8**		
V1, Layer 2 -------->	5600.0			"V0_2	0.092
X_critical 2 -------->		121.0			0.820
Layer 2 thickness			**35.8**		
V2, Layer 3 -------->	12000.0			"V1_2	0.486
				k 0.684	0.603

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ----------->	**7.8**	**656.5**
Layer 3 ----------->	**43.6**	**620.7**





Prepared by: _____ Date: _____

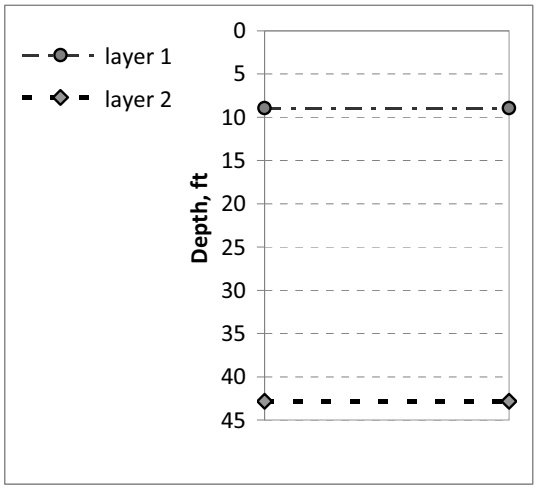
Reviewed by: _____ Date: _____

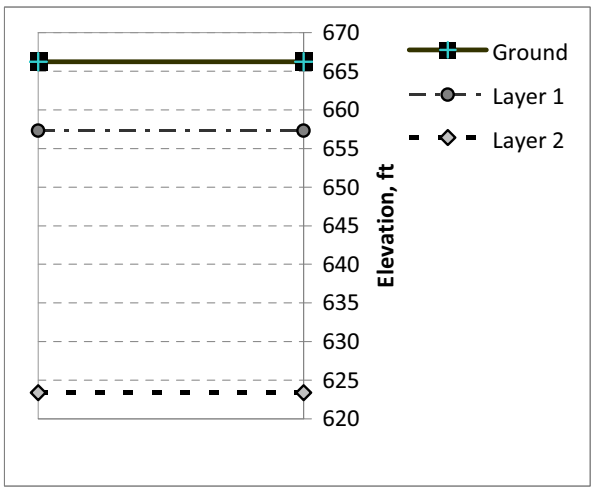
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	666.2		
NAD1983	Coordinates:	**Easting:**	2405811.1		
PA State Plane	Eastern	**Northing:**	339149.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		21.5			
Layer 1 thickness			8.9		
V1, Layer 2 -------->	6000.0			"V0_2	0.097
X_critical 2 -------->		125.0			0.831
Layer 2 thickness			33.9		
V2, Layer 3 -------->	11300.0			"V1_2	0.560
				k 0.701	0.553

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	8.9	657.3	
Layer 3 ---------->	42.8	623.4	





Prepared by: _____ Date: _____

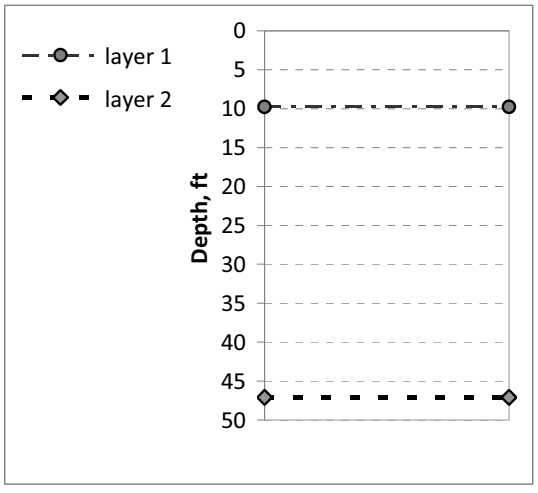
Reviewed by: _____ Date: _____

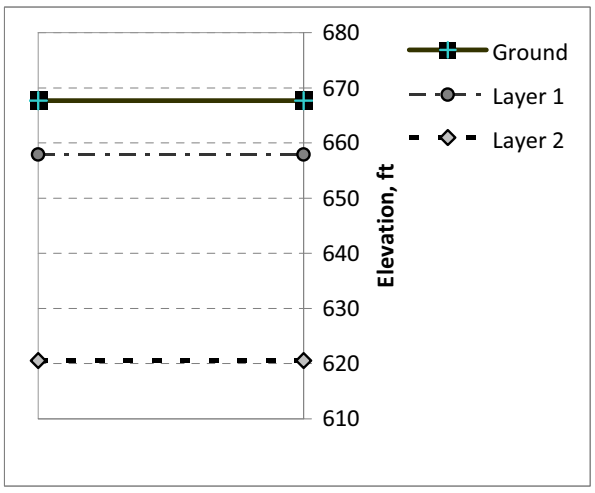
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:	-26		
		Elevation, ft:	667.7		
NAD1983	Coordinates:	**Easting:**	2405805.7		
PA State Plane	Eastern	**Northing:**	339209.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.162
X_critical 1 ------->		23.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	6800.0			"V0_2	0.087
X_critical 2 -------->		139.0			0.849
Layer 2 thickness			37.3		
V2, Layer 3 -------->	12600.0			"V1_2	0.570
				k 0.671	0.547

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	9.8	657.9	
Layer 3 ---------->	47.1	620.6	





Prepared by: _____ Date: _____

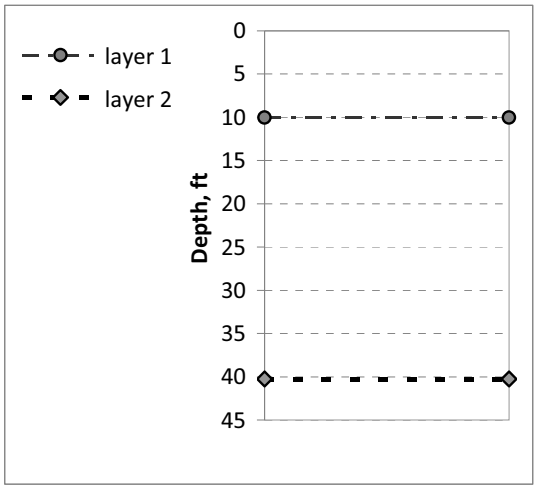
Reviewed by: _____ Date: _____

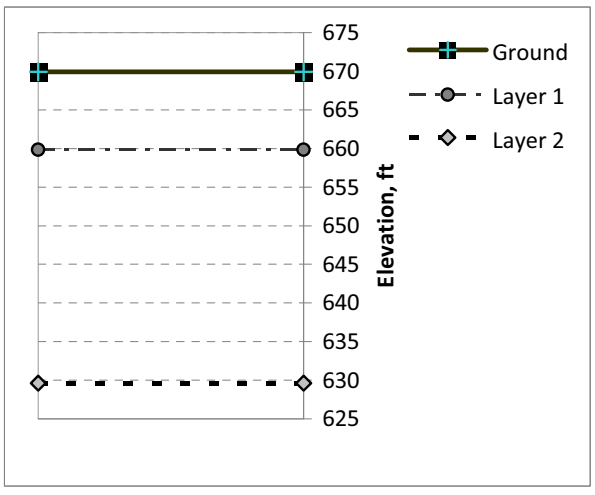
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-18		
		Elevation, ft:	669.9		
NAD1983	Coordinates:	**Easting:**	2405799.9		
PA State Plane	Eastern	**Northing:**	339273.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		25.0			
Layer 1 thickness			10.1		
V1, Layer 2 -------->	5600.0			"V0_2	0.087
X_critical 2 -------->		96.0			0.804
Layer 2 thickness			30.2		
V2, Layer 3 -------->	13800.0			"V1_2	0.418
				k 0.998	0.650

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.1	659.8
Layer 3 ---------->	40.3	629.6





Prepared by: _____ Date: _____

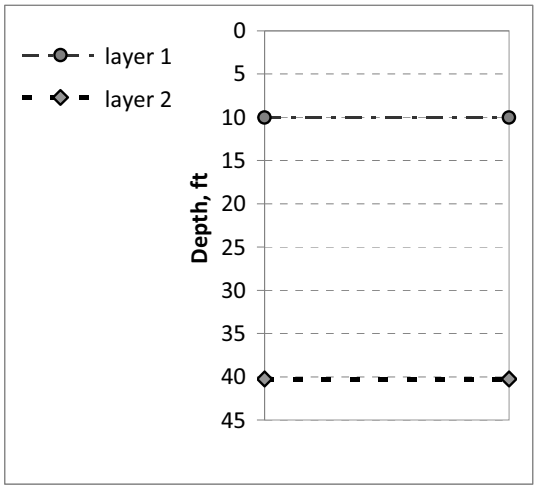
Reviewed by: _____ Date: _____

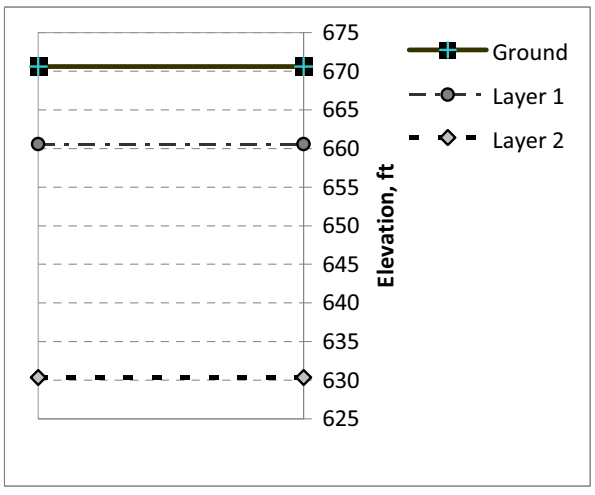
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	300	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	670.6		
NAD1983	Coordinates:	**Easting:**	2405795.3		
PA State Plane	Eastern	**Northing:**	339323.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		25.0			
Layer 1 thickness			**10.1**		
V1, Layer 2 -------->	5600.0			"V0_2	0.087
X_critical 2 -------->		96.0			0.804
Layer 2 thickness			**30.2**		
V2, Layer 3 -------->	13800.0			"V1_2	0.418
				k 0.998	0.650

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**10.1**	**660.6**
Layer 3 ---------->	**40.3**	**630.3**

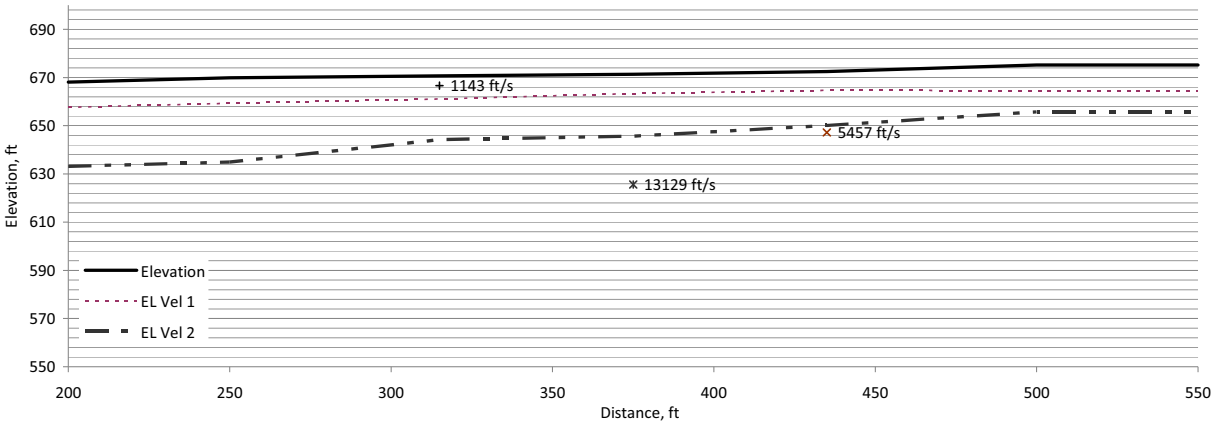




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

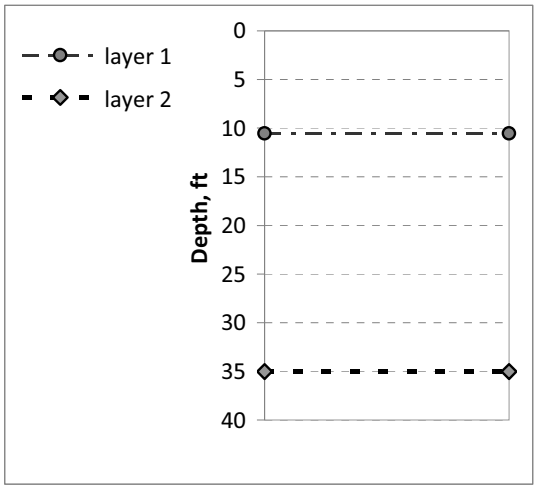
Approved by: _____ Date: _____

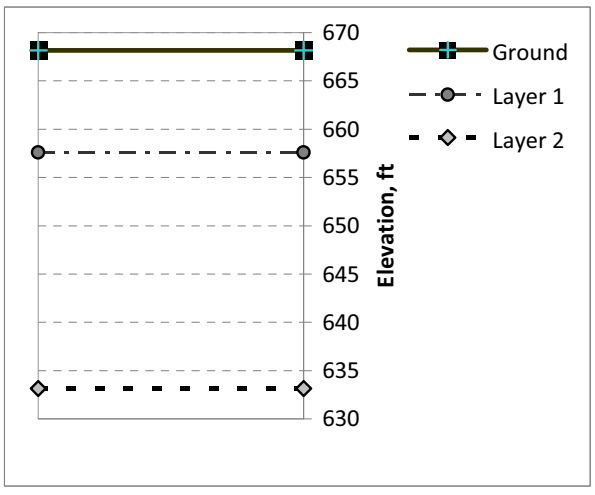

690
670
650
630
610
590
570
550
200
250
300
350
400
450
500
550
Elevation, ft
Distance, ft
1143 ft/s
5457 ft/s
13129 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	3	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405804.4		
PA State Plane	Eastern	**Northing:**	339224.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.208
X_critical 1 ------->		26.0			
Layer 1 thickness			**10.5**		
V1, Layer 2 -------->	5800.0			"V0_2	0.069
X_critical 2 -------->		72.0			0.811
Layer 2 thickness			**24.5**		
V2, Layer 3 -------->	17500.0			"V1_2	0.338
				k 1.041	0.709

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**10.5**	**657.6**
Layer 3 ---------->	**35.0**	**633.1**





Prepared by: _____ Date: _____

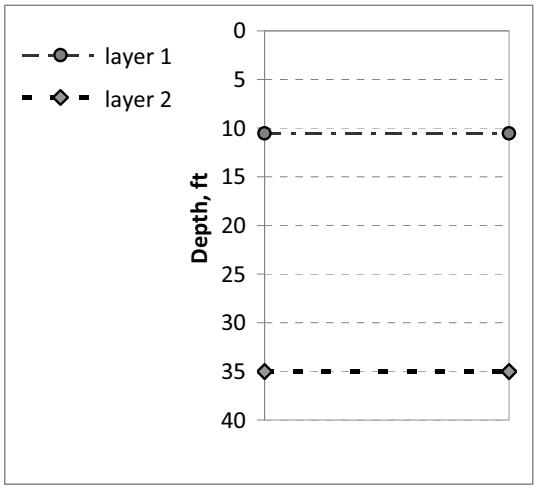
Reviewed by: _____ Date: _____

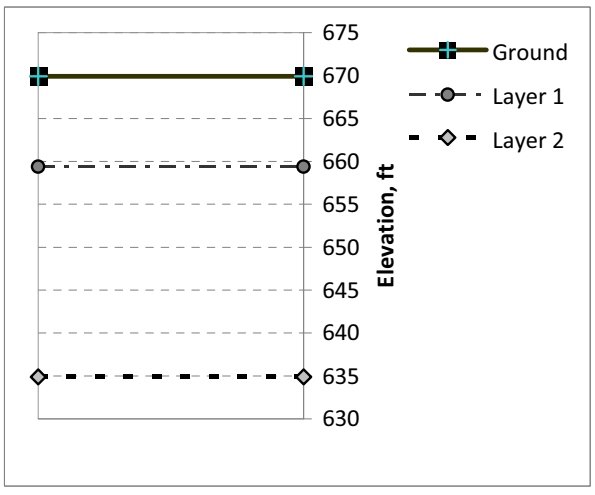
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	12		
		Elevation, ft:	669.9		
NAD1983	Coordinates:	**Easting:**	2405799.9		
PA State Plane	Eastern	**Northing:**	339273.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.208
X_critical 1 ------->		26.0			
Layer 1 thickness			10.5		
V1, Layer 2 -------->	5800.0			"V0_2	0.069
X_critical 2 -------->		72.0			0.811
Layer 2 thickness			24.5		
V2, Layer 3 -------->	17500.0			"V1_2	0.338
				k 1.041	0.709

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.5	659.4
Layer 3 ---------->	35.0	634.9





Prepared by: _____ Date: _____

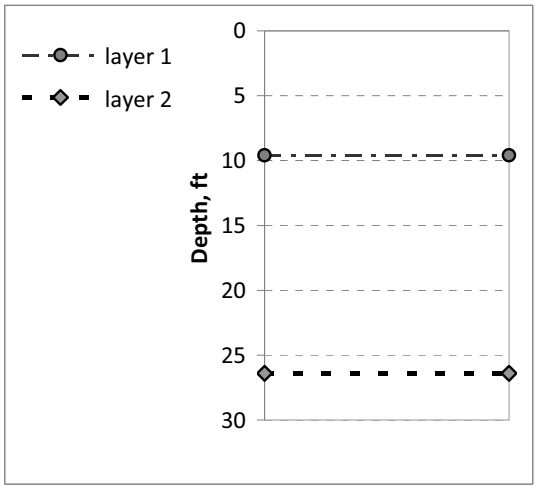
Reviewed by: _____ Date: _____

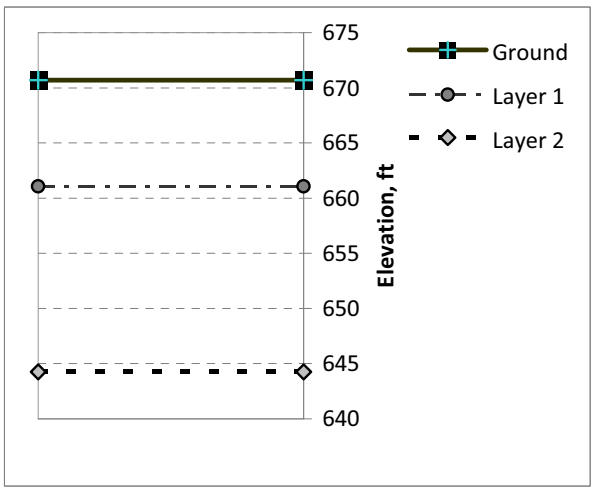
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	12		
		Elevation, ft:	670.7		
NAD1983	Coordinates:	**Easting:**	2405793.9		
PA State Plane	Eastern	**Northing:**	339338.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.222
X_critical 1 ------->		24.0			
Layer 1 thickness			9.6		
V1, Layer 2 -------->	5000.0			"V0_2	0.090
X_critical 2 -------->		55.0			0.800
Layer 2 thickness			16.8		
V2, Layer 3 -------->	12200.0			"V1_2	0.422
				k 0.977	0.647

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	9.6	661.1	
Layer 3 ---------->	26.4	644.3	





Prepared by: _____ Date: _____

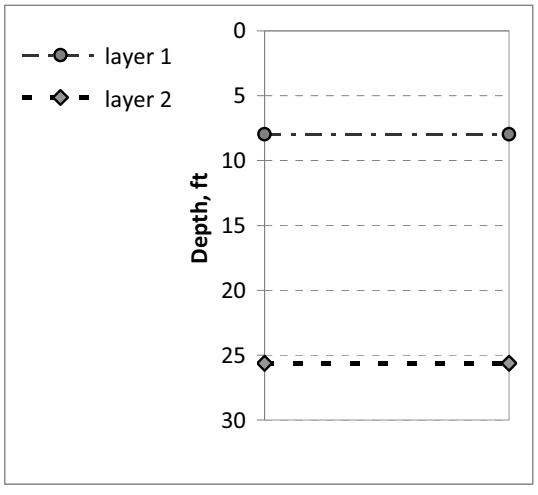
Reviewed by: _____ Date: _____

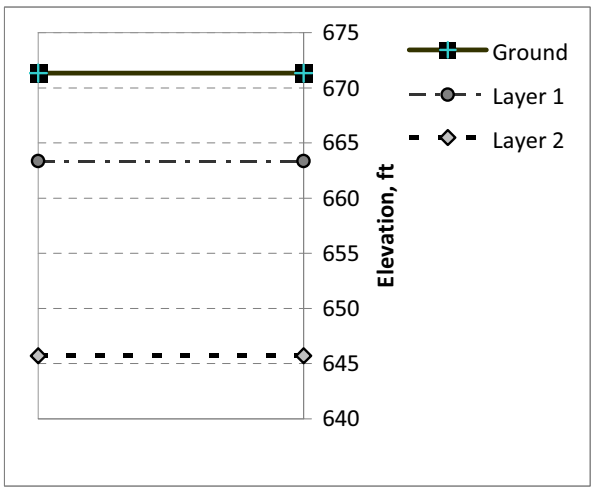
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	671.3		
NAD1983	Coordinates:	**Easting:**	2405788.4		
PA State Plane	Eastern	**Northing:**	339397.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.224
X_critical 1 ------->		20.0			
Layer 1 thickness			8.0		
V1, Layer 2 -------->	5400.0			"V0_2	0.115
X_critical 2 -------->		65.0			0.798
Layer 2 thickness			17.6		
V2, Layer 3 -------->	10500.0			"V1_2	0.540
				k 0.772	0.566

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.0	663.3
Layer 3 ---------->	25.6	645.7





Prepared by: _____ Date: _____

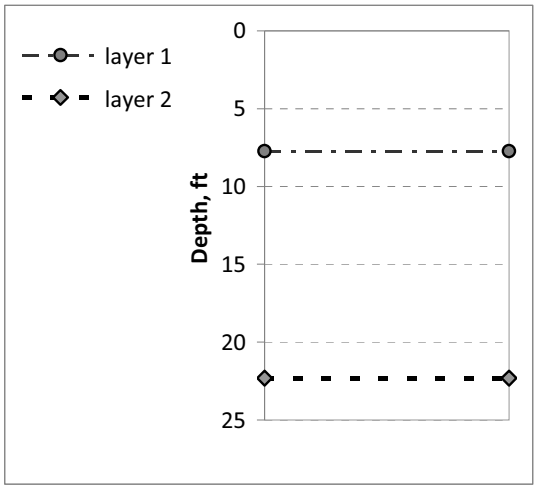
Reviewed by: _____ Date: _____

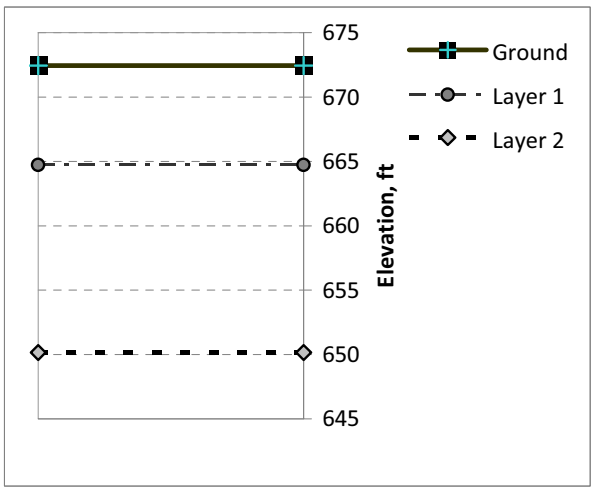
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	672.4		
NAD1983	Coordinates:	**Easting:**	2405782.9		
PA State Plane	Eastern	**Northing:**	339457.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.205
X_critical 1 ------->		19.0			
Layer 1 thickness			7.7		
V1, Layer 2 -------->	5400.0			"V0_2	0.108
X_critical 2 -------->		55.0			0.813
Layer 2 thickness			14.6		
V2, Layer 3 -------->	10200.0			"V1_2	0.558
				k 0.677	0.555

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.7	664.7
Layer 3 ---------->	22.3	650.1





Prepared by: _____ Date: _____

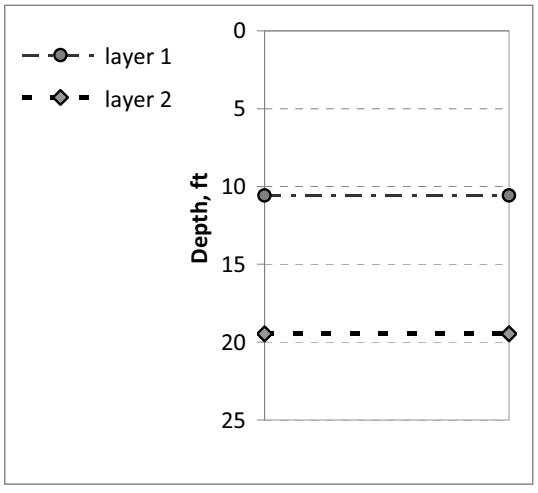
Reviewed by: _____ Date: _____

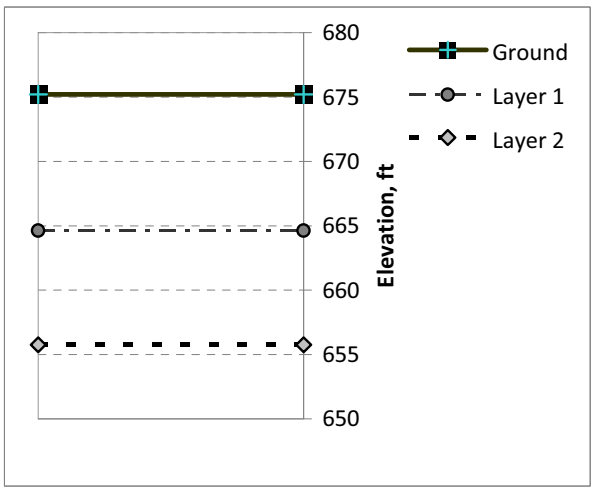
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	675.2		
NAD1983	Coordinates:	**Easting:**	2405777.0		
PA State Plane	Eastern	**Northing:**	339522.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.205
X_critical 1 ------->		26.0			
Layer 1 thickness			10.6		
V1, Layer 2 -------->	5400.0			"V0_2	0.092
X_critical 2 -------->		32.0			0.813
Layer 2 thickness			8.9		
V2, Layer 3 -------->	12000.0			"V1_2	0.467
				k 0.974	0.616

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.6	664.6
Layer 3 ---------->	19.5	655.7





Prepared by: _____ Date: _____

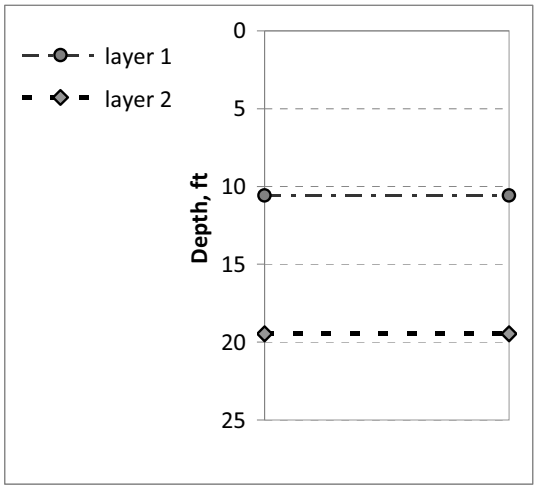
Reviewed by: _____ Date: _____

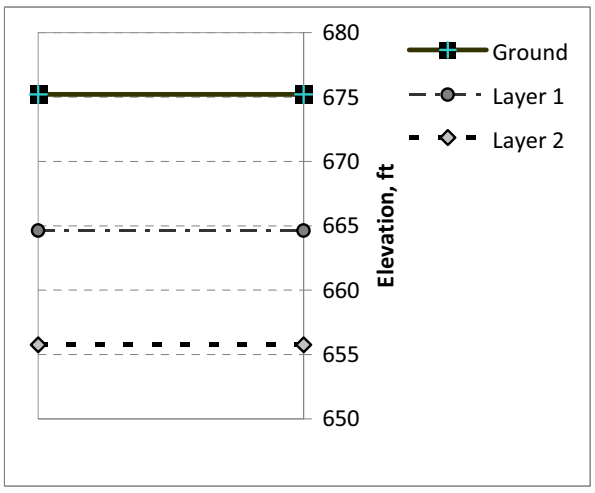
Approved by: _____ Date: _____

Line No.:	3	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	675.2		
NAD1983	Coordinates:	**Easting:**	2405772.4		
PA State Plane	Eastern	**Northing:**	339571.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.205
X_critical 1 ------->		26.0			
Layer 1 thickness			**10.6**		
V1, Layer 2 -------->	5400.0			"V0_2	0.092
X_critical 2 -------->		32.0			0.813
Layer 2 thickness			**8.9**		
V2, Layer 3 -------->	12000.0			"V1_2	0.467
				k 0.974	0.616

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ----------->	**10.6**	**664.6**
Layer 3 ----------->	**19.5**	**655.7**

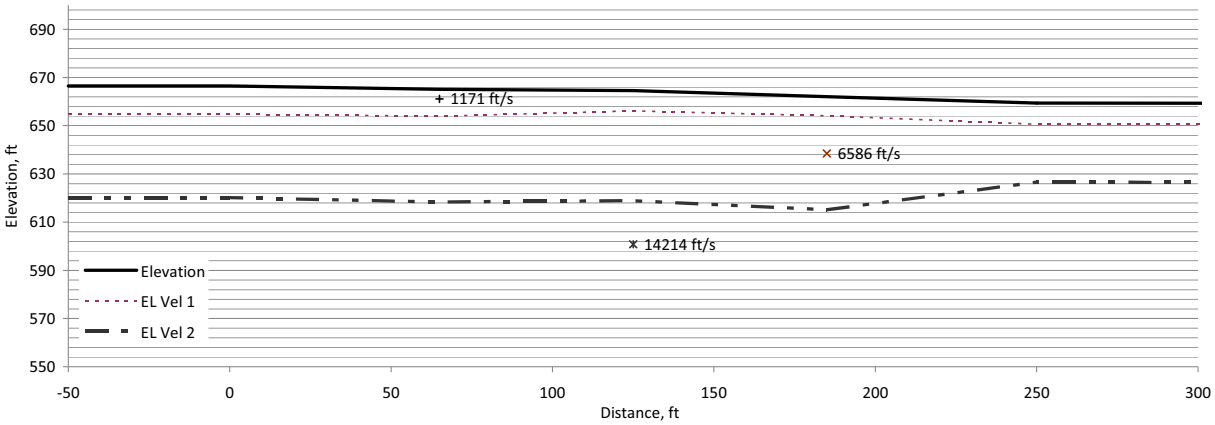




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

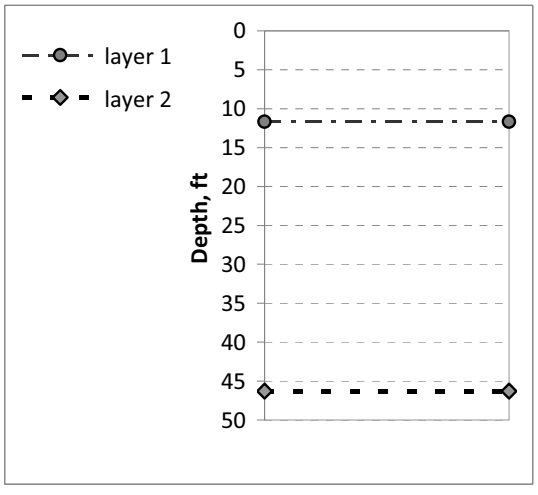
Approved by: _____ Date: _____

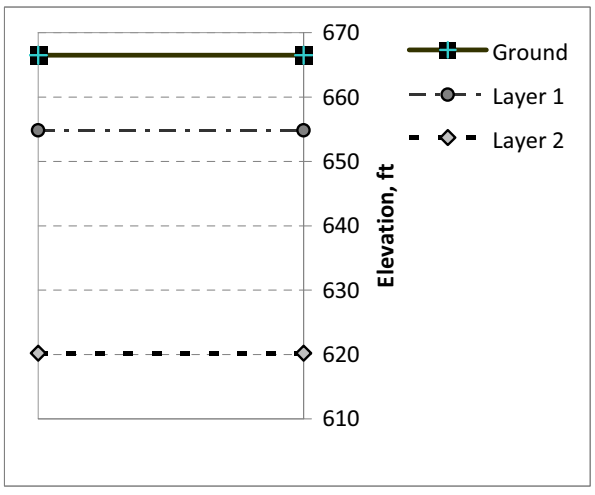

690
670
650
630
610
590
570
550
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
1171 ft/s
6586 ft/s
14214 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	A	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	666.5		
NAD1983	Coordinates:	**Easting:**	2405042.5		
PA State Plane	Eastern	**Northing:**	338987.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		28.0			
Layer 1 thickness			**11.7**		
V1, Layer 2 -------->	6700.0			"V0_2	0.077
X_critical 2 -------->		113.0			0.834
Layer 2 thickness			**34.6**		
V2, Layer 3 -------->	15500.0			"V1_2	0.447
				k 0.952	0.630

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ---------->	**11.7**	**654.8**
Layer 3 ---------->	**46.3**	**620.2**





Prepared by: _____ Date: _____

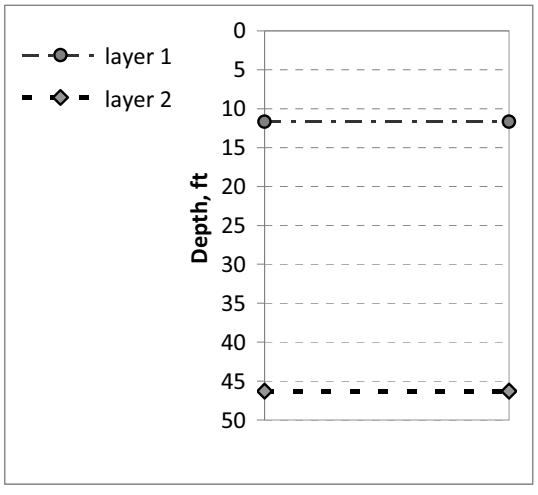
Reviewed by: _____ Date: _____

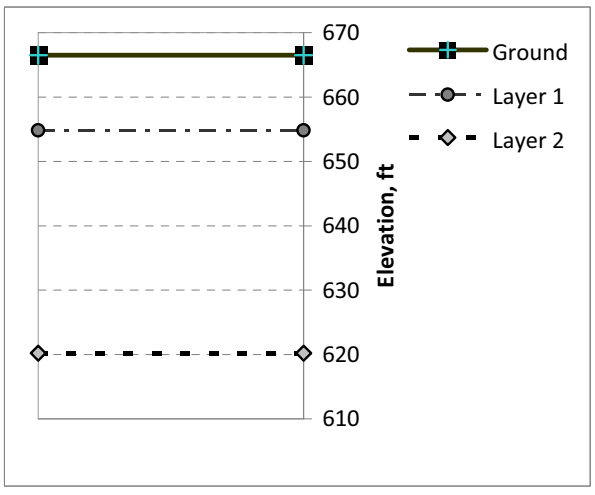
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	21		
		Elevation, ft:	666.5		
NAD1983	Coordinates:	**Easting:**	2405092.2		
PA State Plane	Eastern	**Northing:**	338991.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		28.0			
Layer 1 thickness			11.7		
V1, Layer 2 -------->	6700.0			"V0_2	0.077
X_critical 2 -------->		113.0			0.834
Layer 2 thickness			34.6		
V2, Layer 3 -------->	15500.0			"V1_2	0.447
				k 0.952	0.630

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	11.7	654.8	
Layer 3 ---------->	46.3	620.2	





Prepared by: _____ Date: _____

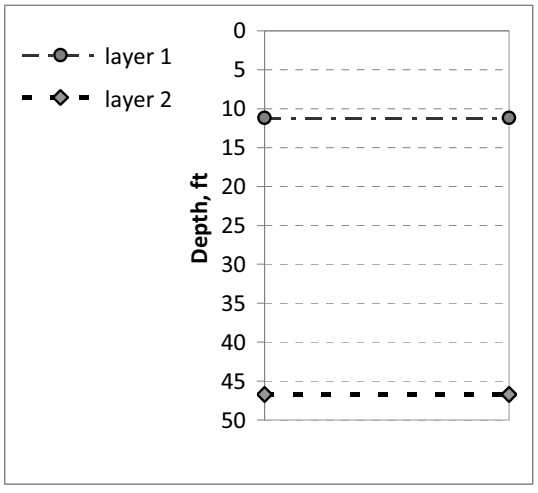
Reviewed by: _____ Date: _____

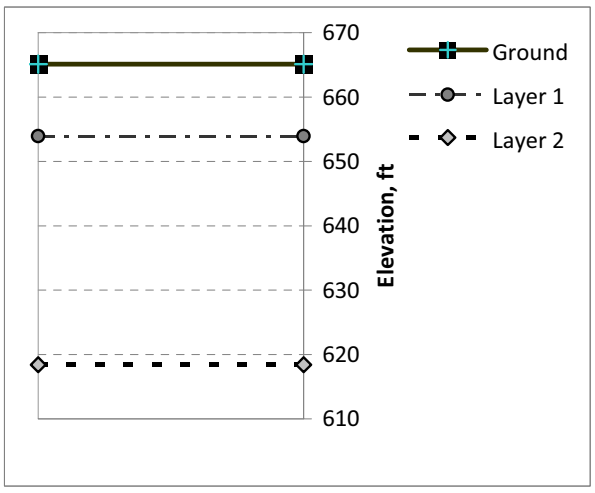
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	21		
		Elevation, ft:	665.1		
NAD1983	Coordinates:	**Easting:**	2405156.8		
PA State Plane	Eastern	**Northing:**	338997.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.186
X_critical 1 ------->		27.0			
Layer 1 thickness			11.2		
V1, Layer 2 -------->	6500.0			"V0_2	0.084
X_critical 2 -------->		119.0			0.830
Layer 2 thickness			35.5		
V2, Layer 3 -------->	14300.0			"V1_2	0.472
				k 0.931	0.612

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	11.2	653.9	
Layer 3 ---------->	46.7	618.4	





Prepared by: _____ Date: _____

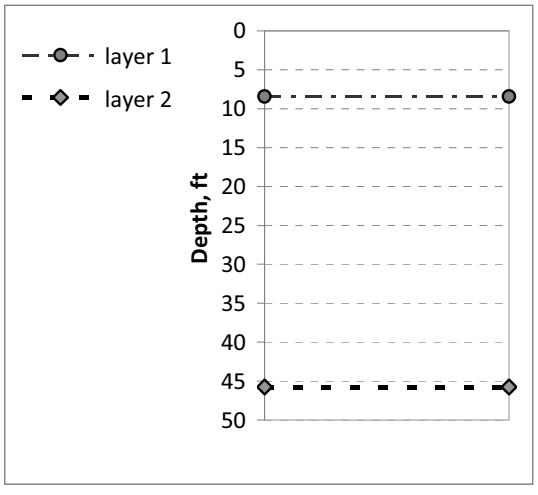
Reviewed by: _____ Date: _____

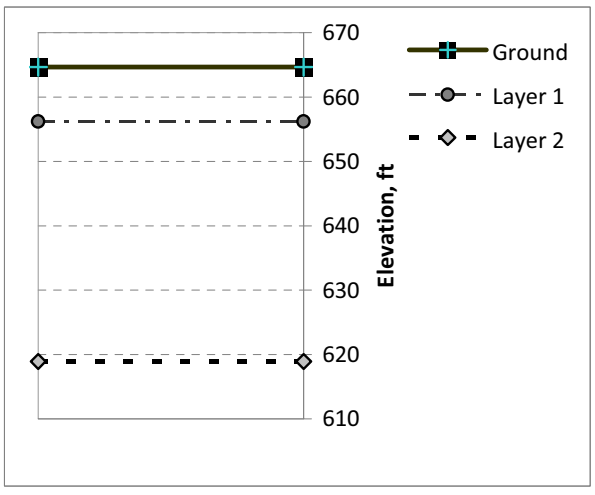
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	664.7		
NAD1983	Coordinates:	**Easting:**	2405216.4		
PA State Plane	Eastern	**Northing:**	339002.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.167
X_critical 1 ------->		20.0			
Layer 1 thickness			8.5		
V1, Layer 2 -------->	6600.0			"V0_2	0.077
X_critical 2 -------->		125.0			0.845
Layer 2 thickness			37.3		
V2, Layer 3 -------->	14300.0			"V1_2	0.480
				k 0.630	0.607

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	8.5	656.2	
Layer 3 ---------->	45.8	618.9	





Prepared by: _____ Date: _____

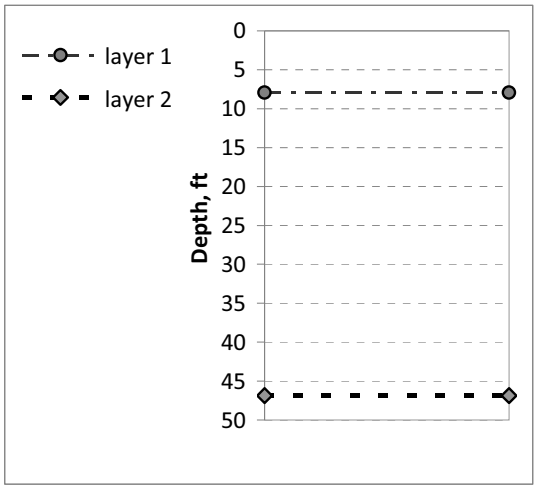
Reviewed by: _____ Date: _____

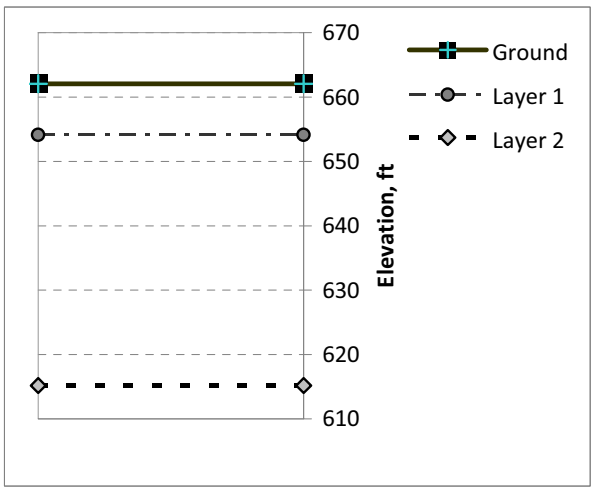
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:	-21		
		Elevation, ft:	662.1		
NAD1983	Coordinates:	**Easting:**	2405276.0		
PA State Plane	Eastern	**Northing:**	339007.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.178
X_critical 1 ------->		19.0			
Layer 1 thickness			7.9		
V1, Layer 2 -------->	6200.0			"V0_2	0.076
X_critical 2 -------->		125.0			0.836
Layer 2 thickness			38.9		
V2, Layer 3 -------->	14500.0			"V1_2	0.442
				k 0.643	0.633

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.9	654.1	
Layer 3 ---------->	46.9	615.2	





Prepared by: _____ Date: _____

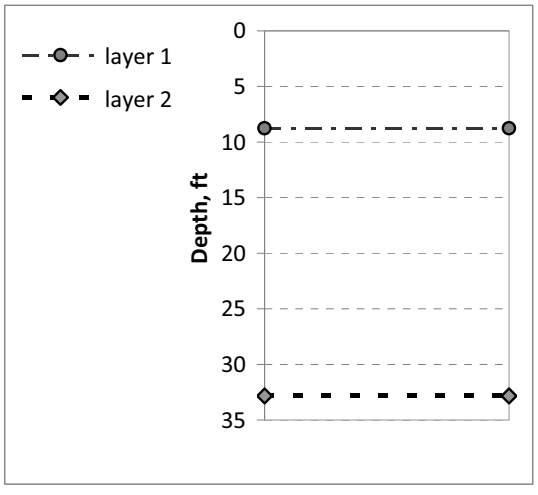
Reviewed by: _____ Date: _____

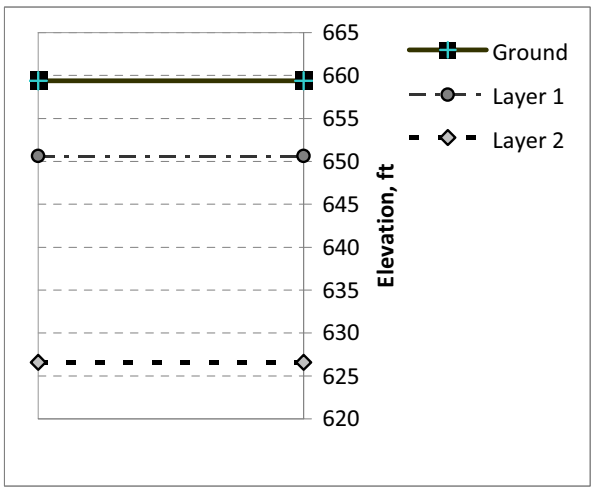
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-19		
		Elevation, ft:	659.4		
NAD1983	Coordinates:	**Easting:**	2405340.6		
PA State Plane	Eastern	**Northing:**	339012.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		21.0			
Layer 1 thickness			8.8		
V1, Layer 2 -------->	6700.0			"V0_2	0.095
X_critical 2 -------->		89.0			0.834
Layer 2 thickness			24.1		
V2, Layer 3 -------->	12700.0			"V1_2	0.556
				k 0.673	0.556

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.8	650.6
Layer 3 ---------->	32.8	626.6





Prepared by: _____ Date: _____

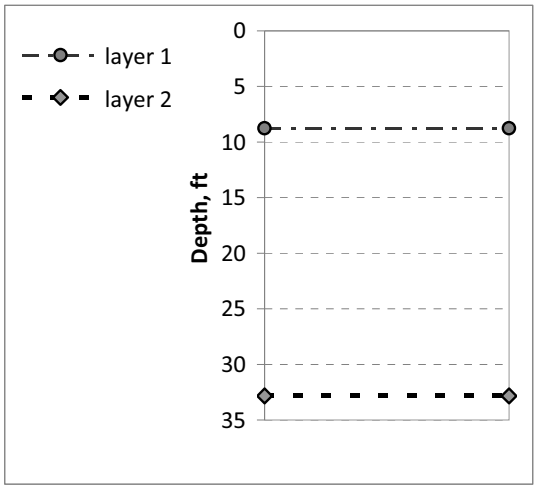
Reviewed by: _____ Date: _____

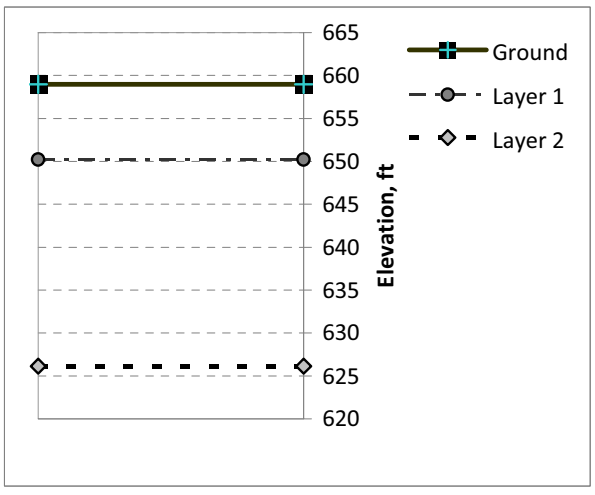
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	659.0		
NAD1983	Coordinates:	**Easting:**	2405389.9		
PA State Plane	Eastern	**Northing:**	339017.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.180
X_critical 1 ------->		21.0			
Layer 1 thickness			8.8		
V1, Layer 2 -------->	6700.0			"V0_2	0.095
X_critical 2 -------->		89.0			0.834
Layer 2 thickness			24.1		
V2, Layer 3 -------->	12700.0			"V1_2	0.556
				k 0.673	0.556

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.8	650.2
Layer 3 ---------->	32.8	626.1

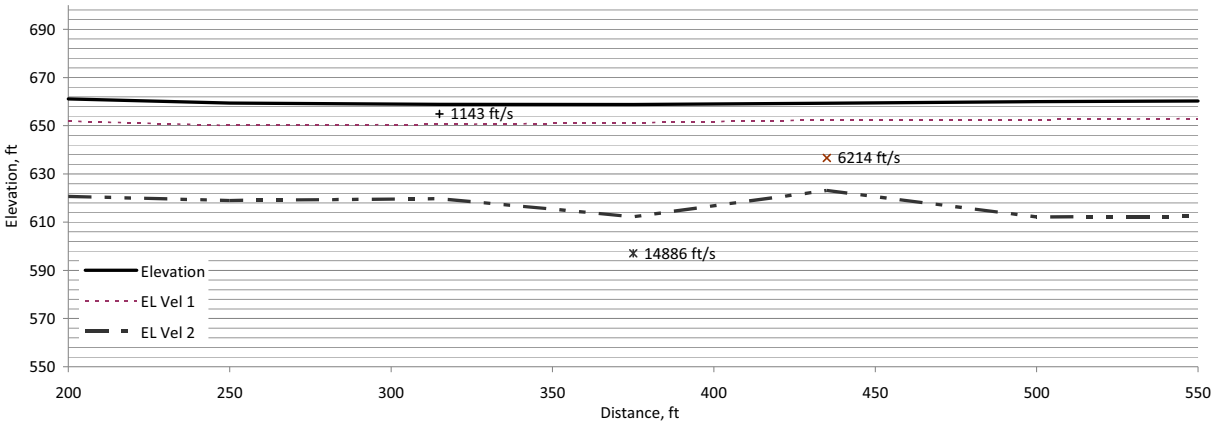




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

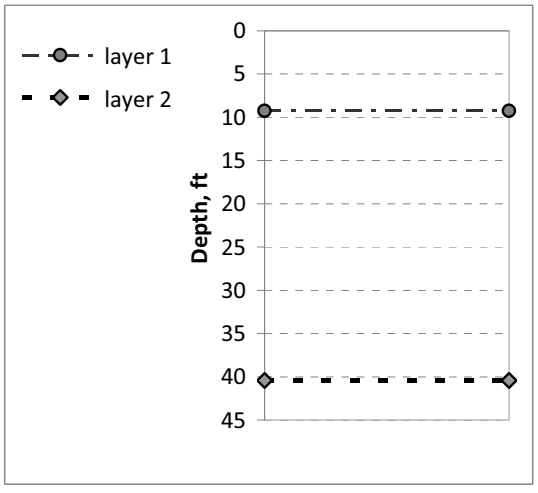
Approved by: _____ Date: _____

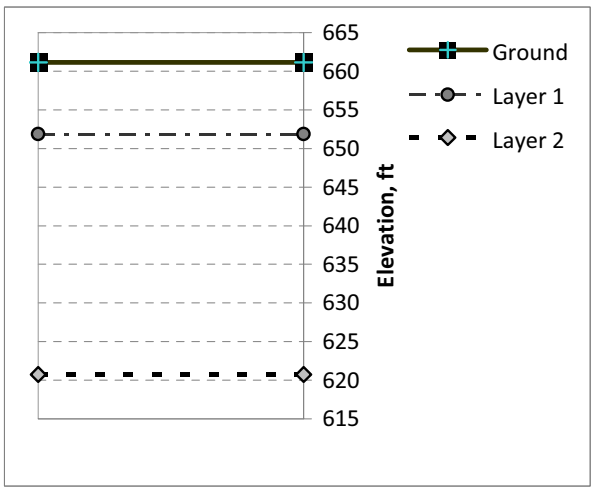

690
670
650
630
610
590
570
550
200
250
300
350
400
450
500
550
Elevation, ft
Distance, ft
1143 ft/s
6214 ft/s
14886 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	A	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	661.1		
NAD1983	Coordinates:	**Easting:**	2405290.9		
PA State Plane	Eastern	**Northing:**	339008.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.172
X_critical 1 ------->		22.0			
Layer 1 thickness			9.3		
V1, Layer 2 -------->	7000.0			"V0_2	0.077
X_critical 2 -------->		103.0			0.841
Layer 2 thickness			31.2		
V2, Layer 3 -------->	15700.0			"V1_2	0.462
				k 0.716	0.619

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.3	651.9
Layer 3 ---------->	40.4	620.7





Prepared by: _____ Date: _____

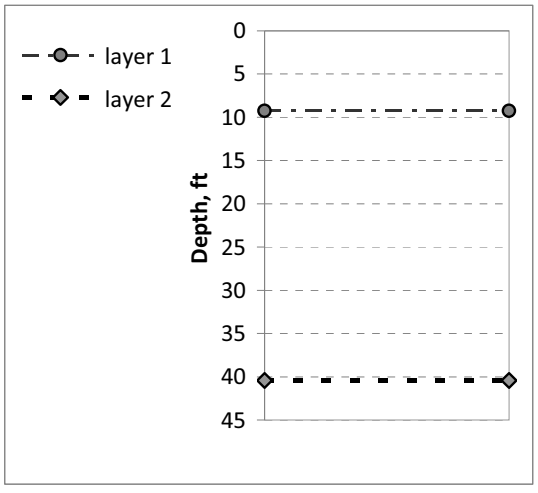
Reviewed by: _____ Date: _____

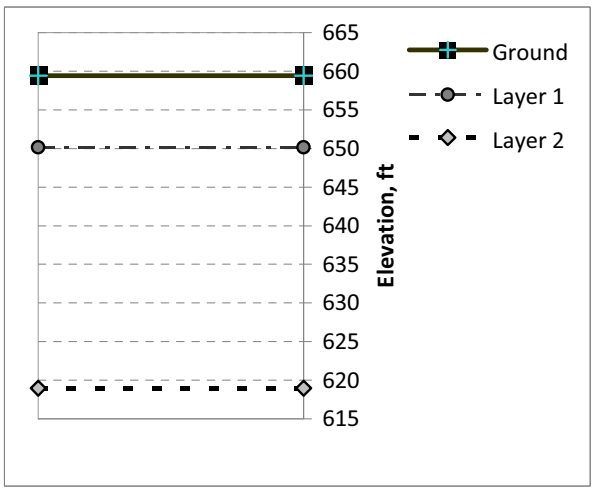
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	19		
		Elevation, ft:	659.4		
NAD1983	Coordinates:	**Easting:**	2405340.6		
PA State Plane	Eastern	**Northing:**	339012.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.172
X_critical 1 ------->		22.0			
Layer 1 thickness			9.3		
V1, Layer 2 -------->	7000.0			"V0_2	0.077
X_critical 2 -------->		103.0			0.841
Layer 2 thickness			31.2		
V2, Layer 3 -------->	15700.0			"V1_2	0.462
				k 0.716	0.619

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.3	650.1
Layer 3 ---------->	40.4	619.0





Prepared by: _____ Date: _____

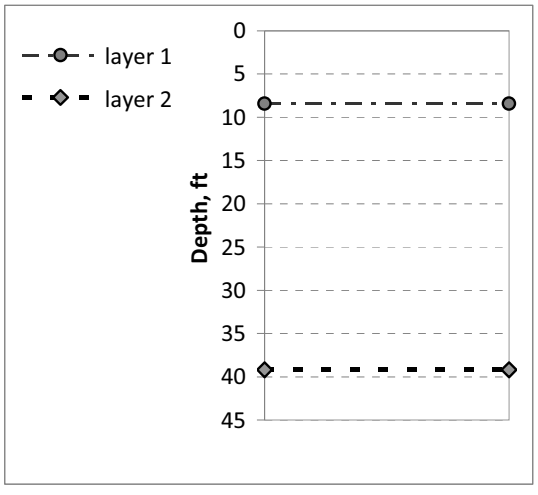
Reviewed by: _____ Date: _____

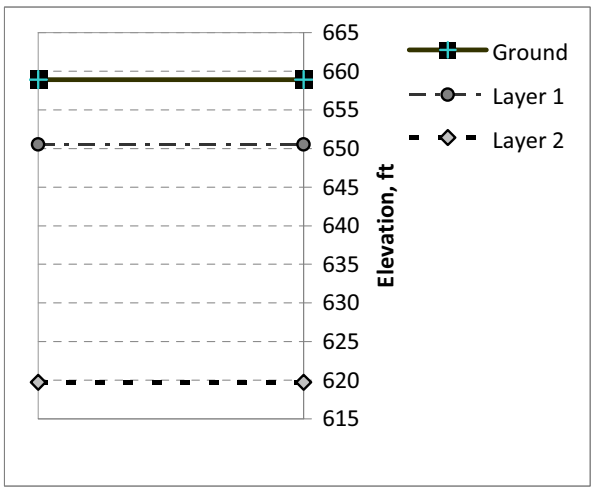
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	19		
		Elevation, ft:	658.9		
NAD1983	Coordinates:	**Easting:**	2405404.7		
PA State Plane	Eastern	**Northing:**	339018.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.173
X_critical 1 ------->		20.0			
Layer 1 thickness			8.4		
V1, Layer 2 -------->	6400.0			"V0_2	0.076
X_critical 2 -------->		101.0			0.841
Layer 2 thickness			30.8		
V2, Layer 3 -------->	14500.0			"V1_2	0.457
				k 0.654	0.623

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.4	650.5
Layer 3 ---------->	39.2	619.7





Prepared by: _____ Date: _____

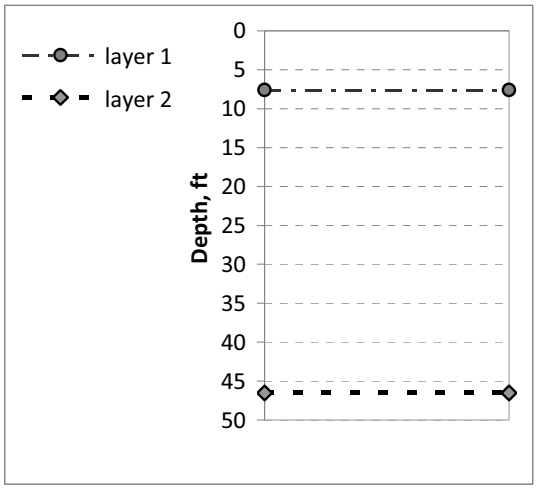
Reviewed by: _____ Date: _____

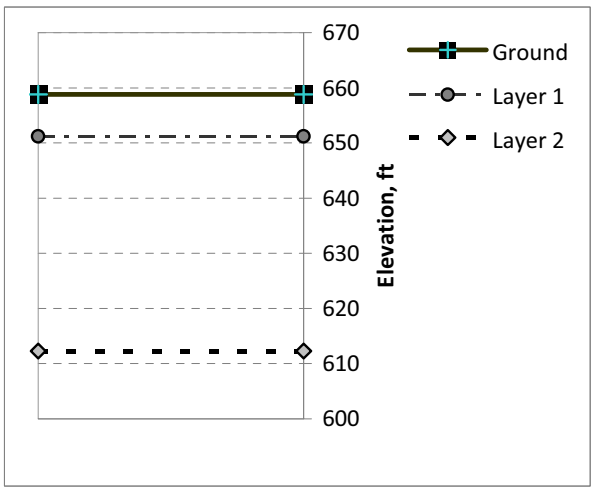
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	658.8		
NAD1983	Coordinates:	**Easting:**	2405463.8		
PA State Plane	Eastern	**Northing:**	339024.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.195
X_critical 1 ------->		18.5			
Layer 1 thickness			**7.6**		
V1, Layer 2 -------->	6200.0			"V0_2	0.083
X_critical 2 -------->		125.0			0.822
Layer 2 thickness			**38.9**		
V2, Layer 3 -------->	14500.0			"V1_2	0.442
				k 0.673	0.633

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**7.6**	**651.2**
Layer 3 ---------->	**46.5**	**612.3**





Prepared by: _____ Date: _____

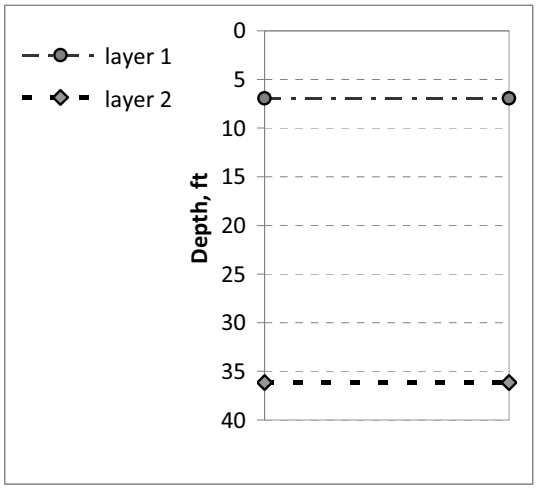
Reviewed by: _____ Date: _____

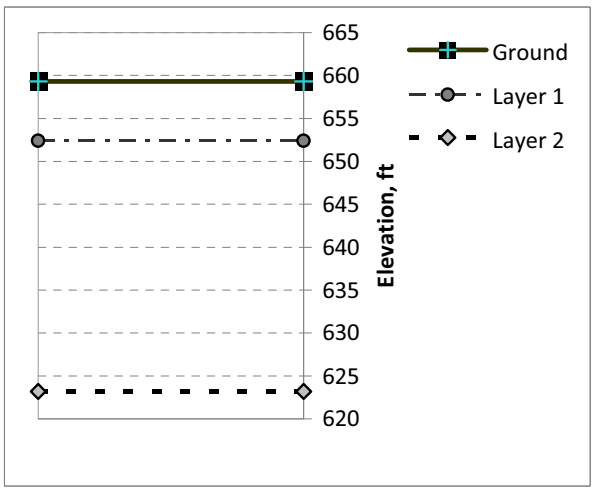
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-17		
		Elevation, ft:	659.3		
NAD1983	Coordinates:	**Easting:**	2405523.0		
PA State Plane	Eastern	**Northing:**	339030.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.201
X_critical 1 ------->		17.0			
Layer 1 thickness			6.9		
V1, Layer 2 -------->	5500.0			"V0_2	0.090
X_critical 2 -------->		97.0			0.816
Layer 2 thickness			29.2		
V2, Layer 3 -------->	12200.0			"V1_2	0.468
				k 0.627	0.615

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	6.9	652.4
Layer 3 ---------->	36.2	623.2





Prepared by: _____ Date: _____

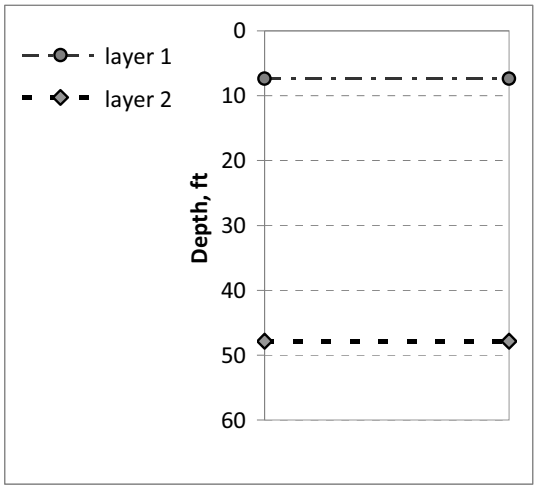
Reviewed by: _____ Date: _____

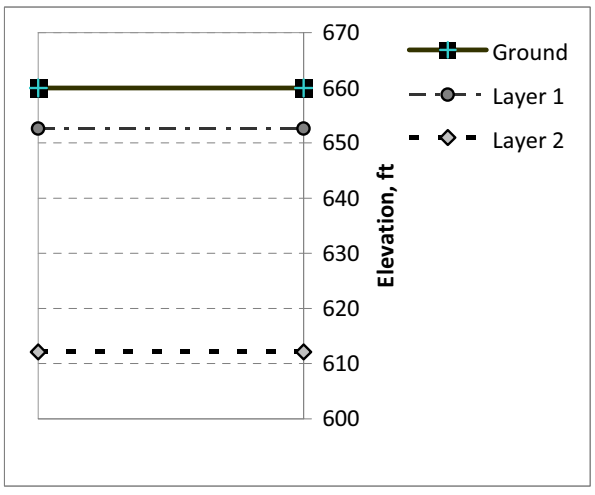
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-19		
		Elevation, ft:	660.0		
NAD1983	Coordinates:	**Easting:**	2405587.0		
PA State Plane	Eastern	**Northing:**	339036.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.194
X_critical 1 ------->		18.0			
Layer 1 thickness			7.4		
V1, Layer 2 -------->	5700.0			"V0_2	0.070
X_critical 2 -------->		120.0			0.822
Layer 2 thickness			40.5		
V2, Layer 3 -------->	15800.0			"V1_2	0.369
				k 0.673	0.685

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.4	652.6	
Layer 3 ---------->	47.9	612.1	





Prepared by: _____ Date: _____

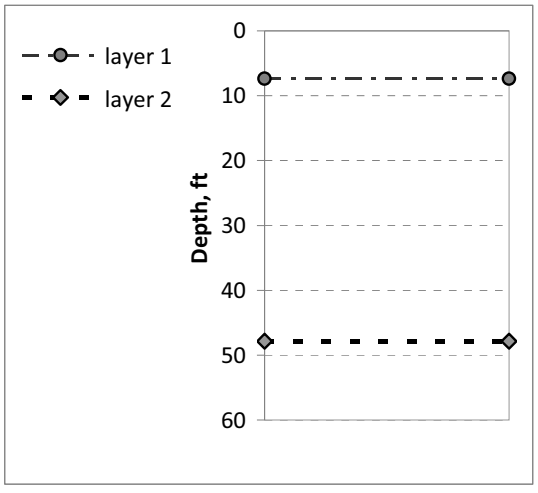
Reviewed by: _____ Date: _____

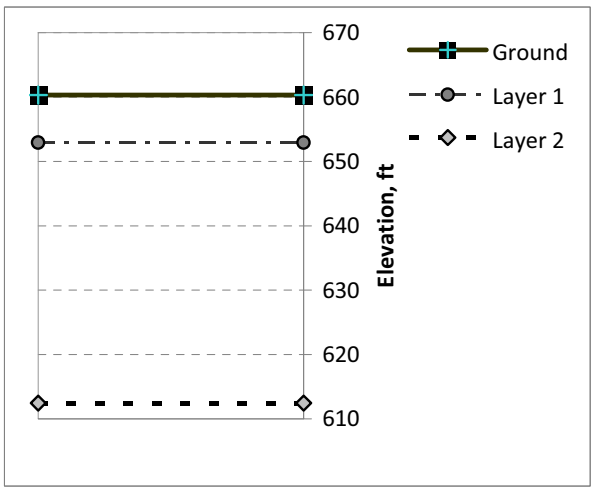
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	660.3		
NAD1983	Coordinates:	**Easting:**	2405637.0		
PA State Plane	Eastern	**Northing:**	339041.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.194
X_critical 1 ------->		18.0			
Layer 1 thickness			7.4		
V1, Layer 2 -------->	5700.0			"V0_2	0.070
X_critical 2 -------->		120.0			0.822
Layer 2 thickness			40.5		
V2, Layer 3 -------->	15800.0			"V1_2	0.369
				k 0.673	0.685

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.4	652.9
Layer 3 ---------->	47.9	612.4

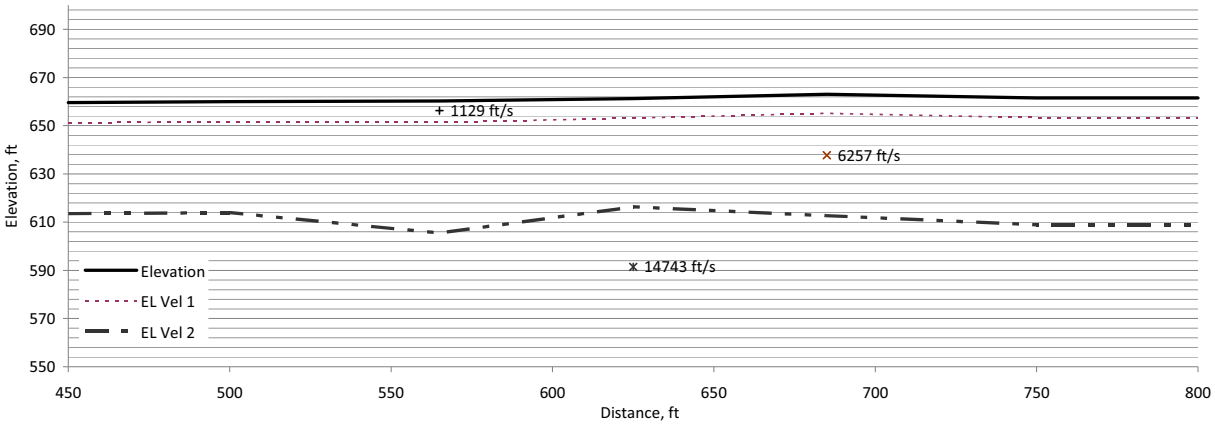




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

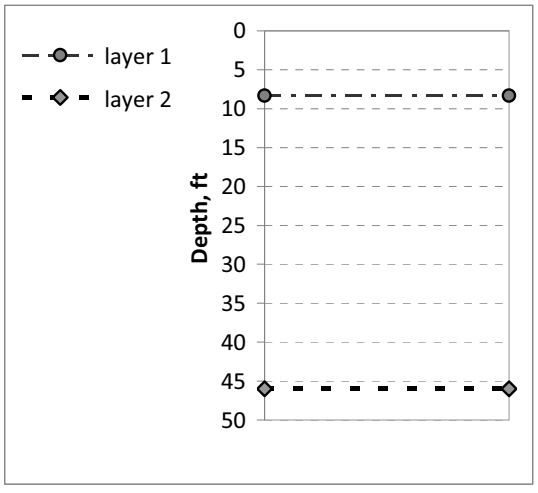
Approved by: _____ Date: _____

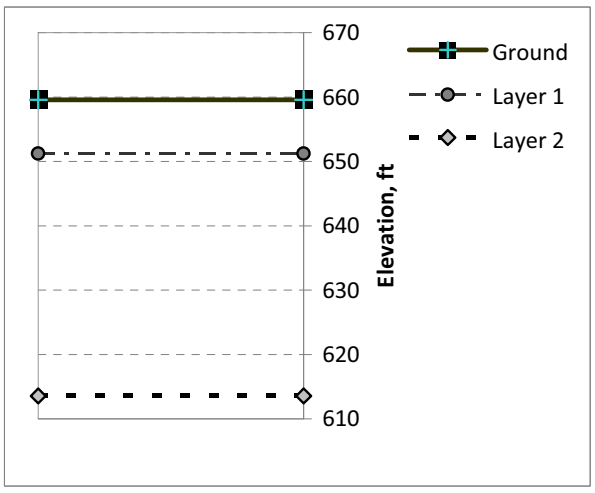

690
670
650
630
610
590
570
550
Elevation, ft
1129 ft/s
6257 ft/s
14743 ft/s
Elevation
EL Vel 1
EL Vel 2
450
500
550
600
650
700
750
800
Distance, ft

Line No.:	A	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	450	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	659.5		
NAD1983	Coordinates:	**Easting:**	2405537.8		
PA State Plane	Eastern	**Northing:**	339031.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.181
X_critical 1 ------->		20.0			
Layer 1 thickness			8.3		
V1, Layer 2 -------->	6100.0			"V0_2	0.077
X_critical 2 -------->		121.0			0.833
Layer 2 thickness			37.7		
V2, Layer 3 -------->	14300.0			"V1_2	0.441
				k 0.686	0.634

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.3	651.2
Layer 3 ---------->	46.0	613.5





Prepared by: _____ Date: _____

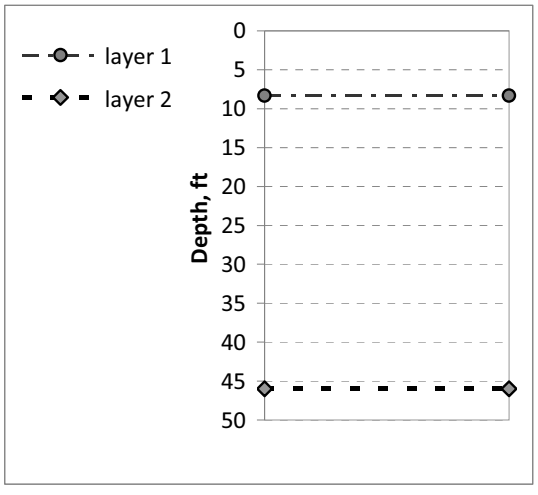
Reviewed by: _____ Date: _____

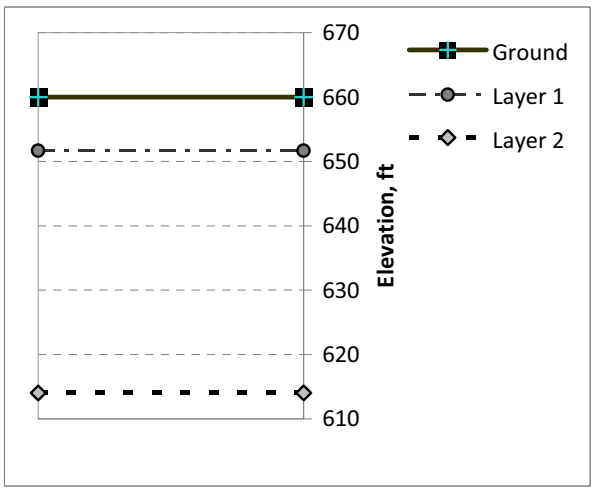
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	21		
		Elevation, ft:	660.0		
NAD1983	Coordinates:	**Easting:**	2405587.0		
PA State Plane	Eastern	**Northing:**	339036.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.181
X_critical 1 ------->		20.0			
Layer 1 thickness			8.3		
V1, Layer 2 -------->	6100.0			"V0_2	0.077
X_critical 2 -------->		121.0			0.833
Layer 2 thickness			37.7		
V2, Layer 3 -------->	14300.0			"V1_2	0.441
				k 0.686	0.634

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.3	651.7
Layer 3 ---------->	46.0	614.0





Prepared by: _____ Date: _____

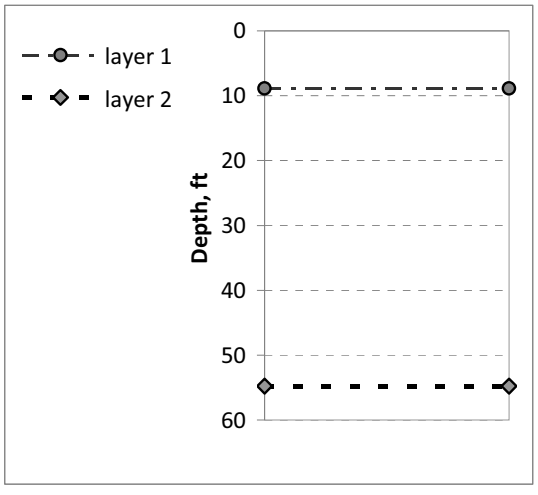
Reviewed by: _____ Date: _____

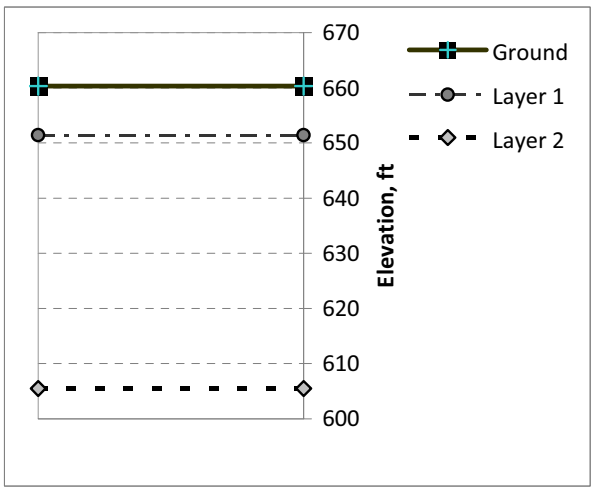
Approved by: _____ Date: _____

Line No.:	A1	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	565	**Location:**	Berwick
		Depth Offset, ft:	25		
		Elevation, ft:	660.3		
NAD1983	Coordinates:	**Easting:**	2405652.0		
PA State Plane	Eastern	**Northing:**	339043.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.167
X_critical 1 ------->		21.0			
Layer 1 thickness			8.9		
V1, Layer 2 -------->	6600.0			"V0_2	0.078
X_critical 2 -------->		154.0			0.845
Layer 2 thickness			45.9		
V2, Layer 3 -------->	14200.0			"V1_2	0.483
				k 0.660	0.604

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.9	651.4
Layer 3 ---------->	54.8	605.5





Prepared by: _____ Date: _____

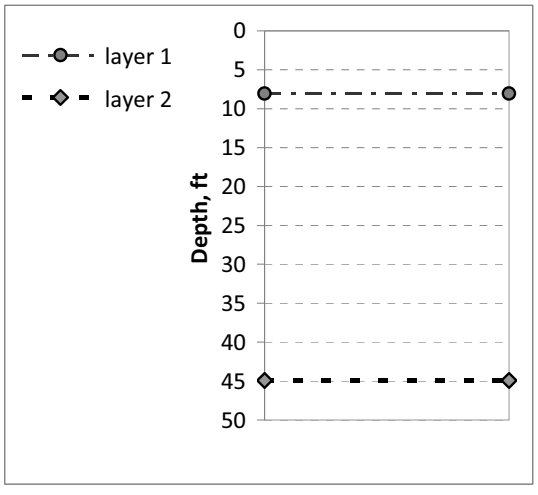
Reviewed by: _____ Date: _____

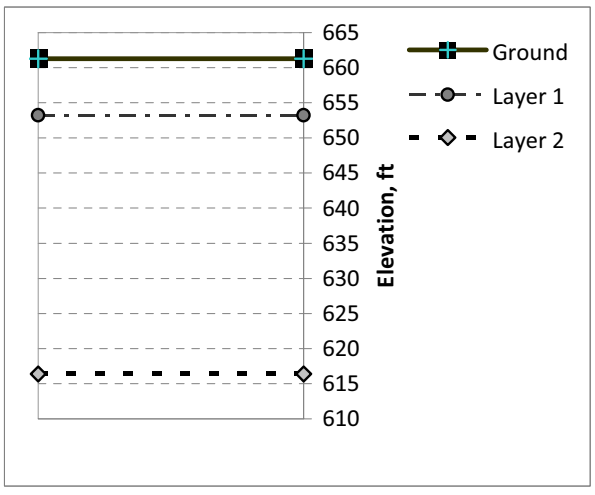
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	625	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	661.3		
NAD1983	Coordinates:	**Easting:**	2405712.0		
PA State Plane	Eastern	**Northing:**	339049.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.165
X_critical 1 ------->		19.0			
Layer 1 thickness			8.0		
V1, Layer 2 -------->	6700.0			"V0_2	0.078
X_critical 2 -------->		125.0			0.847
Layer 2 thickness			36.9		
V2, Layer 3 -------->	14200.0			"V1_2	0.491
				k 0.587	0.599

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.0	653.2
Layer 3 ---------->	44.9	616.4





Prepared by: _____ Date: _____

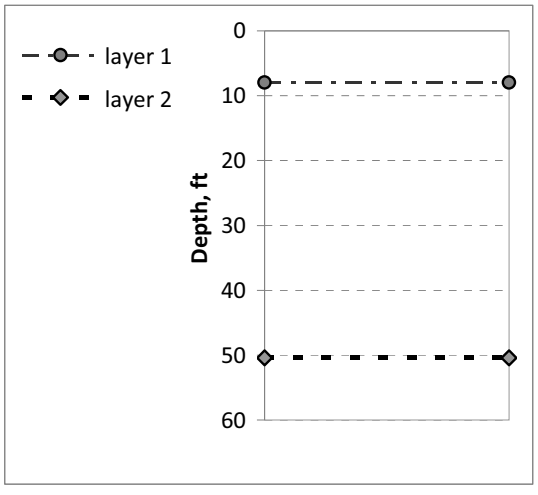
Reviewed by: _____ Date: _____

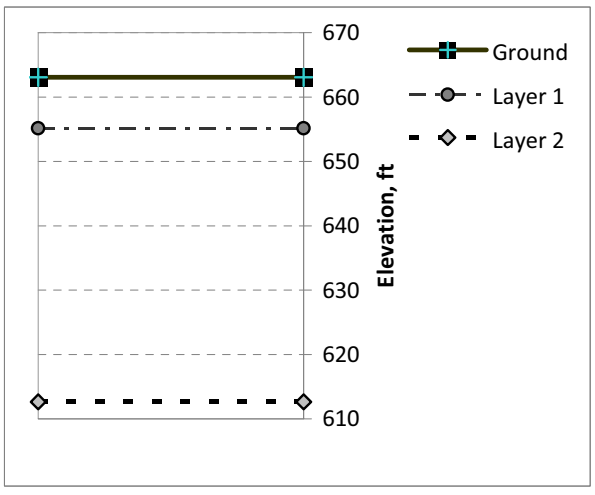
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	685	**Location:**	Berwick
		Depth Offset, ft:	-22		
		Elevation, ft:	663.1		
NAD1983	Coordinates:	**Easting:**	2405771.9		
PA State Plane	Eastern	**Northing:**	339055.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.176
X_critical 1 ------->		19.0			
Layer 1 thickness			8.0		
V1, Layer 2 -------->	6300.0			"V0_2	0.072
X_critical 2 -------->		134.0			0.838
Layer 2 thickness			42.5		
V2, Layer 3 -------->	15200.0			"V1_2	0.427
				k 0.638	0.643

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.0	655.1
Layer 3 ---------->	50.4	612.6





Prepared by: _____ Date: _____

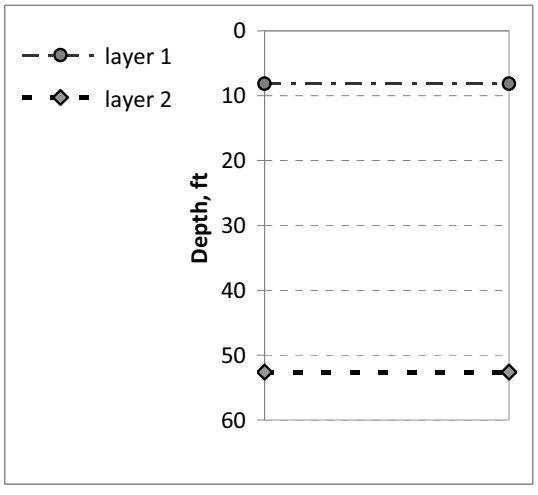
Reviewed by: _____ Date: _____

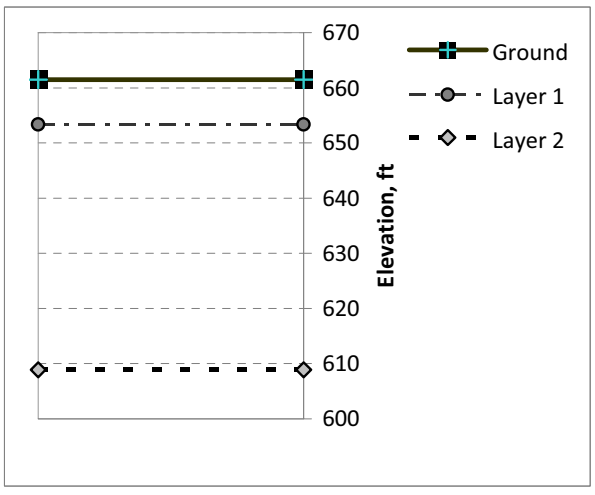
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	-22		
		Elevation, ft:	661.5		
NAD1983	Coordinates:	**Easting:**	2405836.9		
PA State Plane	Eastern	**Northing:**	339062.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.201
X_critical 1 ------->		20.0			
Layer 1 thickness			8.2		
V1, Layer 2 -------->	6000.0			"V0_2	0.077
X_critical 2 -------->		136.0			0.816
Layer 2 thickness			44.4		
V2, Layer 3 -------->	15500.0			"V1_2	0.397
				k 0.762	0.665

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.2	653.3
Layer 3 ---------->	52.6	608.9





Prepared by: _____ Date: _____

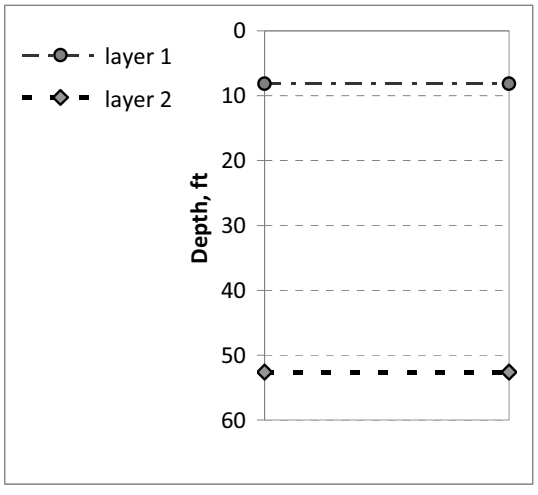
Reviewed by: _____ Date: _____

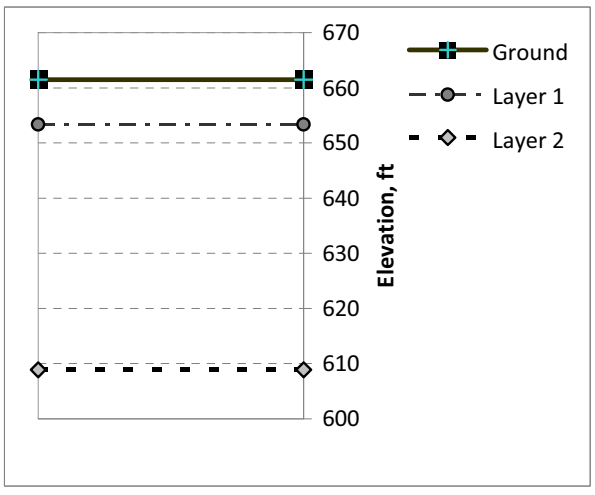
Approved by: _____ Date: _____

Line No.:	A	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	800	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	661.5		
NAD1983	Coordinates:	**Easting:**	2405886.8		
PA State Plane	Eastern	**Northing:**	339067.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.201
X_critical 1 ------->		20.0			
Layer 1 thickness			8.2		
V1, Layer 2 -------->	6000.0			"V0_2	0.077
X_critical 2 -------->		136.0			0.816
Layer 2 thickness			44.4		
V2, Layer 3 -------->	15500.0			"V1_2	0.397
				k 0.762	0.665

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.2	653.3
Layer 3 ---------->	52.6	608.9

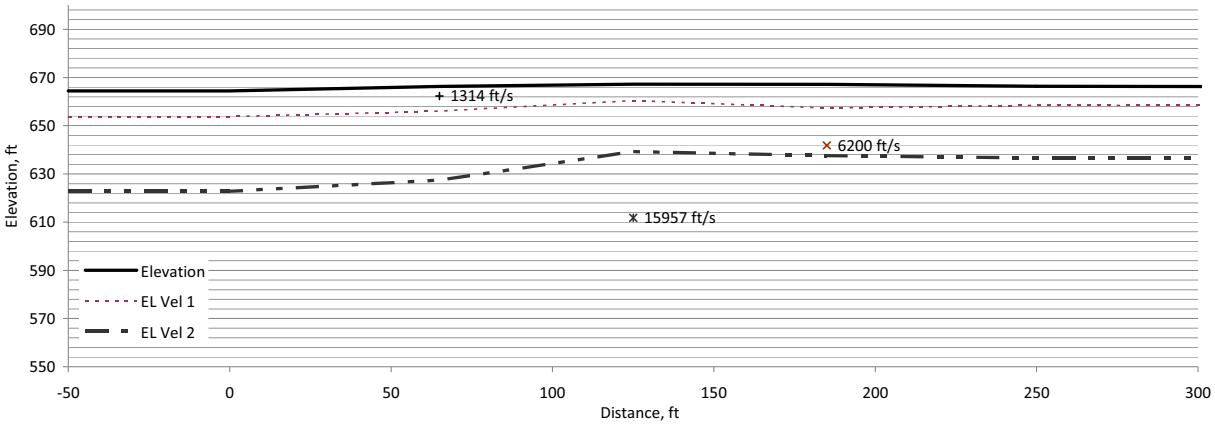




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

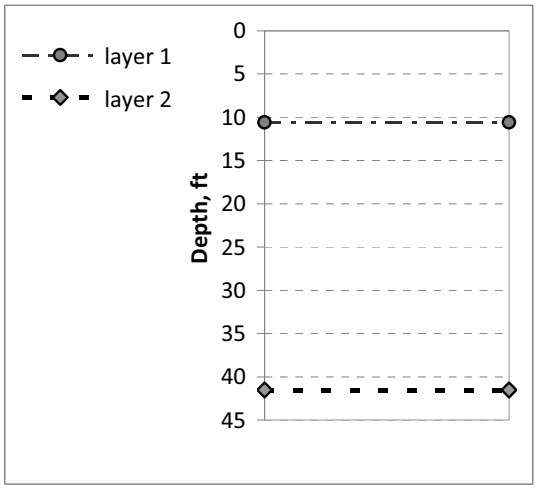
Approved by: _____ Date: _____

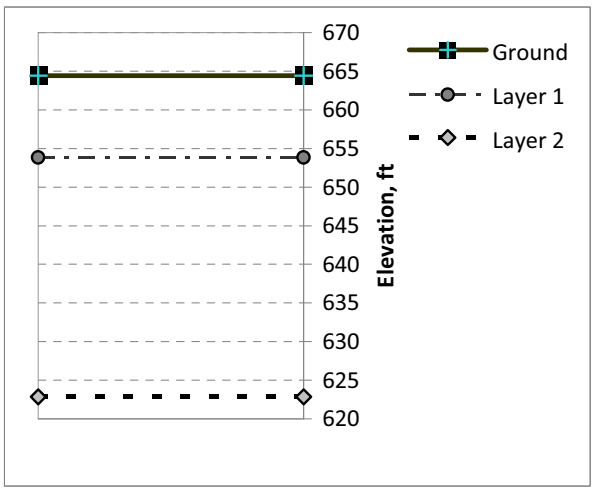

690
670
650
630
610
590
570
550
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
1314 ft/s
6200 ft/s
15957 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	B	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	664.4		
NAD1983	Coordinates:	**Easting:**	2404837.8		
PA State Plane	Eastern	**Northing:**	339095.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1300.0			"V0_1	0.205
X_critical 1 ------->		26.0			
Layer 1 thickness			**10.6**		
V1, Layer 2 -------->	6400.0			"V0_2	0.077
X_critical 2 -------->		95.0			0.814
Layer 2 thickness			**31.0**		
V2, Layer 3 -------->	17000.0			"V1_2	0.386
				k 1.007	0.673

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**10.6**	**653.8**
Layer 3 ----------->	**41.5**	**622.9**





Prepared by: _____ Date: _____

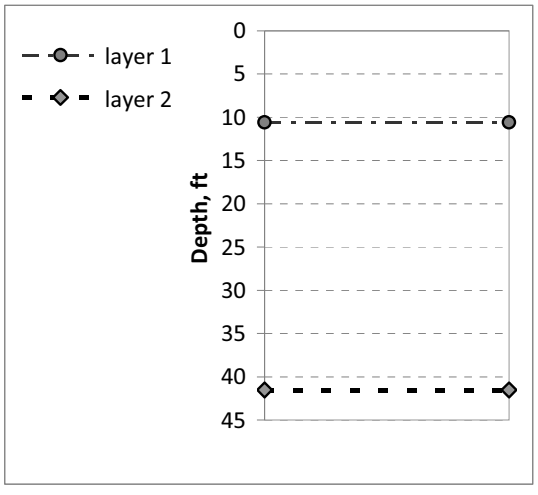
Reviewed by: _____ Date: _____

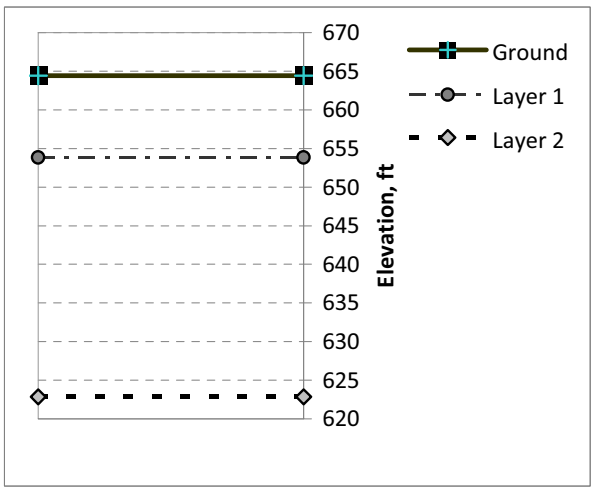
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	18		
		Elevation, ft:	664.4		
NAD1983	Coordinates:	**Easting:**	2404887.4		
PA State Plane	Eastern	**Northing:**	339102.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1300.0			"V0_1	0.205
X_critical 1 ------->		26.0			
Layer 1 thickness			10.6		
V1, Layer 2 -------->	6400.0			"V0_2	0.077
X_critical 2 -------->		95.0			0.814
Layer 2 thickness			31.0		
V2, Layer 3 -------->	17000.0			"V1_2	0.386
				k 1.007	0.673

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	10.6	653.8	
Layer 3 ---------->	41.5	622.9	





Prepared by: _____ Date: _____

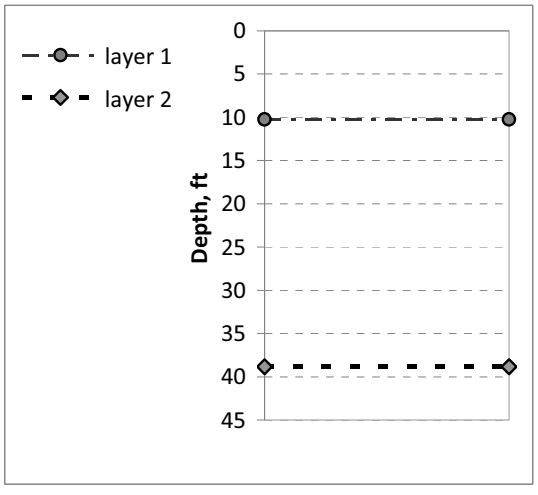
Reviewed by: _____ Date: _____

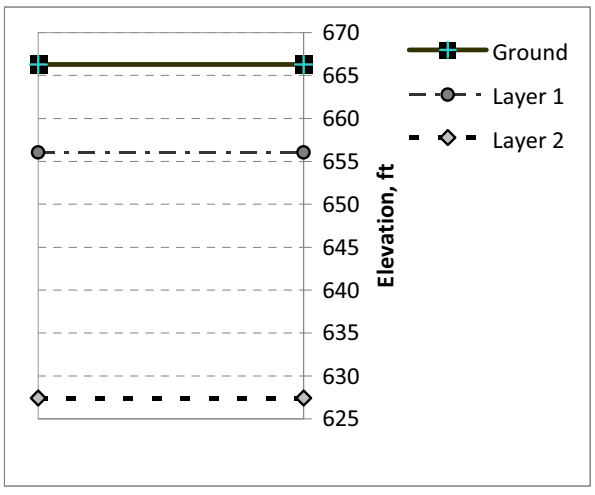
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	17		
		Elevation, ft:	666.3		
NAD1983	Coordinates:	**Easting:**	2404951.9		
PA State Plane	Eastern	**Northing:**	339112.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1300.0			"V0_1	0.198
X_critical 1 ------->		25.0			
Layer 1 thickness			**10.2**		
V1, Layer 2 -------->	6600.0			"V0_2	0.077
X_critical 2 -------->		89.0			0.819
Layer 2 thickness			**28.6**		
V2, Layer 3 -------->	17000.0			"V1_2	0.399
				k 0.940	0.664

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ---------->	**10.2**	**656.0**
Layer 3 ---------->	**38.8**	**627.4**





Prepared by: _____ Date: _____

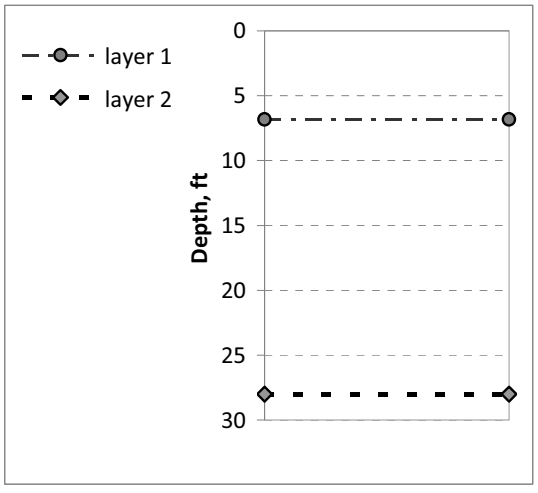
Reviewed by: _____ Date: _____

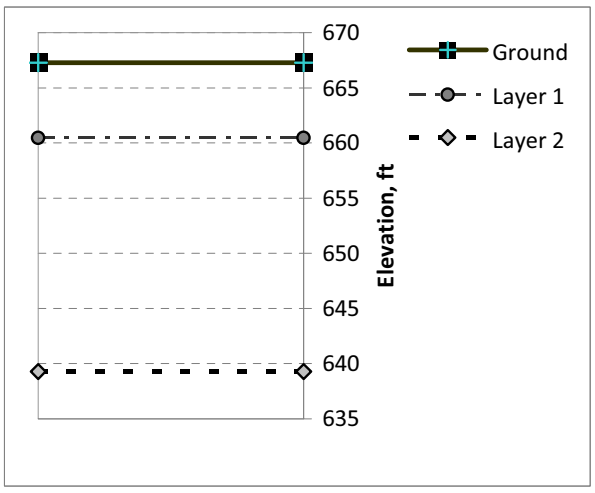
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	667.3		
NAD1983	Coordinates:	**Easting:**	2405011.4		
PA State Plane	Eastern	**Northing:**	339120.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		17.0			
Layer 1 thickness			6.8		
V1, Layer 2 -------->	5600.0			"V0_2	0.085
X_critical 2 -------->		66.5			0.804
Layer 2 thickness			21.2		
V2, Layer 3 -------->	14100.0			"V1_2	0.408
				k 0.681	0.657

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ---------->	**6.8**	**660.5**
Layer 3 ---------->	**28.0**	**639.3**





Prepared by: _____ Date: _____

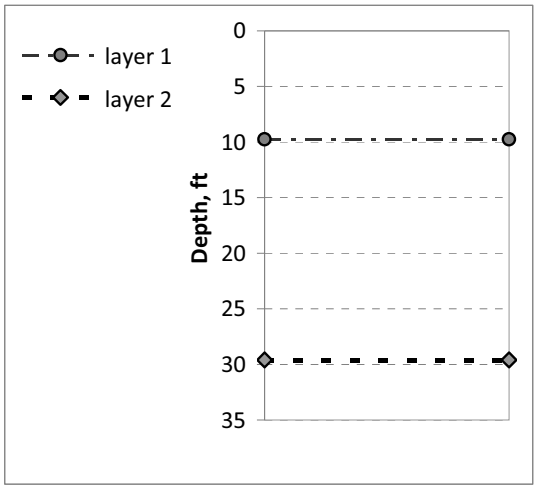
Reviewed by: _____ Date: _____

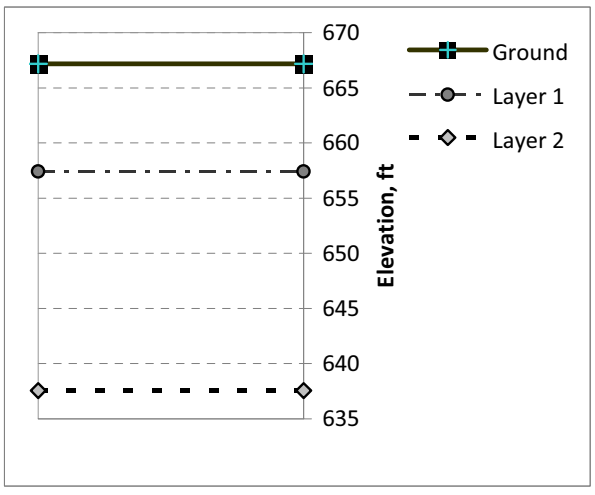
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	667.2		
NAD1983	Coordinates:	**Easting:**	2405071.0		
PA State Plane	Eastern	**Northing:**	339129.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1300.0			"V0_1	0.205
X_critical 1 ------->		24.0			
Layer 1 thickness			9.8		
V1, Layer 2 -------->	6400.0			"V0_2	0.086
X_critical 2 -------->		65.0			0.814
Layer 2 thickness			19.8		
V2, Layer 3 -------->	15200.0			"V1_2	0.435
				k 0.911	0.638

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.8	657.4
Layer 3 ---------->	29.6	637.6





Prepared by: _____ Date: _____

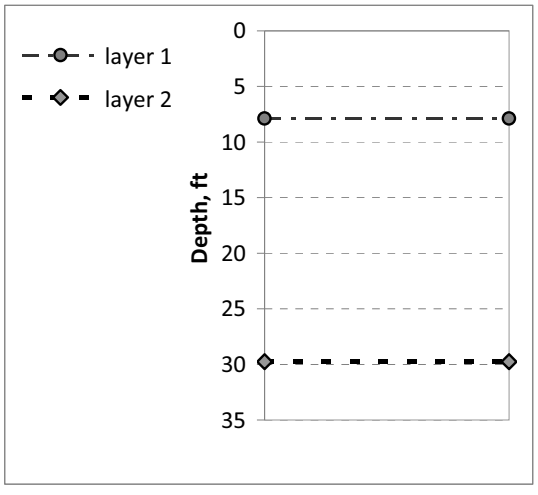
Reviewed by: _____ Date: _____

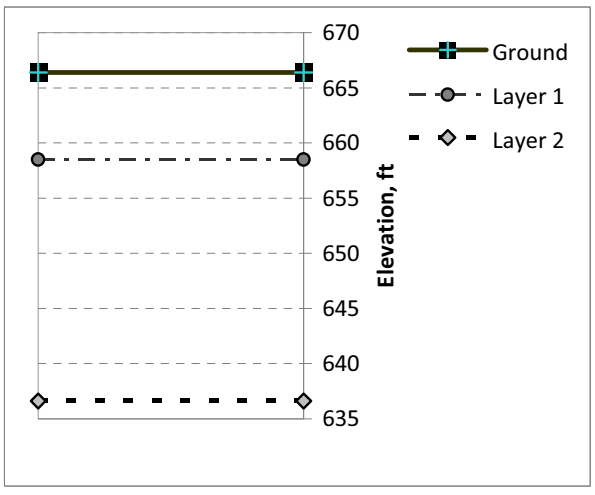
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-12		
		Elevation, ft:	666.4		
NAD1983	Coordinates:	**Easting:**	2405135.5		
PA State Plane	Eastern	**Northing:**	339139.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.236
X_critical 1 ------->		20.0			
Layer 1 thickness			7.9		
V1, Layer 2 -------->	6000.0			"V0_2	0.089
X_critical 2 -------->		68.0			0.788
Layer 2 thickness			21.9		
V2, Layer 3 -------->	15700.0			"V1_2	0.392
				k 0.864	0.669

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.9	658.5
Layer 3 ---------->	29.8	636.6





Prepared by: _____ Date: _____

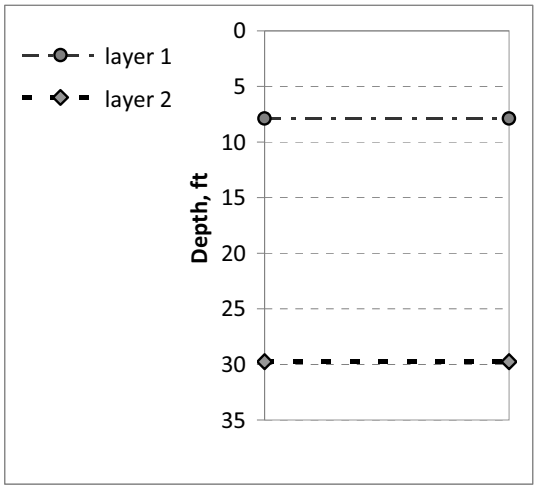
Reviewed by: _____ Date: _____

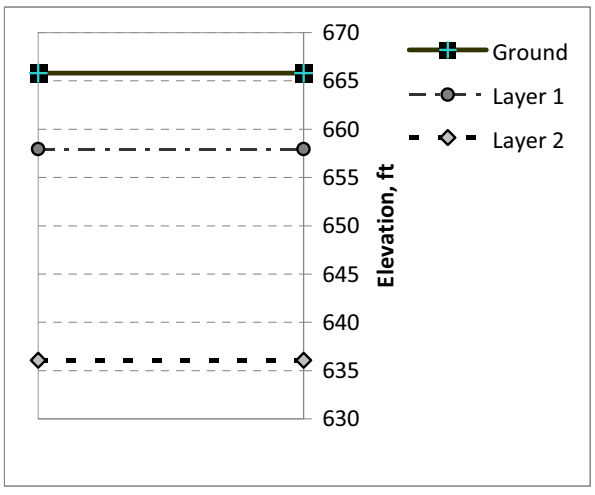
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	665.8		
NAD1983	Coordinates:	**Easting:**	2405185.7		
PA State Plane	Eastern	**Northing:**	339141.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.236
X_critical 1 ------->		20.0			
Layer 1 thickness			7.9		
V1, Layer 2 -------->	6000.0			"V0_2	0.089
X_critical 2 -------->		68.0			0.788
Layer 2 thickness			21.9		
V2, Layer 3 -------->	15700.0			"V1_2	0.392
				k 0.864	0.669

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	7.9	657.9	
Layer 3 ---------->	29.8	636.1	

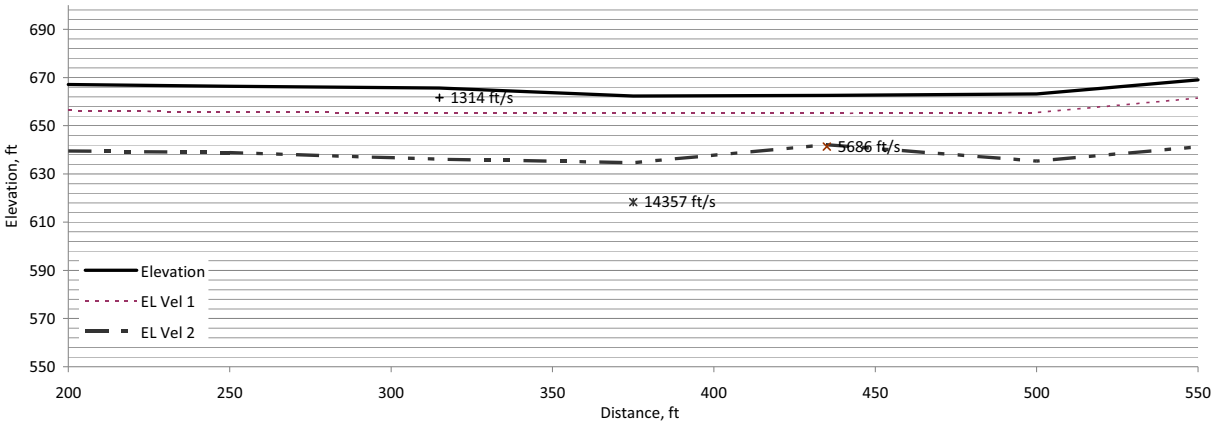




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

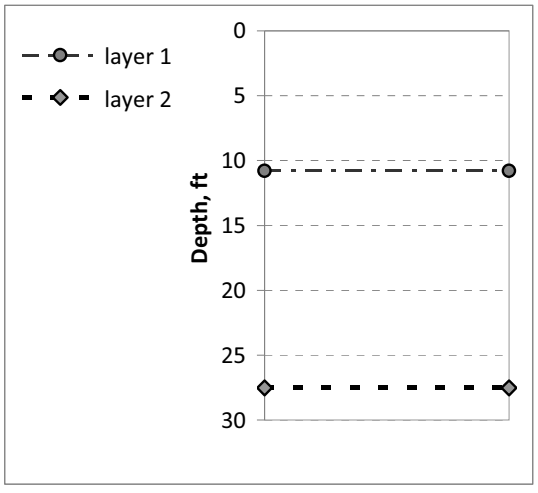
Approved by: _____ Date: _____

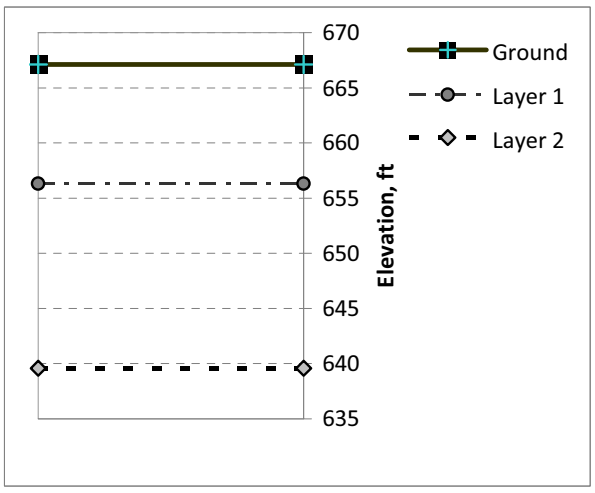

690
670
650
630
610
590
570
550
200
250
300
350
400
450
500
550
Elevation, ft
Distance, ft
1314 ft/s
5686 ft/s
14357 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	B	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	667.1		
NAD1983	Coordinates:	**Easting:**	2405085.9		
PA State Plane	Eastern	**Northing:**	339131.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.257
X_critical 1 ------->		28.0			
Layer 1 thickness			**10.8**		
V1, Layer 2 -------->	5500.0			"V0_2	0.093
X_critical 2 -------->		53.0			0.771
Layer 2 thickness			**16.7**		
V2, Layer 3 -------->	15000.0			"V1_2	0.375
				k 1.302	0.681

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ---------->	**10.8**	**656.3**
Layer 3 ---------->	**27.5**	**639.6**





Prepared by: _____ Date: _____

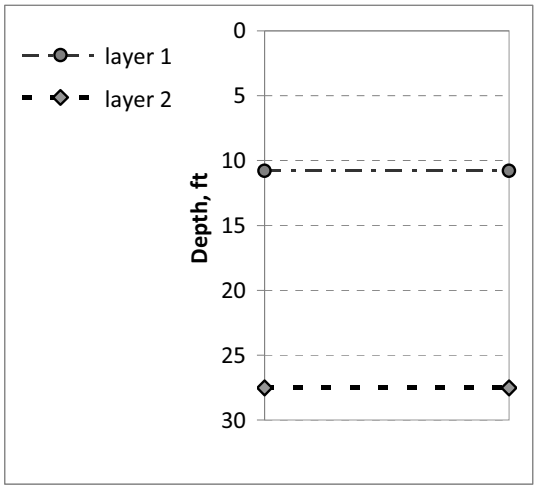
Reviewed by: _____ Date: _____

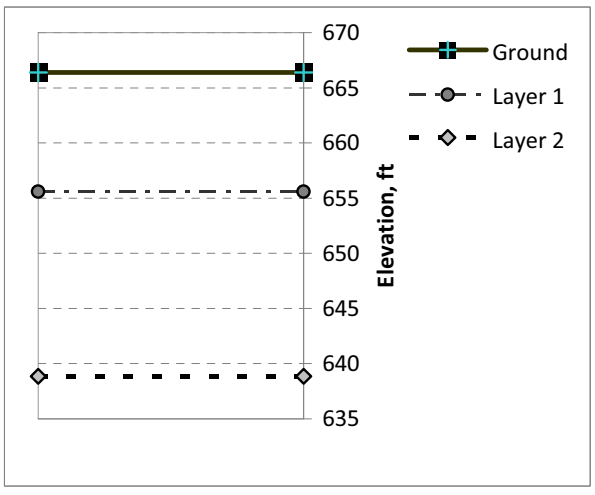
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	11		
		Elevation, ft:	666.4		
NAD1983	Coordinates:	**Easting:**	2405135.5		
PA State Plane	Eastern	**Northing:**	339139.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.257
X_critical 1 ------->		28.0			
Layer 1 thickness			10.8		
V1, Layer 2 -------->	5500.0			"V0_2	0.093
X_critical 2 -------->		53.0			0.771
Layer 2 thickness			16.7		
V2, Layer 3 -------->	15000.0			"V1_2	0.375
				k 1.302	0.681

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.8	655.6
Layer 3 ---------->	27.5	638.9





Prepared by: _____ Date: _____

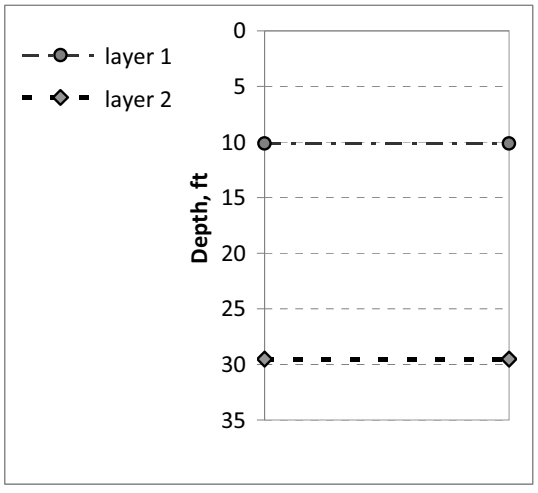
Reviewed by: _____ Date: _____

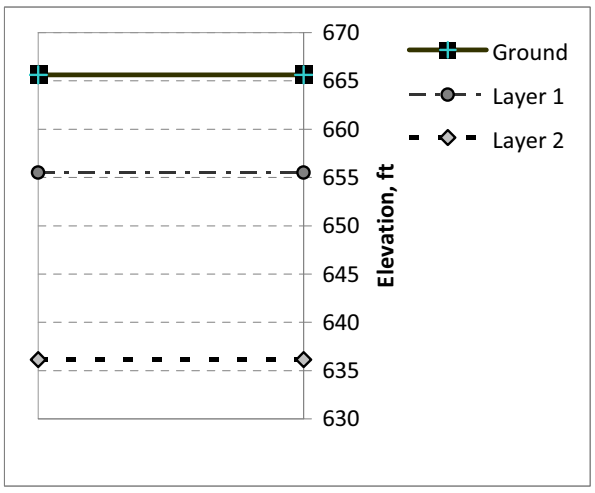
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	18		
		Elevation, ft:	665.6		
NAD1983	Coordinates:	**Easting:**	2405200.7		
PA State Plane	Eastern	**Northing:**	339141.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.207
X_critical 1 ------->		25.0			
Layer 1 thickness			10.1		
V1, Layer 2 -------->	6800.0			"V0_2	0.117
X_critical 2 -------->		77.0			0.812
Layer 2 thickness			19.4		
V2, Layer 3 -------->	12000.0			"V1_2	0.602
				k 0.873	0.526

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.1	655.5
Layer 3 ---------->	29.5	636.1





Prepared by: _____ Date: _____

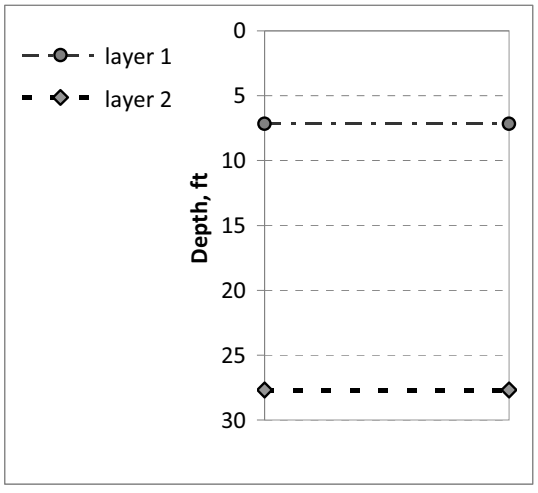
Reviewed by: _____ Date: _____

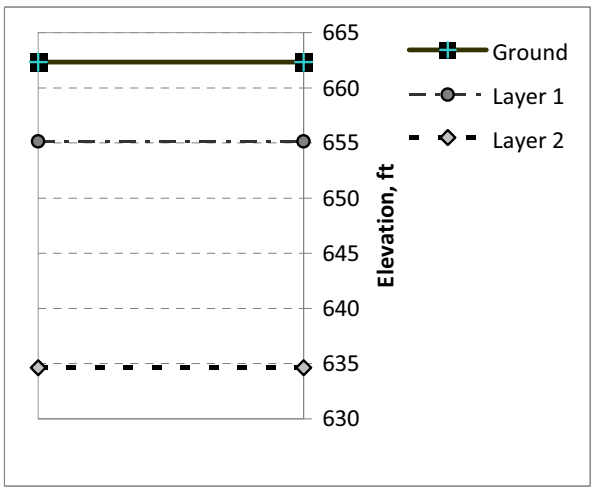
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	662.3		
NAD1983	Coordinates:	**Easting:**	2405261.0		
PA State Plane	Eastern	**Northing:**	339144.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		17.5			
Layer 1 thickness			7.2		
V1, Layer 2 -------->	5600.0			"V0_2	0.077
X_critical 2 -------->		64.0			0.820
Layer 2 thickness			20.5		
V2, Layer 3 -------->	14300.0			"V1_2	0.402
				k 0.655	0.661

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.2	655.1
Layer 3 ---------->	27.7	634.6





Prepared by: _____ Date: _____

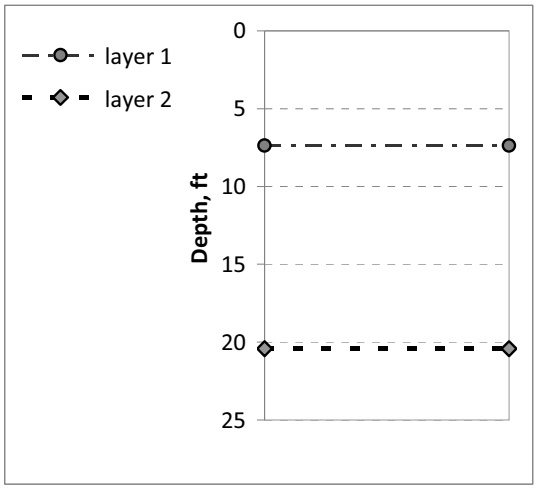
Reviewed by: _____ Date: _____

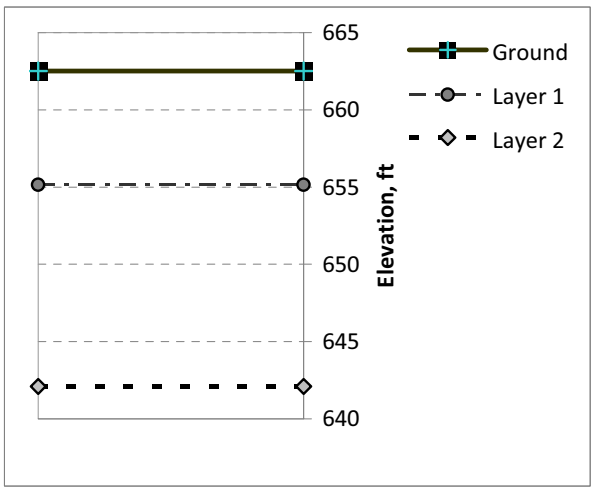
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-10		
		Elevation, ft:	662.5		
NAD1983	Coordinates:	**Easting:**	2405321.3		
PA State Plane	Eastern	**Northing:**	339146.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		18.0			
Layer 1 thickness			7.4		
V1, Layer 2 -------->	5600.0			"V0_2	0.090
X_critical 2 -------->		45.0			0.820
Layer 2 thickness			13.0		
V2, Layer 3 -------->	12200.0			"V1_2	0.477
				k 0.651	0.609

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.4	655.2
Layer 3 ---------->	20.4	642.1





Prepared by: _____ Date: _____

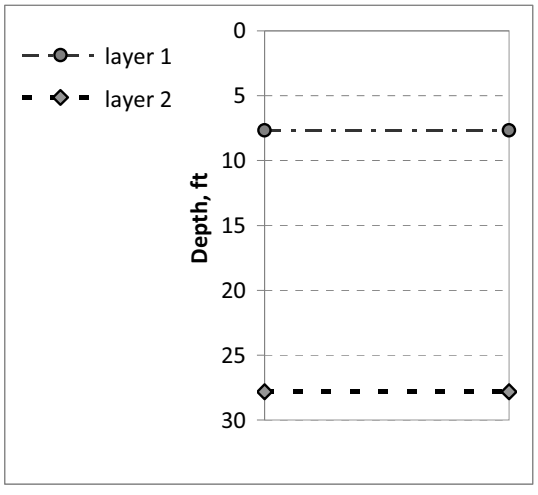
Reviewed by: _____ Date: _____

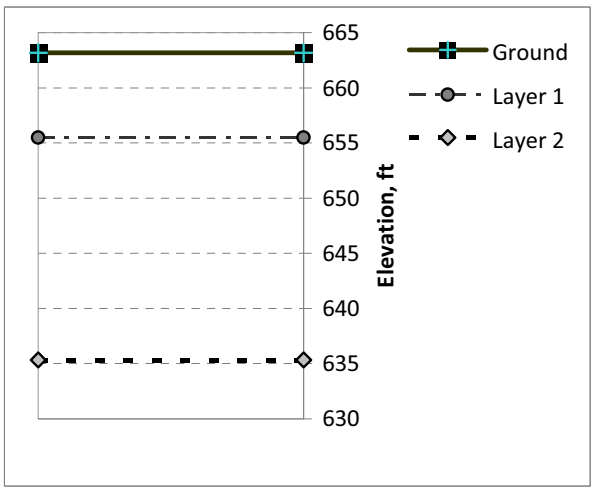
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	663.2		
NAD1983	Coordinates:	**Easting:**	2405386.5		
PA State Plane	Eastern	**Northing:**	339148.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.262
X_critical 1 ------->		20.0			
Layer 1 thickness			7.7		
V1, Layer 2 -------->	5400.0			"V0_2	0.088
X_critical 2 -------->		60.0			0.767
Layer 2 thickness			20.2		
V2, Layer 3 -------->	16000.0			"V1_2	0.344
				k 0.954	0.704

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.7	655.5
Layer 3 ---------->	27.8	635.3





Prepared by: _____ Date: _____

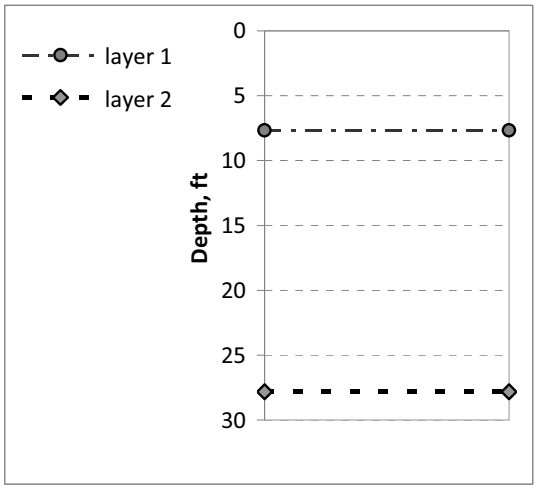
Reviewed by: _____ Date: _____

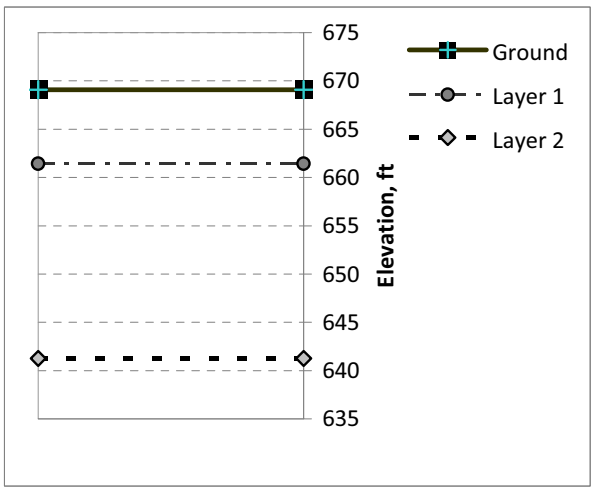
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	669.1		
NAD1983	Coordinates:	**Easting:**	2405436.3		
PA State Plane	Eastern	**Northing:**	339153.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.262
X_critical 1 ------->		20.0			
Layer 1 thickness			7.7		
V1, Layer 2 -------->	5400.0			"V0_2	0.088
X_critical 2 -------->		60.0			0.767
Layer 2 thickness			20.2		
V2, Layer 3 -------->	16000.0			"V1_2	0.344
				k 0.954	0.704

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**7.7**	**661.4**
Layer 3 ----------->	**27.8**	**641.3**

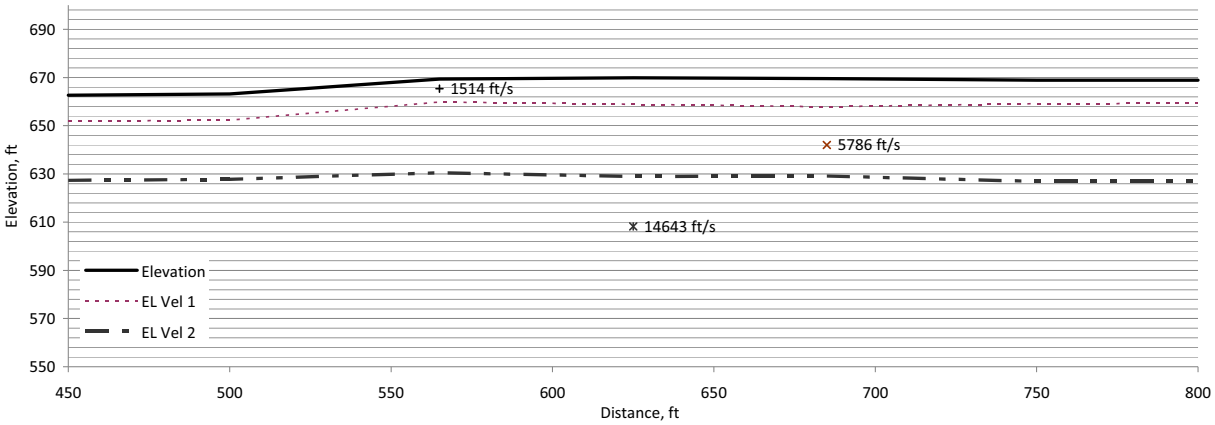




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

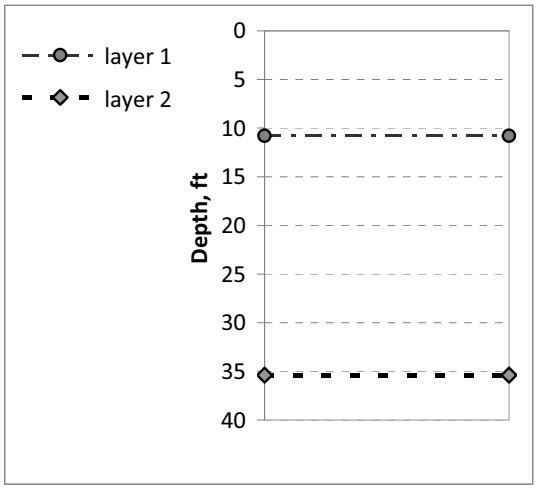
Approved by: _____ Date: _____

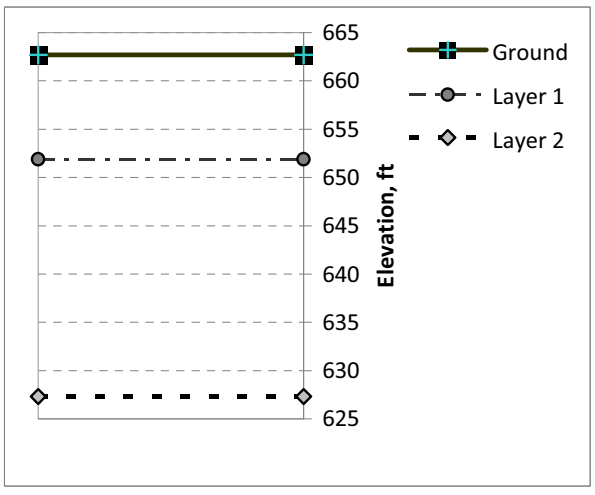

690
670
650
630
610
590
570
550
Elevation, ft
450
500
550
600
650
700
750
800
Distance, ft
1514 ft/s
5786 ft/s
14643 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	B	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	450	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	662.7		
NAD1983	Coordinates:	**Easting:**	2405336.3		
PA State Plane	Eastern	**Northing:**	339147.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.257
X_critical 1 ------->		28.0			
Layer 1 thickness			**10.8**		
V1, Layer 2 -------->	5500.0			"V0_2	0.105
X_critical 2 -------->		80.0			0.771
Layer 2 thickness			**24.6**		
V2, Layer 3 -------->	13400.0			"V1_2	0.423
				k 1.277	0.647

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**10.8**	**651.9**
Layer 3 ---------->	**35.4**	**627.3**





Prepared by: _____ Date: _____

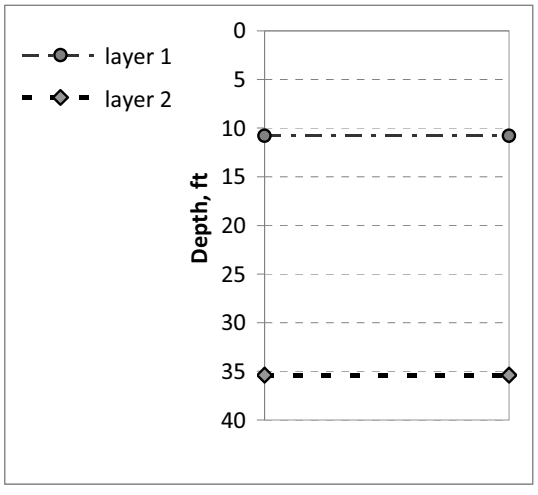
Reviewed by: _____ Date: _____

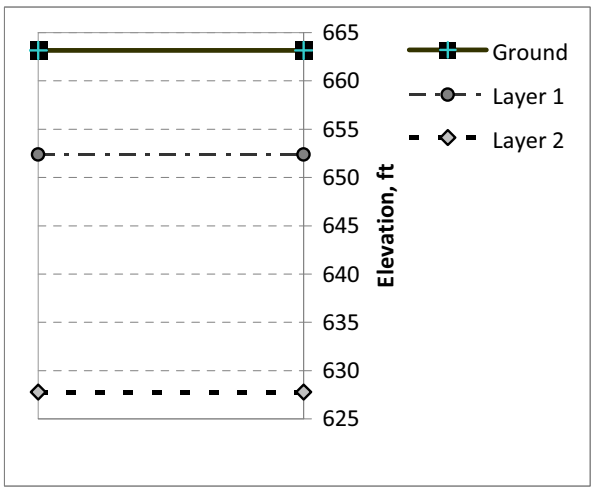
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	15		
		Elevation, ft:	663.2		
NAD1983	Coordinates:	**Easting:**	2405386.5		
PA State Plane	Eastern	**Northing:**	339148.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.257
X_critical 1 ------->		28.0			
Layer 1 thickness			10.8		
V1, Layer 2 -------->	5500.0			"V0_2	0.105
X_critical 2 -------->		80.0			0.771
Layer 2 thickness			24.6		
V2, Layer 3 -------->	13400.0			"V1_2	0.423
				k 1.277	0.647

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.8	652.4
Layer 3 ---------->	35.4	627.8





Prepared by: _____ Date: _____

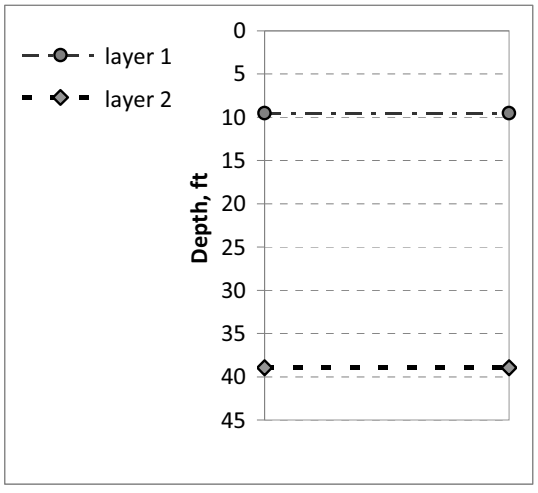
Reviewed by: _____ Date: _____

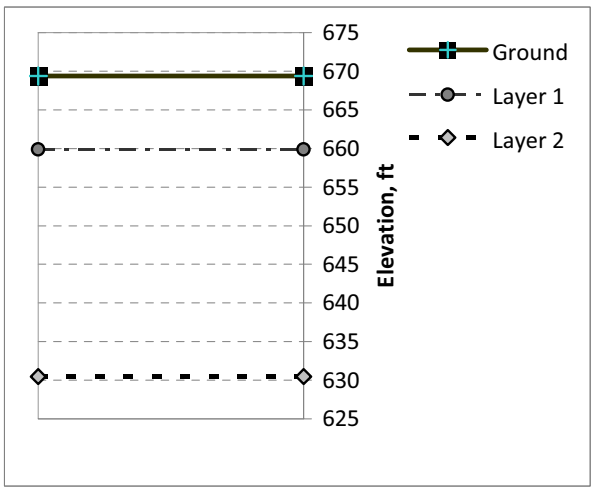
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	565	**Location:**	Berwick
		Depth Offset, ft:	19		
		Elevation, ft:	669.4		
NAD1983	Coordinates:	**Easting:**	2405451.2		
PA State Plane	Eastern	**Northing:**	339154.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.228
X_critical 1 ------->		24.0			
Layer 1 thickness			9.5		
V1, Layer 2 -------->	6200.0			"V0_2	0.110
X_critical 2 -------->		103.0			0.795
Layer 2 thickness			29.4		
V2, Layer 3 -------->	12800.0			"V1_2	0.506
				k 0.957	0.589

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.5	659.9
Layer 3 ---------->	38.9	630.5





Prepared by: _____ Date: _____

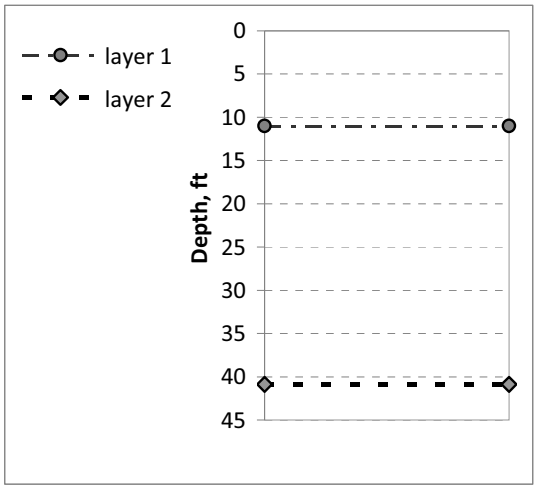
Reviewed by: _____ Date: _____

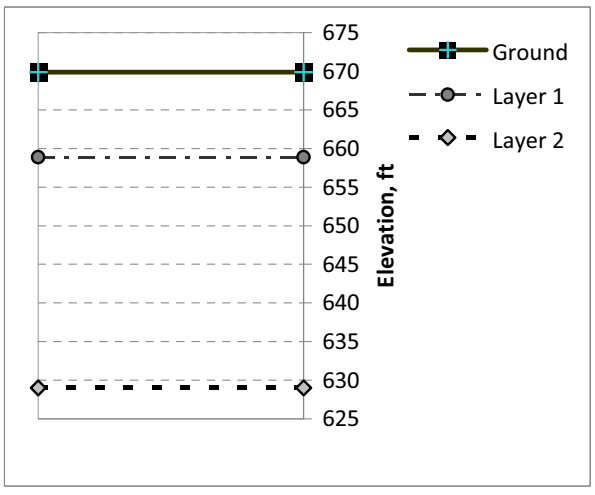
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	625	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	669.9		
NAD1983	Coordinates:	**Easting:**	2405510.9		
PA State Plane	Eastern	**Northing:**	339159.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	2000.0			"V0_1	0.365
X_critical 1 ------->		32.0			
Layer 1 thickness			11.0		
V1, Layer 2 -------->	5600.0			"V0_2	0.140
X_critical 2 -------->		96.0			0.688
Layer 2 thickness			29.9		
V2, Layer 3 -------->	14300.0			"V1_2	0.402
				k 1.881	0.661

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ----------->	**11.0**	**658.9**	
Layer 3 ----------->	**40.9**	**629.0**	





Prepared by: _____ Date: _____

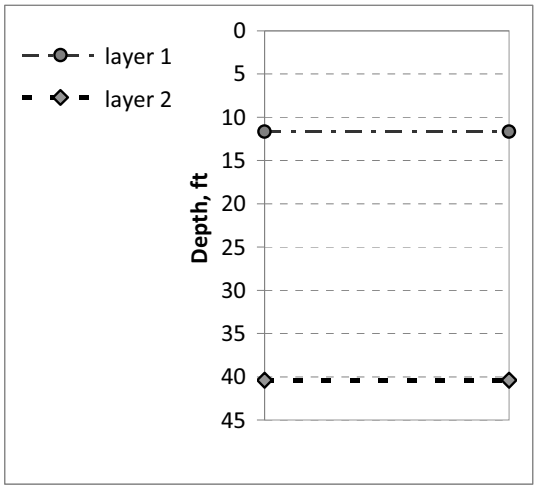
Reviewed by: _____ Date: _____

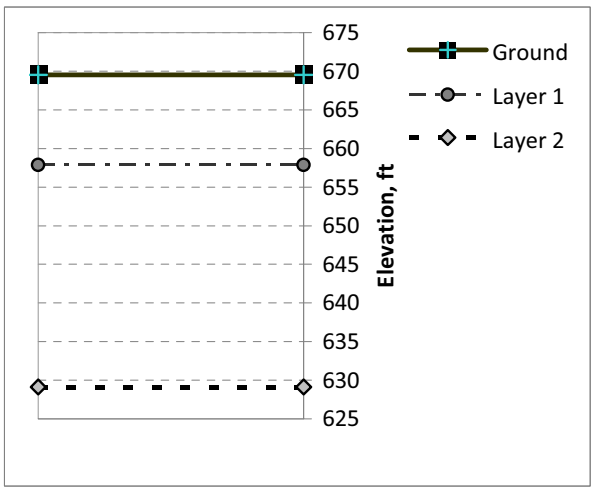
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	685	**Location:**	Berwick
		Depth Offset, ft:	-19		
		Elevation, ft:	669.5		
NAD1983	Coordinates:	**Easting:**	2405570.6		
PA State Plane	Eastern	**Northing:**	339164.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1600.0			"V0_1	0.249
X_critical 1 ------->		30.0			
Layer 1 thickness			**11.7**		
V1, Layer 2 -------->	6500.0			"V0_2	0.110
X_critical 2 -------->		97.0			0.778
Layer 2 thickness			**28.7**		
V2, Layer 3 -------->	14600.0			"V1_2	0.461
				k 1.310	0.620

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**11.7**	**657.9**
Layer 3 ---------->	**40.4**	**629.1**





Prepared by: _____ Date: _____

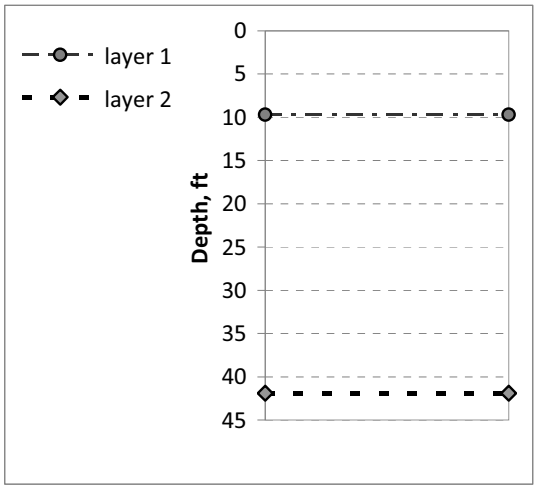
Reviewed by: _____ Date: _____

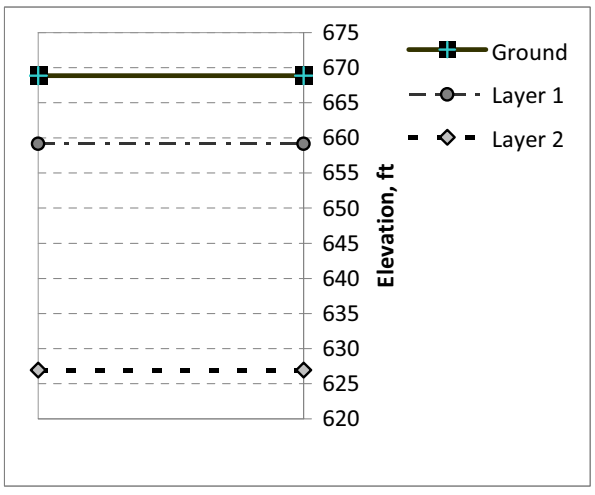
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	-15		
		Elevation, ft:	668.8		
NAD1983	Coordinates:	**Easting:**	2405635.3		
PA State Plane	Eastern	**Northing:**	339169.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.253
X_critical 1 ------->		25.0			
Layer 1 thickness			9.7		
V1, Layer 2 -------->	5600.0			"V0_2	0.082
X_critical 2 -------->		94.0			0.775
Layer 2 thickness			32.2		
V2, Layer 3 -------->	17000.0			"V1_2	0.336
				k 1.163	0.710

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.7	659.2
Layer 3 ---------->	41.9	626.9





Prepared by: _____ Date: _____

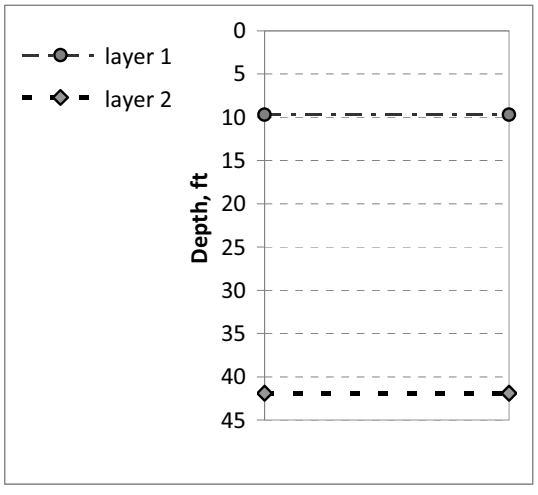
Reviewed by: _____ Date: _____

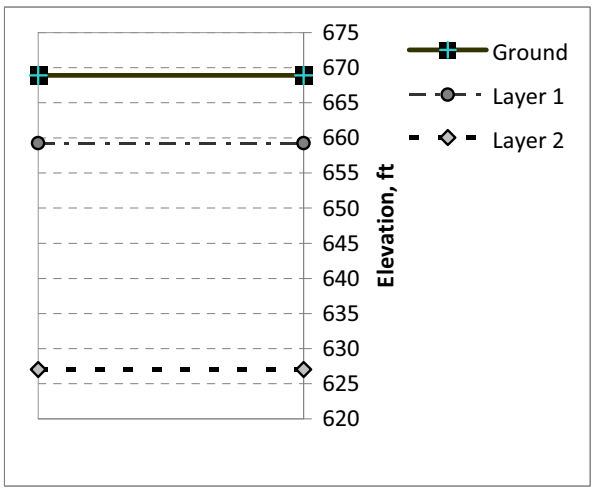
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	800	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.9		
NAD1983	Coordinates:	**Easting:**	2405685.2		
PA State Plane	Eastern	**Northing:**	339175.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.253
X_critical 1 ------->		25.0			
Layer 1 thickness			9.7		
V1, Layer 2 -------->	5600.0			"V0_2	0.082
X_critical 2 -------->		94.0			0.775
Layer 2 thickness			32.2		
V2, Layer 3 -------->	17000.0			"V1_2	0.336
				k 1.163	0.710

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.7	659.2
Layer 3 ---------->	41.9	627.0

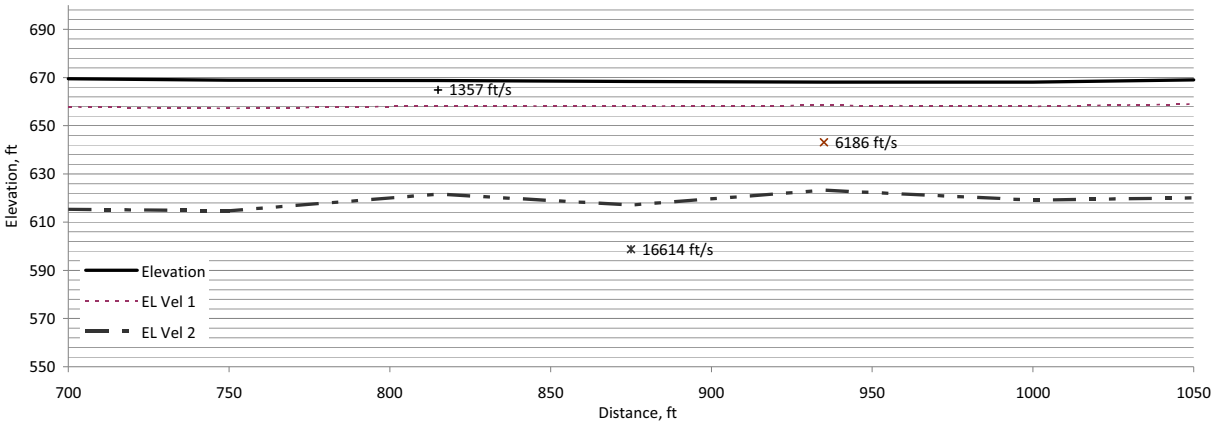




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

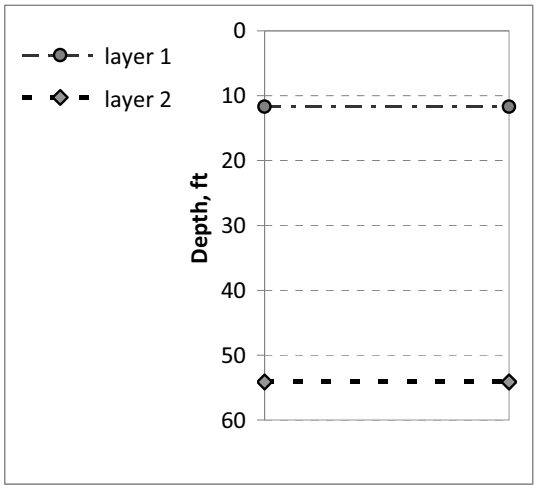
Approved by: _____ Date: _____

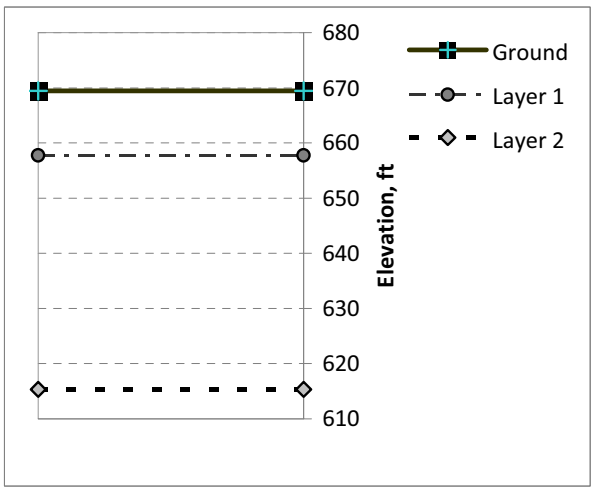

690
670
650
630
610
590
570
550
Elevation, ft
1357 ft/s
6186 ft/s
16614 ft/s
Elevation
EL Vel 1
EL Vel 2
700
750
800
850
900
950
1000
1050
Distance, ft

Line No.:	B	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	700	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	669.5		
NAD1983	Coordinates:	**Easting:**	2405585.5		
PA State Plane	Eastern	**Northing:**	339165.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.214
X_critical 1 ------->		29.0			
Layer 1 thickness			**11.7**		
V1, Layer 2 -------->	6600.0			"V0_2	0.081
X_critical 2 -------->		130.0			0.806
Layer 2 thickness			**42.4**		
V2, Layer 3 -------->	17400.0			"V1_2	0.389
				k 1.162	0.671

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**11.7**	**657.8**
Layer 3 ---------->	**54.1**	**615.3**





Prepared by: _____ Date: _____

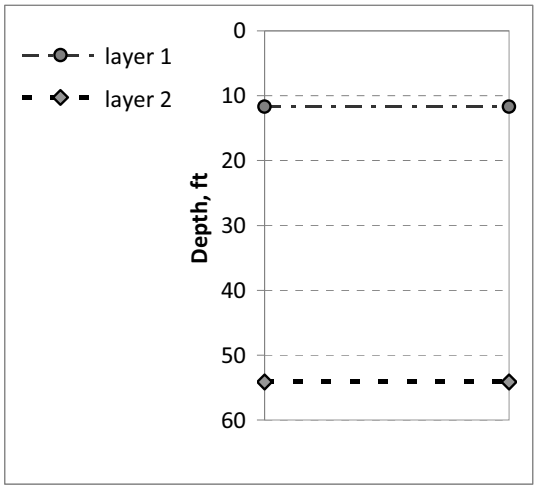
Reviewed by: _____ Date: _____

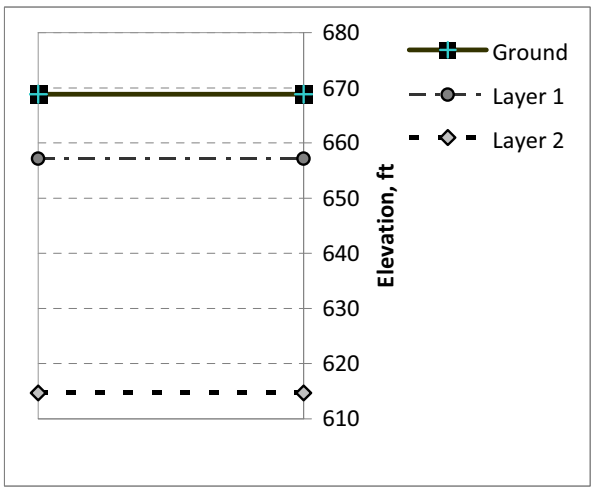
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	22		
		Elevation, ft:	668.8		
NAD1983	Coordinates:	**Easting:**	2405635.3		
PA State Plane	Eastern	**Northing:**	339169.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.214
X_critical 1 ------->		29.0			
Layer 1 thickness			11.7		
V1, Layer 2 -------->	6600.0			"V0_2	0.081
X_critical 2 -------->		130.0			0.806
Layer 2 thickness			42.4		
V2, Layer 3 -------->	17400.0			"V1_2	0.389
				k 1.162	0.671

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	11.7	657.1
Layer 3 ---------->	54.1	614.7





Prepared by: _____ Date: _____

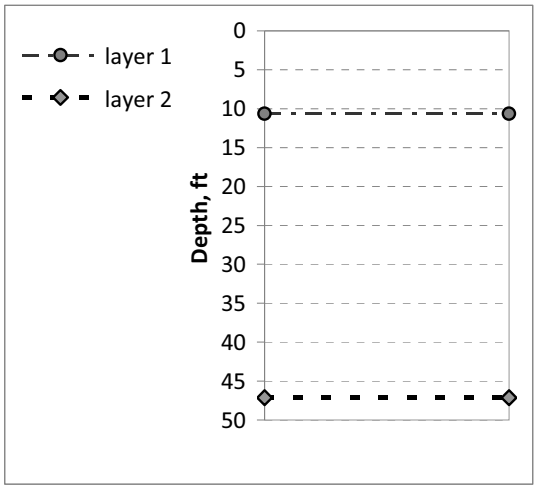
Reviewed by: _____ Date: _____

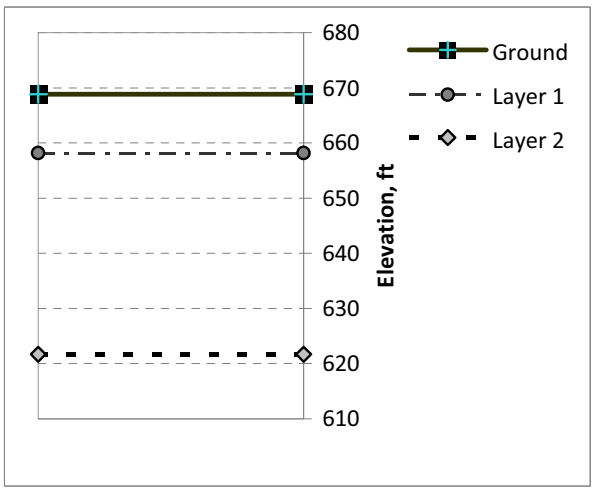
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	815	**Location:**	Berwick
		Depth Offset, ft:	19		
		Elevation, ft:	668.8		
NAD1983	Coordinates:	**Easting:**	2405700.2		
PA State Plane	Eastern	**Northing:**	339176.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.236
X_critical 1 ------->		27.0			
Layer 1 thickness			**10.6**		
V1, Layer 2 -------->	6000.0			"V0_2	0.082
X_critical 2 -------->		109.0			0.788
Layer 2 thickness			**36.5**		
V2, Layer 3 -------->	17000.0			"V1_2	0.361
				k 1.180	0.692

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**10.6**	**658.2**
Layer 3 ---------->	**47.2**	**621.7**





Prepared by: _____ Date: _____

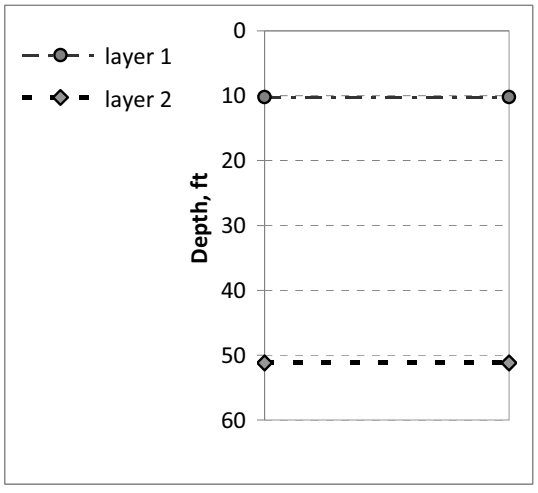
Reviewed by: _____ Date: _____

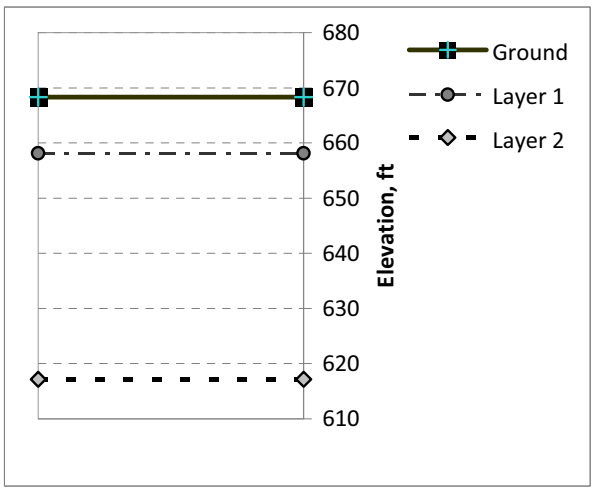
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	875	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.3		
NAD1983	Coordinates:	**Easting:**	2405760.2		
PA State Plane	Eastern	**Northing:**	339182.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.181
X_critical 1 ------->		24.5			
Layer 1 thickness			10.2		
V1, Layer 2 -------->	6100.0			"V0_2	0.069
X_critical 2 -------->		125.0			0.833
Layer 2 thickness			41.0		
V2, Layer 3 -------->	16000.0			"V1_2	0.391
				k 0.859	0.669

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.2	658.1
Layer 3 ---------->	51.2	617.1





Prepared by: _____ Date: _____

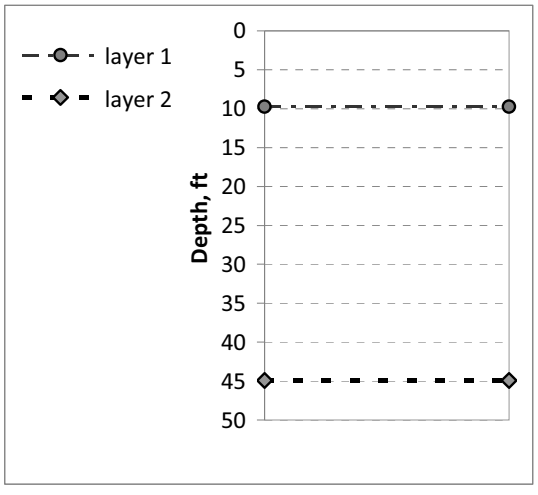
Reviewed by: _____ Date: _____

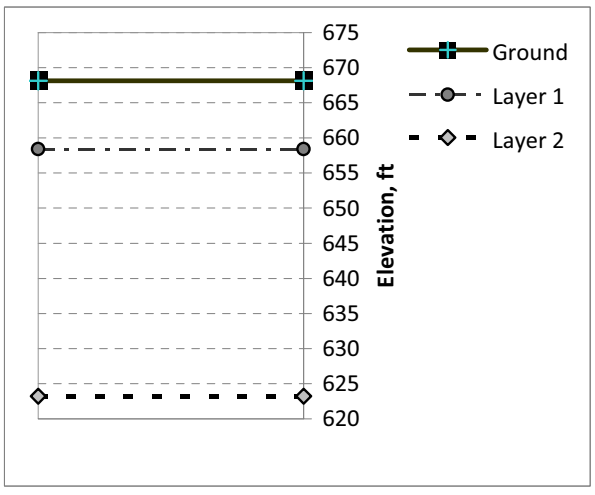
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	935	**Location:**	Berwick
		Depth Offset, ft:	-22		
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405820.2		
PA State Plane	Eastern	**Northing:**	339189.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.207
X_critical 1 ------->		24.0			
Layer 1 thickness			9.7		
V1, Layer 2 -------->	6800.0			"V0_2	0.097
X_critical 2 -------->		120.0			0.812
Layer 2 thickness			35.2		
V2, Layer 3 -------->	14500.0			"V1_2	0.488
				k 0.897	0.601

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.7	658.4
Layer 3 ---------->	44.9	623.2





Prepared by: _____ Date: _____

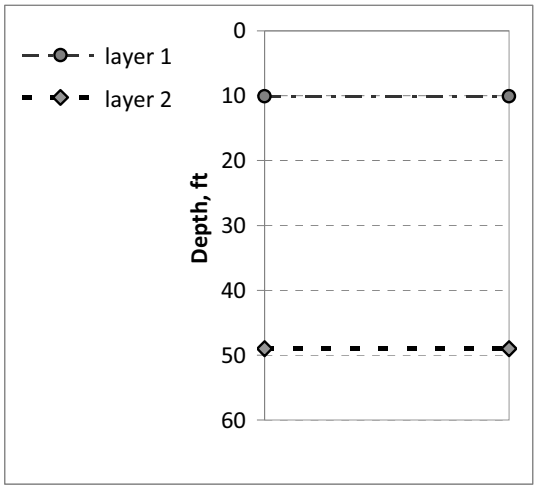
Reviewed by: _____ Date: _____

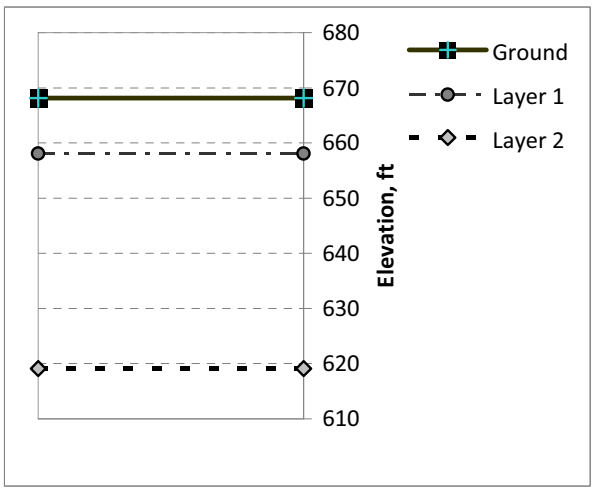
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	1000	**Location:**	Berwick
		Depth Offset, ft:	-17		
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405885.1		
PA State Plane	Eastern	**Northing:**	339195.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.253
X_critical 1 ------->		26.0			
Layer 1 thickness			10.1		
V1, Layer 2 -------->	5600.0			"V0_2	0.082
X_critical 2 -------->		113.0			0.775
Layer 2 thickness			38.9		
V2, Layer 3 -------->	17000.0			"V1_2	0.336
				k 1.210	0.710

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.1	658.1
Layer 3 ---------->	49.0	619.1





Prepared by: _____ Date: _____

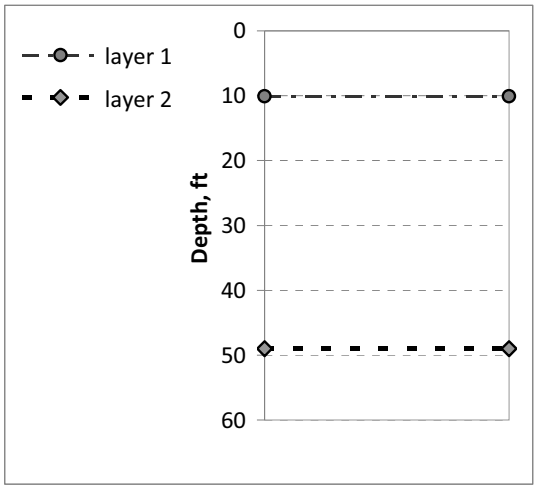
Reviewed by: _____ Date: _____

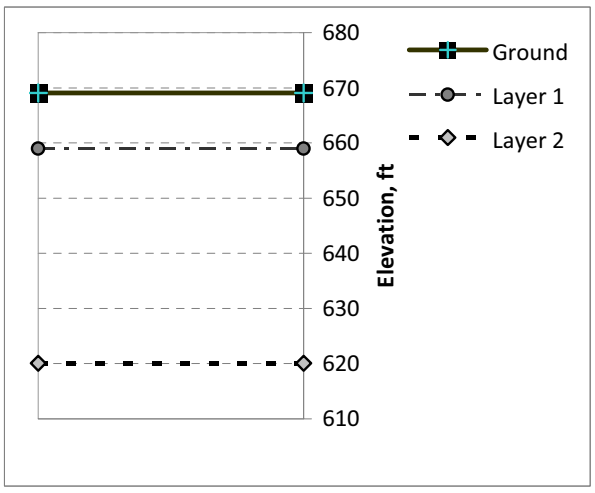
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	1050	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	669.0		
NAD1983	Coordinates:	**Easting:**	2405934.6		
PA State Plane	Eastern	**Northing:**	339200.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.253
X_critical 1 ------->		26.0			
Layer 1 thickness			**10.1**		
V1, Layer 2 -------->	5600.0			"V0_2	0.082
X_critical 2 -------->		113.0			0.775
Layer 2 thickness			**38.9**		
V2, Layer 3 -------->	17000.0			"V1_2	0.336
				k 1.210	0.710

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**10.1**	**659.0**
Layer 3 ----------->	**49.0**	**620.1**

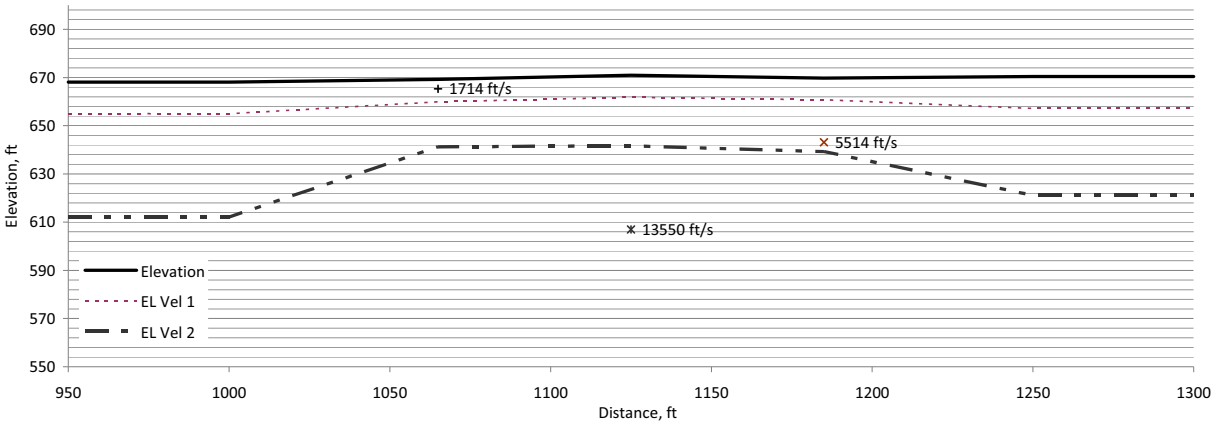




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

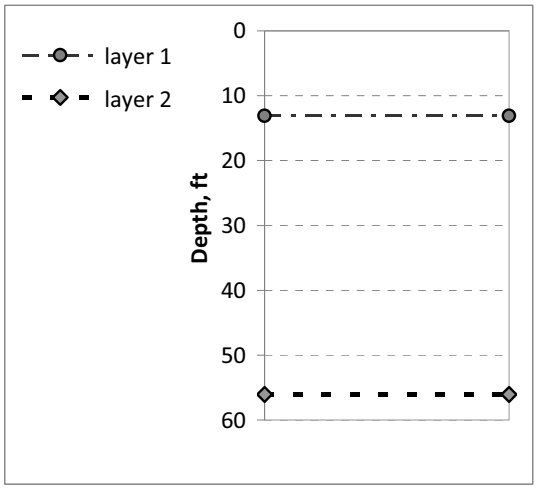
Approved by: _____ Date: _____

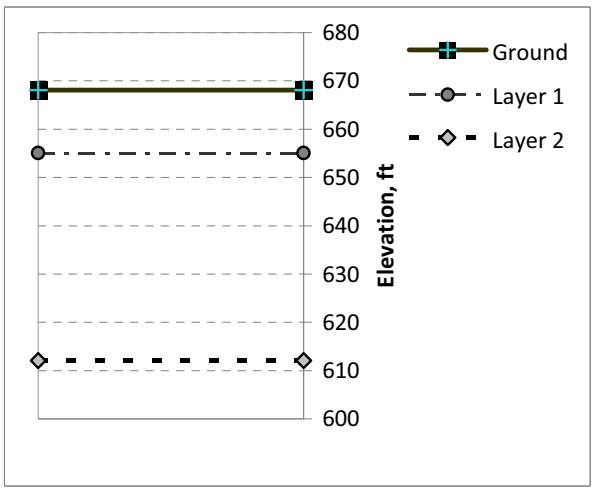

690
670
650
630
610
590
570
550
Elevation, ft
950
1000
1050
1100
1150
1200
1250
1300
Distance, ft
1714 ft/s
5514 ft/s
13550 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	B	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	950	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405835.2		
PA State Plane	Eastern	**Northing:**	339190.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.228
X_critical 1 ------->		33.0			
Layer 1 thickness			**13.1**		
V1, Layer 2 -------->	6200.0			"V0_2	0.078
X_critical 2 -------->		127.0			0.795
Layer 2 thickness			**42.9**		
V2, Layer 3 -------->	18000.0			"V1_2	0.352
				k 1.410	0.698

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**13.1**	**655.0**
Layer 3 ---------->	**56.0**	**612.1**





Prepared by: _____ Date: _____

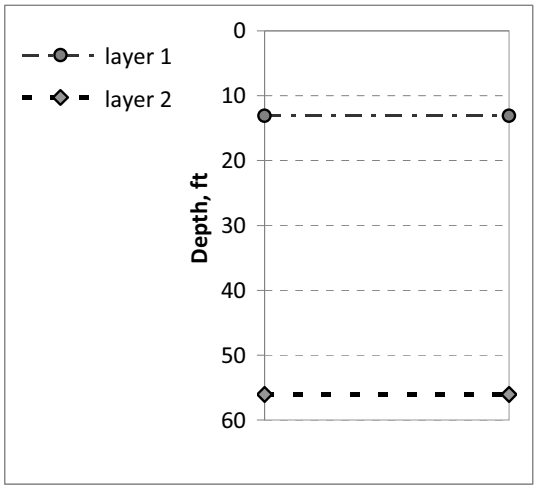
Reviewed by: _____ Date: _____

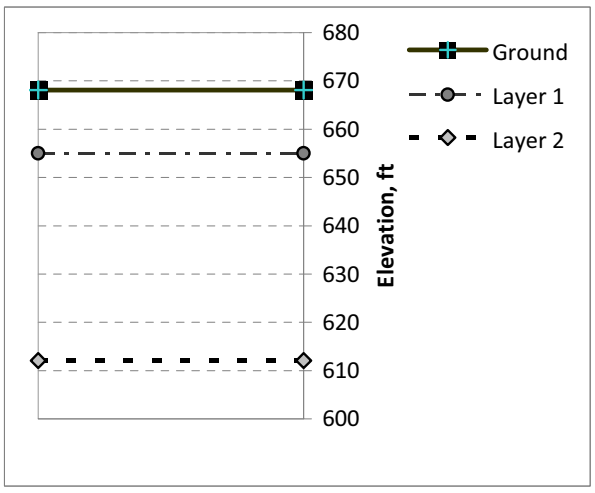
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1000	**Location:**	Berwick
		Depth Offset, ft:	20		
		Elevation, ft:	668.1		
NAD1983	Coordinates:	**Easting:**	2405885.1		
PA State Plane	Eastern	**Northing:**	339195.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.228
X_critical 1 ------->		33.0			
Layer 1 thickness			13.1		
V1, Layer 2 -------->	6200.0			"V0_2	0.078
X_critical 2 -------->		127.0			0.795
Layer 2 thickness			42.9		
V2, Layer 3 -------->	18000.0			"V1_2	0.352
				k 1.410	0.698

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	13.1	655.0
Layer 3 ---------->	56.0	612.1





Prepared by: _____ Date: _____

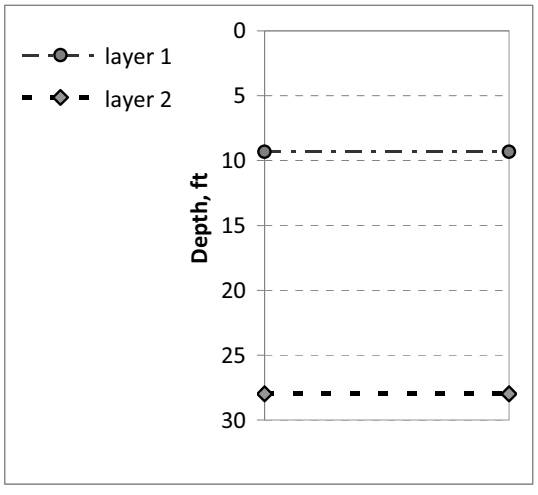
Reviewed by: _____ Date: _____

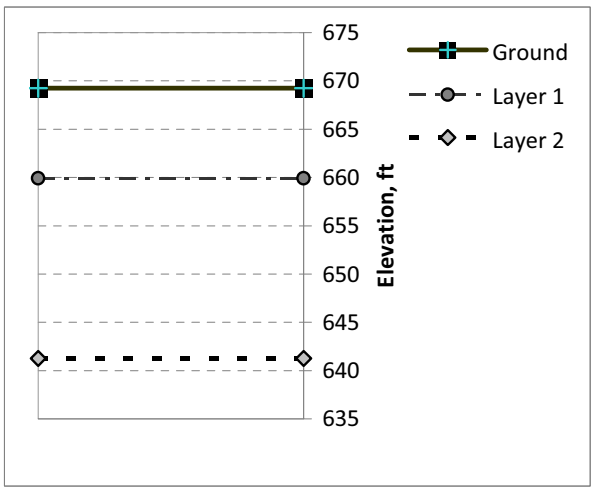
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1065	**Location:**	Berwick
		Depth Offset, ft:	15		
		Elevation, ft:	669.3		
NAD1983	Coordinates:	**Easting:**	2405949.5		
PA State Plane	Eastern	**Northing:**	339201.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1600.0			"V0_1	0.326
X_critical 1 ------->		26.0			
Layer 1 thickness			9.3		
V1, Layer 2 -------->	5000.0			"V0_2	0.156
X_critical 2 -------->		68.0			0.718
Layer 2 thickness			18.7		
V2, Layer 3 -------->	10300.0			"V1_2	0.507
				k 1.349	0.589

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	9.3	659.9	
Layer 3 ---------->	28.0	641.3	





Prepared by: _____ Date: _____

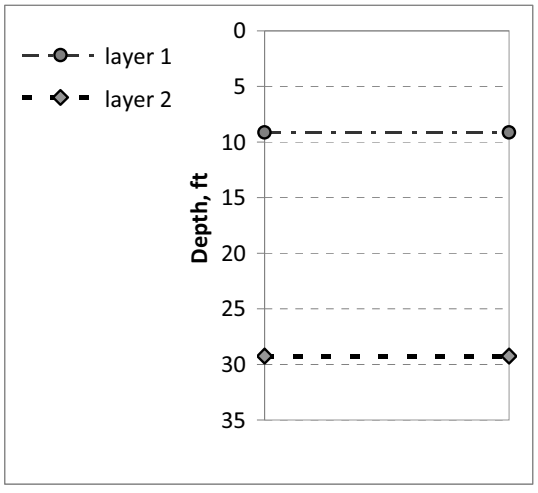
Reviewed by: _____ Date: _____

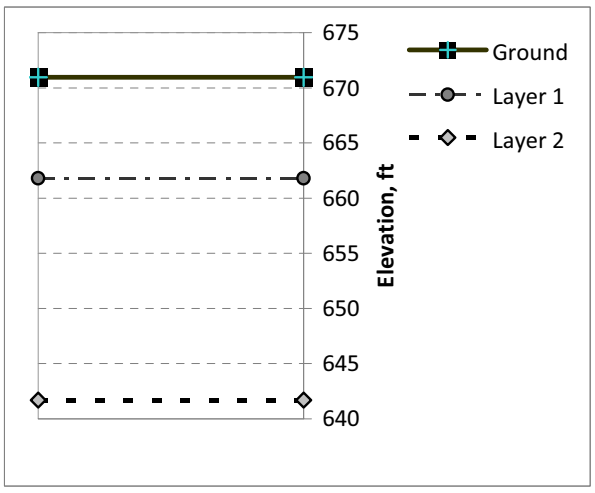
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	671.0		
NAD1983	Coordinates:	**Easting:**	2406008.8		
PA State Plane	Eastern	**Northing:**	339207.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1600.0			"V0_1	0.326
X_critical 1 ------->		25.5			
Layer 1 thickness			9.2		
V1, Layer 2 -------->	5000.0			"V0_2	0.158
X_critical 2 -------->		73.5			0.718
Layer 2 thickness			20.1		
V2, Layer 3 -------->	10150.0			"V1_2	0.515
				k 1.317	0.583

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.2	661.8
Layer 3 ---------->	29.3	641.7





Prepared by: _____ Date: _____

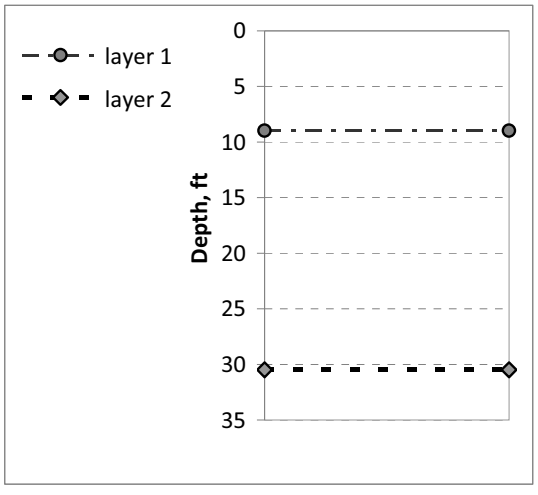
Reviewed by: _____ Date: _____

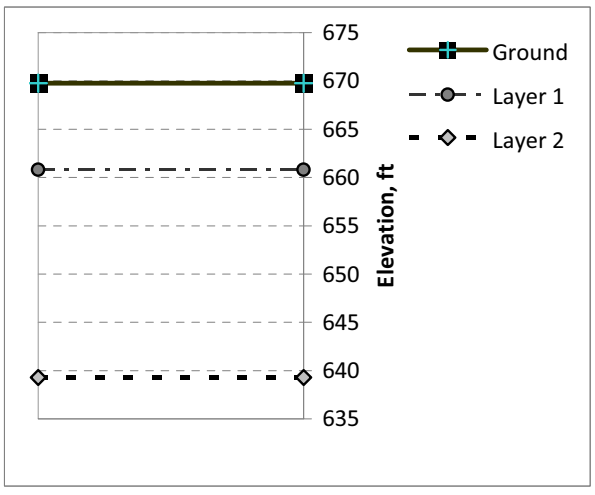
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1185	**Location:**	Berwick
		Depth Offset, ft:	-16		
		Elevation, ft:	669.8		
NAD1983	Coordinates:	**Easting:**	2406068.2		
PA State Plane	Eastern	**Northing:**	339213.2		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1600.0			"V0_1	0.326
X_critical 1 ------->		25.0			
Layer 1 thickness			9.0		
V1, Layer 2 -------->	5000.0			"V0_2	0.161
X_critical 2 -------->		79.0			0.718
Layer 2 thickness			21.5		
V2, Layer 3 -------->	10000.0			"V1_2	0.524
				k 1.285	0.577

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.0	660.8
Layer 3 ---------->	30.5	639.3





Prepared by: _____ Date: _____

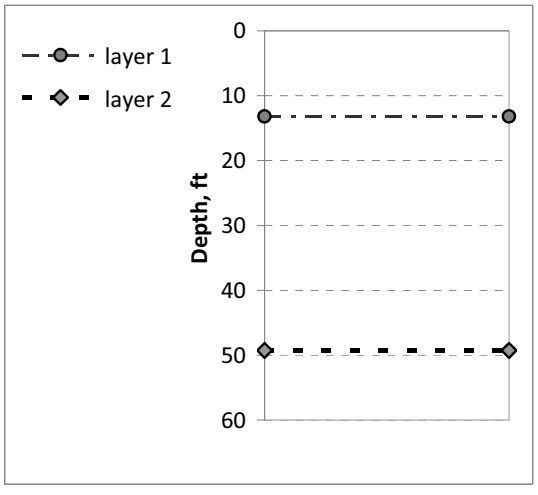
Reviewed by: _____ Date: _____

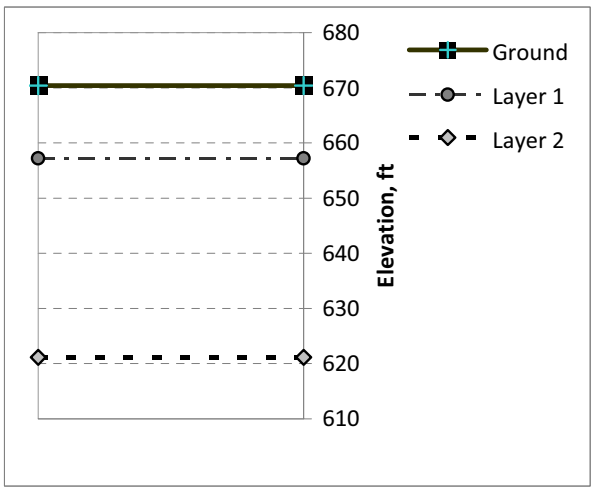
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1250	**Location:**	Berwick
		Depth Offset, ft:	-20		
		Elevation, ft:	670.4		
NAD1983	Coordinates:	**Easting:**	2406132.5		
PA State Plane	Eastern	**Northing:**	339219.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	2200.0			"V0_1	0.404
X_critical 1 ------->		40.0			
Layer 1 thickness			13.2		
V1, Layer 2 -------->	5600.0			"V0_2	0.156
X_critical 2 -------->		117.0			0.660
Layer 2 thickness			36.1		
V2, Layer 3 -------->	14200.0			"V1_2	0.405
				k 2.499	0.659

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	13.2	657.2
Layer 3 ---------->	49.3	621.1





Prepared by: _____ Date: _____

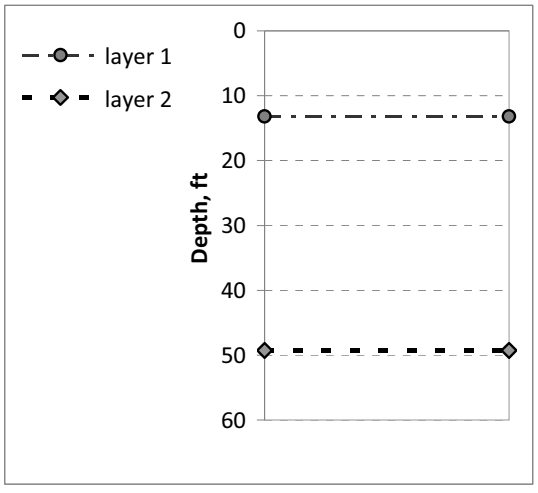
Reviewed by: _____ Date: _____

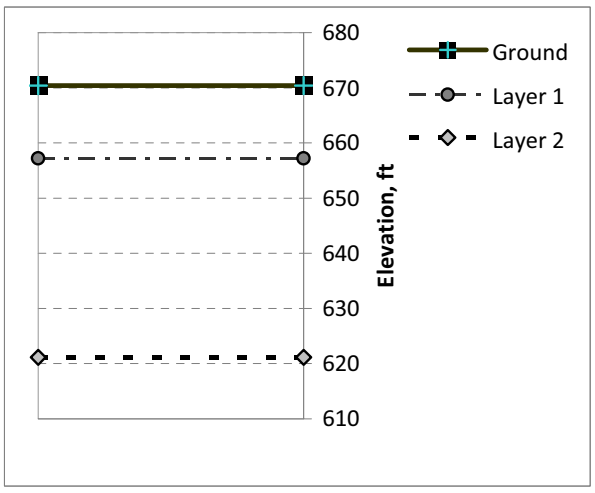
Approved by: _____ Date: _____

Line No.:	B	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1300	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	670.4		
NAD1983	Coordinates:	**Easting:**	2406182.0		
PA State Plane	Eastern	**Northing:**	339224.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	2200.0			"V0_1	0.404
X_critical 1 ------->		40.0			
Layer 1 thickness			**13.2**		
V1, Layer 2 -------->	5600.0			"V0_2	0.156
X_critical 2 -------->		117.0			0.660
Layer 2 thickness			**36.1**		
V2, Layer 3 -------->	14200.0			"V1_2	0.405
				k 2.499	0.659

Output	***Depth, ft***	***Elevation, ft***
Layer 2 ----------->	**13.2**	**657.2**
Layer 3 ----------->	**49.3**	**621.1**

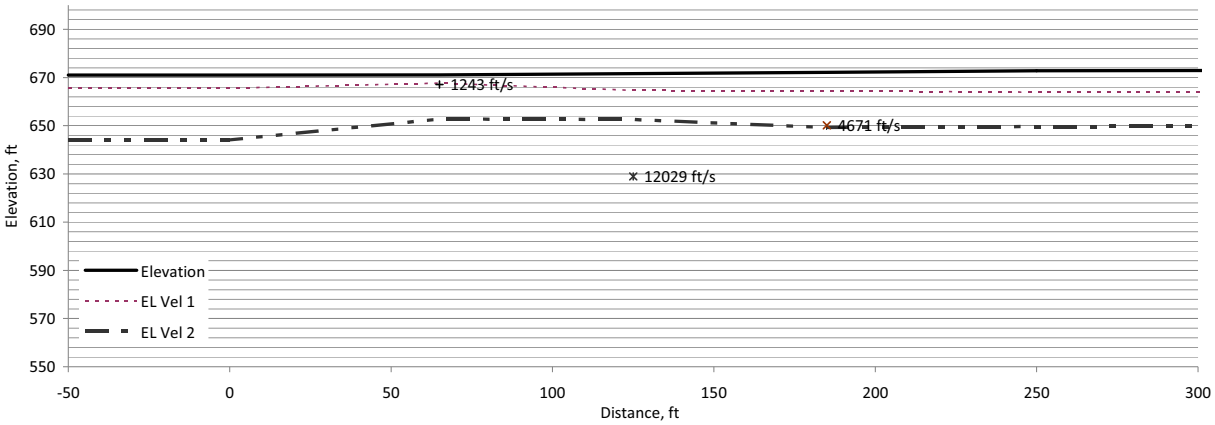




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

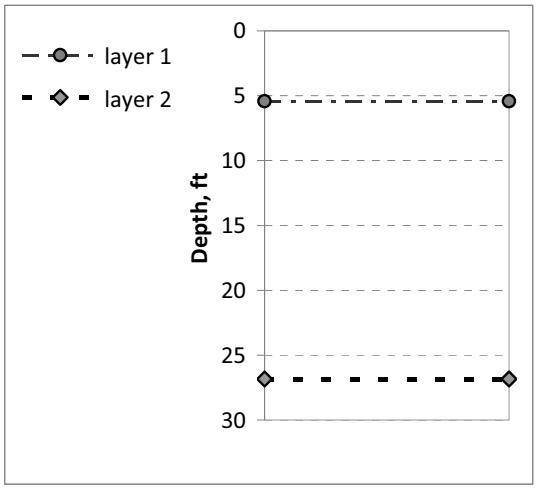
Approved by: _____ Date: _____

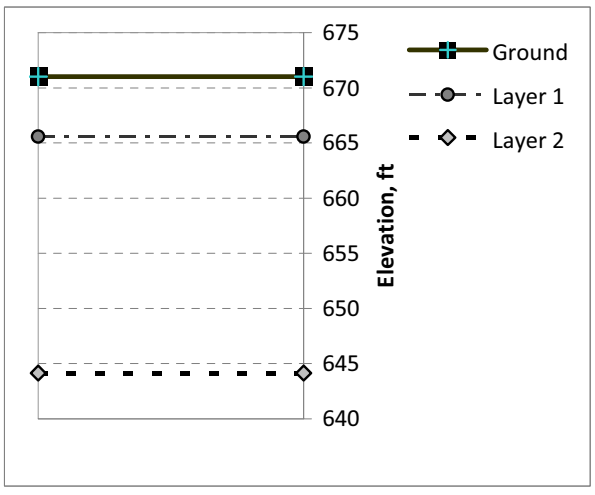

690
670
650
630
610
590
570
550
Elevation, ft
-50
0
50
100
150
200
250
300
Distance, ft
1243 ft/s
4671 ft/s
12029 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	C	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	-50	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	671.0		
NAD1983	Coordinates:	**Easting:**	2404808.6		
PA State Plane	Eastern	**Northing:**	339426.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.377
X_critical 1 ------->		16.0			
Layer 1 thickness			**5.4**		
V1, Layer 2 -------->	3800.0			"V0_2	0.110
X_critical 2 -------->		61.0			0.679
Layer 2 thickness			**21.4**		
V2, Layer 3 -------->	12700.0			"V1_2	0.304
				k 0.993	0.734

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**5.4**	**665.6**
Layer 3 ----------->	**26.8**	**644.2**





Prepared by: _____ Date: _____

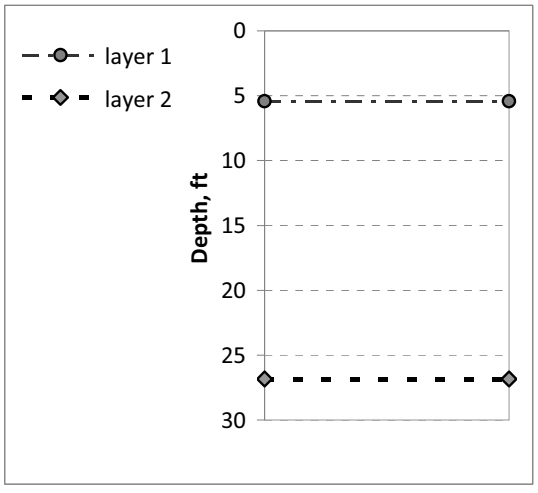
Reviewed by: _____ Date: _____

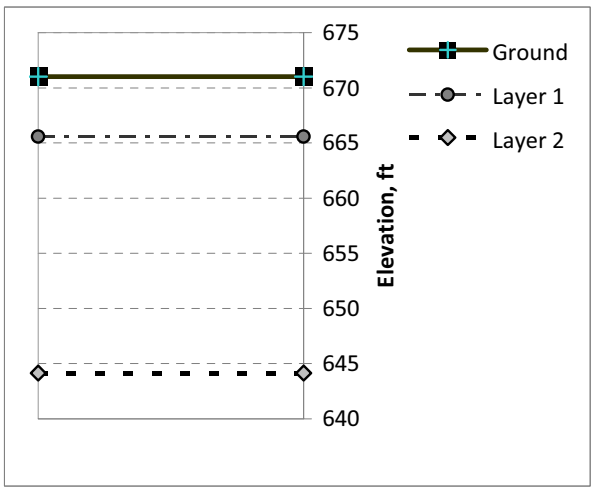
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	0	**Location:**	Berwick
		Depth Offset, ft:	9		
		Elevation, ft:	671.0		
NAD1983	Coordinates:	**Easting:**	2404858.4		
PA State Plane	Eastern	**Northing:**	339430.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.377
X_critical 1 ------->		16.0			
Layer 1 thickness			5.4		
V1, Layer 2 -------->	3800.0			"V0_2	0.110
X_critical 2 -------->		61.0			0.679
Layer 2 thickness			21.4		
V2, Layer 3 -------->	12700.0			"V1_2	0.304
				k 0.993	0.734

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	5.4	665.6
Layer 3 ---------->	26.8	644.2





Prepared by: _____ Date: _____

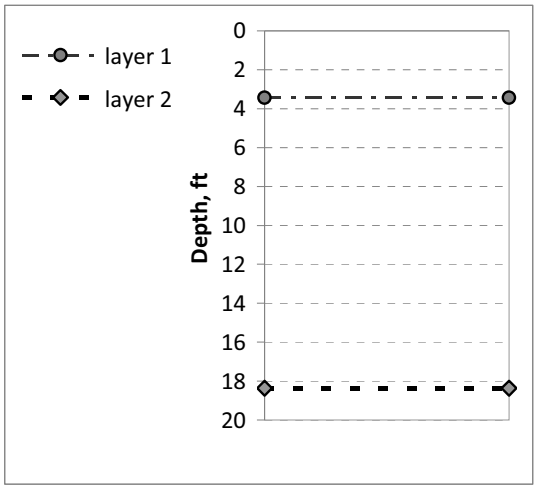
Reviewed by: _____ Date: _____

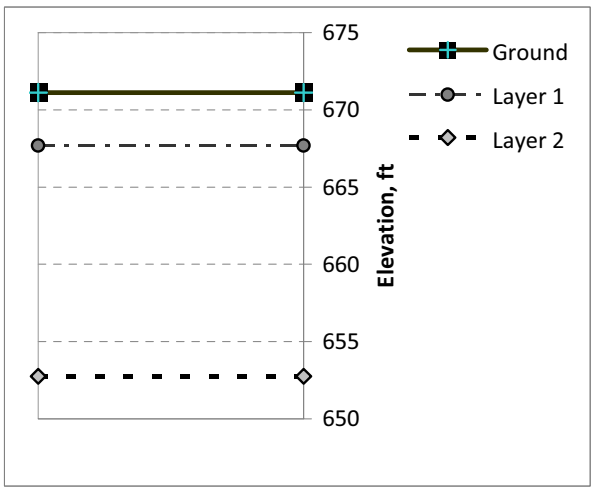
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	65	**Location:**	Berwick
		Depth Offset, ft:	8		
		Elevation, ft:	671.1		
NAD1983	Coordinates:	**Easting:**	2404923.1		
PA State Plane	Eastern	**Northing:**	339436.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1400.0			"V0_1	0.367
X_critical 1 ------->		10.0			
Layer 1 thickness			3.4		
V1, Layer 2 -------->	3900.0			"V0_2	0.128
X_critical 2 -------->		45.0			0.687
Layer 2 thickness			14.9		
V2, Layer 3 -------->	11000.0			"V1_2	0.362
				k 0.599	0.690

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	3.4	667.7
Layer 3 ---------->	18.4	652.8





Prepared by: _____ Date: _____

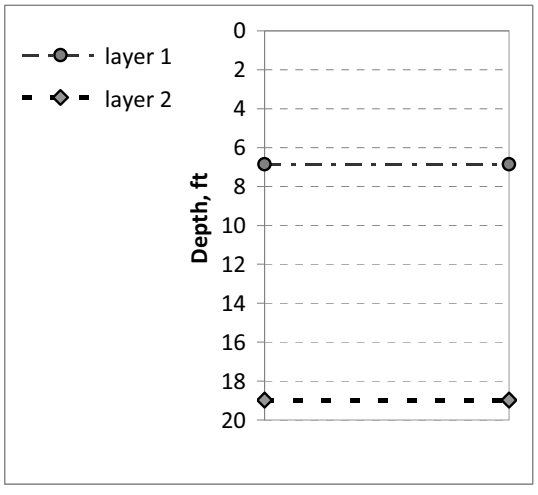
Reviewed by: _____ Date: _____

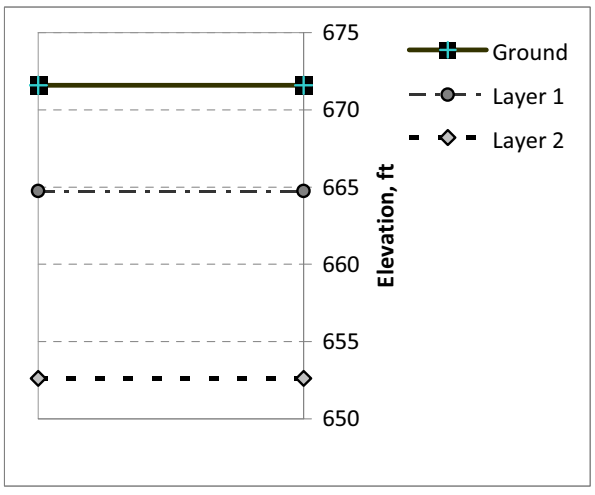
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	125	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	671.6		
NAD1983	Coordinates:	**Easting:**	2404982.9		
PA State Plane	Eastern	**Northing:**	339442.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		17.0			
Layer 1 thickness			6.9		
V1, Layer 2 -------->	5200.0			"V0_2	0.112
X_critical 2 -------->		46.0			0.807
Layer 2 thickness			12.1		
V2, Layer 3 -------->	9800.0			"V1_2	0.559
				k 0.624	0.554

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	6.9	664.7
Layer 3 ---------->	19.0	652.6





Prepared by: _____ Date: _____

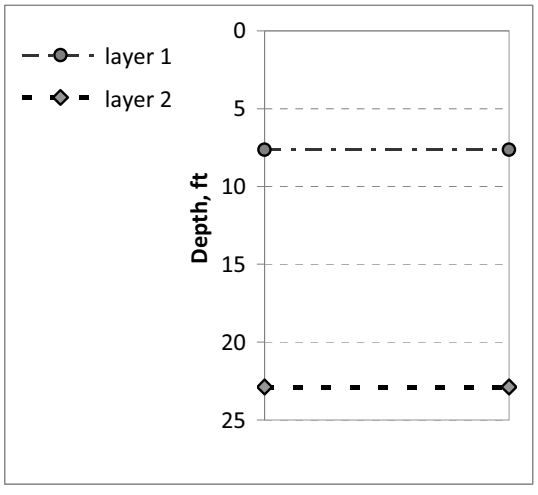
Reviewed by: _____ Date: _____

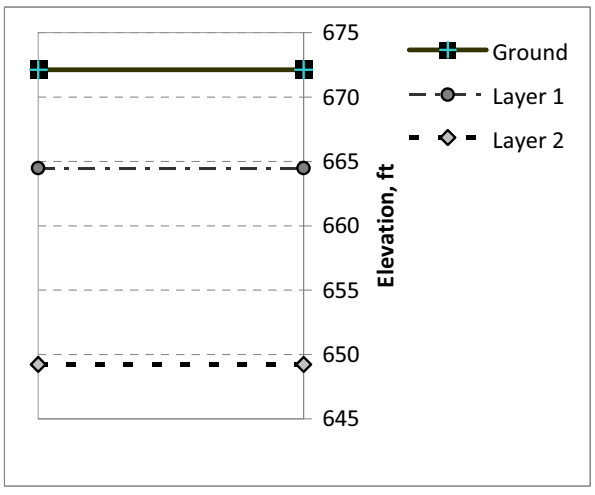
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	185	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	672.1		
NAD1983	Coordinates:	**Easting:**	2405042.6		
PA State Plane	Eastern	**Northing:**	339447.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.216
X_critical 1 ------->		19.0			
Layer 1 thickness			7.6		
V1, Layer 2 -------->	5600.0			"V0_2	0.100
X_critical 2 -------->		53.0			0.804
Layer 2 thickness			15.2		
V2, Layer 3 -------->	12000.0			"V1_2	0.486
				k 0.735	0.603

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	7.6	664.5
Layer 3 ---------->	22.9	649.2





Prepared by: _____ Date: _____

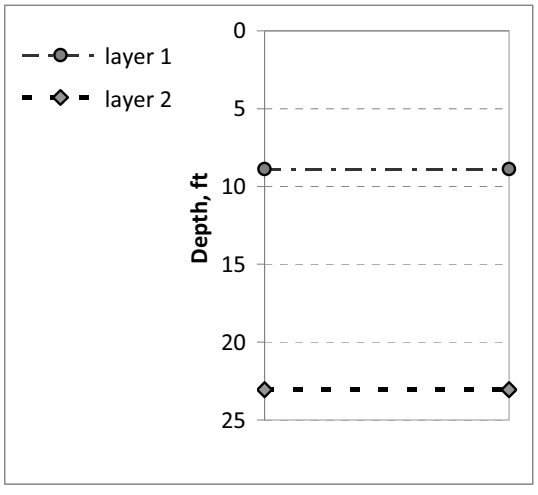
Reviewed by: _____ Date: _____

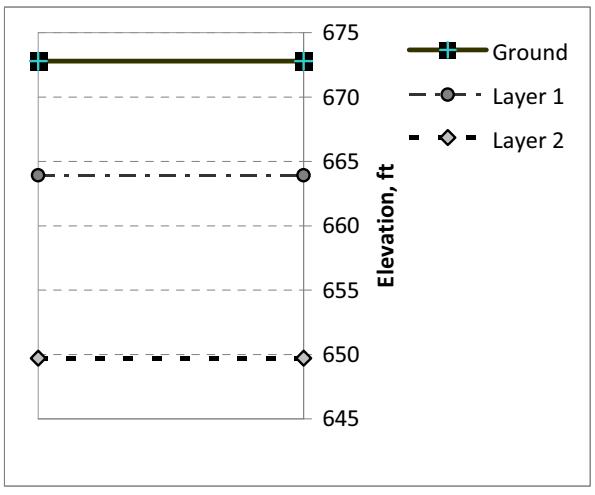
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	-10		
		Elevation, ft:	672.8		
NAD1983	Coordinates:	**Easting:**	2405107.3		
PA State Plane	Eastern	**Northing:**	339453.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		22.0			
Layer 1 thickness			8.9		
V1, Layer 2 -------->	5200.0			"V0_2	0.085
X_critical 2 -------->		46.0			0.807
Layer 2 thickness			14.2		
V2, Layer 3 -------->	13000.0			"V1_2	0.412
				k 0.872	0.655

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.9	663.9
Layer 3 ---------->	23.1	649.7





Prepared by: _____ Date: _____

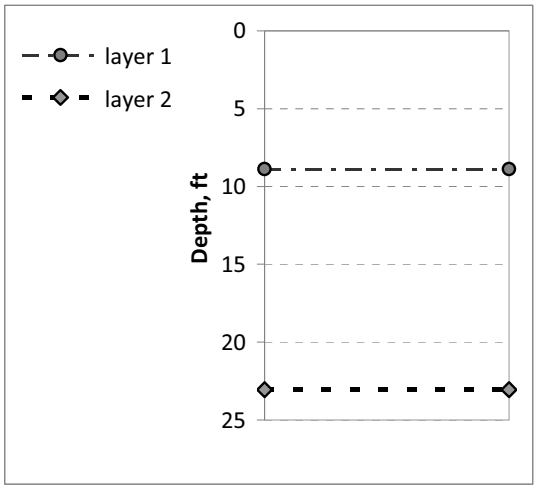
Reviewed by: _____ Date: _____

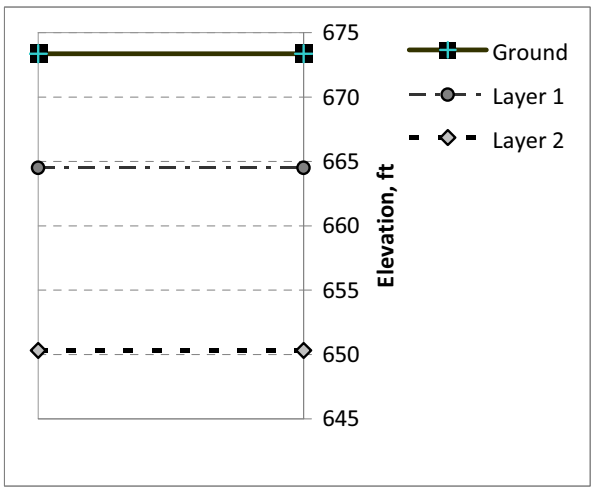
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	1	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	673.4		
NAD1983	Coordinates:	**Easting:**	2405157.1		
PA State Plane	Eastern	**Northing:**	339458.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		22.0			
Layer 1 thickness			8.9		
V1, Layer 2 -------->	5200.0			"V0_2	0.085
X_critical 2 -------->		46.0			0.807
Layer 2 thickness			14.2		
V2, Layer 3 -------->	13000.0			"V1_2	0.412
				k 0.872	0.655

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.9	664.5
Layer 3 ---------->	23.1	650.3

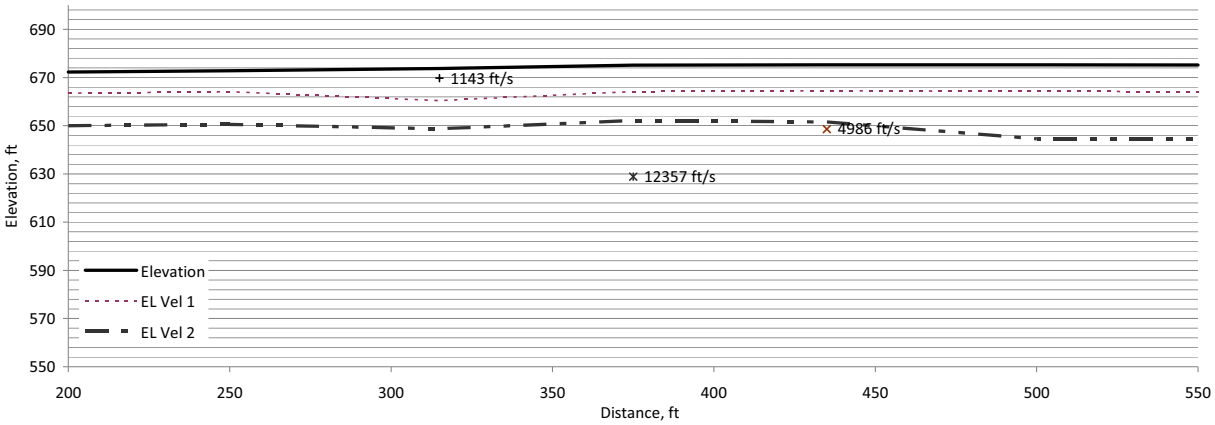




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

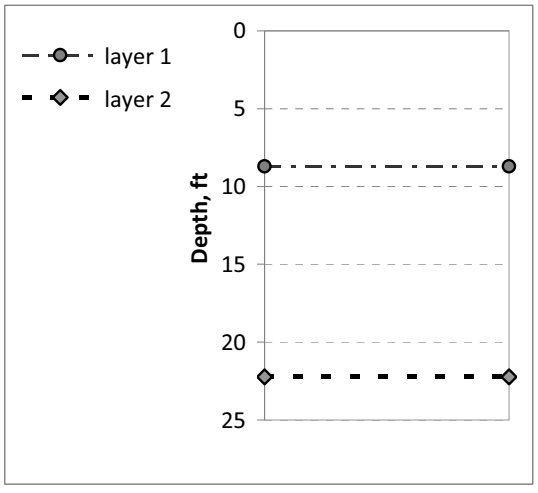
Approved by: _____ Date: _____

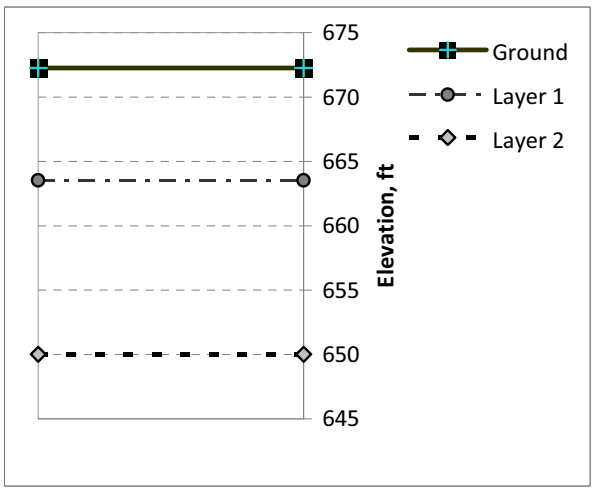

690
670
650
630
610
590
570
550
200
250
300
350
400
450
500
550
Elevation, ft
Distance, ft
1143 ft/s
4986 ft/s
12357 ft/s
Elevation
EL Vel 1
EL Vel 2

Line No.:	C	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	200	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	672.2		
NAD1983	Coordinates:	**Easting:**	2405057.6		
PA State Plane	Eastern	**Northing:**	339449.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.231
X_critical 1 ------->		22.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	4800.0			"V0_2	0.104
X_critical 2 -------->		47.0			0.792
Layer 2 thickness			13.5		
V2, Layer 3 -------->	10600.0			"V1_2	0.470
				k 0.904	0.614

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.7	663.5
Layer 3 ---------->	22.2	650.0





Prepared by: _____ Date: _____

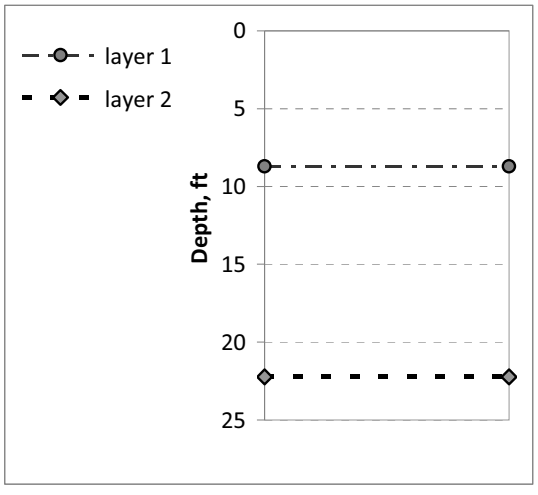
Reviewed by: _____ Date: _____

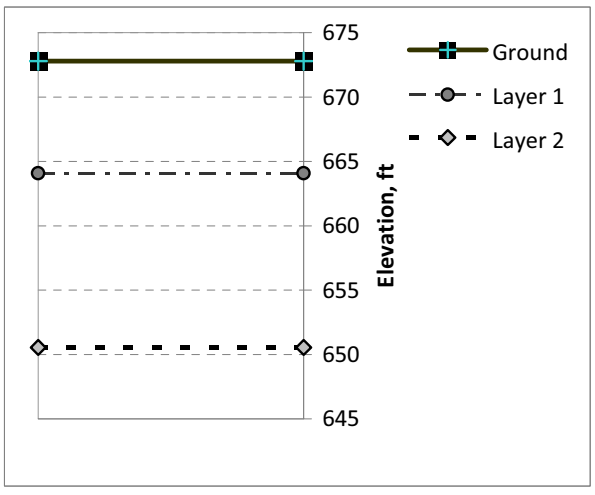
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	250	**Location:**	Berwick
		Depth Offset, ft:	10		
		Elevation, ft:	672.8		
NAD1983	Coordinates:	**Easting:**	2405107.3		
PA State Plane	Eastern	**Northing:**	339453.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.231
X_critical 1 ------->		22.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	4800.0			"V0_2	0.104
X_critical 2 -------->		47.0			0.792
Layer 2 thickness			13.5		
V2, Layer 3 -------->	10600.0			"V1_2	0.470
				k 0.904	0.614

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**8.7**	**664.1**
Layer 3 ----------->	**22.2**	**650.6**





Prepared by: _____ Date: _____

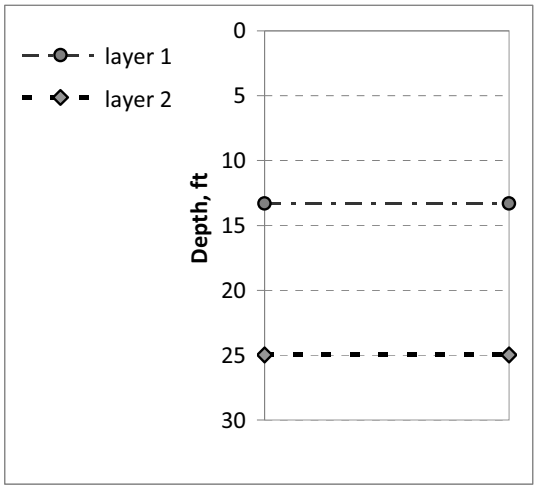
Reviewed by: _____ Date: _____

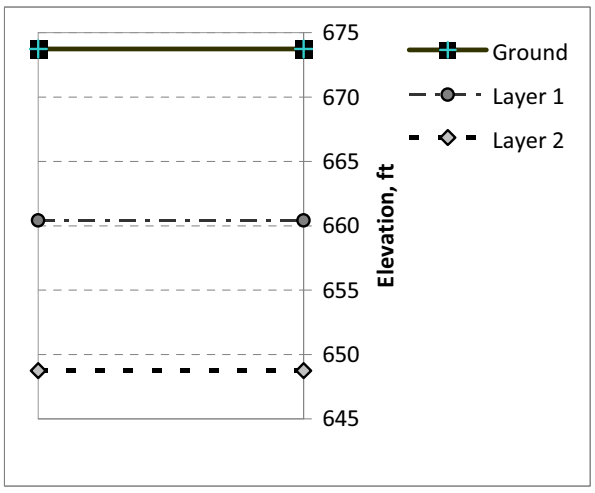
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	315	**Location:**	Berwick
		Depth Offset, ft:	14		
		Elevation, ft:	673.7		
NAD1983	Coordinates:	**Easting:**	2405172.0		
PA State Plane	Eastern	**Northing:**	339459.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.242
X_critical 1 ------->		34.0			
Layer 1 thickness			13.3		
V1, Layer 2 -------->	5000.0			"V0_2	0.119
X_critical 2 -------->		45.0			0.783
Layer 2 thickness			11.7		
V2, Layer 3 -------->	10100.0			"V1_2	0.518
				k 1.413	0.581

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	13.3	660.4
Layer 3 ---------->	25.0	648.8





Prepared by: _____ Date: _____

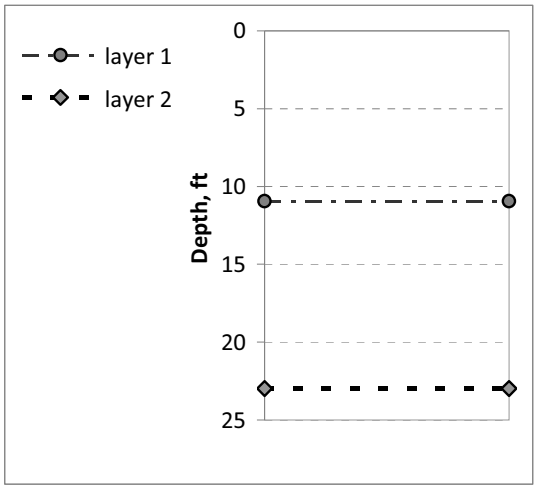
Reviewed by: _____ Date: _____

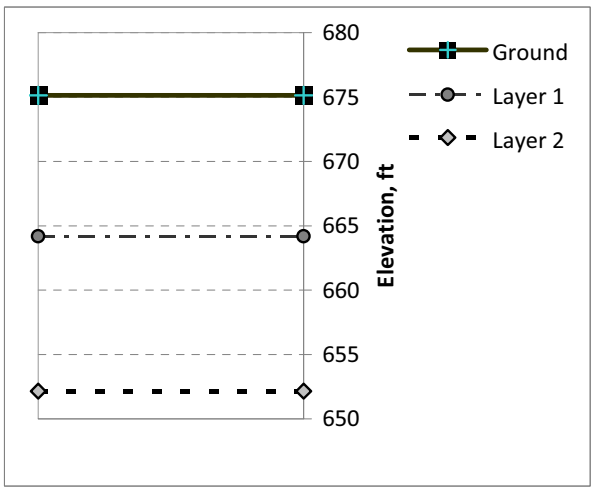
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	675.1		
NAD1983	Coordinates:	**Easting:**	2405231.6		
PA State Plane	Eastern	**Northing:**	339464.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.209
X_critical 1 ------->		27.0			
Layer 1 thickness			10.9		
V1, Layer 2 -------->	5300.0			"V0_2	0.107
X_critical 2 -------->		46.0			0.810
Layer 2 thickness			12.0		
V2, Layer 3 -------->	10300.0			"V1_2	0.540
				k 0.987	0.566

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.9	664.2
Layer 3 ---------->	23.0	652.1





Prepared by: _____ Date: _____

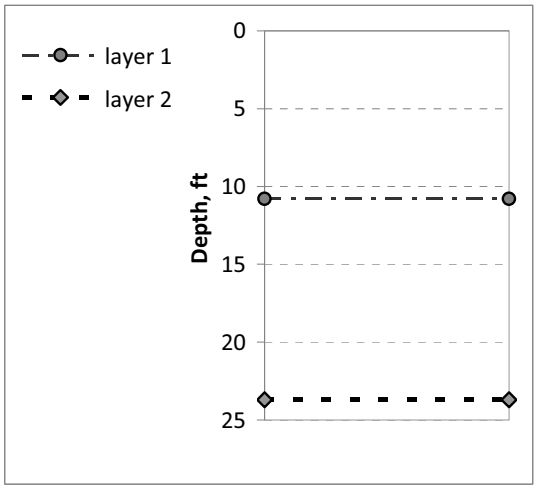
Reviewed by: _____ Date: _____

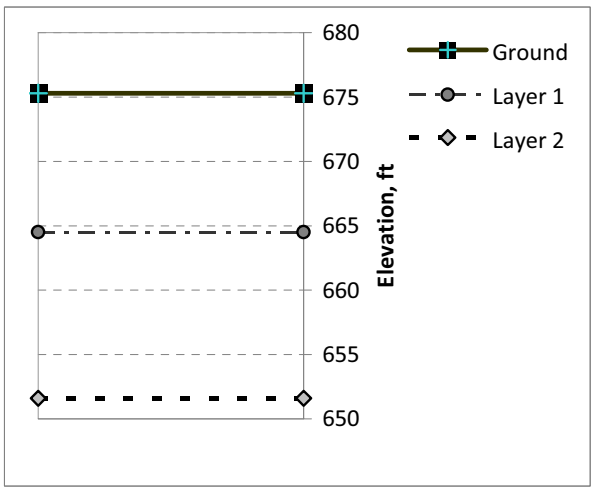
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	435	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	675.3		
NAD1983	Coordinates:	**Easting:**	2405291.3		
PA State Plane	Eastern	**Northing:**	339470.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.222
X_critical 1 ------->		27.0			
Layer 1 thickness			10.8		
V1, Layer 2 -------->	5000.0			"V0_2	0.097
X_critical 2 -------->		45.0			0.800
Layer 2 thickness			12.9		
V2, Layer 3 -------->	11300.0			"V1_2	0.458
				k 1.081	0.622

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.8	664.5
Layer 3 ---------->	23.7	651.6





Prepared by: _____ Date: _____

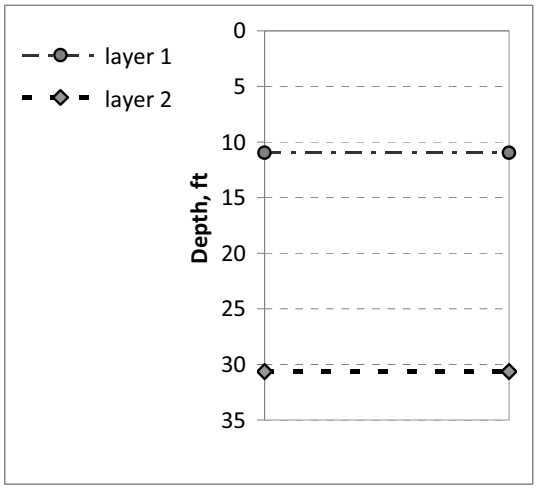
Reviewed by: _____ Date: _____

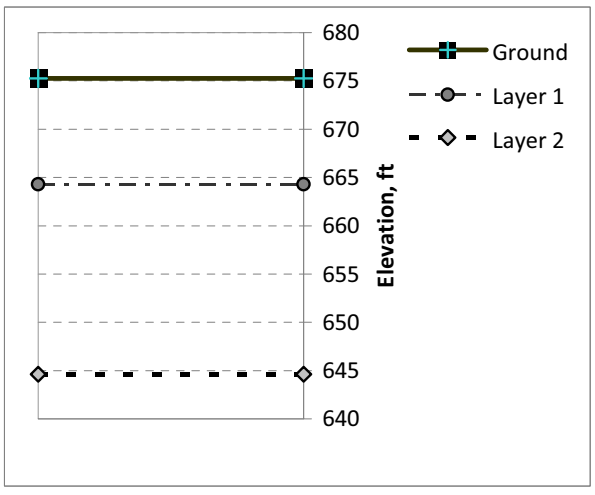
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	-10		
		Elevation, ft:	675.3		
NAD1983	Coordinates:	**Easting:**	2405355.9		
PA State Plane	Eastern	**Northing:**	339475.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.242
X_critical 1 ------->		28.0			
Layer 1 thickness			11.0		
V1, Layer 2 -------->	5000.0			"V0_2	0.071
X_critical 2 -------->		57.0			0.783
Layer 2 thickness			19.7		
V2, Layer 3 -------->	16800.0			"V1_2	0.302
				k 1.276	0.736

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	11.0	664.3	
Layer 3 ---------->	30.7	644.6	





Prepared by: _____ Date: _____

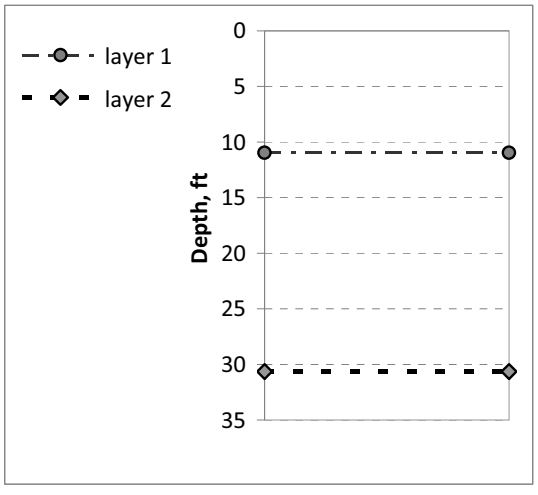
Reviewed by: _____ Date: _____

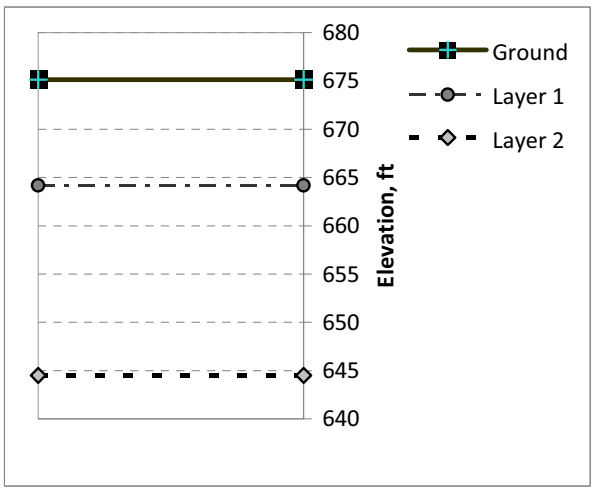
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	550	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	675.1		
NAD1983	Coordinates:	**Easting:**	2405406.0		
PA State Plane	Eastern	**Northing:**	339479.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.242
X_critical 1 ------->		28.0			
Layer 1 thickness			**11.0**		
V1, Layer 2 -------->	5000.0			"V0_2	0.071
X_critical 2 -------->		57.0			0.783
Layer 2 thickness			**19.7**		
V2, Layer 3 -------->	16800.0			"V1_2	0.302
				k 1.276	0.736

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**11.0**	**664.2**
Layer 3 ----------->	**30.7**	**644.5**

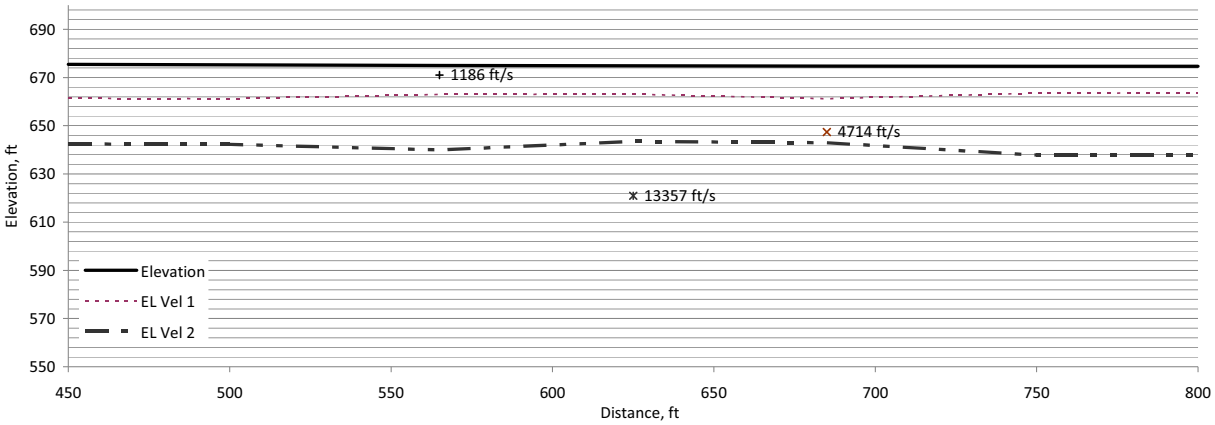




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

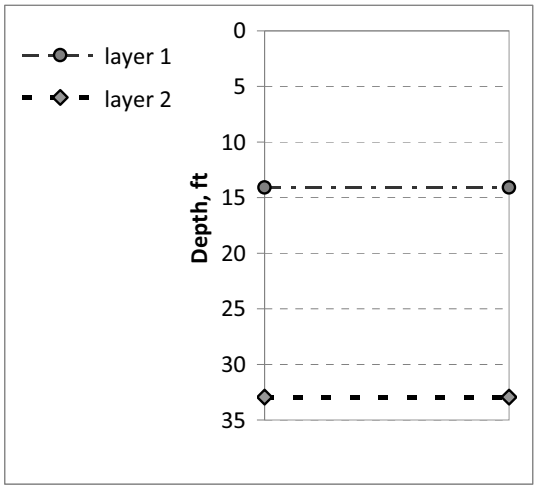
Approved by: _____ Date: _____

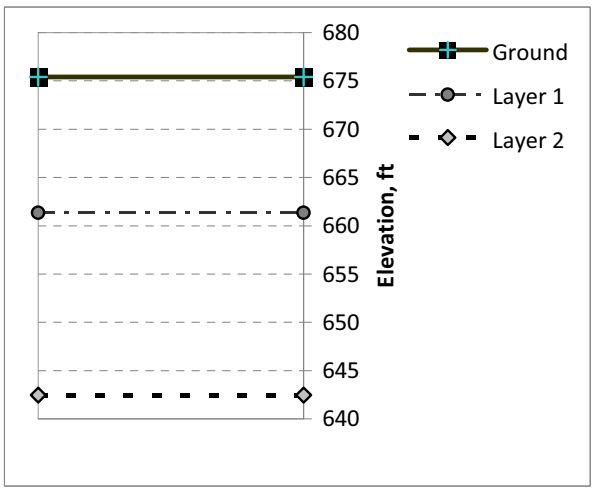

690
670
650
630
610
590
570
550
Elevation, ft
1186 ft/s
4714 ft/s
13357 ft/s
Elevation
EL Vel 1
EL Vel 2
450
500
550
600
650
700
750
800
Distance, ft

Line No.:	C	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	450	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	675.4		
NAD1983	Coordinates:	**Easting:**	2405306.2		
PA State Plane	Eastern	**Northing:**	339471.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.242
X_critical 1 ------->		36.0			
Layer 1 thickness			**14.1**		
V1, Layer 2 -------->	5000.0			"V0_2	0.088
X_critical 2 -------->		60.0			0.783
Layer 2 thickness			**18.9**		
V2, Layer 3 -------->	13700.0			"V1_2	0.374
				k 1.601	0.682

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**14.1**	**661.3**
Layer 3 ----------->	**33.0**	**642.5**





Prepared by: _____ Date: _____

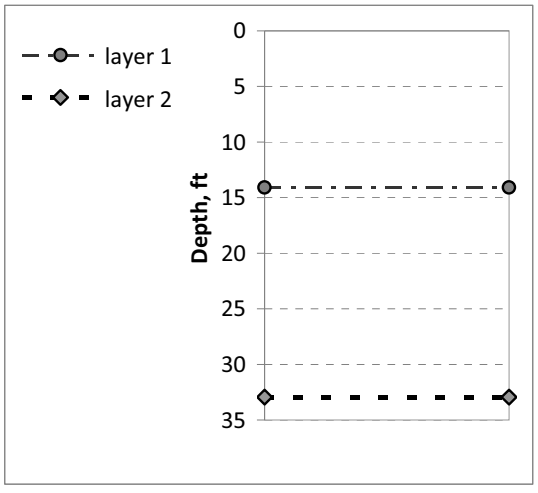
Reviewed by: _____ Date: _____

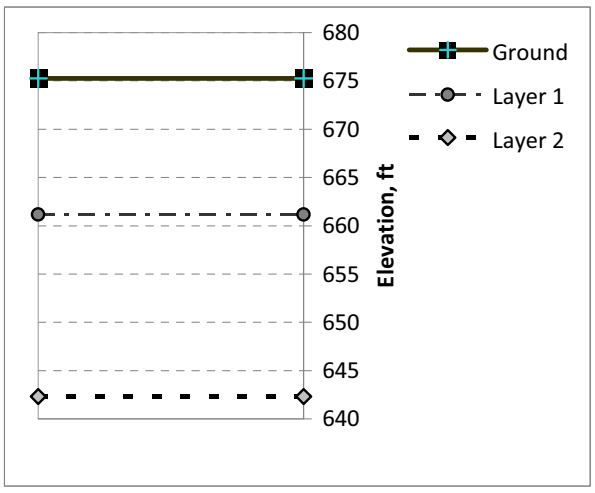
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	500	**Location:**	Berwick
		Depth Offset, ft:	13		
		Elevation, ft:	675.3		
NAD1983	Coordinates:	**Easting:**	2405355.9		
PA State Plane	Eastern	**Northing:**	339475.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.242
X_critical 1 ------->		36.0			
Layer 1 thickness			14.1		
V1, Layer 2 -------->	5000.0			"V0_2	0.088
X_critical 2 -------->		60.0			0.783
Layer 2 thickness			18.9		
V2, Layer 3 -------->	13700.0			"V1_2	0.374
				k 1.601	0.682

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	14.1	661.2
Layer 3 ---------->	33.0	642.3





Prepared by: _____ Date: _____

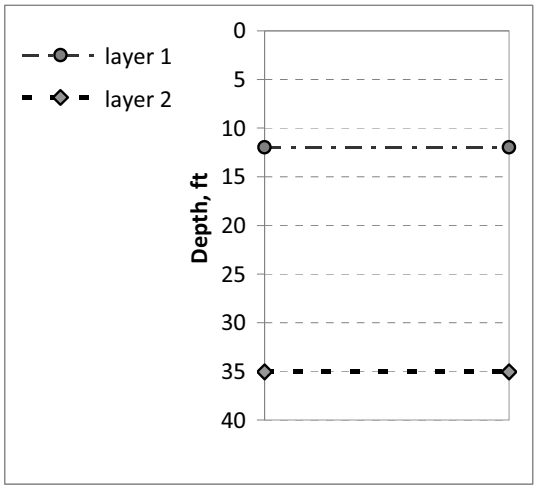
Reviewed by: _____ Date: _____

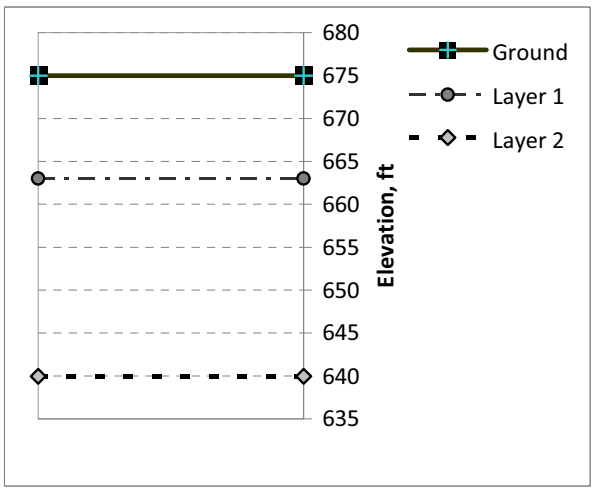
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	565	**Location:**	Berwick
		Depth Offset, ft:	14		
		Elevation, ft:	675.0		
NAD1983	Coordinates:	**Easting:**	2405421.0		
PA State Plane	Eastern	**Northing:**	339480.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.222
X_critical 1 ------->		30.0			
Layer 1 thickness			12.0		
V1, Layer 2 -------->	5000.0			"V0_2	0.077
X_critical 2 -------->		70.0			0.800
Layer 2 thickness			23.0		
V2, Layer 3 -------->	14300.0			"V1_2	0.357
				k 1.253	0.694

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	12.0	663.0	
Layer 3 ---------->	35.0	639.9	





Prepared by: _____ Date: _____

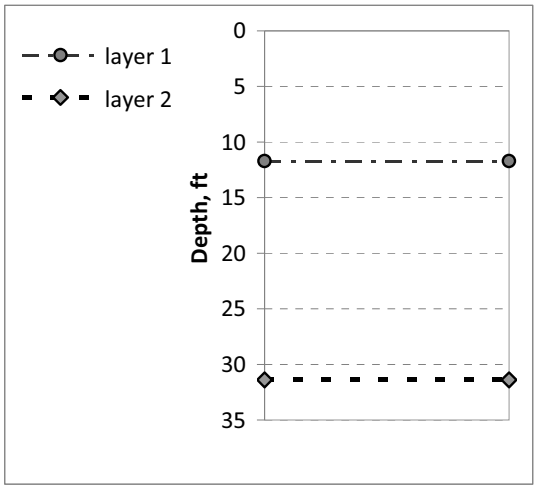
Reviewed by: _____ Date: _____

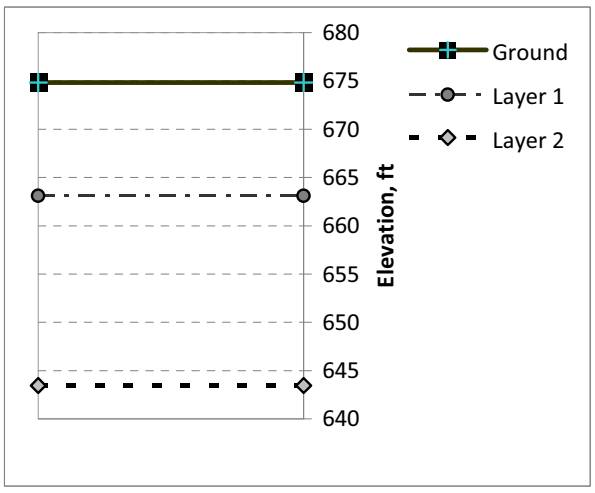
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	625	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	674.8		
NAD1983	Coordinates:	**Easting:**	2405481.0		
PA State Plane	Eastern	**Northing:**	339485.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.276
X_critical 1 ------->		31.0			
Layer 1 thickness			11.7		
V1, Layer 2 -------->	4400.0			"V0_2	0.091
X_critical 2 -------->		60.0			0.756
Layer 2 thickness			19.7		
V2, Layer 3 -------->	13200.0			"V1_2	0.340
				k 1.539	0.707

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	11.7	663.1
Layer 3 ---------->	31.4	643.4





Prepared by: _____ Date: _____

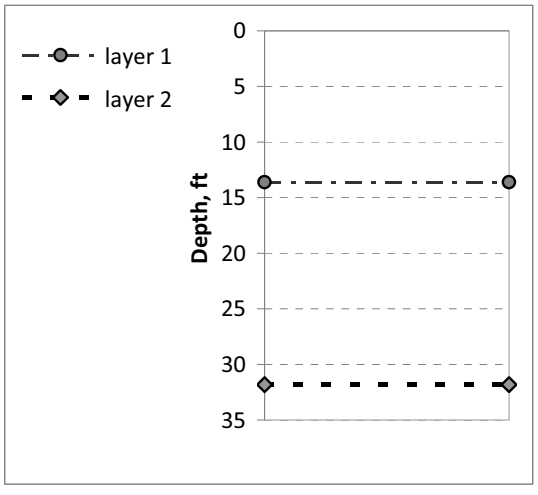
Reviewed by: _____ Date: _____

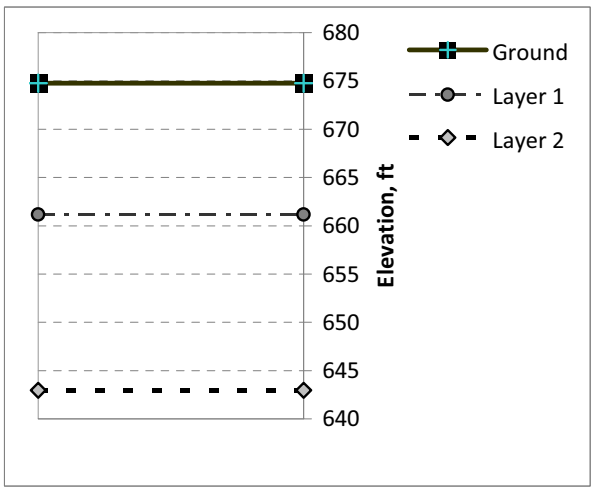
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	685	**Location:**	Berwick
		Depth Offset, ft:	-13		
		Elevation, ft:	674.8		
NAD1983	Coordinates:	**Easting:**	2405541.0		
PA State Plane	Eastern	**Northing:**	339490.5		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.276
X_critical 1 ------->		36.0			
Layer 1 thickness			13.6		
V1, Layer 2 -------->	4400.0			"V0_2	0.105
X_critical 2 -------->		60.0			0.756
Layer 2 thickness			18.2		
V2, Layer 3 -------->	11400.0			"V1_2	0.396
				k 1.750	0.666

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	13.6	661.2	
Layer 3 ---------->	31.8	642.9	





Prepared by: _____ Date: _____

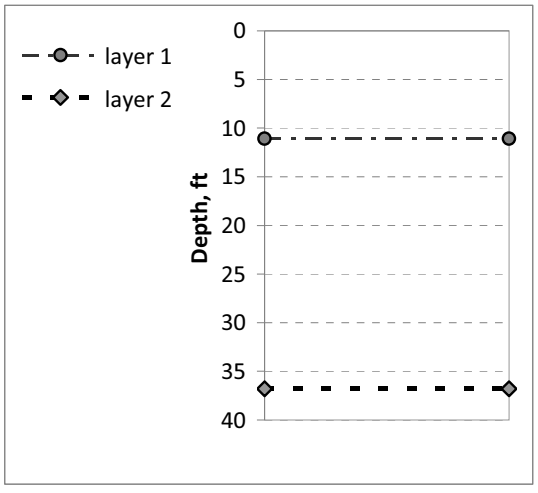
Reviewed by: _____ Date: _____

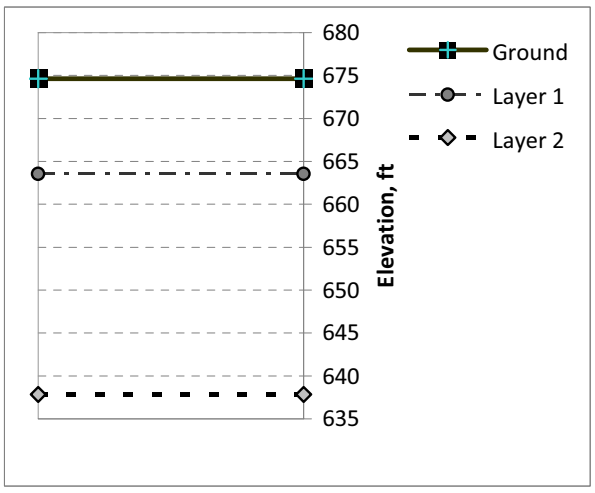
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	-14		
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405606.0		
PA State Plane	Eastern	**Northing:**	339495.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.264
X_critical 1 ------->		29.0			
Layer 1 thickness			11.1		
V1, Layer 2 -------->	4600.0			"V0_2	0.088
X_critical 2 -------->		77.0			0.766
Layer 2 thickness			25.7		
V2, Layer 3 -------->	13600.0			"V1_2	0.345
				k 1.389	0.703

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	11.1	663.5
Layer 3 ---------->	36.8	637.9





Prepared by: _____ Date: _____

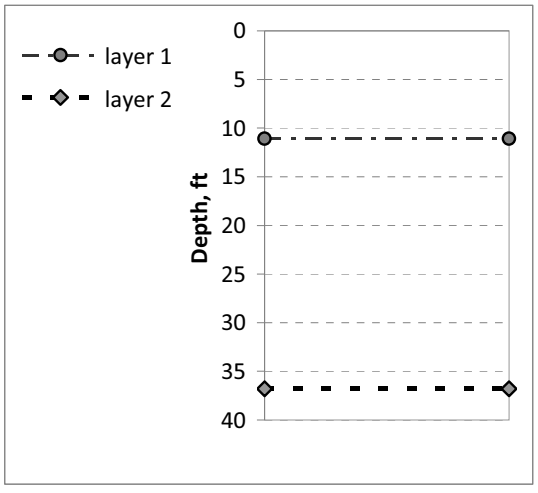
Reviewed by: _____ Date: _____

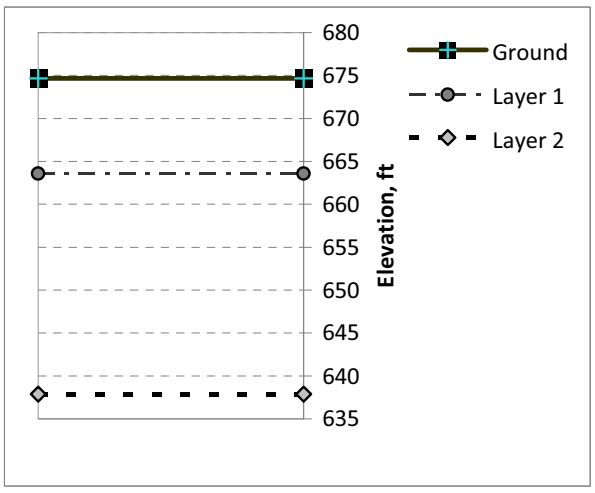
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	3	**Shot Distance, ft:**	800	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	674.7		
NAD1983	Coordinates:	**Easting:**	2405655.5		
PA State Plane	Eastern	**Northing:**	339501.0		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.264
X_critical 1 ------->		29.0			
Layer 1 thickness			**11.1**		
V1, Layer 2 -------->	4600.0			"V0_2	0.088
X_critical 2 -------->		77.0			0.766
Layer 2 thickness			**25.7**		
V2, Layer 3 -------->	13600.0			"V1_2	0.345
				k 1.389	0.703

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**11.1**	**663.6**
Layer 3 ---------->	**36.8**	**637.9**

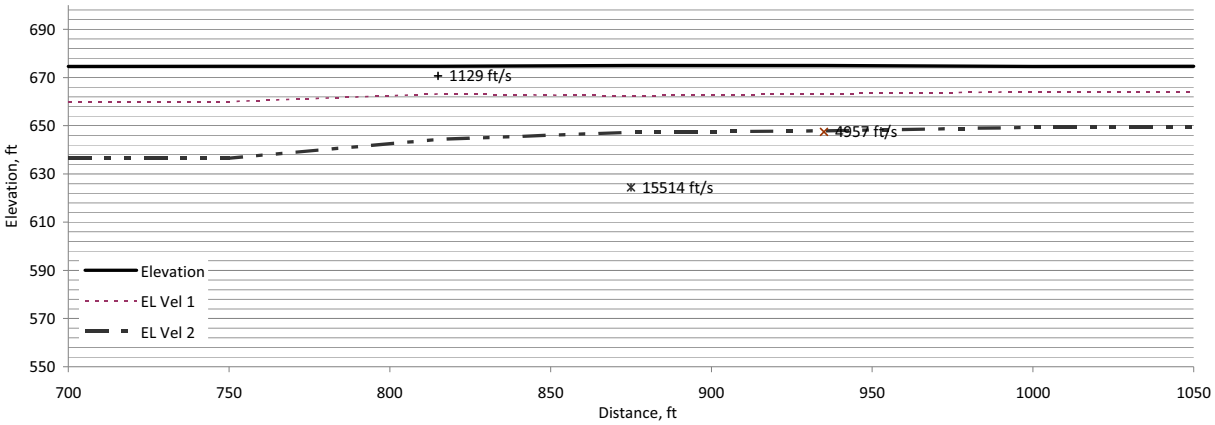




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

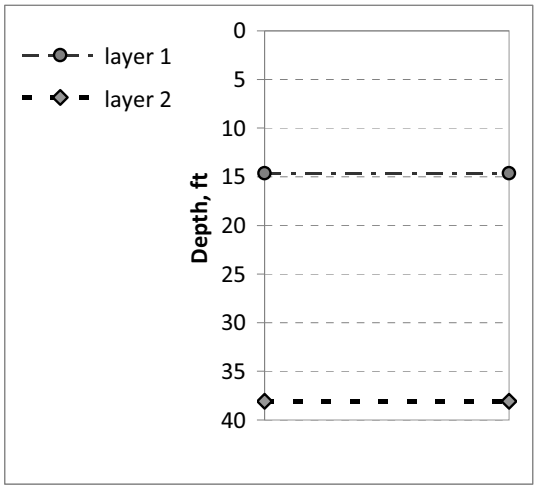
Approved by: _____ Date: _____

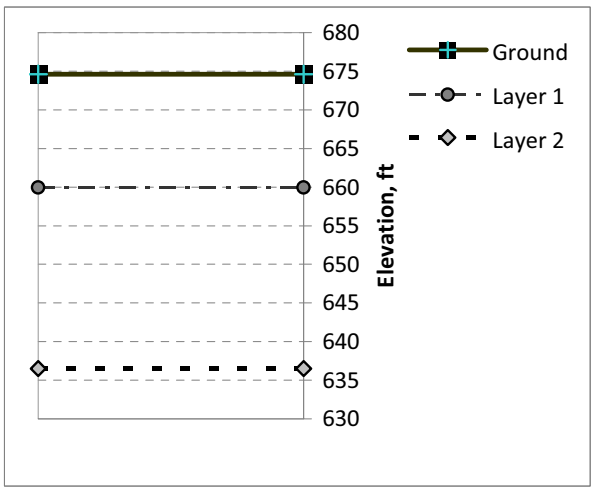

690
670
650
630
610
590
570
550
Elevation, ft
1129 ft/s
4957 ft/s
15514 ft/s
Elevation
EL Vel 1
EL Vel 2
700
750
800
850
900
950
1000
1050
Distance, ft

Line No.:	C	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	700	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405556.0		
PA State Plane	Eastern	**Northing:**	339491.7		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.283
X_critical 1 ------->		39.0			
Layer 1 thickness			**14.6**		
V1, Layer 2 -------->	4300.0			"V0_2	0.067
X_critical 2 -------->		65.0			0.751
Layer 2 thickness			**23.4**		
V2, Layer 3 -------->	18000.0			"V1_2	0.241
				k 2.026	0.784

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**14.6**	**660.0**
Layer 3 ---------->	**38.1**	**636.5**





Prepared by: _____ Date: _____

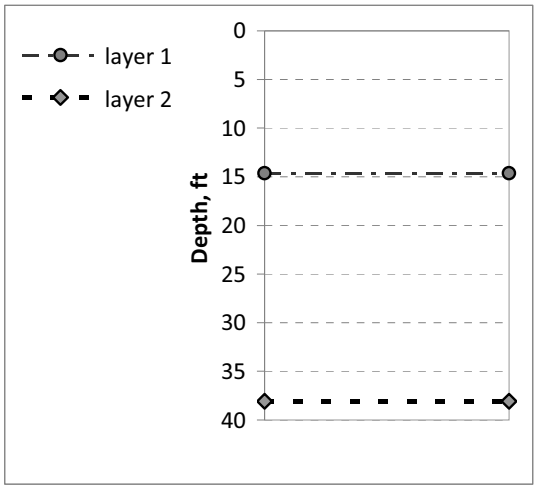
Reviewed by: _____ Date: _____

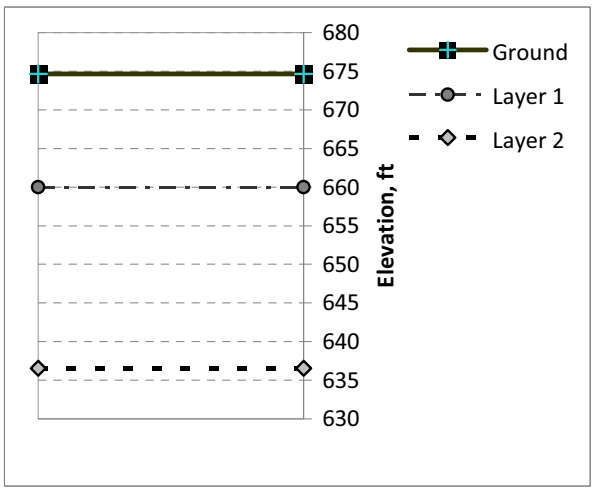
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	750	**Location:**	Berwick
		Depth Offset, ft:	10		
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405606.0		
PA State Plane	Eastern	**Northing:**	339495.8		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1200.0			"V0_1	0.283
X_critical 1 ------->		39.0			
Layer 1 thickness			14.6		
V1, Layer 2 -------->	4300.0			"V0_2	0.067
X_critical 2 -------->		65.0			0.751
Layer 2 thickness			23.4		
V2, Layer 3 -------->	18000.0			"V1_2	0.241
				k 2.026	0.784

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	14.6	660.0
Layer 3 ---------->	38.1	636.6





Prepared by: _____ Date: _____

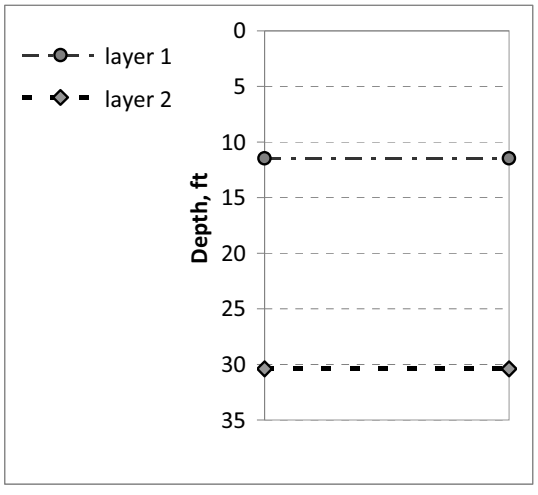
Reviewed by: _____ Date: _____

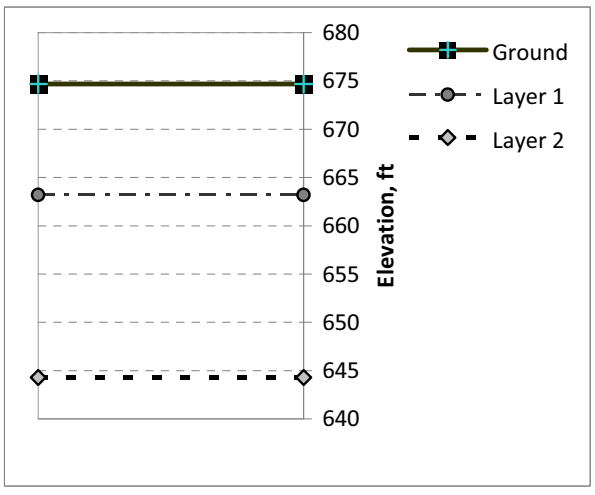
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	815	**Location:**	Berwick
		Depth Offset, ft:	10		
		Elevation, ft:	674.7		
NAD1983	Coordinates:	**Easting:**	2405670.3		
PA State Plane	Eastern	**Northing:**	339502.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.231
X_critical 1 ------->		29.0			
Layer 1 thickness			11.5		
V1, Layer 2 -------->	4800.0			"V0_2	0.065
X_critical 2 -------->		54.0			0.792
Layer 2 thickness			18.9		
V2, Layer 3 -------->	17000.0			"V1_2	0.286
				k 1.281	0.748

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	11.5	663.2
Layer 3 ---------->	30.4	644.3





Prepared by: _____ Date: _____

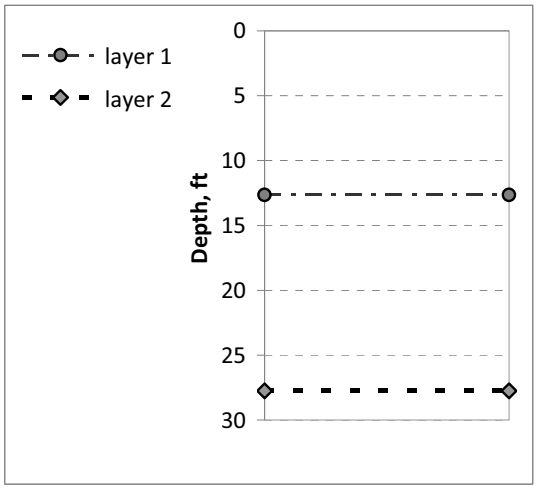
Reviewed by: _____ Date: _____

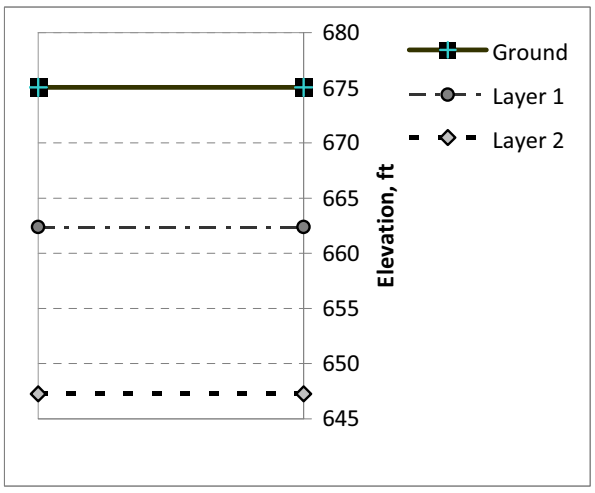
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	875	**Location:**	Berwick
		Depth Offset, ft:	0		
		Elevation, ft:	675.0		
NAD1983	Coordinates:	**Easting:**	2405729.7		
PA State Plane	Eastern	**Northing:**	339508.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.201
X_critical 1 ------->		31.0			
Layer 1 thickness			12.7		
V1, Layer 2 -------->	5500.0			"V0_2	0.081
X_critical 2 -------->		50.0			0.816
Layer 2 thickness			15.1		
V2, Layer 3 -------->	13600.0			"V1_2	0.416
				k 1.171	0.651

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	12.7	662.4
Layer 3 ---------->	27.8	647.3





Prepared by: _____ Date: _____

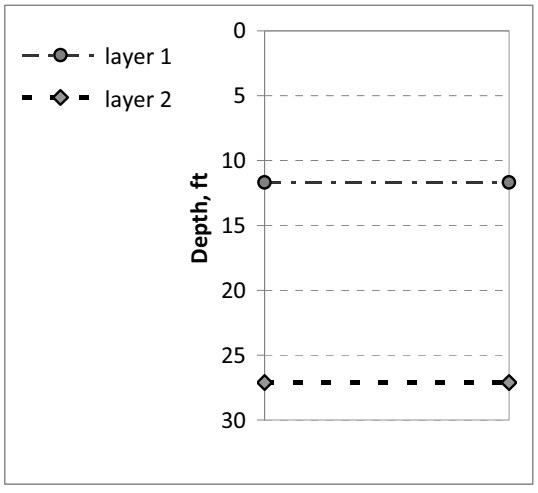
Reviewed by: _____ Date: _____

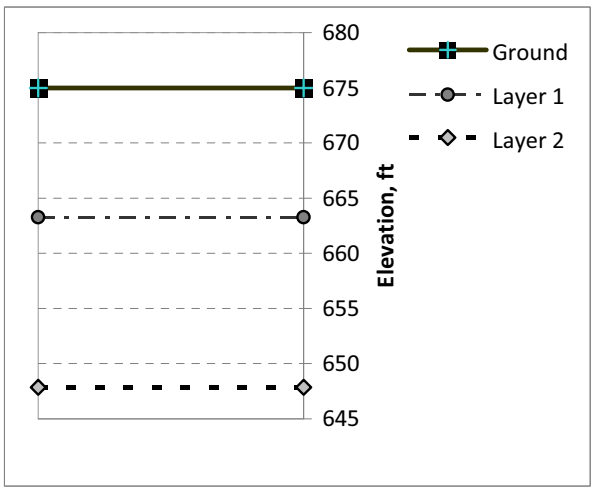
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	935	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	675.0		
NAD1983	Coordinates:	**Easting:**	2405789.1		
PA State Plane	Eastern	**Northing:**	339515.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		29.0			
Layer 1 thickness			11.7		
V1, Layer 2 -------->	5200.0			"V0_2	0.079
X_critical 2 -------->		49.0			0.807
Layer 2 thickness			15.4		
V2, Layer 3 -------->	14000.0			"V1_2	0.381
				k 1.164	0.677

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	11.7	663.3
Layer 3 ---------->	27.1	647.9





Prepared by: _____ Date: _____

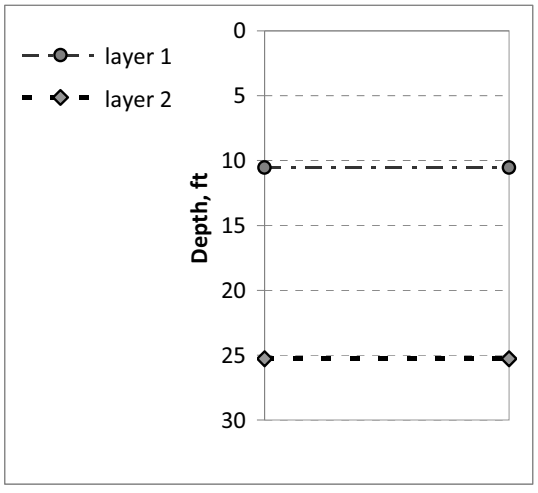
Reviewed by: _____ Date: _____

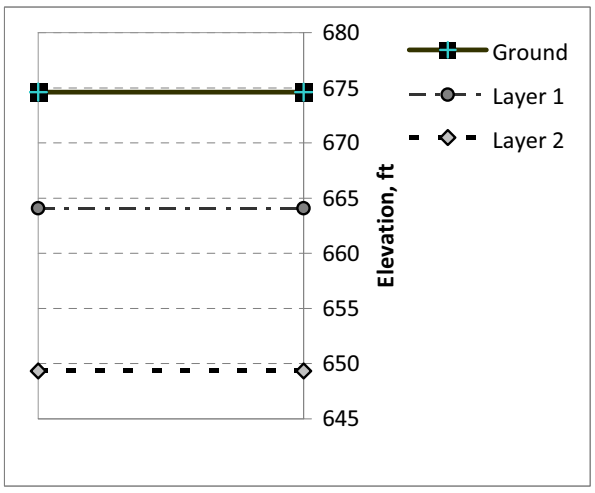
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	1000	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405853.4		
PA State Plane	Eastern	**Northing:**	339522.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.209
X_critical 1 ------->		26.0			
Layer 1 thickness			10.5		
V1, Layer 2 -------->	5300.0			"V0_2	0.079
X_critical 2 -------->		47.0			0.810
Layer 2 thickness			14.8		
V2, Layer 3 -------->	14000.0			"V1_2	0.388
				k 1.024	0.671

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.5	664.1
Layer 3 ---------->	25.3	649.3





Prepared by: _____ Date: _____

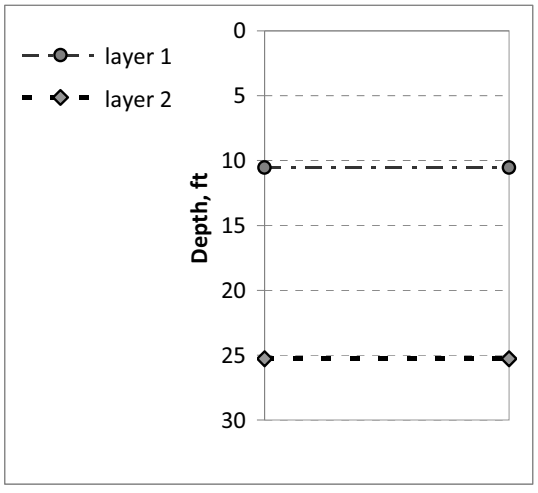
Reviewed by: _____ Date: _____

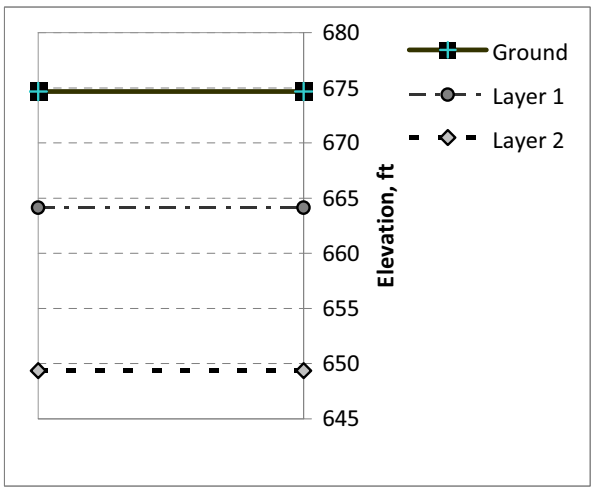
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	4	**Shot Distance, ft:**	1050	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	674.7		
NAD1983	Coordinates:	**Easting:**	2405903.0		
PA State Plane	Eastern	**Northing:**	339526.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.209
X_critical 1 ------->		26.0			
Layer 1 thickness			**10.5**		
V1, Layer 2 -------->	5300.0			"V0_2	0.079
X_critical 2 -------->		47.0			0.810
Layer 2 thickness			**14.8**		
V2, Layer 3 -------->	14000.0			"V1_2	0.388
				k 1.024	0.671

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ----------->	**10.5**	**664.1**
Layer 3 ----------->	**25.3**	**649.4**

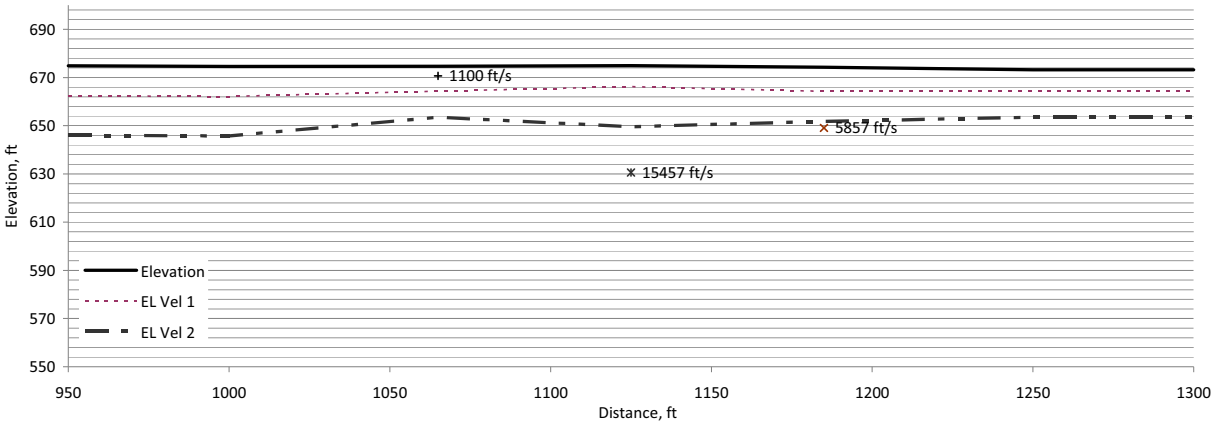




Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

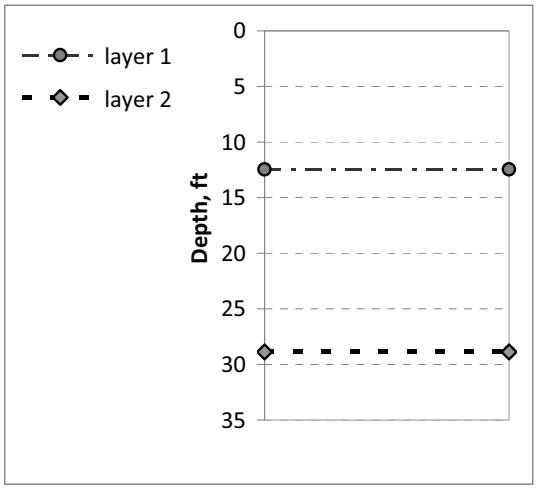
Approved by: _____ Date: _____

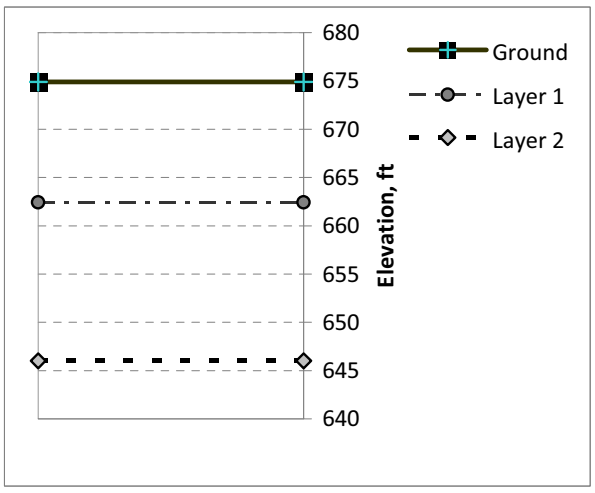

690
670
650
630
610
590
570
550
Elevation, ft
1100 ft/s
5857 ft/s
15457 ft/s
Elevation
EL Vel 1
EL Vel 2
950
1000
1050
1100
1150
1200
1250
1300
Distance, ft

Line No.:	C	**Shot Location:**	Low Offset	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	950	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	674.9		
NAD1983	Coordinates:	**Easting:**	2405803.9		
PA State Plane	Eastern	**Northing:**	339516.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		30.0			
Layer 1 thickness			**12.5**		
V1, Layer 2 -------->	6000.0			"V0_2	0.059
X_critical 2 -------->		49.0			0.831
Layer 2 thickness			**16.4**		
V2, Layer 3 -------->	18500.0			"V1_2	0.330
				k 1.091	0.714

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	**12.5**	**662.4**
Layer 3 ---------->	**28.9**	**646.0**





Prepared by: _____ Date: _____

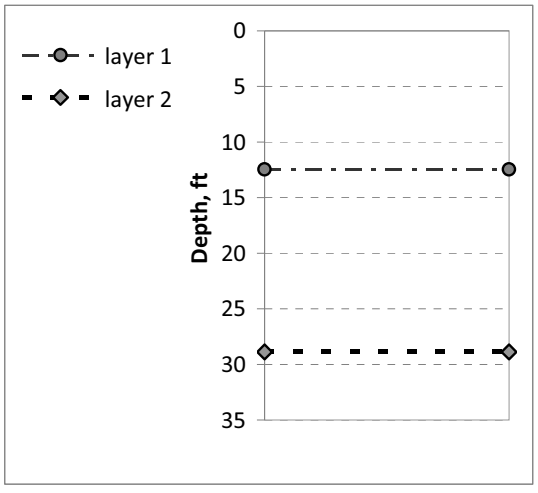
Reviewed by: _____ Date: _____

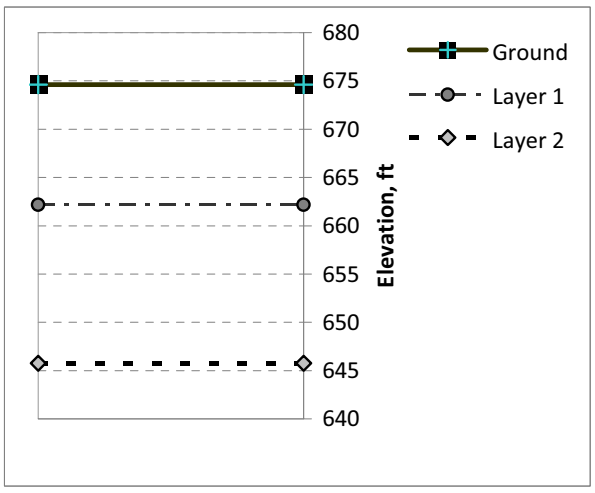
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low End	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1000	**Location:**	Berwick
		Depth Offset, ft:	11		
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405853.4		
PA State Plane	Eastern	**Northing:**	339522.1		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		30.0			
Layer 1 thickness			12.5		
V1, Layer 2 -------->	6000.0			"V0_2	0.059
X_critical 2 -------->		49.0			0.831
Layer 2 thickness			16.4		
V2, Layer 3 -------->	18500.0			"V1_2	0.330
				k 1.091	0.714

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	12.5	662.2
Layer 3 ---------->	28.9	645.7





Prepared by: _____ Date: _____

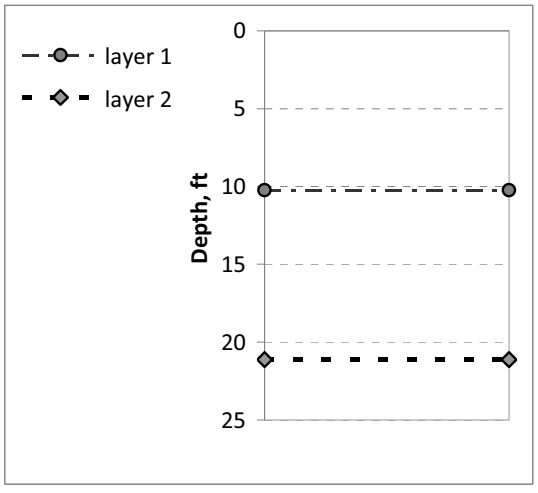
Reviewed by: _____ Date: _____

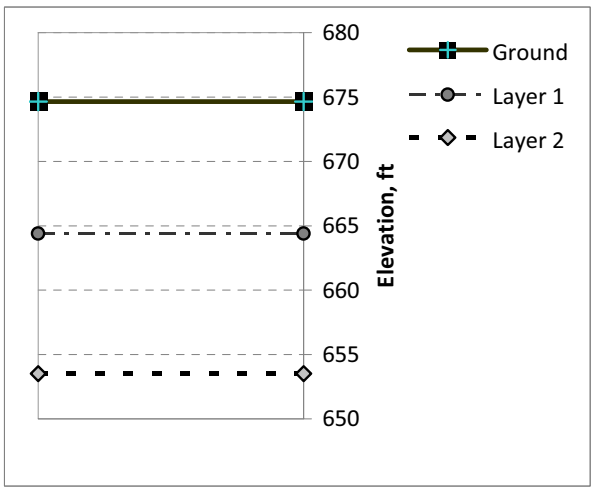
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Low Quarter	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1065	**Location:**	Berwick
		Depth Offset, ft:	9		
		Elevation, ft:	674.6		
NAD1983	Coordinates:	**Easting:**	2405917.9		
PA State Plane	Eastern	**Northing:**	339527.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.198
X_critical 1 ------->		25.0			
Layer 1 thickness			10.2		
V1, Layer 2 -------->	5600.0			"V0_2	0.073
X_critical 2 -------->		35.0			0.820
Layer 2 thickness			10.9		
V2, Layer 3 -------->	15000.0			"V1_2	0.383
				k 0.944	0.676

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	10.2	664.4
Layer 3 ---------->	21.1	653.5





Prepared by: _____ Date: _____

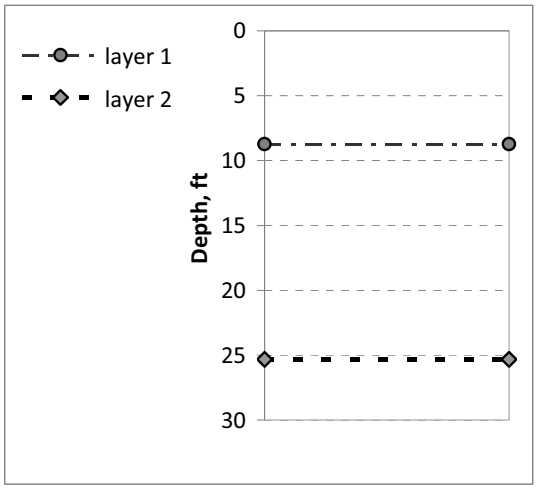
Reviewed by: _____ Date: _____

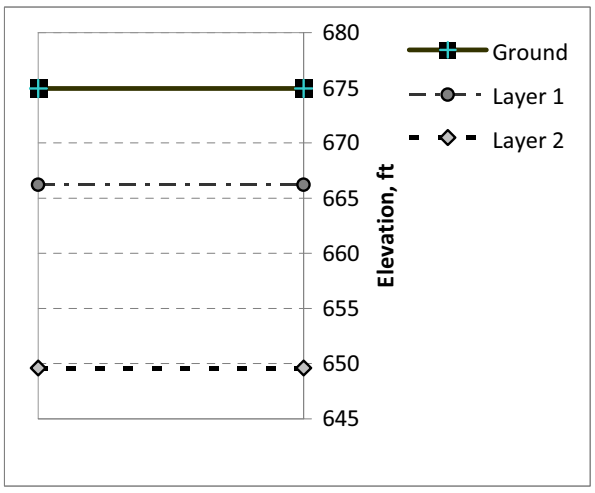
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1125	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	674.9		
NAD1983	Coordinates:	**Easting:**	2405977.5		
PA State Plane	Eastern	**Northing:**	339533.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.184
X_critical 1 ------->		21.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	6000.0			"V0_2	0.069
X_critical 2 -------->		51.5			0.831
Layer 2 thickness			16.6		
V2, Layer 3 -------->	16000.0			"V1_2	0.384
				k 0.748	0.674

Output	*Depth, ft*	*Elevation, ft*	
Layer 2 ---------->	8.7	666.2	
Layer 3 ---------->	25.3	649.6	





Prepared by: _____ Date: _____

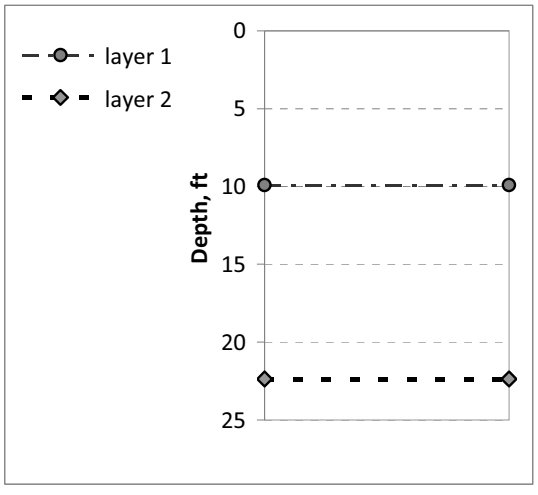
Reviewed by: _____ Date: _____

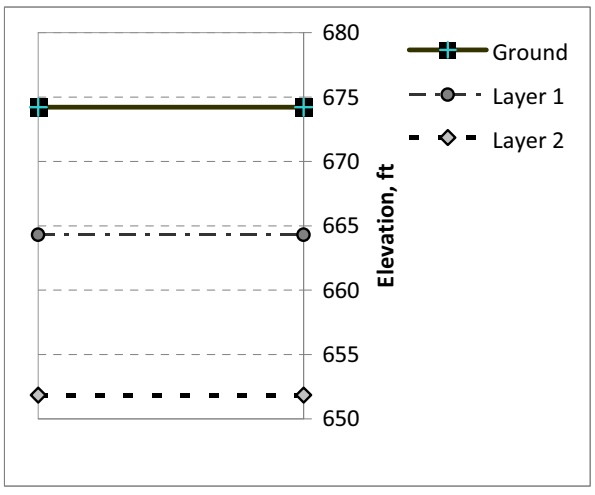
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Quarter	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1185	**Location:**	Berwick
		Depth Offset, ft:	-11		
		Elevation, ft:	674.2		
NAD1983	Coordinates:	**Easting:**	2406037.0		
PA State Plane	Eastern	**Northing:**	339538.6		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.191
X_critical 1 ------->		24.0			
Layer 1 thickness			9.9		
V1, Layer 2 -------->	5800.0			"V0_2	0.085
X_critical 2 -------->		43.0			0.825
Layer 2 thickness			12.5		
V2, Layer 3 -------->	13000.0			"V1_2	0.462
				k 0.850	0.619

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.9	664.3
Layer 3 ---------->	22.4	651.8





Prepared by: _____ Date: _____

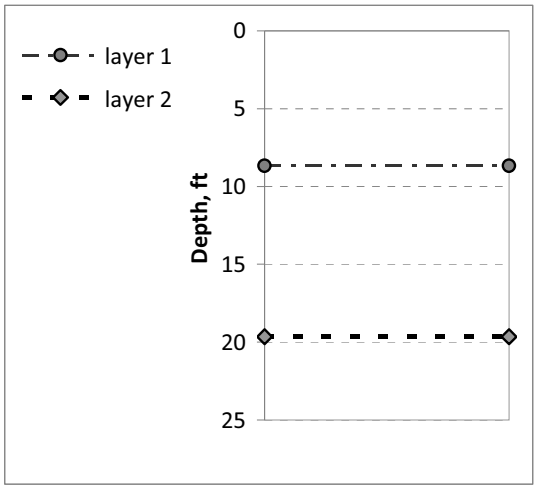
Reviewed by: _____ Date: _____

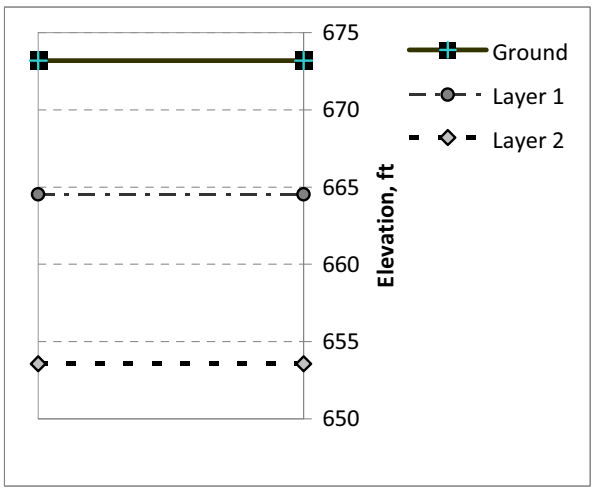
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High End	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1250	**Location:**	Berwick
		Depth Offset, ft:	-10		
		Elevation, ft:	673.2		
NAD1983	Coordinates:	**Easting:**	2406101.5		
PA State Plane	Eastern	**Northing:**	339544.4		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.191
X_critical 1 ------->		21.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	5800.0			"V0_2	0.081
X_critical 2 -------->		37.0			0.825
Layer 2 thickness			11.0		
V2, Layer 3 -------->	13600.0			"V1_2	0.441
				k 0.751	0.634

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.7	664.5
Layer 3 ---------->	19.6	653.6





Prepared by: _____ Date: _____

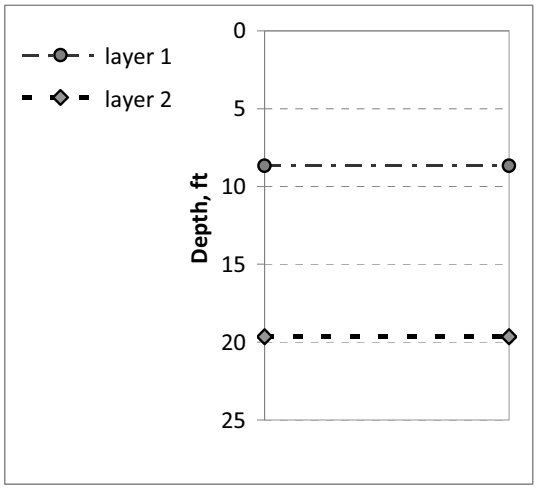
Reviewed by: _____ Date: _____

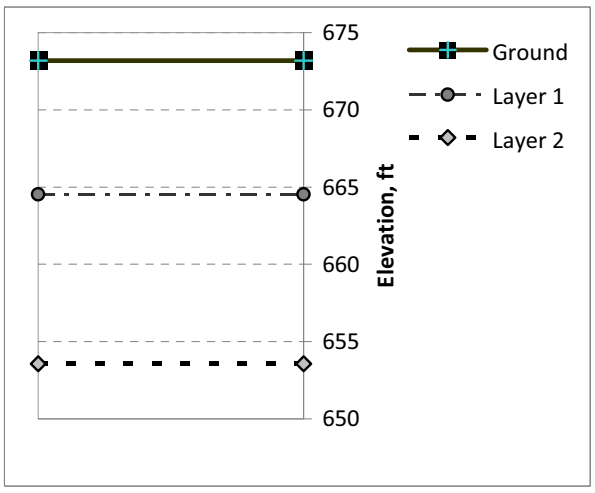
Approved by: _____ Date: _____

Line No.:	C	**Shot Location:**	High Offset	**Project:**	W7017
Spread No.:	5	**Shot Distance, ft:**	1300	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	673.2		
NAD1983	Coordinates:	**Easting:**	2406151.2		
PA State Plane	Eastern	**Northing:**	339548.9		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.191
X_critical 1 ------->		21.0			
Layer 1 thickness			8.7		
V1, Layer 2 -------->	5800.0			"V0_2	0.081
X_critical 2 -------->		37.0			0.825
Layer 2 thickness			11.0		
V2, Layer 3 -------->	13600.0			"V1_2	0.441
				k 0.751	0.634

Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	8.7	664.5
Layer 3 ---------->	19.6	653.6





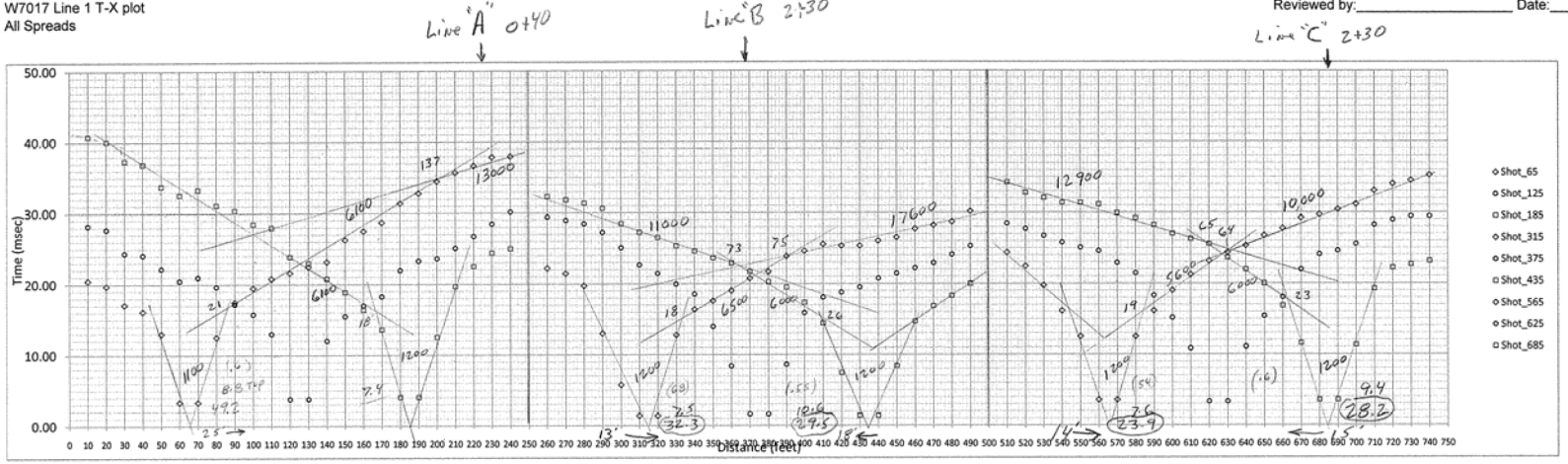
Prepared by: _____ Date: _____

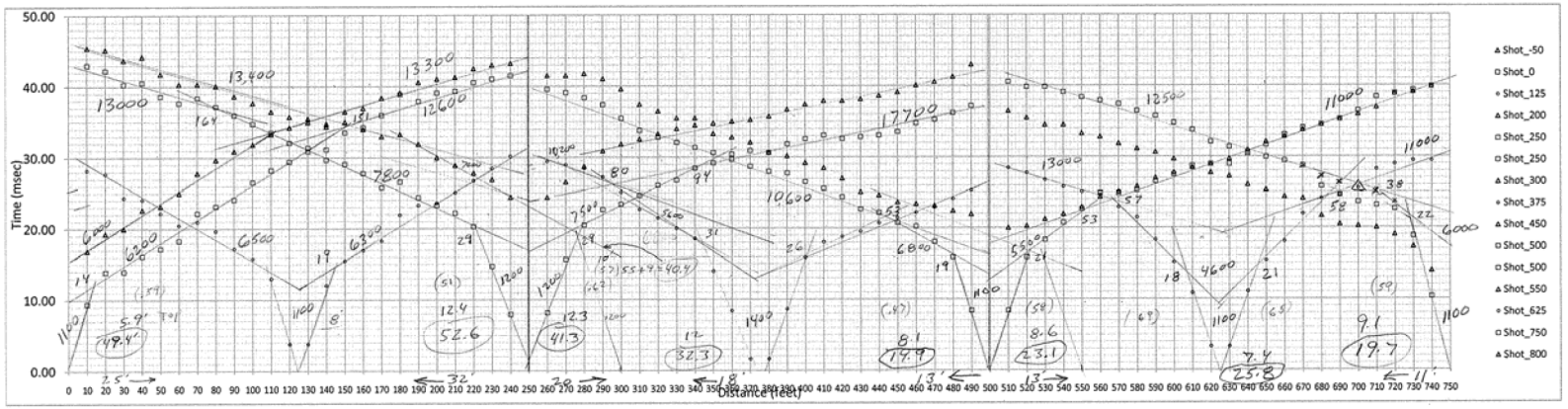
Reviewed by: _____ Date: _____

Approved by: _____ Date: _____

C:\PROJECTS\W7017 PCR Berwick\W7017 Line 1 T-X plot
W7017 Line 1 T-X plot
All Spreads

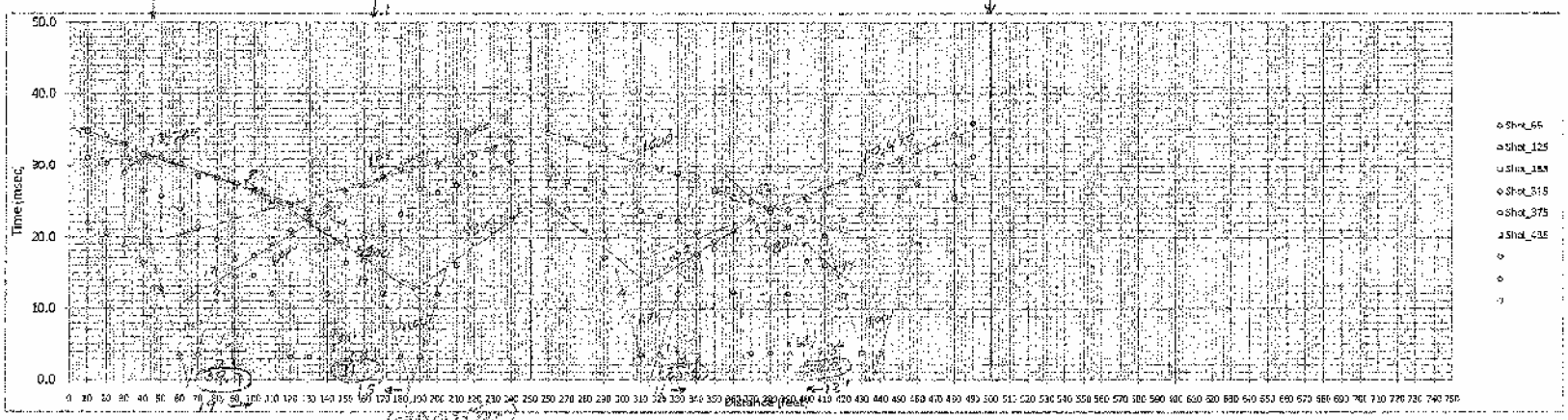
Prepared by:_____ Date:_____
Reviewed by:_____ Date:_____

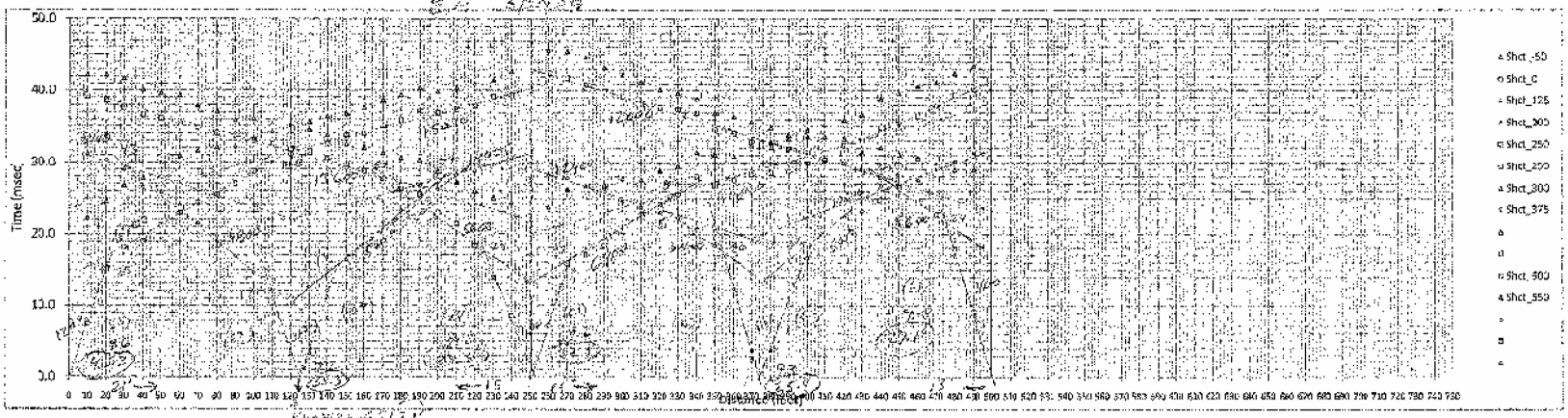




C:\PROJECTS\W7017 PCR Berwick\W7017 Line 2 T-X plot
W7017 Line 2 T-X plot
All Spreads

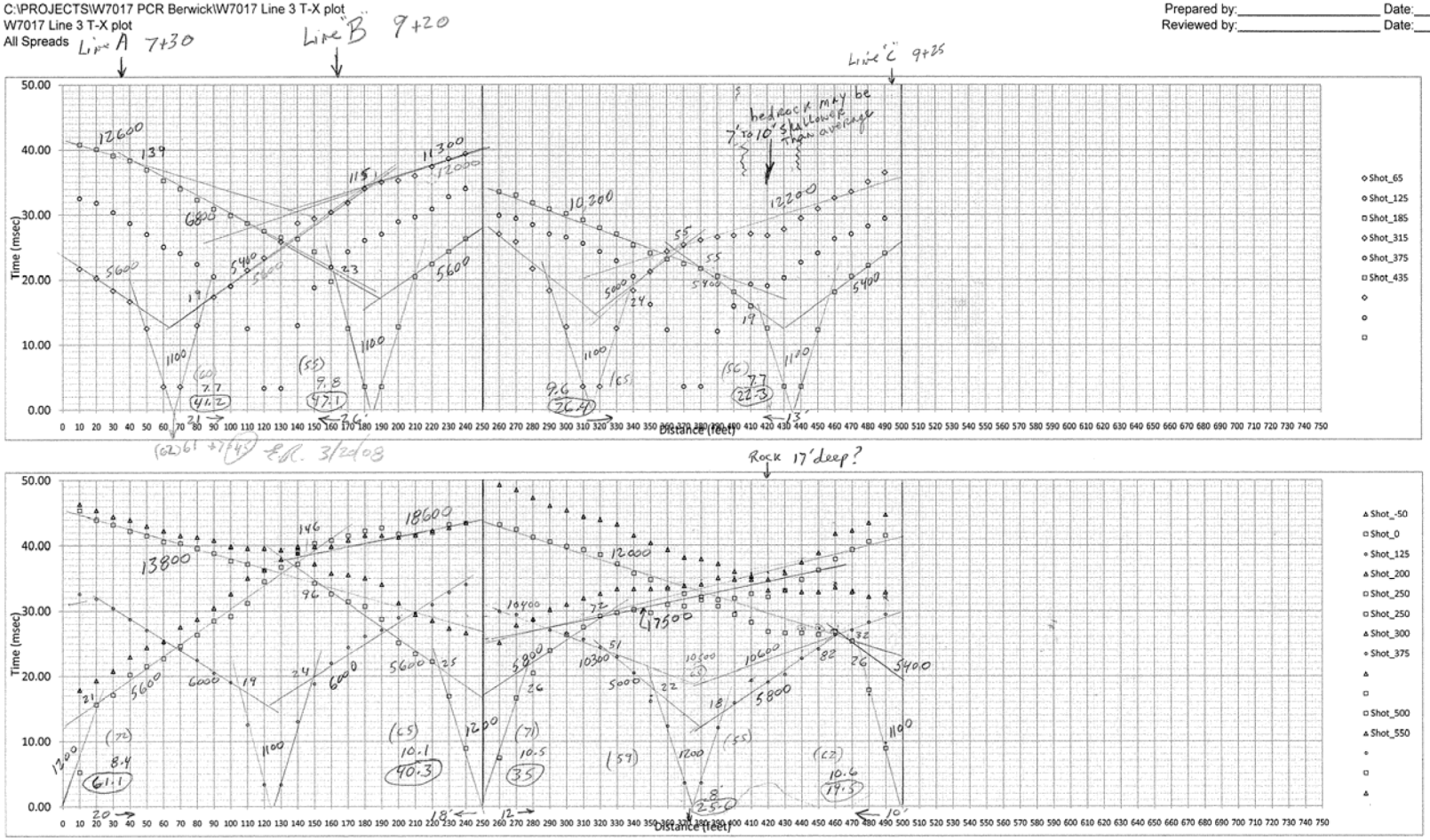
Prepared by:_____ Date:_____
Reviewed by:_____ Date:_____





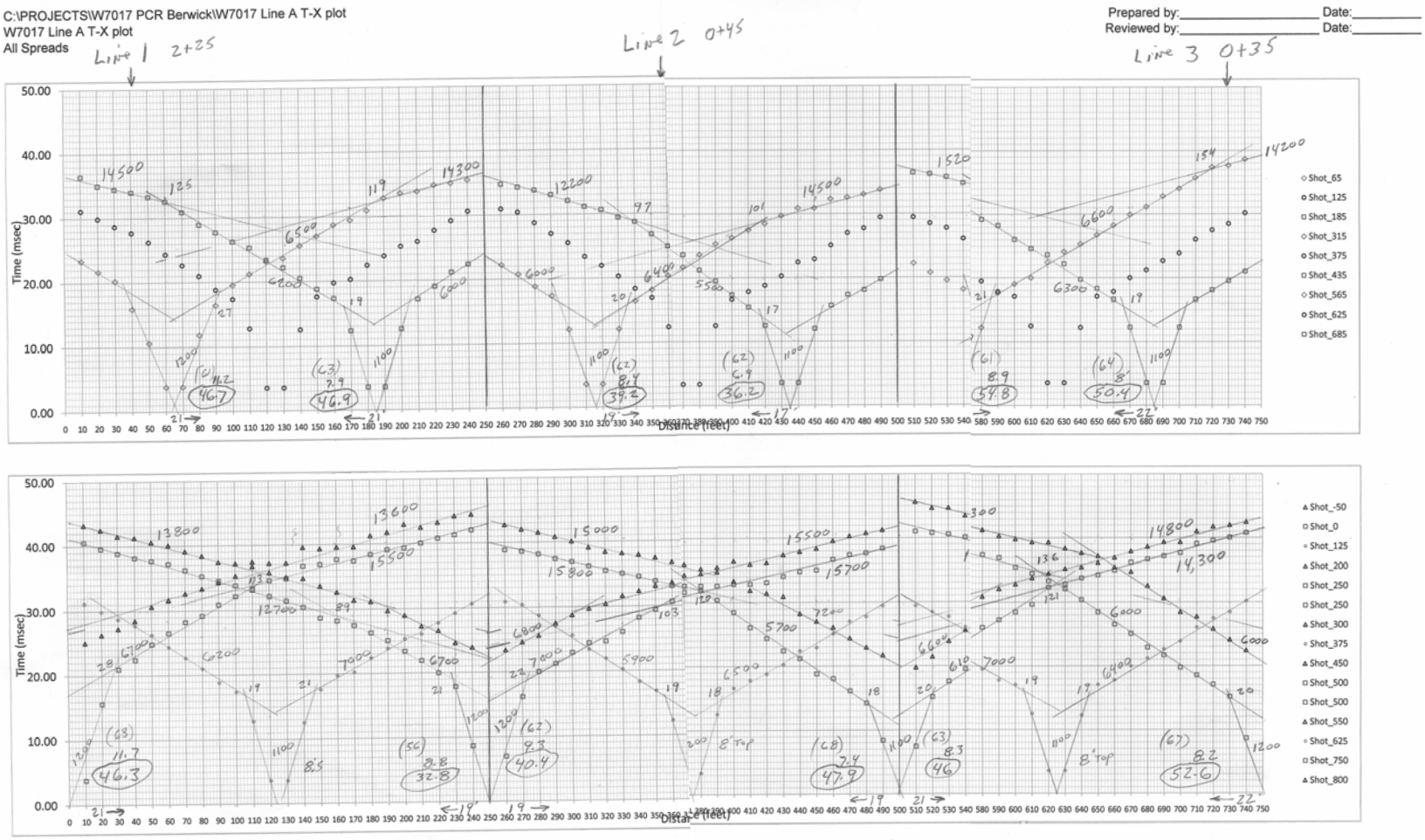
C:\PROJECTS\W7017 PCR Berwick\W7017 Line 3 T-X plot
W7017 Line 3 T-X plot
All Spreads

Prepared by:_____ Date:_____
Reviewed by:_____ Date:_____



C:\PROJECTS\W7017 PCR Berwick\W7017 Line A T-X plot
W7017 Line A T-X plot
All Spreads

Prepared by:_____ Date:_____
Reviewed by:_____ Date:_____



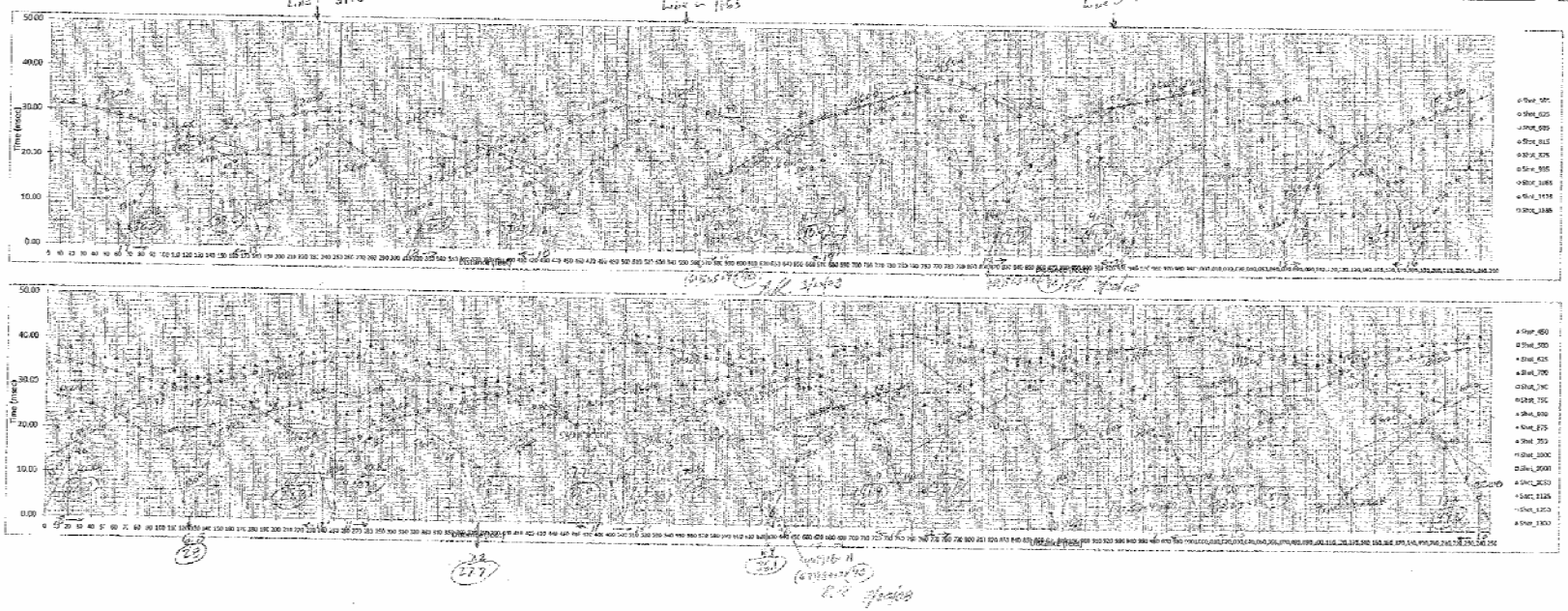
Weston Geophysical Engineers

2/11/2008

Q:\PROJECTS\W7017 PCR Berwick\W7c17 Line B1 T-X plot
W70-7 Line B1 T-X plot
Spreads 1, 2, 3

Prepared by: _____
Reviewed by: _____

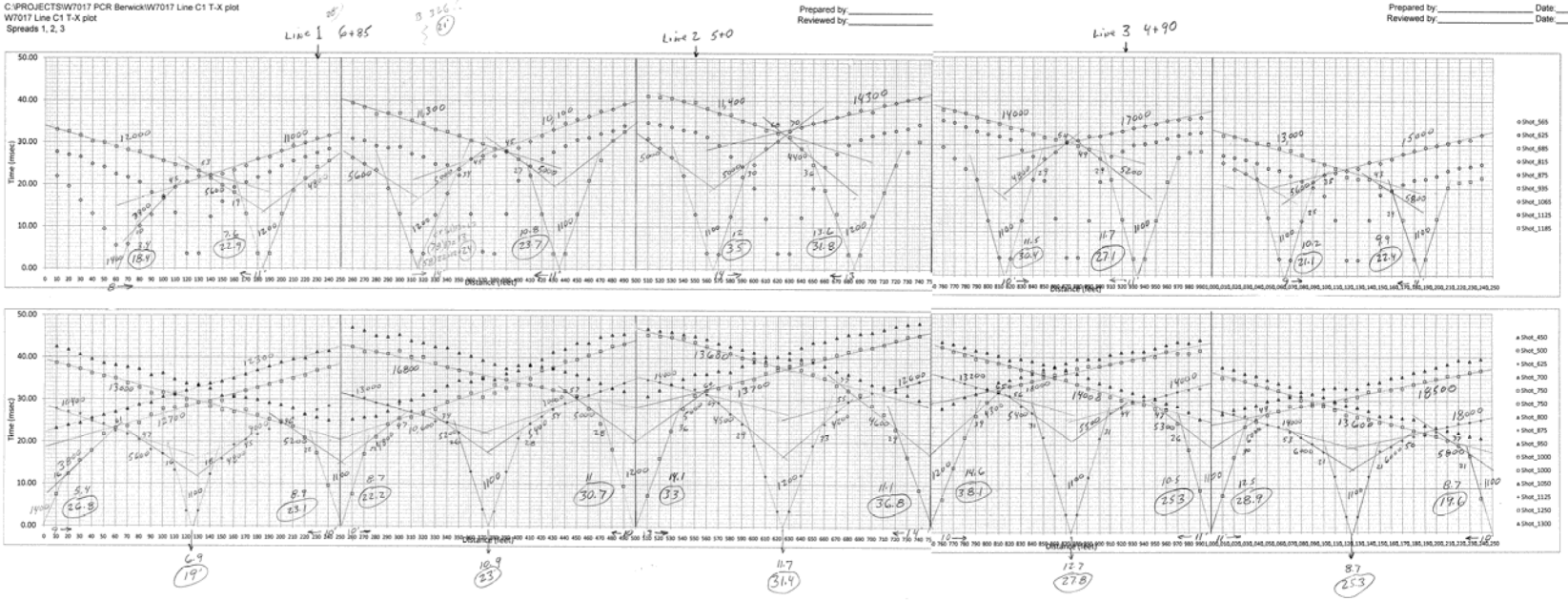
Prepared by: _____ Date: _____
Reviewed by: _____ Date: _____



C:\PROJECTS\W7017 PCR Berwick\W7017 Line C1 T-X plot
W7017 Line C1 T-X plot
Spreads 1, 2, 3

Prepared by:_____
Reviewed by:_____

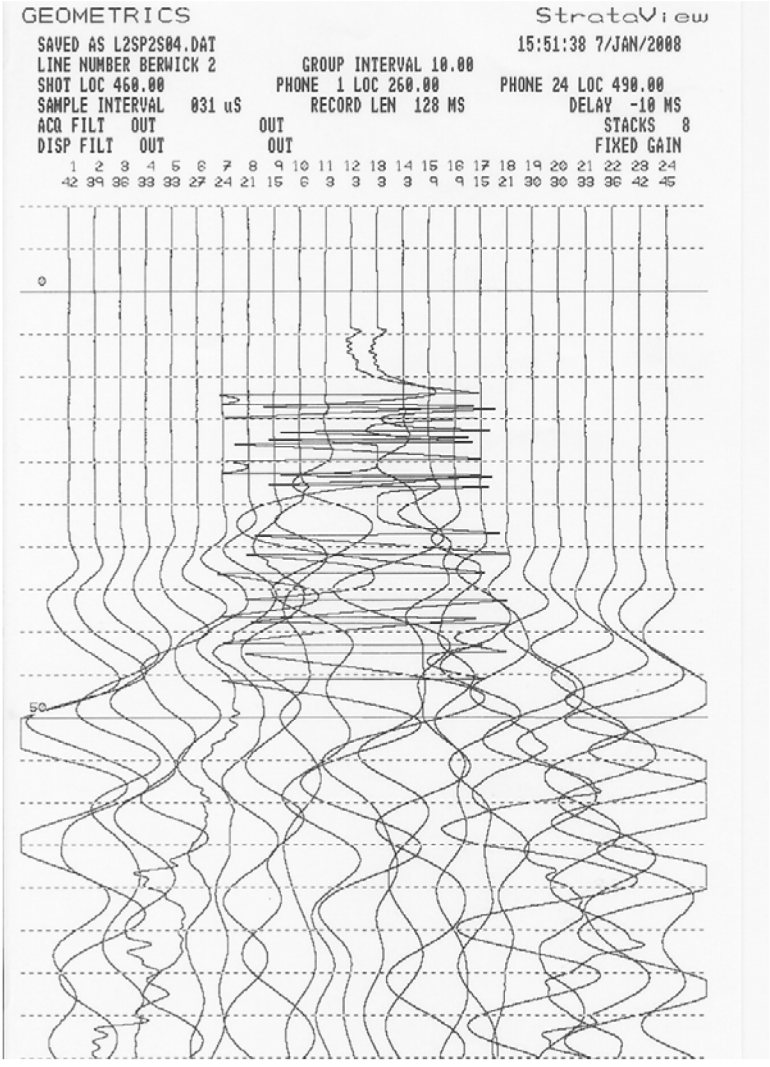
Prepared by:_____ Date:_____
Reviewed by:_____ Date:_____



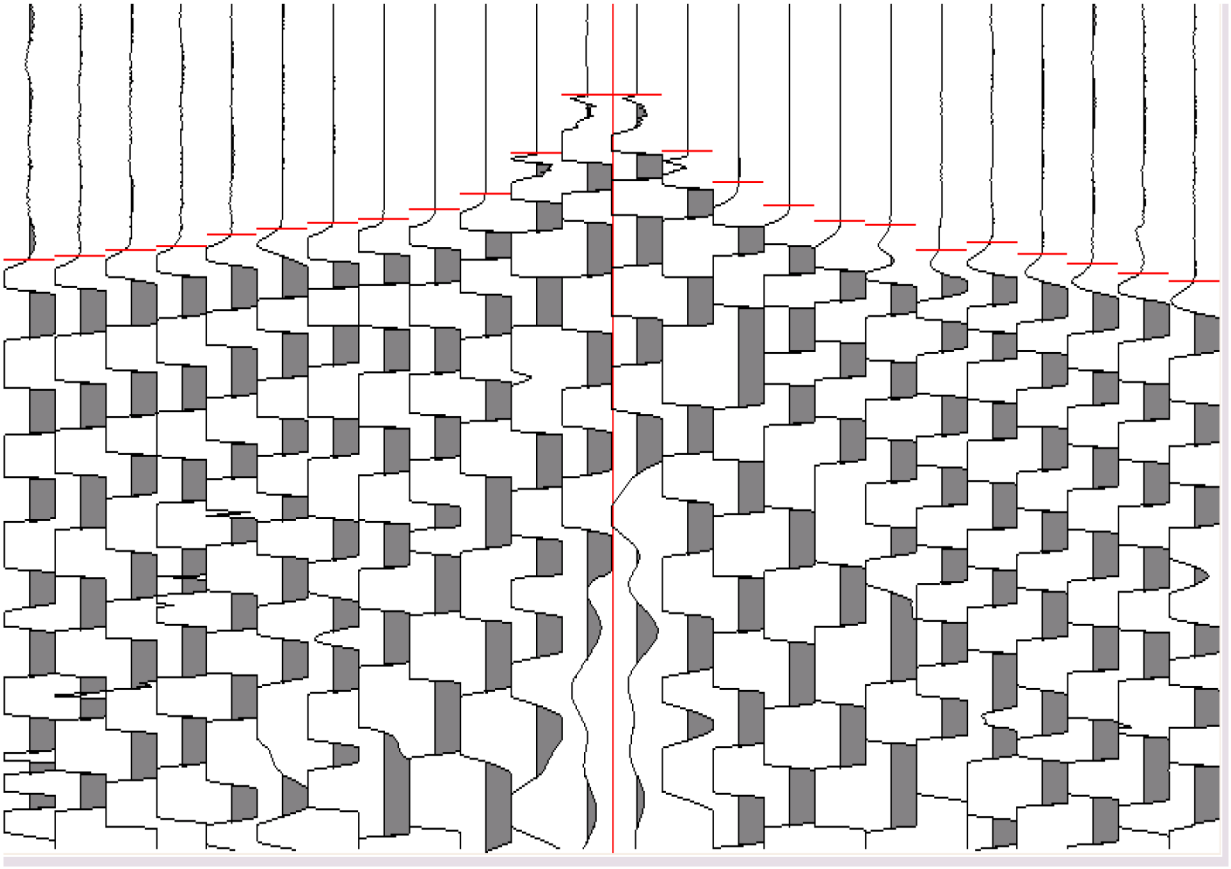
Appendix B
WGE CSS 1 – Critical Distance Calculation Method

The process for calculating the depths to subsurface layers and compressional wave velocities using seismic refraction methods are well documented in geophysical science educational text books and is also described in the methodology section of this report. This WGE CSS-1 document is intended to show a diagrammatic process from data acquisition to the presentation of the depths to various subsurface layers derived from the calculations of the intercepts of the average velocities.

- The first figure is of an actual recording output from the digital seismograph to show that recognizable arrival times of the compressional wave can be interpreted while still at the recoding location. The data at this point can be evaluated to provide estimates of the velocities and approximate thickness of the overburden layer. The strip chart recording displays the recording parameters as well as the time and date that the data was recorded. This data is simultaneously recorded on the digital seismograph for further, more detailed, analysis.



- The second figure shows the data as it is displayed on a computer screen with the red lines indicating where the operator has selected the arrival of the compressional wave energy. The red marks correspond to actual time in milliseconds and are stored with the unique geophone number and can be read into a number of different computer programs. This first break pick data file is converted to an ASCII format file that is read into Microsoft Excel spreadsheets for the next stage of interpretation to determine the critical distances and average velocities.

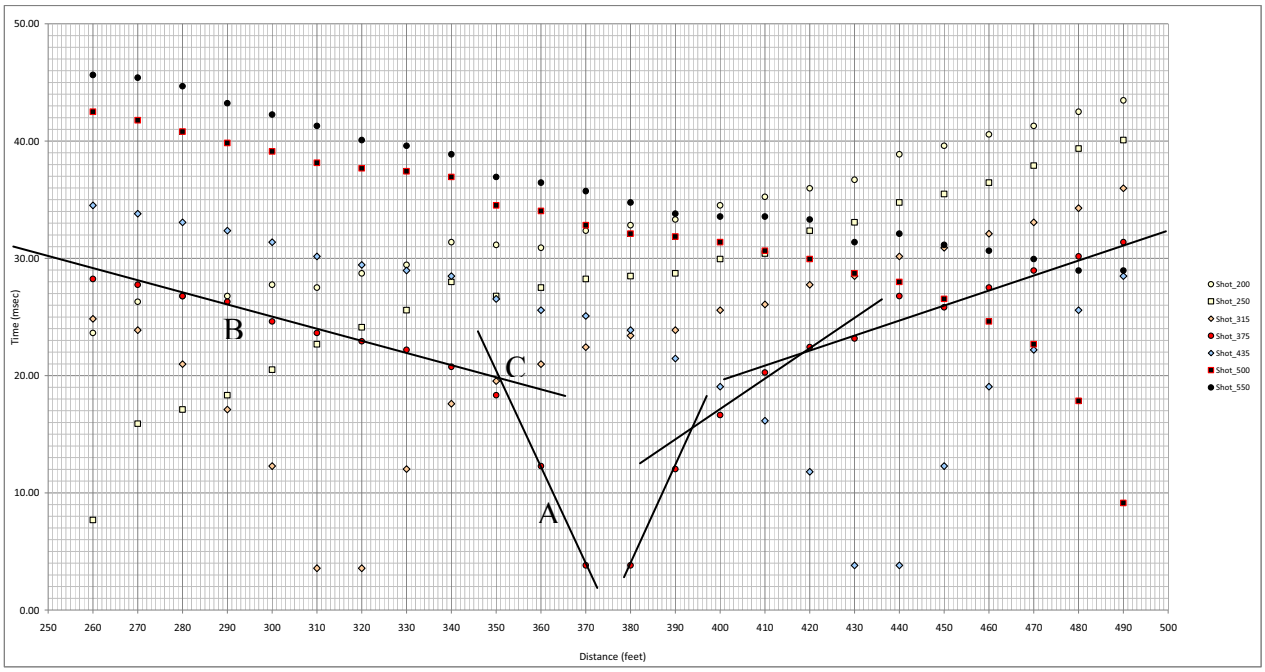


- The third figure shows the tabulations of the 7 energy points for the 250-foot spread for Line 2 from profile station 2+50 to station 5+00. The first breaks for each of the energy points are then combined into spreadsheet format to facilitate the graphical presentation of the data. The data in the spreadsheet is sorted by the location of the energy generation point and the array geophone number. The geophone number is then correlated to the actual distance along the profile and corresponding elevation of the geophones along the array.

W7017 Rizzo Line 2 Spread 2 (times shown in milliseconds)

Geophone	Dist	Elevation	Shot_200	Shot_250	Shot_315	Shot_375	Shot_435	Shot_500	Shot_550
1	260	668.52	23.64	7.68	24.85	28.24	34.52	42.50	45.64
2	270	668.54	26.30	15.90	23.88	27.75	33.80	41.78	45.40
3	280	668.66	26.78	17.11	20.98	26.78	33.07	40.81	44.68
4	290	668.78	26.78	18.32	17.11	26.30	32.35	39.84	43.23
5	300	668.75	27.75	20.50	12.28	24.61	31.38	39.12	42.26
6	310	668.72	27.51	22.67	3.57	23.64	30.17	38.15	41.29
7	320	668.69	28.72	24.12	3.57	22.92	29.44	37.67	40.08
8	330	668.66	29.44	25.58	12.03	22.19	28.96	37.42	39.60
9	340	668.88	31.38	27.99	17.60	20.74	28.48	36.94	38.87
10	350	669.10	31.14	26.78	19.53	18.32	26.54	34.52	36.94
11	360	669.17	30.90	27.51	20.98	12.28	25.58	34.04	36.46
12	370	669.24	32.35	28.24	22.43	3.81	25.09	32.83	35.73
13	380	669.31	32.83	28.48	23.40	3.81	23.88	32.10	34.76
14	390	669.38	33.31	28.72	23.88	12.03	21.46	31.86	33.80
15	400	669.75	34.52	29.93	25.58	16.63	19.05	31.38	33.56
16	410	670.12	35.25	30.41	26.06	20.26	16.15	30.65	33.56
17	420	670.49	35.97	32.35	27.75	22.43	11.79	29.93	33.31
18	430	670.86	36.70	33.07	28.48	23.16	3.81	28.72	31.38
19	440	671.38	38.87	34.76	30.17	26.78	3.81	27.99	32.10
20	450	671.90	39.60	35.49	30.90	25.82	12.28	26.54	31.14
21	460	672.47	40.57	36.46	32.10	27.51	19.05	24.61	30.65
22	470	673.04	41.29	37.91	33.07	28.96	22.19	22.67	29.93
23	480	673.66	42.50	39.36	34.28	30.17	25.58	17.84	28.96
24	490	674.28	43.47	40.08	35.97	31.38	28.48	9.13	28.96

- The forth figure is the display of the first break picks on a time-distance graph with the x axis representing distance and the y axis representing time in milliseconds. The lines drawn of this figure indicate the slope of the average velocities interpreted for the energy point in the middle of the array. The steeper lines (A) indicate slower velocities as compared to the shallower lines (B) that typically indicate more dense material or faster velocities. The critical distance (C) is determined by locating where the two or more velocity lines intersect. The velocities and critical distances determined from this graphical display are the entered into a tabulation spreadsheet to calculate the depth and elevation of the various layers.

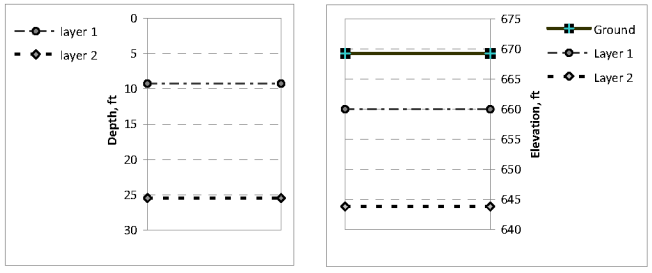


- The final figure shows the compilation of the velocity and critical distances derived from the previous figure. The entry of the initial velocity for the first layer is 1100 feet per second with a critical distance of 22 feet to the crossover from the first velocity to the intermediate second layer velocity of 5200 feet per second then to a critical distance of 55.5 feet between the second and third layer. The entry of the third layer velocity of 11500 feet per second results in thicknesses of the layers of 9.3 feet for the first layer and 16.2 feet for the second layer. This is then converted to elevation relative the ground surface elevation at the energy point, in this case 669.3 feet. The lower portion of this figure shows the graphical presentation of the depths and elevations. This data was then combined with the other energy points along this line to create a elevation profile for the entire line.

Line No.:	2	**Shot Location:**	Center	**Project:**	W7017
Spread No.:	2	**Shot Distance, ft:**	375	**Location:**	Berwick
		Depth Offset, ft:			
		Elevation, ft:	669.3		
NAD1983	Coordinates:	**Easting:**	2405416.0		
PA State Plane	Eastern	**Northing:**	339351.3		

Data Input	Velocity, fps	X critical, ft	Computed Thickness, ft	Critical angles	
V0, Layer 1 -------->	1100.0			"V0_1	0.213
X_critical 1 ------->		23.0			
Layer 1 thickness			9.3		
V1, Layer 2 -------->	5200.0			"V0_2	0.096
X_critical 2 -------->		55.5			0.807
Layer 2 thickness			16.2		
V2, Layer 3 -------->	11500.0			"V1_2	0.469
				k 0.887	0.614

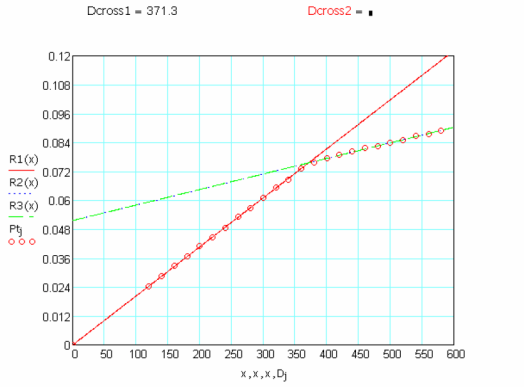
Output	*Depth, ft*	*Elevation, ft*
Layer 2 ---------->	9.3	660.0
Layer 3 ---------->	25.4	643.8



Prepared by: _____ Date: _____

Reviewed by: _____ Date: _____

Approved by: _____ Date: _____



Vel1 = 4914

Vel2 = 15494

Vel3 = 15494

$i12 := \operatorname{asin}\left(\frac{Vel1}{Vel2}\right)$ $i13 := \operatorname{asin}\left(\frac{Vel1}{Vel3}\right)$ $i23 := \operatorname{asin}\left(\frac{Vel2}{Vel3}\right)$

$T1 := \frac{Dcross1}{2}\cdot\sqrt{\frac{Vel2 - Vel1}{Vel2 + Vel1}}$ $T2 := \frac{Dcross2}{2}\cdot\sqrt{\frac{Vel3 - Vel2}{Vel3 + Vel2}} - \frac{T1\cdot(\cos(i13) - \cos(i12))}{\cos(i23)\cdot\sin(i12)}$

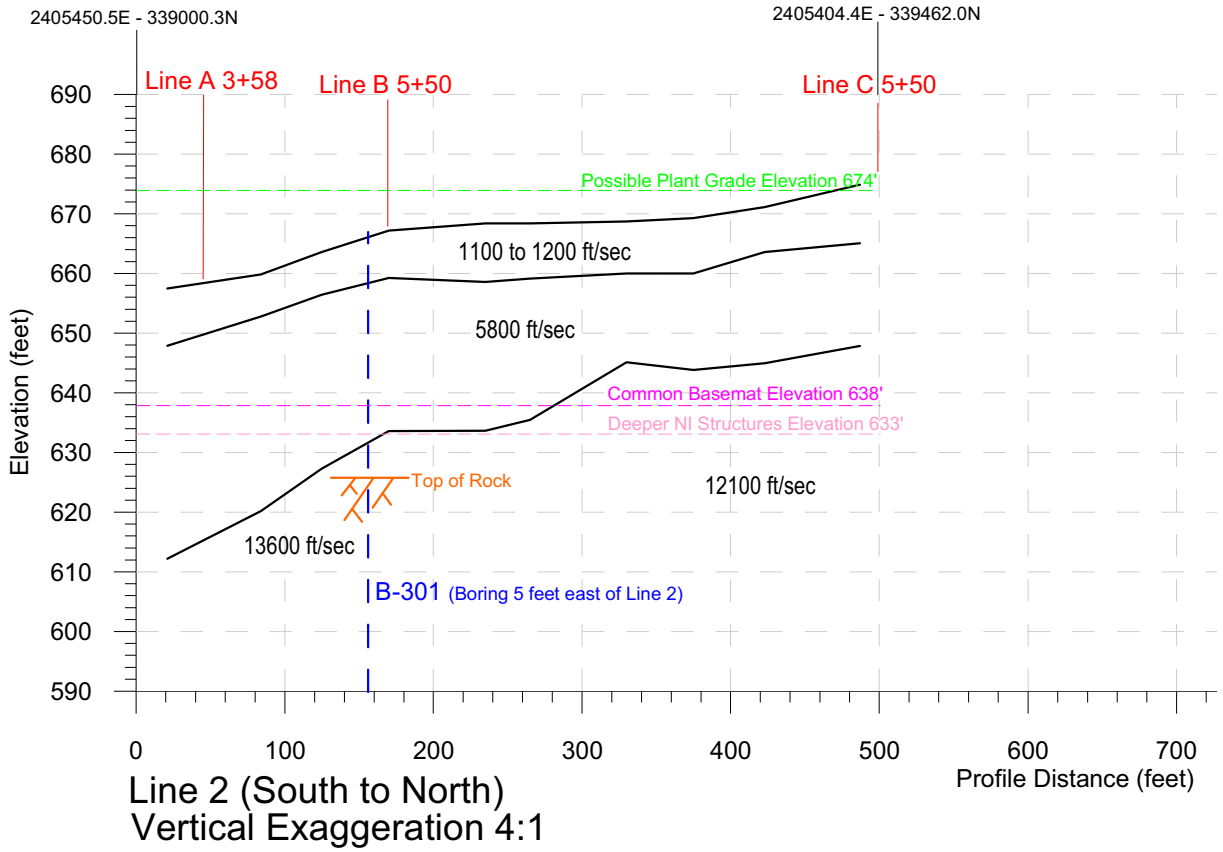
T1 = 133.673 Z1 := T1 T2 = ∎

Z2 := Z1 + T2

Z1 = 133.7 Z2 = ∎

The image above show the computational equations used for the simple three layer case. These equations are the basis for every seismic refraction depth calculation

- The last figure shown is an example of the final profile showing the elevations of the various layers as well as the compressional velocities along the entire profile. The profile horizontal distance is relative to the placement of the consecutive spreads needed to complete the length of the profile.



WGE Procedure P2

Surface Seismic Refraction Surveys

Weston Geophysical Engineers, Inc.
20 Main Street
Acton, MA 01720
(978) 263-3600
(978) 263-3605 fax

Controlled Copy No. _____ Revision No._____

Prepared by: __Peter B. Hubbard_____ Date: _____7-Sep-2007_____

Approved by: _____ Date: _____

George C. Klimkiewicz, President

Table of Contents

WGE Procedure P2
Surface Seismic Refraction Surveys

1.0 SCOPE AND OBJECTIVES 3
2.0 DEFINITIONS 3
3.0 RESPONSIBILITIES AND QUALIFICATIONS 5
4.0 MATERIALS/EQUIPMENT AND CALIBRATION 5
5.0 METHODOLOGY, APPLICATIONS, AND FIELD PROCEDURES 6
6.0 ACCEPTANCE CRITERIA 11
7.0 RECORDS 11
8.0 REFERENCES 12
9.0 ATTACHMENT A 13

Procedure P2 – Indoctrination and Training			
Trainee	*Title*		*Date completed*
Training Level Achieved:	_____	Data analysis & interpretation	_____
	_____	Field data acquisition	_____
	_____	Instrument set-up and Field work assistance	_____
Management Approval	*Title*		*Date*

Record of Revisions		
Revision	**Section**	**Description**
0	All	New procedure

P2 - SURFACE SEISMIC REFRACTION SURVEYS

1.0 SCOPE AND OBJECTIVES

1.1 **Scope** – This Procedure describes methods for conducting surface seismic refraction surveys. Surface seismic refraction surveys are conducted to aid in the characterization of the subsurface. The main purposes of surface seismic refraction surveys are mapping depth to top of bedrock, identifying voids, determining strength and quality of bedrock, and locating faults or steeply dipping contacts.

This procedure shall be utilized at known or new sites, identified by Weston Geophysical Engineers, for surface seismic refraction survey investigations. Seismic refraction surveys will be conducted by a qualified WGE geophysics field crew and shall be performed in accordance with this Procedure.

Performance of surface seismic refraction surveys is based on standard and recognized methodologies first employed to study earth structure in the early 1900's. Oil and mineral explorations using seismic refraction surveys date to the 1920's (Dobrin, 1976). References for this geophysical test method are listed in Reference Section (8.0) of this Procedure.

1.2 **Objectives** – The objectives of this Procedure are to provide instructions for: (1) site preparation, (2) seismic refraction survey field procedures, and (3) seismic refraction data processing.

2.0 DEFINITIONS

2.1 **Anomaly** – A feature distinguished in geophysical data that is different from the general surroundings, i.e., a departure from the expected or normal.

2.2 **Geophone** – (Receiver.) An instrument that is used for detecting ground motion by detecting changes in ground velocity and transforming the motion into electrical impulses that are proportional to this velocity. Geophones vary in resonant frequency, which should be close to the frequency of the signal to be recorded. The selected geophones (40 Hz natural frequency) are designed for a range of engineering geophysics applications specifically for the conduct of land refraction and reflection tests.

2.3 **Off-end** – When detectors/receivers are only on one side of the source, and the source is beyond but still in line with the "spread" of receiver locations.

2.4 **Seismograph** – An instrument that is used for amplifying and recording the ground motion detected and transformed into electrical impulses by geophones.

2.5 **Shot Record** – A group of traces with the same shot position.

2.6 **Shot** – A source of seismic energy. Typically, it is a weight drop or ground surface impact by a sledgehammer. Explosives are used for crustal-scale refraction surveys requiring large energy sources.

2.7 **Stacks** – Stacks are used to improve the signal to background noise ratio. One stack is one 'shot'. In typical cases one 'shot' will be operation of a truck mounted impulse hammer or manual swinging of a sledge hammer. One stack is one impact of a plate fixed to the ground from either of these sources. Two stacks will be two impacts to the ground. With each successive impact the signal (seismic wave) generated by the hammer, being coherent and repeatable, is amplified relative to the background noise, which is incoherent vibration. Computationally, the stacked records are summed, in which process the signal (seismic wave from hammer source) grows as the summed incoherent background noise amplitude is diminished.

3.0 RESPONSIBILITIES AND QUALIFICATIONS

3.1 **General Manager** – WGE's General Manager is responsible for ensuring the surface seismic refraction survey crew is trained and indoctrinated in the content of this procedure. The General Manager is responsible for ensuring that the seismic refraction survey activities are performed in accordance with this Procedure.

3.2 **Project Manager** – WGE's Project Manager will supervise all on-site field data collection activities. The Project Manager shall be responsible for ensuring the completion of all applicable forms and for notifying the General Manager or designee of site-specific activities about seismic refraction survey progress, problems, and results on a weekly basis. The Project Manager is responsible for the interpreted results of the surface seismic refraction survey and for supervising the report effort.

3.3 **Seismic Refraction Survey Field Crew** – Each seismic refraction survey crew shall consist of at least two personnel, as determined by the General Manager. The seismic refraction survey field crew will perform field instrument deployment and data acquisition activities under direction and supervision of the Project Manager.

4.0 MATERIALS/EQUIPMENT AND CALIBRATION

4.1 **Materials and Equipment** – Specific equipment used to conduct refraction surveys may consist of one or more of the following items shown in Table 1. Specific parts and equipment used with this system are listed in detail in the Inventory of Refraction Measurement and Test Equipment form (Attachment A-1).

Table 1
Seismic Refraction Survey Equipment

Equipment	
Name	**Description/Usage**
Geometrics, Inc. Geode 24-48 channel digital seismograph	Ultra-light exploration seismograph
Geometrics, Inc. Strataview 24 channel digital seismograph	Data recorder with strip chart output in addition to data file storage
Geospace 40Hz land geophone, 48 units	Vertical component seismic receiver
Sledgehammer (12 lb) With contact closure trigger for zero-time	Seismic 'shot' source
Truck mounted, spring actuated, seismic source	Seismic 'shot' source for deeper penetration of seismic energy

The following is a list of additional equipment that may be used during a surface seismic refraction survey:

- Laptop computer w/ software, and diskettes
- Compass
- Measuring tapes
- Toolkit
- Wooden stakes and hammer
- Surveyor's paint/chalk and plastic pin flags
- Flagging, cones, and barricades
- Field notebook and project file
- Extra instrument batteries and chargers
- Standard health and safety supplies
- Global Positioning System (GPS)
- Level prism and staff, or laser level and tripod
- Digital camera and diskettes
- Inverter and power strip
- Printer
- Work gloves
- Eye and ear protection

4.2 **Calibration Requirements –** Instruments will be operated in accordance with the manufacturer's procedures. The only instrument requiring calibration is the Crystal Oscillator. This calibration will occur prior to and after all field activities are complete. Seismograph is functionally checked with the Crystal Oscillator which is calibrated by AREVA NP.

5.0 METHODOLOGY, APPLICATIONS, AND FIELD PROCEDURES

5.1 **Seismic Refraction Theory and Applications –** Surface seismic refraction surveys are conducted to aid in the characterization of the subsurface. Seismic refraction occurs when elastic waves strike and then travel along or "refract" at the contact of two geologic strata with different bulk material properties (e.g. mineralogy, density, porosity, etc.). Typically, the lower layer must have a significantly faster intrinsic seismic velocity than the upper layer to provide a distinct boundary refraction event (known as a head wave).

The refraction method obeys Snell's law, which states that the refracted angle of a wave depends only on the change in velocity between boundaries and the angle of incidence (the angle at which the wave arrived at the boundary).

This method differs from seismic reflection in that the distance between the source and detectors in refraction is much larger. The larger source-detector distance enables recording of predominantly horizontal energy rather than vertical, so it easily detects the interfaces of shallow layers.

Collecting seismic refraction data requires a source to generate a seismic wave, and geophones placed in the ground to detect the seismic wave at varying distances. WGE typically uses a 12-pound sledge hammer and plate or a truck-mounted spring actuated hammer (SAH) source to generate seismic waves. Additional energy sources can include a 'buffalo gun' that impels into the ground a shotgun blank engineered for geophysical tests. The geophones are arranged along a line or spread, usually at constant intervals, and connected to a seismograph to record and display their responses.
The recorded values are displayed as wiggle traces on a shot record. Data processing is done by picking the first arrivals of seismic energy at each receiver/geophone, and calculating the velocities of the main layers using a generalized reciprocal method (GRM) and critical distance time-intercept methods. Resulting velocities are used to create a model of the subsurface. Seismic refraction data can be analyzed either by using hand calculations, by using templates devised to aid velocity vs. depth calculations, or by using commercial software. In any of these cases, the mathematics is relatively simple. The basic procedure is application of Snell's Law that describes ray refractions and reflections along layers with differing seismic velocities.

We plan to use the following commercial software packages.

- SeisOpt Pro Version 4.0 by Optim Software and Data Solutions
- WinSism 10 by W-Geosoft Geo2X

Manufacturers will be requested to provide accuracy testaments and case histories and any information related to prior QA documentation of software. If applicable, an alternate calculation method to confirm results will be conducted.

Refraction data along a subset of profile lines will be interpreted using both of these software packages. Similarities of calculated velocity structures will be recognized as a basic confirmation that each software package properly implements the mathematics (e.g. Snell's Law) of seismic refraction interpretations.

In addition, hand calculations will be provided for representative refraction spreads as additional validation for software-produced seismic velocity structures.

The seismic refraction survey design used to conduct a geophysical investigation varies according to site-specific objectives and target depth. The depth of penetration is dependent on site conditions, the force of the seismic source, and receiver (geophone) spacing. The objectives of a seismic refraction survey and expected results are discussed in the project proposal. However, the following issues and concerns are routinely evaluated:

- Review existing site surface and subsurface information.
- Evaluate the potential influence of cultural and natural features.
- Define any health and safety hazards.
- Evaluate the data quality and depth of penetration. Adjust acquisition parameters, if needed, to obtain the optimal results for that particular site.

The project-specific application of the seismic refraction method will be documented in the Project Task Plan (GEI Work Plan 2) developed from the technical proposal submitted and approved for a given project.

5.2 **Seismic Refraction Survey Field Procedures –** The standard field procedures for conducting a surface seismic refraction survey are described below.

5.2.1 **Site Preparation –** Prior to conducting a surface seismic refraction survey, a base grid should be established with a measuring tape. The base grid shall be marked with wooden stakes, pin flags, or surveyor's paint to provide spatial control for the refraction survey. For seismic refraction surveys, the base grid will typically consist of a single line, or multiple intersecting lines, along which the data will be collected. Subsequently, seismic refraction data will be acquired along these lines with appropriate point spacing for the receiver configuration by the refraction survey field team.

The locations of all seismic refraction profile lines including shot points and ends of refraction spread segments will be determined by surveys provided by a project subcontractor.

Vertical control is typically measured to the nearest foot using Procedure P4 Hand Level Procedures. The hand level changes in elevation along refraction profile lines will be tied to available elevations determined for various site features (e.g. borings) by civil surveys of the site, by others.

All seismic refraction profile lines shall also be surveyed for elevations using level surveying equipment according to Procedure P4 – Hand Level Surveys.

5.2.2 **Field Procedures**

5.2.2.1 A visual survey will be conducted along the proposed survey lines. The visual survey shall include:

- Review of site utility plans,
- Preparation of a hand-sketched site map showing any surface features at the site or near the boundary that could affect the geophysical data. This hand-sketched map is for informational purposes only to assist the field personnel in day to day operations.

5.2.2.2 Instrument batteries will be checked for sufficient charge and the instrument will be tested according to manufacturer's instructions. Instrument check results shall be recorded in the Field Project Daily Field Report (DFR) (Attachment A-2).

5.2.2.3 Surface seismic refraction survey data, corresponding line and station numbers, geophone spacing, profile collection name, shot point location, and number of stacks shall be stored automatically in the internal memory of the laptop computer to which the refraction equipment is connected, and/or manually recorded on the Seismic Refraction Data Acquisition Field Notes Form (Attachment A-3) or on DFR (Attachment A-2). Paper output from the seismograph contains all recording parameters in the header section of the output. Instrument operation shall be in accordance with manufacturer's operation instructions.

5.2.2.4 At the end of the field day, seismic refraction survey data shall be backed up onto diskettes and/or the WGE server for further processing per Section 5.3 and archival purposes. The field technician will confirm by examining the contents of the diskette that the data was successfully transferred; the original data stored on the seismograph will be retained as a backup of the transferred data. Summary of activities and data storage information will be documented on the DFR (Attachment A-2).

5.3 **Seismic Refraction Data Processing and Interpretation** – This section presents data tracking, processing, and interpretation procedures for surface seismic refraction data.

5.3.1 Seismic refraction field data shall be tracked by recording the dates of acquisition and site-specific field data file names on the DFR (Attachment A-2).

5.3.2 All refraction field survey files shall be reviewed to ensure data quality in accordance with Acceptance Criteria discussed in Section 6.0 of this Procedure. Refraction data file names, line numbers, station ranges, shot point locations, field errors, corrections made to the files, and corrected file names shall be documented on the Seismic Refraction Data Acquisition Form (Attachment A-3).

5.3.3 Data shall be processed and modeled using WinSism v10, SeisOpt Pro v4 or Multiple Geode Operating Software (MGOS). Spread geometry, elevations, and shot point locations shall be entered and checked using the Seismic Refraction Data Acquisition Form. Optional filtering may be applied to refraction data to reduce noise and amplify the signal. First arrivals of seismic energy shall be identified by a geophysicist for each receiver location on every shot record. The generalized reciprocal method (GRM) shall be used to interpret changes in velocity. Inverse modeling shall be done to generate a model that best approximates the data and represents the geologic conditions of the site. Final inversion data file name and percent error shall be documented on the Seismic Refraction Data Processing Form (Attachment A-4). In addition, critical distance intercepts will be input to calculate depths to stratigraphic layers beneath the shot point locations.

5.3.4 Contour maps of seismic refraction velocity data shall be generated using the Golden Software Grapher (2D) and Surfer (3D) geophysical mapping system. In addition, geophysical data can be presented as GIS layer files in ESRI ArcView and/or ArcMap 9 files geocoded to the project coordinate system. The data will be gridded, optionally filtered, contoured, and printed. The names of the files generated and the processing parameters used shall be recorded on the Geophysical Data Processing Form (Attachment A-5). Contour maps will be color-enhanced to facilitate recognition and interpretation of anomalies.

6.0 ACCEPTANCE CRITERIA

The acquisition of seismic refraction data will be monitored in real time for data quality and viability. Each shot record will be viewed on a computer monitor or strip chart to assure the acquisition of viable and interpretable data. If data quality is poor, or if instrument problems are suspect, the seismic refraction data will be reacquired over the affected spread prior to redeployment of instruments. The procedure will be repeated until the field technician determines that the acceptance criteria of high quality, interpretable refraction records are met.

Acceptance criteria require obtaining 'interpretable' records. These are records on which the first arrivals of seismic waves are evident on many or most of the geophones in a spread. Records are enhanced for interpretation by using additional 'stacks', as defined above. The record data file at that shot point is saved only after the geophysicist determines acquisition of an 'interpretable' record. This may be following one stack (low noise condition) or following multiple stacks (high background noise levels). The number of stacks is registered with the data file for each shot point.

7.0 RECORDS

All project records generated in the field through the performance of this Procedure shall be temporarily filed in a designated project folder and kept with the field crew while in the field. Data will be backed-up to USB storage devices to limit the likelihood of data loss and need to repeat data acquisition field tests. Following the conclusion of field activities, all project records shall be submitted to the project central files for storage.

8.0 REFERENCES

8.1 Requirements and Specifications

8.1.1 *A Compendium of Superfund Field Operations,* EPA/540/P-87/001, December 1987.

8.1.3 *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* EPA, Interim Final, October 1988.

8.1.4 *RCRA Facility Investigation Guidance,* EPA, Interim Final, May 1989.

8.2 Related Procedures

8.2.1 WGE Standard Operating Procedure (SOP), P4: Level Surveys.

8.2.2 GEI Work Plan – 2

8.3 Instruments and Software

8.3.1 Geometrics, Inc., 2002, *Geode Ultra-Light Exploration Seismograph,* San Jose, California.

8.3.2 Geometrics, Inc., 2002, *Multiple Geode Operating Software Manual,* San Jose, California.

8.3.3 W_GeoSoft, 2000, *WinSism 10 Seismic Refraction Processing Software for Windows,* Geneva, Switzerland.

8.3.4 Optim, LLC, 2002, *User Manual for SeisOpt Pro Version 4 Velocity Optimization Software,* Reno, Nevada.

8.4 Seismic Refraction Method

8.4.1 Dobrin, M. B., and Savit, C. H., 1988, *Introduction to Geophysical Prospecting,* 4th edition, McGraw-Hill, New York, New York.

8.4.2 Dobrin, M.B., 1976, *Introduction to Geophysical Prospecting*, 3rd edition, McGraw-Hill, New York, New York, 630p.

8.4.3 Musgrave, A. W., ed., 1967, *Seismic Refraction Prospecting*, The Society of Exploration Geophysicists, Tulsa, OK, 604p

8.4.4 Telford, W.M., L.P. Geldart and R.E. Sheriff, 1990, *Applied Geophysics*, 2nd edition, Cambridge University Press, 770p.

9.0 ATTACHMENT A

9.1 Attachment A-1 – Inventory of Refraction Measurement and Test Equipment

9.2 Attachment A-2 – Field Project Daily Field Report

9.3 Attachment A-3 – Seismic Refraction Field Notes Form

9.4 Attachment A-4 – Seismic Refraction Data Processing Form

Attachment A-1

Weston Geophysical Engineers

Inventory of Refraction Measurement And Test Equipment

Job Number: _____ Job Name: _____
Location: _____ Check out date: _____
Checked out by: _____ Check in date: _____
☐ Internal Calibration Date: _____ ☐ External Calibration ** Date: _____

Equipment	Check Out	Condition	Check In	Condition
Geometrics Geode Seismograph				
Geometrics Strataview Seismograph				
Geophone cables				
Geophones				
Switch/Trigger				
Communications cables				
Battery cables				
Battery chargers				
Batteries				
Spring actuated hammer				
12 lb. Sledgehammer & Hammer plate				
GPS system				
Level system				
Spare contact closure triggers				

Attachment A-2

Weston Geophysical Engineers

Daily Field Report

For _____

This form is to be used to record project-related field activities.
The original, completed form is to be archived and maintained as a permanent record with the project files.

Job Number: _____ Job Name: _____

Client: _____

Location: _____

Date(s) covered by this Report Log: _____

WGE Personnel On-site: _____

_____

_____

Summary Prepared By: (Print):

WGE Vehicles Used: _____

RESOURCES

Check all applicable boxes. If any box has been checked, complete the Resource Chart on back.

- ☐ Geophysical Equipment Used
- ☐ Well and Sampling Materials
- ☐ Samples Submitted for Analysis
- ☐ Subcontractor Used
- ☐ Consultant on Site
- ☐ Other (comment on back)

SUMMARY OF ACTIVITIES AND DATA STORAGE INFORMATION

Attachment A-2 (page 2 of 2)

Job Number: _____ Date(s): _____

RESOURCE CHART

Summary of Materials, Equipment, and Services Provided to Jobsite (complete all 5 sections).

1. GEOPHYSICAL EQUIPMENT (check each instrument used). ☐ None

- ☐ Magnetometer
- ☐ Electromagnetic Induction
- ☐ Ground Penetrating Radar
- ☐ DC Earth Resistivity
- ☐ Surface Seismic _____
- ☐ Borehole Seismic _____
- ☐ Gravity
- ☐ Other (comment below)

Other: _____

_____

2. WELL AND SAMPLING MATERIALS (specify quantity if applicable). ☐ None

☐ Augers	☐ Flush Mounts	☐ Points	☐ Grout
☐ Portable Drill	☐ Above Grade	☐ Sand	☐ Bentonite
☐ Hnu	☐ Data Plates	☐ Bailers	☐ Top Caps
☐ Sample Jars	☐ Rental Equipment	☐ OVM	☐ Locks

Casing (specify type, length, and diameter): _____

3. SUBCONTRACTOR/CONSULTANT (list name, service provided, and time on site). ☐ None

_____

_____

4. ANALYTICAL SAMPLES. ☐ None

Laboratory Name and Address:

Chain of Custody Number: _____ Date(s) Submitted: _____

5. WGE PERSONNEL ON SITE (name of each). ☐ None

_____

_____

ADDITIONAL COMMENTS AND ACTION ITEMS

_____

_____

_____

_____

Signature: _____ Date: _____

Attachment A-3 Seismic Refraction Field Note

Shot Hole	Energy Source	Depth	Disk Number	File Name	Soil S-M-H	Time

Job Number:

Location:

Date:

Instrument/SN:

Line No.:

Record Count: _____ - _____ to _____ - _____

In the space below note: line intersections, boring locations, and ground conditions (visible outcrop, plowed field, fill area, rocky, sandy, clayey, wet, dry, etc.)

Form Prepared by: _____ Date:_____

Shells Out ☐

Shells In ☐

Instrumentation Located at Station _____

Station _____+___

Field Data Records Stored by: _____ Date_____

Records of Acceptable Quality by:_____Date_____

Records Checked by :_____Date_____

12-ch array

24-ch Array

Station _____+___

Attachment A-4

Weston Geophysical Engineers, Inc.

Seismic Refraction Data Processing Form

Job Number: _____ Job Name: _____
Location: _____ Date: _____
Form Entered: _____ Form Reviewed: _____

Line Number	Acquired Filename	Final Processed Filename	Post-processing Filename	File Types
				.CSV
				.GRD
				.SRF
				.GRF
				.CSV
				.GRD
				.SRF
				.GRF
				.CSV
				.GRD
				.SRF
				.GRF
				.CSV
				.GRD
				.SRF
				.GRF
				.CSV
				.GRD
				.SRF
				.GRF
				.CSV
				.GRD
				.SRF
				.GRF

WGE Procedure P4

Hand Level Surveys

Weston Geophysical Engineers, Inc.
20 Main Street
Acton, MA 01720
(978) 263-3600
(978) 263-3605 fax

Controlled Copy No. _____ Revision No._____

Prepared by: _____ Date: _____

Approved by: _____ Date: _____

George C. Klimkiewicz, President

Table of Contents

WGE Procedure P4
Level Surveys

1.0 SCOPE AND OBJECTIVES 3
2.0 DEFINITIONS 3
3.0 RESPONSIBLITIES AND QUALIFICATIONS 3
4.0 MATERIALS/EQUIPMENT AND CALIBRATION 4
5.0 METHODOLOGY, APPLICATIONS, AND FIELD PROCEDURES 4
6.0 ACCEPTANCE CRITERIA 6
7.0 RECORDS 6
8.0 REFERENCES 6
9.0 ATTACHMENT A 6

Procedure P4 – Indoctrination and Training			
Trainee	*Title*		*Date completed*
_____	_____		_____
Training Level Achieved:	_____	Data analysis & interpretation	_____
	_____	Field data acquisition	_____
	_____	Instrument set-up and Field work assistance	_____
Management Approval	*Title*		*Date*
_____	_____		_____

Record of Revisions		
Revision	**Section**	**Description**
0	All	New procedure

P4 - LEVEL SURVEYS

1.0 SCOPE AND OBJECTIVES

1.1 **Scope –** This Procedure (P4) describes procedures for conducting level surveys. Level surveys are conducted to vertically position geophysical data collected at discrete stations. Level surveys shall be conducted in conjunction with the following geophysical surveys: gravity, seismic, resistivity, and induced polarization.

This procedure shall be utilized at known or new sites, identified by Weston Geophysical Engineers, for level survey investigations. Level surveys will be conducted by a qualified WGE geophysical or level survey field crew and shall be performed in accordance with this Procedure.

1.2 **Objectives –** The objectives of this Procedure are to provide instructions for (1) survey preparation, (2) level survey field procedures, and (3) level survey data processing.

2.0 DEFINITIONS

2.1 **Datum –** A level reference surface of known elevation. The datum is generally an established benchmark, monument, survey nail, or monitoring well to which all other survey points are referenced. If completion of the project requires only relative elevations, the datum may be a temporary benchmark established at some point on the site (generally the end of a profile or southeast corner of a grid) and removed when site work is completed.

3.0 RESPONSIBLITIES AND QUALIFICATIONS

3.1 **WGE General Manager –** The WGE General Manager is responsible for ensuring the level survey crew is trained and indoctrinated in the content of this procedure. The WGE General Manager is responsible for ensuring that the level survey activities are performed in accordance with this Procedure.

3.2 **WGE Project Manager –** The WGE Project Manager is responsible for all level survey procedures as they apply to the specific site being investigated. The WGE Project Manager shall be responsible for ensuring the completion of all applicable forms and for notifying the WGE General Manager or designee of site-specific activities about level survey progress, problems, and results on a weekly basis. The WGE Project Manager is responsible for ensuring that level survey activities are performed in accordance with this Procedure.

3.3 **WGE Level Survey Field Crew –** Each level survey crew shall consist of at least one trained and qualified person, as determined by the WGE General Manager or Project Manager. The WGE level crew will perform level survey activities under direction and supervision of the Project Manager.

4.0 MATERIALS/EQUIPMENT AND CALIBRATION

4.1 **Materials and Equipment** – Specific equipment used to conduct level surveys may consist of one or more of the following items shown in Table 1. Specific parts and equipment used with these systems are listed in detail in the Inventory of Level Survey Measurement and Test Equipment form (Attachment A-1).

Table 1
Level Survey Equipment

Equipment	
Name	**Type**
Topcon Hand Level (5x)	Level Prism
Sokkia	Folding Leveling Rod
Miscellaneous	Level survey instruments

The following is a list of additional equipment that may be used during a level survey:

- Laptop computer and diskettes
- Compass
- Measuring tapes
- Wooden stakes and hammer
- Surveyor's paint/chalk and plastic pin flags
- Field notebook and project file
- Standard health and safety supplies

4.2 **Calibration Requirements** – Calibration and use of the instruments shall be in accordance with manufacturer's instructions.

5.0 METHODOLOGY, APPLICATIONS, AND FIELD PROCEDURES

5.1 **Level Survey Theory and Applications** – Leveling is used for determining the elevations of points or the differences in elevation between points on the earth's surface. Data from a finished level survey are used to establish the elevations of geophysical data collection points for (1) positional control and (2) to provide vital topography information for geophysical data processing.

5.2 **Level Survey Field Procedures** – Standard field procedures for conducting level surveys vary depending on the geophysical survey objectives and the elevation accuracy required. This information is stated in the site-specific project proposal. The following sections describe the level survey methods and procedures most commonly used by geophysical survey crews.

5.2.1 **Manual Level Survey Procedures** – Manual level surveying is acquired with the human eye and a level prism, and can be used to obtain data at resolution of a tenth of a foot or higher. The field procedures used to collect manual level data will include those outlined below.

5.2.1.1 Prior to conducting a level survey, a datum will be established at a location that is accessible, visible, stable, and of known elevation, if available. If a previously surveyed benchmark/monument or monitoring well is not available, then an arbitrarily located datum will be established for determining relative elevations. The level survey data will be processed with this known reference to provide correct elevations. The location of the datum shall be clearly marked in the field and recorded in the Field Project Daily Field Report (DFR) (Attachment A-2).

5.2.1.2 The manual level data, including elevations, positions, field crew comments, and reference points, will be recorded on the Level Survey Data Acquisition Form (Attachment A-3).

5.2.2 **Laser Level Survey Procedures** – Laser level surveying equipment can be used to obtain sub-centimeter resolution data or less. Accuracy and precision requirements for the laser level survey data will be evaluated prior to the survey. The appropriate equipment will be chosen, and parameters will be set and monitored to assure that the required level of precision is maintained. The field procedures used to collect laser level data will include those outlined below.

5.2.2.1 Instrument batteries will be checked for sufficient charge and the instrument will be tested according to manufacturer's instructions. This shall be performed prior to commencement of field activities each day and a minimum of once more each day. Instrument checks shall be recorded in the Field Project Daily Field Report (DFR) (Attachment A-2).

5.2.2.2 A datum shall be established at the site following the procedures outlined above in Section 5.2.1.1. The location of the datum shall be clearly marked in the field and recorded on the DFR.

5.2.2.3 The laser level data, including elevations, positions, field crew comments, and reference points, will be recorded on the Level Survey Data Acquisition Form (Attachment A-3). Instrument operation shall be in accordance with manufacturer's operation instructions.

5.3 Level Survey Data Processing – This section presents data tracking and processing procedures for elevation data. All level survey data will be entered into a database file on the computer. Field crew comments and file names assigned to the data files shall be recorded in the DFR (Attachment A-2). Once entered into a database, the level survey data shall be backed up onto diskettes and/or the WGE server for further processing and archival purposes. Level survey data shall be maintained in project files for geophysical survey elevation positioning

6.0 ACCEPTANCE CRITERIA

Elevation data shall be compared to topography maps, previously surveyed elevations, and/or data from objects of known elevation (e.g., monitoring wells, benchmarks, and survey nails), if available. Corrected level survey data points shall be consistent with objects of known elevation, to the accuracy specified in the project proposal. Elevation data shall be reacquired, if possible, until all points meet the specified acceptance criteria.

7.0 RECORDS

All project records generated in the field through the performance of this Procedure shall be temporarily filed in a designated folder and kept with the field crew while in the field. Following the conclusion of field activities, all project records shall be submitted to the project central files for storage according to WGE Procedure P5: Geophysical Data Management. The following is a list of the forms generated by this procedure:

- Inventory of Level Survey Measurement and Test Equipment (Attachment A-1).
- Field Project Report Log (Attachment A-2).
- Level Survey Data Acquisition Form (Attachment A-3).

8.0 REFERENCES

8.1 Related Procedures

8.1.1 WGE Procedure P2: Surface Seismic Refraction Surveys

8.1.2 WGE Procedure P5: Geophysical Data Management.

9.0 ATTACHMENT A

9.1 Attachment A-1 – Inventory of Level Survey Measurement and Test Equipment

9.2 Attachment A-2 – Field Project Daily Field Report

9.3 Attachment A-3 – Level Survey Data Acquisition Form

Weston Geophysical Engineers

Inventory of Level Survey Measurement and Test Equipment

Job Number: _____ Job Name: _____

Location: _____ Check Out Date: _____

Checked Out By: _____ Check In Date: _____

Equipment	Check Out	Condition	Check In	Condition
Sokkia Leveling Rod				
Topcon Level Prism				

Attachment A-2

Weston Geophysical Engineers

Daily Field Report

For _____

This form is to be used to record project-related field activities.
The original, completed form is to be archived and maintained as a permanent record with the project files.

Job Number: _____ Job Name: _____

Client: _____

Location: _____

Date(s) covered by this Report Log: _____

WGE Personnel On-site: _____

_____

_____

WGE Vehicles Used: _____

RESOURCES

Check all applicable boxes. If any box has been checked, complete the Resource Chart on back.

- ☐ Geophysical Equipment Used
- ☐ Well and Sampling Materials
- ☐ Samples Submitted for Analysis
- ☐ Subcontractor Used
- ☐ Consultant on Site
- ☐ Other (comment on back)

SUMMARY OF ACTIVITIES

Attachment A-2 (page 2 of 2)

Job Number: _____ Date(s): _____

RESOURCE CHART

Summary of Materials, Equipment, and Services Provided to Jobsite (complete all 5 sections).

1. GEOPHYSICAL EQUIPMENT (check each instrument used). ☐ None

- ☐ Magnetometer
- ☐ Electromagnetic Induction
- ☐ Ground Penetrating Radar
- ☐ DC Earth Resistivity
- ☐ Surface Seismic _____
- ☐ Borehole Seismic _____
- ☐ Gravity
- ☐ Other (comment below)

Other: _____

2. WELL AND SAMPLING MATERIALS (specify quantity if applicable). ☐ None

☐ Augers	☐ Flush Mounts	☐ Points	☐ Grout
☐ Portable Drill	☐ Above Grade	☐ Sand	☐ Bentonite
☐ Hnu	☐ Data Plates	☐ Bailers	☐ Top Caps
☐ Sample Jars	☐ Rental Equipment	☐ OVM	☐ Locks

Casing (specify type, length, and diameter): _____

3. SUBCONTRACTOR/CONSULTANT (list name, service provided, and time on site). ☐ None

_____

_____

4. ANALYTICAL SAMPLES. ☐ None

Laboratory Name and Address: _____

Chain of Custody Number: _____ Date(s) Submitted: _____

5. WGC PERSONNEL ON SITE (name of each). ☐ None

_____

_____

ADDITIONAL COMMENTS AND ACTION ITEMS

_____

_____

Signature: _____ Date: _____

Weston Geophysical Engineers

Level Survey Data Acquisition Form
Sheet _____of _____

Job Number: _____ Job Name: _____

Location: _____

Acquired by: _____ Date: _____

Instrument Type: _____

Line Number	Station Number	Reference Point(*)	Relative Elevation (ft)	Comments

(*) = *Station where stood to sight to other station elevations*

Procedure P7

Field Seismograph System Calibration

Weston Geophysical Engineers, Inc.
20 Main Street
Acton, MA 01720
(978) 263-3600
(978) 263-3605 fax

Controlled Copy No. _____ Revision No._____

Approved By: _____ Date: _____

George C. Klimkiewicz, President

Table of Contents

Procedure P7
Field Seismograph System Calibration

1.0 SCOPE AND OBJECTIVES 2
2.0 RESPONSIBLITIES AND QUALIFICATIONS 2
3.0 DATA COLLECTION AND PROCESSING FORMS 3
4.0 FIELD DATA MANAGEMENT PROCEDURES 4
5.0 OFFICE DATA MANAGEMENT PROCEDURES 6
6.0 RELATED PROCEDURES 7

Procedure P7 – Indoctrination and Training			
Trainee	*Title*		*Date completed*
_____	_____		_____
Training Level Achieved:	_____	Use of Frequency Standard	_____
	_____	Use of Digital DAQ, Scopes	_____
	_____	Use of Field Seismographs	_____
Management Approval	*Title*		*Date*
_____	_____		_____

P7 – Field Seismograph System Calibration

1.0 SCOPE AND OBJECTIVES

1.1 **Scope –** This Procedure (P7) describes office procedures used to calibrate field seismograph systems operated by Weston Geophysical Engineers to acquire certain geophysical data at project sites. A seismograph system includes (1) digital data recorder (seismograph), (2) 'geophones', i.e. sensors that connect to the earth to receive geophysical data, and (3) cables that connect the geophones with the data recorder. The purpose of a seismograph system is to accurately determine the time in which certain seismic waves (e.g. P-wave, S-wave) propagate through earth material (e.g. soil and bedrock strata). Success of these seismic wave velocity measurements depends on the proven accurate function of internal time bases engineered into digital seismographs. Calibration of the field seismograph system includes the following two steps.

- Calibration of the internal clocks of the digital seismograph (data recorder).
- Calibration of the system including data recorder, geophones and cables.

This procedure shall be utilized for all projects to be performed by WGE requiring the operation of field seismograph systems. All geophysical surveys and data management conducted by WGE personnel will be performed in accordance with this Procedure.

1.2 **Objectives –** The objectives of this Procedure are to provide instructions for (1) calibration of the Frequency Standard device, (2) calibration of field seismographs using the Frequency Standard device, and (3) calibration of field seismograph systems including data recorder, geophones and cables.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

2.1 **WGE General Manager –** The WGE General Manager is responsible for ensuring that WGE geophysics personnel are trained and indoctrinated in the content of this procedure. The WGE General Manager is responsible for ensuring that associated data management activities are performed in accordance with this Procedure.

2.2 **WGE Project Manager –** The WGE Project Manager shall document that all field seismograph systems are calibrated according to the requirements of this procedure prior to, and upon return from, field data acquisition activities. Calibration results shall be maintained in accordance with WGE Procedure P5 – Geophysical Data Management. Copies of manufacturer and WGE calibration certificates shall be maintained at the home and field project offices. The Project Manager is responsible for ensuring that all geophysical data are collected using a properly calibrated seismograph system. The Project Manager will return the field seismograph system for re-calibration if there is evidence of system timing malfunctions.

2.3 **WGE Geophysics Personnel (Field) –** The WGE geophysics field personnel will be responsible for proper handling and operation of the field seismograph system to assure proper instrument calibrations are maintained throughout the duration of field data acquisition activities.

2.4 **WGE Geophysics Personnel (Office) –** The WGE geophysics office personnel will be responsible for conducting field seismograph calibrations using the Frequency Standard device in accordance with these procedures.

3.0 Frequency Standard Device

The Frequency Standard (FS) device was designed and built by WGE for the purpose of calibrating internal clocks of other geophysical systems and devices versus a highly accurate and stable 'frequency standard." The FS device incorporates a crystal oscillator manufactured by Seiko-Epson. Table 3-1 lists the specifications of the WGE FS device and incorporated crystal oscillator. A product sheet for the crystal oscillator is included in Attachment A-1

Table 3-1

Manufacturer:	WGE (1998)
Crystal Oscillator:	Seiko – Epson SPG Series Model 8651B Selectable Output
Source Frequency	100 kHz
Output Frequencies	1 kHz and 100 kHz
Frequency Tolerance	± 5 ppm
Operating Temperature:	-10^{O} C - $+60^{O}$C
Aging	± 3 ppm/year maximum

The specified frequency tolerance (± 5 ppm) and aging factors (± 3 ppm/year maximum) indicate a high degree of frequency output accuracy over many years of operation of the crystal oscillator. For example, frequency tolerance and aging factors translate into the following frequency outputs expected for 0 and 25 year aging time frames.

Frequency Output Target:	1000 Hz
Frequency Tolerance: 0 years	999.995 Hz to 1000.005 Hz
Frequency Tolerance: 25 years	999.925 Hz to 1000.075 Hz (max)

4.0 FREQUENCY STANDARD CALIBRATION PROCEDURES

Calibration of the WGE Frequency Standard device is to be performed prior to conducting geophysical tests using field seismograph systems. This calibration can be performed internally by trained WGE staff using a recently calibrated test and measurement system capable of recording and analyzing the frequency of signals output by the FS device.

Also, the FS device can be sent to a certified calibration lab to perform the required instrument calibrations.

Following is a procedure for internal calibration of the FS device. This procedure involves storing a short time segment of the pulse signal output by the FS device for either the 1 kHz or 100 kHz output frequencies. It is noted that timing systems of field seismographs are designed for data recording and analyses in the 1 kHz range rather than at very high frequencies in the 100 kHz range. The maximum sampling frequency for certain field seismographs is 32,000 samples per second. This sampling rate is insufficient to record 100 kHz signals output by the Frequency Standard device. Internal calibrations thus are to be performed for the 1 kHz output of the Frequency Standard device.

Measurement and tests instruments and software to be used for the internal calibration of the Frequency Standard device are listed in Table 4-1.

Table 4-1

Manufacturer	Model/Version/sn	Description/Usage
IOTECH	Wavebook/516 1 megaHz waveform acquisition system Serial No.: 213695 Serial No.: 213696	Data acquisition instrument with selectable sampling rate to maximum of 1,000,000 samples per second. To be used at sampling rates of 32,000/sec and 200,000/sec to record output from the Frequency Standard device.
DasyLab	Version 6.0 part 472-0606	Data acquisition system laboratory, used to interface with Wavebook/516 to store data files of frequency pulses output by the Frequency Standard device.
DSP Corporation	DaDISP 2000	Digital signal processing software used to display and analyze various digital waveform data

4.1 **Measurement of the Frequency Standard 1 kHz Pulse** – The output cable of the Frequency Standard device is to be connected to the 1 kHz connector. Channel 1 on the IOTECH Wavebook/516 Waveform Acquisition System is to be configured with a data cable to receive the pulse generated by the Frequency Standard device. The FS device is to be turned on using the toggle switch and the generated pulse (1 kHz) is to be recorded for duration of several seconds. The Wavebook/516 is to be configured to record the FS device pulse with a sampling rate of 32,000/second or greater. The recorded pulse is to be stored with a filename recorded on Calculation Sheet P7-1 Frequency Standard Device Internal Calibration.

4.2 **Data Management** – Data files recorded by the Wavebook/516 are to be stored in DaDISP file format (*.DSP). Data filenames are to be recorded on Calculation Sheet P7-1.

4.3 **Data Analyses** – Data files are to be imported into DaDISP signal processing software for analyses of the pulse waveform output by the Frequency Standard device. The pulse is to be analyzed to determine the central frequency and harmonics. The pulse signal and frequency spectrum should be illustrated to show the exact frequency of the time pulse output from the FS device. Time domain and frequency domain illustrations of analyses of the time pulse are to be attached to Calculation Sheet P7-1.

4.4 **Acceptance Criteria for Frequency Standard** – The FS device will be accepted to be in proper calibration if results in 4.3 are within ±99.9 % of the selected output frequency of 1 kHz (e.g. 1000 Hz). The acceptance range for frequencies output by the FS device thus will be 999.0 Hz to 1001.0 Hz.

4.5 **Calibration of Field Seismographs** – Following acceptance of the calibration of the FS device in 4.4, the FS device is to be used to calibrate all field seismographs to be used to acquire project-related geophysical data. The procedure for calibration of field seismographs will follow steps 4.1 through 4.3.

4.6 **Acceptance Criteria for Timing of Field Seismographs** – The timing of field seismographs will be accepted to be in proper calibration if results in 4.3 are within ±99.5 % of the selected output frequency of 1 kHz (e.g. 1000 Hz). The acceptance range for frequencies measured by the field seismograph for the 1000 Hz pulse generated by the FS device thus will be 995.0 Hz to 1005.0 Hz.

5.0 FIELD CALIBRATION OF SEISMOGRAPH SYSTEMS

A seismograph system includes the digital data recorder, geophones connected to the earth to receive induced seismic waveforms, and cables used to connect geophones to the data recorder. Digital recorders with acceptable calibrations determined in Section 4.0 are to be used to perform real-world calibrations of complete seismograph systems using the following procedures. This procedure requires the usage of two separate field data acquisition systems whose timing systems have acceptable calibrations.

5.1 **Preparation of Test Site –** A test site will be prepared so that seismic velocity measurements can be made within natural earth materials. A source point and a receiver point will be marked on the ground and the distance between these points will be accurately measured (.1 inch accuracy). The distance between these points should be between 50 and 250 feet. The test site layout including distance between the source and receiver points should be recorded in Calculation Sheet P7-2.

5.2 **Geophone Calibration –** All geophones to be used on a project site are to be field calibrated for proper response. Geophones used for geophysical seismic velocity tests (e.g. seismic refraction tests, cross-hole seismic velocity tests) are to be placed in small clusters of 6 to 8 units at the receiver point on the test site. The impulse generated at the source point (e.g. vertical impact of the ground surface by sledge hammer, or truck mounted spring-actuated hammer) is to be recorded by the cluster of geophones using the calibrated field seismograph and necessary data cables. This test is to be repeated for all geophones in clusters of 6 to 8 units. It is recommended that one common geophone be included in each of the clusters. Recorded waveforms for clusters of geophones are to be attached to Calculation Sheet P7-2.

5.2.1 ***Geophone Calibration Acceptance Criteria*** – Geophone performance and calibration is accepted if each geophone in the cluster illustrates the same waveform shape and amplitude and identical measurement of the arrival time of the induced seismic impulse. Accepted geophones are to be tagged and recorded in Calculation Sheet P7-2.

5.3 **Seismograph System 1 Field Calibration –** The first field seismograph system is to be calibrated using the test site (5.1) and one of the calibrated geophones (5.2). Seismic velocity between the source point and receiver point is to be measured using the field seismograph system including the data recorder, selected geophone, and necessary cables. A seismic impulse (hammer blow) is to be imparted to the ground at the source point and measured at the receiver point. The time difference between the seismic source and recorded time of arrival of the generated seismic impulse is to be measured and recorded in Calculation Sheet P7-2. The seismic velocity is to be determined using Equation 5.3-1. The measured velocity is to be recorded in Calculation Sheet P7-2.

$$V = D/T \qquad [5.3\text{-}1]$$

Where V = velocity (ft/sec)
D = distance (ft)
T = time for induced wave to arrive at the receiver location

5.4 **<u>Seismograph System 2 Calibration</u> –** The second field seismograph system is to be calibrated using the test site (5.1) and a digital data acquisition system entirely different than that used for system tests in 5.3. The data recorder used in this second system is to be calibrated for proper internal timing using procedures in Section 4.0. The inventory of instruments for this second system is to be recorded in Calculation Sheet P7-2. Seismic velocity between the source point and receiver point is to be measured using this second field data acquisition system including the data recorder, selected sensor, and necessary cables. A seismic impulse (hammer blow) is to be imparted to the ground at the source point and measured at the receiver point. The time difference between the seismic source and recorded time of arrival of the generated seismic impulse is to be measured and recorded in Calculation Sheet P7-2. The seismic velocity over the test site using the second seismic data acquisition system is to be determined using Equation 5.3-1. Seismic velocity measurements determined for the two independent data acquisition systems are to be recorded on Calculation Sheet P7-2. The comparison of real-world seismic velocities measured using two independent systems is used as a basis for evaluation of the proper and accurate functioning of both systems. The principal used to assess instrument calibration *is that independent determinations of the same seismic velocity value using independent systems, each engineered and designed for this function, leads to a highly likely conclusion that each system operates as specified and provides the correct velocity; versus the highly unlikely conclusion that each system malfunctioned in ways that resulted in the same, but wrong velocity.* Thus, seismograph systems are determined to be mutually calibrated for the case that measured real-world seismic velocities are identical within small error tolerances.

5.4.1 ***Seismograph System Calibration Acceptance Criteria*** – Seismograph system performances and calibrations are mutually accepted if seismic velocities independently measured over the identical real world test site using the 2 seismic data acquisitions systems are within 5% of each other. The 5% acceptance level implies the following seismic velocity ranges. Permitting a 5% variation does not impede the ability to properly characterize the material type according to measured seismic velocity.

- Soil (with hypothetical V=1,000 ft/sec); range of 950 to 1050 ft/sec
- Rock (with hypothetical V=10,000 ft/sec); range of 9,500 to 10,500 ft/sec

6.0 RELATED PROCEDURES

- WGE Procedure, P1: Cross-hole Seismic Velocity Surveys
- WGE Procedure, P2: Surface Seismic Refraction Surveys
- WGE Procedure, P5: Geophysical Data Management

7.0 Attachments

Calculation Sheet P7-1 – Frequency Standard Device Internal Calibration

Calculation Sheet P7-2 – Field Calibration of Seismograph Systems

Calculation Sheet P7-1

Weston Geophysical Engineers

Frequency Standard Device
Internal Calibration

☐ Project Related Calibration ☐ Scheduled Calibration

Job Number: _____ Job Name: _____

Client: _____ Site Location: _____

WGE Model XOSC-101 Crystal Oscillator Frequency Standard	
Crystal Oscillator: Seiko-Epson SPG Model 8651B	Source Frequency: 100 kHz
Date of Last Internal Calibration: _____	Date of Last External Calibration: _____

Internal Calibration Measurement and Test Instruments and Analysis Software	
☐ IOtech Wavebook/516 s/n 213695	☐ DasyLab Pro Analysis Toolkit
☐ IOtech Wavebook/516 s/n 213696	☐ DaDISP 2000 DSP Software
☐ IOtech WBK14 s/n 204683	☐ Microsoft EXCEL
☐ IOtech WBK14 s/n 204685	☐ Mathsoft MathCAD
☐ Other (specify): _____	☐ Other (specify): _____

XOSC-101 Internal Calibration Results	
Performed by: _____	Date: _____
Frequency Tested: ☐ 1 kHz ☐ 100 kHz	Test Device Sampling Rate: _____
Test Results (center frequency, Hz): _____	Test Results: 1st harmonic, Hz: _____
Test Results: 2nd harmonic, Hz: _____	Test Results: 3rd harmonic, Hz: _____
Acceptance Criteria: ± 99.9 % on center frequency	Acceptable Frequency Range: _____
Calibration Status: ☐ Passed ☐ Failed	Comments: _____
Test Data Attachments	**Data File Names and Storage Locations**
☐ Time series plot of XOSC-101 pulse	Pulse data file: _____
☐ Frequency spectrum plot of XOSC-101	Spectrum data file: _____

Management approval by: _____ *Date*:_____

Calculation Sheet P7-2

Weston Geophysical Engineers

Field Calibration
Of Seismograph Systems

☐ Project Related Calibration ☐ Scheduled Calibration

Job Number: _____ Job Name: _____

Client: _____ Site Location: _____

[A] WGE Field Seismograph Systems for Field Test and Deployment

☐	Geometrics Strataview s/n 75095	☐	GeoSource GS-20DM Qty: _____
☐	Geometrics Geode s/n 3258	☐	Other Transducers: _____ Qty: _____
☐	Geometrics Geode s/n 3365	☐	Cables: _____
☐	Sledge Hammer Seismic Source	☐	Truck Mounted Seismic Source

[B] Alternate System Used in Seismograph Field Test

☐	IOtech Wavebook/516 s/n 213695	☐	DasyLab Pro Analysis Toolkit
☐	IOtech Wavebook/516 s/n 213696	☐	DaDISP 2000 DSP Software
☐	IOtech WBK14 s/n 204683	☐	Microsoft EXCEL
☐	IOtech WBK14 s/n 204685	☐	Mathsoft MathCAD
☐	PCB seismic accelerometer U393 s/n _____	☐	Seismometer or geophone _____
☐	PCB ICP accelerometer 337F04 s/n _____	☐	Cables: _____
☐	PCB Force Hammer 086D20 s/n 20374	☐	Other (specify): _____

Field Calibration Test Results

Performed by: _____ Date: _____

Test site location: _____ Test site length (ft): _____

Test site description: _____

Test results for system **[A]:** Earliest arrival time (msec): _____ Velocity (ft/s): _____

Test results for system **[B]:** Earliest arrival time (msec): _____ Velocity (ft/s): _____

Acceptance Criteria:
± 5 % on measured seismic velocity

System calibration results: ☐ Passed ☐ Failed

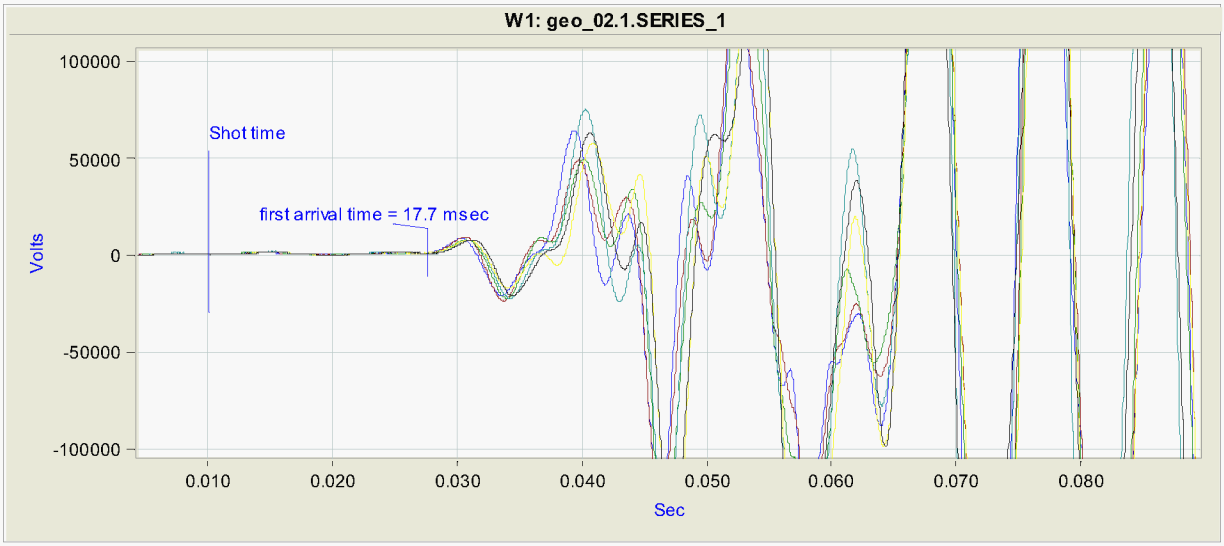
Test Data Attachments		Data File Names and Storage Locations	
☐	Seismograms system [A]	Filename [A]:	_____
☐	Seismograms system [B]	Filename [B]:	_____

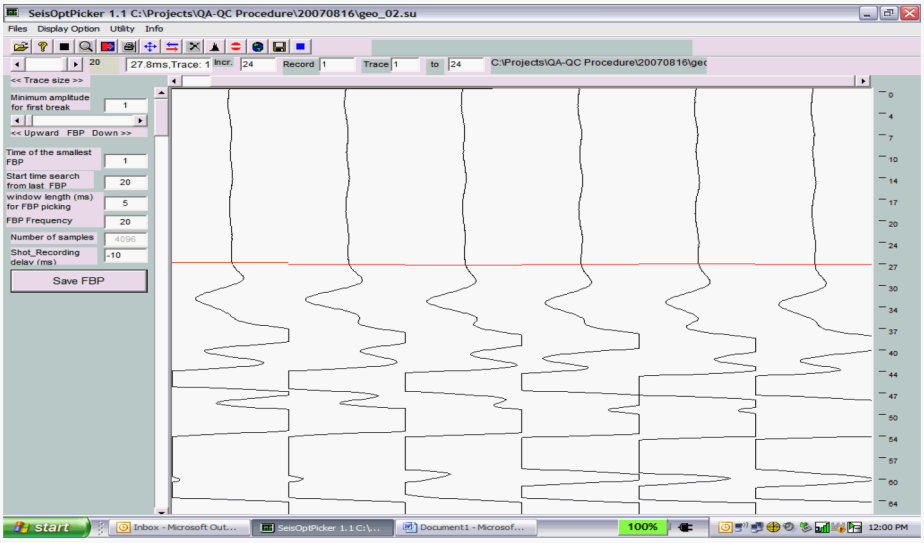
Management approval by: _____ *Date:* _____

Prepared by: __Peter Hubbard_ *Date:* _8/21/07_

Attachments to:
Calculation Sheet
P7-2

☒ System [A] Records
☐ System [B] Records
☐ Photo
Filename:
_geo_02.1_____





Comments: First figure shows the 6 traces from the 6 geophones superimposed and the first arrival pick of the seismic refracted wave energy.

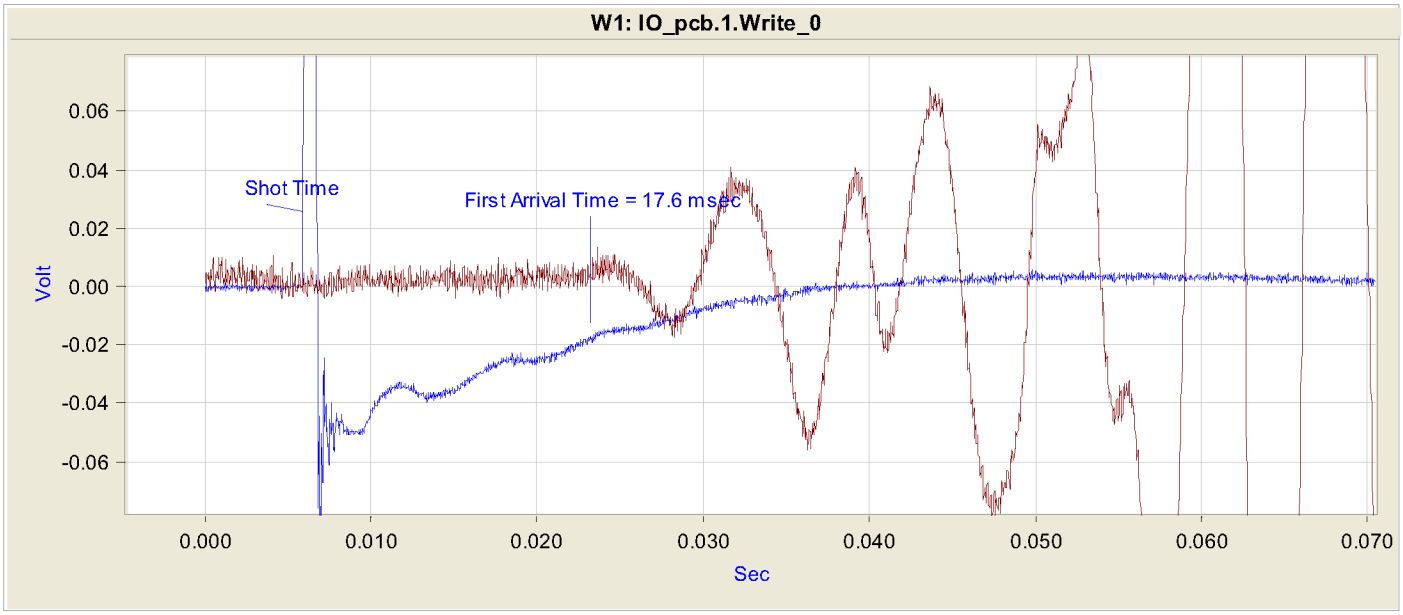
The red line on the second figures shows the individual arrival times at each of the six geophones side by side. The first arrivals range from 17.6 to 17.8 milliseconds.

Prepared by: ___Peter Hubbard____ *Date:* _8/21/07_

Attachments to:
Calculation Sheet
P7-2

☐ System [A] Records
☒ System [B] Records
☐ Photo
Filename: _IO_pcb.1__

Insert picture

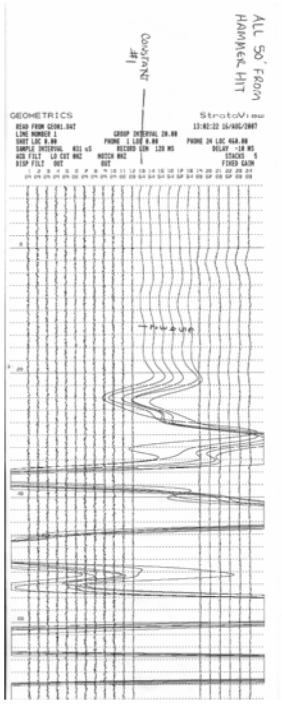


Comments:

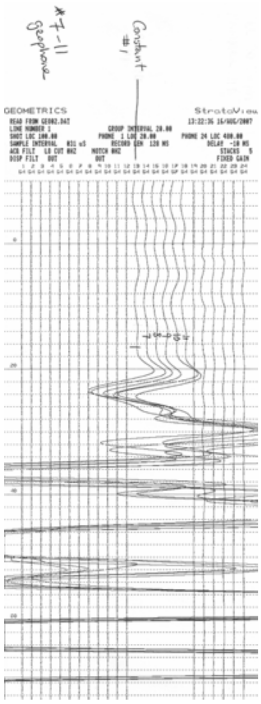
Prepared by: __Peter Hubbard____ *Date:* _8/21/07_

Attachments to:
Calculation Sheet
P7-2

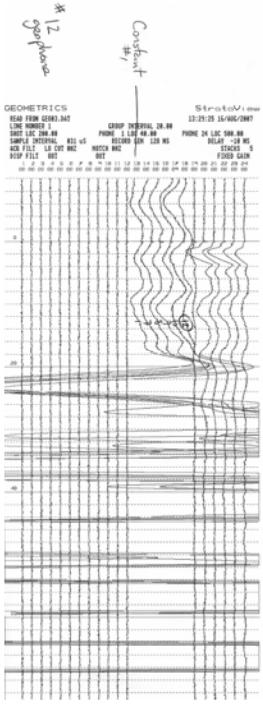
☒ System [A] Records
☐ System [B] Records
☐ Photo
Filename: _geo_01 to geo_03__



Geophones 1-6



Geophones 7-11



Geophone 12

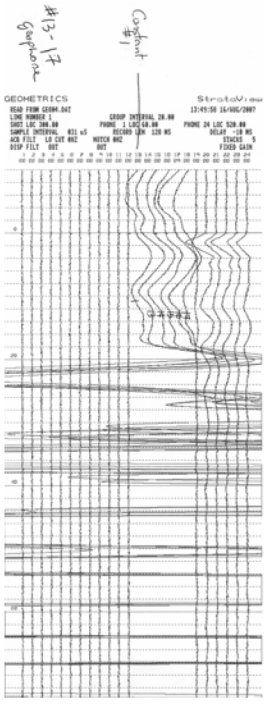
Comments: The three figures above show the similarity of the signal and arrival time at the first twelve geophones. The test was done keeping the #1 geophone the same from test to test to compare all the geophones.

These figures are scanned images of the paper records from the Strataview Seismograph

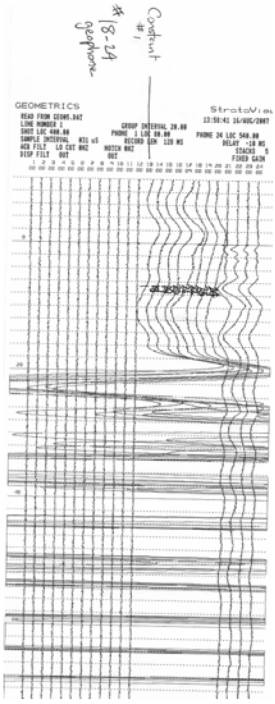
Prepared by: ___Peter Hubbard___ *Date:* _8/2/107_

Attachments to:
Calculation Sheet
P7-2

☒ System [A] Records
☐ System [B] Records
☐ Photo
Filename: _geo_04 and geo_05_



Geophones 13-17



Geophones 18-24

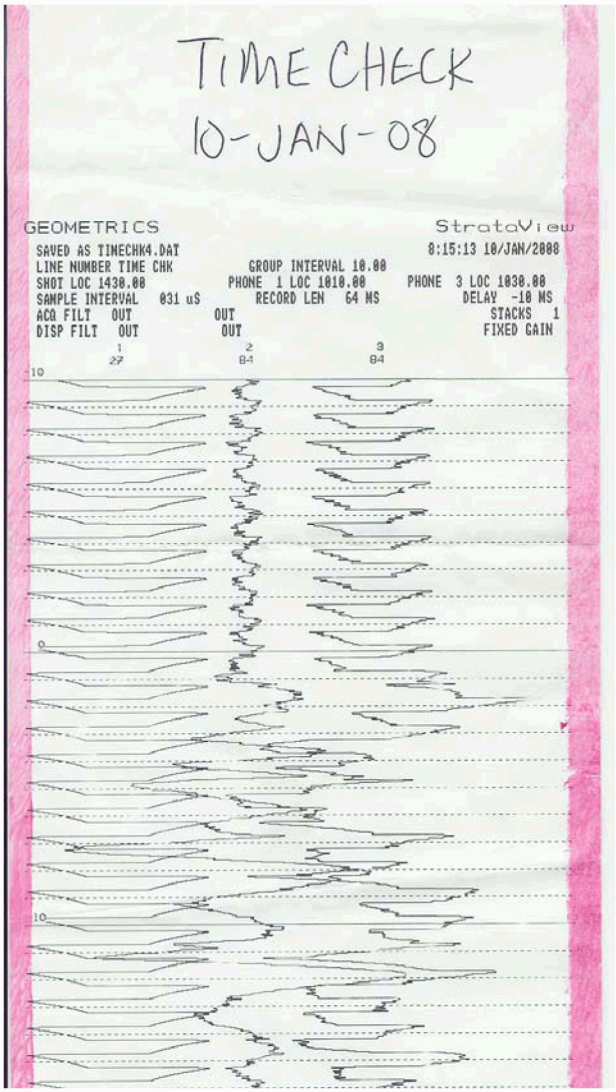
Comments: The two figures above show the similarity of the signal and arrival time at the second twelve geophones. The test was done keeping the #1 geophone the same from test to test to compare all the geophones.

These figures are scanned images of the paper records from the Strataview Seismograph

Prepared by: _____ *Date:* _____

Attachments to:
Calculation Sheet
P7-2

☐ System [A] Records
☐ System [B] Records
☐ Photo
Filename: _____



Comments: Final Check of Daily Field Check of !MHz Input

Prepared by: _____ *Date:* _____

Attachments to:
Calculation Sheet
P7-2

☐ System [A] Records
☐ System [B] Records
☐ Photo
Filename: _____

Davis Calibration

ACCREDITED

Certificate of Calibration
1974429
Certificate Page 1 of 2

Instrument Identification

Company ID: 83247
WESTON GEOPHYSICAL ENGINEERS
20 MAIN ST
ACTON,MA,01720

PO #: CC

Instrument ID: **VH-10738**
Manufacturer: WESTON GEOPHYSICAL
Description: CRYSTAL FREQUENCY OSCILLATOR STANDARD
Accuracy: Data Only

Model Number: XOSC-101
Serial Number: N/A

Certificate Information

Reason For Service: CALIBRATION
Type of Cal: 17025 ACCREDITED
As Found Condition: DATA ONLY
As Left Condition: LEFT AS FOUND
Procedure: NA17-20AG-143 OSCILLATORS

Technician: MARC BLITZ
Cal Date: 17Dec2007
Cal. Due Date: 17Dec2008
Temperature: 20.0 C
Humidity: 14.0 %

Remarks:

The instrument listed on this certification has been calibrated against standards traceable to the National Institute of Standards and Technology (NIST) or other recognized national metrology institutes, derived from ratio type measurments, or compared to nationally or internationally recognized consensus standards.

A test uncertainty ratio (T.U.R.) of 4:1 [K=2, approx. 95% Confidence Level] was maintained unless otherwise stated.

Davis Inotek Instruments Calibration Laboratory is certified to ISO 9001:2000 by Eagle Registrations (certificate # 3046). Lab Operations meet the requirements of ANSI/NCSL Z540-1-1994, ISO 10012, 10CFR50 AppxB, and 10CFR21.

ISO/IEC 17025-2005 accredited calibrations are per A2LA certificate # 1590.01 within the scope for which the lab is accredited. All results contained within this certification relate only to item(s) calibrated. Any number of factors may cause the calibration item to drift out of calibration before the instrument's calibration interval has expired.

This certificate shall not be reproduced except in full and with the written consent of Davis Inotek Instruments Calibration Laboratory.

Approved By: SHILO BIVINS
Service Representative

Calibration Standards

NIST Traceable#	Inst. ID#	Description	Model	Cal Date	Date Due
1591944	01-0090	EXACTIME GPS TIME CODE & FREQ. GENERATOR	9390-6000	09Oct2007	09Apr2008
1643917	01-NC-0334	UNIVERSAL COUNTER	5335A	04Nov2007	04Nov2008

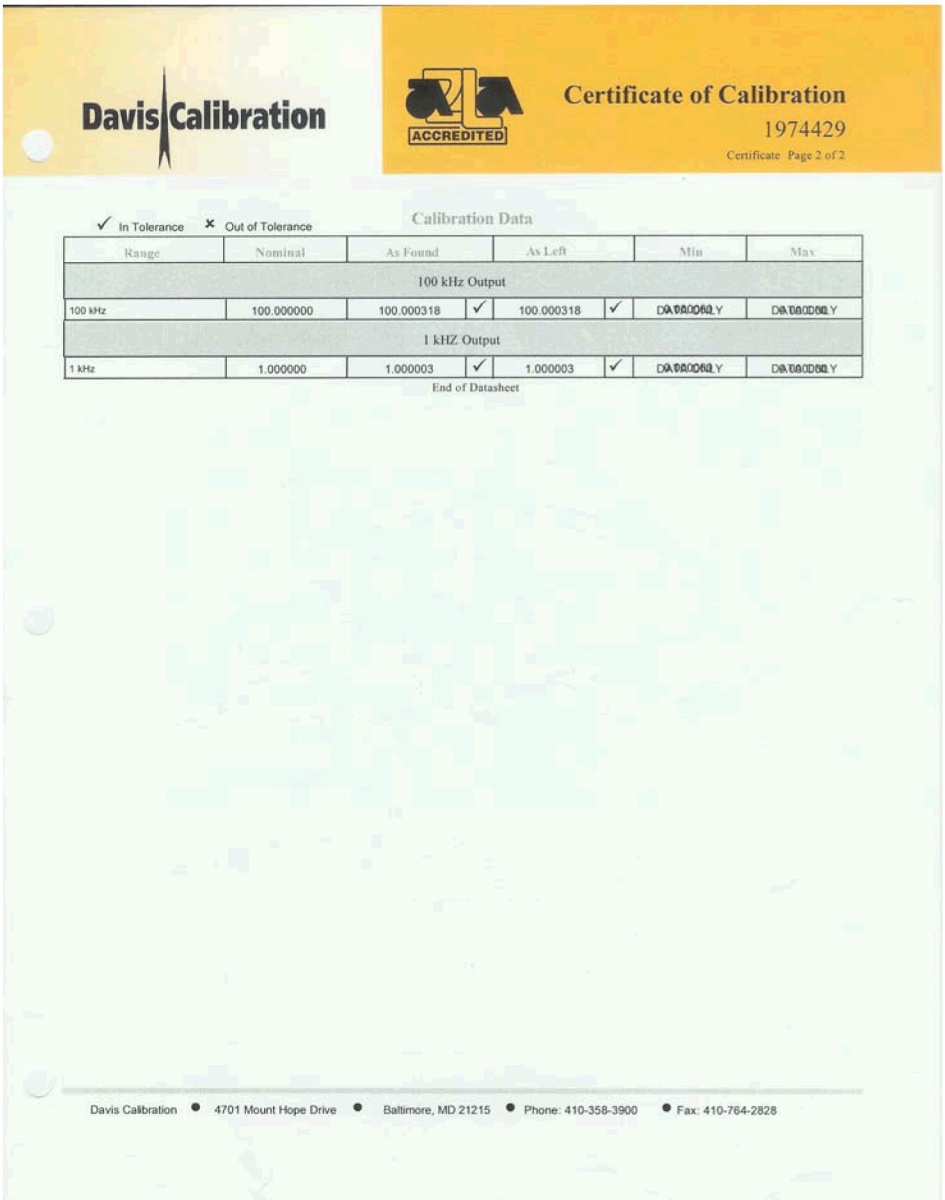
Davis Calibration • 4701 Mount Hope Drive • Baltimore, MD 21215 • Phone: 410-358-3900 • Fax: 410-764-2828

Comments: Davis Calibration Certificate – Page 1

Prepared by: _____ *Date:* _____

Attachments to:
Calculation Sheet
P7-2

☐ System [A] Records
☐ System [B] Records
☐ Photo
Filename: _____



Davis Calibration

ACCREDITED

Certificate of Calibration
1974429
Certificate Page 2 of 2

✓ In Tolerance ✕ Out of Tolerance

Calibration Data

Range	Nominal	As Found		As Left		Min	Max
100 kHz Output							
100 kHz	100.000000	100.000318	✓	100.000318	✓	DATADOQ.Y	DATADOQ.Y
1 kHZ Output							
1 kHz	1.000000	1.000003	✓	1.000003	✓	DATADOQ.Y	DATADOQ.Y

End of Datasheet

Davis Calibration ● 4701 Mount Hope Drive ● Baltimore, MD 21215 ● Phone: 410-358-3900 ● Fax: 410-764-2828

Comments: Davis Calibration Certificate – Page 2