

May 23, 2019

Via Electronic Mail

Mr. Scott R. Williamson
Program Manager, Waterways & Wetlands Program
Pennsylvania Department of Environmental Protection
Southcentral Regional Office
909 Elmerton Avenue
Harrisburg, PA 17110-8200

**Re: Responses to DEP Comments for Hydrogeological HDD Re-Evaluation Report
White House Ln. 16-Inch Horizontal Directional Drill Location (S3-0011-16)
Permit No. E22-617
Lower Swatara Township, Dauphin County**

Dear Mr. Williamson:

In compliance with the Corrected Stipulated Order dated August 10, 2017 a Re-evaluation Report for the above-referenced horizontal directional drill (HDD) was submitted to the Pennsylvania Department of Environmental Protection (Department) on February 19, 2019. In a letter dated March 22, 2019, the Department requested further information. Please accept this letter as a response. The data requests are bolded below followed by Sunoco Pipeline, LP (SPLP) responses.

- 1. As required by Paragraph 4. and 5. of the Environmental Hearing Board's August 10, 2017 Corrected Stipulated Order (Order), SPLP failed to fully utilize information gathered during the HDD of the 20-inch bore as part of the HDD Re-evaluation for the 16-inch pipeline. Please gather geologic and drilling information collected by various site personnel during the 20-inch bore that can be used to provide a summary confirmation of the geology at the site. This should include the full geologic profile from the drilling of the 20-inch HDD. Additionally, the location of the loss of 5,000 gallons of drilling fluid was not noted on any figures or in the text. At what point along the drill path was the loss discovered? Geologic drilling log notes should indicate the location of the loss and be provided and incorporated into the re-evaluation. The re-evaluation should also discuss and consider precautions, such as casing, that may prevent or further minimize the risks associated with potential inadvertent returns (IRs) on entry and exit activities of the HDD in the overburden.**

This information should then be used to further describe why the chosen bore path for the 16-inch pipeline was determined and how such information has been used to minimize the potential for IRs to occur and as part of the discussion of construction alternatives, including why HDD activity is still the preferred and chosen methodology for pipeline construction at this location. Within the construction alternatives analysis, please provide an evaluation and discussion of other trenchless methodologies and why they are not a feasible alternative to HDD.

SPLP utilized all the information obtained during drilling of the 20-inch HDD in our internal assessment and evaluation of the 16-inch HDD profile, and as required by paragraph 5 of the Corrected Stipulated Order, described and presented the results of this study in the HDD Reevaluation Report. Nevertheless, the Department has requested that SPLP provide additional details concerning the conditions associated this HDD location and the conclusion to proceed with an HDD for the 16-inch line at this location along a revised profile. In the interest of working cooperatively with the Department, the following information is provided in response to the Department's request.

A review of the 2014 geotechnical investigation identified the permitted 16- and 20-inch HDD profiles would be advanced through the Gettysburg Formation, consisting of reddish-brown to maroon silty mudstone, shale and fine- to medium-grained sandstone with thin beds of immature limestone. Additional soil borings were completed in 2017 to gather additional formation characteristics of the unconsolidated materials and bedrock proximate to the permitted profiles. The 2017 geotechnical investigation provided supporting data to confirm that the permitted HDD profiles would be completed through unconsolidated material (consisting of weathered material from the native Gettysburg Formation) and bedrock of the Gettysburg Formation. Further, a review of the HDD Daily Inspection Reports identified cuttings generated during completion of the 20-inch HDD consisted of reddish-brown to maroon silt- to gravel-sized unconsolidated alluvial material and fragments of sandstone and siltstone bedrock. It should be noted that the White House Lane 20-inch HDD was completed prior to the collection of drill cutting samples at 5-foot intervals, but the drill cuttings were examined multiple times throughout each day that the 20-inch pilot tool and reamers were advanced.

The reported 5,000 gallon loss of drilling fluid occurred when the pilot bit was located at a trajectory length of 128.64 feet and a depth of 28.78 feet below ground surface while the pilot bit was still advancing through unconsolidated material (a punch in loss). The unconsolidated material at both the eastern and western entry/exit points consists of fine- to coarse-grained sand and gravel with some silt. The reported loss of drilling fluid occurred while the boring was being swabbed at the end of the day on October 17, 2017. Once the fluid loss was identified all drilling activities were immediately suspended. Two separate reconnaissance surveys were completed. The first reconnaissance survey was performed when the event occurred on October 17, 2017 and the second survey was performed the following morning of October 18, 2017, prior to resumption of any drilling activities. No surfacing of drilling fluids or groundwater was observed during either survey. The viscosity of the drilling fluid was increased and drilling resumed on October 18, 2017 with no additional reported significant losses until the first IR reported on November 7, 2017.

As a result of the loss of returns and the two IRs all occurring at the bedrock and unconsolidated material interface or within unconsolidated material during completion of the 20-inch HDD, the entry and exit angles for the 16-inch pipeline were increased to minimize the length of time for the pilot bit to advance through these zones. The use of surface casing is only possible at the HDD entry during the pilot phase, and the IRs occurred at the pilot exit. It is highly unlikely to "hit" the opening of a preset casing end at the exit point during the pilot phase. Secondly, short drilling a large diameter casing into competent bedrock has an elevated IR risk equal to or exceeding the risk of IR during a pilot phase exit due to the lack of an annulus relief while reaming an opening to hammer the casing through and into bedrock.

As mentioned in the Alternative Analysis of the Horizontal Direction Drill Analysis White House Lane, the HDD methodology was confirmed to be the preferred installation method because it will ultimately cause the least amount of direct impact to the residents and the environment. Changing the installation technique to an open cut would result in disturbance to residents and potential damage and disruption of service to existing utility services. Further, the open cut construction method would result in a direct increase in the physical disturbance to 0.05 acres of wetlands, including approximately 0.01 acres of forested wetland conversion. Re-routing the pipeline is not a viable option at this location because any other proposed re-route would still cross the same infrastructure and require creation of a new greenfield corridor and likely require condemnation to acquire an easement. A re-route to the east would result in impacts to forested woodlands and forested/scrub/shrub wetlands and Lisa Lake, while a shift of the route to the north would conflict with residential home site.

The only other possible “trenchless” construction methods not discussed in the Reevaluation Report include Conventional Auger Bore, FlexBor, and Direct Pipe Bore.

Planning for a conventional bore must account for the extent or width of the feature (road, stream, etc.) being bored under, as well as the length and width of the setup-entry pit for setting the boring equipment within while operating, and the receiving pit through which the product pipeline is pulled back through after the boring machinery exits.

Based on experience gained during construction of the Mariner II Pipeline project, conventional auger bores should be limited to approximately 200 linear foot at a time, or less, varying by the underlying substrate. Conventional auger bores for the 16 and 20-inch pipelines, attempted at longer distances, have at times had alignment drift and elevation deflections which have complicated installation. Drift and deflection are safety concerns when boring adjacent to in-service pipelines and other utilities.

The proposed HDD is 1,800 ft in length, laying parallel to a public road and multiple other utility lines. The density of adjacent paralleling utility infrastructure makes the use of conventional auger bore not preferred.

SPLP contractors attempted three (3) FlexBors and partially completed two of these to replace HDDs on the Mariner Project. One FlexBor failed in the pilot phase and was replaced with a conventional bore under a highway and open cut construction. The two partially successful FlexBors completed the pilot phases, but both had difficulties completing the reaming phase. SPLP’s analysis is that this technology is not perfected for larger diameter bore attempts. Therefore, SPLP did not include this method in alternatives analysis section of the Reevaluation Report.

The Direct Pipe Bore method is also known as "microtunneling". This method of pipeline installation is a remote-controlled, continuously supported pipe jacking method. During the direct pipe installation, operations are managed by an operator in an above-ground control room alongside of the installation pit. Rock and soil cutting and removal occurs by drilling fluid injection through the cutting tool during rotation at the face of the bore, and the cuttings are forced into inlet holes in the crushing cone at the tool face for circulation to a recycling plant through a closed system. The entire operating system for this

method of pipeline installation, including the cutting tool drive hydraulics, fluid injection, fluid return, and operating controls are enclosed inside the outside diameter bore pipe (or casing pipe) being installed. At the launching point/entry pit, the bore pipe is attached to a "jacking block" that hammers the bore pipe while the tool is cutting through the substrate or geology. The cutting tool face is marginally larger in diameter than the pipe it is attached to. As a result, there is minimal annulus space, which minimizes the potential for drilling fluid returns or the production of groundwater returning back to the point of entry.

SPLP's construction contractors have successfully completed one (1) Direct Pipe Bore approximately 925 ft in extent on the Mariner Pipeline project. The White House Lane HDD length, however, is 1,800 ft, which exceeds the limits of Direct Pipe bore technology. Due to the presence of surface development, adjacent utility lines, and natural resources, there are no feasible entry-exit points subset within the length of this HDD to employ this technology.

Based on the analysis of all alternatives, the HDD method remains the preferred option for this location.

2. Relating to the Analysis of well production zones and use of information obtained during construction of the 20-inch pipeline;

From the re-evaluation report it is unclear whether additional water supplies within 450 feet of the HDD were investigated or identified prior to construction of the 20-inch pipeline. In accordance with the Order, did SPLP identify the three private water supplies noted in the re-evaluation prior to October 2017? In addition, the re-evaluation report fails to include evaluation of the information and data collected for the three private water supplies within 450 feet of the HDD.

Any private or public water supply data obtained within 450 feet or otherwise obtained in the vicinity of the 20-inch or proposed 16-inch HDD should be used and discussed as part of this HDD re-evaluation. This data should include but not be limited to any applicable water supply sampling data and any water supply complaints that SPLP may have obtained and received for water supplies within 450 feet of the HDD or within the general vicinity during construction of the 20-inch pipeline. The results of SPLP's water supply sampling program, investigation, disposition of a complaint, and any correlation or non-correlation to SPLP's construction activities should be evaluated and discussed in the HDD re-evaluation report and used to demonstrate that the proposed 16-inch HDD activity will minimize the potential for IR's and impacts to water supplies. Please revise the re-evaluation report to include this information.

In accordance with the Order, SPLP conducted a search and landowner outreach for any water supply wells located within 450 feet of the White House Lane HDD prior to initiating construction of the 20-inch HDD. A total of three water wells (WL-09082017-613-02, WL-05222017-604-01 and WL-05222017-604-02) were identified. Water quality samples collected from each of the residences prior to and during the installation of the 20-inch HDD. One of the locations (WL-09082017-613-02)

was also sampled following the completion of the 20-inch HDD as a result of a water well complaint. All four of the sampling locations are identified on Attachment 3 of the Hydrogeologic Re-Evaluation Report. A review of the analytical results from the sampling events did not identify any changes which could be attributed to impacts from the installation of the 20-inch HDD at the White House Lane location. None of the water quality parameters that are typically identified in samples impacted by drilling fluids (i.e., turbidity, total suspended solids, iron and manganese) were identified at concentrations higher than observed in the pre-construction samples. With the exception of total dissolved solids and iron, none of these water quality parameters were identified at levels exceeding the Department's secondary drinking water standards/maximum contaminant levels (SMCLs). Summary tables containing the analytical results from the various water quality sampling events are attached.

On October 28, 2017, a complaint was made for a change in water quality, including orange discoloration identified at the Earl Kachel rental property located at 691 Second Street, Highspire, Dauphin County, Pennsylvania. At the time of the complaint the property was vacant and Mr. Kachel was present to prepare the residence for a potential renter. A water sample was collected by a representative of RETTEW from the outdoor spigot for visual inspection of water quality. The collected sample was clear, and no discoloration was observed. At this time, Mr. Kachel indicated that the water was only discolored in the toilet bowls and tanks located in the upstairs and downstairs bathrooms. Five water quality samples (one pre-construction (9/8/2017), two during construction (10/31/2017 and 11/14/2017) and two post-construction (3/22/2019 and 4/3/2019)) were collected to further evaluate the water quality within the residence. The analytical results were similar across the five sampling events, with the exception of iron, turbidity and dissolved solids. The observed variation between these three parameters is not unexpected and is within the range of variation typically seen in samples collected from the same source at different times of the year (i.e., seasonal variations). The measured pH was within range and no detectable levels of residual bentonite were identified. Further evaluations conducted by a Pennsylvania-licensed Professional Geologist have concluded that the Kachel well was not impacted from construction activities at the White House Lane HDD site. As discussed in the S3-0011 White House Lane Kachel Water Well Complaint Report, that was submitted to the Department on May 9, 2018 and revised on January 3, 2019, the analytical results show no significant change in water quality between the pre-construction, during construction and post-construction water sampling events. This PG report is currently under review by the Department.

3. Seismic survey and ground penetrating radar surveys were conducted but the data was not provided in the report. DEP requests that you provide the data for both surveys.

A copy of the geophysical report is attached.


4. The HDD Re-evaluation Analysis summary identifies that only two IRs occurred during construction of the 20-inch pipeline. DEP has previous documentation from SPLP and Section 6.0 of the Geological Report acknowledges that four IRs occurred at this HDD site. Please provide clarification about whether all of the reported IRs were considered as part of this re-evaluation. If all of the IRs at this site were not considered, revise the applicable sections of the re-evaluation report accordingly to include the consideration of all of the IRs

that occurred at this site. Locations of IRs should be documented on profile maps, as done in other re-evaluation reports.

All IRs were evaluated and considered during the 16-inch HDD profile redesign. A total of two IRs occurred at this location. A punch out release of drilling fluid occurred along the northwestern shoulder of White House Lane, at an approximate length of 1229 feet (approximately 300 feet from the exit point) on November 2, 2017. The drilling fluid flowed down slope into a grass field at Reservoir Park and did not result in any impacts to environmental resources. All drilling activities were immediately suspended, and a containment structure was built around the accumulated drilling fluid and recovery efforts initiated. When advancement of the pilot hole resumed between November 3 and 6, 2017, the release re-activated and migrated north and east along the shoulder of White House Lane as the pilot tool was advanced. To address the migration of the release, the drilling contractor expanded the containment structures as new “release points” emerged. On November 7, 2017, drilling fluid emerged on the southeastern side of White House Lane and a containment structure was constructed around the release and recovery efforts were started. No impacts to Waters of the Commonwealth occurred as a result of this release; however, the continual releases of fluids were classified as additional IRs vs. a re-activation and drilling activities were suspended pending a Department inspection. It is believed that these releases were the result of the pilot tool advancing through the bedrock/weathered bedrock/unconsolidated material interface. SPLP was granted authorization to resume drilling on November 9, 2017 and on November 10, 2017, a second IR event occurred and flowed into Wetland W-118. All drilling activities were stopped, a containment structure (silt fence and sand bags) constructed around the IR, and recovery of the drilling fluid began. All drilling activities remained suspended until re-start approval was received from the Department.

SPLP submits that we have been, and are, in complete compliance with the agreed terms and analysis requirements of the Order, as agreed to by the Department, and that no further analysis is required for the Department to consent to the start of this HDD. SPLP therefore requests that the Department approve the Re-Evaluation Report for White House Lane Horizontal Directional Drill (S3-0011-16) as soon as possible.

Sincerely,



Larry J. Gremminger, CWB
Geotechnical Evaluation Leader
Vice-President – Environmental, Health & Safety
Energy Transfer Partners
Mariner East 2 Pipeline Project

Mr. Scott Williamson
Response to DEP Comments on S3-0011-16
May 23, 2019
Page 7

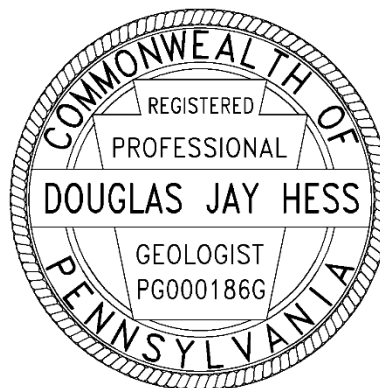
Pertaining to the practice of geology and information conveyed.



Douglas J. Hess, P.G.
License No. PG-000186-G
Skelly and Loy, Inc.
Director of Groundwater and Site Characterization
Geo-Environmental Services

5/23/2019

Date



Attachments as stated

January 10, 2019

Mr. Larry J. Gremminger
Sunoco Logistics, L.P.
535 Fritztown Road
Sinking Spring, PA 19608

RE: Geophysical Survey
Sunoco Pipeline, L.P. Pipeline Project
Horizontal Directional Drill S3-0011– White House Lane
PA-DA-0005.0000-RD-16
Lower Swatara Township, Dauphin County, Pennsylvania
RETTEW Project No. 096302009

Engineers
Environmental
Consultants
Surveyors
Landscape
Architects
Safety
Consultants
Geophysicists

Dear Mr. Gremminger:

RETTEW Associates, Inc. completed a multi-technique geophysical survey at the S3-0011, White House Lane horizontal directional drill (HDD) location. The purpose of the survey was to detect and delineate a suspected fracture zone (mapped by others), which could increase the risk of an inadvertent return (IR) and/or a loss of returns. In addition, the survey determined the rock profile and rock rippability to evaluate the ease-of-excavation. The following report, figures, and attachments describe the methods and results of the investigation.

EXECUTIVE SUMMARY

The multi-technique geophysical survey was completed on November 15, 2018. Seismic refraction, multispectral analysis of surface waves (MASW), and ground penetrating radar (GPR) were used to profile the shallow soils and bedrock surface to detect low-velocity features that could be indicative of fracture zones.

Results from the geophysical testing are consistent with the presence of several possible steeply-dipping features (including near the location mapped by Wood, 1980 and Berg, et al., 1980). These features could increase the risk of IRs and/or a loss of returns. The top-of-rock is expected to be slightly weathered at the soil-bedrock interface, with high-velocity (non-rippable) material not far below the top of rock.

SITE DESCRIPTION

The S3-0011 White House Lane HDD location crosses PA Route 230 (2nd Street) and extends northeast along the eastern edge of White House Lane and west of Lisa Lake in Middletown, Dauphin County, Pennsylvania (see **Figure 1**). A geophysical survey was conducted along the HDD alignment where it crosses the end of an interpreted fracture trace and encompassed an area roughly 20 feet wide by 1,100 feet in length (**Figure 2**).

The site bedrock geology consists of the Triassic-aged Gettysburg Formation (see **Figure 2**). The Gettysburg Formation is described as reddish-brown to maroon, silty mudstone (Berg et al., 1980). Wood (1980) identified a fracture trace with a southwest-to-northeast strike as depicted in green on **Figure 2** that could extend through the proposed HDD. According to the Pennsylvania Geological Survey (PAGS),



Fourth Series, Bulletin G23, "Pleistocene Terraces of the Susquehanna River Pennsylvania", Peltier, 1949, surficial geology at the site consists of unconsolidated alluvial deposits. Additionally, geotechnical evaluations completed by Tetra Tech and PSI/Intertek for the White House Lane site identified unconsolidated alluvium consisting of silts, sands, and gravels with varying amounts of secondary gravel and cobbles, and fill material consisting of silts, sands, and gravels. Weathered bedrock was encountered at depths ranging from 25.2 to 44.2 feet below the ground surface.

SEISMIC MASW AND REFRACTION SURVEY

Seismic MASW and refraction methods utilize the speed of seismic waves through various geologic layers and features to characterize the subsurface geologic conditions. The methods enable determination of the general material types, including the approximate depth to bedrock (rock profile) and the competence of rock. MASW can detect low-velocity zones that might be associated with fractured rock. See **Appendix A** for a more detailed explanation of the seismic refraction method.

The seismic survey consisted of a single profile along the HDD center line (see blue triangles representing geophone locations in **Figure 2**). Color-contour velocity models of the seismic profiles for the seismic refraction and MASW are presented on **Figure 3**. The vertical scale represents relative elevation (or depth on the MASW profile) in feet, and the horizontal axis represents an along-profile distance in feet. The color contours represent average seismic velocity variations, with increasing velocities from blue to green to yellow to orange to brown. The high- and low-velocity data along the first and last fifteen feet of any profile have higher uncertainty. The refraction model displays seismic primary or compressional- (P-) wave velocities, while the MASW shows secondary or shear- (S-) wave velocities. Specific seismic refraction and MASW survey parameters are listed in **Appendix B**.

GROUND PENETRATING RADAR SURVEY

In an effort to detect and delineate potential voids and other anomalous features within the top five to eight feet of the ground surface, RETTEW also completed a GPR investigation over the accessible proposed pipe alignment. Scanning was performed using a Sensors & Software Noggin GPR controller with a color display and internal hard drive, utilizing a digital 250-megaHertz (mHz) frequency scanning antenna. Profiles were scanned along the proposed alignment in a southwest direction. Specific GPR survey parameters are listed in **Appendix B**.

The GPR data were analyzed in the field, in real time, for anomalous features commonly associated with voids as well as any other features that may be related to deeper fractures, or other potential anomalies. Additionally, the GPR data were saved to an internal hard drive for post-processing. Individual two-dimensional profiles were re-examined in the office and are shown on **Figures 4 and 5**. The exaggerated vertical scale is in depth based on an average two-way travel time of the GPR signal, while the horizontal distance is in feet. The data show the anomalous features as high GPR response in black (-) and white (+) contours. Note that only response magnitude (and not polarity, - or +) is relevant to the results; both positive and negative anomalies indicate areas of concern or buried targets. Known targets, such as buried pipelines, are indicated on the profiles.

RESULTS

The seismic refraction data are presented as cross-sectional profiles of P-wave velocity on **Figure 3**, and indicate a general three-layer stratigraphy consisting of an alluvial or residual soil mantle, a thin zone of weathered rock, and competent bedrock below. The uppermost layer has average P-wave velocities

generally less than 5,000 feet per second (fps) with a thickness of approximately 25 to 30 feet. This is consistent with a saturated soil mantle (shaded blue to green). The deepest layers have velocities over 10,000 fps (shaded orange to brown) consistent with competent bedrock (Carmichael, 1989). The area between roughly the 5,000 and 10,000 fps contours is a transitional zone consisting of weathered rock grading downward into competent bedrock. Apparent bedrock surface depressions and low-velocity zones below the 10,000-fps contour could represent deeply weathered fracture zones. These are highlighted with magenta hatching on **Figure 3**. These features, if fractures, could represent possible pathways for IR during the HDD. Rock probably becomes non-rippable not far below the top-of-rock (i.e. just below the dashed contour on the P-wave profile).

The MASW S-wave model is presented below the seismic refraction cross section on **Figure 3**. The S-wave velocity model shows a relatively wide velocity low in the west-central portion of the site (11260+85 to 11267+85), southwest of the extended mapped fracture trace. This low-velocity zone may be related to the mapped fracture trace. If so, it could represent a possible pathway for IR during the HDD.

The seismic velocity models from the ray-tracing method (not shown) were compared to standard ripping charts (see **Appendix C**, Caterpillar, Inc., 1995) using the inferred/assumed layer compositions to determine the general rippability of each stratum. In general, the surficial layer and some of the material down to about the top of inferred bedrock layer (wavy dashed contour) should be readily to marginally rippable with a D9 multi- or single-shank ripper doing open field ripping, based on a weighted average velocity of about less than 5,000 fps. Below the 5,000-fps contour, ripping will get more difficult with depth, with the transition zone expected to become non-rippable below the 10,000 fps contours (based on the average ray-trace velocity or over 10,000 fps and Caterpillar charts). The basal half-space has a weighted average layer velocity of over 10,000 fps based on the ray-tracing model (not shown), and is well into the non-rippable range. For trenching (as opposed to open field ripping), material below the 5,000-fps contour line may become non-rippable (for a CAT-330 tracked excavator or equivalent) as well. The selection of the contour cut-off for trenching is based on correlations between the ray-tracing models (not shown), material properties, and various excavation strategies investigated by Kirsten (1982).

CONCLUSIONS

In general, the geophysical survey results display anomalies indicative of possible fractures in the zone mapped by Wood (1980) and along the remaining proposed HDD.

LIMITATIONS

The survey described above was completed using standard and/or routinely accepted practices of the geophysical industry, and the equipment employed represents, in RETTEW's professional opinion, the best available technology. RETTEW does not accept responsibility for survey limitations due to inherent technological limitations or unforeseen site-specific conditions. We will notify you of such limitations or conditions, when they are identifiable.

Rippability, while historically closely-correlated with seismic P-wave velocity, also depends on geotechnical properties of the material, on the specific method of excavation, and on the variety and size of equipment employed. For mechanical excavation, the teeth or other cutting elements must be forced into discontinuities of competent rock masses, or penetrate the fabric of weak rocks. Thus, joint or fracture spacing, aperture, and infilling will all play a role in determining whether existing discontinuities in apparently-competent rock masses can allow mechanical excavation. The strength of the intact rock

will also control whether fresh discontinuities can be induced during excavation activities. Therefore, while seismic data can provide reliable guidelines, RETTEW recommends that the rocks to be excavated be checked for these other geotechnical characteristics through examination of local outcrops, test pits, or boring logs.

We have enjoyed and appreciated the opportunity to have worked with you. If you have any questions, please do not hesitate to contact the undersigned.



Charles H. Rhine, MSc, PG
Senior Project Manager



Timothy D. Bechtel, PhD, PG
Senior Project Manager



Felicia Kegel Bechtel, MSc, PG
Director of Geophysics

Enclosures

Figure 1: Topographic Basemap
Figure 2: Data Coverage Map and Geologic Setting
Figure 3: Seismic Survey Results
Figure 4: GPR Profiles 11277+80 to 11269+80
Figure 5: GPR Profiles 11269+80 to 11259+70
Appendix A: Introduction to Seismic Refraction
Appendix B: Geophysical Survey Parameters
Appendix C: Caterpillar Ripping Charts

References

Berg, T.M., Edmunds, W.E., Geyer, A.R., and others, 1980, Geologic Map of Pennsylvania, PA Geological Survey, 4th series.

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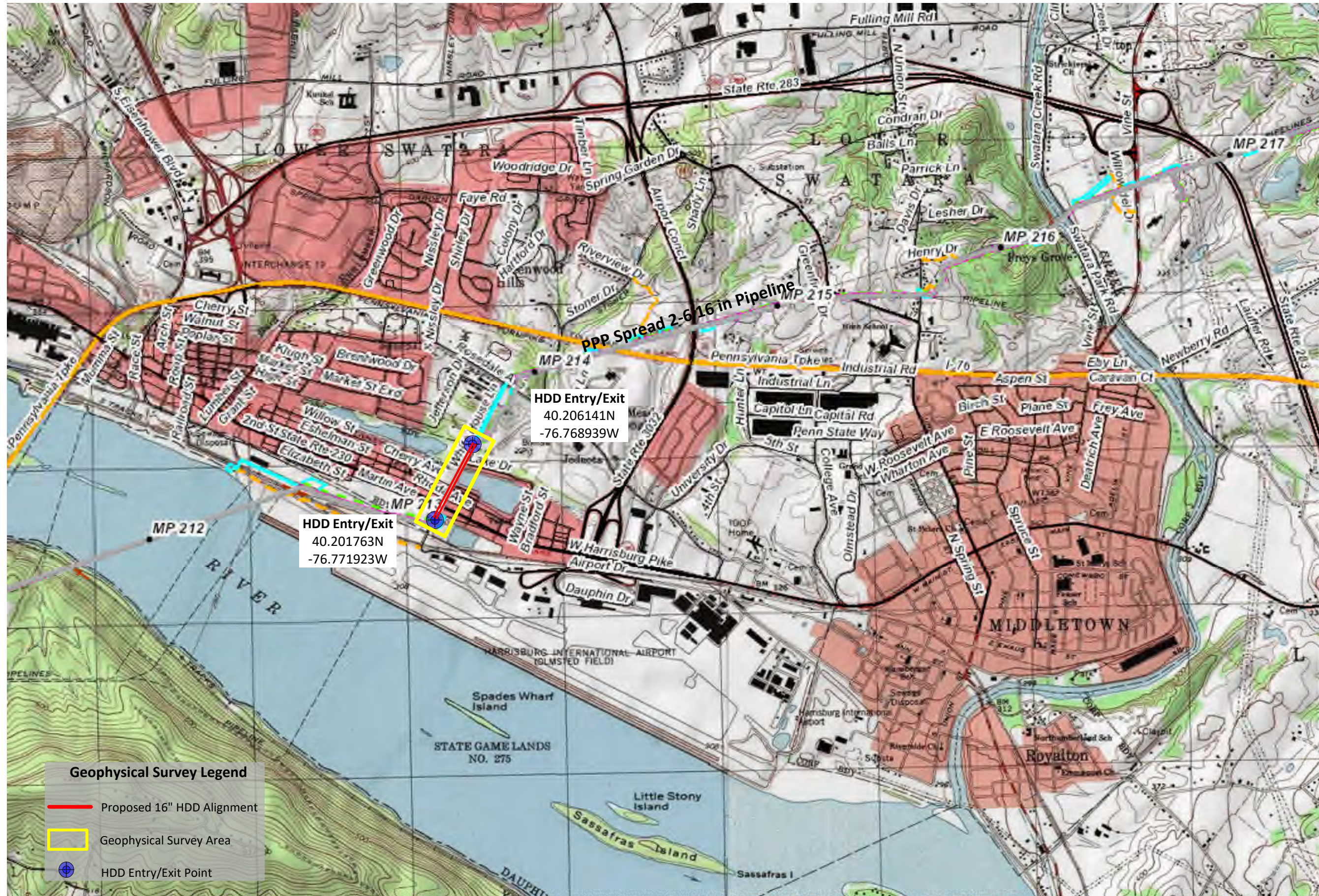
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Kirsten, HAD (1982). A classification system for excavating in natural materials. Civil Engineering (Siviele Ingenieursweise), 24(7), 293-308.

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ENCLOSURES

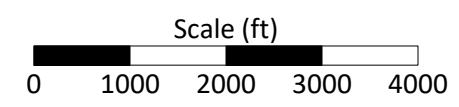


Geophysical Survey Legend

- Proposed 16" HDD Alignment
- Geophysical Survey Area
- ⊕ HDD Entry/Exit Point

Notes:

Basemap extracted from USGS US Topographic WMS Server, extracted 11/2018.



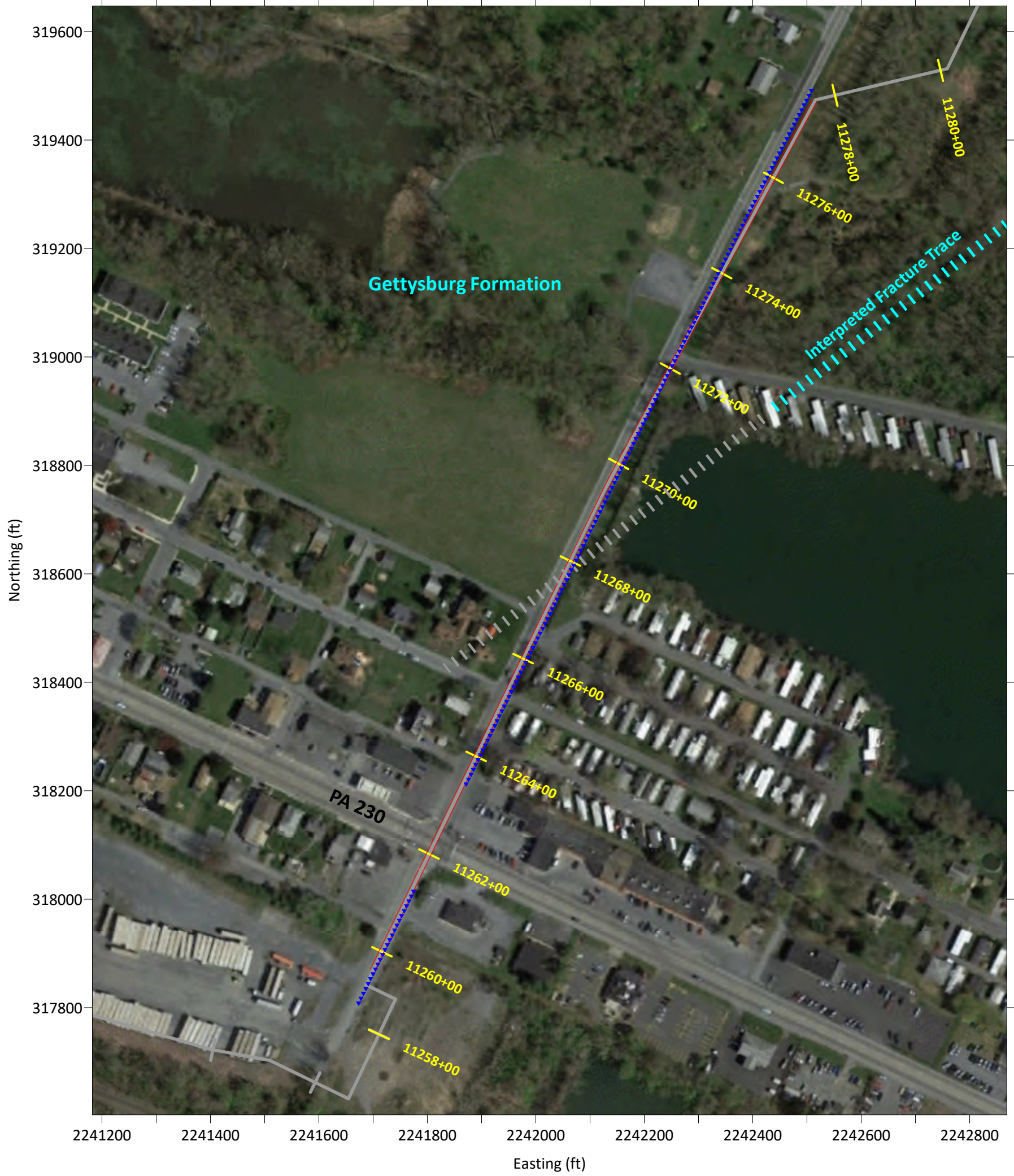
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RETTEW No.:	096302009
REVIEWED BY:	FKB
DRAWN BY:	CHR
DATE:	01/05/2019
SCALE:	1" = 2000'
FIGURE NO.:	1 of 5




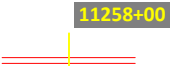

RETTEW Associates, Inc.
3020 Columbia Avenue, Lancaster, PA 17603
Phone (717) 394-3721 Fax (717) 394-1063

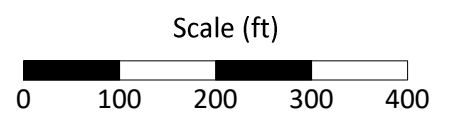
Figure 1: Topographic Basemap

White House Lane
S3-0011
PA-DA-0005.0000-RD-16



Geophysical Survey Legend

-  Seismic Geophone Location (every other posted)
-  16" Product Line with Station Number
-  Interpreted Fracture Trace (by others)



Notes:
 Basemap from Google Earth Pro, extracted 11/2018.
 Survey profiles/stations from DGPS survey by RETTEW.
 Geologic information from DCNR WMS Server, extracted 11/2018, and Wood, 1980.

Figure 2: Data Coverage Map and Geologic Setting

White House Lane
 S3-0011
 PA-DA-0005.0000-RD-16

LOWER SWATARA TOWNSHIP

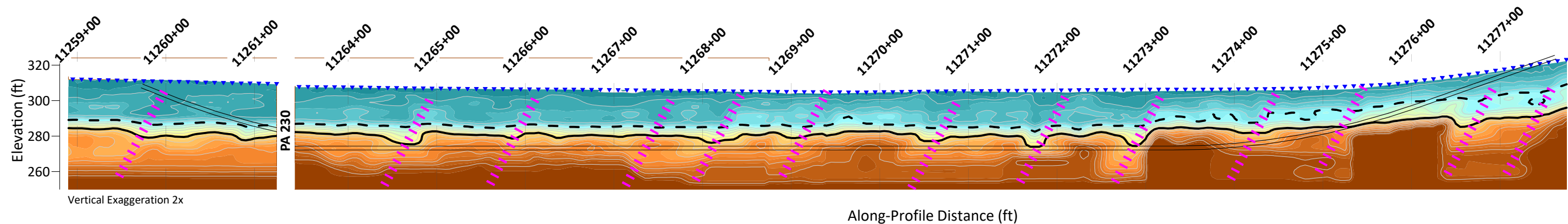
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SURVEY DATE: 11/15/2018
 RETTEW No.: 096302009
 REVIEWED BY: FKB
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 FIGURE NO. 2 of 5



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SCALE:	1" = 120'
FIGURE NO.:	3 of 5



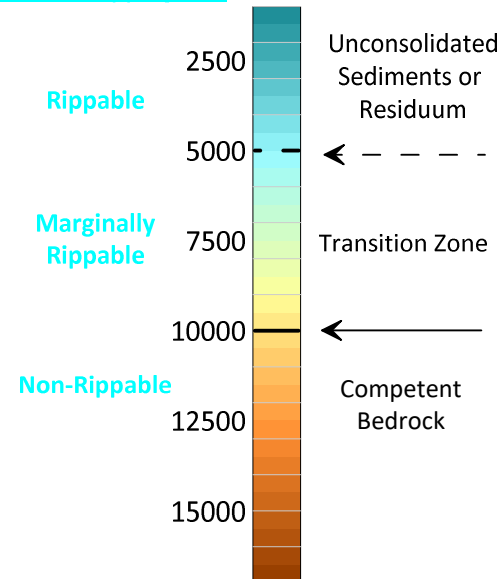
Figure 3: Seismic Survey Results

White House Lane
S3-0011
PA-DA-0005.0000-RD-16

DAUPHIN COUNTY, PA
LOWER SWATARA TOWNSHIP

Relative P-Wave Velocity (fps)

Open Field Ripping (D9)

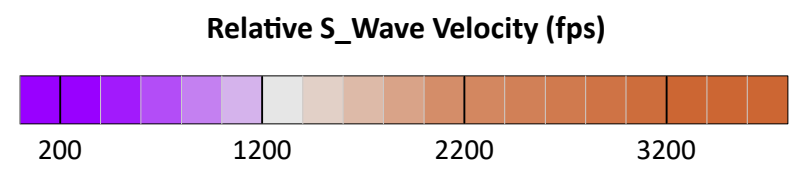
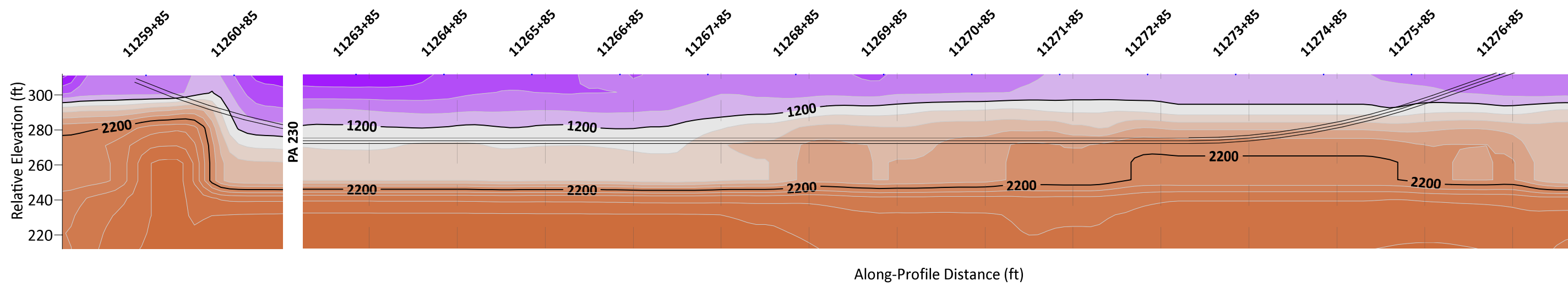


Weighted Average
P-Wave Velocity

$$\frac{V_1 = 1,271 \text{ fps}}{V_2 = 9,260 \text{ fps}}$$

Geophysical Survey Legend

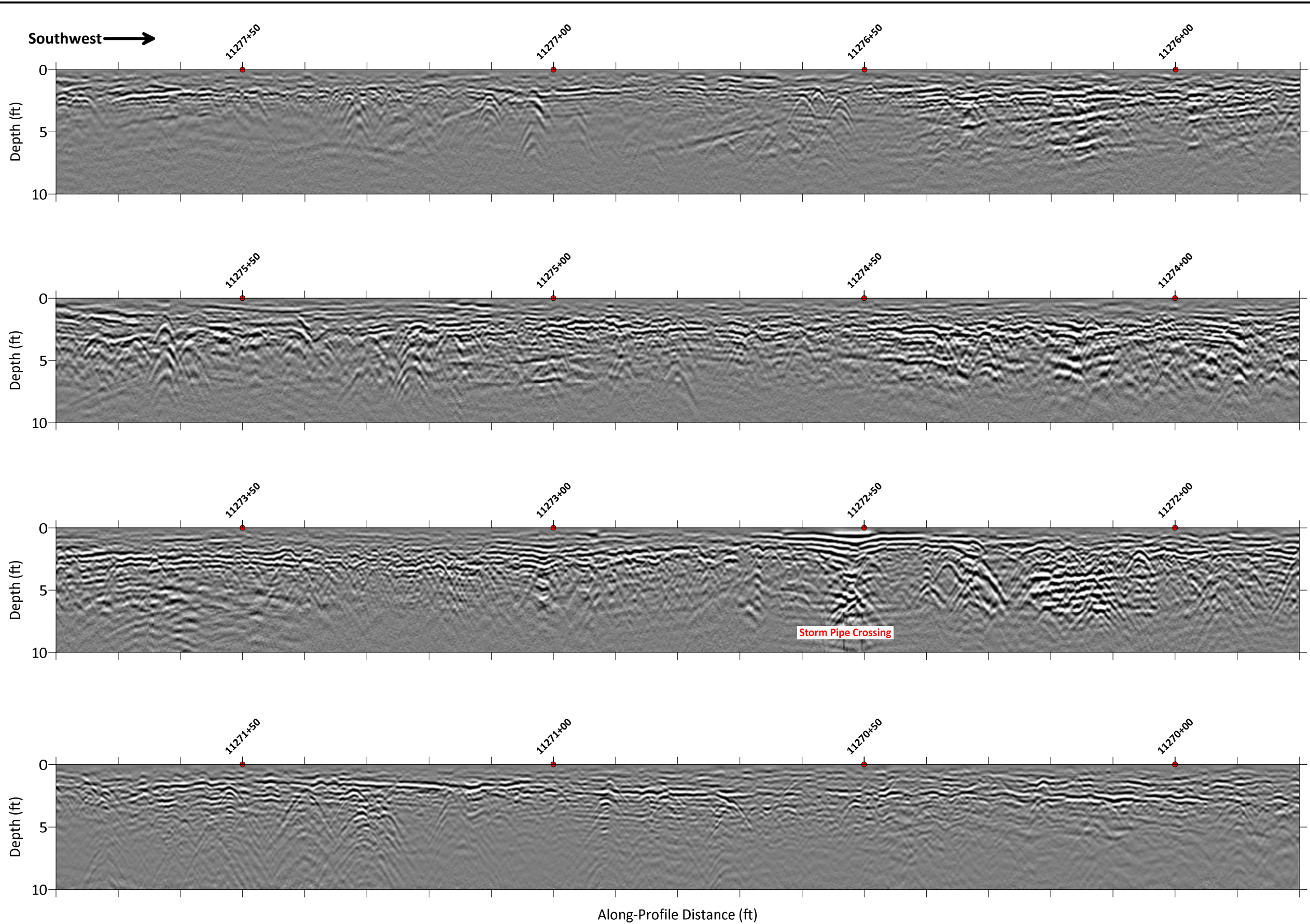
- ▼ Seismic Geophone Location
- ▬ Possible Fracture Zone
- ▬▬ Proposed 16" HDD
- 11627+00 Station Number



Notes:

Seismic data from Geometrics 24-channel Geode with 4.0 Hz geophones.

Relative seismic velocity models from SeisImager (by Oyo Corporation) tomographic and ReMi inversions.



Notes:

GPR data from Sensors & Software Noggin Sytem, 250 MHz antenna.

SURVEY DATE:	11/15/2018
RETTEW No.:	096302009
REVIEWED BY:	FKB
DRAWN BY:	CHR
DATE:	01/05/2019
SCALE:	1" = 16'
FIGURE NO.:	4 of 5



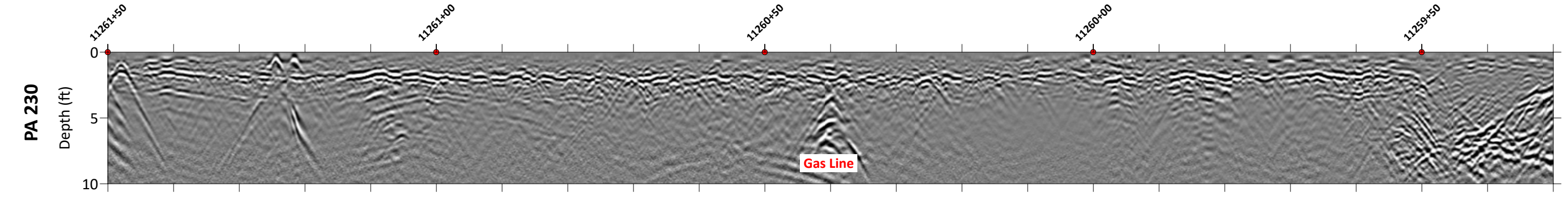
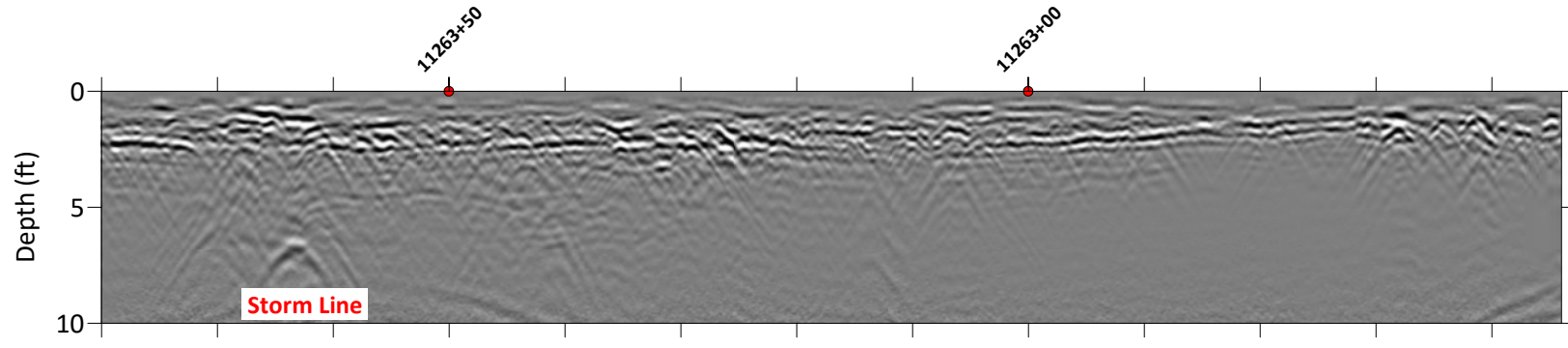
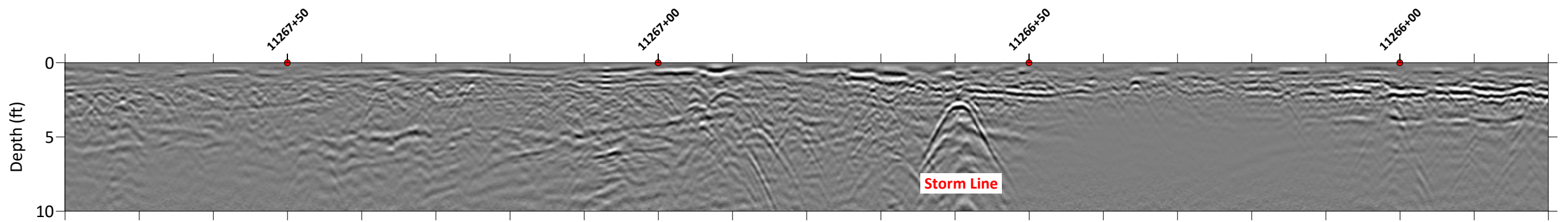
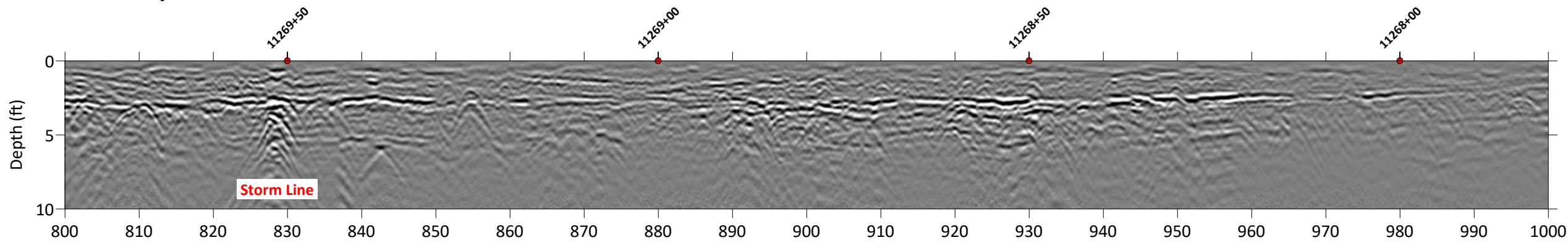
RETTEW Associates, Inc.
 3020 Columbia Avenue, Lancaster, PA 17603
 Phone (717) 394-3721 Fax (717) 394-1063

Figure 4: GPR Profiles 11277+80 to 11269+80

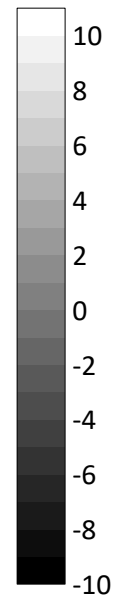
White House Ln
 S3-0011
 PA-DA-0005.0000-RD-16

LOWER SWATARA TOWNSHIP
 DAUPHIN COUNTY, PA

Southwest →



Relative GPR Signal Amplitude



SURVEY DATE: 11/15/2018
 RETTEW No.: 096302009
 REVIEWED BY: FKB
 DRAWN BY: CHR
 DATE: 01/05/2019
 SCALE: 1" = 16'
 FIGURE NO. 5 of 5



RETTEW Associates, Inc.
 3020 Columbia Avenue, Lancaster, PA 17603
 Phone (717) 394-3721 Fax (717) 394-1063

Figure 5: GPR Profiles 11269+80 to 11259+70

White House Ln
 S3-0011
 PA-DA-0005.0000-RD-16

DAUPHIN COUNTY, PA

LOWER SWATARA TOWNSHIP

Notes:
 GPR data from Sensors & Software Noggin Sytem, 250 mHz antenna.

APPENDIX A
Introduction to Seismic Refraction

INTRODUCTION TO SEISMIC REFRACTION

BY TIMOTHY D. BECHTEL, PHD, PG

ENERGY

Mechanical elastic (seismic) waves generated by a hammer blow, weight drop, or explosion.

SENSITIVITY

Sensitive to elastic properties or moduli – generally strongly correlated with density.

BASIC EQUIPMENT

Recording Seismograph (generally 24 or more channels); Geophones (one for each channel); Geophone cable; Hammer or weight plus strike plate or explosives; Trigger switch.

COMMON APPLICATIONS

Determination of the depth and dip of soil horizons and bedrock surfaces. Recent processing advances allow some detection and delineation of discrete targets.

PRINCIPLES

In a uniform isotropic earth, the shock wave from a blow or explosion at the surface travels outward and downward in a hemispherical wave front like a three-dimensional ripple from a pebble in a still pond. At any point on the wave front, a straight line from the shock source to the wave front depicts the path of the seismic wave and is called a ray path (see **Figure SR-1**). In reality, there are several independent shock waves; the fast-moving primary, compressional or P wave front; the slower moving secondary, shear or S wave (both of which form hemispherical wavefronts); and several disk-like wave fronts that travel only along the surface of the earth (called surface waves or ground roll). For the purposes of most seismic refraction surveys, only the fastest moving wave front — the P wave — is considered. S-wave refraction is used in selected circumstances where complete determination of elastic moduli is desired – particularly when it may be desirable to eliminate the effects of water saturation.

In a layered earth, the hemispherical P shock wave defined by the radially distributed P ray paths are deflected according to the laws of optics (Snell's Law) at interfaces between materials with differing seismic velocities (i.e. densities or elastic properties). Figure SR-2 depicts the deflection of ray paths due to an increase in P velocity at a bedding plane. The type of deflection that a ray path will undergo is dependent upon the angle at which it strikes the interface, and falls into one of four categories:

Some direct rays (green in **Figures SR-2** and **SR-3**) travel parallel to the ground surface at the seismic velocity of the upper layer, do not strike the underlying interface, and consequently are not deflected.

Reflected rays (purple in **Figures SR-2** and **SR-3**) arise where direct rays strike the interface, and a portion of the energy is reflected symmetrically back towards the surface.



The portion of the energy of the incident direct wave that is not reflected upward is refracted or bent as it crosses the interface – making refracted waves in the lower layer (red in **Figures SR-2** and **SR-3**).

At a precise angle called the critical angle, the incident ray is refracted directly along the interface, and travels at the higher seismic velocity of the lower layer (see Critically Refracted Wave in **Figure SR-3**). As this critically refracted or head wave races along beneath the interface, it generates a secondary elastic disturbance that travels back to the surface along ray paths that define a wave front analogous to the bow wake of a ship. These returning rays again travel at the slower velocity of the upper layer.

To perform a refraction survey, a linear array of ground motion sensors or geophones is spaced out from the seismic source or shot point, forming a geophone spread. Each geophone is connected to a separate channel in a seismograph which records a wiggle trace representing the ground motion resulting from the passage of the various seismic rays.

As depicted in the time-distance (T-X) curve in **Figure SR-4**, the layered earth structure can be determined by analyzing the seismographic wiggle traces. At distances close to the seismic source, the first wiggle or ground motion (the first arrival after the shot) is due to passage of the direct wave travelling at the velocity of the upper layer. Reflected waves arrive later since they have by definition traveled a greater distance at the same velocity (additional later wiggles are caused by passage of the more slowly travelling S and surface waves). Beyond a distance dictated by the critical angle, the first arrival of seismic energy represents the head wave of the critically refracted ray. These refracted rays also by definition travel a greater distance than the direct wave. However, along part of their path, they have traveled at the higher velocity of the underlying more consolidated layer. At greater distances from the shot point, where the path length in the higher velocity layer becomes significant, the head wave arrivals actually race past the direct wave and become the first arrival (see labeled crossover in **Figure SR-4**). By extension, it can be shown that if a third layer with even greater velocity lies at greater depth, the head wave from this layer will become the first arrival at a sufficient distance from the shot point.

In conventional seismic refraction, only the first P wave arrivals can be reliably selected on a wiggle trace record. The later reflected P wave arrivals are generally obscured by the slower-travelling S and surface waves, and the very slow air blast or sound wave from the shot. To interpret a seismic refraction record, the first arrival travel times are measured for each wiggle trace and plotted at the appropriate point on a time-distance (T-X) curve (see **Figure SR-4**). In a plane-layered earth, these first arrivals define a series of line segments, each representing a discrete layer. The seismic velocity of each layer is simply the reciprocal of the slope of the associated line segment. The thickness of each layer can be calculated from the distances where the line segments intersect. The mathematics for these calculations are easily derived, and can be found in any introductory geophysics text.

True geologic strata are rarely perfectly horizontal. The effect of a dipping interface on a travel time curve cannot be recognized using a single shot point. Calculations based on a T-X curve from a single shot point should always be considered as producing apparent depths to interfaces and apparent seismic velocities for all but the uppermost layer. To determine the true depths and dips of interfaces and the true seismic velocities, it is necessary to reverse the seismic line; that is, move the shot point to a location at or beyond the farthest geophone in the spread, and repeat the shot. The calculation of true depths, dips and velocities from reversed seismic lines is also readily performed.

CAPABILITIES

Conventional seismic refraction can yield accurate measurements of depths and attitudes of soil horizons, groundwater tables, and other relatively distinct and planar strata. Modern computer analysis of multi-fold seismic refraction data (i.e. with many and overlapping shot points) can provide delineation of undulating or even irregular (as opposed to simply planar) interfaces. The latest generation of computer processing techniques require very high-fold data, but in favorable conditions, are capable of resolving even discrete targets such as foundation elements, tunnels or cavities, and can resolve gradational boundaries as well as distinct interfaces. The seismic P-wave velocities of materials are generally an indication of relative density or compaction. S-wave refraction data (collected using specialized geophones, shock sources and field procedures) can provide S-wave velocities that bear a well-constrained empirical relationship to standard penetration test (SPT) N values and therefore bearing capacity. For surveys where matching P- and S-wave velocities are determined, the dynamic elastic moduli of subsurface materials can be calculated (including Poisson's Ration, Young's or Bulk Modulus, and Shear Modulus or Rigidity).

LIMITATIONS

Seismic data is collected at spaced geophones, and therefore does not provide continuous profile data. If geophones are spaced too widely, thin layers can be missed entirely.

Conventional refraction interpretations are only accurate where the velocity of strata increase with depth. Velocity inversions not only alter the data, but are particularly insidious since the presence of a low velocity zone at depth is not apparent in first arrival data. The latest generation of computer processing techniques do allow detection and delineation of laterally restricted low velocity zones (e.g. tunnels, cavities, gravel lenses, etc.).

Sharp or dramatic interface relief such as limestone pinnacles cannot always be resolved even with very tight geophone spacing. Therefore, refraction profiles of expectedly irregular interfaces should be assumed to represent somewhat smoothed versions of actual relief (see e.g. Figure **SR-5**).

Seismic records can contain noise due to heavy machinery vibrations, vehicular traffic, and sometimes even wind or distant earthquakes. Care must be taken to identify potential sources of seismic noise prior to beginning a survey.

The effective survey depth is limited to approximately 1/5 of the greatest shotpoint to geophone distance. Therefore, very deep surveys may require impractically long lines (requiring consideration of other geophysical techniques such as seismic reflection).

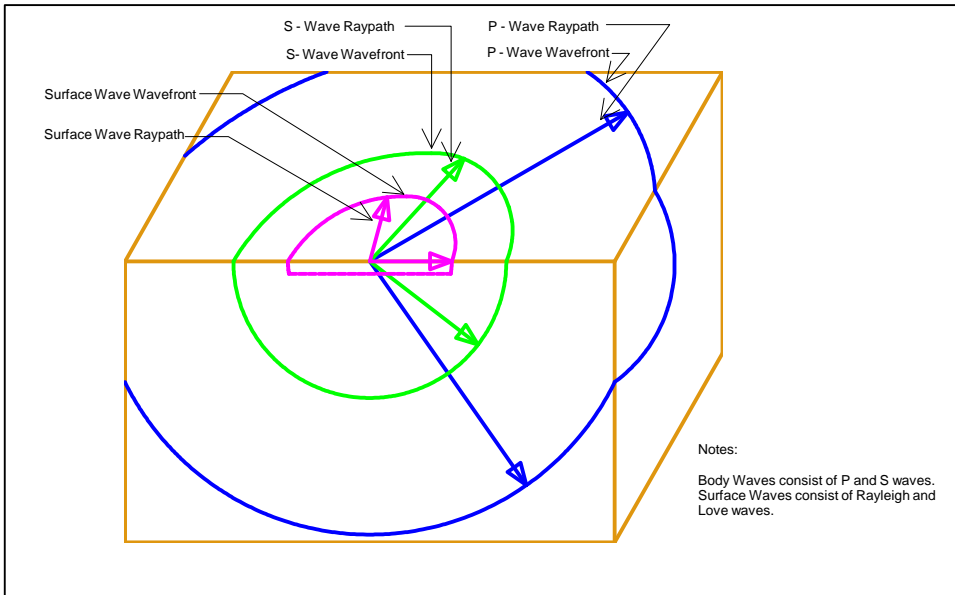


Figure SR-1

Seismic Wave Types

Rev. 04/2018

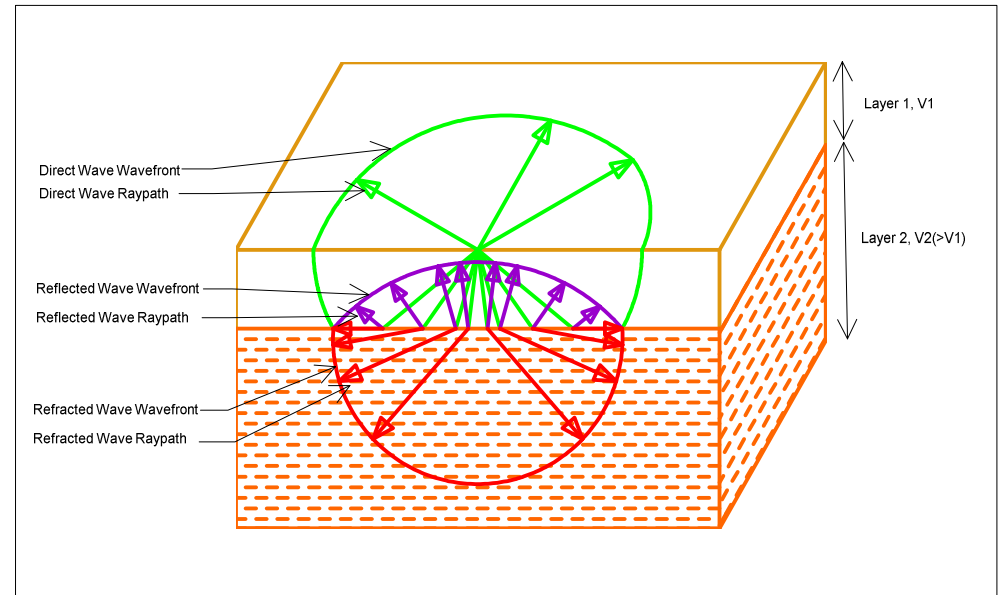


Figure SR-2

Effect of Layering
on Body Wave Raypath

Rev. 04/2018

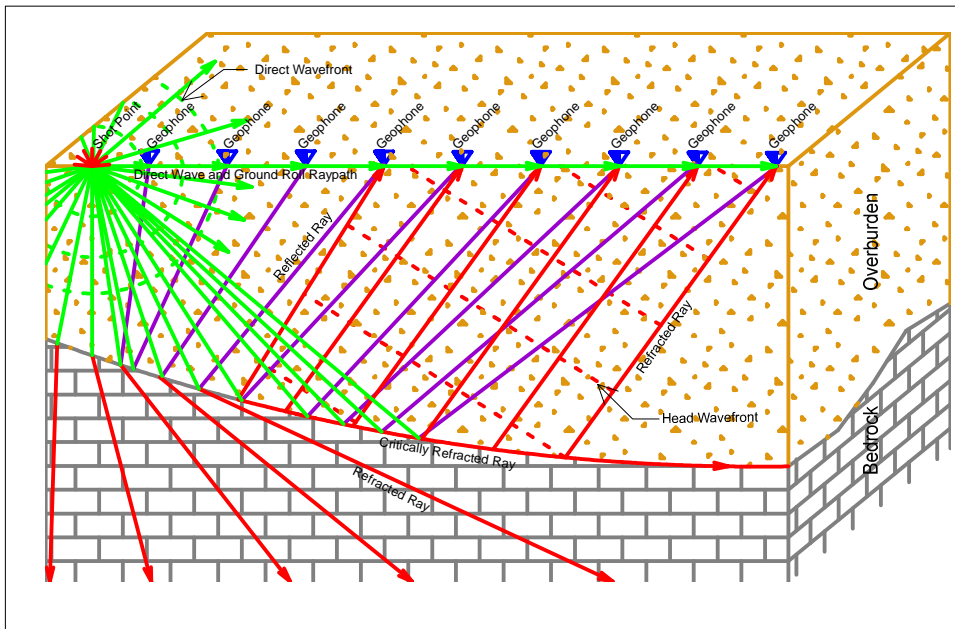


Figure SR-3

Seismic Ray Path Geometry

Rev. 04/2018

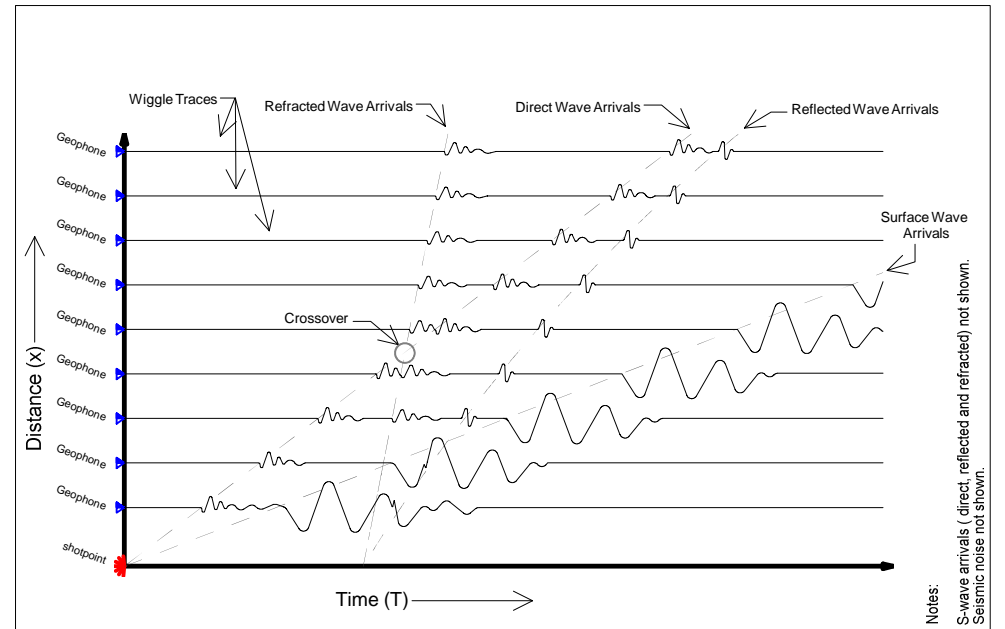


Figure SR-4

Idealized
Seismic Record
and T- X Graph

Rev. 04/2018



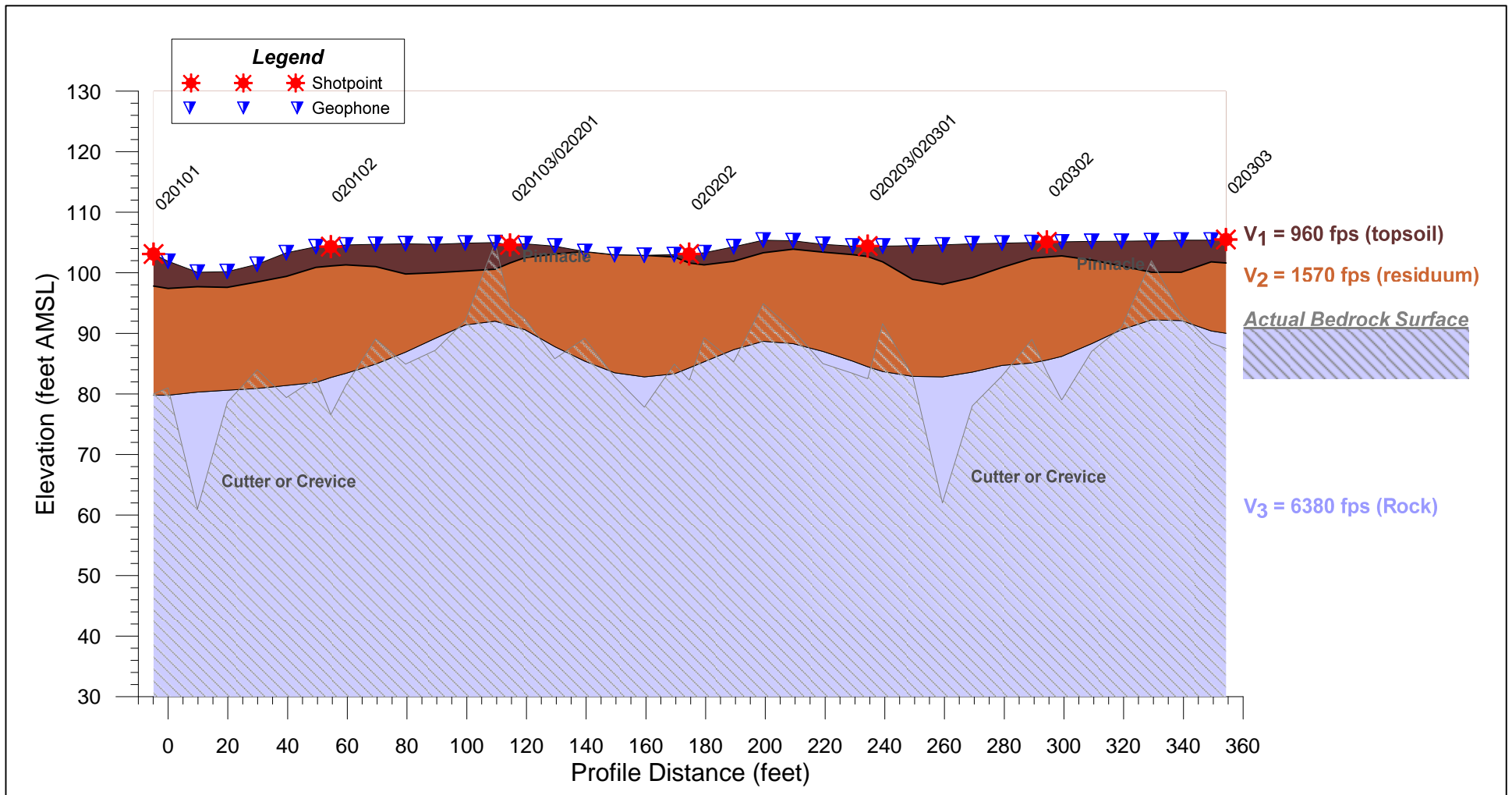


Figure SR-5

Example Karst Terrane Seismic Profile

Revised 04/2018



APPENDIX B
Geophysical Survey Parameters

Geophysical Survey Parameters -- White House Lane

	Spacing ¹ (feet)	Shot Interval ² (feet)	Offset ³ (feet)	Spread Length ⁴ (feet)	Center Frequency ⁶ (MHz)	Effective Depth ⁷ (feet)	Lateral Resolution ⁷ (feet)	Vertical Resolution ⁷ (percent)	System
Seismic Refraction	5	40	20	120		24	5	15	Geometrics Geode
Seismic MASW	5	5	20	120		40	5	25	Geometrics Geode
GPR	continuous		20		400	depends on soil	depends on depth	5	GSSI SIR-3000

¹ geophone, electrode, or station

² Seis (27-lb slide) ³ distance between parallel profiles

⁴ ERI or Seis

⁵ ERI

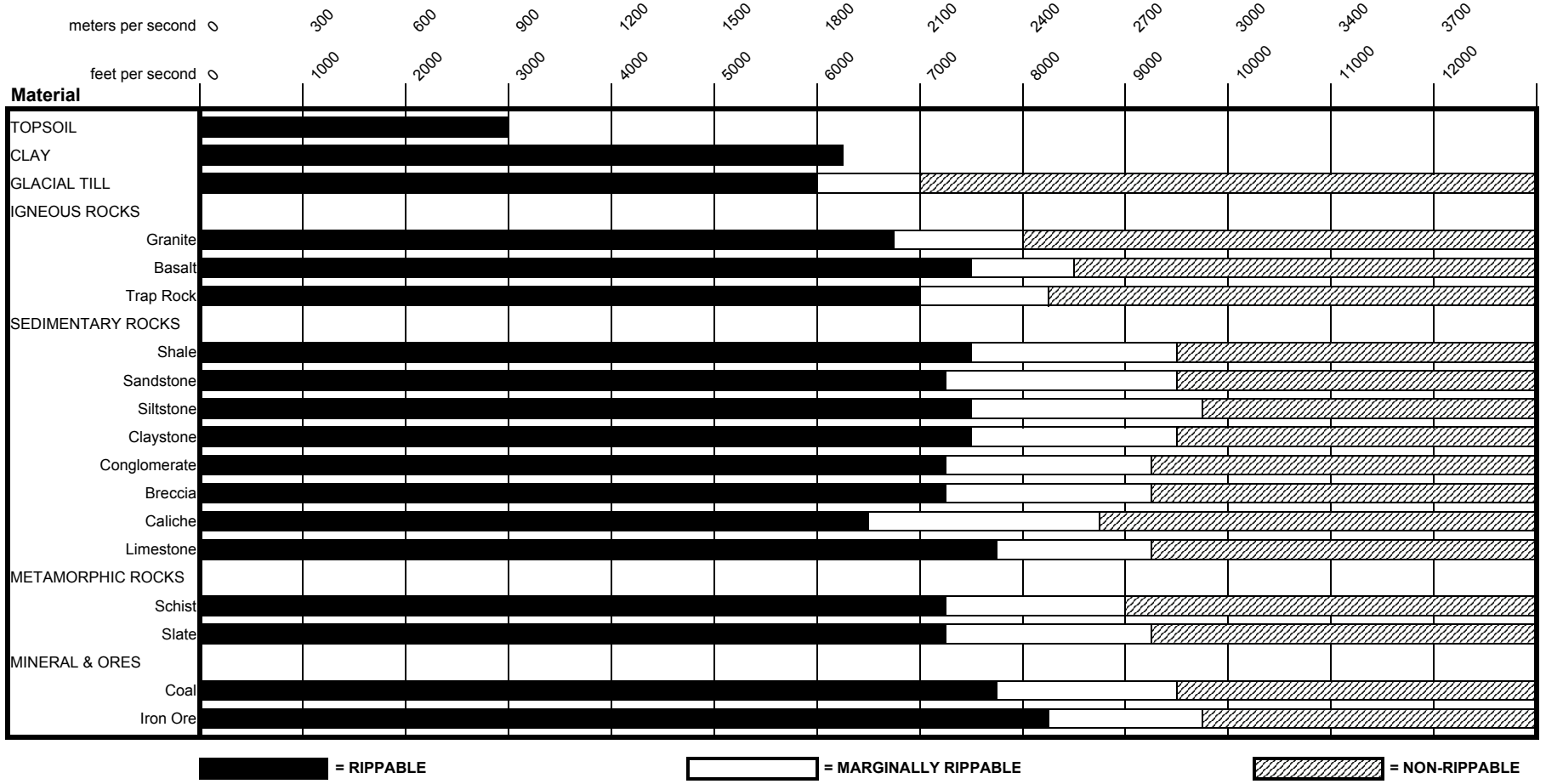
⁶ GPR

⁷ rule-of-thumb only (most depend on site-specific soil properties, sampling interval, depth, and target dimensions)

APPENDIX C
Caterpillar Ripping Charts

Ripping Chart *
D9R
 Multi or Single Shank No. 9 Ripper
 Estimated by Seismic P-Wave Velocities

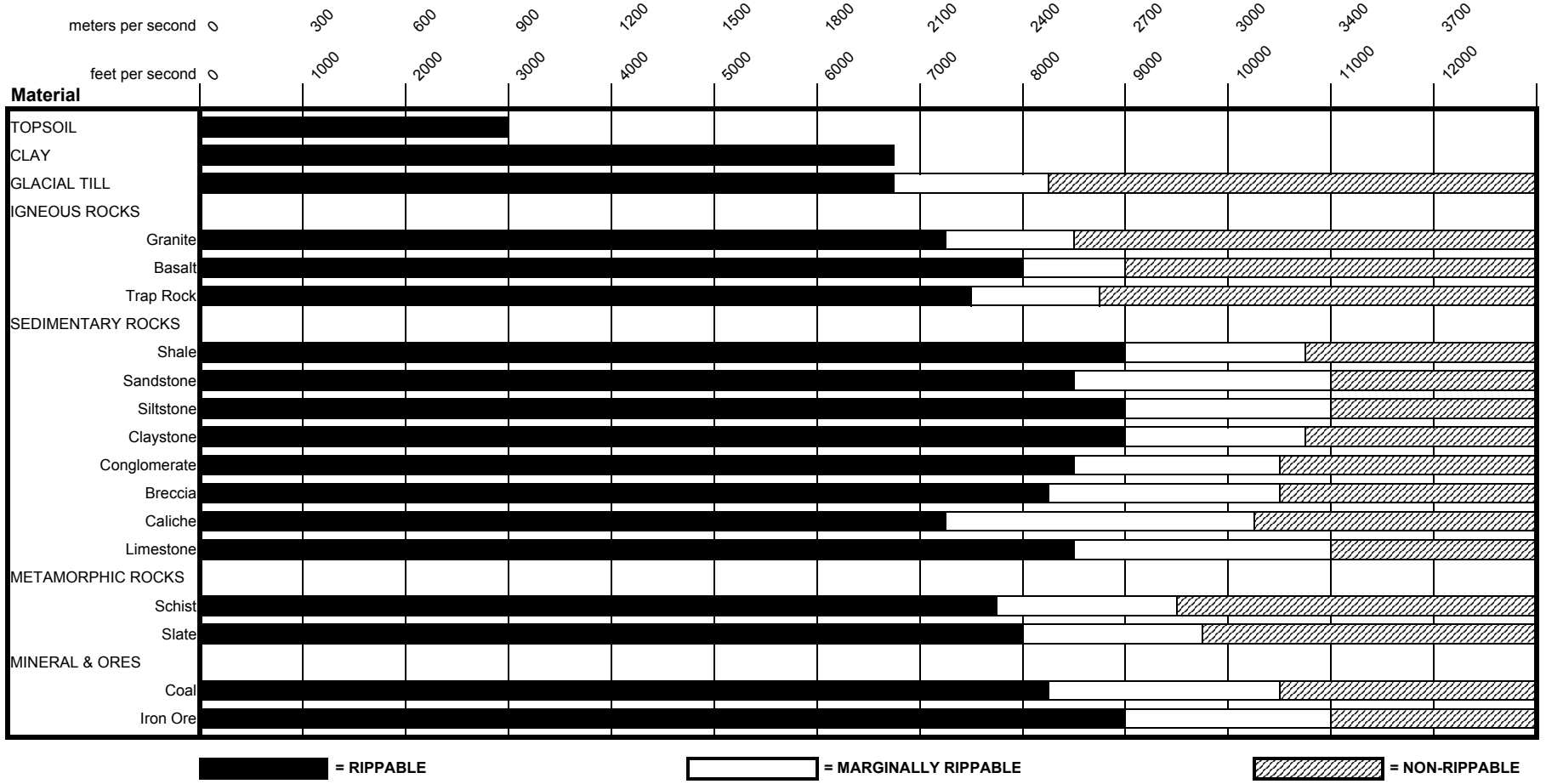
Seismic Velocity



* Caterpillar Performance Handbook, Edition 26, Caterpillar, Inc., Peoria, Illinois

Ripping Chart *
D10N
 Multi or Single Shank No. 10 Ripper
 Estimated by Seismic P-Wave Velocities

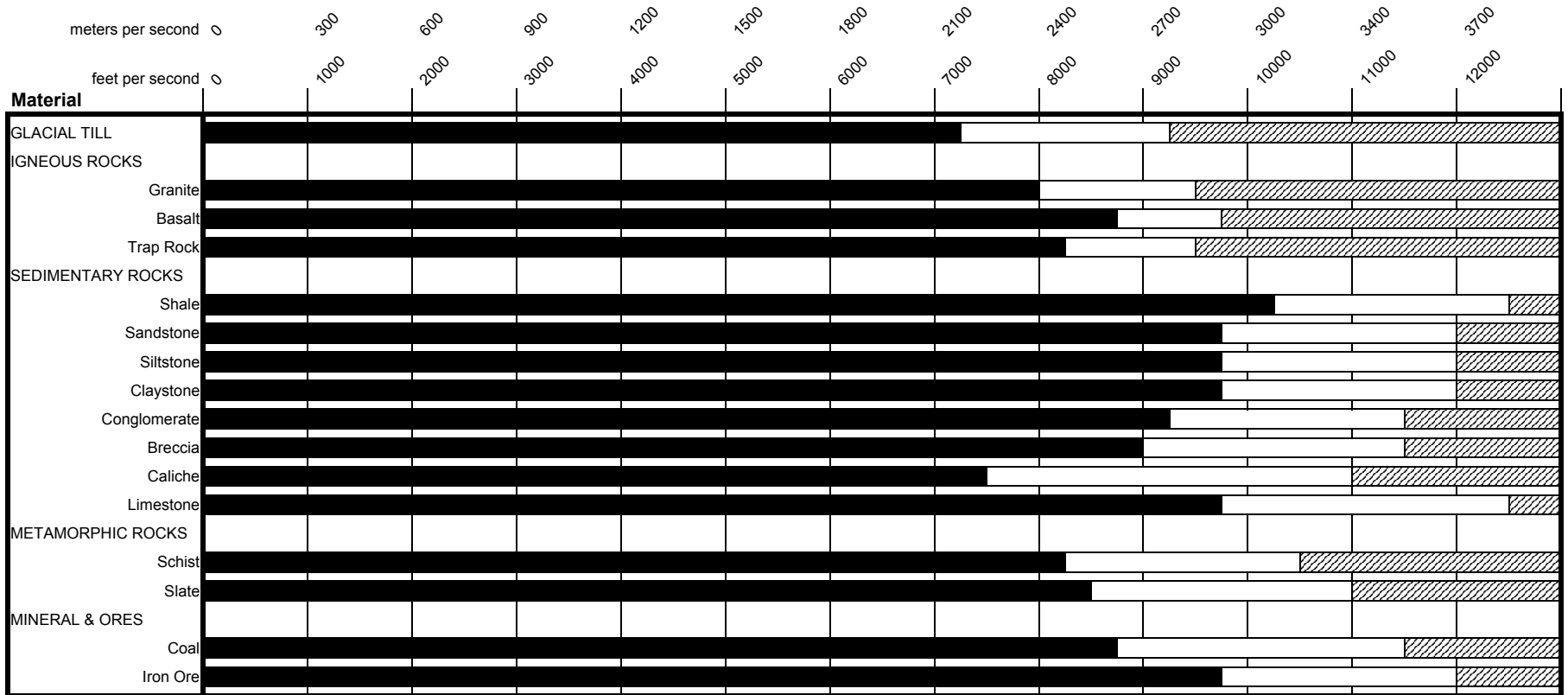
Seismic Velocity



* Caterpillar Performance Handbook, Edition 26, Caterpillar, Inc., Peoria, Illinois

Ripping Chart *
D11N
Multi or Single Shank No. 11 Ripper
Estimated by Seismic P-Wave Velocities

Seismic Velocity



■ = RIPPABLE

□ = MARGINALLY RIPPABLE

▨ = NON-RIPPABLE

* Caterpillar Performance Handbook, Edition 26, Caterpillar, Inc., Peoria, Illinois

Kachel Water Sample Analytical Results Summary

Parcel ID: 30-029-013 (691 Second Street)
 Well Location Map ID: WL-09082017-613-02

Parameter	Units	Sample Date: 9/8/2017	Sample Date: 10/31/2017	Sample Date: 11/14/2017	Sample Date: 3/22/2019	Sample Date: 4/3/2019	PA DEP Drinking Water MCL/SMCL
		Sample I.D.: 09082017-613-02	Sample I.D.: 10312017-610-01	Sample I.D.: 11142017-612-01	Sample I.D.: 03222019-611-01	Sample I.D.: 04032019-520-01	
Coliform, fecal	col/100ml	1.00	<1	<1	<1	<1	-
E. Coli	MPN/100ml	1.00	<1	<1	<1	<1	-
Coliform, total	MPN/100ml	83.9	6.30	1.00	<1	<1	-
Dissolved Solids	mg/l	592	221	509	493	597	500
Suspended Solids	mg/l	ND	ND	ND	5.5	ND	-
Hardness (colorimetric) as CaCO3	mg/l	239	150	191	194	222	-
Turbidity	NTU	0.448	12.5	1.85	0.503	2.92	-
Alkalinity	mg/l	118	100	105	121	127	-
pH	SU	7.14	7.59	6.65	6.77	6.88	-
Specific Conductance	umhos/cm	915	373	826	866	892	-
Bromide	mg/l	ND	ND	ND	ND	ND	-
Chloride	mg/l	178	25.6	158	160	157	250
Sulfate	mg/l	29.9	24.1	26.6	25.7	26.4	250
Barium	mg/l	0.172	0.0302	0.158	0.162	0.162	2
Calcium	mg/l	80.2	51.2	72.4	75.7	78.1	-
Iron	mg/l	0.151	1.02	0.219	0.306	0.300	0.3
Magnesium	mg/l	13.1	7.67	11.7	11.9	12.3	-
Manganese	mg/l	ND	ND	ND	ND	ND	0.05
Potassium	mg/l	3.29	1.76	3.09	3.02	3.15	-
Sodium	mg/l	75.2	12.1	69.8	76.3	77.5	-
Methane	mg/l	ND	ND	ND	ND	ND	-
Ethane	mg/l	ND	ND	ND	ND	ND	-
Ethene	mg/l	ND	ND	ND	ND	ND	-
Propane	mg/l	ND	ND	ND	ND	ND	-
Benzene	mg/l	ND	ND	ND	ND	ND	0.005
Toluene	mg/l	ND	ND	ND	ND	ND	1
Ethylbenzene	mg/l	ND	ND	ND	ND	ND	0.7
Total Xylenes	mg/l	ND	ND	ND	ND	ND	10
Residual Bentonite	-	NA	NA	ND	NA	NA	-

20-inch HDD construction dates: October 17, 2017 through December 20, 2017
 16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:

1. MCL - Maximum Primary Contaminant Level
 2. SMCL - Maximum Secondary Contaminant Level
 3. NA - Not Analyzed
 4. ND - Not Detected
 5. col/100ml - colonies per 100 milliliters
 6. MPN/100ml - most probable number per 100 milliliters
 7. mg/l - milligrams per liter
 8. NTU - nephelometric turbidity units
 9. SU - standard units
 10. umhos/cm - micro ohms per centimeter
- Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Bollinger Water Sample Analytical Results Summary

Parcel ID: 36-018-043-000 (321 White House Lane)
Well Location Map ID: WL-05222017-604-02

Parameter	Units	Sample Date: 5/22/2017	Sample Date: 10/25/2017	PA DEP Drinking Water MCL/SMCL
		Sample I.D.: 05222017-604-02	Sample I.D.: 10252017-613-01	
Coliform, fecal	col/100ml	NA	<1	-
E. Coli	MPN/100ml	NA	<1	-
Coliform, total	MPN/100ml	NA	<1	-
Dissolved Solids	mg/l	514	531	500
Suspended Solids	mg/l	2.70	ND	-
Hardness (colorimetric) as CaCO3	mg/l	285	280	-
Turbidity	NTU	0.111	0.321	-
Alkalinity	mg/l	148	152	-
pH	SU	7.25	7.42	-
Specific Conductance	umhos/cm	654	653	-
Bromide	mg/l	ND	ND	-
Chloride	mg/l	94.1	95.5	250
Sulfate	mg/l	16.2	15.0	250
Barium	mg/l	1.01	0.981	2
Calcium	mg/l	105	105	-
Iron	mg/l	ND	ND	0.3
Magnesium	mg/l	8.71	8.89	-
Manganese	mg/l	ND	ND	0.05
Potassium	mg/l	1.06	1.04	-
Sodium	mg/l	9.83	9.95	-
Methane	mg/l	ND	ND	-
Ethane	mg/l	ND	ND	-
Ethene	mg/l	ND	ND	-
Propane	mg/l	ND	ND	-
Benzene	mg/l	ND	ND	0.005
Toluene	mg/l	ND	ND	1
Ethylbenzene	mg/l	ND	ND	0.7
Total Xylenes	mg/l	ND	ND	10
Residual Bentonite	-	NA	NA	-

20-inch HDD construction dates: October 17, 2017 through December 20, 2017
 16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:

1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Stephey Water Sample Analytical Results Summary

Parcel ID: 36-018-044-000 (311 White House Lane)
Well Location Map ID: WL-05222017-604-01

Parameter	Units	Sample Date: 5/22/2017	Sample Date: 10/25/2017	Sample Date: 11/14/2017	PA DEP Drinking Water MCL/SMCL
		Sample I.D.: 05222017-604-01	Sample I.D.: 10252017-619-01	Sample I.D.: 11142017-612-02	
Coliform, fecal	col/100ml	NA	<1	<1	-
E. Coli	MPN/100ml	NA	<1	<1	-
Coliform, total	MPN/100ml	NA	6.30	<1	-
Dissolved Solids	mg/l	415	454	418	500
Suspended Solids	mg/l	4.40	ND	ND	-
Hardness (colorimetric) as CaCO3	mg/l	261	258	243	-
Turbidity	NTU	0.173	2.57	0.346	-
Alkalinity	mg/l	144	146	144	-
pH	SU	7.50	7.65	7.27	-
Specific Conductance	umhos/cm	591	583	611	-
Bromide	mg/l	ND	ND	ND	-
Chloride	mg/l	75.5	80.3	77.4	250
Sulfate	mg/l	16.2	15.1	15.2	250
Barium	mg/l	0.902	0.881	0.886	2
Calcium	mg/l	94.7	93.9	93.6	-
Iron	mg/l	ND	ND	ND	0.3
Magnesium	mg/l	8.86	8.87	8.82	-
Manganese	mg/l	ND	ND	ND	0.05
Potassium	mg/l	1.04	1.00	ND	-
Sodium	mg/l	9.35	9.06	8.77	-
Methane	mg/l	ND	ND	ND	-
Ethane	mg/l	ND	ND	ND	-
Ethene	mg/l	ND	ND	ND	-
Propane	mg/l	ND	ND	ND	-
Benzene	mg/l	ND	0.00101	ND	0.005
Toluene	mg/l	ND	ND	ND	1
Ethylbenzene	mg/l	ND	ND	ND	0.7
Total Xylenes	mg/l	ND	ND	ND	10
Residual Bentonite	-	NA	NA	ND	-

20-inch HDD construction dates: October 17, 2017 through December 20, 2017

16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:

1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL

Cramer Water Sample Analytical Results Summary

Parcel ID: 36-024-006 (1998 West Harrisburg Pike)
Well Location Map ID: 09082017-613-01

Parameter	Units	Sample Date: 9/8/2017	Sample Date: 10/25/2017	Sample Date: 11/01/2017	PA DEP Drinking Water MCL/SMCL
		Sample I.D.: 09082017-613-01	Sample I.D.: 10252017-628-01	Sample I.D.: 11012017-619-01	
Coliform, fecal	col/100ml	<1	<1	<1	-
E. Coli	MPN/100ml	<1	<1	<1	-
Coliform, total	MPN/100ml	1.00	517	76.7	-
Dissolved Solids	mg/l	463	482	483	500
Suspended Solids	mg/l	ND	ND	ND	-
Hardness (colorimetric) as CaCO3	mg/l	293	321	299	-
Turbidity	NTU	0.283	0.493	ND	-
Alkalinity	mg/l	241	255	255	-
pH	SU	6.95	6.93	7.07	-
Specific Conductance	umhos/cm	825	860	825	-
Bromide	mg/l	ND	ND	ND	-
Chloride	mg/l	98.2	107	94.8	250
Sulfate	mg/l	28.9	32.8	31.8	250
Barium	mg/l	0.172	0.179	0.184	2
Calcium	mg/l	99.0	106	103	-
Iron	mg/l	0.146	ND	ND	0.3
Magnesium	mg/l	13.4	14.0	13.9	-
Manganese	mg/l	ND	ND	ND	0.05
Potassium	mg/l	3.86	4.00	4.21	-
Sodium	mg/l	53.1	55.4	54.6	-
Methane	mg/l	ND	ND	ND	-
Ethane	mg/l	ND	ND	ND	-
Ethene	mg/l	ND	ND	ND	-
Propane	mg/l	ND	ND	ND	-
Benzene	mg/l	ND	ND	ND	0.005
Toluene	mg/l	ND	ND	ND	1
Ethylbenzene	mg/l	ND	ND	ND	0.7
Total Xylenes	mg/l	ND	ND	ND	10
Residual Bentonite	-	NA	NA	ND	-

20-inch HDD construction dates: October 17, 2017 through December 20, 2017

16-inch HDD construction dates: Awaiting PA DEP authorization to start

Notes:

1. MCL - Maximum Primary Contaminant Level
2. SMCL - Maximum Secondary Contaminant Level
3. NA - Not Analyzed
4. ND - Not Detected
5. col/100ml - colonies per 100 milliliters
6. MPN/100ml - most probable number per 100 milliliters
7. mg/l - milligrams per liter
8. NTU - nephelometric turbidity units
9. SU - standard units
10. umhos/cm - micro ohms per centimeter

Concentrations that are bolded exceed or are equivalent to their respective PA DEP MCL/SMCL