PENNEAST PIPELINE PROJECT

Susquehanna River Crossing

Alternatives Analysis

January 2018, Revised August 2019

Submitted by:

PennEast Pipeline Company, LLC

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Acronyms and Abbreviations

°F	degrees Fahrenheit
AMLIS	Abandoned Mine Lands Inventory System
BAMR	Bureau of Abandoned Mine Reclamation
BMP	best management practice
cfs	cubic feet per second
E&SCP	Erosion and Sediment Control Plan
EIS	Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
gpm	gallons per minute
HDD	horizontal directional drill
MP	milepost
NAVD	North American Vertical Datum
NRHP	National Register of Historic Places
PADEP	Pennsylvania Department of Environmental Protection
PennDOT	Pennsylvania Department of Transportation
PennEast	PennEast Pipeline Company, LLC
PHMC	Pennsylvania Historical and Museum Commission
Project	PennEast Pipeline Project
ROW	right of way
USACE	U.S. Army Corps of Engineers

1.0 Introduction

PennEast Pipeline Company, LLC (PennEast) prepared this Alternatives Analysis for the Susquehanna River Crossing to support the PennEast Pipeline Project's (Project's) U.S. Army Corps of Engineers (USACE) application for a Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (33. U.S.C. 1344) permit. This document is meant to supplement the Project-wide Alternatives Analysis for the Project, which includes the no action alternative, systems alternatives, and overall route and construction alternatives that were implemented to avoid and minimize potential impacts and risks, while satisfying the needs of the Project. The Project-wide Alternatives Analysis was provided to the USACE in February 2016, and an updated version was submitted in January 2017 to account for changes implemented in PennEast's September 2016 Route. Due to the complexity of the Project's proposed Susquehanna River crossing, PennEast prepared this Alternatives Analysis specific to the Susquehanna River crossing.

The Susquehanna River, located in the USACE Baltimore District, is a navigable water of the United States. PennEast proposes to cross the Susquehanna River through Wyoming Borough on the north side of the river and Jenkins Township to the south. The crossing location presented a challenge to the Project with its geologic setting and historic coal workings that occurred throughout the area. PennEast has investigated this regional geohazard, and has implemented field investigations and routing that support the design for construction and long-term operation of the Project. Justification for the proposed crossing location and crossing method are provided herein.

2.0 Geological Setting and Historical Mining

PennEast evaluated geological and historical mine maps near the proposed Susquehanna River crossing location to understand the underlying geology and evaluate potential risks associated with Project construction and operation. PennEast also consulted with the Pennsylvania Department of Environmental Protection Bureau of Abandoned Mine Reclamation (PADEP BAMR) to obtain additional maps, inspection reports, and information about related remediation projects. The information obtained through the desktop analysis and discussions with PADEP BAMR were then used to establish the methodology for physical geotechnical investigations, which were performed on both northern and southern banks of the Susquehanna River. The results of the data gathering and field investigations were ultimately used to determine the method that would be used to successfully construct the crossing.

PennEast is aware of the Knox Mine disaster of 1959 which occurred approximately 1 mile from the proposed crossing location, described in greater detail in Section 2.3 of this report.

2.1 Data Sources and PADEP Consultations

PennEast held discussions in February 2015, and March, April, May, June, and July 2016 with the PADEP BAMR. Project representatives visited the Department's office in Wilkes Barre on February 23, 2015 and April 28 and July 6, 2016.

During these visits, discussions were held with Mike Walsh and Bernard Walko of PADEP BAMR. Data obtained from the PADEP included historical underground mine working maps and records, as well as details of remedial projects carried out in the area post mine closure. In addition to the printed maps obtained from the PADEP BAMR, PennEast used the Pennsylvania Mine Map Atlas, an extensive catalog of maps maintained by the PADEP, to provide supplementary details. The data set is maintained by the Pennsylvania

State University, current to 2014. Along with mapping, colliery inspection reports were reviewed for additional details on mine shafts, working dates, and contextual information. Historical mine maps are provided for reference in Appendix A. The maps are layered such that the shallowest worked seam (closest to the River bottom) is shown. Figure 2.1 displays the stratigraphic relationship (layering) of the named coal seams and indicates zones where records indicate the coal was mined.

A site inspection was performed by Project representatives on several occasions to ground-truth recorded conditions from the map review. In addition, physical geotechnical boreholes were advanced on both the northern and southern banks of the Susquehanna River to verify and confirm the available mapped information. A discussion and summary of the drilling investigation are provided under Section 2.7.

2.2 Geological Setting

The Geologic Map of Pennsylvania names the bedrock beneath the Wyoming Valley as the Llewellyn Formation (Berg et al., 1980), which is described as typically gray, fine to coarse-grained sandstone, siltstone, shale, conglomerate, and numerous anthracite coal seams in repetitive sequences. This geological unit is of Pennsylvanian age, which is a subdivision of the Carboniferous period and represents the time period of approximately 323 to 298 million years ago.

On a macro scale, the bedrock beneath the Wyoming Valley forms a large syncline structure. The limbs of the syncline outcrop along the valley sides and the central beds are relatively flat. On a local scale, beds are deformed and faulted into complex structures. The anthracite coal, or "hard coal," present within the Susquehanna River valley is of high economic value due to its high purity and high calorific value. These coal recourses are formed by lithification and metamorphic conditions beyond those required to produce bituminous, or "soft" coals.

Above the bedrock formation, shallower surficial soils of the named Olean Till deposits from the Wisconsonian Glaciation exist below more recent alluvial deposits from the Susquehanna River.

Borings performed on the banks of the Susquehanna River generally confirmed the mapped conditions, including the presence of recent alluvial deposits, till, and consolidated bedrock. Although summarized in greater detail in Section 2.7, it was observed that bedrock was not encountered until 165 feet depth on the northern bank of the River, and 60 feet depth on the southern side of the River.

2.3 Historical Mining

Mining of anthracite coal in Pennsylvania began in the 1800s and was the first large-scale coal mining operation undertaken in the Americas. Anthracite was mined in several separate fields in northeastern Pennsylvania. The Project crosses the area known as the Northern Anthracite field. The mining operations in the Northern Anthracite field were divided into separately operated collieries, or coal mines. Where the Project crosses the Susquehanna River, the workings of two collieries are of relevance. The Westmoreland Colliery operated to the north of the river and the Penna No. 14 Colliery operated to the south and directly beneath the river. Unworked zones were left between the collieries to isolate the ventilation and drainage systems. These unworked zones formed barrier pillars which are approximately 125 feet thick. Through discussions with the PADEP BAMR, PennEast learned that these barrier pillars were sometimes worked thinner than records indicate, and they may have been breached by illegal mining.

In this region, underground mining was conducted through the traditional room and pillar method. Secondary mining was also a common method in these operations. Secondary mining (robbing) was a procedure that would extract the additional remaining coal from the support pillars once primary extraction was finished.

The primary phase of mining near the proposed river crossing was from the 1920's to 1950's. The termination of mining in the region can partially be attributed to the Knox Mine Disaster of 1959 in which twelve miners died. The disaster was caused when the roof of the River Slope Mine in the Pittston Seam collapsed, approximately one mile upriver of the proposed Project. In this disaster, an estimated 10 billion gallons of water from the Susquehanna River flooded the mine after the Knox Coal Company ignored a regulation that required a minimum roof thickness of 35 feet. The coal was mined to a roof thickness of approximately 6 feet, the roof failed, and the river broke through (U.S. Department of Interior, Jan. 1959).

The historical mine maps reviewed by the Project team confirmed that coal mines exist at the location where the proposed Project will cross the Susquehanna River; however, given the variability in the historical mining operations, the lack of certainty in historical mine maps, and the occurrence of the Knox Mine Disaster within the vicinity of the alignment, PennEast advanced two geotechnical boreholes to determine the depth of the nearest worked coal seam under the proposed pipeline. The geotechnical investigation results are further discussed in Section 2.7 below; however, in summary, in the upland area near the river banks, a vertical separation of approximately 55 feet was observed between the top of shallowest worked coal seam (the Hillman seam) and the proposed elevation of the trench bottom.

2.4 Coal Seams

In reviewing the historical mine maps, PennEast discovered that ten coal seams had been worked in the Westmoreland and Penna No. 14 Collieries near the proposed crossing location. This list of named coal seams, their elevation ranges, thicknesses, and approximate worked dates are presented in Table 2-1. The stratigraphy of the different veins, their depths with respect to the Susquehanna River, and determination of whether the veins were worked or untouched are provided as Figure 2-1. As indicated in notes for Table 2-1, known and recorded mining has occurred directly beneath the river at depths between 130 and 640 feet below the surface. South of the river, two coal seams, the Hillman and Diamond seams, were worked from the surface to depths of 70 and 120 feet, respectively; however, based on recorded mapping, neither of these two coal seams have been worked under the river. The uppermost worked seam directly beneath the river, the Pittston seam, is mapped to have been worked, at shallowest, 130 feet directly below the river bed at the proposed crossing location.

Table 2-1
Coal Seams in Close Proximity to the Proposed Susquehanna River Crossing

Coal Seam Name	Worked Depth Ranges	Typical Thickness[1]	Approximate Worked Dates	Notes
Hillman	Surface to 70 feet	8 feet	1910's to 1950's	Only present south of the river. Subcrop approximated to southern river bank. **Workings do not extend beneath the river.**
Diamond	Surface to 120 feet	5 feet	1910's to 1950's	
Top Checker	130 feet to 250 feet	5 feet	1900's to 1950's	

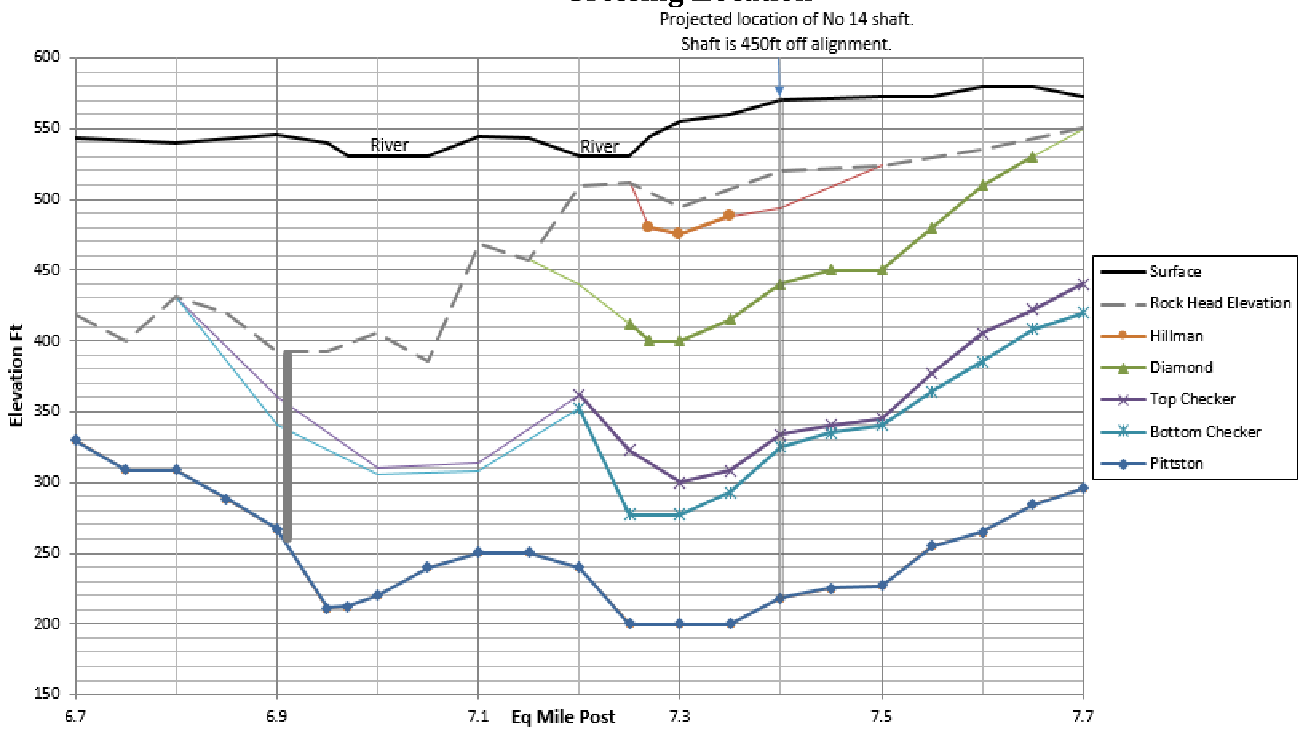
Coal Seam Name	Worked Depth Ranges	Typical Thickness[1]	Approximate Worked Dates	Notes
Bottom Checker	120 feet to 250 feet	5 feet	1900's to 1950's	Worked beneath the river by No. 14 Colliery. Not worked by Westmoreland colliery.
Pittston	280 feet to 350 feet	9 feet	1920's to 1960's	Extensively worked beneath river and by both collieries north and south of the river.
Marcy	320 feet to 410 feet	5 feet	1940's to 1960's	
Top Clark Top Ross	380 feet to 500 feet	5 feet	1940's to 1950's	Worked to limited extent beneath river and on both sides.
Bottom Clark Bottom Ross	404 feet to 500 feet	4 feet	1940's to 1950's	
Top Red Ash Babylon	540 feet to 640 feet	4 feet	1940's	
Bottom Red Ash	540 feet to 640 feet	6 feet	1930's to 1950's	

[1] Coal seam thickness is locally variable.

Coal seam stratigraphy and working history was interpreted from numerous historic maps obtained from the DEP *Pennsylvania Mine Map Atlas.* These maps included the following:

- Westmoreland Colliery Map - Pittston Vein (PADEP Map Code Geor_WBDO_095-0A-10-07)
- No14 Colliery Map - Hillman Vein (PADEP Map Code Geor_BMSA_4889-00)
- No14 Colliery Map (1" = 100' Scale) - Diamond Vein (PADEP Map Code Geor_BMSA_4889-004)
- Southern Division Area Map (1"=400' Scale) - Top Checker Vein (PADEP Map Code Geor_BMSA_6825-001) Southern Division Area Map (1"=400' Scale) - Bottom Checker Vei (PADEP Map Code Geor_BMSA_6824-001)
- Southern Division Area Map (1"=400' Scale) - Pittston Vein (PADEP Map Code Geor_BMSA_6816-001)
- Title Not Legible - Six Foot Vein (PADEP Map Code Geor_WBDO_095-17-10)
- Laflin Colliery - Ross Vein (PADEP Map Code Geor_BMSA_4904-003)
- Laflin Colliery - Ross Vein (PADEP Map Code Geor_BMSA_4947-005)
- Southern Division Area Map (1"=400' Scale) – Marcy Vein (PADEP Map Code Geor_BMSA_6823-001)
- Laflin Colliery - Bottom Red Ash Vein (PADEP Map Code Geor_BMSA_4904-009)
- Southern Division Area Map (1"=400' Scale) - Bottom Red Ash (PADEP Map Code Geor_BMSA_5085-007)
- Laflin Colliery - Three Foot Vein (PADEP Map Code BMSA_4947-002_B)
- DEP BMAR OSM_FOLIO_100_N-5C-00 through N-5C-10 and N-5C-XS
- DEP BMAR OSM_FOLIO_100_N-5B000 through N-5B-08 and N-5B-XS

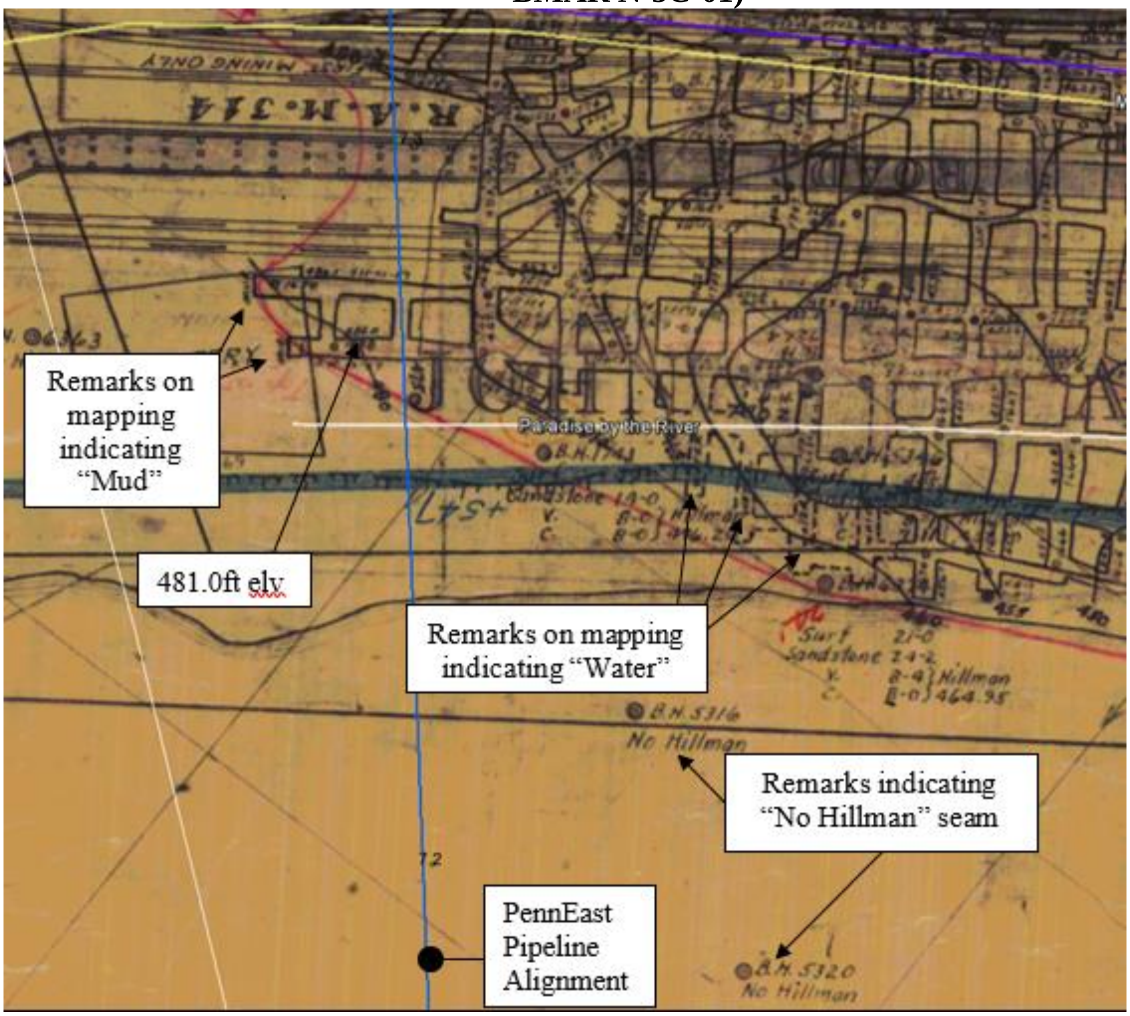
Figure 2-1
Approximate Depths of Coal Seams under the Proposed Susquehanna River Crossing Location



Based on records which indicated extensive mining occurred beneath the river at depths greater than 130 feet, PennEast determined that crossing the river via horizontal directional drill (HDD) method was not a suitable pipeline construction method for this crossing. As crossing via HDD was not deemed feasible, PennEast focused additional studies on the coal seams nearer the surface, namely the two shallowest Hillman and Diamond seams, to ensure trenching operations would not intersect the shallow underground workings.

The shallowest worked coal seam to the Susquehanna River is the Hillman Coal seam. The seam was worked at a depth of 60 feet (elevation 460) at the south bank of the river; however, the workings of this coal seam do not extend out under the river. When reviewing maps of the Hillman seam (PADEP BMAR Map reference DEP BMAR N-5C-01) a number of historic exploratory boreholes advanced indicate the absence of the Hillman seam at the proposed crossing location. In addition, remarks on historic mapping at the termination of the workings contained notations of "Mud" or "Water" at the southeastern banks of the river, indicating the workings ran into ground conditions making it infeasible or impossible to continue extraction under the River. An excerpt of the No. 14 Colliery Map of the Hillman Vein showing this notation is provided as Figure 2-2 for reference. Given these available data, it is likely that the seam is not present beneath the River at this specific crossing, and that the layer was eroded out by the natural geologic valley in the bedrock surface beneath the Susquehanna River.

Figure 2-2
Excerpt of Hillman Seam Notation (From PADEP BMAR Map reference DEP BMAR N-5C-01)



2.5 Mine Portals

PennEast also conducted a review of available historical resources to determine if any mine portals, or mine entry points, exist near the proposed crossing location. No portals were located within the proposed crossing alignment. The review revealed four portals within 1,500 feet of the proposed crossing location:

1. **No. 14 Shaft – Approximately 150 feet away from Pipeline Centerline at MP 7.5R2: (60 feet from workspace)**

   PennEast's discussions with PADEP BMAR and its document review indicate the No. 14 shaft was approximately 370 feet deep and was used to access the Pittston coal seam. The shaft contained six separate winching compartments and had a surface opening of approximately 12 feet by 50 feet (Map DEP BAMR N-5C-00 and N-5C-XS). No remediation or backfilling records were located during the document review.

   The shaft may have been backfilled during colliery closure or subsequent site grading operations, but no confirmatory documentation of backfilling was found. Discussions with the PADEP indicated that some shafts were capped off a few feet below the surface with timber boards upon which backfill was placed. PennEast's field inspection of the shaft location shows a mounded area with the relic shaft mouth visible in the center. The shaft area is overgrown with vegetation and appears to be filled with large boulders and timbers (See mine portal field inspection reports in Appendix B). Derelict concrete and iron work is visible on the railway side of the shaft mound. The original concept layout for PennEast's Pipeyard PE-A-04 overlapped with the No. 14 Shaft. However, through document review and recognition of this feature, PennEast has removed this wareyard from the workspace. The pipeline route was also adjusted to the north. The proposed pipeline remains at least 150 feet away from the location of this shaft, and the workspace maintains a distance of 60 feet away from this feature.

2. **No. 14 Air Shaft – Approximately 80 feet away from Pipeline Centerline at MP: 7.5R2 (within workspace)**

   This shaft was used to provide ventilation to the deep workings. A fan house sat atop the shaft, as marked on historic maps. The details of this shaft are not as well documented as the primary No. 14 shaft. The shaft dimensions are thought to be approximately 6 feet by 6 feet by scaling off historic maps, but no specific details were uncovered during PennEast's recent field investigation. There were no obvious surface features that would indicate the air shaft's location (see mine portal field inspection reports in Appendix B). It is possible that the extensive grading that occurred on this site in the 1990's filled in this shaft, or the air shaft may have been filled in decades prior by spoil generated from strip mining activities in the area. The mapped location of the No.14 air Shaft is within the proposed Project work space, but is approximately 80 feet from the proposed pipeline centerline.

3. **The Hillman Slope – Approximately 85 feet away from Pipeline Centerline at MP 7.5R2: (15 feet from workspace)**

   Mine slopes are inclined entrance ways, at an angle of approximately 45°. They present less of a severe hazard than vertical shafts/entranceways. During PennEast's recent field investigation, no signs of the Hillman Slope were observed (see mine portal field inspection reports in Appendix B).

It is possible that the entrance way was backfilled during more recent strip mining operations in the area, colliery closure, or site grading. The mapped location is approximately 85 feet from the proposed pipeline centerline and is outside of the proposed workspace boundaries.

4. **Red Ash Shaft – Approximately 600 feet away from Pipeline Centerline at MP 7.5R2**

The Red Ash Shaft is mapped to have contained two separate winching compartments and had a surface opening size of approximately 12 feet by 24 feet. The shaft is approximately 600 feet deep, which allowed access to the Red Ash coal seams, which are the deepest worked seams in this location. During PennEast's field investigation, surficial observations confirm the location of the mapped shaft entrance (see mine portal field inspection reports in Appendix B). No Project work is planned at the location of this shaft, and the pipeline remains a sufficient distance away to avoid influence from this feature.

2.6 Mapped Workings with Respect to the Project Alignment

The historic mine shafts which exist in close proximity to the proposed Susquehanna River crossing (No. 14 Shaft and Red Ash Shaft) are not intersected by the currently proposed Project alignment. At the specific crossing of the Susquehanna River, there is estimated to be over 60 feet of vertical clearance between the ground surface and previously worked coal seams. This vertical clearance is derived from review of PADEP map BAMR N-5-C-01 and comparison with ground surface elevation. The clearance is approximately 40 feet of soil and 20 feet of rock. This clearance distance provides considerable distance between trenching operations for the pipeline and intersection with historic workings.

2.7 Geotechnical Investigations

Two exploratory soil borings were performed adjacent to the Susquehanna River in August 2016 and January 2017. The following is a summary of the cross section at each location. The locations of the boreholes are shown on Figure 2-3; the boring logs and photos are provided in Appendix C.

Borehole B-RR-2

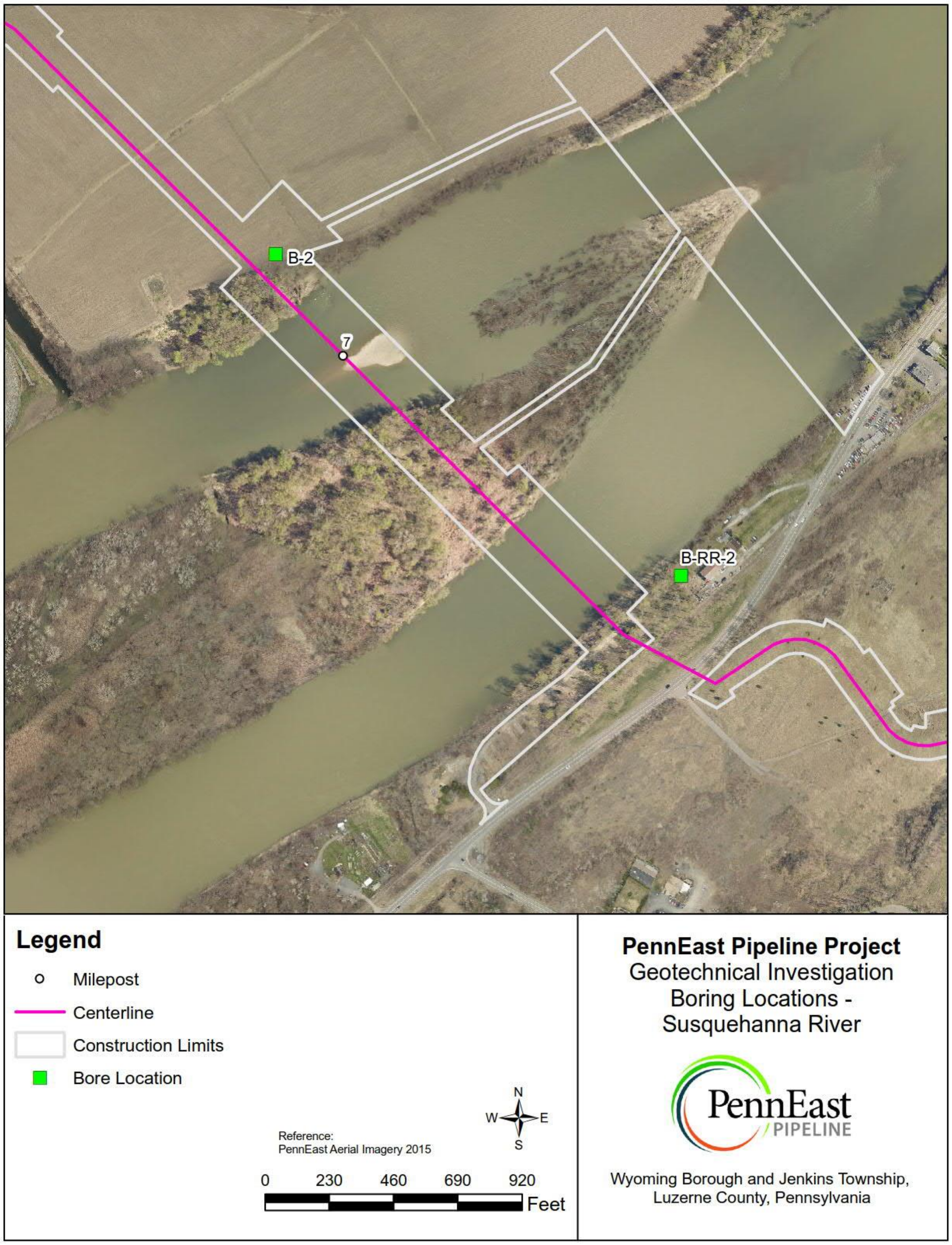
The geotechnical borehole (B-RR-2) was drilled on the south bank of the river between August 29th and 31st, 2016 to a depth of 150 feet. The objective of this investigation was to observe the ground conditions, specifically the rock head elevation and presence or absence of workable coal or former coal workings. Borehole B-RR-2 is located 115 feet away from the river's edge and approximately 300 feet northeast of the PennEast pipeline alignment. The surface elevation at the location is 554 feet, which is approximately 20 feet elevated above the river's average water surface elevation. A generalized profile is described below:

- Borehole B-RR-2 Profile
  - Depth: Ground level to 60 feet depth
    - Materials Encountered: Silts, clays and gravels. (river and glacial deposits)
  - Depth: 60 feet to 107 feet
    - Materials Encountered: Bedrock of interbedded shale, sandstone and quartzite.
  - Depth: 107 feet to 107.8 feet
    - Materials Encountered: 9-inch-thick layer of coal amongst some fractured slate.
  - Depth: 107.8 feet to 150 feet
    - Materials Encountered: Bedrock of interbedded shale, slate and quartzite.

<u>Borehole B-2</u>
On January 17th to 19th, 2017, a second boring (B-2) was drilled to a depth of 170 feet on the north bank of the river and approximately 90 feet from the PennEast pipeline alignment. The ground surface elevation is 548 feet, which is approximately 15 feet above the average river water surface elevation. A generalized profile is described below:

- <u>Borehole B-2</u>
    - Depth: Ground level to 165 feet depth
        - Materials Encountered: Silts, clays and gravels. (river and glacial deposits)
    - Depth: 166 to 170 feet
        - Materials Encountered: Bedrock of sandstone.

Figure 2-3
Geotechnical Investigation Boring Locations - Susquehanna River

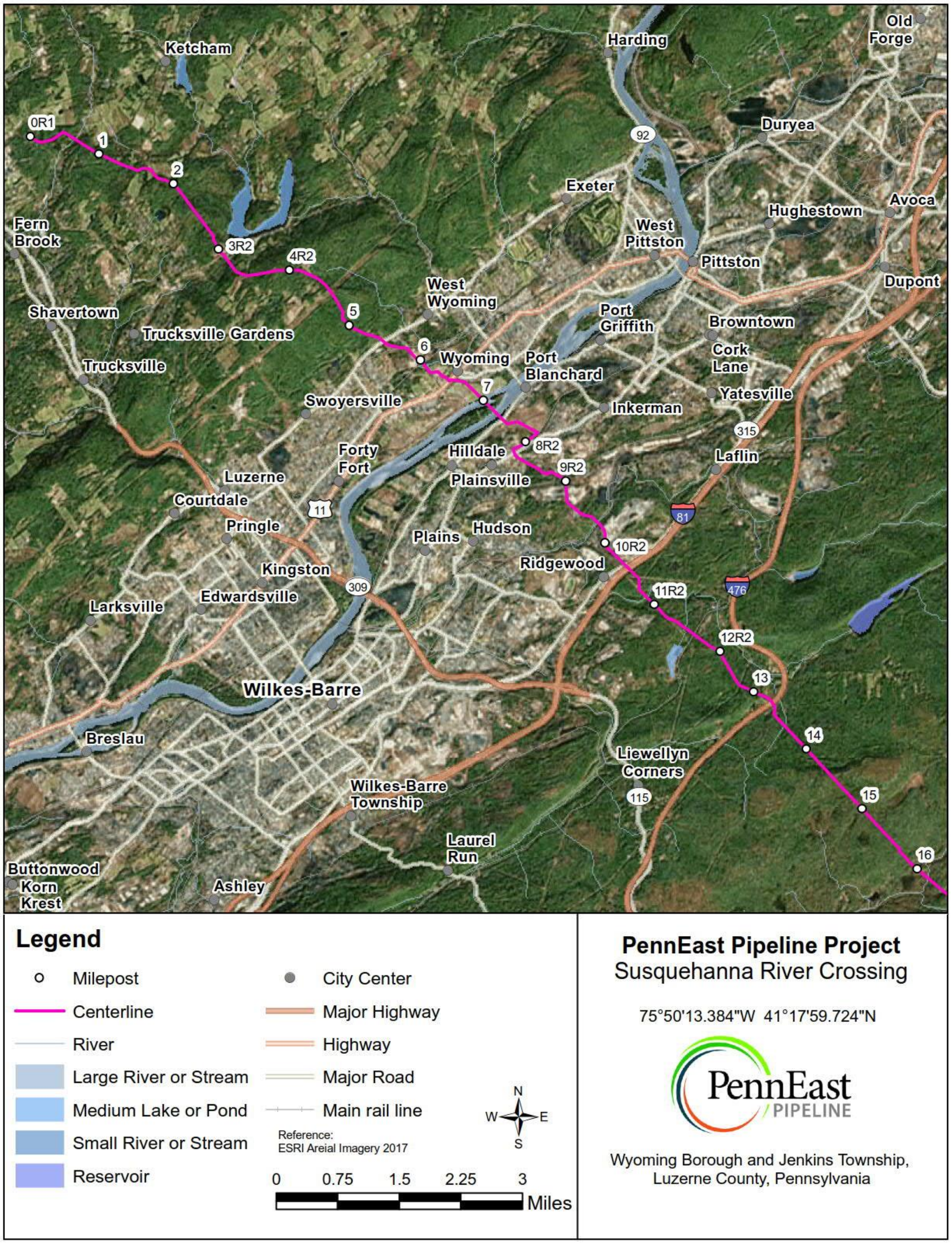


3.0 Crossing Location

As described in Section 1.7 of the Project-wide Alternatives Analysis that was provided to the USACE in February 2016 and updated in January 2017, PennEast evaluated several pipeline route alternatives that would meet the Project's purpose, would be constructible, and minimizes impacts to the environment and surrounding communities. PennEast carefully examined existing utility corridors (natural gas, liquid pipeline, electric transmission, water, and sewer) to identify potential areas where the proposed pipeline could parallel or be co-located within existing maintained right-of-ways (ROWs). Where environmental impacts were not greater, PennEast has aligned the Project with as many existing utility corridors as practicable, while ensuring a Project that can be safely constructed and operated. As stated in the Federal Energy Regulatory Commission's (FERC) Environmental Impact Statement (EIS), approximately 44.4 miles, or 37 percent, of the 120.2-mile-long pipeline route will be constructed adjacent to existing ROW (FERC, 2017).

The Susquehanna River crossing location presented a challenge due to the existing geologic setting and densely populated surroundings. The proposed crossing location was selected to maximize the use of open, previously-disturbed land and to avoid densely developed areas along the banks of the Susquehanna River. As shown in Figure 3.1, there is dense residential development northeast of the proposed crossing location, including the towns of Wyoming, Laflin, Port Griffith, and Pittston. Dense development to the southeast includes Swoyersville, Luzerne, Plain, Edwardsville, and Wilkes-Barre. The installation of the pipeline, further described in Section 4, will require significant workspace adjacent to the river to stage construction equipment and pipe. The proposed crossing location will allow PennEast to temporarily occupy open and agricultural land to complete the crossing, rather than disrupting residential or commercial areas. To find a similar crossing location with substantial workspace on both sides of the river that avoids dense development, the pipeline would need to be rerouted at least 13 river miles downstream of the proposed crossing location, which would result in a substantial increase in the Project length and increased environmental impacts.

Figure 3-1
Dense Development Surrounding the Proposed Crossing Location



Other nearby existing infrastructure and sensitive resources also influenced the siting of the proposed crossing location. The crossing location is bordered by the Wyoming Valley Levee System and the Wilkes-Barre Wyoming Valley Airport to the southwest, and the Wyoming Monument and the recently constructed Wyoming Bridge (8th Street Bridge) to the north.

3.1.1 The Wyoming Valley Levee System

The Wyoming Valley Levee System is a USACE Project that was constructed to provide flood protection to the region. It is designed to contain the flow from the 1 percent annual chance of flood, significantly reduces the risk of flood damages, and has prevented more than $7.5 billion in flood damages since 1968 (USACE and FEMA, 2014). The Luzerne County Flood Protection Agency and local residents voiced concern for the siting of the PennEast Project near the levee due to the potential risks of compromising the integrity of the flood control system. The Project has been sited approximately 1,000 feet upstream of the Kingston to Exeter Segment of the levee system, and construction will not have any impact on the levee. The levee system, which is comprised of several separate levees, continues approximately 9.5 miles downstream of the proposed crossing.

3.1.2 The Wilkes-Barre Wyoming Valley Airport

The Wilkes-Barre Wyoming Valley Airport is a small county-owned airport with one 3,375-foot asphalt runway and one 2,191-foot turf runway. It occupies 135 acres of land and is located north and east of the Wyoming Valley Levee System, approximate 1,200 feet southwest of the proposed Project.

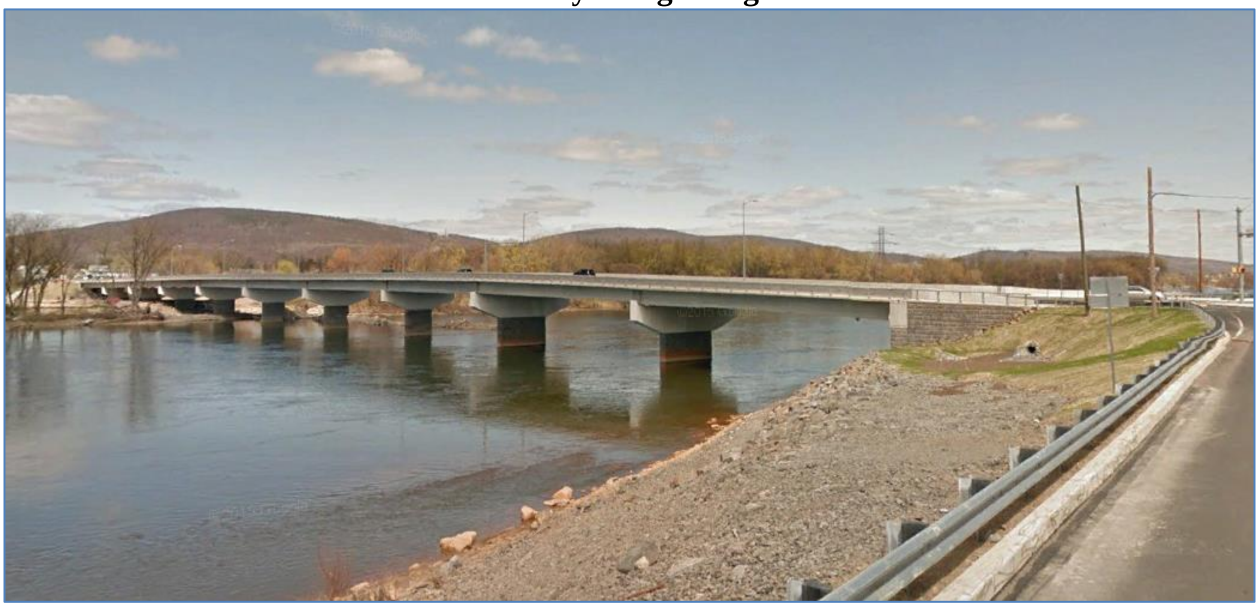
3.1.3 The Wyoming Monument

The Wyoming Monument is a National Register of Historic Places (NRHP)-listed resource that is located at the corner of Wyoming Avenue and Susquehanna Street in Wyoming Township. It is situated approximately 630-feet northeast of the proposed Project centerline. PennEast has developed a comprehensive plan for identifying historic properties within the proposed Project workspace, as well as within the line of sight of proposed aboveground facilities and areas where landscape alterations may occur. This plan has been developed in collaboration with the Pennsylvania Historical and Museum Commission (PHMC). Based on the current proposed route and associated features, PennEast and the PHMC do not anticipate any impacts to this historic property.

3.1.4 The Wyoming Bridge

The Wyoming Bridge, or 8th Street Bridge, crosses the Susquehanna River connecting Wyoming and Plains Townships. The Project was sited approximately 0.5 mile downstream of the bridge, avoiding the bridge abutments and densely populated residential areas of Wyoming Borough. In response to discussions held during interagency meetings, PennEast evaluated the possibility of attaching the pipeline to the 8th Street Bridge. There are a couple of factors that would prevent PennEast from adopting this alternative. The pipeline is 36-diameter and weighs approximately 285 pounds per foot. The size and weight of the pipeline makes hanging the pipeline not a practical solution. Based on the configuration of the bridge beams and foundation (see Figure 3-2), the pipe would likely need to be bolted to the side of the concrete bridge beams, making it the lowest member of the bridge and susceptible to damage from debris floating in the river. If the pipeline is the lowest member of the bridge structure, the pipeline could also restrict the floodway capacity under the bridge. In summary, burying pipelines and maintaining sufficient cover is an effective method of protecting the pipeline against potential external damage.

Figure 3-2
The Wyoming Bridge



Source – Google Earth Pro

4.0 Construction Methods and Feasibility

As part of the alternatives analysis for the Susquehanna River, PennEast has considered several construction methods to install the pipeline under the river. These fall into two primary categories – trenchless and conventional/open-cut. The Federal Department of Transportation requires a minimum of 48 inches of cover for crossing under inland bodies of water that are at least 100 feet wide, unless it is impracticable to comply with the requirements and additional protection is provided that is equivalent to the minimum required cover (49 CFR 195.248). Therefore, alternatives that would not result in at least 48 inches of cover were not considered.

4.1 Trenchless Crossings

Trenchless crossings are utilized to avoid or minimize the impacts to sensitive surface features. Many factors are considered and evaluated during design to determine the feasibility of the trenchless crossing and the associated risks. Some of the factors considered in design include, but are not limited to, subsurface conditions, site constraints, type of trenchless method, and product pipe stresses. PennEast has evaluated the following trenchless methods for the crossing of the Susquehanna River which include: HDD, Direct Pipe®, microtunneling, conventional boring (auger and guided). A description of each methodology and primary risk discussions are provided below.

4.1.1 Horizontal Directional Drilling

4.1.1.1 Process Description

The HDD method is a trenchless installation technique used to install pipelines beneath the ground surface, in areas where neither traditional open-cut excavations nor conventional bores are feasible due to sensitive resource areas or logistical reasons. This technique involves drilling a pilot bore, reaming the bore (with multiple passes) to a certain diameter, swabbing the bore to gauge the condition of the drilled bore, and pulling in a product pipe to complete the installation. Drilling fluids (consisting of water and bentonite) are pumped downhole during all phases of the installation process.

Controlling and managing the drilling fluid pressures is key to a successful HDD installation. When the soils encountered by an HDD installation provide sufficient strength to resist the required drilling fluid pressures, flow of drilling fluids occurs within the HDD bore created with the drilling tools. However, if the soils encountered by the HDD bore are not capable of providing sufficient strength to resist the required drilling fluid pressures, flow of drilling fluids within the HDD bore cannot be controlled or maintained, resulting in drilling fluid migration into the surrounding soils. These escaping fluids will continue to flow into the surrounding soil until the induced fluid pressure within the HDD bore is relieved. When these fluids reach the ground surface, the term "*inadvertent return*" is used to describe the ponding fluids.

Design of an HDD installation must consider the depth of cover beneath the critical feature, the entry and exit locations, the allowable bend radius, the anticipated geotechnical materials, and the setback distance from the critical feature. As such, HDD installations typically require longer installation lengths than other trenchless methods. This longer length increases the setback distance from the critical feature.

HDD installations are typically completed with entry angles between 10 and 15 degrees, and exit angles between 8 and 12 degrees. The bending radius is typically 1200 times the outer diameter (inches) of the product pipe. For a typical 36-inch pipeline, the bending radius would be 3,600 feet. Vertical curves are inherent to all HDD installations.

Workspace requirements include a launch/entry area of approximately 200 feet wide by 200 feet long to stage the necessary equipment. The exit area requires an approximate workspace area of 150 feet by 150 feet. The pipe string is staged on the opposite side of the HDD rig. A pipe staging area of 50 feet wide along the installation length is typically required to fully fabricate the pipe string. While multiple strings could be assembled, stopping during pullback operations to perform an intermediate weld increases risks to the pipe string.

4.1.1.2 Primary Risk Factors for an HDD Installation at the Proposed Susquehanna River Crossing Location

The primary site-specific risks associated with an HDD installation include the following:

Geotechnical Risks

Two borings were completed for the Susquehanna River Crossing, one on each side of the river. Based on these borings, the site-specific geotechnical risks include:

- Loose sands / Soft Clays
  - Presence of loose sand and soft clays at various depths on the northwest side of the river was encountered in Boring B-2.
  - These soils can present challenges associated with controlling and maintaining drilling fluid flow within the HDD bore during an installation, due to the low strength these soils offer to resist the required drilling fluid pressures. Fluid losses within these soils can be significant and will increase risks associated with an inadvertent return is significant.
- Open Graded Gravels
  - Extensive deposits of gravels and cobbles were noted on both sides of the river extending down to 60 and 34 feet on the southeast and northwest sides of the river, respectively. The gravels were noted to be open-grained and highly permeable.
  - HDD installations are designed to avoid soils or layers containing a high percentage of gravels and cobbles. Extensive deposits of open graded gravels, such as those present at the crossing location, present bore stability, steering, and drilling fluid management issues for an HDD installation. Fine gravel is not often able to self-support resulting in high raveling tendencies that may not allow for advancement and retraction of drilling equipment.
  - Cuttings removal and drilling fluid management presents a significant challenge where open graded gravels occur. To properly remove the cuttings and support the open bore, the drilling fluids must remain and flow within the bore without excessive loss to the surrounding formations. Open-graded deposits of gravel and cobble-sized clasts allow drilling fluids to easily escape into the surrounding formations. If drilling fluid returns cannot be maintained, then the produced cuttings cannot be removed from the bore increasing risks associated with stuck tooling and/or the product pipe. The excessive loss of drilling fluids into gravel deposits increase risks associated with inadvertent returns.
- Transition for soil to bedrock / bedrock to soil

- Beneath the river, the geotechnical conditions are anticipated to change from soil to bedrock as the bedrock surface appears to drop from an elevation above 500 feet on the east side of the river to below 400 feet on the west side of the river. Transition from soil to bedrock presents a challenge with the passage of downhole drilling assemblies through the soil and into the bedrock. Heavy reamer assemblies will tend to drop or down cut into the soil layer at the transition to bedrock resulting in formation of a ledge in the HDD bore. This ledge can impact the ability to advance reaming assemblies through the bore and an increased risk for pipe coating damage.

Historical Mining Operations

Historical records indicate underground coal mines extend fully beneath the Susquehanna River within the bedrock materials, the shallowest mine workings are on the southern bank of the river at a minimum depth of 60ft. Mine workings present significant challenges to HDD operations when encountered by drilling equipment. These include:

- Stress relief induced fracturing of the surrounding bedrock that potentially creates flow pathways for drilling fluid flow.
- Difficulty managing and controlling drilling fluid flow if preferential flow pathways are intersected by an HDD bore.
- Difficulty advancing drilling tools and the drill pipe through old mine workings. An unsupported drill pipe can result in twist off or buckling of drilling assemblies, resulting in loss of equipment downhole.
- Inability to maintain design alignment as pilot hole will follow mine network voids once breached.
- Inability to seal preferential flow pathways due to connectivity of mine workings.
- Potential for encountering and spreading contamination or contaminated groundwater arising from coal mine operations.
- Significant drilling fluid/water losses within mine workings resulting in the need for excessive water supply.
- Overall high risk of numerous drilling and pipeline integrity problems if voids are encountered due to historical mining activity and likelihood of encountering contaminated mine groundwater (AMD).

4.1.1.3 HDD Feasibility Summary

Due to the anticipated geotechnical and historical mining operations in the area, HDD methods are deemed to carry a very high risk of failure and are not recommended for the proposed crossing. The primary risks include drilling through gravels, soils with little resistance to drilling fluid pressures, transition zones between soil and bedrock, and historical mine works.

4.1.2 Direct Pipe® and Microtunneling

4.1.2.1 Process Description

The Direct Pipe® installation method is a trenchless installation technique used to install pipelines beneath the ground surface in areas where traditional open-cut excavations or other trenchless methods (HDD or conventional bore) are infeasible, due to sensitive resource areas or for logistical reasons. Microtunneling is similar to Direct Pipe with the exception that shafts are used to launch and retrieve the microtunneling bore machine. This introduces additional feasibility considerations which are discussed in further detail in Section 4.1.2.2.

The Direct Pipe and microtunneling techniques involve pushing a steel product pipeline with a microtunnel machine attached to the lead pipe from the entry location through to the exit location using a pipe thruster. The thruster is set up within a shallow shaft or on the ground surface at the entry location. As the microtunnel machine is pushed through the ground, the encountered geotechnical materials are consumed through the cutterhead of the machine and removed through installed pipe using a closed-loop, slurry system.

This process involves pumping water down to the front of the machine and pumping the water and cuttings mixture back up to the ground surface for processing. Bentonite is often added to the slurry system to help with processing and removal of the cuttings within the machine. The cutterhead at the front of the microtunnel machine excavates a larger bore diameter than that of the product pipe. Lubrication is pumped into this annular space to help reduce frictional forces acting on the pipe string. Water jets directed within the crushing chamber of the machine and cutterhead are often used to help process the encountered geotechnical materials within the crushing chamber, especially within cohesive soils.

Cutterheads, used to excavate the encountered geotechnical conditions, must be matched for the anticipated ground conditions along an alignment. Cutterheads used to excavate soils are not capable of excavating bedrock materials. Similarly, bedrock machines are not capable of excavating soil materials without great difficulty and high jacking forces. Mixed-face cutterheads, used to excavate soils containing some cobbles and/or boulders, do not work well within clayey soils or bedrock materials.

Direct Pipe allows for the direct installation of the pipeline along an alignment that resembles an HDD installation. Curves are routinely completed for Direct Pipe installations, with a curve radius slightly tighter to that used for HDD installations. Alignments are typically designed similar to the requirements for an HDD installation but at a much shallower depth, as no drilling fluid is used to convey the excavated material outside of the pipe string. Unlike HDD installations, a return line slurry pump, located within the microtunnel boring machine, pumps the cuttings out of the machine and to the ground surface.

As a result, the overlying soils are not required to resist high drilling fluid pressures as they are for an HDD installation. This allows for shallower installation depths with this construction method.

The Direct Pipe method does not have the ability to change out cutters during an installation without removing it from the ground. If cutters are worn out to the point they need to be replaced, the thruster is used to pull the entire installed pipe string and machine out of the excavated bore. As the machine and pipe string are retracted, a thick bentonite mixture (similar to the properties of the lubrication fluid) is pumped into the excavation to help support the surrounding soil. Once out of the ground, repairs can be made to the machine.

When ready, the machine and pipe string are then re-installed into the previously excavated bore. If any material falls into the bore during and following removal of the pipe string and machine, the machine excavates the material as it did previously. Too much ground loss can lead to excessive settlements where significant bore collapse occurs.

Direct Pipe operations are conducted from a launch pit with entry angles typically between 5 and 15 degrees. Curve criteria are similar to those used in HDD installations. For the proposed pipe diameter, the minimum design radius used to establish the alignment profile is anticipated to be 3,600 feet.

Workspace requirements include a launch/entry area of approximately 150 feet wide by 200 feet long, to stage the necessary equipment and to allow for construction of a shallow launch pit. The exit area requires a workspace area of approximately 50 feet by 100 feet and a large crane to retrieve the microtunnel boring machine. The pipe string is staged on the same side as the thruster/launch pit. A pipe staging area of 75 feet wide by at least half of the installation length is typically required to fabricate the pipe strings and to stage the required slurry and lubrication and pipe handling equipment. This length is in addition to the staging area required for the launch pit.

4.1.2.2 Direct Pipe and Microtunneling Primary Site-Specific Risk Factors

The primary site-specific risks associated with a Direct Pipe or Microtunnel installation include the following:

<u>Geotechnical Risks</u>

Two borings were completed for the Susquehanna River Crossing, one on each side of the river. Based on these borings, the site-specific geotechnical risks include:

- Open Graded Gravels
    - Extensive deposits of gravels and cobbles were noted on both sides of the river extending down to 60 and 34 feet on the southeast and northwest sides of the river, respectively. The gravels were noted to be open grained and highly permeable. The high percentage of gravels within the site soils present challenges with excessive machine wear and tooling damage. Excessive machine wear requires removal of the machine from the ground to make repairs. For Direct Pipe operations, the machine and pipe string can be pulled back out of the bore to address. Raveling and bore stability concerns similar to HDD methods would be anticipated as the soil is not capable of self-supporting leading to significant over excavation of the site soils. For microtunneling, pulling out of the bore is not possible resulting in the need for a rescue shaft construction vertically from the ground surface would be needed to retrieve the machine.
- Unconfined Compressive Strength
    - The unconfined compressive strength of the Quartzite bedrock has been tests at 21,000 psi. This strength exceeds the maximum strength of 20,000 psi as specified by the equipment manufacturers for this method. Attempting to complete a Direct Pipe in higher strength bedrock is not recommended.
- Transition for soil to bedrock / bedrock to soil
    - Beneath the river, the geotechnical conditions are anticipated to change from soil to bedrock as the bedrock surface appears to drop from an elevation above 500 feet on the east side of the river to below 400 feet on the west side of the river. Transition from soil to bedrock presents a challenge for Direct Pipe and microtunnel methods. The cutterhead at the front of the microtunnel boring machine must be matched for the anticipated ground conditions. Soil cutterheads do not work in bedrock and bedrock cutterheads do not work

in soils. For microtunnel, typically a shaft is located at the transition zone to prevent these issues. However, for the given project, this would require a shaft constructed in the river.

Product Pipe Diameter

The proposed product pipe has a diameter of 36 inches. This diameter is considered too small for personnel entry into the pipe string and machine to address issues and maintenance needs for a Susquehanna River crossing. Long installations as anticipated for the Susquehanna River crossing would require periodic surveying of the installed product pipe for line and grade accuracy. Again, a pipe diameter of 36 inches is not sufficient to allow for personnel entry into the pipe string.

Historical Mining Operations

Historical records indicate underground coal mines extend fully beneath the Susquehanna River within the bedrock materials, the shallowest mine workings are on the southern bank of the river at a minimum depth of 60ft. Mine workings present significant challenges to HDD operations when encountered by drilling equipment. These include:

- Stress relief induced fracturing of the surrounding bedrock that potentially creates flow pathways for lubrication and slurry fluid flow.
- Difficulty advancing machine and the product pipe through old mine workings. An unsupported pipe can result in buckling, resulting in loss of equipment and pipe downhole.
- Inability to seal preferential flow pathways due to connectivity of mine workings.
- Difficulty advancing microtunnel boring machine through old mine workings. Unsupported machine or product pipe can result in buckling or separation of the microtunnel boring machine from the product pipe resulting in a lost or stuck machine. Potential for encountering and spreading contamination or contaminated groundwater arising from coal mine operations.
- Overall high risk of numerous drilling and pipeline integrity problems if voids are encountered due to historical mining activity and likelihood of encountering contaminated mine groundwater (AMD).

4.1.2.3 Direct Pipe and Microtunneling Feasibility Summary

Due to the anticipated geotechnical and historical mining operations in the area, Direct Pipe and microtunneling methods are deemed to carry a very high risk of failure and are not recommended. The primary risks include encountering the transition zone between soil and bedrock, access to the pipe string and machine and historical mine works.

4.1.3 Conventional Boring

4.1.3.1 Process Description

Auger boring, often referred to as "jack and bore" or "conventional boring", involves jacking a casing pipe housing auger flights from a launch pit to a retrieval pit. A hydraulic unit located within the jacking pit thrusts the casing pipe forward as the auger flight is rotated to convey the encountered geotechnical material at the leading edge of the casing pipe back to launch pit. Once brought back to the launch pit, a muck bucket/excavator is used to remove the spoil. For soil installations, the leading auger flight is kept within the casing pipe. In bedrock installations, the cutting head leads the casing pipe.

The guided bore installation technique is a slight modification to the auger bore installation technique. It is identical to the auger bore installation methodology, with the addition of a new first step that involves pushing short five (5) foot sections of drill rods from the launch pit through the ground surface to the retrieval pit. The auger equipment is then attached to the installed drill rods and pushed through the ground to completion. The benefit of the guided bore method is that it eliminates the line and grade inaccuracy associated with an auger bore installation. In addition, no material is removed during this phase of the work. Instead, the soil is displaced outwards as the drill rods are advanced.

4.1.3.2 Conventional Boring Site-Specific Risk Factors

Auger and guided bore installations are typically limited installation lengths of 300 to 400 feet. The entire Susquehanna River crossing is approximately 1,560 feet wide, including the portion that crosses Monocanock Island. The river channel north of the island is approximately 540 feet wide, and the channel south of the island is approximately 460 feet wide. Based on this limitation alone, PennEast did not continue analysis of this trenchless crossing method.

4.1.3.3 Conventional Boring Feasibility Summary

Because the length of the proposed Susquehanna River crossing exceeds the capacity of the auger and guided bore technologies for the size of the PennEast Pipeline, this trenchless construction method was determined to be infeasible.

4.2 Open-Cut Crossing Methods

Upon determining that trenchless techniques were infeasible at the proposed Susquehanna River crossing location, PennEast explored several open-cut crossing methods including a wet open-cut crossing and variations of dry open-cut crossings.

4.2.1 Wet Open-Cut Crossing

4.2.1.1 Process Description

A wet open-cut installation technique does not use any method (dam, pump, flume, etc.) to divert the river flow during the pipeline installation. The pipe trench is excavated and backfilled using various means and methods, including but not limited to, excavation equipment working from pontoons in the flowing river channel or from shore with drag lines. Following excavation, prefabricated pipe strings are lowered into the ditch, fitted with any necessary buoyancy control, and covered with backfill. At the proposed river crossing location, backfilling would be accomplished from the center of the river, working toward the water’s edge. Following pipeline burial, the river would be stabilized using approved restoration methods.

4.2.1.2 Wet Open-Cut Primary Risk Factors

Primary risk factors for a wet open-cut crossing consist of performing the work with variable river conditions and excavating a trench while inundated with river water. Variable river conditions may lead to inefficiencies during excavation and installation of the pipeline which would lengthen the time of pipeline installation due to the potential equipment requirements and depths of river at the time of crossing. The volume of material that would be removed to establish a stable trench would require additional material management and handling. The river flow could cause material to be transported downstream and not recoverable for trench backfill and riverbed restoration. Additional risk factors are control and mitigation of short-term increased sedimentation downstream and inspecting trench and pipe laying prior to backfilling.

4.2.1.3 Wet Open-Cut Site Specific Feasibility

A wet open-cut crossing that necessitates excavating a trench without the use of diversion and/or cofferdams has been considered, but is likely not feasible based on several factors. Based on historical flow data of the river, river currents would move sediment into the trench, cause limited trench visibility, and result in short-term increased sedimentation downstream. Additionally, given the river bed material, a large volume trench excavation will be required for the side-slopes to be 4 horizontal on 1 vertical (4H:1V) or flatter for stable trench side slopes.

Wet open-cut crossings result in short-term sedimentation that can impact downstream aquatic life and their habitats. Typically, the effects are temporary, and benthic and fish communities recover within one year of the disturbance (Reid and Anderson, 1999). However, utilizing a dry, open-cut crossing technique can significantly reduce downstream turbidity and sedimentation (Reid et al., 2002). Therefore, PennEast evaluated dry crossing techniques to minimize impacts to aquatic life.

4.2.2 Dry Open-Cut Crossing

Dry open-cut crossing construction is composed of building temporary dams (i.e., diversion dams or cofferdams) to divert or block a portion of the river and allow dewatering of the river channel where the work will be performed. Temporary dams are necessary to create a dry working area within the river channel for trench excavation, pipeline installation, backfilling and riverbed restoration. This technique serves to reduce downstream river sedimentation potential and is therefore favored over wet open-cut crossing techniques.

Various types of cofferdams and have been considered for this application, and the type of cofferdam used will depend on the flow conditions at the time of construction. Crossing of the Susquehanna River includes installing a diversion dam upstream of the pipeline trench worksite at the tip of Monocanock Island. The division dam would be constructed to block off one of the river channels to divert flow into the opposite channel on the other side of the island. Two temporary coffer dam alternatives PennEast considered for this approach include a Portadam® style cofferdam and a steel sheet pile cofferdam. Once the river channel flow is diverted, a set of cofferdams would be installed at the edge of the worksite to isolate the construction workspace from river flow. An overview of the construction sequence is described below:

Stage 1 (North Channel):

1. Assess current weather conditions, weather forecast, and flows of north channel for crossing feasibility.
2. Acquire sign-off from Environmental inspector, Contractor, and PennEast representative prior to commencement of construction activities.

3. Construct Stage 1 Diversion Dam at the upstream tip of Monocanock Island in the northern channel. The diversion dam will reduce the river velocity, but the river channel will remain flooded between the diversion dam and the cofferdam.
4. Construct Stage 1 Cofferdams at the edge of workspace.
5. Excavate Stage 1 trench, install pipeline, and backfill.
6. Restore pre-construction contours to the extent practicable.
7. Remove Stage 1 Cofferdams.
8. Remove Stage 1 Diversion Dam.

Stage 2 (South Channel):

1. Assess current weather conditions, weather forecast, and flows of south channel for crossing feasibility.
2. Acquire sign-off from Environmental inspector, Contractor, and PennEast representative prior to commencement of construction activities.
3. Construct Stage 2 Diversion Dam at the upstream tip of Monocanock Island in the southern channel.
4. Construct Stage 2 Cofferdams at the edge of workspace.
5. Excavate Stage 2 trench, install pipeline in the dry, and backfill.
6. Excavate the trench on the island, install pipeline, tie-in weld on the island, and backfill.
7. Restore pre-construction contours to the extent practicable.
8. Remove Stage 2 Cofferdams.
9. Remove Stage 2 Diversion Dam.

4.2.2.1 Dry Open-Cut Primary Risk Factors

The primary construction risk factor for using a diversion dam and cofferdam approach for a dry open-cut crossing is the river water overtopping the diversion and cofferdams. River gage data is available from USGS Station 01536500-Susquehanna River at Wilkes-Barre, approximately 4.4 miles downstream from the Project site. The period of record available online is from April 1899 to the current year. The river gage data was reviewed. Water elevations and river flows were considered, including the period of historical low monthly flow conditions in the river. Low monthly flow conditions typically occur between July and September, which is when PennEast would propose crossing the river. If the river is flowing under low mean monthly flow conditions at the time of crossing, then the Portadam® option has a low risk of being overtopped in the deepest part of the river channels. However, if flow conditions are greater than the mean river flow, the Portadam® system has a risk of being overtopped by river water. In this case, PennEast would use a steel sheet pile wall diversion dam and cofferdam system. A typical construction sequence for a sheet pile cofferdam would be phased in two stages (north and south):

Stage 1(North Channel):

1. Assess current weather conditions, weather forecast, and flows of north channel for crossing feasibility.
2. Acquire sign-off from Environmental inspector, Contractor, and PennEast representative prior to commencement of construction activities.
3. Install Stage 1 temporary support piles.
4. Construct Stage 1 brace framework between support piles.

5. Set Stage 1 sheet piles within support piles.
6. Install Stage 1 sheet piles to proper embedment within riverbed.
7. Dewater Stage 1 cofferdam.
8. Excavate Stage 1 trench, install pipeline, and backfill.
9. Restore pre-construction contours and riverbed to the extent practicable.
10. Flood Stage 1 cofferdam, remove Stage 1 sheet piles, and then remove Stage 1 bracing.

Stage 2 (South Channel):

1. Assess current weather conditions, weather forecast, and flows of south channel for crossing feasibility.
2. Acquire sign-off from Environmental inspector, foreman, and PennEast representative prior to commencement of construction activities.
3. Install Stage 2 temporary support piles.
4. Construct Stage 2 brace framework between support piles.
5. Set Stage 2 sheet piles within support piles.
6. Install Stage 2 sheet piles to proper embedment within riverbed.
7. Dewater Stage 2 cofferdam.
8. Excavate the Stage 2 trench on the island, install pipeline, tie-in weld on the island, and backfill.
9. Restore pre-construction contours and riverbed to the extent practicable.
10. Flood Stage 2 cofferdam, remove Stage 2 sheet piles, and then remove Stage 2 bracing.

A technical memorandum that summarizes the results of the hydraulic evaluation is provided in Appendix D.

4.2.2.2 Dry Open-Cut Site-Specific Feasibility - Portadam® Cofferdam

Portadams® are freestanding cofferdams comprised of a rigid steel frame that rests directly on the channel bottom, overlain with an impermeable membrane, which is secured to the frame. The Portadam® approach includes minimal subsurface impact and shorter installation and breakdown times than other comparable cofferdam systems. Portadam® was considered for construction of the crossing with the use of diversion dams and worksite cofferdams. The maximum allowable retained water depth is approximately 10 to 12 feet. During the timeframe from July to September, the mean river flow is low enough such that the Portadam® will have a low risk of being overtopped during pipeline installation. However, if the weather outlook is projecting a severe weather event, then PennEast would plan to stabilize the riverbed at the trench worksite and remove equipment and the Portadam® system. This would allow the river to flow with no obstructions. The flexibility to set up and remove a Portadam® provides an advantage over a temporary steel sheet pile wall system that requires longer set up and take-down timeframes. If the river is not flowing in a low flow condition when PennEast is scheduled to install the pipeline, then the Portadam® system is more likely to be overtopped, and in that event a steel sheet pile cofferdam would be constructed as an alternative.

4.2.3 Dry Open-Cut Site-Specific Feasibility - Sheet Pile Cofferdam

Steel sheet piles are long structural sections with a vertical interlocking system that creates a continuous wall. Sheet pile walls are able to retain water by transferring pressure from the high side of the wall to the soil in front of the wall. The sheets could be designed support up to 15 feet water pressure, which could accommodate water levels higher than typical low flow conditions. A similar design had been utilized a short distance upstream in the Susquehanna River for the construction of the Wyoming Bridge piers, which proved to be an effective design. An overview of the Wyoming Bridge construction project is provided in Figure 4-1 below. Sheet pile cofferdam is a proven technology, but it would require mobilizing additional equipment and in-river work to install the cofferdam.

Figure 4-1
Sheet Pile Cofferdams Used to Construct the Wyoming Bridge

Source: www.BingMaps.com

5.0 Summary

PennEast evaluated route and construction method alternatives for the proposed Susquehanna River crossing. The route was selected to avoid extensive development, flood projects, and other critical infrastructure, and to maximize use of previously-disturbed land and open space. Due to historical mining operations and geotechnical conditions, a trenchless crossing was deemed to be infeasible at the proposed crossing location. A dry, open-cut crossing that utilizes diversion dams and cofferdams was determined to be the most practicable alternative, and has therefore been incorporated in the Project design. PennEast intends to construct the crossing during the summer, which is the low flow season. To minimize impacts further, PennEast will implement best management practices (BMPs) outlined in the Project Erosion and Sediment Control Plan (E&SCP) and FERC Plan and Procedures, as well as any additional, practicable recommendations provided by federal and state agencies.

6.0 References

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Appendix A – Historical Mine Maps

Appendix B – Mine Portal Field Inspection Reports

Appendix C – Boring Logs and Photographs

Appendix D – Hydraulic Evaluation