APPENDIX E

Lackawanna Cut-Off Restoration – Passenger Rail Study

DRAINAGE ANALYSIS

E.1 –Drainage Study

- E.1.a – Water Gap Station to Slateford Junction Corridor
- E.1.b – Slateford Junction to Delaware River Bridge Corridor

E.2 – Existing Drainage Plans

E.3 – Drainage Catalog

E.4 – Drainage Area Maps

E.5 – Drainage Capacity Calculations

APPENDIX E.1

DRAINAGE STUDY

E.1.A – WATER GAP TO SLATEFORD JUNCTION CORRIDOR

E.1.B – SLATEFORD JUNCTION TO DELAWARE RIVER BRIDGE CORRIDOR

APPENDIX E.1 – EXISTING DRAINAGE STUDY

List of Tables

Table 1 - Summary of Drainage Structures Between Water Gap Station and Slateford Junction 4
Table 2 - Major Drainage Structures Between Water Gap Station and Slateford Junction 4
Table 3 - Inadequate and/or Buried Drainage Structures Between Water Gap Station and Slateford Junction 5
Table 4 - Drainage Categories 6
Table 5 - Drainage Category Summary Between Water Gap Station and Slateford Junction 6
Table 6 - Summary of Drainage Structures Between Slateford Junction and the Delaware River Bridge . 7
Table 7 - Major Drainage Structures Between Slateford Junction and the Delaware River Bridge 8
Table 8 - Drainage Category Summary South of Slateford Junction 11

E.1.a: WATER GAP STATION TO SLATEFORD JUNCTION CORRIDOR

GENERAL DRAINAGE CONDITIONS

The railroad is aligned generally north to south between Water Gap Station and Slateford Junction and is mostly paralleled to the east by the Delaware River. The river receives all drainage passing through the railroad right-of-way, either through direct discharge to the river or by indirect connection via a drainage channel or waterway. Interstate 80 is located to the west of the railroad from Station 00+00 to Station 42+00 (Drainage Baseline), at which point the interstate crosses over the railroad and into New Jersey. From Station 42+00 to Slateford Junction at STA 202+00, the railroad is situated downslope of, and parallel to, SR 0611 (Main Street), located west of the railroad, with the Appalachian Mountains upslope of SR 0611 further to the west.

Drainage generally flows from west to east through the corridor, originating as sheet flow on the forested peaks of the Appalachian Mountains west of the railroad, and is conveyed beneath the railroad by cross pipes, culverts, and small bridges. The railroad crosses two perennial tributaries to the Delaware River between Water Gap Station and Slateford Junction - Cherry Creek at Station 19+75 (Drainage Baseline) and Caledonia Creek at Station 51+50. The topography west of the railroad is mostly flat north of Cherry Creek, with slopes generally less than 5%. North of Cherry Creek, the railroad is elevated above the surrounding ground, and runoff west of the railroad flows south overland toward Cherry Creek. No drainage structures cross the railroad north of Cherry Creek. Oak Street, east of the Interstate in Water Gap, acts as a drainage divide, with runoff north of Oak Street flowing overland toward Cherry Creek, and runoff south of Oak Street draining to cross pipes beneath the railroad.

South of Cherry Creek, the railroad begins to cut through the Delaware River valley and Appalachian Mountain range, with slopes exceeding 100% in some areas with rock cuts immediately adjacent to the railroad.

Cross pipes, bridges, and box culverts dispersed along the rail line between STA 25+50 and STA 202+00 (Drainage Baseline), near Slateford Junction, convey runoff from the west side of the tracks to the Delaware River on the east side of the tracks. Drainage from an area west of the railroad, extending from STA 42+00 to STA 47+50, sheet flows over the railroad and into the Delaware River. From STA 25+50 to STA 202+00, the railroad is bounded to the west by steep terrain and the embankment for SR 0611, which winds along the mountain slope west of the railroad. In several locations, runoff is conveyed by drainage structures beneath SR 0611 and discharges directly toward the railroad.

A general summary of the materials, pipe diameter, and size of the drainage structures observed within the corridor from Water Gap Station to Slateford Junction, by the number of pipes encountered, is provided in the table below.

Table 1 - Summary of Drainage Structures Between Water Gap Station and Slateford Junction

Pipe Materials	Number	Pipe Diameter	Number	Large Structures	Number
Clay	1	≤ 24 inches	18	Bridge	1
Concrete	1	24 to 36 inches	1	Concrete Box	3
Cast Iron	13	>= 36 inches	2	Masonry Box	0
Metal	4	Unknown	1	Concrete Arch	0
Plastic	0				
Unknown	1				

Most drainage features through the corridor convey runoff from drainage areas of approximately 40 acres or smaller. However, several pipes and structures convey runoff from drainage areas larger than 50 acres and were considered major drainage structures for this analysis. These are outlined in the table below.

Table 2 - Major Drainage Structures Between Water Gap Station and Slateford Junction

Major Drainage Structure	Station*	Structure Size (ft)	Drainage Area (acres)
Box 3	80+80	5.5 (span) x 4 (rise)	209
Pipe 18	169+10	1	77
Bridge 1	176+75	16 (span) x 6 (rise)	111

**Station refers to the Drainage Baseline. See APPENDIX E.4 for a Drainage Area Map.*

DRAINAGE CAPACITY

A cursory analysis was completed to determine if the drainage structures conceptually have capacity to convey the runoff to each feature. For this analysis, larger structures such as bridges were not evaluated. Each drainage structure was divided into one of three groups based on the size of their drainage area. The time of concentration and runoff coefficient were determined for one representative drainage area within each group, based on the steep topography and densely forested terrain within each drainage area. The 2-year and 10-year flows to each of these representative drainage areas were calculated via the Rational Method, and a ratio of the flows to the drainage area size was determined. These ratios were applied to the other structures and drainage areas within each drainage group to determine flows for the other structures. The flows were compared to the capacity of each pipe or other drainage feature to determine which pipes could convey the theoretical 2-year and 10-year flows. Individual pipe capacities were analyzed based on the pipe material, diameter, and an assumed slope of 4%. The capacity analysis determined that just one pipe (Pipe 18, Station 169+10 on the Drainage Baseline) out of the twenty pipes and three box culverts analyzed between Water Gap Station and Slateford Junction does not have the capacity to convey the 10-year discharge (approximately 4% of the system is under capacity). See APPENDIX E.5 for the Drainage Capacity Calculations.

PRIMARY DRAINAGE ISSUES

The primary issue diminishing the functionality of the drainage system north of Slateford Junction is the partial blocking or complete burying of pipes with sediment, stone, and debris

(see the Drainage Catalog in APPENDIX E.3). Pipe 18 (Station 169+10 on the Drainage Baseline) is a good example of common conditions affecting pipes between Water Gap Station and Slateford Junction. The topography suggests that the pipe should convey drainage from about 77 acres of the watershed, but the upstream end of the pipe could not be located in the field and is assumed to be buried or overgrown and blocked by grass and weeds.

Another common drainage problem north of Slateford Junction is the instability of the downstream channels receiving drainage from the existing pipes. In many cases, the channel cross section geometry is poorly defined, filled with sediment, heavily eroded, or overgrown with vegetation, diminishing the capacity of the channel to move water away from the drainage infrastructure, potentially impeding the performance of the infrastructure. For example, the concrete outlet of Box 2 at STA 71+90 is heavily eroded and the gravel railroad embankment above the outlet has partially collapsed into the downstream channel.

Significant ponding was observed between the railroad and the SR 0611 embankment in several locations. The lack of an observed functional cross pipe at these low points is a deficiency in the existing drainage system which allows the formation of relatively large pools of standing water during and after storm events which could eventually impact the stability of the railroad. See the Drainage Catalog in APPENDIX E.3 for the locations, dimensions, and photographs of the observed ponding areas.

At several points along the railroad, the existing topography suggests a cross pipe should be present to convey drainage beneath the railroad and into the Delaware River, but a pipe was not located during the field inspection. Without a cross pipe present, runoff draining to these points either infiltrates into the railroad ballast or ponds above the natural ground until it crosses the railroad and is able to discharge to the river.

Table 3 - Inadequate and/or Buried Drainage Structures Between Water Gap Station and Slateford Junction

STA*	Crossing Feature	Anticipated Drainage Area (acres)
121+25	Railroad	9
145+00	Railroad	22
147+50	Railroad	17
150+10	SR 0611	7
151+75	Railroad	41

** Station refers to the Drainage Baseline*

DRAINAGE CATEGORY

Each pipe or drainage structure was assigned a Drainage Category from 1 to 4, based on the extent of repairs required to restore the full drainage function. Category 1 is the lowest level, with the categorization increasing with need and extent of repairs required, with Category 4 structures requiring the most effort to restore drainage function. See Table 5 below (next page) for a more detailed description of each category. Refer to APPENDIX E.3 for the Drainage Catalog.

Table 4 - Drainage Categories

Category 1	• No action required; drainage infrastructure is functioning without notable issues
Category 2	• Small pipes (≤ 24" diameter) requiring limited structure cleaning or channel cleaning/reshaping to restore drainage function
Category 3	• Small pipes (≤ 24" diameter) requiring significant structure cleaning or channel cleaning/reshaping to restore drainage function • Large pipes (>24" diameter) or structures requiring limited structure cleaning or channel cleaning/reshaping to restore drainage function • Fully buried pipes or structures requiring significant excavation to restore drainage function • Pipes that potentially do not provide capacity to convey the 10-year flow, and should be replaced with a pipe offering more conveyance capacity
Category 4	• Pipes or structures of any size, damaged or significantly impeded by physical features, beyond repair and requiring replacement to restore drainage function • Pipes or structures of any kind that pose a risk to nearby infrastructure

In the Water Gap to Slateford Junction Corridor, only one (1) pipe was identified as a Category 4 (Box 2, at Sta 71+90). Fourteen (14) drainage structures were identified as Category 3 drainage structures. A summary of drainage structure categorizations per field views is included in Table 6 below.

Table 5 - Drainage Category Summary Between Water Gap Station and Slateford Junction

Drainage Category	Number of Drainage Structures
Category 1	2
Category 2	7
Category 3	14
Category 4	1

Station Refers to the Drainage Baseline

PROPOSED DRAINAGE IMPROVEMENTS

Category 4 pipes either are damaged beyond repair or inhibited from functioning by physical feature. Some also present a potential risk to nearby infrastructure. The replacement of these pipes would increase the efficiency of the drainage network and reduce the potential for ponding, erosion, and destabilization of the rail bed. Several Category 3 pipes require only cleaning or downstream channel grading to provide capacity to convey the 10-year flow. However, the replacement of Category 3 pipes that do not provide capacity to convey the 10-year flow, or are completely buried, would further improve the ability of the drainage network to remove stormwater runoff from the site. Assuming the replacement of half the Category 3 pipes is a conservative estimate of the required drainage work. See APPENDIX E.3 for the Drainage Catalog.

E.1.b. - SLATEFORD JUNCTION TO DELAWARE RIVER BRIDGE CORRIDOR

GENERAL DRAINAGE CONDITIONS

As with the portion of the railroad corridor extending from Water Gap Station to Slateford Junction, the portion of the corridor from Slateford Junction to the Delaware River Bridge extends generally from north to south and is paralleled to the east by the Delaware River. The Delaware River receives all drainage conveyed through the railroad right-of-way, with runoff originating on the forested slopes of the Appalachian Mountains to the west of the abandoned section of track. Along its way from the mountains to the river, runoff crosses SR 0611 and then Slateford Road before reaching the active freight line, either as sheet flow or as concentrated flow conveyed by drainage structures. The railroad crosses one perennial tributary to the Delaware River, Slateford Creek, at STA 205+75 (Drainage Baseline). From Slateford Creek to the Delaware River Bridge, the active freight line traverses a mostly flat, residential area with slopes generally less than 5% adjacent to the tracks, downslope of SR 0611 and the steeper mountainsides further to the west.

A general summary of the materials, pipe diameter, and size of the drainage structures observed within the corridor, by the number of pipes encountered, is provided in Table 7 below.

Table 6 - Summary of Drainage Structures Between Slateford Junction and the Delaware River Bridge

Pipe Materials	Number	Pipe Diameter	Number	Large Structures	Number
Clay	0	≤ 24 inches	9	Bridge	1
Concrete	2	24 to 36 inches	1	Concrete Box	0
Cast Iron	5	>= 36 inches	1	Masonry Box	1
Metal	2	Unknown	0	Concrete Arch	2
Plastic	1				
Unknown	0				

Most drainage features through the corridor convey runoff from drainage areas of approximately 40 acres or smaller. However, several pipes and structures convey runoff from drainage areas larger than 50 acres and were considered major drainage structures for this analysis.

Table 7 - Major Drainage Structures Between Slateford Junction and the Delaware River Bridge

Major Drainage Structure	Station	Structure Size (ft)	Drainage Area (acres)
Bridge 2	205+70	15 (span) x 10 (rise)	1,919
Pipe 21	222+50	1.5	59
Box 4	235+75	2.8 (span) x 3.5 (rise)	273
Arch 1	238+00	4 (span) x 3 (rise)	242

Station refers to the Drainage Baseline. See APPENDIX E.4 for a Drainage Area Map.

To support the drainage assessment in this section of the project near Slateford, officials from Upper Mount Bethel Township were contacted for information related to known drainage problems, in or around Slateford. Township Manager Richard Fisher indicated that drainage patterns from Slateford Junction to the Village of Portland were studied approximately three years ago (2016) as part of an effort by Upper Mount Bethel Township and Northampton County to extend an existing bicycle trail through the area. Mr. Fisher stated that thirteen cross pipes and three streams were found in the vicinity of the railroad within the studied area. He did not indicate that any of these drainage features presented chronic or notable drainage problems. During the field work conducted on April 11th and 12th and on May 9th of 2019, each drainage feature located within the railroad right-of-way was observed and its conditions documented in the Drainage Catalog (APPENDIX E.3) with an assessment of its inlet and outlet condition and photographs of each opening and the upstream and downstream channels, wherever possible.

DRAINAGE FOR ACTIVE FREIGHT LINE

Slateford Road intersects SR 0611 near STA 201+00 of the Drainage Baseline and parallels the active freight line to the west of the tracks all the way to the southern project limits. The active freight line is carried over Slateford Creek at STA 205+75 by a two-span concrete bridge, immediately downstream of a bridge carrying Slateford Road over Slateford Creek. Runoff from STA 202+00 to STA 212+50 generally flows overland to Slateford Creek. Cross pipes connected to the drainage system along Slateford Road convey runoff from STA 212+50 to STA 229+00 to a single cross pipe at station 222+50, which crosses beneath the active freight line and discharges to the Delaware River. From STA 229+00 to the southern project limit, runoff either sheet flows off Slateford Road toward the Delaware River or is conveyed by a swale on the eastern shoulder of Slateford Road into a stone masonry box that crosses beneath the active freight line at STA 235+75 and discharges to the Delaware River.

DRAINAGE FOR ABANDONED RAIL LINE

At Slateford Junction, the rail line formerly spilt into two lines, with the active freight line continuing south along the river and a presently abandoned, deteriorated line located further to the west between Slateford Road and the toe of SR 0611 embankment. The abandoned line extends approximately 4,600 feet south of the junction, before turning east and crossing over the active freight line and the Delaware River. This former line is covered by fill at the intersection of Slateford Road and SR 0611. A short length of abandoned track remains visible between the Slateford Junction Switch Tower at STA 195+00 (Drainage Baseline) and the Slateford Road/SR 0611 intersection. Most of the area between the Slateford Road/SR 0611 intersection and the Slateford Creek drains overland toward the creek. However, a localized low point in the terrain, south of the intersection drains to the north of the intersection via an 18-inch corrugated metal pipe. The drain pipe was found protruding from the roadway embankment on the south side of

Slateford Road, near the bend in Slateford Road, but the downstream end of the pipe was not located as part of the drainage field work.

Remnants of the abandoned railroad can be found sporadically dispersed along the length of the line between Slateford Road and the Delaware River Bridge, near the toe of the SR 0611 embankment. The area is heavily overgrown by brush and trees. From STA 201+00 to STA 238+00 (Drainage Baseline), cross pipes convey runoff from SR 0611 beneath the abandoned line and discharge it freely to an irregular, somewhat haphazard drainage collection systems east of the abandoned rail line.

A swale runs along the western shoulder of the abandoned rail line downslope of SR 0611. Concrete inlet boxes with missing grates, receive drainage from cross pipes under SR 0611 and convey it to drainage pipes under the abandoned rail line. At most locations where a pipe was found protruding from the east side of the railroad embankment, a corresponding inlet box was discovered between the abandoned rail line and SR 0611. In areas where an inlet was not discovered between the rail line and SR 0611, it was assumed that the inlet was fully buried. These inlets act as junctions between the cross pipes beneath SR 0611 and the cross pipes beneath the abandoned rail line.

At STA 238+00 (Drainage Baseline), a 4-foot wide by tall 3-foot concrete arch conveys flow beneath the abandoned rail line and into a channel downstream of the abandoned rail. Flow in the channel is conveyed beneath Slateford Road in a 24-inch wide by 32-inch tall concrete box culvert. A swale extending from STA 239+00 to STA 244+00 along the western side of the abandoned rail line receives runoff from SR 0611 via a 48” smooth-lined plastic pipe and conveys the runoff to a 54” wide by 37” tall concrete box culvert beneath Slateford Road, south of the Delaware River Bridge

DRAINAGE CAPACITY

As with the portion of the railroad corridor extending from Water Gap Station to Slateford Junction, the conveyance capacity of existing drainage structures located along the portion of the corridor from Slateford Junction to the Delaware River Bridge within the railroad right-of-way was evaluated. The capacity analysis determined that just one pipe (Pipe 21 at Station 22+50 on the Drainage Baseline) between Slateford Junction and the Delaware River Bridge does not have the capacity to convey the 10-year discharge. See APPENDIX E.5 for the Drainage Capacity Calculations and the Drainage Capacity Section of Section E.1.a of this report for a description of the hydrologic methodology used to determine approximate flows to each drainage structure and the process used to evaluate the drainage capacity.

PRIMARY DRAINAGE ISSUES-ACTIVE FREIGHT LINE

The primary drainage issue impeding effective drainage along the active freight line south of Slateford Junction is that most of the area south of Slateford Creek and west of Slateford Road, between STA 212+50 and STA 229+00 (Drainage Baseline), drains to a swale west of the active freight line. A pipe located at STA 222+50 conveys drainage from the swale directly to the Delaware River. The swale is shallow and flat with limited conveyance capacity. This has resulted in either portions of the channel that are poorly drained or are incapable of fully draining. To improve drainage in this swale, the swale should be regraded to provide positive drainage, from both directions, toward the upstream opening of the pipe at STA 222+50. Refer to APPENDIX E.3 – Drainage Catalog, for photographs of the poorly-drained swale.

One of the most significant drainage problems observed within the southern corridor occurs at the Delaware River Bridge. Pipes 22, 23, and 24, are three parallel, 24-inch, cast iron pipes near the west bank of the Delaware River which discharge water directly toward a pier of the bridge carrying the abandoned rail line over the Delaware River. The alignment of these pipes and their configuration is creating bank stability problems and significant channel erosion near the existing bridge pier. Consideration should be given to relocating these pipes to cross the active freight line about 125 feet further to the south, with a new outlet channel to the river, directing their discharge away from the bridge pier and reducing the potential for scour at the pier. To maintain the upstream drainage connection, a new channel could conceivably be constructed between the active rail line and Slateford Road from the outlet of the Slateford Road box culvert to the relocated pipes. For an alternative to constructing a new channel between Slateford road and the railroad, the Slateford Road box culvert, upstream of the pipes, could be relocated to cross Slateford Road further to the south, aligning the box culvert with the relocated pipes, with the channel upstream of the box culvert extended to culvert to maintain the connection to the upstream watershed. Refer to APPENDIX E.3 – Drainage Catalog, for photographs of Pipes 22, 23, and 24.

The field inspection also identified a location at the toe of the eastern embankment of the active freight line near STA 229+00 (Drainage Baseline) where the embankment was destabilized, possibly by surface drainage adjacent to the tracks. A residential driveway downslope of the embankment, and to the north of the problem area, was also partially eroded by surface drainage as the flow cut a gully in the yard to the north of the embankment where the runoff flowed downslope to the river. This erosion potentially occurred due to insufficient drainage between Slateford Road and the active freight line between STA 226+50 and STA 232+00 with blocked or poorly functioning drainage on Slateford Road possibly contributing to the problem. Irregular topography outside the railroad right-of-way may further add to the drainage problems in this area, by not providing a clear drainage path either to the existing swale running south along the eastern shoulder of Slateford Road between Station 233+00 and 235+50 or to the drainage swale west of the active freight line between STA 213+00 to STA 229+00. The pipe capacity analysis indicates that Pipe 21, at STA 222+50, which drains the swale west of the active freight line, has insufficient capacity to convey drainage flowing to it during the 10-year event. Therefore, to improve the drainage in this area Pipe 21 should be replaced with a pipe offering greater capacity, or a new drainage channel should be constructed along the western side of the active freight line, draining to the south from STA 229+00 and directing surface runoff to the channel crossing beneath the active freight line at STA 235+50. Note that one new cross pipe would be needed to implement this solution, to provide a crossing for the access road near STA 231+50 for the road leading to properties located east of the active freight line and along the river.

PRIMARY DRAINAGE ISSUES-ABANDONED LINE

The primary drainage issue along the abandoned section of the line is the blockage of the inlets and swale to the west of the abandoned line, downslope from SR 0611. These inlets provide a connection between the drainage system on SR 0611 to the west of the abandoned rail line and the drainage system along Slateford Road to the east of the abandoned line. Additionally, the irregular topography of the ground adjacent to the railbed lacks a defined drainage pathway connecting the above ground drainage features to the underground drainage infrastructure, allowing ponding to occur along the western shoulder of the abandoned line.

Near the southern end of the abandoned line there are several larger drainage structures that convey runoff to the river. Although there are no known significant problems in this area with these structures any widening of the abandoned railroad embankment or realignment of the abandoned rail line should carefully consider the changes in topography on the function of the existing drainage.

DRAINAGE CATEGORY

Each pipe or drainage structure was assigned a Drainage Category from 1 to 4, based on the extent of repairs required to restore the full drainage function. Category 1 is the lowest level, with the categorization increasing with need and extent of repairs required, with Category 4 structures requiring the most effort to restore drainage function. At the southern end of the study area there are three drainage structures identified as Category 4 (Pipes 22, 23 and 24 at STA 244+00) drainage structures. These three pipes basically function as a single drainage structure and were previously discussed in the drainage issues section. Six drainage structures were identified as Category 3 drainage structures, 2 on the Active Line and 4 on the Abandoned Line. Whereas, only a cursory drainage analysis was completed for this assessment, each of these drainage structures should be surveyed and studied using detailed hydrologic and hydraulic methods to determine, if the drainage infrastructure truly requires rehabilitation or replacement. See the Drainage Categories Section in Section E.1.a for a description of the drainage categories and refer to APPENDIX E.3 for the Drainage Catalog.

Table 8 - Drainage Category Summary South of Slateford Junction

Drainage Category	Number of Drainage Structures	
	Active Freight Line	Abandoned Line
Category 1	1	2
Category 2	0	2
Category 3	2	4
Category 4	3	0

PROPOSED DRAINAGE IMPROVEMENTS AND PERMITTING

As with the corridor extending from Water Gap Station to the Slateford Junction, the replacement of all pipes classified in Category 4 is recommended. Due to the varied extent of repairs required for pipes classified in Category 3, and the potential that some pipes which are fully or partially buried are more damaged than this study revealed, it is a conservative estimate that half the Category 3 pipes should be replaced to ensure the hydraulic function of the drainage network. See APPENDIX E.3 for the Drainage Catalog.

As part of the Passenger Rail project, the abandoned rail line will be reactivated along its former alignment. To connect the reactivated line to the switch at Slateford Junction, a portion of Slateford Road will be excavated and replaced with a bridge adjacent to the Slateford Road/SR 0611 intersection, allowing trains on the restored rail line to pass beneath Slateford Road. All stormwater inlet boxes located in the swale between the SR 0611 embankment and the abandoned line will be replaced. The cross pipes beneath the abandoned line connecting these inlets to the stormwater drainage system in the town of Slateford, east of the abandoned rail line, will be replaced as well.

The restoration of the abandoned rail line will replace some of the trees and natural land cover that exist today south of Slateford Junction with a gravel bedding for the reactivated rail line. This change in the existing land cover will result in increased stormwater runoff from the project. However, the gravel railbed presents air voids and a path through which stormwater runoff may infiltrate into the ground or be conveyed overland downslope of the reactivated rail line toward the Delaware River. As a measurable increase in stormwater runoff rate or volume is not anticipated, and there is no reason to suspect that the addition of gravel and wooden ties to the site will reduce the stormwater quality, the construction of Structural Stormwater Management Best Management Practices (BMPs) will not be necessary to mitigate this project's effects upon the watershed.

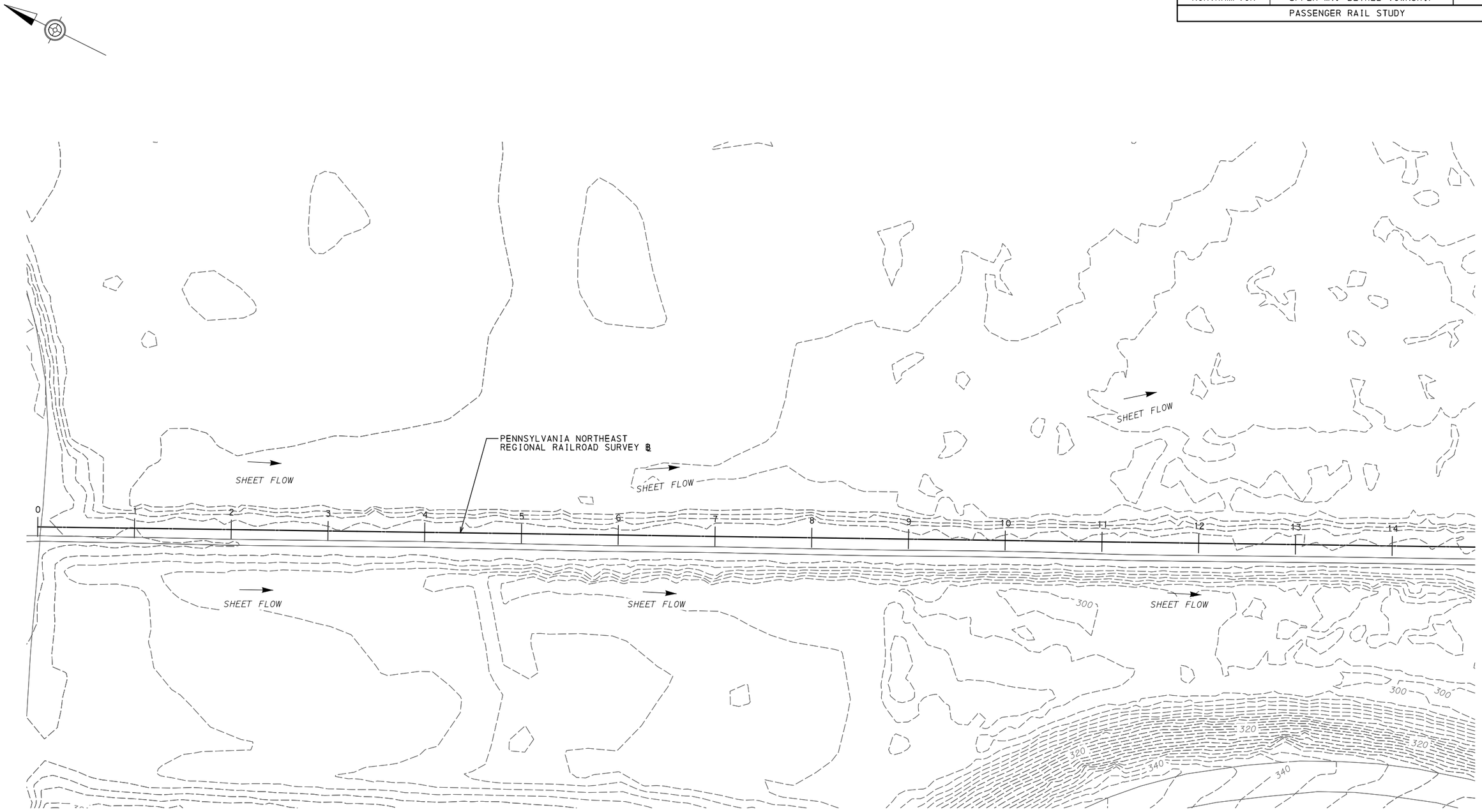
Due to the similarity of this project to a linear PennDOT roadway project such as a full-depth pavement reconstruction of a rural road, post-construction stormwater management for the Slateford Rail project will be managed consistent with PennDOT's approach to Level 1 Stormwater Management Projects for its roadway projects, which includes small projects such as bridge replacements or roadway restoration projects that present very limited potential for increases in post-construction stormwater runoff. Therefore, this project will rely on 1, Minimizing Compaction by limiting the amount of equipment working beyond the limits of the abandoned rail bed; 2, Preserving Trees by removing only those trees necessary to obtain access and complete the construction; and 3, Restoring Disturbed Areas, including staging areas outside of the existing roadway and the abandoned rail bed, with vegetation after the project is complete, to minimize the impact of the project on post-construction stormwater runoff. The implementation of these non-structural Stormwater Best Management Practices will ensure that the project is compliant with the Delaware River Sub-Basins Act 167 Plan and the Global Act 167 Stormwater Management Plan Water Quality Update.

The majority of the proposed work will occur within the railroad Legal Right-of-Way and should be considered a Roadway Maintenance Activity. The Pennsylvania State Code allows for up to 25-acres of railroad maintenance activities without requiring a National Pollutant Discharge Elimination System (NPDES) permit. These maintenance activities include shaping or restabilizing unpaved roads, shoulder grading, cutting of existing cut slopes, inlet and endwall cleaning, pipe replacement, minor vertical alignment adjustments to meet grade of resurfaced areas, ballast cleaning, laying of additional ballast, and replacing ballast, ties, and rails. Since the restoration of the abandoned rail line includes activities that fall exclusively within these categories, an NPDES permit will not be required.

APPENDIX E.2

EXISTING DRAINAGE PLANS

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	1 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:

Greenman-Pedersen, Inc.

52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777

GREENMAN-PEDERSEN, INC. DATE:7/8/2019 TIME:12:10:44 PM FILE:X:\SCR-2019407.00_Passenger Rail Water Gap to Slateford\Rail Study - Water Gap to Slateford\EngWaterRes\Plans\Slateford Rail Study_001_Plan.dgn

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	2 OF 19
PASSENGER RAIL STUDY		

SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
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SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	3 OF 19
PASSENGER RAIL STUDY		

SCALE

0 50 100 FEET

NOTE:

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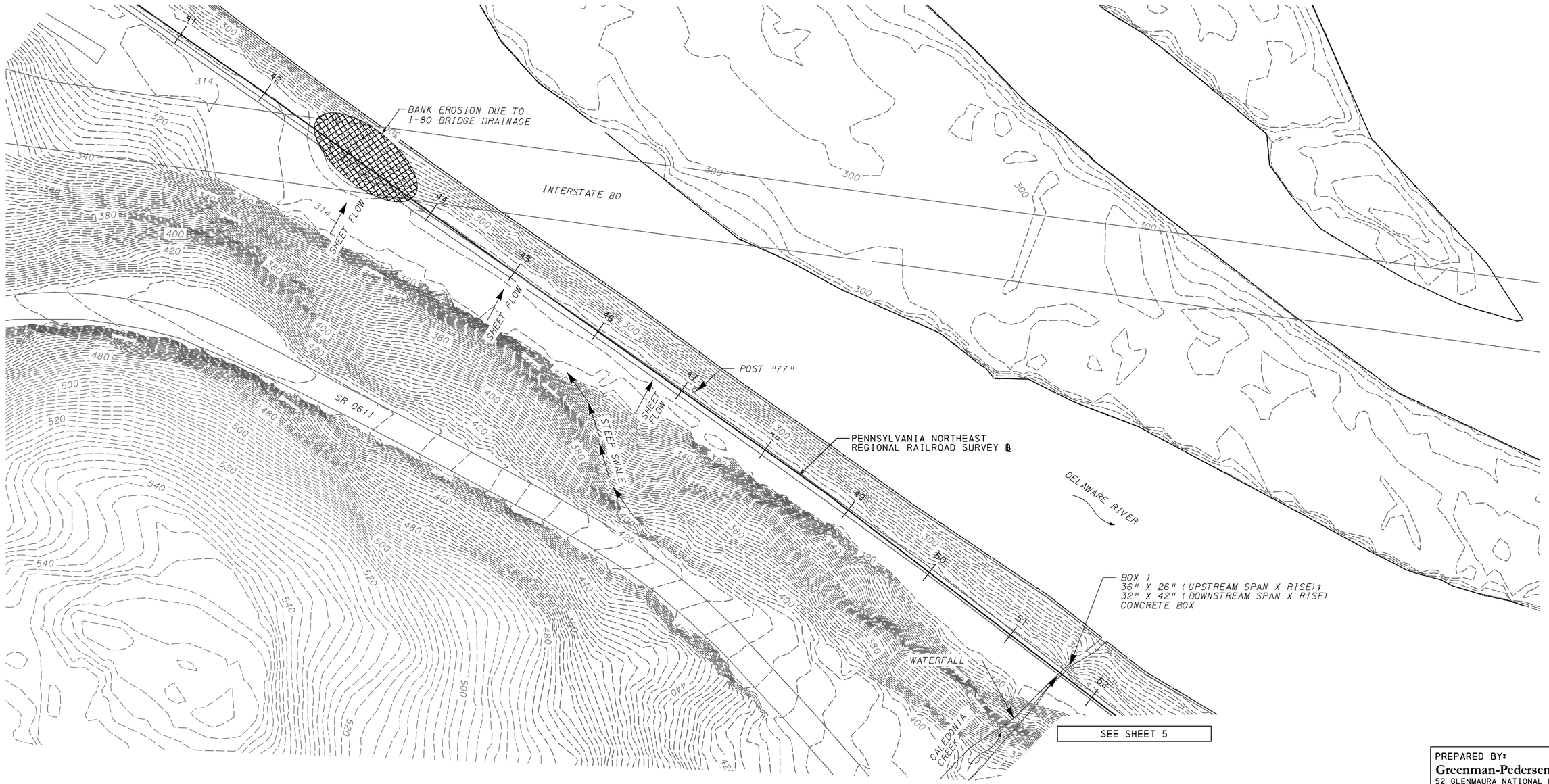
EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	4 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 3



SEE SHEET 5

SCALE

0 50 100 FEET

NOTE:
ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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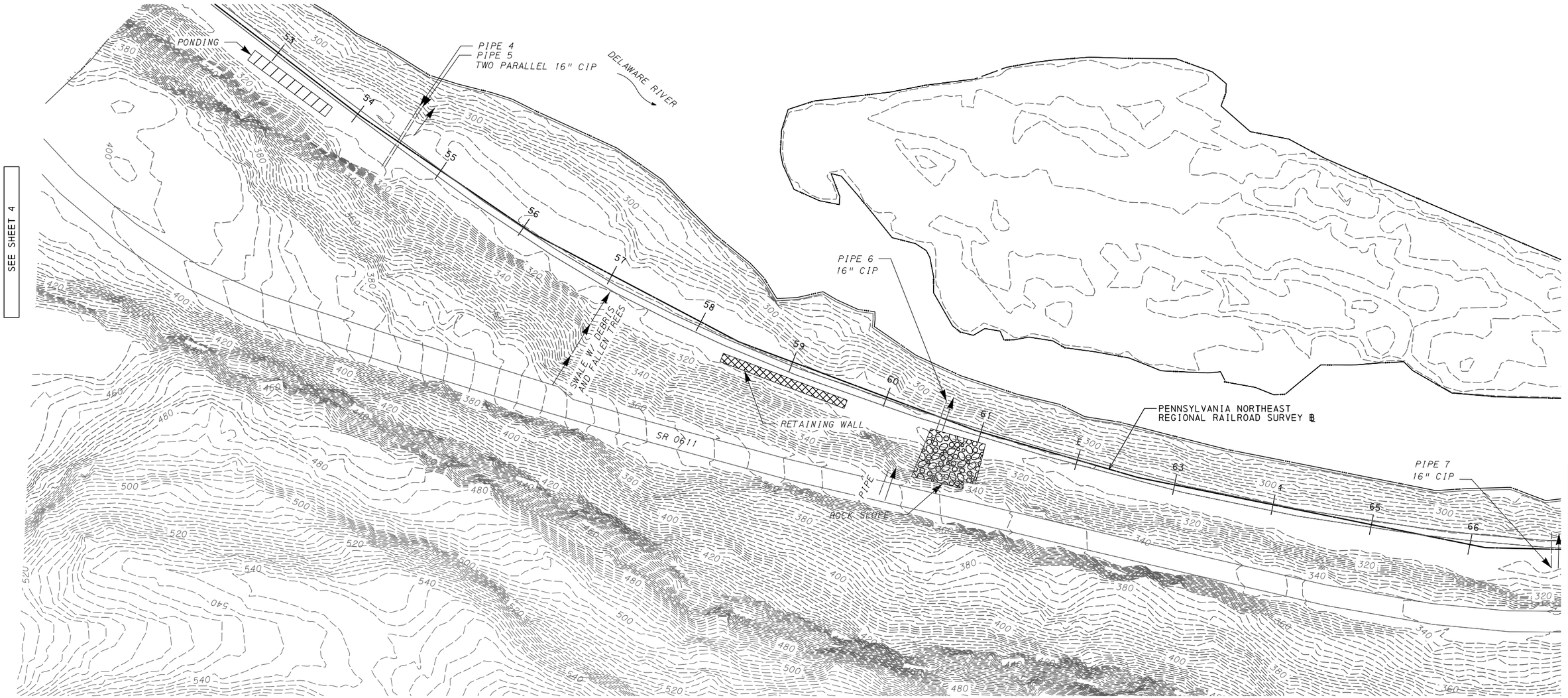
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	5 OF 19
PASSENGER RAIL STUDY		



SEE SHEET 4

SEE SHEET 6

SCALE

0 50 100 FEET

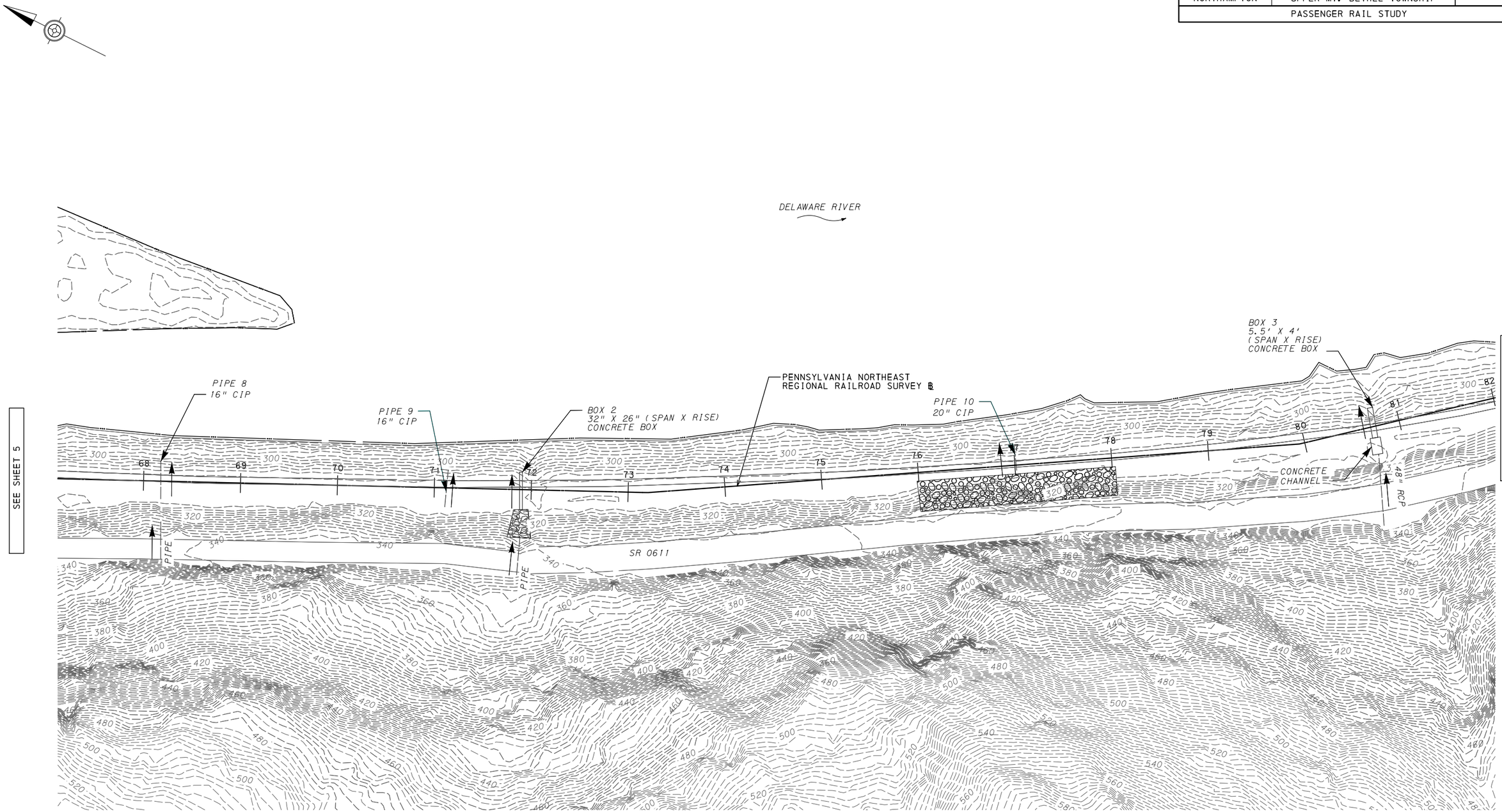
NOTE:
ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777

GREENMAN-PEDERSEN, INC. DATE: 7/8/2019 TIME: 12:10:48 PM FILE: X:\SCR-2019407.00_Passenger Rail Water Gap to Slateford\Rail Study - Water Gap to Slateford\Eng\WaterRes\Plans\Slateford Rail Study_D05_Plan.dgn

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	6 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

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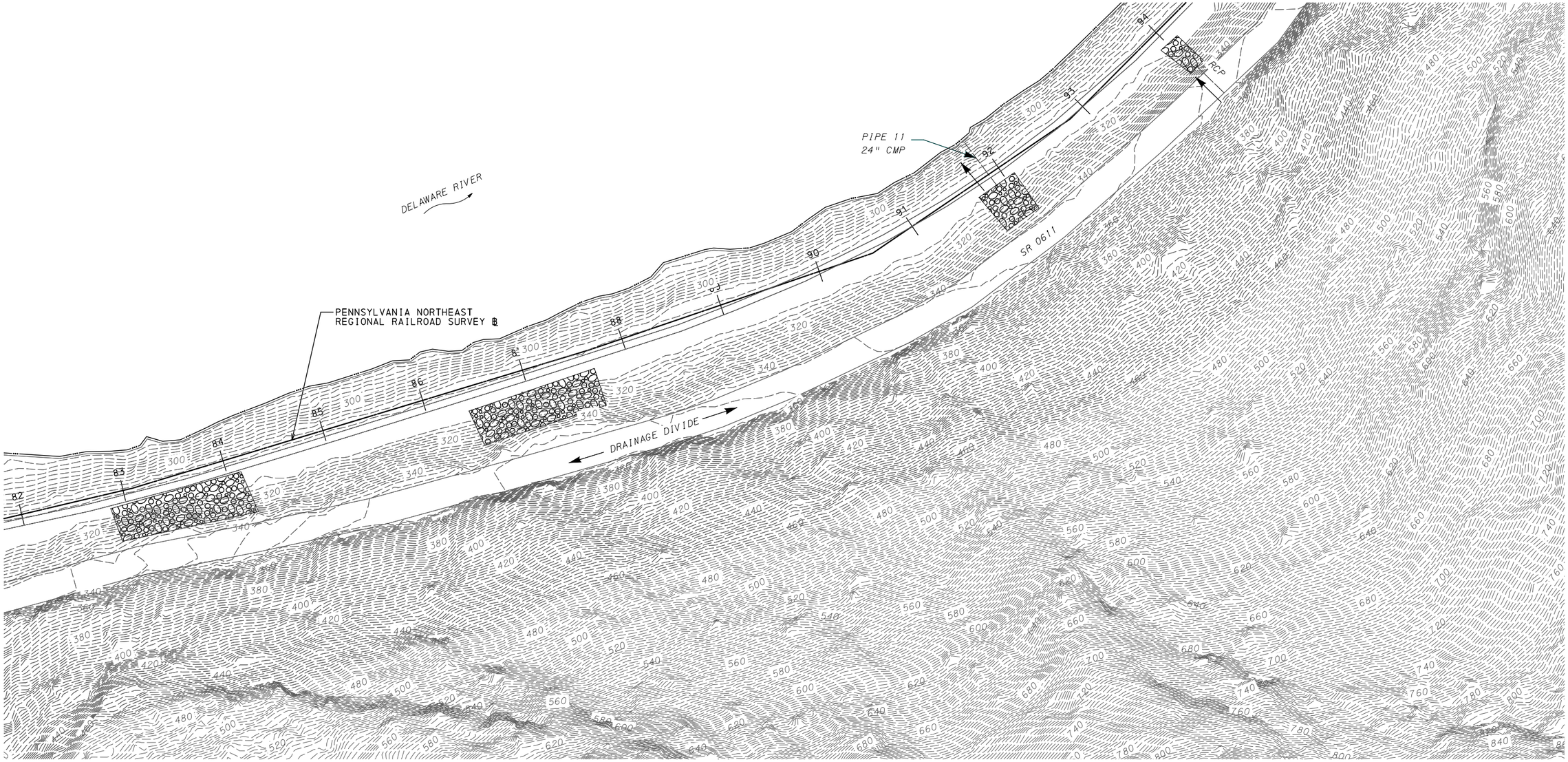
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	7 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 8



SEE SHEET 6

SCALE

0 50 100 FEET

NOTE:

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EXISTING DRAINAGE PLANS

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COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	8 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 9

SEE SHEET 7

SCALE

0 50 100 FEET

NOTE:
ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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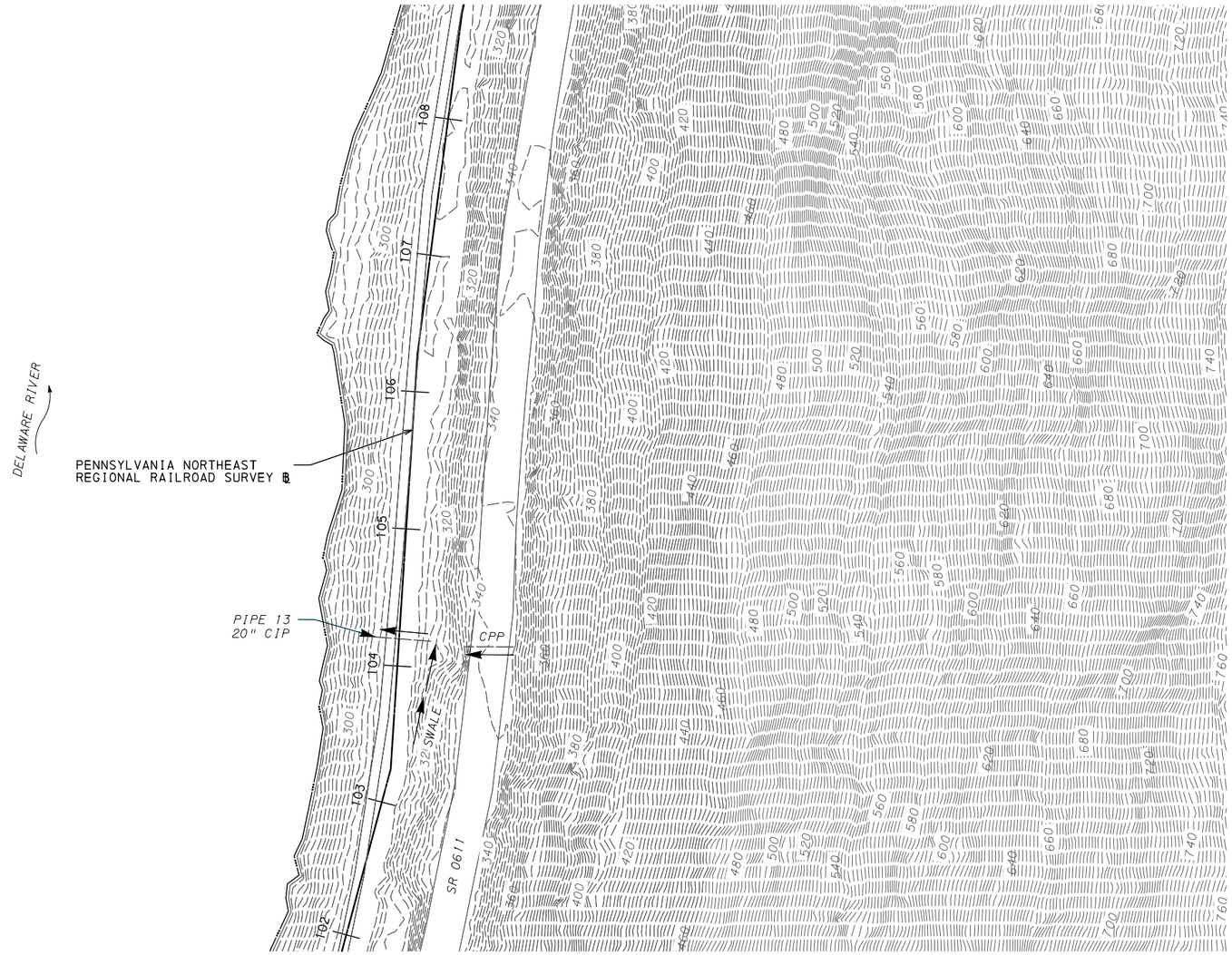
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	9 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 10



SEE SHEET 8

SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

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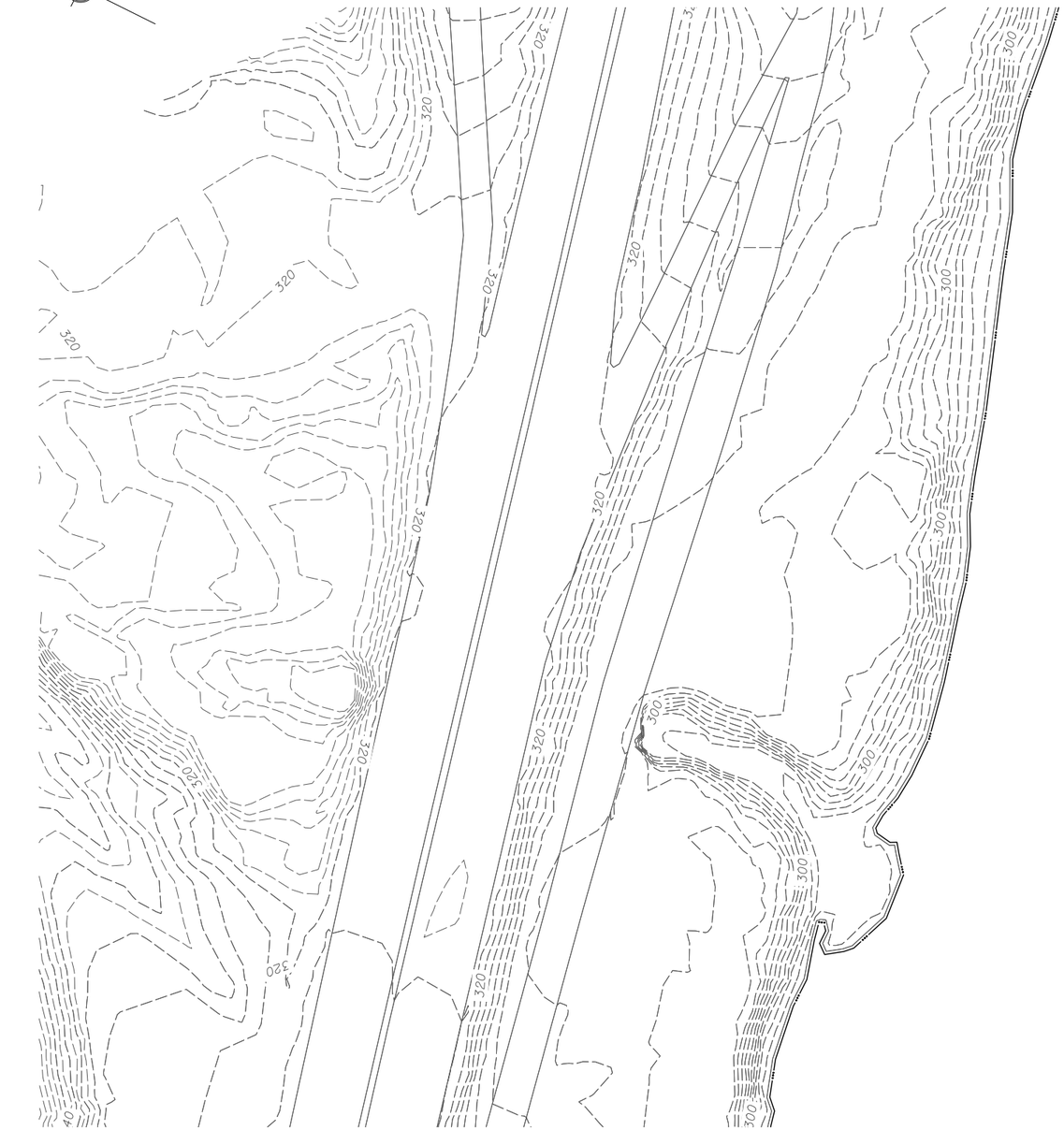
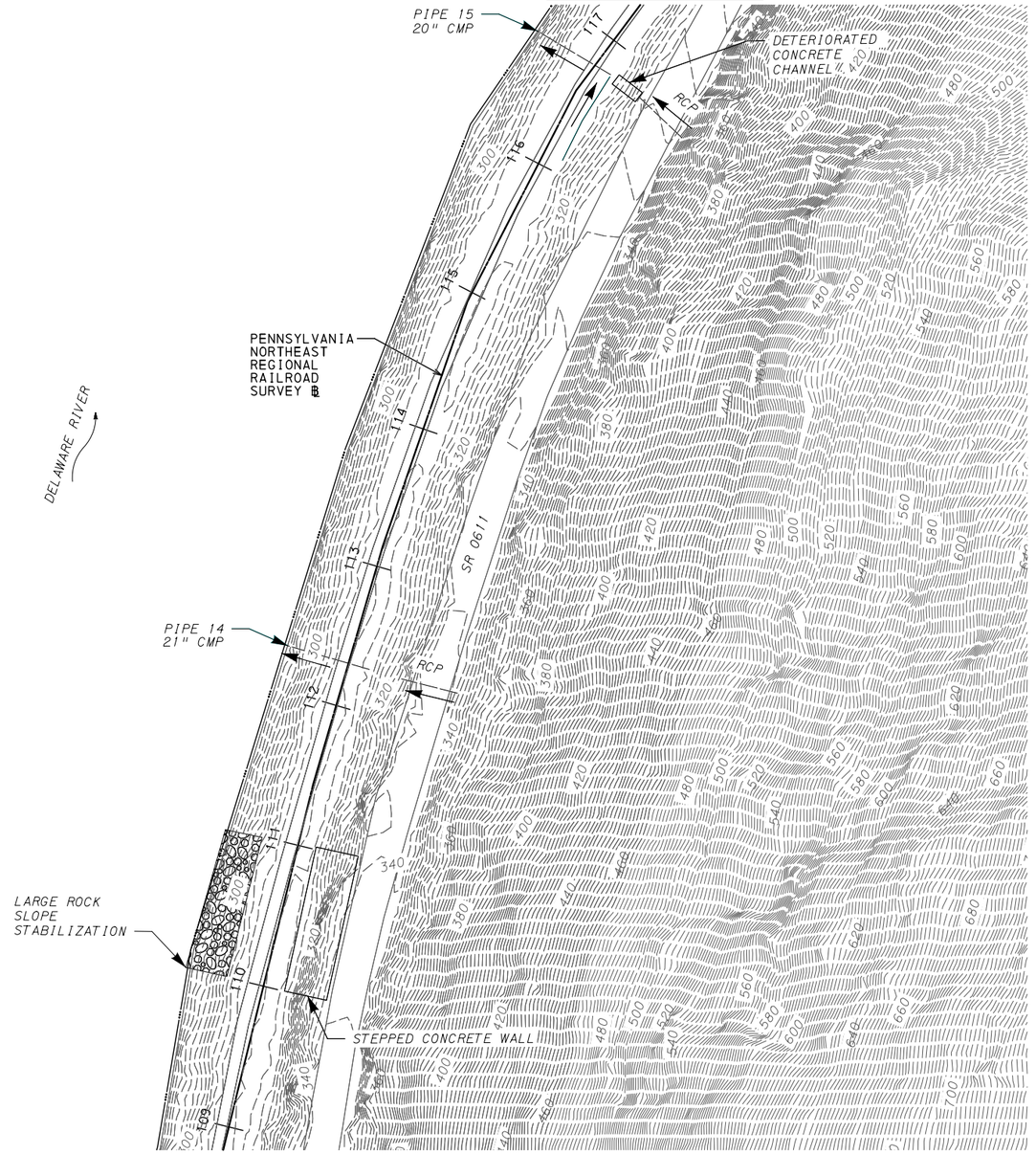
GREENMAN-PEDERSEN, INC. DATE: 7/8/2019 TIME: 12:11:10 PM FILE: X:\SCR-2019407.00_Passenger Rail Water Gap to Slateford\Rail Study - Water Gap to Slateford\Eng\WaterRes\Plans\Slateford Rail Study_D09_Plan.dgn

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	10 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 11





DELAWARE RIVER

SEE SHEET 9

SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

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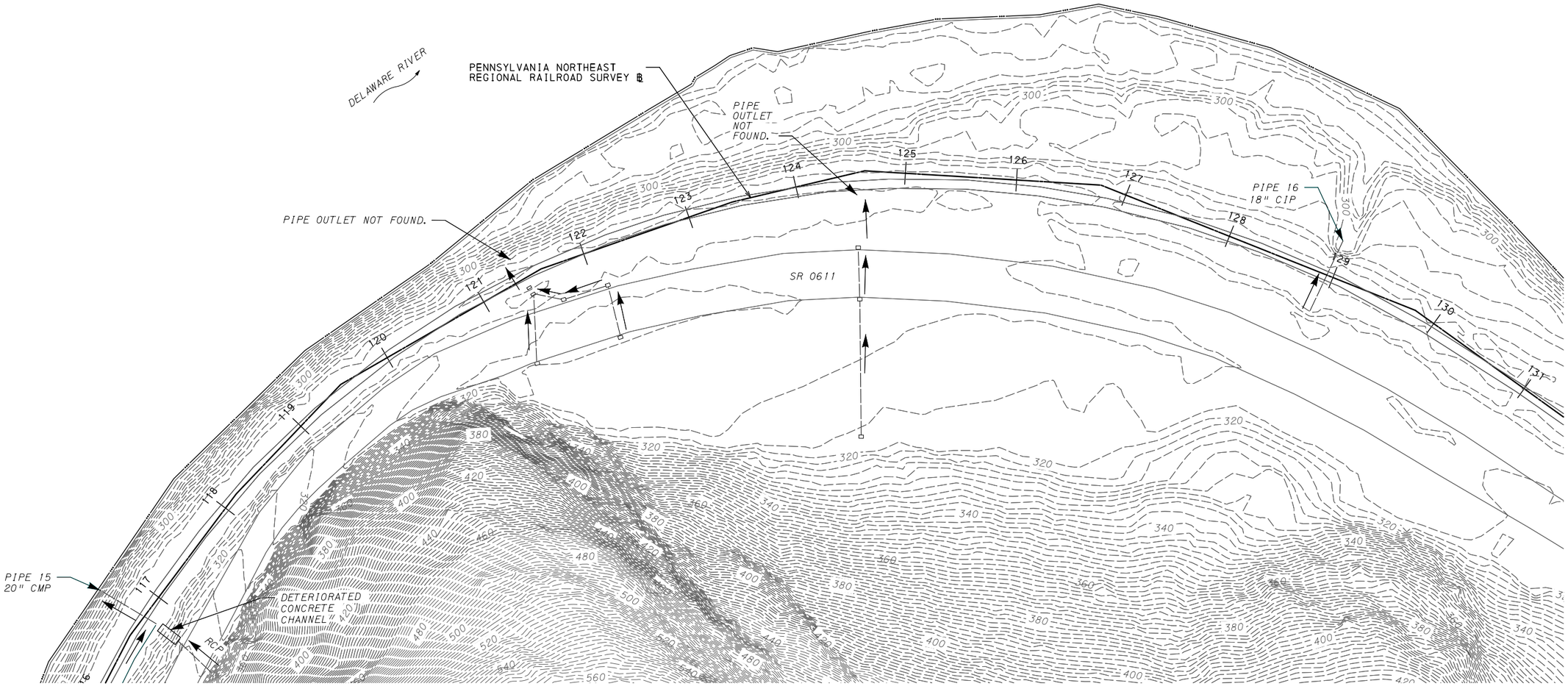
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	11 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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52 GLENMAURA NATIONAL BLVD.
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COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	12 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 11

DELAWARE RIVER

PENNSYLVANIA NORTHEAST REGIONAL RAILROAD SURVEY B

18" RCP

PIPE 17
24" CLAY PIPE

SR 0611

ASSUMED PIPE LOCATION; PIPE NOT LOCATED

18" RCP

PONDING

SEE SHEET 13

SCALE
0 50 100 FEET

NOTE:
ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
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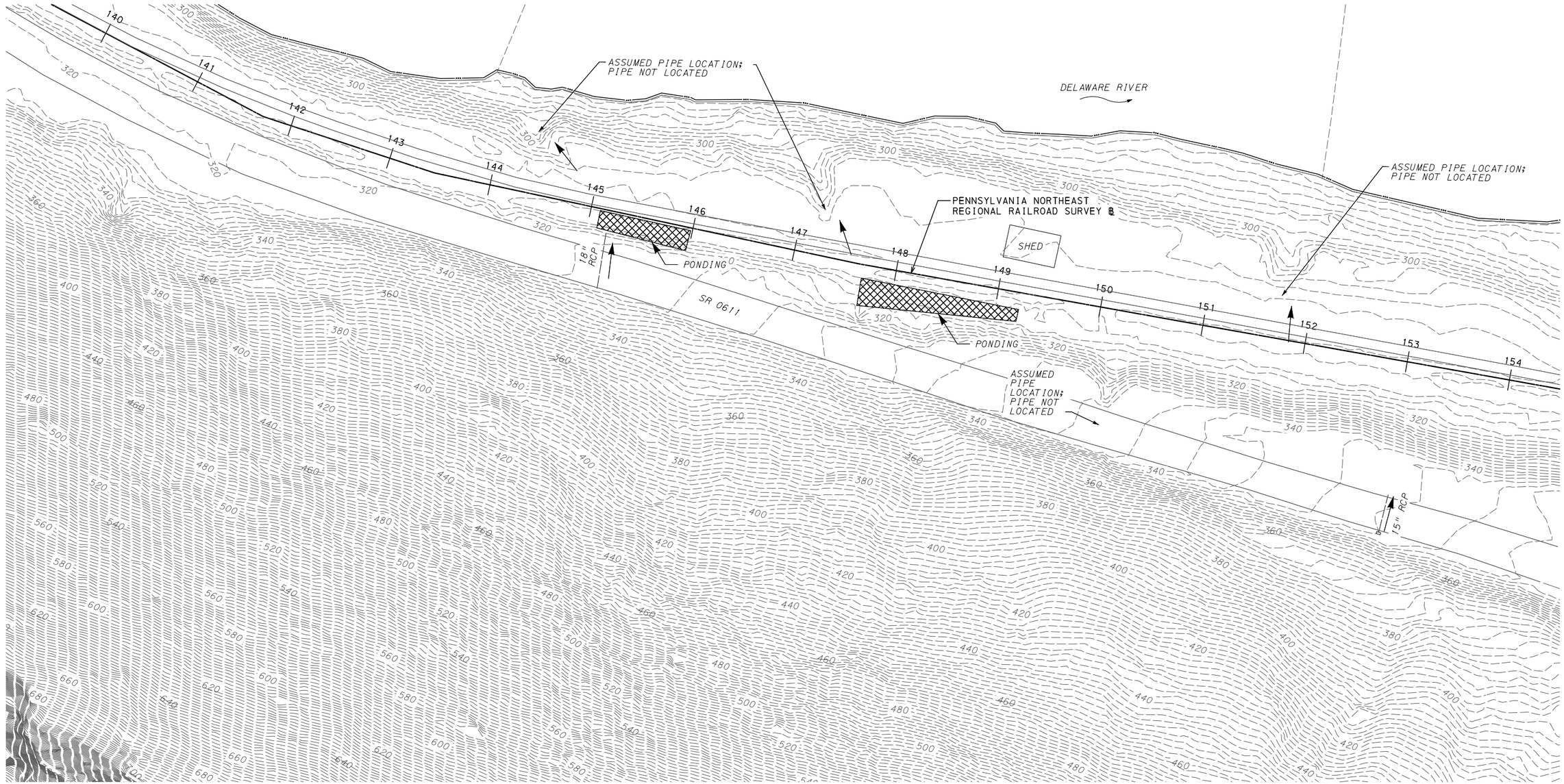
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	13 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 12



SEE SHEET 14

SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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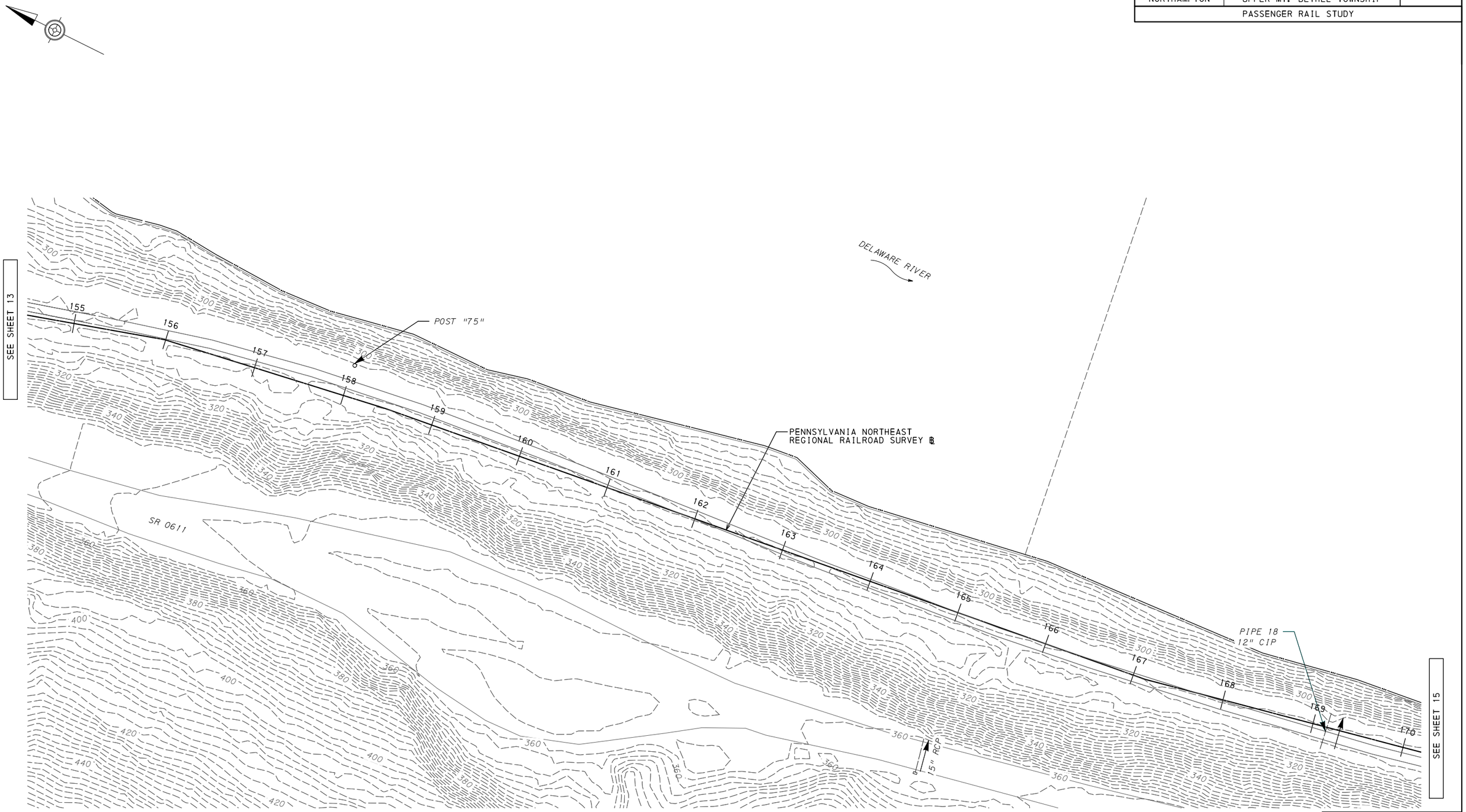
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	14 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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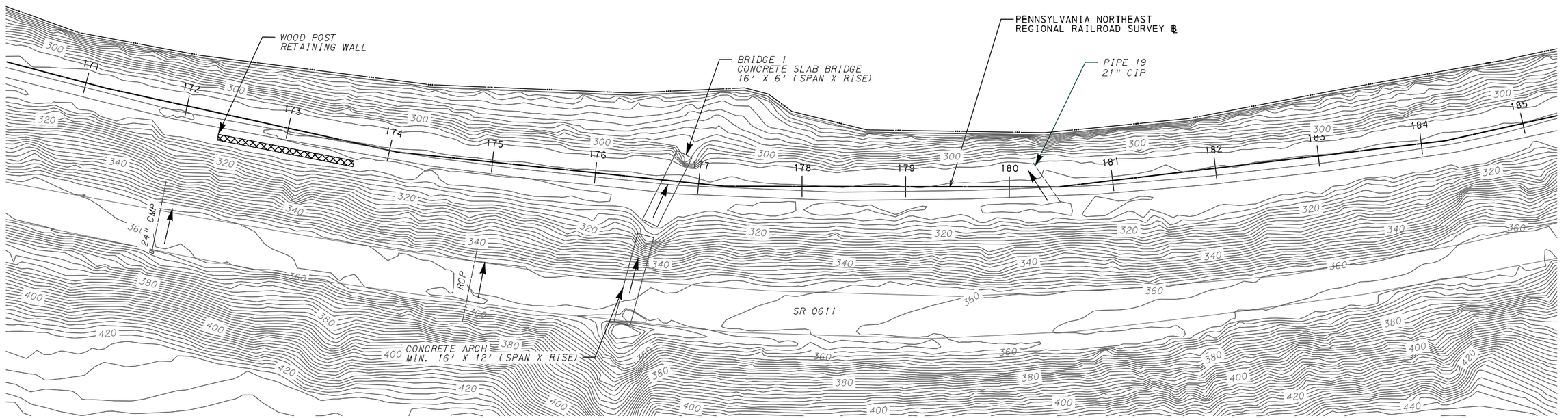
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	15 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 14



SEE SHEET 16

SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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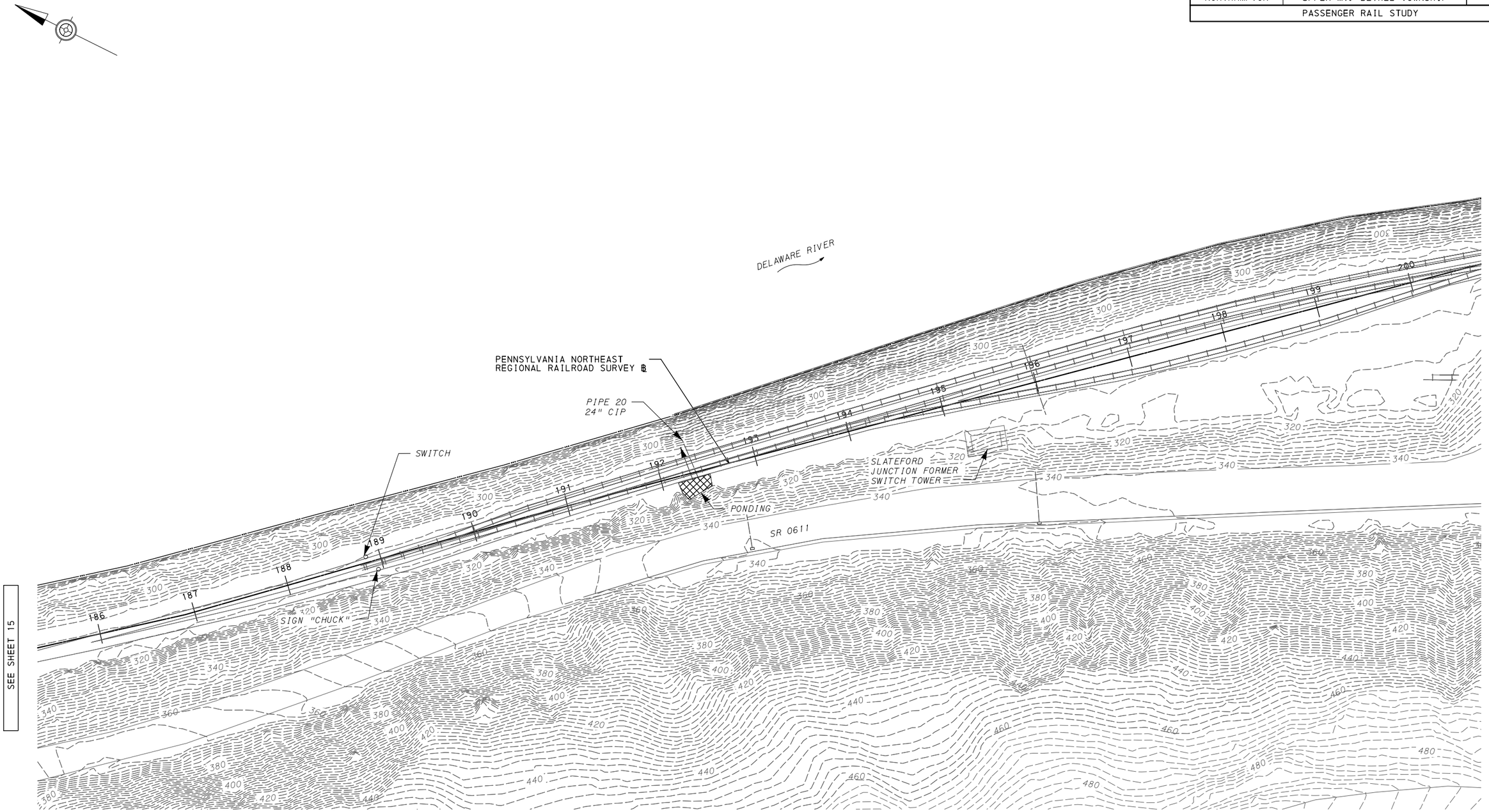
COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	16 OF 19
PASSENGER RAIL STUDY		



SEE SHEET 15

SEE SHEET 17

SCALE

0 50 100 FEET

NOTE:

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EXISTING DRAINAGE PLANS

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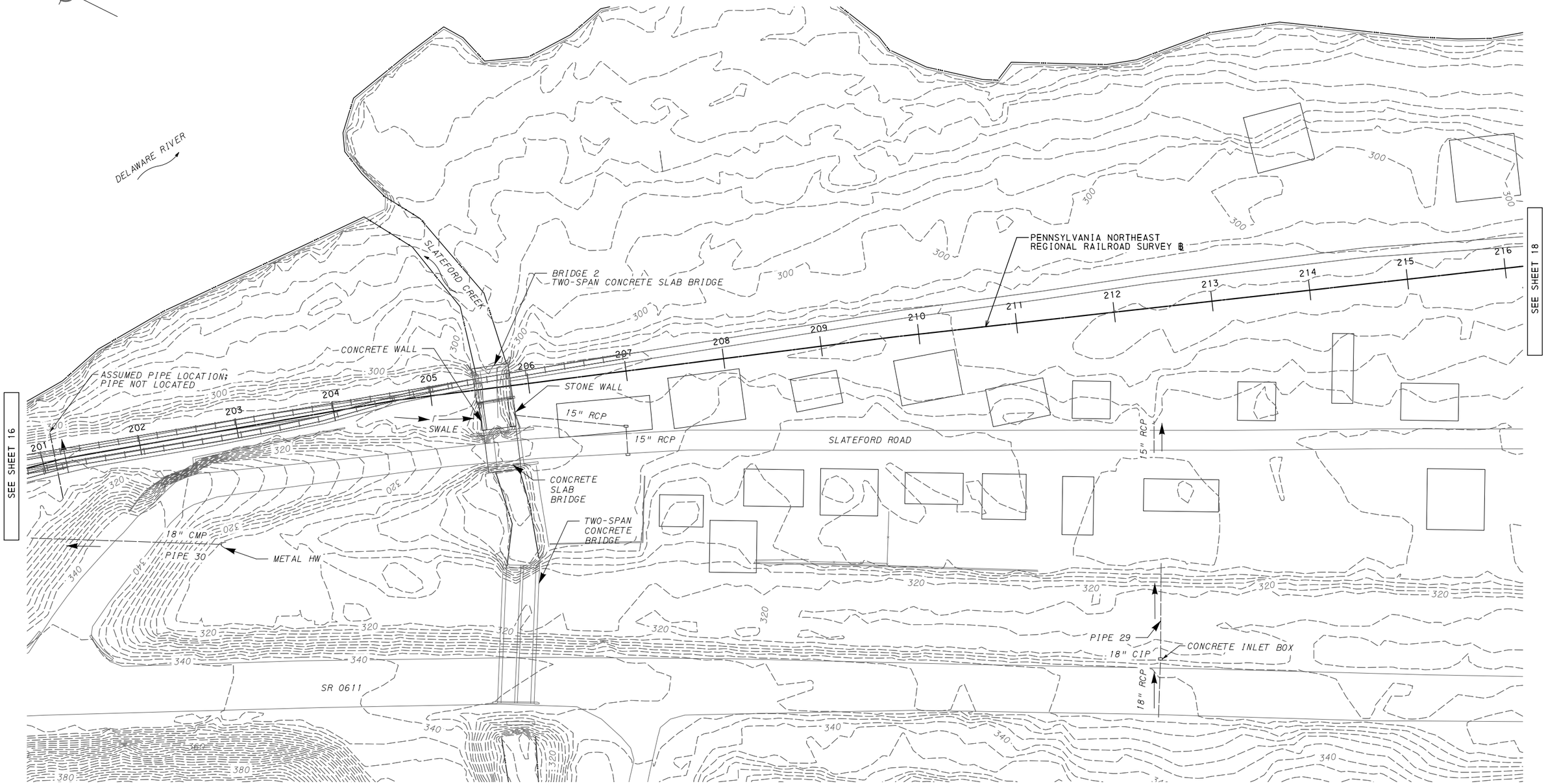
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	17 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

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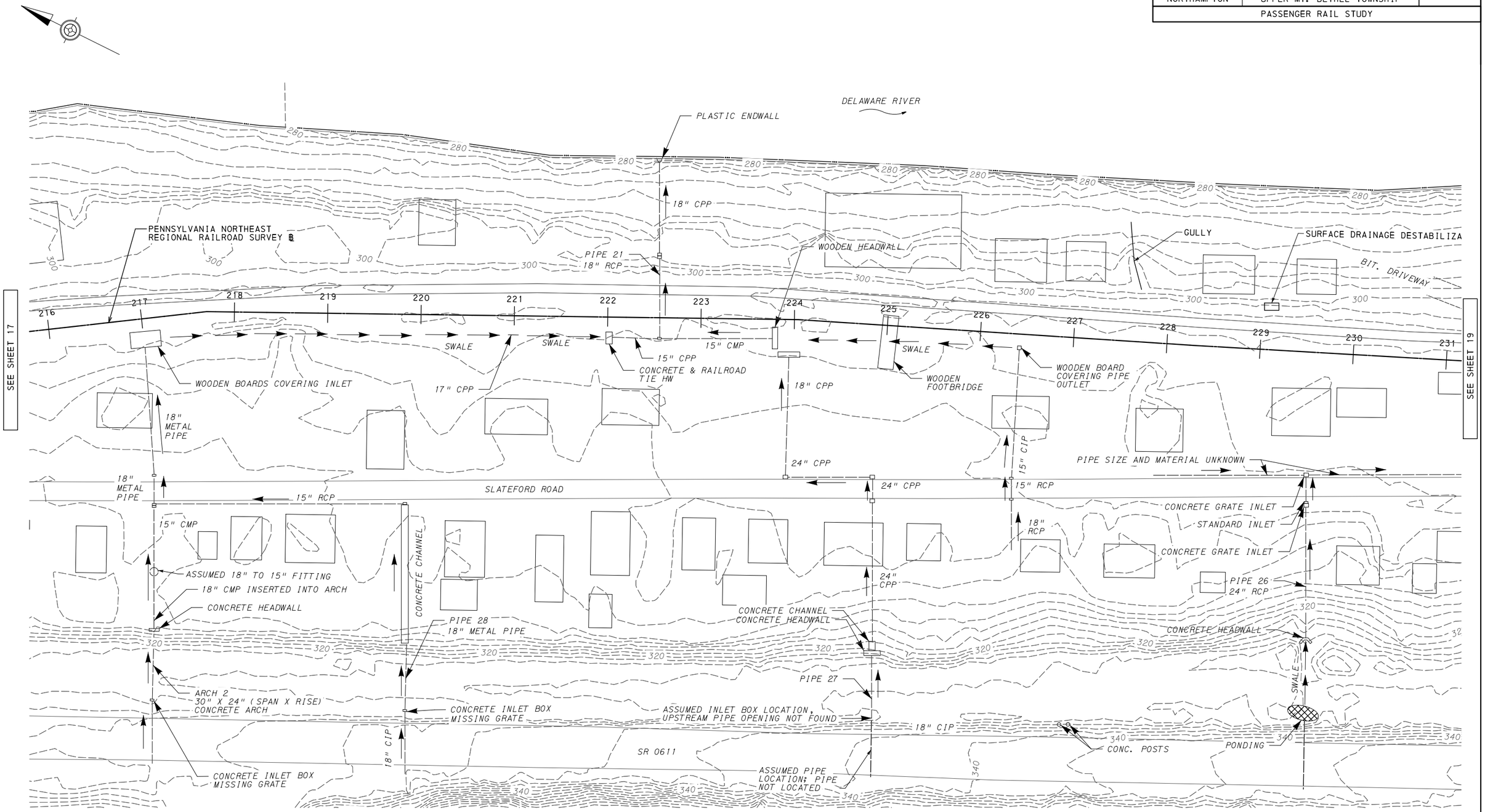
EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	18 OF 19
PASSENGER RAIL STUDY		



SCALE

0 50 100 FEET

NOTE:

ALL STRUCTURES SOUTH OF SLATEFORD CREEK ARE SHOWN IN THEIR APPROXIMATE LOCATIONS BASED ON AERIAL IMAGERY.

EXISTING DRAINAGE PLANS

PREPARED BY:
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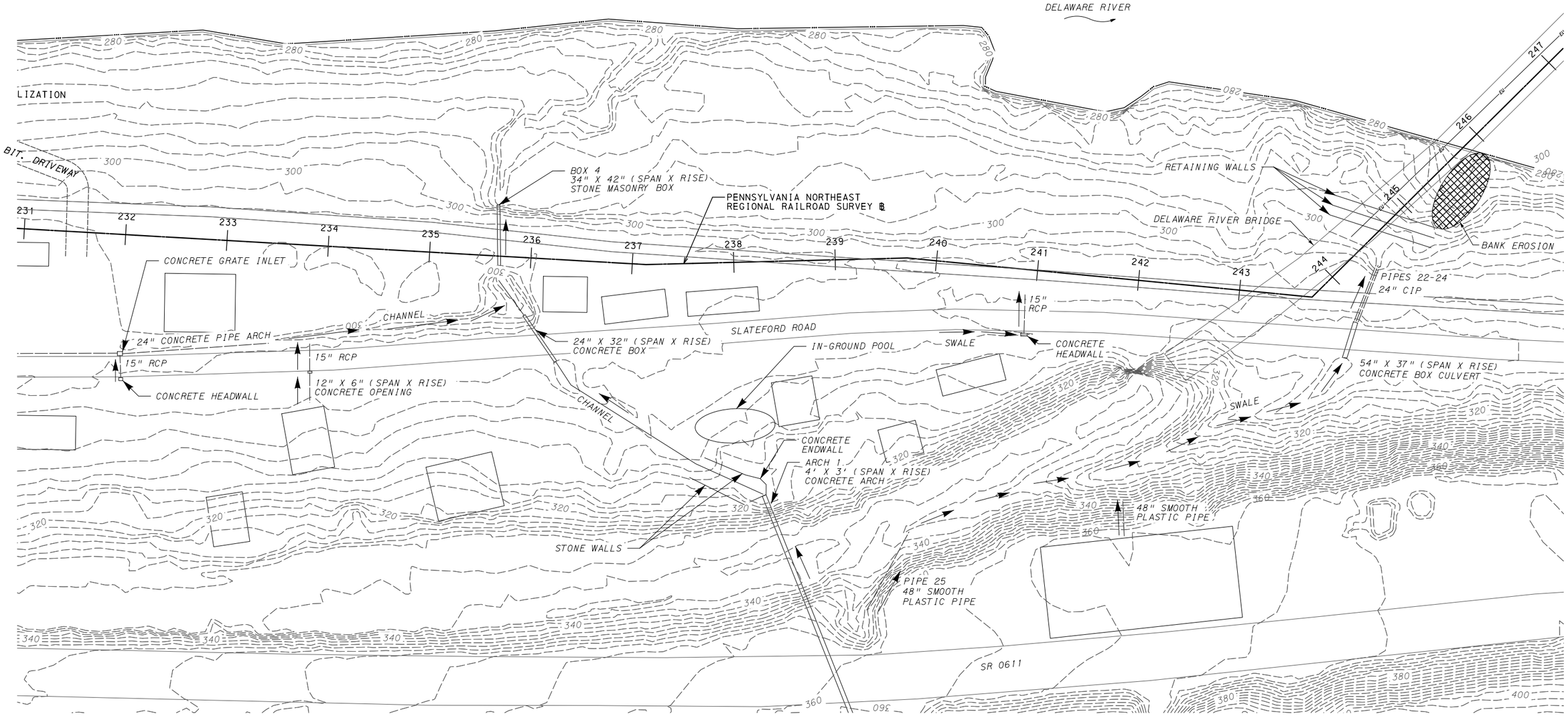
SCRANTON, PA 18505-5777

COUNTY	MUNICIPALITY	SHEET
MONROE & NORTHAMPTON	DELAWARE WATER GAP BOROUGH & UPPER MT. BETHEL TOWNSHIP	19 OF 19
PASSENGER RAIL STUDY		

SEE SHEET 18



SCALE

0 50 100 FEET

NOTE:

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EXISTING DRAINAGE PLANS

PREPARED BY:
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
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SCRANTON, PA 18505-5777

APPENDIX E.3

DRAINAGE CATALOG

Passenger Rail Study
Drainage Catalog

Table of Contents:

Drainage Structures……2
Ponding Locations……38
Other Noteworthy Drainage Features……..……..……41

GPI

Slateford Rail Study
Drainage Catalog:

Drainage Structures

Drainage Categories

Category 1	• No action required; drainage infrastructure is functioning without notable issues
Category 2	• Small pipes (≤ 24" diameter) requiring limited structure cleaning or channel cleaning/reshaping to restore drainage function
Category 3	• Small pipes (≤ 24" diameter) requiring significant structure cleaning or channel cleaning/reshaping to restore drainage function • Large pipes (>24" diameter) or structures requiring limited structure cleaning or channel cleaning/reshaping to restore drainage function • Fully buried pipes or structures requiring significant excavation to restore drainage function • Pipes that potentially do not provide capacity to convey the 10-year flow, and should be replaced with a pipe offering more conveyance capacity
Category 4	• Pipes or structures of any size, damaged or significantly impeded by physical features, beyond repair and requiring replacement to restore drainage function • Pipes or structures of any kind that pose a risk to nearby infrastructure

Drainage Data:

Pipe ID: Pipe 1
Pipe Station: 27+25
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 2.97 acres

Drainage Recommendations:

- Remove debris from channel and clean upstream and downstream channel.
- Remove sediment from pipe.
- Stabilize inlet and outlet.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 2

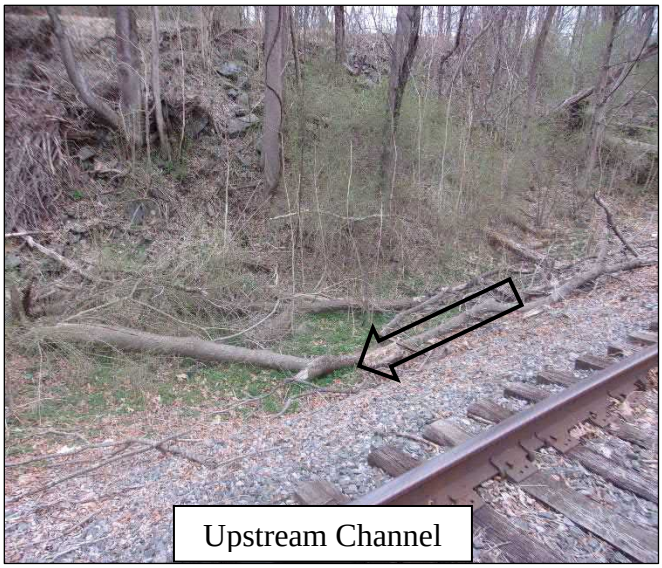
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		X
Estimated % Blocked	90	60
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

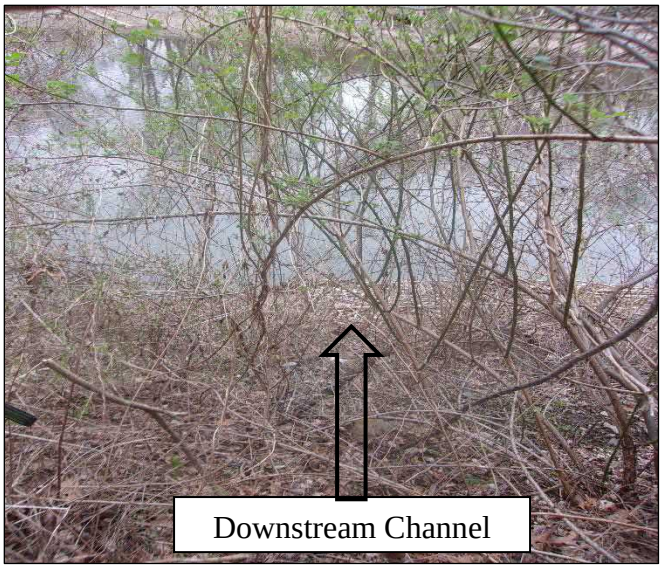
Arrow shown in photos represent direction of flow

Drainage Data:


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Pipe ID: Pipe 2
Pipe Station: 33+25
Pipe Size: Unknown
Pipe Material: Unknown
Apron: Yes / **No**
Drainage Area: 1.20 acres

Drainage Recommendations:

- Remove debris from channel and clean upstream and downstream channel.
- Clean out pipe.
- Stabilize upstream and downstream channels with rock aprons.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 3

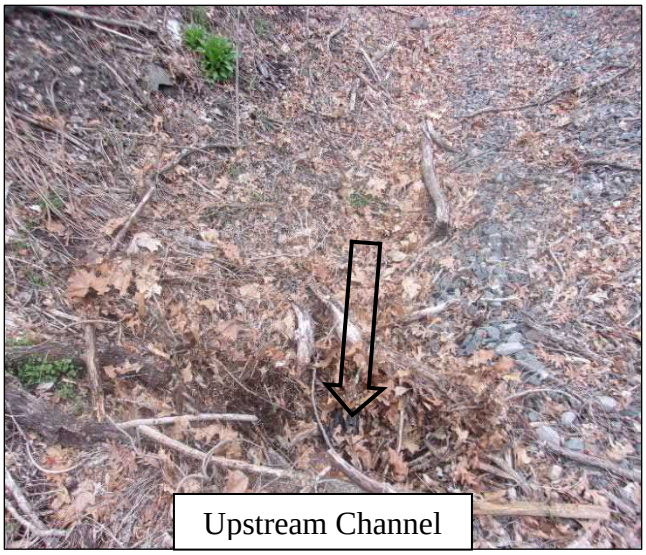
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	95	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Upstream Opening

Could Not Locate

Downstream Opening



Upstream Channel

Could Not Locate

Downstream Channel

Drainage Data:

Pipe ID: Pipe 3
Pipe Station: 39+50
Pipe Size: 48”
Pipe Material: Concrete
Apron: **Yes** / No
Drainage Area: 14.85 acres

Drainage Recommendations:

- Remove sediment and debris from upstream opening and channel.
- Stabilize upstream channel with rock apron.
- Replace deteriorated upstream concrete headwall.

Drainage Category 3

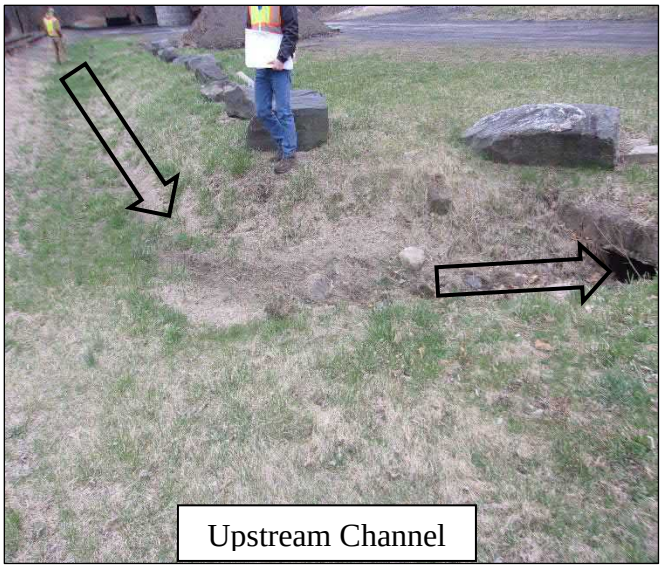
Refer to Appendix A, Existing Drainage Plans, Sheet 3

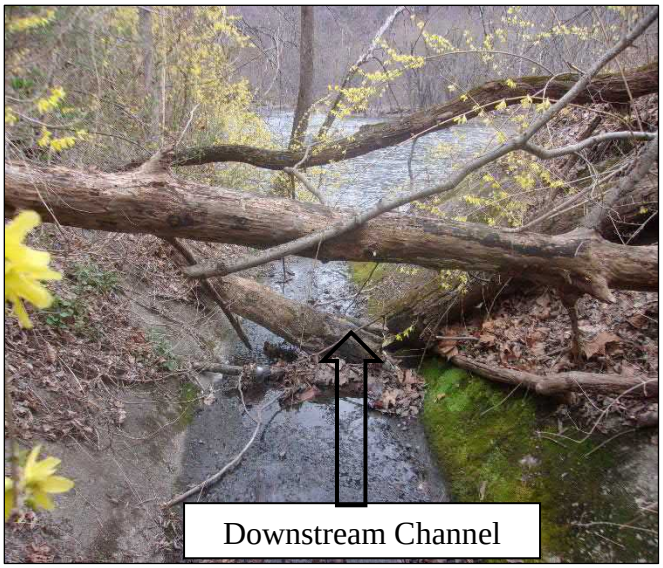
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	50	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Box 1
Pipe Station: 51+50
Pipe Size: 36" x 26" (span x rise) Upstream, 32" x 42" Downstream
Pipe Material: Concrete
Apron: Yes / **No**
Drainage Area: 31.56 acres
Note: Conveys Caledonia Creek.

Drainage Recommendations:

- Remove debris from upstream opening.

Drainage Category 1

Refer to Appendix A, Existing Drainage Plans, Sheet 4

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment	X	
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 4 & Pipe 5
Pipe Station: 54+50
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 1.24 acres

Drainage Recommendations:

- Remove debris and excavate as needed to expose inlets.
- Grade a channel to ensure positive drainage from location of observed ponding to inlets.
- Stabilize entrance with a rock apron.

Drainage Category 2

Refer to Appendix A, Existing Drainage Plans, Sheet 5

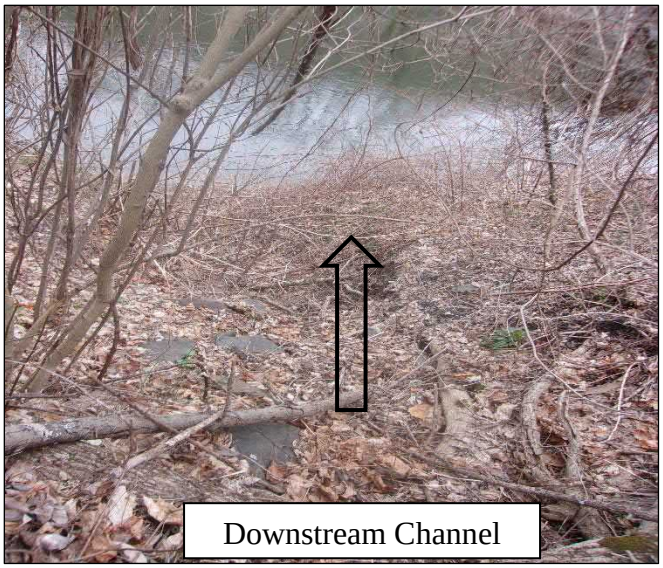
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	70	
Deteriorated/Rusted		
Ponding/Incomplete Drainage	X	
Poor Channel Alignment	X	
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 6
Pipe Station: 60+50
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 8.53 acres

Drainage Recommendations:

- Excavate as needed to exxpose upstream opening.
- Stabilize upstream channel with rock apron.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 5

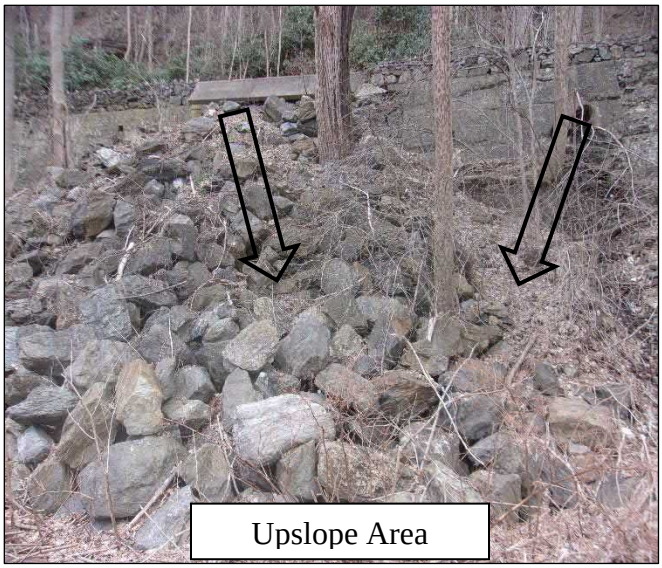
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening



Upslope Area

Downstream Channel

GPI

Drainage Data:

Pipe ID: Pipe 7
Pipe Station: 66+80
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: **Yes** / No
Drainage Area: 15.14 acres

Drainage Recommendations:

- Remove debris from inlet.
- Grade a more defined channel to the inlet.

Drainage Category 2

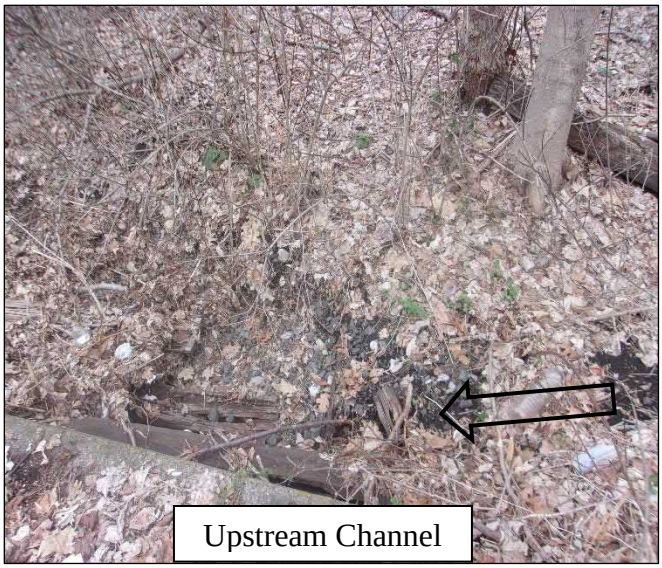
Refer to Appendix A, Existing Drainage Plans, Sheet 5

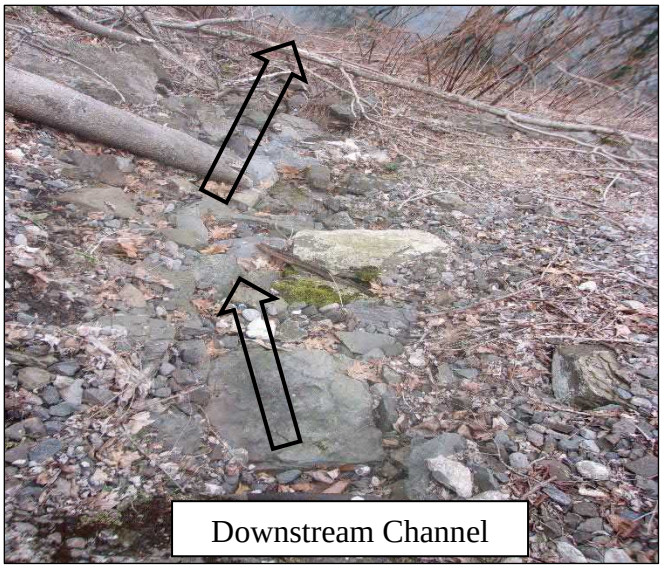
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation	X	
Estimated % Blocked	50	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 8
Pipe Station: 68+20
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: **Yes** / No
Drainage Area: 1.93 acres

Drainage Recommendations:

- Excavate to expose inlet.
- Stabilize upstream channel with rock apron.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 6

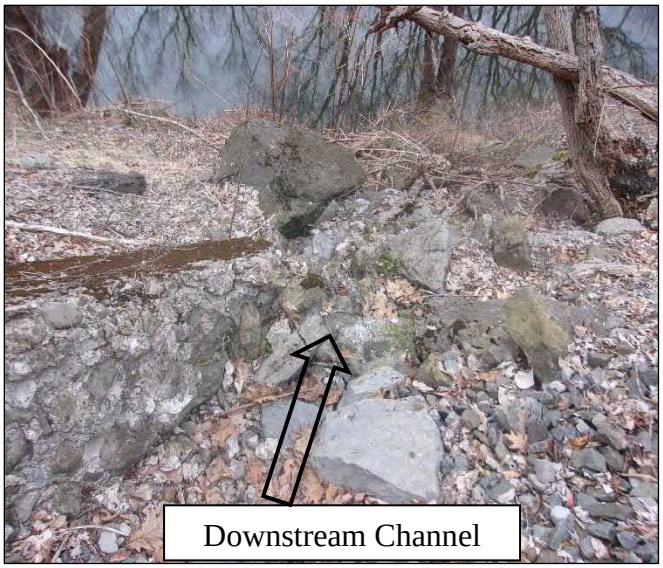
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	90	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel, Viewed from Rail


Downstream Channel

Drainage Data:

Pipe ID: Pipe 9
Pipe Station: 71+10
Pipe Size: 16”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 1.48 acres

Drainage Recommendations:

- Remove leaves and debris from pipe and upstream channel.

Drainage Category 1

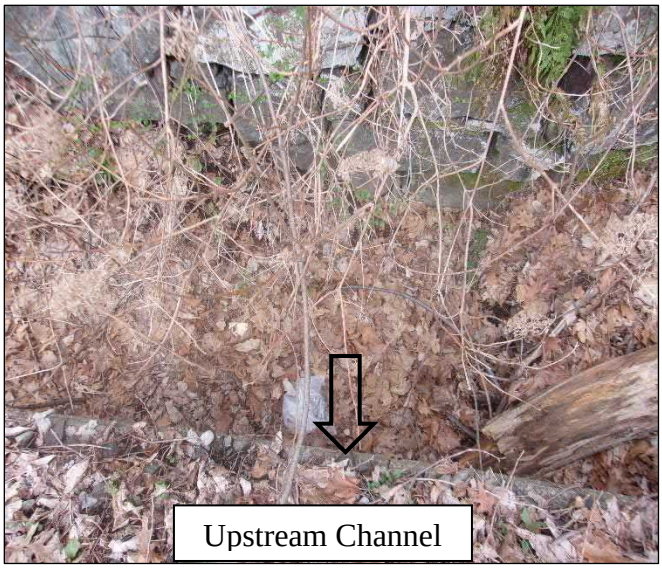
Refer to Appendix A, Existing Drainage Plans, Sheet 6

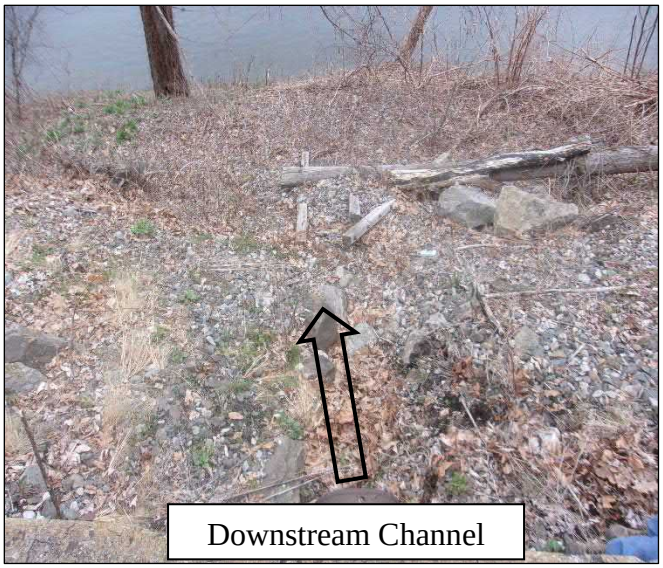
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Box 2
Pipe Station: 71+90
Pipe Size: 32" x 26" (span x rise)
Pipe Material: Concrete
Apron: Yes / **No**
Drainage Area: 28.66 acres

Drainage Recommendations:

- Remove debris from inlet.
- Construct new concrete endwall at outlet to shore up gravel rail embankment.

Drainage Category 4

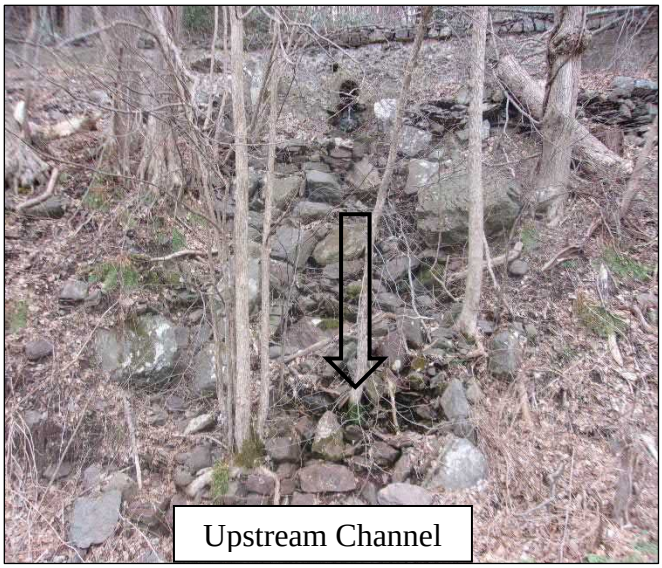
Refer to Appendix A, Existing Drainage Plans, Sheet 6

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	20	
Deteriorated/Rusted		X
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 10
Pipe Station: 77+00
Pipe Size: 20”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 7.73 acres

Drainage Recommendations:

- Remove sediment from pipe.
- Excavate as needed to expose upstream opening.
- Stabilize upstream channel with rock apron

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 6

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		X
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream

Upslope Area

Downstream Channel

Drainage Data:

Pipe ID: Box 3
Pipe Station: 80+80
Pipe Size: 5.5 ft x 4 ft (span x rise)
Pipe Material: Concrete
Apron: Yes / **No**
Drainage Area: 209.38 acres

Drainage Recommendations:

- Remove debris from entrance.

Drainage Category 2

Refer to Appendix A, Existing Drainage Plans, Sheet 6

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		X
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Pipe and Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 11
Pipe Station: 91+90
Pipe Size: 24”
Pipe Material: Corrugated Metal
Apron: Yes / **No**
Drainage Area: 9.89 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.
- Replace downstream end of pipe.
- Construct endwall to protect pipe outlet.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 7

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		X
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		X
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening

Upstream Slope Area

Downstream Channel

GPI

Drainage Data:

Pipe ID: Pipe 12
Pipe Station: 94+90
Pipe Size: 18”
Pipe Material: Corrugated Metal
Apron: Yes / **No**
Drainage Area: 23.35 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.
- Clear brush from downstream channel.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 8

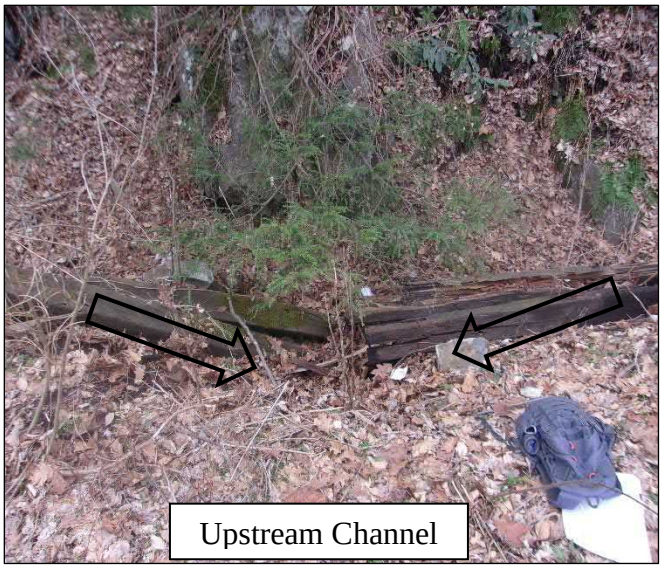
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

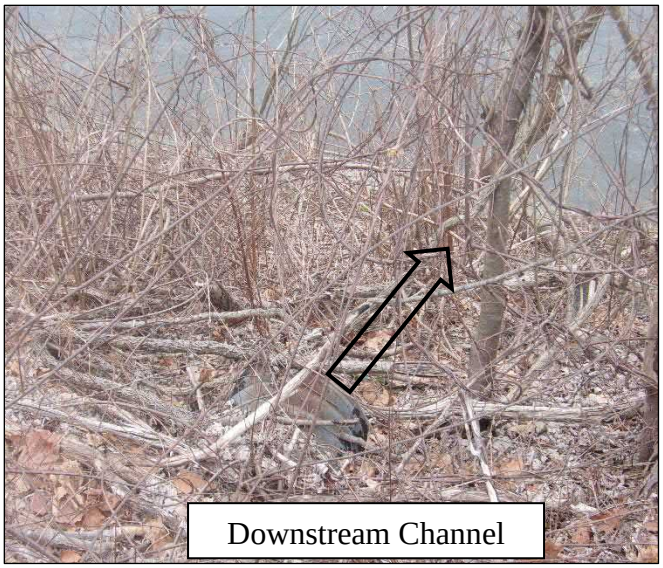
Could Not Locate

Upstream Opening

Downstream Opening



Upstream Channel



Downstream Channel

Drainage Data:

Pipe ID: Pipe 13
Pipe Station: 104+15
Pipe Size: 20”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 49.58 acres

Drainage Recommendations:

- Clear upstream channel of debris.

Drainage Category 2

Refer to Appendix A, Existing Drainage Plans, Sheet 9

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 14
Pipe Station: 112+20
Pipe Size: 21”
Pipe Material: Corrugated Metal
Apron: Yes / **No**
Drainage Area: 10.71 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 10

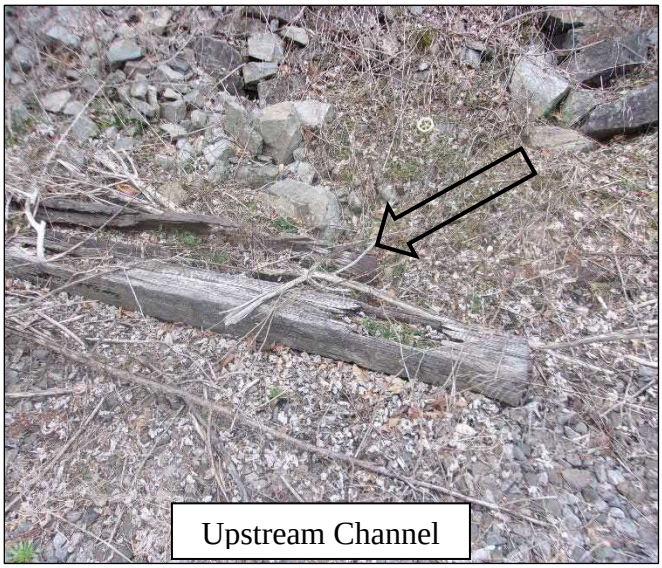
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening



Upstream Channel

Downstream Channel

Drainage Data:

Pipe ID: Pipe 15
Pipe Station: 116+80
Pipe Size: 20”
Pipe Material: Corrugated Metal
Apron: Yes / **No**
Drainage Area: 2.62 acres

Drainage Recommendations:

- Remove sediment from upstream channel.
- Replace/extend upstream end of pipe.
- Replace stone headwall with concrete headwall to stabilize railroad embankment above pipe inlet.

Drainage Category 3

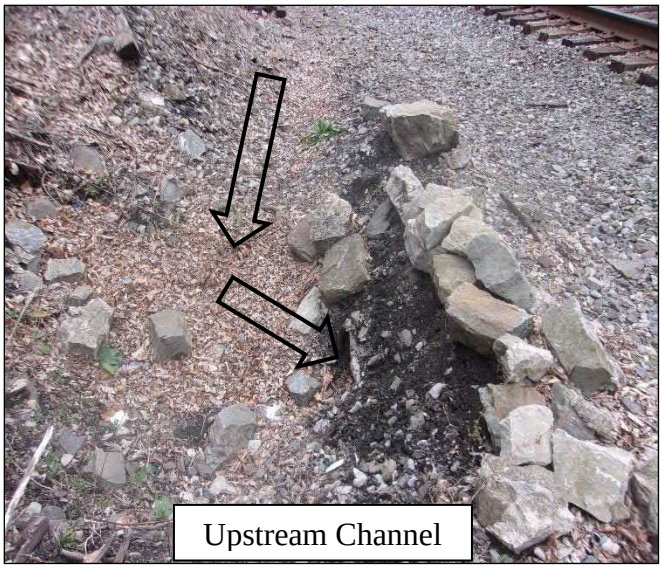
Refer to Appendix A, Existing Drainage Plans, Sheet 10

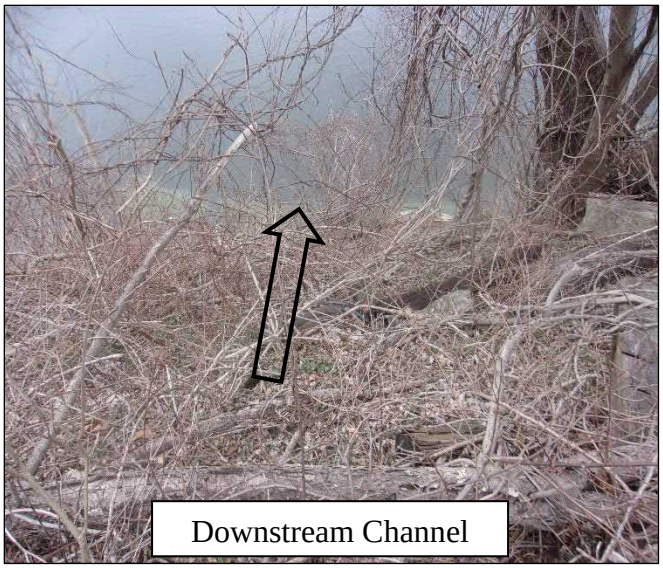
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation	X	
Estimated % Blocked	20	
Deteriorated/Rusted	X	
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 16
Pipe Station: 129+00
Pipe Size: 18”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 17.77 acres

Drainage Recommendations:

- Remove sediment from upstream channel.
- Clear brush from downstream channel.

Drainage Category 2

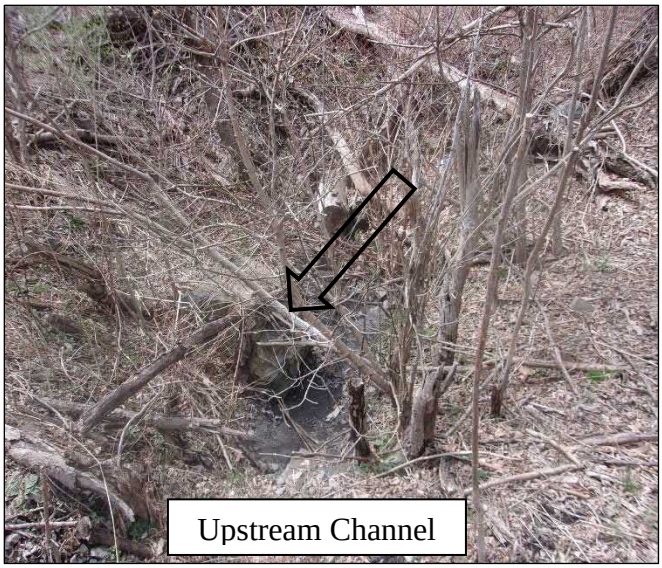
Refer to Appendix A, Existing Drainage Plans, Sheet 11

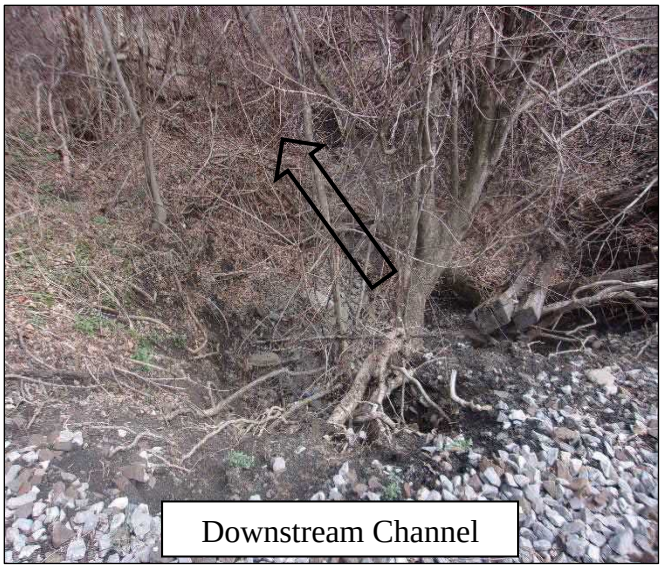
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation	X	
Estimated % Blocked	50	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 17
Pipe Station: 139+00
Pipe Size: 24”
Pipe Material: Clay
Apron: Yes / **No**
Drainage Area: 31.95 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.
- Remove brush and pipe debris from downstream channel.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 12

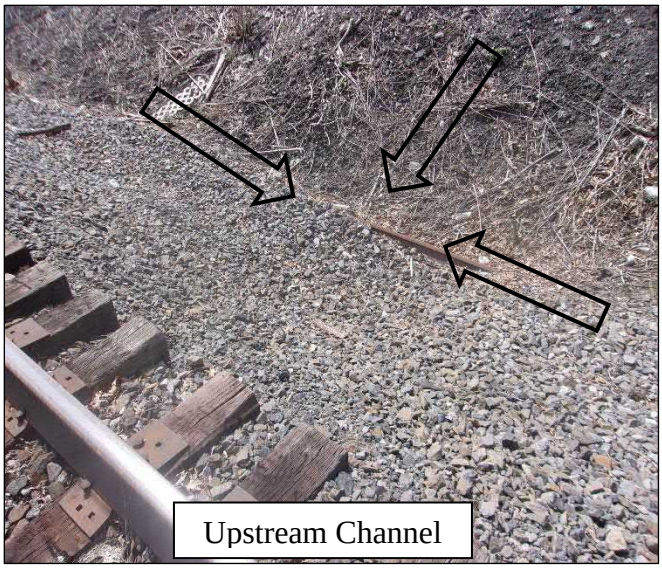
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation		X
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening



Upstream Channel

Downstream Channel

Drainage Data:

Pipe ID: Pipe 18
Pipe Station: 169+10
Pipe Size: 12”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 76.58 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.
- Increase conveyance capacity by replacing with a larger pipe or adding pipes.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 14

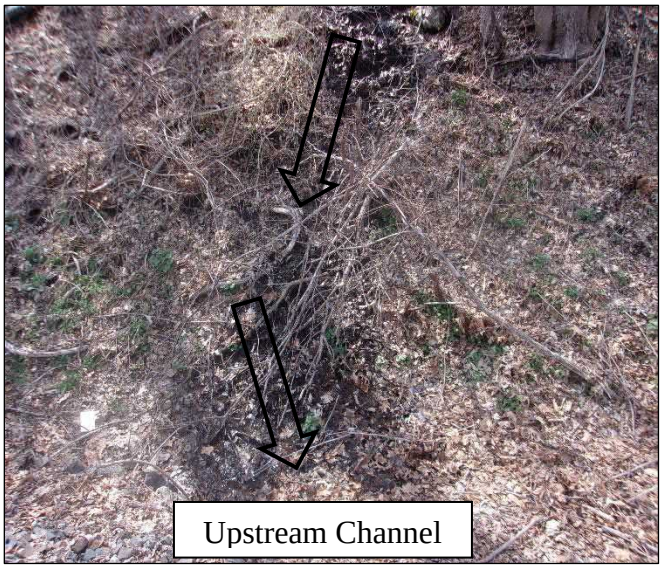
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		X

Arrow shown in photos represent direction of flow

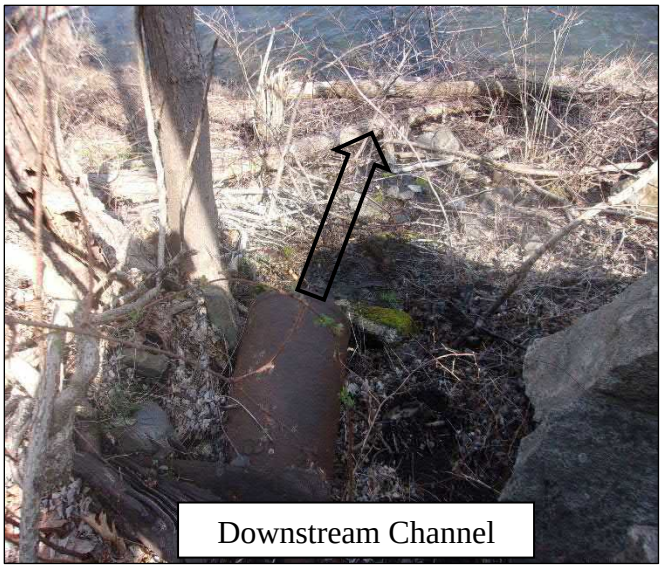
Could Not Locate

Upstream Opening

Downstream Opening



Upstream Channel



Downstream Channel

Drainage Data:

ID: Bridge 1
Station: 176+75
Size: 16’ x 6’ (span x rise)
Material: Concrete
Apron: Yes / **No**
Drainage Area: 111.16 acres

Drainage Recommendations:

- Excavate and line channel between Bridge 1 and upstream arch with rock to prevent future sedimentation.
- Remove sediment from within bridge and brush from downstream channel.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 15

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation	X	X
Estimated % Blocked	90	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 19
Pipe Station: 180+30
Pipe Size: 21”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 41.16 acres

Drainage Recommendations:

- Remove debris from inlet and sedimentation from outlet.
- Remove brush from downstream channel.

Drainage Category 2

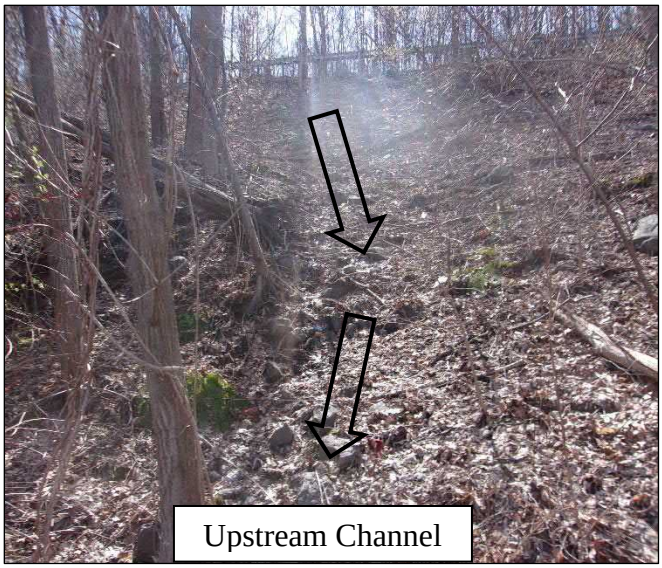
Refer to Appendix A, Existing Drainage Plans, Sheet 15

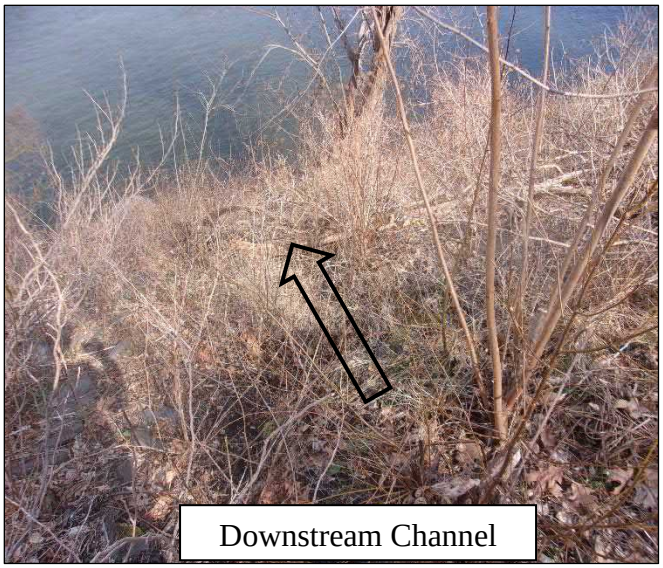
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		X
Estimated % Blocked	50	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipe 20
Pipe Station: 192+35
Pipe Size: 24”
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 13.99 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Stabilize upstream channel with rock apron.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 16

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage	X	
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening

Assumed Upstream Channel

Downstream Channel

GPI

Drainage Data:

ID: Bridge 2
Station: 205+70
Size: 15’ x 10’ (span x rise)
Material: Concrete
Apron: Yes / **No**
Drainage Area: 1,919 acres

Drainage Recommendations:

- Clear sediment and stone from northern span.
- Clear brush from walls of upstream channel.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 17

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation	X	X
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

ID: Pipe 21
Station: 222+50
Size: 18”
Material: Concrete (at upstream end); Plastic (at downstream end)
Apron: Yes / **No**
Drainage Area: 59.37 acres

Drainage Recommendations:

- Increase conveyance capacity by replacing with a larger pipe or adding pipes.

Drainage Category 3

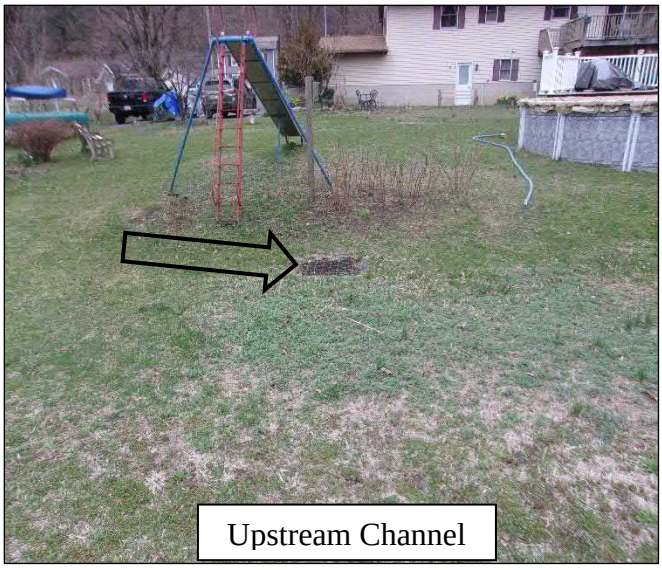
Refer to Appendix A, Existing Drainage Plans, Sheet 18

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Box 4
Pipe Station: 235+75
Pipe Size: 34" x 42" (span x rise)
Pipe Material: Stone Masonry
Apron: Yes / **No**
Drainage Area: 273.14 acres

Drainage Recommendations:

- None.

Drainage Category 1

Refer to Appendix A, Existing Drainage Plans, Sheet 19

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

Pipe ID: Pipes 22, 23, and 24
Pipe Station: 244+00
Pipe Size: (Three) 24"
Pipe Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 25.92 acres

Drainage Recommendations:

- Clear debris and install grate across upstream opening between headwalls.
- Realign pipes and downstream channel to direct flow away from pier of Delaware River Bridge.

Drainage Category 4

Refer to Appendix A, Existing Drainage Plans, Sheet 19

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked	50	
Deteriorated/Rusted		
Ponding/Incomplete Drainage		X
Poor Channel Alignment	X	
Baseflow Present	X	X

Arrow shown in photos represent direction of flow


Upstream Opening


Downstream Opening


Upstream Channel


Downstream Channel

Drainage Data:

ID: Pipe 25
Station: 239+50 (Abandoned Line)
Size: 48”
Material: Plastic
Apron: Yes / **No**
Drainage Area: 14.87 acres

Drainage Recommendations:

- None. This pipe is likely owned by an adjacent property owner.

Drainage Category 1

Refer to Appendix A, Existing Drainage Plans, Sheet 19

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Upstream Opening

Could Not Locate

Downstream Opening

Upstream Channel

Could Not Locate

Downstream Channel

Drainage Data:

ID: Arch 1
Station: 238+00 (Abandoned Line)
Size: 4' x 3' (span x rise)
Material: Concrete
Apron: Yes / **No**
Drainage Area: 241.93 acres

Drainage Recommendations:

- Remove debris from downstream channel.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 19

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		X

Arrow shown in photos represent direction of flow

Could Not Locate
Upstream Opening.
Arch is likely connected
to the west side of SR 0611.

Downstream Opening

Could Not Locate
Upstream Channel

Downstream Channel

Drainage Data:

ID: Pipe 26
Station: 229+50 (Abandoned Line)
Size: 24”
Material: Concrete
Apron: Yes / **No**
Drainage Area: 19.60 acres

Drainage Recommendations:

- Grade upstream channel to ensure positive drainage to headwall.
- Reestablish upstream connection to SR 0611 drainage system to eliminate ponding on abandoned rail bed.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 18

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown	X	
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage	X	
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Drainage Data:

Upstream Opening

Could Not Locate

Downstream Opening.

Connected into Slateford Road

Drainage System

Upstream Channel

No Downstream Channel.

Connected into Slateford Road

Drainage System

ID: Pipe 27
Station: 225+00 (Abandoned Line)
Size: 18”
Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 4.42 acres

Drainage Recommendations:

- Reestablish upstream connection to SR 0611 drainage system.
- Stabilize upstream swale with rock.
- Provide inlet bag in upstream inlet to clean out sediment as needed.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 18

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		X

Arrow shown in photos represent direction of flow

Drainage Data:

Could Not Locate

Upstream Opening;

Opening is Likely a Buried Inlet

Within the Swale Between

SR 0611 and the Abandoned Rail Line

Downstream Opening

No Upstream Channel

Downstream Channel

ID: Pipe 28
Station: 220+00 (Abandoned Line)
Size: 18”
Material: Metal
Apron: Yes / **No**
Drainage Area: 15.70 acres

Drainage Recommendations:

- Remove debris from inlet box and install grate.
- Stabilize upstream swale with rock.
- Provide inlet bag in upstream inlet to clean out sediment as needed.

Drainage Category 2

Refer to Appendix A, Existing Drainage Plans, Sheet 18

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Upstream Opening

Photograph of Downstream

Opening Not Available

Could Not Locate

Upstream Channel;

Swale Between

SR 0611 and the Abandoned Line

Likely Acts as the Upstream Channel

Downstream Channel

Drainage Data:

ID: Arch 2
Station: 217+00 (Abandoned Line)
Size: Arch - 30" x 24" (span x rise); Pipe – 18"
Material: Concrete
Apron: Yes / **No**
Drainage Area: 23.50 acres

Drainage Recommendations:

- Replace headwall with a manhole or provide bulkhead across upstream opening to direct all flow into pipe and avoid seepage.

Drainage Category 3

Refer to Appendix A, Existing Drainage Plans, Sheet 18

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		50
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening

Could Not Locate

Upstream Channel

No Downstream Channel Present

Drainage Data:

ID: Pipe 29
Station: 212+00 (Abandoned Line)
Size: 18”
Material: Cast Iron
Apron: Yes / **No**
Drainage Area: 5.47 acres

Drainage Recommendations:

- Reestablish upstream connection to SR 0611 drainage system.
- Stabilize upstream swale with rock.

Drainage Category 2

Refer to Appendix A, Existing Drainage Plans, Sheet 17

DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown		X
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		X
Baseflow Present		

Arrow shown in photos represent direction of flow

Could Not Locate

Upstream Opening

Downstream Opening

Could Not Locate

Upstream Channel

Downstream Channel

Drainage Data:

Pipe ID: Pipe 30
Pipe Station: 202+50 (Abandoned Line)
Pipe Size: 18”
Pipe Material: Corrugated Metal
Apron: Yes / **No**
Drainage Area: 6.27 acres

Drainage Recommendations:

- Excavate to expose upstream opening.
- Clear brush from outlet and downstream channel.

Drainage Category 1

Refer to Appendix A, Existing Drainage Plans, Sheet 17

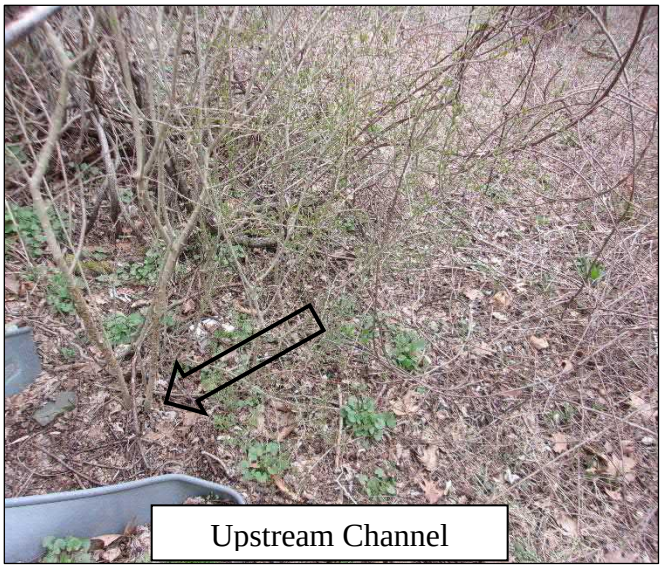
DRAINAGE OBSERVATION		
Condition	**Inlet**	**Outlet**
Overgrown	X	
Crushed		
Eroded		
Sedimentation		
Estimated % Blocked		
Deteriorated/Rusted		
Ponding/Incomplete Drainage		
Poor Channel Alignment		
Baseflow Present		
Could Not Locate		X

Arrow shown in photos represent direction of flow

Upstream Opening

Photograph of Downstream

Opening Not Available



Upstream Channel

Photograph of Downstream

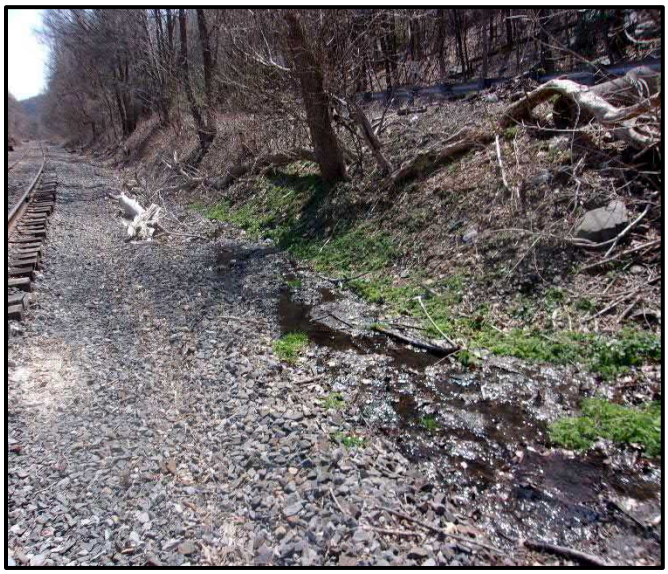
Channel Not Available

Passenger Rail Study
Drainage Catalog:

Ponding Locations

Refer to Appendix A, Existing Drainage Plans, Sheet 5
STA: 52+90 to 53+90
Location: West of Active Freight Line
Length: 100 ft
Width: 10 ft
Depth: 0.25 ft

Refer to Appendix A, Existing Drainage Plans, Sheet 13
STA: 147+50 to 149+25
Location: West of Active Freight Line
Length: 175 ft
Width: 20 ft
Depth: 0.75 ft



Refer to Appendix A, Existing Drainage Plans, Sheet 13
STA: 145+00 to 146+00
Location: West of Active Freight Line
Length: 100 ft
Width: 15 ft
Depth: 0.50 ft

Refer to Appendix A, Existing Drainage Plans, Sheet 16
STA: 192+10 to 192+40
Location: West of Active Freight Line
Length: 230 ft
Width: 20 ft
Depth: 0.75 ft

Refer to Appendix A, Existing Drainage Plans, Sheet 18

STA: 229+50 to 229+60

Location: Between SR 0611 and Abandoned Rail Line

Length: 10 ft

Width: 5 ft

Depth: 0.25 ft

Passenger Rail Study
Drainage Catalog:

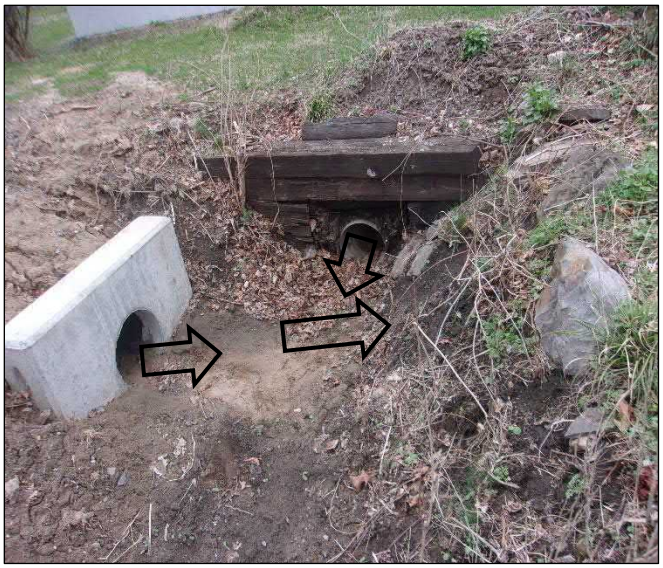
Other Noteworthy Drainage Features

Flow Exit Point from Swale

Drainage Feature:

ID: Swale West of Active Freight Line
Station: 217+00 to 226+50
Length: 950 ft
Width: 5 to 10 ft
Depth: 1 to 2 ft

Refer to Appendix A, Existing Drainage Plans, Sheet 18

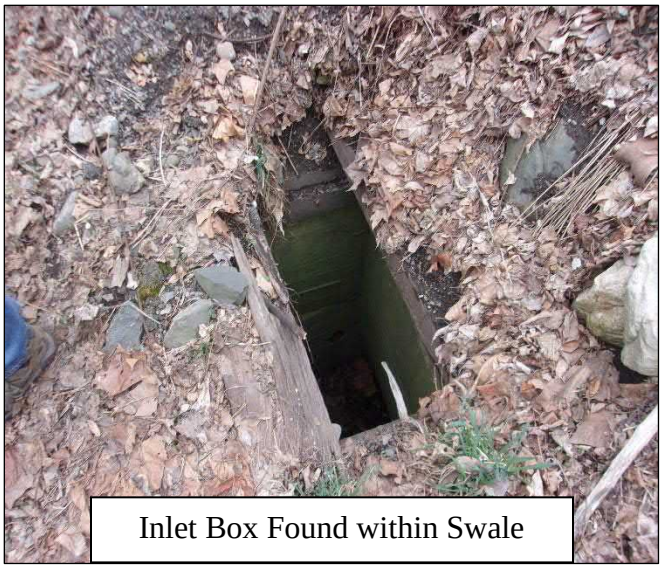


Drainage Feature:

ID: Swale West of Abandoned Rail Line
Station: 206+00 to 238+00
Length: 32,000 ft
Width: 5 to 10 ft
Depth: 0.5 to 2 ft

Refer to Appendix A, Existing Drainage Plans, Sheets 17-19

Stone Wall Along Swale



Inlet Box Found within Swale

Stone Masonry Wall Along Swale

Drainage Feature:

ID: Erosion Near Delaware River Bridge
Station: 244+00 to 246+00
Length: 200 ft
Width: 5 to 30 ft

Refer to Appendix A, Existing Drainage Plans, Sheets 17-19

Scour Hole Downstream of Pipes 22, 23, 24

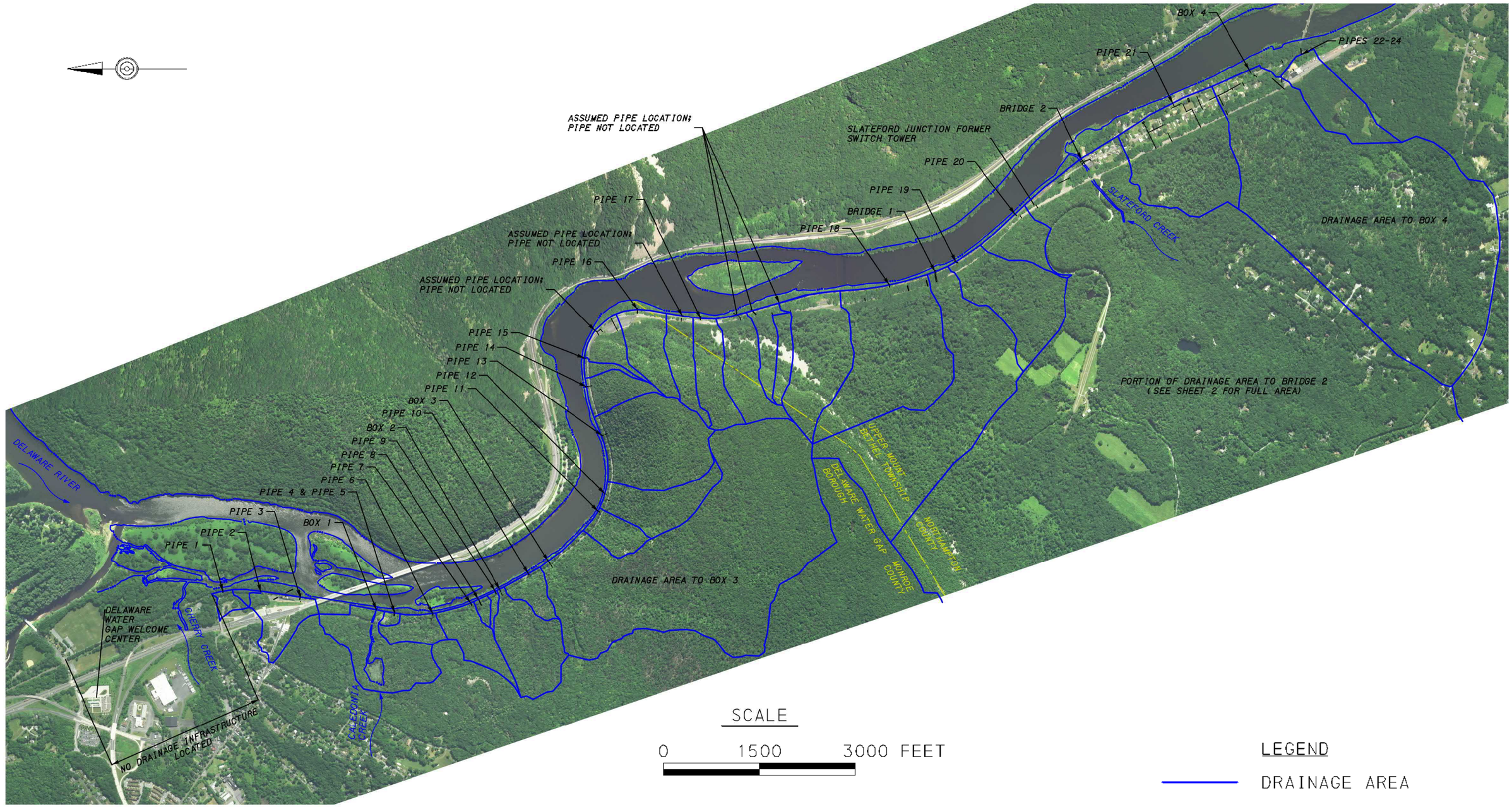
Flow Directed At Delaware Bridge Pier

Retaining Walls East of Slateford Road

Channel Downstream of Pipes 22, 23, 24

APPENDIX E.4

DRAINAGE AREA MAPS



SCALE

0 1500 3000 FEET

LEGEND

DRAINAGE AREA

NOTE: DRAINAGE AREAS ARE IDENTIFIED BY THE ID OF THE STRUCTURE OR PIPE.

DRAINAGE AREA MAP

PASSENGER RAIL STUDY
DELAWARE WATER GAP BOROUGH, MONROE COUNTY
UPPER MOUNT BETHEL TOWNSHIP, NORTHAMPTON COUNTY

GPI
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777
TELE: 570.342.3700
FAX: 570.342.4080
www.gpinet.com

DWG: JSC | CKD: PAK

SCALE

0 1500 3000 FEET

DRAINAGE AREA MAP

PASSENGER RAIL STUDY
DELAWARE WATER GAP BOROUGH, MONROE COUNTY
UPPER MOUNT BETHEL TOWNSHIP, NORTHAMPTON COUNTY

LEGEND

DRAINAGE AREA

NOTE: DRAINAGE AREAS ARE IDENTIFIED BY THE ID OF THE STRUCTURE OR PIPE.

SHEET 2 OF 2

DWG: JSC	CKD: PAK

GPI
Greenman-Pedersen, Inc.
52 GLENMAURA NATIONAL BLVD.
SUITE 302, P.O. BOX 5777
SCRANTON, PA 18505-5777
TEL: 570.342.3700
FAX: 570.342.4080
www.gpinet.com

APPENDIX E.5

DRAINAGE CAPACITY CALCULATIONS

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/18/2019
CHECK BY:	PAK	DATE	6/26/2019

DRAINAGE CAPACITY ANALYSIS

Drainage areas were delineated with the use of LiDAR contours and tabulated below. Pipes were grouped based on diameter and color-coded based on drainage area size. Flows were computed for one pipe within each drainage area size group, and the ratio of that pipe's flow to its drainage area was applied to the other pipes in its group, to determine an approximate flow for each. For parallel pipes, such as Pipes 4 and 5, the computed flow was divided between the number of pipes equally. The flows to each box and arch were calculated as well.

All Structures

ID	Drainage Area (ac)	Diameter (in)	2-yr Discharge (cfs)	10-yr Discharge (cfs)
Pipe 1	2.97	16	1.3	1.7
Pipe 2*	1.2	16	0.5	0.7
Pipe 3	14.85	48	4.8	6.9
Box 1	31.56	36 x 26	9.1	12.6
Pipe 4 & Pipe 5	1.24	16	0.6	0.7
Pipe 6	8.53	16	3.8	4.9
Pipe 7	15.14	16	4.8	7.0
Pipe 8	1.93	16	0.9	1.1
Pipe 9	1.48	16	0.7	0.9
Box 2	28.66	32 x 26	8.3	11.5
Pipe 10	7.73	20	3.5	4.5
Box 3	209.38	66 x 48	60.3	83.8
Pipe 11	9.89	24	4.4	5.7
Pipe 12	23.35	18	6.7	9.3
Pipe 13	49.58	20	14.3	19.8
Pipe 14	10.71	21	3.4	5.0
Pipe 15	2.62	20	1.2	1.5
Pipe 16	17.77	18	5.7	8.2
Pipe 17	31.95	24	9.2	12.8
Pipe 18	76.58	12	22.1	30.6
Bridge 1	111.16	192 x 72	32.0	44.5
Pipe 19	41.16	21	11.9	16.5
Pipe 20	13.99	24	4.5	6.5
Bridge 2	1919	180 x 120	552.7	767.6
Pipe 21	59.37	18	17.1	23.7
Box 4	273.14	34 x 42	78.7	109.3
Pipes 22, 23, and 24	25.92	24	7.5	10.4
Pipe 25	14.87	48	4.8	6.9
Arch 1	241.93	48 x 36	69.7	96.8
Pipe 26	19.6	24	6.3	9.1
Pipe 27	4.42	18	2.0	2.5
Pipe 28	15.7	18	5.0	7.3
Arch 2	23.5	30 x 24	6.8	9.4
Pipe 29	5.47	18	1.8	2.5
Pipe 30	6.27	18	2.0	2.9

12" - 18" Pipes

ID	Drainage Area (ac)	Diameter (in)
Pipe 1	2.97	16
Pipe 2	1.2	16
Pipe 4 & Pipe 5	1.24	16
Pipe 6	8.53	16
Pipe 7	15.14	16
Pipe 8	1.93	16
Pipe 9	1.48	16
Pipe 12	23.35	18
Pipe 16	17.77	18
Pipe 18	76.58	12
Pipe 21	59.37	18
Pipe 27	4.42	18
Pipe 28	15.7	18
Pipe 29	5.47	18
Pipe 30	6.27	18

20" - 24" Pipes

ID	Drainage Area (ac)	Diameter (in)
Pipe 10	7.73	20
Pipe 11	9.89	24
Pipe 13	49.58	20
Pipe 14	10.71	21
Pipe 15	2.62	20
Pipe 17	31.95	24
Pipe 19	41.16	21
Pipe 20	13.99	24
Pipes 22, 23, and 24	25.92	24
Pipe 26	19.6	24

48" Pipes

ID	Drainage Area (ac)	Diameter (in)
Pipe 3	14.85	48
Pipe 25	14.87	48

Drainage Area Size	Pipe Analyzed	Drainage Area (ac)	Discharge (cfs) 2-year	Discharge (cfs) 10-year	Discharge/Drainage Area Ratio (cfs/ac) 2-year	Discharge/Drainage Area Ratio (cfs/ac) 10-year
Less than 10 acres	Pipe 10	7.73	3.5	4.5	0.448	0.576
10 to 20 acres	Pipe 7	15.14	4.8	7.0	0.320	0.464
Greater than 20 acres	Pipe 13	49.58	14.3	19.8	0.288	0.400

Notes:

The pipes chosen to represent each drainage area size group are surrounded by bold borders.

*Pipe size assumed

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Input

Time of Concentration

Pipe 10 DA **7.73 ac**

Sheet Flow

Rainfall Region	5
2-Year, 24 hour rainfall (in)	3.4
Surface Type	Woods, Dense Underbrush
Manning's Roughness Coefficient	0.8
Flow Length (ft)	100
Top Elevation (ft)	702
Bottom Elevation (ft)	690
Slope (ft/ft)	0.12
Subtotal (min)	**17.71**

Shallow Concentrated Flow

Segment Number	Land Cover	Length (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft)	Velocity (fps)	Time (min)
1	Unpaved	610	690	492	0.32	8.99	1.13
2	Unpaved	140	492	338	1.10	25.61	0.09
3							
4							
						Subtotal (min)	**1.22**

Channel Flow (Mannings Equation)

Channel Segment	Length (ft)	n	base (ft)	Z1 (x:1)	Z2(X:1)	depth (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft	Area (SF)	WP (ft)	Rh	V (fps)	Time (min)
1	190	0.1	4	2	2	1	338	312	0.14	6.00	8.47	0.71	4.38	0.72
2														
3														
4														
													Subtotal (min)	**0.72**
													Total Time of Concentration (min)	**20**

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Pipe 7 DA **15.14 ac**

Sheet Flow

Rainfall Region	5
2-Year, 24 hour rainfall (in)	3.4
Surface Type	Woods, Dense Underbrush
Manning's Roughness Coefficient	0.8
Flow Length (ft)	100
Top Elevation (ft)	651
Bottom Elevation (ft)	646
Slope (ft/ft)	0.05
Subtotal (min)	**25.14**

Shallow Concentrated Flow

Segment Number	Land Cover	Length (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft)	Velocity (fps)	Time (min)
1	Unpaved	780	646	560	0.11	4.39	2.96
2							
3							
4							
						Subtotal (min)	**2.96**

Channel Flow (Mannings Equation)

Channel Segment	Length (ft)	n	base (ft)	Z1 (x:1)	Z2(X:1)	depth (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft	Area (SF)	WP (ft)	Rh	V (fps)	Time (min)
1	1010	0.1	4	2	2	1	560	338	0.22	6.00	8.47	0.71	5.55	3.03
2														
3														
4														
													Subtotal (min)	**3.03**
													Total Time of Concentration (min)	**32**

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Pipe 13 DA **49.58 acres**

Sheet Flow

Rainfall Region	5
2-Year, 24 hour rainfall (in)	3.4
Surface Type	Woods, Dense Underbrush
Manning's Roughness Coefficient	0.8
Flow Length (ft)	100
Top Elevation (ft)	1300
Bottom Elevation (ft)	1298
Slope (ft/ft)	0.02
Subtotal (min)	**36.27**

Shallow Concentrated Flow

Segment Number	Land Cover	Length (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft)	Velocity (fps)	Time (min)
1	Unpaved	1670	1298	348	0.57	14.22	1.96
2							
3							
4							
						Subtotal (min)	**1.96**

Channel Flow (Mannings Equation)

Channel Segment	Length (ft)	n	base (ft)	Z1 (x:1)	Z2(X:1)	depth (ft)	Top Elevation (ft)	Bottom Elevation (ft)	Slope (ft/ft	Area (SF)	WP (ft)	Rh	V (fps)	Time (min)
1	190	0.017	4	10	2	0.5	342	340	0.01	3.50	10.14	0.35	4.42	0.72
2														
3														
4														
													Subtotal (min)	**0.72**
													Total Time of Concentration (min)	**39**

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

KEY
Input

Intensity - Pipe 10 Drainage Area

Determine the rainfall duration of the storms to be analyzed. For the rational method, the required storm duration is equal to the time of concentration.

Time of Concentration, t_c = **20** **min.**

From PennDOT Pub. 584 Table 7A.1, determine Rainfall Region Map.

Freq.	Map
1 yr	A
2 yr	A
5 yr	A
10 yr	A
25 yr	C
50 yr	C
100 yr	C

Table 7A.1 Appropriate Rainfall Region Map for each Storm Duration and Frequency

	Frequency							
Duration	1 year	2 year	5 year	10 year	25 year	50 year	100 year	500 year
5 min	C	C	C	C	B	B	B	-
10 min	C	C	C	C	C	C	C	-
15 min	A	A	A	A	C	C	C	-
30 min	A	A	A	A	A	C	C	-
60 min	A	A	A	A	A	C	C	-
2 hr	E	E	E	E	E	E	E	-
3 hr	E	E	E	E	E	E	E	-
6 hr	D	D	D	D	D	D	D	-
12 hr	F	F	F	F	F	F	F	-
24 hr	F	F	F	F	F	F	F	F

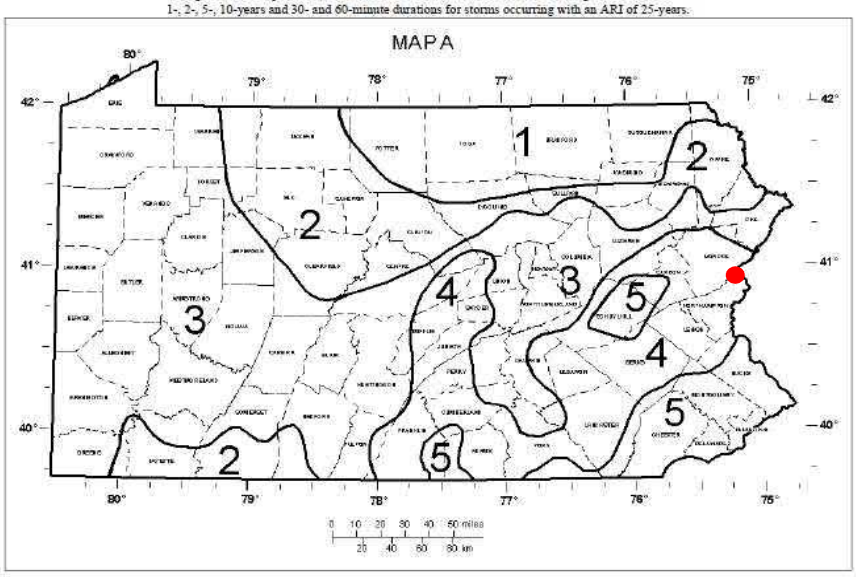
NOTE: For the analysis of the drainage pipes, events larger than the 10-year are not being considered. Therefore, only Map A has been included.

Indicate area of interest on the relevant map(s) of PennDOT Pub. 584 Figures 7A.1 through 7A.6.

Chapter 7, Appendix A - Field Manual for Pennsylvania Design Rainfall Intensity Charts from NOAA Atlas 14 Version 3 Data

Publication 584
2010 Edition

Figure 7A.1 Map A. 15-, 30- and 60-minute durations for storms occurring with an ARI of 1-, 2-, 5-, 10-years and 30- and 60-minute durations for storms occurring with an ARI of 25-years.



7A - 9

Project Location Region = 4

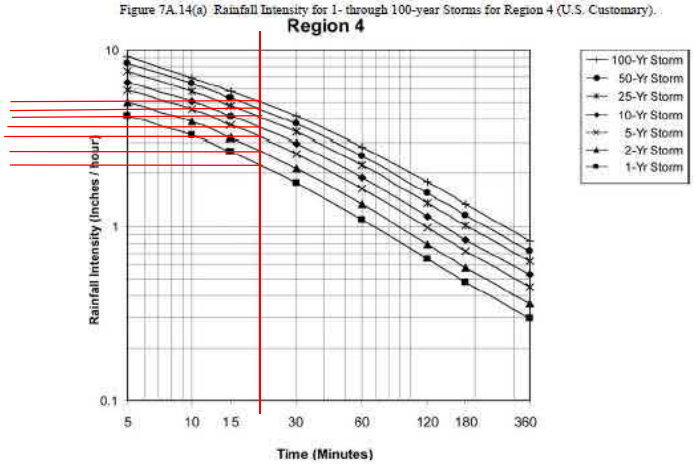
GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Return Period (yr)	*Intensity (in/hr)*
100	*5.00*
50	*4.60*
25	*4.10*
10	*3.60*
5	*3.20*
2	*2.80*
1	*2.10*

Figure 7A.14(a) Rainfall Intensity for 1- through 100-year Storms for Region 4 (U.S. Customary).



GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

KEY
Input

Intensity - Pipe 7 Drainage Area

Determine the rainfall duration of the storms to be analyzed. For the rational method, the required storm duration is equal to the time of concentration.

Time of Concentration, t_c = **32** **min.**

From PennDOT Pub. 584 Table 7A.1, determine Rainfall Region Map.

Freq.	Map
1 yr	A
2 yr	A
5 yr	A
10 yr	A
25 yr	A
50 yr	C
100 yr	C

Table 7A.1 Appropriate Rainfall Region Map for each Storm Duration and Frequency

	Frequency							
Duration	1 year	2 year	5 year	10 year	25 year	50 year	100 year	500 year
5 min	C	C	C	C	B	B	B	-
10 min	C	C	C	C	C	C	C	-
15 min	A	A	A	A	C	C	C	-
30 min	A	A	A	A	A	C	C	-
60 min	A	A	A	A	A	C	C	-
2 hr	E	E	E	E	E	E	E	-
3 hr	E	E	E	E	E	E	E	-
6 hr	D	D	D	D	D	D	D	-
12 hr	F	F	F	F	F	F	F	-
24 hr	F	F	F	F	F	F	F	F

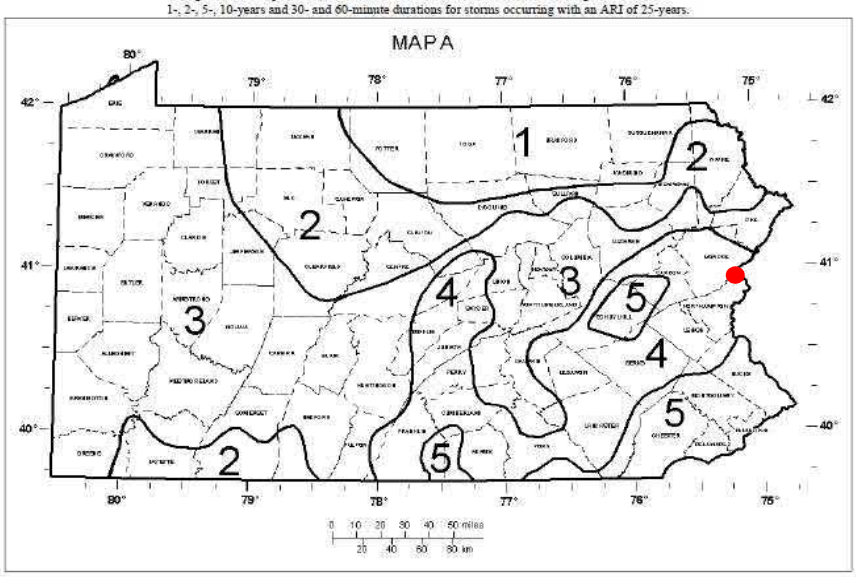
NOTE: For the analysis of the drainage pipes, events larger than the 10-year are not being considered. Therefore, only Map A has been included.

Indicate area of interest on the relevant map(s) of PennDOT Pub. 584 Figures 7A.1 through 7A.6.

Chapter 7, Appendix A - Field Manual for Pennsylvania Design Rainfall Intensity Charts from NOAA Atlas 14 Version 3 Data

Publication 584
2010 Edition

Figure 7A.1 Map A. 15-, 30- and 60-minute durations for storms occurring with an ARI of 1-, 2-, 5-, 10-years and 30- and 60-minute durations for storms occurring with an ARI of 25-years.



Project Location Region = 4

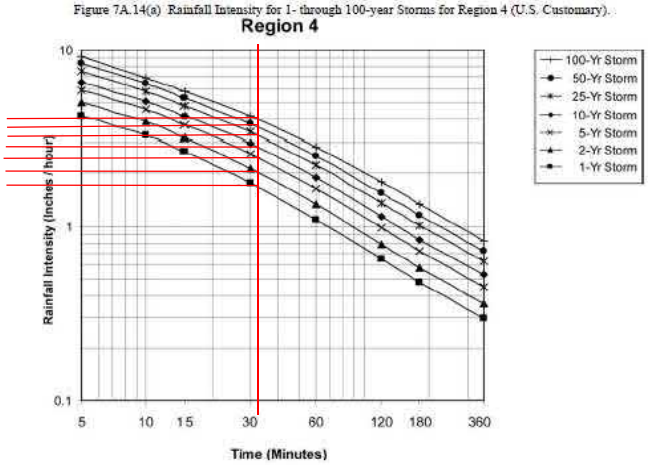
GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Return Period (yr)	*Intensity (in/hr)*
100	*4.00*
50	*3.80*
25	*3.30*
10	*2.90*
5	*2.50*
2	*2.00*
1	*1.70*

Figure 7A.14(a) Rainfall Intensity for 1- through 100-year Storms for Region 4 (U.S. Customary).



GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

KEY
Input

Intensity - Pipe 13 Drainage Area

Determine the rainfall duration of the storms to be analyzed. For the rational method, the required storm duration is equal to the time of concentration.

Time of Concentration, t_c = **39** **min.**

From PennDOT Pub. 584 Table 7A.1, determine Rainfall Region Map.

Freq.	Map
1 yr	A
2 yr	A
5 yr	A
10 yr	A
25 yr	A
50 yr	C
100 yr	C

Table 7A.1 Appropriate Rainfall Region Map for each Storm Duration and Frequency

	Frequency							
Duration	1 year	2 year	5 year	10 year	25 year	50 year	100 year	500 year
5 min	C	C	C	C	B	B	B	-
10 min	C	C	C	C	C	C	C	-
15 min	A	A	A	A	C	C	C	-
30 min	A	A	A	A	A	C	C	-
60 min	A	A	A	A	A	C	C	-
2 hr	E	E	E	E	E	E	E	-
3 hr	E	E	E	E	E	E	E	-
6 hr	D	D	D	D	D	D	D	-
12 hr	F	F	F	F	F	F	F	-
24 hr	F	F	F	F	F	F	F	F

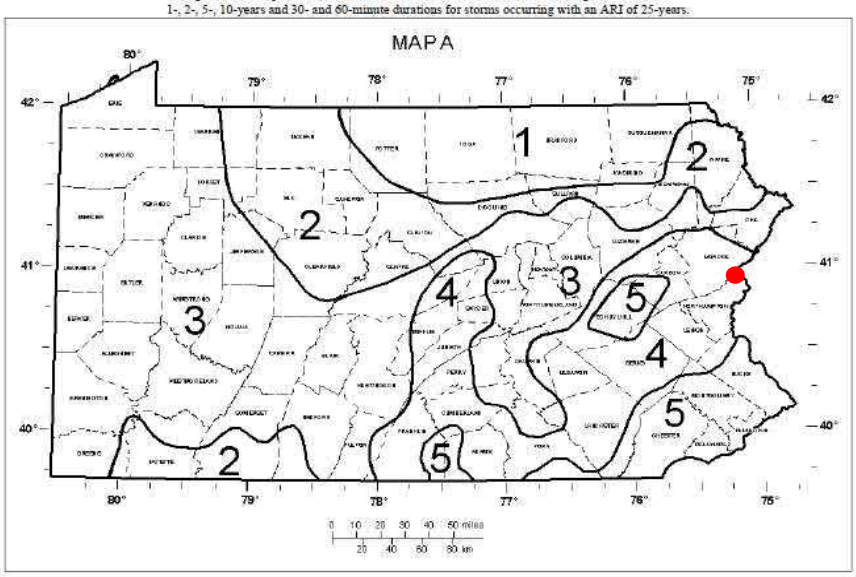
NOTE: For the analysis of the drainage pipes, events larger than the 10-year are not being considered. Therefore, only Map A has been included.

Indicate area of interest on the relevant map(s) of PennDOT Pub. 584 Figures 7A.1 through 7A.6.

Chapter 7, Appendix A - Field Manual for Pennsylvania Design Rainfall Intensity Charts from NOAA Atlas 14 Version 3 Data

Publication 584
2010 Edition

Figure 7A.1 Map A. 15-, 30- and 60-minute durations for storms occurring with an ARI of 1-, 2-, 5-, 10-years and 30- and 60-minute durations for storms occurring with an ARI of 25-years.



7A - 9

Project Location Region = 4

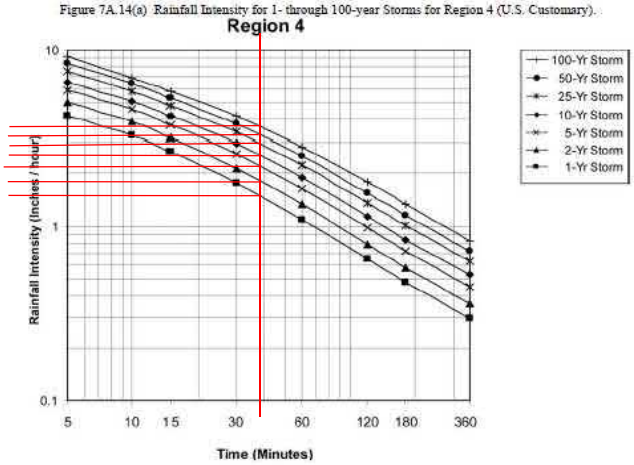
GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/13/2019
CHECK BY:	PAK	DATE	6/26/2019

Return Period (yr)	*Intensity (in/hr)*
100	*3.70*
50	*3.40*
25	*3.00*
10	*2.50*
5	*2.10*
2	*1.80*
1	*1.60*

Figure 7A.14(a) Rainfall Intensity for 1- through 100-year Storms for Region 4 (U.S. Customary).



GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME: Slateford Passenger Rail
LOCATION: Delaware Water Gap Borough
CALC BY: JSC DATE: 6/13/2019
CHECK BY: PAK DATE: 6/26/2019

Input

		Cover Type / Hydrologic Soil Group						C, Runoff Coefficient *					I, Intensity (in/hr) **					Q, Flowrate (cfs)				
		Runoff Coefficient(s)						Return Period (yr)					Return Period (yr)					Return Period (yr)				
Drainage Area/Point of Interest Name	Avg. Slope (%)	Forest / C	Open Space / D	Residential 1/4 ac Lot / A	Residential 1/4 ac Lot / C	Impervious (Waterbodies, etc)	A, Total Area (ac)	2	10	25	50	100	2	10	25	50	100	2	10	25	50	100
Pipe 10	>6%	0.16	0.28	0.29	0.36	1																
DA	Area (ac)	7.73	0	0	0	0	7.73	0.16	0.16	0.18	0.19	0.20	2.80	3.60	4.10	4.60	5.00	3.5	4.5	5.6	6.8	7.7
	>6%	0.16	0.28	0.29	0.36	1																
Pipe 7 DA	Area (ac)	15.14	0	0	0	0	15.14	0.16	0.16	0.18	0.19	0.20	2.00	2.90	3.30	3.80	4.00	4.8	7.0	8.8	11.0	12.1
Pipe 13	>6%	0.16	0.28	0.29	0.36	1																
DA	Area (ac)	49.58	0	0	0	0	49.58	0.16	0.16	0.18	0.19	0.20	1.80	2.50	3.00	3.40	3.70	14.3	19.8	26.2	32.4	36.7

**Includes Runoff Coefficient Adjustment Factor*

***See attached Intensity Backup Sheet(s)*

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/18/2019
CHECK BY:	PAK	DATE	6/26/2019

Depth of Flow in a Circular pipe/ Equivalent Pipe Diameter

Input Variables						Output Variables								
2-year Design Event														
Pipe ID	D	$Q_{2\text{-year}}$	Material	n	s [1]	Φ	A	c	S	R	Design d	Qmax	V design	Equiv Pipe Size
-	(ft)	(cfs)	(CMP / RCP)	-	(ft/ft)	(radians)	(ft^2)	(ft)	(ft)	(ft)	d (ft)	(cfs)	(ft/s)	(ft)
Pipe 1	1.33	1.33	Cast Iron	0.014	0.04	1.89	0.21	1.08	1.26	0.17	0.28	14.25	6.40	0.51
Pipe 2 [2]	1.33	0.54	Cast Iron	0.014	0.04	1.49	0.11	0.90	0.99	0.11	0.18	14.25	4.89	0.37
Pipe 3	4.00	4.75	RCP	0.012	0.04	1.19	0.53	2.25	2.38	0.22	0.34	311.23	9.04	0.82
Pipes 4 & 5 [3]	1.33	0.56	Cast iron	0.014	0.04	1.50	0.11	0.91	1.00	0.11	0.18	28.50	4.94	0.38
Pipe 6	1.33	3.82	Cast Iron	0.014	0.04	2.55	0.44	1.27	1.70	0.26	0.47	14.25	8.65	0.75
Pipe 7	1.33	4.84	Cast Iron	0.014	0.04	2.75	0.52	1.31	1.83	0.29	0.54	14.25	9.23	0.82
Pipe 8	1.33	0.86	Cast Iron	0.014	0.04	1.68	0.15	0.99	1.12	0.14	0.22	14.25	5.63	0.44
Pipe 9	1.33	0.66	Cast Iron	0.014	0.04	1.57	0.13	0.94	1.05	0.12	0.20	14.25	5.21	0.40
Pipe 10	1.67	3.46	Cast Iron	0.014	0.04	2.08	0.42	1.44	1.73	0.24	0.41	25.84	8.25	0.73
Pipe 11	2.00	4.43	CMP	0.024	0.04	2.27	0.75	1.81	2.27	0.33	0.58	24.51	5.92	0.98
Pipe 12	1.50	6.72	CMP	0.024	0.04	3.35	1.00	1.49	2.52	0.40	0.83	11.38	6.71	1.13
Pipe 13	1.67	14.28	Cast Iron	0.014	0.04	3.26	1.18	1.66	2.72	0.43	0.88	25.84	12.14	1.22
Pipe 14	1.75	3.43	CMP	0.024	0.04	2.33	0.62	1.61	2.04	0.30	0.53	17.17	5.57	0.89
Pipe 15	1.67	1.17	CMP	0.024	0.04	1.80	0.29	1.30	1.50	0.19	0.31	15.07	4.10	0.60
Pipe 16	1.50	5.69	Cast Iron	0.014	0.04	2.61	0.59	1.45	1.96	0.30	0.55	19.51	9.57	0.87
Pipe 17	2.00	9.20	Clay	0.013	0.04	2.34	0.81	1.84	2.34	0.35	0.61	45.24	11.30	1.02
Pipe 18	1.00	22.06	Cast Iron	0.014	0.04	N/A	N/A	N/A	N/A	N/A	N/A	6.62	N/A	N/A
Pipe 19	1.75	11.85	Cast Iron	0.014	0.04	2.91	1.02	1.74	2.54	0.40	0.77	29.43	11.57	1.14
Pipe 20	2.00	4.48	Cast Iron	0.014	0.04	1.95	0.51	1.66	1.95	0.26	0.44	42.01	8.71	0.81
Pipe 21	1.50	17.10	RCP	0.012	0.04	3.74	1.21	1.43	2.80	0.43	0.97	22.76	14.14	1.24
Pipes 21, 22, & 23 [3]	2.00	7.46	Cast Iron	0.014	0.04	2.25	0.74	1.81	2.25	0.33	0.57	126.04	10.10	0.97
Pipe 25	4.00	4.76	TP	0.012	0.04	1.19	0.53	2.25	2.38	0.22	0.34	311.23	9.04	0.82
Pipe 26	2.00	6.27	RCP	0.012	0.04	2.06	0.59	1.71	2.06	0.28	0.48	49.02	10.72	0.86
Pipe 27	1.50	1.98	Cast Iron	0.014	0.04	1.93	0.28	1.23	1.45	0.19	0.32	19.51	7.09	0.60
Pipe 28	1.50	5.02	CMP	0.024	0.04	3.00	0.81	1.50	2.25	0.36	0.70	11.38	6.24	1.01
Pipe 29	1.50	1.75	Cast Iron	0.014	0.04	1.87	0.26	1.21	1.40	0.18	0.30	19.51	6.84	0.57
Pipe 30	1.50	2.01	CMP	0.024	0.04	2.25	0.41	1.35	1.69	0.25	0.43	11.38	4.85	0.73

Notes:

(1) An average slope of 0.04 feet was selected based on Light Detection and Ranging (LiDAR) topographic data.

(2) Pipe 2 was assumed to be a 16" Cast Iron pipe, based on the material and size of nearby pipes.

(3) Parallel pipes were assumed to convey equal portions of the computed flow.

(4) Pipes lacking sufficient capacity to convey the design event are shown in red text with a pink highlight.

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	6/18/2019
CHECK BY:	PAK	DATE	6/26/2019

10-year Design Event

Input Variables						Output Variables									
Pipe ID	D	$Q_{10\text{-year}}$	Material	n	s [1]	Φ	A	c	S	R	Design d		Qmax	V design	Equiv Pipe Size
-	(ft)	(cfs)	(CMP / RCP)	-	(ft/ft)	(radians)	(ft^2)	(ft)	(ft)	(ft)	d (ft)		(cfs)	(ft/s)	(ft)
Pipe 1	1.33	1.71	Cast Iron	0.014	0.04	2.02	0.25	1.13	1.35	0.18	0.31		14.25	6.88	0.56
Pipe 2 [2]	1.33	0.69	Cast Iron	0.014	0.04	1.59	0.13	0.95	1.06	0.12	0.20		14.25	5.27	0.41
Pipe 3	4.00	6.89	RCP	0.012	0.04	1.31	0.68	2.43	2.61	0.26	0.41		311.23	10.11	0.93
Pipes 4 & 5 [3]	1.33	0.71	Cast Iron	0.014	0.04	1.60	0.13	0.96	1.07	0.13	0.20		28.50	5.32	0.41
Pipe 6	1.33	4.91	Cast Iron	0.014	0.04	2.76	0.53	1.31	1.84	0.29	0.54		14.25	9.26	0.82
Pipe 7	1.33	7.02	Cast Iron	0.014	0.04	3.13	0.69	1.33	2.08	0.33	0.66		14.25	10.17	0.94
Pipe 8	1.33	1.11	Cast Iron	0.014	0.04	1.80	0.18	1.04	1.20	0.15	0.25		14.25	6.07	0.48
Pipe 9	1.33	0.85	Cast Iron	0.014	0.04	1.68	0.15	0.99	1.12	0.14	0.22		14.25	5.61	0.44
Pipe 10	1.67	4.45	Cast Iron	0.014	0.04	2.23	0.50	1.50	1.86	0.27	0.47		25.84	8.86	0.80
Pipe 11	2.00	5.70	CMP	0.024	0.04	2.44	0.90	1.88	2.44	0.37	0.66		24.51	6.35	1.07
Pipe 12	1.50	9.34	CMP	0.024	0.04	3.92	1.30	1.39	2.94	0.44	1.03		11.38	7.19	1.29
Pipe 13	1.67	19.83	Cast Iron	0.014	0.04	3.78	1.52	1.58	3.15	0.48	1.09		25.84	13.06	1.39
Pipe 14	1.75	4.97	CMP	0.024	0.04	2.61	0.80	1.69	2.28	0.35	0.64		17.17	6.18	1.01
Pipe 15	1.67	1.51	CMP	0.024	0.04	1.92	0.34	1.37	1.60	0.21	0.36		15.07	4.42	0.66
Pipe 16	1.50	8.25	Cast Iron	0.014	0.04	2.96	0.78	1.49	2.22	0.35	0.68		19.51	10.58	1.00
Pipe 17	2.00	12.78	Clay	0.013	0.04	2.59	1.03	1.92	2.59	0.40	0.73		45.24	12.38	1.15
Pipe 18	1.00	30.63	Cast Iron	0.014	0.04	N/A	N/A	N/A	N/A	N/A	N/A		6.62	N/A	N/A
Pipe 19	1.75	16.46	Cast Iron	0.014	0.04	3.28	1.31	1.75	2.87	0.46	0.94		29.43	12.58	1.29
Pipe 20	2.00	6.49	Cast Iron	0.014	0.04	2.17	0.67	1.77	2.17	0.31	0.53		42.01	9.70	0.92
Pipe 21	1.50	23.75	RCP	0.012	0.04	N/A	N/A	N/A	N/A	N/A	N/A		22.76	N/A	N/A
Pipes 21, 22, & 23 [3]	2.00	10.37	Cast Iron	0.014	0.04	2.48	0.94	1.89	2.48	0.38	0.68		126.04	11.08	1.09
Pipe 25	4.00	6.90	TP	0.012	0.04	1.31	0.68	2.43	2.61	0.26	0.41		311.23	10.12	0.93
Pipe 26	2.00	9.09	RCP	0.012	0.04	2.28	0.76	1.82	2.28	0.33	0.58		49.02	11.93	0.99
Pipe 27	1.50	2.55	Cast Iron	0.014	0.04	2.07	0.33	1.29	1.55	0.22	0.37		19.51	7.63	0.65
Pipe 28	1.50	7.28	CMP	0.024	0.04	3.47	1.07	1.48	2.60	0.41	0.87		11.38	6.83	1.17
Pipe 29	1.50	2.54	Cast Iron	0.014	0.04	2.06	0.33	1.29	1.55	0.22	0.37		19.51	7.62	0.65
Pipe 30	1.50	2.91	CMP	0.024	0.04	2.51	0.54	1.43	1.88	0.29	0.52		11.38	5.39	0.83

Notes:

(1) An average slope of 0.04 feet was selected based on Light Detection and Ranging (LiDAR) topographic data.

(2) Pipe 2 was assumed to be a 16" Cast Iron pipe, based on the material and size of nearby pipes.

(3) Parallel pipes were assumed to convey equal portions of the computed flow.

(4) Pipes lacking sufficient capacity to convey the design event are shown in red text with a pink highlight.

GPI Greenman - Pedersen, Inc.

Engineers, Architects, Planners, Construction Engineers and Inspectors

PROJECT NAME	Slateford Passenger Rail		
LOCATION	Delaware Water Gap Borough		
CALC BY:	JSC	DATE	7/8/2019
CHECK BY:	LJS	DATE	7/8/2019

Conveyance Capacity of Box Culverts

Input Variables									Output Variables			
	DA	Flow (cfs)		Span	Height							
Box No.	(ac)	2-year	10-year	(ft)	(ft)	Material	n	S	Design d (ft)	A (sf)	Wp (ft)	Qmax (cfs)
1	31.56	9.1	12.6	3.0	2.2	Concrete	0.017	0.04	0.47	1.42	3.95	12.62
2	28.66	8.3	11.5	2.7	2.2	Concrete	0.017	0.04	0.49	1.30	3.64	11.46
3	209.38	60.3	83.8	5.5	4.0	Concrete	0.017	0.04	1.05	5.75	7.59	83.75
4	273.14	78.7	109.3	2.8	3.5	Stone	0.020	0.04	2.71	7.69	8.26	109.26

Note:
The Design depth (d) was determined for the 10-year flow. All boxes provide more than enough capacity for the 10-year event.

Conveyance Capacity of Arches

Input Variables									Output Variables			
	DA	Flow (cfs)		Span	Height							Sufficient
Arch No.	(ac)	2-year	10-year	(ft)	(ft)	Material	n	S	A (sf)	Wp (ft)	Qfull (cfs)	Capacity
1	241.93	69.7	96.8	4.0	3.0	Concrete	0.017	0.04	9.42	8.01	184.12	**Yes**
2	23.5	6.8	9.4	2.5	2.0	Concrete	0.017	0.04	3.93	5.24	56.81	**Yes**

Note:
Arches are assumed to be flowing full.