ATTACHMENT 21

COWANESQUE RIVER CROSSING INFORMATION

CONFIDENTIAL

- Geotechnical Investigation Report
- HDD Feasibility Report
- Inadvertent Return Plan

MARCH 22, 2024

GEOTECHNICAL INVESTIGATION REPORT

COWANESQUE HDD INVESTIGATION

WESTFIELD BOROUGH, TIOGA COUNTY, PA

Edward L. Balsavage, P.E.

Signature ________________ Date 3-22-2024

Jess D. Cogan, M.S.

Signature Jess Cogan Date 3-22-2024

Endeavor Professional Services, LLC Project No. 004240.0429

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GEOTECHNICAL INVESTIGATION REPORT
NATIONAL FUEL GAS SUPPLY CORPORATION, COWANESQUE HDD INVESTIGATION
WESTFIELD BOROUGH, TIOGA COUNTY, PENNSYLVANIA

I. A. INTRODUCTION AND BACKGROUND

This report was prepared by Endeavor Professional Services, LLC (Endeavor), on behalf of National Fuel Gas Supply Corporation, of Erie, Pennsylvania, and contains the results of a subsurface geotechnical investigation conducted at the location of a proposed Horizontal Directional Drilling (HDD) location for pipeline replacement located in Westfield Borough, Tioga County, PA. The purpose of this exploration has been to define the stratification and engineering properties of the subsurface materials beneath the footprint of the proposed HHD location for pipeline replacement. The scope of this work includes a subsurface exploration. This report summarizes the results of the work completed.

II. PROJECT NARRATIVE

A. Site Description

The project is located within Westfield Borough off State Route 49 near the intersection of Brace Road, Cowanesque, Pennsylvania. The proposed HDD locations consists of meadow and woodland. Access to the site is gained via State Route 49.

The surface elevation at the center of the proposed HDD location for pipeline replacement is approximately 1318 feet Above Mean Sea Level (AMSL). The topography across the proposed HDD location is varying with areas of approximately 32 feet of grade variation across the footprint.

B. Project Description

The project consisted of drilling four (4) test borings in the location of the proposed HDD. The borings are referenced as B-1, B-2, B-3, and B-4 on the Test Boring Location Exhibit presented in Appendix A and extended to depths ranging from approximately 50 to 100 feet below existing ground surface.

C. Geology

Based on the Pennsylvania Geologic Survey, the project site is underlain by the Lock Haven Formation Dlh. The Lock Haven Formation includes interbedded olive-gray mudstone, siltstone, sandstone, and thin conglomerate. Representative rock cores obtained from the site confirms that the site is underlain by siltstone, sandstone, conglomerate and mudstone. See Appendix D for geologic map.

D. Subsurface Investigation

In order to evaluate the subsurface conditions at the project site, a subsurface geotechnical investigation was performed at the site on February 19, 2024 through February 23, 2024. Four (4) test borings, referenced as B-1, B-2, B-3 and B-4 were drilled at the location of the proposed pipeline. The approximate location of the test borings is shown on the Test Boring Location Exhibit presented in Appendix A.

The test borings each extended until the target depth was achieved. The test borings were advanced using a track mounted drill rig equipped with hollow stem augers and split spoon samplers. The split spoon samples were conducted in accordance with ASTM D1586 and were recovered throughout the test boring. Standard Penetration Test (SPT) values were recorded for each soil sample. SPT values are the number of blows required to drive a 2 inch (outer-diameter), split barrel sampler 2 feet using a 140-pound weight dropped 30 inches. The number of blows required to advance the sampler over the 12-inch interval from 6 to 18 inches is considered the "N" value.

Auger/casing refusal on the underlying bedrock surface was encountered at depths ranging from approximately 24 to 56 feet below surface elevation. B-4 did not encounter auger refusal, SPT testing was conducted to the target depth of 50.0’. Rock core sampling was performed at the locations of B-1, B-2, and B-3.

Additional details regarding the soils encountered, the soil and rock samples obtained, and other subsurface information obtained in the test boring program can be found within the Test Boring Logs, presented in Appendix B.

SOILS

Stratum I was encountered at ground surface in each test boring and extended to the bedrock surface with the exception of test boring B-4. This stratum varied in gradation and plasticity. The test boring logs and laboratory testing should be consulted for detailed descriptions of stratum I. In general, stratum I consisted of brown to tan clayey silt, brown to tan silty clay, brown/ brown to tan fine sand and brown silt with varying secondary constituent amounts of fine sand and rock fragments.

BEDROCK

Auger/casing refusal was encountered at approximately 24 to 56 feet below grade. Thirty-eight (38) rock cores, referenced C-1 through C-38 were extracted from the test borings. The cores showed that the bedrock consisted of highly fractured sandstone, mudstone, siltstone, and glacial till. Following the coring operation the percent recovery and rock quality designation (RQD) were determined for the core samples retrieved. Percent recovery (%REC) is calculated by dividing the actual length of the rock core retained from the core barrel by the total length of the rock core run and multiplying by

100. RQD is calculated by summing the total of all the rock fragments in the core run greater than or equal to four (4) inches in length and dividing by the total length of the rock core run and multiplying by 100. Percent recoveries and the rock quality designations of the bedrock cores are provided in Table 1 below. A photo exhibit of the rock cores is located in Appendix F.

Table 1

BEDROCK CORING RESULTS

Location	**Core Depth**	**%REC**	**RQD**
C-1, B-1	24-26’6”	50%	13%
C-2, B-1	26’6”-31’	62%	10%
C-3, B-1	31’-36’	3%	0%
C-4, B-1	36’-41’	3%	0%
C-5, B-1	41’-46’	42%	0%
C-6, B-1	46’-51’	3%	0%
C-7, B-1	51’-56’	10%	0%
C-8, B-1	56’-61’	25%	7.5%
C-9, B-1	61’-66’	0%	0%
C-10, B-1	66’-71’	100%	0%
C-11, B-1	71’-76’	100%	50%
C-12, B-1	76’-81’	100%	97%
C-13, B-1	81’-86’	100%	63%
C-14, B-1	86’-91’	100%	82%
C-15, B-1	91’-96’	100%	63%
C-16, B-1	96’-100’	100%	79%
C-17, B-2	7’6”- 10’6”	23%	0%
C-18, B-2	10’6”-15’6”	5%	0%
C-19, B-2	56’-61’	45%	7%
C-20, B-2	61’-66’	100%	47%
C-21, B-2	66’-71’	100%	68%
C-22, B-2	71’-76’	100%	73%
C-23, B-2	76’-81’	100%	92%
C-24, B-2	81’-86’	100%	85%
C-25, B-2	86’-91’	100%	92%
C-26, B-2	91’-96’	100%	55%
C-27, B-2	96’-100’	100%	100%
C-28, B-3	49’6”-51’6”	21%	0%
C-29, B-3	51’6”-56’6”	40%	15%
C-30, B-3	56’6”-61’6”	7%	0%
C-31, B-3	61’6”-66’6”	7%	0%
C-32, B-3	66’6”-71’6”	20%	0%
C-33, B-3	71’6”-76’6”	100%	52%

C-34, B-3	76’6”-81’6”	100%	38%
C-35, B-3	81’6”-86’6”	100%	75%
C-36, B-3	86’6”-91’6”	100%	85%
C-37, B-3	91’6”-96’6”	100%	38%
C-38, B-3	96’6”-100’	100%	72%

GROUNDWATER

Groundwater was encountered only in all four (4) Borings. Groundwater water was encountered at B-1 at approximately 15.0’ below existing grade (Elevation: 1315.30’). Groundwater was encountered at B-2 at approximately 2.0’ below existing grade (Elevation: 1316.11’). Groundwater was encountered at B-3 at approximately 5.0’ below existing grade (Elevation: 1315.35’). Groundwater was encountered at B-4 at approximately 28.0’ below existing grade (Elevation: 1321.88’). These observations were made at the time of the test boring operation, and groundwater table elevations will vary with daily, seasonal, and climatological conditions.

E. Laboratory Testing

Representative samples of the subsurface materials encountered in the test borings were subjected to laboratory analysis. The laboratory test results are presented in Appendix C.

F. Limitations

This report has been prepared in accordance with generally accepted geotechnical design practices for specific application to this project. The conclusions and recommendations contained in this report are based upon the subsurface data obtained in the test borings. Soil conditions may vary widely from location to location and from point to point on the project site. The validity of the conclusions and recommendations contained in this report are necessarily limited by the scope of the field investigation and by the number of test borings that were made. It is understood that the number of test locations made are consistent with good engineering practice but, given the nature of subsurface conditions, there is a possibility that actual conditions encountered may differ significantly from those projected in this report.

The scope of this investigation was limited to the evaluation of the subsoils. Oil, hazardous waste, radioactivity, irritants, pollutants, radon or other dangerous substances and conditions were not the subject of this study. Their presence and/or absence are not implied, inferred or suggested by this report or results of this study.

G. Acid Producing Rock

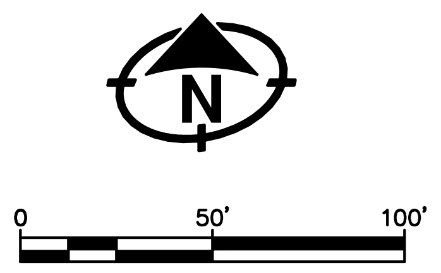
A desktop investigation was completed on the Cowanesque HDD Investigation site referencing DCNR’s Geologic Units Containing Potentially Significant Acid-Producing Sulfide Minerals. It was found that the Cowanesque HDD Investigation site is not located within a known acid producing rock formation. The Exhibit in Appendix E depicts the location of the site in relation to acid producing rock formations. While the site is not located in a known acid producing rock formation, Endeavor Professional Services, LLC does not warrant that acid producing rock is not present on the site.

END OF SECTION

APPENDIX A
TEST BORINGS LOCATION EXHIBIT AND LOCATION MAP

#	DESC.	LATITUDE	LONGITUDE
1	B–1	N41.9237674	W77.5155889
2	B–2	N41.9244685	W77.5153712
3	B–3	N41.9254588	W77.5162532
4	B–4	N41.9269885	W77.5165724

COORDINATE DATA



DRAWING
EXH-BOR
SHEET NO.
1 OF 1
PROJECT: 004240.0429
LAST REVISED BY

PROJ. MGR.: CCC
DESIGN: JDC
CADD: KML
CHECKED: CCC
SCALE: 1" = 50'
DATE: 2024.03.18

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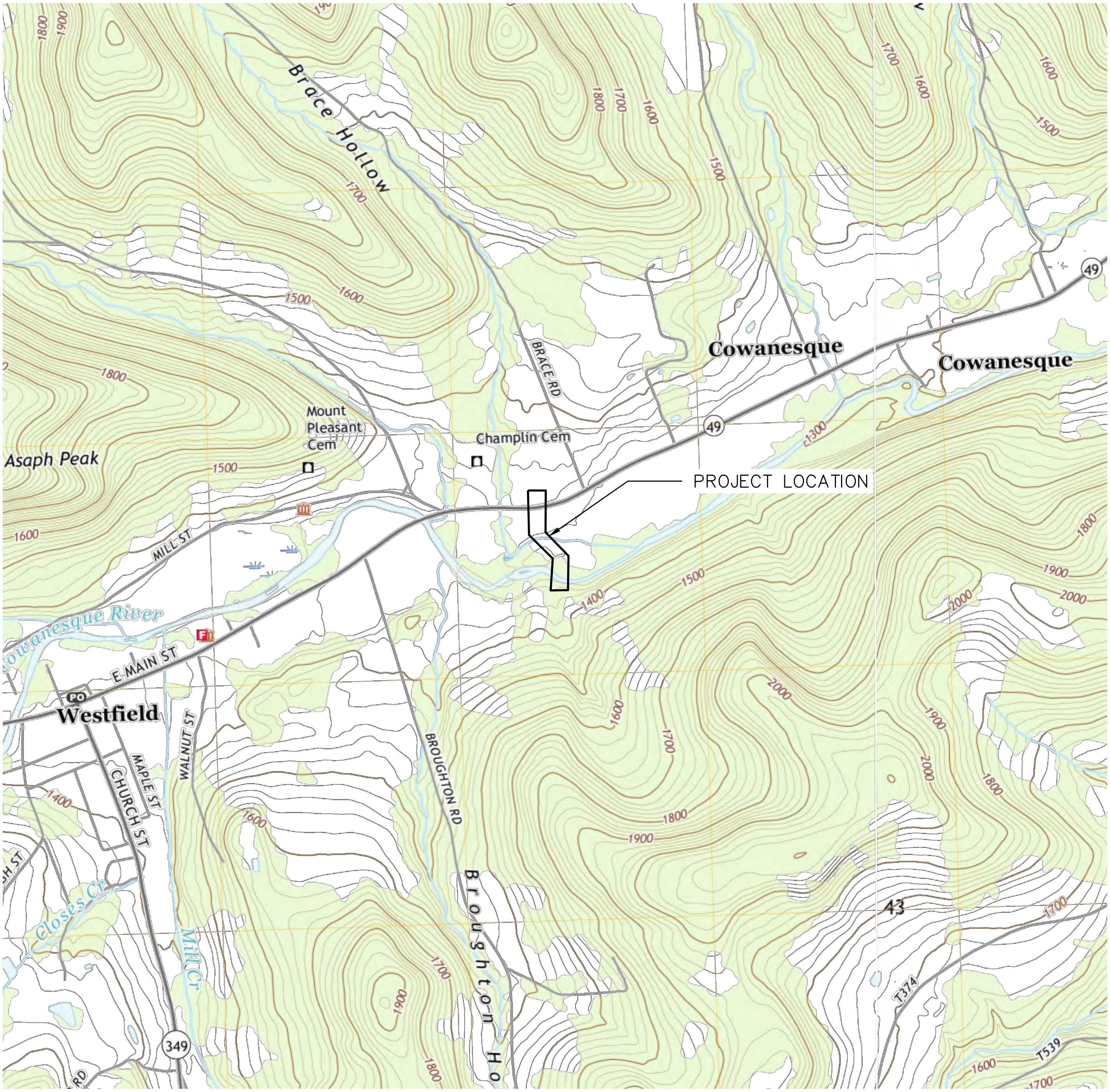
PREPARED FOR:
national Fuel
NATIONAL FUEL GAS
1100 STATE STREET
ERIE, PA 16501

BORING EXHIBIT
FOR THE
COWANESQUE HDD INVESTIGATION

WESTFIELD BOROUGH **TIOGA COUNTY** **PENNSYLVANIA**

File name: P:\004240_NFG\0429 Cowanesque HDD Investigation\C3D\Plan Sets\EXH\G0042400429EXH_BOR.dwg Layout:Layout1 Mar 22, 2024–10:35am klepionka



GRAPHIC SCALE

2,000' 1,000' 0' 2,000'

SCALE: 1"= 2,000'

QUAD NAME: POTTER BROOK, PA

File name: P:\004240_NFG\0429 Cowanesque HDD Investigation\C3D\Plan Sets\G0042400429CV.dwg Layout:LOCATION MAP Feb 22, 2024–1:29pm klepionka

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LOCATION MAP
FOR THE
COWANESQUE HDD INVESTIGATION

WESTFIELD BOROUGH TIOGA COUNTY PENNSYLVANIA

PROJ. MGR. – CCC
DESIGN– JDC
CADD– KML
CHECKED– CCC
SCALE– 1" = 2000'
DATE– 2024.02.22

DRAWING NO.
LM
SHEET NO.
01 OF 01
PROJECT 004240.0429

APPENDIX B
TEST BORING LOGS

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-1

PROJECT NUMBER: 004240.0429 CLIENT: National Fuel Gas Corporation

LOCATION: 41.9237674, -77.5155889

☒ FIELD SURVEYED ☐ TOPO ESTIMATE

TOP OF GROUND: 1330.30'

GROUNDWATER DATA: Present

ELEV: 1315.30' Time: 4 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	
0		0-2'	2-4-4-4		Brown to tan clayey silt and rock fragments	**Topsoil - 0"**
		2-4'	5-2-2-10		Brown to tan clayey silt and rock fragments	
5		4-6'	6-7-12-13		Brown to tan clayey silt and rock fragments	
		6-8'	25-17-18-19		Brown to tan clayey silt and rock fragments	
10		8-10'	13-12-9-9		Brown to tan silty clay and Rock fragments	
15		13-15'	28-25-16-15		Brown to tan silt and rock fragments	
20		18-20'	8-9-12-20		Brown to tan silt and rock fragments	
25		23-25'	28-50/3		Brown to tan silt and rock fragments SPT Refusal at 23' 9"	Auger Refusal at 24.0'

Rock Core 24'-26'6"
Coring Time - 4 min
% Recovery - 50%
RQD - 13%

After rock core 24'-26'6", core barrel was getting obstructed. Auger was put back down to try to seal off sand/silt.

Auger Refusal at 27'6"

Rock Core 27'6"-31'
Coring Time - 10 min
% Recovery - 62%
RQD - 10%

Rock Core 31'-36'
Coring Time - 3 min
% Recovery - 3%
RQD - 0%

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RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: February 19, 2024

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: Cowanesque Creek HDD Investigation
BORING NO.: B-1
PROJECT NUMBER: 004240.0429 CLIENT: National Fuel Gas Corporation
LOCATION: 41.9237674, -77.5155889
☒ FIELD SURVEYED ☐ TOPO ESTIMATE

TOP OF GROUND: 1330.30'
GROUNDWATER DATA: Present
ELEV: 1315.30' Time: 4 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	

Rock Core 36'-41'
Coring Time - 7 min
% Recovery - 3%
RQD - 0%

Rock Core 41'-46'
Coring Time - 32 min
% Recovery - 42%
RQD - 0%

Rock Core 46'-51'
Coring Time - 6 min
% Recovery - 3%
RQD - 0%

Rock Core 51'-56'
Coring Time - 7 min
% Recovery - 10%
RQD - 0%

Rock Core 56'-61'
Coring Time - 12 min
% Recovery - 25%
RQD - 7.5%

Rock Core 61'-66' Casing Refusal at 66'
Coring Time - 4 min
% Recovery - 0%
RQD - 0%

Rock Core 66'-71'
Coring Time - 14 min
% Recovery - 100%
RQD - 0%

RIG TYPE: Acker XLS Track Rig
DRILLING METHOD: Hollow Stem Auger
ENDEAVOR REPRESENTATIVE: G. LaBar
DATE DRILLED: February 19, 2024

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-1

PROJECT NUMBER: 004240.0429 CLIENT: National Fuel Gas Corporation

TOP OF GROUND: 1330.30'

LOCATION: 41.9237674, -77.5155889

GROUNDWATER DATA: Present

☒ FIELD SURVEYED ☐ TOPO ESTIMATE

ELEV: 1315.30' Time: 4 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	

Rock Core 71'-76'
Coring Time - 6 min
% Recovery - 100%
RQD - 50%

Rock Core 76'-81'
Coring Time - 7 min
% Recovery - 100%
RQD - 97%

Rock Core 81'-86'
Coring Time - 8 min
% Recovery - 100%
RQD - 63%

Rock Core 86'-91'
Coring Time - 8 min
% Recovery - 100%
RQD - 82%

Rock Core 91'-96'
Coring Time - 9 min
% Recovery - 100%
RQD - 63%

Rock Core 96'-100'
Coring Time - 8 min
% Recovery - 100%
RQD - 79%

End of Boring 100 Feet

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RIG TYPE: Acker XLS Track Rig
DRILLING METHOD: Hollow Stem Auger
ENDEAVOR REPRESENTATIVE: G. LaBar
DATE DRILLED: February 19, 2024

TEST BORING LOG

SHEET 1 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-2

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9244685, -77.5153712

☒ FIELD SURVEYED

☐ TOPO ESTIMATE

TOP OF GROUND: 1318.11'

GROUNDWATER DATA: Present

ELEV: 1316.11'

Time: 2 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	
0		0-2'	7-8-9-4		Brown to tan fine sand and rock fragments	**Topsoil 0"**
		2-4'	4-7-9-20		Brown to tan fine sand and rock fragments	
5		4-6'	11-27-10-36		Brown to tan fine sand and rock fragments trace brown to tan clayey silt	
		6-8'	50/1		Brown to tan fine sand and rock fragments SPT Refusal at 6' 1"	
					Casing Refusal at 7' 6"	
20		18-20'	16-20-34-26		Brown to tan clayey silt and rock fragments little fine sand	
25		23-25'	18-32-29-37		Brown silt and rock fragments	
30		28-30'	50/1		No recovery SPT refusal at 28' 1"	
35		33-35'	21-33-48-13		Rock fragments and gray silt little fine sand	
40		38-40'	28-28-36-50/3		Brown to tan fine sand and rock fragments SPT Refusal at 39' 9"	
45		43-45'	18-20-29-36		Brown to tan clayey silt and rock fragments	
50		48-50'	18-27-32-25		Brown to tan clayey silt and rock fragments	
55		53-55'	22-50/1		Brown to tan clayey silt and rock fragments SPT Refusal 53' 7"	
					Casing Refusal at 56.0'	

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RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: February 22, 2024

TEST BORING LOG

SHEET 2 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-2

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9244685, -77.5153712

☒ FIELD SURVEYED ☐ TOPO ESTIMATE

TOP OF GROUND: 1318.11'

GROUNDWATER DATA: Present

ELEV: 1316.11' Time: 2 hours

Rock Core 7'6"-10'6"
Coring Time - 4 min
% Recovery - 23%
RQD - 0%

Rock Core 10'6"-15'6"
Coring Time - 4 min
% Recovery - 5%
RQD - 0%

Rock Core 56'-61'
Coring Time - 24 min
% Recovery - 45%
RQD - 7%

Rock Core 61'-66'
Coring Time - 10 min
% Recovery - 100%
RQD - 47%

Rock Core 66'-71'
Coring Time - 9 min
% Recovery - 100%
RQD - 68%

Rock Core 71'-76'
Coring Time - 10 min
% Recovery - 100%
RQD - 73%

Rock Core 76'-81'
Coring Time - 7 min
% Recovery - 100%
RQD - 92%

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RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: February 22, 2024

TEST BORING LOG

SHEET 2 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-2

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9244685, -77.5153712

☒ FIELD SURVEYED ☐ TOPO ESTIMATE

TOP OF GROUND: 1318.11'

GROUNDWATER DATA: Present

ELEV: 1316.11' Time: 2 hours

Rock Core 81'-86'
Coring Time - 8 min
% Recovery - 100%
RQD - 85%

Rock Core 86'-91'
Coring Time - 8 min
% Recovery - 100%
RQD - 92%

Rock Core 91'-96'
Coring Time - 11 min
% Recovery - 100%
RQD - 55%

Rock Core 96'-100'
Coring Time - 8 min
% Recovery - 100%
RQD - 100%

End of Boring 100 Feet

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www.endeavorpros.com

RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: February 22, 2024

TEST BORING LOG

SHEET 1 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-3

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9254588, -77.5162532

☒ FIELD SURVEYED

☐ TOPO ESTIMATE

TOP OF GROUND: 1320.35'

GROUNDWATER DATA: Present

ELEV: 1315.35'

Time: 2 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	
0		0-2'	4-5-8-8		Brown fine sand and rock fragments	**Topsoil 3"**
		2-4'	8-11-8-9		Brown clayey silt and rock fragments	
5		4-6'	14-11-7-12		Brown fine sand some brown clayey silt little rock fragments	
		6-8'	10-6-8-5		Brown fine sand some brown clayey silt little rock fragments	
10		8-10'	9-14-12-16		Brown fine sand some brown clayey silt little rock fragments	
15		13-15'	15-16-14-15		Gray silty clay some rock fragments little fine sand	
20		18-20'	33-21-14-20		Brown to tan fine sand and rock fragments	
25		23-25'	50/5		Brown to tan silty clay and rock fragments SPT Refusal at 23' 5"	
30		28-30'	13-13-13-13		Rock fragments little brown fine sand	
35		33-35'	10-8-18-20		Gray clay and rock fragments	
40		38-40'	14-18-14-12		Rock fragments little brown to gray silty clay	
45		43-45'	15-10-10-18		Brown to gray silt	
50		48-50'	50/5		Rock fragments some brown to tan fine sand trace brown silty clay SPT Refusal at 48'5"	

Casing Refusal at 49' 6"

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RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: 2/20&21/2024

TEST BORING LOG

SHEET 2 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-3

PROJECT NUMBER: 004240.0429 CLIENT: National Fuel Gas Corporation

LOCATION: 41.9254588, -77.5162532

☒ FIELD SURVEYED

TOP OF GROUND: 1320.35'

GROUNDWATER DATA: Present

ELEV: 1315.35' Time: 2 hours

Rock Core 49'6"-51'6"
Coring Time - 4 min
% Recovery - 21%
RQD - 0%

Rock Core 51'6"-56'6"
Coring Time - 8 min
% Recovery - 40%
RQD - 15%

Rock Core 56'6"-61'6"
Coring Time - 4 min
% Recovery - 7%
RQD - 0%

Rock Core 61'6"-66'6"
Coring Time - 5 min
% Recovery - 7%
RQD - 0%

Rock Core 66'6"-71'6"
Coring Time - 5 min
% Recovery - 20%
RQD - 0%

Rock Core 71'6"-76'6"
Coring Time - 7 min
% Recovery - 100%
RQD - 52%

Rock Core 76'6"-81'6"
Coring Time - 10 min
% Recovery - 100%
RQD - 38%

RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: 2/20&21/2024

TEST BORING LOG

SHEET 2 OF 2

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-3

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9254588, -77.5162532

☒ FIELD SURVEYED ☐

TOP OF GROUND: 1320.35'

GROUNDWATER DATA: Present

ELEV: 1315.35' Time: 2 hours

Rock Core 81'6"-86'6"
Coring Time - 8 min
% Recovery - 100%
RQD - 75%

Rock Core 86'6"-91'6"
Coring Time - 10 min
% Recovery - 100%
RQD - 85%

Rock Core 91'6"-96'6"
Coring Time - 9 min
% Recovery - 100%
RQD - 38%

Rock Core 96'6"-100'
Coring Time - 5 min
% Recovery - 100%
RQD - 72%

End of Boring 100 Feet

RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: 2/20&21/2024

TEST BORING LOG

SHEET 1 OF 1

PROJECT NAME: Cowanesque Creek HDD Investigation

BORING NO.: B-4

PROJECT NUMBER: 004240.0429

CLIENT: National Fuel Gas Corporation

LOCATION: 41.9269885, -77.5165724

☒ FIELD SURVEYED

☐ TOPO ESTIMATE

TOP OF GROUND: 1349.88'

GROUNDWATER DATA: Present

ELEV: 1321.88'

Time: 2 hours

DEPTH (feet)	SAMPLE NUMBER	SAMPLE DEPTH (feet)	BLOWS PER 6"	RECOVERY (%)	SOIL DESCRIPTION	
0		0-2'	2-2-3-6		Brown to tan clayey silt trace rock fragments	**Topsoil 6"**
		2-4'	29-15-14-14		Brown to tan clayey silt little rock fragments	
5		4-6'	12-9-11-13		Brown to tan silty clay little rock fragments	
		6-8'	16-18-15-14		Brown to tan silty clay little rock fragments	
10		8-10'	12-11-13-12		Brown to tan silty clay little rock fragments	
15		13-15'	11-9-12-12		Brown to tan silty clay and rock fragments	
20		18-20'	8-8-11-14		Brown silty clay some rock fragments	
25		23-25'	9-9-10-16		Brown silt little rock fragments	
30		28-30'	16-14-15-20		Brown silt little rock fragments	
35		33-35'	13-14-14-15		Brown silt little rock fragments	
40		38-40'	8-10-13-20		No recovery	
45		43-45'	16-16-23-39		Brown silt little rock fragments	
		45-47'	28-29-42-40		Brown silt	
50		48-50'	25-30-38-35		Brown silt	

End of Boring 50 Feet

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2505 Green Tech Drive, Suite AB, State College, PA 16803
Office: (814) 308-8086 Email: info@endeavorpros.com
www.endeavorpros.com

RIG TYPE: Acker XLS Track Rig

DRILLING METHOD: Hollow Stem Auger

ENDEAVOR REPRESENTATIVE: G. LaBar

DATE DRILLED: February 20, 2024

APPENDIX C
LABORATORY TESTING RESULTS

PROJECT NAME Cowanesque HDD Investigation
PROJECT NUMBER 2403SL047-1
Date 7/3/2023

Boring No.	Sample Depth (ft.)	Rock Type	Sample Diam. (in)	Sample Height (in)	Load (lb)	Comp. Strength (tsf)	Failure Type	Sample Notes/ Remarks
B-1	81-86	siltstone	1.979	4.019	9590	224.5	shear	-
B-1	96-100	siltstone	1.983	4.032	15220	354.8	shear	-
B-2	61-66	siltstone	1.978	4.028	23600	553.0	shear	-
B-2	81-86	siltstone	1.984	4.025	9830	228.9	shear	-
B-2	96-100	siltstone	1.984	4.031	14230	331.4	shear	-
B-3	76.5-81.5	siltstone	1.993	4.024	8940	206.3	shear	-
B-3	86.5-91.5	fine-grained sandstone	1.997	4.028	23780	546.6	shear	-
B-3	96.5-100	fine-grained sandstone	1.999	4.026	44200	1014.0	shear	-
					Avg.	432.4		

Moisture Condition of Samples Air-dry
Temperature at Testing 72 deg.
Rate of Loading 150 lbs/sec
Direction of Load Application Vertical to core

Dimensional & Shape Tolerances not verified at client request. Results may differ from rock cores that meet ASTM D4543 tolerances.

NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

UNCONFINED COMPRESSIVE STRENGTH OF INTACT ROCK CORE

ASTM D7012-C

By: JDP Ckd: BBB

PROJECT NAME Cowanesque HDD Investigation
PROJECT NUMBER 2402SL047-1
Date 3/15/2024

Boring No.	Sample Depth (ft.)	Test Type	Sample Width (mm)	Platen Distance at Failure (mm)	Equivalent Core Diameter (Axial & Irregular Lump) D_e^2 (mm^2)	Equivalent Core Diameter (Diametral) D_e (mm)	P (max load) (lbs)	P (max load) (N)	Uncorrected Point Load Strength Is (Mpa)	Uncorrected Point Load Strength Is (psi)	Generalized Index to Strength Conversion Factor (K)	Estimated Uniaxial Strength Sc (psi)	Size Correction Factor (F)	Size Corrected Point Load Strength Index Is(50) (psi)
B-1	21.0-46.0	diametral	-	48	2448	51	4500	20017	8.18	1186	23	27277	1.01	1197
B-1	21.0-46.0	axial	51	23	1494	25	3000	13345	8.94	1296	19	24623	0.73	949
B-1	21.0-46.0	diametral	-	50	2550	51	1120	4982	1.95	283	23	6517	1.01	286
B-1	61.0-76.0	axial	51	23	1494	25	1300	5783	3.87	562	19	10670	0.73	411
B-1	61.0-76.0	diametral	-	50	2550	51	1200	5338	2.09	304	23	6983	1.01	306
B-1	61.0-76.0	axial	51	20	1299	23	1500	6672	5.14	745	19	14158	0.71	525
B-1	81.0-86.0	diametral	-	50	2550	51	640	2847	1.12	162	23	3724	1.01	163
B-1	96.0-100.0	axial	51	23	1494	24	760	3381	2.26	328	19	6238	0.72	236
B-2	7.0-57.0	diametral	-	48	2448	51	360	1601	0.65	95	23	2182	1.01	96
B-2	7.0-57.0	axial	51	21	1364	24	2400	10676	7.83	1135	19	21574	0.72	816
B-2	7.0-57.0	diametral	-	49	2499	51	2700	12010	4.81	697	23	16032	1.01	703
B-2	61.0-66.0	axial	51	24	1558	25	1400	6228	4.00	580	19	11012	0.73	424
B-2	81.0-86.0	diametral	-	50	2550	51	580	2580	1.01	147	23	3375	1.01	148
B-2	96.0-100.0	axial	51	23	1494	25	1040	4626	3.10	449	19	8536	0.73	329
B-3	49.0-66.0	diametral	-	48	2448	51	3800	16903	6.90	1001	23	23034	1.01	1010
B-3	49.0-66.0	axial	51	25	1623	26	880	3914	2.41	350	19	6645	0.75	261
B-3	49.0-66.0	diametral	-	49	2499	51	3000	13345	5.34	775	23	17814	1.01	781
B-3	76.5-81.5	axial	51	25	1623	27	820	3648	2.25	326	19	6192	0.76	247
B-3	86.5-91.5	diametral	-	49	2499	51	5300	23576	9.43	1368	23	31471	1.01	1381
B-3	96.5-100.0	axial	51	23	1494	24	1180	5249	3.51	510	19	9685	0.72	366
													Avg.	487

Sample Details:

Remarks:

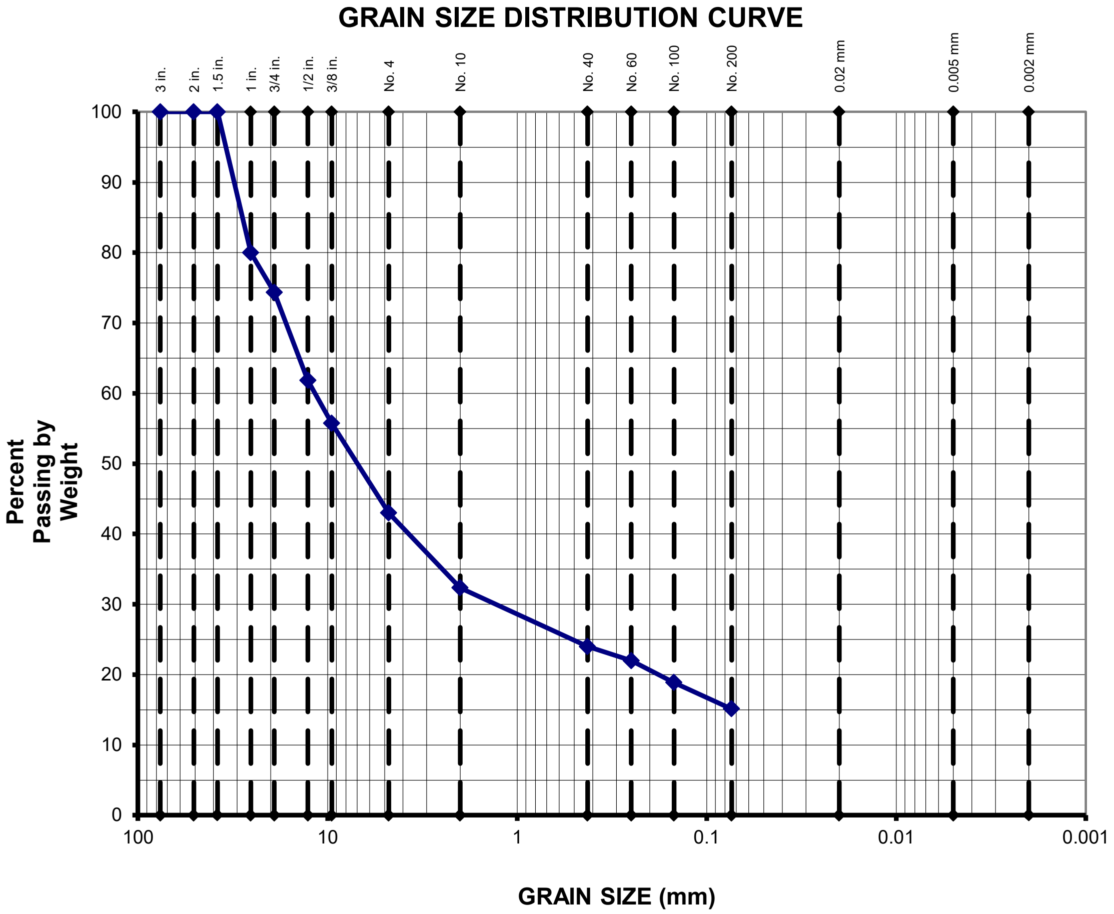
NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

AASHTO R18

POINT LOAD STRENGTH OF ROCK

ASTM D5731

By: JDP Ckd: BBB



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
57.0%		27.9%			15.1%	
25.6%	31.4%	10.6%	8.4%	8.9%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
67.7%			17.2%		15.1%	
20.0%	24.2%	23.4%	8.4%	8.9%	-	-

AASHTO

Project: Cowanesque HDD Investigation
Boring No.: B-1
Station: -
Offset: -
Sample No.: 1 LL = 26 % PL = 21 %
Depth: 2-4', 4-6', 6-8' ft PI = 5 % w = 13.6%
Spec. Grav.: 2.7 (assumed)

Note: dry unit weight = 103.5 pcf & wet unit weight = 117.6 pcf

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

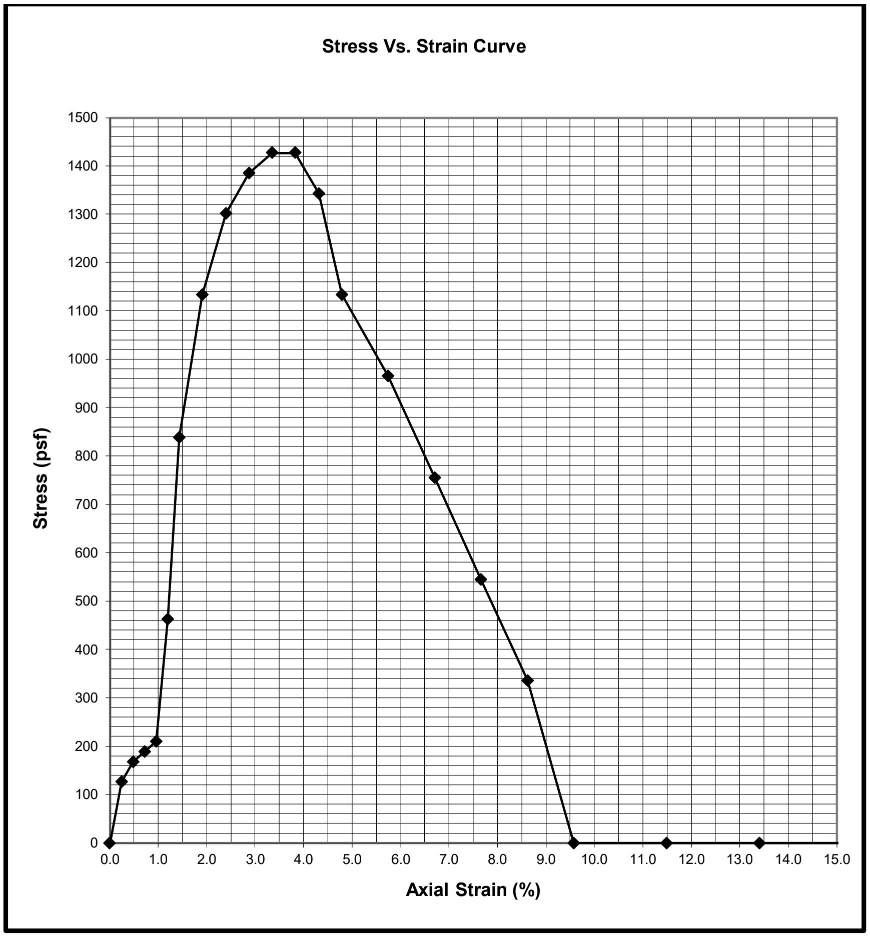
AASHTO R18

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.2	126
0.02	0.5	168
0.03	0.7	189
0.04	1.0	210
0.05	1.2	462
0.06	1.4	839
0.08	1.9	1133
0.1	2.4	1301
0.12	2.9	1385
0.14	3.4	1427
0.16	3.8	1427
0.18	4.3	1343
0.2	4.8	1133
0.24	5.7	965
0.28	6.7	755
0.32	7.7	545
0.36	8.6	336
0.4	9.6	0
0.48	11.5	0
0.56	13.4	0
0.64	15.3	0
0.72	17.2	0

Project: Cowanesque HDD Investigation
Boring No.: B-1
Station: -
Offset: -
Sample No.: 1
Depth: 2-4', 4-6', 6-8' ft
Sample Ht. (in.): 4.177 in.
Sample Dia. (in.): 2.09 in.
Ht.-Dia. Ratio %: 2.0
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 26 %   PI = 5 %
Initial Dry Density (pcf): 103.50
Initial Moisture %: 13.6
Unconfined Comp. Strength (psf) : 1427
Shear Strength (psf) : 714
Strain at Failure %: 3.8
Average Rate of Strain to Failure%: 1.6

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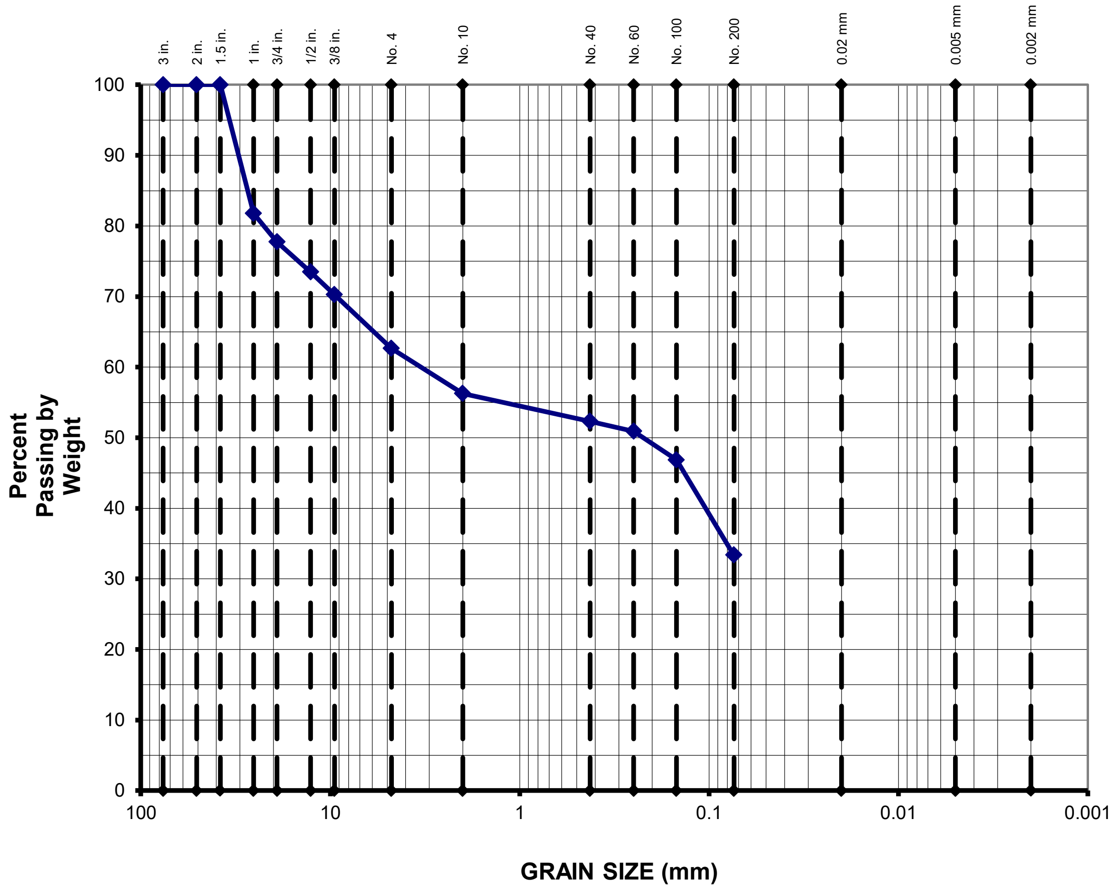
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
37.4%		29.3%			33.4%	
22.3%	15.1%	6.4%	3.9%	19.0%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
43.7%			22.9%		33.4%	
18.2%	11.5%	14.0%	3.9%	19.0%	-	-

AASHTO

Project:	Cowanesque HDD Investigation		
Boring No.:	B-1		
Station:	-		
Offset:	-		
Sample No.:	2	LL = 19 %	PL = 18 %
Depth:	13-15', 18-20', 23-25' ft	PI = 1 %	w = 15.8%
Spec. Grav.:	2.7 (assumed)		

Note: dry unit weight = 113.3 pcf & wet unit weight = 131.2 pcf

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

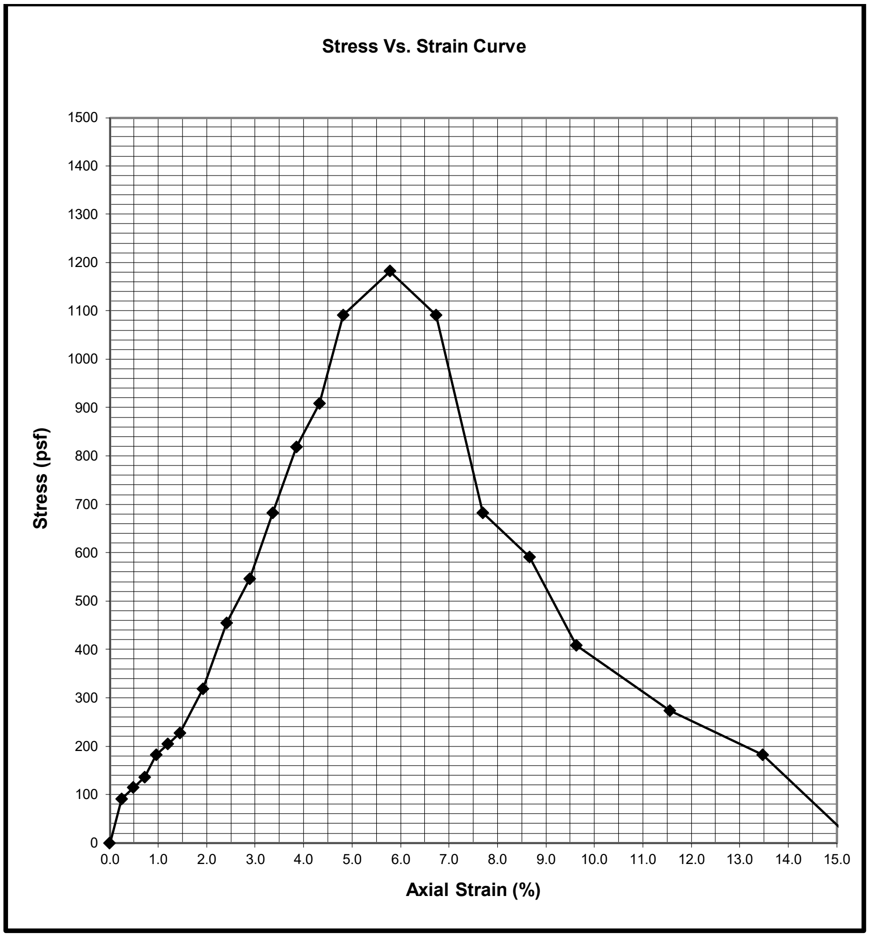
AASHTO R18

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.2	91
0.02	0.5	114
0.03	0.7	136
0.04	1.0	182
0.05	1.2	205
0.06	1.4	227
0.08	1.9	318
0.1	2.4	455
0.12	2.9	546
0.14	3.4	682
0.16	3.9	818
0.18	4.3	909
0.2	4.8	1091
0.24	5.8	1182
0.28	6.7	1091
0.32	7.7	682
0.36	8.7	591
0.4	9.6	409
0.48	11.6	273
0.56	13.5	182
0.64	15.4	0
0.72	17.3	0

Project:	Cowanesque HDD Investigation	**Soil Type:**	-
Boring No.:	B-1	**Classification:**	-
Station:	-		LL = 19 % PI = 1 %
Offset:	-	**Initial Dry Density (pcf):**	113.26
Sample No.:	2	**Initial Moisture %:**	15.8
Depth:	13-15', 18-20', 23-25' ft	**Unconfined Comp. Strength (psf) :**	1182
Sample Ht. (in.):	4.155 in.	**Shear Strength (psf) :**	591
Sample Dia. (in.):	2.008 in.	**Strain at Failure %:**	5.8
Ht.-Dia. Ratio %:	2.1	**Average Rate of Strain to Failure%:**	2.3
Test Type:	Remolded		
Description of Sample:			

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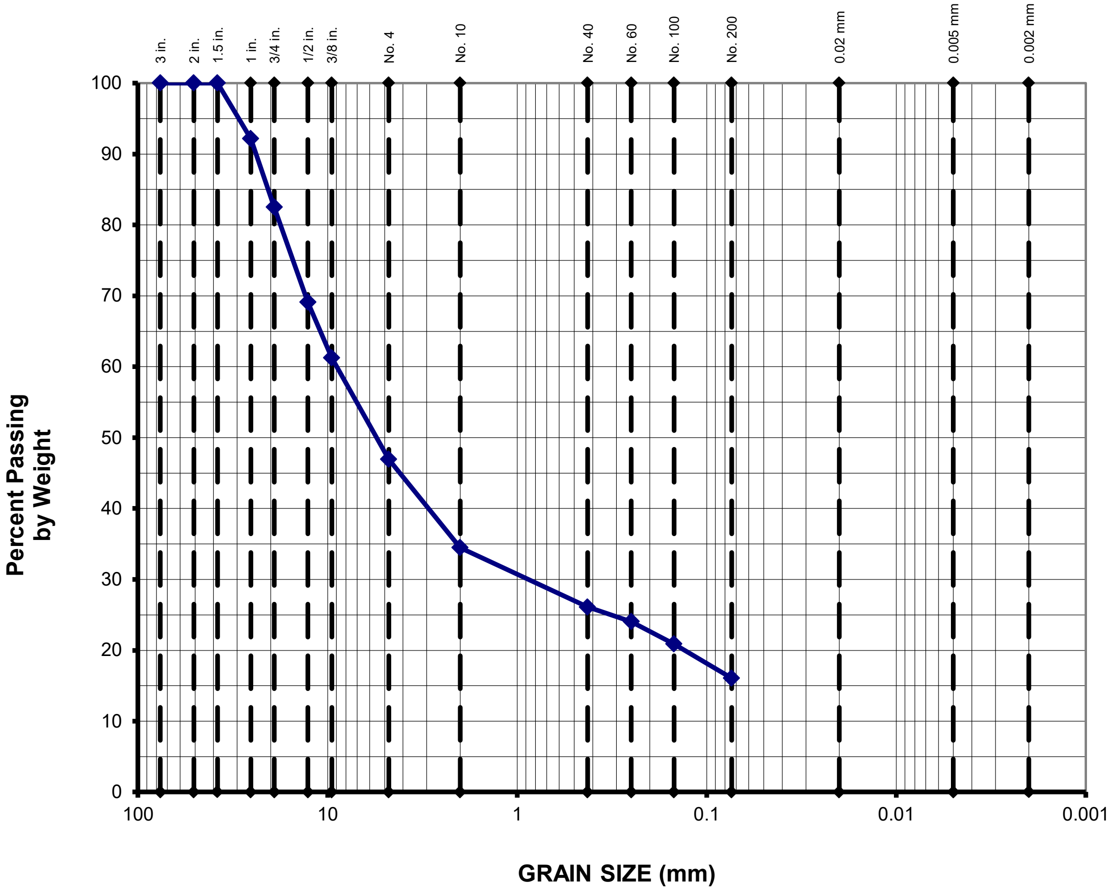
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AASHTO R18

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
53.1%		30.8%			16.1%	
17.5%	35.6%	12.5%	8.4%	10.0%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
65.5%			18.4%		16.1%	
7.9%	30.9%	26.8%	8.4%	10.0%	-	-

AASHTO

Project: Cowanesque HDD Investigation
Boring No.: B-2
Station: -
Offset: -
Sample No.: 3 LL = 22 % PL = 21 %
Depth: 4-6', 6-8', 18-20' ft PI = 1 % w = 9.9%
Spec. Grav.: 2.7 (assumed)

Note: dry unit weight = 108.8 pcf & wet unit weight = 119.6 pcf

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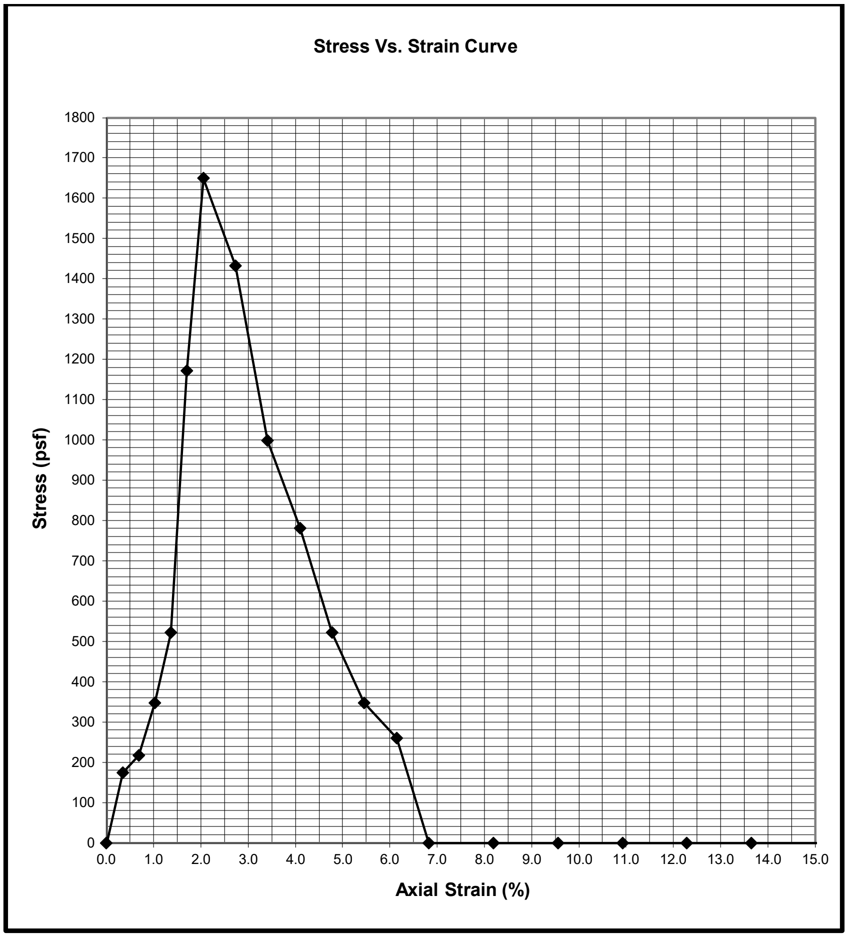
AASHTO R18

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.3	174
0.02	0.7	217
0.03	1.0	347
0.04	1.4	521
0.05	1.7	1172
0.06	2.0	1649
0.08	2.7	1432
0.1	3.4	998
0.12	4.1	781
0.14	4.8	521
0.16	5.5	347
0.18	6.1	260
0.2	6.8	0
0.24	8.2	0
0.28	9.6	0
0.32	10.9	0
0.36	12.3	0
0.4	13.7	0
0.48	16.4	0
0.56	19.1	0
0.64	21.8	0
0.72	24.6	0

Project: Cowanesque HDD Investigation
Boring No.: B-2
Station: -
Offset: -
Sample No.: 3
Depth: 4-6', 6-8', 18-20' ft
Sample Ht. (in.): 2.93 in.
Sample Dia. (in.): 2.055 in.
Ht.-Dia. Ratio %: 1.4
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 22 % PI = 1 %
Initial Dry Density (pcf): 108.78
Initial Moisture %: 9.9
Unconfined Comp. Strength (psf) : 1649
Shear Strength (psf) : 825
Strain at Failure %: 2.0
Average Rate of Strain to Failure%: 1.0

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

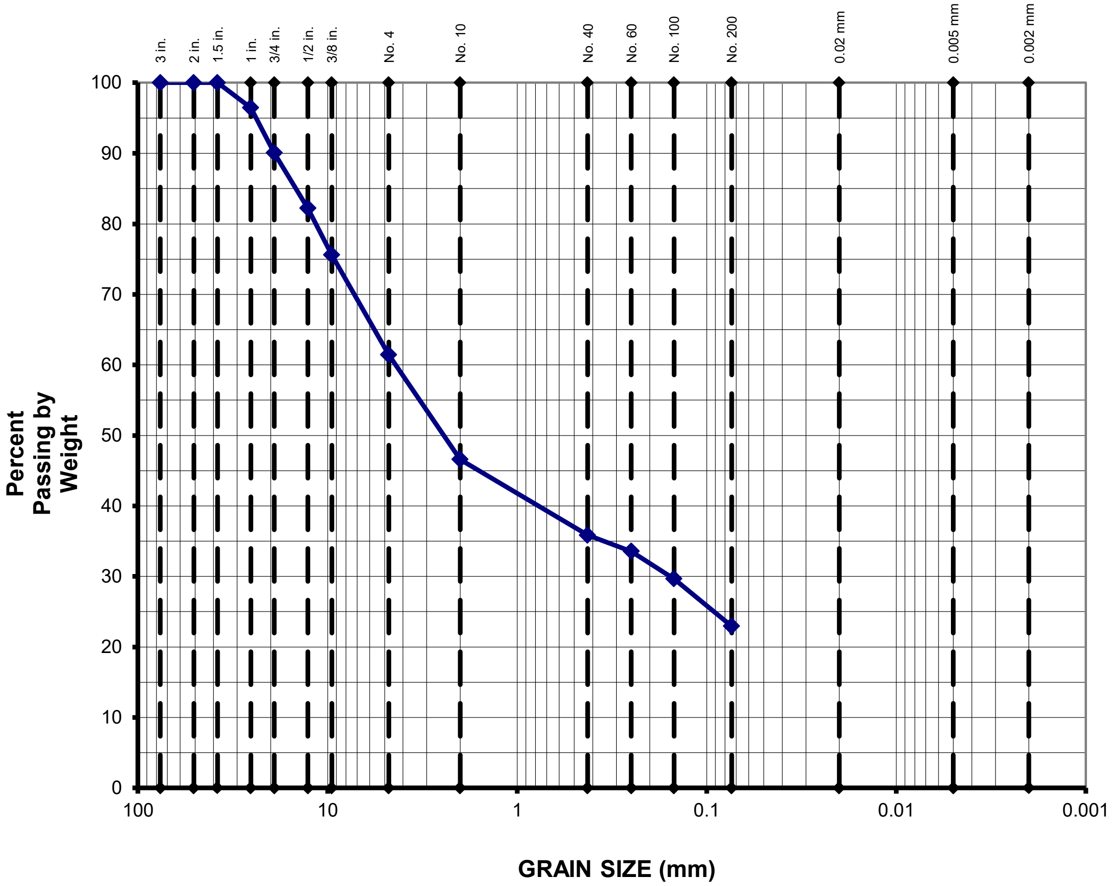
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AAP® AASHTO R18

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
38.6%		38.5%			22.9%	
9.9%	28.7%	14.8%	10.7%	12.9%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
53.4%			23.6%		22.9%	
3.5%	20.9%	29.0%	10.7%	12.9%	-	-

AASHTO

Project: Cowanesque HDD Investigation
Boring No.: B-2
Station: -
Offset: -
Sample No.: 4 LL = 20 % PL = 19 %
Depth: 43-45', 48-50', 53-55' ft PI = 1 % w = 9.8%
Spec. Grav.: 2.7 (assumed)

Note: dry unit weight = 123.9 pcf & wet unit weight = 136.0 pcf

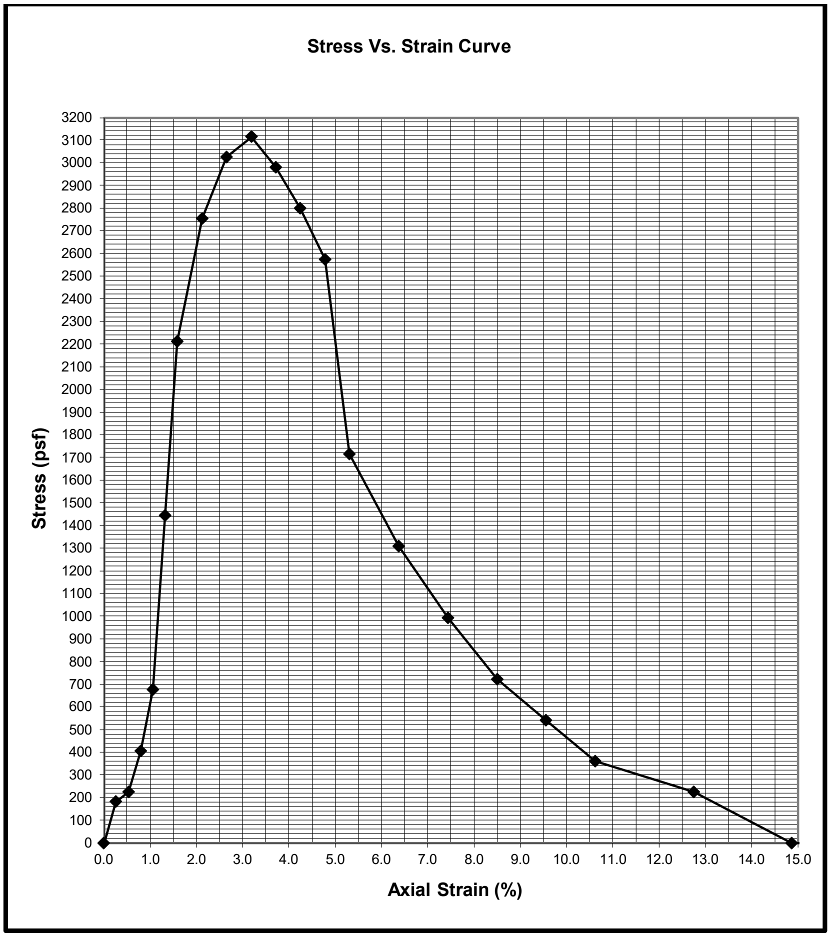
NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.3	181
0.02	0.5	226
0.03	0.8	406
0.04	1.1	677
0.05	1.3	1445
0.06	1.6	2212
0.08	2.1	2754
0.1	2.7	3025
0.12	3.2	3115
0.14	3.7	2979
0.16	4.2	2799
0.18	4.8	2573
0.2	5.3	1715
0.24	6.4	1309
0.28	7.4	993
0.32	8.5	722
0.36	9.6	541
0.4	10.6	361
0.48	12.7	225
0.56	14.9	0
0.64	17.0	0
0.72	19.1	0

Project: Cowanesque HDD Investigation
Boring No.: B-2
Station: -
Offset: -
Sample No.: 4
Depth: 43-45', 48-50', 53-55' ft
Sample Ht. (in.): 3.766 in.
Sample Dia. (in.): 2.015 in.
Ht.-Dia. Ratio %: 1.9
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 20 % PI = 1 %
Initial Dry Density (pcf): 123.89
Initial Moisture %: 9.8
Unconfined Comp. Strength (psf) : 3115
Shear Strength (psf) : 1558
Strain at Failure %: 3.2
Average Rate of Strain to Failure%: 1.4

NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

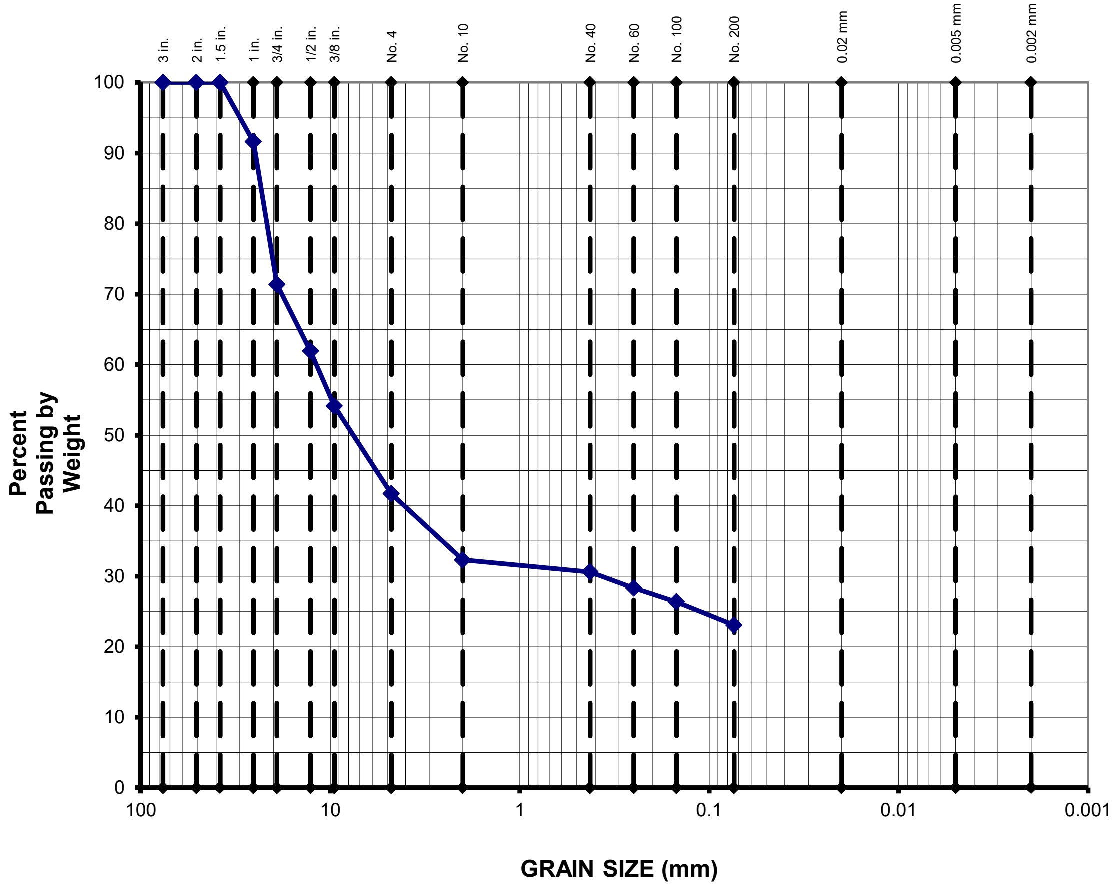
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AASHTO R18

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
58.3%		18.6%			23.0%	
28.6%	29.7%	9.4%	1.7%	7.5%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
67.7%			9.3%		23.0%	
8.4%	37.5%	21.8%	1.7%	7.5%	-	-

AASHTO

Project: Cowanesque HDD Investigation
Boring No.: B-3
Station: -
Offset: -
Sample No.: 5 LL = 21 % PL = 19 %
Depth: 4-6', 6-8', 8-10' ft PI = 2 % w = 11.7%
Spec. Grav.: 2.7 (assumed)

Note: dry unit weight = 122.1 pcf & wet unit weight = 136.4 pcf

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

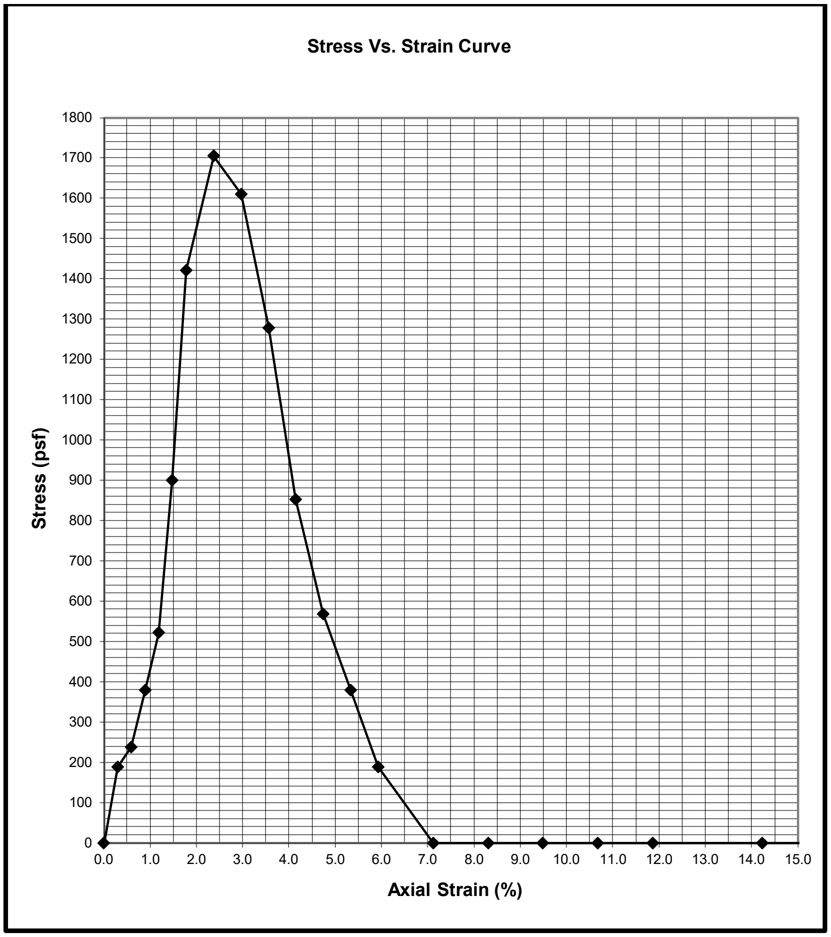
AASHTO R18

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.3	189
0.02	0.6	237
0.03	0.9	379
0.04	1.2	521
0.05	1.5	899
0.06	1.8	1420
0.08	2.4	1704
0.1	3.0	1609
0.12	3.6	1278
0.14	4.2	852
0.16	4.7	568
0.18	5.3	379
0.2	5.9	189
0.24	7.1	0
0.28	8.3	0
0.32	9.5	0
0.36	10.7	0
0.4	11.9	0
0.48	14.2	0
0.56	16.6	0
0.64	19.0	0
0.72	21.4	0

Project: Cowanesque HDD Investigation
Boring No.: B-3
Station: -
Offset: -
Sample No.: 5
Depth: 4-6', 6-8', 8-10' ft
Sample Ht. (in.): 3.372 in.
Sample Dia. (in.): 1.968 in.
Ht.-Dia. Ratio %: 1.7
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 21 % PI = 2 %
Initial Dry Density (pcf): 122.08
Initial Moisture %: 11.7
Unconfined Comp. Strength (psf) : 1704
Shear Strength (psf) : 852
Strain at Failure %: 2.4
Average Rate of Strain to Failure%: 1.1

NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

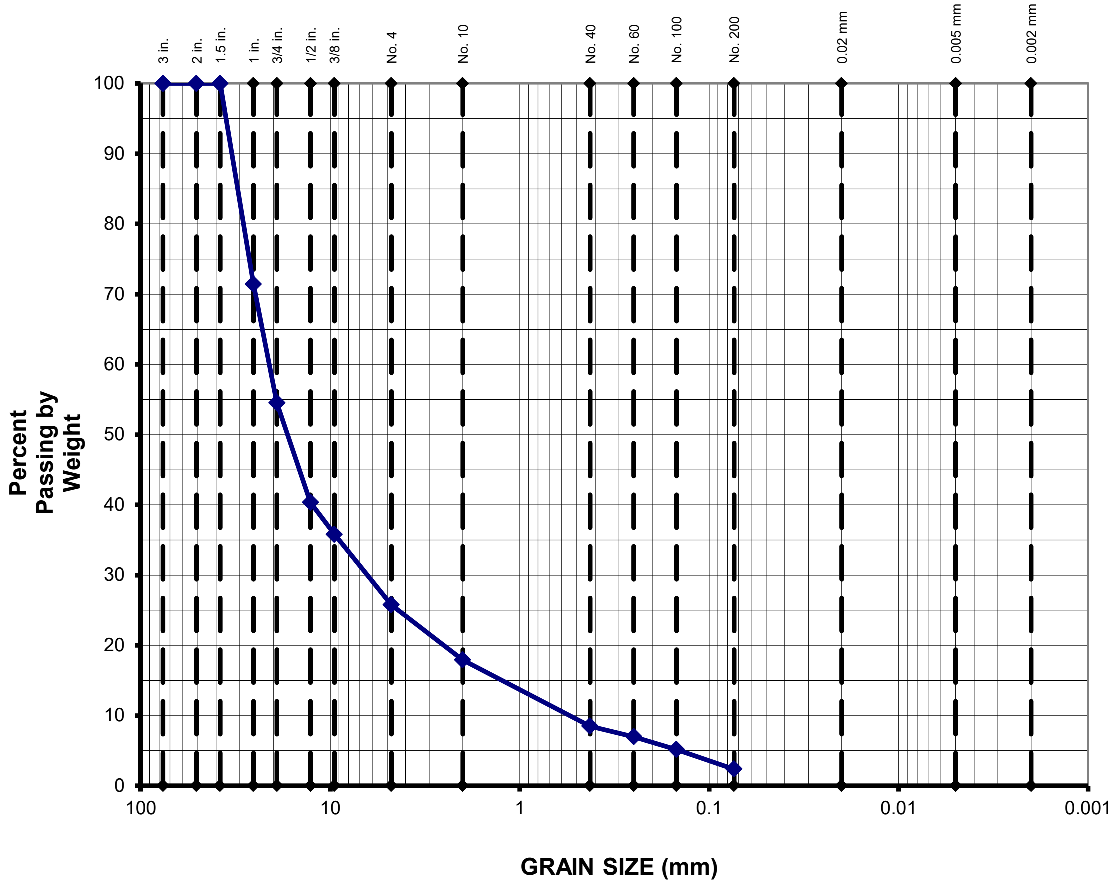
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AASHTO R18

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
74.3%		23.4%			2.4%	
45.5%	28.8%	7.8%	9.4%	6.1%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
82.1%			15.5%		2.4%	
28.6%	35.6%	17.9%	9.4%	6.1%	-	-

AASHTO

Project:	Cowanesque HDD Investigation		
Boring No.:	B-3		
Station:	-		
Offset:	-		
Sample No.:	6	LL = 21 %	PL = 19 %
Depth:	38-40', 43-45', 48-50' ft	PI = 2 %	w = 23.0%
Spec. Grav.:	2.7 (assumed)		

Note: dry unit weight = 93.0 pcf & wet unit weight = 114.4 pcf

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

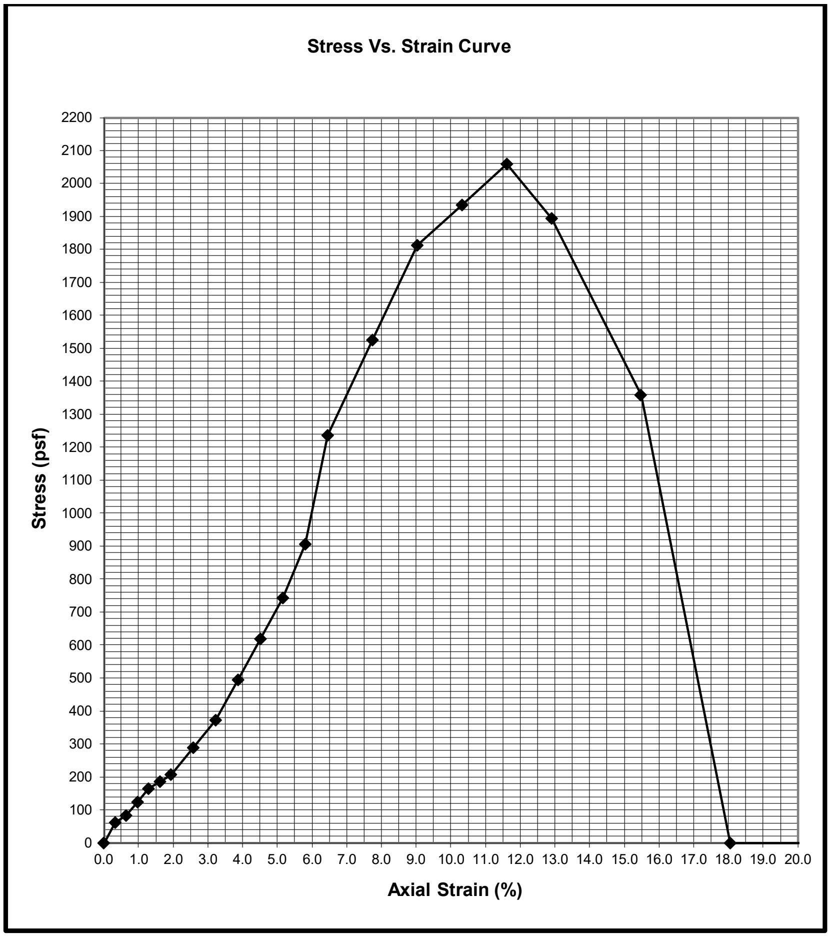
AASHTO R18

3/15/2024

Gradation Testing Results

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.3	62
0.02	0.6	82
0.03	1.0	124
0.04	1.3	165
0.05	1.6	185
0.06	1.9	206
0.08	2.6	288
0.1	3.2	371
0.12	3.9	494
0.14	4.5	618
0.16	5.2	742
0.18	5.8	906
0.2	6.4	1236
0.24	7.7	1524
0.28	9.0	1812
0.32	10.3	1935
0.36	11.6	2059
0.4	12.9	1894
0.48	15.5	1358
0.56	18.1	0
0.64	20.6	0
0.72	23.2	0

Project: Cowanesque HDD Investigation
Boring No.: B-3
Station: -
Offset: -
Sample No.: 6
Depth: 38-40', 43-45', 48-50' ft
Sample Ht. (in.): 3.101 in.
Sample Dia. (in.): 2.109 in.
Ht.-Dia. Ratio %: 1.5
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 21 % PI = 2 %
Initial Dry Density (pcf): 93.01
Initial Moisture %: 23.0
Unconfined Comp. Strength (psf) : 2059
Shear Strength (psf) : 1030
Strain at Failure %: 11.6
Average Rate of Strain to Failure%: 4.3

NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

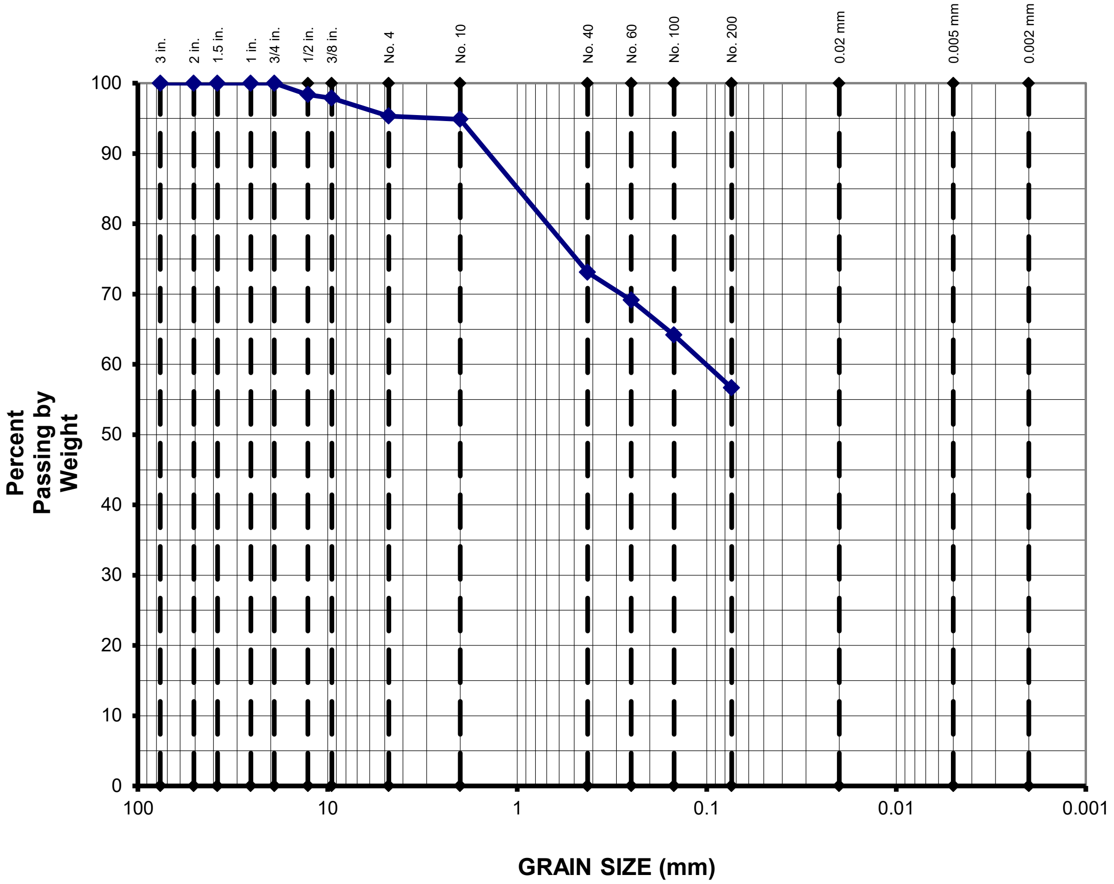
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AASHTO R18

3/15/2024

GRAIN SIZE DISTRIBUTION CURVE



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY
4.7%		38.7%			56.6%	
0.0%	4.7%	0.4%	21.8%	16.5%	-	-

USCS

GRAVEL			SAND		FINES	
COARSE	MEDIUM	FINE	COARSE	FINE	SILT	CLAY
5.1%			38.2%		56.6%	
0.0%	2.1%	3.0%	21.8%	16.5%	-	-

AASHTO

Project: Cowanesque HDD Investigation
Boring No.: B-4
Station: -
Offset: -
Sample No.: 6 LL = 22 % PL = 17 %
Depth: 28-30', 33-35', 43-45' ft PI = 5 % w = 22.4%
Spec. Grav.: 2.7 (assumed)

Note: dry unit weight = 104.0 pcf & wet unit weight = 127.3 pcf

NAVARRO & WRIGHT CONSULTING ENGINEERS, INC.

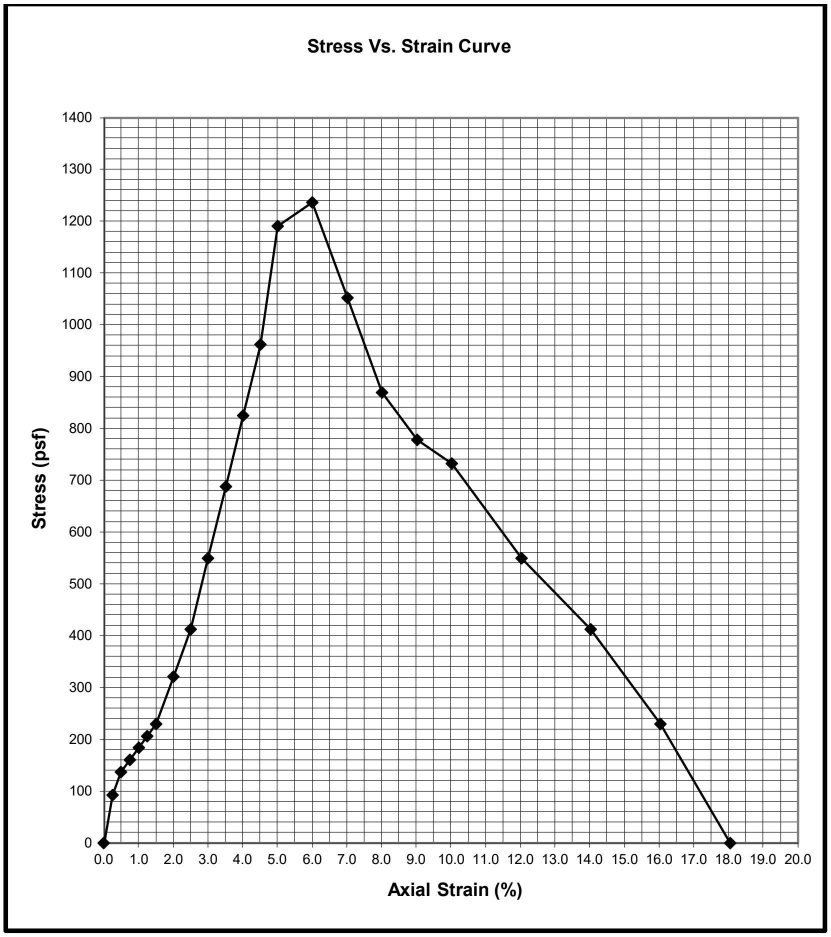
AASHTO R18

Gradation Testing Results

3/15/2024

USCS & AASHTO

By: JDP Ckd: BBB



Strain Dial (in.)	Unit Strain (%)	Stress (psf)
0	0.0	0
0.01	0.3	92
0.02	0.5	137
0.03	0.8	160
0.04	1.0	183
0.05	1.3	206
0.06	1.5	229
0.08	2.0	320
0.1	2.5	412
0.12	3.0	549
0.14	3.5	687
0.16	4.0	824
0.18	4.5	961
0.2	5.0	1190
0.24	6.0	1236
0.28	7.0	1052
0.32	8.0	869
0.36	9.0	778
0.4	10.0	732
0.48	12.0	549
0.56	14.0	412
0.64	16.0	229
0.72	18.0	0

Project: Cowanesque HDD Investigation
Boring No.: B-4
Station: -
Offset: -
Sample No.: 7
Depth: 28-30', 33-35', 43-45' ft
Sample Ht. (in.): 3.989 in.
Sample Dia. (in.): 2.001 in.
Ht.-Dia. Ratio %: 2.0
Test Type: Remolded
Description of Sample:

Soil Type: -
Classification: -
LL = 22 % PI = 5 %
Initial Dry Density (pcf): 104.02
Initial Moisture %: 22.4
Unconfined Comp. Strength (psf) : 1236
Shear Strength (psf) : 618
Strain at Failure %: 6.0
Average Rate of Strain to Failure%: 2.4

NAVARRO & WRIGHT
CONSULTING ENGINEERS, INC.

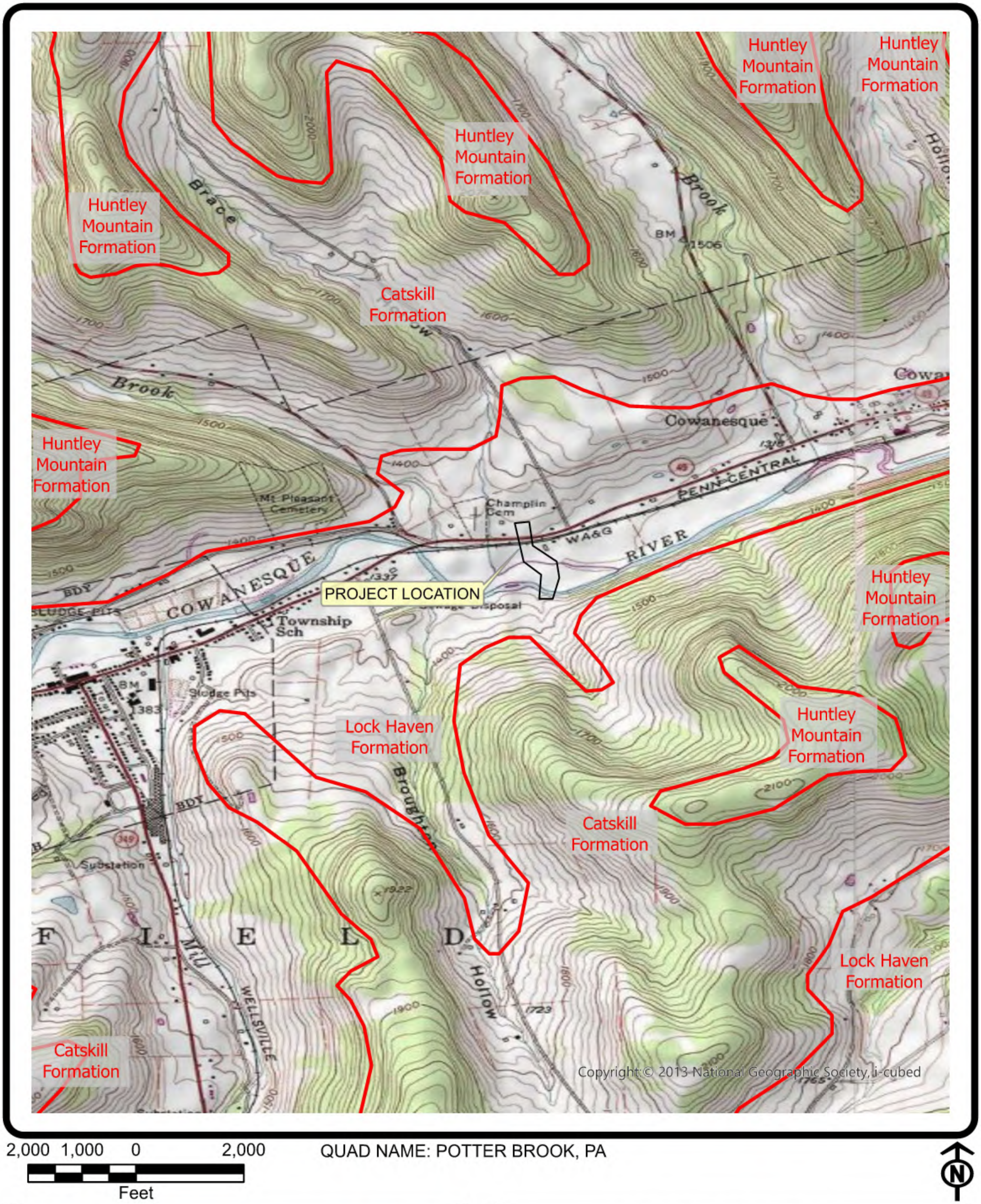
Unconfined Compressive Strength of Cohesive Soil

ASTM D2166/ AASHTO T208

AASHTO R18

3/15/2024

APPENDIX D
GEOLOGIC MAP



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QUAD NAME: POTTER BROOK, PA

ENDEAVOR Professional Services | ENGINEERING & DESIGN

GEOLOGIC FORMATIONS
FOR
COWANESQUE HDD INVESTIGATION

WESTFIELD TWP TIOGA COUNTY PENNSYLVANIA

APPENDIX E
ACID PRODUCING ROCK MAP

Geologic Units Containing Potentially Significant Acid-Producing Sulfide Minerals

Open-File Miscellaneous Investigation
OFMI-05-01.1
April 14, 2005
rev. March 7, 2006

ENDEAVOR
Professional Services | ENGINEERING & DESIGN

JOB#: 4240.0429
FEBRUARY 2024

ACID PRODUCING ROCK
COWANESQUE HDD INVESTIGATION
WESTFIELD BOROUGH, TIOGA COUNTY, PA

File name: P:\004240_NFG\0429 Cowanesque HDD Investigation\C3D\Plan Sets\EXH\G0042400429_ACIDPROD.dwg Layout: AcidRock Feb 23, 2024–8:54am klepionka

APPENDIX F
ROCK CORE PHOTO EXHIBIT

2505 Green Tech Drive, Suite AB
State College, PA 16803
(814) 308-8086
www.endeavorpros.com

MARCH 22, 2024

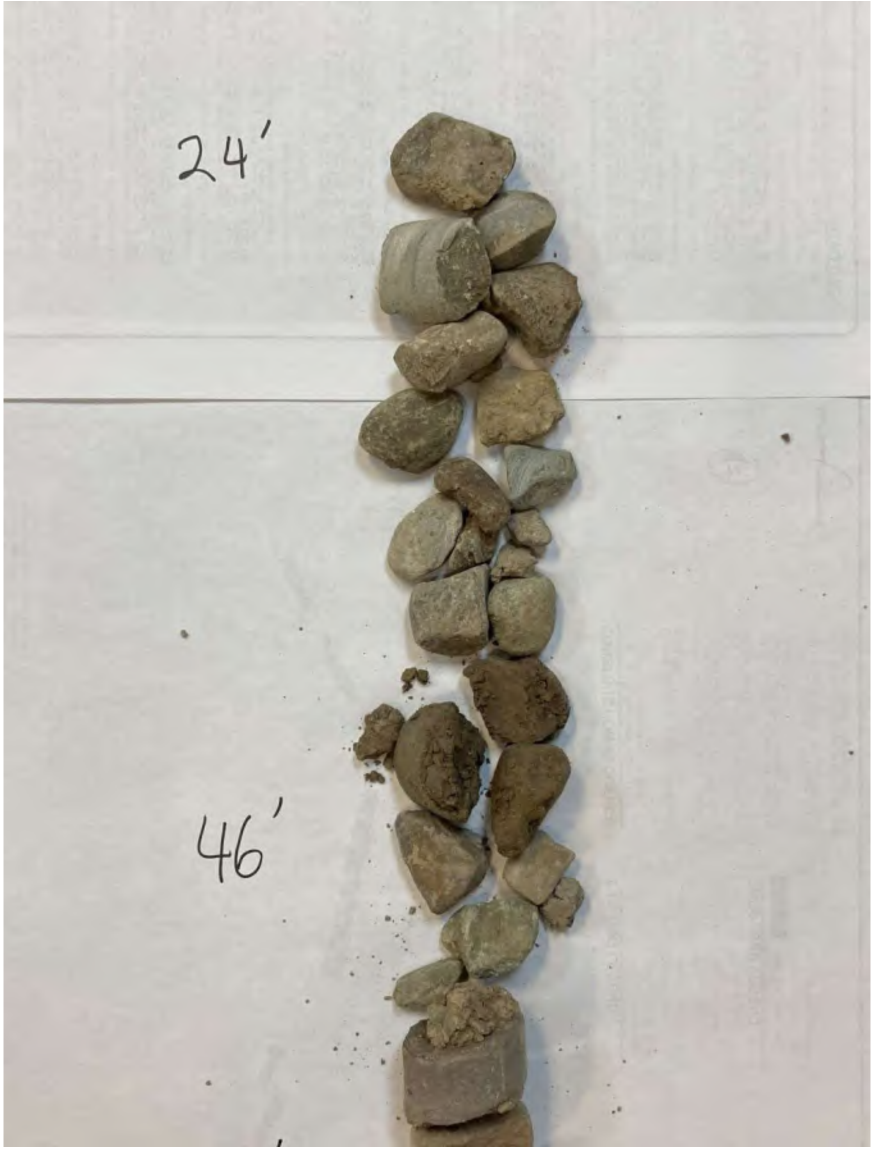
ROCK CORE PHOTO EXHIBIT
FOR
COWANESQUE HDD INVESTIGATION

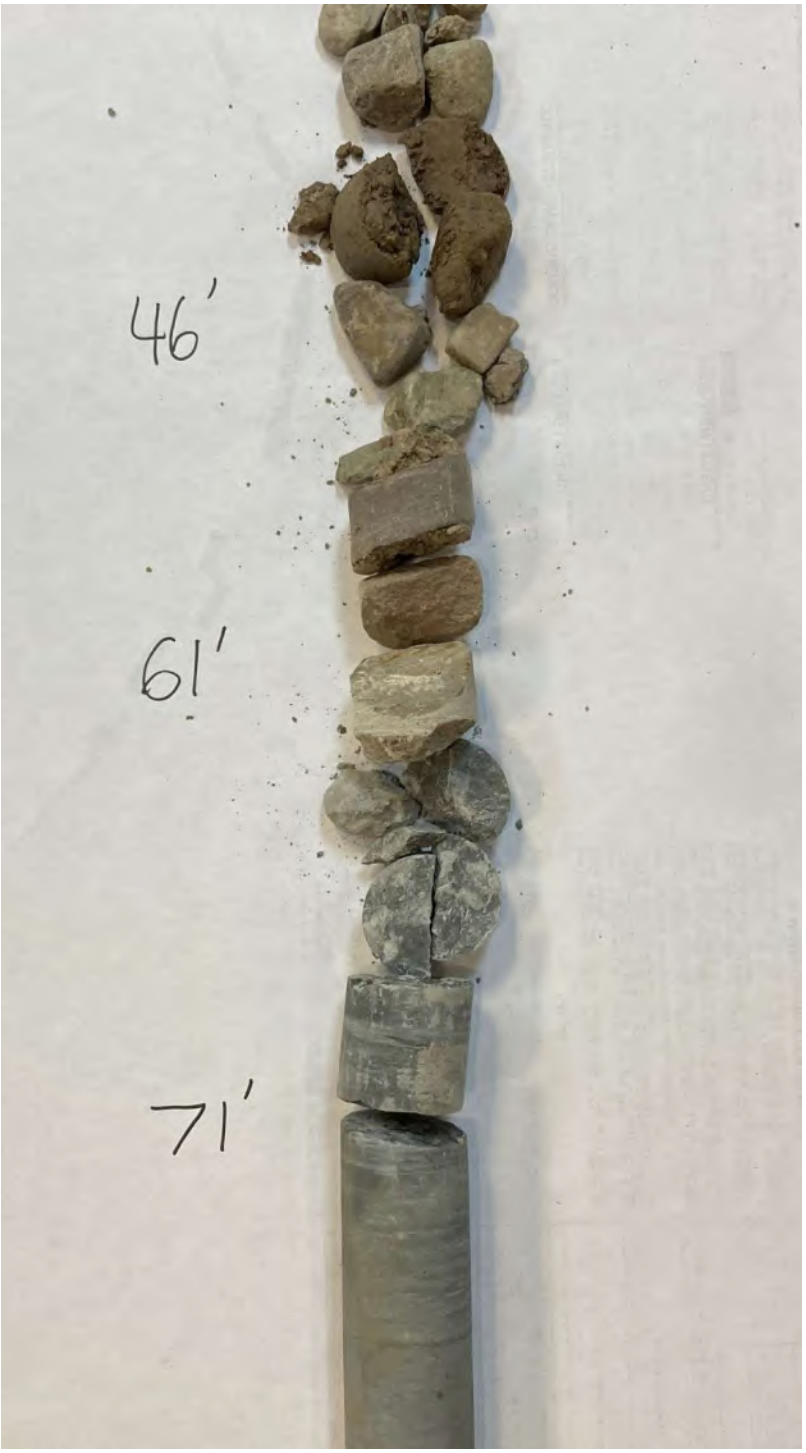
WESTFIELD BOROUGH, TIOGA COUNTY, PA

Endeavor Professional Services, LLC Project No. 004240.0429

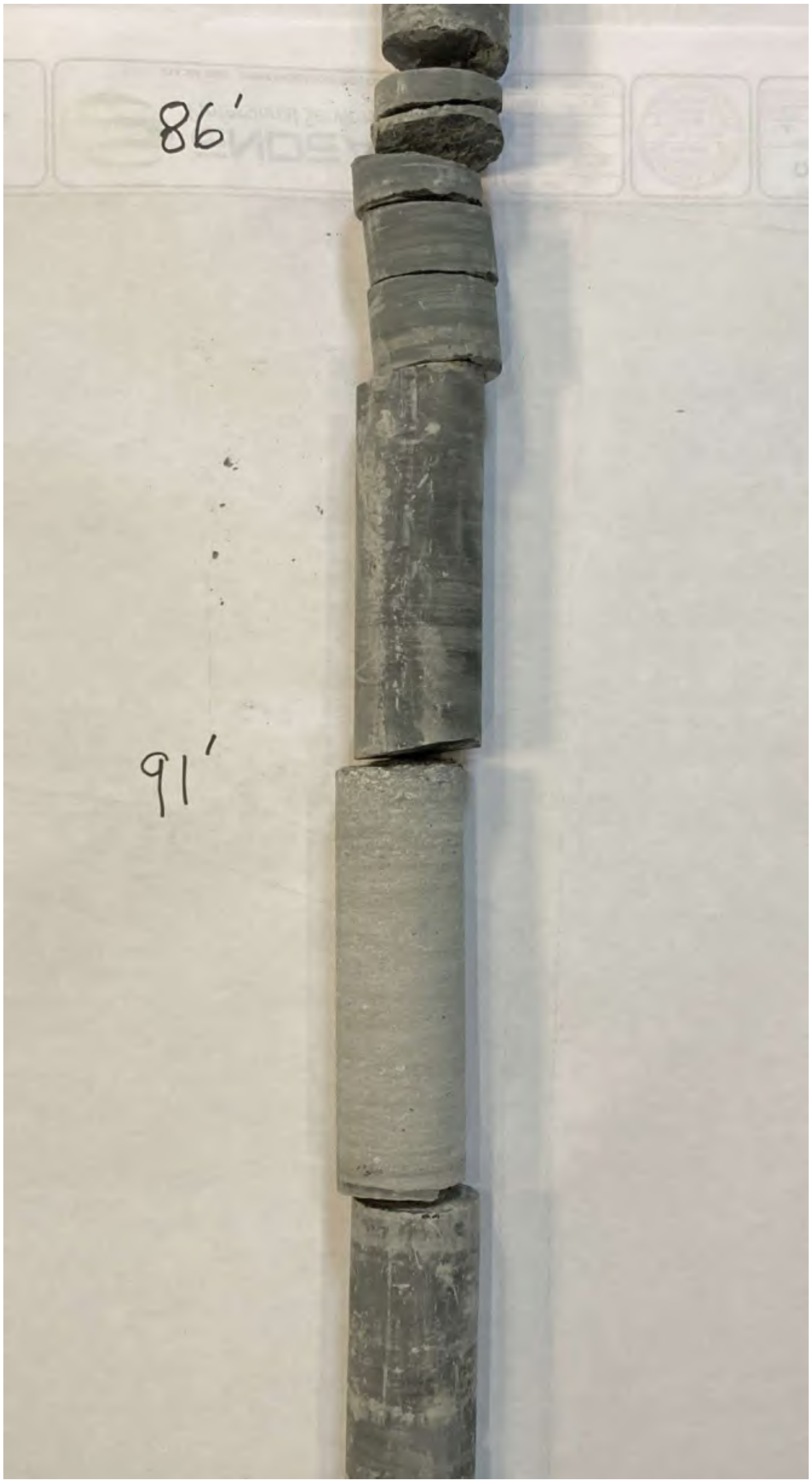
ROCK CORE SAMPLE PHOTOS
FOR
COWANESQUE HDD INVESTIGATION
WESTFIELD BOROUGH, TIOGA COUNTY, PENNSYLVANIA

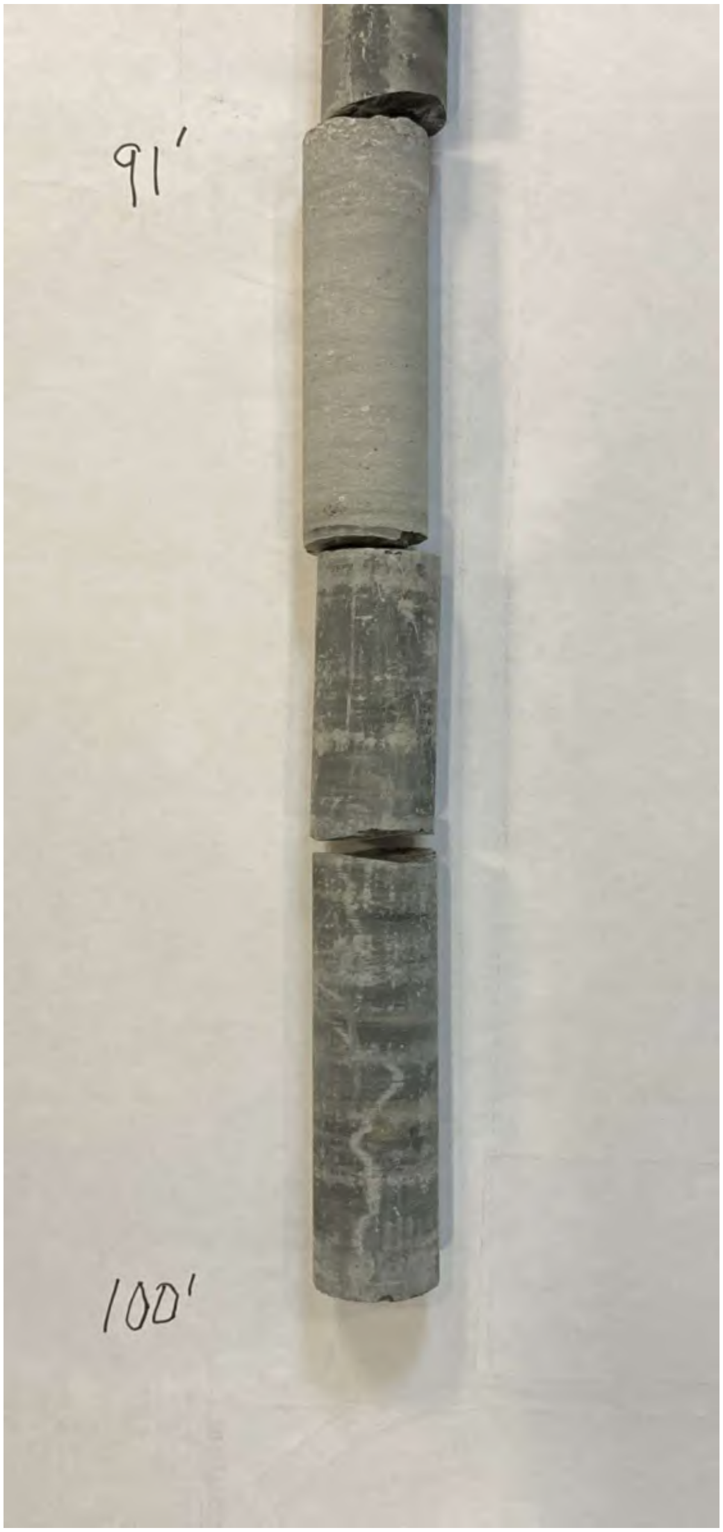
Bore 1: 24’ – 100’




46'
61'
71'

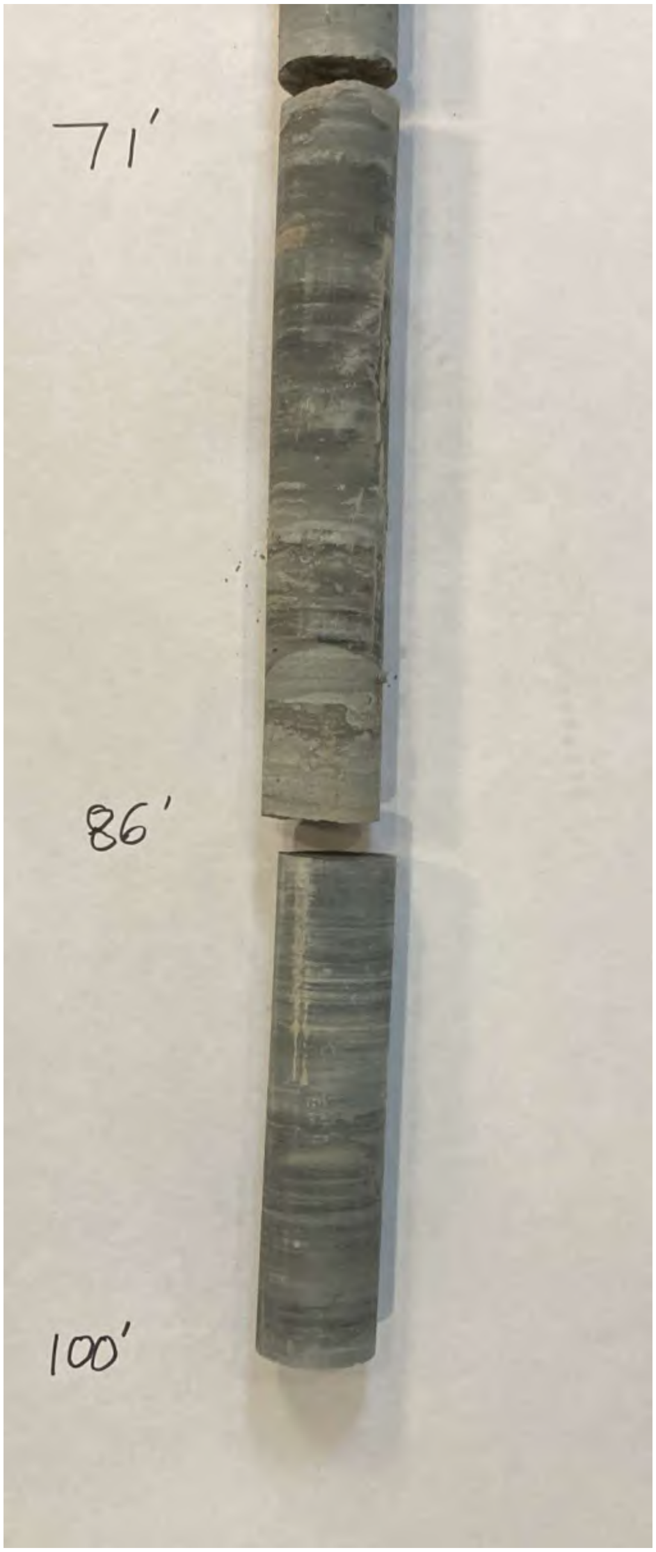

71'
86'


86'
91'


91'
100'

Bore 2: 10’6” – 100’


61'
71'


71'
86'
100'

Bore 3: 49’6” – 100’


71'6"
81'6"


81'6"


96.6'
100'

National Fuel Gas Supply Corporation

Cowanesque River HDD

HDD Feasibility Report

DOCUMENT No. 4418-ENG-RPT-0001
CCI PROJECT No. 4418

Prepared for:
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Date: **2024/07/19**
Revision: **A**

Revision Log

Revision	Issue Status	Prepared by	Reviewed by	Approved by	Date Approved
A	IFR	A. Dumas	A. Faghih	G. Busch	2024-07-19

Prepared by:

ADumas

Alexandre Dumas. P.Eng.
Project Manager

Reviewed by:

A. Faghih

Ash Faghih Ph.D., P.Eng.
West Coast Senior Manager

Approved by:

Gunnar Busch, P.E.
Trenchless Engineering Lead (U.S.)
PA P.E. # PE091005

CCI & Associates Inc.

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1 INTRODUCTION

National Fuel Gas Supply Corporation (NFG) is currently developing the Tioga Pathway Project, which aims to increase transportation capacity for Marcellus and Utica Shale gas from the Appalachian Basin into the interstate pipeline grid. The project includes constructing approximately 19.5 miles of new pipeline (Line YM59) in Harrison, Brookfield, Westfield, Deerfield, and Chatham Townships, as well as in Tioga and Potter Counties, Pennsylvania. Additionally, about 4 miles of existing pipeline facilities on Supply's Line Z20 pipeline system in Bingham and Harrison Townships, Potter County, Pennsylvania, will be replaced.

The new pipeline design and construction will require a FERC 7C permit application. The route for the new Line YM59 pipeline crosses the Cowanesque River and State Route 49 (SR 49) in Tioga County, PA, requiring a trenchless pipeline installation. This crossing will use an NPS 20 steel pipeline, and NFG plans to employ Horizontal Directional Drilling (HDD) methodology for this installation.

This report provides a feasibility assessment of site conditions, incorporating available geotechnical information and a geometric review of the proposed NPS 20 Cowanesque River HDD alignment and design. It also outlines the challenges the contractor may face and proposes mitigation strategies to minimize project risks.

2 DESIGN PARAMETERS

The parameters utilized in the design of the crossing are as follows:

a) The Pipeline Research Council International (PRCI) design guidelines (PR-277-144507-R01) and ASME B31.8 2022 requirements were utilized to model the bending, external hoop, tensile, and combined stress cases for the installation and operating conditions imposed on the pipe. The calculations consider the pipe diameter, wall thickness, grade, depth, and geometric design of the crossing.

b) The NFG Engineering Design Manual, Chapter 3, Section 3.15 – Horizontal Directional Drilling (HDD), Revision 01, dated 01/31/17, was referenced during the design process in order to ensure adherence to NFG requirements.

c) The HDD has been designed with consideration given to and meeting the requirements of the Federal Energy Regulatory Commission (FERC) Guidance for Horizontal Directional Drill Monitoring, Inadvertent Return Response, and Contingency Plans, Dated October 2019.

d) The geotechnical conditions at the site were considered in an effort to design the drill for progression primarily through formations that are favorable for horizontal directional drills, with consideration given to potential terrain instability and the provided "no-drill" zone (NDZ).

e) The HDD crossing was designed by completing an assessment of the annular pressure to minimize the risk of hydraulic fracture to the surface or water body during drilling of the pilot hole. The annular pressure calculation models the potential fracture pressure of the overburden formation versus the downhole pressures created during the pilot hole phase of the construction.

f) Space limitations associated with the right of way (ROW), constraints such as points of inflection (PI), and achievable temporary workspace (TWS) were also considered. Additional temporary workspace has been requested to ensure that the required equipment can be set up on site to complete the work.

g) The entry and exit positions have been identified as per drilling convention rather than pipeline placement convention. The entry point is the location where the drill rig is set up and in general, the start of drilling activities. Conversely, the exit location is the location where the HDD bottom hole assembly (BHA) will exit the formation and generally where the pipe section is laid out for installation.

h) The drawings have been designed with consideration of the pullback section and available layout. These plans will be updated (if required) to allow for grading of the layout space, safety for pullback, multiple sections, curved layout, and/or contractor input to ensure the proper design is used in all situations.

3 COWANESQUE RIVER HDD CROSSING

3.1 CROSSING LOCATION AND SITE DESCRIPTION

As part of the Tioga Pathway Project, NFG is planning to cross the Cowanesque River and State Route 49 using HDD methodology in Tioga County, PA. The crossing location is approximately 1.30 miles east of Westfield, PA. The crossing will require a FERC 7C permit application.

The proposed NPS 20 HDD crossing will traverse the Cowanesque River, State Route 49, some identified wetlands, and overhead powerlines, following a southeast to northwest alignment. The topography along the HDD alignment varies significantly, with some areas having over 30 ft of grade variation. The entry point of the drill is on the south side of the alignment, south of the Cowanesque River, on a southern slope that will require grading and leveling to accommodate the HDD equipment. The exit point is north of State Route 49 and the river, in a farm field parallel to Brace Hollow Road, where the pullback pipe string will be laid out.

There are residences near the proposed alignment, situated between State Route 49 and the Cowanesque River. Access routes to the entry and exit workspaces have been identified, branching off State Route 49 and Brace Hollow Road, respectively.

The proposed crossing location is shown in Figure 1 below.

Figure 1. Proposed HDD Crossing Location

3.2 GEOTECHNICAL REVIEW

A site-specific geotechnical investigation was completed by Endeavor Professional Services, LLC (Endeavor) along the proposed crossing alignment. The associated geotechnical report (Report No. 004240.0429) entitled "Geotechnical Investigation Report – Cowanesque HDD Investigation," dated March 2024, was reviewed for HDD design purposes. The report references four (4) boreholes, B-1 through B-4, drilled to depths between 50 and 100 ft. A report amendment, dated June 2024, containing additional lab testing was also provided. The site-specific geotechnical boreholes are shown in Figure 2 below.

Figure 2. Borehole Location Plan for Cowanesque River HDD Crossing

The geotechnical borehole depths and coordinates, as staked in the field, are shown below in Table 1.

Table 1. Geotechnical Borehole Coordinates for Cowanesque River HDD Crossing

Borehole	Depth (ft)	Latitude	Longitude
B-1	100.0	41.923767°	-77.515589°
B-2	100.0	41.924468°	-77.515372°
B-3	100.0	41.925459°	-77.516254°
B-4	50.0	41.926988°	-77.516573°

With the exception of Borehole B-4, similar subsurface conditions were encountered, which generally consisted of 24 to 54 ft of granular material and 23 to 37 ft of "unconsolidated overburden" overlying bedrock to the final depths. However, in Borehole B-2, no unconsolidated overburden was encountered. In Borehole B-4, 20 ft of sandy/gravelly clay was encountered overlying compact to dense sandy silt, which extended to the final depth of 50 ft.

The granular material predominantly consisted of sandy clayey gravel, with a gravel content ranging between 38 to 74%. The unconsolidated overburden was described as a mixture of gravel and fractured bedrock with washed away fines. The bedrock consisted of either siltstone or fine-grained sandstone with rock quality designation (RQD) generally ranging between 38 and 100%; however, localized fractured zones with a 0% RQD were also encountered.

A summary of the generalized borehole descriptions is presented in Table 2.

Table 2. Summary of Borehole Logs and Primary Concerns for Cowanesque River HDD Crossing

Borehole	Approximate Location	Description	Primary Geotechnical Concerns
B-1	150 ft N of HDD Entry	0-24 ft: Clayey Sandy Gravel 24-61 ft: Unconsolidated Overburden 61-100 ft: Siltstone (bedrock)	Gravel causes drilling difficulties and borehole wall to slough. Fractured bedrock can result in fluid losses.
B-2	125 ft S of River Centerline	0-40 ft: Clayey Sandy Gravel 40-54 ft: Gravelly Sand 54-100 ft: Siltstone (bedrock)	Gravel causes drilling difficulties and borehole wall to slough. Fractured bedrock can result in fluid losses.
B-3	25 ft N of Wetland Boundary	0-40 ft: Clayey Sandy Gravel 40-48 ft: Gravel 48-71 ft: Unconsolidated Overburden 71-86 ft: Siltstone (bedrock) 86-100 ft: Sandstone (bedrock)	Gravel causes drilling difficulties and borehole wall to slough. Fractured bedrock can result in fluid losses.
B-4	350 ft S of HDD Exit	0-10 ft: Sandy Clay 10-20 ft: Gravelly Clay 20-50 ft: Sandy Silt	Granular material can result in sloughing of borehole wall. Silt can affect fluid properties.

No standpipes were installed. Instead, groundwater was observed during drilling operations. Groundwater was encountered at depths of 15.0, 2.0, 5.0, and 28.0 ft in Boreholes B-1, B-2, B-3, and B-4, respectively. It is expected that the groundwater is hydraulically connected with the river.

The proposed HDD path is anticipated to predominantly pass through bedrock for the majority of the bore, encountering unconsolidated overburden and granular deposits as it surfaces on both the entry and exit locations. The risks and challenges due to the subsurface conditions and the mitigation strategies to minimize them will be discussed later within this report.

Due to geometric constraints imposed on the HDD profile, which will be discussed below, the current HDD design extends roughly 38 ft below the deepest geotechnical borehole. It is expected that additional geotechnical data will be obtained by Endeavor at a future date prior to the IFC HDD design. It is understood that the additional data will consist of extending Borehole B-4 to verify the depth to bedrock and the thickness of unconsolidated overburden, if present, and adding another borehole between B-3 and B-4 that will extend below the HDD profile depth to verify the quality of bedrock at and below the current HDD depth. The intent is to delineate the unconsolidated overburden as well as the bedrock interface along the north approach.

3.3 HDD CROSSING CONSIDERATIONS

3.3.1 Pipe Specifications

The pipeline specifications provided by NFG are summarized in Table 3. These parameters were used in the engineering design of Cowanesque River HDD crossing.

Table 3. Pipe Specifications for Cowanesque River HDD Crossing

Pipe Specifications	Value
Pipe Size	NPS 20
Outer Diameter (OD) (inches)	20
Wall Thickness (WT) (inches)	0.500
Material	Steel
Grade	X65
Specification	API 5L
Product	Natural Gas
Maximum Allowable Operating Pressure (psi)	1,440
Minimum Installation Temperature (°F)	30
Maximum Operating Temperature (°F)	100
Internal Coating	None
Outer Coating	FBE / PRW
Class Location	1
Joint Factor	1
Temperature Factor	1

3.3.2 HDD Alignment

The proposed Cowanesque River HDD crossing follows the proposed YM59 pipeline alignment centerline, which is centered within a 50 ft ROW. The proposed HDD is planned to have a southeast-to-northwest drilling alignment, measuring 1,714 ft horizontally, and will cross beneath the south river valley slope, the Cowanesque River, Wetland W23, State Route 49, some overhead powerlines and Wetland W59. The proposed entry point, approximately 520 ft south of the Cowanesque River's edge of water, is located directly on the YM59 pipeline centerline point of inflection (P.I.) on the south river slope, where some leveling and clearing work will be required to construct the entry pad. The exit point is located approximately 500 ft north of SR 49 in a farm field parallel to Brace Hollow Road, where the pullback pipe string will be laid out. The exit point extends approximately 258 ft to the north of the planned P.I. in the YM59 pipeline alignment which will require adjustments to match the HDD alignment and tie-ins. According to available survey information, the proposed HDD does not cross any existing buried utilities.

Based on available LiDAR data, the topography along the alignment consists of a mix of gentle slopes and more pronounced elevation changes, typical of the region's rolling hills. There is an elevation difference of 7.2 ft between the proposed entry and exit points along the pipeline alignment. The southern end of the alignment is situated on the river valley slope, with the Cowanesque River being the lowest elevation point between the entry and exit. As the alignment approaches SR 49 towards the exit point, the terrain gradually ascends, reflecting the area's characteristic undulating topography, and reaches the agricultural fields on the other side of SR 49.

The details of the design are shown on drawing 4418-EG-0101 provided in Appendix A.

3.3.3 HDD Workspaces

Temporary workspace (TWS) is required at the entry and exit areas to facilitate drilling operations and product pipe installation. The entry side pad irregular TWS is located on a slope at the south end of the proposed pipeline alignment within the 50 ft wide proposed ROW and 25 ft of ATWS on either side of the ROW. There is irregular TWS around the entry point, allocated on the slope, which will be used to construct, grade, and level the entry pad. It is anticipated that the available TWS footprints will be adequate for the HDD equipment setup, though the risks related to the construction of the entry pad on the slope should be considered.

The exit point is located on the north side of the crossing alignment and extends approximately 258 ft to the north of the planned P.I. in the YM59 pipeline alignment, which will require adjustments to match the HDD alignment and tie-ins. The exit point is located within the 25 ft wide ATWS adjacent to the pipeline ROW. There is a 100 x 194 ft ATWS located east of the P.I., and a 25 x 60 ft ATWS to the west. The exit pad is currently in a field near Wetland W59 (PEM) and will require additional TWS due to the exit point being off the YM59 pipeline alignment to ensure all equipment stays within the approved workspace. The exit pad construction requirements within or near an identified wetland should be carefully reviewed and considered.

The proposed pipe staging and stringing area for pullback is located northeast of the exit pad and is discussed further in Section 3.3.4. The HDD contractor should confirm their equipment workspace requirements and mobilization plan in their drilling execution plan.

3.3.4 Laydown Area

Pipe pullback is planned to be completed behind the exit point to the northwest of the HDD alignment along the proposed ROW. Generally, the workspace must be wide enough to accommodate staging and assembly of the pipe string, pipe supports, equipment, welding and inspection operations, as well as safe vehicle access along the length of the workspace. The length of the laydown area must be equal to the total crossing length with additional space on either side of the pipe section for equipment access.

The proposed laydown area would consist of irregular temporary workspace behind the exit point for a length of approximately 1,500 ft with varying width. Given that the total drill length is 1,760 ft, it is expected that the pullback string will be laid out in two (2) separate sections and will require an intermediate weld. Overall, the proposed workspace is considered suitable for pipe staging, assembly, and pullback operations. Pipe lifting stresses and pullback recommendations are provided in Section 3.4.2.4.

The proposed pipe pullback workspace is illustrated in Figure 3, below

Figure 3. Proposed Pullback Workspace for Cowanesque River HDD

3.3.5 Borehole Size

The final borehole diameter must be larger than pipe outer diameter to facilitate pipeline installation and reduce drag forces acting on the pipe while allowing for proper drilling fluid circulation within the annulus. The general industry standard for pipes with diameter less than 20 inches is a final borehole diameter of 1.5 times larger than the pipe outer diameter. For larger installations, a borehole with an OD of 12 inches larger than the pipe outer diameter is recommended. The final ream size may be dependent on the size of reamer that is available to the contractor, however, CCI would recommend that the contractor adhere to the minimum industry standard as described above.

For the proposed NPS 20 HDD crossing, the final borehole diameter is expected to be 30”.

3.3.6 Entry and Exit Angles

The entry and exit angles were determined based on stress analysis, bending restrictions, surface casing length, the support of the pullback section, workspace requirements, and slope of the topography above the entry and exit tangents. The entry angle of 18° is optimal for minimizing the crossing length while achieving the necessary depth below the river to reduce the risk of hydraulic fracture. Additionally, this angle helps minimize the surface casing length needed to reach the anticipated bedrock interface and is suitable for the required rig size for this crossing while helping to ensure that the casing can be properly seated into the bedrock given the angle of intersection with top-of-bedrock surface.

The exit angle, set at 16° for the Cowanesque River HDD, was selected to optimize the HDD length, ensure safe support of the section during installation, and reduce the surface casing length required to reach the assumed bedrock interface. As mentioned within Section 3.2, a supplemental geotechnical investigation is planned by NFG which will aim to verify depth to bedrock near the exit point (by extending boring B-4) which may influence the required exit angle depending on the final casing length requirement and angle of bedrock interface.

3.3.7 HDD Depth of Cover

The selection of an appropriate HDD depth is based on several parameters, including geological formation, the required overburden pressure to overcome drilling fluid annular pressure, buried facilities in the area, watercourse/roadway/rail geometric parameters, pipe geometry, and space limitations. The proposed installation depths were chosen to allow the drill path to progress through favorable materials for directional drilling while maximizing borehole stability during hole opening and pipe installation.

Table 4 lists the provided depths of cover beneath the identified critical features that are crossed by the proposed HDD, based on the current design drill path geometries, in order from the entry point to the exit point. The current design depth of cover is expected to provide adequate overburden pressure to minimize the risk of hydraulic fracture to the surface, with the help of surface casing installation, as well as minimizing the impact on buried utilities and settlement or heave at the surface, assuming proper construction methods are utilized during construction. Further details about annular pressure modeling are discussed in Section 3.4.1.

Table 4. HDD Depths of Cover

Feature	Depth of Cover Beneath Centerline (ft)
Cowanesque River C/L	114.2
Wetland W23	138.8
State Route 49 (SR 49)	113.1
Overhead Powerlines	74.8
Wetland W59	56.6

3.3.8 Design Radius

The standard practice in HDD industry is to utilize 100 times (in feet) the nominal pipe diameter (in inches) as the radius of curvature (ROC). For instance, a 12-inch diameter pipe would utilize a ROC of 1,200 feet. This is a conservative general “Rule of Thumb” for quick calculations which is developed over years based on constructability as opposed to pipe stress limitations. The minimum radius calculated from stress limiting criteria are often substantially smaller (and sometimes larger) than the general rule of thumb as the latter does not consider pipe materials, bending stress, combination of stress or strain within the pipe section itself.

For the proposed Cowanesque River HDD, a 1,600 ft vertical curve radius was selected as the design ROC. Although this is smaller than the typical industry guideline for this pipe size, stress analysis indicates that it meets the necessary criteria, resulting in a maximum bending stress of 34.4% of allowable and a maximum operational shear stress of 83.4% of allowable (according to PRCI and ASME limits). The minimum allowable 100-ft (3-joint) design radius (MADR) has been calculated to be 1,250 ft, with a bending stress of 44.1% of allowable and an operational shear stress of 90.7% of allowable. The minimum allowable 30-ft (single joint) design radius has been calculated to be 1,050 ft, with a bending stress of 52.5% of allowable and an operational shear stress of 97.1% of allowable. Detailed discussions on the contributing bending, combined, and operational stresses imposed on the pipe are found in Section 3.4.2.

An essential part of the engineering design of HDD crossings is to provide the contractor with minimum steering tolerances during the pilot-hole phase of the construction, based on an acceptable level of stress on the pipe. These tolerances are designed to allow the contractor to follow the designed drill path as close as possible and avoid any variation that could cause overstressing of the pipe. CCI recommends the minimum radius specifications as seen in Table 5 below.

Table 5. Minimum Radius Allowances

Case	Radius Specification
Design Radius	1,600 ft
100-ft Average (3-joint) / MADR	1,250 ft
30-ft (single joint)	1,050 ft

Assuming the Contractor adheres to these minimum radius specifications, the product pipe will be within allowable stress limits during installation and operation.

3.3.9 Surface Casing

The geotechnical investigation at this project location revealed a significant amount of granular content in the "unconsolidated overburden" overlying the bedrock. This granular material predominantly consists of sandy, clayey gravel, with a gravel content ranging between 38% and 74%. The unconsolidated overburden is described as a mixture of gravel and fractured bedrock with washed-away fines. The bedrock comprises either siltstone or fine-grained sandstone, with RQD generally ranging between 38% and 100%; however, localized fractured zones with a 0% RQD were also encountered.

These challenging conditions pose several considerable risks during HDD construction, mainly borehole instability during drilling/reaming and the risk of hydraulic fracture. To mitigate these risks, CCI proposes installing surface casing at both the entry and exit locations to reach the underlying bedrock interface and isolate the problematic overburden material.

Based on the available information, it is anticipated that a minimum of 314 ft of 42” steel surface casing will need to be installed on the entry side until the bedrock interface is reached. Surface casing diameter is typically required to be 12” larger than the final ream size for installation. It is to be noted that the contractor should independently evaluate and determine the need to upsize or telescope the casing to achieve the minimum final diameter. Given the larger span between B-3 and B-4 and that the thickness of unconsolidated overburden, if present, and the elevation to top-of-rock are unknown within B-4, there is higher uncertainty regarding the exact elevation and angle of the bedrock interface near exit; therefore, it has been assumed, based on the available information, that a minimum of 424 ft of 42” steel surface casing will be required on the exit side. However, the exit side surface casing length needs to be evaluated once additional geotechnical info becomes available. Understanding that precise data is crucial; additional geotechnical information will be collected to better understand the bedrock interface at the exit tangent and to provide a more accurate estimate of the surface casing requirement.

Other risks and considerations relating to the surface casing are discussed further within Section 3.5.

3.4 HDD ENGINEERING ANALYSES

The proposed Cowanesque River HDD has been designed by incorporating all specified design considerations including supplied topographical, geotechnical, and survey information, as well as other site information as noted in the previous sections. In addition to these considerations, detailed annular pressure analysis and pipe stress analysis calculations have been completed as outlined below.

3.4.1 Annular Pressure Modelling

Annular Pressure (AP) modeling was developed to model the expected drilling pressure that is required to drill a pilot hole along a proposed path. This information has been modeled very accurately as confirmed by many HDD installations using pressure monitoring tools. CCI has modeled the potential overburden or confining pressure and used this information to assist in the choice of HDD depth and placement of the entry and exit locations. Over the last several years, this has been relatively successful in that there has been a reduced number of drilling fluid releases to the waterbody, highway, or railroad as well as improving the reliability and consistency of the design and construction process.

The ability to accurately assess when the HDD will fracture to surface is highly dependent on the homogeneous nature of the formation, level of fracturing in the bedrock (if present) and type/consistency of the overburden. It is also important to note that the information provided by borehole investigations is accurate at that specific location but may vary significantly some distance away. A vertical borehole may not identify the vertical fractures that can significantly affect risk of fluid migration from the borehole. This potential inaccuracy is accounted for by being conservative in the modeling assessment and considering the AP pressure model as a process to reduce drilling fluid releases (generally) based on the quality of information provided.

HDD construction begins with drilling a pilot hole (typically 9 7/8 to 12 1/4 inches in diameter) along the proposed drill path. The method of installing the pilot hole is highly dependent on the size of the crossing and type and quality of soils along the drill path. Installing the pilot hole within softer, weaker soils is generally completed using a jetting assembly. A jetting assembly uses a high-pressure jet of fluid to open the hole ahead of the bit and pushes its way through the soil to create the borehole. Installing the pilot hole within harder and stronger soils or bedrock may require a mud motor assembly to complete the hole, which utilizes a positive displacement mud motor with an appropriately sized rotating drill bit to mechanically shear through the soil or rock at the face of the bit to create the hole.

Based on the available geotechnical information it is expected that a mud motor assembly will be utilized for the pilot hole installation of the proposed HDD, however, tooling and techniques utilized in the field will be dependent on actual subsurface conditions.

Drilling fluid properties are dependent on construction practices of the HDD contractor, field conditions, and interpretations of the drilling fluid technician. Annular drilling fluid pressures can significantly change with changes in drilling fluid properties. Therefore, it is important to re-evaluate drilling fluid pressures based on fluid properties during HDD operations and compare them with estimated limiting pressures of the formation. Additionally, annular pressure measurement tools should be used to monitor annular pressure during the HDD installation.

The AP simulation was conducted with CCI’s analysis tools which have been developed with industry standard calculation models (Bingham Plastic, General Overburden, and USACE/Delft model) and additional modified safety factors based on our experience from over 15,000 completed HDD crossings.

CCI completed the annular pressure analysis for the proposed HDD crossing using a mud motor drill assembly. The drill assemblies utilized to model the annular pressure during pilot hole construction of the HDD are as follows in Table 6:

Table 6. Drill Parameters Used for Annular Pressure Model

Parameter	**12 1/4" Mud-Motor Assembly**
Pilot Hole Size (in)	12.25
Drill Pipe Size (in)	5.5
Pump Rate (gal/min)	400
Drilling Fluid Density (lb/gal)	9.6
Drilling Fluid Plastic Viscosity (cP)	20
Drilling Fluid Yield Point (lb/100 ft^2)	25

CCI has developed geotechnical parameters for the crossings that closely represent the geologic formations observed in the geotechnical borehole logs, as summarized in Section 3.2 of the report. Based on the geotechnical investigation provided, CCI has identified three (3) geological formations used for this analysis, as shown below. The geologic formations utilized in the analysis include a layer of Clayey Gravel that extends to approximately 40 ft below the river, followed by a layer of disintegrated, poor-quality Siltstone right above the bedrock interface, mainly represented by the unconsolidated overburden identified in the geotechnical report, and finally a layer of blocky, fair-quality Siltstone, through which the bottom portion of the HDD will progress. The geotechnical parameters utilized by CCI for the Clayey Gravel were as follows:

- 0° Internal Friction Angle
- 0.0 psf Cohesion
- 135 pcf Unit Weight
- 0.0 ksi Shear Modulus
- 0.0 ksi Youngs Modulus
- 1,050 psf Undrained Shear Strength

The geotechnical parameters utilized by CCI for the Disintegrated Siltstone were as follows:

- 23° Internal Friction Angle
- 302.6 psf Cohesion
- 130.0 pcf Unit Weight
- 0.9 ksi Shear Modulus
- 2.6 ksi Youngs Modulus

The geotechnical parameters utilized by CCI for the Blocky Siltstone were as follows:

- 27° Internal Friction Angle

- 1426.4 psf Cohesion
- 135 pcf Unit Weight
- 7.8 ksi Shear Modulus
- 21.2 ksi Youngs Modulus

The water table was conservatively assumed to be at ground surface along the crossing alignment so that the entire soil layer contributes its effective unit weight to the total limiting pressure. CCI has modeled the geologic formations along the drill paths with what we consider to be conservative physical properties to account for anomalies and discrepancies that may exist between the soil types described in the site investigation and actual field conditions.

CCI utilized the Undrained Equation model to calculate the limiting pressure for the Clayey Gravel formation and the modified Delft Equation model to calculate the limiting pressure for the Siltstone formations identified. The anticipated annular pressure was calculated using conservative assumptions for the drilling fluid properties and flow rates as described above. It is important to note that the annular pressure model created by CCI is only valid based on the geotechnical and drilling parameters utilized herein, and it is recommended that the annular pressure analysis be re-evaluated with the contractor's proposed drilling fluid parameters, bit size, and drill stem. Figure 4 below shows the formation parameters and expected annular pressure for the HDD during the pilot hole phase of construction at the current designed depth.

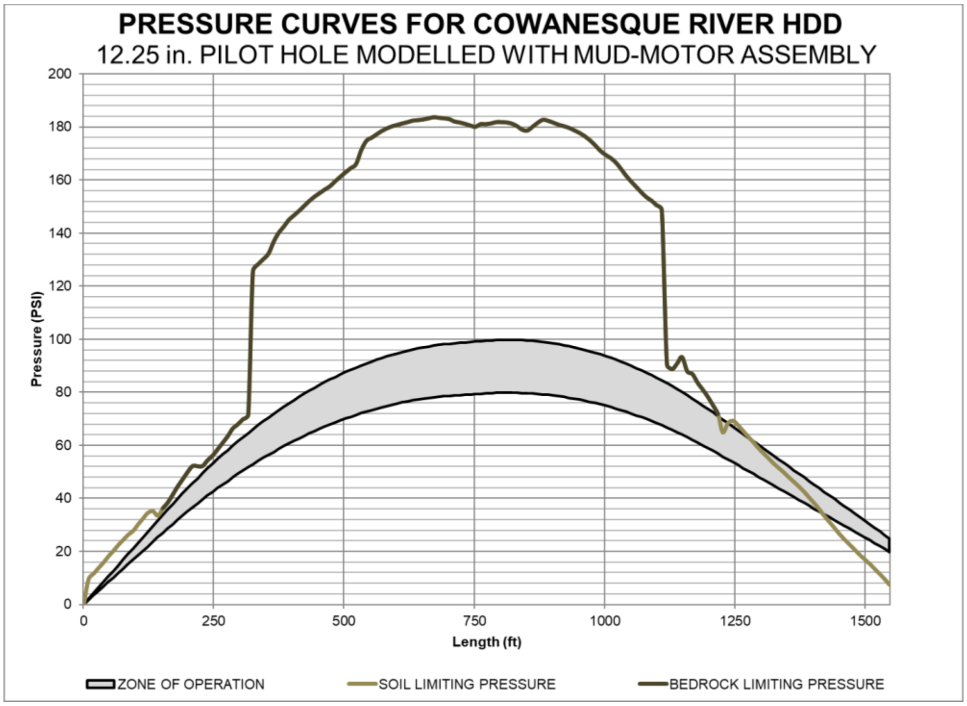


Figure 4. Annular Pressure Curves for Cowanesque River HDD

The Annular Pressure Analysis performed by CCI indicates a low overall risk of hydraulic fracture. The primary risk area for the Cowanesque River HDD crossing is the final 300 ft approaching the exit point, where the soil limiting pressure is exceeded by the upper and lower limits of drilling fluid pressure. This indicates a risk of hydraulic fracture within this zone. However, this section of the borehole is currently planned to be cased, which will help mitigate the risk of fracture as we approach the exit side by shielding the surrounding soil from experiencing the drilling fluid pressures along the encased length of bore.

The risk of fracture near the exit point is expected for HDD crossings, as drilling fluid pressures increase towards the exit point while the overburden strength decreases with depth. Since the drilling pressures remain below soil limiting pressures beneath Cowanesque River and along the majority of the drill length, with the exception of the final roughly 300 ft, the overall risk of hydraulic fracture for this HDD installation is considered low and manageable with proper planning and construction practices. The installation of surface casing will significantly mitigate the risk of hydraulic fracture for this crossing near entry and exit sides. This concern should be noted by the contractor, but the Annular Pressure Analysis indicates that the design for Cowanesque River HDD is feasible from a geological standpoint with good construction practices.

The relevance of the annular pressure model depends heavily on the accuracy of the geotechnical information available along the HDD alignment. The geotechnical parameters used in the annular pressure analysis are conservative. It is recommended that the annular pressure model be re-evaluated after completion of the supplemental geotechnical investigation planned by NFG, as is likely that the exit-side subsurface model may require adjustment. It is also recommended that the contractor independently evaluate the geotechnical information provided and properly assess the site conditions prior to construction.

3.4.2 HDD Stress Analysis

The installation and operating conditions imposed on the HDD sections of pipeline during and after installation have been calculated in compliance with PRCI (PR-277-144507-R01) and ASME B31.8. The HDD stress modeling determines if given pipe specifications are adequate for the design.

3.4.2.1 Pulling Load

The load required to pull the product line inside the borehole must overcome several resisting forces including effective weight of the pipe, fluidic drag, frictional drag between the pipe and the borehole walls and between the pipe and the rollers, drag due to length of drill strings in the hole and the reamer assembly in front of the pull section.

The theoretical pull force was calculated under the assumption that buoyancy control would not be used during HDD installation. Buoyancy control is generally advised for HDD installations involving pipelines larger than NPS 20 because the buoyancy of larger pipes can significantly increase the required pull force. Achieving neutral or near-neutral buoyancy could reduce this force and minimize the risk of pipe and coating damage during installation.

For larger pipelines, the uplift forces due to the submerged weight of the pipe within the borehole can be substantial. Implementing buoyancy control measures can effectively reduce these forces and, consequently, the required pulling load. However, a buoyancy control plan is not recommended for this specific HDD crossing.

CCI recommends utilizing a safety factor of 1.5 when calculating anticipated pull force to account for variations in the field regarding drilling practices, geology, etc. and to account for the addition of the reamer and swivel in the pullback bottom hole assembly.

The maximum expected pull load for the proposed Cowanesque River HDD crossing as well as the minimum recommended rig size (capable of the required length and ream size that will provide adequate torque, pull/push force, and flow rates, if equipped with suitable pumps and drill stem) are listed below in Table 7.

Table 7. Calculated Theoretical Pull Forces & Recommended Rig Size for HDD Installation

Theoretical Pull Force[1] (without Buoyancy Control, lbs)	Minimum Recommended HDD Rig Size (Pull Capacity, lbs)
210,000	440,000

Note 1: Theoretical pull forces calculated using PRCI Calculation methods with F.S. of 1.5 applied

3.4.2.2 Installation Stresses

As the pipeline is installed through the final borehole, it is subjected to three primary loading conditions: tension, bending and external pressure. As part of the design process, the individual stresses and their combined effect on the pipe were evaluated to check the pipeline potential failure. The maximum combined installation stress for the crossing was calculated to be 30% of allowable. The results of the installation stress analysis completed for Cowanesque River HDD crossing are illustrated in Table 8, below.

Table 8. Calculated Installation Stresses for Cowanesque River HDD

Maximum Stress Case	Stress (psi)	% Allowable
Tensile (PRCI 5.1.1, 5.5)	4,554	7.8
Bending (PRCI 5.2.2)	15,365	34.4
Hoop (PRCI 5.2.3)	2,437	22.5
Combined (Tensile and Bending) (PRCI 5.2.4)	42%	
Combined (Tensile, Bending, and Hoop)(PRCI 5.2.4)	23%	

3.4.2.3 Operating Stresses

During operation, the stress imposed on a pipeline installed by HDD is similar to a conventionally installed pipe with the exception of the elastic bending resulting from a continually welded pipeline pulled through a curved borehole. The operating loads including bending, net hoop stress (difference between external and internal pressures), thermal expansion and the combined stresses were checked to evaluate the risk of pipeline failure. The Minimum Allowable Design Radius (MADR) for these crossings was calculated to be 1,250 ft based on operating stresses. The design radii for the proposed crossing are above the MADR and produces a bending stress lower than 45% (as recommended by the PRCI for allowable bending stress), which is considered acceptable.

The maximum combined operating stresses at the design radius of 1,600 ft and MADR of 1,250 ft were calculated to be and 83.4% and 90.7%, respectively, as per PRCI and ASME allowable limits, which is considered to be acceptable. A summary of the maximum expected operating stresses and their allowable limits are presented in Appendix B.

3.4.2.4 Pipe Lifting Stress Modelling

Although CCI has not yet complete a detailed pullback lifting plan design for the proposed Cowanesque River HDD crossing, the following guidelines are recommended to be followed by the Contractor in order to prevent over-stressing of the NPS 42 product pipe and overloading of the support equipment during pullback:

Table 9. Pullback Recommendations for Cowanesque River HDD

Parameter	Value
Minimum Allowable Overbend Radius (ft)	850
Maximum Support Spacing (ft)	75
Maximum Roller Spacing (ft)	60
Maximum Unsupported Overhang (ft)	65

A minimum allowable vertical overbend radius of 850 ft has been chosen for the NPS 20 product pipe during pullback. The overbend vertical curve radius of 850 ft would produce a maximum bending and combined tensile and bending stress of 55.8% of SMYS and 52.5% SMYS, respectively. A maximum support spacing of 75 ft through the overbend and 60 ft roller spacing are recommended for the safe pipeline installation. These spacings have been chosen to ensure that the product pipe and supporting equipment will not be overstressed at any point during staging and pullback operations, however, it is recommended that the selected Contractor verify that the pipe lifting and supporting equipment are rated for the intended loads and reduce the spacing if required. The maximum unsupported length at leading and tailing ends of the pipeline should not exceed 65 ft to avoid overstressing the pipe due to excessive bending from its own weight or overloading the supports. A summary of the maximum expected support loading and pipe stress is presented in Appendix C.

Care should be taken when incorporating a horizontal curve into the pipe layout, as the supporting equipment would need to be sized properly to support and anchor the pipe in place through the elastic bending. Incorporating a horizontal curve into the pipe layout may also create a compound curve, if simultaneously bent vertically, which would produce a bending radius smaller than the individual horizontal and vertical radius of curve. It is also recommended that the product pipe is properly anchored and restrained from sliding down any gradients that exist where it is staged, assembled and installed. Other risks associated with the pipe pullback phase of construction are discussed in Section 3.5.

3.4.3 Design Summary

For the proposed Cowanesque River HDD, the operating stresses govern the design of the pipe, and not the installation stresses. Calculations carried out by CCI indicate that a wall thickness of 0.500” for the NPS 20 pipe using Grade X65 steel is suitable for the crossing, based upon the operating conditions supplied. Table 9 shows a summary of the design for the proposed crossing as part of the Cowanesque River HDD Project.

Table 10. Design Summary for Cowanesque River HDD HDD Crossing

Parameters	Value
Pipe Specification	NPS 20 x 0.500 in W.T.
Entry Angle (Degrees from Horiz.)	18
Exit Angle (Degrees from Horiz.)	16
Design Radius of Curvature (ft)	1,600
MADR (ft)	1,250
Length (ft)	1,760
Borehole Size (in)	30

Parameters	Value
Pull Force (lbs) (incl. 1.5 SF with Buoyancy Control)	210,000
Minimum Recommended Rig Size (lbs)	440,000
Installation Stress (% Allowable)	42.0%
Operating Stress (% Allowable)	83.4%
Overall Risk of Hydraulic Fracture	Low

3.5 HDD CONSTRUCTION RISK ASSESSMENT

The main construction risks and challenges for Cowanesque River HDD crossing were identified based on the risk assessment conducted by CCI and previous experience. The risk items are ranked into the risk categories ranging from low risk to very high risk based on the probability and the consequence of each risk factor.

The descriptions of risk items and a summary of the risk assessment for the crossing detailing the risks prior to any mitigation and after mitigation are presented in Appendix D.

4 RECOMMENDATIONS

The following recommendations outline the main action items that should be completed in order to ensure smooth progression of the project into the construction phase:

a) Complete additional geotechnical investigation to gain better understanding of the bedrock interface, gravel contents, and better define the unconsolidated overburden material to more accurately evaluate surface casing needs.
b) Review of information by all stakeholders and issuance of the Issued for Construction (IFC) drawings to chosen Contractors.
c) Ensure all required ROW and TWS, environmental notifications and permits, and water withdrawal and disposal sites are acquired.
d) Review the Contractor prepared Execution Plan, including but not limited to Pullback and Buoyancy Control Plans, Water Management and Drilling Fluid Disposal Plan, Drilling Rig Anchoring Plan, Casing Plan, Engineered Drilling Fluid Plans, and Site-Specific Environmental Plan.
e) Scope of construction inspection, turbidity monitoring (if required) and fluid disposal management services should be identified.
f) Review any new environmental concerns with respect to the crossings and develop contingency plans if required.
g) Select an appropriate level of qualified supervision on site for all stages of the drill to ensure that the drill profile is adhered to within the radius limits set forth on the IFC drawing, the proper drilling techniques and equipment are utilized, and schedule and costs are controlled.

5 CONCLUSIONS

This assessment details the design selection and analysis conducted for the Cowanesque River HDD crossing. It also underscores identified risks, emphasizing that implementing effective mitigation measures will minimize their impact on the project. Based on the available data, constructing the 20-inch Cowanesque River HDD crossing along the proposed alignment of the Cowanesque River HDD Project is deemed feasible.

6 LIMITATIONS

This report has been prepared based on the available site-specific information for the exclusive use of NFG in the construction of the proposed Cowanesque River HDD crossing. No other warranty is expressed or implied and the information presented within this report shall not be applied to other projects.

Although subsurface conditions are not expected to vary significantly from those shown on the drawings, it should be appreciated that extrapolation of subsurface conditions between boreholes and to depths below the depth of exploration is subject to interpretation and could be at variance with actual field conditions.

7 REFERENCE DOCUMENTS

This report is based on the following HDD design drawings.

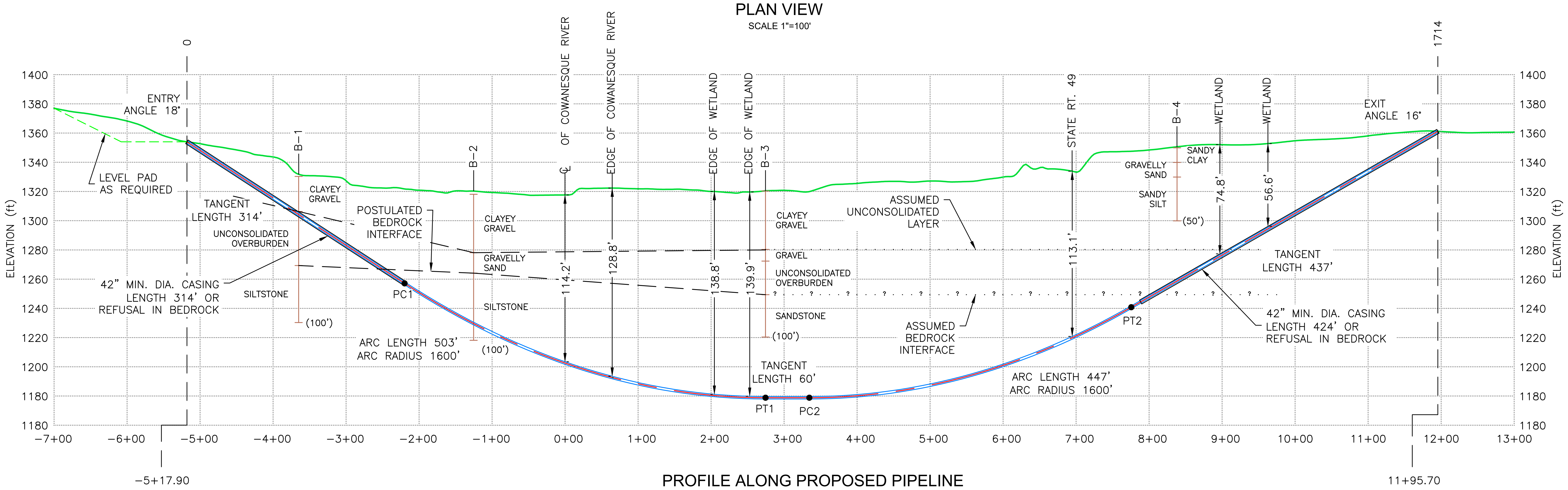
Description	Drawing Number
HDD Plan and Profile	4418-EG-0101
Construction Notes	4418-EG-0102

The following documents were referenced during the development of the design and report:

- Geotechnical Report: Endeavor Professional Services, LLC. Report No. 004240.0429 entitled “Geotechnical Investigation Report – Cowanesque HDD Investigation,” dated March 2024.

APPENDIX A – HDD DRAWINGS

PLAN VIEW
SCALE 1"=100'



TOTAL DRILL LENGTH 1761'

PROFILE ALONG PROPOSED PIPELINE
SCALE 1"=100' HORIZONTAL
SCALE 1"=50' VERTICAL

Pilot Hole Tolerances	
Item	Tolerance
Pilot entry angle	Increase angle up to 1° (higher), but no decrease in angle allowed or adjust as required as long as design profile radius is not compromised.
Pilot entry location	As staked by COMPANY. No change without COMPANY approval.
Pilot exit angle	Increase angle up to 1° (higher). Decrease up to 2° (flatter), but design profile radius cannot be compromised.
Pilot exit location	Up to 20 feet longer or 10 feet shorter than exit stake. Between 5 feet left and 5 feet right of COMPANY survey centerline.
Pilot depth	Up to 5 feet decrease in pipe design depth allowed except under critical areas such as roads, utilities, etc., near the entry and exit points. Up to 10 feet increase in depth allowed. Best efforts shall be made to stay at or below pipe design profile depth.
Pilot alignment	Shall remain within 5 feet left or right of COMPANY centerline survey.

GEOTECHNICAL BOREHOLE DATA

NAME	B-1	B-2	B-3	B-4
GROUND ELEV.	1,330.30	1,318.11	1,320.35	1,394.88
NORTHING	640300.53	640556.18	640916.40	641473.60
EASTING	2032293.08	2032351.63	2032110.63	2032022.26
LATITUDE	N41° 55' 25.56"	N41° 55' 28.09"	N41° 55' 31.65"	N41° 55' 37.16"
LONGITUDE	W77° 30' 56.12"	W77° 30' 55.34"	W77° 30' 58.51"	W77° 30' 59.66"

HORIZONTAL DIRECTIONAL DRILL DATA
COWANESQUE RIVER

DESCRIPTION	HORIZONTAL DRILL STATION (ft)	DIRECTIONAL DRILL STATION (ft)	ELEVATION (ft)
ENTRY @ 18°	-5+17.90	0+00.00	1354.01
PC1 = 1600' RADIUS	-2+19.70	3+14	1257.11
PT1	2+74.70	8+17	1178.80
PC2 = 1600' RADIUS	3+34.70	8+77	1178.80
PT2	7+75.70	13+24	1240.78
EXIT @ 14°	11+95.70	17+61	1361.20
HORIZONTAL DISTANCE (ft) = 1714			
DIRECTIONAL DRILL PIPE LENGTH (ft) = 1761			

REFERENCE DOCUMENT NO.	DATE
1. 01-Cowanesque_River_LiDAR	2024-05-06
2. 4418-01-STEEL STRESS-01	2024-06-20

CCI & Associates Inc.
20445 State Highway 249, Suite 250
Houston, TX 77070

ENGINEER AND PERMIT STAMPS

PRELIMINARY
NOT FOR
CONSTRUCTION

1"=100'
FT 0 100 200 400

PIPELINE SPECIFICATIONS

	NPS 20
OUTSIDE DIAMETER (OD)(in)	20
WALL THICKNESS (WT)(in)	0.500
GRADE	X65
PRODUCT	GAS
MATERIAL	STEEL
SPECIFICATIONS	API 5L
INTERNAL COATING	N/A
OUTER COATING	FBE/PRW
MAX. OPER. PRESSURE (psi)	1,440
MIN. TEST PRESSURE (psi)	1,800
MAX. OPER. TEMP (°F)	100
MIN. INSTALLATION TEMP (°F)	30

1"=50'
FT 0 50 100 200

STEERING TOLERANCES

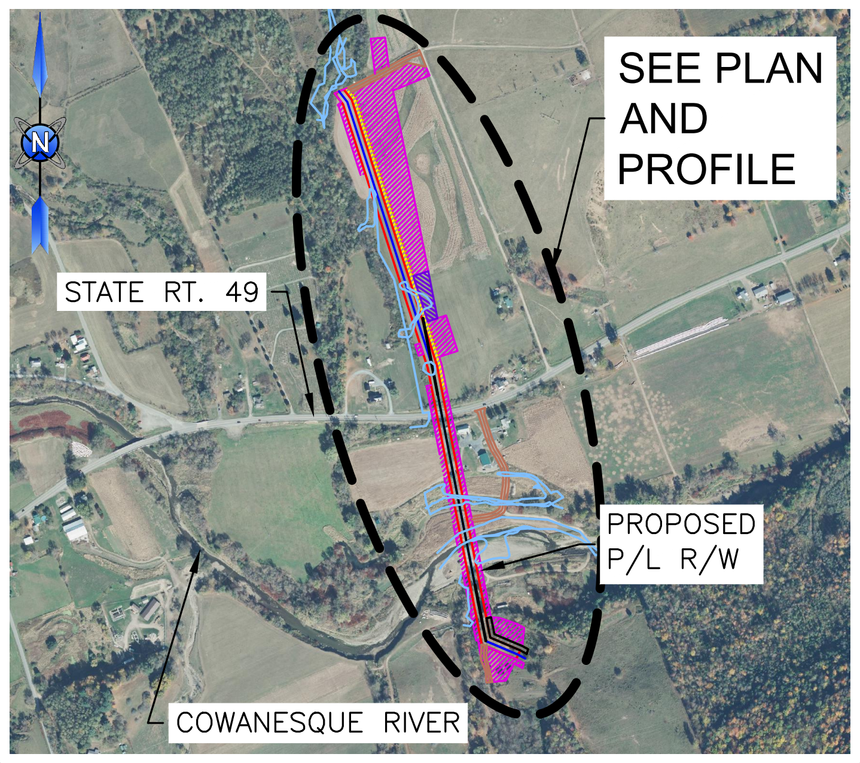
	DESIGN	100ft	30ft
MINIMUM RADIUS (ft)	1600	1250	1050

PULL FORCE / RIG SIZE / STRESS

PULL FORCE (w/o BUOYANCY CONTROL):	210,000 lbs (w/sf)
MINIMUM RECOMMENDED RIG SIZE:	440,000 lbs
COMBINED STRESS UNITY CHECK:	0.42
OPERATING STRESS:	83.4%

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR REVIEW (60% DESIGN)	2024-07-03	MS	AD	TY	LC	GB	MM
PRELIMINARY (30% DESIGN)	2024-05-10	MS	AD	TY	LC	GB	MM

LOCATION PLAN (1"=1000')



HARN/PA.PA-NF

National Fuel®

FERC 7C TIOGA PATHWAY PROJECT

COWANESQUE RIVER HDD CROSSING
HDD PLAN AND PROFILE - NPS 20

POTTER COUNTY, PENNSYLVANIA

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	4418-EG-0101	B	1 OF 2

NOTES

1. All dimensions are in feet unless otherwise specified. All dimensions are to the centerline of borehole unless otherwise specified.
2. All drill path lengths are rounded to the nearest foot and angles are rounded to the nearest degree, unless otherwise specified.
3. This drawing is based on information provided from various sources. Consulting company does not take responsibility for the accuracy of information provided by others.
4. The crossing shall be constructed in accordance with ASME B31.8 2022.

CONSTRUCTION

5. The estimated theoretical pull force (including safety factor) for this HDD crossing has been calculated to be 210,000 lbs without the consideration of pipeline buoyancy control.
6. Assumed final borehole size is 30".
7. The Contractor shall submit a Drilling Execution Plan for Company approval (prior to start of drilling operations) meeting the minimum requirements of the Contract Documents. Any deviation from the Execution Plan shall only be allowed with Company approval.
8. The Contractor shall verify topographical survey information represented on this drawing in the field prior to construction. Contractor shall inform the Owner of any topographical discrepancies identified.
9. The design drill path and existing utilities being crossed shall have a minimum separation of 10ft.
10. Contractor shall supply and use an approved annular pressure tool capable of operating within the expected pressure range. Annular pressure information provided is based on a mud motor assembly for a 12 1/4" pilot hole.
11. The locations of existing utilities, pipelines and structures shown on the drawing are approximate and shall be verified in the field by the Contractor prior to start of any excavation or pilot hole operations. Verification shall be in accordance with Company specifications and procedures. The Contractor shall ensure any utilities, pipelines and structures in the area are protected and not damaged by the construction.
12. The Contractor shall take specific precautions in protecting existing utilities, pipelines and structures at the entry and exit sites. Such precautions may include: entry/exit pits excavated below existing utilities, casing or sheet piling used to protect pipelines, ramping/matting and special drilling precautions employed during drilling. These precautions shall be used to ensure the drilling tools, pipe and product pipe maintain a safe distance from the existing pipelines, utilities and structures.
16. The current design proposes that surface casing be installed on entry and exit and seated into bedrock, however, the Contractor shall independently assess the need for temporary casing, including both small diameter "wash–over" type casing during pilot hole, and large diameter hammered–in place casing. Temporary casing shall be sized to accommodate the final ream pass and shall utilize centralizer casing within the temporary conductor casing. Casing diameter, wall thickness, grade, and drive shoe design shall be determined by the Contractor. A Contractor's Casing Plan shall be submitted and approved by Company prior to casing installation.
17. Casing final position should be surveyed after final length is installed prior to beginning pilot hole installation.
19. All temporary casings shall be removed at completion unless otherwise noted.
20. The pilot hole shall be drilled along the design drill path with the designated design radius of curvature shown in the drawing. The pilot hole shall be within the tolerances shown in the HDD drawing.
21. The design radius for this crossing is 1800 ft. The pilot hole drilling shall adhere to the following tolerances:
   30–ft (single joint) radius shall not be less than 1050 ft
   100–ft (3–joint) average radius shall not be less than 1250 ft
22. This engineered design is based on the following minimum equipment requirements that the Contractor shall have onsite:
   a. Drilling Equipment:
      - Drilling Rig with a minimum pull force of 440,000 lbs;
      - If using a forward reaming methodology, a device shall be supplied to provide tension on the drilling string on exit side (excavator, winch or second drill rig);
      - Drill Pipe 5 1/2" (inspected as per the HDD specification);
      - Drill Bit – 12 1/4" in diameter or larger (provide details, condition, and supplier);
      - 8" Mud Motor or larger capable of running within its specified maximum load range (provide details, condition, and supplier);
      - Annular Pressure Tool (0 to 510 psi range);
      - Reamers designed for the formation (provide manufacturer's operating specifications, condition, and supplier);
      - Magnetic and/or gyroscopic steering system;
      - Casing (specifications and details to be provided for approval).
   b. Drilling Fluid Recycling Equipment:
      - Pump Capacity (Operable Rate – 530 gpm);
      - Shakers (Operable Rate – 530 gpm);
      - Centrifuge/Desander/Desilter (Minimum Capacity of 400 gpm per minute).
      - Engineered Drilling Fluid Plan must be able to be implemented in the field with the proposed equipment.
   c. This is a minimum list of equipment and should not be considered a directive on how to complete the work. The Contractor is responsible for the execution of the work under its Approved Execution Plan and shall supply all necessary equipment to complete its plan at its own cost. All equipment shall be supplied in good working order, maintained, fueled and serviced.
23. Drilling Fluid is assumed to have a maximum density of 10 lbs/gallon and 1.0% sand content;

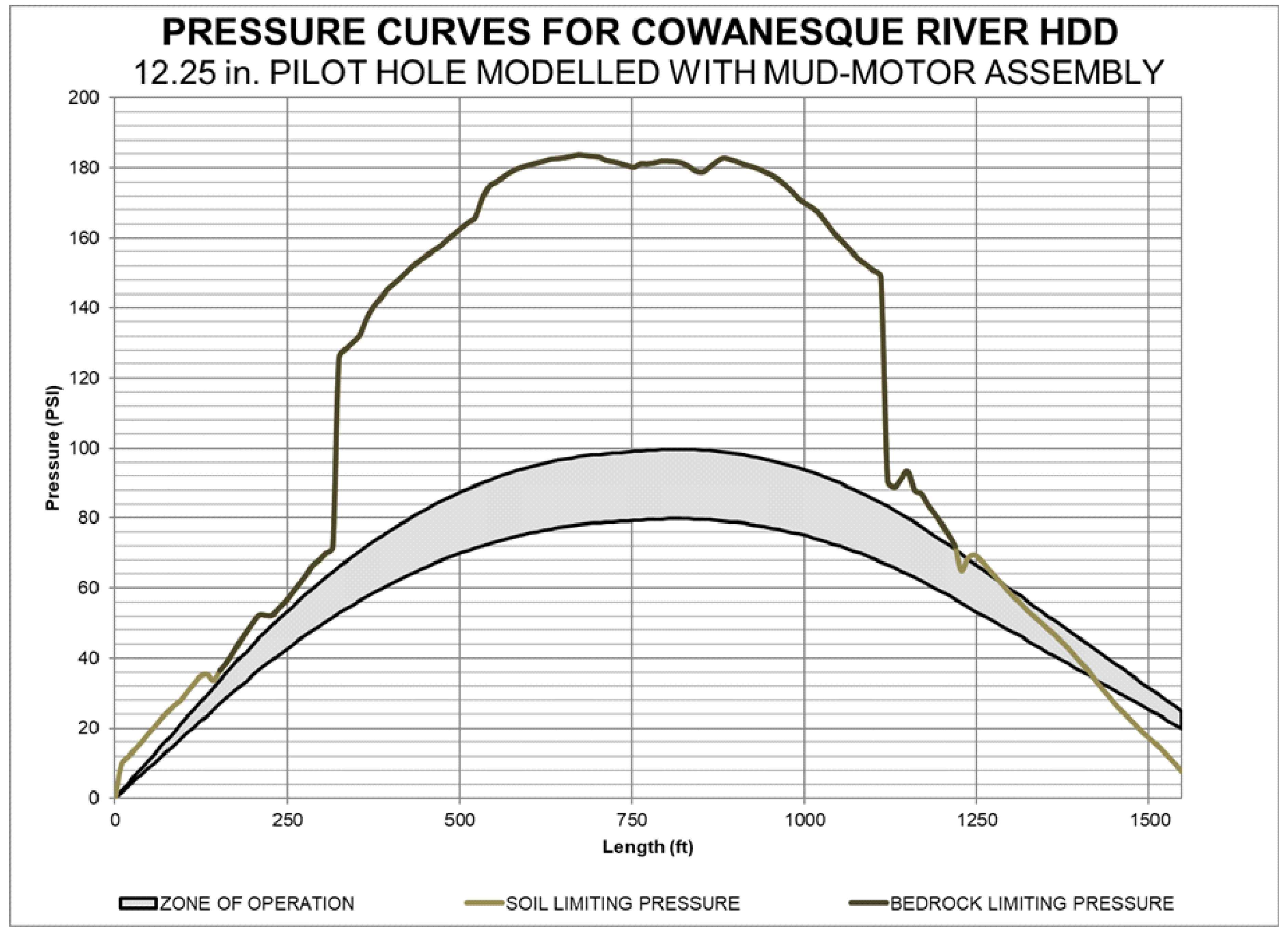
ENVIRONMENTAL

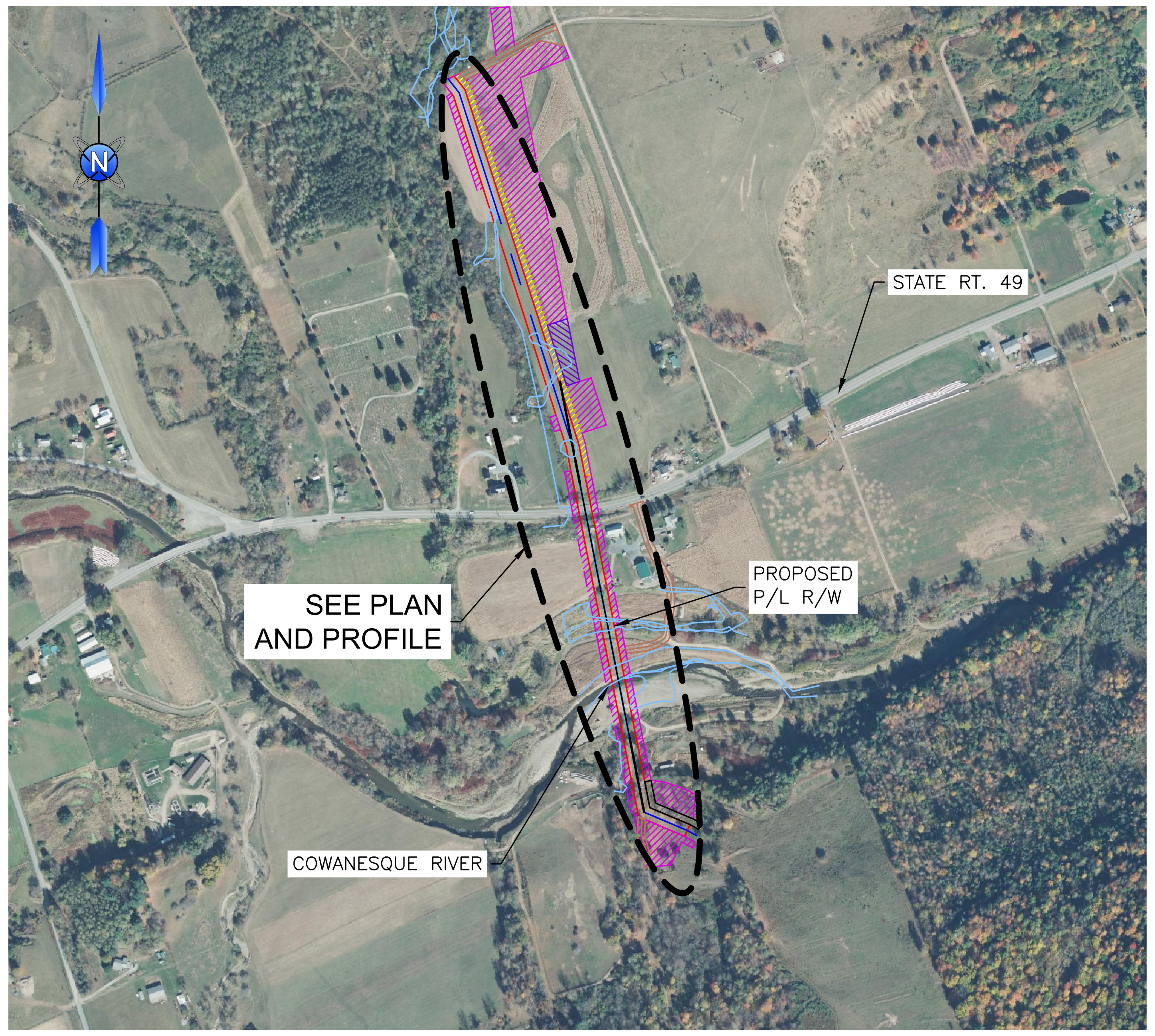
24. Emergency response spill kits must be on–site and available for use for the duration of the project.
25. Terrestrial "inadvertent return walks" shall be initiated every 4hrs. (at a minimum), or immediately following a loss of fluid event.
26. Contractor's proposed drilling fluid composition, including all expected additives, shall be reviewed and approved by the Owner's representative prior to construction.
27. The watercourse must be monitored for a potential release of drilling fluid and to assess the immediate effects of the works on the aquatic environment in accordance with applicable Federal and State regulations.
28. The Contractor shall ensure that the following documentation is on–site and readily available at all times (at a minimum):
   a. Emergency Response Procedure (ERP);
   b. Environmental Protection Plan (EPP);
   c. MSDS for all on–site material;
   d. Copies of Land Use Agreements.

GEOTECHNICAL

29. A geotechnical investigation was completed at this site by Endeavor Professional Services, LLC (Endeavor). Refer to the report for Project No. 004240.0429 titled "Geotechnical Investigation Report for Cowanesque HDD Investigation," dated March 22, 2024.
30. The soil and bedrock stratigraphy shown is based on interpretation of data from four (4) boreholes, drilled at the locations shown and the designer's understanding of the local geology. Due to natural variations in subsurface conditions and inherent uncertainties associated with the interpretation of subsurface data, some variation in stratigraphy between boreholes and along the length of the bore should be expected.
31. The Contractor should independently evaluate the crossing with due consideration given to the suitability of its proposed equipment and construction procedures. Proposed construction means and methods shall be submitted to Company for approval but remain the sole responsibility of the Contractor.

ANNULAR PRESSURE CHART





LOCATION PLAN

SCALE 1"=500'

REFERENCE DOCUMENT NO.	DATE
1. 01-Cowanesque_River_LiDAR	2024-05-06
2. 4418-01-STEEL STRESS-01	2024-06-20
3. 4418-01-AP-01	2024-06-20

CCI & Associates Inc.
20445 State Highway 249, Suite 250
Houston, TX 77070

ENGINEER AND PERMIT STAMPS

PRELIMINARY
NOT FOR
CONSTRUCTION

PIPELINE SPECIFICATIONS

	NPS 20
OUTSIDE DIAMETER (OD)(in)	20
WALL THICKNESS (WT)(in)	0.500
GRADE	X65
PRODUCT	GAS
MATERIAL	STEEL
SPECIFICATIONS	API 5L
INTERNAL COATING	N/A
OUTER COATING	FBE/PRW
MAX. OPER. PRESSURE (psi)	1,440
MIN. TEST PRESSURE (psi)	1,800
MAX. OPER. TEMP (°F)	100
MIN. INSTALLATION TEMP (°F)	30

STEERING TOLERANCES

	DESIGN	100ft	30ft
MINIMUM RADIUS (ft)	1600	1250	1050

PULL FORCE / RIG SIZE / STRESS

PULL FORCE (w/o BUOYANCY CONTROL):	210,000 lbs (w/sf)
MINIMUM RECOMMENDED RIG SIZE:	440,000 lbs
COMBINED STRESS UNITY CHECK:	0.42
OPERATING STRESS:	83.4%

DRAWING STATUS	DATE	DRN	CHK	DES	GEO	APR	CR
ISSUED FOR REVIEW (60% DESIGN)	2024-07-03	MS	AD	TY	LC	GB	SM

HARN/PA.PA-NF

National Fuel®

FERC 7C TIOGA PATHWAY PROJECT

COWANESQUE RIVER HDD CROSSING
CONSTRUCTION NOTES - NPS 20

POTTER COUNTY, PENNSYLVANIA

SCALE	DWG. #	REVISION	SHEET
AS SHOWN	4418-EG-0102	A	2 OF 2

File Name: W:\US Current Jobs\4418–National Fuel Gas Supply–Cowanesque River HDD\Eng\Drawings\01–Cowanesque River\IFR (60% Design)\4418–EG–0101–B.dwg Date/Time: 3–Jul–24 / 3:38:59 PM Last Saved By: Gunnar.Busch

APPENDIX B – HDD STRESS ANALYSIS SUMMARIES

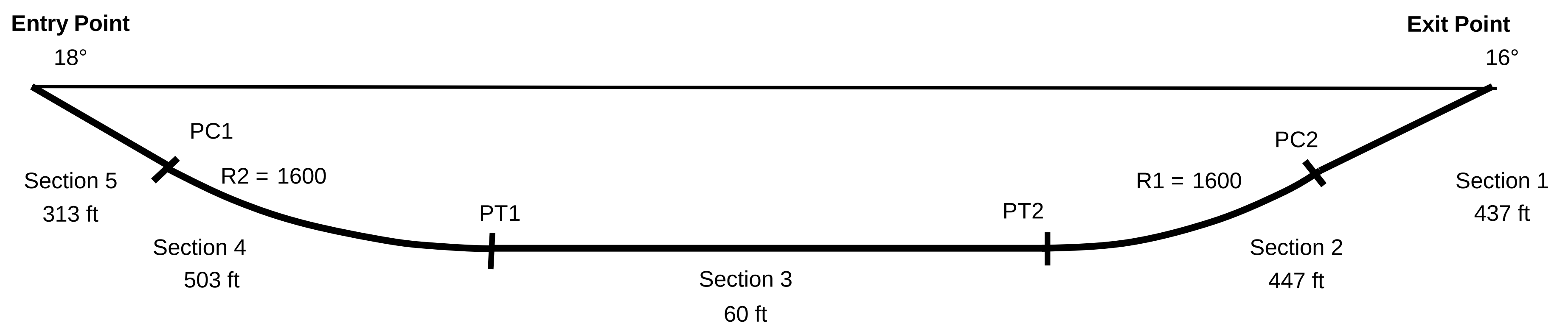
DESIGN RADIUS

Owner:	National Fuel Gas Supply Corporation
Project:	Tioga Pathway Project
Date:	6/20/2024
Calculation Description:	Stress Assessment NPS 20 HDD
Applicable Crossings:	Cowanesque River HDD

CCI & Associates Inc.

Completed By: TY | Reviewed By: AD / GB | Sheet Revision: R20

Pipe Information			Design Criteria					Crossing Characteristics	
Pipe Diameter (in)	**Pipe W.T. (in)**	**Pipe Grade (psi)**	**MOP (psi)**	**Max. Operating Temperature (°F)**	**Installation Temperature (°F)**	**Design Radius 1 [R1] (ft)**	**Design Radius 2 [R2] (ft)**	**Maximum Depth From Entry Location (ft)**	**HDD Length (ft)**
20.00	0.500	65000	1,440	100	30	1600	1600	175	1760



Design Radius Installation Stresses

Tensile Stress:

			% of Allowable
5	1965.7 psi	**PRCI 5.1.1, 5.5**	3.4%
4	3216.2 psi		5.5%
3	3309.8 psi	**Allowable Tensile Stress**	5.7%
2	4370.5 psi	$F_t = (0.9) * F_y$	7.5%
1	4553.5 psi	= 58500 psi	**7.8%**

Bending Stress:

			% of Allowable
5	245.8 psi	**PRCI 5.2.2**	0.6%
4	15364.6 psi	$f_b = (E/D)/(2R)$	**34.4%**
3	245.8 psi	**Allowable Bending Stress**	0.6%
2	15364.6 psi	F(b)=[0.84 - {1.74 Fy D / (E t)}] Fy	**34.4%**
1	245.8 psi	= 44631.9 psi	0.6%

Hoop Stress:

			% of Allowable
5	1663.9 psi	**PRCI 5.2.3**	15.4%
4	2436.6 psi	$f_h = P_{ext}D/2t$	**22.5%**
3	2436.6 psi	**Allowable Hoop Stress**	**22.5%**
2	2436.6 psi	F(hc) = F (he) for F(he) <= 0.55 x Tensile Strength	**22.5%**
1	1460.2 psi	= 10816.7 psi	13.5%

Combined Stress (Tensile and Bending)

			% of Allowable
5	0.04	**PRCI 5.2.4**	4%
4	0.40	$f_t/0.9F_y+f_b/F_b \leq 1$	40%
3	0.06		6%
2	0.42		**42%**
1	0.08		8%

Combined Stress (Tensile, Bending, and Hoop)

			% of Allowable
5	0.03	**PRCI 5.2.4**	3%
4	0.21	$A^2+B^2+2v\|A\|B \leq 1$	21%
3	0.06	$A = ((f_t+f_b-0.5f_h)1.25)/F_y$	6%
2	0.23	$B = 1.5f_h/F_{hc}$	**23%**
1	0.03		3%

Operating Stresses

Operating Stresses:

			% of Allowable
5	16825.8 psi	**PRCI 5.4.4.2:**	57.5%
4	24385.1 psi	**Allowable Shear Stress**	**83.4%**
3	16825.7 psi	F(v) = 45% of F_y	57.5%
2	24385.1 psi	F(v) = 29250 psi	**83.4%**
1	16825.8 psi		57.5%

Estimated PullForce (without Buoyancy Control)

139,405 lbs 209,108 lbs (including 1.5x Safety Factor)

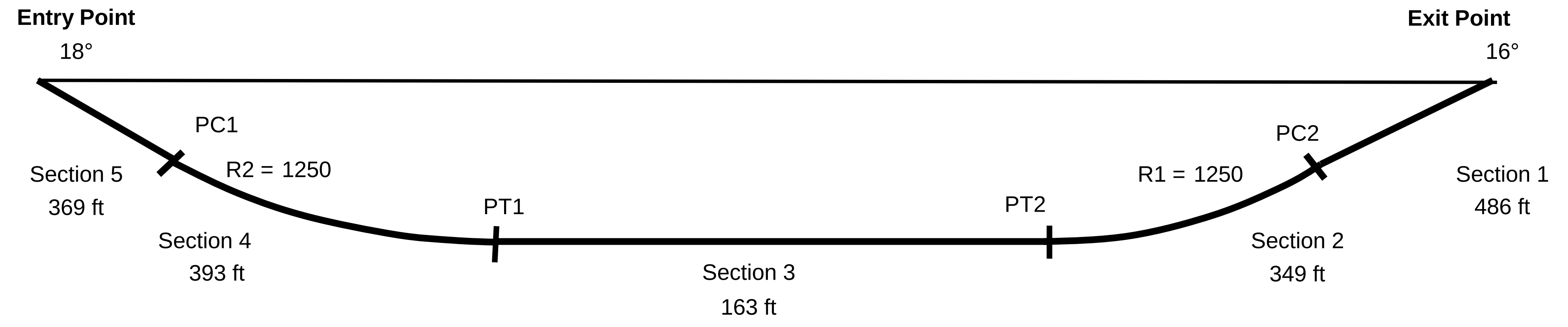
3-JOINT MADR

Owner: National Fuel Gas Supply Corporation
Project: Tioga Pathway Project
Date: 6/20/2024
Calculation Description: 3-Joint Stress Assessment NPS 20 HDD
Applicable Crossings: Cowanesque River HDD

CCI & Associates Inc.

Completed By: TY Reviewed By: AD / GB Sheet Revision: R20

Pipe Information			Design Criteria					Crossing Characteristics	
Pipe Diameter (in)	**Pipe W.T. (in)**	**Pipe Grade (psi)**	**MOP (psi)**	**Max. Operating Temperature (°F)**	**Installation Temperature (°F)**	**Design Radius 1 [R1] (ft)**	**Design Radius 2 [R2] (ft)**	**Maximum Depth From Entry Location (ft)**	**HDD Length (ft)**
20.00	0.500	65000	1,440	100	30	1250	1250	175	1760



3-Joint Installation Stresses

Tensile Stress:

		% of Allowable
5	2081.4 psi	3.6%
4	3167.3 psi	5.4%
3	3421.5 psi	5.8%
2	4398.2 psi	7.5%
1	4613.5 psi	**7.9%**

PRCI 5.1.1, 5.5

Allowable Tensile Stress
$F_t = (0.9) * F_y$
= 58500 psi

Bending Stress:

		% of Allowable
5	245.8 psi	0.6%
4	19666.7 psi	**44.1%**
3	245.8 psi	0.6%
2	19666.7 psi	**44.1%**
1	245.8 psi	0.6%

PRCI 5.2.2
$f_b = (E/D)/(2R)$
Allowable Bending Stress
F(b)=[0.84 - {1.74 Fy D / (E t)}] Fy
= 44631.9 psi

Hoop Stress:

		% of Allowable
5	1833.0 psi	16.9%
4	2436.6 psi	**22.5%**
3	2436.6 psi	**22.5%**
2	2436.6 psi	**22.5%**
1	1673.9 psi	15.5%

PRCI 5.2.3
$f_h = P_{ext}D/2t$
Allowable Hoop Stress
F(hc) = F (he) for F(he) <= 0.55 x Tensile Strength
= 10816.7 psi

Combined Stress (Tensile and Bending)

		% of Allowable
5	0.04	4%
4	0.49	49%
3	0.06	6%
2	0.52	**52%**
1	0.08	8%

PRCI 5.2.4
$f_t/0.9F_y+f_b/F_b \leq 1$

Combined Stress (Tensile, Bending, and Hoop)

		% of Allowable
5	0.03	3%
4	0.28	28%
3	0.06	6%
2	0.30	**30%**
1	0.04	4%

PRCI 5.2.4
$A^2+B^2+2v|A|B \leq 1$
$A = ((f_t+f_b-0.5f_h)1.25)/F_y$
$B = 1.5f_h/F_{hc}$

Operating Stresses

Operating Stresses:

		% of Allowable
5	16825.7 psi	57.5%
4	26536.1 psi	**90.7%**
3	16825.7 psi	57.5%
2	26536.1 psi	**90.7%**
1	16825.8 psi	57.5%

PRCI 5.4.4.2:
Allowable Shear Stress
F(v) = 45% of F_y
F(v) = 29250 psi

Estimated PullForce (without Buoyancy Control)
141,244 lbs 211,866 lbs (including 1.5x Safety Factor)

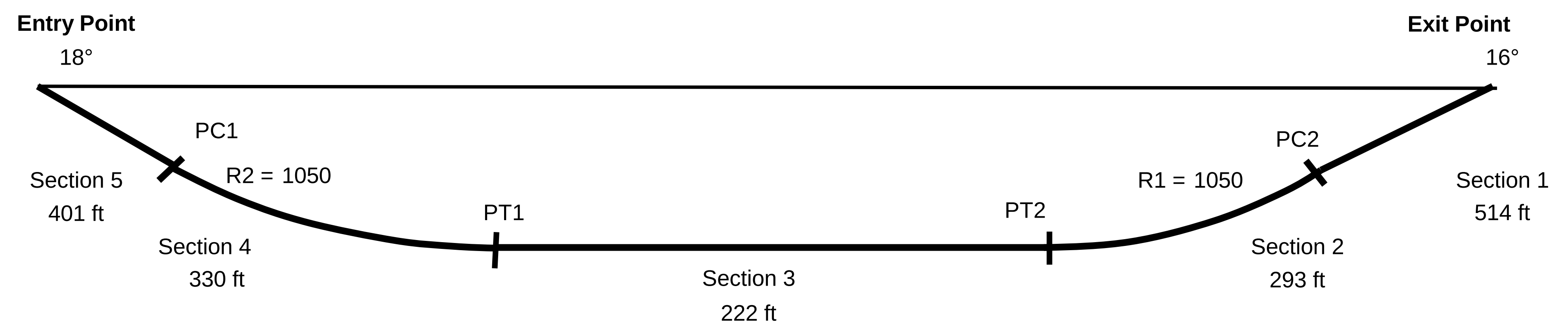
MINIMUM ALLOWABLE 1-JOINT

CCI PROJECT No. 4418
19/07/2024

Owner:	National Fuel Gas Supply Corporation
Project:	Tioga Pathway Project
Date:	6/20/2024
Calculation Description:	Single-Joint Stress Assessment NPS 20 HDD
Applicable Crossings:	Cowanesque River HDD

Completed By:	TY	Reviewed By:	AD / GB	Sheet Revision: R20

Pipe Information			**Design Criteria**					**Crossing Characteristics**	
Pipe Diameter (in)	**Pipe W.T. (in)**	**Pipe Grade (psi)**	**MOP (psi)**	**Max. Operating Temperature (°F)**	**Installation Temperature (°F)**	**Design Radius 1 [R1] (ft)**	**Design Radius 2 [R2] (ft)**	**Maximum Depth From Entry Location (ft)**	**HDD Length (ft)**
20.00	0.500	65000	1,440	100	30	1050	1050	175	1760



Single-Joint Installation Stresses

Tensile Stress:

		% of Allowable
5	2147.6 psi	3.7%
4	3154.4 psi	5.4%
3	3500.3 psi	6.0%
2	4444.3 psi	7.6%
1	4678.1 psi	**8.0%**

PRCI 5.1.1, 5.5

Allowable Tensile Stress

$F_t = (0.9) * F_y$

= 58500 psi

Bending Stress:

		% of Allowable
5	245.8 psi	0.6%
4	23412.7 psi	**52.5%**
3	245.8 psi	0.6%
2	23412.7 psi	**52.5%**
1	245.8 psi	0.6%

PRCI 5.2.2

$f_b = (E/D)/(2R)$

Allowable Bending Stress

F(b)=[0.84 - {1.74 Fy D / (E t)}] Fy

= 44631.9 psi

Hoop Stress:

		% of Allowable
5	1929.5 psi	17.8%
4	2436.6 psi	**22.5%**
3	2436.6 psi	**22.5%**
2	2436.6 psi	**22.5%**
1	1796.0 psi	16.6%

PRCI 5.2.3

$f_h = P_{ext}D/2t$

Allowable Hoop Stress

F(hc) = F (he) for F(he) <= 0.55 x Tensile Strength

= 10816.7 psi

Combined Stress (Tensile and Bending)

		% of Allowable
5	0.04	4%
4	0.58	58%
3	0.07	7%
2	0.60	**60%**
1	0.09	9%

PRCI 5.2.4

$f_t/0.9F_y+f_b/F_b \le 1$

Combined Stress (Tensile, Bending, and Hoop)

		% of Allowable
5	0.04	4%
4	0.35	35%
3	0.06	6%
2	0.38	**38%**
1	0.04	4%

PRCI 5.2.4

$A^2+B^2+2v|A|B \le 1$

$A = ((f_t+f_b-0.5f_h)1.25)/F_y$

$B = 1.5f_h/F_{hc}$

Operating Stresses

Operating Stresses:

		% of Allowable
5	16825.7 psi	57.5%
4	28409.2 psi	**97.1%**
3	16825.7 psi	57.5%
2	28409.2 psi	**97.1%**
1	16825.7 psi	57.5%

PRCI 5.4.4.2:

Allowable Shear Stress

F(v) = 45% of F_y

F(v) = 29250 psi

Estimated PullForce (without Buoyancy Control)

143,220 lbs 214,830 lbs (including 1.5x Safety Factor)

APPENDIX C – PIPE LIFTING STRESS ANALYSIS SUMMARY

Owner:	National Fuel Gas Supply Corporation
Project:	Tioga Pathway Project
Date:	7/16/2024
Calculation Description:	HDD Pipe Pullback Analysis NPS 20
Applicable Crossings:	Cowanesque River HDD

Completed By:	AD	Reviewed By:	GB	Sheet Revision: R20

Pipe Information			**Design Criteria**					
Pipe Diameter (in)	**Pipe W.T. (in)**	**Pipe Grade (psi)**	**Overbend Radius (ft)**	**Total Supported Weight (lbs/ft)**	**Maximum Support Spacing (ft)**	**Roller Spacing (ft)**	**Maximum Unsupported Overhang (ft)**	**Estimated Pullforce (lbs)**
20.00	0.500	65000	850	103.6	75	60	65	214,830

The pipe pullback is modelled such that the pipe is not over-stressed due to the combination of bending, tensile, and shear stresses throughout the pullback section, both in the spans between supports and at the support locations.
The pullback is also modelled such that the supports are not overloaded with the weight of the pipe at any point during the pipe installation, including as the tailing end passes from support to support.

Definitions:

SMYS	- Specified Minimum Yield Strength
Overhang	- Where Unsupported Tail End of Pipe Extends Beyond Support
Full Span	- Where Pipe Is Supported Between 2 Supports at Maximum Support Spacing Shown Above

SUPPORT LOADING

Vertical Load at Each Boom/Crane Support — **% of Support Capacity ***

At Support With Full Span:

5,400 kg — 11,800 lbs — 41.5%

At Support With Overhang:

6,600 kg — 14,600 lbs — **50.8%**

Longitudinal Load at Each Boom/Crane Support

660.0 kg — 1,460 lbs

* based on load capacity of Darby 12" - 24"D Rolli-Cradle

Horizontal Load at Each Boom/Crane Support

0 kg — 0 lbs

Horizontal Load at Each Roller Support

0 kg — 0 lbs

PIPE STRESS

	% SMYS	**% of Allowable (PRCI)**
Bending Stress		
At Support With Full Span:		
32922.1 psi	50.6%	75.7%
At Support with Overhanging Pipe:		
36285.4 psi	55.8%	**83.5%**
Tensile Stress		
1190.3 psi	1.8%	**2.0%**
Combined Stress (Tensile and Bending)		
34112.4 psi	52.5%	**78%**

APPENDIX D – RISK ASSESSMENT SUMMARY

Risk Assessment Legends

Probability		
Value	**Description**	**Chance**
1	Rare	≤ 5%
2	Unlikely	~ 25%
3	Possible	~ 50%
4	Likely	~ 75%
5	Almost Certain	≥ 95%

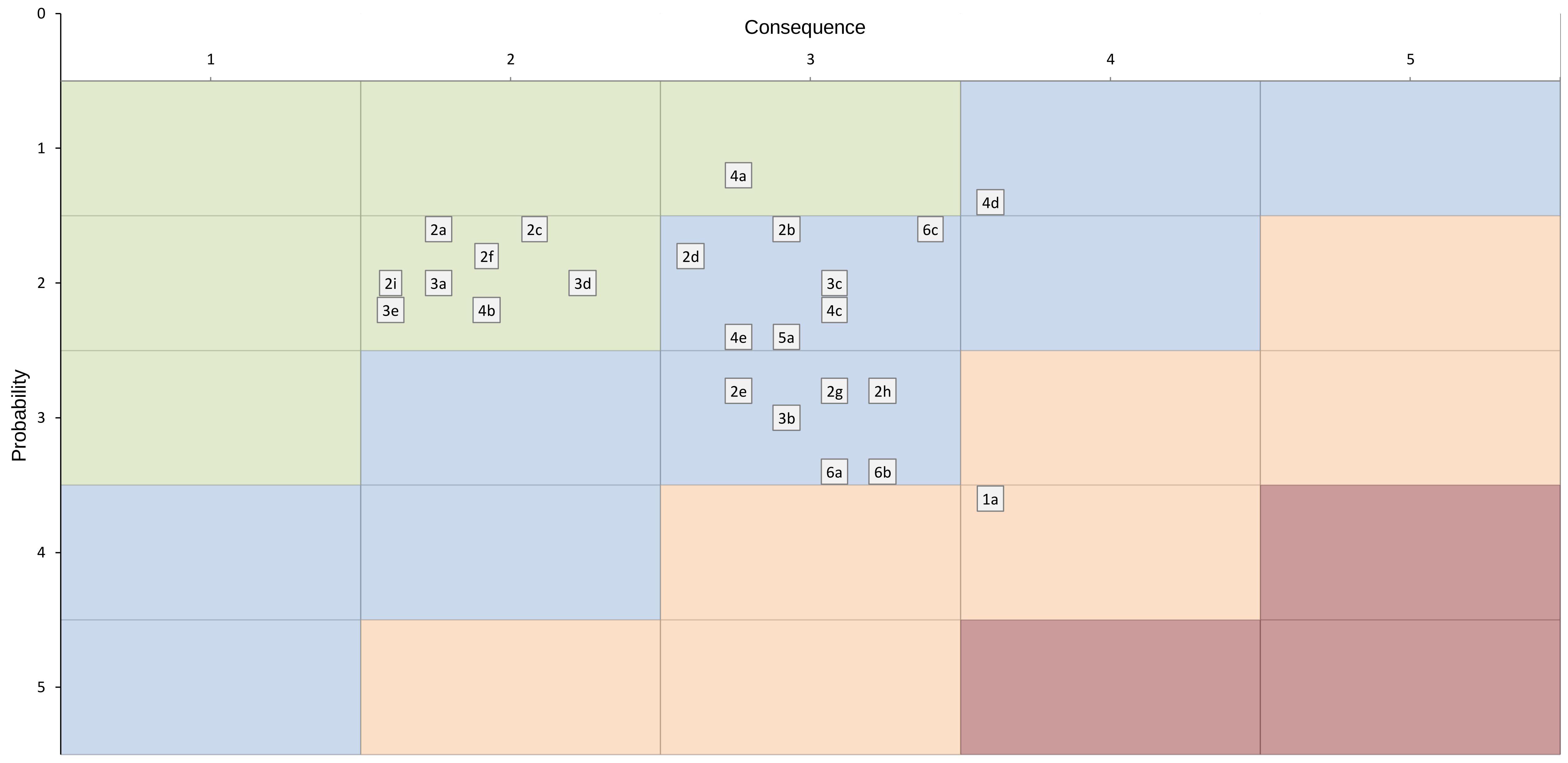
Consequence	
Value	**Description**
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Catastrophic

Risk Types	1 - Insignificant	2 - Minor	3 - Moderate	4 - Major	5 - Catastrophic
Safety and Health	**First Aid Case**	**Minor Injury** - Medical treatment case with/or Restricted Work Case	**Serious Injury** or Lost Work Case	**Major or Multiple Injuries** - permanent injury or disability	**Fatality**
Environment	**No Impact** on baseline environment. Localized to point source. No action required.	**Localised** within site boundaries. Recovery measureable within 1 month of impact	**Moderate** harm with possible wider effect. Recovery in 1 year	**Significant** harm with local effect. Recover longer than 1 year	**Significant** harm with widespread effect. Recovery longer than 1 year. Limited prospect of full recovery
Financial	1 - 5% over Budget	5 - 20% over Budget	20 - 50% over Budget	50 - 100% over Budget	> 100% over Budget
Production/Schedule	< 1 - 5 days	6 days - 2 weeks	3 - 4 weeks	5 - 6 weeks	> 6 weeks
Reputation	Localised temporary impact	Localised, short term impact	Localised, long term impact but manageable	Localised, long term impact with unmanageable outcomes	Long term regional impact
Business Impact	Impact can be absorbed through normal activity	An adverse event which can be absorbed with some management effort	A serious event which requires additional management effort	A critical event which required extraordinary management effort	Disaster with potential to lead to collapse of the project

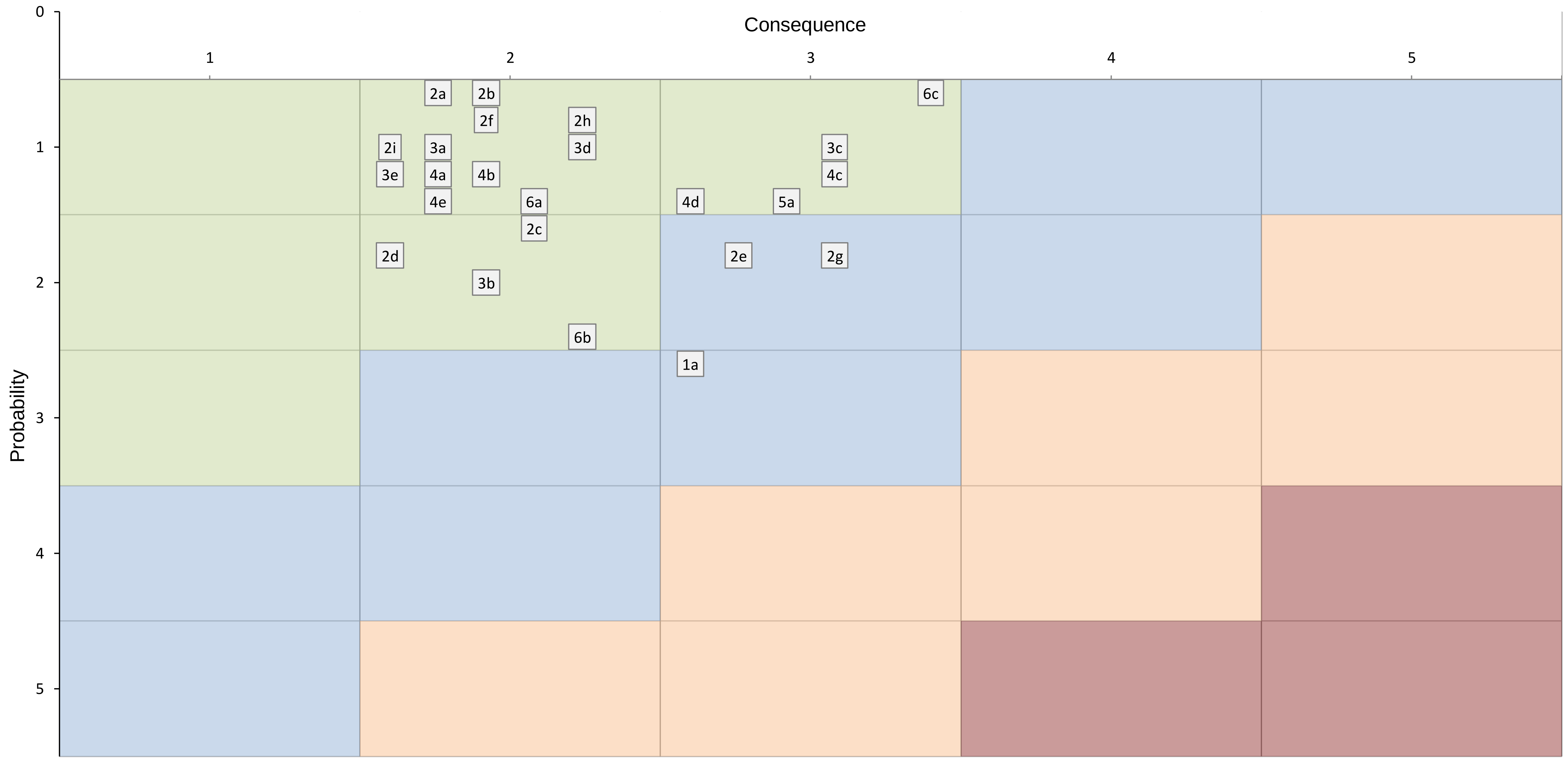
		Consequence				
Probability		**1**	**2**	**3**	**4**	**5**
	1	L	L	L	M	M
	2	L	L	M	M	H
	3	L	M	M	H	H
	4	M	M	H	H	VH
	5	M	H	H	VH	VH

L	Low Risk - Managed by routine procedures
M	Medium Risk - Planned Mitigation Strategy Required
H	High Risk - Prioritized Mitigation Strategy Required
VH	Very High Risk - Immediate Mitigation Strategy Required

Cowanesque River HDD Risk Assessment Before Mitigation



Cowanesque River HDD Risk Assessment After Mitigation



Cowanesque River HDD Risk Assessment Summary

Phase	#	Description	Safety and Health Risk	Environmental Risk	Financial Risk	Production/Schedule Risk	Reputation Risk	Business Impact Risk	Risk Before Mitigation	Risk After Mitigation
Installation of Casing (Entry and Exit Points)	1a	Casing not Being Installed to Depth		✓	✓	✓			High Risk	Medium Risk
Pilot Hole	2a	Fracture to Surface	✓	✓	✓	✓			Low Risk	Low Risk
	2b	Fracture to Water Body	✓	✓	✓	✓			Medium Risk	Low Risk
	2c	Large Fluid Loss to the Formation (>25% of total volume)	✓	✓	✓	✓			Medium Risk	Low Risk
	2d	Unstable Borehole (swelling, broken up, etc.)	✓	✓	✓	✓			Medium Risk	Low Risk
	2e	Steering Control Issues	✓	✓	✓	✓			Medium Risk	Medium Risk
	2f	Annular Pressure Issues	✓	✓	✓	✓			Low Risk	Low Risk
	2g	Over-Schedule Risk	✓	✓	✓	✓			Medium Risk	Medium Risk
	2h	Disposal of Drilling Fluid	✓	✓	✓	✓			Medium Risk	Low Risk
	2i	Water Ingress to Borehole	✓	✓	✓	✓			Low Risk	Low Risk
Reaming Operations	3a	Unstable Borehole	✓	✓	✓	✓			Low Risk	Low Risk
	3b	Over-Schedule Risk	✓	✓	✓	✓			Medium Risk	Low Risk
	3c	Loss of Equipment in Borehole		✓	✓	✓			Medium Risk	Low Risk
	3d	Poor Removal of cuttings		✓	✓	✓			Low Risk	Low Risk
	3e	Drilling Fluid Control		✓	✓	✓			Low Risk	Low Risk
Pullback Operations	4a	Pipe Section Gets Stuck in Borehole		✓	✓	✓			Low Risk	Low Risk
	4b	Pull Forces Exceed Theoretical Model		✓	✓	✓			Low Risk	Low Risk
	4c	Coating Damaged during Installation		✓	✓	✓			Medium Risk	Low Risk
	4d	Product Pipe is Damaged during Installation		✓	✓	✓			Medium Risk	Low Risk
	4e	Pipe Handling on Exit	✓	✓	✓	✓			Medium Risk	Low Risk
Pipeline Contractor - Pipe Preparation and Support	5a	HDD Takes Longer than Scheduled to Complete		✓	✓	✓			Medium Risk	Low Risk
Construction Access and Pad Preparation	6a	Construction Access	✓	✓	✓	✓			Medium Risk	Low Risk
	6b	Pad Layout & Construction	✓	✓	✓	✓			Medium Risk	Low Risk
	6c	Travel Safety							Medium Risk	Low Risk
Other Risks	7a									
	7b									
	7c									
	7d									

Probability

Value	Description	Chance
1	Rare	≤ 5%
2	Unlikely	~ 25%
3	Possible	~ 50%
4	Likely	~ 75%
5	Almost Certain	≥ 95%

Consequence

Value	Description
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Catastrophic

L	Low Risk - Managed by routine procedures
M	Medium Risk - Planned Mitigation Strategy Required
H	High Risk - Prioritized Mitigation Strategy Required
VH	Very High Risk - Immediate Mitigation Strategy Required

Attendance: Steve Meaders, Gunnar Busch, Landon Cels, Justin Taylor

Cowanesque River HDD

Date: **July 18, 2024**
Rev: **0**

Mud Motor HDD Risk Assesment

No.	Risk/Issue	Type of Risk/Issue		Pre-Mitigation		Post-Mitigation		Review Cost Needed?
				Probability	Consequence	Probability	Consequence	
Installation of Casing (Entry and Exit Points)								
1a	Casing not Being Installed to Depth	Safety and Health	-	4	4	3	3	Select
		Environment	Yes	High Risk		Medium Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Geotechnical conditions identified gravels, unconsolidated overburden material and rock fragments above bedrock interface which could cause some issues installaling the casing to depth into competent bedrock. Geotechnical boring on north side of crossing near the exit point does not extend into competent bedrock, therefore, exact length of exit-side casing is approximate.		It would be recommended to excavate at the entry and exit locations to shorten the length of the casing that may be required. Contractor should consider telescoping casing to allow desired length of minimum size casing to be installed. Contractor shall provide inspected casing and casing shoe with casing installation plan and ensure proper equipment is on site at all times. It is also recommended that an additional boring be completed near the exit point which extends into competent bedrock to allow for planning of required casing length		
		Reputation	-					
		Business Impact	-					
Pilot Hole								
2a	Fracture to Surface	Safety and Health	Yes	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	[Assuming casing installed to depth] Granular/unconsolidated material near surface can pose a potential risk for conduit where drilling fluid migrates to surface as drill bit nears surface. The geotechnical investigation identified gravels, unconsolidated overburden and rock fragments in which the HDD drill will be progressing through before reaching the bedrock interface.		Surface casing installation will help mitigate most of the Fracture to Surface risks by isolating the problematic geotechnical materials and allow the drilling fluid to be containted within the casing to keep an open borehole. Contractor shall have necessary fluid containment equipment at the entry and exit to prevent the fluid from spilling out from the pits. Ensure the drill operator adheres to the required tolerances for the HDD path and reduces fluid pressures—mechanical trip as necessary. Follow EDFP		
		Reputation	-					
		Business Impact	-					
2b	Fracture to Water Body	Safety and Health	Yes	2	3	1	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Fractured bedrock can provide a potential path for drilling fluid migration to the river where drill bit is crossing underneath the waterbody. A low risk of IR has been identified beneath the identified river. Based on available geo data, the HDD is expected to remain embedded within siltstone bedrock under the river. Unclear of what specific UCS testing of rock is due to limited testing.		Ensure Contractor adheres to the required tolerances for the HDD path and reduce fluid pressures. Mechanical trip as necessary. Follow EDFP.		
		Reputation	-					
		Business Impact	-					
2c	Large Fluid Loss to the Formation (>25% of total volume)	Safety and Health	Yes	2	3	2	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	[Assuming casing installed to depth] Drilling fluid has a potential to migrate outside of the designed drill path in heavily fractured rock, which is anticipated near the bedrock interface. Large fluid loss may have permitting implications.		The Contractor shall ensure that the surface casing is installed to depth into competent bedrock to avoid losing fluid into the fractured bedrock interface. The Contractor shall ensure not to over pressurize the borehole with excessive drilling fluid pressures. Follow EDFP.		
		Reputation	-					
		Business Impact	-					
		Safety and Health	Yes	2	3	2	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		

2d	Unstable Borehole (swelling, broken up, etc.)	Production/Schedule	Yes	[Assuming casing installed to depth] Limited geotechnical information near the exit point may pose difficulty/uncertainty for casing installation throgh loose granular materials. During drilling operations this material can become unstable. Potential for rock fragments within the bedrock.		Surface casing installation will help mitigate most of the Unstable Borehole risks by isolating the problematic geotechnical materials and allow the drilling fluid to be containted within the casing to keep an open borehole. The Contractor shall trip/clean the hole within the bedrock to ensure proper hole integrity. It is also recommended that an additional boring be completed near the exit point which extends into competent bedrock to allow for planning of required casing length		
		Reputation	-					
		Business Impact	-					
2e	Steering Control Issues	Safety and Health	Yes	3	3	2	3	Select
		Environment	Yes	Medium Risk		Medium Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Design radius was selected to be 1,600ft. It is possible that the drill bit could deflect or have a hard time entering the bedrock interface if the surface casing has not properly reached competent bedrock. Casing installed on both ends would require the rig on entry to steer the bit into the 42" casing nearer the exit point which could be very difficult.		Utilize experienced Contractor to complete the work. Ensure surface casing is installed to depth into competent bedrock and utililize centralizer. The Contractor shall ensure that steering equipment is calibrated before construction and adhere to steering tolerances. Ensure that the steering coil can be laid out across the River and road. Contractor to have contingency plan to use Gyro if unable to lay out coil. Intersect pilot hole (rigs on either end) is highly recommended to ensure that the pilot hole can be centetered within the casing from either end. Casing final position should be surveyed after final length is installed prior to beginning pilot hole installation.		
		Reputation	-					
		Business Impact	-					
2f	Annular Pressure Issues	Safety and Health	Yes	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	[Assuming casing installed to depth] Drilling operations require soil cuttings to be cleaned out of the bore and hydro-transported back to the rig by the drilling fluid. This process requires large volumes of pressurized drilling fluid to be pumped downhole.		Utilize experienced Contractor to complete the work. Ensure surface casing is installed to depth into competent bedrock. Ensure drilling fluid pumping equipment is working properly and adjust the drilling fluid properties as needed. Mechanical tripping to clear borehole. Mud engineer on site is recommended. Adhere to EDFP.		
		Reputation	-					
		Business Impact	-					
2g	Over-Schedule Risk	Safety and Health	Yes	3	3	2	3	Select
		Environment	Yes	Medium Risk		Medium Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Unknown geotechnical conditions, groundwater, equipment failure, permitting, and environmental issues can all contribute to delays in the schedule. Casing is required on both ends of the crossing due to poor geotechnical conditions which will add significantly to the schedule.		Utilize experienced Contractor to complete the work. Contractor to develop a detailed casing installation plan to ensure surface casing is installed to depth into competent bedrock. Ensure all communication with relevant stakeholders is maintained and that the Contractor is planned for routine mechanical tripping. Minimize downtime as much as possible while drilling beneath river into the bedrock. Additional boring recommended near exit point which identifies depth of bedrock.		
		Reputation	-					
		Business Impact	-					
2h	Disposal of Drilling Fluid	Safety and Health	Yes	3	3	1	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Drilling fluid needs to be stored and disposed of. Running out of temporary storage can lead to schedule delays and environmental concerns. PADEP enforces strict requirements for mud and cuttings disposal.		Ensure drilling fluid waste management plan created and approved of prior to construction & approved disposal site is selected meeting PADEP and other stakeholder/regulatory body requirements.		
		Reputation	-					
		Business Impact	-					
2i	Water Ingress to	Safety and Health	Yes	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Ground water tends to migrate to where soil has been cut/ displaced				

	Borehole	Reputation	-	Ground water tends to migrate to where soil has been cut/ displaced. Water within the boreholes were noted to be near the elevation of the flowing water within the river at the time of the geotechnical investigation.		Control drilling fluid properties to account for groundwater ingress. Recommend mud engineer on site. EDFP shall be in put place and followed.		
		Business Impact	-					
Reaming Operations								
3a	Unstable Borehole	Safety and Health	Yes	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	[Assuming casing installed to depth] Limited geotechnical information near the exit point may pose difficulty/uncertainty for casing installation throgh loose granular materials. During drilling operations this material can become unstable. Potential for rock fragments within the bedrock.		Surface casing installation will help mitigate most of the Unstable Borehole risks by isolating the problematic geotechnical materials and allow the drilling fluid to be containted within the casing to keep an open borehole. The Contractor shall trip/clean the hole within the bedrock to ensure proper hole integrity. It is also recommended that an additional boring be completed near the exit point which extends into competent bedrock to allow for planning of required casing length. Contractor to make note of any issues encountered during the pilot hole installation phase.		
		Reputation	-					
		Business Impact	-					
3b	Over-Schedule Risk	Safety and Health	Yes	3	3	2	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Unknown geotechnical conditions, groundwater, equipment failure, permitting, and environmental issues can all contribute to delays in the schedule.		Ensure all communication with stakeholders is maintained and that the Contractor is planned for routine mechanical tripping to ensure competent clean borehole.		
		Reputation	-					
		Business Impact	-					
3c	Loss of Equipment in Borehole	Safety and Health	-	2	3	1	3	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Reaming or enlarging the bore to the desired diameter may cause instability areas. These areas may cause downhole tooling to get stuck or lost.		Ensure all connections are properly torqued and all reaming tools have the ability to cut in both directions. Contractor shall use tail string at all times to allow extraction of tooling from either end in the event that a twist off does occur. Contractor should make sure hole is clean and maintain full returns, utilize proper Rate of Penetrations (ROPs) and pump rates. [If intersect pilot hole is used, second rig would assist]		
		Reputation	-					
		Business Impact	-					
3d	Poor Removal of cuttings	Safety and Health	-	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Cuttings need to be efficiently removed from the borehole. Failure to remove the cuttings due to properties of the geological formation can lead to blockages in the bore path and increased fluid pressure.		Develop EDFP to monitor drilling fluid properties to ensure the fluid is the right consistency to remove the cuttings effectively. Recommend mud engineer on site. Contractor should make sure hole is clean and maintain full returns, utilize proper Rate of Penetrations (ROPs) and pump rates.		
		Reputation	-					
		Business Impact	-					
3e	Drilling Fluid Control	Safety and Health	-	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	As the volume of drilling fluid within the borehole increases, it becomes more difficult to change its properties with drillng fluid additives.		Develop EDFP to monitor drilling fluid properties to ensure the fluid is the right consistency to effectively remove the cuttings. Mud engineer recommended on site.		
		Reputation	-					
		Business Impact	-					
Pullback Operations								
4a	Pipe Section Gets Stuck in Borehole	Safety and Health	-	1	3	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	[Assuming casing installed to depth] There is a risk that the pipe section will become stuck in the borehole		Install casing to depth. Effectively remove cuttings from borehole		

	Borehole			There is a risk that the pipe section will become stuck in the borehole due to borehole instability, blockages, or irregularities. Prolonged stoppages during installation could cause borehole to constrict around pipe in these formations.		install casing to depth. Effectively remove cuttings from borehole, perform a swab pass, and effective scheduling of pullback operations to minimize downtime. Track pullforce and torque values during swab pass.		
		Reputation	-					
		Business Impact	-					
4b	Pull Forces Exceed Theoretical Model	Safety and Health	-	2	2	1	2	Select
		Environment	Yes	Low Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	There is a risk that pull forces exceed the theoretical model. Contributing factors can include cuttings in the borehole, having to temporarily halt line pull, borehole instability, and heavy drilling fluid.		Maintain favorable drilling fluid properties and effectively remove cuttings from borehole. Ensure adequate rig size and perform a swab pass.		
		Reputation	-					
		Business Impact	-					
4c	Coating Damaged during Installation	Safety and Health	-	2	3	1	3	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Gravel, cobbles, boulders, and bedrock interfaces within the bore path pose a risk that the pipe coating is damaged during line pull. Gravels and rock fragments were identified within the unconsolidated overburden material, which will be mostly isolated by the surface casing. If borehole is not centered within casing and casing is not properly sized for product pipe then the pipe may be dragged along the mouth of casing during pullback.		Perform a swab pass prior to pullback to confirm that borehole is clear of obstructions or debris. Monitor the bottom sections of surface casing during drilling to get an idea of how rough the transition might be, and if there will be bedrock fragments to get past. Monitoring of torque and pullforce during swab pass. Contractor to follow approved casing plan and ensure borehole is centered within properly sized casing.		
		Reputation	-					
		Business Impact	-					
4d	Product Pipe is Damaged during Installation	Safety and Health	-	1	4	1	3	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Gravel, cobbles, boulders, and bedrock interfaces within the bore path pose a risk that the pipe is damaged during line pull. Gravels and rock fragments were identified within the unconsolidated overburden material, which will be mostly isolated by the surface casing. If borehole is not centered within casing and casing is not properly sized for product pipe then the pipe may be dragged along the mouth of casing during pullback.		Perform a swab pass prior to pullback to confirm that borehole is clear of obstructions or debris. Monitor the bottom sections of surface casing during drilling to get an idea of how rough the transition might be, and if there will be bedrock fragments to get past. Monitoring of torque and pullforce during swab pass.Contractor to follow approved casing plan and ensure borehole is centered within properly sized casing.		
		Reputation	-					
		Business Impact	-					
4e	Pipe Handling on Exit	Safety and Health	Yes	2	3	1	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Pipe will be made-up on exit side and made ready to be pulled into the borehole. This involves many construction crews and lifting equipment to be safely coordinated and operated. Ground slope encounters a gradual incline away from the exit along the pullback alignment.		The contractor needs to develop and approve the pipe lifting plan and entry and exit side crews should stay in communication with one another. Ensure that work-on-slope procedures can be followed to ensure that pipe segments don't slip down the slope.		
		Reputation	-					
		Business Impact	-					
Pipeline Contractor - Pipe Preparation and Support								
5a	HDD Takes Longer than Scheduled to Complete	Safety and Health	-	2	3	1	3	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Unknown geotechnical conditions, groundwater, equipment failure, permitting, and environmental issues can all contribute to delays in the schedule.		Proper schedule communication between the rig, HDD contractor, and pipeline contractor. Contractor to prep the pullback area prior to construction.		
		Reputation	-					
		Business Impact	-					
Construction Access and Pad Preparation								
		Safety and Health	Yes	3	3	1	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		

6a	Construction Access	Production/Schedule	Yes	Constructing new access for entry location located on the north side of the river on a steep hill to bring all necessary equipment to entry location. Exit location will be accessible from public roads, though access roads will need to be built appropriately. Entry-side access requires crossing over the Cowanesque River which may require a temporary bridge. Old bridges may be required to be crossed over with heavy equipment which the bridges may not be rated for.		Ensure the necessary equipment (casing installation & drilling operations) can reach the workspace. Development of suitable access plan prior to construction that is approved by owner and stakeholders. Ensure proper traffic control plan. Check weight requirements for all roads and bridges to be used for access and that proper vehicles/equipments are used for access routes.		
		Reputation	-					
		Business Impact	-					
6b	Pad Layout & Construction	Safety and Health	Yes	3	3	2	2	Select
		Environment	Yes	Medium Risk		Low Risk		
		Financial	Yes	**Description**		**Mitigation Strategy**		
		Production/Schedule	Yes	Constructing entry pad will require leveling and clearing work due to the steep hill on the entry side. The exit side is located within a field which looks flat and clear of trees which would likely require minimal efforts to prep for construction.		Ensure the necessary equipment (casing installation & drilling operations) can reach the workspace. Development of suitable access plan prior to construction that is approved by owner and stakeholders. Ensure proper traffic control plan. Contractor should develop an approved grading plan for the entry pad to allow rig and equipment setup.		
		Reputation	-					
		Business Impact	-					
6c	Travel Safety	Safety and Health	-	2	3	1	3	Select
		Environment	-	Medium Risk		Low Risk		
		Financial	-	**Description**		**Mitigation Strategy**		
		Production/Schedule	-	Contractor will have to travel to site on public and private roads in remote areas. River will need to be crossed to access entry site.		Make sure the contractor knows where they're going and drives safely. Respect and follow signage. Have proper PPE. Clearly mark or flag access routes. Traffic control during heavy traffic. Ensure that river can safely be crossed.		
		Reputation	-					
		Business Impact	-					
Other Risks								
7a		Safety and Health	-	0	0	0	0	Select
		Environment	-	Risk Weighting		Risk Weighting		
		Financial	-	**Description**		**Mitigation Strategy**		
		Production/Schedule	-					
		Reputation	-					
		Business Impact	-					
7b		Safety and Health	-	0	0	0	0	Select
		Environment	-	Risk Weighting		Risk Weighting		
		Financial	-	**Description**		**Mitigation Strategy**		
		Production/Schedule	-					
		Reputation	-					
		Business Impact	-					
7c		Safety and Health	-	0	0	0	0	Select
		Environment	-	Risk Weighting		Risk Weighting		
		Financial	-	**Description**		**Mitigation Strategy**		
		Production/Schedule	-					
		Reputation	-					
		Business Impact	-					
7d		Safety and Health	-	0	0	0	0	Select
		Environment	-	Risk Weighting		Risk Weighting		
		Financial	-	**Description**		**Mitigation Strategy**		
		Production/Schedule	-					
		Reputation	-					
		Business Impact	-					

Tioga Pathway Project

National Fuel Gas Company

Inadvertent Return Plan

Potter and Tioga Counties, Pennsylvania

<table>
<tr><th colspan="5">Project Information</th></tr>
<tr><td colspan="2">Project Name</td><td>Waterbody Name</td><td>Agency</td><td>Clearance Date</td></tr>
<tr><td colspan="2" rowspan="2">Tioga Pathway Project</td><td rowspan="2">Cowanesque River (S32) and also:
Unnamed Tributary to Cowanesque River (S31), Wetland W23 and and Wetland W24</td><td colspan="2">Type (N/A) Below if Not Applicable</td></tr>
<tr><td>PAGC</td><td>June 3, 2024</td></tr>
<tr><td>County</td><td>Municipality</td><td>Waterbody Classification</td><td>PADCNR</td><td>May 23, 2024</td></tr>
<tr><td>Tioga</td><td>Westfield</td><td>Warmwater Fishes (WWF)</td><td>PAFBC</td><td>July 1, 2024</td></tr>
<tr><td colspan="3"></td><td>USFWS</td><td>Pending</td></tr>
<tr><td colspan="3"></td><td>USACE</td><td>Pending</td></tr>
<tr><td colspan="3"></td><td>PADEP</td><td>Pending</td></tr>
<tr><td colspan="3"></td><td>SHPO</td><td>Pending</td></tr>
<tr><td colspan="2">DEC/DEP Permit Number(s)</td><td>In-Stream Restriction Dates (if applicable)</td><td colspan="2">HDD Entry/Exit Coordinates</td></tr>
<tr><td colspan="2">Pending</td><td>(to be confirmed in PADEP Ch. 105 permit when issued)</td><td colspan="2">Entry: 41°55'24.59"N, 77°30'55.98"W
Exit: 41°55'39.04"N, 77°30'59.90"W</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Contact Information</td></tr>
<tr><td colspan="5">National Fuel Environmental Compliance Coordinator:</td></tr>
<tr><td colspan="3">PADEP Regional Contact
PADEP RPCO, 400 Market Street, 10th Flr Rachel Carson State Office Bldg.,Harrisburg, PA, (717) 772-5987</td><td colspan="2">PA Fish & Boat Commission (if applicable)
Northcentral Region Office, (814) 359-5250 855-347-4545</td></tr>
<tr><td colspan="3">USACE Contact
Baltimore District, 2 Hopkins Plaza, Baltimore, MD 21201, Phone: (410) 962-2809</td><td colspan="2">Other Interested Parties</td></tr>
</table>

1.0 GENERAL INFORMATION

Horizontal directional drilling (HDD) is a pipeline installation method that typically uses specific drilling equipment to bore a drill path at a shallow inclined angle creating a crossing path beneath surface features. HDD avoids intruding directly on sensitive surface features such as streams, wetlands, roadways, railroads, or any combination of these features. In comparison, the conventional open-cut trenching methods create direct disturbance to the surface feature(s). There is, however, the potential for surface disturbance through an inadvertent drilling fluid release. Drilling fluid releases are typically caused by pressurization of the drill hole beyond the containment capability of the overburdened soil material, which allows the drilling fluid to flow to the ground surface. Releases can also be caused by fractures in bedrock or other voids in the geologic strata that allow the fluid to surface even if downhole pressures are low. The viability of the HDD method is considered on a per project basis, taking into account the substrate in the area, as well as other project information.

The directional drilling process utilizes drilling fluid to remove the cuttings from the borehole, stabilize the borehole, and act as a coolant and lubricant during the drilling process. The fluid is comprised primarily of freshwater, bentonite, and additives. Any additives used to enhance the drilling fluid or additive-enhanced bentonite shall be environmentally safe, approved for use by National Fuel Gas (National Fuel), and NSF 60 Certified[1]. In addition, for **Projects in PA**, drilling fluid additives other than bentonite and water shall be approved by the PADEP prior to use. All approved HDD drilling fluid additives are listed on the Pennsylvania Department of Environmental Protection (PADEP) website[2]. Use of a pre-approved HDD drilling fluid additive does not require separate PADEP approval.

No fluid will be used that does not comply with the permit requirements and environmental regulations. All fluids and materials used shall have the corresponding Material Safety Data Sheets (MSDS) available on site. Drilling fluid is not a hazardous material as it is composed of benign components; however, an inadvertent release will require mitigation measures to reduce the impact to a water body or sensitive area.

The project team is responsible for implementing this plan and determining if an inadvertent release has occurred. The primary individuals listed below will be responsible for the following:

- Contractor Foreman:
  - Install proper controls for the HDD at the beginning of the project.
  - Provide inspection along the drill path.
  - Continuous examination of drilling fluid pressures and returns flows.
  - Periodic documentation of status of conditions during drilling activities.
  - Address an inadvertent return immediately upon discovery.
  - Implementation of this Inadvertent Return Plan.
  - Monitor the direction, progress, and telemetry of the drill head and drill string along the designed HDD drill path.

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[1] http://info.nsf.org/Certified/PwsChemicals/Listings.asp?ProductFunction=Drilling+Fluid&

[2] https://www.dep.pa.gov/Business/Energy/OilandGasPrograms/OilandGasMgmt/IndustryResources/InformationResources/Pages/default.aspx

  - Monitor the condition and character of soil & rock cuttings emerging from the borehole for consistency with geologic conditions anticipated along the drill path.
  - Monitor drill fluid pressure for unexpected changes (particularly decreases in pressure) as the borehole is advanced.
  - Perform visual monitoring of the ground surface along the drill path for signs of inadvertent return (unexpected expansion cracks or emergence of drill fluid).

- National Fuel Gas (National Fuel) Inspector:
  - Provide inspection of HDD work.
  - Notify the project team in a timely matter and respond to observed inadvertent returns in accordance with procedures identified in this Inadvertent Return Plan.

- Environmental Compliance Coordinator:
  - Coordinate Inadvertent Return Plan training prior to the project.
  - Notify agencies of inadvertent release.

2.0 PRE-CONSTRUCTION PLANNING

Prior to construction, environmental and cultural resources will be protected by implementing the following measures:

- Environmental, biological, and cultural surveys, clearances, and applicable permitting for proposed HDD and associated workspace(s) will have been completed prior to commencing drilling operations to minimize potential impacts to resources (see above for clearances).

- Where present, sensitive cultural and biological resources within the right-of-way (ROW) will be flagged for avoidance. Restricted activity locations and construction limits will be clearly marked.

- NOTE: Before any drilling operations begin, all applicable erosion and sedimentation controls included in the site-specific Erosion and Sedimentation Control Plan (E&S Plan) will be properly installed per the included drawings and specifications and inspected by the National Fuel Inspector. The E&S Plans, state permit(s), landowner restriction list, and any other applicable documents must be carefully reviewed before any disturbance occurs.

- Barriers (silt fences and/or compost filter socks) will be erected between the bore site and nearby sensitive resources within or bounding the edge of the ROW prior to drilling, as appropriate, to prevent the potential for released material to reach resources nearby.

- On-site briefings will be conducted for the workers to ensure they have received site-specific training for the HDD drilling operations and contingencies for drilling fluid inadvertent return procedures and clean-up.

- Ensure that all field personnel understand their responsibility for timely reporting of inadvertent returns.

- Maintaining necessary response equipment on-site (or at a readily accessible location(s)) and in good working order.

The areas that present the highest potential for drilling fluid return are the drill entry and exit points where the overburden depth is minimal. The likelihood of inadvertent return decreases as the depth of the pipe increases. HDD drilling on all projects will be located at a minimum of 50 feet away from protected streams or wetlands unless otherwise permitted. At the entry and exit points, a pit will be constructed to collect and provide temporary storage for the drilling fluid until it can be removed. These pits will be sized adequately to accommodate the maximum volume of drilling fluid that may need to be contained in the pits. The drilling entry and exit areas will be clearly marked, including access and egress locations. Secondary containment of the pits will contain returns and minimize migration of the fluid from the work area. This containment system may consist of straw bales, compost filter socks, earthen berms, and silt fencing around the pit. To determine if an inadvertent return has occurred, horizontal directional drilling activities will constantly be monitored by the contractor. The monitoring procedures will include:

- Inspection along the drill path
- Continuous examination of drilling fluid pressures and returns flows
- Periodic documentation of status of conditions during drilling activities

The contractor will address an inadvertent return immediately upon discovery. If a wetland/water body release occurs, inspection to determine the potential movement of released drilling fluid within the wetland/water body will be necessary. To contain and control drilling fluid returns on land or in a water body, the contractor will have equipment and materials available onsite. Photographs of any inadvertent drilling fluid return shall be taken by the contractor or other persons discovering the return in order to document the size, location, and clean-up procedures of any inadvertent return occurrence.

2.1 Training

Prior to the start of construction, the Construction Supervisor and National Fuel Inspector will verify that the construction field crew members receive the following site-specific training:

- Review provisions of the Inadvertent Return Plan, equipment maintenance, and site-specific permit and monitoring requirements.
- Review location of sensitive environmental resources at the site and relevant permit conditions.
- Review inspection procedures for inadvertent return prevention and be familiar with containment equipment and materials.
- Review inspection procedures for inadvertent return prevention and be familiar with containment equipment and materials.
- Review contractor/crew obligations to temporarily suspend forward progress of the drilling upon first evidence of the occurrence of lost circulation and potential inadvertent return, and to report any observed inadvertent returns to the National Fuel Inspector.
- Review operation of inadvertent return control equipment and the location of inadvertent return control materials, as necessary and appropriate; and
- Review protocols for reporting observed inadvertent returns and project team communication with appropriate regulatory agencies.

To contain and control drilling fluid returns on land, the contractor will have equipment and materials available onsite. Containment equipment is referenced in Section 2.2 below.

As stated previously, the Environmental Compliance Coordinator will conduct Inadvertent Return Plan training prior to construction. This training will be for all project team members, specifically the contractor and all on-site inspectors. The training will review what is required as part of the initial plan set up, the responsibilities of the team members (listed above) as well as the applicable permits. Most importantly, the training will outline the steps required if an inadvertent return occurs.

2.2 Containment Materials / Equipment on Site

Appropriate containment, response, and clean-up equipment will be available in sufficient quantities, during all drilling operations. Examples of appropriate containment and clean-up measures are listed below. Additionally, for all projects, the MSDS for the fluid being used must be located on-site at all times.

- Vacuum Truck/Equipment (on standby)
- Track Excavators
- Leak-free portable pumps (with secondary containment).
- Sandbags
- Plastic Sheeting
- Sediment filter Sock/Silt Fence
- 55 Gal. drums with bottoms cut out
- Straw Bales w/ minimum 2 stakes each
- Spill Kits
- Leak-free hoses
- shovels, pails, drums
- push brooms
- squeegees

Containment equipment including portable pumps, hand tools, sandbags, straw bales, silt fencing, sediment sock, inadvertent return barrel, and lumber will be readily available and stored at drilling sites. The drilling contractor will also have heavy equipment such as track excavators that can be utilized to control and clean up drilling fluid. Equipment associated with fluid removal shall be of sufficient enough quality (i.e., pump capacity, hose condition) and quantity (i.e., hose length, number of pumps), to efficiently manage any returns associated with the project.

The following measures will be implemented to minimize or prevent further release, contain the release, and clean up the affected area.

3.0 INADVERTENT RETURN RESPONSE PROCEDURES

The action plan for inadvertent returns includes the following:

- Upon discovery or a return, drill operations will be paused to allow for assessment of the release (If being utilized, drill fluid circulation pumps may remain on unless public health or environmental safety are at risk from leaving these on, because of the potential for drill hole collapse resulting from loss of down-hole pressure.)

- National Fuel will be contacted, and the National Fuel Environmental Compliance Coordinator will then notify the applicable agencies, as necessary.
- Assess current permitting/landowner approvals for areas in question. If approvals do not exist for areas in question, contact National Fuel Land contact/Environmental Compliance Coordinator for assistance.
- As feasible, install necessary downgradient controls (sediment filter sock, silt fence, straw bale containment, etc. in upland areas or turbidity curtains, booms, etc. in waterbody areas to limit ongoing movement of the drilling fluid.) See further conditions below for specific upland/waterbody response procedures.
- Ensure the return is not occurring underneath containment features.
- Utilize pumping or excavation methods to remove the drilling fluid.

3.1 Upland Release

For releases of drilling fluid located in upland areas, the contractor will place containment structures at the affected area to prevent migration of the release.

If the amount of the release is large enough to allow collection, the drilling fluid released into containment structures will be collected and disposed of per procedures included in Section 4.0 of this document. If the amount of the release is not large enough to allow for collection, the affected areas will be diluted with fresh water and restored, as necessary. Steps will be taken to prevent silt-laden water from flowing into a wetland or water body.

If public health and safety are threatened by an inadvertent release, drilling operations will be shut down until the threat is eliminated.

Disturbed areas associated with the release will be stabilized and restored per the specifications outlined in the project E&S Plans.

3.2 Water Body Release

If a release occurs within sensitive areas such as wetlands, streams, or regulated wetland adjacent areas, the contractor will attempt to place containment structures in the affected area to prevent migration of the release, if feasible. If public health and safety are threatened by an inadvertent release, drilling operations will be shut down until the threat is eliminated. In sensitive areas (streams, wetlands, adjacent areas), the release will be removed and disposed of per the Section 4.0 procedures at the end of this document, even if the release quantity is miniscule. In stream areas, where feasible based on stream depths, flow velocity, etc., efforts will be made to contain and isolate the return area and remove any material within the water resource. This may be accomplished through the use of hand tools, dams, turbidity curtains, vacuum equipment, etc. In wetland areas, controls meant to isolate and contain the return areas will be constructed and the material will be removed as soon as practicable through the use of hand tools, pumps, and vacuum equipment. Fresh water washes combined with material recovery via the use of vacuum equipment may be performed to retrieve remnant inadvertent return materials. All disturbed areas associated with the project will be stabilized and restored per the specifications outlined in the project E&S Plans.

In the event of a return to a stream, wetland, other waterbodies, or regulated wetland adjacent areas, the contractor or inspector will contact the National Fuel Environmental Compliance Coordinator immediately, drilling operations will cease, and containment/cleanup operations will commence. National Fuel will use the contact information included in the *Project Information Table* at the beginning of this document to contact the appropriate parties as necessary. For projects occurring in PA: Discharges shall be immediately reported to the PADEP, PA Fish and Boat Commission, and/or Conservation District, and National Fuel shall request an emergency permit under § 105.64 (relating to emergency permits), if necessary, for emergency response or remedial activities to be conducted. For Projects occurring in New York, releases must be reported as soon as feasible, but no later than 2 hours after the incident. National Fuel shall contact the appropriate agencies if an inadvertent return occurs underwater or migrates to water.

Containment is not always feasible for in-stream inadvertent returns. National Fuel will consult with the appropriate above-noted agencies and the relevant property owners regarding next appropriate action among the following:

- If drilling fluid congeals, take no other action that would potentially suspend sediments in the water column. Monitor the inadvertent return for at least 2 hours to determine if the drilling fluid congeals. (Bentonite will usually harden, effectively sealing the inadvertent return location).
- If drilling fluid does not congeal, erect isolation/containment environment (underwater boom and curtain).
- If the fracture becomes excessively large, a spill response team would be called in to contain and clean up excess drilling fluid in the water. Phone numbers of spill response teams in the area will be on site.

3.3 Response Close-Out

Site-specific cleanup measures will be developed by National Fuel and the Construction supervisor following an inadvertent return, in consultation with the appropriate agencies where practicable. National Fuel will coordinate restoration measures with the agencies prior to the site restoration, as applicable.

Drilling fluid will be cleaned up by hand using hand shovels, buckets, and soft- bristled brooms as possible without causing damage to existing vegetation. Freshwater washes will be employed if deemed beneficial and feasible.

The recovered drilling fluid will either be recycled to the return pit or hauled to an approved facility for disposal. No recovered drilling fluids will be discharged into streams, storm drains, or any other water source. Off-site disposal in other than commercially operated disposal locations is subject to compliance with all applicable survey, agency coordination and owner permission, and mitigation requirements. Other construction materials and wastes shall be recycled, or disposed of, as appropriate. Contact Risk Environmental for guidance on fluid disposal.

All inadvertent return excavation and clean-up sites will be returned to pre-project contours using clean fill, as necessary.

All containment measures (sediment filter logs, silt fence, staked straw bales, etc.) will be removed unless otherwise specified by National Fuel and or regulatory personnel.

Containment structures will be pumped out and the ground surface scraped to bare topsoil without causing undue loss of topsoil or ancillary damage to existing and adjacent vegetation. Bare soil will be seeded and stabilized with mulch or erosion blankets as applicable. Material will be collected in containers for temporary storage prior to removal from the site.

3.4 Mobilization for Inadvertent Return

In the event of an inadvertent return outside of permitted disturbance areas, it may be necessary to mobilize equipment and supplies across streams, wetlands, or otherwise regulated areas for containment and remediation of drilling fluid. Equipment to be mobilized across streams and wetlands may consist of a mini excavator, utility terrain vehicle (UTV), and supplies. Regulating authorities (USACE and PADEP/NYSDEC) will be notified prior to mobilization of equipment through regulated areas unless conditions warrant emergency response and necessary emergency response procedures are being followed.

3.5 Drilling Operation Controls/Adjustments

If an inadvertent return takes place, the contractor will immediately pause operations and contact National Fuel. The Environmental Compliance Coordinator will then notify the applicable agencies. If directed by National Fuel, drilling operations will be further reduced or suspended to assess the extent of the release and to implement corrective actions. Drilling will only resume after National Fuel's assessment of the situation.

If public health and safety are threatened, drilling fluid circulation pumps will be turned off. This measure will be taken as a last resort because of the potential for drill hole collapse resulting from loss of down-hole pressure.

After a drilling fluid return has been contained, the contractor will make every effort to determine the cause of the return. After the cause has been determined, measures will be implemented to control the factors causing the return and to minimize the chance of recurrence.

For either waterbody or upland returns, the contractor, in conjunction with National Fuel's Inspector, drill operator, etc., will attempt to adjust the drilling technique or composition of drilling fluid and implement any modifications to minimize or prevent further releases of drilling fluid. This may include:

- Thickening of fluid by increasing bentonite content
- Changing the drilling rate
- Changing the fluid pumping rate
- Attempting a deeper directional drill

Developing the corrective measure will be a joint effort of National Fuel, the contractor, regulatory agencies (if involved) and will be site-specific to address the problem. In some cases, the corrective measure may involve a determination that the existing hole encountered a void, which may be bypassed with a slight change in the profile. In other cases, it may be determined that the existing hole encountered a zone of unsatisfactory soil material, and the hole may have to be abandoned. If abandoned, the hole will be filled with cuttings and drilling fluid. If HDD proves unfeasible for the Project crossings, alternative crossings may consist of bridge/structure attachment, re-routing/alternative routing, or open cut of streams. Any such route changes would be forwarded to any federal, state, tribal, and/or local agencies for proper approvals prior to construction.

3.6 Inadvertent Return Documentation

If an inadvertent return occurs, the following documentation will need to be collected by the National Fuel Inspector to record the incident:

- Details of the inadvertent return event
- Photographs of any return event which depict size, location, and cleanup procedures undertaken
- Location and time of inadvertent return
- Size of the impacted area
- Notifications made
- Summary of the response
- Success of the clean-up action

In the event of an inadvertent return of drilling fluid, a detailed report shall be prepared. In New York, the report shall be submitted to the NYSDEC by the Environmental Compliance Coordinator within appropriate response times dictated by regulatory requirements (most often within 2 days or less) of any drilling fluid surfacing outside of the bore pits. This report will include the following:

- Name and telephone number of person reporting
- Location of the release
- Date and time of release
- Type, quantity, and estimated size of release
- How the release occurred including the substrate and downhole pressure at which the frac-out occurred
- The type of activity that was occurring around the area of the frac-out
- Description of any sensitive areas, and their location in relation to the frac-out
- Listing of the current permits obtained for the project
- Description of the methods used to clean up or secure the site

3.7 Construction Re-Start

For releases not requiring external notification, drilling may continue if:

- Full containment is achieved using stopping compound or through redirection of the bore
- The clean-up crew remains at the inadvertent return location until directed by the National Fuel Inspector that the HDD operations have stabilized
- release potential has subsided.

If the release poses a threat to human health and safety or the environment, drilling operations will not be restarted until conditions have been adequately addressed. For releases requiring external notification and/or other agencies, construction activities will not restart without prior approval from owner.

Prior to restart, the contractor shall evaluate the current drill profile (e.g., drill pressures, pump volume rates, drilling fluid consistency) to identify means to prevent further inadvertent returns. National Fuel approval is required to restart.

4.0 HDD FLUID/CUTTING DISPOSAL

If applicable, a VacBox/Tank/Container for containment will be placed on-site or on-call (within 3 hours) to contain the drilling fluids and cuttings associated with the drilling operation. Excess fluids/cuttings need to be disposed of in accordance with National Fuel policies/requirements. Contact Risk Environmental for additional clarification on disposal requirements. However, if drilling fluid is found to be impacted/contaminated, the contractor will defer to National Fuel for disposal instructions as well as any cost associated with removal of impacted/contaminated soils.

***All residual directional drill material must be disposed of at a location approved by National Fuel.**