



Typical Pipelines Limited

Typical Pipeline Project HDD Feasibility Report

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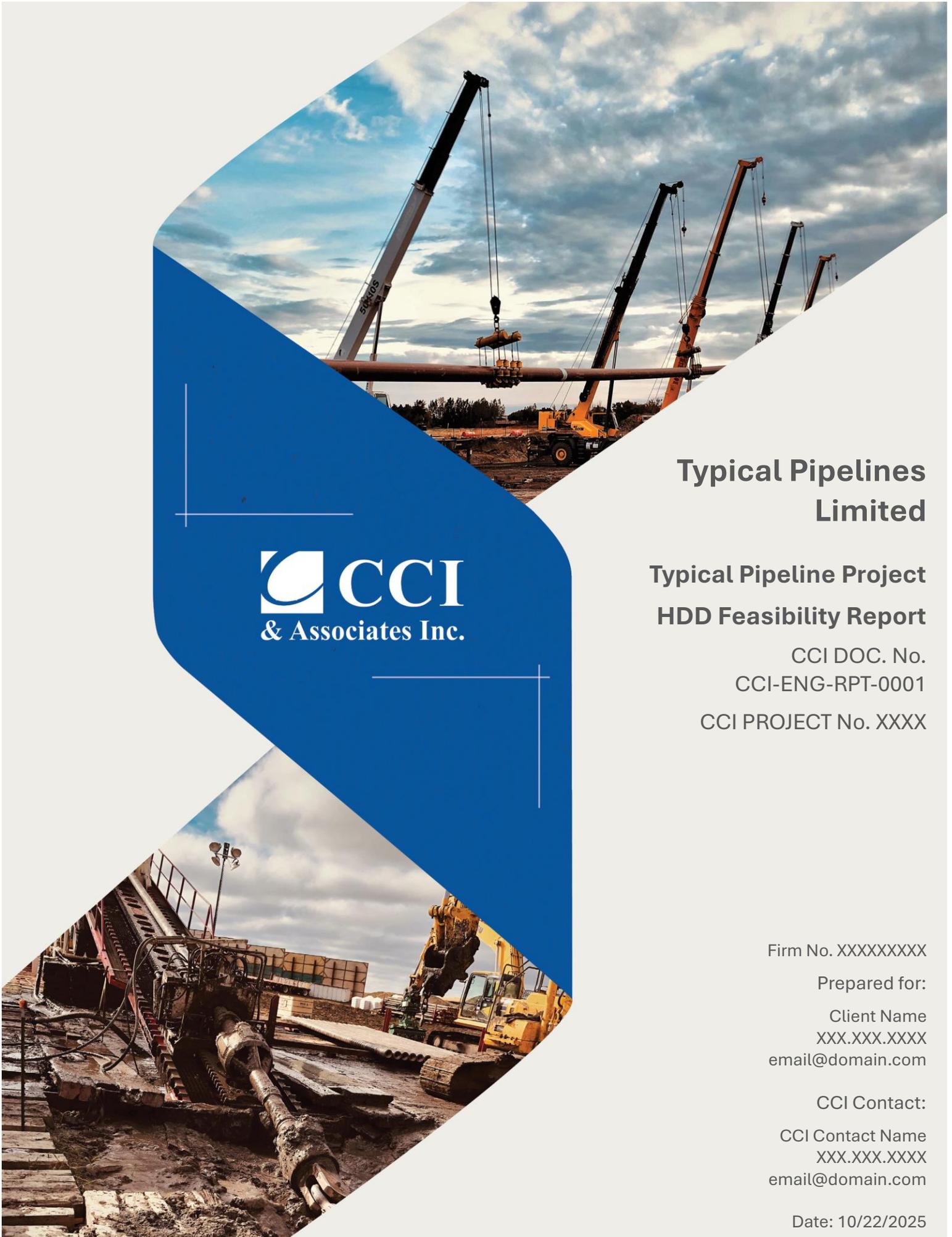
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LIST OF ACRONYMS

AP	Annular Pressure
API	American Petroleum Institute
ASCE	American Society of Civil Engineers
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATWS	Additional Temporary Workspace
CFR	Code of Federal Regulations
DIPS	Ductile Iron Pipe Size
DOT	Department of Transportation
EDFP	Engineered Drilling Fluid Management Plan
EIT	Engineer-in-Training
FERC	Federal Energy Regulatory Commission
FPVC	Fusible PVC (Polyvinyl Chloride)
HDD	Horizontal Directional Drill
HFIR	Hydrofracture and Inadvertent Returns
HDPE	High Density Polyethylene
H2	Hydrogen
IPS	Iron Pipe Size
IR	Inadvertent Return
ISRM	International Society for Rock Mechanics
LIDAR	Light Detection and Ranging
MADR	Minimum Allowable Design Radius
NDZ	No-Drill Zone
NPS	Nominal Pipe Size
OD	Outer Diameter
P.E.	Professional Engineer
PHMSA	Pipeline Hazardous Material Safety Administration
P.I.	Point of Inflection
P/L	Pipeline
PRCI	Pipeline Research Council International
ROC	Radius of Curvature
ROW	Right of Way
SPT	Standard Penetration Test

TAR	Temporary Access Road
TWS	Temporary Workspace
USACE	United States Army Corps of Engineers
W.T.	Wall Thickness

1 EXECUTIVE SUMMARY

This report is a technical evaluation of the feasibility to construct the proposed Typical Trenchless crossing, a key component of the Typical Pipelines Limited (OWNER/COMPANY) Typical Pipeline Project (PROJECT). Located in the State(s) of [REDACTED], the project aims to enhance the safe and efficient delivery of natural gas through approximately [REDACTED] miles of new NPS 42 pipeline infrastructure.

The following report evaluates the feasibility of using Horizontal Directional Drilling (HDD) for the proposed Typical Trenchless crossing and concludes that, based on geotechnical data, site conditions, and pipeline specifications, the design is technically feasible with a high likelihood of success. The proposed HDD is expected to minimize surface and environmental disruption, and potential impacts to sensitive features have been considered. Additional mitigation measures were evaluated and recommended to ensure optimized likelihood of successful construction. Additionally, this report was prepared to meet [REDACTED] regulatory body requirements for the permitting process and considers additional applicable regulatory entities.

The report identifies technical challenges such as [REDACTED].

In conclusion, the proposed Typical Trenchless crossing is considered feasible to construct as part of the PROJECT. The crossing has been developed to optimize risk mitigation and ensure compliance with owner specifications, industry guidelines, and regulatory requirements.

2 INTRODUCTION

OWNER/COMPANY is planning to construct approximately [REDACTED] miles of NPS 42 pipeline known as the Typical Pipeline Project (PROJECT) to safely deliver natural gas through the State(s) of [REDACTED]. Along the proposed pipeline corridor, the pipeline will cross several roads, creeks and rivers. This report will focus on the feasibility of the Typical Trenchless crossing utilizing the HDD methodology.

This report is provided as a feasibility assessment of site conditions, incorporating the available geotechnical information and a geometric review of the proposed HDD alignment and design. A summary of potential risks and associated mitigative strategies for the proposed HDD is also included within this report.

3 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 / ASME B31.4 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 design has been developed utilizing the guideline specifications and codes for applicable alternate pipe materials [e.g. HDPE, FlexSteel, PVC, etc.].
- c. The design development has been performed in accordance with OWNER/COMPANY / rail / USACE, etc., standards, specifications, and codes.
- 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 Typical Trenchless crossing was designed by completing a hydraulic fracture and inadvertent returns (HFIR) analysis to minimize the risk of fluid migration to the surface or nearby waterbodies during pilot hole drilling. This analysis estimates the potential fracture pressure limits of the overlying formation(s) and evaluates the likelihood of inadvertent returns by comparing these limits to the anticipated downhole pressures generated during the pilot bore phase of construction.
- f. Space limitations associated with the right of way (ROW), constraints such as points of inflection (P.I.), and achievable temporary workspace (TWS) were also considered. Additional temporary workspace (ATWS) has been requested (or allocated) 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 installation direction. The HDD entry point is the location where the drill rig is set up and in general, the start of pilot hole phase drilling activities. Conversely, the HDD exit point is the location where the pilot hole phase activity will end. Beyond the exit point is traditionally where the pipe section is laid out for fabrication and future 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.

4 CROSSING LOCATION AND SITE DESCRIPTION

It is understood that the proposed pipeline will cross under the Typical Feature via HDD. The Typical Feature is located approximately [REDACTED] miles west of the city of [REDACTED], in [REDACTED] County.

The Typical Feature at the crossing location is characterized by a relatively wide section of the river valley. The Typical Feature flows in a north-eastward direction. A tributary to the Typical Feature is located immediately adjacent (northeast) to the main branch and the two rivers are separated by a small section of high ground. The two rivers join at a location immediately downstream of the watercourse crossing.

The figure below shows the proposed Typical Trenchless crossing.



Figure 1. Proposed HDD Crossing Location

5 GEOTECHNICAL REVIEW

A geotechnical investigation for the proposed crossing alignment was conducted by Typical Geotechnical Co & Associates (TGCA), and geotechnical report (Document No.: [REDACTED], dated [REDACTED]) was provided to CCI for trenchless design purposes.

A total of two (2) boreholes (designated as Boreholes BH-01-01 to BH-01-02) were drilled along the proposed alignment. Borehole locations are shown in the following figure.



Figure 2. Borehole Location Plan

A summary of the borehole descriptions, along with primary geotechnical concerns for trenchless construction operations, is listed in the table below.

Table 1. Summary of Borehole Logs & Primary Geotechnical Concerns

Borehole	Approximate Location	Description	Primary Geotechnical Concern
BH-01-01 (100.0 ft)	350 ft SW of Entry Point	0 – 2 ft: Sand with Clay (SC) 2 – 13 ft: Fat Clay with Sand (CH) 13 – 24 ft: Clayey Sand (SC) 24 – 37 ft: Fat Clay with Sand (CH) 37 – 46 ft: Clayey Sand (SC) 46 – 52 ft: Sand with Clay (SC) 52 – 100 ft: Fat Clay (CH)	Fat clays swelling in the presence of moisture and constricting the borehole. Non-cohesive soils have potential to result in sloughing of the borehole wall.
BH-01-02 (100.0 ft)	125 ft NW of Exit Point	0 – 8 ft: Poorly Graded Sand(SC-SP) 8 – 38 ft: Sand with Clay (SP) 33 – 100 ft: Fat Clay with Sand (CH)	Fat clays swelling in the presence of moisture and constricting the borehole. Non-cohesive soils have potential to result in sloughing of the borehole wall.

Subsurface conditions encountered at BH-01-01 were comprised of 2.0 ft of sand with clay. This was underlaid by 11.0 ft of stiff fat clay with sand. Beneath this was another 11 ft thick section of loose clayey sand and a 13.0 ft thick section of fat clay with sand. Under this was a 15.0 ft section of compact, poorly sorted sand with varying clay content. This was underlaid by a 48.0 ft thick section of very thick fat clay that continued to the termination depth of 100.0 ft.

The proposed HDD path is anticipated to predominantly pass through sand with varying clay content and high plastic clay with variable sand content. The drill is anticipated to pass through sand with clay near the surface as well as clay with sand, and high plastic clay formations on the entry side of the HDD. On the exit side, the drill is anticipated to pass through poorly graded sand, as well as fat clay with sand.

The anticipated soil conditions near the site and below the crossing are primarily clays with variable sand content with some layers of sand throughout. Additionally, groundwater conditions were reported at 13.0 ft and 3.0 ft in borehole BH-01-01 and BH-01-02, respectively, after which wet rotary drilling was used precluding accurate groundwater measurements. The varying and elevated groundwater levels may increase the risk of water inflow into the borehole resulting in erosion of the borehole walls, loss of drilling fluid circulation, and fluctuating pore pressures. The reported and reviewed subsurface conditions described above are anticipated to be suitable for horizontal directional drilling; however, geotechnical-related risks based on the reviewed client-provided data include swelling of high plastic clays which may result in a constricted borehole and loose to compact non-cohesive soils potentially collapsing the borehole. The risks and challenges due to the subsurface condition and the mitigation strategies to minimize them will be further discussed later within this report.

Given the potential for variability in subsurface conditions along the proposed HDD alignment, such variations should be anticipated during planning and execution. It is recommended that the selected HDD Contractor thoroughly evaluate the geotechnical borehole logs provided within the site-specific geotechnical report, as included in Attachment A, for the proposed crossing location as well as any other available site-specific or regional geologic information prior to construction.

6 HYDROTECHNICAL INFORMATION

A hydrology and scour assessment were conducted by TGCA to estimate scour and setback distance and pipeline burial recommendations for watercourse crossings within the PROJECT (Document No.: Document No.: [REDACTED], dated [REDACTED]).

The recommended sagbend setbacks for the Typical Trenchless Crossing Feature and the adjacent tributaries start from 175.0 ft from the southwest bank of the Typical Trenchless Crossing Feature ([REDACTED]) to 5.0 ft from the northeast bank of Tributary to Typical Trenchless Crossing Feature ([REDACTED]) at the crossing location. The minimum pipeline burial depth is recommended at 3.3 ft beneath the Typical Trenchless Crossing Feature and 1.8 ft beneath the tributaries.

7 HDD CROSSING CONSIDERATIONS

7.1 PIPE SPECIFICATIONS

The pipeline specifications provided by OWNER/COMPANY are summarized in the table below. These parameters were used in the engineering design of the proposed HDD crossing.

Table 2. Pipe Specifications

Pipe Specifications	Value
Pipe Size	[REDACTED]

Pipe Specifications	Value
Outer Diameter (OD) (inches)	[REDACTED]
Wall Thickness (WT) (inches)	[REDACTED]
Material	[REDACTED]
Grade / SMYS (psi)	[REDACTED]
Specification	[REDACTED]
Product Transported	[REDACTED]
Design Pressure (psi)	[REDACTED]
Minimum Installation Temperature (°F)	[REDACTED]
Maximum Operating Temperature (°F)	[REDACTED]
Internal Coating	[REDACTED]
Outer Coating	[REDACTED]
Class Location (ASME B31.8)	[REDACTED]
Design Factor	[REDACTED]
Joint Factor	[REDACTED]
Temperature Factor	[REDACTED]

7.2 HDD ALIGNMENT

The proposed Typical Trenchless crossing follows the centerline of the proposed PROJECT alignment within the designated [REDACTED] ft permanent easement. The Typical Trenchless crossing is designed to follow a north-to-south alignment, extending approximately [REDACTED] ft horizontally, with a total drill length of [REDACTED] ft. The alignment will cross beneath several surface features, including an unnamed tributary ([REDACTED]), Typical Trenchless Crossing Feature ([REDACTED]), and an emergent wetland ([REDACTED]) where the HDD exit point and associated work area are located.

Based on the available survey data, buried 4-inch and 24-inch [REDACTED] pipelines are encountered along the proposed drill path between station [REDACTED]. The HDD is designed to maintain a minimum clearance of [REDACTED] ft and [REDACTED] ft beneath these pipelines, respectively. The nearest non-intersecting utility is the 48-inch [REDACTED] natural gas pipeline, which runs parallel to the proposed HDD alignment and is offset by approximately [REDACTED] ft to [REDACTED] ft to the north.

The details of the design are shown in drawing [REDACTED] provided in Appendix A.

7.3 WORKSPACES

Around the HDD entry point, HDD exit point, and along the pipe staging / pullback alignment area, extra space is usually required for safe and efficient execution. The extra space requirements are wider than the limits of a typical right-of-way. The extra space is usually referenced to as the proposed temporary workspace (TWS) and additional temporary workspace (ATWS) and are outlined

as follows. Reference drawings in Appendix A for more details on entry pad, exit pad, and workspaces.

7.3.1 Entry Pad

The HDD entry TWS / ATWS (commonly known as the entry pad) should be sufficiently large to stage the HDD rig, mud system, auxiliary equipment, pumps, tools, and personnel. Additionally, the entry pad should be able to accommodate the installation of a casing (if required) and the storage of bulk materials. There should be sufficient space around the entry point to allow the positioning of the HDD rig behind the entry. There should also be space to allow for a pit (commonly known as the entry pit) to be excavated near the entry point to handle the collection and recirculation of drilling fluids. It is recommended that as much workspace be provided as practical at the entry point to prevent congestion or potential safety hazards within the work site, and the ultimate size requirement for the entry pad will be dependent on the size of the HDD and amount of drilling mud to be utilized and handled.

Please refer to the design drawing provided in Appendix A for additional workspace details.

7.3.2 Exit Pad

The HDD exit TWS / ATWS (commonly known as the exit pad) is generally located on the opposite side of the HDD crossing from the entry pad. Within the exit pad, essential equipment such as mud containment tanks, cutting settlement tanks, pipe handling tools (like rollers and side booms), and a portion of the product pipe itself, are setup for HDD construction activities. This setup requires adequate workspace to safely accommodate the equipment and allow for efficient operations, with space needs varying based on the pipe length and project scale. The product pipe should be set back and/or offset a sufficient distance from the exit point to allow for handling of the drill pipe and other drilling operations.

Please refer to the design drawing provided in Appendix A for additional workspace details.

7.3.3 Laydown Area

Product pipe stringing and the product pipe pullback section is planned to be completed beyond the exit point to of the HDD alignment along the proposed ROW. In general, the laydown area workspace must be wide enough to allow for the staging and assembly of pipe joints, pipe supports, equipment, welding and inspection operations as well as safe vehicle access along the length of 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. This would allow for the entire pipe pullback to be completed in a single section without the need for intermediate welds. Pipe lifting stresses and pullback recommendations are provided in Section 8.2.4.

The proposed pipe pullback workspace is illustrated in the figure below.



Figure 3. Proposed Pullback Laydown Area

7.4 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 pipe installations of 20-inch diameter (and less) is a final borehole diameter is recommended to be 1.5 times larger than the pipe outer diameter. For larger pipe installations, the borehole is recommended to be 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 42 HDD crossing, the final borehole diameter is expected to be 54 inches.

7.5 ENTRY AND EXIT ANGLES

The entry and exit angles were chosen based on stress analysis, materials, bending restrictions, the support of the pullback section, and to meet the workspace requirements. The entry angle has been designed to be [REDACTED] which is optimal in order to minimize the length of the crossing yet also attaining the required depth below the river to minimize the risk of hydraulic fracture. This entry angle is suitable for the size of rig that will be required for this crossing.

The exit angle has been chosen to optimize the length of the HDD and the amount of equipment required to support the section safely during the installation. The exit angle has been designed to be [REDACTED] for the proposed HDD crossing.

7.6 HDD DEPTH OF COVER

The selection of an appropriate HDD depth is based on several parameters, including geological formation to be crossed, the minimum overburden strength to best mitigate the risk of HFIR, buried facilities in the area that may conflict with the proposed path, 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.

The primary factor determining design depth for this crossing is [REDACTED].

The current design depth of cover is expected to provide adequate overburden strength to minimize the risk of hydraulic fracture to the surface, as well as minimizing the impact on buried utilities and settlement or heave at the surface. Further details about HFIR are discussed in Section 8.1.

Specific depth of cover or design separations along the proposed HDD are provided on the design drawing provided in Appendix A.

7.7 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 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.

A [REDACTED] ft vertical curve radius was chosen as the design ROC for the proposed HDD crossing, consistent with the general industry rule of thumb for this pipe size. The selected ROC also satisfies stress-limiting criteria, including maximum allowable bending stress and operational shear stress, in accordance with PRCI and ASME guidelines specified to account for drilling inaccuracies and construction steering tolerances. This ensures that the pipe remains within allowable stress limits during installation, hydrotesting, and operation, in compliance with standards like ASME B31.4 and B31.8. Further details on pipe stress considerations are discussed in Section 8.2.

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 the table below.

Table 3. Minimum Radius Allowances

Case	Minimum Radius Specification
Vertical Curve Design Radius	[REDACTED] ft
MADR – 3-joint Radius (100-ft Average)	[REDACTED] ft

Case	Minimum Radius Specification
1-Joint Radius (30-ft Average)	[REDACTED] ft

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

8 HDD ENGINEERING ANALYSES

The proposed HDD crossing 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 HFIR analysis and pipe stress analysis calculations have been completed as outlined below.

8.1 HYDRAULIC FRACTURE & INADVERTENT RETURNS (HFIR) ANALYSIS

Hydraulic Fracture & Inadvertent Returns (HFIR) modeling was developed to estimate the expected drilling pressure that is required to drill a pilot hole along a proposed path. The industry-standard drilling pressure models, based on Bingham Plastic fluid model, have been shown to predict downhole pressures in HDD very accurately, as confirmed by countless HDD installations using pressure monitoring tools to measure and verify downhole pressures during construction. 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. This method has been successful in reducing the risk of hydraulic fracture and/or inadvertent returns 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 HFIR model as a process to reduce drilling fluid releases (generally) based on the quality of information provided.

The annular pressure model is the basis for establishing whether a proposed HDD crossing is at risk for hydraulic fracture during pilot hole phase. The graph below shows a calculated downhole pressure, as well as an Operating Zone above the baseline pressure, shown as an estimated upper limit of the calculated pressure. The Operating Zone has been included to account for potential deviations from the modeled parameters and pressure spikes that are likely to occur throughout pilot hole drilling. According to these models, drilling pressures that exceed the overburden fracture pressure do not necessarily indicate a fracture will occur, but rather a higher risk that hydraulic fracture may occur in those areas.

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.

Drilling fluid properties are dependent on construction practices of the HDD Contractor, field conditions, and interpretations of the drilling fluid technician. The risk of hydrofracture and/or inadvertent returns 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.

As part of the design development process, CCI performed an HFIR analysis which was modeled to simulate the downhole pressure during the pilot hole phase of construction and compare it with the expected fracture pressure of the geologic formations above the drill path. The HFIR 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.

Based on the available geotechnical information it is expected that a jetting 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. The assumed drilling assembly parameters used for HFIR modeling during the pilot hole phase of the proposed HDD crossing are summarized in the table below.

Table 4. Drill Parameters for HFIR Analysis

Parameter	Value	
	Lower Bound	Upper Bound
Pilot Hole Size (in)	[REDACTED]	
Drill Pipe Size (in)	[REDACTED]	
Pump Rate (gal/min)	[REDACTED]	[REDACTED]
Drilling Fluid Density (lbs/gal)	[REDACTED]	[REDACTED]
Drilling Fluid Yield Point (lbs/100ft ²)	[REDACTED]	[REDACTED]
Drilling Fluid Viscosity (cP)	[REDACTED]	[REDACTED]

CCI has developed geotechnical parameters for the proposed HDD crossing that are closely representative of the geologic formations observed in the geotechnical borehole logs, as summarized in Section 5 of the report. Based on the geotechnical investigation provided, CCI has developed a geotechnical parameter set which is summarized in the table below.

Table 5. Geotechnical Parameters for HFIR Analysis

Parameter	Formation 1	Formation 2	Formation 3	Formation 4
	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Undrained Shear Strength (psi)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Internal Friction Angle (°)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Cohesion Coefficient (psf)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Unit Weight (pcf)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Shear Modulus (ksi)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Youngs Modulus (ksi)	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]
Calculation Method	[REDACTED]	[REDACTED]	[REDACTED]	[REDACTED]

Though the actual depth of groundwater was not able to be measured during drilling, 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 formation along the drill paths with what we consider to be conservative physical properties as a way of accounting for anomalies and discrepancies that may exist between the soil types described in the site investigation and actual field conditions.

The anticipated annular pressure was calculated by 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. The figure below shows the formation parameters and expected annular pressure for the HDD during the pilot hole phase of construction at the current designed depth.

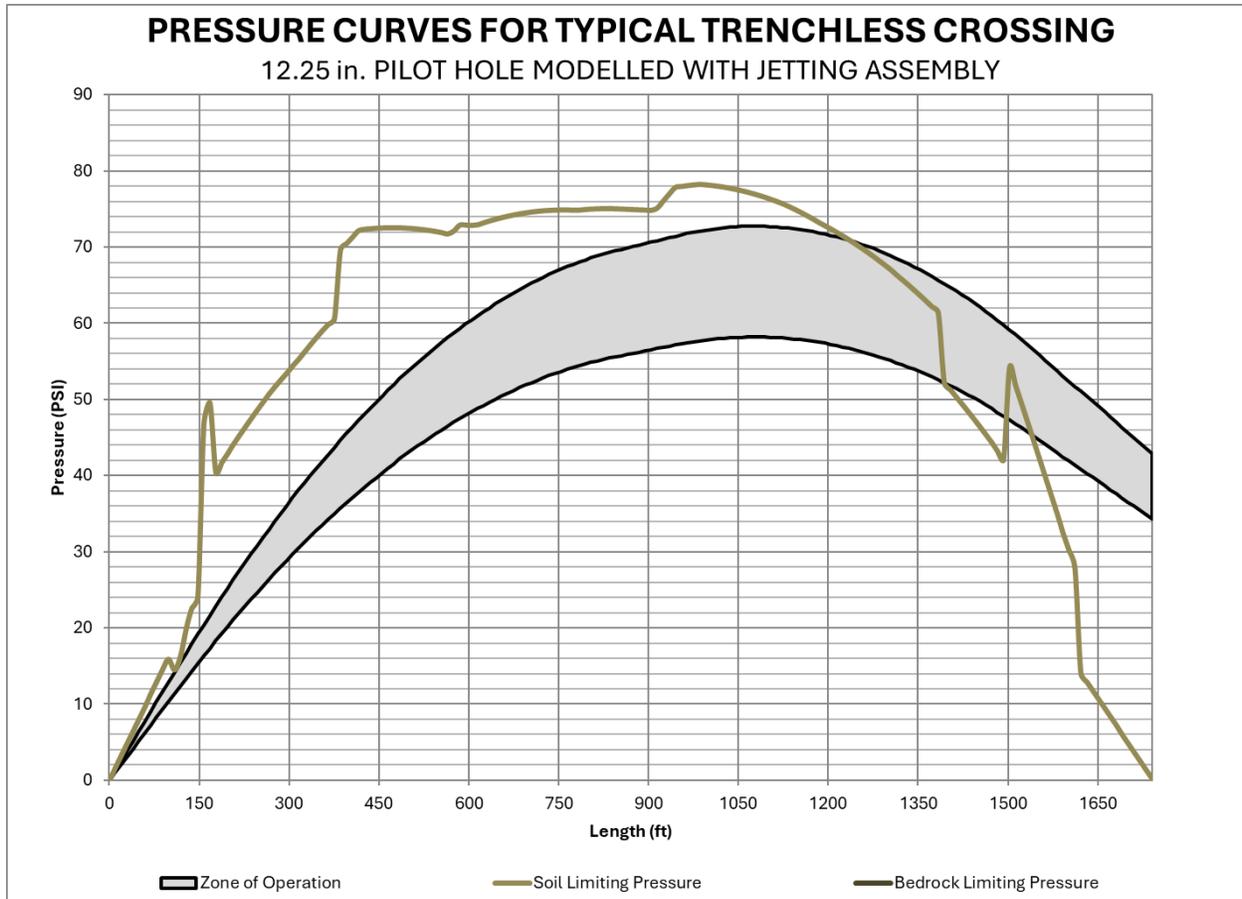


Figure 4. HFIR Analysis Pressure Curves

The HFIR analysis performed by CCI indicates a low overall risk of hydraulic fracture to the main crossing feature. The identified risk to the Typical Trenchless Crossing Feature along the proposed HDD crossing is the final [REDACTED] ft approaching the exit point where the soil limiting pressure is exceeded by the upper and lower limits of drilling fluid pressure which indicates a risk of hydraulic fracture within this (or these) zone(s). The risk of fracture near the exit point is to be expected for HDD crossings along relatively flat topography, as drilling fluid pressures increase as the drill progresses towards the exit point while the overburden strength simultaneously decreases with decreasing depth.

Overall, the risk of hydrofracture is considered to be low and manageable with appropriate construction methods and risk mitigation measures such as lowering pump rates and maintaining drilling fluid densities on the lower range of practical approaching the exit point. It is also recommended to stage cleanup supplies and equipment onsite near the identified high-risk zones in order to quickly react to and reduce the impact of a potential release to surface in the event that one does occur. This risk should be clearly noted by the Contractor.

The HFIR model is highly dependent on the accuracy of the geotechnical information available along the HDD alignment. The geotechnical parameters used to perform the hydrofracture and inadvertent returns analysis are conservative. It is recommended that the Contractor independently evaluate the geotechnical information provided and properly assess the site conditions prior to construction.

8.2 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 the design parameters listed in Section 3. The HDD stress modeling determines if given pipe specifications are adequate for the design.

8.2.1 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 parameters utilized in the pull load calculations are outlined in the table below.

Table 6. HDD Pull Load Parameters

Parameter	Values
6 5/8" Drill Pipe Weight (lb/ft)	[REDACTED]
Borehole Size (in)	[REDACTED]
Soil Density (pcf)	[REDACTED]
Soil Friction Angle (°)	[REDACTED]
Pipe/Drilling Mud Friction (psi)	[REDACTED]
Pipe/Soil Friction Factor ¹	[REDACTED]
Pipe/Roller & Pipe/Water Drag Coefficient	[REDACTED]

Note 1. Increased pipe/soil friction factor to account for downtime caused by mid-weld operations

The theoretical pull force was calculated with the assumption that buoyancy control would be utilized during installation of the HDD. Buoyancy control is generally recommended for HDD installations of larger than NPS 20 pipelines as the uplift forces within the borehole from the buoyancy of larger pipes would substantially increase the required pull force, therefore neutral or near-neutral buoyancy could reduce this required force. The utilization of buoyancy control could also minimize the potential of pipe and pipe coating damage during installation.

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 loads for the proposed HDD crossing are listed below in the table below.

Table 7. Calculated Theoretical Pull Forces

Drilling Fluid Weight (lb/gal)	Buoyancy Control	Pullback Force x 1.5 S.F. (lbs) ¹
[REDACTED]	Yes	[REDACTED]
	No	[REDACTED]

Drilling Fluid Weight (lb/gal)	Buoyancy Control	Pullback Force x 1.5 S.F. (lbs) ¹
[REDACTED]	Yes	[REDACTED]
	No	[REDACTED]
[REDACTED]	Yes	[REDACTED]
	No	[REDACTED]

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

Based on the above pull force calculations for the design geometry and proposed pipe specifications, buoyancy control would aid in reducing pullforces during installation, however, it is recommended that the selected HDD Contractor independently evaluate the need for buoyancy control and, in turn, provide an approved buoyancy control plan if proposed to be used.

For the crossing, the minimum recommended rig size would be [REDACTED] lbs pull capacity. This rig size would be 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.

8.2.2 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 [REDACTED]% of allowable as per PRCI allowable limits. The results of the installation stress analysis completed for the proposed HDD crossing, based on the installation cases from Table 7, are provided within Appendix B.

8.2.3 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 selected ROC considers stress-limiting factors, resulting in a maximum operational shear stress of [REDACTED]%, in line with PRCI and ASME limits. The calculated operational stresses utilizing the 3-joint minimum allowable design radius (MADR) and the 1-joint minimum allowable radius can be found in Appendix B.

8.2.4 Pipe Lifting Stress Modelling

Although CCI did not complete a detailed pullback lifting plan design for the proposed HDD crossing, the guidelines in the following table are recommended to be followed by the Contractor in order to prevent over-stressing of the product pipe and overloading of the support equipment during pullback.

Table 8. Pullback Recommendations

Parameters	Value
Minimum Allowable Radius (ft)	[REDACTED]
Design Overbend Radius (ft)	[REDACTED]
Maximum Support Spacing (ft)	[REDACTED]
Maximum Roller Spacing (ft)	[REDACTED]
Maximum Unsupported Overhang (ft)	[REDACTED]

The recommended spacings have been chosen to help ensure that the product pipe and anticipated 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 trailing ends of the pipeline has been specified 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 9.

8.3 DESIGN SUMMARY

The table below shows a summary of the design for the proposed HDD crossing.

Table 9. Design Summary

Pipe Specifications	Value
Pipe Specification	[REDACTED] x [REDACTED] in W.T.
Entry Angle (Degrees from Horiz.)	[REDACTED]
Exit Angle (Degrees from Horiz.)	[REDACTED]
Design Radius of Curvature (ft)	[REDACTED]
MADR (ft)	[REDACTED]
Length (ft)	[REDACTED]
Borehole Size (in)	[REDACTED]
Pull Force (lbs) (incl. 1.5 SF with Buoyancy Control)	[REDACTED]
Minimum Recommended Rig Size (lbs)	[REDACTED]

Pipe Specifications	Value
Installation Stress (% Allowable)	[REDACTED]
Operating Stress (% Allowable)	[REDACTED]
Overall Risk of HFIR	[REDACTED]

9 HDD CONSTRUCTION RISK ASSESSMENT

The primary construction risks and challenges associated with the proposed HDD crossing were identified through a risk assessment completed by CCI, drawing on a combination of project-specific information and previous experience on similar projects. The assessment considered the available geotechnical data (including borehole logs and laboratory testing results), proposed HDD design parameters (such as alignment geometry, depth, and radius of curvature), and other available site-specific information. These risk items were evaluated and ranked from low to very high based on both the probability of occurrence and the potential consequence of each event.

A detailed breakdown of the key risks identified, along with corresponding mitigation strategies, is provided in Appendix D.

10 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. Review of information by all stakeholders and issuance of the Issued for Construction (IFC) drawings to chosen Contractors.
- b. Ensure all required ROW and TWS, environmental notifications and permits, and water withdrawal and disposal sites are acquired.
- c. 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.
- d. Scope of construction inspection, turbidity monitoring (if required) and fluid disposal management services should be identified.
- e. Review any new environmental concerns with respect to the crossings and develop contingency plans if required.
- f. 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.

11 CONCLUSIONS

This assessment outlines the design selection process and engineering analysis completed for the Typical Trenchless crossing. It also identifies general construction risks and emphasizes that appropriate mitigation measures can effectively minimize their impact on the project. Based on the available design information and site-specific geotechnical information, the construction of the 42-inch Typical Trenchless crossing along the proposed PROJECT alignment is considered feasible.

An HFIR analysis, developed using available geotechnical data, indicates that a hydrofracture or surface release of drilling fluid is not anticipated beneath the Typical Trenchless Crossing Feature itself. However, such a risk could arise near the exit side of the alignment, which is located within an estuarine emergent wetland ([REDACTED]). The pipe stress analysis confirms that all calculated stress values fall within allowable limits for the proposed HDD installation. The results further demonstrate that, when constructed using good drilling practices, the proposed HDD crossing will not adversely impact the Typical Trenchless Crossing Feature along the drill path.

12 LIMITATIONS

This report has been prepared based on the available site-specific information for the exclusive use by OWNER/COMPANY in the construction of the proposed Typical HDD crossing. The information, conclusions, and recommendations contained in this report are not applicable to other sites or projects and should not be used outside the context of this specific installation. In the event that changes in the nature, design, or location of the planned construction are made, the conclusions and recommendations contained in this report will not be considered valid, unless the changes are reviewed by CCI and the conclusions are modified or verified in writing.

The accuracy of this report is dependent on the quality and completeness of available geotechnical data, which may not fully capture subsurface anomalies. It should be noted that actual field conditions may differ from the conclusions of the geotechnical investigation, and such discrepancies can affect construction methods, timelines, and overall feasibility. Variations in subsurface conditions are possible between exploration points and may also change over time.

The scope of services does not include construction safety precautions, and the recommendations are not intended to direct the HDD Contractor's methods, techniques, sequences, or procedures, except as specifically described for consideration in developing a drill plan. The conclusions, recommendations, and opinions presented are based on professional knowledge, judgment, experience, and generally accepted engineering practices common to the local area. No warranty or other conditions, express, written, or implied, should be understood.

13 REFERENCE DOCUMENTS

This report is based on the following HDD design drawings.

Description	Drawing Number
HDD Plan and Profile	[REDACTED]
Pullback Plan	[REDACTED]
Construction Notes	[REDACTED]

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

- Geotechnical Report: [REDACTED]

APPENDIX A – DRAWINGS

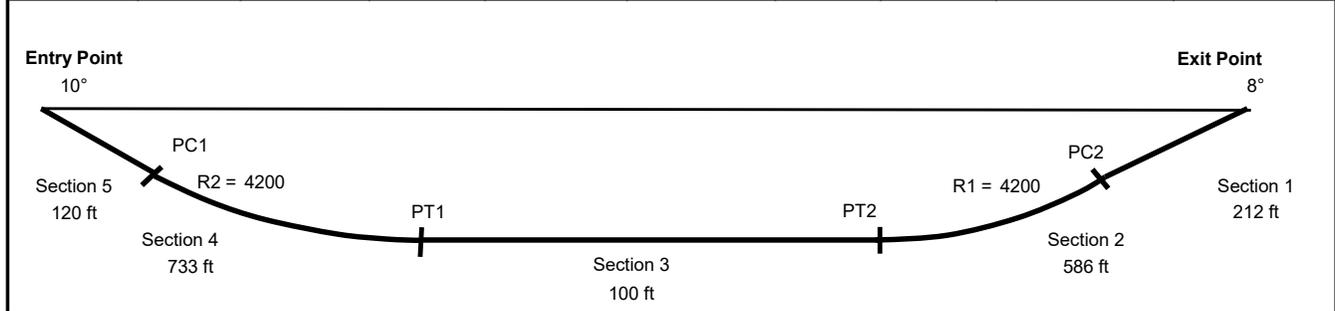
APPENDIX B – STRESS ANALYSIS SUMMARY

DESIGN RADIUS

Owner:	Typical Pipelines Limited	
Project:	Typical Pipeline Project	
Date:	10/22/2025	
Calculation Description:	Stress Assessment NPS 42 HDD	
Applicable Crossings:	Typical Trenchless Crossing	

Completed By: XX	Reviewed By: XX	Sheet Revision: R20
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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)
42.00	1.250	70000	1,880	120	40	4200	4200	85	1752



Design Radius Installation Stresses

Tensile Stress:		PRCI 5.1.1, 5.5 Allowable Tensile Stress $F_t = (0.9) * F_y$ = 63000 psi	% of Allowable	
5	742.6 psi		1.2%	
4	932.2 psi	1.5%		
3	982.2 psi	1.6%		
2	1372.2 psi	2.2%		
1	1498.2 psi	2.4%		

Bending Stress:		PRCI 5.2.2 $f_b = (E/D)/(2R)$ Allowable Bending Stress $F(b) = [0.84 - \{1.74 F_y D / (E t)\}] F_y$ = 49089 psi	% of Allowable	
5	516.3 psi		1.1%	
4	12291.7 psi	25.0%		
3	516.3 psi	1.1%		
2	12291.7 psi	25.0%		
1	516.3 psi	1.1%		

Hoop Stress:		PRCI 5.2.3 $f_h = P_{ext} D / 2t$ Allowable Hoop Stress $F(h_c) = F(h_e)$ for $F(h_e) \leq 0.55 \times \text{Tensile Strength}$ = 15329.7 psi	% of Allowable	
5	573.0 psi		3.7%	
4	1095.9 psi	7.1%		
3	1095.9 psi	7.1%		
2	1095.9 psi	7.1%		
1	157.2 psi	1.0%		

Combined Stress (Tensile and Bending)		PRCI 5.2.4 $f_t / 0.9 F_y + f_b / F_b \leq 1$	% of Allowable	
5	0.02		2%	
4	0.27	27%		
3	0.03	3%		
2	0.27	27%		
1	0.03	3%		

Combined Stress (Tensile, Bending, and Hoop)		PRCI 5.2.4 $A^2 + B^2 + 2v A B \leq 1$ $A = ((f_t + f_b - 0.5f_h) / 1.25) / F_y$ $B = 1.5f_h / F_{hc}$	% of Allowable	
5	0.00		0%	
4	0.07	7%		
3	0.01	1%		
2	0.07	7%		
1	0.00	0%		

Operating Stresses

Operating Stresses:		PRCI 5.4.4.2: Allowable Shear Stress $F(v) = 45\% \text{ of } F_y$ $F(v) = 31500 \text{ psi}$	% of Allowable	
5	18890.2 psi		60.0%	
4	24744.7 psi	78.6%		
3	18857.0 psi	59.9%		
2	24744.7 psi	78.6%		
1	18951.7 psi	60.2%		

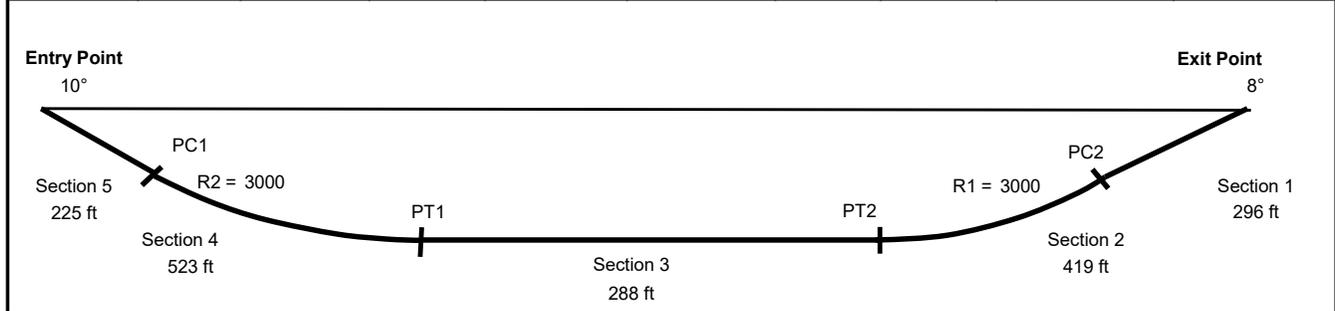
Estimated Pull Force	(with Buoyancy Control)
239,623 lbs	359,434 lbs (including 1.5x Safety Factor)

3-JOINT MADR

Owner:	Typical Pipelines Limited	
Project:	Typical Pipeline Project	
Date:	10/22/2025	
Calculation Description:	3-Joint Stress Assessment NPS 42 HDD	
Applicable Crossings:	Typical Trenchless Crossing	

Completed By: XX	Reviewed By: XX	Sheet Revision: R20
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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)
42.00	1.250	70000	1,880	120	40	3000	3000	85	1752



3-Joint Installation Stresses

Tensile Stress:		PRCI 5.1.1, 5.5 Allowable Tensile Stress $F_t = (0.9) * F_y$ = 63000 psi	% of Allowable	
5	769.0 psi		1.2%	
4	818.1 psi	1.3%		
3	962.2 psi	1.5%		
2	1167.2 psi	1.9%		
1	1368.8 psi	2.2%		

Bending Stress:		PRCI 5.2.2 $f_b = (E/D)/(2R)$ Allowable Bending Stress $F(b)=[0.84 - \{1.74 F_y D / (E t)\}] F_y$ = 49089 psi	% of Allowable	
5	516.3 psi		1.1%	
4	17208.3 psi	35.1%		
3	516.3 psi	1.1%		
2	17208.3 psi	35.1%		
1	516.3 psi	1.1%		

Hoop Stress:		PRCI 5.2.3 $f_h = P_{ext}D/2t$ Allowable Hoop Stress $F(h_c) = F(h_e)$ for $F(h_e) \leq 0.55 \times \text{Tensile Strength}$ = 15329.7 psi	% of Allowable	
5	739.1 psi		4.8%	
4	1095.9 psi	7.1%		
3	1095.9 psi	7.1%		
2	1095.9 psi	7.1%		
1	499.5 psi	3.3%		

Combined Stress (Tensile and Bending)		PRCI 5.2.4 $f_t/0.9F_y + f_b/F_b \leq 1$	% of Allowable	
5	0.02		2%	
4	0.36	36%		
3	0.03	3%		
2	0.37	37%		
1	0.03	3%		

Combined Stress (Tensile, Bending, and Hoop)		PRCI 5.2.4 $A^2 + B^2 + 2v A B \leq 1$ $A = ((f_t + f_b - 0.5f_h) / 1.25) / F_y$ $B = 1.5f_h / F_{hc}$	% of Allowable	
5	0.00		0%	
4	0.12	12%		
3	0.01	1%		
2	0.12	12%		
1	0.00	0%		

Operating Stresses

Operating Stresses:		PRCI 5.4.4.2: Allowable Shear Stress $F(v) = 45\% \text{ of } F_y$ $F(v) = 31500 \text{ psi}$	% of Allowable	
5	18874.9 psi		59.9%	
4	27203.0 psi	86.4%		
3	18857.0 psi	59.9%		
2	27203.0 psi	86.4%		
1	18898.7 psi	60.0%		

Estimated Pull Force	(with Buoyancy Control)
218,925 lbs	328,387 lbs (including 1.5x Safety Factor)

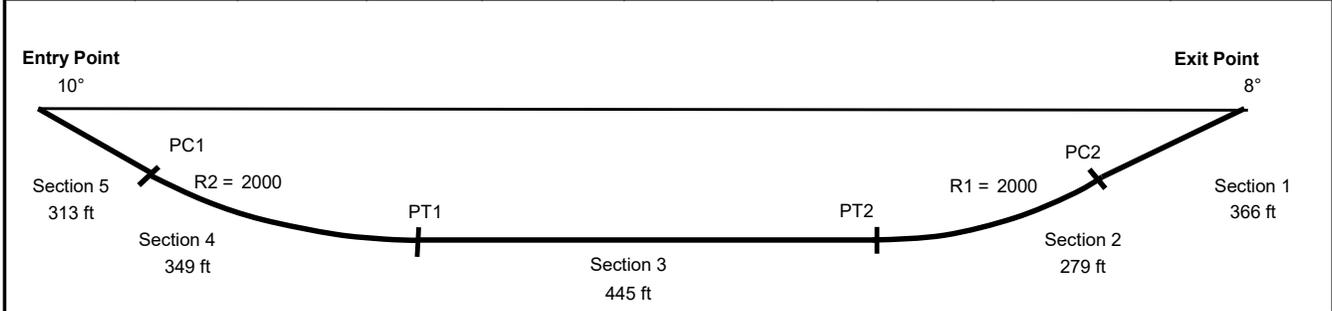
1-JOINT

Owner: Typical Pipelines Limited
 Project: Typical Pipeline Project
 Date: 10/22/2025
 Calculation Description: Single-Joint Stress Assessment NPS 42 HDD
 Applicable Crossings: Typical Trenchless Crossing



Completed By: XX Reviewed By: XX 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)
42.00	1.250	70000	1,880	120	40	2000	2000	85	1752



Single-Joint Installation Stresses

Tensile Stress:

5	791.0 psi
4	978.7 psi
3	1201.2 psi
2	1410.8 psi
1	1675.4 psi

PRCI 5.1.1, 5.5

Allowable Tensile Stress

$$F_t = (0.9) * F_y = 63000 \text{ psi}$$

% of Allowable

1.3%
1.6%
1.9%
2.2%
2.7%

Bending Stress:

5	516.3 psi
4	25812.5 psi
3	516.3 psi
2	25812.5 psi
1	516.3 psi

PRCI 5.2.2

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

Allowable Bending Stress

$$F(b) = [0.84 - \{1.74 F_y D / (E t)\}] F_y = 49089 \text{ psi}$$

% of Allowable

1.1%
52.6%
1.1%
52.6%
1.1%

Hoop Stress:

5	864.9 psi
4	1095.9 psi
3	1095.9 psi
2	1095.9 psi
1	723.1 psi

PRCI 5.2.3

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

Allowable Hoop Stress

$$F(hc) = F(he) \text{ for } F(he) \leq 0.55 \times \text{Tensile Strength} = 15329.7 \text{ psi}$$

% of Allowable

5.6%
7.1%
7.1%
7.1%
4.7%

Combined Stress (Tensile and Bending)

5	0.02
4	0.54
3	0.03
2	0.55
1	0.04

PRCI 5.2.4

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

% of Allowable

2%
54%
3%
55%
4%

Combined Stress (Tensile, Bending, and Hoop)

5	0.00
4	0.24
3	0.01
2	0.25
1	0.00

PRCI 5.2.4

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

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

$$B = 1.5f_h / F_{hc}$$

% of Allowable

0%
24%
1%
25%
0%

Operating Stresses

Operating Stresses:

5	18866.5 psi
4	31505.1 psi
3	18857.0 psi
2	31505.1 psi
1	18876.1 psi

PRCI 5.4.4.2:

Allowable Shear Stress

$$F(v) = 45\% \text{ of } F_y$$

$$F(v) = 31500 \text{ psi}$$

% of Allowable

59.9%
100.0%
59.9%
100.0%
59.9%

Estimated Pull Force

267,971 lbs

(with Buoyancy Control)

401,956 lbs (including 1.5x Safety Factor)

APPENDIX C – PIPE LIFTING STRESS ANALYSIS SUMMARY

Owner:	Typical Pipelines Limited	
Project:	Typical Pipeline Project	
Date:	6/5/2025	
Calculation Description:	HDD Pipe Pullback Analysis NPS 42	
Applicable Crossings:	Typical Trenchless Crossing	

Completed By: XX	Reviewed By: XX	Sheet Revision: R20
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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)
42.00	1.250	70000	2,100	555.9	50	30	60	401,956

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

<u>Vertical Load at Each Boom/Crane Support</u>	<u>% of Support Capacity *</u>
At Support With Full Span: 18,500 kg 40,800 lbs	58.8%
At Support With Overhang: 27,800 kg 61,200 lbs	88.3%

<u>Longitudinal Load at Each Boom/Crane Support</u>	* based on load capacity of Darby 36" - 48"D Rolli-Cradle
2780.0 kg 6,120 lbs	

<u>Horizontal Load at Each Boom/Crane Support</u>	<u>Horizontal Load at Each Roller Support</u>
0 kg 0 lbs	0 kg 0 lbs

PIPE STRESS

<u>Bending Stress</u>	<u>% SMYS</u>	<u>% of Allowable (PRCI)</u>
At Support With Full Span: 25438.1 psi	36.3%	53.9%
At Support with Overhanging Pipe: 14468.1 psi	20.7%	30.7%

<u>Tensile Stress</u>		
1184.9 psi	1.7%	1.9%

<u>Combined Stress (Tensile and Bending)</u>		
26623.0 psi	38.0%	56%

APPENDIX D – RISK ASSESSMENT SUMMARY

ATTACHMENT 1 – GEOTECHNICAL REPORT



For more than two decades, our commitment to safety, efficiency, and environmental responsibility sets us apart in the industry. With a focus on exceeding client expectations and adhering to the highest standards, we continue to be a trusted name, ensuring success in every project we undertake.

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