APPENDIX J: INADVERTENT RELEASE PLAN AND HDD DESIGN SUMMARY REPORT CASE 10-T-0139



December 13, 2022 File No. 322004-000

Kiewit Engineering (NY) Corporation 470 Chestnut Ridge Rd, 2nd Floor Woodcliff Lake, NJ 07677

Attention: Jason Neff, PE, PMP - Design Engineering Manager

Subject: DRAFT HDD Inadvertent Release Plan Champlain Hudson Power Express – Segment 8 Package 5b Fuera Bush to Selkirk, New York

Dear Mr. Neff:

Brierley Associates Underground Engineers, PLLC (Brierley) is pleased to provide this DRAFT HDD Inadvertent Release Plan for Package 5b of the Champlain Hudson Power Express Project. This work was conducted in general accordance with our contract with Kiewit Engineering (NY) Corporation (Kiewit).

We thank you for this opportunity to be of service to you and your team on this project. Should you have any questions or require additional information, please do not hesitate to contact the undersigned at your convenience.

Sincerely,

Brierley Associates Underground Engineers, PLLC

Nick Strater, P.G. Sr. Project Manager Brent Lindelof, P.E. Sr. Engineer

Brian C. Dorwart, P.G., P.E. Sr. Consultant

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APPENDIX A: Annular Pressure Analyses

1.0 Introduction

The Champlain Hudson Power Express (CHPE) project will install a pair of HVDC electrical transmission cables with an associated telecommunications line from Canada to New York City, NY. The portion of the work addressed herein is located in the upland portion of the route from the south end of Lake Champlain to New York City along the uplands of the Hudson River Valley. This work includes approximately 126 crossings under roads, railroads, wetlands water bodies, and obstructions to be installed using horizontal directional drilling (HDD) methods to minimize interference with use or impacts to the surface environment.

This Inadvertent Release Contingency Plan (IRCP) is for Segment 8 - Package 5b which includes 4 HDD crossings. A summary of the crossings is included in Table 1, below.

Package 5b includes a total of 4 crossings, which are summarized in Table 1, below.

HDD #	Approx. Start Station*	Approx. End Station*	Approx. HDD Length, ft	Obstruction Crossed
87B	51106+47	51120+29	1,382	S. Albany St/Route 54, water main
88	51179+09	51193+75	1,466	Coeyman's Creek
89	51201+50	51227+00	2,550	Wetland, Stream
90	51235+01	51247+40	1,239	Route 396/Stream Bank

 Table 1: HDD Locations, Lengths, and Description

*Project stationing shown. Each HDD has its own independent stationing.

A primary potential environmental concern associated with HDD involves the inadvertent release of drilling fluids during the drilling process. The purpose of this plan is to establish general procedures to prevent a fluid release (sometimes referred to as a frac-out) during HDD construction and to present steps to manage, control and minimize the impacts in the event that an inadvertent release of drilling fluid occurs. The objectives of this plan are to:

• Provide an overview of the HDD process with a specific focus on the composition, management and use of drilling fluids.

- Identify controls to be implemented during construction to minimize the potential of an inadvertent release.
- Identify the planned means of monitoring to permit early detection of inadvertent releases.
- Identify planned means to protect areas that are considered environmentally sensitive (rivers, wetlands, other biological resources or cultural resources).
- Establish site-specific environmental protection measures to be utilized prior to, during, and following drilling and pipe installation activities to minimize and control erosion and sediment releases to adjoining wetlands or watercourses.
- Have site specific preplanned general response programs in place at the start of construction that is understood and can be implemented immediately by all field crews in the event of an inadvertent release of drilling fluid occurs.
- Establish a chain of command for reporting and notifying, in a timely manner, the construction management team, the Certificate Holders, and the proper authorities in the event of an inadvertent release of drilling fluid and of the preplanned actions that are to be implemented.

It is important to note that the plan in this document serves as the guiding framework for confirming that the HDD Subcontractor is adhering to the specifications and provisions to be protective of the environment. Since there are a variety of potential measures listed in this document available for preventing inadvertent releases and mitigating the effects of a release should one occur, the specifications require that each HDD Subcontractor submit to the project design team, for its review and acceptance, a supplemental site and Subcontractor specific means and methods plan for each HDD crossing reaffirming and detailing how the Subcontractor will conform with the requirements of this plan and the project specifications to prevent inadvertent releases and to mitigate any effects of a release should one occur. The supplemental plan by the Subcontractor shall be consistent with the site conditions and constraints, and the Subcontractor's selected means, methods, and equipment. The selected HDD Subcontractor will be responsible for incorporating specific permit conditions, applicable regulatory requirements, site specific environmental features and geotechnical information not available at this time into its submittal. The submittal shall be reviewed and approved by the design team and the Environmental Inspector prior to the start of construction of a specific HDD location.

2.0 Description of the HDD Process

The Horizontal Directional Drilling process begins by mechanically excavating shallow (approximately 5 feet wide by 10 feet long by 4 to 5 feet deep) entry and exit pits at either end of the directional bore alignment. A small diameter (on the order of 5 to 9 inches in diameter) pilot bore is then drilled from the entry pit using directional boring methods. During the pilot bore, a drilling fluid (typically bentonite and water based with selected inert biodegradable additives to improve and modify fluid stability, carrying capacity, and drilling properties to address site-specific ground characteristics and Subcontractor preferences) is pumped through nozzles in the drill head to support the hole and to hydraulically transport drill cuttings from the drill bit back to the entry pit. Environmentally acceptable inert biodegradable additives are required by specification for use on this project and those planned for use by the Subcontractor will be checked for compliance by the design team prior to their use.

A guidance system is mounted immediately behind the drilling head to allow the crew to track and steer the path of the drilling so that it follows the preplanned alignment within the specification permitted tolerances. The drilling fluid holds the cuttings in suspension and carries the drill cuttings back through the annular space between the drill rods and the bore hole wall to the entry pit where it is collected and processed for re-used by a recycling system. The cuttings are separated from the bentonite, using screens, centrifuges, and desanding units which prepares the bentonite for re-use. Once the pilot bore reaches the exit pit, a larger diameter back-reaming head is then attached to the drill string and pulled back through the pilot hole to enlarge the hole. Depending on the size of the pipe to be installed and the ground conditions, several successively larger reaming passes may be needed. Again, a bentonite and water slurry is pumped into the bore hole during reaming to remove cuttings and to stabilize the bore hole. Lastly, the drill string is pulled back through the bore hole with the new, preassembled conduit attached to it in one continuous process until the lead end of the conduit emerges at the entry pit. Steps two and three may be combined, with the conduit being pulled back through the bore hole immediately behind the final reaming bit or swabbing pass.

Specific to this plan, it is important to have an awareness of the function and composition of the HDD drilling fluids. The drilling fluid composition and drilling fluid management are integral components of the HDD process with the following primary purposes:

- Support and stabilize the drill hole.
- Suspend and transport cuttings from drill bit through the drill hole annulus.
- Control fluid loss through the bore's side walls by forming a filter cake on the bore hole walls.

- Managing and modifying the drilling fluid mix to improve its cutting carrying characteristics, its pumpability, and its hole stabilization and support characteristics.
- Power the downhole cutting tools (e.g., via mud motors if required).
- Serve as a coolant and lubricant to the drill bit during the drilling process, and lubricant during the pipe insertion process.

The drilling fluids are composed primarily of potable water, which will likely be obtained from nearby sources selected and permitted by the Subcontractor. As mentioned above, the drilling fluid also contains bentonite clay as a viscosifier. Bentonite is a naturally occurring, nontoxic, inert substance that meets NSF/ANSI 60 NSF Drinking Water Additives Standards and is frequently used for drilling potable water wells. While bentonite is non-toxic and commonly used in farming practices, it has the potential to impact plants, fish and their eggs if discharged to waterways in significant quantities. Frequently, additives are used to: amend the drilling fluid, improve its compatibility with the ground and groundwater chemical characteristics, improve its cutting suspension and carrying characteristics, improve its hole stabilization ability, and reduce seepage loss through the ground characteristics. Environmentally acceptable (i.e. inert biodegradable) additives are required by specification for this project.

During the HDD process and subsequent conduit insertion, the drilling fluid pumped downhole will tend to flow along the path of least resistance. Generally, this will be though the annulus between the drill string and the drill hole side wall. However, the bore alignment may encounter ground conditions where the path of least resistance is an existing fracture, fissure or hole of anthropogenic origin, areas with low overburden confinement, areas of hole collapse, or coarse gravel zones in the soil or rock substrate. When this occurs, circulation can be lost or reduced. This is a common occurrence in the HDD process but does not necessarily prevent completion of the bore or result in a release to the surface or adjacent environment. However, the environment may be impacted if the fluid inadvertently releases to the surface at a location on a waterway's banks or within a waterway or wetland. Again, additives to amend the properties of the drilling fluid may be used as necessary to prevent and limit releases and losses through such paths of lower flow resistance.

3.0 Organization and Staffing Responsibilities

The organizational chart shown below list the contact information of the principal organizations involved in this project. The remainder of Section 3 discusses the roles and responsibilities of these principal organizations.

Organizational Chart

Entity	Contact Information
	Name, Title
Certificate Holders	Phone
Continente Holders	Email
Construction Manager	TBD
HDD Construction	TBD
Subcontractor	
Environmental Inspector	TBD
U.S. Army Corps of Engineers, New York District Office	USACE New York District Upstate Regulatory Field Office ATTN; CENAN-OP-UR, Bldg. 10, 3rd Floor North 1 Buffington Street Watervliet, NY 12189-4000 518-266-6350 cenan.rfo@usace.army.mil
New York State Department of Public Service	TBD
	Regional Office(s) Information
New York State Department of Environmental Conservation	NYSDEC REGION 5 Sub-Office Regional Permit Administrator 232 Golf Course Rd Warrensburg, NY 12885-1172 518-623-1281 dep.r5@dec.ny.gov
New York State Department of Environmental Conservation (Spills)	NYS Spill Hotline: 1-800-457-7362

3.1 Responsibilities of Various Organizations

The principal organizations involved in this project include the Regulatory Agencies, Certificate Holders, Design Engineer, HDD Construction Subcontractor, Construction Manager, and Environmental Inspector. The roles and responsibilities of the principal organizations are discussed in the following subsections and are shown in the organizational chart included above.

3.2 Regulatory Agencies

The Certificate of Conditions issued by the NY Public Service Commission is the primary regulatory agency for the requirements associated with the project. The Champlain Hudson Power Express (CHPE) Route Project also has permits from the Department of Energy, and the US Army Corps of Engineers, and the New York Water Quality Certification. Various HDDs within this package take place within or adjacent to wetlands, underneath or adjacent to bodies of water, and underneath or adjacent to railroad tracks. Measures are discussed throughout this report to control/mitigate any potential releases before environmentally sensitive boundaries are reached or impacted.

3.3 Certificate Holders

The project Certificate Holders are TDI. TDI's Project Manager will have the overall responsibility to coordinate this project for TDI. The Project Manager, will be responsible for correspondence and coordination among all parties and will have the authority to stop work as necessary.

3.4 Design Engineer

The Design Engineer for the Package 5b HDD's Design is Brierley Associates (Brierley). During construction, the Design Engineer will be responsible for reviewing and approving required Subcontractor submittals, shop drawings, and material certificates. Brierley will also take responsibility for review and acceptance of submittals, and documenting the materials and methods used in performance of the construction work to document that the construction complies with the contract documents.

3.5 Third Party Engineer

The Third-Party Engineer for the HDD inadvertent return analysis is Brierley Associates. During construction, Brierley/Kiewit will review of the Subcontractor's Inadvertent Release Plan and provide technical assistance as needed with the HDD installation.

3.6 Construction Manager

The Construction Manager for this project has yet to be selected. The Construction Manager will be responsible for on-site management of the project for the Certificate Holders to ensure overall Subcontractor compliance with the EM&CP documents, environmental permits, and local and federal regulations.

3.7 HDD Construction Subcontractor

The HDD Construction Subcontractors (Subcontractors) for the various HDD crossings of this project have yet to be selected. The Subcontractor will be responsible for completion of the conduit installation by HDD methods in accordance with the design criteria, contract documents, environmental compliance permits and federal regulations. The Subcontractor will be expected to use the appropriate construction procedures and techniques to complete the project, including supplemental site Inadvertent Release Prevention and Contingency Plan reviewed and accepted by the design team for each crossing in accordance with the contract documents.

The HDD Drill Operator (Drill Operator) will be responsible for operating the HDD drill rig, and observing and managing changes in annular fluid pressure or loss of circulation. The Drill Operator will communicate with other members of the drill crew as needed when issues arise. The Subcontractor will be responsible for developing the specific lines of communication within their organization and shall dedicate a responsible person for communicating inadvertent releases to the Construction Management team and Environmental Inspector.

3.8 Environmental Inspector

The Environmental Inspector for this project has not yet been determined. In general, the Environmental Inspector will perform full-time observation and documentation during the HDD activities at a specific site. The Environmental Inspector will be responsible for coordination with all county, state and federal resource agencies, compliance with and changes to any environmental permits.

The Environmental Inspector shall have the authority to stop work when the environmental permit conditions are not being followed or when appropriate environmental precautions are being disregarded by the Subcontractor.

3.9 Lines of Communication and Authority

Formal lines of communication will generally follow the established lines of authority. However, open communications between all parties will be encouraged to facilitate more efficient communication and coordination.

3.10 Training

The Subcontractor will verify and document that all construction personnel have appropriate environmental training before they begin work. The Environmental Inspector will also conduct a project orientation meeting for staff assigned with specific roles during the HDD installation and will review the site-specific environmental concerns and permit conditions. The Certificate Holders and Design Engineer will also attend the orientation meeting to review the procedures that will be used to document inadvertent releases in accordance with the HDD specifications.

4.0 Fluid Release Minimization Measures

4.1 Geotechnical Investigation

The first steps taken to characterize and minimize the potential risk of an inadvertent release includes conducting a geotechnical investigation at the site to develop an understanding of the surficial soils. Test borings were conducted near the proposed cable alignment within or immediately adjacent to the HDD sites. We understand that each boring has been backfilled and sealed with a cement/bentonite grout to limit the risk of a release through an abandoned bore hole during the HDD construction.

4.2 HDD Design

The HDD crossings are being designed to reduce the potential risk of an inadvertent fluid release during construction. General design considerations for HDD include:

- Depth of cover during profile design (based on test borings) to limit the potential inadvertent release to the water body, road, railway, wetlands, or ground surface.
- Typically, potential exists for releases near the entry and exit pits of an HDD bore. The distance where there is a potential for releases at the ends depends on the soil conditions, the slope of the ground surface and the length of the bore. Generally, the longer and deeper the bore the greater the slurry pressures required to hold the borehole open and to carry the cuttings back to the entry or exit pit.

- Generally, for the formation of inadvertent releases, the more critical stage of the HDD process tends to be during the initial pilot hole drilling when the annular space between the bore sidewall and the drill string is the smallest and therefore requires large slurry pressures to overcome flow resistance to carry cuttings back to the entry pit.
- Adjusting the drill alignment to avoid infrastructure including existing utilities, and other obstacles.
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up and limit pull back stresses and bending stresses in the conduit, as well as being compatible with the bending capacity of the tool steel.
- Requiring drilling fluid composition and drilling procedures that minimize drilling fluid pressures.
- Requiring drilling fluids that adequately address site-specific drilling concerns while posing the least threat to the environment.
- Requiring that, during the performance of any HDD waterbody crossing, contractors monitor the use of inert biodegradable drilling solution and, in the event of a detected release of fluid, implement the procedures specified in the approved EM&CP. For any release occurring in a waterbody, the Certificate Holders shall immediately notify DPS Staff and NYSDEC of details of the release and the course of action they recommend taking.
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

4.3 Contingency Plan

As mentioned above, prior to construction the selected Subcontractor will be required to submit a supplemental site-and Subcontractor-Specific Inadvertent Release Contingency Plan for review and approval by design team. The project specifications require that the following major elements be addressed in detail in the Subcontractor's Plan:

• Work plan and detailed description of the drilling program (details for executing pilot hole, reaming, pull-back operations, and schedule) this plan shall include necessary procedures for

addressing problems that are typically encountered during HDD installations through the anticipated subsurface for each drill location;

- Drilling fluid composition design and on-hand amendments to alter fluid properties to reduce pressures, potential for plugging, and seepage losses;
- Description of the planned drilling equipment and drill site layout;
- Safety Data Sheet (SDS) information for all drilling fluid products proposed for use;
- Procedures for drilling fluid pressure control, and fluid and pressure loss monitoring and management to aid in the detection of an inadvertent release (i.e., metering of makeup water, recording of drilling fluid product quantities utilized, fluid return volumes, fluid and cuttings disposal quantities, turbidity of river water, etc.);
- Contingency plans for addressing inadvertent releases into wetlands, or other sensitive areas, which includes the specific procedures used to halt the release and then contain, clean-up, and remove materials from the release site;
- Notification procedures and chain-of-command in the event of a release;
- Criteria for evaluating the need for a drill hole abandonment and the associated plan for sealing the drill hole if abandoned;
- Drilling fluid management and disposal procedures;
- The work plan and detailed drilling program description should include documentation regarding site restoration, vegetation management, sedimentation and erosion control, and hazardous material usage (if applicable). Intended approach shall be in compliance with those measures presented in the Project EM & CP.
- Notice shall be provided to residents, businesses, and building, structure, and facility (including underground, aboveground and underwater facilities) owners and operators within one hundred (100) feet of any HDD staging area or trenching activity with an offer to inspect foundations before, during, and after construction. Additional detail regarding this notice, associated inspections, intended benefits, proof of notice, cost reimbursements and associated construction initiation schedule is included in General Condition 154.

In addition to providing a site-specific Inadvertent Release Contingency Plan, the specifications require that the Subcontractor implement the additional necessary safeguards to minimize the likelihood of a fluid release and management/control should a release occur. This includes having a readily available supply of spill response devices (containment booms, pumps, straw bales, silt fence, sediment logs, sandbags, vacuum trucks, and storage tanks) and any other materials or equipment necessary to contain and clean up inadvertent releases. To maximize protection to sensitive environmental areas these measures shall be pre-positioned at the site, readily available and operational prior to the start of any drilling. If needed, additional spill response measures shall be employed immediately, as secondary measures, in the event of a fluid release.

The workspace layout for HDD materials and equipment will be configured to reduce the likelihood of a release.

4.4 Drill Fluids Management

As described in the Project EM&CP document, drilling fluid will be National Sanitation Foundation (NSF) certified and all recycling and reuse regulations will be followed where applicable. The drilling fluid management system and subsequent disposal is the responsibility of the subcontractor performing the HDD work. However, the drilling fluid management system and subsequent disposal will adhere to the following requirements:

- Drilling fluid will be processed through an initial clearing that separates the solid materials from the fluid.
- Solids will be sifted out by a screening apparatus/system and the solids deposited into a dump truck and periodically transported off-site and disposed of at an approved disposal facility determined by the HDD construction subcontractor.
- Drilling fluid that is deemed unacceptable to be reused during construction or left over at the end of drilling will be collected and transferred into a tanker truck for disposal at an approved disposal facility determined by the HDD construction subcontractor.
- Drilling fluid accidentally spilled during construction and operation of drilling rigs will be contained following the mitigation measures described in the SPCC (Appendix K of the EM&CP) and disposed of at an approved disposal facility as determined by the HDD construction subcontractor.

- Supply of spill containment equipment and measures shall be maintained and readily available around drill rigs, drilling fluid mixing system, entry and exit pits and drilling fluid recycling system, if used, to prevent spills into the surrounding environment. Pumps, vacuum trucks, and/or storage of sufficient size will be in place to contain excess drilling fluid.
- Under no circumstances will drilling fluid that has escaped containment be reused in the drilling system.

An overview of the drilling fluid system will be submitted to the Environmental Inspector for approval once determined and prior to any HDD installation activities. The role of the Environmental Inspector is discussed in Chapter 3 of the EM&CP.

4.5 Early Fluid Release Detection

The HDD method has the potential for seepage or fluid loss into pervious geologic formations that the bore path crosses. This may occur due to the presence of fractures in the rock, low overburden confinement, or from seepage through porous soils such as coarse gravels or via prior exploratory boreholes. It is important to note that inadvertent releases of drilling fluid can occur even if the downhole pressures are minimal. Subsurface conditions that could be conducive and lead to inadvertent releases or drill difficulties include:

- Highly permeable soil such as cobbles and gravel.
- Presence of rock fractures, solution features, or other subsurface fractures.
- Considerable differences in the elevations of HDD entry and exit points (typically greater than 20 feet).
- Disturbed soil, such unconsolidated fill.
- Soft soils that have the potential to squeeze.
- Soils that have the potential for collapse.
- Obstructions that require the use of a high flow mud motor.
- Soft soils with low confining capacity.
- Presence of archeological resources.

- Existing deep foundations.
- Existing below-grade utilities.

Our opinions regarding the risks associated with the above conditions at specific crossings are discussed in Section 9 of this report.

An experienced drill crew is the most effective approach to detect drilling fluid seepage prior to a surface release and promptly stop the drilling and they can modify the drilling fluid composition, properties, and pressures to address indications of loss of drill fluid. The HDD Subcontractor is required to utilize experienced drill crews particularly in and adjacent to environmentally sensitive areas. The following factors can be used for identifying the potential for drill fluid release:

- Spikes or loss of pressure within the drill hole utilizing a downhole pressure monitoring system; and
- A substantial reduction in the volume of return fluid (loss of circulation).

In addition to an experienced drill crew, the HDD Subcontractor will be required to perform periodic (at least twice a day) visual inspection and monitoring ground surface in the vicinity of the drill bit or reaming bit for signs of an inadvertent release. Per Article VII Condition 114(n), monitoring of the status of each HDD while construction activities are underway until the crossing has been completed. In the event of any potential or actual failure of the crossing, the Certificate Holders shall have adequate staff and equipment available to take necessary steps to prevent or avoid adverse environmental impacts. If visual monitoring indicates a potential release, additional measures such as turbidity measurements and bentonite accumulation measurements both upstream and downstream of the current active location of the drill bit are required (where applicable)

5.0 Inadvertent Release Monitoring and Notifications

The HDD Subcontractor is responsible for monitoring of the drilling operation to detect a potential inadvertent release by observing and documenting the flow characteristics of drilling fluid returns to the HDD entry/exit pits and by visual inspection along the drill path. If drilling fluid to the HDD entry/exit pits are lost, the Subcontractor shall implement the following steps:

• The Drill Operator will monitor and document pertinent drilling parameters conditions and observe and monitor the drill path for evidence of an inadvertent release, if there is evidence (typically visual) of a release, the Subcontractor will be required to stop the drilling

immediately.

- The Subcontractor shall notify the lead Environmental Inspector of any significant loss of drilling fluid returns at the drill rig; and, in the event of a detected release of drilling fluid during the performance of any HDD waterbody crossing, implement the procedures specified in the approved EM&CP. The Certificate Holders shall immediately notify New York State Department of Public Service (NYSDPS) Staff and New York State Department of Environmental Conservation of details of the release and the course of action they recommend taking.
- The subcontractor will take steps to modify the drill fluid properties and pressures to reduce the potential of drill fluid loss or release; and
- The Drill Operator will take steps to restore drilling fluid circulation in accordance with the requirements of the HDD technical specifications.

If a fluid release is identified, an immediate response is necessary and the Subcontractor is required to take proper corrective actions to minimize impacts, particularly to environmentally sensitive resources (e.g. watercourse, waterbodies, and wetlands).

6.0 Inadvertent Release Response (Upland and Road areas)

A common reason for upward movement and surface release (Inadvertent Return, or IR) of drill fluid is from borehole collapse or blockage and a resulting increase in the pressure exerted by drill pumps. Lowering drill fluid pressure is a first step to limiting extent of a release and can be accomplished by stopping drill rig pumps and allowing pressure to bleed off. With no pumping pressure in the hole, surface seepage will generally stop, then the Subcontractor can trip the drill steel back a selected distance and attempt to clear cuttings from the annulus to re-establish circulation. However, it should be noted that reducing the pump rate too much may result in poor cuttings removal and clogging of the hole, which in turn can also result in an IR.

The Subcontractor will be required to contain/isolate and remove any fluid that has emanated from the surface. On land this can be done through use of berms, straw bales, shovels as needed, or silt fence to contain the release in conjunction with excavating a small sump pit and/or use of vacuum collection equipment, if needed. Sufficient spill-absorbent material will also be required on-site.

If a surface release is identified in an upland area, the Subcontractor will be required to immediately respond as described above to limit the extents of the release. After containment is established, cleanup and removal can be conducted by hand, with vacuum trucks, or other equipment. The Environmental Inspector will be present during clean up and removal activities, as they may need to be conducted outside of the pre-authorized temporary workspace areas. The Environmental Inspector, Construction Manager, and the Subcontractor will work closely to determine the best course of action for inadvertent releases occurring within upland areas.

Upon containment of the release, the Subcontractor will be required to evaluate the cause of the seepage and develop mitigation strategies to limit the likelihood of recurrence. The location of the seepage and the area around the seep will be monitored upon the re-start of the HDD operations for changes in conditions. The segments of borehole nearest the entry and exit points and other areas of low overburden cover tend to be the most susceptible to surface seepage as they have the least amount of soil confinement. These locations will generally be in areas of dry land where seepage detection is easily identified and contained. If areas of high risk for inadvertent releases are identified during the HDD design phase, they can be protected from an uncontrolled release through use of strategically placed confinement/filter beds, straw bales, silt fence, or earth berms place prior to the start of drilling or the use of conductor casings if at entry and exit areas.

7.0 Inadvertent Release Response (wetland, railroad, and open water body areas)

For any release occurring in a waterbody, the Certificate Holders shall immediately notify DPS Staff and NYSDEC of details of the release and the course of action they recommend taking. During the performance of any HDD waterbody crossing, contractors monitor the use of inert biodegradable drilling solution and, in the event of a detected release of fluid, implement the procedures specified in the approved EM&CP. If an inadvertent release occurs when working beneath the waterway, wetland, or railroad the Subcontractor will be required to cease drilling operations and reduce pressures in borehole immediately, and notify the Environmental Inspector, the construction management team and the Certificate Holders. The Environmental Inspector, with input from the Drill Operator, will evaluate the potential impact of the release on a site-specific basis and will determine the appropriate course of action. The Subcontractor is required to develop general in-stream or in-rail response methods and pre-place necessary materials and equipment at the site prior to construction. Specific response actions will be determined in consultation with the Environmental Inspector and Subcontractor and could include the following:

- Slowing the drill fluid pumps.
- Modifying the advance rate and rod/tool rpm, to match pump rate.
- Modifying the drill fluid properties, adding agents to reduce drilling fluid pressures through improved carrying capacity
- Tripping the drill steel and tool back a selected distance and attempt to clear cuttings from the annulus to re-establish circulation.
- Swabbing of the borehole, to increase sidewall stability and to remove clogging or squeezing.
- Stopping drilling activities for 24 hours to allow the bentonite in the subsurface pathways to gel and seal the pathways.
- Evaluate the current drill methods to identify site specific improvements to lower the risk of additional inadvertent releases.
- Potentially implementing a loss-control material (LCM), designed to plug fractures.
- Implementation of proper sedimentation control measures including, but not limited to hay bales, vacuum trucks, silt curtains, containment cells, turbidity curtains, or if suitable, sand bags and confinement/filter beds. These activities will require that qualified construction personnel and other support equipment, and supplies be prepositioned and readily available at or near the site.
- Use of a relief well installed at the location of the release. A well or pit equipped with a subsurface pump to control slurry pressures and future releases at that location by evacuating drilling fluid as it accumulates can also be used. The relief well can be utilized to immediately lower the borehole pressures in the event of an inadvertent release and later to control and manage the release as the drilling continues.

8.0 Drill Hole Abandonment Plan

In the event the Subcontractor must abandon the drilled hole, a plan to fill the abandoned hole will be implemented as detailed in the Subcontractor's supplemental Inadvertent Release Contingency Plan and an alternative plan/alignment for crossing shall be evaluated. If it becomes necessary to abandon a partially completed hole, the abandoned hole will be filled with a mixture of high-yield bentonite, water, and drill spoil. The first ten feet of the bore path will be compacted and filled with soil or a cement-

bentonite mix to prevent future settlement. The Subcontractor submitted site-specific abandonment plan shall be approved by the Design Engineer and the Construction Manager prior to being performed in the field.

After the abandoned hole has been filled, an alternative entry and exit hole and bore path alignment will be evaluated by the Subcontractor, Construction Manager, and the Design Engineer. The new alignment shall be offset from the abandoned hole by at least 15 feet (except at the ends where a 5- foot offset may be used) to help limit the risk steering difficulties due to the presence of or hydraulic connection causing drill fluid loss to the abandoned hole.

9.0 Crossing Specific Conditions and IR Analysis

A generalized geologic profile and an annular pressure analysis for each crossing is included in Appendix A. In each case the results of the analysis are considered applicable to both HDD installations.

9.1 Analysis Method

The annular pressure analyses compares the anticipated range of downhole annular drill fluid pressures required to complete the pilot bore to the estimated confining capabilities of the surrounding geologic materials. This exercise can be useful in the evaluation of risk of inadvertent returns (IR's, or "fracout") during drilling. The potential for an IR may be considered greatest at locations where the anticipated range of downhole drill fluid pressures are close to or exceed the estimated confining capabilities of the surrounding materials. Note that the pilot hole (vs the reamed hole) is generally the most constrained, and presents the greatest risk of IR during the HDD construction process.

The following should be noted:

- HDD requires drill fluid pressures sufficient to stabilize the borehole and remove cuttings. In general, it may be possible to reduce the risk of drill fluid loss through careful drilling and drill fluid management, but IR risk cannot be completely eliminated.
- The annular pressure analysis is considered to be a tool to identify areas of potential risk. *It is not considered an exact predictor of the location or degree of an IR.*

- The annular pressure analysis does not account for existing pathways or zones of weakness in the subsurface, which may be related to existing utilities, foundations, utility poles and below-grade space. Where present, these features will *increase* the risk of drill fluid loss.
- The annular pressure analysis is not an accurate predictor of borehole leakage, where drill fluid leaks to the adjacent materials through existing porosity or fractures.
- Drill fluid loss from the borehole may not migrate to the surface. In some cases, the drill fluid may escape to the surrounding formation.

The static drill fluid pressure is a function of the density of the drill fluid at a specific location and depth below the drill entry elevation. The dynamic pressure is the pressure required to move the drill fluid (and cuttings) up the borehole annulus, and is a function of pump rates, hole geometry, fluid density, fluid velocity, and fluid rheology. The estimated annular pressures included in Appendix A are based on the API-13D method using a Power Law to model the dynamic pressure of a visco-plastic fluid.

Geotechnical parameters used in the analysis were derived through evaluation of laboratory testing and engineering judgement. The confining capability of the native materials was approximated using a variety of methods, which include the following:

- **Total Stress Model**: The Total Stress Model is based on the dead weight of the formation material above the drill path and excludes the potential strength of the formation. This method is considered *conservative* but is considered a reasonable approximation for the formation pressure capacity of bedrock and very dense soil.
- **Cavity Expansion Model (Delft Equation)**: This method considers the strength of the formation along with the total stress (above) and is based on Ko = 1 conditions. The initial equation was derived from the Mohr-Coulomb failure model adjusted by Delft University for low angle cylindrical cavity expansion in a host material when subjected to internal pressure. This method has been found more realistic in sand, silt, and stiffer cohesive formations than the Total Stress Model. However the method require assumptions of a horizontal surface with homogeneous isotropic soil. Additionally, the equations require significant property assumptions such as the Shear Modulus, G.

- Stress plus Strength Model: This method was initially implemented by the US Corps of Engineers to assess the damage potential to levees from the HDD fluids during drilling. This model adds the strength of the formation material to the total stress though results are generally considered to be conservative. The basis of the model, like the cavity expansion model is the Mohr-Coulomb failure approach. This model is generally appropriate for soil or bedrock.
- Queens Model: The Queens model was developed at Queens University. This model also adds the strength of the formation material to the total stress. The basis of this model, similar to the cavity expansion model is the Mohr-Coulomb failure approach. The difference between this model and the Delft model is that the Queens approach permits variation in the Ko of the soil and is considered more realistic in softer cohesive soils.

Additional input assumptions included:

- Jetting tools will be used for fill, lacustrine and glaciofluvial deposits.
- A mud motor will be used to complete the pilot hole for bores encountering glacial till and bedrock.
- A drill fluid pump rate of 200 gpm for pilots using jetting and a drill fluid pump rate 400 gpm for mud motors.
- An average drill fluid density of 78 pcf, and maximum drill fluid density of 94 pcf.
- An estimated drill bit diameter of 8.16 inches and a drill rod diameter of 3.5 inches.

9.2 HDD Crossing #87B

Surface conditions at HDD #87B:

HDD #87B passes below S. Albany St/Route 54 which curves from east-west to northwest-southeast in this vicinity. This roadway is supports two lanes of active traffic and is approximately 23-ft wide. The crossing also passes below a 48-in water main operated by the Albany Water Board, and numerous smaller utilities.

To the southwest of S. Albany St/Route 54 (in the vicinity of the HDD alignment) the ground surface slopes downward toward the center of the alignment, from about El. 170 to El. 155. In this area, the crossing passes below a wetland and 60-in CMP culvert. This area is covered with brush and small trees.

The HDD Entry is located to the northwest, on the south side of S. Albany St/Route 54, adjacent to a small commercial facility (single-story buildings, unpaved parking). The ground surface in this area ranges from about El. 175 to El. 178. Overhead utility poles are located on the opposite (north) side of the road.

The HDD Exits are staggered and located in a grassy area on the northeast side of S. Albany St/Route 54. A paved parking area and a brick office building operated by CSX are located to the immediate. Surface grades at the HDD exit range from about El. 175 to El. 177.

Subsurface conditions at HDD #87B:

The subsurface conditions along the HDD #87B alignment consist of a layer surficial fill overlying glacial lake deposits consisting of consisting of silt and clay (loose to medium dense and very soft to soft), with lesser amounts of loose silty sand and sand. The density/consistency of the silt and clay appears to decrease with depth. It should be noted that the glacial lake deposits contain extensive amounts of "weight-of-hammer" materials.

IR Risk at HDD #87B

In our opinion the conditions conducive to inadvertent releases that may exist this at this site may include:

- Highly permeable soil such as cobbles and gravel in the surficial fill.
- Areas of reduced soil cover.
- Existing below-grade utilities.
- Obstructions such as cobbles and boulders within the overburden soils.
- The soft glacial lake deposits, which do not provide significant capacity for drill fluid pressure containment.

It appears that there is a potential of inadvertent release at the end of the bores (as is common). These could be controlled through the use of conductive casings, haybales, silt fences, erosion control measures and vacuum trucks. There is also the potential for drill fluid loss and IR over the entire length of the crossing due to the soft soils. The drilling contractor will need to monitor drill fluid returns, drill fluid pressures and borehole behavior carefully. Reduced pump volumes and displacement-type drilling and reaming may be necessary. The drilling contractor will need to be prepared to identify and address an IR

over the full length of the bore in each case. This will require full surface monitoring and access, including the wetland areas.

9.3 HDD Crossing #88

Surface conditions at HDD #88:

HDD #88 is located to the east of S. Albany St/Route 54 and passes below Coeyman's Creek and an adjacent wetland. The majority of the site vicinity is covered by trees and brush. Farmland is located to the northwest, southwest and northeast.

The HDD Entry is located to the southwest in an open field (farmland). Surface grades in this area range from about El. 163 to El. 165. The HDD exit is located to the northeast in an area covered by brush and small trees, which has been mapped as wetland. Surface grades in this area range from about El. 174 to El. 176.

Surface grades along the HDD alignment slope downward toward Coeyman's Creek at moderate grades from the northeast and southeast. The Creek is oriented approximately north-south, with a bottom elevations estimated at El. 124 to El. 125.

Subsurface conditions at HDD #88:

The subsurface conditions along the HDD #88 alignment consist of a layer surficial fill overlying glacial lake deposits consisting of consisting of silt and clay (loose to medium dense and very soft to soft), with lesser amounts of loose silty sand and sand. The density/consistency of the silt and clay appears to decrease with depth. It should be noted that the glacial lake deposits contain extensive amounts of "weight-of-hammer" materials.

IR Risk at HDD #88

In our opinion the conditions conducive to inadvertent releases that may exist this at this site may include:

- Highly permeable soil such as cobbles and gravel in the surficial fill.
- Areas of reduced soil cover.
- Existing below-grade utilities.
- Obstructions such as cobbles and boulders within the overburden soils.
- The soft glacial lake deposits, which do not provide significant capacity for drill fluid pressure containment.

It appears that there is a potential of inadvertent release at the end of the bores (as is common). These could be controlled through the use of conductive casings, haybales, silt fences, erosion control measures and vacuum trucks. There is also the potential for drill fluid loss and IR in the vicinity of Coeyman's Creek and the adjacent wetland due to the reduced cover and soft soils. The drilling contractor will need to monitor drill fluid returns, drill fluid pressures and borehole behavior carefully. Reduced pump volumes and displacement-type drilling and reaming may be necessary. The drilling contractor will need to be prepared to identity and address an IR in each case. This will require full surface monitoring and access, including the stream and wetland areas.

9.4 HDD Crossing #89

Surface Conditions at HDD #89:

HDD #89 is located to the southwest of a single CSX rail (oriented northwest-southeast), and passes below a small stream, which is generally oriented north-south. The majority of the HDD alignment is covered by brush and small trees, and has been mapped as wetland. Overhead utility poles are located immediately adjacent to and parallel the northwest portion of the HDD alignment.

In general the surface grades slope downward gently toward the south-southwest. However, moderate slopes are located on either side of the stream. The stream bottom is estimated to be at about El. El. 149.

The HDD entry is located to the southwest, with a surface grade of about El. 158 to El. 160 The HDD exit is located to the northwest, with surface grades of about El. 174 to El. 175. Both the entry and exit areas are covered by brush and small trees and have been mapped as wetlands.

The entirety of the HDD #89 alignments are located within the CSX right-of-way.

Subsurface conditions at HDD #89

The subsurface conditions along the HDD #88 alignment consist of a layer surficial fill overlying glacial lake deposits consisting of consisting of silt and clay (loose to medium dense and very soft to soft), with lesser amounts of loose silty sand and sand. The density/consistency of the silt and clay appears to decrease with depth. It should be noted that the glacial lake deposits contain extensive amounts of "weight-of-hammer" materials.

IR Risk at HDD #89

In our opinion the conditions conducive to inadvertent releases that may exist this at this site may include:

• Highly permeable soil such as cobbles and gravel in the surficial fill.

- Utility pole locations.
- Existing below-grade utilities.
- Obstructions such as cobbles and boulders within the overburden soils.
- The soft glacial lake deposits, which do not provide significant capacity for drill fluid pressure containment.

It appears that there is a potential of inadvertent release at ends of the bores (as is common). These could be controlled through the use of conductive casings, haybales, silt fences, erosion control measures and vacuum trucks. There is also the potential for drill fluid loss and IR over the entire length of the crossing due to the soft soils and areas of reduced cover. The drilling contractor will need to monitor drill fluid returns, drill fluid pressures and borehole behavior carefully. Reduced pump volumes and displacement-type drilling and reaming may be necessary. The drilling contractor will need to be prepared to identity and address an IR in each case. This will require full surface monitoring and access, including the stream and wetland areas. The adjacent railroad tracks should be monitored in close coordination with the Owner prior to, continuously throughout operations, and 1-2 weeks post installation.

9.5 HDD Crossing #90

Surface Conditions at HDD #90:

HDD #90 is located to the southwest of a single CSX rail (oriented northwest-southeast), and passes below the bank and wetland of a small stream, which is generally oriented northwest-southeast. HDD #90 also passes below Route 396 which is about 27-ft wide and oriented northeast-southwest. In this vicinity the CSX rails are elevated, and pass over Route 396 by means steel bridge with concrete wing walls to the northeast of the crossing. In general, the site grades along the alignment slope downward toward the stream to the southwest.

Two (2) separate, northeast-southwest oriented overhead power lines cross the alignment in the Route 396 vicinity. Numerous power poles associated with these lines are located along the southeast portion if the HDD alignment.

The HDD #90 entry area is located to the southeast. This area is covered by small trees and brush, and mapped wetland is locate to the northeast. Surface grades in this immediate area range from about El. 157 to 159.

The HDD #90 exit area is located to the northwest. This area is covered by small trees and brush, and has been mapped as wetland. mapped wetland is locate to the northeast. Surface grades in this immediate area range from about El. 157 to 159.

The surface grade of the adjacent CSX rail (northeast) ranges from about El. 165 to El. 166. The entirety of the HDD #90 alignments are located within the CSX right-of-way.

Subsurface conditions at HDD #90

The subsurface conditions along the HDD #90 alignment consist of a layer surficial fill overlying glacial lake deposits consisting of consisting of silt and clay (loose to medium dense and very soft to soft), with lesser amounts of loose silty sand and sand. The density/consistency of the silt and clay appears to decrease with depth. It should be noted that the glacial lake deposits contain extensive amounts of "weight-of-hammer" materials.

IR Risk at HDD #90

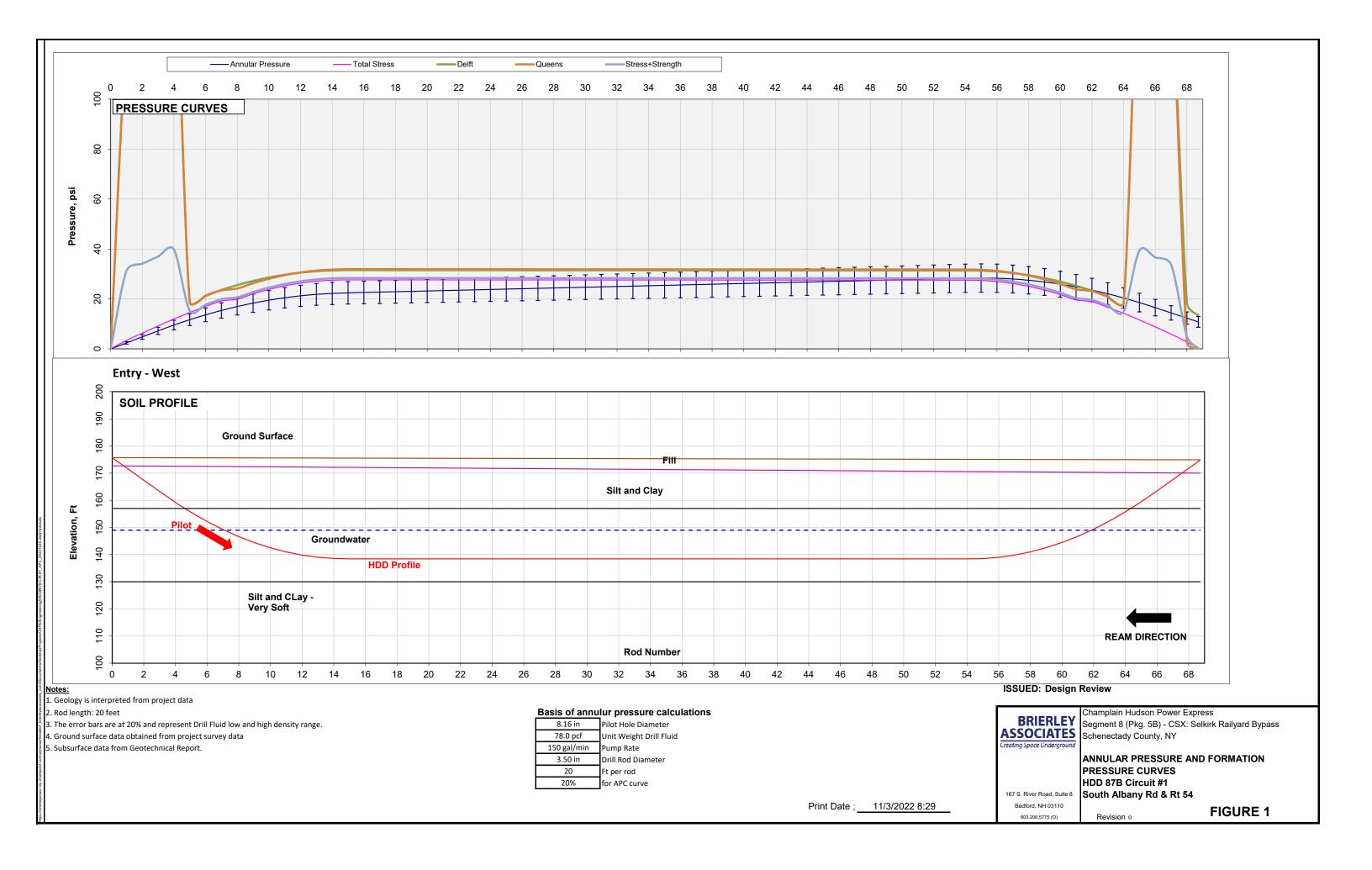
In our opinion the conditions conducive to inadvertent releases that may exist this at this site may include:

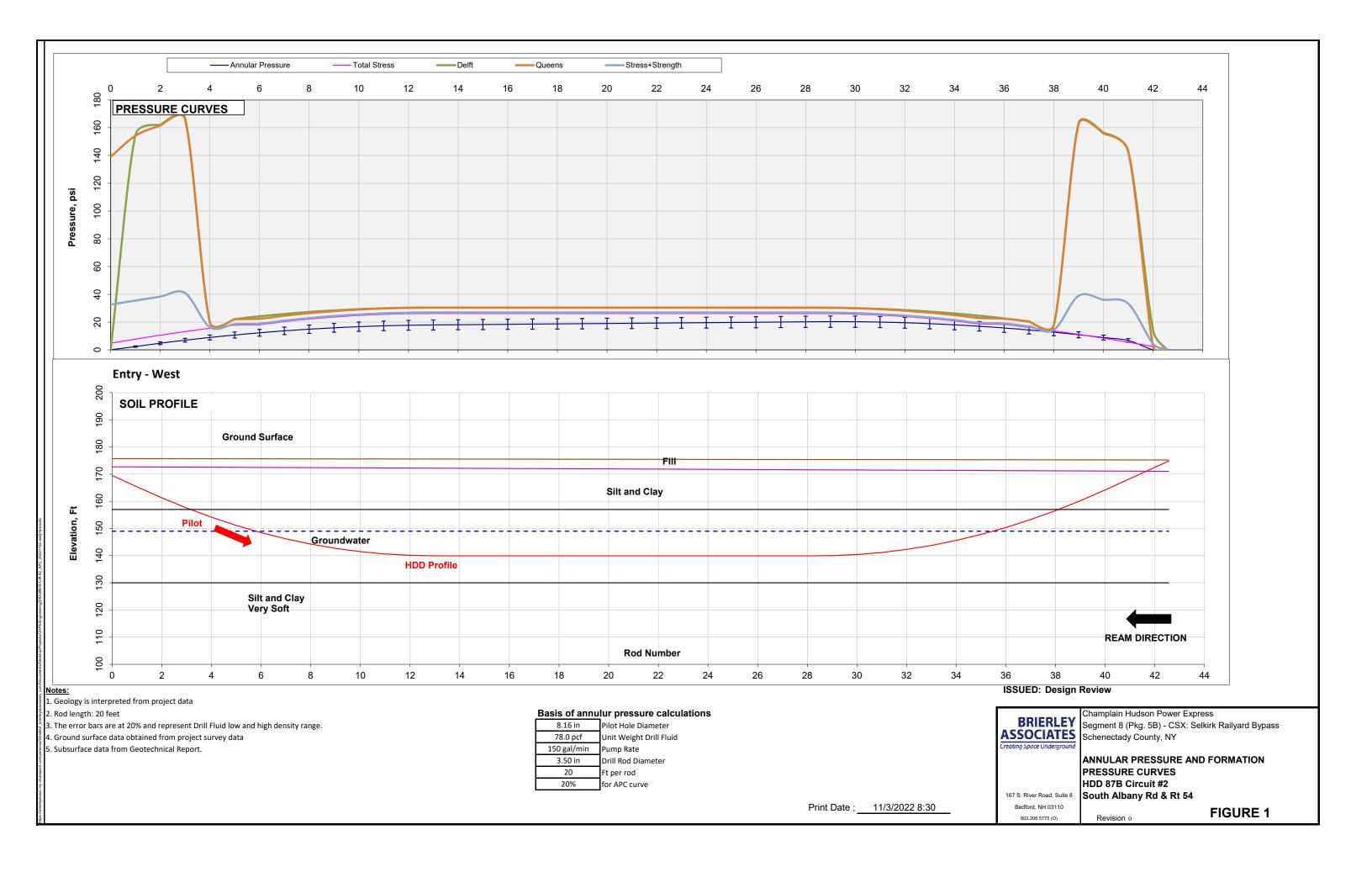
- Highly permeable soil such as cobbles and gravel in the surficial fill.
- Utility pole locations.
- Existing below-grade utilities.
- Potential deep foundations associated with overpass structures.
- Obstructions such as cobbles and boulders within the overburden soils.
- The soft glacial lake deposits, which do not provide significant capacity for drill fluid pressure containment.

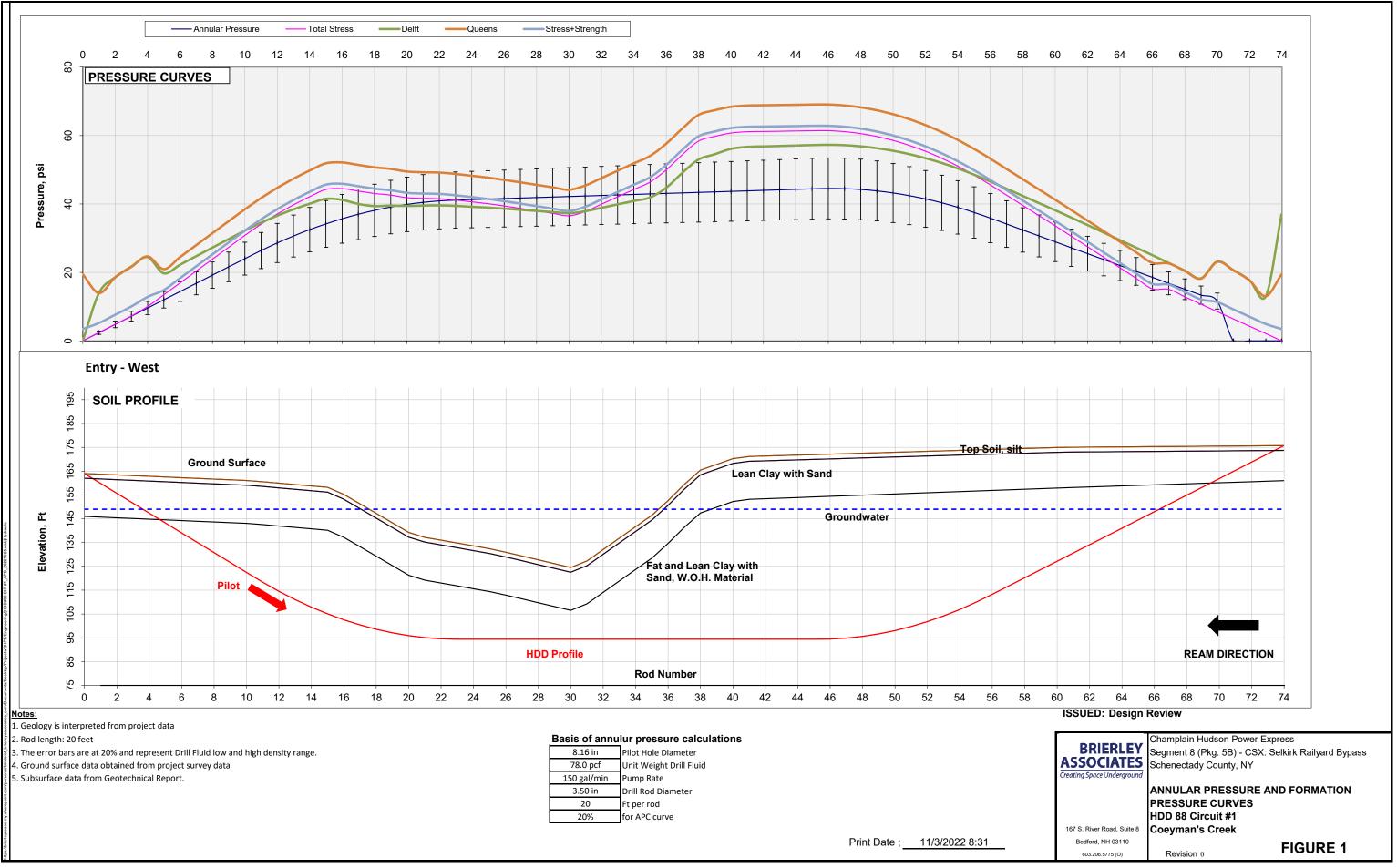
It appears that there is a potential of inadvertent release at ends of the bores (as is common). These could be controlled through the use of conductive casings, haybales, silt fences, erosion control measures and vacuum trucks. There is also the potential for drill fluid loss and IR over the entire length of the crossing due to the soft soils and areas of reduced cover. The drilling contractor will need to monitor drill fluid returns, drill fluid pressures and borehole behavior carefully. Reduced pump volumes and displacement-type drilling and reaming may be necessary. The drilling contractor will need to be prepared to identity and address an IR in each case. This will require full surface monitoring and access, including the stream and wetland areas and Route 396. The adjacent railroad tracks should be monitored in close coordination with the Owner prior to, continuously throughout operations, and 1-2 weeks post installation.

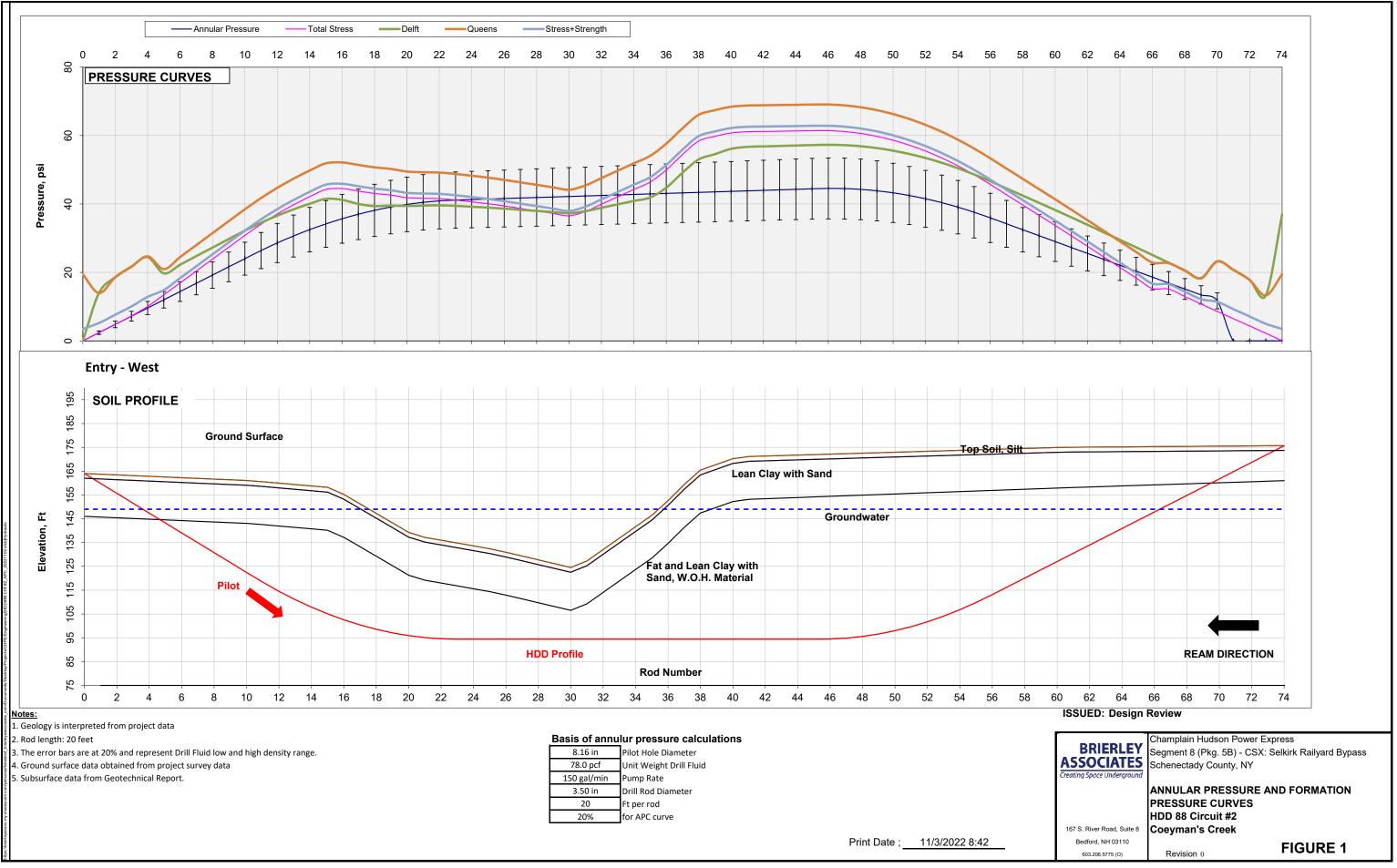
APPENDIX A ANNULAR PRESSURE ANALYSES

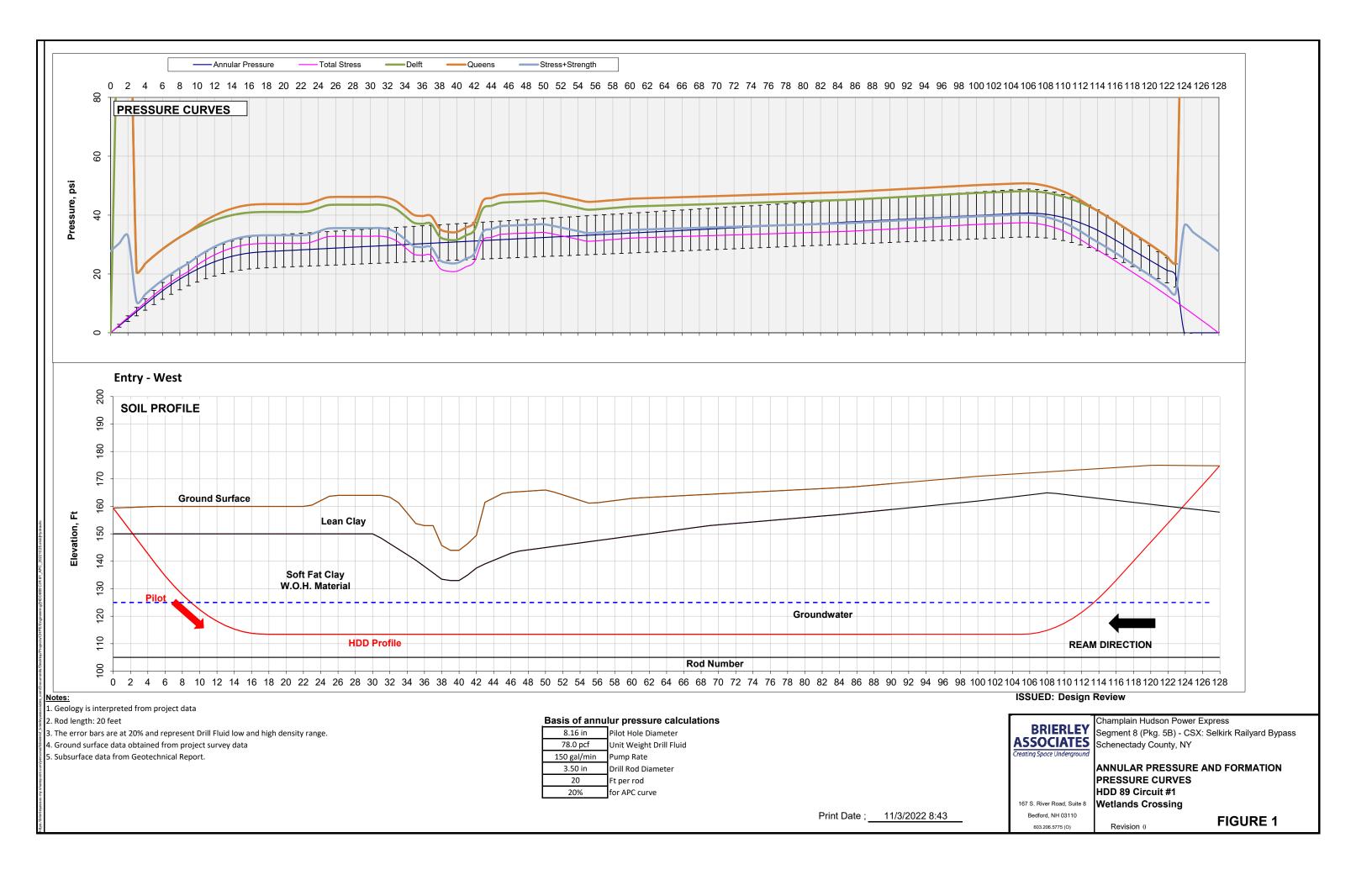


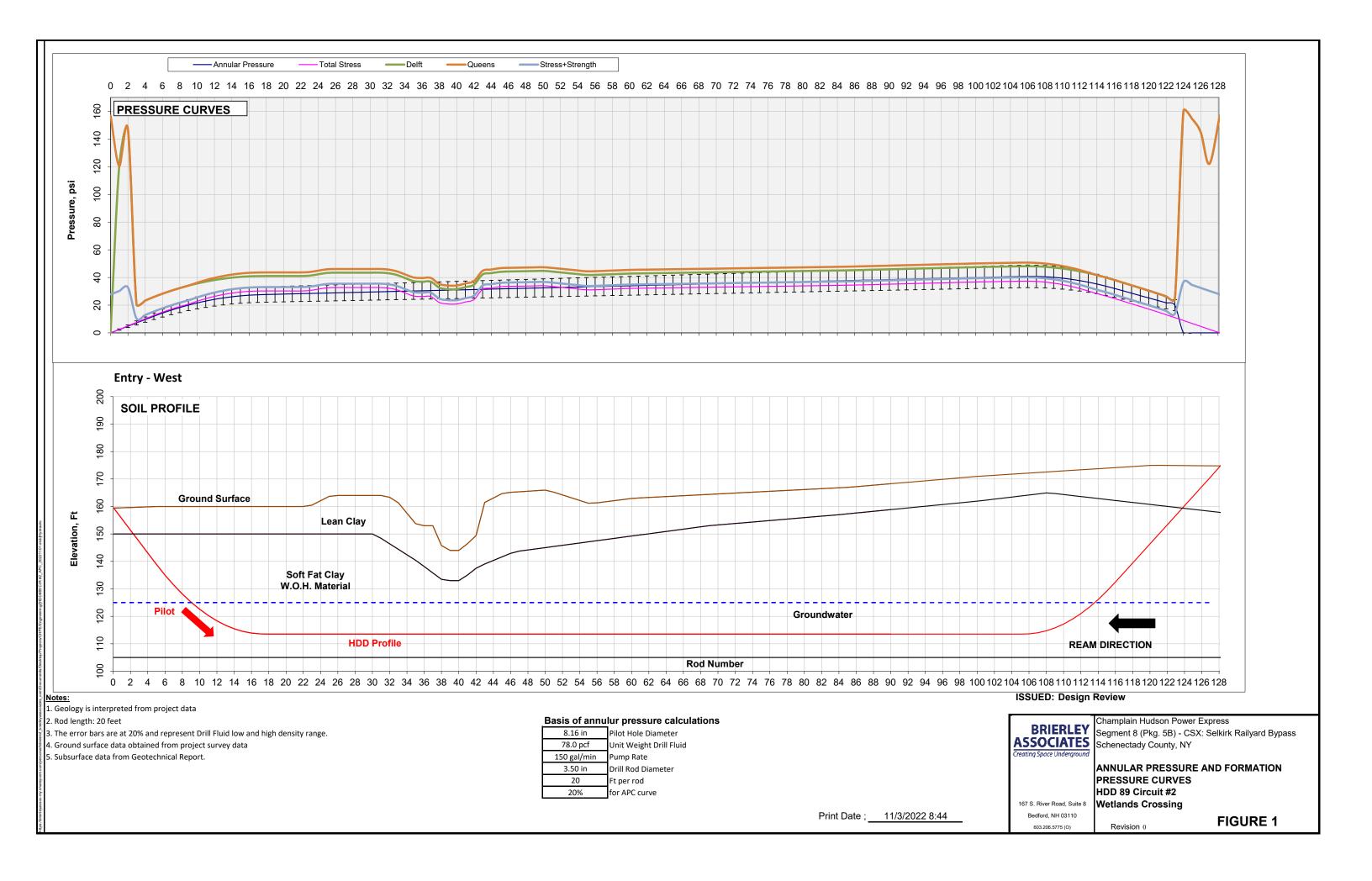


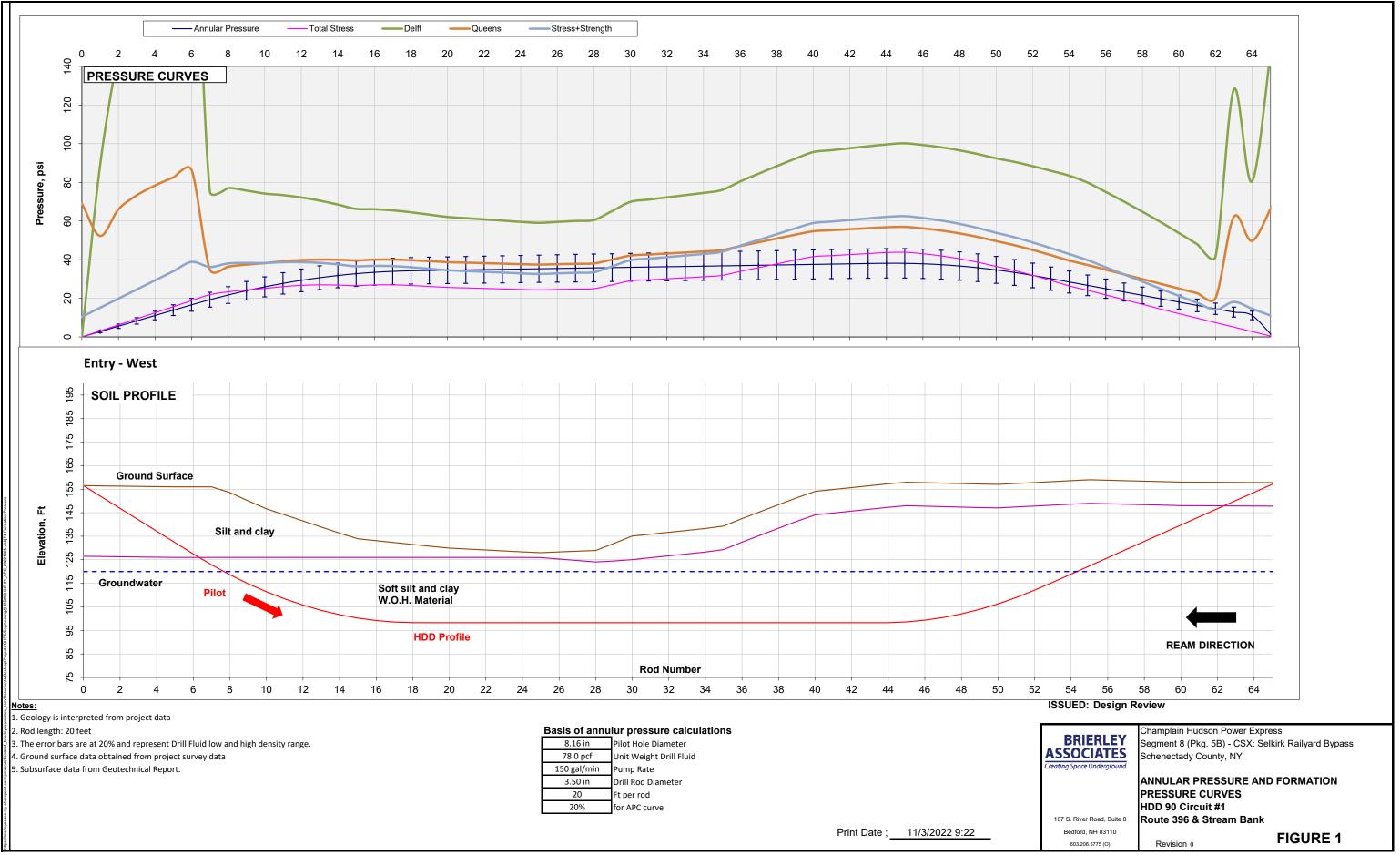


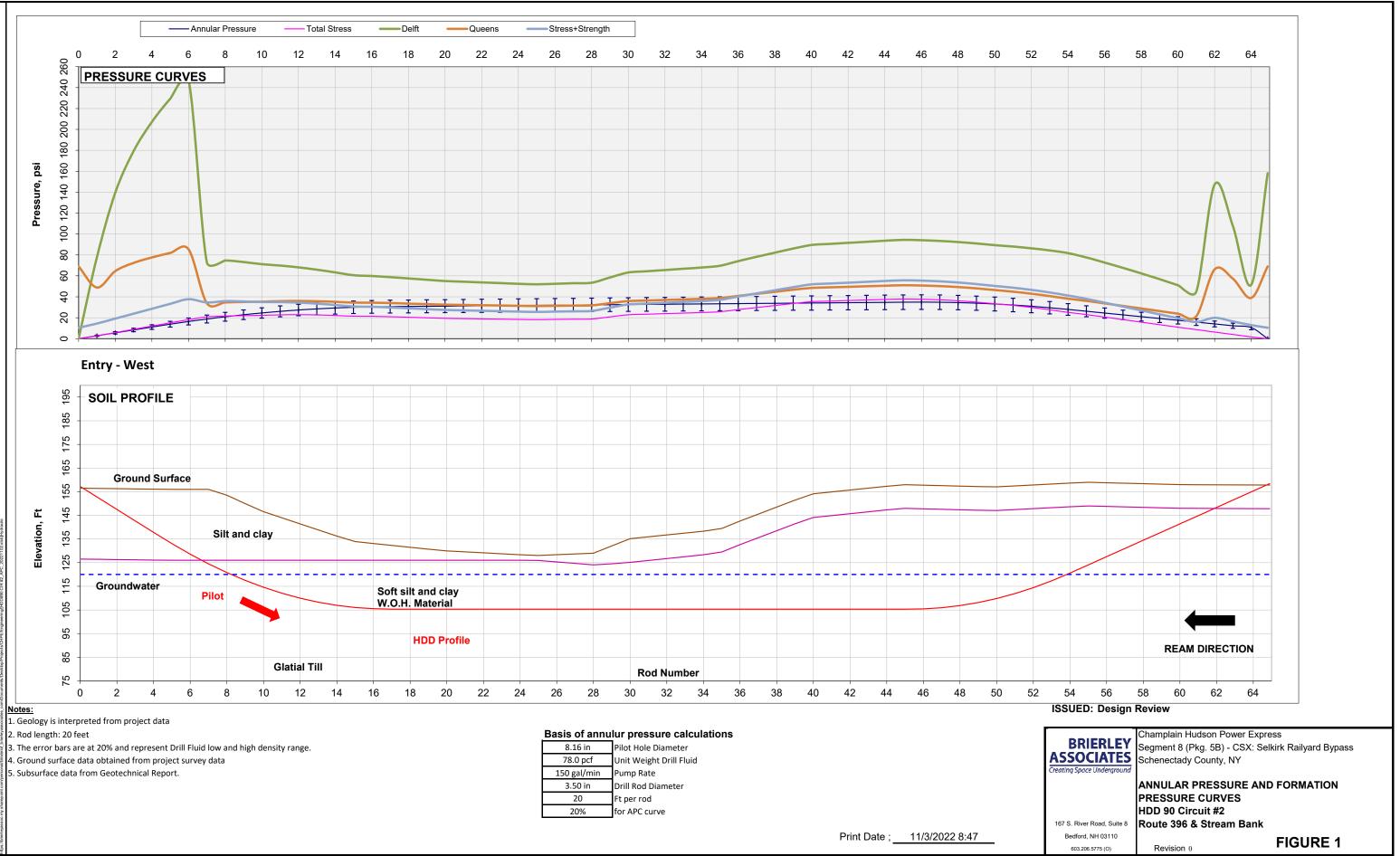














December 13, 2022 File No. 322004-000

Kiewit Engineering (NY) Corporation 470 Chestnut Ridge Rd, 2nd Floor Woodcliff Lake, NJ 07677

Attention: Jason Neff, PE, PMP - Design Engineering Manager

Subject: DRAFT HDD Design Summary Report Champlain Hudson Power Express – Segment 5B Fuera Bush to Bethlehem, New York

Dear Mr. Neff:

Brierley Associates Underground Engineers, PLLC (Brierley) is pleased to provide this DRAFT HDD Design Summary Report for Segment 5B of the Champlain Hudson Power Express Project. This work was conducted in general accordance with our contract with Kiewit Engineering (NY) Corporation (Kiewit).

We thank you for this opportunity to be of service to you and your team on this project. Should you have any questions or require additional information, please do not hesitate to contact the undersigned at your convenience.

Sincerely,

Brierley Associates Underground Engineers, PLLC

Nick Strater, P.G. Sr. Project Manager Brent Lindelof, P.E. Sr. Engineer

Brian C. Dorwart, P.G., P.E. Sr. Consultant

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APPENDIX A: Geotechnical Data

APPENDIX B: HDD Calculations

1.0 Introduction

The Champlain Hudson Power Express (CHPE) project will install a pair of HVDC electrical transmission cables with an associated telecommunications line from Canada to New York City, NY. This work includes approximately 126 crossings under roads, railroads, wetlands water bodies, and obstructions to be installed using horizontal directional drilling (HDD) methods to minimize interference with use or impacts to the surface environment. This Draft Design Summary Report addresses the design for the HDD crossings in Package 5b which extends from Fuera Bush to Bethlehem. Package 5b includes a total of 4 crossings, which are summarized in Table 1, below.

HDD #	Approx. Start Station*	Approx. End Station*	Approx. HDD Length, ft	Obstruction Crossed
87B	51106+47	51120+29	1,382	S. Albany St/Route 54, water main
88	51179+09	51193+75	1,466	Coeyman's Creek
89	51201+50	51227+00	2,550	Wetland, Stream
90	51235+01	51247+40	1,239	Route 396/Stream Bank

Table 1: HDD Locations, Lengths, and Description

*Project stationing shown. Each HDD has its own independent stationing.

The purposes of this Draft Design Summary Report are to provide the following:

- Review of the existing geological and geotechnical conditions for each HDD crossing.
- Provide a descriptive narrative of the HDD crossings in support of the design drawings and technical specifications.
- Present pipe stress and annular pressure analyses that support the proposed designs.
- Present construction considerations including inadvertent return mitigation.

2.0 **Project Description**

The proposed CHPE route follows the Hudson River Valley of New York. The new transmission line will be approximately 146 miles in length, extending from the south end of Lake Champlain to Astoria, NY. Project Maps showing the locations of the HDD crossings are presented in Figure 1.

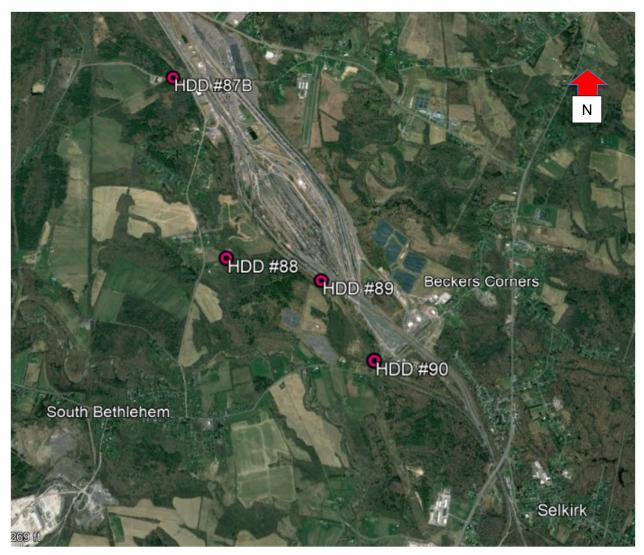


Figure 1 – Crossing Location Plan, HDD #87B through HDD #90. Photo from <u>www.googleearth.com</u>. <i>Not to scale.

3.0 Background

The underground construction of two HVDC electrical transmission cables is proposed to be housed in individual 10-inch-diameter plastic conduit spaced approximately 15 feet apart. A third, minimum 2-inch-

diameter plastic conduit will be bundled with one of the 10-inch diameter conduits for a telecommunications line.

The proposal is to install the cable duct at least 25 feet below congested areas, roads, railroads, under/around other obstructions, 15 to 25 feet below wetland, and 35 to 45 feet below open bodies of water using horizontal directional drilling (HDD) methods.

HDD is a widely used trenchless construction method to install pipe and conduits with limited disturbance to the ground around the bore alignment. The goal for using HDD methods is to install the conduits while controlling and minimizing the amount of impact to congested areas, existing underground obstructions, and to the adjacent wetlands to the extent possible.

4.0 Surface Conditions

<u>HDD #87B</u>

HDD #87B passes below S. Albany St/Route 54 which curves from east-west to northwest-southeast in this vicinity. This roadway is supports two lanes of active traffic and is approximately 23-ft wide. The crossing also passes below a 48-in water main operated by the Albany Water Board, and numerous smaller utilities.

Southwest of S. Albany St/Route 54 (in the vicinity of the HDD alignment) the ground surface slopes downward toward the center of the alignment, from about El. 170 to El. 155. In this area, the crossing passes below a wetland and 60-in CMP culvert. This area is covered with brush and small trees.

The HDD Entry is located to the northwest, on the south side of S. Albany St/Route 54, adjacent to a small commercial facility (single-story buildings, unpaved parking). The ground surface in this area ranges from about El. 175 to El. 178. Overhead utility poles are located on the opposite (north) side of the road.

The HDD Exits are staggered and located in a grassy area on the northeast side of S. Albany St/Route 54. A paved parking area and a brick office building operated by CSX are located to the immediate east. Surface grades at the HDD exit range from about El. 175 to El. 177.

<u>HDD #88</u>

HDD #88 is located to the east of S. Albany St/Route 54 and passes below Coeyman's Creek and an adjacent wetland. The majority of the site vicinity is covered by trees and brush. Farmland is located to the northwest, southwest and northeast.

The HDD Entry is located to the southwest in an open field (farmland). Surface grades in this area range from about El. 163 to El. 165. The HDD exit is located to the northeast in an area covered by brush and small trees, which has been mapped as wetland. Surface grades in this area range from about El. 174 to El. 176.

Surface grades along the HDD alignment slope downward toward Coeyman's Creek at moderate grades from the northeast and southeast. The Creek is oriented approximately north-south, with a bottom elevation estimated at El. 124 to El. 125.

<u>HDD #89</u>

HDD #89 is located to the southwest of a single CSX rail (oriented northwest-southeast), and passes below a small stream, which is generally oriented north-south. The majority of the HDD alignment is covered by brush and small trees, and has been mapped as wetland. Overhead utility poles are located immediately adjacent to and parallel the northwest portion of the HDD alignment.

In general the surface grades slope downward gently toward the south-southwest. However, moderate slopes are located on either side of the stream. The stream bottom is estimated to be at about El. 149.

The HDD entry is located to the southwest, with a surface grade of about El. 158 to El. 160 The HDD exit is located to the northwest, with surface grades of about El. 174 to El. 175. Both the entry and exit areas are covered by brush and small trees and have been mapped as wetlands.

The entirety of the HDD #89 alignments are located within the CSX right-of-way.

<u>HDD #90</u>

HDD #90 is located to the southwest of a single CSX rail (oriented northwest-southeast), and passes below the bank and wetland of a small stream, which is generally oriented northwest-southeast. HDD #90 also passes below Route 396 which is about 27-ft wide and oriented northeast-southwest. In this vicinity the CSX rails are elevated, and pass over Route 396 by means of steel bridge with concrete wing walls to the northeast of the crossing. In general, the site grades along the alignment slope downward toward the stream to the southwest.

Two (2) separate, northeast-southwest oriented overhead power lines cross the alignment in the Route 396 vicinity. Numerous power poles associated with these lines are located along the southeast portion if the HDD alignment.

The HDD #90 entry area is located to the southeast. This area is covered by small trees and brush, and mapped wetland is locate to the northeast. Surface grades in this immediate area range from about El. 157 to El. 159.

The HDD #90 exit area is located to the northwest. This area is covered by small trees and brush, and has been mapped as wetland. Surface grades in this immediate area range from about El. 157 to El. 159.

The surface grade of the adjacent CSX rail (northeast) ranges from about El. 165 to El. 166. The entirety of the HDD #90 alignments are located within the CSX right-of-way.

5.0 Below-grade Structures

5.1 Utilities

The location of existing known below-grade utilities are shown on the design drawings. Additional soft dig information will be evaluated during final design and prior to issued-for-construction drawing submittal. Minimum offsets between the known utilities and the HDD borepaths are included on the profiles.

5.2 Foundations

The location of existing foundations (bridges, retaining walls) will be added to the issued-for-construction drawings based on as-built information provided by others, where available.

6.0 Subsurface Conditions

The subsurface conditions in the vicinity of the HDD crossings were investigated by subsurface investigations and laboratory testing completed by others. Subsurface investigations included sampled test borings and cone penetrometer testing.

In general, the subsurface conditions at each of the 5b crossings are generally similar, and consist of surficial fill overlying glacial lake deposits consisting of silt and clay (loose to medium dense and very soft to soft), with lesser amounts of loose silty sand and sand. The density/consistency of the silt and clay appears to decrease with depth. It should be also noted that the glacial lake deposits contain extensive amounts of "Weight-of-Hammer" materials.

7.0 HDD Process

HDD involves drilling a small diameter (4 to 9-in) "pilot hole" along a pre-established, design alignment from and entry pit to an exit pit. The pilot is then enlarged as necessary by a series of reaming passes, and the product pipe or duct bundle is pulled into place. HDD generally does not require pits (or shafts), or dewatering. The depth and trajectory of the HDD needs to be carefully designed to account for subsurface conditions and the bending tolerances of the drill rods, steering limits of the drill tools, anticipated reaction of the subsurface conditions, and bending tolerances and the product pipe/conduit. All stages of the HDD process involve pumping a bentonite-based, environmentally safe drilling fluid into the borehole through the drill rods. The drilling fluid travels back to the surface within the annular space between the drill rods and surrounding soil. The drilling fluid maintains borehole stability, removes cuttings, and cools the drilling tools. A common risk associated with HDD is release of drilling fluid to the ground surface, which is referred to as an inadvertent return (IR) or "frac-out". This may occur when the downhole drill fluid pressure exceeds the confining capability of the surrounding soil, or if zones of weakness or previous disturbance are present (e.g., existing utilities, utility poles, deep foundations). Drilling fluid and drilling fluid additives are chemically inert, biodegradable, and non-toxic. However, the occurrence of a frac-out typically requires cleanup, may result in surface heave or settlement, and may result in borehole instability (e.g., collapse, squeezing).

8.0 Design Components

8.1 HDD Geometry

The proposed bore path alignments, entry and exit locations, entry angle, exit angle, and a vertical and horizontal design radii of curvature for each HDD crossing in this segment are shown in the design drawings. The HDD technical specifications are found in Section 33 05 07.13 of the Technical Specifications. Inadvertent release prevention and mitigation plans for each HDD crossing are provided as separate documents.

The HDD design alignments for Package 5b have been developed in general accordance with the Project Design Criteria Manual (document entitled "Project Design Criteria", Champlain Hudson Power Express, 400kV HVDC Underground Transmission Line, KIEWIT PROJECT NO. 104809, Dated June 2022, herein referred to as the "Design Manual").

8.2 Annular Pressure Analysis

Drill fluid loss from the borehole typically occurs as a result of one or a combination of the following:

- Hydraulic Jacking: Hydraulic jacking occurs when there are existing cracks in the formation such as fractures within bedrock or stiff cohesive soils, or relatively high permeability zones contained within a relatively low permeability materials (e.g. a sand lense in clay). When the drill fluid pressure exceeds the weight or force restraining the materials on the sides of the fracture or higher permeability zone, the confining material will be hydraulically jacked open resulting in an enlarged opening with more fluid volume capacity and eventually, the possibility of a new flow path for the fluid. The Total Stress calculations provides a conservative method for assessment of this type of drill fluid loss.
- Hydraulic Fracturing. Hydraulic fracturing occurs when the drill fluid pressure exceeds the static stress state in the formation *plus* the strength of the formation material. The result is a fracturing of the formation providing access for the drill fluid to a path that will continue to grow until the drill fluid pressure is reduced or the formation strength increases. The stress plus strength and the Kirsch methods may be used to assess this type of drill fluid loss in rock. In soil formations the Delft may be used to model for drill fluid loss when hydraulic fracturing occurs.
- Leakage: Flow of the drill fluid into existing open space, such as open bedrock fractures and soil porosity.

It's common to loose upwards of 30% (or more) of the drill fluid to the adjacent formation (soil and bedrock) during HDD construction. If the drill fluid reaches to ground surface or water (river) mudline, it's referred to as a "fracout" or inadvertent drill fluid return ("IR"). This may require conditioning of the borehole to stop the drill fluid loss, and cleanup of the drill fluid, if accessible.

A preliminary annular pressure analysis was completed for the pilot hole for each of the currently proposed HDD borepath geometries, based on the currently available geotechnical data. This process compares the anticipated range of downhole annular drill fluid pressures required to complete the pilot bore to the estimated confining capabilities of the surrounding geologic materials. This exercise can be useful in the evaluation of risk of inadvertent returns (IR's, or "fracout") during drilling. The potential for an IR may be considered greatest at locations where the anticipated range of downhole drill fluid

pressures are close to or exceed the estimated confining capabilities of the surrounding materials. Note that the pilot hole (vs the reamed hole) is generally the most constrained, and presents the greatest risk of IR during the HDD construction process.

The following should be noted:

- HDD requires drill fluid pressures sufficient to stabilize the borehole and remove cuttings. In general, it may be possible to reduce the risk of drill fluid loss through careful drilling and drill fluid management, but IR risk cannot be completely eliminated.
- The annular pressure analysis is considered to be a tool to identify areas of potential risk. *It is not considered an exact predictor of the location or degree of an IR.*
- The annular pressure analysis does not account for existing pathways or zones of weakness in the subsurface, which may be related to existing utilities, foundations, utility poles and below-grade space. Where present, these features will *increase* the risk of drill fluid loss.
- The annular pressure analysis is not an accurate predictor of borehole leakage, where drill fluid leaks to the adjacent materials through existing porosity or fractures.
- Drill fluid loss from the borehole may not migrate to the surface. In some cases, the drill fluid may escape to the surrounding formation through localized fractures, porosity, or dilation.

The anticipated range of downhole drill fluid pressures (combined static and dynamic) for each HDD crossing in Package 5b are shown in Appendix B along with a generalized subsurface profile for each bore. The static drill fluid pressure is a function of the density of the drill fluid at a specific location and depth below the drill entry elevation. The dynamic pressure is the pressure required to move the drill fluid (and cuttings) up the borehole annulus, and is a function of pump rates, hole geometry, fluid density, fluid velocity, and fluid rheology. The estimated annular pressures included in Appendix B are based on the API-13D method using a Power Law to model the dynamic pressure of a visco-plastic fluid.

Geotechnical parameters used in the analysis were derived through evaluation of laboratory testing and engineering judgement. The confining capability of the native materials was approximated using a variety of methods, which include the following:

- **Total Stress Model**: The Total Stress Model is based on the dead weight of the formation material above the drill path and excludes the potential strength of the formation. This method is considered *conservative* but is considered a reasonable approximation for the formation pressure capacity of bedrock and very dense soil.
- **Cavity Expansion Model (Delft Equation)**: This method considers the strength of the formation along with the total stress (above) and is based on Ko = 1 conditions. The initial equation was derived from the Mohr-Coulomb failure model adjusted by Delft University for low angle cylindrical cavity expansion in a host material when subjected to internal pressure. This method has been found more realistic in sand, silt, and stiffer cohesive formations than the Total Stress Model. However the method require assumptions of a horizontal surface with homogeneous isotropic soil. Additionally, the equations require significant property assumptions such as the Shear Modulus, G. *This model is not generally appropriate for most bedrock, particularly hard sedimentary bedrock, and metamorphic and igneous lithologies.*
- Stress plus Strength Model: This method was initially implemented by the US Corps of Engineers to assess the damage potential to levees from the HDD fluids during drilling. This model adds the strength of the formation material to the total stress though results are generally considered to be conservative. The basis of the model, like the cavity expansion model is the Mohr-Coulomb failure approach. This model is generally appropriate for soil or bedrock.
- Queens Model: The Queens model was developed at Queens University. This model also adds the strength of the formation material to the total stress. The basis of this model, similar to the cavity expansion model is the Mohr-Coulomb failure approach. The difference between this model and the Delft model is that the Queens approach permits variation in the Ko of the soil and is considered more realistic in softer cohesive soils.

Additional input assumptions included:

- Jetting tools will be used for fill, lacustrine and glaciofluvial deposits.
- A mud motor will be used to complete the pilot hole for bores encountering glacial till and bedrock.
- A drill fluid pump rate of 150 gpm for pilots using jetting and a drill fluid pump rate 400 gpm for mud motors.

- An average drill fluid density of 78 pcf, and maximum drill fluid density of 94 pcf.
- An estimated drill bit diameter of 8.16 inches and a drill rod diameter of 3.5 inches.

The results of the annular pressure analyses included in Appendix B suggest that each of the 5b HDD centerlines will encounter very soft silty fat clays with very low strength characteristics, Weight of Hammer (W.O.H.) materials, with a stronger lean clay layer above, providing some pressure capacity for the drills.

- For these 4 crossings, there is an apparent risk of IR for the entire length of each bore. This is due to the poor strength characteristics (W.O.H. material) of the formation and equates to limited confining capabilities. At these locations careful consideration during drilling operations needs to be given to maintain borehole stability.
- In W.O.H materials, it is common to lose returns without IR, as the formation dilates. However, this may require additional drill fluid volumes and hole conditioning.
- HDDs #89 and #90 have critical areas with Factors of Safety below 1.0.
 - Contingency plans for track movement and impact should be developed in coordination with the Owner prior to executing the work.
 - The adjacent railroad tracks should be monitored in close coordination with the Owner prior to, continuously throughout operations, and 1-2 weeks post installation.

The HDD contractor(s) should be prepared to monitor the downhole drill fluid pressures in each bore, and respond to elevated pressures and drill fluid loss. The Inadvertent Return Contingency Plan details additional methods for mitigating inadvertent returns.

8.3 Conduit Material Selection

The conduit installed by HDD for the CHPE project must be plastic to satisfy cable ampacity requirements. The conduit must also be designed to withstand the short-term installation (pullback) loads, and the long-term external loads.

The conduit selected for the Package 5b HDD installations is PE4710 DR9 High Density Polyethylene (HDPE), consistent with the requirements of the Design Manual. Note that we have assumed that the telecommunications conduit will be minimum 3-in diameter (versus 2-in) to improve pullback survivability.

Pullback calculations for each HDD crossing are included in Appendix B, along with the conduit details. These will be updated during final design. These calculations have been developed in general accordance with ASTMF-1962 as modified to account for invert tangent section, independent vertical curves, and fluid drag. The safe pull force has been calculated in accordance with recommendations of the Plastic Pipe Institute. Both water ballasted and unballasted conduit have been considered. Water ballasting is recommended to reduce the pull force in each case.

It should be noted that HDPE is assembled through butt-fusion, which creates an internal "bead" which must be removed during fusion ("debeading") to reduce risk of cable damage during cable pulling.

9.0 Construction Considerations

The following construction considerations are presented for discussion purposes.

9.1 Subsurface Conditions

The following soils encountered along the package 5b alignment present specific construction considerations:

- Fill: Fill soils were encountered at each of the HDD crossing locations. These materials are expected to be uncontrolled, and could contain obstructions to HDD construction, including debris, abandoned utilities, cobbles and boulders, and trash. In addition, fill soils located within and adjacent to railway easements may contain contamination which could impact the performance of HDD drill fluid, requiring more frequent replacement. Drill fluid containing contamination may require specialized disposal.
- Glacial Lake Deposits: Glacial Lake Deposits (fine sand, silt, clay) were encountered at numerous HDD crossing locations. Where soft to very soft, fine grained soils are present, squeezing behavior may result in choking of the hole and increased risk of downhole pressure spikes and inadvertent drill fluid returns. Drill fluid additives and frequent hole conditioning may be required to control this behavior. In addition, very soft soils may present difficulties in maintaining the drill tool alignment.
 - In W.O.H materials, it can be common to lose returns without IR, as the formation dilates. However, this may require additional drill fluid volumes and hole conditioning.

9.2 Steering Tools

A downhole steering tool will be required for each HDD to maintain the desired alignment, and offsets from adjacent sensitive structures. Walkover steering tools are not considered appropriate to potential magnetic interference associated adjacent utilities and railroad structures, and (depending on the crossing) the depth of the installation.

9.3 Drill Fluid Pressure Monitoring

The HDD contractor should employ a downhole pressure tool during pilot hole drilling to monitor and the annular drill fluid pressures. This will help maintain pressure levels below an established threshold, reduce risk of IR's, and may provide details on locations where drilling fluid is lost.

9.4 Conduit Laydown and Pullback

As-noted, butt-fused plastic conduit (HDPE) used for cable raceway must be completely assembled and de-beaded prior to pullback. This will require significant work space in each case. The conduit is typically assembled during drilling, and will need to be protected prior to installation.

In each case, pullback of the conduit should be completed without interruption to reduce the risk of the conduit becoming stuck and damaged. We recommend that the conduit be fully water-ballasted to reduce the pullback forces.

10.0 References

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APPENDIX A GEOTECHNICAL DATA

CHPE PACKAGE 5B DRAFT HDD Design Summary Report December 12, 2022

APPENDIX B HDD CALCULATIONS PER CROSSING



HORIZONTAL DIRECTIONAL DRILL DESIGN

- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 87B Circuit #1 South Albany Rd Wetlands

ISSUE: Design Submittal

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 Project No:
 322004-000

 Print Date:
 2-Nov-2022

Revision	ID	DESCRIPTION	BY
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Alter of the second sec	1 -12.000 deg. 61.924 ft 63.307 ft -13.162 ft 175.700 ft 162.538 ft -12.000 deg URVE CALCUL/ 0+01.92 61.92 63.31 -13.16 Iles - positive (+) 0 degrees.	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	V 228.703 ft 230.383 ft -24.038 ft 138.500 ft 138.500 ft 138.500 ft 0.000 deg 0+61.92 2+90.63 290.63 293.69 -37.20	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 790.86425 ft 790.86425 ft 0.00000 ft 138.500 ft 138.500 ft 0.000 deg 2+90.63 10+81.49 ft 1084.56 ft -37.20 ft a	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	1100.00 12.000 deg. ▼ 228.703 ft 230.383 ft 24.038 ft 138.500 ft 138.500 ft 138.500 ft 162.538 ft 12.000 deg 10+81.49 13+10.19 1314.94 -13.1624	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length	174.90 12.00 deg 58.160 ft 59.460 ft 12.362 ft 162.538 ft 1368.354348 13+10.19 13+68.354 1368.35 1374.40 -0.80	SUMS 1,368.354 ft 1,374.398 ft -0.800 ft Stationin OK STAT Plan Leng OK CALC Elevation Ch OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	g Check Minimun g Check TIONING th Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson P. Segment 8 (Pkg. 5B) Schenectady County,	y to Exit Eleva Minimum Desig Invert Depth n Plan Length (Compound Co Compound Co Compound Co Compound Co Suppound Co Compound Co Compound Co Compound Co Compound Co	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Irve at Entry = Curve at Exit =	138.50 f 36.40 ff 37.20 ff 1,374.40 1,368.35 577.49 f -12.00 de NO
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Alter the second	1 -12.000 deg. 61.924 ft 63.307 ft -13.162 ft 175.700 ft 162.538 ft -12.000 deg URVE CALCUL/ 0+01.92 61.92 63.31 -13.16 Iles - positive (+) 0 degrees.	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	V 228.703 ft 230.383 ft -24.038 ft 138.500 ft 138.500 ft 138.500 ft 0.000 deg 0+61.92 2+90.63 290.63 293.69 -37.20	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 790.86425 ft 790.86425 ft 0.00000 ft 138.500 ft 138.500 ft 0.000 deg 2+90.63 10+81.49 ft 1084.56 ft -37.20 ft a	Radius Angle Change Calculate Vertical P' Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	1100.00 12.000 deg. 228.703 ft 230.383 ft 24.038 ft 138.500 ft 138.500 ft 162.538 ft 12.000 deg 10+81.49 13+10.19 1314.94 -13.1624	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length	174.90 12.00 deg 58.160 ft 59.460 ft 12.362 ft 162.538 ft 1368.354348 13+10.19 13+68.354 1368.35 1374.40 -0.80	SUMS 1,368.354 ft 1,374.398 ft -0.800 ft -0.800 ft Stationin OK STAT Plan Leng OK CALCI Elevation Ch OK CALCI ISSUE: BRIERLEY ASSOCIATES Linted Liability Company "Creating Space Undeground"	Entr Minimun g Check rIONING th Check ULATION ange Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pi Segment 8 (Pkg. 58) Schenectady County, TABLE 2 DESIGN DRILL P.	y to Exit Eleva Minimum Desi Invert Depi Invert Depth n Plan Length (Compound Ct Compound	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	138.50 f 36.40 ff 37.20 ff 1,374.40 1,368.35 577.49 f -12.00 de NO
try Tangent Segment 3 Entry Angle Entry Angle Network Angle Network Angle Start Elevation End Vert Angle MMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Rod Length Cum Depth	1 -12.000 deg. 61.924 ft 63.307 ft -13.162 ft 175.700 ft 162.538 ft -12.000 deg URVE CALCUL/ 0+01.92 61.92 63.31 -13.16 Iles - positive (+) 0 degrees.	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	V 228.703 ft 230.383 ft -24.038 ft 138.500 ft 138.500 ft 138.500 ft 0.000 deg 0+61.92 2+90.63 290.63 293.69 -37.20	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 790.86425 ft 0.00000 ft 138.500 ft 138.500 ft 0.000 deg 2+90.63 10+81.49 ft 1084.56 ft -37.20 ft a L1 PCen	Radius Angle Change Calculate Vertical P' Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	1100.00 12.000 deg. 12 228.703 ft 230.383 ft 24.038 ft 138.500 ft 138.500 ft 162.538 ft 12.000 deg 10+81.49 13+10.19 1314.94 -13.1624	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Cum Plan Length Cum Plan Length Cum Rod Length Cum Depth EXIT	174.90 12.00 deg 58.160 ft 59.460 ft 12.362 ft 162.538 ft 1368.354348 13+10.19 13+68.354 1368.35 1374.40 -0.80	SUMS 1,368.354 ft 1,374.398 ft -0.800 ft -0.800 ft Stationin OK STAT Plan Leng OK CALC Elevation Ch OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company "Creating Space Underground"	G Check Minimun g Check TIONING th Check JLATION ange Check JLATION Indicates inputs Indicates status or Design Review Champlain Hudson P. Segment 8 (Pkg. 5B) Schenectady County, TABLE 2 DESIGN DRILL P. HDD 87B Circuit 1	y to Exit Eleva Minimum Desi, Invert Depi Invert Depth n Plan Length (Compound Ct Compound Ct Compoun	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	138.50 36.40 f 37.20 f 1,374.40 1,368.35 577.49 -12.00 de NO
try Tangent Segment 3 Entry Angle Entry Angle Network Angle Network Angle Start Elevation End Vert Angle MMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Rod Length Cum Depth	1 -12.000 deg. 61.924 ft 63.307 ft -13.162 ft 175.700 ft 162.538 ft -12.000 deg URVE CALCUL/ 0+01.92 61.92 63.31 -13.16 Iles - positive (+) 0 degrees.	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	V 228.703 ft 230.383 ft -24.038 ft 138.500 ft 138.500 ft 138.500 ft 0.000 deg 0+61.92 2+90.63 290.63 293.69 -37.20	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 790.86425 ft 790.86425 ft 0.00000 ft 138.500 ft 138.500 ft 0.000 deg 2+90.63 10+81.49 ft 1084.56 ft -37.20 ft a	Radius Angle Change Calculate Vertical P' Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	1100.00 12.000 deg. IV 228.703 ft 230.383 ft 24.038 ft 138.500 ft 138.500 ft 162.538 ft 12.000 deg 10+81.49 13+10.19 1314.94 -13.1624 IGTH PCex ► EXIT CU	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Cum Plan Length Cum Plan Length Cum Rod Length Cum Depth EXIT	174.90 12.00 deg 58.160 ft 59.460 ft 12.362 ft 162.538 ft 1368.354348 13+10.19 13+68.354 1368.35 1374.40 -0.80	SUMS 1,368.354 ft 1,374.398 ft -0.800 ft -0.800 ft Stationin OK STAT Plan Leng OK CALC Elevation Ch OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company "Creating Space Underground"	Entr Minimun g Check rIONING th Check ULATION ange Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pi Segment 8 (Pkg. 58) Schenectady County, TABLE 2 DESIGN DRILL P.	y to Exit Eleva Minimum Desi, Invert Depi Invert Depth n Plan Length (Compound Ct Compound Ct Compoun	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	138.50 36.40 f 37.20 f 1,374.40 1,368.35 577.49 -12.00 d 12.00 d NO

Ī	Pull Geometry								Pipe	Entry Location - Drill	Exit				
									•	o show definition of var		1			
	Lengths (Path	N	Angles		Radius, R	-	Pipe Exit El =	175 70 ft			labice enily,		Dino E	ntry El =	174.90 ft
	L1 = 100.0 ft	Overbend	deg	radian	500.0 ft			110.10 K	1				T IPE L		11 1.00 11
	L2 = 59.5 ft	α	5	-0.2094		β	N.							ζα	
	L3 = 230.4 ft		12.0	0.2001	1,100.0 ft	- ·	<u>∳``</u> , F						A , ć	<u>▼</u> .	
	L4 = 790.9 ft	χ=	= 0.0 °	0.0000	1,100.011	-	Contraction of the second					J.	K	www.com.com	and the second second
	L5 = 230.4 ft	λ.	0.0	0.0000	1,100.0 ft	-			neveren i i	NANA NA.	2.94 2.14	в	0.00		
	L6 = 63.3 ft	β =	= 12.0 °	0.2094	.,			E							
	LT = 1474.4 ft		-							D	c		Overt	bend	
ł	INPUT: Assun		actors				-		15				 _	1	_
	μ _G		dry + roller	S				- 10 7	LJ		L3			_ 1	
	μ _b		drill fluid in	hole					Cal	culated Pull Force	9			ASS	ESS
	μ_{c}	= 0.30	in hole no fl	luid			DOINT	Pull Force, F _D		ASSESS	Pull Force, F _B	Max Tensile	ASSESS	F _x <	SPS
	INPUT: Assun						POINT	No Ballast	Stress, σ_T	$\sigma_{\rm T} < \sigma_{\rm PM}$	Ballasted Pipe	Stress, σ_T	$\sigma_{T} < \sigma_{PM}$	Air	Ballast
	τ _f	= 0.005 psi	Drill Fluid S	hear Str	ess		A	2,614 lb	143 psi	OK	2,614 lb	143 psi	OK	OK	OK
ļ	INPUT: Pipe P				-		В	3,180 lb	80 psi	OK	3,231 lb	82 psi	OK	OK	OK
		al HDPE	1	IPS			С	4,885 lb	158 psi	OK	4,049 lb	137 psi	OK	OK	OK
ี้เปราร.	Safe Pull Max. Stress, o		PPI Table 1) 73Deg F		D	8,359 lb	211 psi	OK	7,524 lb	190 psi	OK	OK	OK
0701	Pile/Bundle Diam. 14.25		PIPE/BUNE	JLE			E	13,088 lb	365 psi	OK	10,026 lb	288 psi	OK	OK	OK
2022	Material Density		<u> </u>				F	14,296 lb	361 psi	OK	10,600 lb	267 psi	OK	OK	OK
'ר דר	Outside Diameter, D		Pipe or Bun				ASSES	S Pull Restricted	BUCKIING Ca	pacity, P_{PA} > ∆P invert	$P_{PA} = P_A F_R =$	97.63 psi	Balla		OK OK
- #	Pipe Dry Weight, W _P Min. Wall Thickness,		Pipe or Bun		an null atraas			Maximum tens	ile stress duri	ng pullback = $\sigma_t = (F_T/\pi)$	t(Dt))+F_D	/2R 【	No Ba PPI Ch 12		UK
5	DR = D_0/t_{min}		D _{OD} Stress		on pull stress	Calculate	d Material Des	ign Limits For		01 1 1		00/211		LY 10	
0#0	Avg. Inside Diameter, D		Bundle Mul						-	fe Pull Strength, SPS =	45,606 lb	SSPS = σ_{PM}	τDop ² ((1/D)R)-(1/DF	(²)
ing/lm	12 Hr Pullback Modulus, E _T		-	73 deg l	,	-		Allowable Short		strained Buckling, $P_A =$		$P_A = (2E_T/(1-$, ,	
	Poisson Ratio, µ	,		ro dog i						Stress Reduction, $F_R =$					/
n ling	Ovality Factor, f		2%	1						r =		$r = \sigma_T/2SPS$,,		
	Buckling Safety, N			1					Maximum a	pplied pull Stress, σ_T =	365 psi	From Pull Fo	rce Calcul	ations	
lacrs/	Hydrostatic Design Stress, HDS	s = 1,008 psi	HDB/2				Ballas	ted Max. Differe	ntial Pressure	e on Pipe, ∆P_B invert =	3.85	psi (-) indicat	es pipe is	pressuriz	zed
DIL /d	Pressure Rating, PR(80F)	= 252 psi	PR = 2HDS	SF _T A _F /(E	0R-1) [F _T =1]		Unballas	ted Max. Differe	ntial Pressure	e on Pipe, ΔP_U invert =	19.23	psi (-) indicat	es pipe is	pressuriz	zed
ASKIO	INPUT: Assun	ned Fluid Den	sities/Elevat	ions								-			
נוווא ב	Ballast Densi	ty 62.4	pcf							Calculated Drill Hole	Diameter Assu	med for Calc	ulations		
culle	Drill Fluid Densi	,	pcf	Estima	ted for pull					D _H =					
	Drill fluid elevation, H _F		_							D _O <8" Use D _H =D _O +4"; 8'	" <d<sub>O<24" Use D_H=</d<sub>	=1.5*D ₀ ; D ₀ >24	" Use D _H =[D _o +12"	
Case.	Ballast Water El., H _w		4								1000				
socia	Lowest Invert El., El _m						NOTES:	 1 - Calculations we vertical curves, an 	ere done in gene d fluid drag. AS	ral accordance with ASTMF- IM applies hydrokinetic press	1962 as modified to sure as shear per un	account for invert it pipe length regi	tangent sec uiring a back	tion, indepe calculatior	endent 1 to determine
eyas	Calculated Pipe and Flui	•			-			actual pull force ba				11 5 1	5		
		Pressure Pipe													
inian		neter Length, F			_						Design Revie				
al/DIII		ection Area, A _v			_						Champlain Huds				
i soi		ne Outside, V _{D0}			_						Segment 8 (Pkg.	-	kirk Railyar	d Bypass	
dillo	Vol	ume Inside, V _C			_					Limited Liability Company	Schenectady Cou	unty, NY			
		q _d =			Drill Fluid (unit	0,				"Creating Space Underground"					
	ASTM EQ 18: Hy		= 0.64 ll	b/ft	Comparison O	niy @ 8psi					TABLE 3 - PUL				
2 million	Calculated Buoyant Fore	-				٦							RCE - HD	PE PULI	<u> </u>
asso(~ ~	Pipe	Air Fil		Ballasted	-					HDD 87B Circu				
(allal	On G In Hole with Dril	bround, w _a /w _{af} =			42.80 Lb/LF	-					South Albany	ka Wetlands			
'n// .sc			-37.01 L		-11.58 Lb/LF	4				167 S. River Road, Suite 8					
ΞĨ										Bedford, NH 03110	Revision	0			

TABLE 4		Pg 1 of 3		
HDPE PROPERTIES		i g i oi o		BRIERLEY
Champlain Hudson P		22		
Segment 8 (Pkg. 5B)	-		Svnass	ASSOCIATES
Schenectady County			Jpuee	Limited Liability Company
HDD 87B Circuit #1	,			"Creating Space Underground"
	un din			
South Albany Rd Wetla	inas			
INPUTS				
Pipe Material Propertie	S			
		and Plastic Pir	e Institute Public	cations and as referenced
Design Working Pre		250 psi		Test Pressure, P _{TEST} 0 psig At high point
	-			rest riessure, ritest o psig
Quantity of Pipe		1		MTERIAL REALON REACON REACTO
	Pipe Material	HDPE		MATERIAL: PE3408, PE3608, PE4710
ASTM D3350 Cell		0	Design resin wit	h minimum PENT test of 10,000 hours
	rd Dimension	3	IDS "Iron Dine C	riza" of DIPS "Ductile Iron Ding Ciza"
Pipe measurem		IPS 9	IPS IION PIPES	ize" of DIPS "Ductile Iron Pipe Size"
	/linimum Wall Diameter, D _o =	9 3.500 in	Standard Manuf	acturer's Data Sheets
	Diameter, $D_0 =$	2.680 in		acturer's Data Sheets
•	um Wall, t _{min} =	0.389 in		acturer's Data Sheets
	on Area, A _W =		$A_W = \pi^* ((D_o/2)^2 -$	_
Unit OD Surface Area,			$A_{OD} = 12^{*}\pi^{*}D_{OD}$	
	-		$V_{Do} = \pi^* (D_o/2)^2/2$	
Unit Inside	Volume, V _{Di} =		$V_{Di} = \pi^* (D_i/2)^2 / 1$	
Unit Outside V Unit Inside Design Factor f Hydrostatic Design S Environmenta We Tensile V	HDB =			ublication TR-4/2015 and ASTM 2837
Design Factor f	or HDB, DF =	0.63		E Handbook 2nd ED Chapter 5
Hydrostatic Design S	Stress, HDS =	1008 psi	HDS = HDB*DF	•
Environmenta	l Factor, Af _e =	1	Reference 2: Us	e for pressure rating only
	Density =	59.28 pcf	1.410 g/cc	Average from WL Plastics WL122 for PE4710
We	ight Dry, W =		Lb/LF	
Tensile Y	Yield, Ty psi =	1,120 psi	@73°F	Minimum from ASTM D3350 determined by ASTM D638
	Load Duration Duration Time	10 hours	Long Term 50 yrs	
E	mperature, °F	73 deg F	73 deg F	Assumed
Desi	gn Ovality, %	2%	2%	See Sheets 4 of 5 for design ovality
Factor o	f Safety, FS =	2.5	2.5	Industry Practice
Modulus for given load		65,000 psi	28,000 psi	Based on PPI Handbook Ch. 3 and WL Plastics WL118-0314
Poise	son Ratio, υ =	0.45	0.45	WL118: Use 0.35 if load duration is less than 12 hours
	ality factor f _o = ure factor, f _t =	0.84	0.6 1.00	Reference 1: Based on Selected Design Ovality Source: WL Plastics WL118
Project Fluids	are lactor, i _t -	1.00	1.00	
Ē.	Dine Internet	Ever stad		Buoyant forces
Fluids Density, γ = Buoya Buoyan Buoyan	Pipe Internal Ballast	Expected External Fluid	Heavy External Fluid	Dry Weight Pipe on ground, $W_P = 1.66$ lb/ft From MFG. Data Sheet
Fluids	Fresh Water	Drill Fluid 1	Drill Fluid 2	Internal Ballast Weight, $W_B = 2.44 \text{ Ib/ft} W_B = V_{Di} \gamma_{INT}$
	γ_{INT}	γ_{EXT1}	γ_{EXT2}	Expected Displaced Fluid Weight, $W_{D1} = 5.21 \text{ Ib/ft} W_{D1} = V_{D0} * \gamma_{EXT1}$
Density, γ =	62.4	78	80	Heavy Displaced Fluid Weight, $W_{D2} = 5.35 \text{ lb/ft}$ $W_{D2} = V_{D0} * \gamma_{EXT2}$
Buoya	Int Unballasted		-3.55 lb/ft	Wp-W _{D1}
Buoya	Int Unballasted		-3.69 lb/ft	Wp-Wp2
D		n ground, B _G =	4.10 lb/ft	W _P +W _B
Buoyan		Fluid 1, BB _{B1} =		BG-W _{D1}
Buoyar	nt Ballasted in	i iuiu ∠, ¤ _{BB2} =	-1.24 lb/ft	BG-W _{D2}
L				

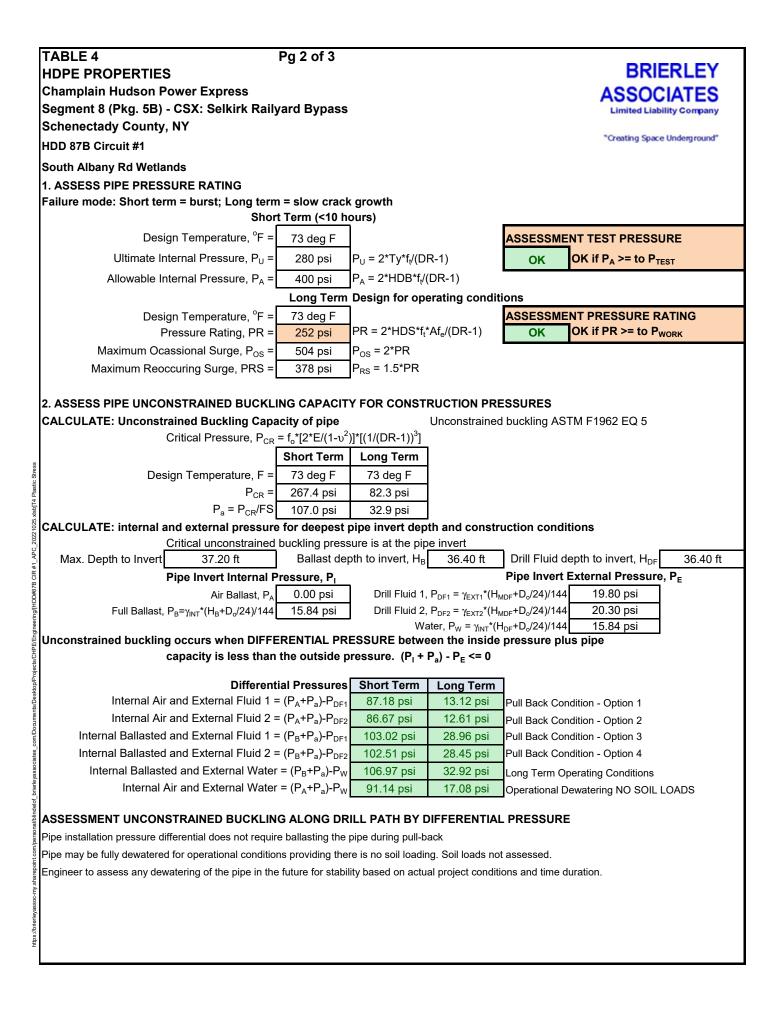
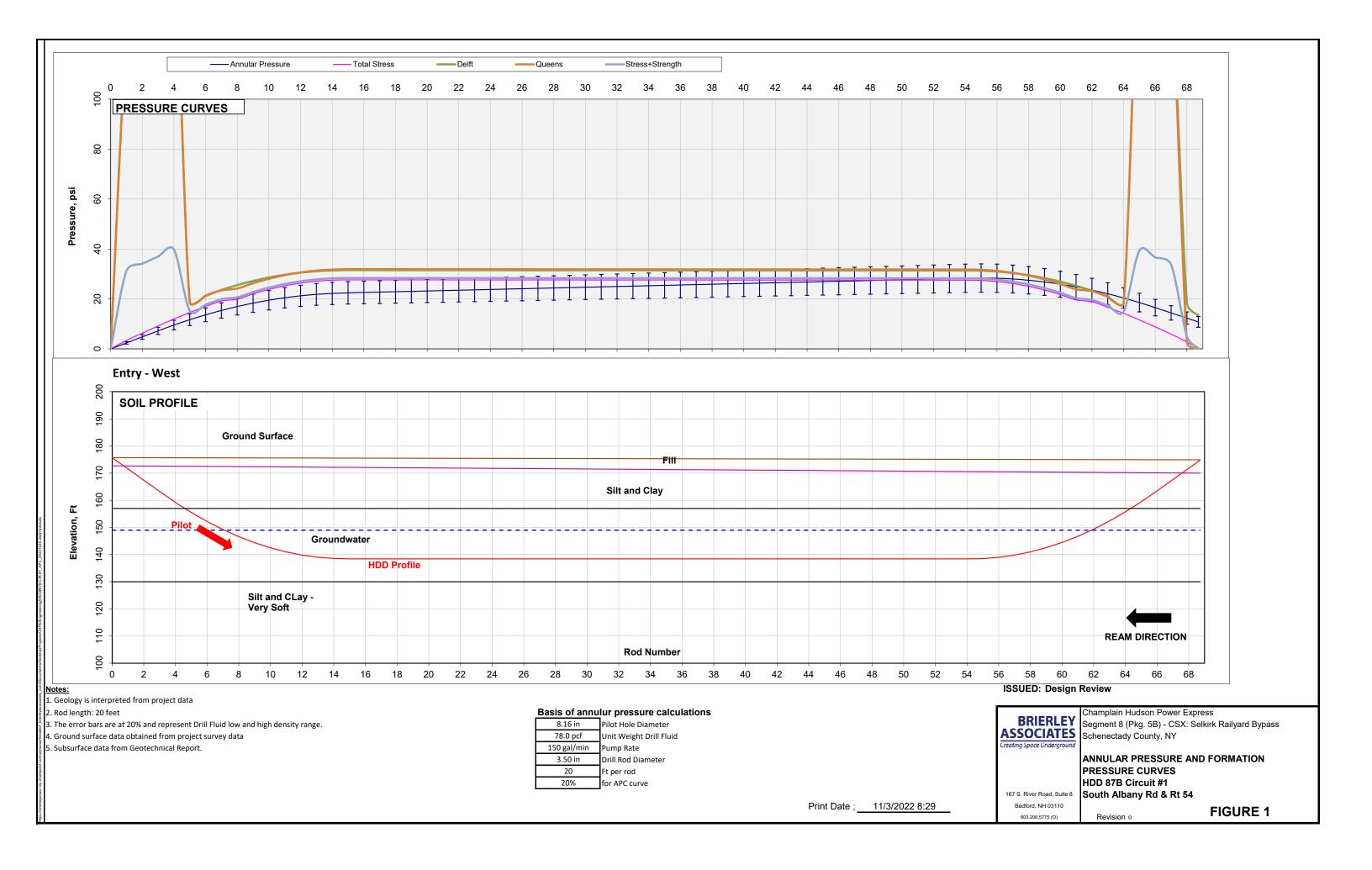


	TABLE 4	Pg 3 of 3		
	HDPE PROPERTIES	U		BRIERLEY
	Champlain Hudson Power Express			ASSOCIATES
	Segment 8 (Pkg. 5B) - CSX: Selkirk Raily	vard Bypass		Limited Liability Company
	Schenectady County, NY			Emitted Elability Company
	HDD 87B Circuit #1			"Creating Space Underground"
	South Albany Rd Wetlands			
	3. ASSESS ULTIMATE PULL STRENGTH (UF	S) AND SAFE	PULL STRENGTH (SPS	5)
	Source PPI PE Handbook Ch 12 Formula 17			,
	Designed Pull Duration Time =	12 hr		Quantity of pipes, Q = 1
	Yield Strength Factor, f _Y =	0.4	Recommended (FS = 2.	5) Pull Temperature, F = 73 deg.
	Pull Time factor, f_{T} =	1	Plexco Engineering Man	
	Design Factor, DF = $f_T * f_Y$		FE PULL STRENTH, SF	
	Temperature factor, f _{temp} =		JItimate Pull Strength, UF	
	Temp Corr Tensile Yield, Ty*f _{temp} =	1,120 psi	, ci	
	Safe Allowable Stress, SAS =	448 psi	SAS = Ty*f _{temp} *DF Sug	gested SSAS = 1,150 psi
	Safe Pull Strength, SPS Pipe =	1,703 lb	Useing SSAS = 4,371	
	.			
	Short Term Critical Unconstrained Buckling	Pcr reduced f	or pull tension, P _{CRR} = F	C _R *f _r
	(ASTM F-1962 EQ. 22)			
	Pull Duration Time =	12 Hr		Pcr = 267.4 psi
ss	SAS =	448 psi	Design Depth in DF, H _№	DF = 0.0 ft
tic Stre	Estimated Maximum Pull Stress, σ_i =	1,150 psi	Design Assumption as M	laximum
T4 Plas	fr = ((5.57-(r+1.09)^2)^.5)-1.09 =	0.91263		
Engineering/[HDD#87B CIR #1_APC_20221025.xlsb]T4 Plastic Stress	$r = \sigma_i/2^*(SSAS) =$	0.15879	Example from	n Table T5, σ _i = 365 psi
022102	P _{CRR} =	244.1 psi		
APC_2	FS = P _{ACRR} = P _{CRR} /FS =	2.0 122.0 psi	Allowable Reduced Sho	t Term Buckling pressure during pull
CIR#1	Internal Ballasted and External Fluid 1 = (F	-		ck Condition - C OK as >0
0#87B (Internal Ballasted and External Fluid $2 = (F$			ck Condition - C OK as >0
IGH]/6u	ASSESSMENT OF SAFE PULL STRENGTH			
Igineeri	ACCEPTIBLE Acceptible if differential pres	sures > 0 for re	educed buckling capacity	
Ш				
jects/C	REFERENCE 1 - Plastic Pipe Institute - Handborner REFERENCE 2 - Plastic Pipe Institute - Handborner			
top/Pro	Design Factor (fe) to apply t			
com/Documents/Desktop/Projects/CHP	CHAPTER 6 - TABLE 1-2			
nambo	REFERENCE 3 - Plexco Engineering Manual B	look 3 Ch 3 Tal	ble 3.7	
com/Dc	Time factor for pull duration, f _T			
	f _T Time factor for pull			
leyasso	1.00 Up to 1 hour pull	1		
of_brier	0.95 Up tp 12 hours pull	12		
blindele	0.91 Up to 24 hours	24		
ersonal				
.com/pe				
repoint				
-my.sha				
yassoc-				
https://brierleyassoc-my.sharepoint.com/personal/blindelof_brierleyassociates				
https://				





HORIZONTAL DIRECTIONAL DRILL DESIGN

- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 87B Circuit #2 South Albany Rd Wetlands

ISSUE: Design Submittal

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Table 2	DESIGN DRILL PATH CALCULATION
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Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

 Project No:
 322004-000

 Print Date:
 2-Nov-2022

Revision	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

ntry Station it Station ntry and Exit Design Co	8+46.04 oordinates & Ele			Wate	er Surface Elev.* Mudline Elev.*	r of entry or exit elevati 149.00 ft 168.00 ft	ion							
Entry	East 667153.9290	North 1358436.4480	Elevation 169.50 ft	Lowest	centerline Elev.	140.00 ft								
Horizontal Curve PI	667517.1360	1358373.9910	109.50 11				su	MMARY HORIZONTAI	L CURVE CALC	ULATIONS				
Exit	667896.3270		174.90 ft			Start			Er					
Depth to Mudline	1.50 ft	Clearance Depth =	28.00 ft		Station	Easting	Northing	Station	Easting	Northing	Azimuth	Length	Radius	Angle
	Length at ties = rdinate Length = OK-H			Tangent Curve Tangent	0+00.00 1+06.11 6+19.39	667153.9290 667258.5061 667720.6004	1358436.4480 1358418.4649 1358208.2515	1+06.11 6+19.39 8+46.04	667258.5061 667720.6004 667896.3270	1358418.4649 1358208.2515 1358065.1070	E 099.75714 N E 129.16581 N E 129.16581 N	106.11 513.28 226.65	1000.00	29.409 d
	НО	RIZONTAL PL/	AN CALCU	LATIONS (FT)					Pull Geom	etry			
ntry Tangent Segment		Horizontal Curve Seg		Exit Tangent Segme			Pipe Entry	Exit	Enter the pipe e	ntry location into th				
Plan Length, ft.	106.11	Input Radius, ft.	1000.00	Plan Length, ft.	226.65			Elevatio		N N	/ertical Angle		Path	Curve
Entry Azimuth, deg. ⁵		Curve, deg	29.409 deg.	Exit Azimuth, deg. ⁵		_	Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad.⁵	1.74109	Curve, rad	0.51328	Exit Azimuth, rad. ⁵	2.25437		Entry Tangent	174.90 ft	164.04 ft	-12.00 deg	-12.00 deg	0.00 deg	52.25 ft	0.00 ft
alculate PCH		Calculate PTH Chord Length, ft.	507.66	Calculate Exit	667896.3270		Entry Curve Bottom Tangent	164.04 ft 140.00 ft	140.00 ft 140.00 ft	-12.00 deg 0.00 deg	0.00 deg 0.00 deg	12.00 deg 0.00 deg	230.38 ft 311.83 ft	<u>1100.00 f</u> 0.00 ft
PCH Easting	667258.5061	Arc Length, ft.	513.28	Easting Northing	1358065.1070		Exit Curve	140.00 ft	140.00 π 164.04 ft	0.00 deg	12.00 deg	12.00 deg	230.38 ft	<u>0.00 π</u> 1100.00 f
PCH Northing		Chord Azimuth, deg	114.4615	rorunig	1000000.1070		Exit Tangent	164.04 ft	169.50 ft	12.00 deg	12.00 deg	0.00 deg	26.27 ft	0.00 ft
Ū		PI Easting =	667517.1360			0.0000	9				1	otal Check =	851.12 ft	OK
		PI Northing =	1358373.9910			OK CALC		Compound Curve As						
		PTH Easting =	667720.6004					Start	Vert. Plan	Horiz. Plan				
		PTH Northing =	1358208.2515			Exit Station		Entry	254.40	106.11	Yes Hori:	z < Exit V(Tan+	Curve	
		1 III Koruling	1000200.2010			8+46.04		Exit	279.81	226.65		z < Exit V(Tan+		
Cum Plan Length	106.11	Cum Plan Length	619.39	Cum Plan Length	846.0399386	OK STA								
		CALCULATIO								I I	Summary of D			
ntry Tangent Segment	1	Entry Vert. Curve Seg	gment 2	Middle Tangent Seg		Exit Vert. Curve Seg		Exit Tangent Segmen			Entr	y to Exit Eleva	tion Change =	5.40 ft
		Entry Vert. Curve Sec Vertical Radius	gment 2 1100.00	End Vert Angle	<i>ment 3</i> 0.000 deg. NO	Radius	1100.00	Exit Elevation	174.90		Entr	y to Exit Eleva Vinimum Desig		140.00 ft
ntry Tangent Segment f Entry Angle	1	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg.	gment 2 1100.00 12.000 deg.	End Vert Angle Inclined Bottom Tan	0.000 deg. NO	Radius Angle Change	1100.00 12.000 deg.	Exit Elevation Design Exit Angle			Entr	y to Exit Eleva Minimum Desig Invert Dept	tion Change = gn Elevation =	140.00 f 34.90 ft
ntry Tangent Segment of Entry Angle	-12.000 deg.	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT	gment 2 1100.00 12.000 deg.	End Vert Angle Inclined Bottom Tan Calculate Vertical Pe	0.000 deg. NO	Radius Angle Change Calculate Vertical P1	1100.00 12.000 deg. TV	Exit Elevation Design Exit Angle Calculate Exit	174.90 12.00 deg	SUMS	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = th below exit = below entry = Path Length =	140.00 ft 34.90 ft 29.50 ft 851.12 ft
ntry Tangent Segment of Entry Angle alculate Vertical PCV Plan Length	-12.000 deg. -12.698 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length	gment 2 1100.00 12.000 deg. ℃ 228.703 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical Po Plan Length	0.000 deg. NO CV 311.83244 ft	Radius Angle Change Calculate Vertical P1 Plan Length	1100.00 12.000 deg. rv 228.703 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	174.90 12.00 deg 51.103 ft	SUMS 846.040 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = th below exit = below entry = Path Length = Plan Length =	140.00 ft 34.90 ft 29.50 ft 851.12 ft 846.04 ft
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	$\mu_{\rm G} = 0.10$ dry + rollers $\mu_{\rm b} = 0.25$ drill fluid in hole						·	,			•	I	·				
		μ _b =	0.25								culated Pull Force		M		ASS		
	μ _c = <u>0.30</u> INPUT: Assumed Hydrokin			in hole no fl	uld			POINT	Pull Force, F _D			Pull Force, F _B			F _x <		
2	INPUT: Assumed Hydrokin τ _f = <mark>0.005 psi</mark>				hoor Str	000		٨	No Ballast	Stress, σ_T	σ _T < σ _{PM} ΟΚ	Ballasted Pipe		σ _T < σ _{PM} ΟΚ	Air OK	Ballast OK	
000	ייוסואו	^{رہ –} T: Pipe Pro	•		neal Oll	633		A B	1,523 lb 1,901 lb	101 psi 53 psi	OK	1,523 lb 1,921 lb	101 psi 54 psi	OK	OK	OK	
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Safe P	ull Max.	Stress, σ_{PM}		PPI Table 1		J 73Dea F		D	4,205 lb	117 psi	OK	3,422 lb	97 psi 95 psi	OK	OK	OK	
Pile/Bundl			Pipe	PIPE/BUNE	0	,		E	8,203 lb	255 psi	OK	5,407 lb	177 psi	OK	OK	OK	
		al Density, γ	59.28 pcf	+				F	8,663 lb	242 psi	ОК	5,619 lb	157 psi	ОК	OK	OK	
Ou	tside Dia	ameter, D _{OD}		Pipe or Bur	ndle			ASSES	,		pacity, P_{PA} > ∆P invert	,		Ballas	sted	OK	
	e Dry W	/eight, W _P =	15.68 lb/ft	Pipe or Bur	ndle					0				No Ba	llast	OK	
Min	. Wall T	hickness, t _m	1.194 in	For design	installati	on pull stress			Maximum tens	ile stress duri	ng pullback = σ_t = (F _T / π	$t_m(D_{OD}-t_m))+E_TD_0$	_{od} /2R	PPI Ch 12	Eq 16		
Min Avg. I	DF	$R = D_O/t_{min} =$	9	D _{OD} Stress	10.75	inches	Calculate	ed Material Des	ign Limits For	Designed Dr	ill Path						
Avg. I	nside D	iameter, D _{IA}	8.22 in	Bundle Mul	tiplier F _D	1.0000					fe Pull Strength, SPS =		SSPS = σ_{PM}				
12 Hr Pull	back Mo	odulus, E _T =	65,000 psi	@T =	73 deg I	=					strained Buckling, P _A =		$P_{A} = (2E_{T}/(1+$			l)	
e libi		on Ratio, μ =	0.45		,				Maximum	12 hour Pull	Stress Reduction, F_R =	0.941644171			1.09		
	-	/ Factor, f _o =	0.84	2%	J						r=		$r = \sigma_T/2SPS$				
7	•	Safety, N =	2.5								pplied pull Stress, $\sigma_T =$	•	From Pull Fo				
5	•	Stress, HDS =		HDB/2							e on Pipe, ∆P_B invert =		psi (-) indica	•••			
Press		ng, PR _(80F) =		PR = 2HD		$(\mathbf{F}_{T} = \mathbf{I})$		Unballas	ted Max. Differe	ential Pressure	e on Pipe, ΔP_U invert =	15.71	psi (-) indica	tes pipe is	pressuriz	zea	
		ast Density	d Fluid Dens 62.4	pcf	ions						Calculated Drill Hole	Diamator Acou	mod for Cold	ulationa			
		uid Density		pcr	Fetima	ted for pull						18		ulations			
Drill flu		vation, $H_F =$		1001	_50111a						D _o <8" Use D _H =D _o +4"; 8"		ו 1.5*D₀; D₀>2∘	4" Use D _µ =D	0 _∩ +12"		
-		er El., H _w =		1								5 II	5, 6		-		
2		rt El., El _m =		1				NOTES:	1 - Calculations we	ere done in gene	ral accordance with ASTMF-1	1962 as modified to a	account for inver	t tangent sect	tion, indep	endent	
		and Fluid					4		vertical curves, an actual pull force ba	d fluid drag. AST	ΓM applies hydrokinetic press	ure as shear per uni	it pipe length rec	luiring a back	calculatior	to determine	
			essure Pipe:	YES	3	1				accu on average	אוייס מוטמ.						
			ter Length, P			1					ISSUE:	Design Review	w				
			ion Area, A _w	37.7073		1						Champlain Hudso		ess			
			Outside, V _{DO}			1									d Bypass		
and			ne Inside, V _{DI}			1						Segment 8 (Pkg. 5B) - CSX: Selkirk Railyard Bypass Schenectady County, NY					
			q _d =	2.03		Drill Fluid (unit	drag)				"Creating Space Underground"	Concretionary County, INT					
A	STM E	Q 18: Hydro	okinetic, $\Delta T =$	0.77		Comparison O	0,					TABLE 3 - PUL	L ASSESSM	ENT			
0		yant Forces	,	L		ц.,	ANTICIPATED PULLING FORCE - HDPE PU						PE PULI	L			
		,	Pipe	Air Fil	led	Ballasted											
eyas		On Gro	und, w _a /w _{af} =			38.67 Lb/LF	1					South Albany F					
	In Hole		luid, w _b /w _{bf} =			-10.49 Lb/LF	1				167 S. River Road, Suite 8						
in the second							-				Bedford, NH 03110	Revision	0				

TABLE 4		Pg 1 of 3		
HDPE PROPERTIE	S	_		BRIERLEY
Champlain Hudson F	Power Expres	SS		
Segment 8 (Pkg. 5B)	-		Bypass	ASSOCIATES
Schenectady County		-		Limited Liability Company
HDD 87B Circuit #2	-			"Creating Space Underground"
South Albany Rd Wetla	ande			
South Albany Nu Wette	1105			
INPUTS				
Pipe Material Propertie	S			
		and Plastic Pir	e Institute Public	cations and as referenced
Design Working Pre	1	250 psi		Test Pressure, P _{TEST} 0 psig At high point
				rest riessure, ritest o psig At high point
Quantity of Pipe		1		
	Pipe Material	HDPE		MATERIAL: PE3408, PE3608, PE4710
ASTM D3350 Cell			Design resin wit	h minimum PENT test of 10,000 hours
	rd Dimension	10		
Pipe measurem		IPS	IPS "Iron Pipe S	Size" of DIPS "Ductile Iron Pipe Size"
	/inimum Wall	9		
	Diameter, $D_o =$	10.750 in		facturer's Data Sheets
-	Diameter, D _i =	8.219 in		facturer's Data Sheets
	um Wall, t _{min} =	1.194 in		facturer's Data Sheets
Unit OD Surface Area	on Area, $A_W =$		$A_W = \pi^* ((D_0/2)^2 - 12\pi)^2$	
	-		$A_{OD} = 12^* \pi^* D_{OD}$	
	Volume, V _{Do} =		$V_{Do} = \pi^* (D_0/2)^2/2$	
	Volume, V _{Di} =		$V_{Di} = \pi^* (D_i/2)^2/1$	
Unit Outside V Unit Inside Design Factor f Hydrostatic Design S Environmenta We Tensile V	HDB =	1,600 psi		ublication TR-4/2015 and ASTM 2837
Design Factor f		0.63		E Handbook 2nd ED Chapter 5
Hydrostatic Design S Environmenta		1008 psi 1	HDS = HDB*DF	se for pressure rating only
	Density =	59.28 pcf		Average from WL Plastics WL122 for PE4710
	ight Dry, W =	15.68	Lb/LF	
Tensile '	Yield, Ty psi =	1,120 psi		Minimum from ASTM D3350 determined by ASTM D638
	Load Duration		Long Term	
	Duration Time	10 hours	50 yrs	
	mperature, °F	73 deg F	73 deg F	Assumed
Desi	gn Ovality, %	2%	2%	See Sheets 4 of 5 for design ovality
Modulus for given load	f Safety, FS =	2.5 65,000 psi	2.5 28,000 psi	Industry Practice Based on PPI Handbook Ch. 3 and WL Plastics WL118-0314
	son Ratio, ບ =	0.45	0.45	WL118: Use 0.35 if load duration is less than 12 hours
	ality factor $f_o =$	0.40	0.6	Reference 1: Based on Selected Design Ovality
Temperat	ture factor, $f_t =$	1.00	1.00	Source: WL Plastics WL118
Project Fluids	, .,			
2	Pipe Internal	Expected	Heavy External	Buoyant forces
Fluids Density, γ = Buoya Buoyan Buoyan	Ballast	Expected External Fluid	Fluid	Dry Weight Pipe on ground, $W_P = 15.68 \text{ lb/ft}$ From MFG. Data Sheet
Fluids	Fresh Water	Drill Fluid 1	Drill Fluid 2	Internal Ballast Weight, $W_B = 22.99 \text{ Ib/ft} W_B = V_{Di}^* \gamma_{INT}$
	γιντ	$\gamma_{\rm EXT1}$	γ_{EXT2}	Expected Displaced Fluid Weight, $W_{D1} = \frac{49.16 \text{ lb/ft}}{49.16 \text{ lb/ft}} W_{D1} = V_{D0} * \gamma_{EXT1}$
Density, γ =	62.4	78	80	Heavy Displaced Fluid Weight, $W_{D2} = 50.42 \text{ lb/ft} W_{D2} = V_{D0} * \gamma_{EXT2}$
Buoya	ant Unballasted		-33.48 lb/ft	W _P -W _{D1}
Buoya	ant Unballasted		-34.74 lb/ft	W _P -W _{D2}
_		$B_{G} =$	38.67 lb/ft	W _P +W _B
Buoyan	t Ballasted in F		-10.49 lb/ft	BG-W _{D1}
Buoyar	nt Ballasted in	Fluid 2, B _{BB2} =	-11.75 lb/ft	BG-W _{D2}

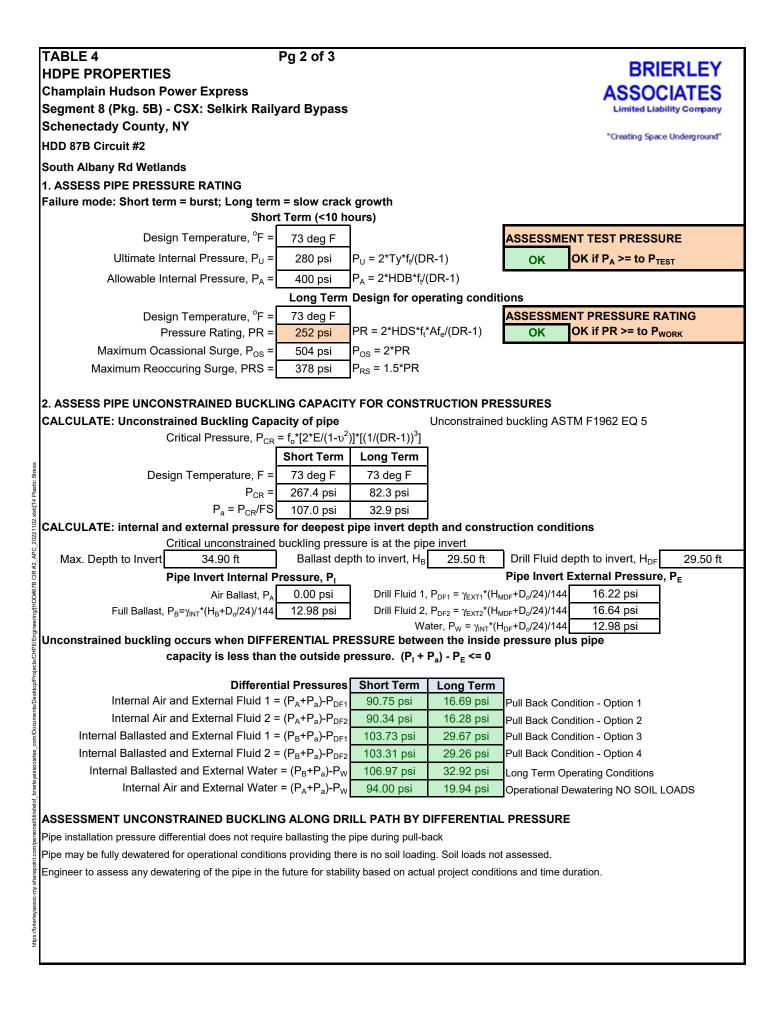
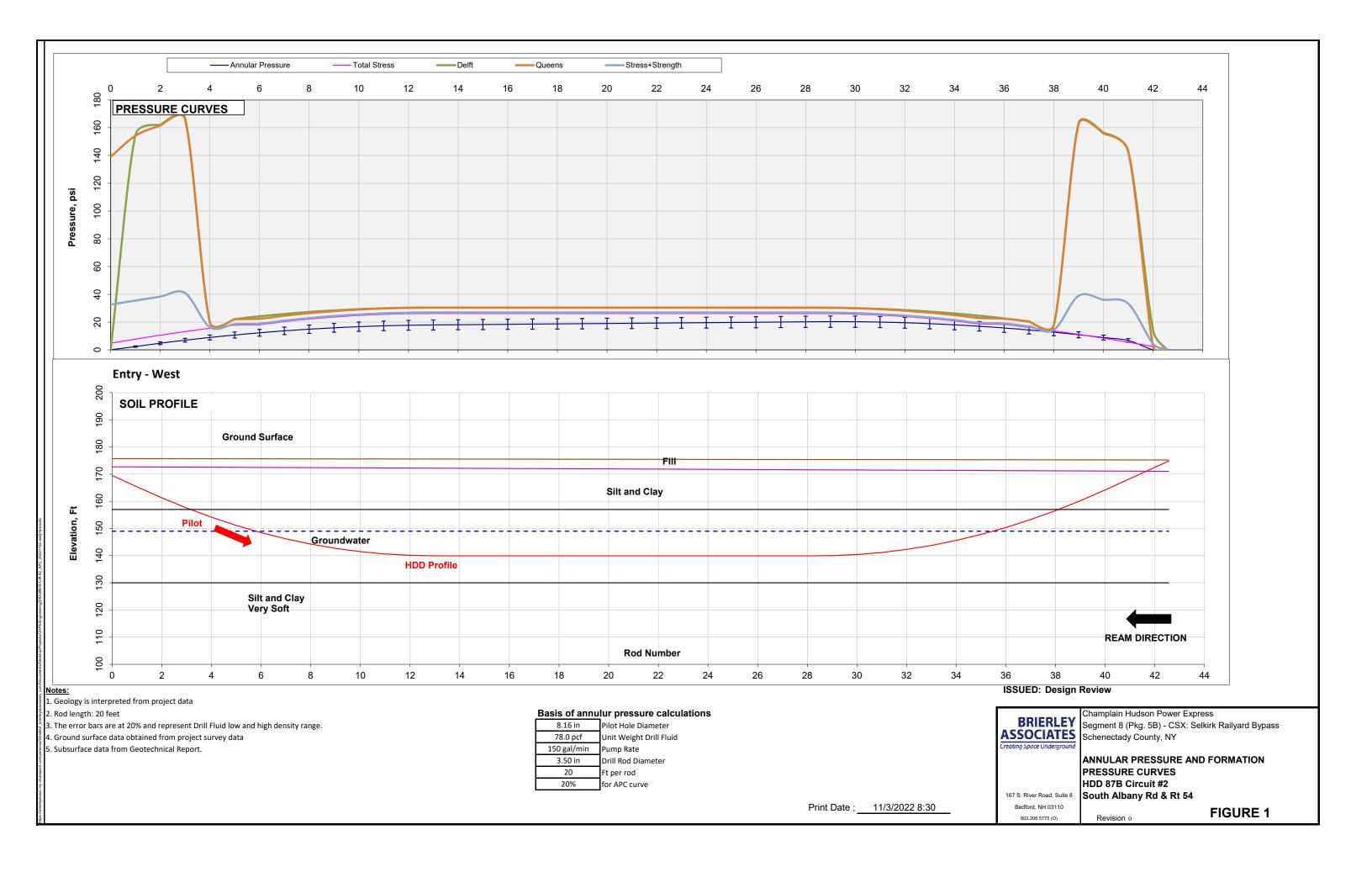


TABLE 4	Pg 3 of 3	BRIERLEY
HDPE PROPERTIES		
Champlain Hudson Power Express		ASSOCIATES
Segment 8 (Pkg. 5B) - CSX: Selkirk Rail	yard Bypass	Limited Liability Company
Schenectady County, NY		"Creating Space Underground"
HDD 87B Circuit #2		
South Albany Rd Wetlands		
3. ASSESS ULTIMATE PULL STRENGTH (U		
Source PPI PE Handbook Ch 12 Formula 17	$SPS = \pi^*DF^*(I)$	y)*D _o ⁻ *((1/DR)-(1/DR ⁻))
Designed Pull Duration Time =	12 hr	Quantity of pipes, $Q = 1$
Yield Strength Factor, $f_Y =$		Recommended (FS = 2.5) Pull Temperature, $F = 73 \text{ deg.}$
Pull Time factor, f_T =		Plexco Engineering Manual Table 3.7
Design Factor, DF = $f_T * f_Y$		FE PULL STRENTH, SPS = 16,064 lb
Temperature factor, $f_{temp} =$	1	Jltimate Pull Strength, UPS = 40,160 lb
Temp Corr Tensile Yield, Ty*f _{temp} =	-	
Safe Allowable Stress, SAS =		SAS = Ty*f _{temp} *DF Suggested SSAS = <mark>1,150 psi</mark>
Safe Pull Strength, SPS Pipe =		Useing SSAS = 41,235 lb
Short Term Critical Unconstrained Buckling	Pcr reduced f	or pull tension, P _{CRR} = P _{CR} *f _r
(ASTM F-1962 EQ. 22)		
Pull Duration Time =		Pcr = <u>267.4 psi</u>
² SAS =	448 psi	Design Depth in DF, H _{MDF} = 0.0 ft
Estimated Maximum Pull Stress, $\sigma_i =$	1,150 psi	Design Assumption as Maximum
$fr = ((5.57 - (r + 1.09)^{2})^{.5}) - 1.09 =$		
$r = \sigma_i/2^*(SSAS) =$		Example from Table T5, $\sigma_i = 255 \text{ psi}$
P _{CRR} = FS =	-	
PACRR = P _{CRR} /FS =		Allowable Reduced Short Term Buckling pressure during pull
Internal Ballasted and External Fluid 1 = (
Estimated Maximum Pull Stress, $\sigma_i = fr = ((5.57-(r+1.09)^2)^{.5})-1.09 = r = \sigma_i/2*(SSAS) = P_{CRR} = P_{CRR}$ P _{CRR} = P _{CRR} = P _{CRR} /FS = P _{ACRR} = P _{CRR} /FS = Internal Ballasted and External Fluid 1 = (Internal Ballasted and External Fluid 2 = (ASSESSMENT OF SAFE PULL STRENGTH ACCEPTIBLE Acceptible if differential pre		
ASSESSMENT OF SAFE PULL STRENGTH		
ACCEPTIBLE Acceptible if differential pre	ssures > 0 for re	educed buckling capacity
5		and Edition
REFERENCE 2 - Plastic Pipe Institute - Hands		
REFERENCE 1 - Plastic Pipe Institute - Handb REFERENCE 2 - Plastic Pipe Institute - Handb Design Factor (fe) to apply CHAPTER 6 - TABLE 1-2 REFERENCE 3 - Plexco Engineering Manual I		
CHAPTER 6 - TABLE 1-2		
REFERENCE 3 - Plexco Engineering Manual I	Book 3 Ch 3 Tal	ble 3.7
f _T Time factor for pull		
1.00 Up to 1 hour pull	1	
8 0.95 Up tp 12 hours pull 9 0.91 Up to 24 hours	12 24	
	24	
PL OSLAR		
tt com/		
ar rep oi		
tr Time factor for pull 1.00 Up to 1 hour pull 0.95 Up tp 12 hours pull 0.91 Up to 24 hours		
leyassc		
s:/brier		
http		
L		





HORIZONTAL DIRECTIONAL DRILL DESIGN

- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 88 Circuit #1 Wetlands Crossing

ISSUE: Design Submittal

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Table 1	DESIGN SUMMARY, ASSUMPTIONS, CONDITIONS
Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

 Project No:
 322004-000

 Print Date:
 2-Nov-2022

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

	CALCULA	TIONS												
Entry Station	0+00.00	FT		*If no water or mudlin	e then use lowe	r of entry or exit eleva	tion	l						
Exit Station		FT		Wate	r Surface Elev.*	153.00 ft								
Entry and Exit Design Co	cordinates & Ele East	evations (Ft) (Note 2) North	Elevation	Lowest	Mudline Elev.* centerline Elev.	<u>163.00 ft</u> 94.40 ft								
Entry	669912.3610		164.00 ft	Lowest	Contonino Elov.	04.40 1								
Horizontal Curve PI	670589.5950						SU	MMARY HORIZONTA				-		
Exit	671266.8300		175.70 ft		24 - 41	Start	N a setta isa se	Otatian	Er		A	L a se anthe	Dealling	A
Depth to Mudline Measured Plan	1.00 ft Length at ties =	Clearance Depth = 1466.3579 ft	68.60 ft	Tangent	Station 0+00.00	Easting 669912.3610	Northing 1352972.7580	Station 7+33.18	Easting 670589.5950	Northing 1353253.6580	Azimuth E 067.47253 N	Length 733.18	Radius	Angle
	rdinate Length =			Curve	7+33.18			7+33.18	670589.5950	1353253.6580		0.00	0.00	0.000 deg
	ŐK-H	ORIZONTAL CURVE		Tangent	7+33.18	670589.5950	1353253.6580	14+66.36	671266.8300	1353534.5580	E 067.47256 N	733.18		
	HOF		AN CALCU	LATIONS (FT)					Pull Geom	etrv			
Entry Tangent Segment		Horizontal Curve Seg		Exit Tangent Segme			Pipe Entry	Exit	Enter the pipe er		he hole: Entry/Exit			
Plan Length, ft.	733.18	Input Radius, ft.	0.00	Plan Length, ft.	733.18			Elevatio			Vertical Angle		Path	Curve
Entry Azimuth, deg. ⁵		Curve, deg	0.000 deg.	Exit Azimuth, deg.5			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad. ⁵	1.17762	Curve, rad	0.00000	Exit Azimuth, rad. ⁵	1.17762		Entry Tangent	175.70 ft	112.63 ft	-10.00 deg	-10.00 deg	0.00 deg	363.20 ft	0.00 ft
Calculate PCH	、	Calculate PTH Chord Length, ft.	0.00	Calculate Exit Easting	671266.8300	Check	Entry Curve Bottom Tangent	112.63 ft 94.40 ft	94.40 ft 94.40 ft	-10.00 deg 0.00 deg	0.00 deg 0.00 deg	10.00 deg 0.00 deg	209.44 ft 446.73 ft	1200.00 ft 0.00 ft
PCH Easting	670589.5950	Arc Length, ft.	0.00	Northing	1353534.5580		Exit Curve	94.40 π 94.40 ft	94.40 π 120.62 ft	0.00 deg	12.00 deg	12.00 deg	446.73 ft 251.33 ft	1200.00 ft
PCH Northing		Chord Azimuth, deg	67.4725			0.0000	Exit Tangent	120.62 ft	164.00 ft	12.00 deg	12.00 deg	0.00 deg	208.63 ft	0.00 ft
	l	PI Easting =	670589.5950			0.0000					-	Fotal Check =	1479.33 ft	OK
	l	PI Northing = PTH Easting =	1353253.6580 670589.5950			OK CALC		Compound Curve As Start	Vert. Plan	Horiz. Plan	1			
	l	T TT Lasting -	070505.5550					Otart	Vert. 1 Idii	110112.11011				
	l	PTH Northing =	1353253.6580			Exit Station		Entry				> Entry V(Tan+		
Cum Plan Length	733.18	Cum Plan Length	733.18	Cum Plan Length	1466.357907	14+66.36 OK STA		Exit			No, Horiz	> Entry V(Tan+	Curve)	
Guilt Flair Echgui	733.10	Out in han Eengui	755.10	Guilt Flair Eoligar	1400.001 001	OROTA								
VERTICLE PATH	- DESIGN	CALCULATIO	NS (FT)								Summary of D	rill Calculati	ons	
Entry Tangent Segment		Entry Vert. Curve Seg		Middle Tangent Segi	ment 3	Exit Vert. Curve Se		Exit Tangent Segmer			Entr	y to Exit Eleva	tion Change =	11.70 ft
Entry Angle	-12.000 deg.	Vertical Radius	1200.00	End Vert Angle	0.000 deg.		1200.00	Exit Elevation	175.70				gn Elevation =	94.40 ft
	I	Vert. Curve, deg.	12.000 deg.	Inclined Bottom Tan	NO	Angle Change	10.000 deg.	Design Exit Angle	10.00 deg			•	h below exit = below entry =	81.30 ft 69.60 ft
Calculate Vertical PCV	I												Path Length =	
Plan Length		Calculate Vertical PT	V	Calculate Vertical P		Calculate Vertical F	ידע	Calculate Exit		SUMS			Fath Length –	1,479.33 ft
	204.073 ft	Plan Length	249.494 ft	Plan Length	446.72896 ft	Plan Length	208.378 ft	Plan Length	357.684 ft	1,466.358 ft			Plan Length =	1,466.36 ft
Rod Length	208.632 ft	Plan Length Arc Rod Length	249.494 ft 251.327 ft	Plan Length Rod Length	446.72896 ft 446.72896 ft	Plan Length Arc Rod Length	208.378 ft 209.440 ft	Plan Length Rod Length	363.202 ft	1,466.358 ft 1,479.330 ft	Minimun		Plan Length = No Tangent) =	1,466.36 ft 1,019.63 ft
Rod Length Vertical Depth		Plan Length	249.494 ft	Plan Length	446.72896 ft	Plan Length Arc Rod Length	208.378 ft	Plan Length		1,466.358 ft	Minimun		Plan Length =	1,466.36 ft 1,019.63 ft
	208.632 ft	Plan Length Arc Rod Length	249.494 ft 251.327 ft	Plan Length Rod Length	446.72896 ft 446.72896 ft	Plan Length Arc Rod Length	208.378 ft 209.440 ft	Plan Length Rod Length	363.202 ft	1,466.358 ft 1,479.330 ft	Minimun		Plan Length = No Tangent) =	1,466.36 ft 1,019.63 ft
Vertical Depth	208.632 ft -43.377 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	249.494 ft 251.327 ft -26.223 ft 94.400 ft	Plan Length Rod Length Vertical Depth	446.72896 ft 446.72896 ft 0.00000 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft	Plan Length Rod Length Vertical Depth CK Total Cum Depth	363.202 ft 63.069 ft 11.700 ft	1,466.358 ft 1,479.330 ft	Minimun	ı Plan Length (Plan Length = No Tangent) = Entry Angle = Exit Angle =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg
Vertical Depth Start Elevation	208.632 ft -43.377 ft 164.000 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft	Plan Length Rod Length Vertical Depth Start Elevation	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft	Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation	363.202 ft 63.069 ft	1,466.358 ft 1,479.330 ft	Minimun	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth	208.632 ft -43.377 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	249.494 ft 251.327 ft -26.223 ft 94.400 ft	Plan Length Rod Length Vertical Depth	446.72896 ft 446.72896 ft 0.00000 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft	Plan Length Rod Length Vertical Depth CK Total Cum Depth	363.202 ft 63.069 ft 11.700 ft	1,466.358 ft 1,479.330 ft	Minimun	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907	1,466.358 ft 1,479.330 ft 11.700 ft Stationin	ng Check	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE Start Station	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle TIONS Start Station	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 dt 0.000 deg 2+04.07	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30	Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation <i>Prop. Plan Length</i> Start Station	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA	ng Check TIONING	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CL Start Station PVC Station	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Len	ng Check TIONING gth Check	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE Start Station	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle TIONS Start Station	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 dt 0.000 deg 2+04.07	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30	Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation <i>Prop. Plan Length</i> Start Station	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Leny OK CALC	ng Check TIONING	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 204.07	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check CULATION	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 204.07 208.63	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 900.69 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35 1469.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check ULATION hange Check ULATION	n Plan Length (Compound Cu	Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 204.07 208.63 -43.38	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 900.69 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Bepth	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35 1469.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check SULATION hange Check	n Plan Length (Compound Cu Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = Curve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: . Sign convention for ang Due East is defined as	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 204.07 208.63 -43.38	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 900.69 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35 1469.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC	ng Check TIONING gth Check ULATION hange Check CULATION Indicates inputs Indicates status or Design Review	n Plan Length (Compound Cu Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = Curve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CU Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as to	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 204.07 208.63 -43.38	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 900.69 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Bepth	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35 1469.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Leny OK CALC Elevation Cl OK CALC	ng Check TIONING gth Check ULATION hange Check ULATION Indicates inputs Indicates status or Design Review (Champiain Hudson Pr	n Plan Length (Compound Cu Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth VOTES: 1. Sign convention for ang Due East is defined as in 0 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 900.69 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Bepth	363.202 ft 63.069 ft 11.700 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.35 1469.35	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES	ng Check TIONING gth Check ULATION hange Check ULATION Indicates inputs Indicates status or Design Review (Champiain Hudson Pr	n Plan Length (Compound Cu Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as in 0 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 906.69 ft -69.60 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.36 1479.33 11.70	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	ng Check TIONING gth Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pi Segment 8 (Pkg. 5B) Schenectady County,	n Plan Length (Compound Cu Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as in 0 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 906.69 ft -69.60 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.36 1479.33 11.70	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES	ng Check TIONING gth Check ULATION hange Check ULATION Indicates status or Design Review Champlain Hudson Pr Segment 8 (Pkg. 5B) Schenectady County, TABLE 2	n Plan Length (Compound Cu Compound C Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as in 0 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 906.69 ft -69.60 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1108.67 1116.13 -51.3693	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.36 1479.33 11.70	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	ng Check TIONING gth Check ULATION hange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pr Segment 8 (Pkg. 58) Schenectady County, TABLE 2 DESIGN DRILL P/	n Plan Length (Compound Cu Compound C Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CU Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as to 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 906.69 ft -69.60 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PLAN LE	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1116.13 -51.3693 NGTH PCex EXIT CU	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.36 1479.33 11.70	1,466.358 ft 1,479.330 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	ng Check TIONING gth Check ULATION hange Check ULATION Indicates status or Design Review Champlain Hudson Pr Segment 8 (Pkg. 5B) Schenectady County, TABLE 2	Plan Length (Compound CL Compound C Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE CI Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as in 0 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCULA 0+00.00 2+04.07 208.63 -43.38 yles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	446.72896 ft 446.72896 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+00.30 900.30 ft 906.69 ft -69.60 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PDW	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+00.30 11+08.67 1116.13 -51.3693 NGTH PCex EXIT CU	Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	363.202 ft 63.069 ft 112.631 ft 1466.357907 11+08.67 14+66.358 1466.36 1479.33 11.70	1,466.358 ft 1,479.330 ft 11.700 ft Stationin OK STA Plan Leny OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC CL Elevation Cl OK CALC CL CL Elevation Cl OK CALC CL CL Elevation Cl OK CALC CL CL Elevation Cl OK CALC CL CL Elevation Cl OK CALC CL CL CL Elevation Cl OK CALC CL CL CL Elevation Cl OK CALC CL CL CL CL CL Elevation Cl OK CALC CL CL CL CL CL CL CL CL CL CL CL CL C	Ig Check TIONING gth Check CULATION Indicates inputs Indicates status or Design Review Champlain Hudson P Segment 8 (Pkg. 5B) Schenectady County, TABLE 2 DESIGN DRILL P, HDD 88 Circuit #1	Plan Length (Compound CL Compound C Compound C	Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry = 2urve at Exit =	1,466.36 ft 1,019.63 ft -12.00 deg 10.00 deg NO

II Geometry							Dine	Entry Location - Drill	Exit			
li Geometry							•	-				
							(schematic, t	o show definition of vari	iables only)			
Lengths (Path)		Angles		Radius, R	Pipe Exit El	= 164.00 ft	l				Pipe	Entry El =
L1 = <mark>100.0 ft</mark>	Overbend	deg	radian	500.0 ft	₽ ▼						/	λα
L2 = 363.2 ft	α =	-10.0 °	-0.1745		P 7	F					A ,	★
L3 = 209.4 ft				1,200.0 ft	Table Contraction of the second se		~ ~			<u></u>	VI - K RACE	<u>en anna a</u>
L4 = 446.7 ft	χ =	0.0 °	0.0000		1	\sim	a a a a a a a a a a a a a a a a a a a	and the second		в		
L5 = 251.3 ft	β =	40.0		1,200.0 ft		E						
L6 = 208.6 ft	р –	12.0 °	0.2094					D	С			
LT = 1579.3 ft										-	Overb	ena
INPUT: Assume							—— L5 –	→ ↓	—► – L3	► <	2 •	L1 ——
μ _G = μ _b =	0.10	dry + rollers drill fluid in h			i			laulated Dull Care	•			ASS
	0.25	in hole no flu				Pull Force, F _D		Iculated Pull Ford	Pull Force, F _B	May Tensile	ASSESS	A55 F _x <
$\mu_c =$ INPUT: Assume			JIU		POINT	No Ballast	Stress, σ_T		Ballasted Pipe	Stress, σ_T		Air
τ _f =		Drill Fluid Sh	near Str	ess	А	2,790 lb	148 psi	σ _T < σ _{PM} ΟΚ	2,790 lb	148 psi	σ _T < σ _{PM} OK	OK
INPUT: Pipe Pro					B	5,836 lb	140 psi 147 psi	OK	6,372 lb	140 psi 161 psi	OK	OK
Material		[IPS	1	C	7.622 lb	224 psi	OK	7,280 lb	216 psi	OK	OK
Safe Pull Max. Stress, σ_{PM}		PPI Table 1		73Deg F	D	8,979 lb	226 psi	OK	8,637 lb	218 psi	OK	OK
e/Bundle Diam. 14.25	BUNDLE	PIPE/BUND	LE	-	E	14,124 lb	388 psi	OK	11,385 lb	319 psi	OK	OK
Material Density, γ	59.28 pcf				F	18,498 lb	467 psi	OK	13,413 lb	338 psi	OK	OK
Outside Diameter, D _{OD}	14.25	Pipe or Bund	dle		ASSE	SS Pull Restricted	d Buckling Ca	pacity, P_{PA} > ∆P invert	$P_{PA} = P_A F_R =$	94.62 psi	Ballas	ted
Pipe Dry Weight, W _P =	17.36 lb/ft	Pipe or Bund	dle								No Ba	
Min. Wall Thickness, t _m	1.194 in			on pull stress				ng pullback = $\sigma_t = (F_T/\pi)$	$t_m(D_{OD}-t_m))+E_TD$	_{op} /2R	PPI Ch 12 Ec	q 16
$DR = D_0/t_{min} =$	9	D _{OD} Stress			Calculated Material De	esign Limits For	-			_		
Avg. Inside Diameter, D _{IA}		Bundle Multi						fe Pull Strength, SPS =			πD _{OD} ² ((1/DR)	
Hr Pullback Modulus, E _T =	65,000 psi	@T = 1	73 deg F	=				strained Buckling, $P_A =$			-μ ²))(1/(DR-1)	
Poisson Ratio, μ =	0.45					Maximum	12 hour Pull	Stress Reduction, $F_R =$	0.88446413			99
Ovality Factor, f _o =	0.84	2%					Maximum a	$r = pplied pull Stress, \sigma_T =$		$r = \sigma_T / 2SPS$	orce Calculatio	
Buckling Safety, N = rostatic Design Stress, HDS =	2.5 1,008 psi	HDB/2			Pall	natad Max Difford		e on Pipe, ΔP_{B} invert =	467 psi 7.43			
Pressure Rating, PR(80F) =		PR = 2HDS		$(P_1) = -11$				e on Pipe, ΔP_B invert =		,	tes pipe is pre tes pipe is pre	
INPUT: Assume		-		, (<- 1) [1] - 1]	Ulibalia	asted Max. Differe		e on ripe, Δευπivert -	57.10	psi (-) indica	tes pipe is pie	ssunzeu
Ballast Density		pcf	0113					Calculated Drill Hole	Diameter Assu	med for Calo	culations	
Drill Fluid Density	78		Estima	ted for pull				D _H =]		
Drill fluid elevation, H _F =	163.00 ft	1		•				D _O <8" Use D _H =D _O +4"; 8"	<d<sub>0<24" Use D_H=</d<sub>	=1.5*D ₀ ; D ₀ >24	4" Use D _H =D _O +	12"
Ballast Water El., H _w =	163.00 ft											
Lowest Invert El., El _m =	94.40 ft				NOTE	S: 1 - Calculations w	ere done in gener	ral accordance with ASTMF-	1962 as modified to	account for inver	rt tangent section	, independe
culated Pipe and Fluid	Properties					curves, and fluid c force based on av	•	ies hydrokinetic pressure as s	shear per unit pipe le	ength requiring a	back calculation	to determin
Pi	ressure Pipe:	YES]								
OD Perime	ter Length, P	44.77	in	1				ISSUE:	Design Revie	w		
Wall Sect	tion Area, A _W	41.68747	7289]					Champlain Hudso		ess	
Volume	Outside, V _{DO}	0.697 cf	f/LF]				ASSOCIATES	Segment 8 (Pkg.	5B) - CSX: Se	lkirk Railyard B	ypass
Volun	ne Inside, V _{DI}	0.408 cf	f/LF]					Schenectady Cou	unty, NY		
	q _d =	2.69 lb	/ft	Drill Fluid (unit	lrag)			"Creating Space Underground"				
ASTM EQ 18: Hydro			/ft	Comparison Or	0,				TABLE 3 - PUL	L ASSESSM	IENT	
culated Buoyant Forces				-					ANTICIPATED	PULLING FC	ORCE - HDPE	PULL
	Pipe	Air Fill	ed	Ballasted					HDD 88 Circuit	: #1		
	und, w _a /w _{af} =			42.80 Lb/LF				Brierley Associates	Wetlands Cros	sing		
On Gro In Hole with Drill F				-11.58 Lb/LF				167 S. River Road, Suite 8				

Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement sta DR = OD/Minimum Outside Diamete Avg. Inside Diamete Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty	Selk D3350 P_{WORK} e, Q = aterial cation nsion ndard $r, D_o =$ $r, D_i =$ $, A_{W} =$ $A_{OD} =$ $V_{Do} =$	and Plastic Pip 250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	be Institute Public INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	144
Segment 8 (Pkg. 5B) - CSX: Schenectady County, NY HDD 88 Circuit #1 Wetlands Crossing INPUTS Pipe Material Properties Sources: ASTM I Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement stal DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume Besign Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	Selk D_{3350} P_{WORK} e, Q = aterial cation nsion ndard $tr, D_{0} =$ $r, D_{i} =$ $, t_{min} =$ $A_{OD} =$ $V_{Do} =$ $, V_{Di} =$	and Plastic Pip 250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	be Institute Public INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	Limited Liability Company "Creating Space Underground" cations and as referenced Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets
Segment 8 (Pkg. 5B) - CSX: Schenectady County, NY HDD 88 Circuit #1 Wetlands Crossing INPUTS Pipe Material Properties Sources: ASTM I Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement stal DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume Besign Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	Selk D_{3350} P_{WORK} e, Q = aterial cation nsion ndard $tr, D_{0} =$ $r, D_{i} =$ $, t_{min} =$ $A_{OD} =$ $V_{Do} =$ $, V_{Di} =$	and Plastic Pip 250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	be Institute Public INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	Limited Liability Company "Creating Space Underground" cations and as referenced Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets
Schenectady County, NY HDD 88 Circuit #1 Wetlands Crossing INPUTS Pipe Material Properties Sources: ASTM L Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement stat DR = OD/Minimum Outside Diamete Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	D3350 P_{WORK} e, Q = aterial cation nsion ndard tr, D _o = r, D _i = r, D _i = A_{OD} = V_{Do} = , V_{Di} =	and Plastic Pip 250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	be Institute Public INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	Creating Space Underground cations and as referenced Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets
Wetlands Crossing INPUTS Pipe Material Properties Sources: ASTM L Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement stal DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du Duratior Design Temperatu	P_{WORK} e, Q = aterial cation nsion ndard n Wall r, D _o = er, D _i = , t _{min} = A _{OD} = V _{Do} = , V _{Di} =	250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	cations and as referenced Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets
INPUTS Pipe Material Properties Sources: ASTM L Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement stat DR = OD/Minimum Outside Diamete Avg. Inside Diamete Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	P_{WORK} e, Q = aterial cation nsion ndard n Wall r, D _o = er, D _i = , t _{min} = A _{OD} = V _{Do} = , V _{Di} =	250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets ($(D_o-2t)/2)^2$)
Pipe Material Properties Sources: ASTM L Design Working Pressure, Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement star DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	P_{WORK} e, Q = aterial cation nsion ndard n Wall r, D _o = er, D _i = , t _{min} = A _{OD} = V _{Do} = , V _{Di} =	250 psi 1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	INPUT RESIN M Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2 / 1$	Test Pressure, P_{TEST} 0 psig At high point MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets ($(D_o-2t)/2)^2$)
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Quantity of Pipes in Hol Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement star DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume Hoesign Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	e, Q = aterial cation ndard n Wall r, D _o = er, D _i = , $t_{min} =$, $A_W =$ $A_{OD} =$ $V_{Do} =$, $V_{Di} =$	1 HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF	Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_0/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_0/2)^2/1$ V _{Di} = $\pi^*(D_1/2)^2/1$	MATERIAL: PE3408, PE3608, PE4710 th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$
Pipe M ASTM D3350 Cell Classifi Standard Dime Pipe measurement star DR = OD/Minimum Outside Diameter Avg. Inside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du Duratior	aterial cation nsion ndard n Wall r, $D_0 =$ er, $D_i =$, $t_{min} =$, $A_W =$ $A_{OD} =$ $V_{Do} =$, $V_{Di} =$	HDPE 3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF	Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_0/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_0/2)^2/1$ V _{Di} = $\pi^*(D_1/2)^2/1$	th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$ 144
ASTM D3350 Cell Classifi Standard Dime Pipe measurement sta DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du Duratior	cation nsion ndard n Wall r, $D_o =$ r, $D_i =$, $t_{min} =$, $A_W =$ $A_{OD} =$ $V_{Do} =$, $V_{Di} =$	3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Design resin wit IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_0/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_0/2)^2/1$ V _{Di} = $\pi^*(D_1/2)^2/1$	th minimum PENT test of 10,000 hours Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$ 144
Standard Dime Pipe measurement star DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume, B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	$\begin{array}{l} \text{nsion} \\ \text{ndard} \\ nd$	3 IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	IPS "Iron Pipe S Standard Manuf Standard Manuf Standard Manuf A _W = $\pi^*((D_o/2)^2$ - A _{OD} = $12^*\pi^*D_{OD}$ V _{Do} = $\pi^*(D_o/2)^2/1$ V _{Di} = $\pi^*(D_i/2)^2/1$	Size" of DIPS "Ductile Iron Pipe Size" facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$ 144
Pipe measurement star DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	ndard n Wall r, D _o = er, D _i = , t _{min} = , A _W = A _{OD} = , V _{Do} =	IPS 9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Standard Manuf Standard Manuf Standard Manuf $A_W = \pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ $V_{Do} = \pi^*(D_o/2)^2/1$ $V_{Di} = \pi^*(D_i/2)^2/1$	facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$ 144
DR = OD/Minimum Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume, B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du Duratior Design Temperati	$ Wall r, D_o = er, D_i = , t_{min} = , A_W = A_{OD} = V_{Do} = , V_{Di} = $	9 3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Standard Manuf Standard Manuf Standard Manuf $A_W = \pi^*((D_o/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ $V_{Do} = \pi^*(D_o/2)^2/1$ $V_{Di} = \pi^*(D_i/2)^2/1$	facturer's Data Sheets facturer's Data Sheets facturer's Data Sheets $((D_o-2t)/2)^2)$ 144
Outside Diameter Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du Duratior Design Temperatu	r, D _o = er, D _i = , t _{min} = , A _W = A _{OD} = V _{Do} = , V _{Di} =	3.500 in 2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Standard Manuf Standard Manuf $A_W = \pi^*((D_0/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ $V_{Do} = \pi^*(D_0/2)^2/1$ $V_{Di} = \pi^*(D_i/2)^2/1$	facturer's Data Sheets facturer's Data Sheets ((D _o -2t)/2) ²) 144
Avg. Inside Diameter Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	$er, D_i =$, $t_{min} =$, $A_W =$ $A_{OD} =$ $V_{Do} =$, $V_{Di} =$	2.680 in 0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Standard Manuf Standard Manuf $A_W = \pi^*((D_0/2)^2 - A_{OD} = 12^*\pi^*D_{OD}$ $V_{Do} = \pi^*(D_0/2)^2/1$ $V_{Di} = \pi^*(D_i/2)^2/1$	facturer's Data Sheets facturer's Data Sheets ((D _o -2t)/2) ²) 144
Minimum Wall Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	, t _{min} = , A _W = A _{OD} = V _{Do} = , V _{Di} =	0.389 in 3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	Standard Manuf $A_{W} = \pi^{*}((D_{o}/2)^{2} - A_{OD} = 12^{*}\pi^{*}D_{OD}$ $V_{Do} = \pi^{*}(D_{o}/2)^{2}/$ $V_{Di} = \pi^{*}(D_{i}/2)^{2}/1$	facturer's Data Sheets ((D _o -2t)/2) ²) 144
Wall Section Area Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume H Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	, A _W = A _{OD} = V _{Do} = , V _{Di} =	3.80093926 131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	$A_{W} = \pi^{*}((D_{o}/2)^{2} - A_{OD} = 12^{*}\pi^{*}D_{OD}$ $V_{Do} = \pi^{*}(D_{o}/2)^{2}/V_{Di} = \pi^{*}(D_{i}/2)^{2}/1$	((D _o -2t)/2) ²) 144
Unit OD Surface Area, in ² /LF, Unit Outside Volume, Unit Inside Volume B Design Factor for HDB Hydrostatic Design Stress, H Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	$A_{OD} =$ $V_{Do} =$, $V_{Di} =$	131.95 in^2/LF 0.067 cf/LF 0.039 cf/LF	$A_{OD} = 12^{*}\pi^{*}D_{OD}$ $V_{Do} = \pi^{*}(D_{o}/2)^{2}/$ $V_{Di} = \pi^{*}(D_{i}/2)^{2}/1$	144
Unit Outside Volume, Unit Inside Volume E Design Factor for HDB Hydrostatic Design Stress, F Environmental Factor Der Weight Dry Tensile Yield, Ty Load Du	V _{Do} = , V _{Di} =	0.067 cf/LF 0.039 cf/LF	$V_{Do} = \pi^* (D_o/2)^2 / V_{Di} = \pi^* (D_i/2)^2 / 1$	144
	, V _{Di} =	0.039 cf/LF	$V_{Di} = \pi^* (D_i/2)^2/1$	
				44
	HDB =	1,600 psi	Based on PPI P	
			1	Publication TR-4/2015 and ASTM 2837
				E Handbook 2nd ED Chapter 5
		· · · · · · · · · · · · · · · · · · ·	HDS = HDB*DF	
				se for pressure rating only
	nsity =	· · · ·	1.410 g/cc Lb/LF	Average from WL Plastics WL122 for PE4710
			LD/LF @73°F	Minimum from ASTM D3350 determined by ASTM D638
		Short Term	Long Term	
Design Temperatu			50 yrs	
Design Oval			73 deg F	Assumed
		2%	2%	See Sheets 4 of 5 for design ovality
Factor of Safety Modulus for given load duratio			2.5 28,000 psi	Industry Practice
Poisson Rat			0.45	Based on PPI Handbook Ch. 3 and WL Plastics WL118-0314 WL118: Use 0.35 if load duration is less than 12 hours
Ovality fact			0.6	Reference 1: Based on Selected Design Ovality
Temperature fact			1.00	Source: WL Plastics WL118
Project Fluids	, i			1
Pipe In	ternal	Expected	Heavy External	Buoyant forces
Pipe In Balla Fluids Fresh V Ω Density, γ = <u>62</u> . Buoyant Unba Buoyant Unba Balla Buoyant Ballas Buoyant Ballas		Expected External Fluid	Fluid	Dry Weight Pipe on ground, $W_P = 1.66 \text{ lb/ft}$ From MFG. Data Sheet
Fluids Fresh	Nater	Drill Fluid 1	Drill Fluid 2	Internal Ballast Weight, $W_B = 2.44 \text{ Ib/ft} W_B = V_{Di}^* \gamma_{INT}$
ΥιΝ		$\gamma_{\rm EXT1}$	γ_{EXT2}	Expected Displaced Fluid Weight, $W_{D1} = 5.21 \text{ lb/ft}$ $W_{D1} = V_{D0}^* \gamma_{EXT1}$
Density, $\gamma = 62$.		78	80	Heavy Displaced Fluid Weight, $W_{D2} = 5.35 \text{ lb/ft}$ $W_{D2} = V_{Do}^* \gamma_{EXT2}$
		d Fluid 1, B _{B1} =		W _P -W _{D1}
-		d Fluid 2, B _{B2} =	-3.69 lb/ft	W _P -W _{D2}
	sted o	n ground, B _G =		W _P +W _B
Buoyant Ballas				BG-W _{D1} BG-W _{D2}
Buoyant Ballas	ted in	Fiuld Z, $B_{BB2} =$	-1.24 lb/ft	DG-W _{D2}

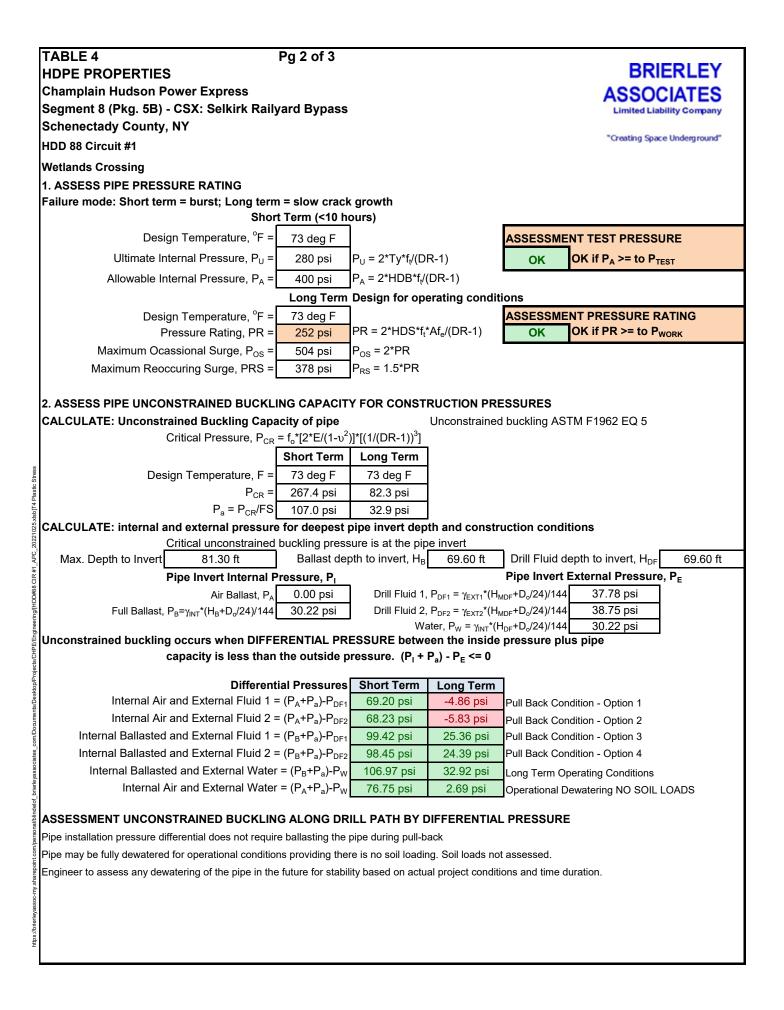
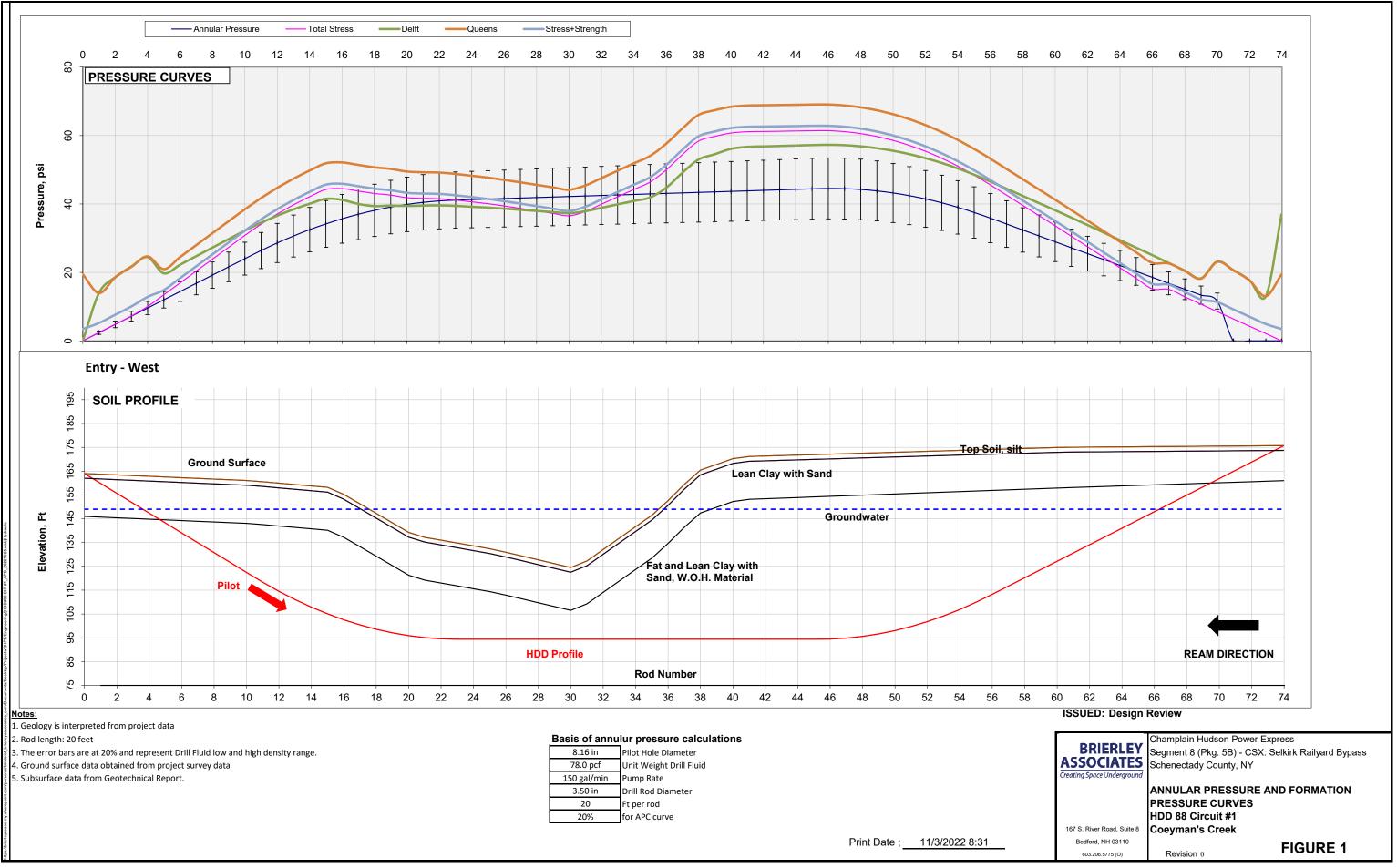


TABLE 4		Pg 3 of 3		DDI	
HDPE PROPERT	IES			BRI	ERLEY
Champlain Hudsor	n Power Express			ASSOC	CIATES
Segment 8 (Pkg. 5	B) - CSX: Selkirk Raily	ard Bypass		Limited Liab	ility Company
Schenectady Cour	nty, NY			"Creating Space	e Underground"
HDD 88 Circuit #1				Creating space	e onderground
Wetlands Crossing					
3. ASSESS ULTIMAT	E PULL STRENGTH (UP	S) AND SAFE	PULL STRENG	TH (SPS)	
Source PPI PE Hand	book Ch 12 Formula 17	SPS = π^* DF*(T	y)*D _o ² *((1/DR)-(1	/DR ²))	
Desig	ned Pull Duration Time =	12 hr		Quantity of pipes, C	Q = 1
Y	′ield Strength Factor, f _Y =	0.4	Recommended (FS = 2.5) Pull Temperature, I	= 73 deg.
	Pull Time factor, $f_T =$	1		ing Manual Table 3.7	
	Design Factor, DF = $f_T * f_Y$		-	NTH, SPS = 1,703 lb	
	emperature factor, f _{temp} =	1		ngth, UPS = $4,257$ lb	
	r Tensile Yield, Ty*f _{temp} =	1,120 psi		1,201 10	
	Allowable Stress, SAS =	448 psi	SAS = Ty*f _{temp} *D	F Suggested SSAS = 1,150 p	osi
	Pull Strength, SPS Pipe =	1,703 lb	Useing SSAS =		
	5,				
Short Term Critical L	Jnconstrained Buckling	Pcr reduced f	or pull tension,	P _{CRR} = P _{CR} *f _r	
(ASTM F-1962 EQ. 22					
	Pull Duration Time =	12 Hr		Pcr = 267.4 psi	
	SAS =	448 psi	Design Depth ir	DF, $H_{MDF} = 0.0 \text{ ft}$	
Estimated M	laximum Pull Stress, σ _i =	1,150 psi	Design Assumpt	ion as Maximum	
fr = ((5.	57-(r+1.09)^2)^.5)-1.09 =	0.88446			
kisbjT4	$r = \sigma_i/2^*(SSAS) =$	0.20286	Exam	pple from Table T5, $\sigma_i = 467$ p	si
21025.	P _{CRR} =	236.5 psi			
Estimated M fr = ((5.1 Internal Ballaster Internal Ballaster ACCEPTIBLE Ac	FS =	2.0			
	$P_{ACRR} = P_{CRR}/FS =$			ed Short Term Buckling pressu	
	d and External Fluid 1 = (F d and External Fluid 2 = (F			Pull Back Condition - C OK as Pull Back Condition - C OK as	
	AFE PULL STRENGTH (~0
	ceptible if differential pres				
ш 					
	stic Pipe Institute - Handb				
REFERENCE 2 - Plas	stic Pipe Institute - Handb ssign Factor (fe) to apply t		2nd Edition		
	HAPTER 6 - TABLE 1-2				
	co Engineering Manual E	Book 3 Ch 3 Tal	ole 3.7		
REFERENCE 1 - Plas REFERENCE 2 - Plas De CH REFERENCE 3 - Ples Time factor for pull du	u				
	me factor for pull				
1.00 Up	to 1 hour pull	1			
0.95 Up	tp 12 hours pull	12			
ອຼ <u>ອ</u> 0.91 Up	o to 24 hours	24			
ona/bli					
m/pers					
ooint.co					
fT Tirr 1.00 Up 0.955 Up 0.91 Up					
soc-m)					
erleyas					
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- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 88 Circuit #2 Wetlands Crossing

ISSUE: Design Submittal

Contents:

Table 1	DESIGN SUMMARY, ASSUMPTIONS, CONDITIONS
Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

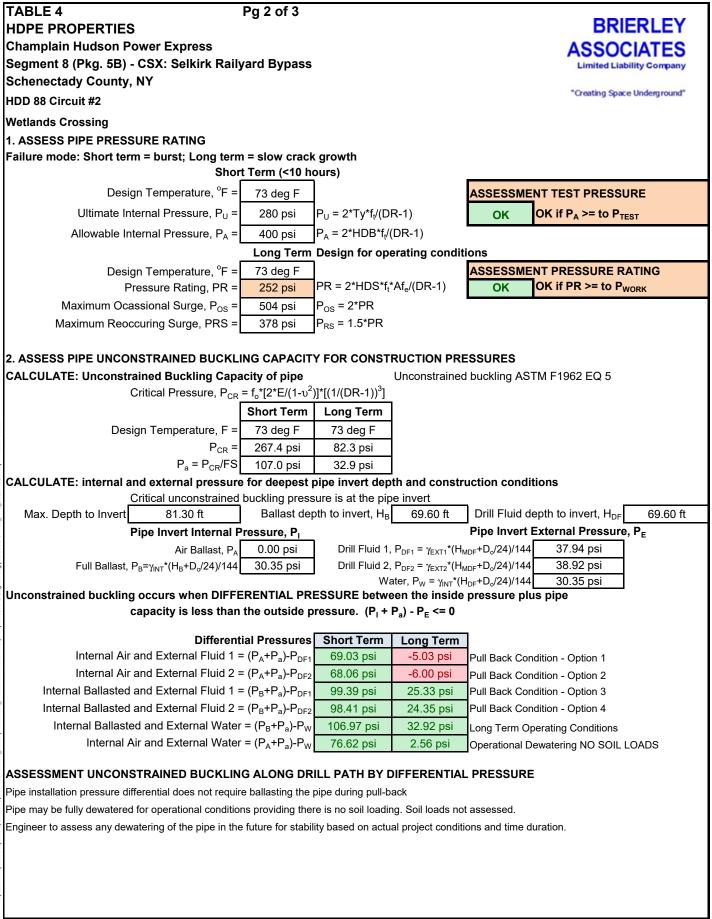
Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

	CALCULA	TIONS												
Entry Station		FT		*If no water or mudlin	e then use lowe	r of entrv or exit eleva	tion	1						
Exit Station		FT			r Surface Elev.*	153.00 ft								
Entry and Exit Design C					Mudline Elev.*	163.00 ft								
Entry	East	North 1352991,2610	Elevation	Lowest	centerline Elev.	94.40 ft								
Entry Horizontal Curve PI			164.00 ft				SI	MMARY HORIZONTA						
Exit			175.70 ft			Start			Er					
Depth to Mudline		Clearance Depth =	68.60 ft		Station	Easting	Northing	Station	Easting	Northing	Azimuth	Length	Radius	Angle
	n Length at ties =			Tangent	0+00.00	669904.6160		7+33.55	670582.2020	1353272.2750		733.55	0.00	0.000 da
00	ordinate Length = OK-H	ORIZONTAL CURVE		Curve Tangent	7+33.55 7+33.55	670582.2020 670582.2020		7+33.55 14+67.09	670582.2020 671259.7880	1353272.2750 1353553.2890		0.00 733.55	0.00	0.000 deg
					•			•		Pull Geom	otru			
Entry Tangent Segment		Horizontal Curve Seg		Exit Tangent Segme	1		Pipe Entry	Exit	Futer the nine of		etry ne hole: Entry/Exit			
Plan Length, ft.	733.55	Input Radius, ft.	0.00	Plan Length, ft.	733.55		Pipe Entry	Elevatio			Vertical Angle		Path	Curve
Entry Azimuth, deg.5			0.000 deg.	Exit Azimuth, deg. ⁵			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad.5		Curve, rad	0.00000	Exit Azimuth, rad. ⁵	1.17766		Entry Tangent	175.70 ft	112.63 ft	-10.00 deg	-10.00 deg	0.00 deg	363.20 ft	0.00 ft
-		Calculate PTH		Calculate Exit			Entry Curve	112.63 ft	94.40 ft	-10.00 deg	0.00 deg	10.00 deg	209.44 ft	1200.00 ft
Calculate PCH	`	Chord Length, ft.	0.00	Easting	671259.7880	Check	Bottom Tangent	94.40 ft	94.40 ft	0.00 deg	0.00 deg	0.00 deg	447.47 ft	0.00 ft
PCH Easting PCH Northing		Arc Length, ft. Chord Azimuth, deg	0.00 67.4748	Northing	1353553.2890	<i>Delta</i> 0.0000	Exit Curve Exit Tangent	94.40 ft 120.62 ft	120.62 ft 164.00 ft	0.00 deg 12.00 deg	12.00 deg 12.00 deg	12.00 deg 0.00 deg	251.33 ft 208.63 ft	1200.00 ft 0.00 ft
For Northing	1555272.2750	PI Easting =	670582.2020			0.0000	LAIL Tangent	120.02 11	104.00 1	12.00 deg	¥	Fotal Check =	1480.07 ft	OK
		PI Northing =	1353272.2750			OK CALC		Compound Curve As	sessment					
		PTH Easting =	670582.2020					Start	Vert. Plan	Horiz. Plan				
		PTH Northing =	1353272.2750			Exit Station		Entry			No Horiz	> Entry V(Tan+	Curve)	
		1 III Kording	1000212.2100			14+67.09		Exit				> Entry V(Tan+		
Cum Plan Length	733.55	Cum Plan Length	733.55	Cum Plan Length	1467.094619	OK STA								
VERTICLE PAT			NS (FT)							l	Summary of D	rill Calculati	one	
Entry Tangent Segment		Entry Vert. Curve Sed	<u> </u>	Middle Tangent Segi	ment 3	Exit Vert. Curve Se	ament 4	Exit Tangent Segmer	at 5				tion Change =	11.70 ft
Entry Angle		Vertical Radius	1200.00	End Vert Angle	0.000 deg.	Radius	1200.00	Exit Elevation	175.70				gn Elevation =	94.40 ft
		Vert. Curve, deg.	12.000 deg.	Inclined Bottom Tan	NO	Angle Change	10.000 deg.	Decise Evit Angle	10.00 1			Invert Dent	h below exit =	81.30 ft
Calculate Vertical PCV							10.000 deg.	Design Exit Angle	10.00 deg			•		
		Coloulate Vortical BT	N.	Coloulate Vertical B		0 0	-		10.00 deg	CUME		Invert Depth	below entry =	69.60 ft
Plan Length	204 073 ft	Calculate Vertical PT		Calculate Vertical Po	cv	Calculate Vertical F	ידע	Calculate Exit		SUMS		Invert Depth	below entry = Path Length =	69.60 ft 1,480.07 ft
Plan Length Rod Length		Calculate Vertical PT Plan Length Arc Rod Length	℃ 249.494 ft 251.327 ft	Calculate Vertical Po Plan Length Rod Length		Calculate Vertical F Plan Length	-	Calculate Exit	357.684 ft 363.202 ft	SUMS 1,467.095 ft 1,480.067 ft	Minimum	Invert Depth	below entry =	69.60 ft 1,480.07 ft 1,467.09 ft
5	208.632 ft	Plan Length	249.494 ft	Plan Length	CV 447.46567 ft	Calculate Vertical F Plan Length Arc Rod Length	208.378 ft	Calculate Exit Plan Length Rod Length	357.684 ft	1,467.095 ft	Minimum	Invert Depth	below entry = Path Length = Plan Length =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft
Rod Length	208.632 ft	Plan Length Arc Rod Length	249.494 ft 251.327 ft	Plan Length Rod Length	CV 447.46567 ft 447.46567 ft	Calculate Vertical F Plan Length Arc Rod Length	208.378 ft 209.440 ft	Calculate Exit Plan Length Rod Length	357.684 ft 363.202 ft	1,467.095 ft 1,480.067 ft	Minimum	Invert Depth	below entry = Path Length = Plan Length = No Tangent) =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft
Rod Length	208.632 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth	249.494 ft 251.327 ft -26.223 ft	Plan Length Rod Length	CV 447.46567 ft 447.46567 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth	208.378 ft 209.440 ft 18.231 ft	Calculate Exit Plan Length Rod Length Vertical Depth	357.684 ft 363.202 ft 63.069 ft	1,467.095 ft 1,480.067 ft	Minimum	Invert Depth	below entry = Path Length = Plan Length = No Tangent) = Entry Angle =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg
Rod Length	208.632 ft -43.377 ft	Plan Length Arc Rod Length	249.494 ft 251.327 ft	Plan Length Rod Length	CV 447.46567 ft 447.46567 ft	Calculate Vertical F Plan Length Arc Rod Length	208.378 ft 209.440 ft 18.231 ft	Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth	357.684 ft 363.202 ft	1,467.095 ft 1,480.067 ft		Invert Depth	below entry = Path Length = Plan Length = No Tangent) =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg
Rod Length Vertical Depth Start Elevation End Elevation	208.632 ft -43.377 ft 164.000 ft 120.623 ft	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft	Plan Length Rod Length Vertical Depth Start Elevation End Elevation	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft	Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft	1,467.095 ft 1,480.067 ft		Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft	Plan Length Rod Length Vertical Depth Start Elevation	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft	Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation	357.684 ft 363.202 ft 63.069 ft 11.700 ft	1,467.095 ft 1,480.067 ft 11.700 ft		Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE C	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCUL/	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg	Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation Prop. Plan Length	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619	1,467.095 ft 1,480.067 ft 11.700 ft Stationin	ng Check	Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg URVE CALCUL 0+00.00	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft	Plan Length Rod Length Vertical Depth Start Elevation End Elevation	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg	Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA		Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg :URVE CALCUL 0+00.00 2+04.07 204.07	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length	2V 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+01.03 901.03 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09	1,467.095 ft 1,480.067 ft 11.700 ft Stationin OK STA Plan Leny OK CALC	ng Check TIONING gth Check ULATION	Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check ULATION ange Check	Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length	2V 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+01.03 901.03 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09	1,467.095 ft 1,480.067 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check ULATION	Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96	Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationin OK STA Plan Len OK CALC Elevation Cl	ng Check TIONING gth Check ULATION ange Check	Invert Depth Plan Length (Compound Cu	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+)	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Len OK CALC Elevation Cl OK CALC	ng Check TIONING th Check ULATION ange Check ULATION Indicates inputs Indicates status on	Invert Depth Plan Length (Compound Ct Compound C	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: I. Sign convention for ang Due East is defined as	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+)	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87 -51.3693	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC	ng Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review	Invert Depth	below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: I. Sign convention for ang Due East is defined as	208.632 ft -43.377 ft 120.623 ft -12.000 deg URVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87 -51.3693	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leny OK CALC Elevation Cl OK CALC	ng Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson Pc	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 94.400 deg 4+53.57 9+01.03 901.03 ft 907.43 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87 -51.3693	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES	ng Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87 -51.3693	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth EXIT	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07 11.70	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	g Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) - Schenectady County,	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth End Elevation End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as 0	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+01.03 907.43 ft -69.60 ft 2a	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1116.87 -51.3693 NGTH	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07 11.70	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES	ng Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) - Schenectady County, TABLE 2	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: I. Sign convention for ang Due East is defined as)	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+01.03 901.03 ft 907.43 ft -69.60 ft 2a	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1109.41 1109.41 1116.87 -51.3693 NGTH PT PCex	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07 11.70	1,467.095 ft 1,480.067 ft 11.700 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	ng Check TIONING 3th Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B). Schenectady County, TABLE 2 DESIGN DRILL PA	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1109.41 1116.87 -51.3693 NGTH PT PCex • EXIT CU	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07 11.70	1,467.095 ft 1,480.067 ft 1,480.067 ft 11.700 ft Stationin OK STA Plan Leny OK CALC Elevation Cl OK CALC Elevation Cl OK CALC SUE: BRIERLEY ASSOCIATES Limited Liability Company "Creating Space Underground Briefley Associates	ng Check TIONING gth Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) - Schenectady County, TABLE 2	Invert Depth	below entry = Path Length = Plan Length = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO
Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth NOTES: I. Sign convention for ang Due East is defined as)	208.632 ft -43.377 ft 164.000 ft 120.623 ft -12.000 deg CURVE CALCUL 0+00.00 2+04.07 208.63 -43.38 gles - positive (+) 0 degrees.	Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	249.494 ft 251.327 ft -26.223 ft 94.400 ft 120.623 ft 94.400 ft 0.000 deg 2+04.07 4+53.57 453.57 459.96 -69.60	Plan Length Rod Length Vertical Depth End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	2V 447.46567 ft 447.46567 ft 0.00000 ft 94.400 ft 94.400 ft 0.000 deg 4+53.57 9+01.03 901.03 ft 907.43 ft -69.60 ft 2a	Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	PTV 208.378 ft 209.440 ft 18.231 ft 94.400 ft 94.400 ft 112.631 ft 10.000 deg 9+01.03 11+09.41 1109.41 1109.41 1116.87 -51.3693 NGTH PT PCex • EXIT CU	Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length EXIT	357.684 ft 363.202 ft 63.069 ft 11.700 ft 112.631 ft 1467.094619 11+09.41 14+67.095 1467.09 1480.07 11.70	1,467.095 ft 1,480.067 ft 11.700 ft 11.700 ft Stationin OK STA Plan Leny OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC	Ig Check TIONING th Check ULATION ange Check ULATION Indicates inputs Indicates status on Design Review Champlain Hudson PC Segment 8 (Pkg. 5B) - Schenectady County, TABLE 2 DESIGN DRILL P/ HDD 88 Circuit #2	Invert Depth Plan Length (Compound CL Compound C Compound C	below entry = Path Length = Plan Length = Entry Angle = Entry Angle = Exit Angle = Irve at Entry = Curve at Exit = Curve at Exit =	69.60 ft 1,480.07 ft 1,467.09 ft 1,019.63 ft -12.00 deg 10.00 deg NO

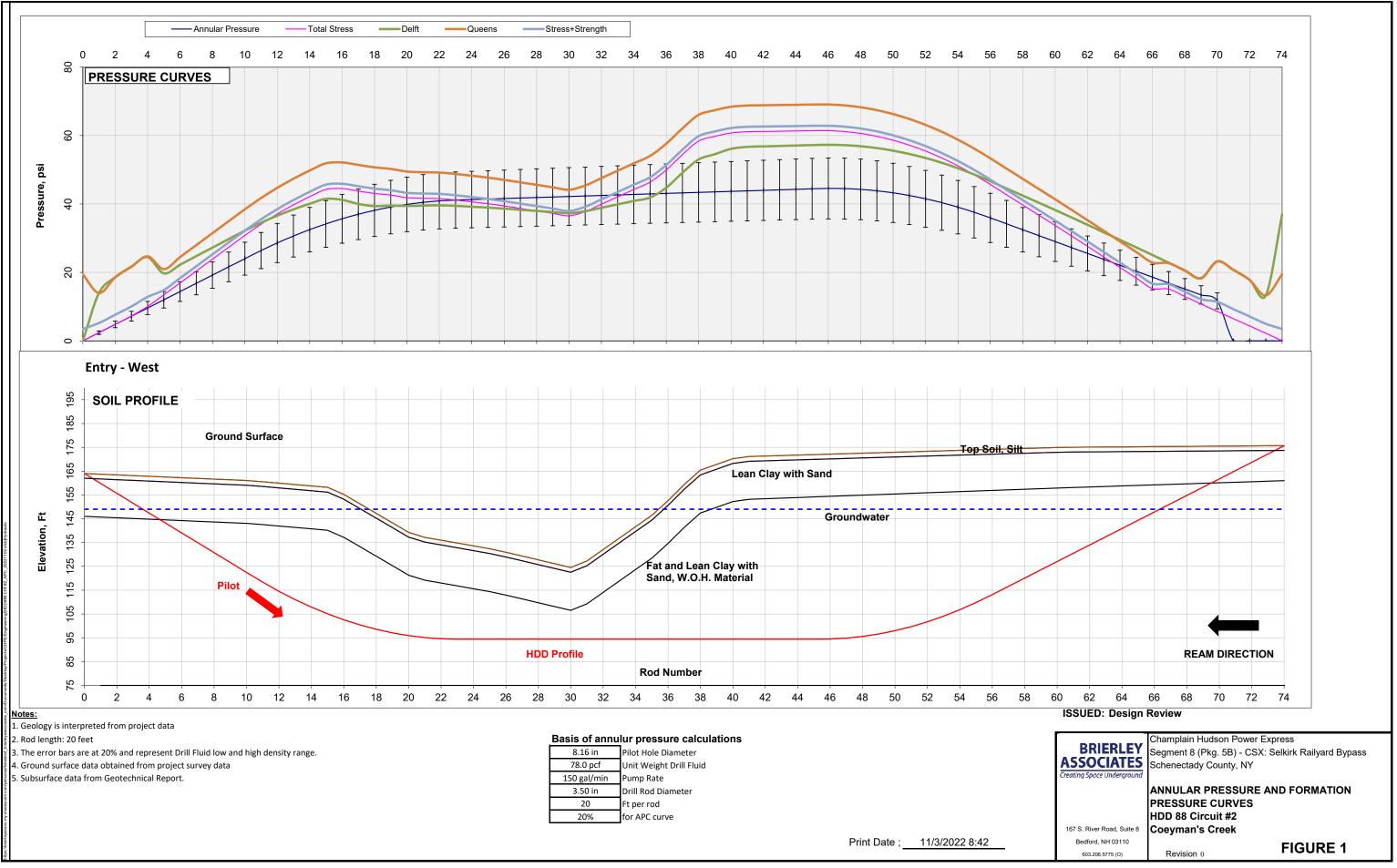
Pull Geometry	,								Pipe	Entry Location - Drill	Exit				
i un ocomony									•	to show definition of var					
Lengt	hs (Path)		Angles		Radius, R	-	Pipe Exit El =	164 00 ft			lables only)		Pine F	ntry Fl =	175.70 ft
	100.0 ft	Overbend	deg	radian	500.0 ft			101.001					Tipe L		in on one
	363.2 ft	α =	-10.0 °	-0.1745		β							1	λα	
	209.4 ft		-10.0	-0.1740	1,200.0 ft	- '	<u>∳``</u> , F						A ,	<u> </u>	
	447.5 ft	~ -	0.0 °	0.0000	1,200.0 1	-	and the second	and the second					A Contractor	Na	Contraction of the second
	251.3 ft	χ=	0.0	0.0000	1,200.0 ft	4	Dawn		1999-9999-9999-9999-9999-9999-9999-999	998) 'A		в	HANNE.		
	208.6 ft	β =	12.0 °	0.2094	1,200.0 1			E							
	1580.1 ft	1.	12.0	0.2004		-				D	c		Over	hend	
		d Friction Fa	otoro			4	I.					1			1
INFUI.	μ _G =		dry + roller	\$					L5	-► <l4< td=""><td>—► L3 —</td><td>—► --L2 ►</td><td></td><td>L1 ——</td><td></td></l4<>	—► L3 —	—► - -L2 ►		L1 ——	
	μ _b =	0.10	drill fluid in l				r		Cal	culated Pull Force				ASS	FSS
	μ _c =	0.23	in hole no fl					Pull Force, F _D			Pull Force, F _B	Max Tensile	ASSESS		SPS
INPUT		d Hydrokine	1	ulu			POINT	No Ballast	Stress, σ_T	σ _T < σ _{PM}	Ballasted Pipe	Stress, σ_T	$\sigma_T < \sigma_{PM}$	Air	Ballast
	τ _f =		Drill Fluid S	hear Str	ess		A	2,521 lb	148 psi	OK	2,521 lb	148 psi	OK	OK	OK
INDI IT-	: Pipe Pro		12				В	5,196 lb	145 psi	OK	5,680 lb	158 psi	OK	OK	OK
	Material			IPS	1		C	6,864 lb	224 psi	OK	6,556 lb	215 psi	OK	OK	OK
Safe Pull Max. S			PPI Table 1		73Deg F		D	8,094 lb	224 psi	OK	7,785 lb	210 psi 217 psi	OK	OK	OK
Pile/Bundle Diam.	14.25	BUNDLE	PIPE/BUND				E	12,813 lb	390 psi	OK	10,337 lb	321 psi	OK	OK	OK
5	I Density, γ	59.28 pcf	ł				F	16,821 lb	469 psi	ОК	12,225 lb	341 psi	ОК	ОК	ОК
Outside Diar			Pipe or Bun	ndle			ASSES			apacity, P_{PA} > ΔP invert			Balla	-	OK
Pipe Dry We	-		Pipe or Bun							,,,, , , , , , , , , , , , , , , ,			No Ba	allast	OK
Min. Wall Thi	-	1.194 in	+ '		on pull stress			Maximum tens	ile stress duri	ing pullback = $\sigma_t = (F_T/\pi)$	t _m (D _{OD} -t _m))+E _T D	_{od} /2R	PPI Ch 12		
5	$= D_0/t_{min} =$		D _{OD} Stress	-		Calculate	ed Material Des	ign Limits For	Designed Dr	rill Path					
Avg. Inside Dia	-		Bundle Mult					•	-	fe Pull Strength, SPS =	41,235 lb	SSPS = σ_{PN}	πD _{OD} ² ((1/Ε)R)-(1/DF	R ²))
12 Hr Pullback Mod			+	73 deg F				Allowable Shor		strained Buckling, $P_A =$		P _A = (2E _T /(1		, ,	
D	Ratio, μ =	0.45	e.	5						Stress Reduction, $F_R =$,
20	Factor, $f_0 =$	0.84	2%	1						r=					
Buckling S	-	2.5		1					Maximum a	pplied pull Stress, σ_T =		From Pull Fo		ations	
Hydrostatic Design Str		1,008 psi	HDB/2				Ballas	ted Max. Differe	ential Pressure	e on Pipe, ∆P_B invert =	7.43	psi (-) indica	tes pipe is	pressuri	zed
Pressure Rating			PR = 2HDS	SF _⊤ A _F /(D	R-1) [F _⊤ =1]					e on Pipe, ∆P u invert =		psi (-) indica	•••	•	
5	. ,	d Fluid Dens	-		,							,			
Ballas	st Density	62.4	pcf							Calculated Drill Hole	Diameter Assu	med for Calo	culations		
Drill Flui	id Density	78	, pcf	Estima	ted for pull					D _H =	22]			
Drill fluid eleva	tion, $H_F =$	163.00 ft	ľ		•					D _O <8" Use D _H =D _O +4"; 8'	" <d<sub>O<24" Use D_H=</d<sub>	=1.5*D _o ; D _o >2	4" Use D _H =l	D _o +12"	
Ballast Water	EI., H _w =	163.00 ft	Ī												
Lowest Invert			1				NOTES:	1 - Calculations w	ere done in gene	eral accordance with ASTMF-	1962 as modified to	account for inve	rt tangent seo	tion, indep	endent
Calculated Pipe a	and Fluid	Properties				-4		vertical curves, an actual pull force ba	0	TM applies hydrokinetic press	sure as shear per un	it pipe length rec	quiring a back	calculation	n to determine
		ressure Pipe:	YES	3					ased on average	pipe area.					
		ter Length, P								ISSUE:	Design Revie	w			
		tion Area, A _W	37.7073							BRIERLEY	Champlain Huds		ess		
		Outside, V _{DO}			-					ASSOCIATES	Segment 8 (Pkg.	•		d Bynass	
b b		ne Inside, V _{DI}			-					Limited Liability Company	Schenectady Cou	-	inter tanya	a Dypaoo	
	Volum	q _d =	2.69		Drill Eluid (unit	drog)				"Creating Space Underground"	Concludy Col	anty, N			
	10. Uvdr				Drill Fluid (unit Comparison O	0,				creating space onderground					
	•	okinetic, ∆T = -	0.00 1	on		iny @ opsi					TABLE 3 - PUL ANTICIPATED			ייים	
Calculated Buoya	AIIL FOFCE		A: E''	lad	Pollostor	٦								FEFUL	L
	0n 0	Pipe ound, w _a /w _{af} =	Air Fil 15.68 L		Ballasted	-				Brierley Associates	HDD 88 Circuit				
In Holes		Fluid, w _a /w _{af} = Fluid, w _b /w _{bf} =			38.67 Lb/LF	-					Wetlands Cros	sing			
			-33.48 L	D/LF	-10.49 Lb/LF					167 S. River Road, Suite 8					
=										Bedford, NH 03110	Revision	0			

TABLE 4		Pg 1 of 3							
HDPE PROPERTIES	S	•			BRIERLEY				
Champlain Hudson F		SS			ASSOCIATES				
Segment 8 (Pkg. 5B)	-		Bvpass		Limited Liability Company				
Schenectady County		5	<i>.</i>						
HDD 88 Circuit #2	,				"Creating Space Underground"				
Wetlands Crossing									
INPUTS									
Pipe Material Propertie	S								
Sources:	ASTM D3350	and Plastic Pip	e Institute Public	ations and as referenced					
Design Working Pre	1	250 psi	1	Test Pressure, P _{TEST} 0 psig	At high point				
	-	1		Tost Tostalo, Tiest oppig	, a high point				
Quantity of Pipe		-			0				
	Pipe Material	HDPE		MATERIAL: PE3408, PE3608, PE471					
ASTM D3350 Cell	-	10	Design resin wit	h minimum PENT test of 10,000 hour	rs				
	rd Dimension	10	IDC "Iron Ding C	ize" of DIDC "Dustile Iren Dine Size"					
Pipe measurem		IPS	IFS IION PIPES	ize" of DIPS "Ductile Iron Pipe Size"					
	/linimum Wall Diameter, D _o =	9 10.750 in	Standard Mar.	acturer's Data Sheets					
	Diameter, $D_0 =$	8.219 in		acturer's Data Sheets					
_	um Wall, t _{min} =	1.194 in		acturer's Data Sheets					
			_	-					
Unit OD Surface Area			$A_{W} = \pi^{*}((D_{o}/2)^{2} - ((D_{o}-2t)/2)^{2})$ $A_{OD} = 12^{*}\pi^{*}D_{OD}$						
	√olume, V _{Do} =								
	Volume, V _{Do} = Volume, V _{Di} =								
	HDB =		1000000000000000000000000000000000000						
Design Factor f		0.63	Based on PPI PE Handbook 2nd ED Chapter 5						
Hydrostatic Design S		1008 psi	HDS = HDB*DF						
Environmenta		1	Reference 2: Use for pressure rating only						
×*	Density =	59.28 pcf	1.410 g/cc	Average from WL Plastics WL122 fo	r PE4710				
We	ight Dry, W =	15.68	Lb/LF						
Tensile `	Yield, Ty psi =	1,120 psi	0.5	Minimum from ASTM D3350 determ	ined by ASTM D638				
	Load Duration		Long Term						
	Duration Time	10 hours	50 yrs	Assumed					
Design Le	mperature, °F gn Ovality, %	73 deg F 2%	73 deg F 2%	Assumed See Sheets 4 of 5 for design ovality					
	f Safety, FS =	2.5	2.5	Industry Practice					
Modulus for given load	l duration, E =	65,000 psi	28,000 psi	Based on PPI Handbook Ch. 3 and WL I	Plastics WL118-0314				
Pois	son Ratio, υ =	0.45	0.45	WL118: Use 0.35 if load duration is I	ess than 12 hours				
Ova	ality factor $f_o =$	0.84	0.6	Reference 1: Based on Selected De	sign Ovality				
Temperat	ure factor, f _t =	1.00	1.00	Source: WL Plastics WL118					
Project Fluids									
Fluids Density, γ = Buoya Buoya Buoyan Buoyar	Pipe Internal	Expected	Heavy External		Buoyant forces				
Fluids	Ballast Fresh Water	External Fluid Drill Fluid 1	Fluid Drill Fluid 2	Dry Weight Pipe on ground, W _P = Internal Ballast Weight, W _B =					
FiuluS	γ _{INT}			Expected Displaced Fluid Weight, $W_{D1} =$	$\frac{22.99 \text{ lb/ft}}{49.16 \text{ lb/ft}} \text{ W}_{\text{B}} = \text{V}_{\text{Di}}^* \gamma_{\text{INT}}$				
Density, γ =	62.4	78	80	Heavy Displaced Fluid Weight, $W_{D2} =$					
Buova	Int Unballasted		-33.48 lb/ft	W _P -W _{D1}	•••D2 •D0 [EX12				
Buova	int Unballasted		-34.74 lb/ft	W _P -W _{D2}					
		n ground, $B_G =$	38.67 lb/ft	W _P +W _B					
Buoyan	t Ballasted in F	0 0	-10.49 lb/ft	BG-W _{D1}					
Buoyar	nt Ballasted in		-11.75 lb/ft	BG-W _{D2}					



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	TABLE 4	Pg 3 of 3		
	HDPE PROPERTIES	-		BRIERLEY
	Champlain Hudson Power Express			ASSOCIATES
	Segment 8 (Pkg. 5B) - CSX: Selkirk Raily	ard Bypass		Limited Liability Company
	Schenectady County, NY			
	HDD 88 Circuit #2			"Creating Space Underground"
	Wetlands Crossing			
	3. ASSESS ULTIMATE PULL STRENGTH (UF Source PPI PE Handbook Ch 12 Formula 17			
	Source PPI PE Handbook CIT 12 Formula 17	3F3 – 11 DF (1	y) D ₀ ((1/DR)-(1	
	Designed Pull Duration Time =	12 hr		Quantity of pipes, $Q = 1$
	-		_	
	Yield Strength Factor, f _Y =	0.4		(FS = 2.5) Pull Temperature, F = 73 deg.
	Pull Time factor, $f_T =$	1	_	ing Manual Table 3.7
	Design Factor, DF = $f_T * f_Y$			NTH, SPS = 16,064 lb
	Temperature factor, f _{temp} =	1	JItimate Pull Stre	ngth, UPS = 40,160 lb
	Temp Corr Tensile Yield, Ty*f _{temp} =	1,120 psi		
	Safe Allowable Stress, SAS =	448 psi		DF Suggested SSAS = 1,150 psi
	Safe Pull Strength, SPS Pipe =	16,064 lb	Useing SSAS =	41,235 lb
	Short Term Critical Unconstrained Buckling	Pcr reduced f	or pull tension, I	$\mathbf{P}_{CRR} = \mathbf{P}_{CR}^{*}\mathbf{f}_{r}$
	(ASTM F-1962 EQ. 22)	10.11	I	
	Pull Duration Time =	12 Hr	Design Depth in	Pcr = 267.4 psi
ss	SAS =	448 psi	Design Depth in	
tic Stree	Estimated Maximum Pull Stress, σ_i =	1,150 psi	Design Assumpt	ion as Maximum
4 Plas	fr = ((5.57-(r+1.09)^2)^.5)-1.09 =	0.88370	-	
2.xlsb]7	r = σ _i /2*(SSAS) =	0.20403	Exam	nple from Table T5, $\sigma_i = 469 \text{ psi}$
221102	P _{CRR} = FS =	236.3 psi		
PC_20	P3 - P _{ACRR} = P _{CRR} /FS =	2.0 118.2 psi	Allowable Reduc	ced Short Term Buckling pressure during pull
R #2_A	Internal Ballasted and External Fluid 1 = (F			Pull Back Condition - C OK as >0
#88 CI	Internal Ballasted and External Fluid 2 = (F			Pull Back Condition - C OK as >0
Engineering/[HDD#88 CIR #2_APC_20221102.xlsb]T4 Plastic Stress	ASSESSMENT OF SAFE PULL STRENGTH (
gineerin	ACCEPTIBLE Acceptible if differential pres			
ш.				
cts/CH	REFERENCE 1 - Plastic Pipe Institute - Handb			
p/Proje	REFERENCE 2 - Plastic Pipe Institute - Handbo Design Factor (fe) to apply t		2nd Edition	
Deskto	CHAPTER 6 - TABLE 1-2			
ments/.	REFERENCE 3 - Plexco Engineering Manual B	look 3 Ch 3 Tak	ale 3.7	
com/Documents/Desktop/Projects/CHF	Time factor for pull duration, f_T		50 0.7	
	f_{T} Time factor for pull			
https://brierleyassoc-my.sharepoint.com/personal/blindelof_brierleyassociates	1.00 Up to 1 hour pull	1		
rierleya	0.95 Up to 12 hours pull	12		
delof_b	0.91 Up to 24 hours	24		
aVblin				
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- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 89 Circuit #1 Wetlands Crossing

ISSUE: Design Submittal

Contents:

Table 1	DESIGN SUMMARY, ASSUMPTIONS, CONDITIONS
Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

Entry Station														
	0+00.00	FT		*If no water or mudlin	e then use lowe	r of entry or exit eleva	tion	1						
xit Station		FT			er Surface Elev.*	152.00 ft								
ntry and Exit Design Co	ordinates & El East	evations (Ft) (Note 2) North	Elevation	Lowest	Mudline Elev.*	158.00 ft 113.50 ft								
Entry	674059.411000		159.40 ft	Lowest	Centennie Liev.	113.30 10								
Horizontal Curve PI		1352891.563000					SU	JMMARY HORIZONTA	-					
	<mark>671989.784000</mark> 1.40 ft		174.70 ft		Otation	Start	Neuthing	Otation	Er		A mine with	Lanath	Dedius	Angle
Depth to Mudline Measured Plan		Clearance Depth = 2550.0007 ft	44.50 ft	Tangent	Station 0+00.00	Easting 674059.4110	Northing 1352073.9160	Station 8+27.37	Easting 673475.1005	Northing 1352659.6801	Azimuth E 315.07118 N	Length 827.37	Radius	Angle
	dinate Length =	2550.0007 ft		Curve	8+27.37	673475.1005	1352659.6801	14+76.66	672950.6041	1353037.5530	E 296.47047 N	649.29	2000.00	-18.601 de
	OK-H	ORIZONTAL CURVE		Tangent	14+76.66	672950.6041	1353037.5530	25+50.00	671989.7840	1353515.9820	E 296.47047 N	1073.35		
	HO		AN CALCU	LATIONS (FT)					Pull Geom	etry			
ntry Tangent Segment		Horizontal Curve Seg		Exit Tangent Segme			Pipe Entry				he hole: Entry/Exit			
Plan Length, ft.	827.37	Input Radius, ft.	2000.00	Plan Length, ft.	1073.35			Elevatio			Vertical Angle		Path	Curve
Entry Azimuth, deg. ⁵		. 0	-18.601 deg.	Exit Azimuth, deg. ⁵			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad. ⁵	5.49903	Curve, rad Calculate PTH	-0.32464	Exit Azimuth, rad. ⁵ Calculate Exit	5.17439		Entry Tangent Entry Curve	159.40 ft 139.72 ft	139.72 ft 113.50 ft	-12.00 deg -12.00 deg	-12.00 deg 0.00 deg	0.00 deg 12.00 deg	94.64 ft 251.33 ft	0.00 ft 1200.00 ft
alculate PCH		Calculate PTH Chord Length, ft.	646.44	Easting	671989.7840	Check	Entry Curve Bottom Tangent	139.72 ft 113.50 ft	113.50 ft 113.50 ft	-12.00 deg 0.00 deg	0.00 deg	12.00 deg 0.00 deg	251.33 ft 1755.86 ft	0.00 ft
PCH Easting	673475.1005	Arc Length, ft.	649.29	Northing	1353515.9820	Delta	Exit Curve	113.50 ft	131.73 ft	0.00 deg	10.00 deg	10.00 deg	209.44 ft	1200.00 f
PCH Northing	1352659.6801	Chord Azimuth, deg	305.7708			0.0000	Exit Tangent	131.73 ft	174.70 ft	10.00 deg	10.00 deg	0.00 deg	247.45 ft	0.00 ft
		PI Easting = PI Northing =	673243.7930 1352891.5630			0.0000 OK CALC		Compound Curve As	coccmont		1	Total Check =	2558.72 ft	OK
		PTH Easting =	672950.6041			OR CALC		Start	Vert. Plan	Horiz. Plan	1			
									342.07	827.37				
		PTH Northing =	1353037.5530			Exit Station 25+50.00		Entry Exit	452.07	1073.35		> Entry V(Tan+ > Entry V(Tan+		
Cum Plan Length	827.37	Cum Plan Length	1476.66	Cum Plan Length	2550.000667			EAR	402.01	1070.00	110, 11012		Ourve)	
VERTICLE PATH			NS (FT)							1	Summary of D	rill Calculati	one	
Entry Tangent Segment 1		Entry Vert. Curve Sec	· /	Middle Tangent Seg	mont 3	Exit Vert. Curve See			at E				tion Change =	45.00.0
Entry Angle								LEXIT Langent Segmer						
	-12.000 deg.	Vertical Radius	1200.00	End Vert Angle	0.000 deg.	Radius	1200.00	Exit Tangent Segmen Exit Elevation	174.70				gn Elevation =	15.30 ft 113.50 ft
	-12.000 deg.	Vertical Radius Vert. Curve, deg.	1200.00					Exit Elevation				Minimum Desig Invert Dept	gn Elevation = th below exit =	113.50 ft 61.20 ft
alculate Vertical PCV	-12.000 deg.	Vert. Curve, deg.	1200.00 12.000 deg.	End Vert Angle Inclined Bottom Tan	0.000 deg. NO	Radius Angle Change	1200.00 10.000 deg.	Exit Elevation Design Exit Angle	174.70	SUMS		Minimum Desig Invert Dept Invert Depth	gn Elevation = th below exit = a below entry =	113.50 ft 61.20 ft 45.90 ft
alculate Vertical PCV Plan Length	-12.000 deg. 92.574 ft		1200.00 12.000 deg.	End Vert Angle Inclined Bottom Tan Calculate Vertical P	0.000 deg. NO	Radius Angle Change Calculate Vertical F	1200.00 10.000 deg.	Exit Elevation Design Exit Angle Calculate Exit	174.70	SUMS 2,550.001 ft		Minimum Desig Invert Dept Invert Depth	gn Elevation = th below exit =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f
Plan Length Rod Length	92.574 ft 94.642 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length	1200.00 12.000 deg. ♥ 249.494 ft 251.327 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1200.00 10.000 deg. TV 208.378 ft 209.440 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length	174.70 10.00 deg 243.691 ft 247.450 ft	2,550.001 ft 2,558.723 ft		Minimum Desig Invert Dept Invert Depth	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f 2,550.00 f 794.14 ft
Plan Length	92.574 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length	1200.00 12.000 deg. ℃ 249.494 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length	0.000 deg. NO CV 1,755.86422 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1200.00 10.000 deg. TV 208.378 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	174.70 10.00 deg 243.691 ft	2,550.001 ft		Minimum Desig Invert Dept Invert Depth	gn Elevation = th below exit = below entry = Path Length = Plan Length =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f 2,550.00 f 794.14 ft
Plan Length Rod Length	92.574 ft 94.642 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft	2,550.001 ft 2,558.723 ft		Minimum Desig Invert Dept Invert Depth	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle =	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg
Plan Length Rod Length Vertical Depth	92.574 ft 94.642 ft -19.677 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.500 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft	2,550.001 ft 2,558.723 ft		Minimum Desi Invert Depi Invert Depth	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f 2,550.00 f 794.14 ft -12.00 deg
Plan Length Rod Length Vertical Depth Start Elevation	92.574 ft 94.642 ft -19.677 ft 159.400 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.500 ft 139.723 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 113.500 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft	2,550.001 ft 2,558.723 ft		Minimum Desig Invert Dept Invert Depth Plan Length (Compound Cu	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO
Plan Length Rod Length Vertical Depth	92.574 ft 94.642 ft -19.677 ft	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.500 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft	2,550.001 ft 2,558.723 ft		Minimum Desig Invert Dept Invert Depth Plan Length (Compound Cu	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle =	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg
Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	92.574 ft 94.642 ft -19.677 ft 159.400 ft 139.723 ft -12.000 deg JRVE CALCUL	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle ATIONS	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.500 ft 139.723 ft 113.500 ft 0.000 deg	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 0.000 deg	Radius Angle Change Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 113.500 ft 131.731 ft 10.000 deg	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation Prop. Plan Length	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667	2,550.001 ft 2,558.723 ft 15.300 ft Stationin	Minimum	Minimum Desig Invert Dept Invert Depth Plan Length (Compound Cu	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO
Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle UMMARY VERTICLE CL Start Station	92.574 ft 94.642 ft -19.677 ft 159.400 ft -12.000 deg IRVE CALCUL 0+00.00	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle TIONS Start Station	1200.00 12.000 deg. V 249.494 ft -261.327 ft -26.223 ft 113.500 ft 139.723 ft 113.500 ft 0.000 deg 0+92.57	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	0.000 deg. NO 20 1,755.86422 ft 0.00000 ft 113.500 ft 113.500 ft 0.000 deg 3+42.07	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 113.500 ft 131.731 ft 10.000 deg 20+97.93	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation CK Total Cum Depth Start Elevation Prop. Plan Length Start Station	174.70 10.00 deg 243.691 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667 23+06.31	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA	Minimum Minimum G Check TTONING	Minimum Desig Invert Dept Invert Depth Plan Length (Compound Cu	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f 2,550.00 f 794.14 ft -12.00 deg NO
Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	92.574 ft 94.642 ft -19.677 ft 159.400 ft 139.723 ft -12.000 deg JRVE CALCUL	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle ATIONS	1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.500 ft 139.723 ft 113.500 ft 0.000 deg	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 0.000 deg	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 113.500 ft 131.731 ft 10.000 deg	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation CK Total Cum Depth Start Elevation Prop. Plan Length Start Station	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA Plan Len	Minimum	Minimum Desig Invert Dept Invert Depth Plan Length (Compound Cu	gn Elevation = th below exit = below entry = Path Length = Plan Length = (No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.50 ft 61.20 ft 45.90 ft 2,558.72 f 2,550.00 f 794.14 ft -12.00 deg NO
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Plan Length Rod Length Vertical Depth End Elevation End Vert Angle UMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	92.574 ft 94.642 ft -19.677 ft 139.723 ft -12.000 deg IRVE CALCULI 0+00.00 0+92.57 92.57 94.64 -19.68 es - positive (+) 0 degrees.	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	1200.00 12.000 deg. 249.494 ft 251.327 ft -26.223 ft 113.500 ft 113.500 ft 0.000 deg 0+92.57 3+42.07 342.07 342.07 345.97 -45.90	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 113.500 ft 0.000 deg 3+42.07 20+97.93 ft 2101.83 ft -45.90 ft a	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PLAN LE	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 131.731 ft 10.000 deg 20+97.93 23+06.31 2311.27 -27.6693	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Rod Length	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667 23+06.31 25+50.001 2558.72 15.30	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA Plan Len OK CALC Elevation Cl OK CALC	Minimum Minimum TIONING gth Check CULATION Indicates status or Design Review Champlain Hudson Pr Segment 8 (Pkg. 5B) Schenectady County, TABLE 2	Minimum Desig Invert Dept Invert Depth Invert Depth In Plan Length (Compound Cu Compound	gn Elevation = th below exit = below entry = Path Length = Plan Length = Entry Angle = Exit Angle = urve at Entry = Curve at Exit = n checks	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO
Plan Length Rod Length Vertical Depth End Elevation End Vert Angle UMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	92.574 ft 94.642 ft -19.677 ft 139.723 ft -12.000 deg IRVE CALCULI 0+00.00 0+92.57 92.57 94.64 -19.68 es - positive (+) 0 degrees.	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	1200.00 12.000 deg. 249.494 ft 251.327 ft -26.223 ft 113.500 ft 113.500 ft 0.000 deg 0+92.57 3+42.07 342.07 342.07 345.97 -45.90	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 113.500 ft 0.000 deg 3+42.07 20+97.93 2097.93 ft 2101.83 ft -45.90 ft L1 PCen	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 131.731 ft 10.000 deg 20+97.93 23+06.31 2306.31 2311.27 -27.6693	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Rod Length Cum Exit Station	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667 23+06.31 25+50.001 2558.72 15.30	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA Plan Len OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC	Minimum Minimu	Minimum Desig Invert Depth Invert Depth Invert Depth In Plan Length (Compound Ct Compound	gn Elevation = th below exit = below entry = Path Length = Plan Length = Entry Angle = Exit Angle = urve at Entry = Curve at Exit = n checks	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO
Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: . Sign convention for angl Due East is defined as 0	92.574 ft 94.642 ft -19.677 ft 139.723 ft -12.000 deg IRVE CALCULI 0+00.00 0+92.57 92.57 94.64 -19.68 es - positive (+) 0 degrees.	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	1200.00 12.000 deg. 249.494 ft 251.327 ft -26.223 ft 113.500 ft 113.500 ft 0.000 deg 0+92.57 3+42.07 342.07 342.07 345.97 -45.90	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 113.500 ft 0.000 deg 3+42.07 20+97.93 ft 2101.83 ft -45.90 ft a	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 131.731 ft 10.000 deg 20+97.93 23+06.31 2310.27 -27.6693 NGTH PCex EXIT CU	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Rod Length Cum Exit Station	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667 23+06.31 25+50.001 2558.72 15.30	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA Plan Len OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company "Oresting Space Underground Brierley Associates	Minimum Minimum TIONING gth Check CULATION Indicates inputs Indicates status or Champiain Hiddson Pr Segment 8 (Pkg. 5B) Schenectady County, TABLE 2 DESIGN DRILL P/	Minimum Desig Invert Depth Invert Depth Invert Depth In Plan Length (Compound Ct Compound	gn Elevation = th below exit = below entry = Path Length = Plan Length = Entry Angle = Exit Angle = urve at Entry = Curve at Exit = n checks	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO
Plan Length Rod Length Vertical Depth End Elevation End Vert Angle UMMARY VERTICLE CL Start Station PVC Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Depth	92.574 ft 94.642 ft -19.677 ft 139.723 ft -12.000 deg IRVE CALCULI 0+00.00 0+92.57 92.57 94.64 -19.68 es - positive (+) 0 degrees.	Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	1200.00 12.000 deg. 249.494 ft 251.327 ft -26.223 ft 113.500 ft 113.500 ft 0.000 deg 0+92.57 3+42.07 342.07 342.07 345.97 -45.90	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Rod Length	0.000 deg. NO CV 1,755.86422 ft 1,755.86422 ft 0.00000 ft 113.500 ft 113.500 ft 0.000 deg 3+42.07 20+97.93 2097.93 ft 2101.83 ft -45.90 ft L1 PCen	Radius Angle Change Calculate Vertical F Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE rDw PTen PTen	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.500 ft 131.731 ft 10.000 deg 20+97.93 23+06.31 2310.27 -27.6693 NGTH PCex EXIT CU	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length Cum Rod Length Cum Exit Station	174.70 10.00 deg 243.691 ft 247.450 ft 42.969 ft 15.300 ft 131.731 ft 2550.000667 23+06.31 25+50.001 2558.72 15.30	2,550.001 ft 2,558.723 ft 15.300 ft Stationii OK STA Plan Len OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC	Minimum Minimu	Minimum Desig Invert Depth Invert Depth Invert Depth Plan Length (Compound Ct Compound Ct	gn Elevation = th below exit = below entry = Path Length = Plan Length = Entry Angle = Exit Angle = urve at Entry = Curve at Exit = n checks	113.50 ft 61.20 ft 45.90 ft 2,558.72 ft 2,550.00 ft 794.14 ft -12.00 deg NO

Pull Geometry				Pipe	Entry Location - Drill	ENTRY	<u>]</u>		
				(schematic, t	o show definition of var	iables only)			
Lengths (Path) Angles	Radius, R	Pipe Exit El =	174.70 ft]				Pipe Entry I	EI = 159.40 ft
L1 = 100.0 ft Overbend deg ra	dian <u>500.0 ft</u>	_		4				, i'	
L2 = 94.6 ft α = -12.0 ° -0	.2094	β					•	Ţα	
L3 = 251.3 ft	1,200.0 ft	- ' <u>¥``</u> , F					A		<u> </u>
L4 = 1755.9 ft $\chi = 0.0^{\circ} 0.0^{\circ}$	0000		and a start of the second second		al and a second a se			a National States and Alexandria Management States and Alexandria	
L5 = 209.4 ft	1,200.0 ft		E				В		
L6 = 247.5 ft β = 10.0 ° 0.	1745				_				
LT = 2658.7 ft					D			Overbend	
INPUT: Assumed Friction Factors				15				11	
$\mu_{\rm G} = 0.10$ dry + rollers				20	- - L4	- - L3		L 1	-
$\mu_{\rm b} = 0.25$ drill fluid in hole	e			Cal	culated Pull Force			A	SSESS
$\mu_c = 0.30$ in hole no fluid		DOWE	Pull Force, F _D				Max Tensile AS	SESS F	x < SPS
INPUT: Assumed Hydrokinetic Drag		POINT	No Ballast	Stress, σ_T	σ _τ < σ _{PM}	Ballasted Pipe		< σ _{PM} Ai	
τ _f = 0.005 psi Drill Fluid Shea	ar Stress	A	4,713 lb	196 psi	OK	4,713 lb	196 psi	OK O	
INPUT: Pipe Properties		В	5,593 lb	141 psi	OK	5,674 lb	143 psi	OK O	K OK
Material HDPE	PS	С	7,567 lb	223 psi	OK	6,682 lb	201 psi	OK O	K OK
Safe Pull Max. Stress, σ_{PM} 1,150 psi PPI Table 1 12	hr @ 73Deg F	D	15,848 lb	400 psi	OK	14,964 lb	377 psi	OK O	K OK
Pile/Bundle Diam. 14.25 BUNDLE PIPE/BUNDLE		E	20,274 lb	544 psi	OK	17,479 lb	473 psi	OK O	K OK
Material Density, γ 59.28 pcf		F	23,718 lb	598 psi	OK	19,307 lb	487 psi	OK O	K OK
Outside Diameter, D _{OD} 14.25 Pipe or Bundle	I.	ASSES	S Pull Restricted	d Buckling Ca	pacity, P_{PA} > ∆P invert	$P_{PA} = P_A F_R =$	90.48 psi	Ballasted	OK
Pipe Dry Weight, $W_P = 17.36 \text{ lb/ft}$ Pipe or Bundle	I.							No Ballast	OK
Min. Wall Thickness, t _m 1.194 in For design inst	allation pull stress				ng pullback = σ_t = (F _T / π	t _m (D _{OD} -t _m))+E _T D	_{od} /2R PF	'I Ch 12 Eq 1	16
$DR = D_0/t_{min} = 9$ D_{OD} Stress 1	0.75 inches	Calculated Material Des	ign Limits For	Designed Dr	ill Path		_		
Avg. Inside Diameter, D _{IA} BUNDLE Bundle Multipli	er F _D 0.9042				fe Pull Strength, SPS =		SSPS = $\sigma_{PM}\pi D_0$		
12 Hr Pullback Modulus, $E_T = 65,000 \text{ psi}$ @T = 73	deg F				strained Buckling, P _A =		$P_A = (2E_T/(1-\mu^2))$		(f _o /N)
Poisson Ratio, $\mu = 0.45$			Maximum	12 hour Pull	Stress Reduction, F_R =	0.845769381	F _R = (5.57-(r+1.	09) ²) ^{1/2} -1.09	
Ovality Factor, $f_o = 0.84$ 2%					r =	0.26010996	$r = \sigma_T/2SPS$		
Buckling Safety, N = 2.5					pplied pull Stress, σ_T =	598 psi	From Pull Force	Calculation	S
Hydrostatic Design Stress, HDS = 1,008 psi HDB/2					e on Pipe, ∆P_B invert =	4.82	psi (-) indicates	• • •	
	A _F /(DR-1) [F _T =1]	Unballasi	ted Max. Differe	ential Pressure	e on Pipe, ΔP_U invert =	24.10	psi (-) indicates	pipe is press	surized
INPUT: Assumed Fluid Densities/Elevation	s								
Ballast Density 62.4 pcf					Calculated Drill Hole		med for Calcula	itions	
	timated for pull				D _H =				
Drill fluid elevation, $H_F = 158.00 \text{ ft}$					D _O <8" Use D _H =D _O +4"; 8'	' <d<sub>O<24" Use D_H=</d<sub>	=1.5*D ₀ ; D ₀ >24" U	se D _H =D ₀ +12	
Ballast Water EI., $H_W = \frac{158.00 \text{ ft}}{158.00 \text{ ft}}$			1 0-1						
Lowest Invert El., El _m = 113.50 ft		NOTES:	vertical curves, an	d fluid drag. AS	ral accordance with ASTMF- TM applies hydrokinetic press	sure as shear per un	it pipe length requirir	igent section, ir ig a back calcul	ation to determine
Calculated Pipe and Fluid Properties			actual pull force ba					0	
Pressure Pipe: YES									
OD Perimeter Length, P 44.77 in						Design Revie	W		
Wall Section Area, A _w 41.6874728					BRIERLEY	Champlain Hudso	on Power Express		
Volume Outside, V _{DO} 0.697 cf/Ll	=					Segment 8 (Pkg.	5B) - CSX: Selkirk	Railyard Byp	ass
Volume Inside, V _{DI} 0.408 cf/Ll	=				Limited Liability Company	Schenectady Cou	unty, NY		
$q_d = 2.69 \text{ lb/ft}$	Drill Fluid (unit	drag)			"Creating Space Underground"				
ASTM EQ 18: Hydrokinetic, ∆T = 0.34 lb/ft	Comparison O	nly @ 8psi				TABLE 3 - PUL	L ASSESSMEN	т	
Calculated Buoyant Forces						ANTICIPATED	PULLING FORC	E - HDPE P	ULL
Pipe Air Filled	Ballasted					HDD 89 Circuit	: #1		
On Ground, $w_a/w_{af} = \frac{17.36 \text{ Lb/L}}{17.36 \text{ Lb/L}}$	F 42.80 Lb/LF				Brierley Associates	Wetlands Cros	sing		
In Hole with Drill Fluid, w _b /w _{bf} = <u>-37.01 Lb/L</u>	.F -11.58 Lb/LF				167 S. River Road, Suite 8				
	·	-			Bedford, NH 03110	Revision	0		

TABLE 4 HDPE PROPERTIES		Pg 1 of 3		BRIERLEY					
Champlain Hudson P	-			ASSOCIATES Limited Liability Company					
Segment 8 (Pkg. 5B) Schenectady County		rk Rallyaru i	Sypass	Limited Liability Company					
HDD 89 Circuit #1	, IN I			"Creating Space Underground"					
Wetlands Crossing									
INPUTS									
Pipe Material Properties	s								
Sources: /	ASTM D3350	and Plastic Pip	pe Institute Public	cations and as referenced					
Design Working Pre		250 psi		Test Pressure, P _{TEST} 0 psig At high point					
Quantity of Pipes	-	1							
	Pipe Material	HDPE	INPLIT RESIN N	/IATERIAL: PE3408, PE3608, PE4710					
ASTM D3350 Cell	•	1101 2		h minimum PENT test of 10,000 hours					
	rd Dimension	3	Design resin wit						
Pipe measurem		IPS	IPS "Iron Pine S	Size" of DIPS "Ductile Iron Pipe Size"					
DR = OD/N	9								
	Diameter, $D_0 =$	3.500 in	Standard Manut	facturer's Data Sheets					
	Diameter, D _i =	2.680 in	4	facturer's Data Sheets					
-	ım Wall, t _{min} =	0.389 in	Standard Manut	facturer's Data Sheets					
	on Area, A _w =		$A_{W} = \pi^{*}((D_{o}/2)^{2})^{2}$						
Unit OD Surface Area,	in^2/LF , $A_{OD} =$		$A_{OD} = 12^* \pi^* D_{OD}$						
Unit Outside \	/olume, V _{Do} =	0.067 cf/LF							
	Volume, V _{Di} =		$V_{Di} = \pi^* (D_i/2)^2 / 1$						
	HDB =	1,600 psi		ublication TR-4/2015 and ASTM 2837					
Design Factor f	or HDB, DF =	0.63	Based on PPI P	E Handbook 2nd ED Chapter 5					
Hydrostatic Design S	Stress, HDS =	1008 psi	HDS = HDB*DF						
Environmenta	l Factor, Af _e =	1	Reference 2: Us	e for pressure rating only					
	Density =	59.28 pcf	1.410 g/cc	Average from WL Plastics WL122 for PE4710					
	ight Dry, W =	1.66	Lb/LF						
	Yield, Ty psi =	1,120 psi	@73°F	Minimum from ASTM D3350 determined by ASTM D638					
	_oad Duration Duration Time	10 hours	Long Term 50 yrs						
	mperature, °F	73 deg F	73 deg F	Assumed					
	gn Ovality, %	2%	2%	See Sheets 4 of 5 for design ovality					
	f Safety, FS =	2.5	2.5	Industry Practice					
Modulus for given load		65,000 psi	28,000 psi	Based on PPI Handbook Ch. 3 and WL Plastics WL118-0314					
	son Ratio, υ =	0.45	0.45	WL118: Use 0.35 if load duration is less than 12 hours					
	ality factor $f_o =$	0.84	0.6	Reference 1: Based on Selected Design Ovality					
	ure factor, f _t =	1.00	1.00	Source: WL Plastics WL118					
Project Fluids				1					
	Pipe Internal Ballast	Expected External Fluid	Heavy External Fluid	Buoyant forces Dry Weight Pipe on ground, W _P = 1.66 lb/ft From MFG. Data Shee					
Fluids	Fresh Water	Drill Fluid 1	Drill Fluid 2	Internal Ballast Weight, $W_B = 2.44 \text{ lb/ft}$ $W_B = V_{Di}^* \gamma_{INT}$					
	γ _{INT}	γ _{EXT1}	Y _{EXT2}	Expected Displaced Fluid Weight, $W_{D1} = 5.21 \text{ lb/ft}$ $W_{D1} = V_{D0} * \gamma_{EXT1}$					
Density, γ =	62.4	78	80	Heavy Displaced Fluid Weight, $W_{D2} = 5.35 \text{ lb/ft}$ $W_{D2} = V_{D0}^* \gamma_{EXT2}$					
		l Fluid 1, B _{B1} =	-3.55 lb/ft	Wp-W _{D1}					
	nt Unballasted	l Fluid 2, B _{B2} =		W _P -W _{D2}					
Buoya				W _P +W _B					
Buoya	Ballasted or	n grouna, в _G =	4.10 10/11	VVP+VVB					
-		Fluid 1, BB _{B1} =		BG-W _{D1}					

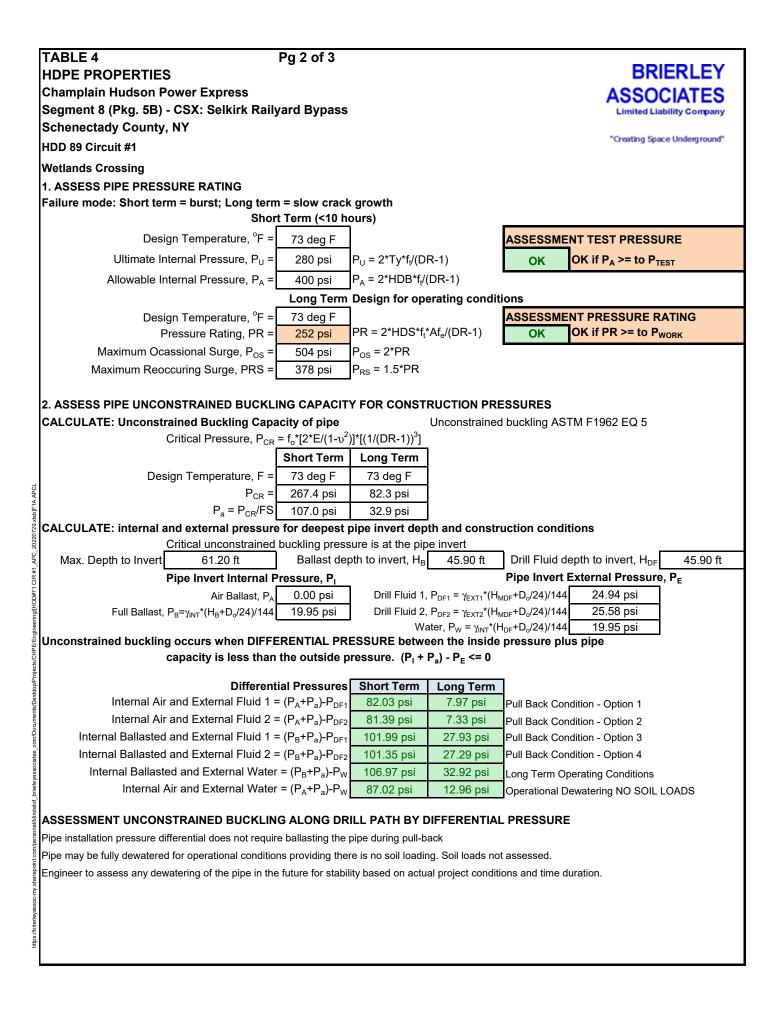
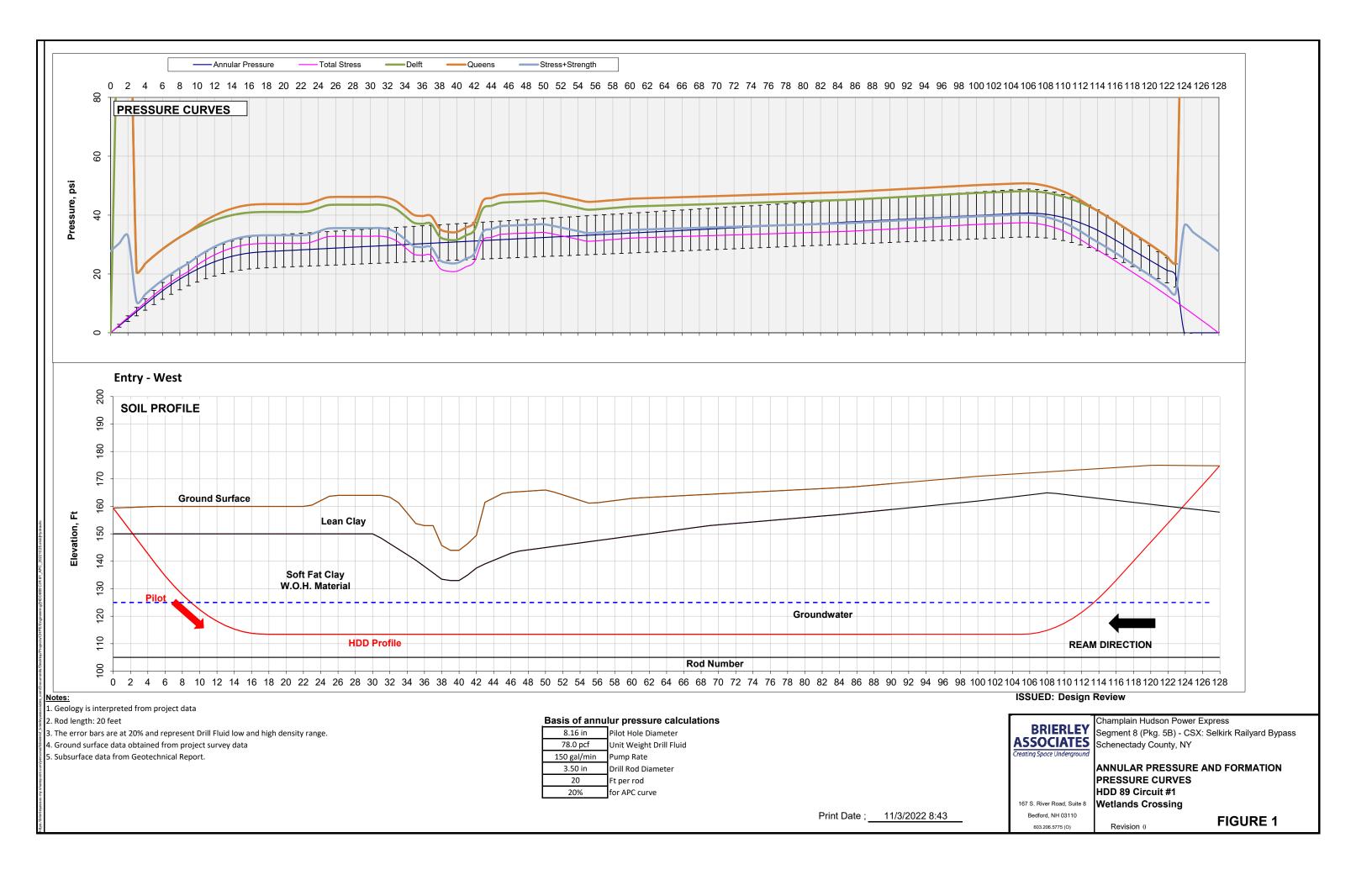


TABLE 4	Pg 3 of 3						
HDPE PROPERTIES	•	BRIERLEY					
Champlain Hudson Power Express		ASSOCIATES					
Segment 8 (Pkg. 5B) - CSX: Selkirk Rail	yard Bypass	Limited Liability Company					
Schenectady County, NY							
HDD 89 Circuit #1		"Creating Space Underground"					
Wetlands Crossing							
3. ASSESS ULTIMATE PULL STRENGTH (U	PS) AND SAFE	PULL STRENGTH (SPS)					
Source PPI PE Handbook Ch 12 Formula 17							
	, v						
Designed Pull Duration Time =	12 hr	Quantity of pipes, Q =1					
Yield Strength Factor, f_Y =	0.4	Recommended (FS = 2.5) Pull Temperature, F = 73 deg.					
Pull Time factor, f_T =		Plexco Engineering Manual Table 3.7					
Design Factor, DF = $f_T * f_Y$		FE PULL STRENTH, SPS = 1,703 lb					
Temperature factor, $f_{temp} =$	1	Jltimate Pull Strength, UPS = 4,257 lb					
Temp Corr Tensile Yield, Ty*f _{temp} =							
Safe Allowable Stress, SAS =		SAS = Ty*f _{temp} *DF Suggested SSAS = <mark>1,150 psi</mark>					
Safe Pull Strength, SPS Pipe =		Useing SSAS = 4,371 lb					
Sale Full Stieligth, SFS Fipe –	1,703 15						
Short Term Critical Unconstrained Buckling	Pcr reduced f	or pull tension, PCBB = PCB*f.					
(ASTM F-1962 EQ. 22)	,						
Pull Duration Time =	12 Hr	Pcr = 267.4 psi					
SAS =		Design Depth in DF, $H_{MDF} = 0.0$ ft					
Estimated Maximum Pull Stress, σ_i =	-	Design Assumption as Maximum					
	· · ·						
$fr = ((5.57 - (r+1.09)^2)^{5}) - 1.09 =$ $r = \sigma_i/2^*(SSAS) =$ $P_{CRR} =$ $FS =$ $P_{ACRR} = P_{CRR}/FS =$ Internal Ballasted and External Fluid 1 = (Internal Ballasted and External Fluid 2 = (Example from Table T5, $\sigma_i = 598$ psi					
$P_{CRR} =$	226.2 psi						
FS =	-						
$P_{ACRR} = P_{CRR}/FS =$	113.1 psi	Allowable Reduced Short Term Buckling pressure during pull					
Internal Ballasted and External Fluid 1 = (· · · · · · · · · · · · · · · · · · ·					
Internal Ballasted and External Fluid 2 = (
ASSESSMENT OF SAFE PULL STRENGTH							
ACCEPTIBLE Acceptible if differential pre	ssures > 0 for re	educed buckling capacity					
REFERENCE 1 - Plastic Pipe Institute - Handt	ook of PE Pipe	2nd Edition					
REFERENCE 2 - Plastic Pipe Institute - Handt							
Design Factor (fe) to apply	to HDB						
CHAPTER 6 - TABLE 1-2							
REFERENCE 3 - Plexco Engineering Manual	Book 3 Ch 3 Ta	ble 3.7					
Time factor for pull duration, f _T							
f _T Time factor for pull							
1.00 Up to 1 hour pull	1						
0.95 Up tp 12 hours pull	12 24						
	24						
ersona							
tt comit							
are point							
0.91 Up to 24 hours							
yassoc							
/bnere							

0#71 CIR #1_APC_20220729.xlsb]F1A APCL





- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 89 Circuit #2 Wetlands Crossing

ISSUE: Design Submittal

Contents:

Table 1	DESIGN SUMMARY, ASSUMPTIONS, CONDITIONS
Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

ntry Station														
	0+00.00	FT		*If no water or mudlin	e then use lowe	r of entry or exit eleval	tion							
Entry and Exit Design Co		FT		Wate	er Surface Elev.*	125.00 ft								
	ordinates & Ele East	evations (Ft) (Note 2) North	Elevation	Lowest	Mudline Elev.*	158.00 ft 113.60 ft								
Entry	674071.228000		159.70 ft	LOWEST	Centennie Liev.	113.00 ft								
Horizontal Curve PI	673242.167000	1352924.022000					SU	MMARY HORIZONTAI	-			-		
	671997.902000		175.00 ft		04-4	Start	N a statistica ar	End Station Easting Northing Azimuth Length Radius					Deditor	A
Depth to Mudline Measured Plan I	1.70 ft ength at ties =	Clearance Depth = 2555.3888 ft	44.40 ft	Tangent	Station 0+00.00	Easting 674071.2280	Northing 1352090.5020	Station 8+40.55	673478.4676			Length 840.55	Radius	Angle
	dinate Length =			Curve	8+40.55	673478.4676	1352686.4505	15+04.54	672941.3381	1353071.6030		663.99	2000.00	-19.022 deg
	OK-H	ORIZONTAL CURVE		Tangent	15+04.54	672941.3381	1353071.6030	671997.9020	1353534.4350	E 296.13170 N	1050.85			
HORIZONTAL PLAN CALCULATIONS (FT) Pull Geometry														
Entry Tangent Segment	_	Horizontal Curve Seg		Exit Tangent Segme	/		Pipe Entry	ENTRY	Inter the pipe er	ntry location into th				
Plan Length, ft.	840.55	Input Radius, ft.	2000.00	Plan Length, ft.	1050.85			Elevatio			Vertical Angle		Path	Curve
Entry Azimuth, deg.5		Curve, deg	-19.022 deg.	Exit Azimuth, deg.5			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad. ⁵	5.50047	Curve, rad	-0.33200	Exit Azimuth, rad. ⁵	5.16847		Entry Tangent	159.70 ft	139.82 ft	-12.00 deg	-12.00 deg	0.00 deg	95.60 ft	0.00 ft
Calculate PCH		Calculate PTH Chord Length, ft.	660.95	Calculate Exit Easting	671997.9020	Check	Entry Curve Bottom Tangent	139.82 ft 113.60 ft	113.60 ft 113.60 ft	-12.00 deg 0.00 deg	0.00 deg 0.00 deg	12.00 deg 0.00 deg	251.33 ft 1759.18 ft	1200.00 ft 0.00 ft
PCH Easting	673478.4676	Arc Length, ft.	663.99	Northing	1353534.4350	Delta	Exit Curve	113.60 ft	131.83 ft	0.00 deg	10.00 deg	10.00 deg	209.44 ft	1200.00 ft
PCH Northing	1352686.4505		305.6427	Ĵ		0.0000	Exit Tangent	131.83 ft	175.00 ft	10.00 deg	10.00 deg	0.00 deg	248.60 ft	0.00 ft
		PI Easting = PI Northing =	673242.1670 1352924.0220			0.0000 OK CALC		Compound Curve As			I	Total Check =	2564.15 ft	OK
		PTH Easting =	672941.3381			UK CALC		Start	Vert. Plan	Horiz. Plan	1			
									343.01	840.55				
		PTH Northing =	1353071.6030			Exit Station 25+55.39		Entry Exit	453.20	1050.85		> Entry V(Tan+ > Entry V(Tan+		
Cum Plan Length	840.55	Cum Plan Length	1504.54	Cum Plan Length	2555.388793			EXI	400.20	1000.00	110, 11012		ourvo)	
VERTICLE PATH	DESIGN		NO (ET)											
		UALUULAIIU	1N3 (FI)								Summary of D	rill Calculati	ons	
Entry Tangent Segment 1		Entry Vert. Curve Seg	. /	Middle Tangent Seg	ment 3	Exit Vert. Curve Seg	ment 4	Exit Tangent Segmen	t 5		Summary of D		ons tion Change =	15.30 ft
Entry Tangent Segment 1 Entry Angle	-12.000 deg.	Entry Vert. Curve Seg Vertical Radius	gment 2 1200.00	End Vert Angle	0.000 deg.	Radius	1200.00	Exit Elevation	175.00		Entr	y to Exit Eleva Minimum Desig	tion Change = gn Elevation =	113.60 ft
		Entry Vert. Curve Seg	gment 2 1200.00								Entr	y to Exit Eleva Minimum Desi Invert Dept	tion Change = gn Elevation = h below exit =	113.60 ft 61.40 ft
		Entry Vert. Curve Seg Vertical Radius	gment 2 1200.00 12.000 deg.	End Vert Angle	0.000 deg. NO	Radius	1200.00 10.000 deg.	Exit Elevation	175.00	SUMS	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation =	113.60 ft 61.40 ft 46.10 ft
Entry Angle Calculate Vertical PCV Plan Length	-12.000 deg. 93.515 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length	gment 2 1200.00 12.000 deg. V 249.494 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length	0.000 deg. NO CV 1,759.17716 ft	Radius Angle Change Calculate Vertical P Plan Length	1200.00 10.000 deg. TV 208.378 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	175.00 10.00 deg 244.825 ft	SUMS 2,555.389 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft
Entry Angle Calculate Vertical PCV Plan Length Rod Length	-12.000 deg. 93.515 ft 95.604 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1200.00 10.000 deg. TV 208.378 ft 209.440 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length	175.00 10.00 deg 244.825 ft 248.602 ft	SUMS 2,555.389 ft 2,564.150 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft
Entry Angle Calculate Vertical PCV Plan Length	-12.000 deg. 93.515 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length	gment 2 1200.00 12.000 deg. V 249.494 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length	0.000 deg. NO CV 1,759.17716 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1200.00 10.000 deg. TV 208.378 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	175.00 10.00 deg 244.825 ft	SUMS 2,555.389 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft
Entry Angle Calculate Vertical PCV Plan Length Rod Length	-12.000 deg. 93.515 ft 95.604 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft	SUMS 2,555.389 ft 2,564.150 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) = Entry Angle =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg
Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.600 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft 0.00000 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft 15.300 ft	SUMS 2,555.389 ft 2,564.150 ft	Entr	y to Exit Eleva Minimum Desig Invert Depi Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) = Entry Angle =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg
Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth Start Elevation	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft 159.700 ft	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	gment 2 1200.00 12.000 deg. V 249.494 ft -251.327 ft -26.223 ft 113.600 ft 139.823 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft 0.00000 ft 113.600 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft 113.600 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft	SUMS 2,555.389 ft 2,564.150 ft	Entr	y to Exit Eleva Vinimum Desi Invert Dept Invert Depth Plan Length (Compound Cu	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg 10.00 deg NO
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Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft 159.700 ft 139.823 ft -12.000 deg RVE CALCUL	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.600 ft 139.823 ft 113.600 ft 0.000 deg	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle	0.000 deg. NO CV 1,759.17716 ft 0.00000 ft 113.600 ft 113.600 ft 0.000 deg	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft 113.600 ft 131.831 ft 10.000 deg	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth CK Total Cum Depth Start Elevation Ck Exit Elevation Prop. Plan Length	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft 15.300 ft 131.831 ft 2555.388793	SUMS 2,555.389 ft 2,564.150 ft 15.300 ft Stationir	Entr Minimum ng Check	y to Exit Eleva Vinimum Desi Invert Dept Invert Depth Plan Length (Compound Cu	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg 10.00 deg NO
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Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth End Elevation End Vert Angle SUMMARY VERTICLE CU Start Station PVC Station Cum Plan Length Cum Rod Length	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft 139.823 ft -12.000 deg RVE CALCUL 0+00.00 0+93.51 93.51 95.60	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Elevation End Vert Angle TIONS Start Station PTV Station Curn Plan Length Curn Rod Length	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.600 ft 139.823 ft 113.600 deg 0.000 deg 0+93.51 343.01 343.01 346.93	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft 0.00000 ft 113.600 ft 113.600 ft 0.000 deg 3+43.01 21+02.19 ft 2106.11 ft -46.10 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft 131.831 ft 10.000 deg 21+02.19 23+10.56 2310.56 2315.55	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft 15.300 ft 131.831 ft 2555.388793 23+10.56 25+55.389 2555.39 2555.49	SUMS 2,555 389 ft 2,564.150 ft 15.300 ft Stationin OK STA Plan Leng OK CALC Elevation Cr OK CALC	Minimum Minimum Ig Check TIONING th Check ULATION ange Check	y to Exit Eleva Vinimum Desi Invert Dept Invert Depth Plan Length (Compound Cu	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = urve at Entry =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg 10.00 deg NO
Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE CU Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth VOTES: . Sign convention for angle	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft 139.823 ft -12.000 deg RVE CALCUL 0+00.00 0+93.51 93.51 93.60 -19.88 es - positive (+)	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.600 ft 139.823 ft 113.600 ft 0.000 deg 0+93.51 3+43.01 343.01 343.01 346.93 -46.10	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft 0.00000 ft 113.600 ft 113.600 ft 0.000 deg 3+43.01 21+02.19 ft 2106.11 ft -46.10 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft 131.831 ft 10.000 deg 21+02.19 23+10.56 2310.56 2315.55	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft 15.300 ft 131.831 ft 2555.388793 23+10.56 25+55.389 2555.39 2555.49	SUMS 2,555.389 ft 2,564.150 ft 15.300 ft Stationin OK STA Plan Leng OK CALC Elevation Ct OK CALC	Minimum Minimum Ing Check TIONING Ith Check ULATION Indicates inputs Indicates status or	y to Exit Eleva Minimum Desig Invert Depth Plan Length (Compound Cu Compound Cu	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Lurve at Exit =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg 10.00 deg NO
Entry Angle Calculate Vertical PCV Plan Length Rod Length Vertical Depth Start Elevation End Vert Angle SUMMARY VERTICLE CU Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for angle Due East is defined as 0	-12.000 deg. 93.515 ft 95.604 ft -19.877 ft 139.823 ft -12.000 deg RVE CALCUL 0+00.00 0+93.51 93.51 93.60 -19.88 es - positive (+)	Entry Vert. Curve Seg Vertical Radius Vert. Curve, deg. Calculate Vertical PT Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	gment 2 1200.00 12.000 deg. V 249.494 ft 251.327 ft -26.223 ft 113.600 ft 139.823 ft 113.600 ft 0.000 deg 0+93.51 3+43.01 343.01 343.01 346.93 -46.10	End Vert Angle Inclined Bottom Tan Calculate Vertical P Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO CV 1,759.17716 ft 1,759.17716 ft 0.00000 ft 113.600 ft 113.600 ft 0.000 deg 3+43.01 21+02.19 ft 2106.11 ft -46.10 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	1200.00 10.000 deg. TV 208.378 ft 209.440 ft 18.231 ft 113.600 ft 131.831 ft 10.000 deg 21+02.19 23+10.56 2310.56 2315.55 -27.8693	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Ck Exit Elevation Ck Exit Elevation Cum Plan Length Cum Plan Length Cum Rod Length Cum Depth	175.00 10.00 deg 244.825 ft 248.602 ft 43.169 ft 15.300 ft 131.831 ft 2555.388793 23+10.56 25+55.389 2555.39 2555.49	SUMS 2,555.389 ft 2,564.150 ft 15.300 ft Stationin OK STA Plan Leng OK CALC Elevation Ct OK CALC	Minimum Minimum Minimum TIONING th Check ULATION Indicates status on Design Review	y to Exit Eleva Minimum Desig Invert Depth Plan Length (Compound C Compound C	tion Change = gn Elevation = h below exit = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irve at Entry = Lurve at Exit =	113.60 ft 61.40 ft 46.10 ft 2,564.15 ft 2,555.39 ft 796.21 ft -12.00 deg NO
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Pull Geometry								Dine	Entry Leastion Drill	ENTDY				
Full Geometry								•	Entry Location - Drill					
				1	4	r		(schematic, t	o show definition of var	iables only)				
Lengths (Pat	h)	Angles		Radius, R	Pipe Exit	EI = 17	75.00 ft					Pipe E	ntry El =	159.70 ft
L1 = <mark>100.0 ft</mark>	Overbend	deg	radian	500.0 ft	. *								Ŕ	
L2 = 95.6 ft	α =	-12.0 °	-0.2094		β	F						A	↓ ^u	
L3 = 251.3 ft				1,200.0 ft	``			_				the second		
L4 = 1759.2 ft	χ=	- 0.0 °	0.0000		an a	<u>i</u> d	erenanan d	and the second	a da a a a a a a a a a a a a a a a a a		Ļ	5 -1		10000
L5 = 209.4 ft				1,200.0 ft			E				В			
L6 = 248.6 ft	β =	10.0 °	0.1745					_	D	C				
LT = 2664.1 ft										\neg		Over	pend	
INPUT: Assur	ned Friction Fa	actors				-	-L6	—— L5 —	-► <	 L3	L2 ►		L1 ——	-
μ _G	= 0.10	dry + roller	s			I	I		1	1 =0	I	I		I
μ	= 0.25	drill fluid in	hole						culated Pull Force				ASS	
μα		in hole no fl	uid		POINT	г Р	Pull Force, F_D	Max Tensile	ASSESS	Pull Force, F_B	Max Tensile	ASSESS	F _x <	SPS
INPUT: Assun	•	•				·	No Ballast	Stress, σ_T	$\sigma_{\rm T} < \sigma_{\rm PM}$	Ballasted Pipe	Stress, σ_T	$\sigma_T < \sigma_{PM}$	Air	Ballast
		Drill Fluid S	hear Str	ess	A		4,723 lb	196 psi	OK	4,723 lb	196 psi	OK	OK	OK
INPUT: Pipe F				٦	В		5,606 lb	141 psi	OK	5,688 lb	143 psi	OK	OK	OK
5	ial HDPE		IPS]	С		7,581 lb	223 psi	OK	6,696 lb	201 psi	OK	OK	OK
Safe Pull Max. Stress, σ		PPI Table 1		73Deg F	D		15,878 lb	401 psi	OK	14,993 lb	378 psi	OK	OK	OK
Pile/Bundle Diam. 14.25		PIPE/BUNE	JLE		E		20,305 lb	544 psi	OK	17,510 lb	474 psi	OK	OK	OK
Material Density					F	0500 5	23,744 lb	599 psi	OK	19,340 lb	488 psi	OK	OK	OK
Outside Diameter, D		Pipe or Bun			AS	SESS P	Pull Restricted	BUCKIING Ca	pacity, P_{PA} > ∆P invert	$P_{PA} = P_A F_R =$	90.45 psi	Balla		OK
Pipe Dry Weight, W _F		Pipe or Bun				м	lavimum tens	ilo stross duri	ing pullback = $\sigma_t = (F_T/\pi)$	+ (Dt))+E_D	/2R	No Ba PPI Ch 12		OK
Min. Wall Thickness,		- U		on pull stress	Calculated Material				•••••••••••••••••••••••••••••••••••••••		0D/211	FFI GII 12	Eq 10	
$DR = D_0 / t_{mir}$		D _{OD} Stress				Desigi				45,606 lb	SSPS = σ_{PM}	πD ² ((1/Γ		2 211
Avg. Inside Diameter, [Bundle Mul			4	All	owable Short		fe Pull Strength, SPS = strained Buckling, P _A =		$P_{A} = (2E_{T}/(1))$			
12 Hr Pullback Modulus, E		@1=	73 deg F	-					Stress Reduction, $F_R =$					•)
Poisson Ratio, µ Ovality Factor, f		2%	1				Maximum					1.03))	-1.05	
Buckling Safety, N		Z%	J					Maximum a	r = pplied pull Stress, σ _T =		From Pull Fo	orce Calcul	ations	
Hydrostatic Design Stress, HDS		HDB/2			B	allastad	May Differe		e on Pipe, ΔP_B invert =	4.81	psi (-) indica			zed
Pressure Rating, PR _{(80E}		1	SE-A-//D	PR-1) [F _⊤ =1]					e on Pipe, ΔP_u invert =		psi (-) indica	• •	•	
INPUT: Assun	,	-			Onbo	anasteu		Inter ressure	ο on ripe, Δi η invent =	24.00	p3i (-) indica	ies pipe is	pressuri	200
Ballast Dens		pcf	10113						Calculated Drill Hole	Diameter Assu	med for Calo	ulations		
Drill Fluid Dens		pcf	Estima	ted for pull					D _H =			Julutionio		
Drill fluid elevation, H _E	,	100	200	lou ioi puil					D ₀ <8" Use D _H =D ₀ +4"; 8'		I =1.5*D₀; D₀>2	4" Use D _µ =I	D₀+12"	
Ballast Water El., H _w									0 11 0 1	0 11	0.0		0	
Lowest Invert El., El _m					NO	TES ¹	- Calculations we	ere done in gene	ral accordance with ASTMF-	1962 as modified to	account for inve	t tangent sec	tion, indep	endent
Calculated Pipe and Flu		1				ve	ertical curves, an	d fluid drag. AS	TM applies hydrokinetic press	sure as shear per un	it pipe length rec	luiring a back	calculation	n to determine
•	Pressure Pipe	YES	3	1		ac	tual puil lorce ba	ased on average	pipe area.					
	neter Length, F								ISSUE	Design Revie	w			
	ection Area, A _W			-					BRIERLEY	Champlain Hudso		855		
2	ne Outside, V _{DC}			-					ASSOCIATES	Segment 8 (Pkg.	•		d Rynass	
5	ume Inside, V_{D}								Limited Liability Company	Schenectady Cou	,	in in in the ingen	u Dypuss	
	q _d =				(drog)				"Creating Space Underground"	Schenectady Cot	inty, NT			
				Drill Fluid (unit Comparison O	0,				Creating space onderground	TABLE 3 - PUL		ENT		
ASTM EQ 18: Hy		0.54 1	on		ing the obsi								ייים	
Calculated Buoyant For		A: E:-	lad	Pollostor	7									
0.0	Pipe Ground, w _a /w _{af} =	Air Fil 17.36 L		Ballasted	-				Brierley Associates	HDD 89 Circuit				
In Hole with Dri				42.80 Lb/LF	-				,	Wetlands Cros	Silly			
		-37.01 L	J/LF	-11.58 Lb/LF					167 S. River Road, Suite 8					
4									Bedford, NH 03110	Revision	U			

TABLE 4		Pg 1 of 3									
HDPE PROPERTIES	5	5			BRIERLEY						
Champlain Hudson Po		ss			ASSOCIATES						
Segment 8 (Pkg. 5B) -	-		Rynass		Limited Liability Company						
Schenectady County,		in nuinguru i	Jpace								
HDD 89 Circuit #2					"Creating Space Underground"						
Wetlands Crossing											
INPUTS											
Pipe Material Properties	5										
Sources: A	STM D3350	and Plastic Pip	e Institute Public	cations and as referenced							
Design Working Pres	1	250 psi			At high point						
Quantity of Pipes	-	1			0.1						
	Pipe Material	HDPE	INPUT RESIN N	MATERIAL: PE3408, PE3608, PE471	0						
ASTM D3350 Cell (h minimum PENT test of 10,000 hour							
	d Dimension	3	2 Soigh Toolin Wit		5						
Pipe measureme		IPS	IPS "Iron Pine S	Size" of DIPS "Ductile Iron Pipe Size"							
	inimum Wall	9									
	iameter, $D_o =$	3.500 in	Standard Manuf	facturer's Data Sheets							
Avg. Inside D		2.680 in		facturer's Data Sheets							
-	m Wall, t _{min} =	0.389 in	Standard Manuf	facturer's Data Sheets							
	n Area, A _w =	3.80093926	$A_W = \pi^* ((D_o/2)^2 -$	$((D_o-2t)/2)^2)$							
Unit OD Surface Area,		131.95 in^2/LF	$A_{OD} = 12^{*}\pi^{*}D_{OD}$								
Unit Outside V	olume, V _{Do} =	0.067 cf/LF	$V_{Do} = \pi^* (D_o/2)^2/2$	144							
Unit Inside V	/olume, V _{Di} =	0.039 cf/LF	$V_{Di} = \pi^* (D_i/2)^2/1$	44							
Design Factor fo Hydrostatic Design S Environmental Weig Tensile Y	HDB =	1,600 psi	Based on PPI P	ublication TR-4/2015 and ASTM 283	7						
Design Factor fo	or HDB, DF =	0.63	Based on PPI P	E Handbook 2nd ED Chapter 5							
Hydrostatic Design S		1008 psi	HDS = HDB*DF								
Environmental		1		se for pressure rating only							
	Density =	59.28 pcf		Average from WL Plastics WL122 fo	r PE4710						
Weig Tanaila M	ght Dry, W =	1.66	Lb/LF								
	ield, Ty psi =	1,120 psi Short Term	@73 [°] F Long Term	Minimum from ASTM D3350 determi	ined by ASTM D038						
	oration Time	10 hours	50 yrs								
Design Ten	nperature, °F	73 deg F	73 deg F	Assumed							
Desig	n Ovality, %	2%	2%	See Sheets 4 of 5 for design ovality							
Factor of	Safety, FS =	2.5	2.5	Industry Practice							
Modulus for given load		65,000 psi		Based on PPI Handbook Ch. 3 and WL F							
	on Ratio, υ = lity factor f _o =	0.45	0.45 0.6	WL118: Use 0.35 if load duration is l Reference 1: Based on Selected Des							
Temperatu	$r_{o} = 1$ interval to the fractor, $f_{t} = 1$	1.00	1.00	Source: WL Plastics WL118	Sign Ovality						
Project Fluids		1.00	1.00								
	Pipe Internal	Expected	Heavy External		Buoyant forces						
5	Ballast	Expected External Fluid	Fluid	Dry Weight Pipe on ground, W_P =	1.66 lb/ft From MFG. Data Sheet						
Fluids I	Fresh Water	Drill Fluid 1	Drill Fluid 2	Internal Ballast Weight, W _B =	2.44 lb/ft $W_B = V_{Di}^* \gamma_{INT}$						
	Ϋ́INT	YEXT1	ILA12	Expected Displaced Fluid Weight, W_{D1} =	5.21 lb/ft $W_{D1} = V_{Do} \gamma_{EXT1}$						
Density, $\gamma =$	62.4	78	80	Heavy Displaced Fluid Weight, W _{D2} =	5.35 lb/ft $W_{D2} = V_{Do} * \gamma_{EXT2}$						
Buoyar		l Fluid 1, B _{B1} =	-3.55 lb/ft	W _P -W _{D1}							
Buoyar		I Fluid 2, B _{B2} =	-3.69 lb/ft	W _P -W _{D2}							
Duovent		n ground, B _G =	4.10 lb/ft	W _P +W _B							
Buoyant		Fluid 1, BB _{B1} = Fluid 2, B _{BB2} =	-1.11 lb/ft	BG-W _{D1} BG-W _{D2}							
Buoyant	น มลแสรเชน ที่ไ	i iuiu ∠, D _{BB2} =	-1.24 lb/ft								

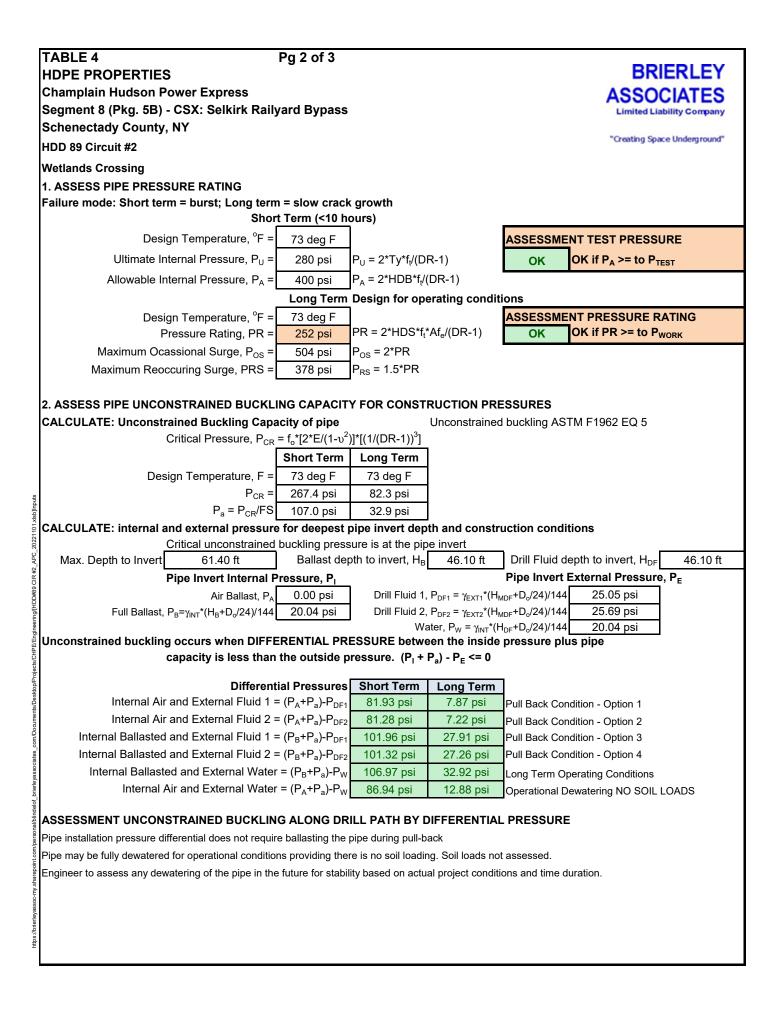
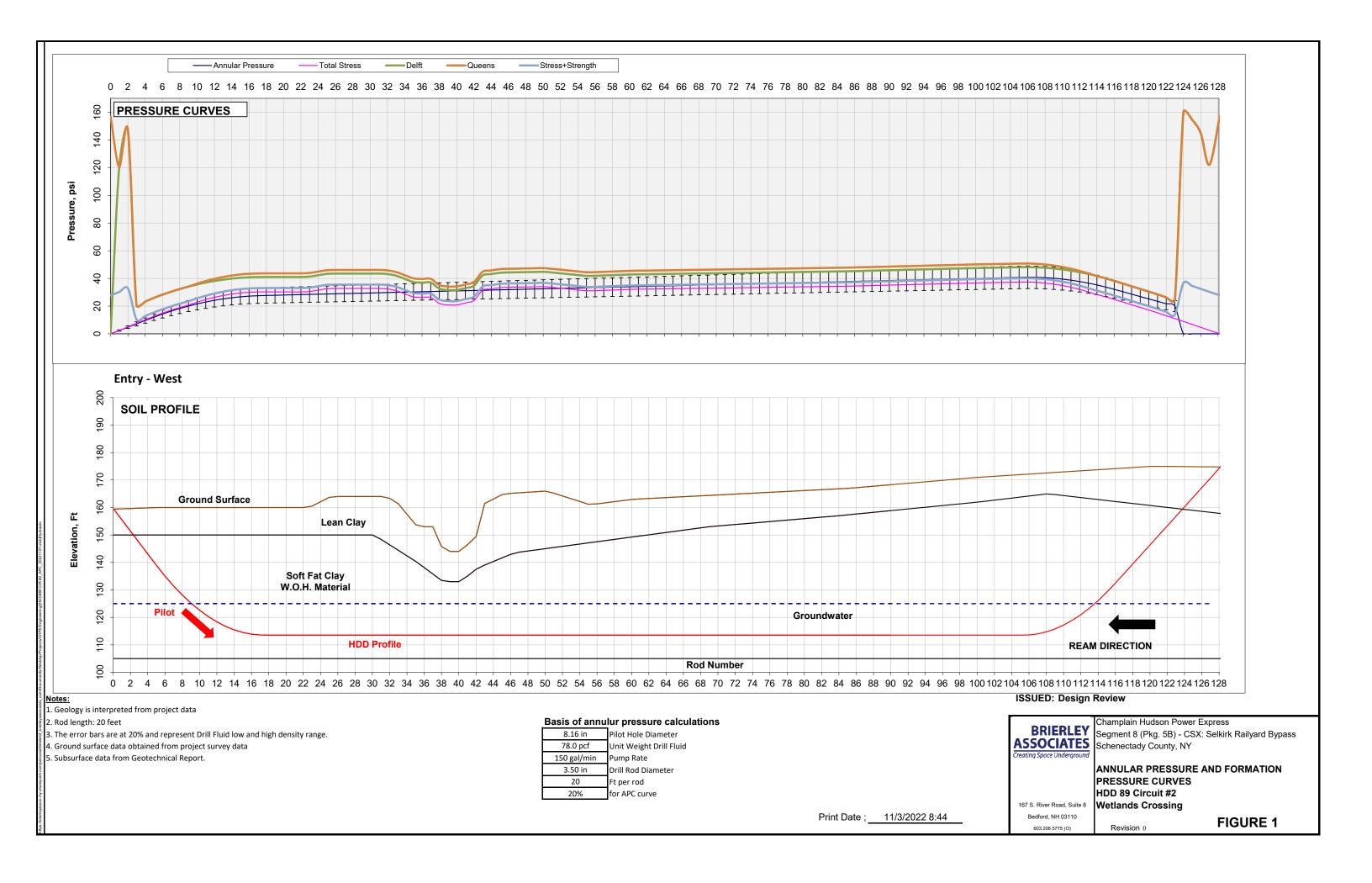


TABLE 4		Pg 3 of 3						
HDPE PROPERTIES	6	-		BRIERLEY				
Champlain Hudson P	ower Express			ASSOCIATES				
Segment 8 (Pkg. 5B)	- CSX: Selkirk Raily	ard Bypass		Limited Liability Company				
Schenectady County,	, NY							
HDD 89 Circuit #2				"Creating Space Underground"				
Wetlands Crossing								
3. ASSESS ULTIMATE F	PULL STRENGTH (U	PS) AND SAFE	PULL STRENG	TH (SPS)				
Source PPI PE Handboo								
		,	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,					
Designed	Pull Duration Time =	12 hr		Quantity of pipes, $Q = 1$				
Yield	d Strength Factor, f _Y =	0.4	Recommended ((FS = 2.5) Pull Temperature, F = 73 deg.				
	Pull Time factor, $f_T =$	1		ring Manual Table 3.7				
Des	sign Factor, DF = $f_T * f_Y$		_	NTH, SPS = 1,703 lb				
	perature factor, $f_{temp} =$	0.4						
	1		Jltimate Pull Stre	ngth, UPS = 4,257 lb				
	ensile Yield, Ty*f _{temp} = owable Stress, SAS =	1,120 psi	ςλς – Τν*f *Γ	DF Suggested SSAS = 1,150 psi				
			Useing SSAS =					
Sale Pull	Strength, SPS Pipe =	1,703 lb	Uselling 33A3 -	4,57110				
Short Term Critical Unc	onstrained Buckling	Per reduced f	or null tension	P = P*f				
(ASTM F-1962 EQ. 22)	onstrained Bucking			CRR - CR 'r				
(//01/11-1002 EQ. 22)	Pull Duration Time =	12 Hr	1	Pcr = 267.4 psi				
	SAS =		Design Depth ir					
Estimated Maxi	mum Pull Stress, σ _i =	· ·		tion as Maximum				
fr = (15, 57)	(r+1.09)^2)^.5)-1.09 =	0.84557	Design Assumpt					
	$r = \sigma_i / 2^* (SSAS) =$	0.26040	Exam	nple from Table T5, σ _i = 599 psi				
01.xist	$P_{CRR} =$	226.1 psi						
202211	FS =	-						
PPC	$P_{ACRR} = P_{CRR}/FS =$	113.1 psi	Allowable Reduc	ced Short Term Buckling pressure during pul				
Internal Ballasted ar	nd External Fluid 1 = (I	P _B +P _{ACRR})-P _{DF1}	108.06 psi	Pull Back Condition - C OK as >0				
Internal Ballasted ar	nd External Fluid 2 = (I	P _B +P _{ACRR})-P _{DF2}	107.42 psi	Pull Back Condition - C OK as >0				
ASSESSMENT OF SAFI								
ACCEPTIBLE Accer	otible if differential pres	ssures > 0 for re	educed buckling o	capacity				
	Pine Institute - Handh	ook of PE Pine	2nd Edition					
REFERENCE 2 - Plastic	•							
	n Factor (fe) to apply t							
CHAF	PTER 6 - TABLE 1-2							
REFERENCE 3 - Plexco		3ook 3 Ch 3 Tal	ble 3.7					
Time factor for pull durati			1					
f _T Time	factor for pull							
	1 hour pull	1						
	12 hours pull	12						
0.91 Up to	24 hours	24	l					
rsonaW								
ed/uuo								
ep oint:c								
0.91 Up to								
L-200								
rierleys								
ttps://b								
÷								

D#89 CIR #2_APC_20221101.xlsb]Inputs





- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 90 Circuit #1 Bridge Street
- ISSUE: Design Submittal

Contents:

Table 1	DESIGN SUMMARY, ASSUMPTIONS, CONDITIONS
Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

PATH DESIGN (LIUNG												
Entry Station Exit Station		FT			e then use lower or Surface Elev.*	of entry or exit eleva 152.00 ft	tion							
Entry and Exit Design Co				vv ale	Mudline Elev.*	152.00 ft								
	East	North	Elevation	Lowest	centerline Elev.	98.30 ft								
Entry			156.50 ft											
Horizontal Curve PI Exit			157.80 ft			Start	SU	IMARY HORIZONTAL CURVE CALCULATIONS						
Depth to Mudline		Clearance Depth =	57.70 ft		Station	Easting	Northing	Station	Easting	Northing	Azimuth	Length	Radius	Angle
	n Length at ties =			Tangent	0+00.00	675577.4160		4+75.64	675174.5232	1350925.2651	E 302.10765 N	475.64		3
Coo	ordinate Length =	1292.4478 ft ORIZONTAL CURVE		Curve	4+75.64 8+73.04	675174.5232		8+73.04	674878.6796	1351187.8806		397.40 419.40	1200.00	18.975 deg
	UK-H	URIZUNTAL CURVE		Tangent	0+73.04	674878.6796	1351187.8806	12+92.45	674615.2080	1351514.1970	E 321.08220 N	419.40		
HORIZONTAL PLAN CALCULATIONS (FT) Pull Geometry														
Entry Tangent Segment		Horizontal Curve Seg	ment	Exit Tangent Segme	nt		Pipe Entry	ENTRY	Enter the pipe er	ntry location into the	ne hole: Entry/Exit			
Plan Length, ft.		Input Radius, ft.	1200.00	Plan Length, ft.	419.40			Elevation			Vertical Angle		Path	Curve
Entry Azimuth, deg. ⁵			18.975 deg.	Exit Azimuth, deg. ⁵			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad. ⁵	5.27277	Curve, rad	0.33117	Exit Azimuth, rad. ⁵	5.60394		Entry Tangent	156.50 ft 128.00 ft	128.00 ft 98.30 ft	-14.00 deg	-14.00 deg	0.00 deg	117.79 ft 244.35 ft	0.00 ft 1000.00 ft
alculate PCH	•	Calculate PTH Chord Length, ft.	395.59	Calculate Exit Easting	674615.2080	Check	Entry Curve Bottom Tangent	98.30 ft	98.30 ft 98.30 ft	-14.00 deg 0.00 deg	0.00 deg 0.00 deg	14.00 deg 0.00 deg	244.35 ft 511.31 ft	0.00 ft
PCH Easting		Arc Length, ft.	397.40	Northing	1351514.1970	Delta	Exit Curve	98.30 ft	113.49 ft	0.00 deg	10.00 deg	10.00 deg	174.53 ft	1000.00 ft
PCH Northing	1350925.2651		311.5949			0.0000	Exit Tangent	113.49 ft	157.80 ft	10.00 deg	10.00 deg	0.00 deg	255.16 ft	0.00 ft
	I	PI Easting = PI Northing =	675004.6580 1351031.8530			0.0000 OK CALC		Compound Curve As	seesement		1	Fotal Check =	1303.13 ft	OK
	I	PTH Easting =	674878.6796			ORCALC		Start	Vert. Plan	Horiz. Plan	1			
	l	J. J							356.21	475.64				
	l	PTH Northing =	1351187.8806			Exit Station 12+92.45		Entry Exit	424.93	419.40		> Entry V(Tan+ z < Exit V(Tan+		
Cum Plan Length	475.64	Cum Plan Length	873.04	Cum Plan Length	1292.447788	OK STA		EXIL	424.93	419.40	Tes, Holl.		Curve	
										I				
VERTICLE PAT			· /								Summary of D			
Entry Tangent Segment Entry Angle		Entry Vert. Curve Seg Vertical Radius	gment 2 1000.00	Middle Tangent Segr End Vert Angle	0.000 deg.	Exit Vert. Curve Seg Radius	gment 4 1000.00	Exit Tangent Segme Exit Elevation	nt 5 157.80				tion Change = qn Elevation =	1.30 ft 98.30 ft
Entry Angle	-14.000 deg.	Vert. Curve, deg.		Inclined Bottom Tan	NO	Angle Change		Design Exit Angle	10.00 deg				th below exit =	59.50 ft
	l		, C			0 0	0		0			Invert Depth	below entry =	58.20 ft
alculate Vertical PCV	444.000 #	Calculate Vertical PT		Calculate Vertical Po		Calculate Vertical P		Calculate Exit	054 000 #	SUMS 1.292.448 ft			Path Length =	,
Plan Length Rod Length		Plan Length Arc Rod Length	241.922 ft 244.346 ft	Plan Length Rod Length	511.30585 ft 511.30585 ft	Plan Length Arc Rod Length	173.648 ft 174.533 ft	Plan Length Rod Length	251.282 ft 255.158 ft	1,292.446 ft 1,303.132 ft	Minimum		Plan Length = No Tangent) =	1,292.45 ft 781.14 ft
Vertical Depth		Curve Δ Vert Depth	-29.704 ft	Vertical Depth	0.00000 ft	Curve Δ Vert Depth			44.308 ft	1.300 ft			Entry Angle =	-14.00 deg
	l													-
	l		00 000 #			Laura de Elauration	00 000 #		4 000 #					40.00 de s
Start Elevation	156.500 ft	Lowest Elevation Start Elevation	98.300 ft 128.004 ft	Start Elevation	98.300 ft	Lowest Elevation Start Elevation		CK Total Cum Depth Start Elevation	1.300 ft 113.492 ft			Compound Cu	Exit Angle = urve at Entry =	10.00 deg NO
					98.300 ft	End Elevation			110.102.1				Curve at Exit =	768 ft
End Elevation	128.004 ft	End Elevation	98.300 ft	End Elevation	96.300 1	Ellu Elevation	113.492 ft	Ck Exit Elevation				eenipeana a		700 11
End Elevation End Vert Angle	-14.000 deg	End Vert Angle	98.300 ft 0.000 deg	End Elevation End Vert Angle	0.000 deg	End Vert Angle			1292.447788	.		1		700 11
End Elevation End Vert Angle UMMARY VERTICLE C	-14.000 deg	End Vert Angle	0.000 deg	End Vert Angle	0.000 deg	End Vert Angle	10.000 deg	Prop. Plan Length		Stationir				700 11
End Elevation End Vert Angle	-14.000 deg CURVE CALCULA 0+00.00	End Vert Angle ATIONS Start Station	0.000 deg 1+14.29	End Vert Angle Start Station	0.000 deg 3+56.21	End Vert Angle Start Station	10.000 deg 8+67.52	Prop. Plan Length Start Station	10+41.17	OK STA	TIONING			700 11
End Elevation End Vert Angle UMMARY VERTICLE C Start Station PVC Station Cum Plan Length	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length	0.000 deg 1+14.29 3+56.21 356.21	End Vert Angle Start Station PCV Station Cum Plan Length	0.000 deg 3+56.21 8+67.52 867.52 ft	End Vert Angle Start Station PTV Station Cum Plan Length	10.000 deg 8+67.52 10+41.17 1041.17	Prop. Plan Length Start Station Exit Station Cum Plan Length	10+41.17 12+92.448 1292.45	OK STA Plan Leng OK CALC	TIONING gth Check CULATION			700 11
End Elevation End Vert Angle UMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length	0.000 deg 1+14.29 3+56.21 356.21 362.14	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	10.000 deg 8+67.52 10+41.17 1041.17 1047.97	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Len OK CALC Elevation Cl	TIONING gth Check CULATION hange Check			700 11
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length	0.000 deg 1+14.29 3+56.21 356.21	End Vert Angle Start Station PCV Station Cum Plan Length	0.000 deg 3+56.21 8+67.52 867.52 ft	End Vert Angle Start Station PTV Station Cum Plan Length	10.000 deg 8+67.52 10+41.17 1041.17	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45	OK STA Plan Len OK CALC Elevation Cl	TIONING gth Check CULATION			705 11
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length	0.000 deg 1+14.29 3+56.21 356.21 362.14	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	10.000 deg 8+67.52 10+41.17 1041.17 1047.97	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Len OK CALC Elevation Cl	TIONING gth Check CULATION hange Check			705 11
End Elevation End Vert Angle UMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth OTES: Sign convention for ang	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+)	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	10.000 deg 8+67.52 10+41.17 1041.17 1047.97	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Leng OK CALC Elevation CI OK CALC	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or			705 11
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+)	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Leny OK CALC Elevation Cl OK CALC	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pr	h internal design	n checks	700 11
End Elevation End Vert Angle UMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth OTES: Sign convention for ang	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Leny OK CALC Elevation Cl OK CALC	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pr	h internal design	n checks	700 11
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45 1303.13	OK STA Plan Leny OK CALC Elevation Cl OK CALC	TIONING gth Check ULATION ULATION Indicates inputs Indicates status or Design Review	h internal design	n checks	700 IL
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg 3+56.21 8+67.52 867.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth EXIT b	10+41.17 12+92.448 1292.45 1303.13 1.30	OK STA Plan Len OK CALC Elevation CL OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) Schenectady County,	h internal design	n checks	700 K
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth NOTES: 1. Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth ENTRY	0.000 deg 3+56.21 8+67.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PDW On	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth	10+41.17 12+92.448 1292.45 1303.13 1.30	OK STA Plan Leny OK CALC Elevation Cl OK CALC	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) Schenectady County, TABLE 2	i internal design ower Express - CSX: Selkirk Ra NY	n checks ilyard Bypass	700 R
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth ENTRY	0.000 deg 3+56.21 8+67.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PDW Dm PTen	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078 NGTH	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth EXIT b EXIT EXIT TAN, L	10+41.17 12+92.448 1292.45 1303.13 1.30	OK STA Plan Len OK CALC Elevation CL OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) Schenectady County,	n internal design over Express - CSX: Selkirk Ra NY ATH CALCULA	n checks ilyard Bypass	700 R
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth ENTRY	0.000 deg 3+56.21 8+67.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PLAN LE PTen RVE, L2	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078 NGTH PCex • EXIT CU	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth EXIT b EXIT EXIT TAN, L	10+41.17 12+92.448 1292.45 1303.13 1.30	OK STA Plan Leny OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Lability Company "Creating Space Underground Brierley Associates	TIONING th Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson Pc Segment 8 (Pkg. 5B) Schenectady County, TABLE 2 DESIGN DRILL P/	n internal design over Express - CSX: Selkirk Ra NY ATH CALCULA	n checks ilyard Bypass	700 R
End Elevation End Vert Angle SUMMARY VERTICLE C Start Station PVC Station Cum Plan Length Cum Rod Length Cum Depth IOTES: . Sign convention for ang Due East is defined as	-14.000 deg CURVE CALCULA 0+00.00 1+14.29 114.29 117.79 -28.50 gles - positive (+) s 0 degrees.	End Vert Angle ATIONS Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth angles are countercloc	0.000 deg 1+14.29 3+56.21 356.21 362.14 -58.20	End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth ENTRY	0.000 deg 3+56.21 8+67.52 ft 873.44 ft -58.20 ft	End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LE PDW Dm PTen	10.000 deg 8+67.52 10+41.17 1041.17 1047.97 -43.0078 NGTH PCex • EXIT CU	Prop. Plan Length Start Station Exit Station Cum Plan Length Cum Rod Length Cum Depth EXIT b EXIT EXIT TAN, L	10+41.17 12+92.448 1292.45 1303.13 1.30	OK STA Plan Leny OK CALC Elevation Cl OK CALC ISSUE: BRIERLEY ASSOCIATES Limited Liability Company	TIONING gth Check ULATION ange Check ULATION Indicates inputs Indicates status or Design Review Champlain Hudson PC Schenectady County, TABLE 2 DESIGN DRILL P/ HDD 90 Circuit #1	n internal design ower Express - CSX: Selkirk Ra NY ATH CALCULA	n checks ilyard Bypass TION	TBD

Bull Coordination									Extended Ball					
Pull Geometry								•	Entry Location - Drill	ENTRY				
								(schematic, t	o show definition of var	iables only)				
Lengths (Path)	Δ	Angles		Radius, R	Pipe	Exit El =	157.80 ft					Pipe E	ntry El =	156.50 ft
L1 = <mark>100.0 ft</mark> Over	rbend	deg	radian	500.0 ft	_			-				,	1	
L2 = 117.8 ft	α=	-14.0 °	-0.2443		β 🦌 🔪							^ <u></u>	\mathbf{r}^{α}	
L3 = 244.3 ft				1,000.0 ft	· ·	à, ſ						A j	<u> </u>	· · · · · · · · · · · · · · · · · · ·
L4 = 511.3 ft	χ=	0.0 °	0.0000		59 59	کر است.	and the second second	and the second			<u> </u>	حًا.		and the second
L5 = 174.5 ft				1,000.0 ft							в			
L6 = 255.2 ft	β =	10.0 °	0.1745						P	0				
LT = 1403.1 ft												Overl	pend	
INPUT: Assumed Frict	tion Fac	tors											1	
		dry + rollers	5					20	- 4 L4	- - L3			- 1	-
	-	drill fluid in h	nole					Cal	culated Pull Force)			ASS	ESS
$\mu_{c} = 0.$.30 i	n hole no fli	uid			0.U.T	Pull Force, F _D			Pull Force, F _B	Max Tensile	ASSESS	F _x <	SPS
INPUT: Assumed Hyd	rokineti	c Drag			P	OINT	No Ballast	Stress, σ_T	$\sigma_{T} < \sigma_{PM}$	Ballasted Pipe	Stress, σ_T		Air	Ballast
$\tau_{\rm f} = 0.00$	5 psi	Drill Fluid Sl	hear Stre	ess		А	2,493 lb	140 psi	OK	2,493 lb	140 psi	OK	OK	OK
INPUT: Pipe Propertie	s					В	4,033 lb	102 psi	OK	4,035 lb	102 psi	OK	OK	OK
Material HDPE			IPS			С	5,760 lb	184 psi	OK	4,928 lb	163 psi	OK	OK	OK
Safe Pull Max. Stress, σ_{PM} 1,15	i0 psi 🛛 F	PPI Table 1	12hr @	73Deg F		D	7,513 lb	190 psi	OK	6,681 lb	169 psi	OK	OK	OK
Pile/Bundle Diam. 14.25 BUN	NDLE F	PIPE/BUND	DLE			Е	10,952 lb	315 psi	OK	8,524 lb	254 psi	OK	OK	OK
Material Density, γ 59.2	8 pcf					F	16,034 lb	404 psi	OK	10,930 lb	276 psi	OK	OK	OK
Outside Diameter, D _{OD} 14	.25 F	Pipe or Bun	dle			ASSESS	S Pull Restricted	d Buckling Ca	pacity, P_{PA} > ΔP invert	$P_{PA} = P_A F_R =$	96.48 psi	Balla	sted	OK
Pipe Dry Weight, $W_P = 17.3$	4 lb/ft F	Pipe or Bun	dle									No Ba	allast	OK
5	94 in 🛛 F	For design i	nstallatio	on pull stress					ing pullback = $\sigma_t = (F_T/\pi)$	$t_m(D_{OD}-t_m))+E_TD$	_{op} /2R	PPI Ch 12	2 Eq 16	
		D _{OD} Stress			Calculated Mate	erial Desi	ign Limits For	Designed Dr	ill Path					
Avg. Inside Diameter, D _{IA} BUN	NDLE E	Bundle Mult	iplier F_D	0.9042					fe Pull Strength, SPS =		SSPS = σ_{PM}			
12 Hr Pullback Modulus, $E_T = 65,00$	00 psi	@T =	73 deg F	:					strained Buckling, P _A =		$P_{A} = (2E_{T}/(1+$			I)
Poisson Ratio, $\mu = 0$.	.45						Maximum	12 hour Pull	Stress Reduction, F_R =	0.901892388	F _R = (5.57-(r	(+1.09) ²) ^{1/2}	-1.09	
Ovality Factor, $f_o = 0$.	.84	2%							r =		$r = \sigma_T/2SPS$			
	.5								pplied pull Stress, σ_T =		From Pull Fo	orce Calcul	ations	
		HDB/2							e on Pipe, ∆P_B invert =		psi (-) indica	•••	•	
				R-1) [F _T =1]		Unballast	ted Max. Differe	ntial Pressure	e on Pipe, ∆P_u invert =	31.80	psi (-) indica	tes pipe is	pressuri	zed
INPUT: Assumed Fluid	d Densit	ties/Elevati	ons											
		ocf							Calculated Drill Hole		med for Calc	culations		
		ocf	Estima	ted for pull					D _H =					
	.00 ft								D _O <8" Use D _H =D _O +4"; 8	' <d<sub>O<24" Use D_H=</d<sub>	:1.5*D _o ; D _o >24	4" Use D _H =I	D _o +12"	
	.00 ft						4.01.11			1000				
	30 ft					NOTES:	 Calculations we vertical curves, an 	ere done in gene d fluid drad. AS	ral accordance with ASTMF- TM applies hydrokinetic press	sure as shear per uni	account for inver it pipe length rec	rt tangent sec Juiring a back	calculation	endent 1 to determine
Calculated Pipe and Fluid Prope	rties			1			actual pull force ba					13		
Pressure		YES												
OD Perimeter Ler		44.77	in						ISSUE:	Design Revie	w			
Wall Section Ar		41.6874							BRIERLEY	Champlain Hudso	on Power Expr	ess		
Volume Outsid	le, V _{DO}	0.697 c	f/LF						ASSOCIATES	Segment 8 (Pkg.	5B) - CSX: Se	lkirk Railyar	d Bypass	
Volume Insi	de, V_{DI}	0.408 c	f/LF						Limited Liability Company	Schenectady Cou	inty, NY			
	q _d =	2.69 lk	o/ft	Drill Fluid (unit	drag)				"Creating Space Underground"					
ASTM EQ 18: Hydrokinetic	c, ∆T =	0.68 lb	o/ft	Comparison Or	nly @ 8psi					TABLE 3 - PUL	L ASSESSM	ENT		
Calculated Buoyant Forces	- E			-						ANTICIPATED	PULLING FO	ORCE - HD	PE PUL	L
	ipe	Air Fill	led	Ballasted]					HDD 90 Circuit				
On Ground, w	/ _a /w _{af} =	17.34 LI	b/LF	42.78 Lb/LF	1				Brierley Associates	Bridge Street				
In Hole with Drill Fluid, w	$v_{\rm b}/w_{\rm bf} =$	-37.03 L		-11.60 Lb/LF	1				167 S. River Road, Suite 8	-				
٠ 	Į				-				Bedford, NH 03110	Revision	0			

TABLE 4	Pg 1 of 3			
HDPE PROPERTIES	9.00			BRIERLEY
Champlain Hudson Power Expre	SS			ASSOCIATES
Segment 8 (Pkg. 5B) - CSX: Selki		Bvpass		Limited Liability Company
Schenectady County, NY		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
HDD 90 Circuit #1				"Creating Space Underground"
Bridge Street				
INPUTS				
Pipe Material Properties				
Sources: ASTM D3350	and Plastic Pip	e Institute Public	ations and as referenced	
Design Working Pressure, P _{WORK}	250 psi		Test Pressure, P _{TEST} 0 psig	At high point
Quantity of Pipes in Hole, Q =	1			
Pipe Material	HDPE	INPUT RESIN N	ATERIAL: PE3408, PE3608, PE4710)
ASTM D3350 Cell Classification			h minimum PENT test of 10,000 hours	
Standard Dimension	3	j		
Pipe measurement standard	IPS	IPS "Iron Pipe S	ize" of DIPS "Ductile Iron Pipe Size"	
DR = OD/Minimum Wall	9	1	•	
Outside Diameter, D _o =	3.500 in	Standard Manuf	acturer's Data Sheets	
Avg. Inside Diameter, D _i =	2.680 in	Standard Manuf	acturer's Data Sheets	
Minimum Wall, t _{min} =	0.389 in	Standard Manuf	acturer's Data Sheets	
Wall Section Area, A _w =	3.80093926	$A_W = \pi^* ((D_o/2)^2 -$	$((D_o-2t)/2)^2)$	
Unit OD Surface Area, in^2/LF , A_{OD} =	131.95 in^2/LF	$A_{OD} = 12^* \pi^* D_{OD}$		
Unit Outside Volume, V _{Do} =	0.067 cf/LF	$V_{Do} = \pi^* (D_o/2)^2/2$	144	
Unit Inside Volume, V _{Di} =	0.039 cf/LF	$V_{Di} = \pi^* (D_i/2)^2 / 1$	44	
HDB =	1,600 psi		ublication TR-4/2015 and ASTM 2837	
Unit Inside Volume, V _{Di} = HDB = Design Factor for HDB, DF = Hydrostatic Design Stress, HDS = Environmental Factor, Af _e = Density = Weight Dry, W = Tensile Yield, Ty psi = Load Duration	0.63		E Handbook 2nd ED Chapter 5	
Hydrostatic Design Stress, HDS = Environmental Factor, Af _e =	1008 psi	HDS = HDB*DF		
Density =	1 59.28 pcf		e for pressure rating only Average from WL Plastics WL122 for	DE4710
Weight Dry, W =	1.66	Lb/LF	Average from WE Flastics WE122 for	FE4710
Tensile Yield, Ty psi =		@73°F	Minimum from ASTM D3350 determir	ned by ASTM D638
		Long Term		
Duration Time	10 hours	50 yrs		
Design Temperature, °F	73 deg F	73 deg F	Assumed	
Duration Time Design Temperature, °F Design Ovality, % Factor of Safety, FS = Modulus for given load duration, E = Poisson Ratio, υ = Ovality factor f _o = Temperature factor, ft	2% 2.5	2% 2.5	See Sheets 4 of 5 for design ovality Industry Practice	
Modulus for given load duration, E =	65,000 psi	28,000 psi	Based on PPI Handbook Ch. 3 and WL PI	lastics WL118-0314
Poisson Ratio, υ =	0.45	0.45	WL118: Use 0.35 if load duration is le	
Ovality factor f _o =	0.84	0.6	Reference 1: Based on Selected Desi	ign Ovality
Temperature factor, f _t =	1.00	1.00	Source: WL Plastics WL118	
Project Fluids				
Pipe Internal	Expected	Heavy External		uoyant forces
Pipe Internal BallastFluidsFresh Waterγιντ γ_{INT} Density, $\gamma = 62.4$ Buoyant UnballastedBuoyant UnballastedBallasted of Ballasted of Buoyant Ballasted in Buoyant Ballasted in	External Fluid	Fluid Drill Fluid 2	Dry Weight Pipe on ground, W _P = Internal Ballast Weight, W _B =	1.66 lb/ft From MFG. Data Sheet
Fluids Fresh Water γ _{iντ}	Drill Fluid 1	Drill Fluid 2	Expected Displaced Fluid Weight, $W_{D1} =$	$\begin{array}{l} 2.44 \text{ Ib/ft} W_{\text{B}} = V_{\text{Di}}^{*} \gamma_{\text{INT}} \\ 5.21 \text{ Ib/ft} W_{\text{D1}} = V_{\text{Do}}^{*} \gamma_{\text{EXT1}} \end{array}$
Density, $\gamma = \frac{100}{62.4}$	γ _{EXT1} 78	γ _{EXT2} 80	Heavy Displaced Fluid Weight, W _{D2} =	5.35 lb/ft $W_{D2} = V_{D0} \gamma_{EXT2}$
Buoyant Unballasted	-	-3.55 lb/ft	W _P -W _{D1}	DZ DO JEXIZ
Buoyant Unballasted		-3.69 lb/ft	W _P -W _{D2}	
Ballasted o	n ground, B _G =		W _P +W _B	
Buoyant Ballasted in			BG-W _{D1}	
Buoyant Ballasted in	Fluid 2, B _{BB2} =	-1.24 lb/ft	BG-W _{D2}	

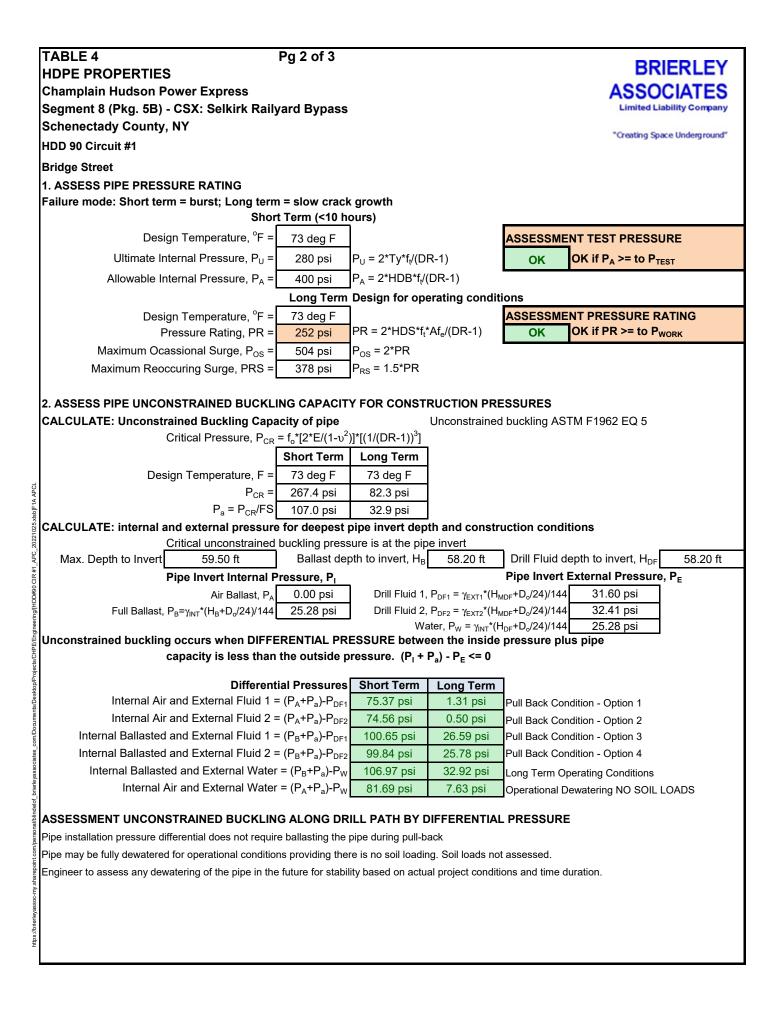
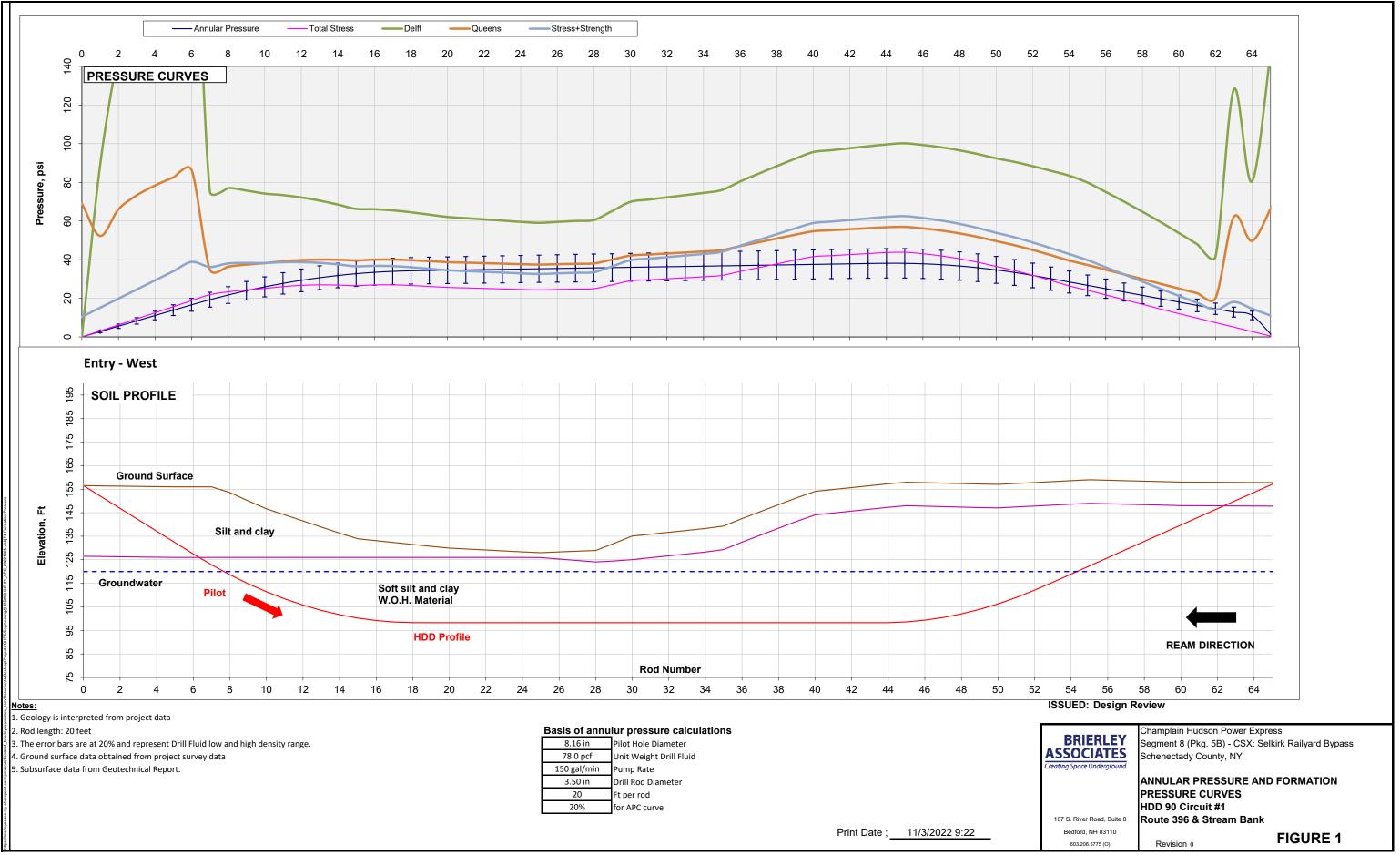


TABLE 4		Pg 3 of 3						
HDPE PROPERT		~		BRIERLEY				
Champlain Hudsor	ASSOCIATES							
-	B) - CSX: Selkirk Raily	ard Bypass		Limited Liability Company				
Schenectady Cour		,,,						
HDD 90 Circuit #1	, ,			"Creating Space Underground"				
Bridge Street								
-								
	E PULL STRENGTH (UF book Ch 12 Formula 17							
		3F3 – 11 DF (1	y) D ₀ ((1/DR)-(1					
Desig	ned Pull Duration Time =	12 hr]	Quantity of pipes, $Q = 1$				
T	ield Strength Factor, f _Y =	0.4		(FS = 2.5) Pull Temperature, F = 73 deg.				
	Pull Time factor, $f_T =$	1	-	ing Manual Table 3.7				
	Design Factor, DF = f _T *f _Y			NTH, SPS = 1,703 lb				
	emperature factor, f _{temp} =	1	Jltimate Pull Stre	ngth, UPS = 4,257 lb				
	r Tensile Yield, Ty*f _{temp} =	1,120 psi		-				
	Allowable Stress, SAS =	448 psi		DF Suggested SSAS = 1,150 psi				
Safe P	Pull Strength, SPS Pipe =	1,703 lb	Useing SSAS =	4,371 lb				
Ohart Tarra Oritiaal I	la constructive of Develotions	Den verdere erd f						
	Jnconstrained Buckling	Pcr reduced to	or pull tension,	$P_{CRR} = P_{CR} T_r$				
(ASTM F-1962 EQ. 22	,	40.11-	1					
	Pull Duration Time = SAS =	12 Hr	Design Depth ir	Pcr = 267.4 psi				
		448 psi						
	laximum Pull Stress, $\sigma_i =$	1,150 psi	Design Assumpt	ion as Maximum				
tr = ((5.: ≦	$57-(r+1.09)^{2}.5)-1.09 =$	0.90189	Evon	pole from Table T5 $\sigma = 404$ rej				
[5.xlsb]	$r = \sigma_i/2^*(SSAS) =$	0.17585						
022102	P _{CRR} = FS =	241.2 psi 2.0						
APC_2	P _{ACRR} = P _{CRR} /FS =							
Internal Ballasted	and External Fluid 1 = (F			Pull Back Condition - C OK as >0				
Internal Ballasted	d and External Fluid 2 = (F			Pull Back Condition - C OK as >0				
	AFE PULL STRENGTH							
ACCEPTIBLE AC	ceptible if differential pres	sures > 0 for re	educed buckling o	capacity				
D .								
	stic Pipe Institute - Handb stic Pipe Institute - Handb							
	esign Factor (fe) to apply t							
ČF	APTER 6 - TABLE 1-2							
REFERENCE 1 - Plas REFERENCE 2 - Plas De CH REFERENCE 3 - Ples Time factor for pull du	co Engineering Manual E	Book 3 Ch 3 Tal	ble 3.7					
Time factor for pull du			_					
	me factor for pull							
fT Tir 1.00 Up 0.955 Up 0.91 Up 0.91 Up	to 1 hour pull	1						
0.95 Up	tp 12 hours pull	12						
କୁ <u>0.91</u> Up	to 24 hours	24						
sonal/b								
un/per								
point.c								
/.share								
lu-co-								
erleyas								
µq//:sd								
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L								





- **PROJECT:**Champlain Hudson Power Express
Segment 8 (Pkg. 5B) CSX: Selkirk Railyard Bypass
Schenectady County, NY
- CROSSING: HDD 90 Circuit #2 Bridge Street
- ISSUE: Design Submittal

Contents:

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Table 2	DESIGN DRILL PATH CALCULATION
Table 3	ANTICIPATED PULLING FORCE - CONSTANT FORCE
Table 4	PLASTIC STRESS
Figure 1	APC AND FPC CURVES AND ASSUMED GEOLOGIC SECTION

Prepared For: Kiewit

Prepared By: Brierley Associates 167 S. River Road, Suite 8 Bedford, NH 03110 603.206.5775 (O)

Date	ID	DESCRIPTION	BY
11/2/2022	0	Design Submittal	ABL

Horizontal Curve PI 675025.8270	ons (Ft) (Note 2)	1											
Exit Station 12+88.59 FT Entry and Exit Design Coordinates & Elevation East Entry 675585.6770 Horizontal Curve PI 675025.8270					af and a submer and a subtraction of	1							
Entry and Exit Design Coordinates & Elevation East Entry 675585.6770 Horizontal Curve PI 675025.8270			*If no water or mudline then use lower of entry or exit elevation Water Surface Elev.* 152.00 ft										
Entry 675585.6770 Horizontal Curve PI 675025.8270	North E		Mudline Elev.* 158.00 ft										
Horizontal Curve PI 675025.8270		Elevation	Lowest centerline Elev. 105.40 ft										
		157.20 ft					MMARY HORIZONTA						
Exit 674628.6200	1351048.1650 1351530.0700 1	158.50 ft	r		Start	50	WIWART HURIZUNTA	E CURVE CALCO					
		52.60 ft	S	Station	Easting	Northing	Station	Easting	Northing	Azimuth	Length	Radius	Angle
	288.5925 ft	•	Tangent	0+00.00	675585.6770	1350685.5920	4+81.50	675181.5290	1350947.3284		481.50		
	288.5925 ft		Curve Tangent	4+81.50 8+49.59	675181.5290 674907.8409	1350947.3284 1351191.3097	8+49.59 12+88.59	674907.8409 674628.6200	1351191.3097 1351530.0700		368.09 439.00	1200.00	17.575 deg
OK-HORIZONTAL CURVE Tangent 8+49.59 674907.8409 1351191.3097 12+88.59 674628.6200 1351530.0700 E 320.50317 N 439.00													
HORIZO	CALCU	LATIONS (FT)						Pull Geom	etry				
	zontal Curve Segmen		Exit Tangent Segmer			Pipe Entry				he hole: Entry/Exit			
	Input Radius, ft.	1200.00	Plan Length, ft.	439.00			Elevatio			Vertical Angle		Path	Curve
Entry Azimuth, deg. ⁵ N 302.92811 E	. 0	17.575 deg.	Exit Azimuth, deg. ⁵			Segment	Start	End	Start	End	∆ Angle	Length	Radius
Entry Azimuth, rad. ⁵ 5.28709	Curve, rad	0.30674	Exit Azimuth, rad. ⁵	5.59384		Entry Tangent	157.20 ft 135.10 ft	135.10 ft 105.40 ft	-14.00 deg	-14.00 deg 0.00 deg	0.00 deg	91.33 ft 244.35 ft	0.00 ft 1000.00 ft
	ulate PTH Chord Length, ft.	366.65	Calculate Exit Easting	674628.6200	Check	Entry Curve Bottom Tangent	135.10 ft 105.40 ft	105.40 π 105.40 ft	-14.00 deg 0.00 deg	0.00 deg	14.00 deg 0.00 deg	244.35 ft 569.42 ft	0.00 ft
	Arc Length, ft.	368.09		1351530.0700	Delta	Exit Curve	105.40 ft	120.59 ft	0.00 deg	10.00 deg	10.00 deg	174.53 ft	1000.00 ft
PCH Northing 1350947.3284 Chord		311.7156	5		0.0000	Exit Tangent	120.59 ft	158.50 ft	10.00 deg	10.00 deg	0.00 deg	218.30 ft	0.00 ft
		675025.8270			0.0000					1	Fotal Check =	1297.93 ft	OK
		351048.1650 674907.8409			OK CALC		Compound Curve As Start	sessment Vert. Plan	Horiz. Plan	1			
	FIN Easing = 0	574907.8409					Siari						
P	PTH Northing = 13	351191.3097			Exit Station		Entry	330.54	481.50		> Entry V(Tan+		
Cum Plan Length 481.50 Cur	um Plan Length	849.59	Cum Plan Length	1288.592527	12+88.59 OK STA		Exit	388.63	439.00	No, Horiz	> Entry V(Tan+	Curve)	
	ani Fian Lengui	049.39		1200.392321	OKSTA								
VERTICLE PATH DESIGN CAL	LCULATIONS	6 (FT)								Summary of D	rill Calculati	ons	
	y Vert. Curve Segmer									Summary of Di		0110	
			Middle Tangent Segn		Exit Vert. Curve Seg		Exit Tangent Segme			Entr	y to Exit Eleva	tion Change =	1.30 ft
	Vertical Radius	1000.00	End Vert Angle	0.000 deg.	Radius	1000.00	Exit Elevation	158.50		Entr	y to Exit Eleva Minimum Desig	tion Change = gn Elevation =	105.40 ft
	Vertical Radius	1000.00								Entr	y to Exit Eleva Minimum Desig Invert Dept	tion Change = gn Elevation = h below exit =	105.40 ft 53.10 ft
Ve	Vertical Radius	1000.00 14.000 deg.	End Vert Angle	0.000 deg. NO	Radius	1000.00 10.000 deg.	Exit Elevation	158.50	SUMS	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation =	105.40 ft
Ve Calculate Vertical PCV Plan Length 88.621 ft	Vertical Radius /ert. Curve, deg.	1000.00 14.000 deg. 241.922 ft	End Vert Angle Inclined Bottom Tan	0.000 deg. NO V 569.41579 ft	Radius Angle Change Calculate Vertical P Plan Length	1000.00 10.000 deg. TV 173.648 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	158.50 10.00 deg 214.986 ft	SUMS 1,288.593 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry =	105.40 ft 53.10 ft 51.80 ft
Calculate Vertical PCV Calcul Plan Length 88.621 ft Rod Length 91.334 ft A	Vertical Radius 'ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length	1000.00 14.000 deg. 241.922 ft 244.346 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length	0.000 deg. NO \$V 569.41579 ft 569.41579 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1000.00 10.000 deg. TV 173.648 ft 174.533 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length	158.50 10.00 deg 214.986 ft 218.302 ft	SUMS 1,288.593 ft 1,297.931 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) =	105.40 ft 53.10 ft 51.80 ft 1,297.93 ft 1,288.59 ft 719.18 ft
Calculate Vertical PCV Calcul Plan Length 88.621 ft Rod Length 91.334 ft A	Vertical Radius 'ert. Curve, deg. ulate Vertical PTV Plan Length	1000.00 14.000 deg. 241.922 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length	0.000 deg. NO V 569.41579 ft	Radius Angle Change Calculate Vertical P Plan Length	1000.00 10.000 deg. TV 173.648 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length	158.50 10.00 deg 214.986 ft	SUMS 1,288.593 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length =	105.40 ft 53.10 ft 51.80 ft 1,297.93 ft 1,288.59 ft
Calculate Vertical PCV Calcul Plan Length 88.621 ft Rod Length 91.334 ft A	Vertical Radius 'ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length	1000.00 14.000 deg. 241.922 ft 244.346 ft	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length	0.000 deg. NO \$V 569.41579 ft 569.41579 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length	1000.00 10.000 deg. TV 173.648 ft 174.533 ft	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length	158.50 10.00 deg 214.986 ft 218.302 ft	SUMS 1,288.593 ft 1,297.931 ft	Entr	y to Exit Eleva Minimum Desig Invert Dept Invert Depth	tion Change = gn Elevation = h below exit = below entry = Path Length = Plan Length = No Tangent) =	105.40 ft 53.10 ft 51.80 ft 1,297.93 ft 1,288.59 ft 719.18 ft
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Calculate Vertical PCV Plan Length 88.621 ft Rod Length 91.334 ft Vertical Depth -22.096 ft Vertical Depth -22.096 ft Curve Start Elevation 157.200 ft End Elevation 157.200 ft End Vert Angle -14.000 deg ESUMMARY VERTICLE CURVE CALCULATIONS Start Station 0+00.00 PVC Station 0+88.62 Cum Plan Length 88.62 Cum Plan Length 88.62 Cum Rod Length 91.33 Cu Cum Depth -22.10 VOTES: 1. Sign convention for angles - positive (+) angles Due East is defined as 0 degrees.	Vertical Radius ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length ve ∆ Vert Depth owest Elevation End Elevation End Vert Angle IS Start Station PTV Station um Rod Length Cum Depth	1000.00 14.000 deg. 241.922 ft 244.346 ft -29.704 ft 105.400 ft 105.400 ft 0.000 deg 0+88.62 3+30.54 330.54 335.68 -51.80	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length Vertical Depth Start Elevation End Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO 569.41579 ft 569.41579 ft 0.00000 ft 105.400 ft 0.000 deg 3+30.54 8+99.96 899.96 ft 905.10 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length	1000.00 10.000 deg. TV 173.648 ft 174.533 ft 15.192 ft 105.400 ft 102.592 ft 10.000 deg 8+99.96 10+73.61 1073.61 1079.63 -36.6078	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Exit Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Rod Length	158.50 10.00 deg 214.986 ft 37.908 ft 1.300 ft 120.592 ft 1288.592527 10+73.61 12+88.59 1297.93 1288.59 1297.93 1.30	SUMS 1.288.593 ft 1.297.931 ft 1.300 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC	Indicates inputs Indicates status on Design Review Champlain Hudson Pc	y to Exit Eleva Minimum Desig Invert Depth Invert Depth Plan Length (Compound Cu Compound Cu Compound C	tion Change = gn Elevation = h below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = Irrve at Entry = Curve at Exit =	105.40 ft 53.10 ft 51.80 ft 1,297.93 ft 1,288.59 ft 719.18 ft -14.00 deg 10.00 deg
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Calculate Vertical PCV Plan Length 88.621 ft Rod Length 91.334 ft Vertical Depth -22.096 ft Curve Start Elevation 157.200 ft End Elevation 135.104 ft End Vert Angle -14.000 deg EUMMARY VERTICLE CURVE CALCULATIONS Start Station 0+00.00 PVC Station 0+88.62 Cum Plan Length 88.62 Cum Plan Length 91.33 Cu Cum Depth -22.10 NOTES: 1. Sign convention for angles - positive (+) angles Due East is defined as 0 degrees. 0 0	Vertical Radius ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length ve ∆ Vert Depth owest Elevation Start Elevation End Elevation End Vert Angle IS Start Station PTV Station um Rod Length Cum Depth es are counterclockwis	1000.00 14.000 deg. 241.922 ft 244.346 ft -29.704 ft 105.400 ft 105.400 ft 0.000 deg 0+88.62 3+30.54 330.54 335.68 -51.80	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length Vertical Depth Start Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO 569.41579 ft 569.41579 ft 0.00000 ft 105.400 ft 105.400 ft 0.000 deg 3+30.54 8+99.96 899.96 ft 905.10 ft -51.80 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation Start Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LEI	1000.00 10.000 deg. TV 173.648 ft 174.533 ft 105.400 ft 105.400 ft 105.400 ft 100.592 ft 10.000 deg 8+99.96 10+73.61 1073.61 1073.63 -36.6078	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Start Station Cum Plan Length Cum Rod Length Cum Depth EXIT	158.50 10.00 deg 214.986 ft 218.302 ft 37.908 ft 120.592 ft 1288.592527 10+73.61 12+88.593 1288.59 1297.93 1.30	SUMS 1,288,593 ft 1,297,931 ft 1.300 ft Stationir OK STA Plan Leng OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Elevation Cl OK CALC Stationir Company Stationir Company Stationir Company Stationir Stationir OK STA Plan Leng OK CALC Clevation Cl OK CALC Clevation Cl OK CALC Clevation Cl OK CALC Stationir Stationir Stationir Stationir Stationir Stationir Stationir Stationir Stationir Stationir Stationir OK CALC Clevation Cl OK CALC Clevation Clevation Clevation Stationir St	Entry Minimum Minimum Minimum Minimum Indicates status on Design Review Champlain Hudson Po Segment 8 (Pkg. 5B) - Schenectady County,	y to Exit Eleva Minimum Desig Invert Depth Invert Depth Plan Length (Compound Cu Compound C Compound C	tion Change = gn Elevation = h below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = irve at Entry = Curve at Exit =	105.40 ft 53.10 ft 1,297.93 ft 1,288.59 ft 719.18 ft -14.00 deg 10.00 deg
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Calculate Vertical PCV Plan Length 88.621 ft Rod Length 91.334 ft Vertical Depth -22.096 ft Curve Start Elevation 157.200 ft End Elevation 135.104 ft End Vert Angle -14.000 deg ESUMMARY VERTICLE CURVE CALCULATIONS Start Station 0+00.00 PVC Station 0+88.62 Cum Plan Length 88.62 Cum Plan Length 91.33 Cu Cum Depth -22.10 NOTES: 1. Sign convention for angles - positive (+) angless Due East is defined as 0 degrees. 0	Vertical Radius ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length ve ∆ Vert Depth owest Elevation Start Elevation End Elevation End Vert Angle IS Start Station PTV Station um Rod Length Cum Depth es are counterclockwis	1000.00 14.000 deg. 241.922 ft 244.346 ft -29.704 ft 105.400 ft 105.400 ft 0.000 deg 0+88.62 3+30.54 330.54 335.68 -51.80	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length Vertical Depth Start Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO 569.41579 ft 569.41579 ft 0.00000 ft 105.400 ft 105.400 ft 0.000 deg 3+30.54 8+99.96 899.96 ft 905.10 ft -51.80 ft	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LEI rDw PTen	1000.00 10.000 deg. TV 173.648 ft 174.533 ft 15.192 ft 105.400 ft 105.400 ft 102.592 ft 10.000 deg 8+99.96 10+73.61 1079.63 -36.6078 NGTH PT PCex ● EXIT CU	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Cum Plan Length Cum Plan Length Cum Rod Length Cum Depth EXIT EXIT TAN, L	158.50 10.00 deg 214.986 ft 218.302 ft 37.908 ft 120.592 ft 1288.592527 10+73.61 12+88.593 1288.59 1297.93 1.30	SUMS 1.288.593 ft 1.297.931 ft 1.300 ft Stationir OK STA Plan Leng OK CALC Elevation CF Elevation CF Elevation CF OK CALC Elevation CF Elevation CF SUE: BRIERLEY ASSOCIATES Limited Liability Company "Creating Space Underground"	Indicates inputs Indicates status on Design Review Champlain Hudson Pet Segment 8 (Pkg. SB) Schenectady County, TABLE 2 DESIGN DRILL PA	y to Exit Eleva Minimum Desig Invert Depth Invert Depth Plan Length (Compound Cu Compound Cu Cu Compound Cu Cu Cu Cu Cu Cu Cu Cu Cu Cu Cu Cu Cu C	tion Change = gn Elevation = h below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = irve at Entry = Curve at Exit =	105.40 ft 53.10 ft 1,297.93 ft 1,288.59 ft 719.18 ft -14.00 deg NO
Calculate Vertical PCV Plan Length 88.621 ft Rod Length 91.334 ft Vertical Depth -22.096 ft Curve Start Elevation 157.200 ft End Elevation 135.104 ft End Vert Angle -14.000 deg EUMMARY VERTICLE CURVE CALCULATIONS Start Station 0+00.00 PVC Station 0+88.62 Cum Plan Length 88.62 Cum Plan Length 91.33 Cu Cum Depth -22.10 VOTES: 1. Sign convention for angles - positive (+) angles Due East is defined as 0 degrees. 0	Vertical Radius ert. Curve, deg. ulate Vertical PTV Plan Length Arc Rod Length ve ∆ Vert Depth owest Elevation Start Elevation End Elevation End Vert Angle IS Start Station PTV Station um Rod Length Cum Depth es are counterclockwis	1000.00 14.000 deg. 241.922 ft 244.346 ft -29.704 ft 105.400 ft 105.400 ft 0.000 deg 0+88.62 3+30.54 330.54 335.68 -51.80	End Vert Angle Inclined Bottom Tan Calculate Vertical PC Plan Length Rod Length Vertical Depth Start Elevation End Vert Angle Start Station PCV Station Cum Plan Length Cum Rod Length Cum Depth	0.000 deg. NO 569.41579 ft 569.41579 ft 0.00000 ft 105.400 ft 105.400 ft 0.000 deg 3+30.54 8+99.96 ft 905.10 ft -51.80 ft 2 a	Radius Angle Change Calculate Vertical P Plan Length Arc Rod Length Curve ∆ Vert Depth Lowest Elevation End Elevation End Vert Angle Start Station PTV Station Cum Plan Length Cum Rod Length Cum Depth PLAN LEI	1000.00 10.000 deg. TV 173.648 ft 174.533 ft 15.192 ft 105.400 ft 105.400 ft 102.592 ft 10.000 deg 8+99.96 10+73.61 1079.63 -36.6078 NGTH PT PCex ● EXIT CU	Exit Elevation Design Exit Angle Calculate Exit Plan Length Rod Length Vertical Depth Start Elevation Ck Total Cum Depth Start Elevation Prop. Plan Length Cum Plan Length Cum Plan Length Cum Rod Length Cum Depth EXIT EXIT TAN, L	158.50 10.00 deg 214.986 ft 218.302 ft 37.908 ft 120.592 ft 1288.592527 10+73.61 12+88.593 1288.59 1297.93 1.30	SUMS 1,288.593 ft 1,297.931 ft 1.300 ft Stationir OK STA Plan Leng OK CALC Elevation CI OK CALC Elevation CI Elevation CI OK CALC Elevation CI Elevation CI OK CALC Values SUMS United Liability Company 'Creating Space Underground	Indicates inputs Indicates inputs Indicates status on Design Review Champlain Hudson PC Segment 8 (Pkg. 5B) - Schenectady County, TABLE 2 DESIGN DRILL P/ HDD 90 Circuit #2	y to Exit Eleva Minimum Desig Invert Depth Invert Depth Plan Length (Compound Cu Compound C Compound C	tion Change = gn Elevation = h below entry = Path Length = Plan Length = No Tangent) = Entry Angle = Exit Angle = irve at Entry = Curve at Exit =	105.40 ft 53.10 ft 1,297.93 ft 1,288.59 ft 719.18 ft -14.00 deg NO

								Extended Ball					
Pull Geometry							•	Entry Location - Drill		J			
				•			_(schematic, t	to show definition of var	iables only)				
Lengths (Path	ו)	Angles		Radius, R	Pipe Exit E	I = 158.50 ft					Pipe E	ntry El =	157.20 ft
L1 = <mark>100.0 ft</mark>	Overbend	deg	radian	500.0 ft	•						,	1	
L2 = 91.3 ft	α =	-14.0 °	-0.2443		β 7	F					۸ <u>ــــــــــــــــــــــــــــــــــــ</u>	γu	
L3 = 244.3 ft				1,000.0 ft	<u> </u>	1					-		
L4 = 569.4 ft	χ =	= 0.0 °	0.0000		يني. المحمدينية						i)		. 1994 - 1997
L5 = 174.5 ft				1,000.0 ft		E				В			
L6 = 218.3 ft	β =	10.0 °	0.1745				_	D	C				
LT = 1397.9 ft								O			Over	pend	
INPUT: Assumed Friction Factors					L6 -	L5		_ ⊳ ∢ _ 3 _	L2 ►	-	L1 ——	-	
μ _G	= 0.10	dry + roller	S										I
μ _b		drill fluid in	hole				Cal	culated Pull Force	9			ASS	ESS
μ _c	= 0.30	in hole no fl	luid		DOINT	Pull Force, F	Max Tensile		Pull Force, F _B	Max Tensile	ASSESS	F _x <	SPS
INPUT: Assum	ned Hydrokine	tic Drag			POINT	No Ballast	Stress, σ_T	$\sigma_{\rm T} < \sigma_{\rm PM}$	Ballasted Pipe	Stress, σ_T	$\sigma_T < \sigma_{PM}$	Air	Ballast
τ _f	= 0.005 psi	Drill Fluid S	hear Str	ess	A	2,246 lb	121 psi	OK	2,246 lb	121 psi	OK	OK	OK
INPUT: Pipe P	roperties	-			В	3,203 lb	89 psi	OK	3,204 lb	89 psi	OK	OK	OK
Materi	al HDPE		IPS]	С	4,632 lb	158 psi	OK	3,879 lb	137 psi	OK	OK	OK
Safe Pull Max. Stress, o	_{Рм} 1,150 psi	PPI Table 1	12hr @	73Deg F	D	6,555 lb	183 psi	OK	5,802 lb	162 psi	OK	OK	OK
Pile/Bundle Diam. 14.25	Pipe	PIPE/BUNE	DLE		E	9,581 lb	296 psi	OK	7,385 lb	235 psi	OK	OK	OK
Material Density	γ 59.28 pcf				F	12,951 lb	361 psi	OK	9,009 lb	251 psi	OK	OK	OK
Outside Diameter, D	DD 10.75	Pipe or Bun	ndle		ASS	ESS Pull Restricte	d Buckling Ca	apacity, P_{PA} > ∆P invert	$\mathbf{P}_{PA} = \mathbf{P}_{A}\mathbf{F}_{R} =$	97.74 psi	Balla	sted	OK
Pipe Dry Weight, W _P	= 15.68 lb/ft	Pipe or Bun	ndle								No Ba	allast	OK
Min. Wall Thickness,	t _m 1.194 in	For design	installati	on pull stress				s during pullback = $\sigma_t = (F_T/\pi t_m(D_{OD}-t_m))+E_T D_{OD}/2R$ PPI Ch 12 Eq 16					
$DR = D_0/t_{min}$	= 9	D _{OD} Stress	10.75	inches	Calculated Material	Design Limits For	[·] Designed Dr	rill Path					
Avg. Inside Diameter, D	0 _{IA} 8.22 in	Bundle Mul	tiplier F _D	1.0000			Sa	fe Pull Strength, SPS =	41,235 lb	SSPS = σ_{PM}	_I πD _{OD} ² ((1/Ε)R)-(1/DF	R ²))
12 Hr Pullback Modulus, E _T	= 65,000 psi	@T =	73 deg F	-				nstrained Buckling, P _A =		$P_{A} = (2E_{T}/(1))$			I)
Poisson Ratio, μ	= 0.45					Maximun	n 12 hour Pull	Stress Reduction, F_R =	0.913688705	F _R = (5.57-(r	+1.09) ²) ^{1/2}	-1.09	
Ovality Factor, f _o	= 0.84	2%					r = 0.157089241 r = σ _T /2SPS						
Buckling Safety, N	= 2.5						Maximum a	applied pull Stress, σ_{T} =	361 psi	From Pull Fo	orce Calcu	ations	
Hydrostatic Design Stress, HDS	= 1,008 psi	HDB/2			Ba	lasted Max. Differ	ential Pressur	e on Pipe, ∆P_B invert =	5.05	psi (-) indica	tes pipe is	pressuri	zed
Pressure Rating, PR(80F)	= 252 psi	PR = 2HDS	SF _T A _F /(D	0R-1) [F _T =1]	Unballasted Max. Differential Pressure on Pipe, ΔP_U invert = 25.24 psi (-) indicates pipe is pressurized							zed	
INPUT: Assum	ne <u>d Fluid Dens</u>	sities/Elevat	ions										
Ballast Densi		pcf						Calculated Drill Hole <u>Diameter Assumed</u> for Calculations					
Drill Fluid Densi	ty <mark>78</mark>	pcf	Estima	ted for pull				D _H =					
Drill fluid elevation, H _F	= 152.00 ft							D _O <8" Use D _H =D _O +4"; 8	" <d<sub>O<24" Use D_H:</d<sub>	=1.5*D _o ; D _o >2	4" Use D _H =l	D _o +12"	
Ballast Water El., H _w	= 152.00 ft												
Lowest Invert El., El _m	= 105.40 ft				NOT	ES: 1 - Calculations w	vere done in gene	eral accordance with ASTMF-	1962 as modified to	account for inver	rt tangent seo	tion, indep	endent
Calculated Pipe and Flui	d Properties					actual pull force b	•	TM applies hydrokinetic pres	sure as snear per un	it pipe length rec	quiring a back	calculation	to determine
	Pressure Pipe	YES	S]			5						
OD Perin	neter Length, F	33.77	' in					ISSUE:	Design Revie	w			
	ection Area, A _W							BRIERLEY	Champlain Huds		ess		
2	ne Outside, V _{DC}		:f/LF	-				ASSOCIATES	Segment 8 (Pkg.	5B) - CSX: Se	lkirk Railvar	d Bvpass	
	ume Inside, V _D							Limited Liability Company	Schenectady Cor				
	q _d =			Drill Fluid (unit	drag)			"Creating Space Underground"					
ASTM EQ 18: Hyd				Comparison O	0,			stating space onderground	TABLE 3 - PUL				
		0.00 1	6/1L		, @ 000				ANTICIPATED				
Calculated Buoyant Ford		Air Fil	lod	Ballasted	7				HDD 90 Circuit			FEFUL	-
0.0	round, w _a /w _{af} =				-			Brierley Associates	Bridge Street	. #∠			
In Hole with Dril				38.67 Lb/LF	-			,	Bridge Street				
		-33.48 L		-10.49 Lb/LF				167 S. River Road, Suite 8					
								Bedford, NH 03110	Revision	0			

TABLE 4		Pg 1 of 3						
HDPE PROPERTIES		. g			BRIERLEY			
Champlain Hudson Pov	ver Expre	ss			ASSOCIATES			
Segment 8 (Pkg. 5B) - C	-		Bypass		Limited Liability Company			
Schenectady County, N								
HDD 90 Circuit #2					"Creating Space Underground"			
Bridge Street								
INPUTS								
Pipe Material Properties								
Sources: AS	TM D3350	and Plastic Pip	e Institute Public	cations and as referenced				
Design Working Press	ure, P _{WORK}	250 psi		Test Pressure, P _{TEST} 0 psig	At high point			
Quantity of Pipes in Hole, $Q = 1$]			
	pe Material	HDPE	INPUT RESIN N	/ATERIAL: PE3408, PE3608, PE471	0			
ASTM D3350 Cell Cla				h minimum PENT test of 10,000 hou				
Standard [10	2 g		-			
Pipe measuremen		IPS	IPS "Iron Pipe S	size" of DIPS "Ductile Iron Pipe Size"				
DR = OD/Mini		9						
Outside Dian	meter, $D_o =$	10.750 in	Standard Manuf	acturer's Data Sheets				
Avg. Inside Dia	meter, D _i =	8.219 in	Standard Manuf	acturer's Data Sheets				
	Wall, t _{min} =	1.194 in		acturer's Data Sheets				
		35.85681985	$A_W = \pi^* ((D_o/2)^2 -$	$((D_o-2t)/2)^2)$				
Unit OD Surface Area, in ²	² /LF, A _{OD} =	405.27 in^2/LF	$A_{OD} = 12^* \pi^* D_{OD}$					
Unit Outside Volu	ume, V _{Do} =	0.630 cf/LF						
Unit Inside Vol	lume, V _{Di} =	0.368 cf/LF	$V_{Di} = \pi^* (D_i/2)^2/1$	44				
	HDB =	<u> </u>		ublication TR-4/2015 and ASTM 283	7			
Design Factor for I		0.63	Based on PPI PE Handbook 2nd ED Chapter 5					
Hydrostatic Design Stre		1008 psi	HDS = HDB*DF					
Environmental Fa				se for pressure rating only	- DE 1710			
Design Factor for I Hydrostatic Design Stre Environmental Fa Weigh Tensile Yiel Loa	Density = t Dry, W =	59.28 pcf 15.68	<mark>1.410 g/cc</mark> Lb/LF	Average from WL Plastics WL122 fo	n PE4710			
Tensile Yiel		1,120 psi	@73°F	Minimum from ASTM D3350 determ	ined by ASTM D638			
		Short Term	Long Term					
Dur	ation Time	10 hours	50 yrs					
Design Temp		73 deg F	73 deg F	Assumed				
E Design Factor of Sa	Ovality, % afety_FS =	<u>2%</u> 2.5	2% 2.5	See Sheets 4 of 5 for design ovality Industry Practice				
Dur Design Temp Design Factor of Sa Modulus for given load du Poisson Ovality Temperature		65,000 psi	28,000 psi	Based on PPI Handbook Ch. 3 and WL	Plastics WL118-0314			
Poisson	n Ratio, υ =	0.45	0.45	WL118: Use 0.35 if load duration is				
Ovality	/ factor f _o =	0.84	0.6	Reference 1: Based on Selected De	sign Ovality			
Temperature	e factor, f _t =	1.00	1.00					
Project Fluids								
Pi	pe Internal	Expected	Heavy External		Buoyant forces			
Pi Fluids Fro Density, γ = Buoyant b Buoyant B Buoyant B Buoyant B	Ballast esh Water	External Fluid	Fluid Drill Fluid 2	Dry Weight Pipe on ground, W _P = Internal Ballast Weight, W _B =				
Fluids Fro	esh Water	Drill Fluid 1	Drill Fluid 2	Expected Displaced Fluid Weight, $W_{D1} =$				
Density, γ =				Heavy Displaced Fluid Weight, W_{D2} =				
Buoyant		I Fluid 1, B _{B1} =	-33.48 lb/ft	W _P -W _{D1}	•••D2 •D0 [EX12			
Buoyant I		I Fluid 2, B_{B2} =	-34.74 lb/ft	W _P -W _{D2}				
E		n ground, $B_G =$	38.67 lb/ft	$\frac{W_{P}-W_{D2}}{W_{P}+W_{B}}$				
Buoyant Ba		Fluid 1, BB _{B1} =	-10.49 lb/ft					
Buoyant B	Ballasted in	Fluid 2, B _{BB2} =	-11.75 lb/ft	BG-W _{D2}				

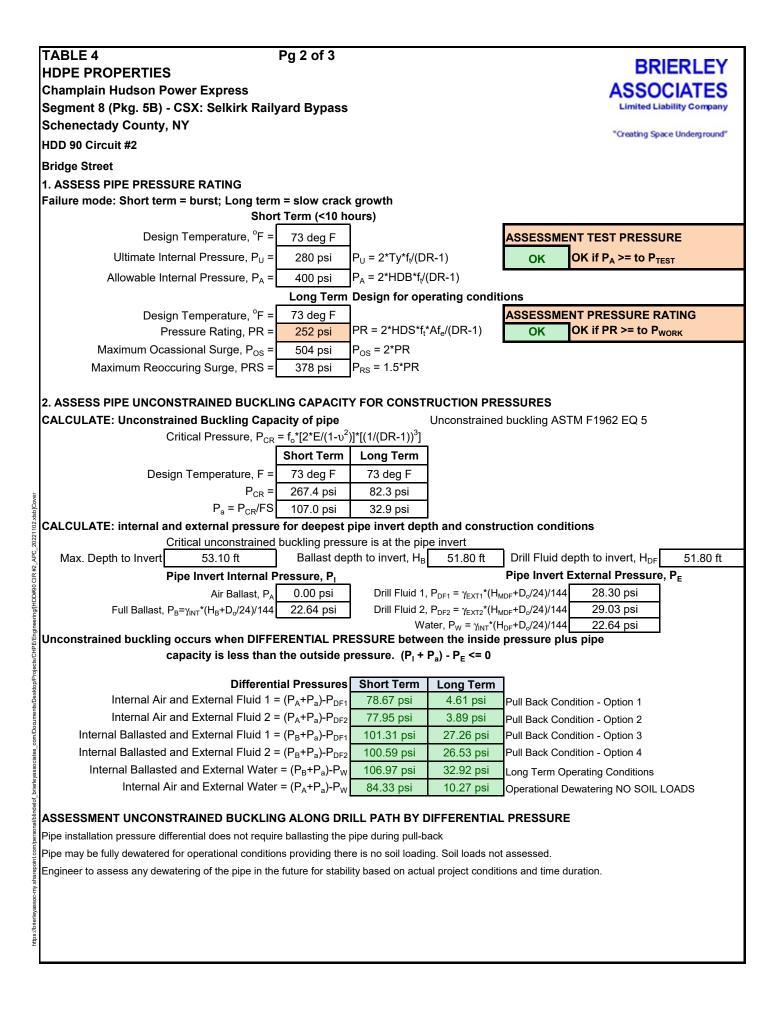


TABLE 4	Pg 3 of 3						
HDPE PROPERTIES	v	BRIERLEY					
Champlain Hudson Power Expr	ASSOCIATES						
Segment 8 (Pkg. 5B) - CSX: Sell		Limited Liability Company					
Schenectady County, NY	·						
HDD 90 Circuit #2		"Creating Space Underground"					
Bridge Street							
3. ASSESS ULTIMATE PULL STRENGTH (UPS) AND SAFE PULL STRENGTH (SPS) Source PPI PE Handbook Ch 12 Formula 17 SPS = $\pi^{+}DF^{+}(Ty)^{+}D_{0}^{-2*}((1/DR)-(1/DR^{2}))$							
Source PPI PE Handbook Cn 12 Forr	$\pi = \pi^{-1} D F^{-1}$	$y) D_0 ((1/DR) - (1/DR))$					
Designed Pull Duratio	n Time = <u>12 hr</u>	Quantity of pipes, $Q = 1$					
Yield Strength Fa	ictor, $f_{\rm Y} = 0.4$	Recommended (FS = 2.5) Pull Temperature, F = 73 deg.					
Pull Time fa		Plexco Engineering Manual Table 3.7					
Design Factor, I	$DF = f_T * f_Y = 0.4$	FE PULL STRENTH, SPS = 16,064 lb					
Temperature fact	or, f _{temp} = 1	JItimate Pull Strength, UPS = 40,160 lb					
Temp Corr Tensile Yield,	Ty*f _{temp} = 1,120 psi						
Safe Allowable Stres	s, SAS = 448 psi	SAS = Ty*f _{temp} *DF Suggested SSAS = <mark>1,150 psi</mark>					
Safe Pull Strength, SF	'S Pipe = 16,064 lb	Useing SSAS = 41,235 lb					
Short Term Critical Unconstrained	Buckling Pcr reduced f	or pull tension, P _{CRR} = P _{CR} *f _r					
(ASTM F-1962 EQ. 22)							
Pull Duratio	n Time = 12 Hr	Pcr = 267.4 psi					
	SAS = 448 psi	Design Depth in DF, H _{MDF} = 0.0 ft					
Estimated Maximum Pull St	ess, σ _i = <mark>1,150 psi</mark>	Design Assumption as Maximum					
ة fr = ((5.57-(r+1.09)^2)^.	5)-1.09 = 0.91369						
$r = \sigma_i/2^*$	SSAS) = 0.15709	Example from Table T5, $\sigma_i = 361 \text{ psi}$					
11022	P _{CRR} = 244.4 psi						
	FS = 2.0						
8	_{CRR} /FS = 122.2 psi	Allowable Reduced Short Term Buckling pressure during pull					
Internal Ballasted and External F							
Internal Ballasted and External F		• • • • • • • • • • • • • • • • • • •					
ACCEPTIBLE Acceptible if difference	ential pressures > 0 101 fe						
REFERENCE 1 - Plastic Pipe Institute	e - Handbook of PE Pipe	2nd Edition					
REFERENCE 2 - Plastic Pipe Institute	· - Handbook of PE Pipe	2nd Edition					
Design Factor (fe)							
CHAPTER 6 - TAI							
REFERENCE 1 - Plastic Pipe Institute REFERENCE 2 - Plastic Pipe Institute Design Factor (fe) CHAPTER 6 - TAI REFERENCE 3 - Plexco Engineering Time factor for pull duration, f _T	Manual Book 3 Ch 3 Ta	ble 3.7					
	. 1	1					
f _T Time factor for pul		4					
fT Time factor for pull 1.00 Up to 1 hour pull 0.955 Up tp 12 hours pul 0.91 Up to 24 hours	1						
0.95 Up tp 12 hours pu		4					
0.91 Up to 24 hours	24						
rsonaV							
ed/mo:							
ap oint.c							
y.shart							
E-005							
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