Inadvertent Release Contingency Plan For Horizontal Directional Drilling in Segment 3 - Package 2

Fort Edward to Kingsbury
Washington County, New York

CHA Project Number: 066076

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1.0 INTRODUCTION

CHA Consulting, Inc. (CHA) and the Kiewit Team, with the support of Boscardin Consulting Engineers (BCE), proposes to design and construct approximately 170horizontal directional drilling (HDD) crossings for a pair of HVDC electrical transmission cables (two crossings at 85 locations) plus a telecommunications line located in upland areas of the Hudson River Valley of New York for Segments 1 through 7 from Putnam Station to Schenectady, NY. Horizontal directional drilling (HDD) methods will be used to route the crossings below congested areas, railroads, under/around obstructions (e.g., existing infrastructure or utilities), and below wetlands and bodies of water. The portions of the cable between HDD bores will be installed in PVC conduits via trenching methods. The trenching construction is addressed in a separate report.

The underground construction of the two HVDC electrical transmission cables is proposed to be housed in individual 10-inch-diameter DR 9 HDPE conduits spaced a distance dependent on depth and soil thermal resistivity (TR) values provided by NKT and as shown on drawing plans (see Appendix B). A third, 2-inch-diameter DR 9 conduit will be bundled with one of the 10-inch-diameter conduits for a telecommunications line. Final conduit diameter and DR values will depend on length and depth of the HDD bores. Longer and deeper bores may require a larger diameter (i.e. 12-inch and 3-inch) HDPE conduits with larger DR values, thicker walls, (i.e. DR 7) to resist tension stresses during installation and collapsing long-term. The conduits are to be installed in 16-inch to 22-inch final reamed diameter bore holes. This is checked and determined on a case-by-case basis and design sizes are shown on the design drawings (see Appendix B).

This Inadvertent Release Contingency Plan (IRCP) is for Segment 3 - Package 2 which includes seventeen HDD crossings: HDD #9 through HDD #21A.

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

A primary potential environmental concern associated with HDD involves the inadvertent release of drilling fluids, also referred to as drilling mud, during the drilling process, which is addressed in this plan. 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 conduit 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; and
- 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 mitigation 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 Construction Subcontractor (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 HDD Subcontractor specific means and methods plan for each HDD crossing reaffirming and detailing how the HDD 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 HDD Subcontractor shall be consistent with the site conditions and constraints, and the HDD 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 within a designated work area. Typical work areas and equipment layouts are discussed in the Design Summary Report. However, final individual work areas and equipment layouts will be site specific and depend on the length of bore, size of drill rig to be used, and site constraints. 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 NSF certified 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 (formally National Sanitation Foundation) NSF certified additives are required by specification for use on this project and those planned for use by the HDD 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's 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 conduit 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. Final reaming or swabbing and conduit pull back may be combined.

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 the 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); and,
- Serve as a coolant and lubricant to the drill bit during the drilling process and serve as a lubricant during the conduit insertion process.

The drilling fluids are composed primarily of potable water, which will likely be obtained from nearby sources selected and permitted by the HDD 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 biodegrable) additives are required by specification for this project and before the start of work at a specific HDD, the HDD Subcontractor is required to submit for each crossing, environmental and toxicity data including Safety Data Sheets (SDS) for review and acceptance by the design team.

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, 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 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 lists 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
Certificate Holders	Name, Title TDI Phone Email
Construction Manager	TBD
HDD Design Engineer Team	TBD – contact
HDD Construction Subcontractor	 TBD
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	Matthew Smith Department of Public Service Empire State Plz 3 Albany, NY 12223 (518) 402-5141 matthew.smith@dps.ny.gov
New York State Department of Environmental Conservation	Regional Office(s) Information 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 Front End Engineering and Design (FEED) Design Engineer for the HDD Design is CHA and Kiewit in collaboration with BCE. During construction, the yet to be confirmed Design Engineer during construction will be responsible for reviewing and approving required Subcontractor submittals, shop drawings, and material certificates. Power Engineers 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 has yet to be confirmed. During construction, the chosen Third Party engineer will be assisting Transmission Developer Inc, with the review of the HDD Subcontractors Inadvertent Release Plan and providing 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 Subcontractors for the various HDD crossing 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 specific and means and methods specific HDD Subcontractors-prepared Inadvertent Release Prevention and Contingency Plans 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 HDD Subcontractor will be responsible for developing the specific lines of communication within their organization and shall dedicate a responsible person(s) for monitoring and 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 HDD 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 HDD 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 minimize the potential risk of an inadvertent release included conducting a geotechnical investigation at the site to develop an understanding of the ground around the Planned HDD bores. 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 or cement/bentonite grout, and located off the planned bore path, to limit the risk of a release through an abandoned bore hole during the HDD construction.

4.2 HDD DESIGN

Each HDD crossing is 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 break through to the water body, road, wetlands, or ground surface;
- Typically, potential exists for releases near the entry and exit pits of a 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;
- Specific provisions regarding exit pit design for underwater cable installation (i.e. via the use of temporary dredged cofferdams or steel conduit riser pipes for pressure relief);
- 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 larger slurry pressures to overcome flow resistance to carry cuttings back to the entry pit;
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, pile foundations, 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 drill steel;

- Requiring drilling fluid composition, flow rates, 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,
- Use of conductor casings/conduit at the entry and exit ends of bores when ability of the ground to provide sufficient confinement to resist the drilling slurry pressures is expected;
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- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling. And;
- Requiring that, during the performance of any HDD waterbody crossing, contractors monitor the use of NSF certified drilling slurry additives (Article VII: General Condition No. 114 [m]) 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 Region 5 Staff of details of the release and the course of action they recommend taking.

4.3 CONTINGENCY PLAN

As mentioned above, prior to construction the selected HDD 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 and to prevent inadvertent releases of drilling slurry;
- 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;
- 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 prevention and 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). The intended approach will 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, above ground 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. Example configurations are shown in Figures 1a-1c, final dimensions to be adjusted based on actual space available and constraints shown on the drawings for each HDD crossing.

4.4 Drilling Fluids Management

As described in the Project EM&CP document, drilling fluid (typically bentonite and water based with selected polymers/additives) will be 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 HDD subcontractor performing the HDD. However, the drilling fluid management system and subsequent disposal will adhere to the following requirements:

- Drilling fluid will be processed through an initial cleaning that separates the solid materials from the fluid;
- Heavy solids will be sifted out by a screening apparatus/system and the solids deposited into a roll-off or a dump truck and periodically transported off-site and disposed of at an approved disposal facility determined by the HDD construction subcontractor;
- All 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;
- Petroleum-based fluids and other potentially hazardous materials associated with drilling operations that are spilled during HDD construction 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 and included in the EM&CP;
- 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 down-hole 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 joints, solution features, or other subsurface fractures;
- Considerable differences in the elevations of HDD entry and exit points (typically greater than 50 feet);
- Disturbed soil, such as unconsolidated fill;
- Soft/weak soils with low overburden confining capacity;
- Low density soils in areas where the HDD bore is relatively shallow;
- Longer Bore alignments and,
- The presence of archeological or anthropogenic features such as, existing wells, piles and culverts, in close proximity to the HDD bore that may provide a preferential path for the drilling slurry to escape from the bore path.

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. They can promptly stop the drilling and modifythe drilling fluid composition, fluid 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:

- The loss of pressure within the drill hole utilizing a downhole pressure monitoring system;

- A large rapid buildup of pressure within the drill hole utilizing a downhole pressure monitoring system or at the drill rig;
- A substantial reduction in the volume of return fluid (loss of circulation); and
- The lack of drill cuttings returning in the drill fluid.

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 of the stream channel bottom and wetlands in the vicinity of the drill bit or reaming bit for signs of an inadvertent release. The Environmental Inspector will monitor the status of each HDD waterbody crossing while construction activities are underway until the crossing has been completed and the stream and stream banks have been restored. In the event of any potential or actual failure of the crossing, the Certificate Holders shall have engaged adequate staff, materials, and equipment 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.

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 and 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 release of drill fluid is a 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 immediately, then the Subcontractor can trip the drill steel back a selected distance and attempt to clear cuttings from the annulus to re-establish circulation.

The HDD Subcontractor will be required to contain/isolate and remove any fluid that has escaped to the ground or mudline 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 release is identified in an upland area, the Subcontractor will be required to respond immediately as described above to limit the extent 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 HDD Subcontractor will work together closely to determine the best course of action for inadvertent releases occurring within upland areas.

Upon containment of the release, the HDD 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 conduits 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 NSF certified and approved 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 HDD Subcontractor will be required to cease drilling operations and reduce pressures in borehole immediately, and notify the Environmental Inspector, the Railroad (if within railroad property), 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. Prior to construction, the HDD Subcontractor is required to develop a detailed, site-specific submittal for general in-stream or in-rail response methods and pre-place necessary materials and equipment at or near the site prior to construction. Specific response actions will be determined in consultation with the Environmental Inspector and HDD Subcontractor and could include the following:

- Shutting down or slowing the drill fluid pumps;
- Modifying the drill fluid properties, add agents to reduce drilling fluid pressures and/or to plug/seal release path;
- Tripping the drill steel back a selected distance and attempt to clear cuttings from the annulus to re-establish circulation
- 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 and,

- Implementation of proper in-wetlands and in upland, road and railroad, hand-placed sedimentation control measures including, but not limited to straw 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 HDD Subcontractor must abandon the drilled hole, a plan to fill the abandoned hole will be implemented as detailed in the HDD 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 HDD Subcontractor, Construction Manager, and the Design Engineer. The new alignment shall be offset from the abandoned hole by at least 10 feet (except at the ends where a 5- foot offset may be used) to help limit the risk of steering difficulties due to the presence of a hydraulic connection causing drill fluid loss to the abandoned hole.

9.0 CROSSING SPECIFIC DISCUSSION

9.1 HDD CROSSING #9

HDD #9 consists of two, straight (in plan view) HDD bores, each approximately 548 and 552 feet long as shown in Appendix B. The HDD bores will pass approximately 15 feet below the bottom of a 63” diameter culvert stream which feeds into the Champlain Canal. The approximate center of the HDD bores located under the culverts at latitude 43.4751°N and longitude -73.4298°W, in Putnam, NY. The ground surface elevations along the HDD path gently undulates between El. 122 and El. 125 (reference datum NAVD 1988).

The bores will have no horizontal curves. The vertical curves of the bore path are designed so that the bore will pass beneath N Old Route 4 and the culvert. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#9</u> - Based on borings drilled for this project, the soil profile for the HDD #9 BoreAid analysis was divided into five (5) layers: fill, loose to medium compact well graded sand, a shallow medium stiff fat clay, loose clayey sand and a deep very soft fat clay. The soil profiles used for BoreAid analyses of the HDDs in this segment are presented in Appendix A.

Specific design considerations for HDD #9 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depth of cover under the culvert is approximately 15 feet near the center of the bores. Preliminary analyses of the bore indicate the allowable lowest maximum allowable pressure capacity in the middle of the bore is to be approximately 42 psi. The total circulating pressure estimated to occur in the middle portion of the bore is approximately 17 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 59 psi and the approximate applied slurry pressure during drilling ranges from 0 to 19 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that there is a potential of inadvertent release at the ending 25 to 30 feet. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and

- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.
- In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.

9.2 HDD Crossing #10

HDD #10 consists of two, curved (in plan view) HDD bores located under the Old N Route 4 at the intersection of State Route 22. The bores are approximately 1210 and 1240 feet long as shown in Appendix B. The HDD bores will pass approximately 46 to 48 feet below the NY State Route 22 centerline. The horizonal alignment of HDD #10 will follow along the civil alignment path and curve across the intersection of NY State 22 and Old N Route 4 with a radius of approximately 2000'. The approximate center of the HDD bores under NY State 22 are at latitude 43.4569°N and longitude -73.4417°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #10 ranges from approximately El. 133 at the north end of the bore alignment, to approximately El. 152 at the centerline of NY State 22, to El. 136 at the south end of the bore alignment (reference datum NAVD 1988).

The bores will have both horizontal and vertical curves, but no segments of the bore path are designed with compound curves (segments with compound curves would have both horizontal and vertical curves). The design curves for both the horizontal and vertical paths of the alignment have a minimum radius of approximately 1000 to 2000 feet to limit steering issues in the soft soils at this site. No work is proposed within the water body and wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#10 - Based on the borings, the soil profile for the HDD #10 BoreAid analysis will be divided into four (4) layers: dense granular fill, medium stiff cohesive fill, soft low plasticity clay and loose well graded sand. The soil profiles used for BoreAid analyses of the HDDs in this segment are presented in Appendix A.

Specific design considerations for HDD #10 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the road intersection are 48 feet. Approximate depth of cover underneath the 40” culvert is 16 feet. Preliminary analyses of the bores indicate the lowest maximum allowable pressure capacity at the culvert crossing to be approximately 36 psi. The total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 25 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 105 psi and the approximate applied slurry pressure during drilling ranges from 0 to 32 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases in the starting 5 to 10 feet and ending 25 to 30 feet of each bore exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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 monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.3 HDD CROSSING #11

HDD#11 consists of two, curved (in plan view), HDD bores, approximately 1200 feet long, one on each side of S. Old Route 4 which is located on a narrow piece of land between Kelsey Pond and the Champlain Canal. The road in this area is curved and the bores are curved as well to follow the road. The bore on the west side of the road will be the 10-inch and 2-inch bundle passing approximately 55 feet (El. 74) below the surface of S Old Route 4 in Fort Ann, Washington County, New York. Due to the proximity of the bore (a single 10-inch conduit) on the east side of the road to the Champlain Canal, it will be approximately 40 feet (El. 88) below the road. The east bore was designed and analyzed based on the assumed mudline (approximately El. 100) due to the proximity of the bore to the canal. (This was done to reduce the potential for an inadvertent release to the Champlain Canal located 50 feet east of the east bore HDD bore with an estimated mudline at El. 100. The bores run from approximately latitude 43.4515°N and longitude 73.4455°W to latitude 43.4487°N and longitude 73.4476°W, see Appendix B. They are shown with both horizontal and vertical curves that will pass along the edges of footprint beneath S Old Route 4.

The bores will have both horizontal and vertical curves, but no segments of the bore path are designed with compound curves (segments with compound curves would have both horizontal and vertical curves). The design curves for both the horizontal and vertical paths of the alignment have a minimum radius of approximately 1000 to 2000 feet to limit steering issues in the soft soils at this site. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#11:</u> Based on the borings, the soil profile for the HDD #11 BoreAid analyses was divided into five (5) layers: medium-dense sand and gravel, loose silt, stiff clay, medium-dense sand, and rock (sandstone). The majority of the drill path appears to be through the layer of medium-dense sand. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 11 include:

- There appears to be shallow rock at the south end of the bore alignment, so the entry pits and entry work areas have been located at the south end of the alignment. It is generally preferable to exit from the rock to the soil in the middle of the bore to avoid steering and alignment problems. The rock to be encountered during the bore is expected to be very high strength and very high abrasivity. Please refer to the test data for boring K-117.6-2.3.
- Depth of cover during profile design (based on soil borings) to limit the potential

inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the S Old Route 4, along the canal, is 38 feet for the west bore and 40’ for the east bore near the centers of each path. The east bore is deeper to reduce the potential for releases to the Champlain Canal located approximately 50 feet east of the bore.

- Preliminary analyses of the west bore, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bore is approximately 98 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 36 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 106 psi and the approximate applied slurry pressure during drilling ranges from 0 to 45 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- Preliminary analyses of the east bore, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bore is approximately 49 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 36 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 64 psi and the approximate applied slurry pressure during drilling ranges from 0 to 44 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in attached Appendix A.

- It appears that a potential for releases in the starting 5 to 10 feet near the entry pit and ending 40 to 60 feet near the exit pit of the west bore exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- It appears that a potential for releases in the ending 100 to 110 feet near the exit pit of the east bore exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize

pressure build-up,

- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.4 HDD CROSSING #12

HDD #12 consists of two HDD bores located under the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 705 and 920 feet long as shown in Appendix B. The eastern born is extended longer than the western bore in order to avoid disturbance to the wetlands. The HDD bores will pass approximately 30 feet below the CP Railroad Canadian Mainline centerline. The approximate center of the HDD bores the under the CP Railroad are at latitude 43.4339°N and longitude -73.4575°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #12 ranges from approximately El. 132 at the west end of the bore alignment, to approximately Elevation 143 at the centerline of the CP Railroad, to El. 142 at the east end of the bore alignment (reference datum NAVD 1988). The proposed work at HDD #12 will be located underneath CP Railroad – Canadian Mainline, and the work on the eastern side of the bores are proposed adjacent to wetlands.

The bores will have no horizontal curves. The bore paths are designed so no work zone is proposed within water bodies or wetlands, but are adjacent to wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#12 - Based on borings drilled for this project, the soil profile for the HDD #12 BoreAid analysis was divided into two (2) layers: loose silty sand and sandstone. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Specific design considerations for HDD #12 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the CP Railroad CP Mainline is 32 feet for the west bore and 30 feet for the east bore near the centers of the bore paths. Preliminary analyses of the bore indicate that the lowest maximum allowable pressure capacity in the middle of the bores to be approximately 140 psi. The total circulating pressure estimated to occur in the middle portion of the bore is approximately 35 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 200 psi and the approximate applied slurry pressure during drilling ranges from 0 to 36 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.

- It appears that a potential for releases in the starting 10 to 20 feet and ending 60 to 80 feet of each bore near entry and exit pits exists. These should be relatively easy to control through the use of conductive conduits, strawbales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.5 HDD CROSSING #12A

HDD #12A consists of two HDD bores located underneath a 60” culvert and an existing tight rock face. The bores are approximately 1492 feet long as shown in Appendix B. The bores cross underneath the rock face with approximately 35 to 43 feet depth and underneath the culvert with a 22 foot clearance. The approximate centers of the bores are at latitude 43.4304°N and longitude

-73.4641°W, in Fort Ann, NY. The ground surface elevations vary between greatly between El. 161 and El. 130 (which is at the culvert crossing with an approximate invert of El. 125) (reference datum NAVD 1988).

The proposed work at HDD #12A is located to the west of CP Rail railroad tracks. No work is proposed within water bodies or wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#12A</u> - Based on borings drilled for this project, the soil profile for the HDD #12A BoreAid analysis was divided into two (2) layers: poorly graded sand and sandstone. The existing boring drilled in this area does not reach the depth of the designed bore paths. The sandstone was assumed to continue through the depth of the HDD paths. We recommend the HDD subcontractor drill a test boring at the start of construction at the HDD 12A site before starting the HDD to confirm the ground conditions through the depth of the bore. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Specific design considerations for HDD #12A include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the culvert is approximately 22 feet. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 125 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 35 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 195 psi and the approximate applied slurry pressure during drilling ranges from 0 to 45 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases in the starting 15 to 30 feet and ending 30 to 60 feet of each bore near entry and exit pits exists. These should be relatively easy to control through the use of conductive conduits, strawbales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities,

and other obstacles,

- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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 monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling, and
- The use of conductor casings, temporary steel casing approximately 30 inches diameter at each end of each bore to contain drilling fluids during drilling reaming and pullback.

9.6 HDD CROSSING #13

HDD #13 consists of two curved (in plan view) HDD bores located near the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 1513 and 1525 feet long as shown in Appendix B. HDD bores will pass approximately 19 to 20 feet below the existing 12.5'x10.4' storm culvert's invert. The approximate center of the HDD bores the under the CP Railroad are at latitude 43.4241°N and longitude -73.4813°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #13 ranges from approximately El. 134 at the east end of the bore alignment, to approximately El. 123 at and the water way and culvert, to El. 132 at the west end of the bore alignment (reference datum NAVD 1988).

The design curves for the vertical path of the alignment have a minimum radius of approximately 1000 feet to limit steering issues in the soft soils at this site. The proposed work at HDD #13 will be located underneath a water way at the existing 12.5'x10.4' Box Culvert. Portions of the work zones on both side of the bores are proposed to minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#13</u> - Based on borings drilled for this project, the soil profile for the HDD #13 BoreAid analysis was divided into two (2) layers: loose silty sand and medium dense poorly graded sand. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Specific design considerations for HDD #13 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the water way at the 12.5 x 10.4' concrete box culvert is 35 feet near the centers of the bore paths. Preliminary analyses of the bore indicate that the lowest maximum allowable pressure capacity in the middle of the bore to be approximately 90 psi. The total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 39 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 119 psi and the approximate applied slurry pressure during drilling ranges from 0 to 48 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting 5 to 10 and ending 20 to 30 feet of each bore near the entry and exit pit exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and

- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.7 HDD CROSSING #13A

HDD #13A consists of two straight (in plan view) HDD bores located under a CP Rail railroad bridge over an arm of the Champlain Canal in Fort Ann, NY. The bores are approximately 925 feet as shown in Appendix B. The HDD bores will pass approximately 40 feet below the estimated mudline (assuming a 5' water depth) and 27 to 28 feet below the bridge wall abutments based on available as-builts. The approximate center of the HDD bores the under the CP Railroad are at latitude 43.4166°N and longitude -73.4850°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #13A gently undulates from approximately El. 138 to El. 132 aside from the dip to the water level which is at approximately El. 124 (reference datum NAVD 1988).

The design curves for the vertical path of the alignment have a minimum radius of approximately 1000 feet to limit steering issues in the soft soils at this site. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#13A– Based on borings drilled for this project, the soil profile for the HDD #13A BoreAid analysis was divided into five (5) layers: loose fill, loose low plasticity silt, very soft low plasticity clay, loose poorly graded sand, and very soft low plasticity clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Specific design considerations for HDD #13A include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the estimated mudline (assuming a 5 foot water depth) are approximately 40 feet with a 27 to 28 foot clearance underneath the bridge abutment walls based on available as-builts. Preliminary analyses of the bore indicate that the lowest maximum allowable pressure capacity in the middle of the bore to be approximately 41 psi. The total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 37 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 62 psi and the approximate applied slurry pressure during drilling ranges from 0 to 40 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.

- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.8 HDD CROSSING #14

HDD #14 consists of two HDD bores located under the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 705 and 819 feet long as shown in Appendix B. The HDD bores will pass approximately 27 to 28 feet below the bottom of the CP Rail Canadian Mainline centerline and an at-grade road crossing (Ann St). The approximate center of the HDD bores the under the CP Railroad are at latitude 43.4138°N and longitude -73.4858°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #14 gently undulates from approximately El. 126 (at the entry) to El. 136 (at the exit) (reference datum NAVD 1988). Portions of the work zones on both side of the bores are proposed to minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#14 - Based on borings drilled for this project, the soil profile for the HDD #14 BoreAid analysis was divided into seven (7) layers: medium dense fill, medium stiff clayey silt, loose silty sand, medium stiff low plasticity clay, loose poorly graded sand, very soft fat clay, medium stiff clayey silt. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Specific design considerations for HDD #14 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the CP Railroad centerline the is 27 to 28 feet near the centers of the bore paths. Preliminary analyses of the bores indicate the lowest maximum allowable pressure capacity at the culvert crossing to be approximately 65 psi. The total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 20 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 66 psi and the approximate applied slurry pressure during drilling ranges from 0 to 26 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting and ending 0 to 40 feet of each bore near the exit pit exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.9 HDD CROSSING #14A

HDD #14A consists of two HDD bores located under the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 612 feet long as shown in Appendix B. The HDD bores will pass approximately 28 feet below the bottom of the CP Rail Canadian Mainline centerline. The approximate center of the HDD bores the under the CP Railroad are at latitude 43.4032°N and longitude -73.4863°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #14A gently undulates between approximately El. 136 and El. 139 (reference datum NAVD 1988).

Portions of the work zones on the north end of the bores are proposed adjacent to wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#14A</u>- Based on borings drilled for this project, the soil profile for the HDD #14A BoreAid analysis was divided into two (2) layers: loose fill and soft to stiff fat clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 14A include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under CP Rail railroad tracks are approximately 30 feet near the centers of the bore paths. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 60 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 20 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 61 psi and the approximate applied slurry pressure during drilling ranges from 0 to 23 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for release is within 5 to 10 feet of the entry pit.. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:

    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.10 HDD CROSSING #15

HDD #15 consists of two HDD bores located to the west side of and parallel to the CP Railroad Canadian Mainline tracks, west of the Champlain Canal. The bores are approximately 624 and 627feet long as shown in Appendix B. The HDD bores will pass approximately 17 to 18 feet below the estimated mudline (based on an assumed 5' water depth) of the existing waterbody related to an 8' reinforced concrete pipe (RCP) culvert which crosses underneath the tracks at this location. The approximate center of the HDD bores is located under an estimated mudline at latitude 43.3798°N and longitude -73.4896°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #15 gently undulates between El. 131 and El. 134 aside at the assumed water level at approximately El. 125 at the centerline of the alignments (reference datum NAVD 1988).

No work is to be proposed within wetlands and/or waterbodies. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#15</u> - Based on borings drilled for this project, the soil profile for the HDD #15 BoreAid analysis was divided into six (6) layers: medium dense fill, loose low plasticity silt, soft fat clay, medium dense poorly graded sand, very soft fat clay, and loose low plasticity silt. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 15 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the estimated mudline is 17 to 18 feet near the centers of the bore paths. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 48 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 24 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 56 psi and the approximate applied slurry pressure during drilling ranges from 0 to 29 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the ending 25 to 30 feet of each bore near the exit pit. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.11 HDD Crossing #16

HDD #16 consists of two HDD bores located parallel to the CP Railroad Canadian Mainline, west of the Champlain Canal. Both bores pass underneath a waterbody and NY Route 149 (an at-grade road crossing) in Fort Ann. NY. The bores are approximately 619 and 641 feet long as shown in Appendix B. The HDD bores will pass approximately 16 to 18 feet below the bottom of the waterbody's estimated mudline and 36 to 38 feet underneath the road. The approximate center of the HDD bores under the road crossing is at latitude 43.3583°N and longitude -73.4952°W, in Fort Ann, NY. The ground surface elevations along the path of HDD #16 gently undulates between El. 144 and El. 141, aside from the dip to the assumed water level at approximately El. 137 (reference datum NAVD 1988).

Portions of the work zones on the southern end of the bores are proposed to minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#16 - Based on borings drilled for this project, the soil profile for the HDD #16 BoreAid analysis was divided into five (5) layers: loose to dense fill, medium stiff low plasticity silt, medium stiff low plasticity clay, loose silty sand, and very soft fat clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 16 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the estimated mudline is 18 feet and 36 to 38 feet underneath Route 149 near the centers of the bore paths. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 43 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 25 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 70 psi and the approximate applied slurry pressure during drilling ranges from 0 to 26 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting 5 to 10 feet of each bore near the entry pit exists. These should be relatively easy to control through the use of conductive

conduits, straw bales, silt fences, erosion control measures and vacuum trucks.

- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.12 HDD CROSSING #17

HDD #17 consists of two HDD bores located parallel to and to west of the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 575 and 662 feet long as shown in Appendix B. The HDD bores will pass approximately 17 feet below the invert of the existing 4' RCP drain, and 26 feet below the estimated mud line of the western water body. The approximate center of the HDD bores the under the waterbody/culvert crossing is at latitude 43.3466°N and longitude -73.5020°W, in Kingsbury, NY. The ground surface elevations along the path of HDD #17 gently undulates between approximately El. 144 to El. 142 aside from a dip down to the assumed water level which is around El. 137 (reference datum NAVD 1988).

Portions of the work zones on the southern ends of the bores are proposed to minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#17</u> Based on borings drilled for this project, the soil profile for the HDD #9 BoreAid analysis was divided into six (6) layers: poorly graded sand, stiff low plasticity clay, stiff fat clay, stiff low plasticity clay, stiff fat clay, and stiff low plasticity clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 17 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the existing 48" RCP Drain is 17 feet and 26 feet below the culvert (conduit 2)and estimated mudline (conduit 1), respectively, near the centers of the bore paths. Preliminary analyses of the bore indicate the lowest maximum allowable pressure capacity in the middle of the bores to be approximately 52 psi (conduit 1) & 40 psi (conduit 2) and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 20 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 63 psi and the approximate applied slurry pressure during drilling ranges from 0 to 26 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting and ending 5 to 10 feet of each bore near the entry pit exists as well as approximately 40 feet at the end near the exit pits exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
  - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
  - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.

- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.13 HDD CROSSING #18

HDD #18 consists of two HDD bores located parallel to the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 614 and 620 feet long as shown in Appendix B. The HDD bores will pass approximately 20 feet below the invert of the existing unknown sized drain, and approximately 17 feet below the estimated mud line of the western water body. The approximate center of the HDD bores the under the waterbody/culvert crossing is at latitude 43.3232°N and longitude -73.5231°W, in Kingsbury, NY. The ground surface elevations along the path of HDD #18 gently undulates between approximately El. 140 and El. 144 (reference datum NAVD 1988). The estimated water level is at approximately El. 141. Elevation 139 at the mudline/storm drain crossing, to El. 142 at the east end of the bore alignment (reference datum NAVD 1988).

The majority of the work zones in this location are proposed to be within and minorly impact wetlands for both bore paths. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

Ground conditions at HDD#18 - Based on borings drilled for this project, the soil profile for the HDD #9 BoreAid analysis was divided into six (6) layers: silty sand, medium stiff organic clay, soft to medium stiff low plasticity silt, medium stiff low plasticity clay, medium dense poorly graded sand, and very soft fat clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 18 include:

- Depth of cover during profile design (based on soil borings) is to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depth of cover under the estimated mudline is 17 feet below the estimated mudline and 20 feet under the culvert invert near the centers of the bore paths. Preliminary analyses of the bores indicate the lowest maximum allowable pressure capacity in the middle of the bore is to be approximately 29 psi. The total circulating pressure estimated to occur in the middle portion of the bore is approximately 17 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 45 psi and the approximate applied slurry pressure during drilling ranges from 0 to 19 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting and ending 5 to 40 feet of each bore near the entry and exists pits exists. These should be relatively easy to control through use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.14 HDD Crossing #19

HDD #19 consists of two HDD bores located parallel to the CP Railroad Canadian Mainline, west of the Champlain Canal. The eastern bore passes underneath a 47” box drain where the western bore passes underneath a waterbody with an estimated mudline assuming a 5’ water depth. The bores are approximately 548 and 594 feet long as shown in Appendix B. The HDD bores will pass approximately 13 feet below the invert of the existing 48" box drain, and 21 feet below the estimated mud line of the western water body. The approximate center of the HDD bores the under the waterbody/culvert crossing is at latitude 43.3130°N and longitude -73.5347°W, in Kingsbury, NY. The ground surface elevations along the path of HDD #19 gently undulates between El. 140 and El. 146 aside from the elevation dip at the standing water at the western bore at approximately El. 138 (reference datum NAVD 1988).

The work in this location is to be proposed within and minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD#19</u> - Based on borings drilled for this project, the soil profile for the HDD #9 BoreAid analysis was divided into five (5) layers: medium stiff fill, medium stiff fat clay, medium stiff low plasticity clay, stiff low plasticity silt and medium dense silty sand. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix A.

Design considerations for HDD 19 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the estimated mudline is 21 feet and 15 feet below the 48" box drain near the center of the bore paths. Preliminary analyses of the bore indicate the lowest maximum allowable pressure capacity in the middle of the bores to be approximately 39 psi. The total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 20 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 43 psi and the approximate applied slurry pressure during drilling ranges from 0 to 20 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the starting 5 to 10 feet of each bore near the entry and exit pits exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).

- In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.

- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and
- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.15 HDD CROSSING #20

HDD #20 consists of two HDD bores located parallel to the CP Railroad Canadian Mainline. Both bores pass under NY route 196 and bond creek with an estimated mudline assuming a 5' water depth. The bores are approximately 1200 feet long as shown in Appendix B. Both HDD bores will pass approximately 26 feet below estimated mud line of Bond creek and approximately 60 feet below NY route 196. The ground surface elevations along the path of HDD #20 gently undulates between El. 146 and El. 140 with a gradual downward slope aside from the elevation peak at Ny route 196 approximately EL. 173. It also dips at Bond creek at approximately El. 138 (reference datum NAVD 1988).

<u>Ground conditions at HDD#20</u> - Based on borings drilled for this project, the soil profile for the HDD #20 BoreAid analysis was divided into six (6) layers: medium dense fill, loose silty sand, soft fat clay, loose silty sand, soft high plasticity silt and soft fat clay. The soil profiles used for BoreAid analyses of the HDD in this segment are presented in Appendix B.

Design Considerations for HDD 20 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depths of cover under the estimated mudline is 21 feet and 15 feet below the 48" box drain near the center of the bore paths. Preliminary analyses of the bores, indicates that the lowest maximum allowable pressure capacity in the middle of the bores is approximately 37 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 34 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 100 psi and the approximate applied slurry pressure during drilling ranges from 0 to 34 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the ending 30 to 40 feet of each bore near the exit pits. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:
    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).
    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.16 HDD CROSSING #21

HDD #21 consists of two HDD bores located northwest to the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 1975 feet long as shown in Appendix B. The ground surface elevation gently undulates between El. 133 to El. 138 (reference datum NAVD 1988).

No work is to be proposed within wetlands and/or waterbodies. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP.

<u>Ground conditions at HDD #21</u> –

Design considerations for HDD 21 include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 46 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 23 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 56 psi and the approximate applied slurry pressure during drilling ranges from 0 to 34 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.
- It appears that a potential for releases at the at the starting and ending 10 to 15 feet of each bore near the entry pit exists as well as approximately 100-120 feet at the end near the exit pits exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.
- 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.
- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,
- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,
- 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, and

- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

9.17 HDD CROSSING #21A

HDD #21A

HDD #21A consists of two HDD bores located northwest to the CP Railroad Canadian Mainline, west of the Champlain Canal. The bores are approximately 1965 feet long as shown in Appendix B. The HDD bores will pass approximately 19 feet below the estimated mudline assuming a 5' water depth. The approximate center of the HDD bores under the waterbody are at latitude 43.2947°N and longitude -73.5557°W, in Kingsbury, NY. The ground surface elevation at the entry pit is at El. 136 and at exit pit is approximately El. 141. The estimated water level is at approximately El. 134 (reference datum NAVD 1988).

Portions of the work zones on the southern ends of the bores are proposed to minorly impact wetlands. The proposed work at this location must be constructed in accordance with the Article VII Certificate and associated EM&CP. (Wetland delineation needed to be verified with further development)

Ground conditions at HDD #21A –

Design considerations for HDD 21A include:

- Depth of cover during profile design (based on soil borings) to limit the potential inadvertent break through to the water bodies, road, wetlands, or ground surface. General depth of cover under the estimated mudline is 17/19 feet. Preliminary analyses of the bores, indicates that the allowable lowest maximum allowable pressure capacity in the middle of the bores is approximately 52 psi and the total circulating pressure estimated to occur in the bore in the middle portion of the bore is approximately 30 psi assuming standard HDD drilling methods. In the remainder of the bores the maximum allowable pressure ranges from approximately 0 to 115 psi and the approximate applied slurry pressure during drilling ranges from 0 to 41 psi. Sketches showing the maximum allowable pressure and the applied pressure is provided in the summary BoreAid analyses in the attached Appendix A.

- It appears that a potential for releases at the at the starting and ending 15 to 20 feet of each bore near the entry pit exists as well as approximately 40-45 feet at the end near the exit pits exists. These should be relatively easy to control through the use of conductive conduits, straw bales, silt fences, erosion control measures and vacuum trucks.

- Due to the work zones being located within wetlands, measures to mitigate the potential inadvertent release are required:

    - Barriers to contain the releases to the ground surface, railroad surface and provisions to clean it up (such as use of a vacuum truck).

    - In addition, down the hole slurry pressure monitoring and/or conductor casings may be implemented to limit the potential for releases depending on the details of the HDD Subcontractor's selected means and methods.

- 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.

- Adjusting the drill alignment to miss existing infrastructure including existing utilities, and other obstacles,

- Establishing a drill alignment line that allows for gradual angular changes to minimize pressure build-up,

- 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, and

- Requiring monitoring and controlling drilling fluid pressures with down-the-hole sensors during pilot hole drilling.

Appendix A

BoreAid HDD Simulation Output

Generated Output

WARNING: The accuracy of the data obtained by the BoreAid® system is highly dependent upon accurate data gathering, data input and proper use of the software. Vermeer is not responsible for that information. BoreAid® data is not intended to replace the need for future on-site utility locating, measuring and verification procedures, which are essential for accurate placement of new underground installations and avoidance of existing utilities.

CALL YOUR ONE-CALL SYSTEM FIRST

WARNING: Always contact your local One-Call system before the start of your digging project. The BoreAid® system is intended to be used with other utility locating methods, such as the use of the One-Call system and the exposing of existing utilities by potholing.

Locate utilities before drilling. Call 811 (U.S. only) or 1-888-258-0808 (U.S. or Canada) or local utility companies or national regulating authority.

Before you start any digging project, do not forget to call the local One-Call system in your area and any utility company that does not subscribe to the One-Call system. For areas not represented by One-Call Systems International, contact the appropriate utility companies or national regulating authority to locate and mark the underground installations. If you do not call, you may have an accident or suffer injuries; cause interruption of services; damage the environment; or experience job delays.

OSHA CFR 29 1926.651 requires that the estimated location of underground utilities be determined before beginning the excavation or underground drilling operation. When the actual excavation or bore approaches an estimated utility location, the exact location of the underground installation must be determined by a safe, acceptable and dependable method. If the utility cannot be precisely located, it must be shut off by the utility company.

Project Summary

General:	HDD #9 - Conduit 1
	Start Date: 02-28-2022
	End Date: 02-28-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	MCS
	CHA

Description:

Input Summary

Start Coordinate	(0.00, 0.00, 127.18) ft
End Coordinate	(546.00, 0.00, 125.88) ft
Project Length	546.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 5

Soil Layer #1 USCS, Gravel (G), GM

Depth: 2.00 ft

Unit Weight: 120.0000 (dry), 140.0000 (sat) [lb/ft3]

Phi: 37.00, S.M.: 1000.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Sand (S), SW

Depth: 6.00 ft

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 200.00, Coh: 0.00 [psi]

Soil Layer #3 USCS, Clay (C), CH

Depth: 2.00 ft

Unit Weight: 80.0000 (dry), 110.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 300.00, Coh: 5.60 [psi]

Soil Layer #4 USCS, Sand (S), SC

Depth: 11.00 ft

Unit Weight: 105.0000 (dry), 115.0000 (sat) [lb/ft3]

Phi: 30.00, S.M.: 200.00, Coh: 0.00 [psi]

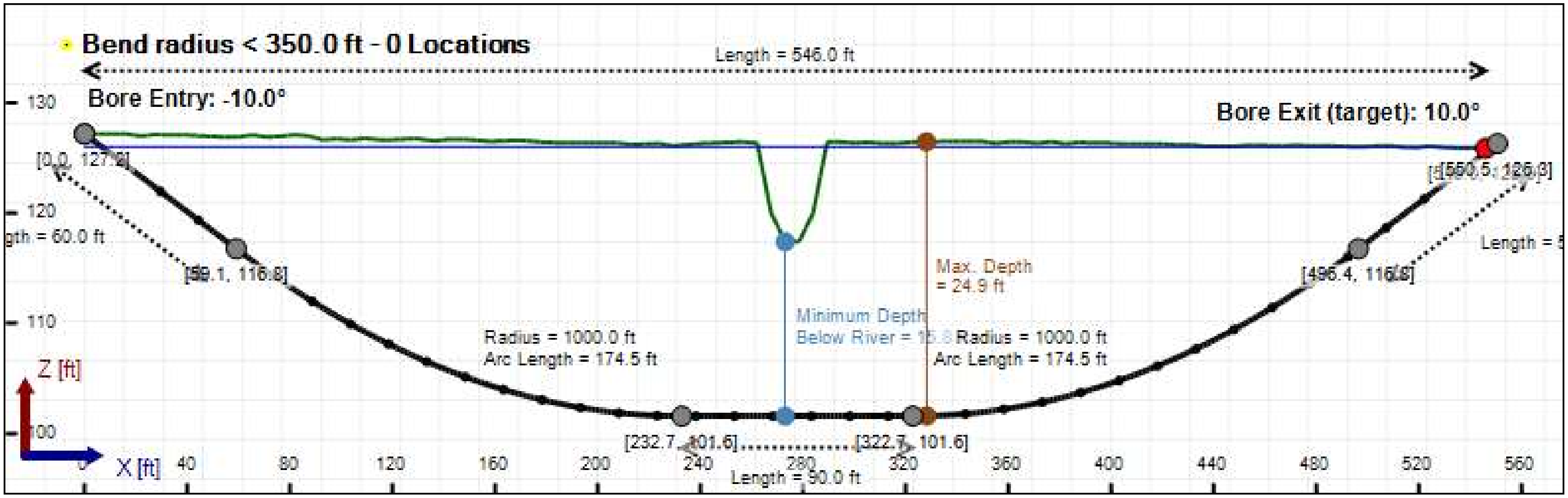
Soil Layer #5 USCS, Clay (C), CH

Depth: 12.00 ft

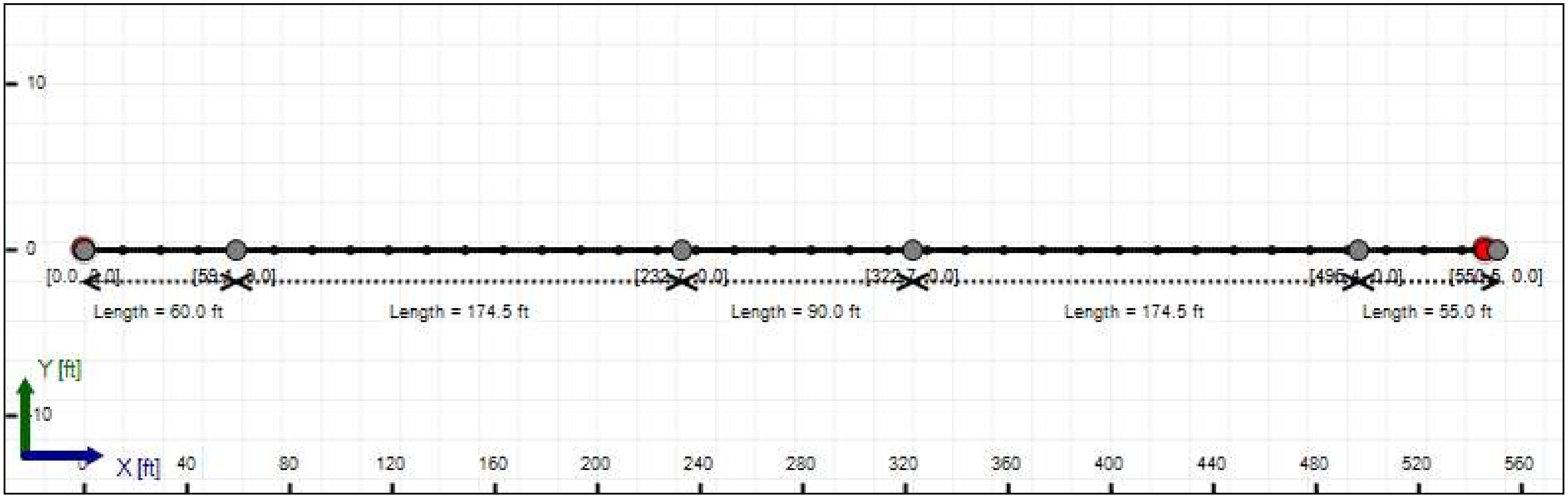
Unit Weight: 70.0000 (dry), 100.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 200.00, Coh: 3.13 [psi]

Bore Cross-Section View



Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 555.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	2.7	9.3
Water Pressure	10.6	10.6
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	13.3	19.9
Deflection		
Earth Load Deflection	0.768	2.536
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	0.900	2.668
Compressive Stress [psi]		
Compressive Wall Stress	59.9	89.5

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	9347.8	9347.8
Pullback Stress [psi]	260.7	260.7
Pullback Strain	4.534E-3	4.534E-3
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	260.7	285.5
Tensile Strain	4.534E-3	5.414E-3

Net External Pressure = 16.8 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.900	7.5	8.3	OK
Unconstrained Collapse [psi]	16.7	127.7	7.7	OK
Compressive Wall Stress [psi]	59.9	1150.0	19.2	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	26.6	240.0	9.0	OK
Tensile Stress [psi]	285.5	1200.0	4.2	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	59.150 psi	52.714 psi
1	8.00 in	12.00 in	58.547 psi	52.184 psi
2	12.00 in	16.13 in	57.787 psi	51.457 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

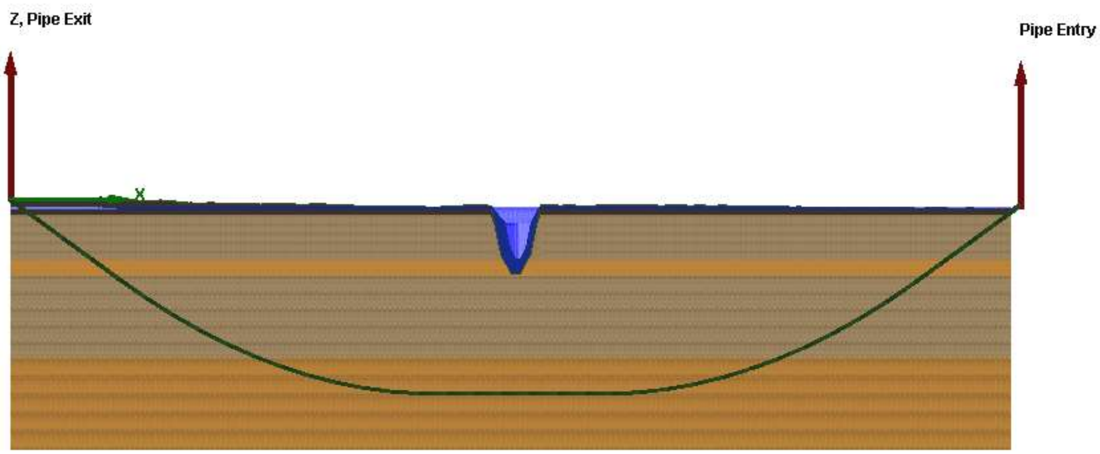
Rheological model: Bingham-Plastic

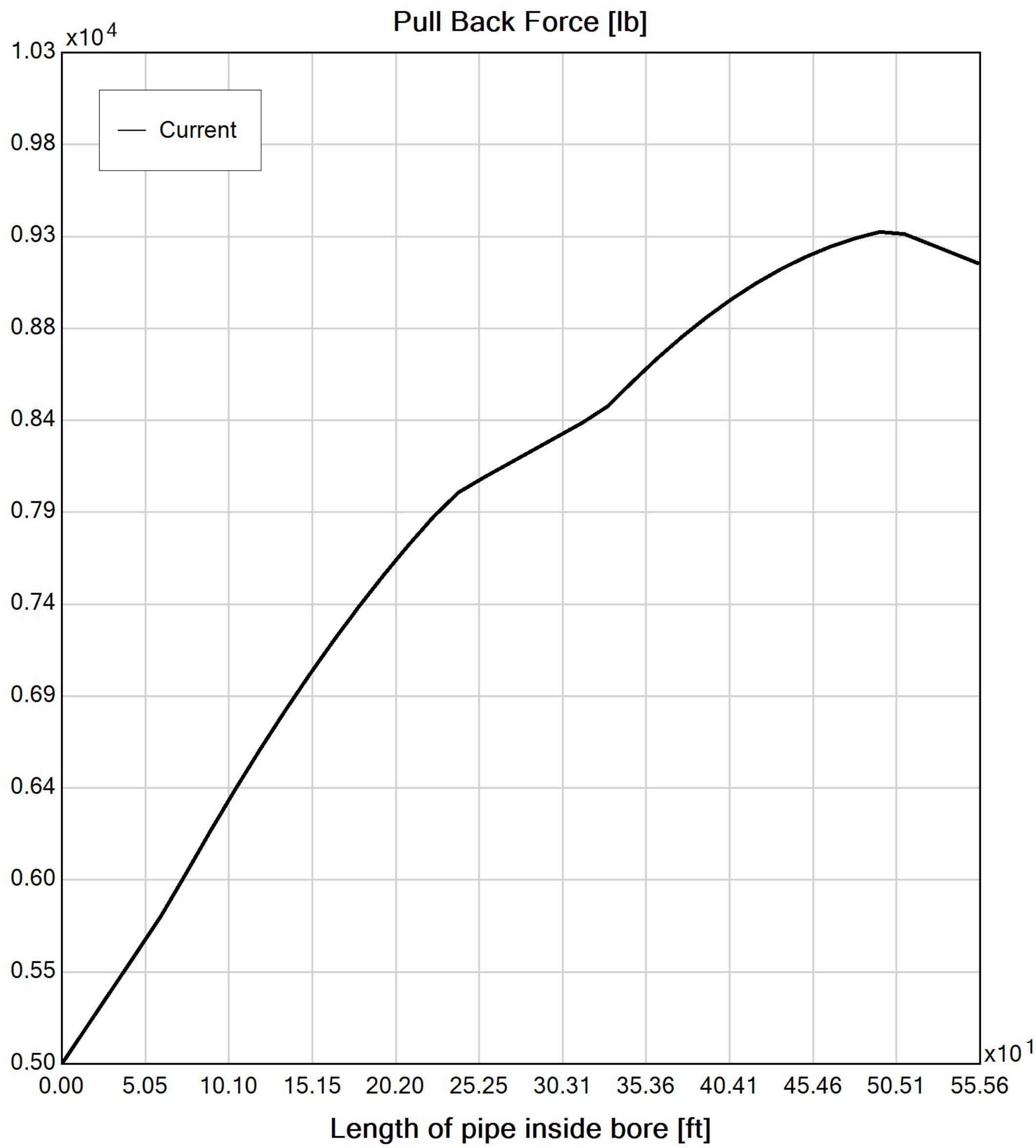
Plastic Viscosity (PV): 25.53

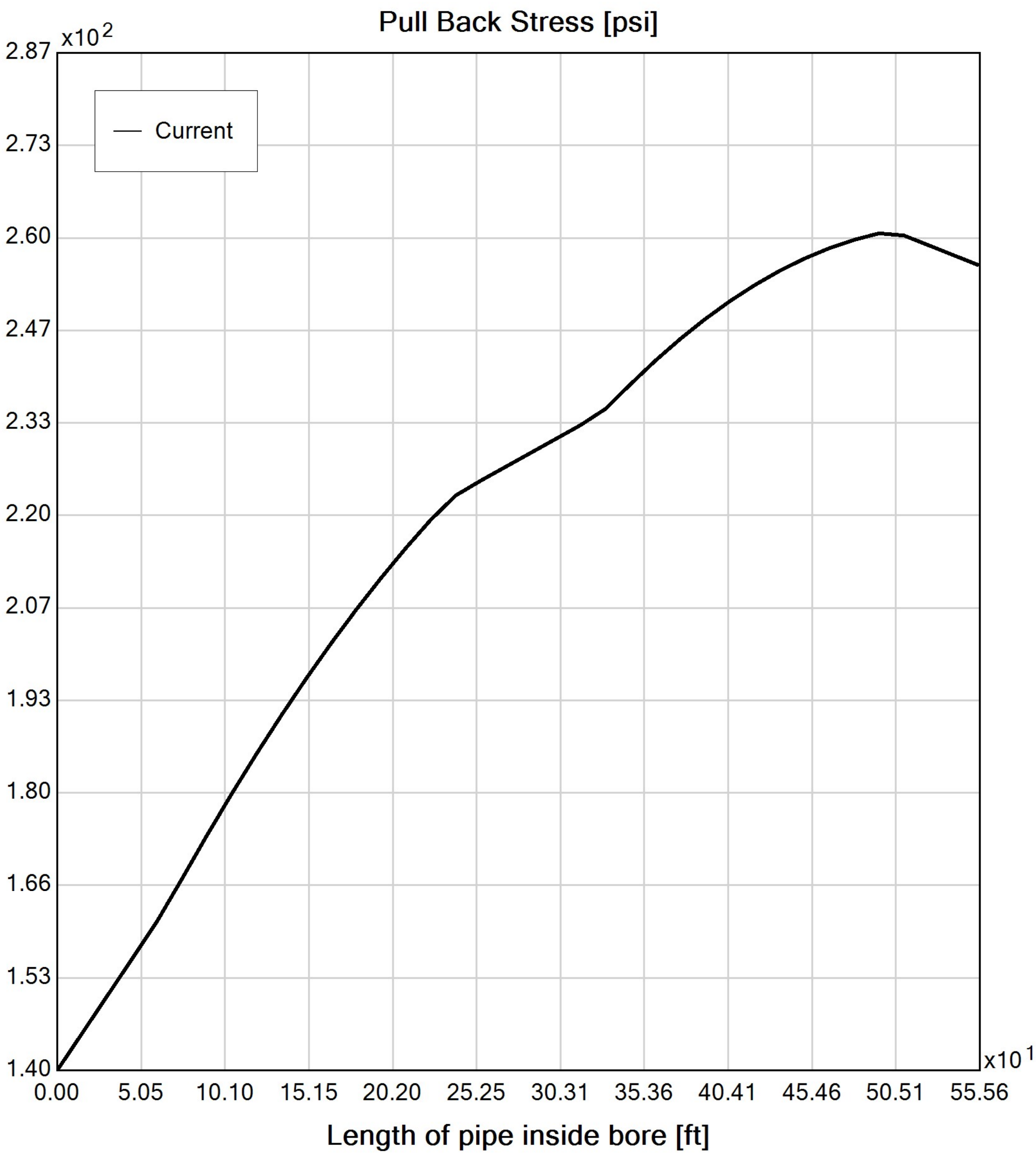
Yield Point (YP): 16.49

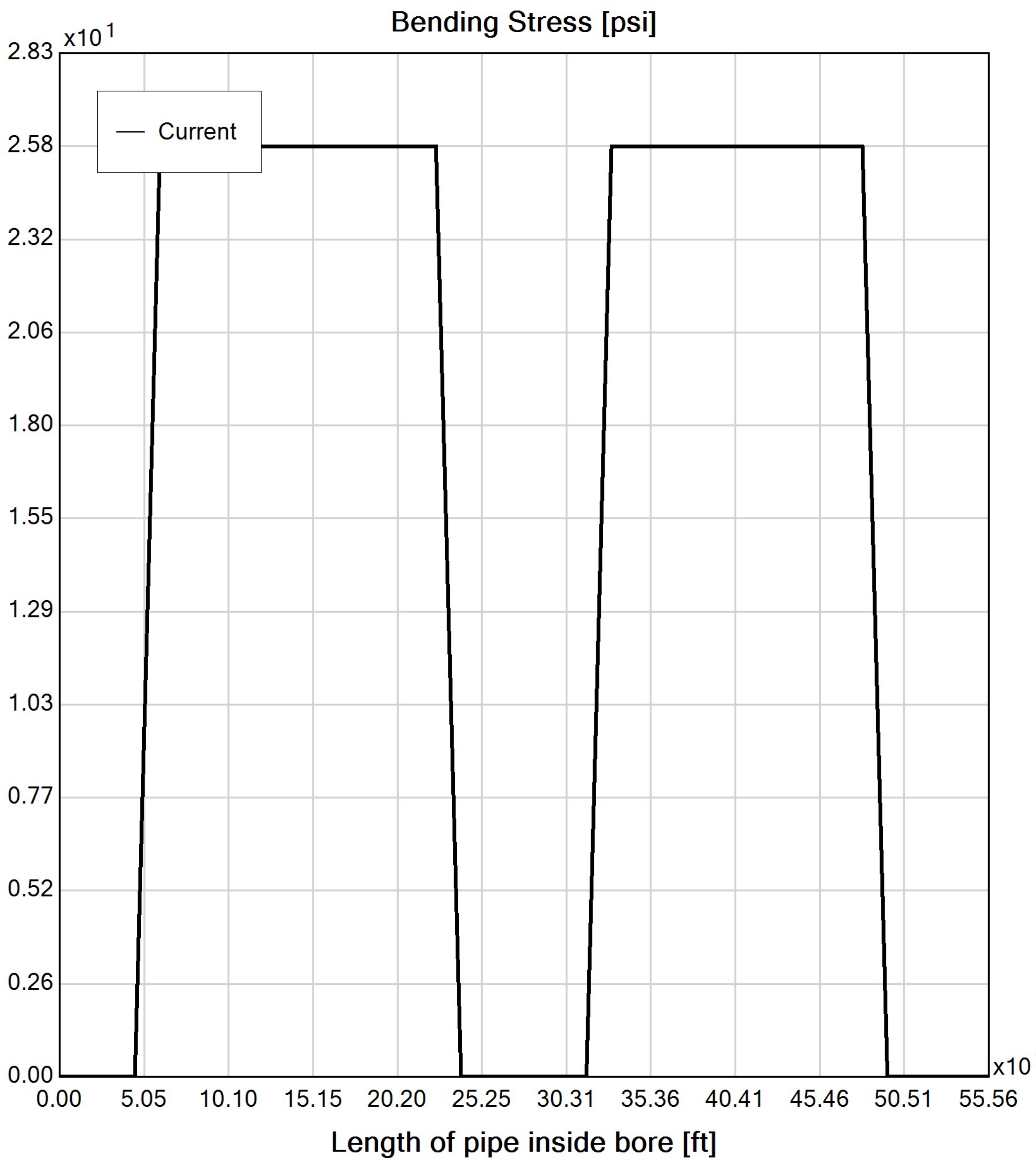
Effective Viscosity (cP): 1202.0

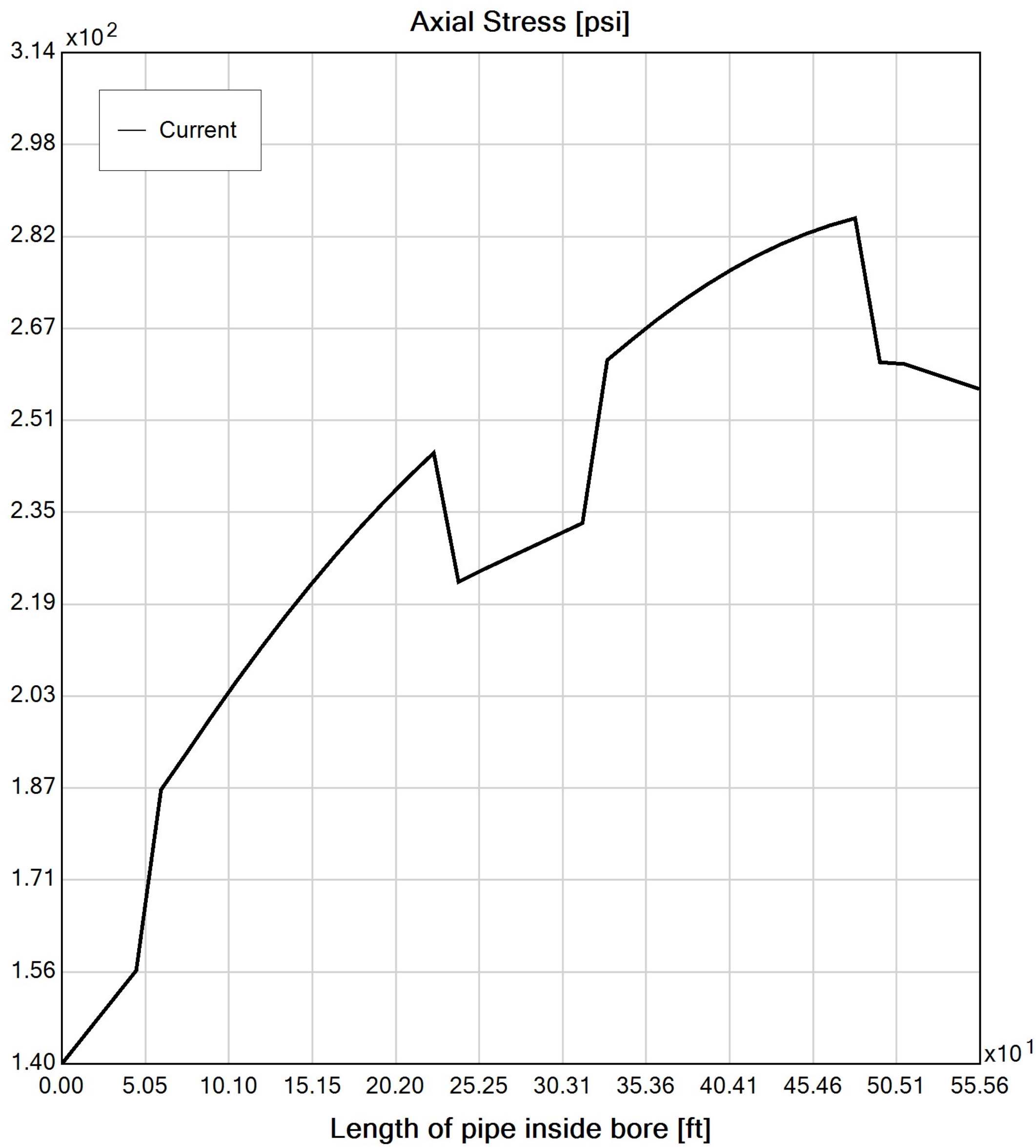
Virtual Site



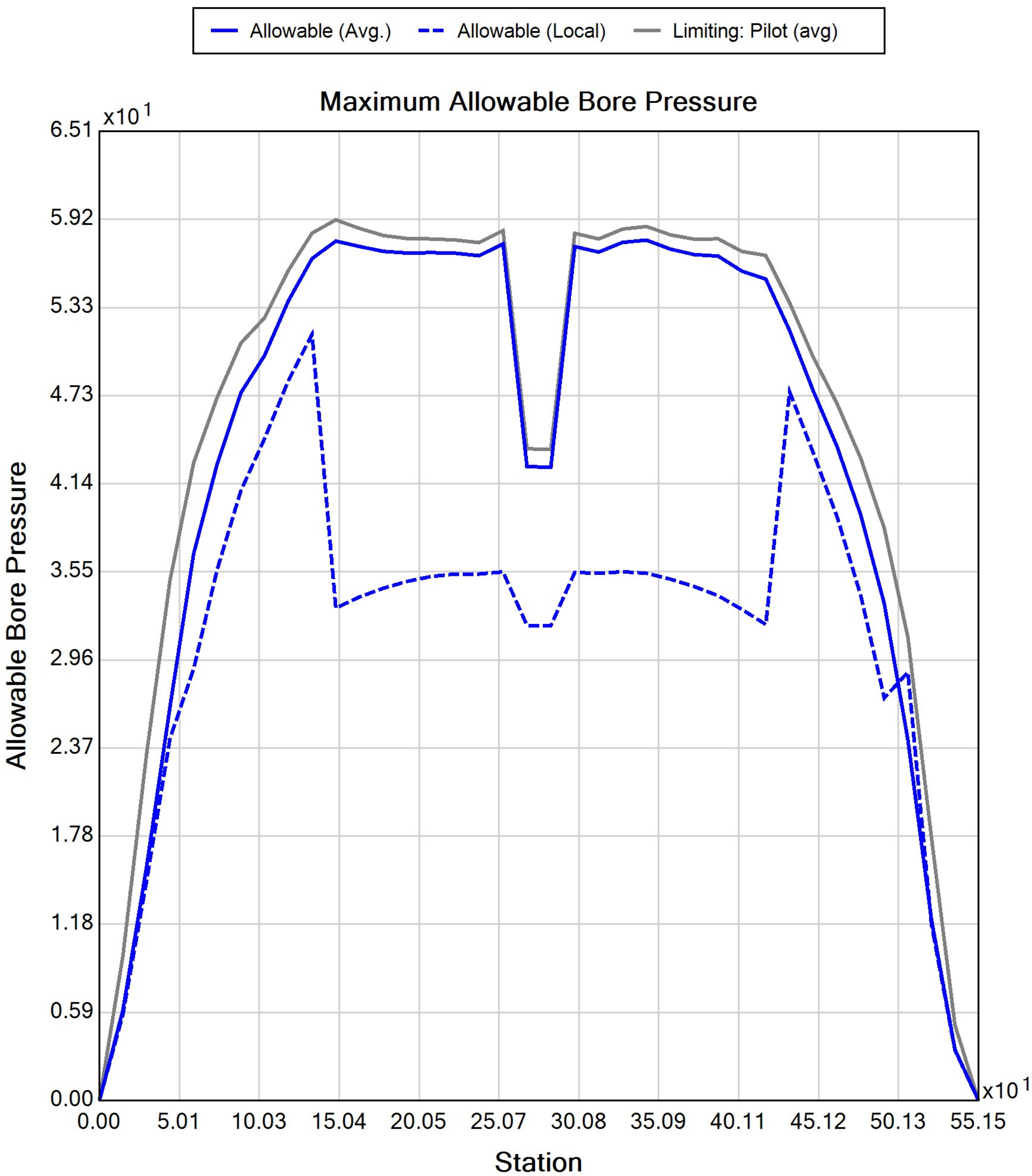

Pull Back Force [lb]
x10^4
1.03
0.98
0.93
0.88
0.84
0.79
0.74
0.69
0.64
0.60
0.55
0.50
Current
x10^1
0.00
5.05
10.10
15.15
20.20
25.25
30.31
35.36
40.41
45.46
50.51
55.56
Length of pipe inside bore [ft]

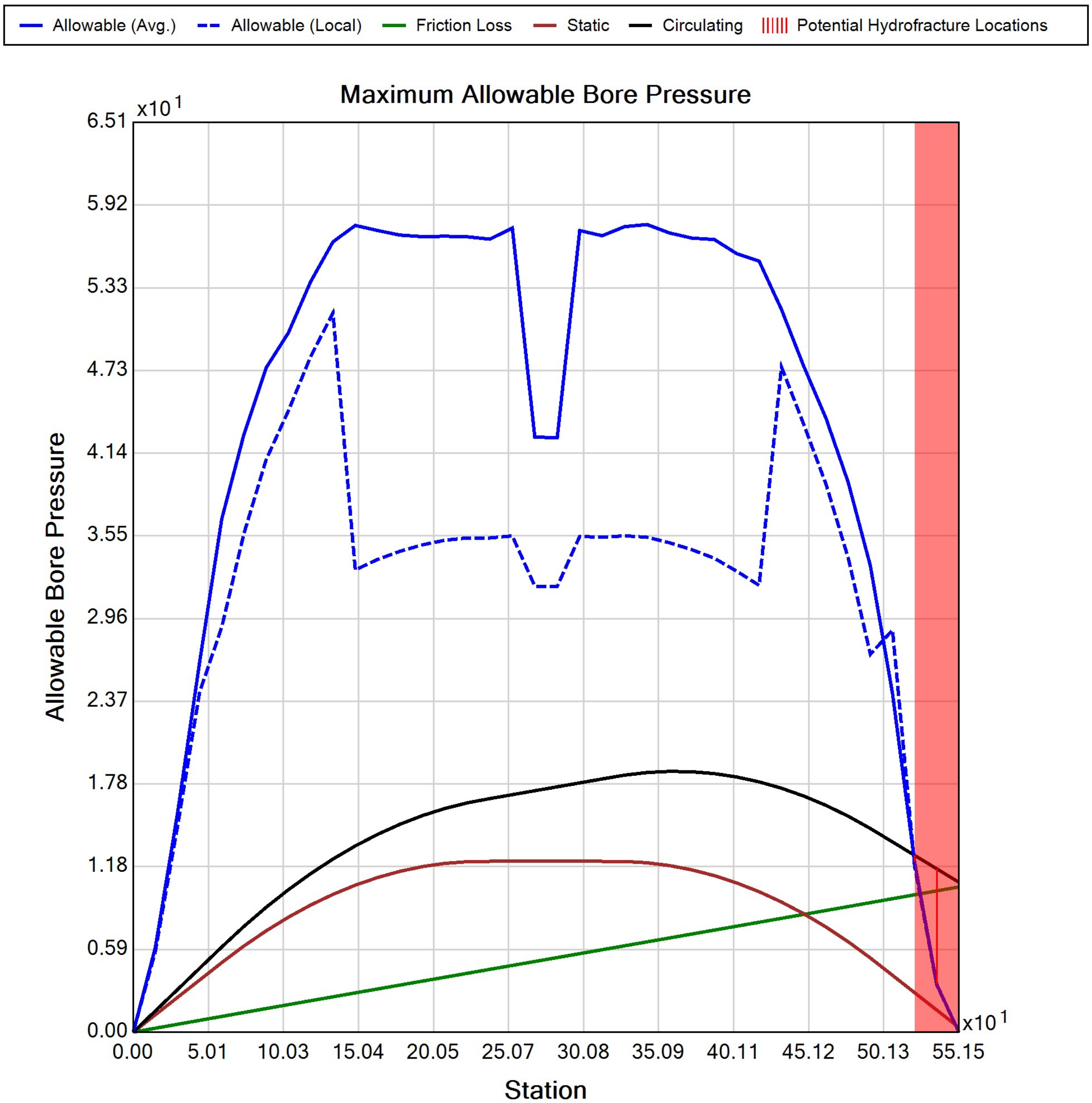

Pull Back Stress [psi]
x10 2
2.87
2.73
2.60
2.47
2.33
2.20
2.07
1.93
1.80
1.66
1.53
1.40
Current
x10 1
0.00 5.05 10.10 15.15 20.20 25.25 30.31 35.36 40.41 45.46 50.51 55.56
Length of pipe inside bore [ft]


Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 1
0.00
5.05
10.10
15.15
20.20
25.25
30.31
35.36
40.41
45.46
50.51
55.56
Length of pipe inside bore [ft]



Axial Stress [psi]
x10^2
3.14
2.98
2.82
2.67
2.51
2.35
2.19
2.03
1.87
1.71
1.56
1.40
Current
x10^1
0.00
5.05
10.10
15.15
20.20
25.25
30.31
35.36
40.41
45.46
50.51
55.56
Length of pipe inside bore [ft]


Allowable (Avg.)
Allowable (Local)
Limiting: Pilot (avg)
Maximum Allowable Bore Pressure
x10 1
6.51
5.92
5.33
4.73
4.14
3.55
2.96
2.37
1.78
1.18
0.59
0.00
Allowable Bore Pressure
x10 1
0.00
5.01
10.03
15.04
20.05
25.07
30.08
35.09
40.11
45.12
50.13
55.15
Station


Allowable (Avg.)
Allowable (Local)
Friction Loss
Static
Circulating
Potential Hydrofracture Locations
Maximum Allowable Bore Pressure
x10 1
6.51
5.92
5.33
4.73
4.14
3.55
2.96
2.37
1.78
1.18
0.59
0.00
Allowable Bore Pressure
0.00
5.01
10.03
15.04
20.05
25.07
30.08
35.09
40.11
45.12
50.13
55.15
x10 1
Station

Generated Output

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Input Summary

Start Coordinate	(0.00, 0.00, 127.18) ft
End Coordinate	(546.00, 0.00, 125.88) ft
Project Length	546.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 555.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.1	9.3
Water Pressure	10.6	10.6
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	11.7	19.9
Deflection		
Earth Load Deflection	0.385	2.536
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.414	2.565
Compressive Stress [psi]		
Compressive Wall Stress	52.7	89.5

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	565.9	565.9
Pullback Stress [psi]	323.3	323.3
Pullback Strain	5.623E-3	5.623E-3
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	323.3	328.1
Tensile Strain	5.623E-3	5.805E-3

Net External Pressure = 16.8 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.414	7.5	18.1	OK
Unconstrained Collapse [psi]	16.7	134.1	8.0	OK
Compressive Wall Stress [psi]	52.7	1150.0	21.8	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	26.6	238.4	9.0	OK
Tensile Stress [psi]	328.1	1200.0	3.7	OK

Generated Output

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Project Summary

General:	HDD #9 - Conduit 2
	Start Date: 02-28-2022
	End Date: 02-28-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	MCS
	CHA
Description:	

Input Summary

Start Coordinate	(0.00, 0.00, 127.18) ft
End Coordinate	(546.00, 0.00, 125.88) ft
Project Length	546.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 5

Soil Layer #1 USCS, Gravel (G), GM

Depth: 2.00 ft

Unit Weight: 120.0000 (dry), 140.0000 (sat) [lb/ft3]

Phi: 37.00, S.M.: 1000.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Sand (S), SW

Depth: 6.00 ft

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 200.00, Coh: 0.00 [psi]

Soil Layer #3 USCS, Clay (C), CH

Depth: 2.00 ft

Unit Weight: 80.0000 (dry), 110.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 300.00, Coh: 5.60 [psi]

Soil Layer #4 USCS, Sand (S), SC

Depth: 11.00 ft

Unit Weight: 105.0000 (dry), 115.0000 (sat) [lb/ft3]

Phi: 30.00, S.M.: 200.00, Coh: 0.00 [psi]

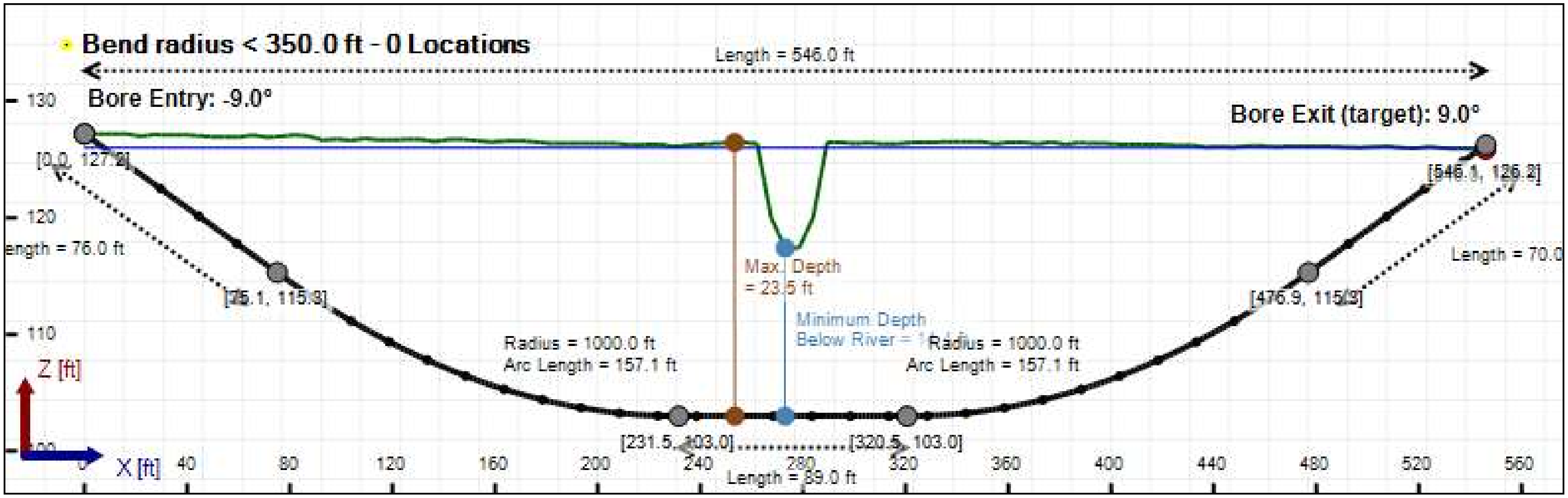
Soil Layer #5 USCS, Clay (C), CH

Depth: 12.00 ft

Unit Weight: 70.0000 (dry), 100.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 200.00, Coh: 3.13 [psi]

Bore Cross-Section View



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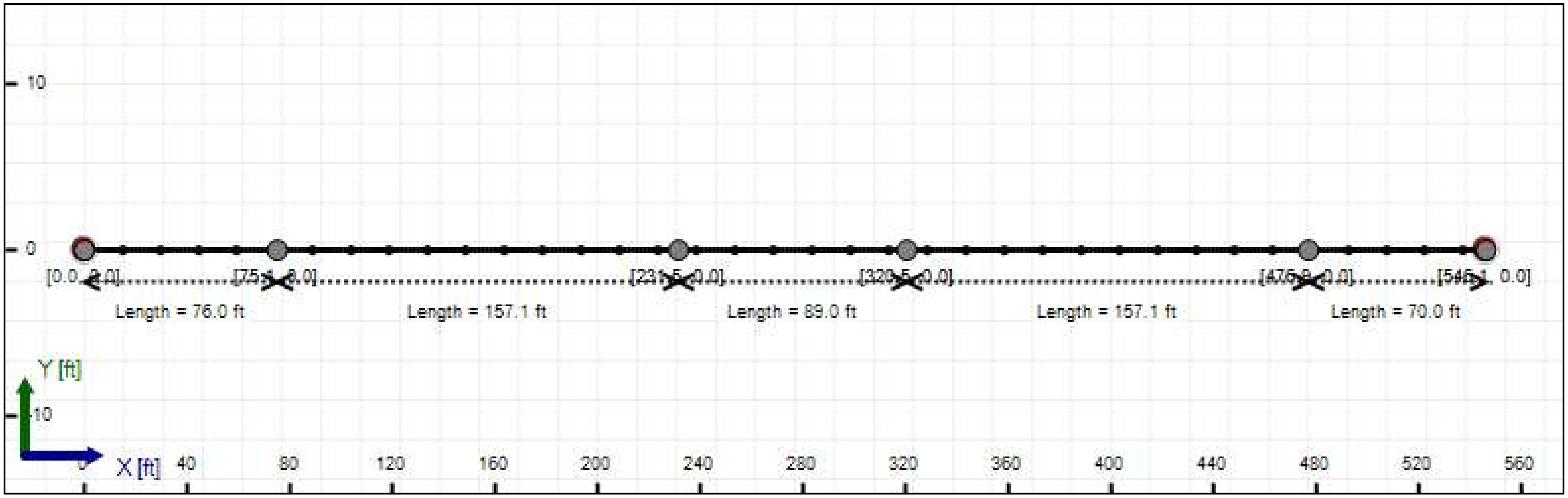
Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 555.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	2.7	8.9
Water Pressure	10.0	10.0
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	12.7	18.9
Deflection		
Earth Load Deflection	0.771	2.435
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	0.903	2.567
Compressive Stress [psi]		
Compressive Wall Stress	57.2	85.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	9230.1	9230.1
Pullback Stress [psi]	257.4	257.4
Pullback Strain	4.477E-3	4.477E-3
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	257.4	281.9
Tensile Strain	4.477E-3	5.351E-3

Net External Pressure = 17.6 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.903	7.5	8.3	OK
Unconstrained Collapse [psi]	15.7	127.7	8.1	OK
Compressive Wall Stress [psi]	57.2	1150.0	20.1	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	25.7	240.1	9.3	OK
Tensile Stress [psi]	281.9	1200.0	4.3	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	58.682 psi	53.027 psi
1	8.00 in	12.00 in	57.961 psi	52.504 psi
2	12.00 in	16.13 in	57.305 psi	51.788 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

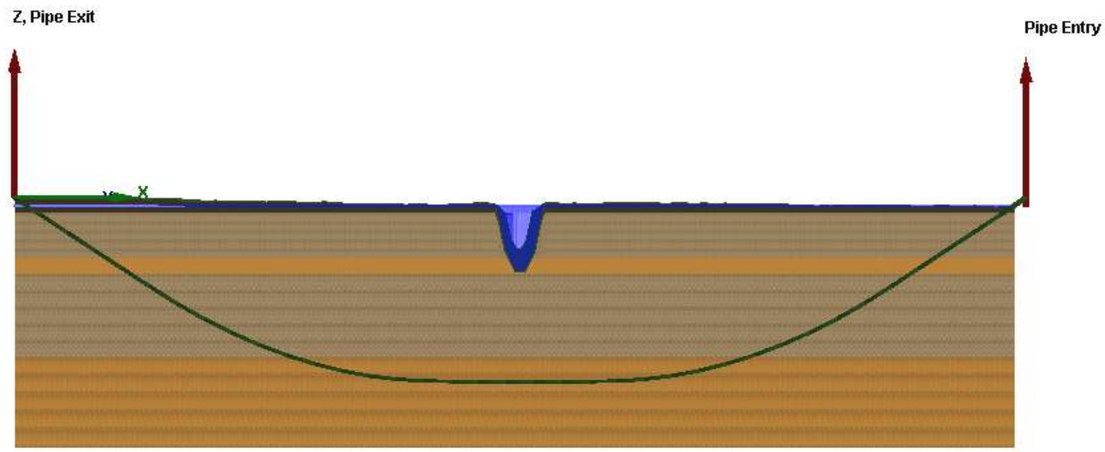
Rheological model: Power-Law

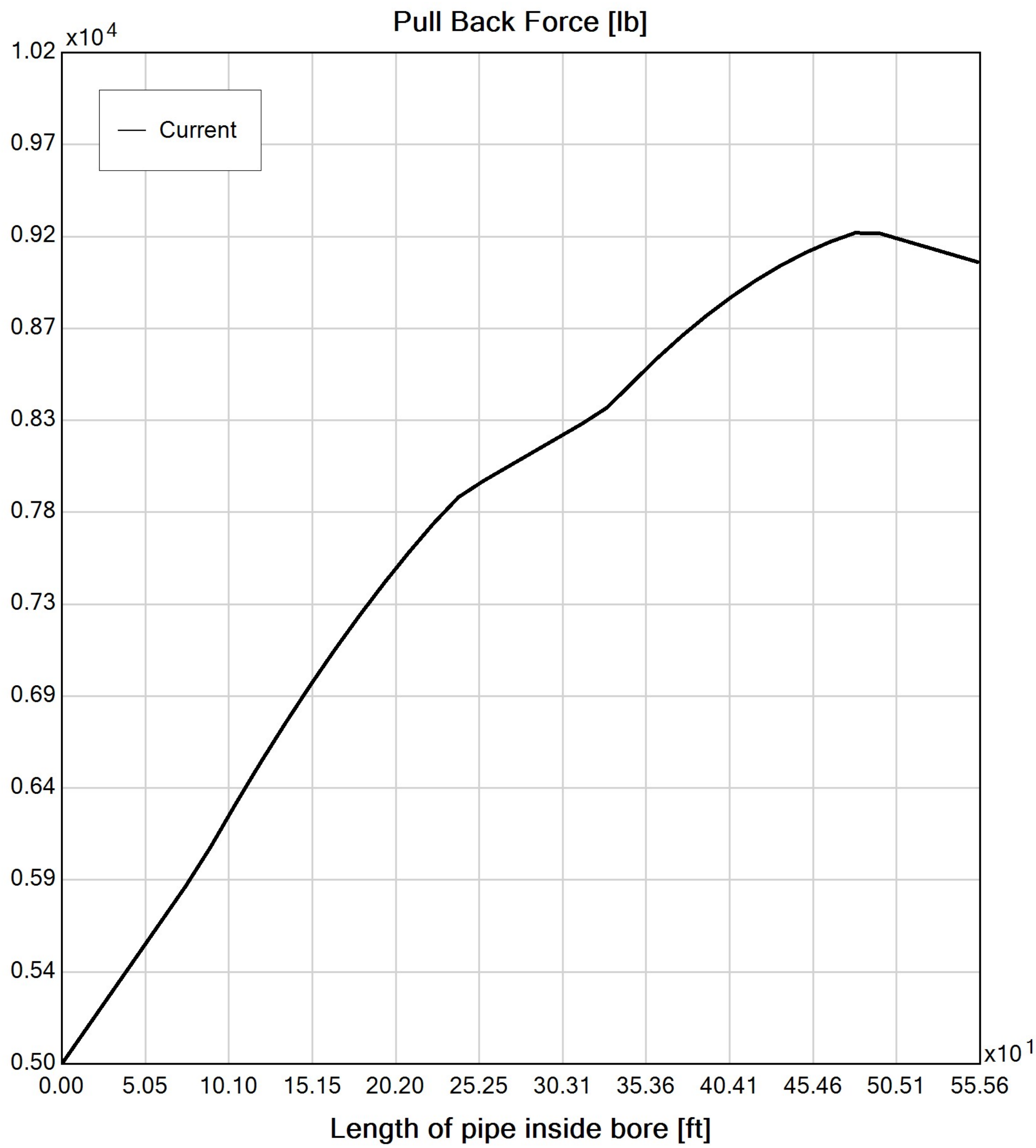
Fluid Consistency Index (K): 63.17

Power Law Exponent (n): 0.14

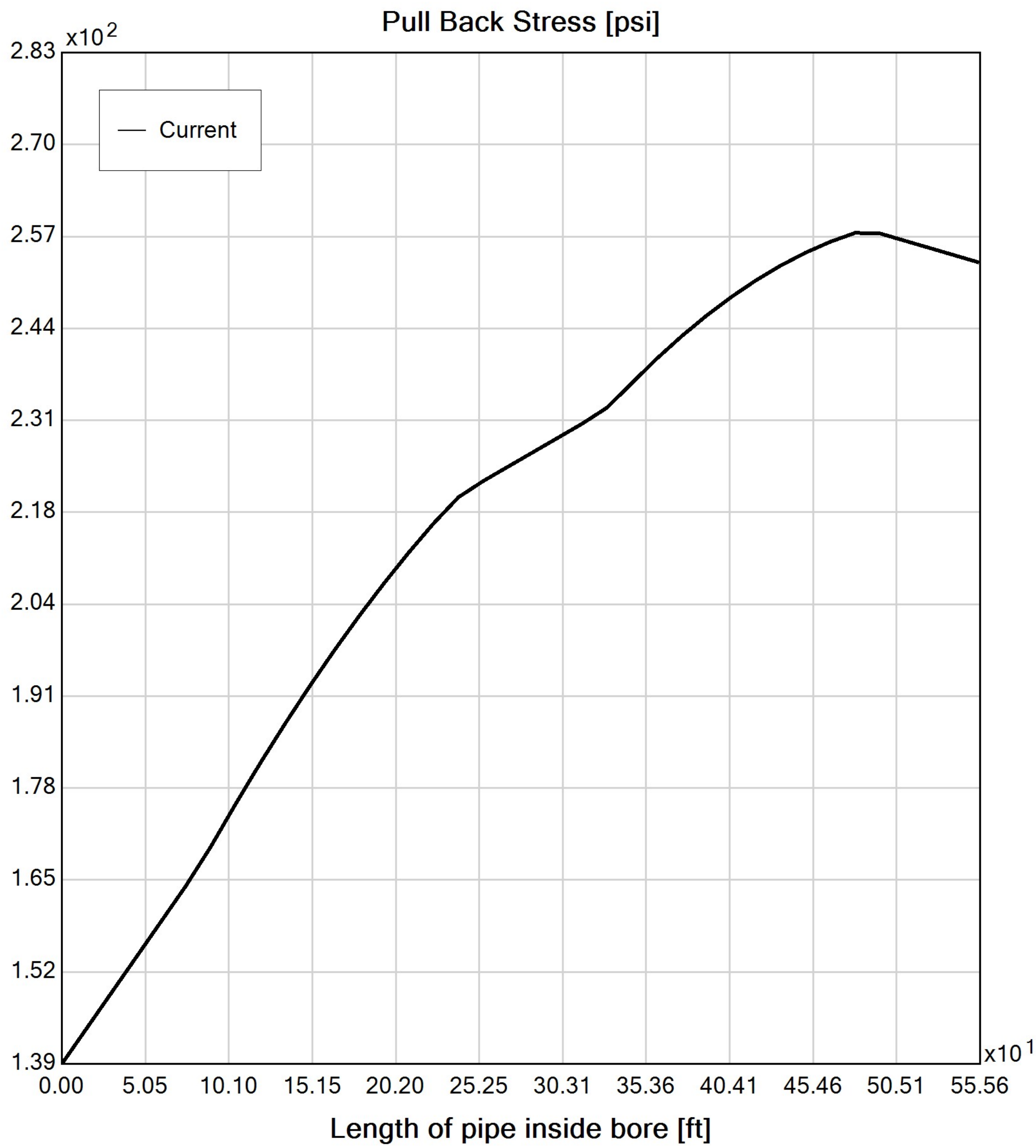
Effective Viscosity (cP): 859.3

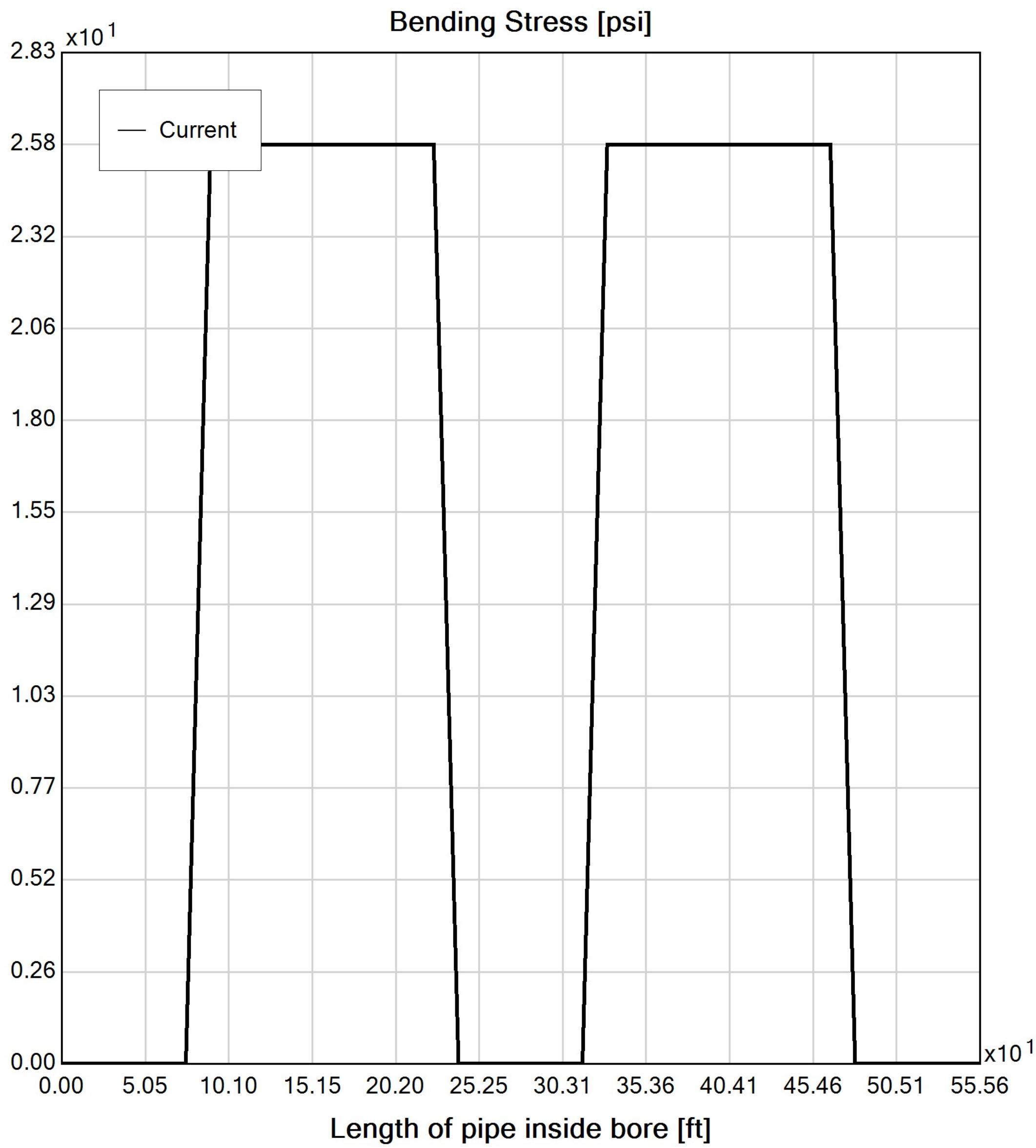
Virtual Site

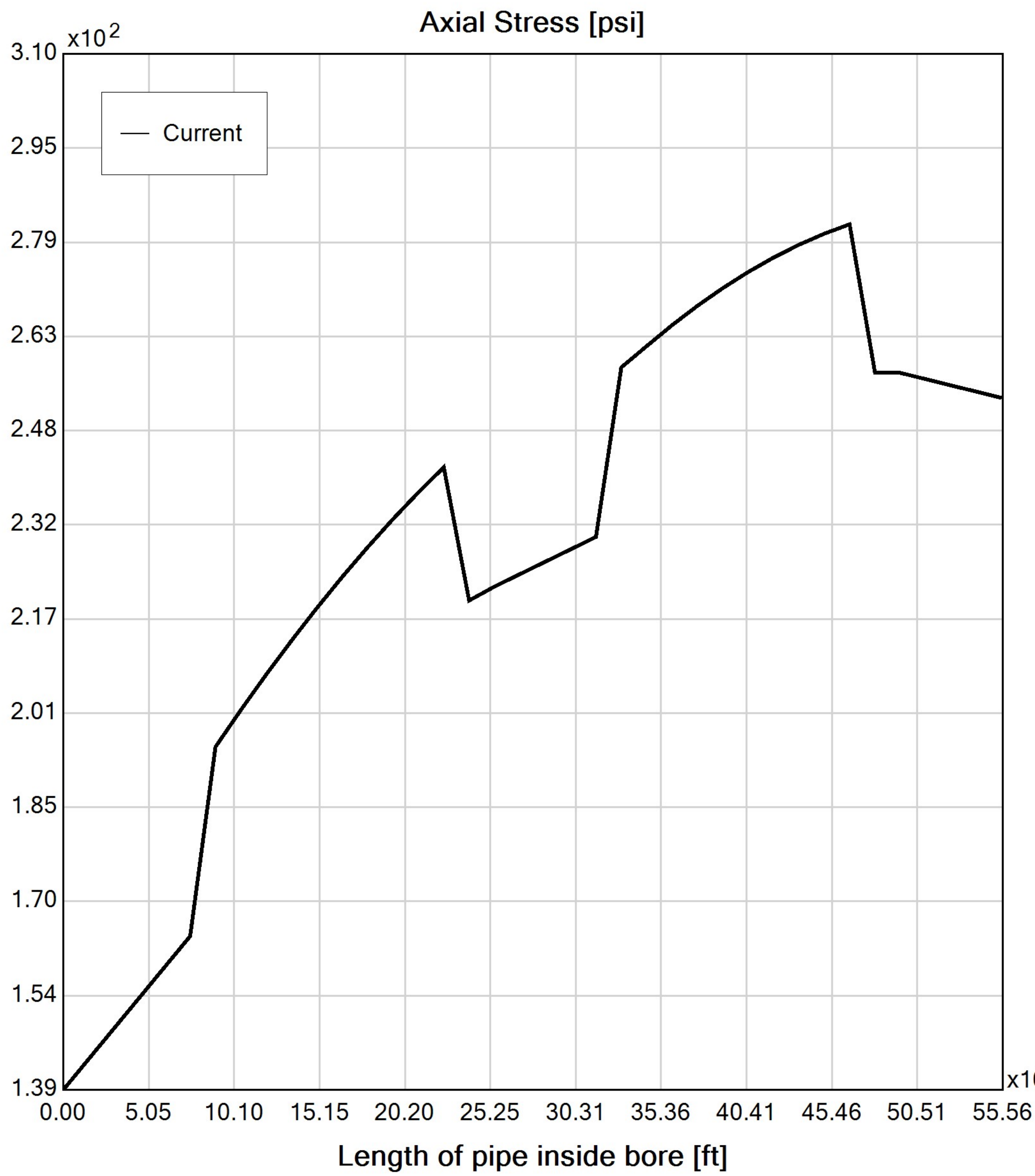



Pull Back Force [lb]
x10^4
1.02
0.97
0.92
0.87
0.83
0.78
0.73
0.69
0.64
0.59
0.54
0.50
Current
x10^1
0.00
5.05
10.10
15.15
20.20
25.25
30.31
35.36
40.41
45.46
50.51
55.56
Length of pipe inside bore [ft]

Pull Back Stress [psi]




Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 1
0.00
5.05
10.10
15.15
20.20
25.25
30.31
35.36
40.41
45.46
50.51
55.56
Length of pipe inside bore [ft]



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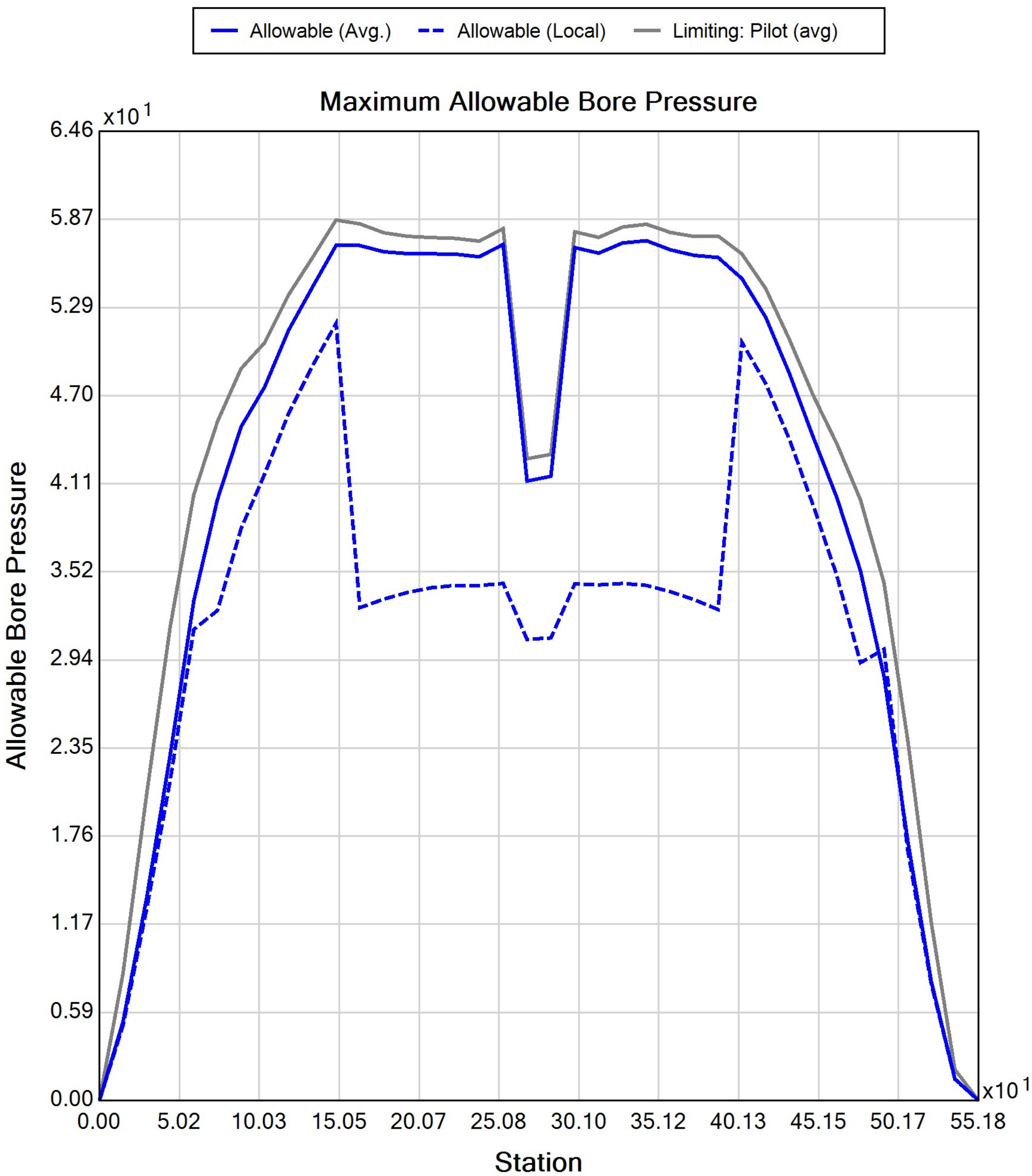

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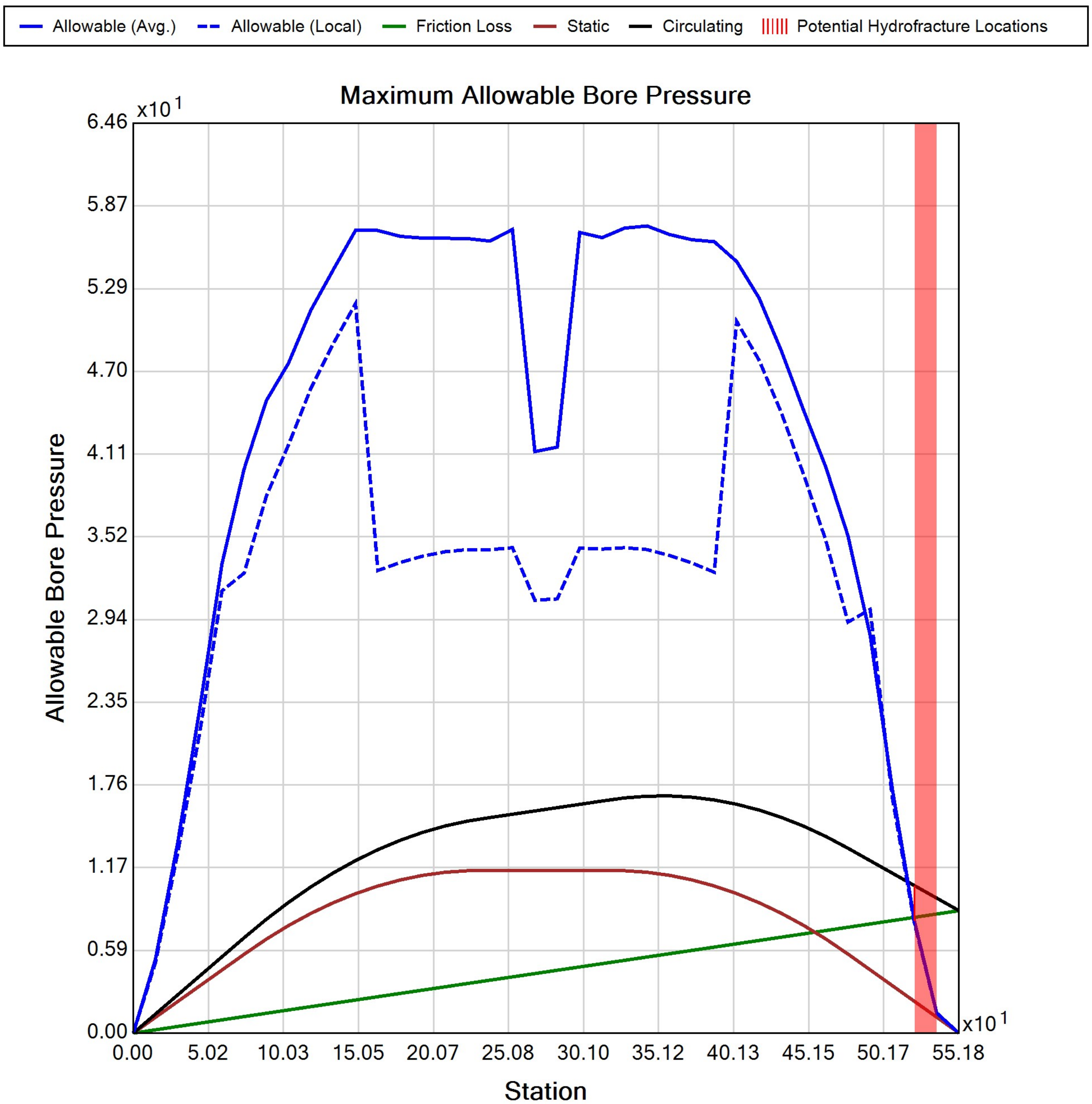
Allowable (Avg.)
Allowable (Local)
Friction Loss
Static
Circulating
Potential Hydrofracture Locations
Maximum Allowable Bore Pressure
x10 1
6.46
5.87
5.29
4.70
4.11
3.52
2.94
2.35
1.76
1.17
0.59
0.00
Allowable Bore Pressure
0.00
5.02
10.03
15.05
20.07
25.08
30.10
35.12
40.13
45.15
50.17
55.18
x10 1
Station

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Input Summary

Start Coordinate	(0.00, 0.00, 127.18) ft
End Coordinate	(546.00, 0.00, 125.88) ft
Project Length	546.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 555.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.1	8.9
Water Pressure	10.0	10.0
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	11.1	18.9
Deflection		
Earth Load Deflection	0.381	2.435
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.410	2.464
Compressive Stress [psi]		
Compressive Wall Stress	50.0	85.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	560.1	560.1
Pullback Stress [psi]	320.0	320.0
Pullback Strain	5.566E-3	5.566E-3
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	320.0	324.5
Tensile Strain	5.566E-3	5.742E-3

Net External Pressure = 17.6 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.410	7.5	18.3	OK
Unconstrained Collapse [psi]	15.7	134.0	8.5	OK
Compressive Wall Stress [psi]	50.0	1150.0	23.0	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	25.7	238.5	9.3	OK
Tensile Stress [psi]	324.5	1200.0	3.7	OK

Generated Output

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OSHA CFR 29 1926.651 requires that the estimated location of underground utilities be determined before beginning the excavation or underground drilling operation. When the actual excavation or bore approaches an estimated utility location, the exact location of the underground installation must be determined by a safe, acceptable and dependable method. If the utility cannot be precisely located, it must be shut off by the utility company.

Project Summary

General:	HDD #10 - Conduit 1
	Start Date: 09-22-2022
	End Date: 09-22-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	Amherst, Massachusetts
Description:	North to South 10" DR 9 8" bit

Input Summary

Start Coordinate	(0.00, 0.00, 129.14) ft
End Coordinate	(1210.00, 0.00, 136.00) ft
Project Length	1210.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 4

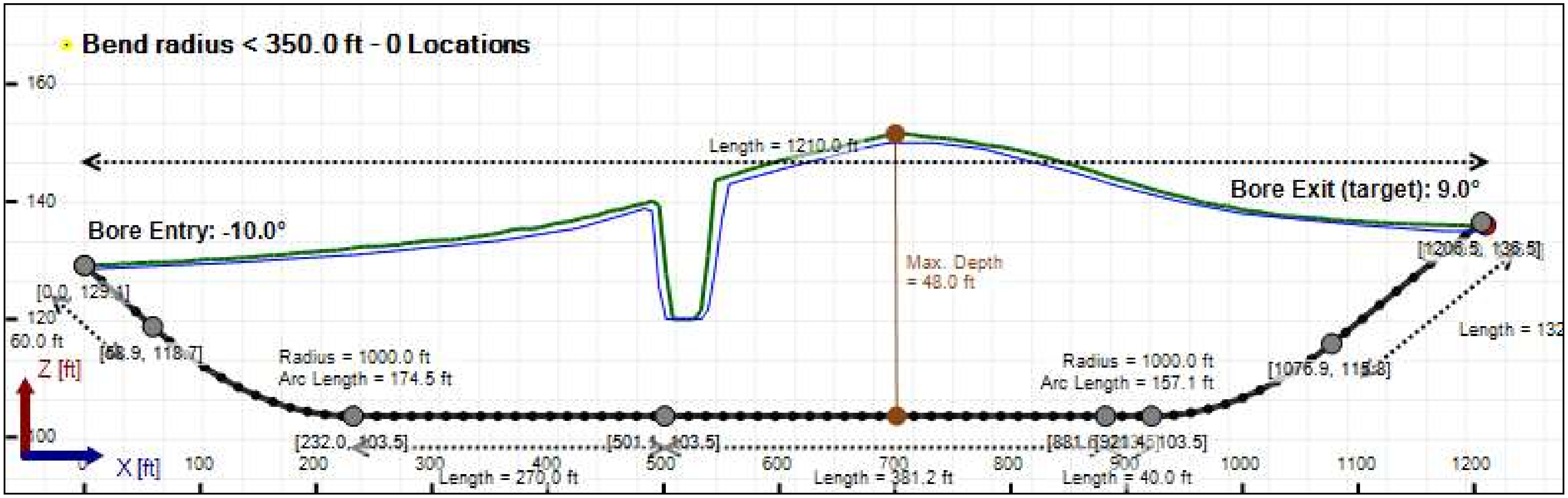
Soil Layer #1 USCS, Sand (S), SM
From Assistant
Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]
Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Clay (C), CL
From Assistant
Unit Weight: 80.0000 (dry), 110.0000 (sat) [lb/ft3]
Phi: 0.00, S.M.: 300.00, Coh: 5.50 [psi]

Soil Layer #3 USCS, Clay (C), CL
From Assistant
Unit Weight: 70.0000 (dry), 100.0000 (sat) [lb/ft3]
Phi: 0.00, S.M.: 200.00, Coh: 3.13 [psi]

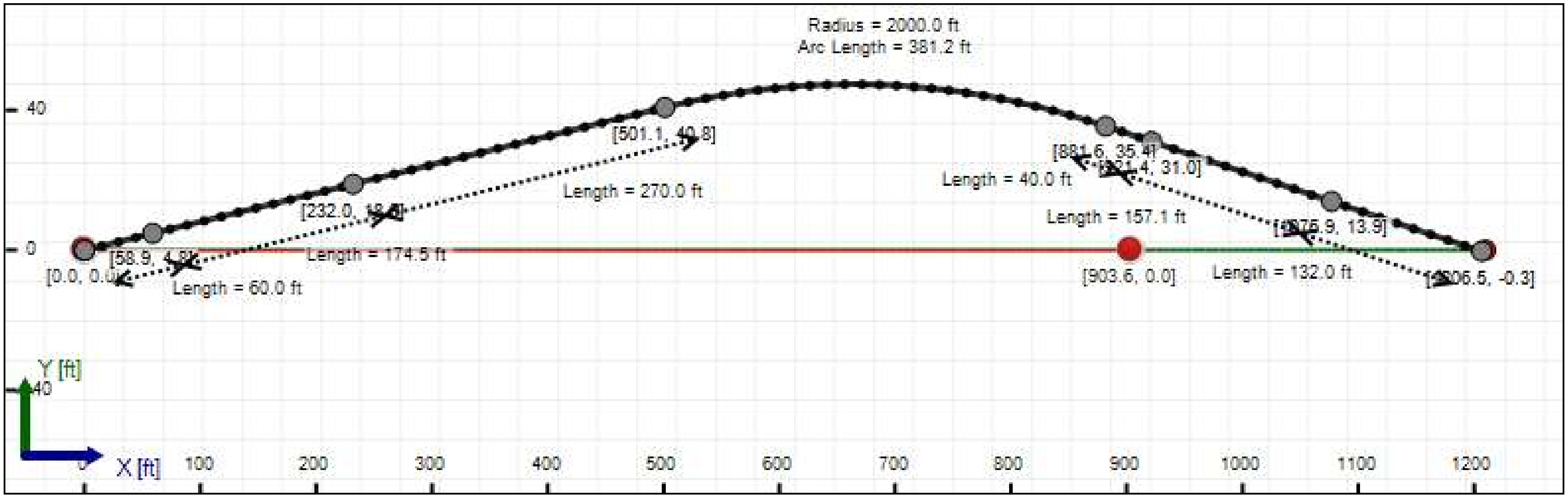
Soil Layer #4 USCS, Sand (S), SW
From Assistant
Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]
Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Bore Cross-Section View



Powered by BoreAid

Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1215.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	3.1	19.0
Water Pressure	20.1	20.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	23.2	39.2
Deflection		
Earth Load Deflection	1.221	5.178
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.353	5.310
Compressive Stress [psi]		
Compressive Wall Stress	104.5	176.2

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	20515.2	20515.2
Pullback Stress [psi]	572.1	572.1
Pullback Strain	9.950E-3	9.950E-3
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	572.1	593.4
Tensile Strain	9.950E-3	1.077E-2

Net External Pressure = 19.9 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.353	7.5	5.5	OK
Unconstrained Collapse [psi]	23.2	126.6	5.5	OK
Compressive Wall Stress [psi]	104.5	1150.0	11.0	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	31.4	221.0	7.0	OK
Tensile Stress [psi]	593.4	1200.0	2.0	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	103.571 psi	60.486 psi
1	8.00 in	12.00 in	103.423 psi	57.148 psi
2	12.00 in	16.13 in	103.210 psi	55.148 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

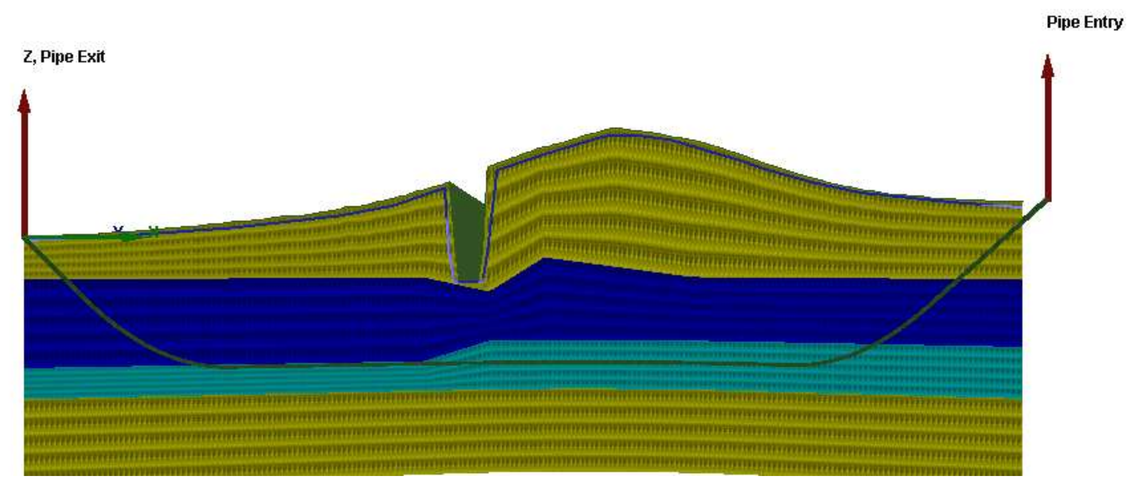
Rheological model: Power-Law

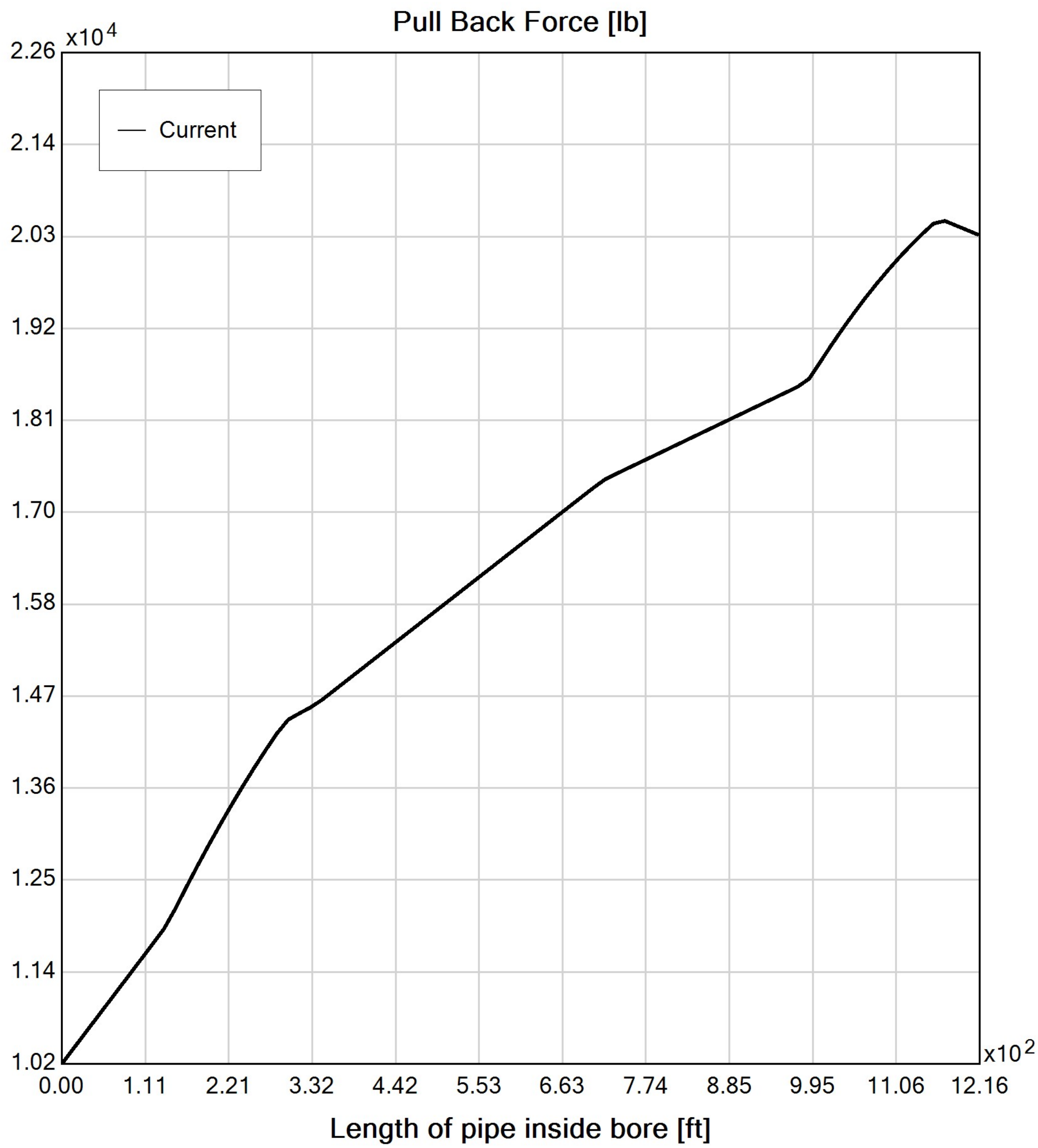
Fluid Consistency Index (K): 63.17

Power Law Exponent (n): 0.14

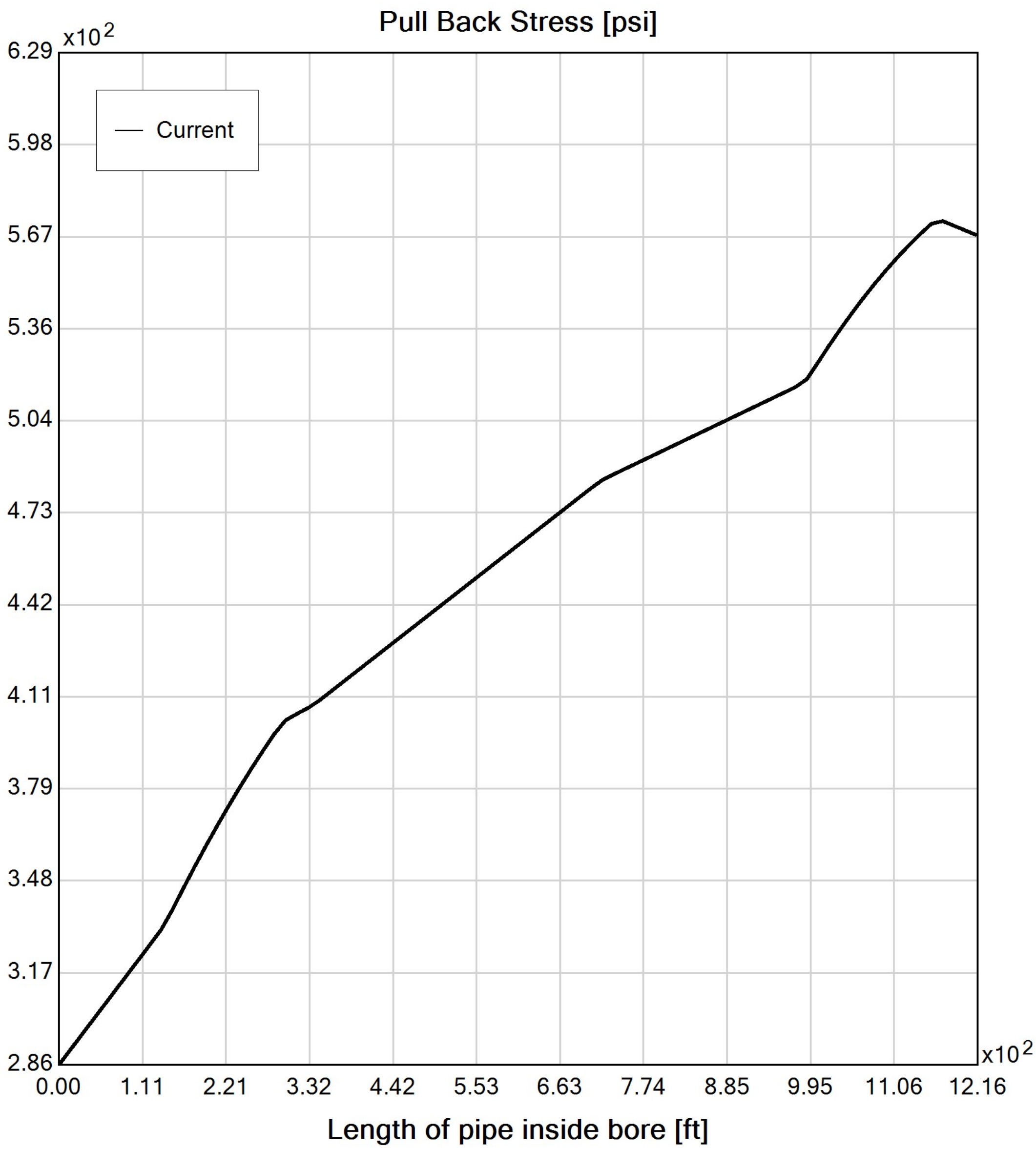
Effective Viscosity (cP): 859.3

Virtual Site

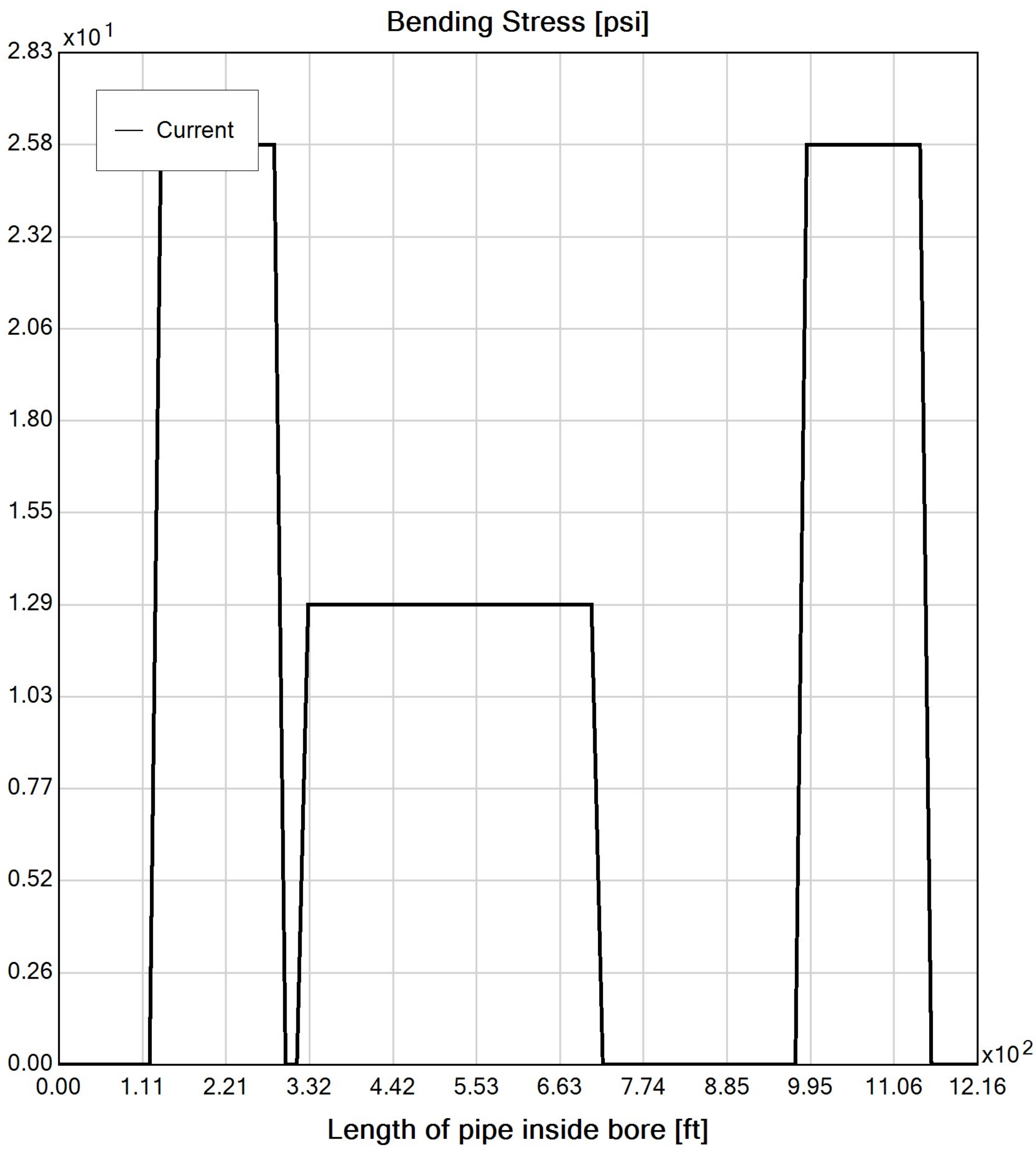




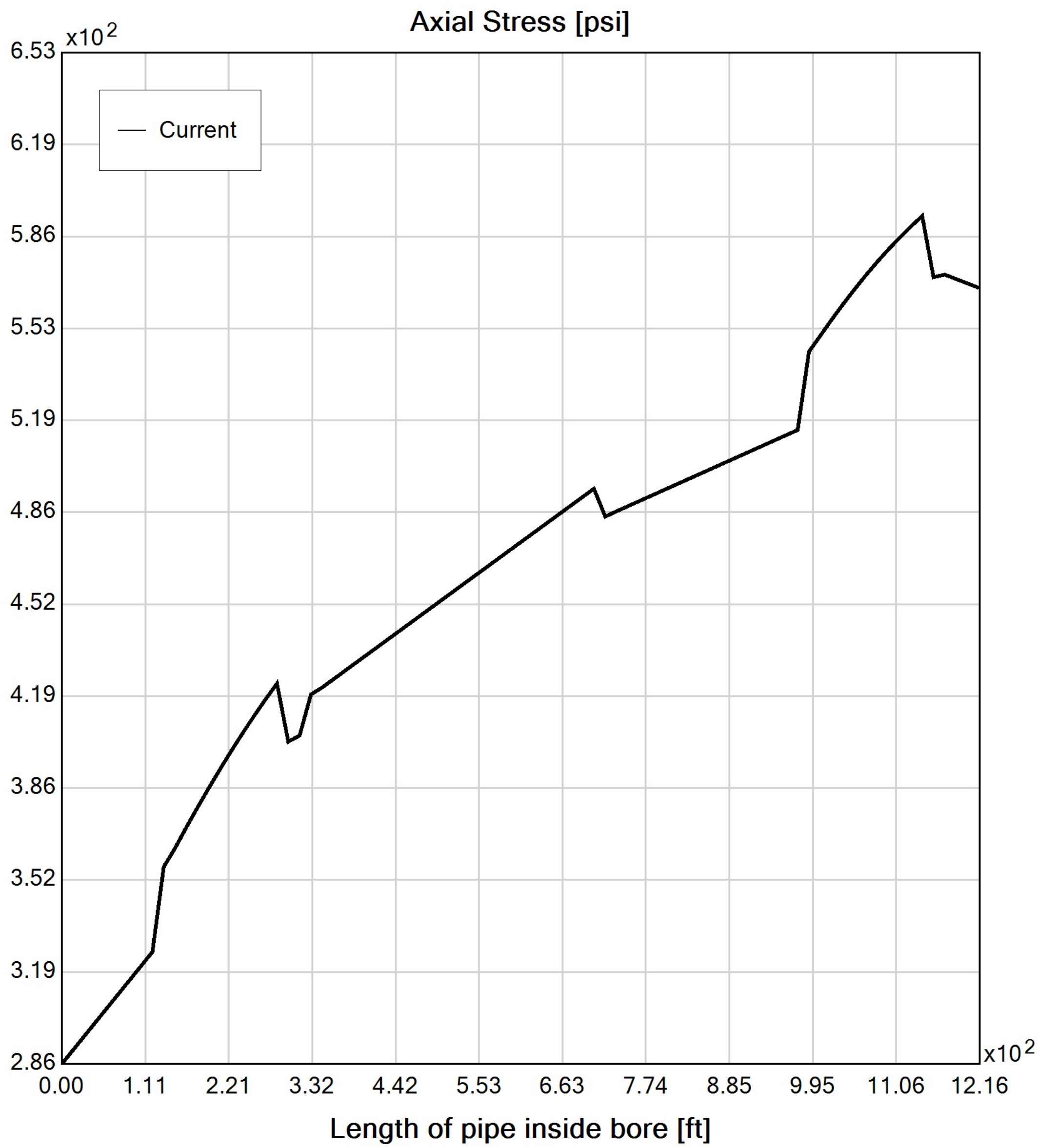
Pull Back Force [lb]
x10^4
2.26
2.14
2.03
1.92
1.81
1.70
1.58
1.47
1.36
1.25
1.14
1.02
Current
x10^2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]



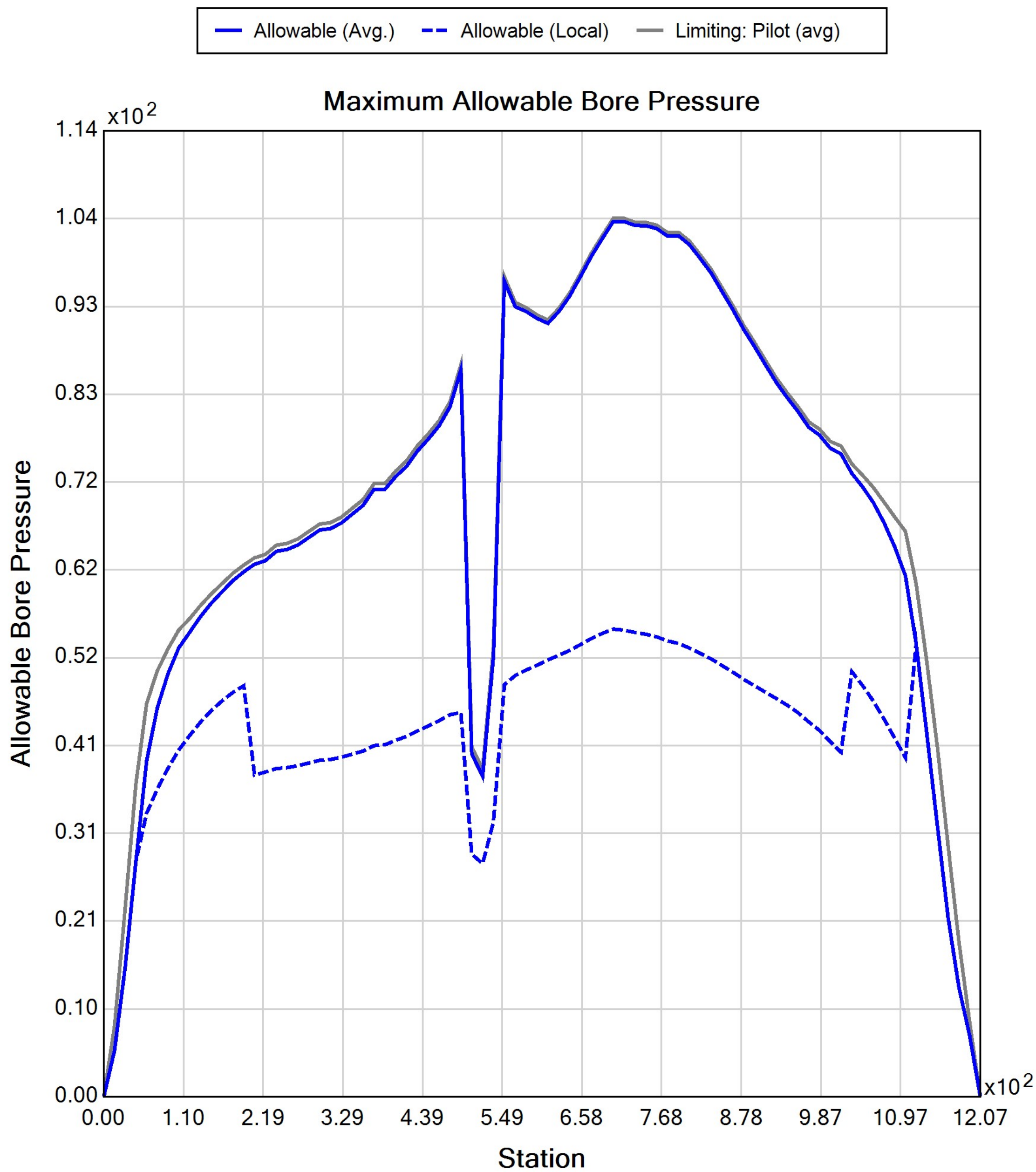
Pull Back Stress [psi]
x10 2
6.29
5.98
5.67
5.36
5.04
4.73
4.42
4.11
3.79
3.48
3.17
2.86
Current
x10 2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]



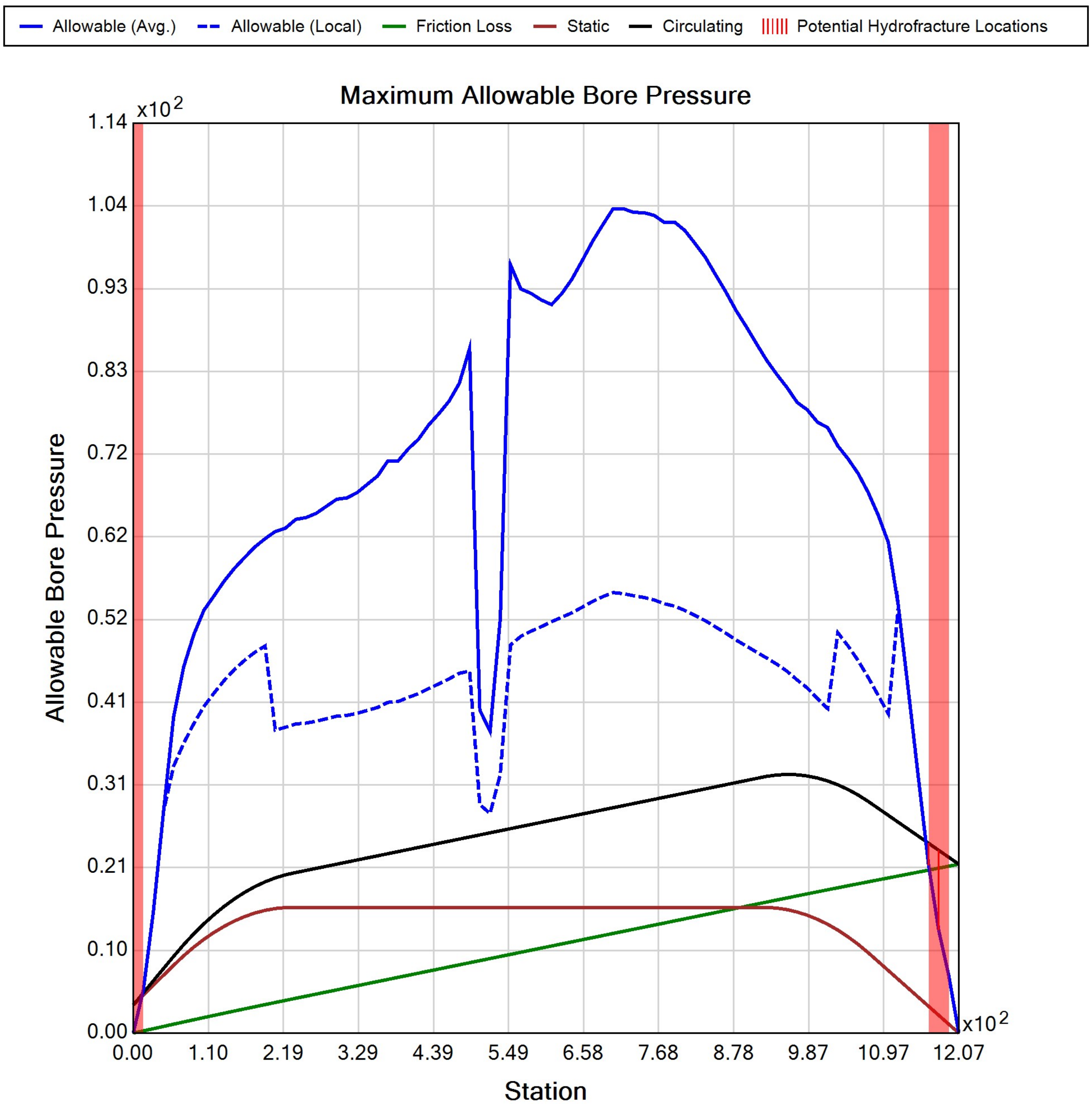
Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]



Axial Stress [psi]
x10^2
6.53
6.19
5.86
5.53
5.19
4.86
4.52
4.19
3.86
3.52
3.19
2.86
Current
x10^2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]



Allowable (Avg.)
Allowable (Local)
Limiting: Pilot (avg)
Maximum Allowable Bore Pressure
x10 2
1.14
1.04
0.93
0.83
0.72
0.62
0.52
0.41
0.31
0.21
0.10
0.00
Allowable Bore Pressure
0.00
1.10
2.19
3.29
4.39
5.49
6.58
7.68
8.78
9.87
10.97
12.07
x10 2
Station


Allowable (Avg.)
Allowable (Local)
Friction Loss
Static
Circulating
Potential Hydrofracture Locations
Maximum Allowable Bore Pressure
x10 2
1.14
1.04
0.93
0.83
0.72
0.62
0.52
0.41
0.31
0.21
0.10
0.00
Allowable Bore Pressure
0.00
1.10
2.19
3.29
4.39
5.49
6.58
7.68
8.78
9.87
10.97
12.07
x10 2
Station

Generated Output

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Input Summary

Start Coordinate	(0.00, 0.00, 129.14) ft
End Coordinate	(1210.00, 0.00, 136.00) ft
Project Length	1210.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 1215.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.2	19.0
Water Pressure	20.1	20.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	21.4	39.2
Deflection		
Earth Load Deflection	0.858	5.178
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.887	5.207
Compressive Stress [psi]		
Compressive Wall Stress	96.1	176.2

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	1110.9	1110.9
Pullback Stress [psi]	634.8	634.8
Pullback Strain	1.104E-2	1.104E-2
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	634.8	636.0
Tensile Strain	1.104E-2	1.116E-2

Net External Pressure = 19.9 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.887	7.5	8.5	OK
Unconstrained Collapse [psi]	21.5	127.5	5.9	OK
Compressive Wall Stress [psi]	96.1	1150.0	12.0	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	31.4	219.0	7.0	OK
Tensile Stress [psi]	636.0	1200.0	1.9	OK

Generated Output

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Project Summary

General:	HDD #10 - Conduit 2 Start Date: 09-22-2022 End Date: 09-22-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	Amherst, Massachusetts
Description:	North to South 10" DR 9 8" bit

Input Summary

Start Coordinate	(0.00, 0.00, 129.14) ft
End Coordinate	(1240.00, 0.00, 136.00) ft
Project Length	1240.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 4

Soil Layer #1 USCS, Sand (S), SM

From Assistant

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Clay (C), CL

From Assistant

Unit Weight: 80.0000 (dry), 110.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 300.00, Coh: 5.50 [psi]

Soil Layer #3 USCS, Clay (C), CL

From Assistant

Unit Weight: 70.0000 (dry), 100.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 200.00, Coh: 3.13 [psi]

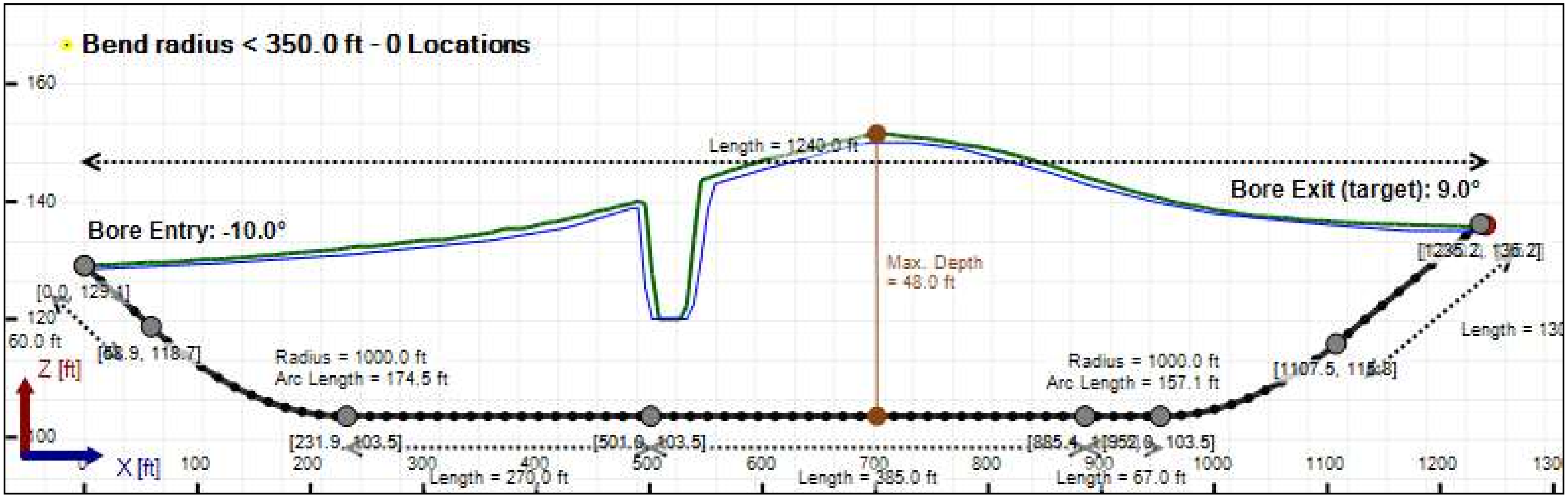
Soil Layer #4 USCS, Sand (S), SW

From Assistant

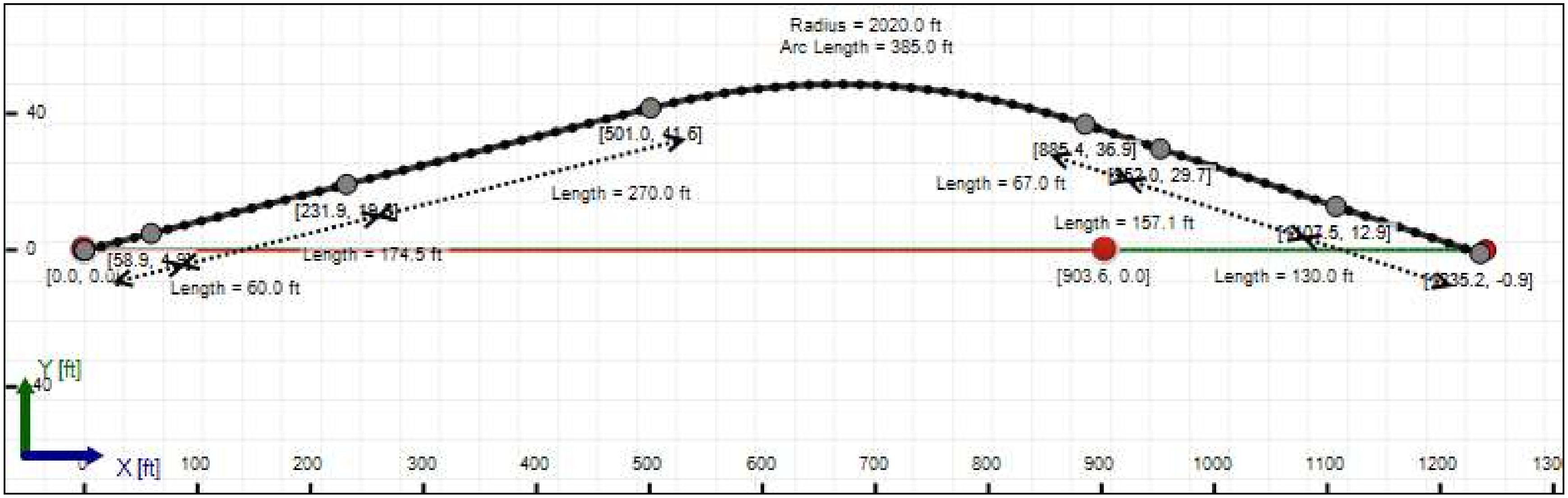
Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Bore Cross-Section View



Bore Plan View



Powered by BoreAid

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1245.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	3.1	19.0
Water Pressure	20.1	20.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	23.2	39.2
Deflection		
Earth Load Deflection	1.217	5.178
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.349	5.310
Compressive Stress [psi]		
Compressive Wall Stress	104.5	176.2

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	20991.8	20991.8
Pullback Stress [psi]	585.4	585.4
Pullback Strain	1.018E-2	1.018E-2
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	585.4	606.5
Tensile Strain	1.018E-2	1.100E-2

Net External Pressure = 19.8 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.349	7.5	5.6	OK
Unconstrained Collapse [psi]	23.2	126.6	5.5	OK
Compressive Wall Stress [psi]	104.5	1150.0	11.0	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	31.3	220.2	7.0	OK
Tensile Stress [psi]	606.5	1200.0	2.0	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	103.573 psi	60.356 psi
1	8.00 in	12.00 in	103.422 psi	56.979 psi
2	12.00 in	16.13 in	103.205 psi	55.146 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

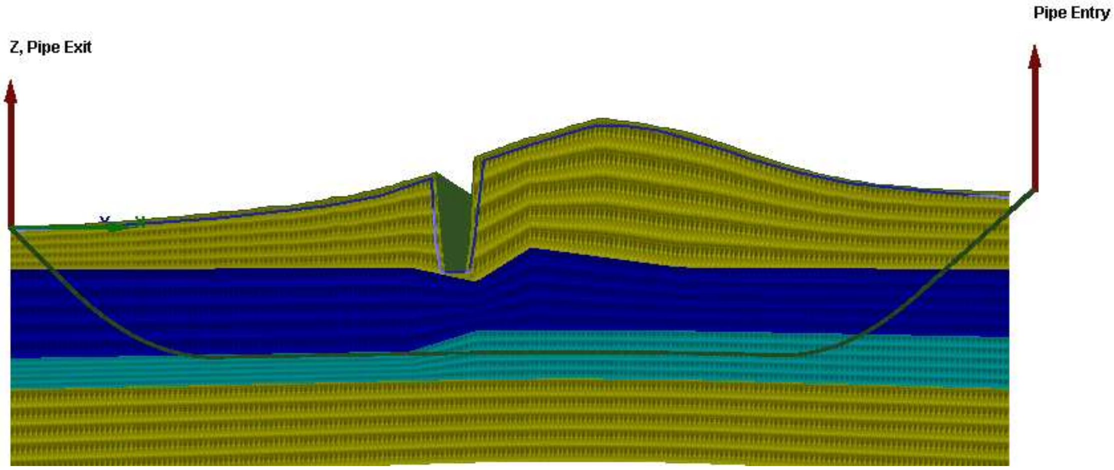
Rheological model: Power-Law

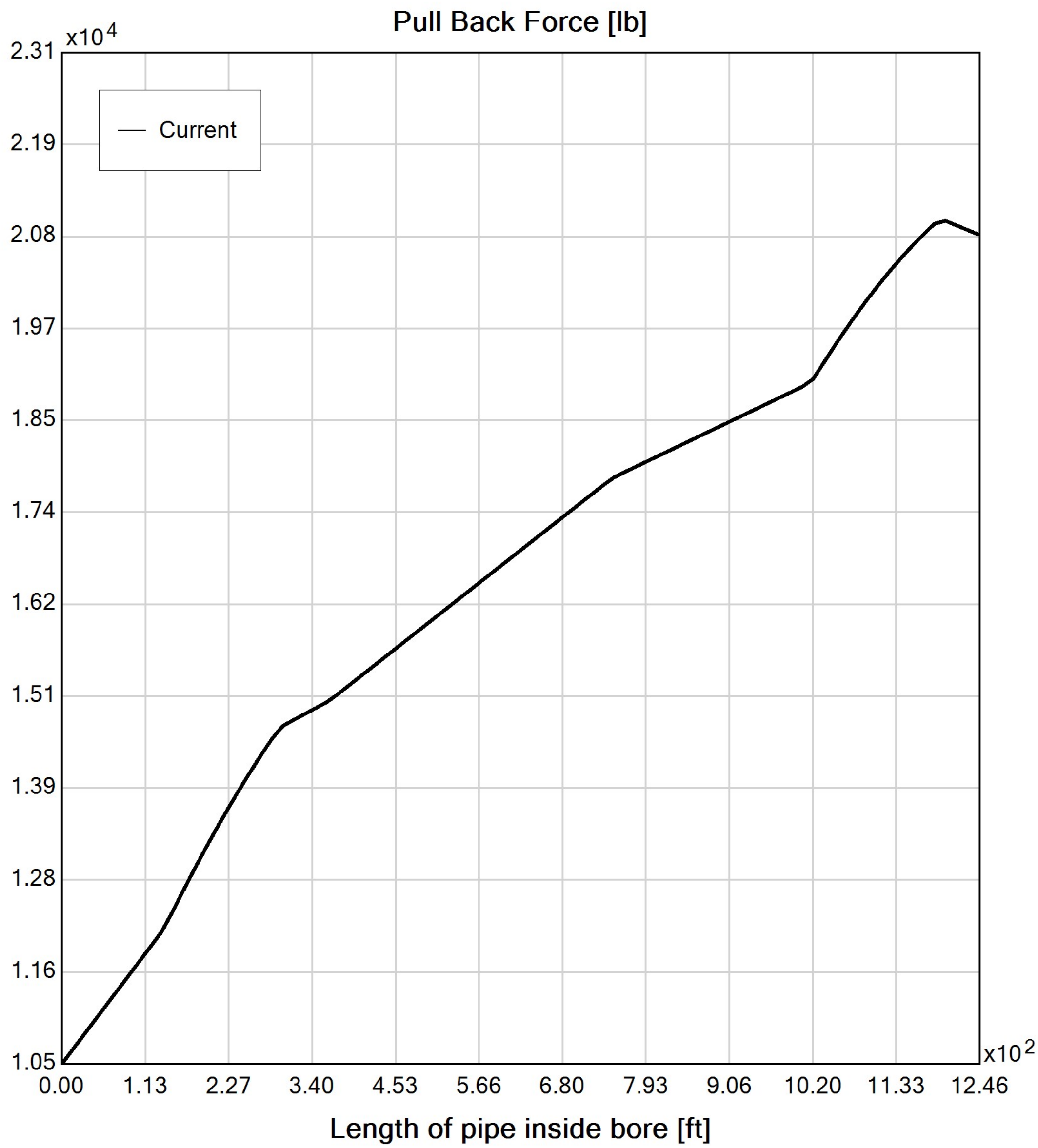
Fluid Consistency Index (K): 63.17

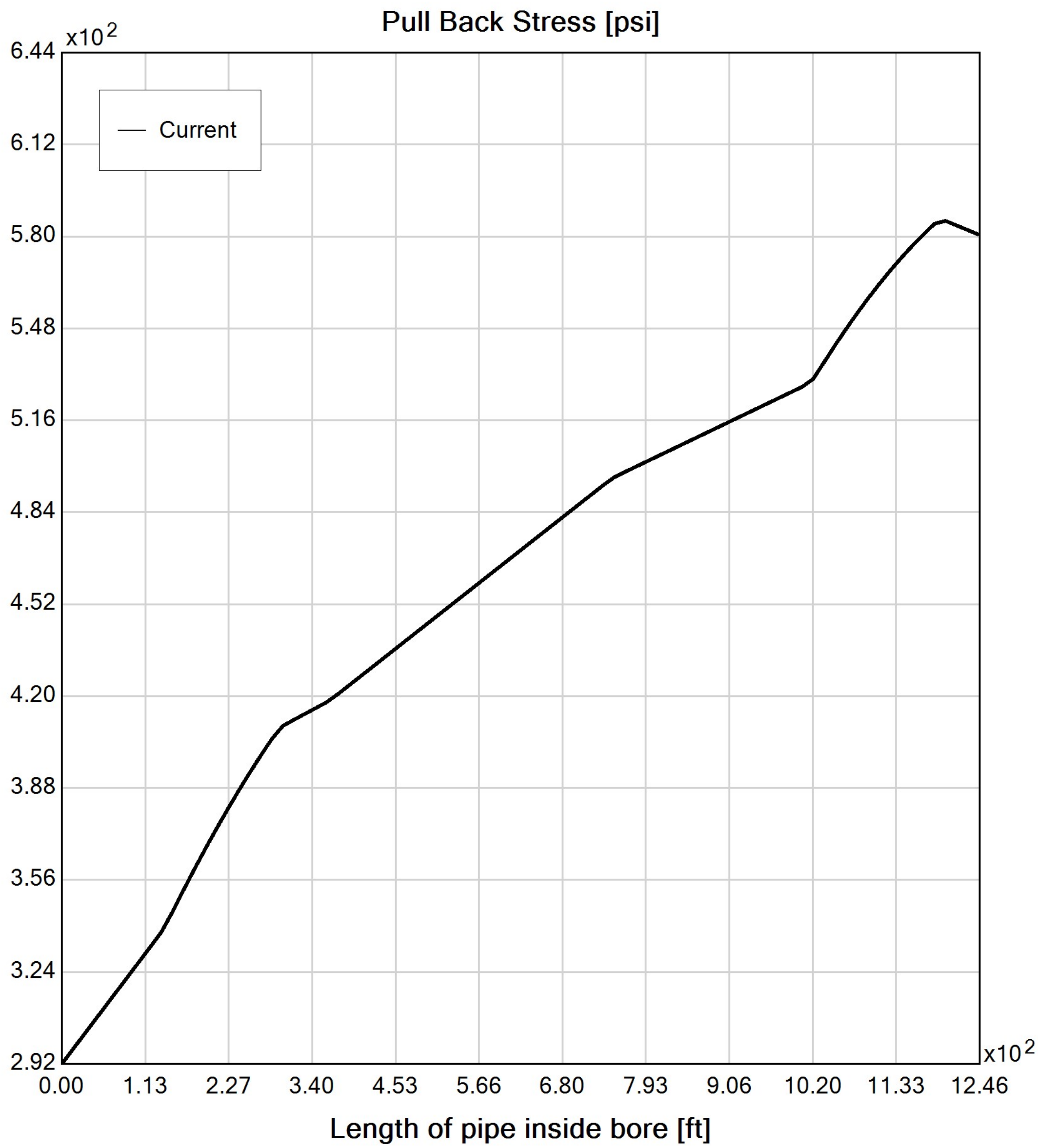
Power Law Exponent (n): 0.14

Effective Viscosity (cP): 859.3

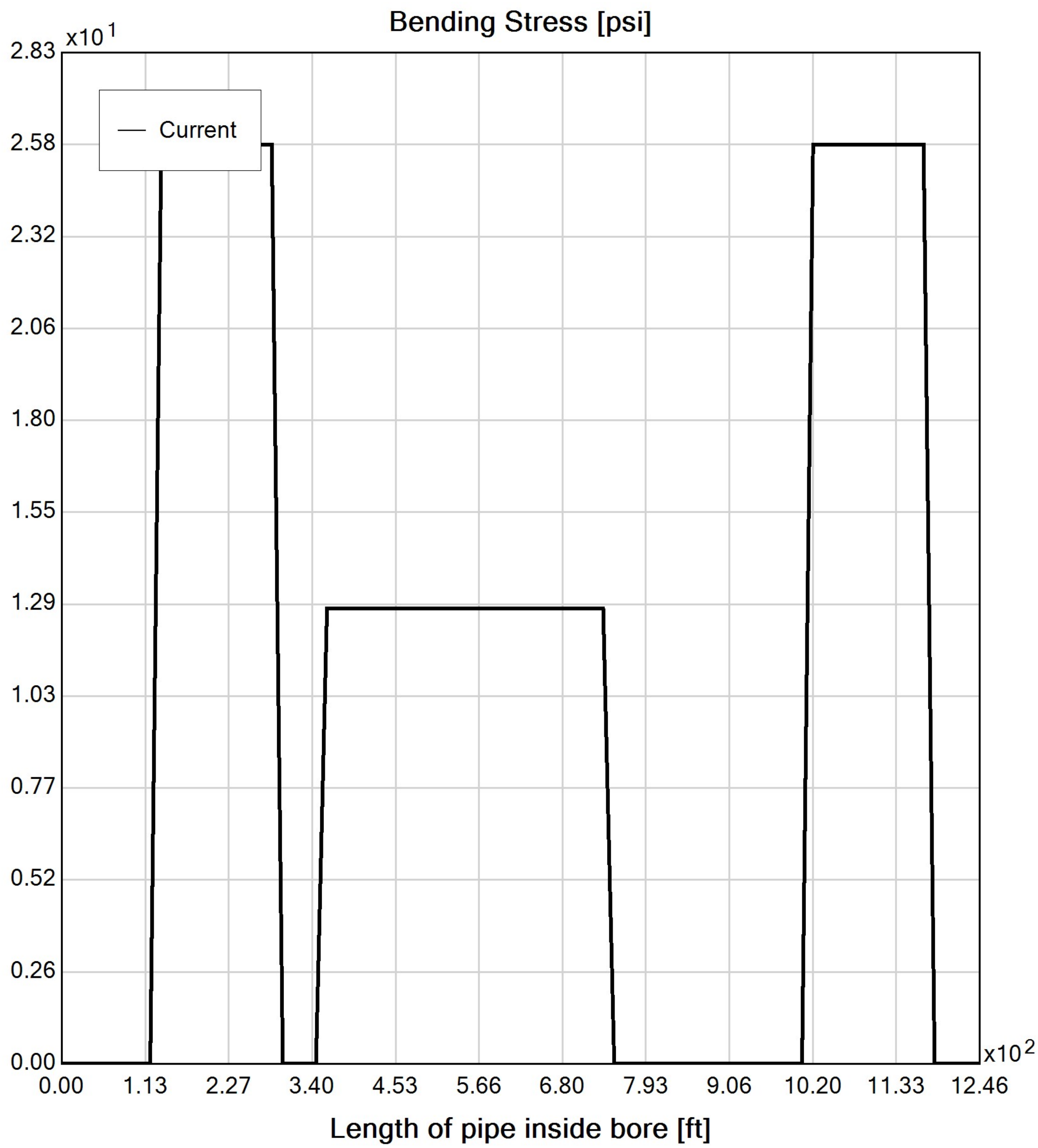
Virtual Site

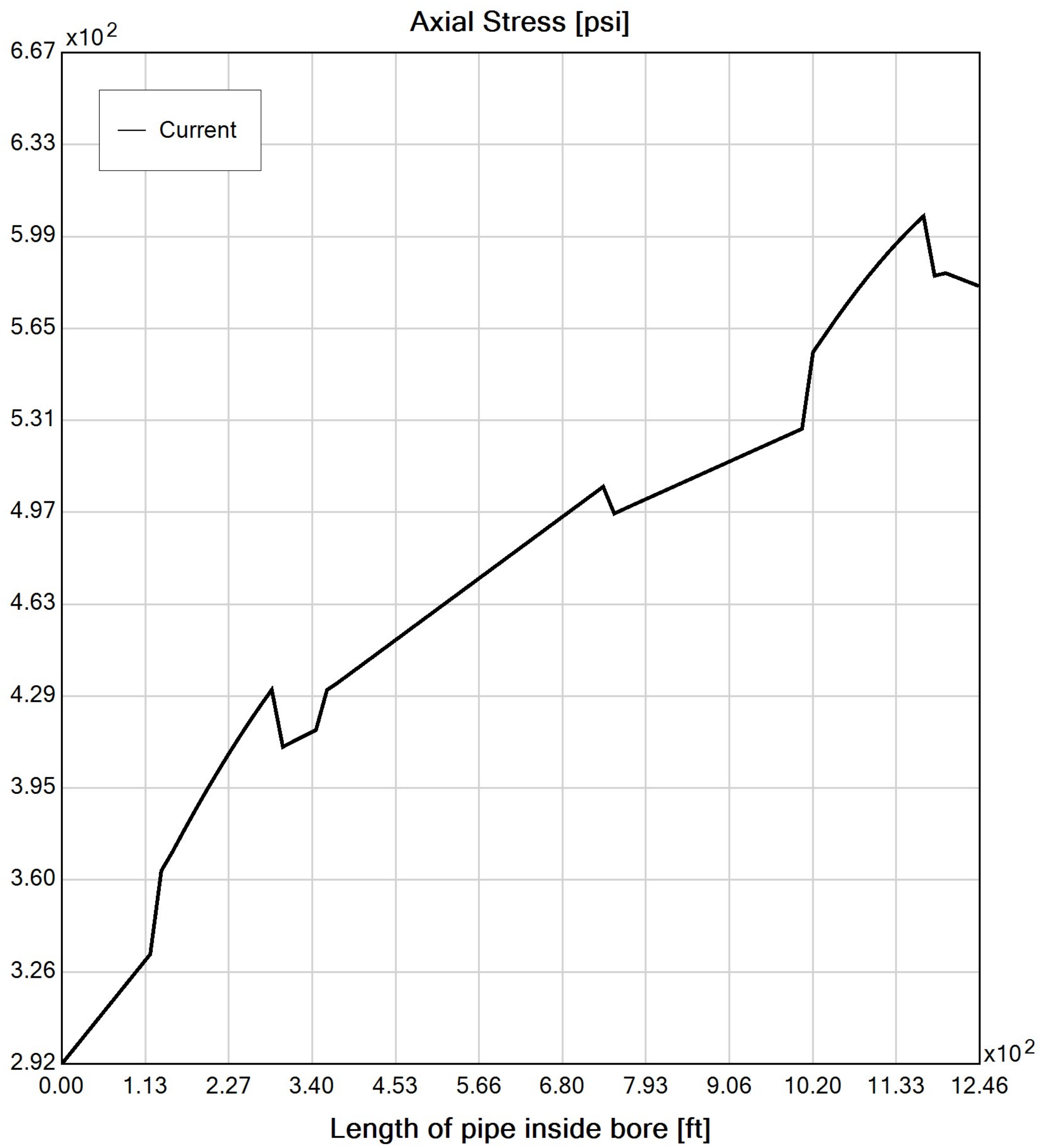



Pull Back Force [lb]
x10^4
2.31
2.19
2.08
1.97
1.85
1.74
1.62
1.51
1.39
1.28
1.16
1.05
Current
x10^2
0.00
1.13
2.27
3.40
4.53
5.66
6.80
7.93
9.06
10.20
11.33
12.46
Length of pipe inside bore [ft]

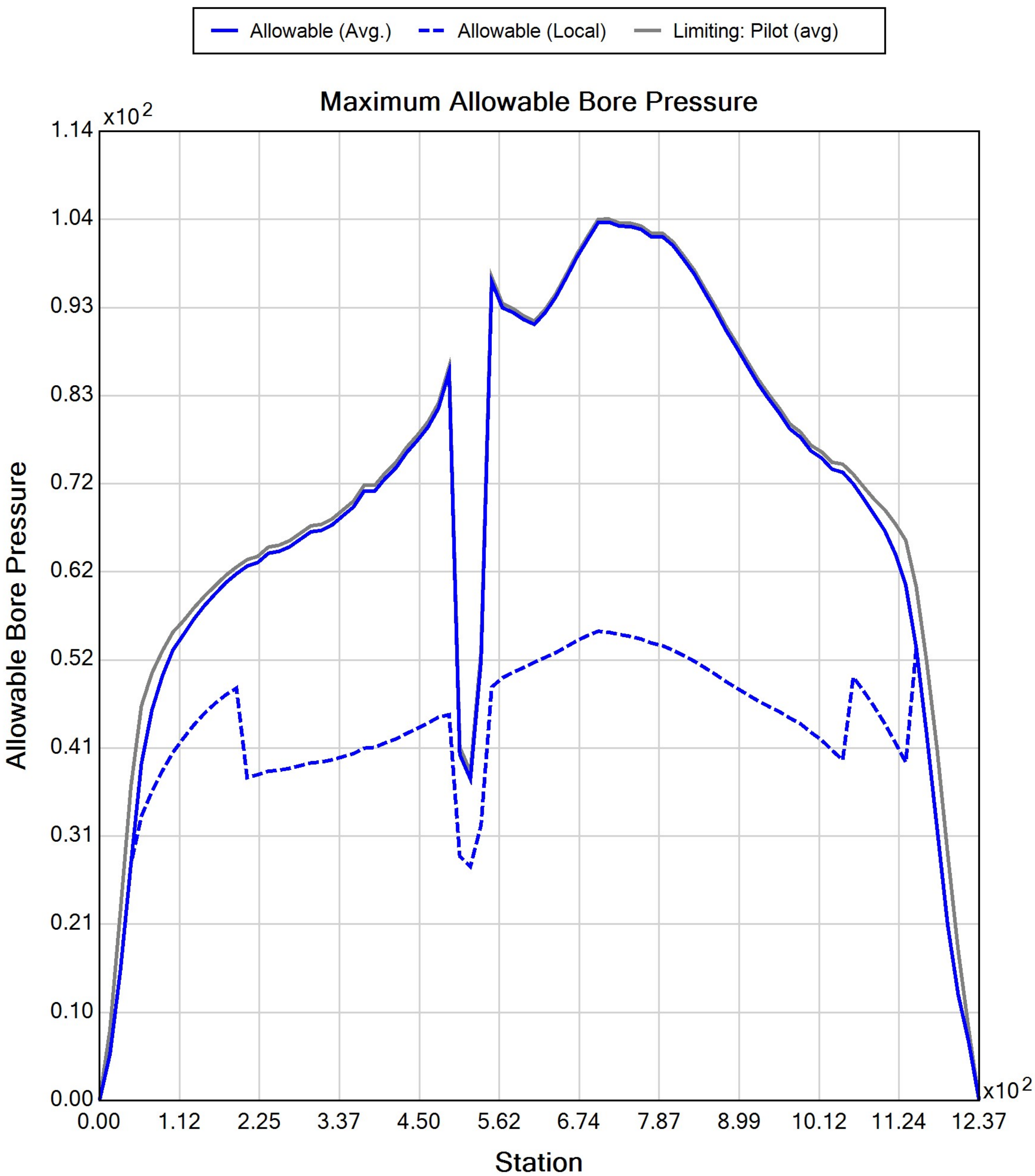


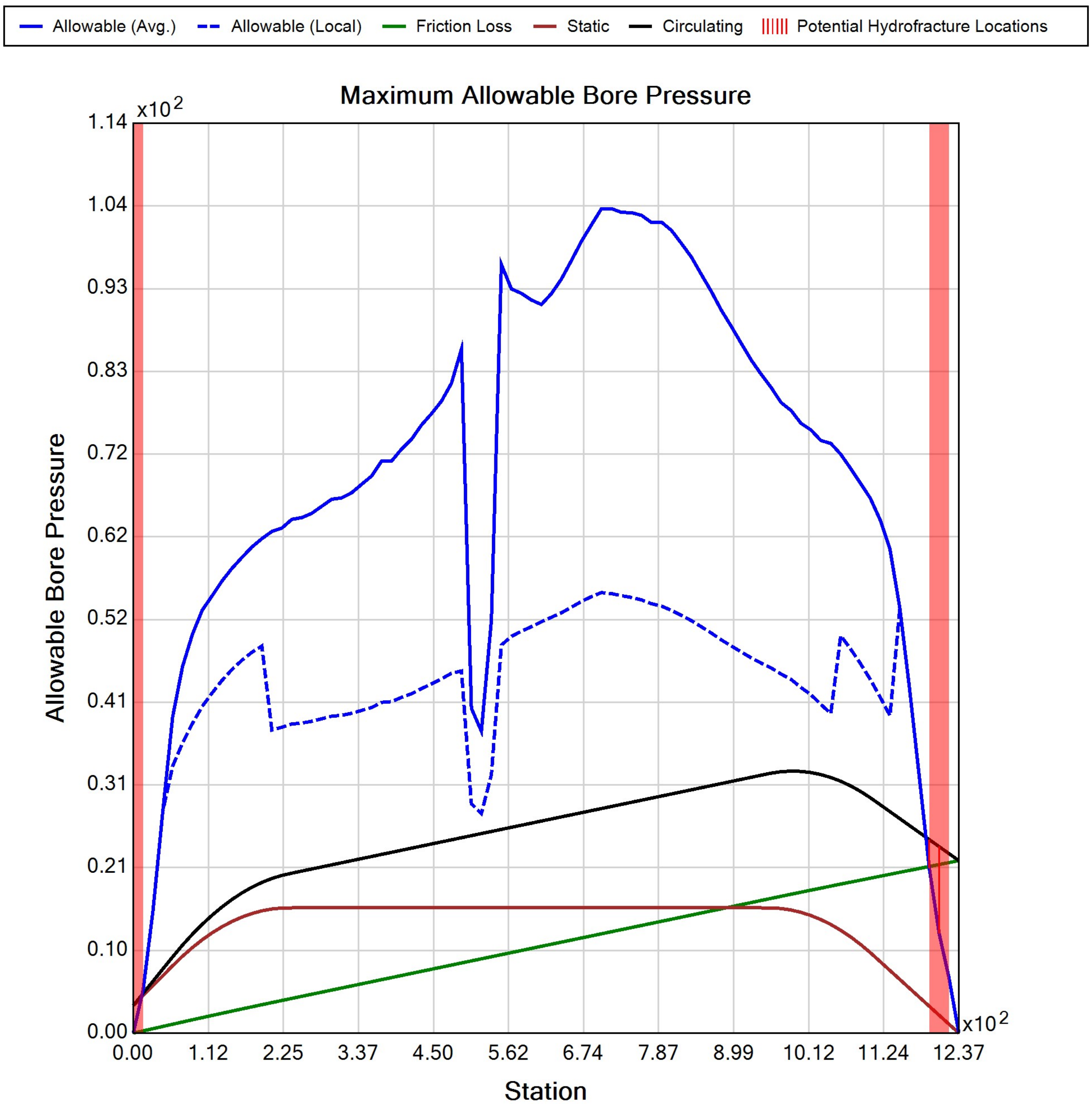
Pull Back Stress [psi]
x10^2
6.44
6.12
5.80
5.48
5.16
4.84
4.52
4.20
3.88
3.56
3.24
2.92
Current
x10^2
0.00
1.13
2.27
3.40
4.53
5.66
6.80
7.93
9.06
10.20
11.33
12.46
Length of pipe inside bore [ft]


Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 2
0.00
1.13
2.27
3.40
4.53
5.66
6.80
7.93
9.06
10.20
11.33
12.46
Length of pipe inside bore [ft]



Axial Stress [psi]
x10 2
6.67
6.33
5.99
5.65
5.31
4.97
4.63
4.29
3.95
3.60
3.26
2.92
Current
x10 2
0.00
1.13
2.27
3.40
4.53
5.66
6.80
7.93
9.06
10.20
11.33
12.46
Length of pipe inside bore [ft]


Allowable (Avg.)
Allowable (Local)
Limiting: Pilot (avg)
Maximum Allowable Bore Pressure
x10 2
1.14
1.04
0.93
0.83
0.72
0.62
0.52
0.41
0.31
0.21
0.10
0.00
Allowable Bore Pressure
0.00
1.12
2.25
3.37
4.50
5.62
6.74
7.87
8.99
10.12
11.24
12.37
x10 2
Station



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Generated Output

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Input Summary

Start Coordinate	(0.00, 0.00, 129.14) ft
End Coordinate	(1240.00, 0.00, 136.00) ft
Project Length	1240.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 1245.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.2	19.0
Water Pressure	20.1	20.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	21.4	39.2
Deflection		
Earth Load Deflection	0.859	5.178
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.888	5.207
Compressive Stress [psi]		
Compressive Wall Stress	96.1	176.2

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	1134.2	1134.2
Pullback Stress [psi]	648.0	648.0
Pullback Strain	1.127E-2	1.127E-2
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	648.0	649.1
Tensile Strain	1.127E-2	1.139E-2

Net External Pressure = 19.8 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.888	7.5	8.4	OK
Unconstrained Collapse [psi]	21.4	127.5	6.0	OK
Compressive Wall Stress [psi]	96.1	1150.0	12.0	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	31.3	218.1	7.0	OK
Tensile Stress [psi]	649.1	1200.0	1.8	OK

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Project Summary

General:	HDD #11 - Conduit 1
	Ref: Fort Ann, NY Washington cty
	J2105
	Start Date: 06-24-2022
	End Date: 06-24-2022
Project Owner:	TDI
Project Contractor:	Kiewit
Project Consultant:	CHA-BCE
Designer:	MDB
	BCE
	Amherst, MA
Description:	West Alignment Running South to North 10" DR9

Input Summary

Start Coordinate	(0.00, 0.00, 129.00) ft
End Coordinate	(1250.00, 0.00, 129.00) ft
Project Length	1250.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 5

Soil Layer #1 USCS, Sand (S), SW

From Assistant

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Silt (M), MH

From Assistant

Unit Weight: 80.0000 (dry), 100.0000 (sat) [lb/ft3]

Phi: 28.00, S.M.: 50.00, Coh: 0.00 [psi]

Soil Layer #3 USCS, Clay (C), CL

From Assistant

Unit Weight: 100.0000 (dry), 120.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 145.00, Coh: 8.30 [psi]

Soil Layer #4 USCS, Sand (S), SW

From Assistant

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

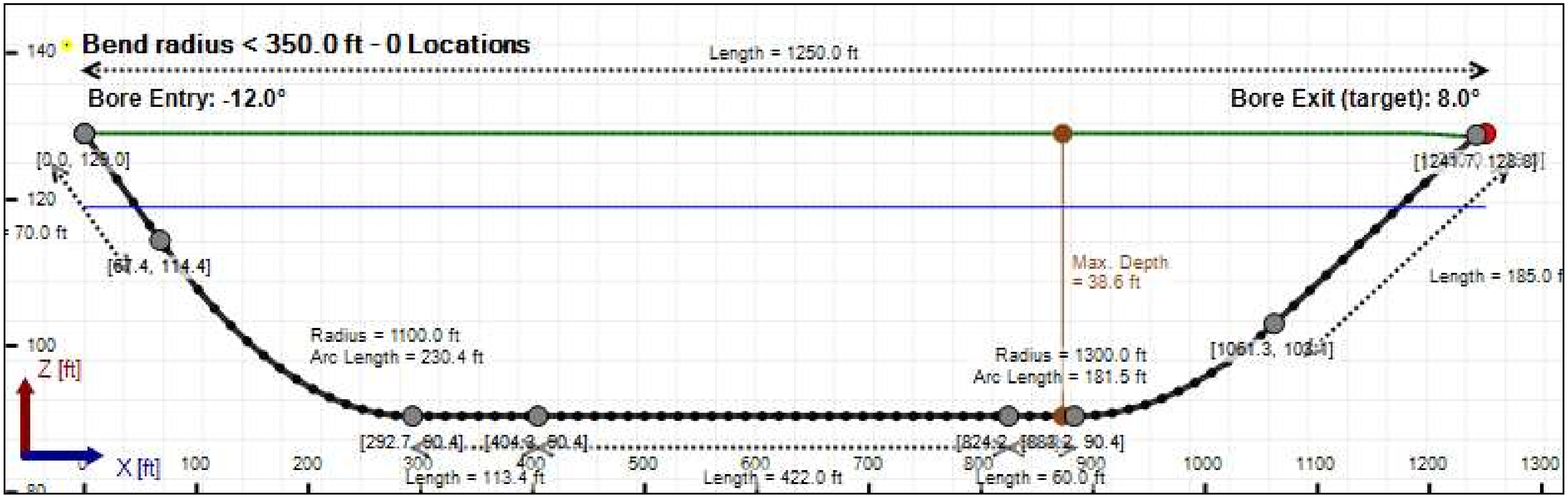
Soil Layer #5 Rock, Geological Classification, Sedimentary Rocks

From Assistant

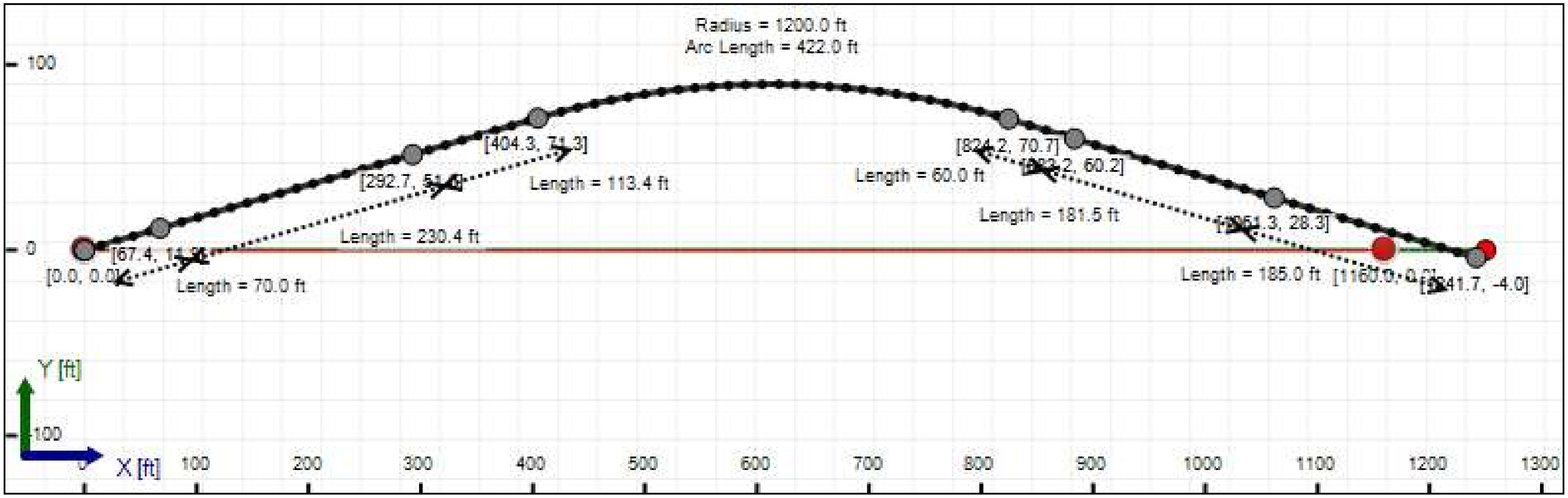
Unit Weight: 107.8272 (dry), 177.6384 (sat) [lb/ft3]

Phi: 35.00, S.M.: 1450.40, Coh: 2900.80 [psi]

Bore Cross-Section View



Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1274.99 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	3.9	19.6
Water Pressure	12.4	12.4
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	16.3	32.0
Deflection		
Earth Load Deflection	1.162	5.344
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.294	5.476
Compressive Stress [psi]		
Compressive Wall Stress	73.2	144.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	22775.1	22775.1
Pullback Stress [psi]	635.2	635.2
Pullback Strain	1.105E-2	1.105E-2
Bending Stress [psi]	0.0	23.4
Bending Strain	0	4.072E-4
Tensile Stress [psi]	635.2	657.0
Tensile Strain	1.105E-2	1.183E-2

Net External Pressure = 19.1 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.294	7.5	5.8	OK
Unconstrained Collapse [psi]	26.1	124.2	4.8	OK
Compressive Wall Stress [psi]	73.2	1150.0	15.7	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	36.1	217.6	6.0	OK
Tensile Stress [psi]	657.0	1200.0	1.8	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	6.50 in	105.909 psi	132.552 psi
1	6.50 in	12.00 in	105.629 psi	132.035 psi
2	12.00 in	16.13 in	105.314 psi	131.455 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

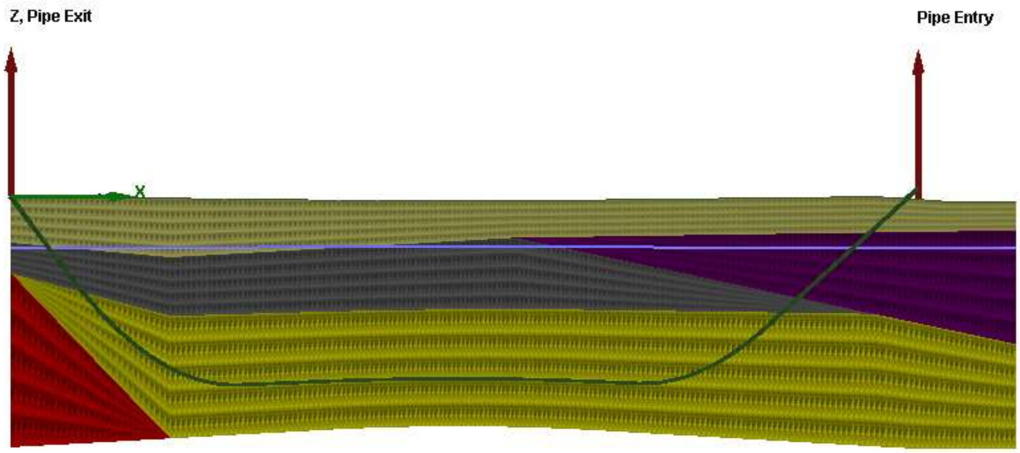
Rheological model: Power-Law

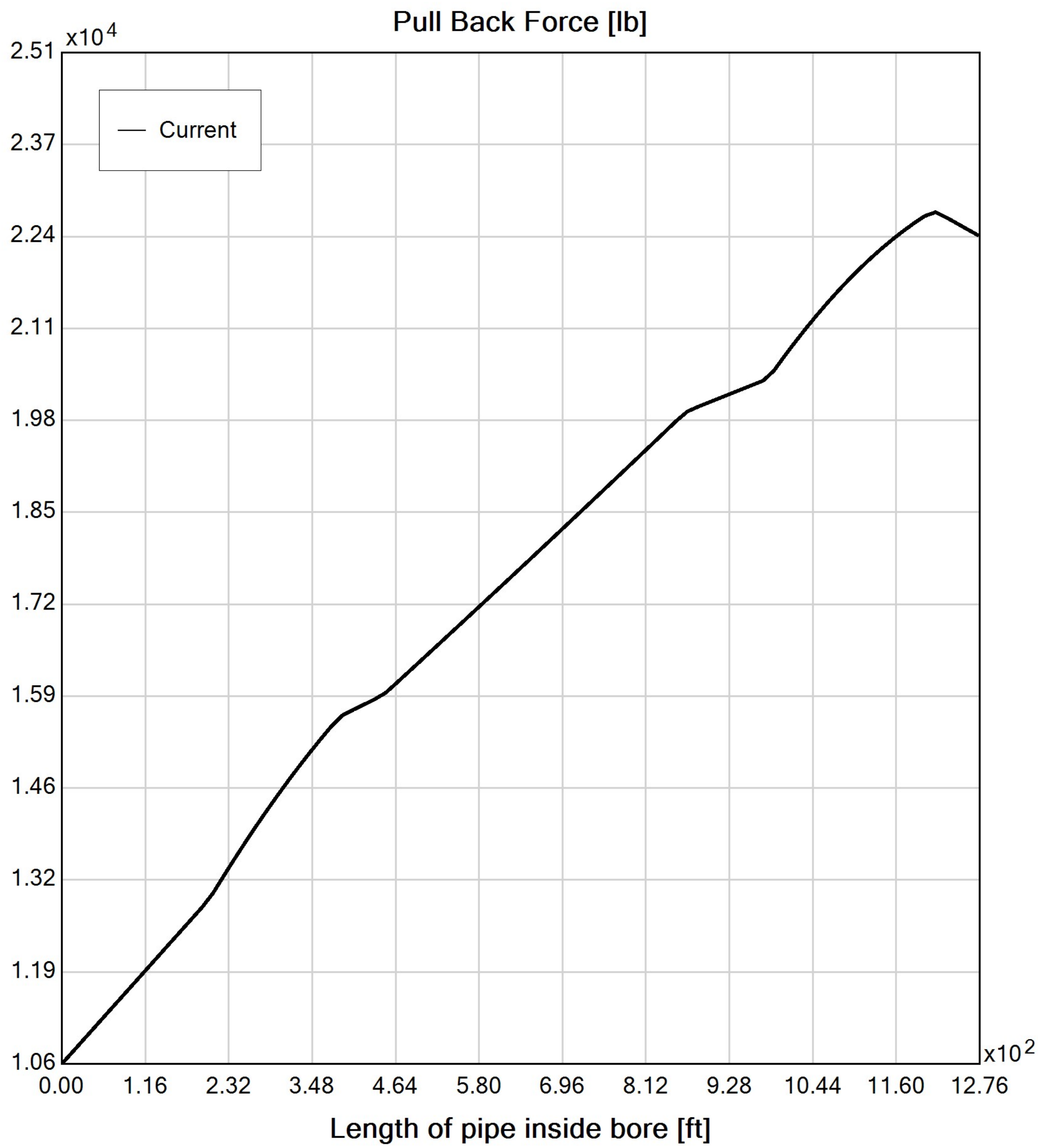
Fluid Consistency Index (K): 63.17

Power Law Exponent (n): 0.14

Effective Viscosity (cP): 378.3

Virtual Site





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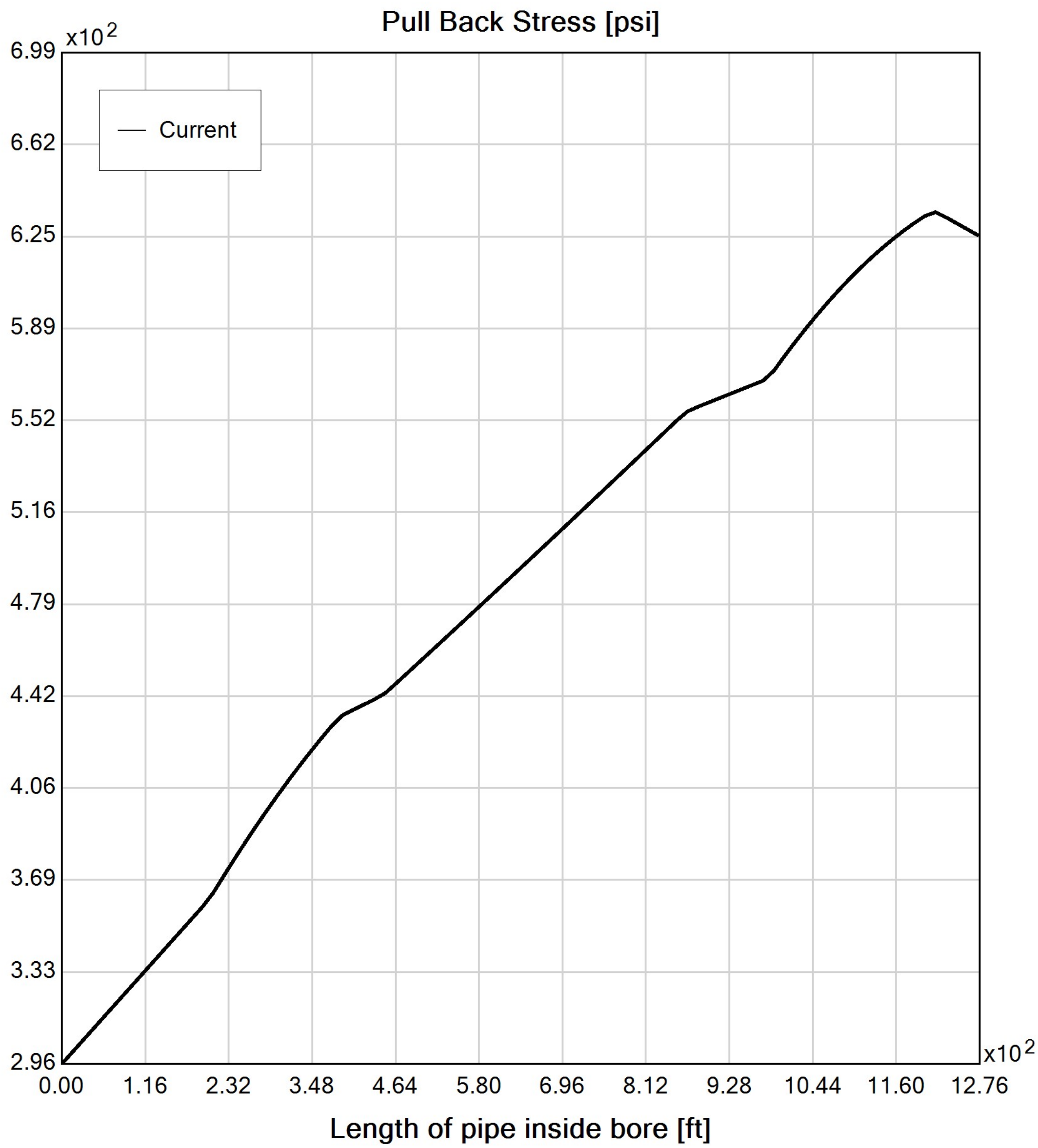
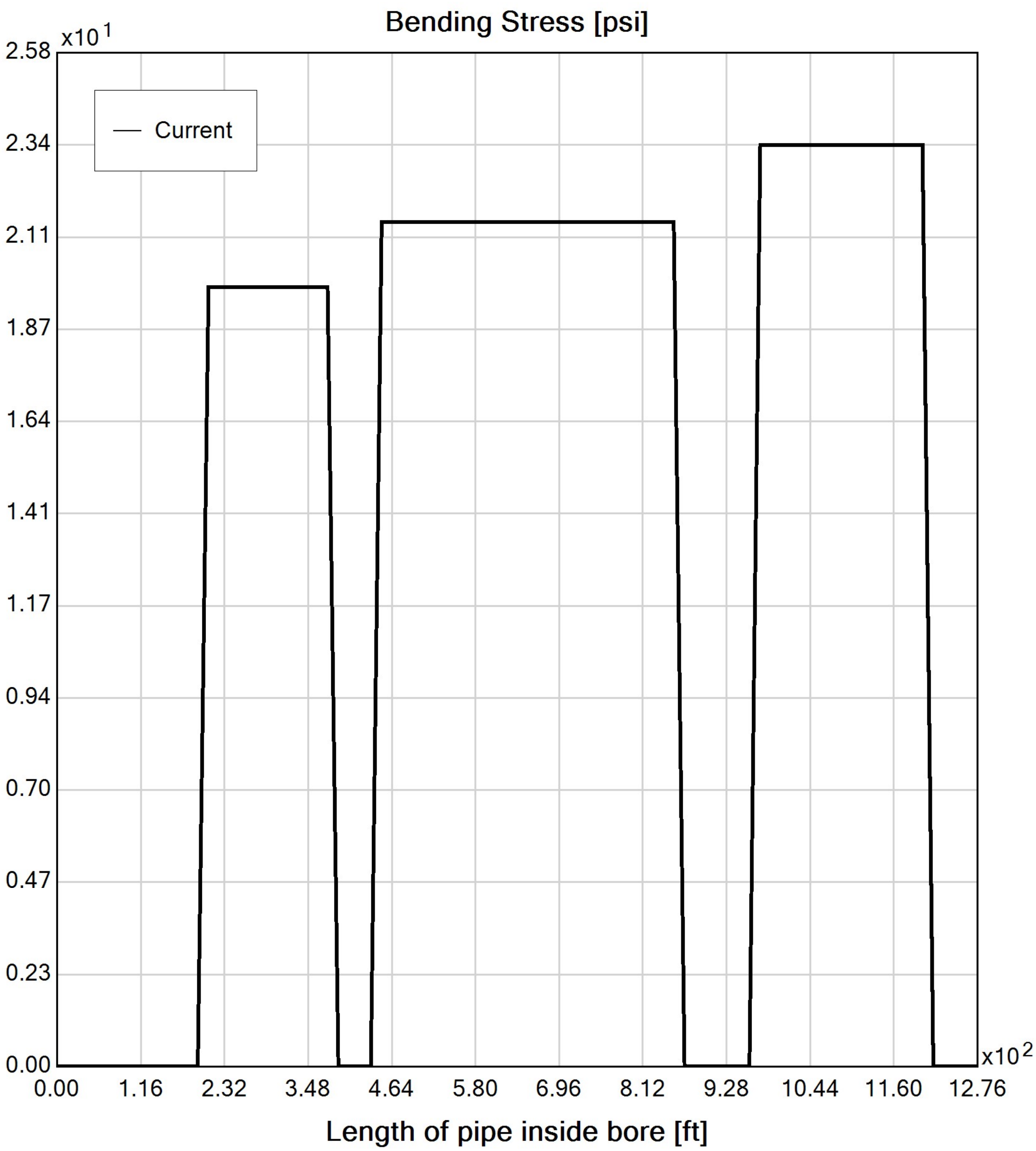
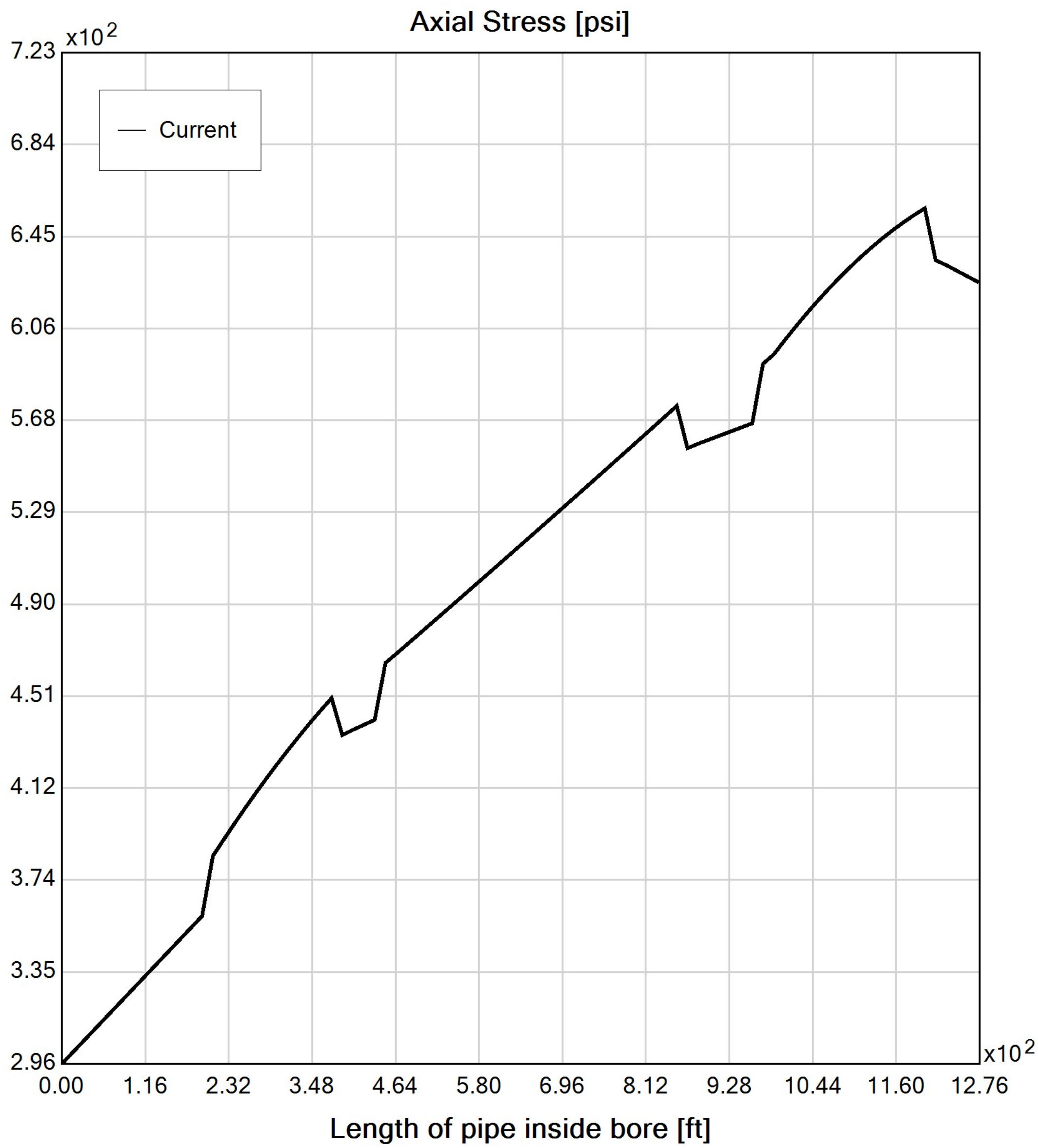
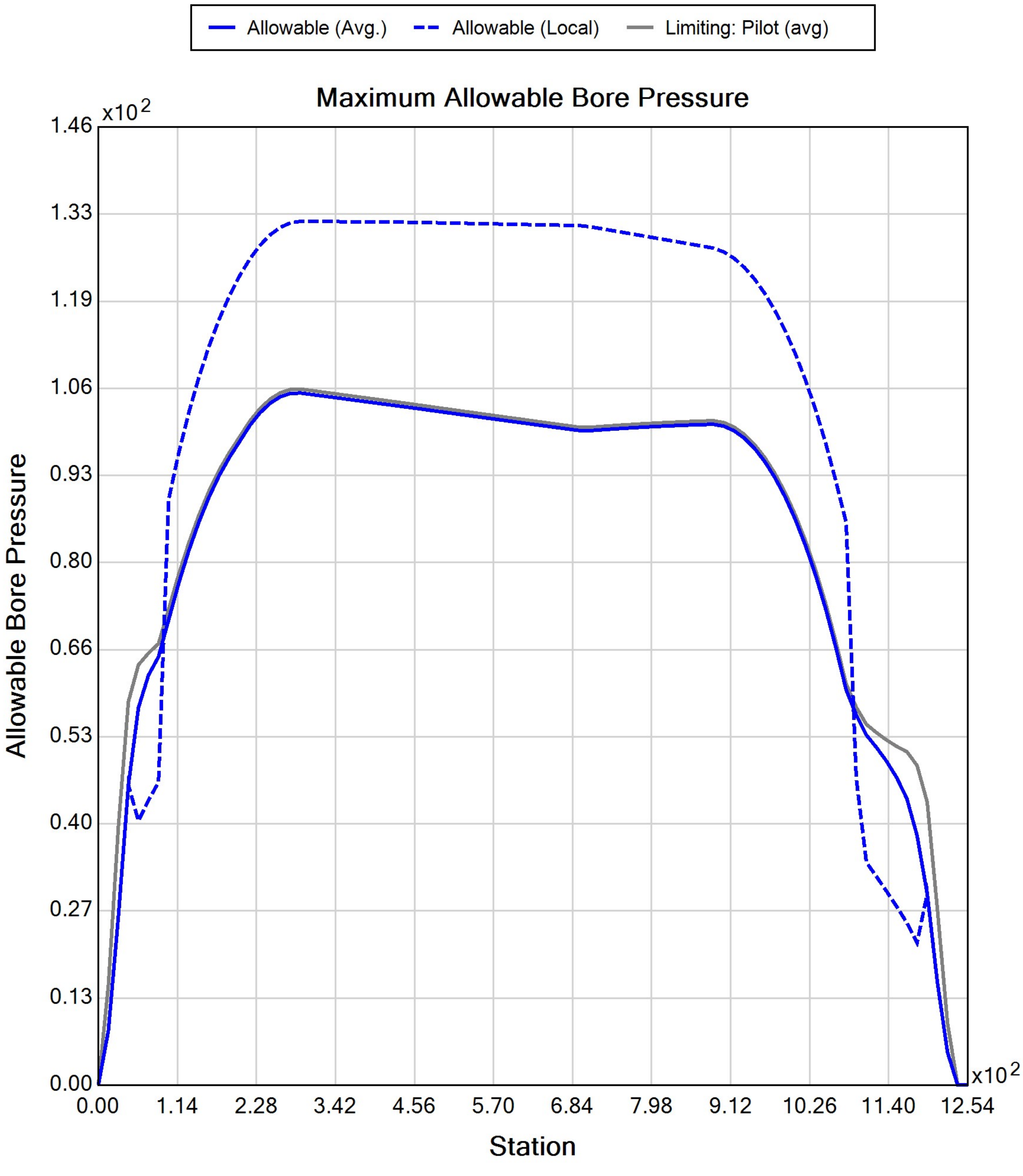
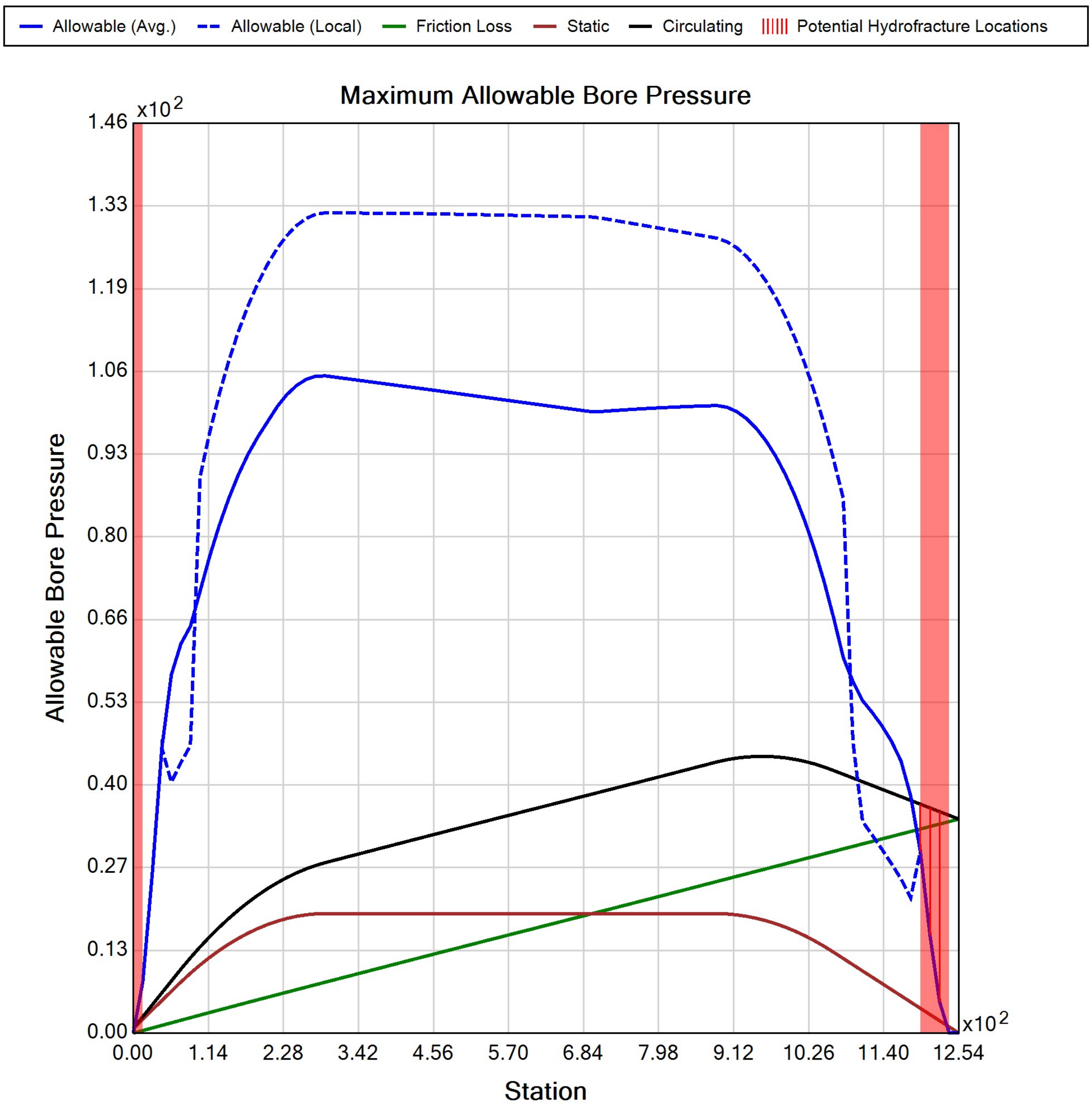

Pull Back Stress [psi]
x10 2
6.99
6.62
6.25
5.89
5.52
5.16
4.79
4.42
4.06
3.69
3.33
2.96
Current
x10 2
0.00
1.16
2.32
3.48
4.64
5.80
6.96
8.12
9.28
10.44
11.60
12.76
Length of pipe inside bore [ft]


Bending Stress [psi]
x10 1
2.58
2.34
2.11
1.87
1.64
1.41
1.17
0.94
0.70
0.47
0.23
0.00
Current
x10 2
0.00
1.16
2.32
3.48
4.64
5.80
6.96
8.12
9.28
10.44
11.60
12.76
Length of pipe inside bore [ft]



Axial Stress [psi]
x10^2
7.23
6.84
6.45
6.06
5.68
5.29
4.90
4.51
4.12
3.74
3.35
2.96
Current
x10^2
0.00
1.16
2.32
3.48
4.64
5.80
6.96
8.12
9.28
10.44
11.60
12.76
Length of pipe inside bore [ft]


Allowable (Avg.)
Allowable (Local)
Limiting: Pilot (avg)
Maximum Allowable Bore Pressure
x10 2
1.46
1.33
1.19
1.06
0.93
0.80
0.66
0.53
0.40
0.27
0.13
0.00
0.00
1.14
2.28
3.42
4.56
5.70
6.84
7.98
9.12
10.26
11.40
12.54
x10 2
Allowable Bore Pressure
Station


Allowable (Avg.)
Allowable (Local)
Friction Loss
Static
Circulating
Potential Hydrofracture Locations
Maximum Allowable Bore Pressure
x10 2
1.46
1.33
1.19
1.06
0.93
0.80
0.66
0.53
0.40
0.27
0.13
0.00
Allowable Bore Pressure
0.00
1.14
2.28
3.42
4.56
5.70
6.84
7.98
9.12
10.26
11.40
12.54
x10 2
Station

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Input Summary

Start Coordinate	(0.00, 0.00, 129.00) ft
End Coordinate	(1250.00, 0.00, 129.00) ft
Project Length	1250.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 1274.99 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.5	19.6
Water Pressure	12.4	12.4
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	13.9	32.0
Deflection		
Earth Load Deflection	0.609	5.344
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.638	5.373
Compressive Stress [psi]		
Compressive Wall Stress	62.7	144.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	1221.2	1221.2
Pullback Stress [psi]	697.8	697.8
Pullback Strain	1.214E-2	1.214E-2
Bending Stress [psi]	0.0	5.2
Bending Strain	0	8.996E-5
Tensile Stress [psi]	697.8	701.4
Tensile Strain	1.214E-2	1.229E-2

Net External Pressure = 19.1 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.638	7.5	11.8	OK
Unconstrained Collapse [psi]	26.1	132.7	5.1	OK
Compressive Wall Stress [psi]	62.7	1150.0	18.3	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	36.1	215.3	6.0	OK
Tensile Stress [psi]	701.4	1200.0	1.7	OK

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Project Summary

General:	HDD #11 - Conduit 2
	Ref: Fort Ann, NY Washington cty
	J2105
	Start Date: 06-29-2022
	End Date: 06-29-2022
Project Owner:	TDI
Project Contractor:	Kiewit
Project Consultant:	CHA-BCE
Designer:	MDB
	BCE
	Amherst, MA
Description:	East Alignment Running South to North 10" DR9

Input Summary

Start Coordinate	(0.00, 0.00, 129.00) ft
End Coordinate	(1200.00, 0.00, 129.00) ft
Project Length	1200.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 5

Soil Layer #1 USCS, Sand (S), SW

From Assistant

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

Soil Layer #2 USCS, Silt (M), MH

From Assistant

Unit Weight: 80.0000 (dry), 100.0000 (sat) [lb/ft3]

Phi: 28.00, S.M.: 50.00, Coh: 0.00 [psi]

Soil Layer #3 USCS, Clay (C), CL

From Assistant

Unit Weight: 100.0000 (dry), 120.0000 (sat) [lb/ft3]

Phi: 0.00, S.M.: 300.00, Coh: 5.50 [psi]

Soil Layer #4 USCS, Sand (S), SW

From Assistant

Unit Weight: 110.0000 (dry), 125.0000 (sat) [lb/ft3]

Phi: 34.00, S.M.: 500.00, Coh: 0.00 [psi]

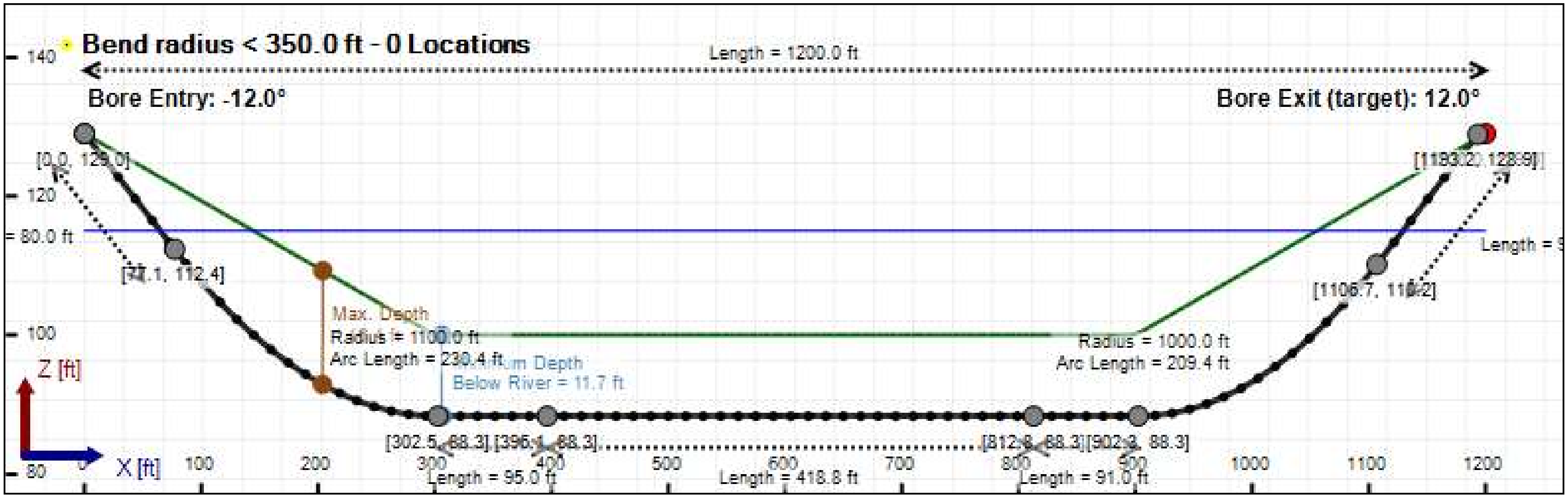
Soil Layer #5 Rock, Geological Classification, Sedimentary Rocks

From Assistant

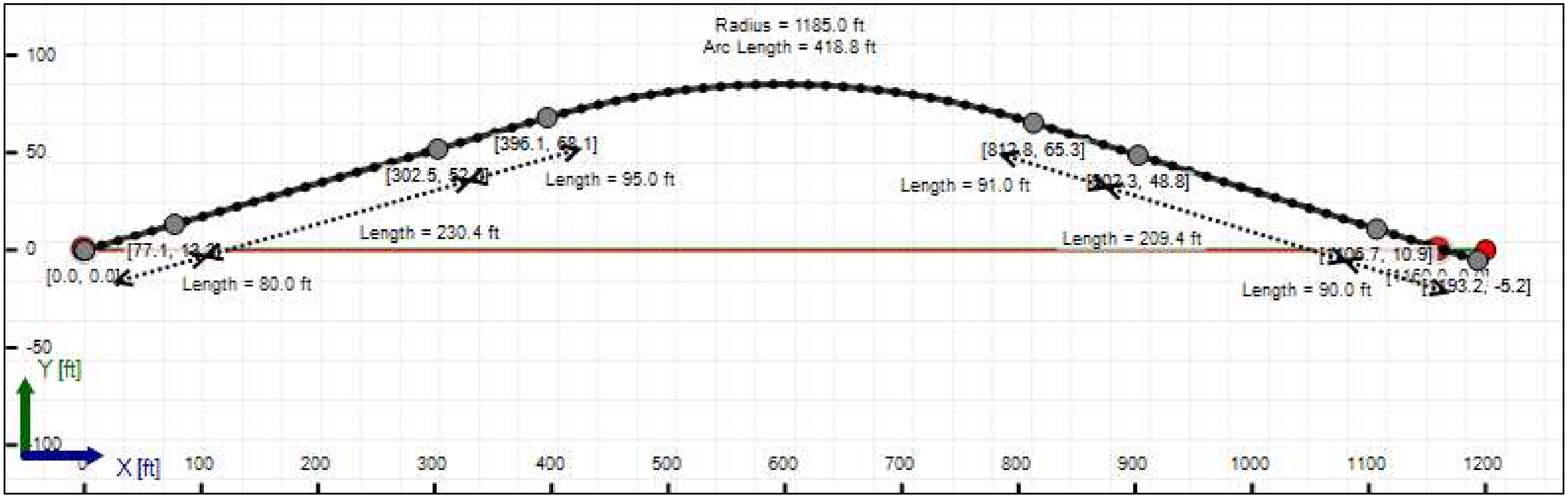
Unit Weight: 107.8272 (dry), 177.6384 (sat) [lb/ft3]

Phi: 35.00, S.M.: 1450.40, Coh: 2900.80 [psi]

Bore Cross-Section View



Bore Plan View



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Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1214.99 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	2.8	6.6
Water Pressure	11.5	11.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	14.3	17.7
Deflection		
Earth Load Deflection	1.166	1.911
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.298	2.043
Compressive Stress [psi]		
Compressive Wall Stress	64.2	79.7

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	22180.9	22180.9
Pullback Stress [psi]	618.6	618.6
Pullback Strain	1.076E-2	1.076E-2
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	618.6	639.9
Tensile Strain	1.076E-2	1.154E-2

Net External Pressure = 20.1 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.298	7.5	5.8	OK
Unconstrained Collapse [psi]	26.4	127.9	4.8	OK
Compressive Wall Stress [psi]	64.2	1150.0	17.9	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	36.4	218.3	6.0	OK
Tensile Stress [psi]	639.9	1200.0	1.9	OK

Maximum Allowable Bore Pressure Summary

Ream Number	**Initial Diameter**	**Final Diameter**	**Estimated Maximum Pressure (Avg.)**	**Estimated Maximum Pressure (Local)**
Pilot Bore	0.00 in	6.50 in	69.919 psi	70.704 psi
1	6.50 in	12.00 in	66.362 psi	67.233 psi
2	12.00 in	16.13 in	63.140 psi	64.058 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	**Shear Rate [rpm]**	**Shear Stress [Fann Degrees]**
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

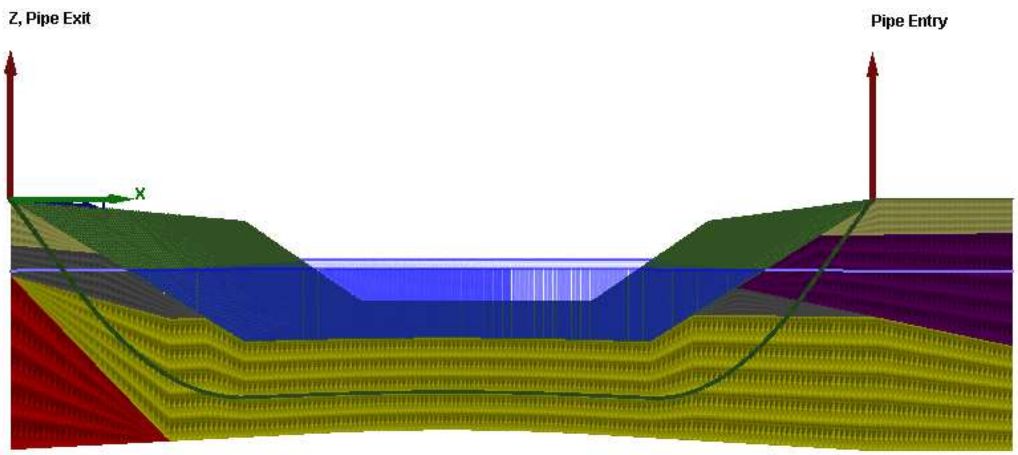
Rheological model: Power-Law

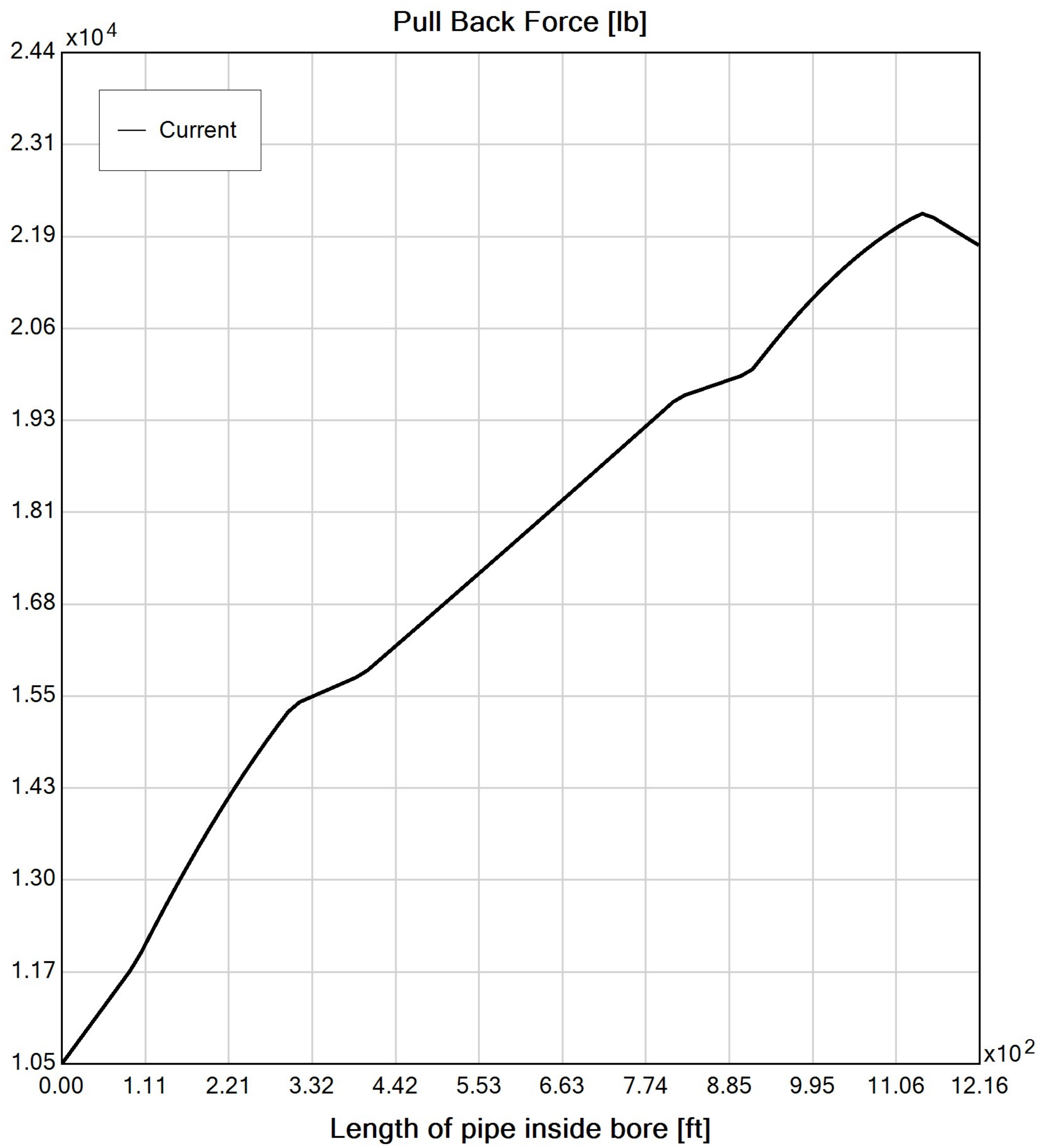
Fluid Consistency Index (K): 63.17

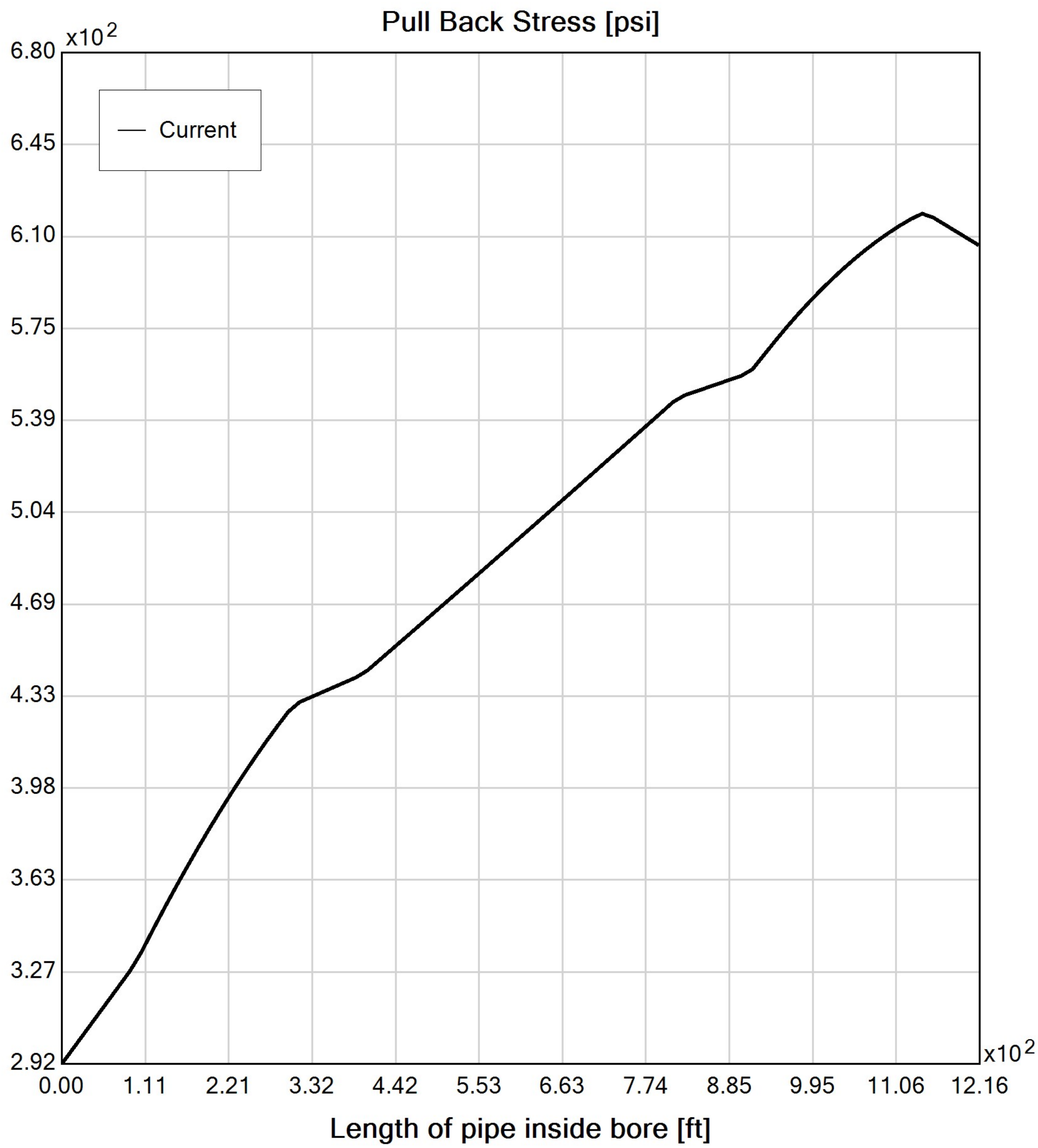
Power Law Exponent (n): 0.14

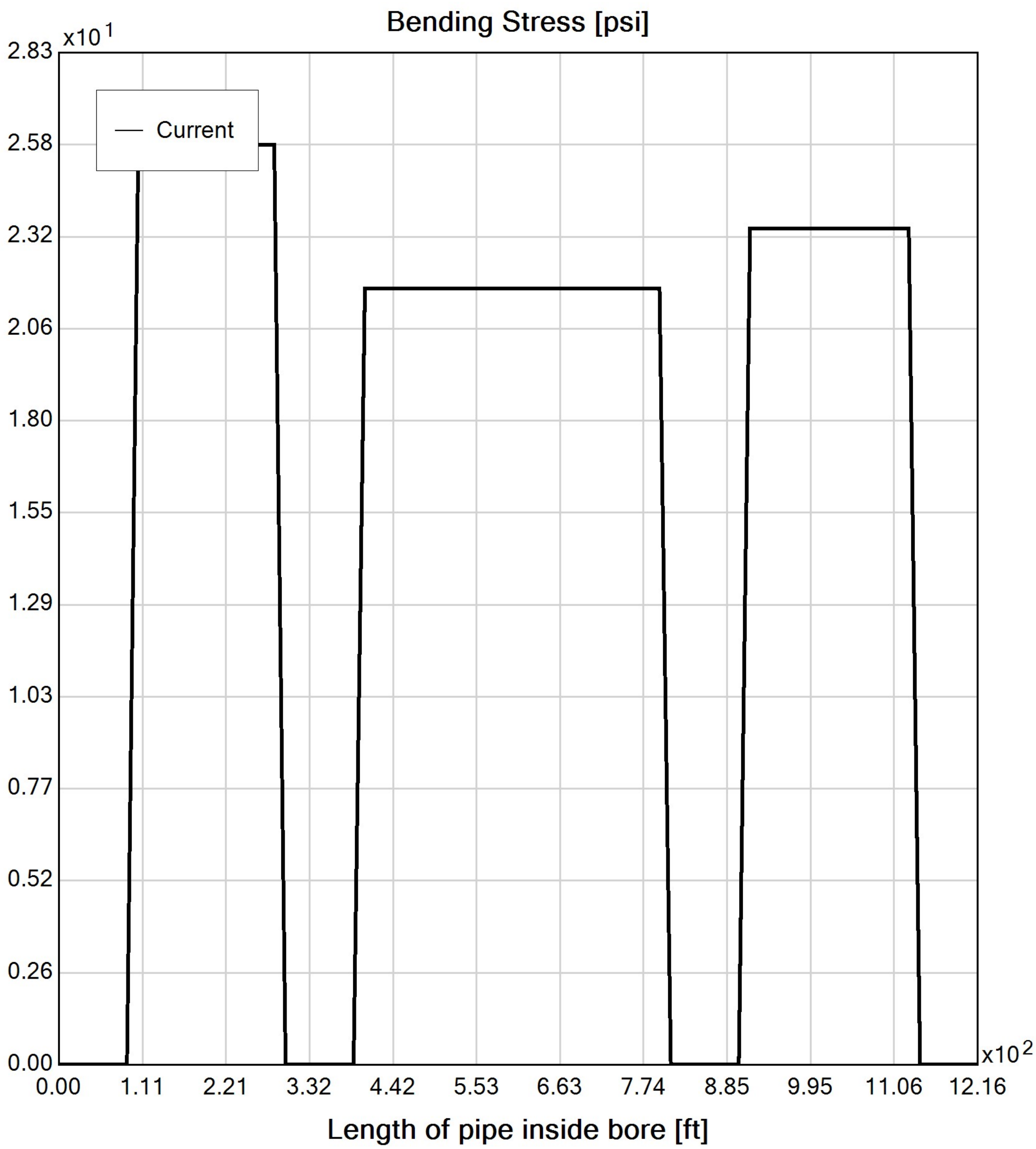
Effective Viscosity (cP): 378.3

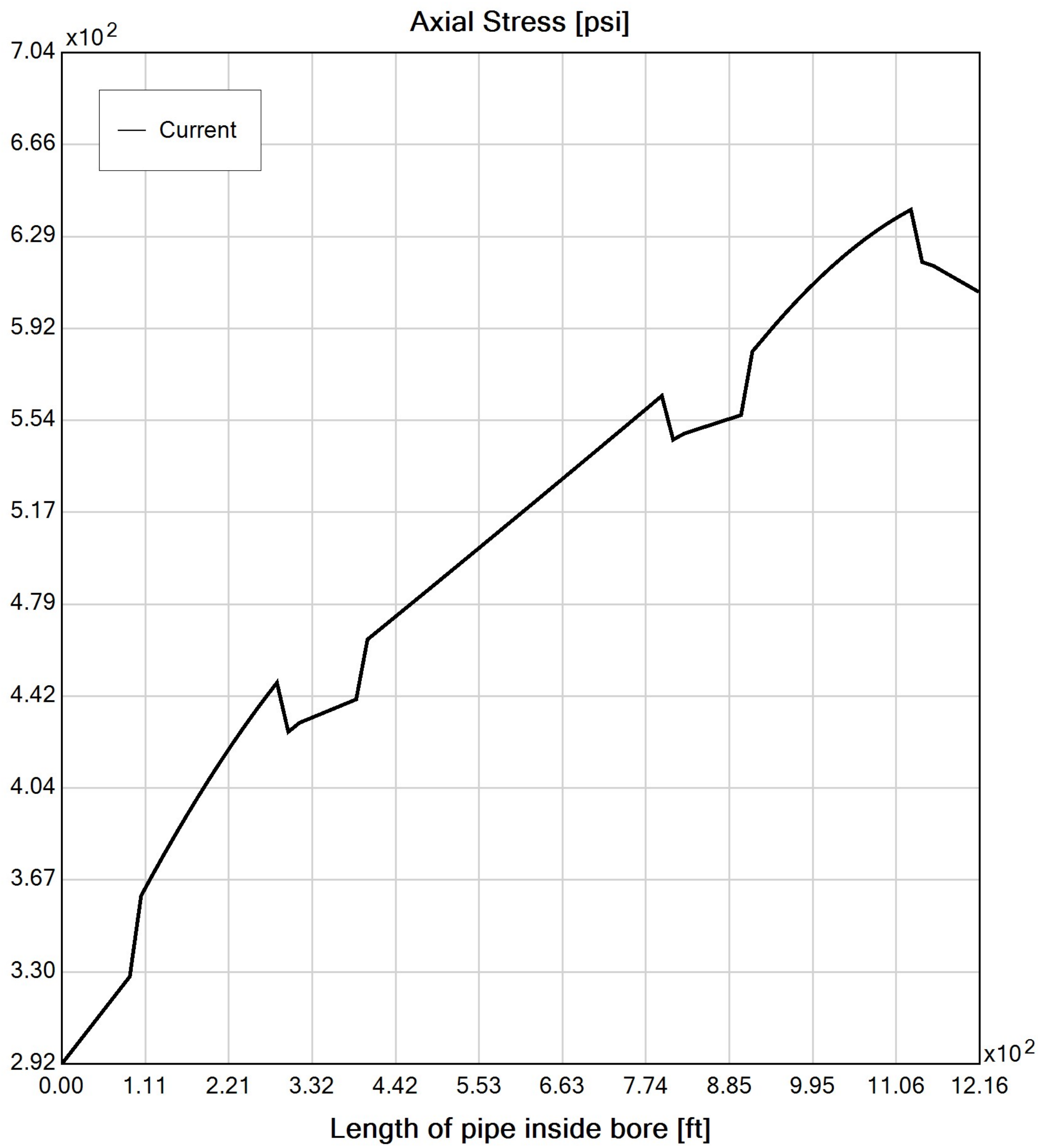
Virtual Site




Pull Back Force [lb]
x10^4
2.44
2.31
2.19
2.06
1.93
1.81
1.68
1.55
1.43
1.30
1.17
1.05
Current
x10^2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]


Pull Back Stress [psi]
x10^2
6.80
6.45
6.10
5.75
5.39
5.04
4.69
4.33
3.98
3.63
3.27
2.92
Current
x10^2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]


Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 2
0.00
1.11
2.21
3.32
4.42
5.53
6.63
7.74
8.85
9.95
11.06
12.16
Length of pipe inside bore [ft]



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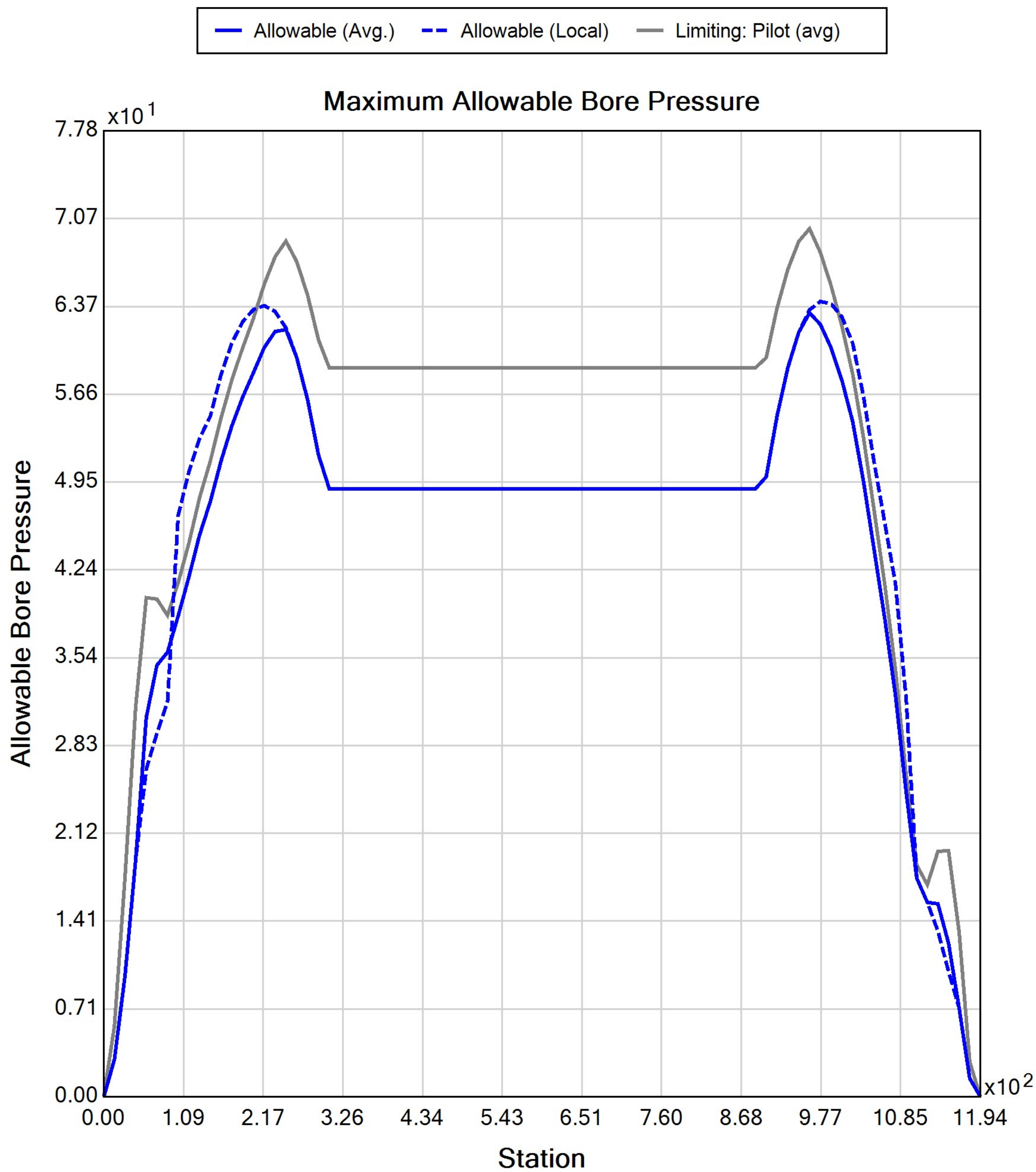

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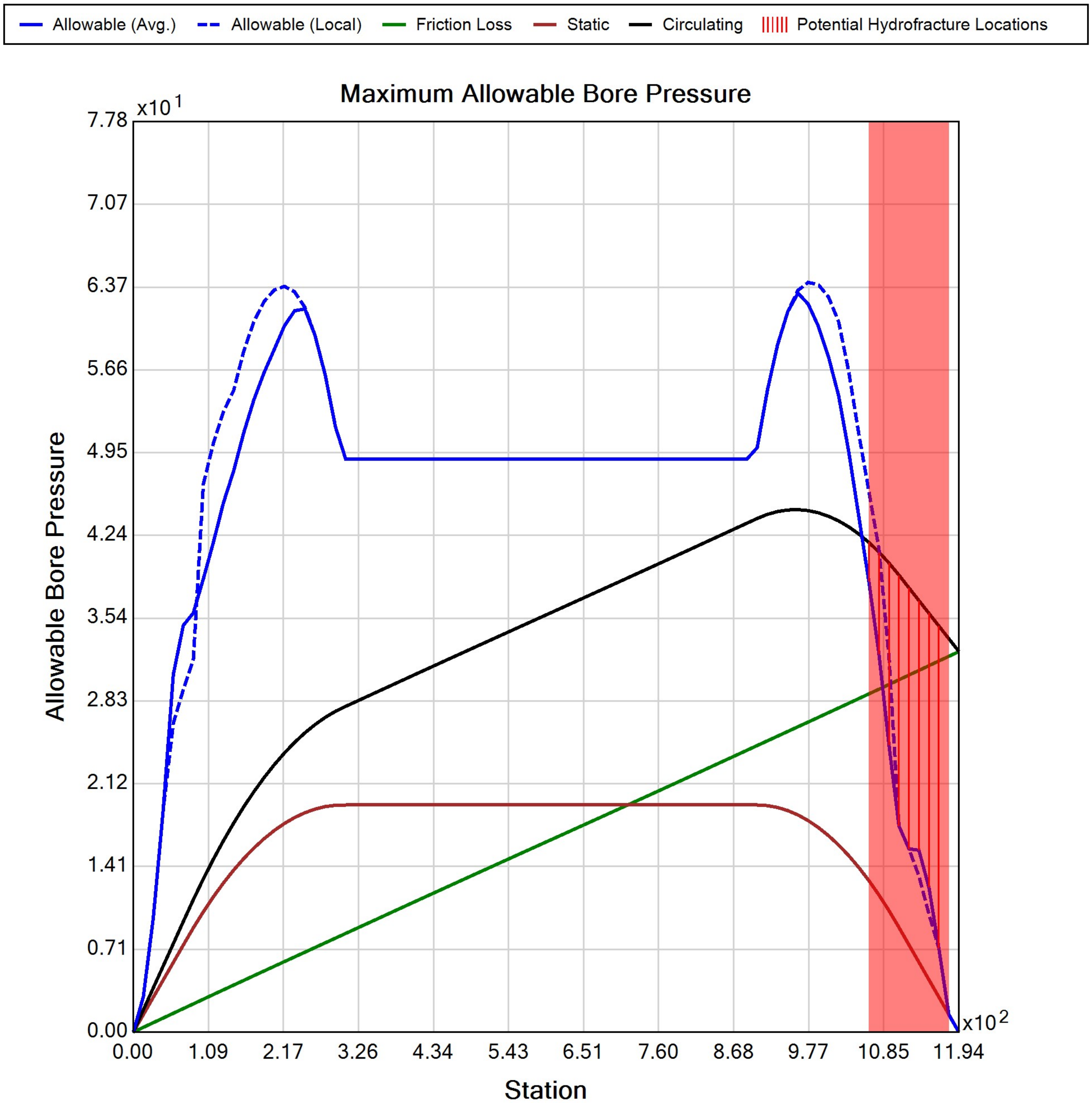

Allowable (Avg.)
Allowable (Local)
Friction Loss
Static
Circulating
Potential Hydrofracture Locations
Maximum Allowable Bore Pressure
x10 1
7.78
7.07
6.37
5.66
4.95
4.24
3.54
2.83
2.12
1.41
0.71
0.00
Allowable Bore Pressure
x10 2
0.00
1.09
2.17
3.26
4.34
5.43
6.51
7.60
8.68
9.77
10.85
11.94
Station

Generated Output

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OSHA CFR 29 1926.651 requires that the estimated location of underground utilities be determined before beginning the excavation or underground drilling operation. When the actual excavation or bore approaches an estimated utility location, the exact location of the underground installation must be determined by a safe, acceptable and dependable method. If the utility cannot be precisely located, it must be shut off by the utility company.

Input Summary

Start Coordinate	(0.00, 0.00, 129.00) ft
End Coordinate	(1200.00, 0.00, 129.00) ft
Project Length	1200.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1214.99 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	2.8	6.6
Water Pressure	11.5	11.1
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	14.3	17.7
Deflection		
Earth Load Deflection	1.166	1.911
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.298	2.043
Compressive Stress [psi]		
Compressive Wall Stress	64.2	79.7

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	22180.9	22180.9
Pullback Stress [psi]	618.6	618.6
Pullback Strain	1.076E-2	1.076E-2
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	618.6	639.9
Tensile Strain	1.076E-2	1.154E-2

Net External Pressure = 20.1 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.298	7.5	5.8	OK
Unconstrained Collapse [psi]	26.4	127.9	4.8	OK
Compressive Wall Stress [psi]	64.2	1150.0	17.9	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	36.4	218.3	6.0	OK
Tensile Stress [psi]	639.9	1200.0	1.9	OK

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Project Summary

General:	HDD #12 - Conduit 1
	Start Date: 06-21-2022
	End Date: 06-21-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	MCS
	CHA
Description:	

Input Summary

Start Coordinate	(0.00, 0.00, 131.80) ft
End Coordinate	(705.20, 0.00, 140.75) ft
Project Length	705.20 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 2

Soil Layer #1 USCS, Sand (S), SM

Depth: 1.00 ft

Unit Weight: 105.0000 (dry), 115.0000 (sat) [lb/ft3]

Phi: 30.00, S.M.: 145.00, Coh: 0.00 [psi]

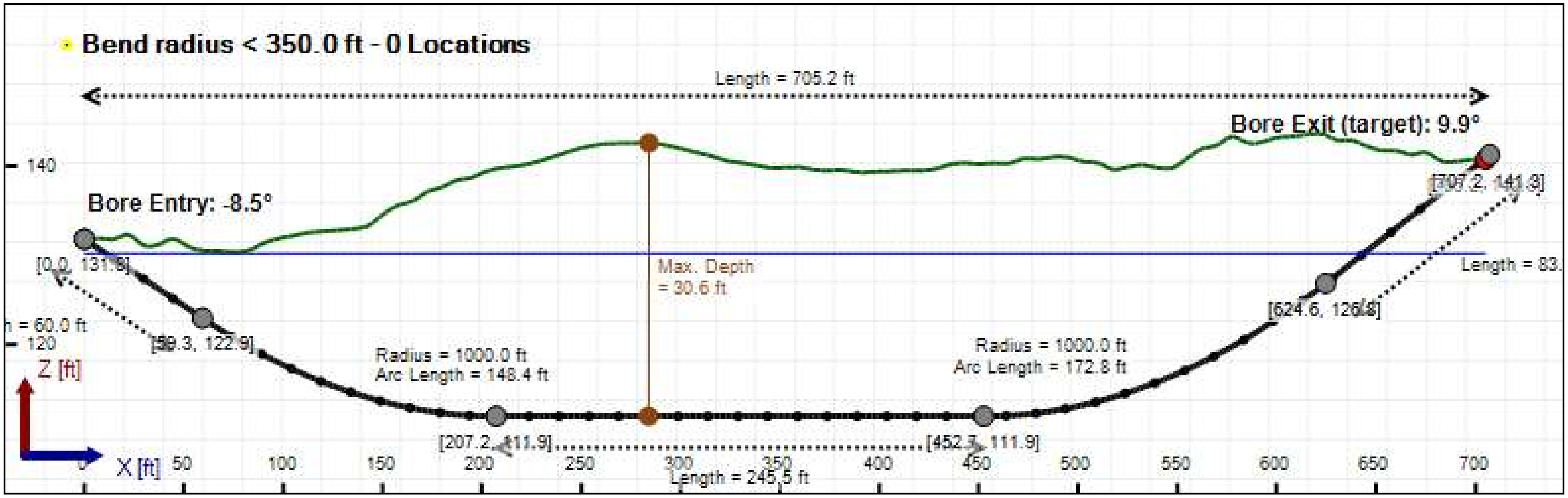
Soil Layer #2 Rock, Geological Classification, Sedimentary Rocks

Depth: 25.00 ft

Unit Weight: 107.8272 (dry), 177.6384 (sat) [lb/ft3]

Phi: 35.00, S.M.: 1450.40, Coh: 2900.80 [psi]

Bore Cross-Section View



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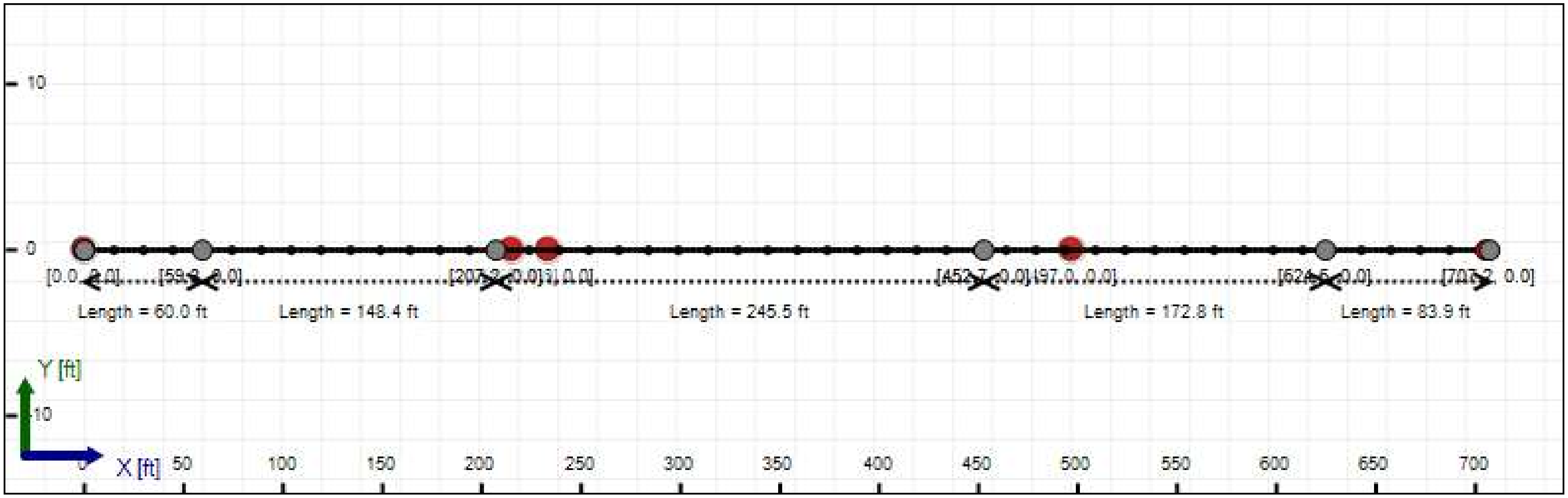
Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 720.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	5.8	23.7
Water Pressure	7.9	7.9
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	13.7	31.6
Deflection		
Earth Load Deflection	1.589	6.444
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.721	6.576
Compressive Stress [psi]		
Compressive Wall Stress	61.9	142.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	12257.2	12257.2
Pullback Stress [psi]	341.8	341.8
Pullback Strain	5.945E-3	5.945E-3
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	341.8	364.9
Tensile Strain	5.945E-3	6.793E-3

Net External Pressure = 21.5 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.721	7.5	4.4	OK
Unconstrained Collapse [psi]	20.1	118.4	5.9	OK
Compressive Wall Stress [psi]	61.9	1150.0	18.6	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	30.1	235.1	7.8	OK
Tensile Stress [psi]	364.9	1200.0	3.3	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	1309.762 psi	1329.978 psi
1	8.00 in	12.00 in	1305.627 psi	1329.576 psi
2	12.00 in	16.13 in	1299.646 psi	1328.993 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

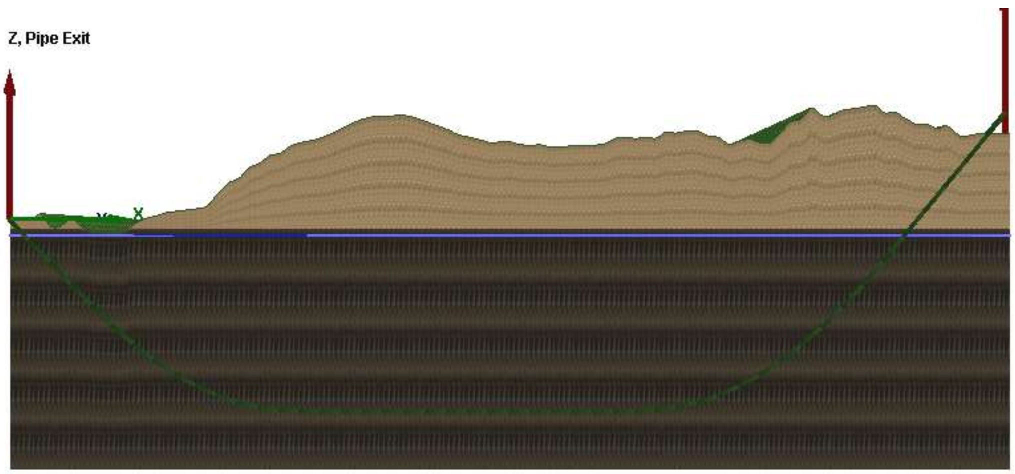
Rheological model: Bingham-Plastic

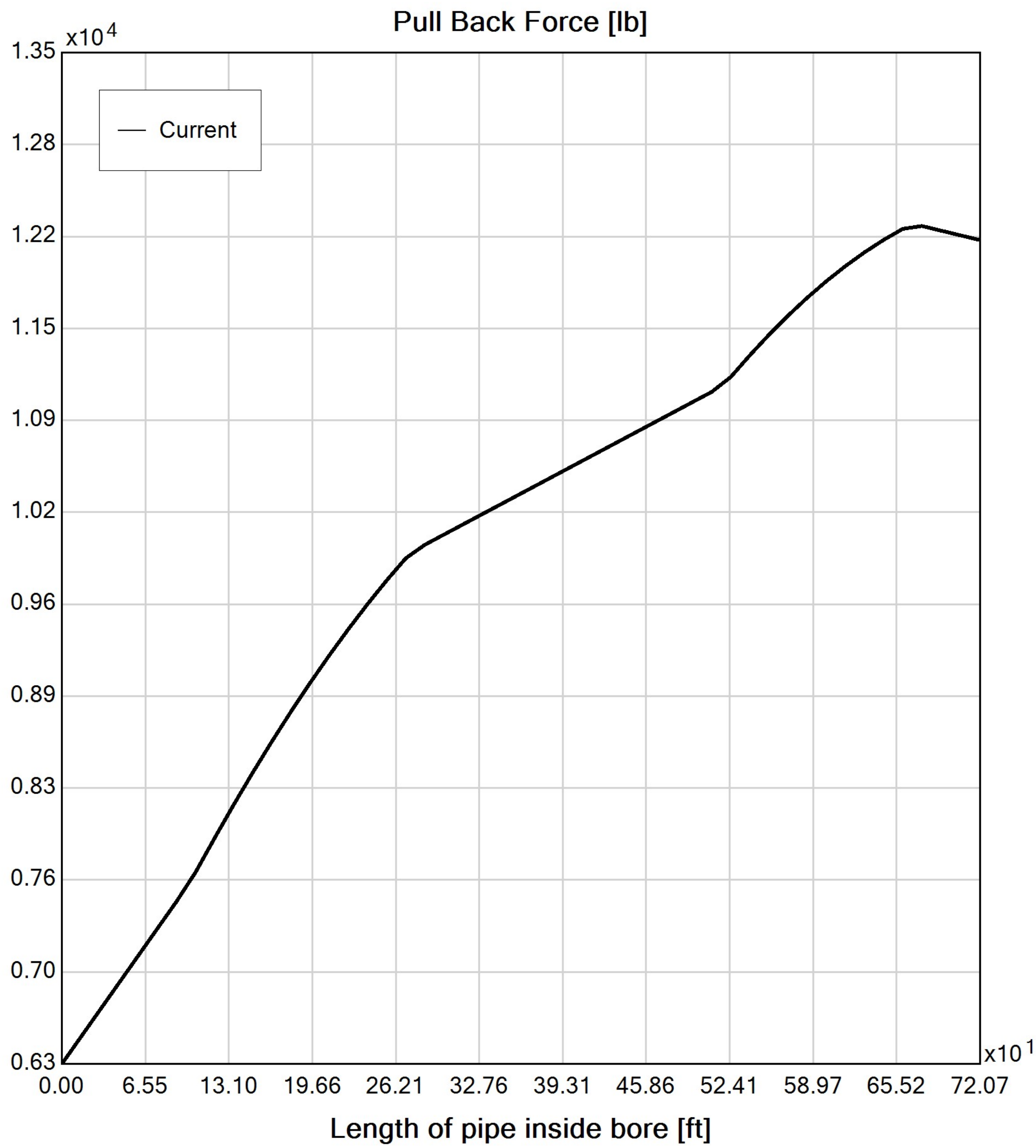
Plastic Viscosity (PV): 25.53

Yield Point (YP): 16.49

Effective Viscosity (cP): 1202.0

Virtual Site





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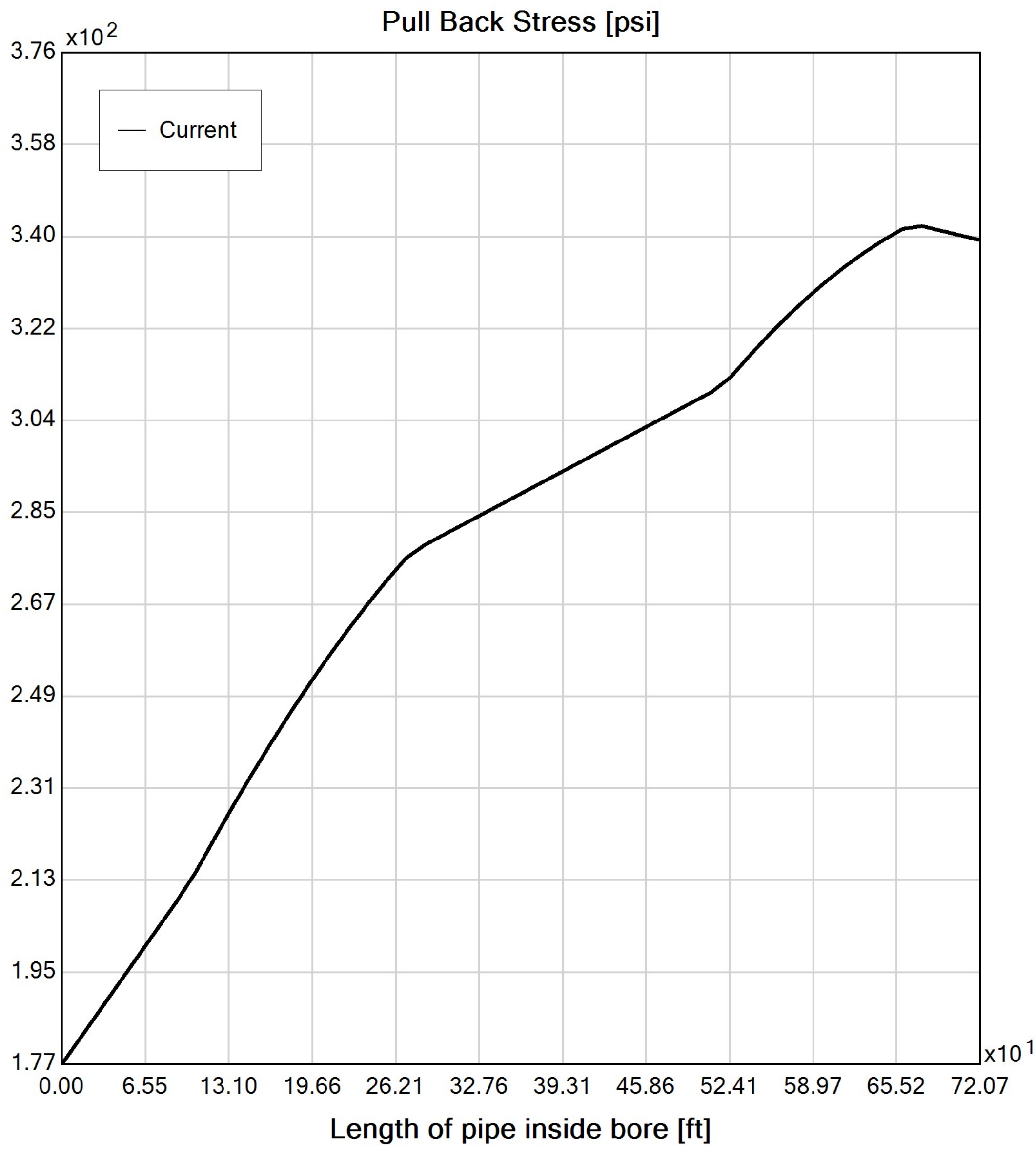

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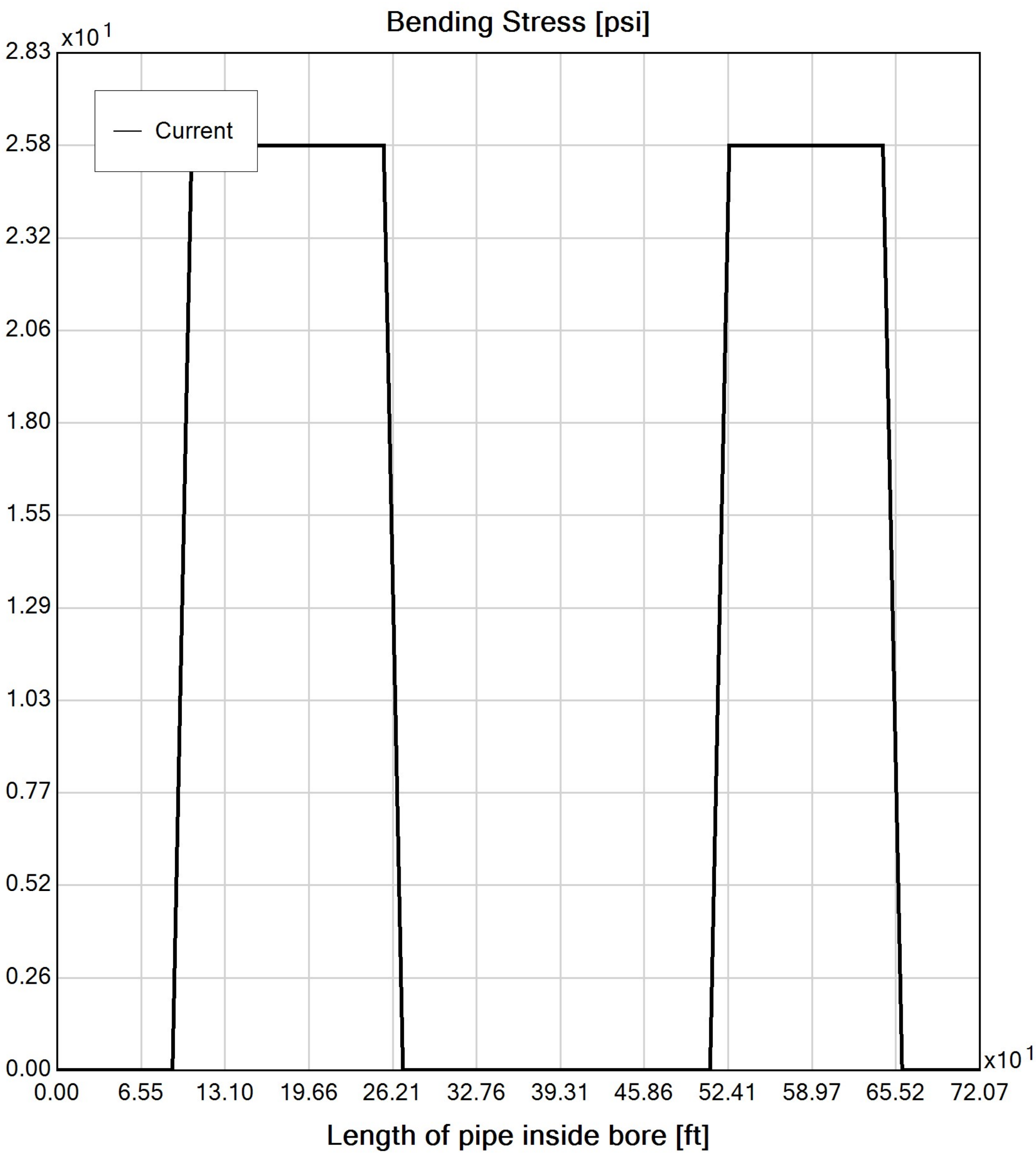
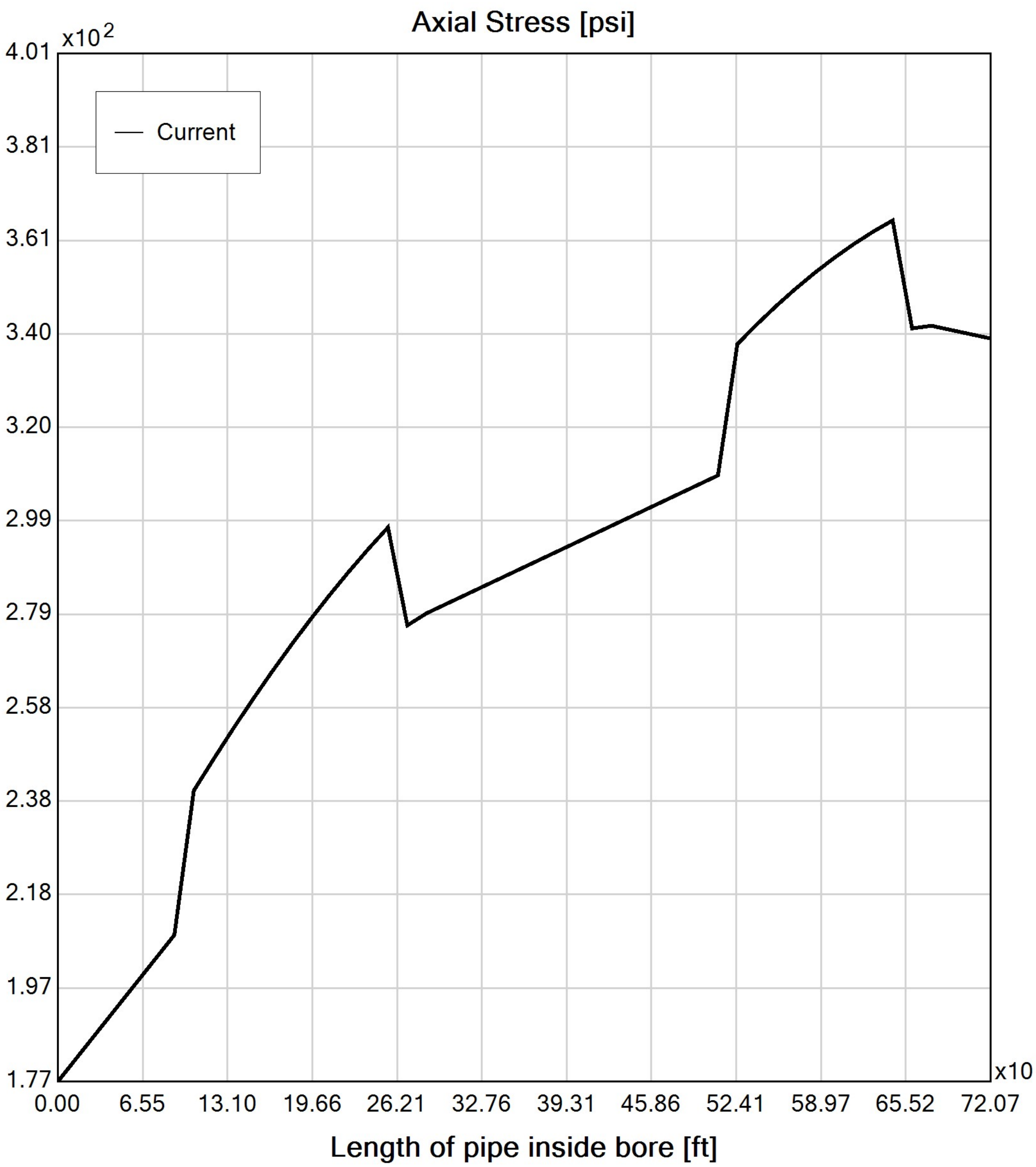
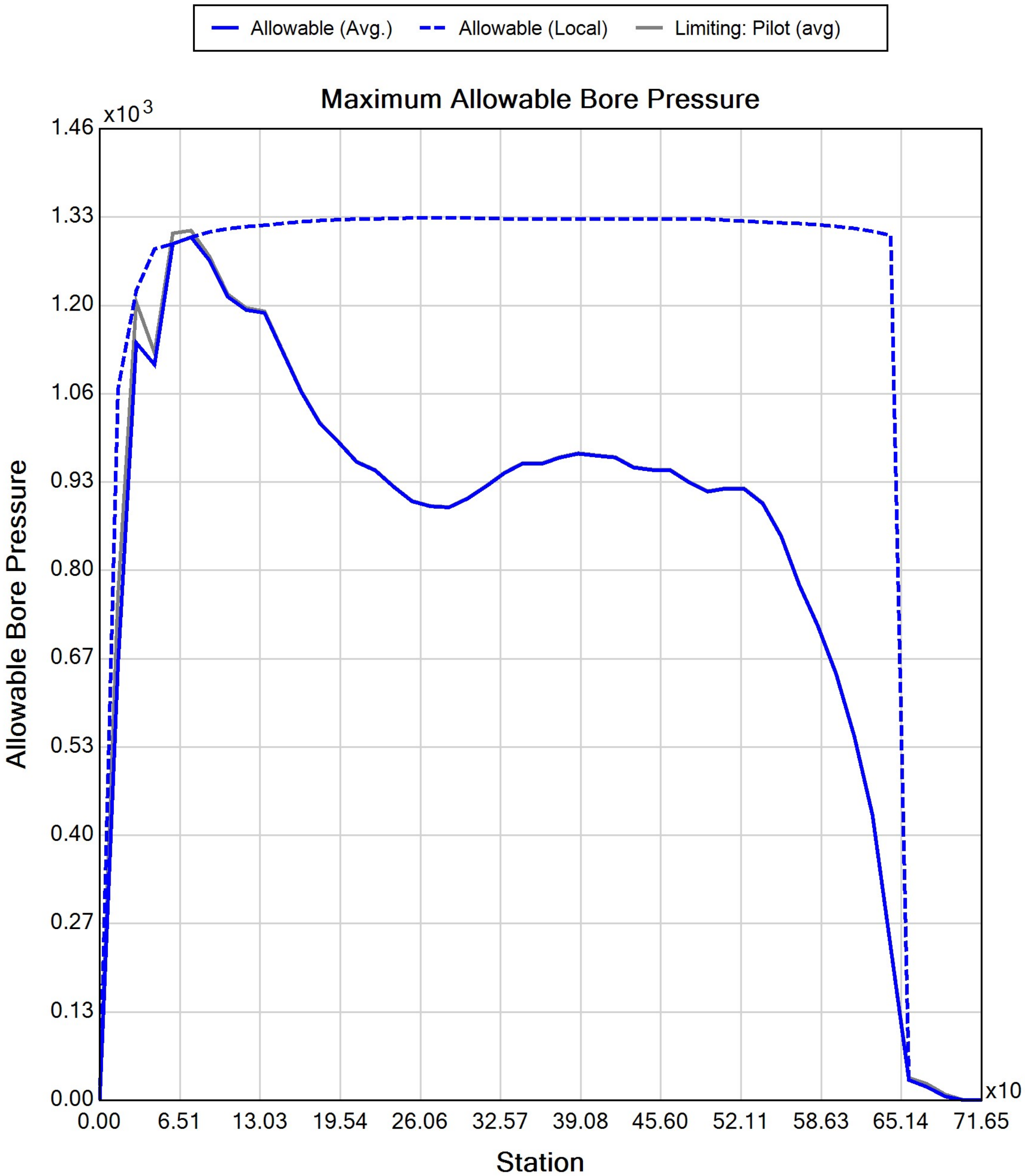


Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 1
0.00
6.55
13.10
19.66
26.21
32.76
39.31
45.86
52.41
58.97
65.52
72.07
Length of pipe inside bore [ft]


Axial Stress [psi]
x10 2
4.01
3.81
3.61
3.40
3.20
2.99
2.79
2.58
2.38
2.18
1.97
1.77
Current
x10 1
0.00
6.55
13.10
19.66
26.21
32.76
39.31
45.86
52.41
58.97
65.52
72.07
Length of pipe inside bore [ft]



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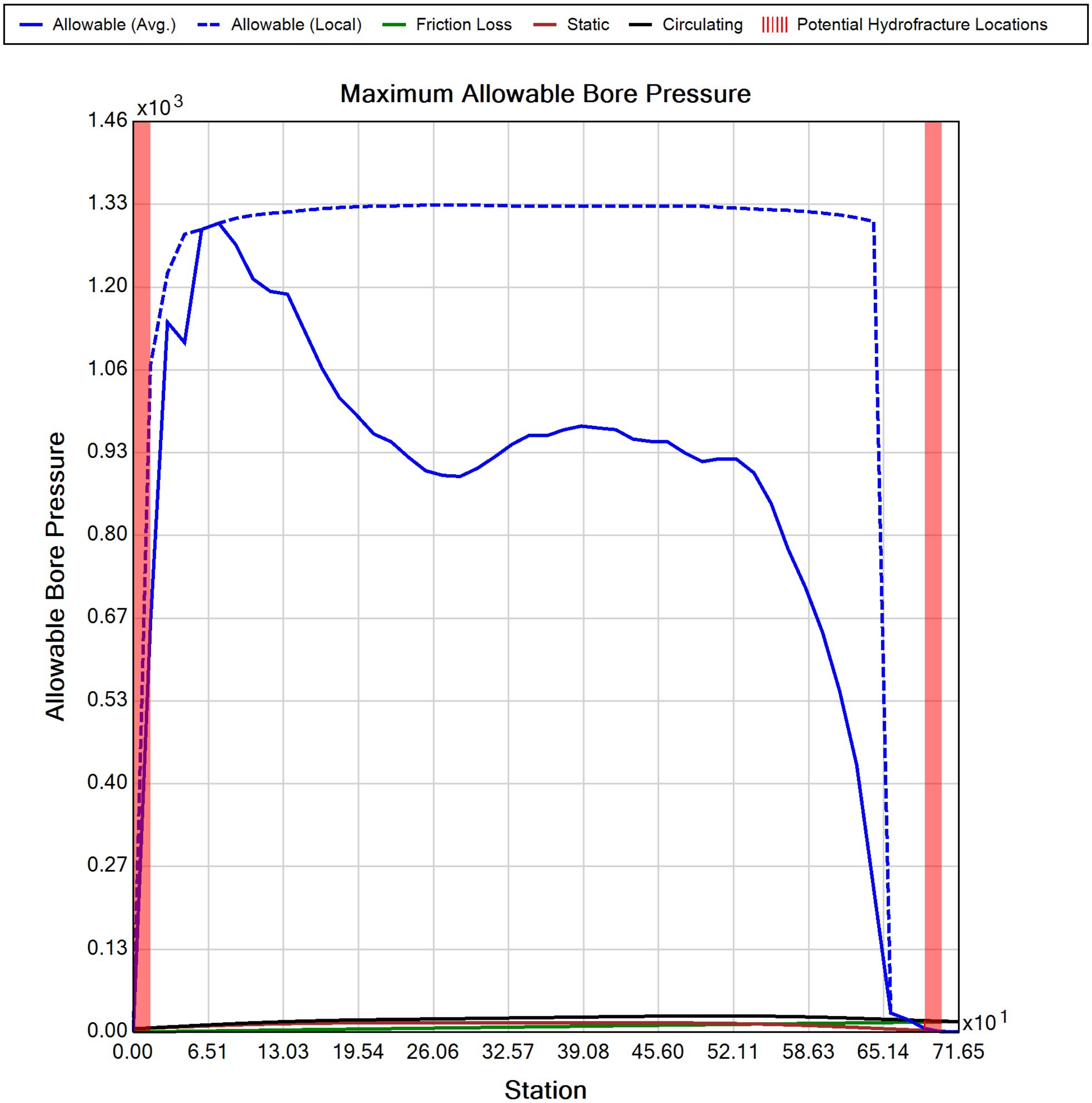

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Generated Output

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Input Summary

Start Coordinate	(0.00, 0.00, 131.80) ft
End Coordinate	(705.20, 0.00, 140.75) ft
Project Length	705.20 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 720.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	2.4	23.7
Water Pressure	7.9	7.9
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	10.3	31.6
Deflection		
Earth Load Deflection	0.662	6.444
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.692	6.473
Compressive Stress [psi]		
Compressive Wall Stress	46.3	142.1

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	707.9	707.9
Pullback Stress [psi]	404.5	404.5
Pullback Strain	7.034E-3	7.034E-3
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	404.5	407.4
Tensile Strain	7.034E-3	7.184E-3

Net External Pressure = 21.5 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.692	7.5	10.8	OK
Unconstrained Collapse [psi]	20.1	130.0	6.5	OK
Compressive Wall Stress [psi]	46.3	1150.0	24.8	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	30.1	233.3	7.8	OK
Tensile Stress [psi]	407.4	1200.0	2.9	OK

Generated Output

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Project Summary

General:	HDD #12 - Conduit 2
	Start Date: 06-21-2022
	End Date: 06-21-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	MCS
	CHA
Description:	

Input Summary

Start Coordinate	(0.00, 0.00, 131.07) ft
End Coordinate	(920.00, 0.00, 142.07) ft
Project Length	920.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 2

Soil Layer #1 USCS, Sand (S), SP

Depth: 4.00 ft

Unit Weight: 105.0000 (dry), 115.0000 (sat) [lb/ft3]

Phi: 30.00, S.M.: 1.39, Coh: 0.00 [psi]

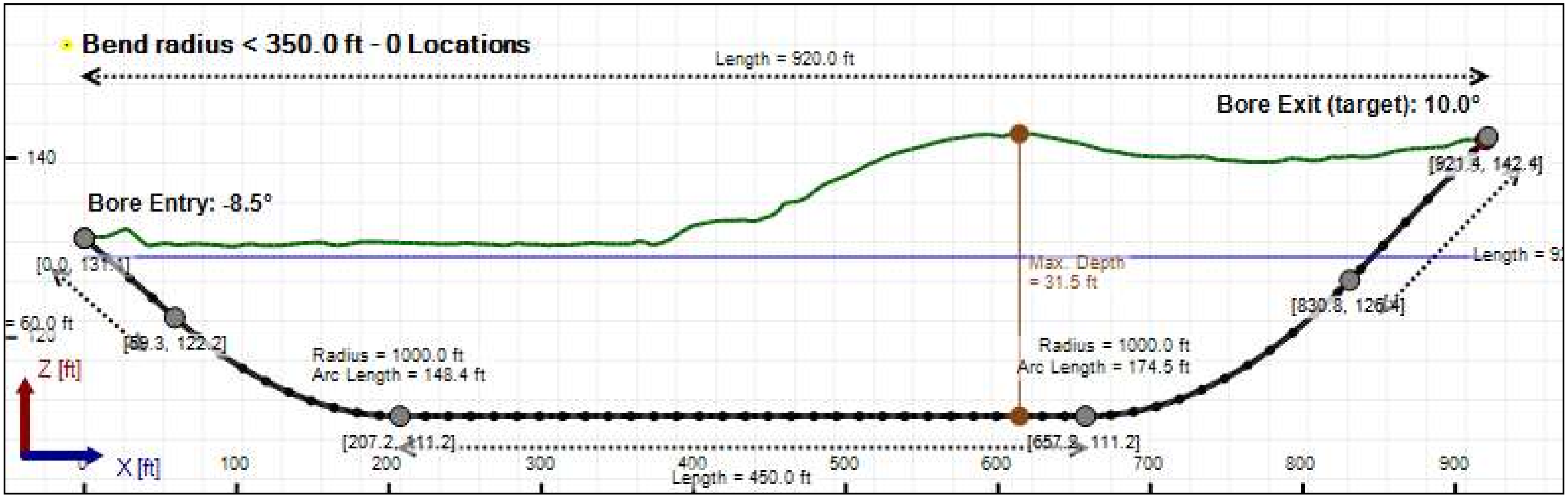
Soil Layer #2 Rock, Geological Classification, Sedimentary Rocks

Depth: 40.00 ft

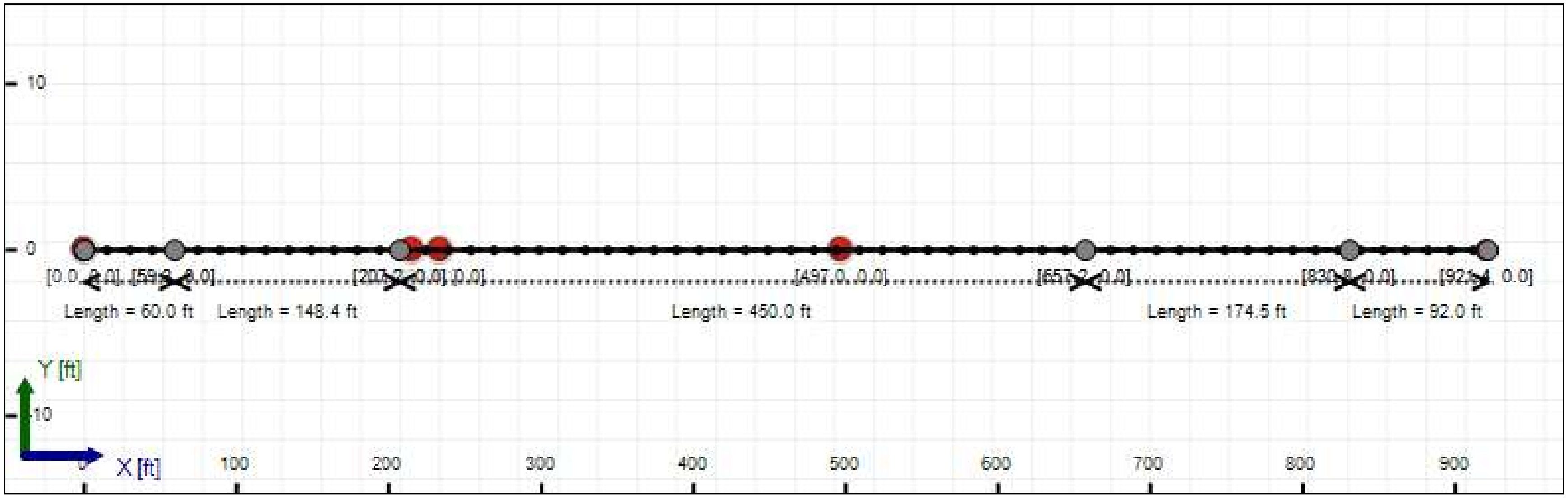
Unit Weight: 120.0000 (dry), 140.0000 (sat) [lb/ft3]

Phi: 37.00, S.M.: 10000.00, Coh: 0.00 [psi]

Bore Cross-Section View



Bore Plan View



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Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 930.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	4.6	19.3
Water Pressure	7.7	7.7
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	12.4	27.0
Deflection		
Earth Load Deflection	1.265	5.245
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.397	5.377
Compressive Stress [psi]		
Compressive Wall Stress	55.6	121.4

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	15479.9	15479.9
Pullback Stress [psi]	431.7	431.7
Pullback Strain	7.508E-3	7.508E-3
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	431.7	453.5
Tensile Strain	7.508E-3	8.336E-3

Net External Pressure = 22.3 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.397	7.5	5.4	OK
Unconstrained Collapse [psi]	20.8	121.8	5.8	OK
Compressive Wall Stress [psi]	55.6	1150.0	20.7	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	30.8	229.6	7.5	OK
Tensile Stress [psi]	453.5	1200.0	2.6	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	264.655 psi	370.953 psi
1	8.00 in	12.00 in	253.489 psi	344.489 psi
2	12.00 in	16.13 in	240.110 psi	316.049 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

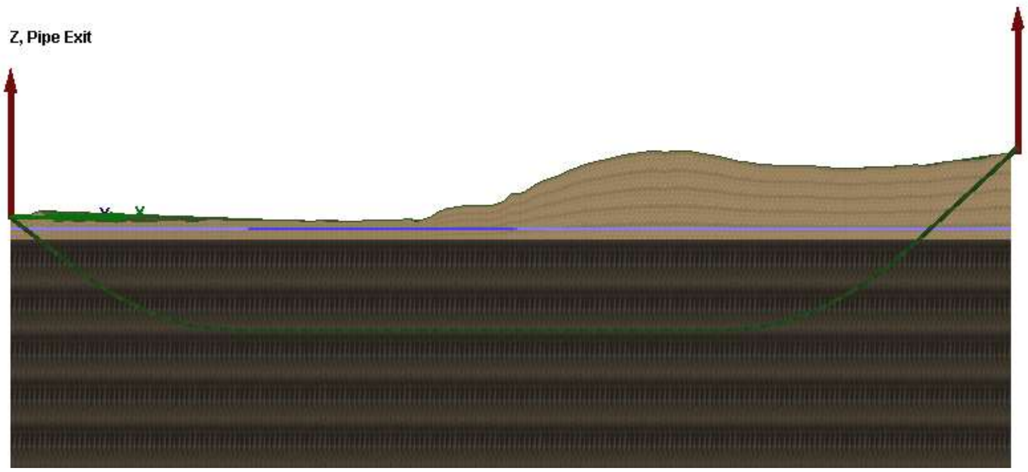
Rheological model: Bingham-Plastic

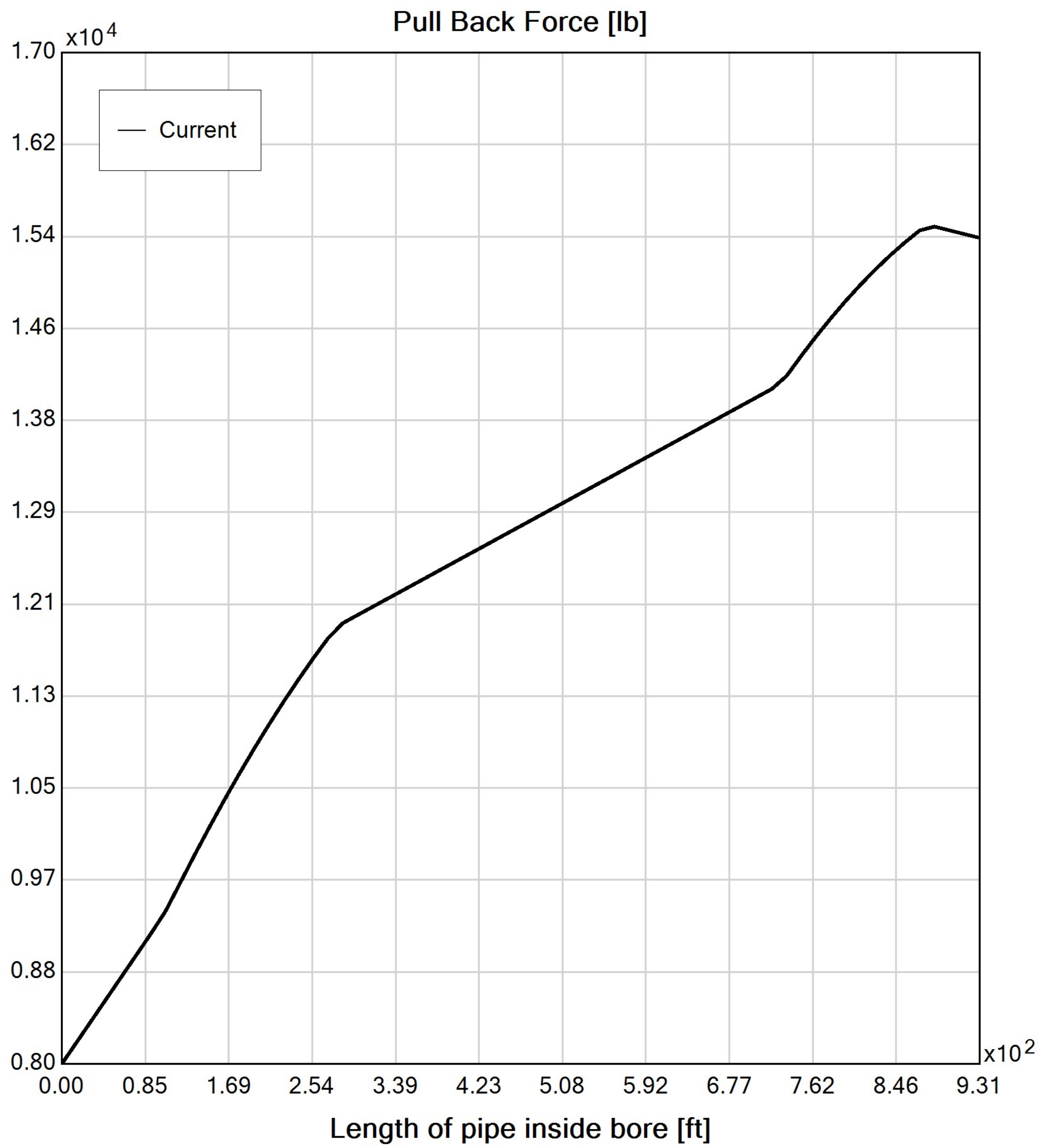
Plastic Viscosity (PV): 25.53

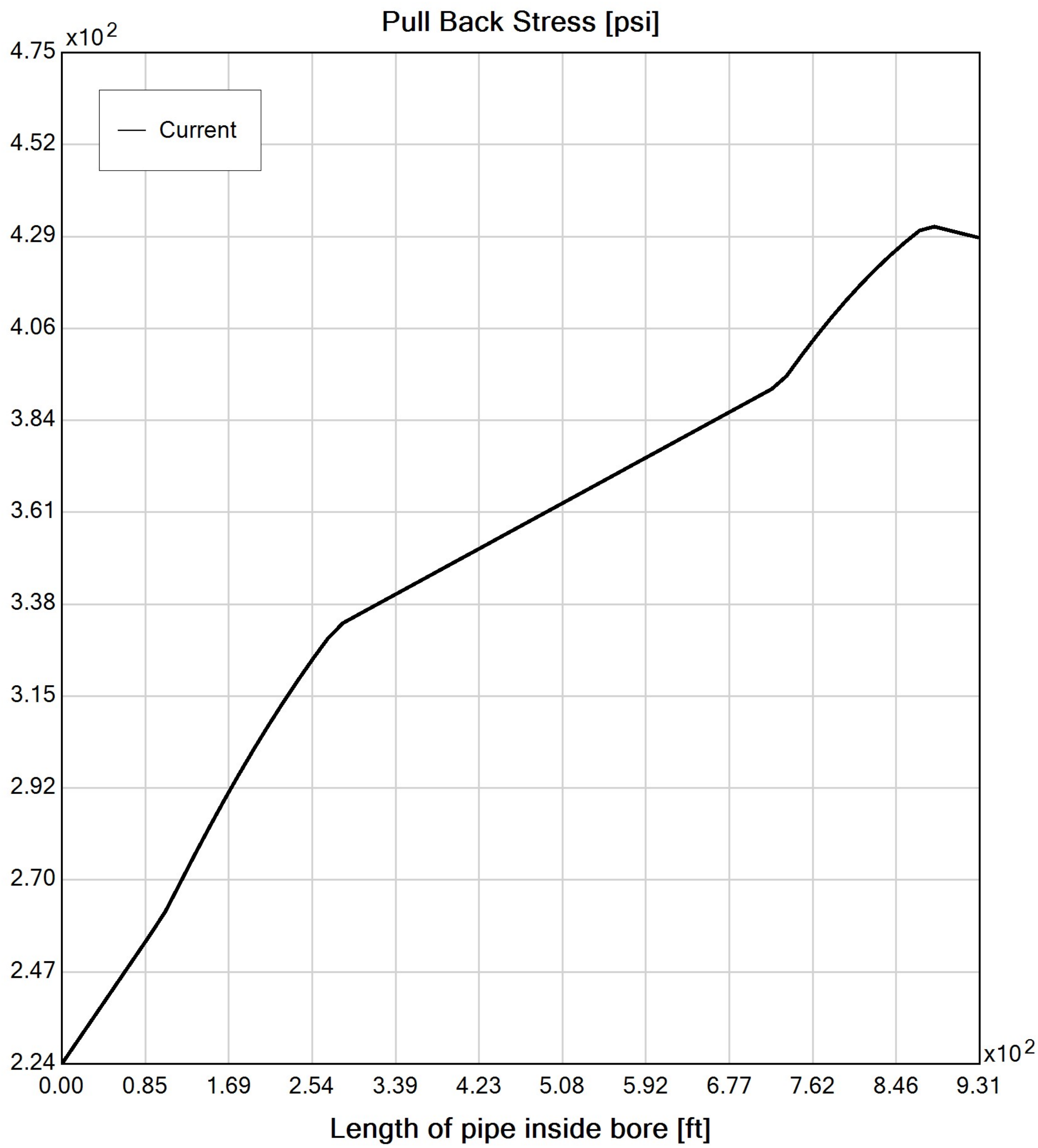
Yield Point (YP): 16.49

Effective Viscosity (cP): 1202.0

Virtual Site




Pull Back Force [lb]
x10^4
1.70
1.62
1.54
1.46
1.38
1.29
1.21
1.13
1.05
0.97
0.88
0.80
Current
x10^2
0.00
0.85
1.69
2.54
3.39
4.23
5.08
5.92
6.77
7.62
8.46
9.31
Length of pipe inside bore [ft]



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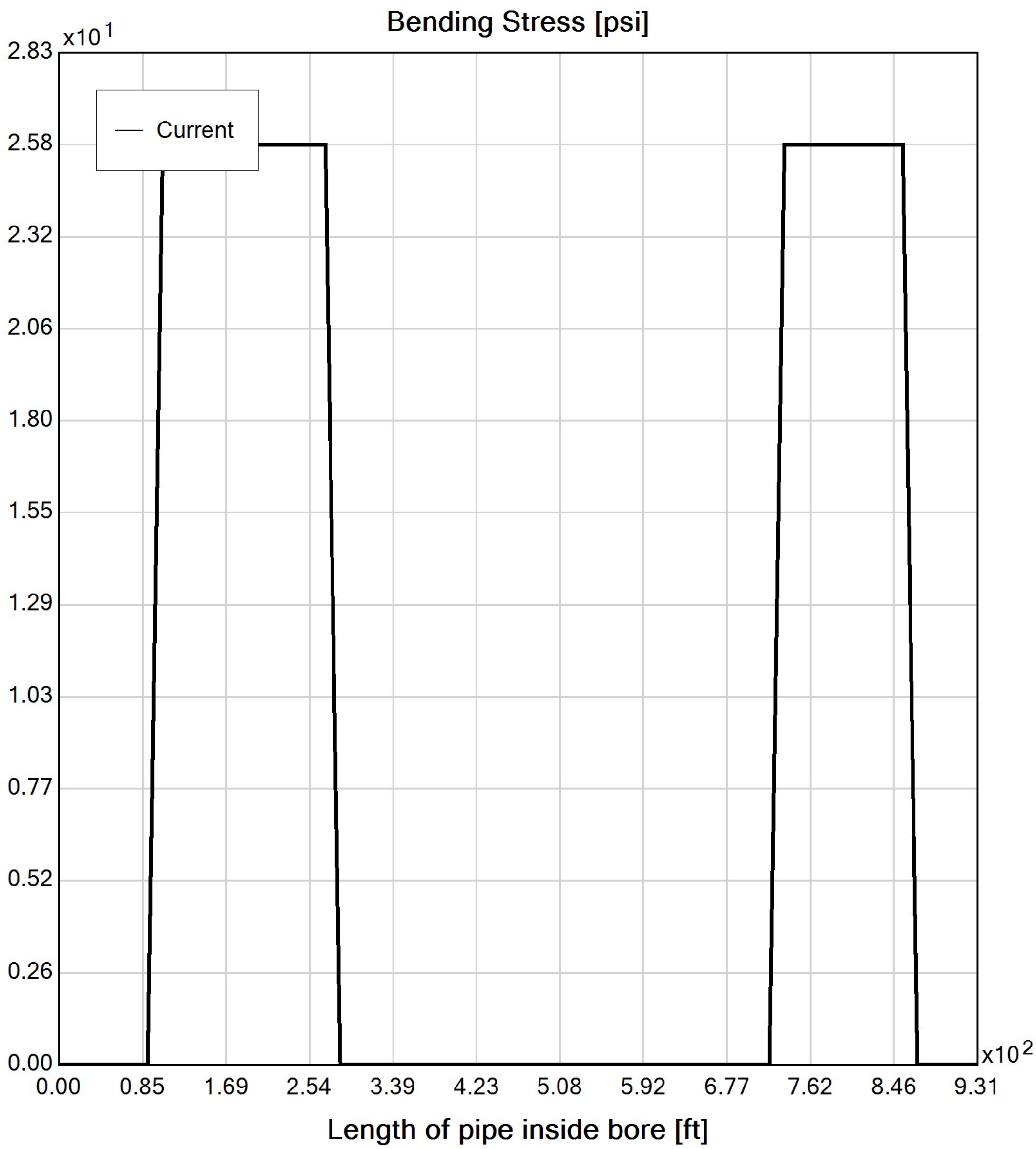
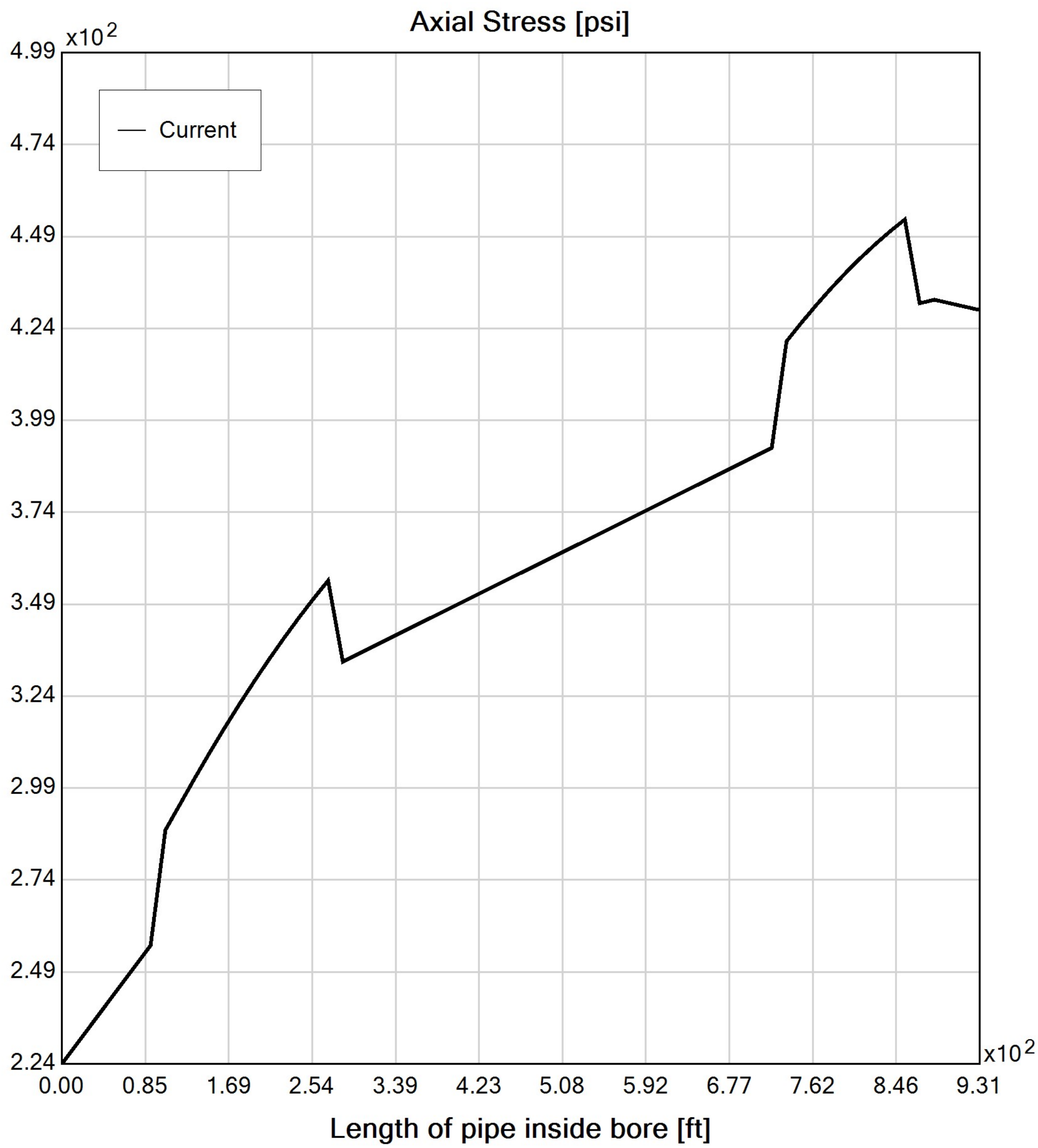
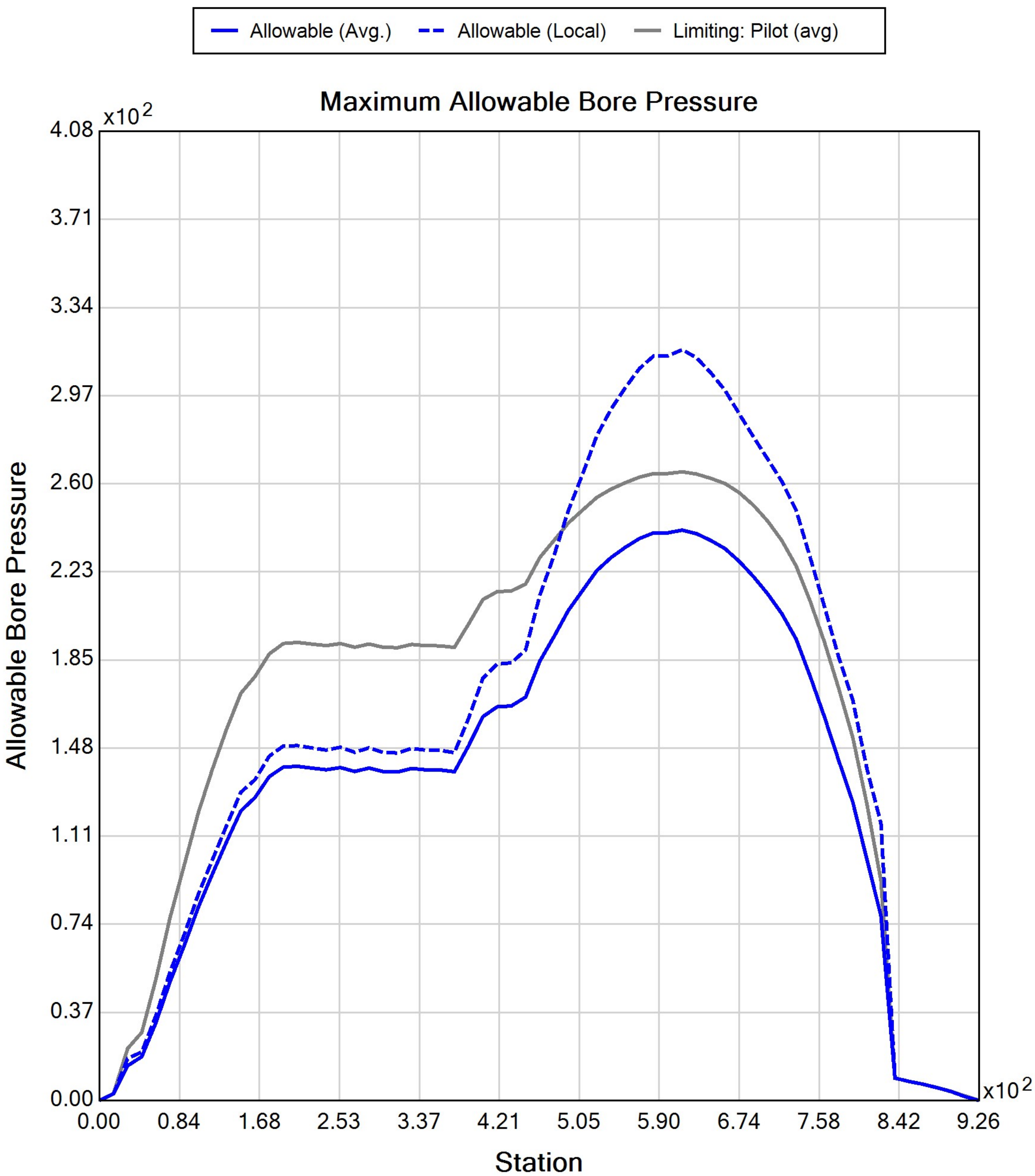

Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 2
0.00
0.85
1.69
2.54
3.39
4.23
5.08
5.92
6.77
7.62
8.46
9.31
Length of pipe inside bore [ft]


Axial Stress [psi]
x10^2
4.99
4.74
4.49
4.24
3.99
3.74
3.49
3.24
2.99
2.74
2.49
2.24
Current
x10^2
0.00
0.85
1.69
2.54
3.39
4.23
5.08
5.92
6.77
7.62
8.46
9.31
Length of pipe inside bore [ft]



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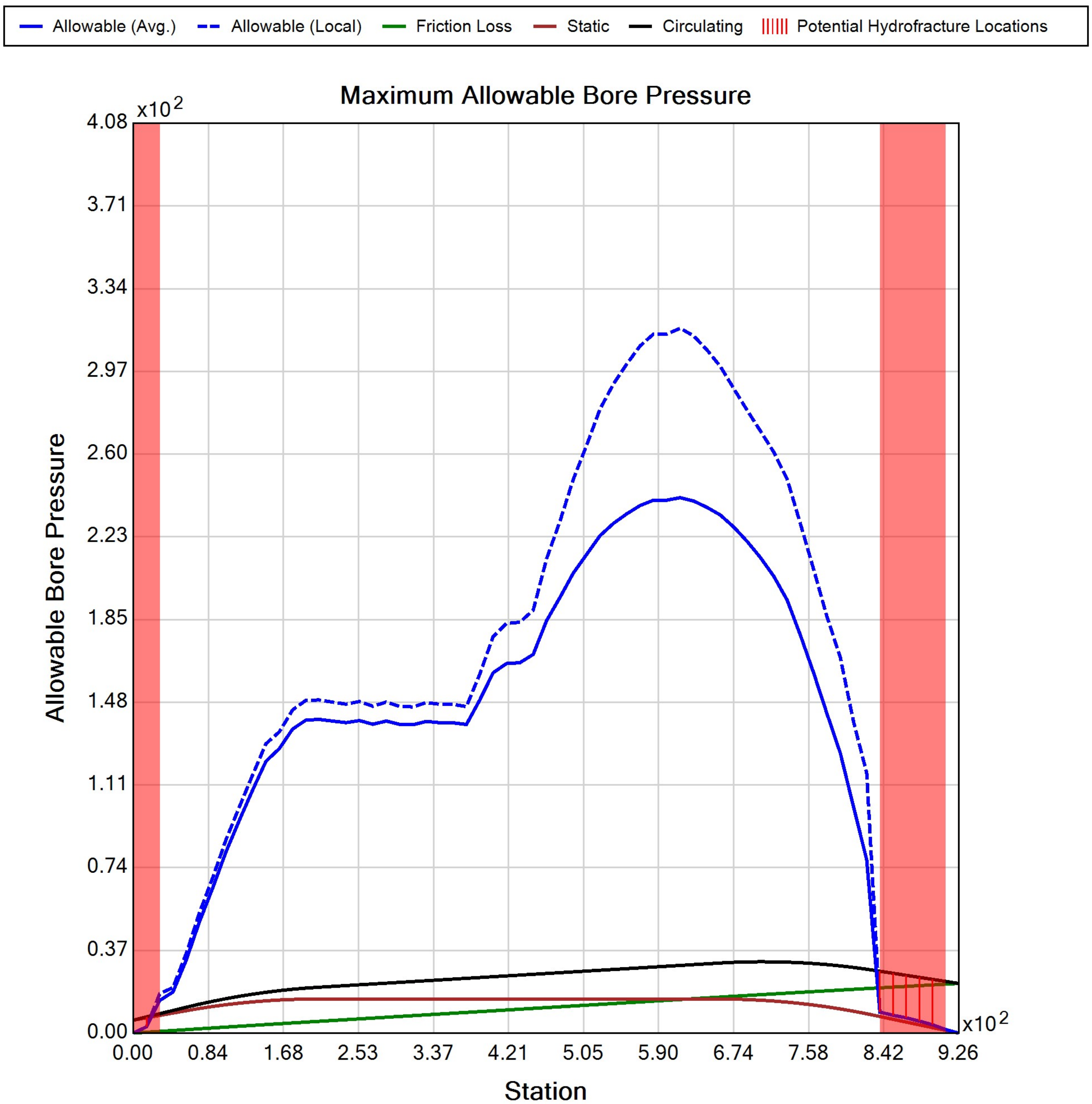

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Input Summary

Start Coordinate	(0.00, 0.00, 131.07) ft
End Coordinate	(920.00, 0.00, 142.07) ft
Project Length	920.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	2.375 in
Pipe DR	9.0
Pipe Thickness	0.26 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 2" (2.375")

Pipe DR: 9

Pipe Length: 930.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 0.531000018119812 ft

Silo Width: 0.531000018119812 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	1.9	19.3
Water Pressure	7.7	7.7
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	9.6	27.0
Deflection		
Earth Load Deflection	0.571	5.245
Buoyant Deflection	0.029	0.029
Reissner Effect	0	0
Net Deflection	0.600	5.274
Compressive Stress [psi]		
Compressive Wall Stress	43.1	121.4

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	865.2	865.2
Pullback Stress [psi]	494.3	494.3
Pullback Strain	8.597E-3	8.597E-3
Bending Stress [psi]	0.0	5.7
Bending Strain	0	9.896E-5
Tensile Stress [psi]	494.3	496.1
Tensile Strain	8.597E-3	8.727E-3

Net External Pressure = 22.3 [psi]

Buoyant Deflection = 0.0

Hydrokinetic Force = 137.3 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.600	7.5	12.5	OK
Unconstrained Collapse [psi]	20.8	131.6	6.3	OK
Compressive Wall Stress [psi]	43.1	1150.0	26.7	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.014	7.5	524.3	OK
Unconstrained Collapse [psi]	30.8	227.8	7.4	OK
Tensile Stress [psi]	496.1	1200.0	2.4	OK

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Project Summary

General:	HDD #12A - Conduit 1
	Start Date: 06-21-2022
	End Date: 06-21-2022
Project Owner:	TDI
Project Contractor:	KIEWIT
Project Consultant:	CHA
Designer:	MCS
	CHA
Description:	

Input Summary

Start Coordinate	(0.00, 0.00, 137.09) ft
End Coordinate	(1490.00, 0.00, 143.80) ft
Project Length	1490.00 ft
Pipe Type	HDPE
OD Classification	IPS
Pipe OD	10.750 in
Pipe DR	9.0
Pipe Thickness	1.19 in
Rod Length	15.00 ft
Rod Diameter	3.5 in
Drill Rig Location	(0.00, 0.00, 0.00) ft

Soil Summary

Number of Layers: 3

Soil Layer #1 USCS, Sand (S), SP

Depth: 4.00 ft

Unit Weight: 105.0000 (dry), 115.0000 (sat) [lb/ft3]

Phi: 30.00, S.M.: 1.39, Coh: 0.00 [psi]

Soil Layer #2 Rock, Geological Classification, Sedimentary Rocks

Depth: 40.00 ft

Unit Weight: 120.0000 (dry), 140.0000 (sat) [lb/ft3]

Phi: 37.00, S.M.: 1000.00, Coh: 0.00 [psi]

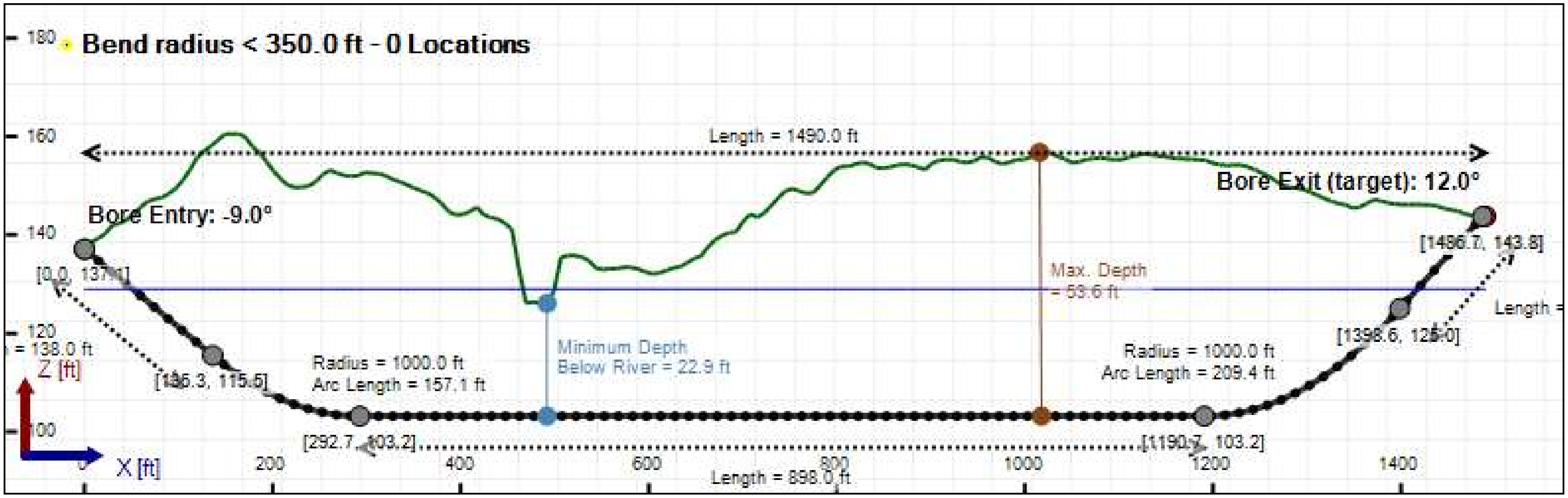
Soil Layer #3 Rock, Geological Classification, Sedimentary Rocks

Depth: 20.00 ft

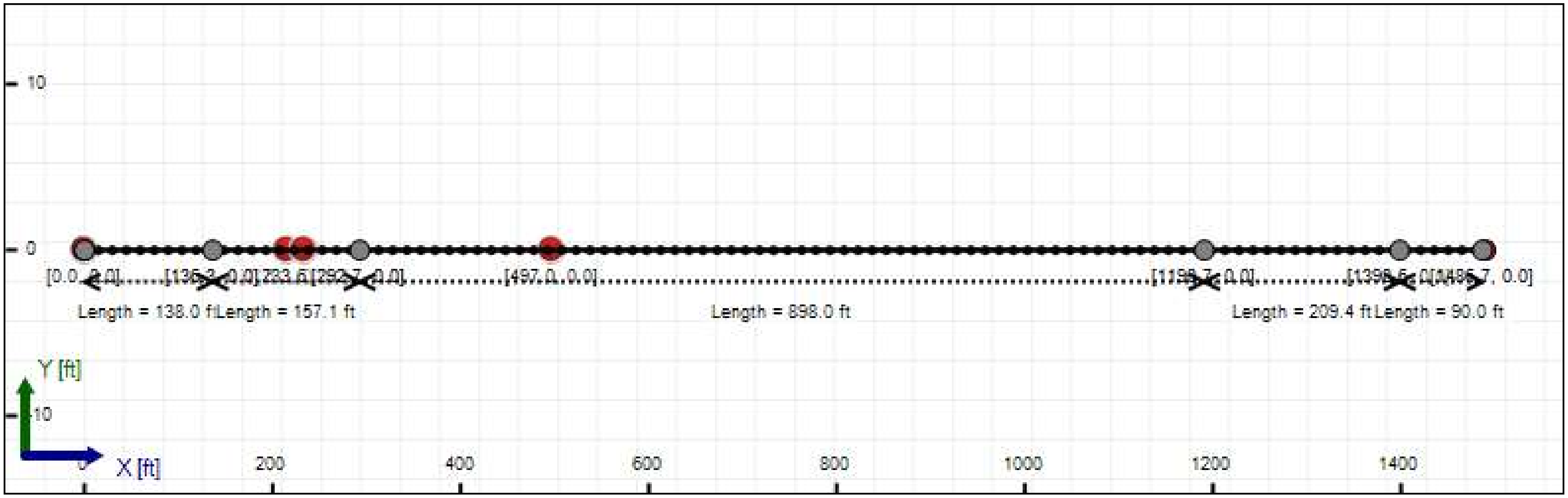
Unit Weight: 120.0000 (dry), 140.0000 (sat) [lb/ft3]

Phi: 37.00, S.M.: 1000.00, Coh: 0.00 [psi]

Bore Cross-Section View



Bore Plan View



Load Verifier Input Summary:

Pipe Application: Electrical Cable

Pipe Type: HDPE

Classification: IPS

Pipe OD: 10" (10.75")

Pipe DR: 9

Pipe Length: 1500.00 ft

Internal Pressure: 0 psi

Borehole Diameter: 1.34400002161662 ft

Silo Width: 1.34400002161662 ft

Surface Surcharge: 0 psi

Short Term Modulus: 57500 psi

Long Term Modulus: 28200 psi

Short Term Poisson Ratio: 0.35

Long Term Poisson Ratio: 0.45

Pipe Unit Weight: 59.30500 lb/ft3

Allowable Tensile Stress (Short Term): 1200 psi

Allowable Tensile Stress (Long Term): 1100 psi

Allowable Compressive Stress (Short Term): 1150 psi

Allowable Compressive Stress (Long Term): 1150 psi

Surface-pipe friction coefficient at entrance: 0.5

Surface-pipe friction coefficient in borehole: 0.3

Pipe-soil friction angle: 30

Slurry Unit Weight: 93.64118 lb/ft3

Hydrokinetic Pressure: 10 psi

Ballast Unit Weight: 62.42746 lb/ft3

In-service Load Summary:

Pressure [psi]	Deformed	Collapsed
Earth Pressure	5.0	34.7
Water Pressure	11.2	11.2
Surface Surcharge	0.0	0.0
Internal Pressure	0.0	0.0
Net Pressure	16.2	45.8
Deflection		
Earth Load Deflection	1.423	9.437
Buoyant Deflection	0.132	0.132
Reissner Effect	0	0
Net Deflection	1.555	9.569
Compressive Stress [psi]		
Compressive Wall Stress	72.9	206.3

Installation Load Summary:

Forces/Stresses	@Maximum Force	Absolute Maximum
Pullback Force [lb]	24484.2	24484.2
Pullback Stress [psi]	682.8	682.8
Pullback Strain	1.188E-2	1.188E-2
Bending Stress [psi]	0.0	25.8
Bending Strain	0	4.479E-4
Tensile Stress [psi]	682.8	703.1
Tensile Strain	1.188E-2	1.268E-2

Net External Pressure = 27.6 [psi]

Buoyant Deflection = 0.1

Hydrokinetic Force = 567.6 lb

In-service Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	1.555	7.5	4.8	OK
Unconstrained Collapse [psi]	27.4	120.8	4.4	OK
Compressive Wall Stress [psi]	72.9	1150.0	15.8	OK

Installation Analysis

	Calculated	Allowable	Factor of Safety	Check
Deflection [%]	0.065	7.5	115.8	OK
Unconstrained Collapse [psi]	37.4	213.4	5.7	OK
Tensile Stress [psi]	703.1	1200.0	1.7	OK

Maximum Allowable Bore Pressure Summary

Ream Number	Initial Diameter	Final Diameter	Estimated Maximum Pressure (Avg.)	Estimated Maximum Pressure (Local)
Pilot Bore	0.00 in	8.00 in	190.926 psi	248.409 psi
1	8.00 in	12.00 in	190.725 psi	247.950 psi
2	12.00 in	16.13 in	190.436 psi	247.288 psi

Note: The maximum bore pressures presented in this table are the maximum values along the length of the bore and not the maximum allowable at any point. The estimated maximum pressures should be compared to the estimated circulating pressures along the bore to determine potential locations of inadvertant returns.

Estimated Circulating Pressure Summary

Active	Shear Rate [rpm]	Shear Stress [Fann Degrees]
No	600	37
No	300	32
No	200	29
Yes	100	25
Yes	6	17
No	3	15

Flow Rate (Q): 40.00 US (liquid) gallon/min

Drill Fluid Density: 68.700 lb/ft3

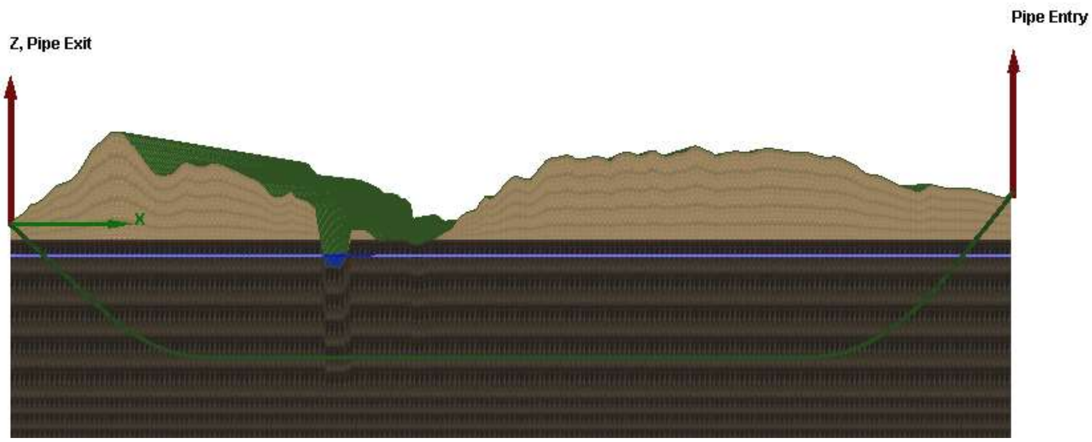
Rheological model: Bingham-Plastic

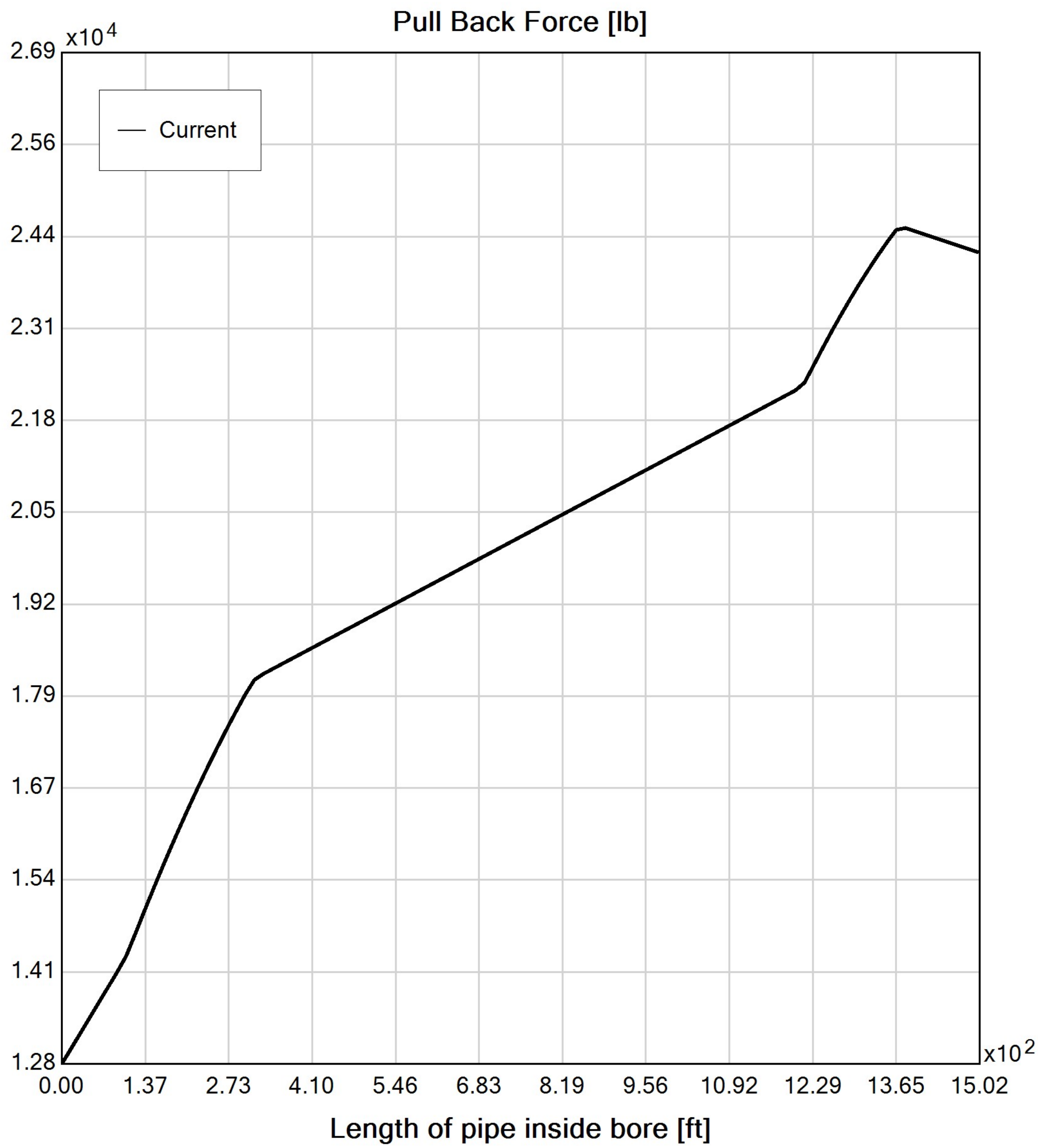
Plastic Viscosity (PV): 25.53

Yield Point (YP): 16.49

Effective Viscosity (cP): 1202.0

Virtual Site





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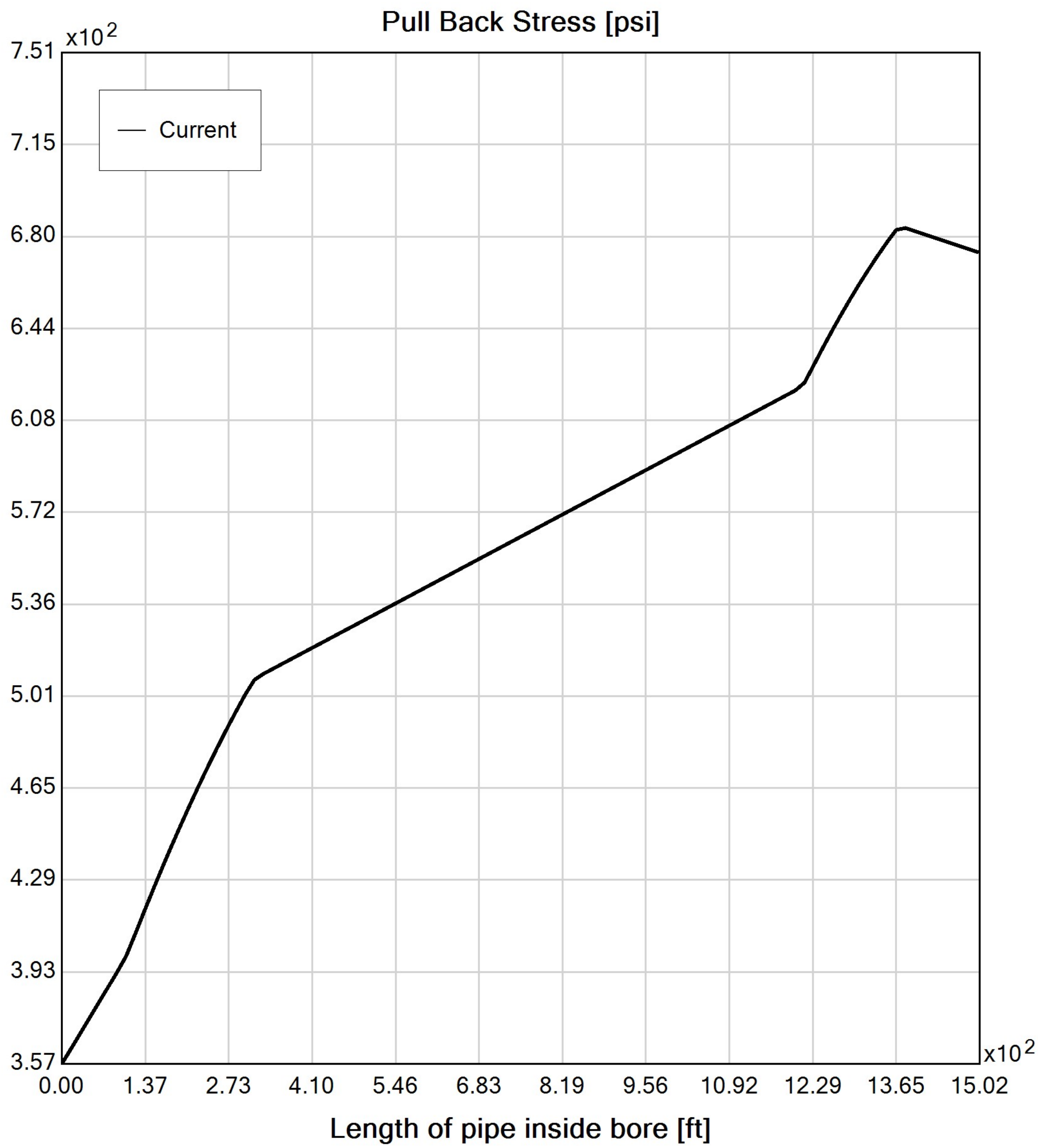
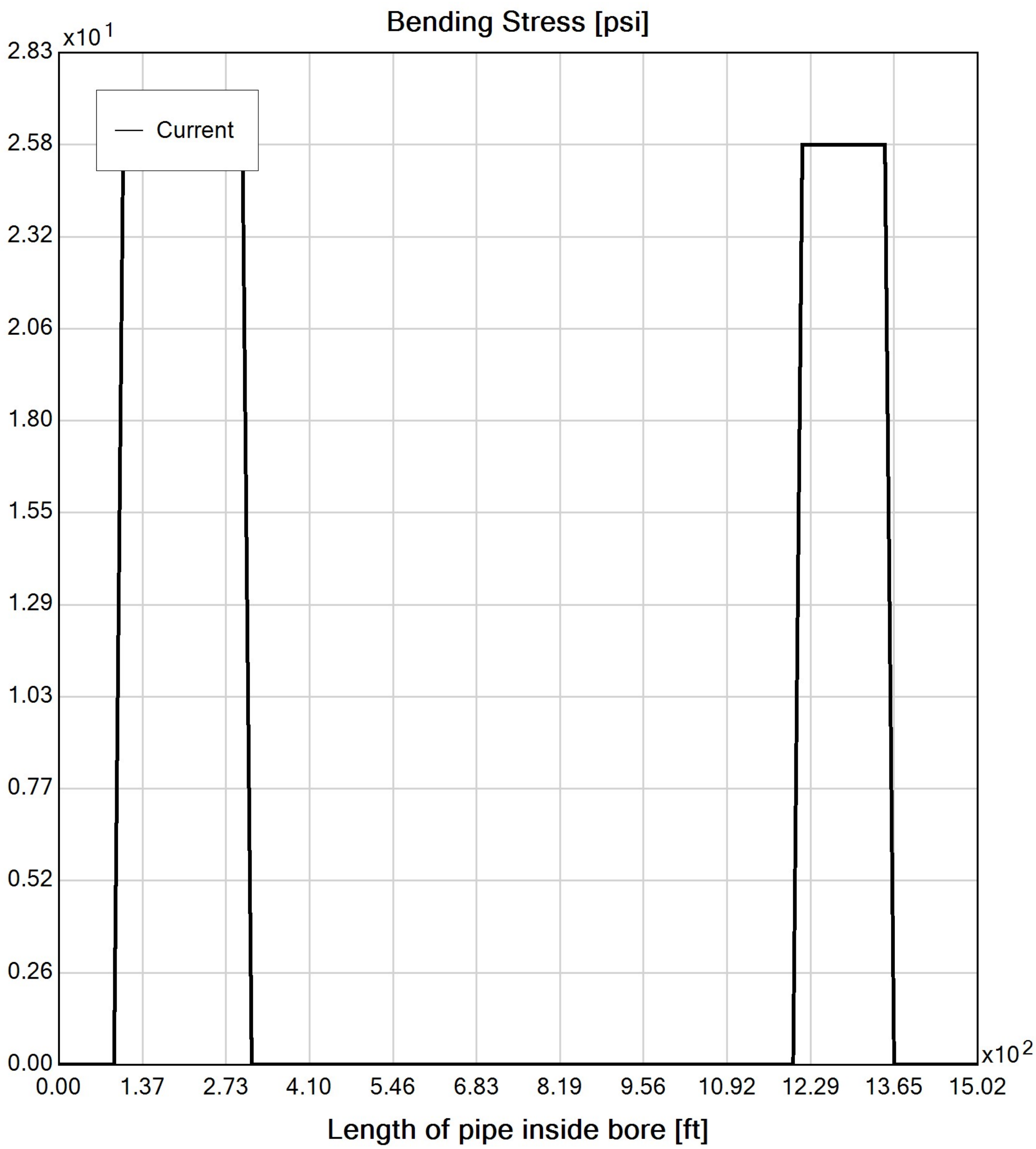
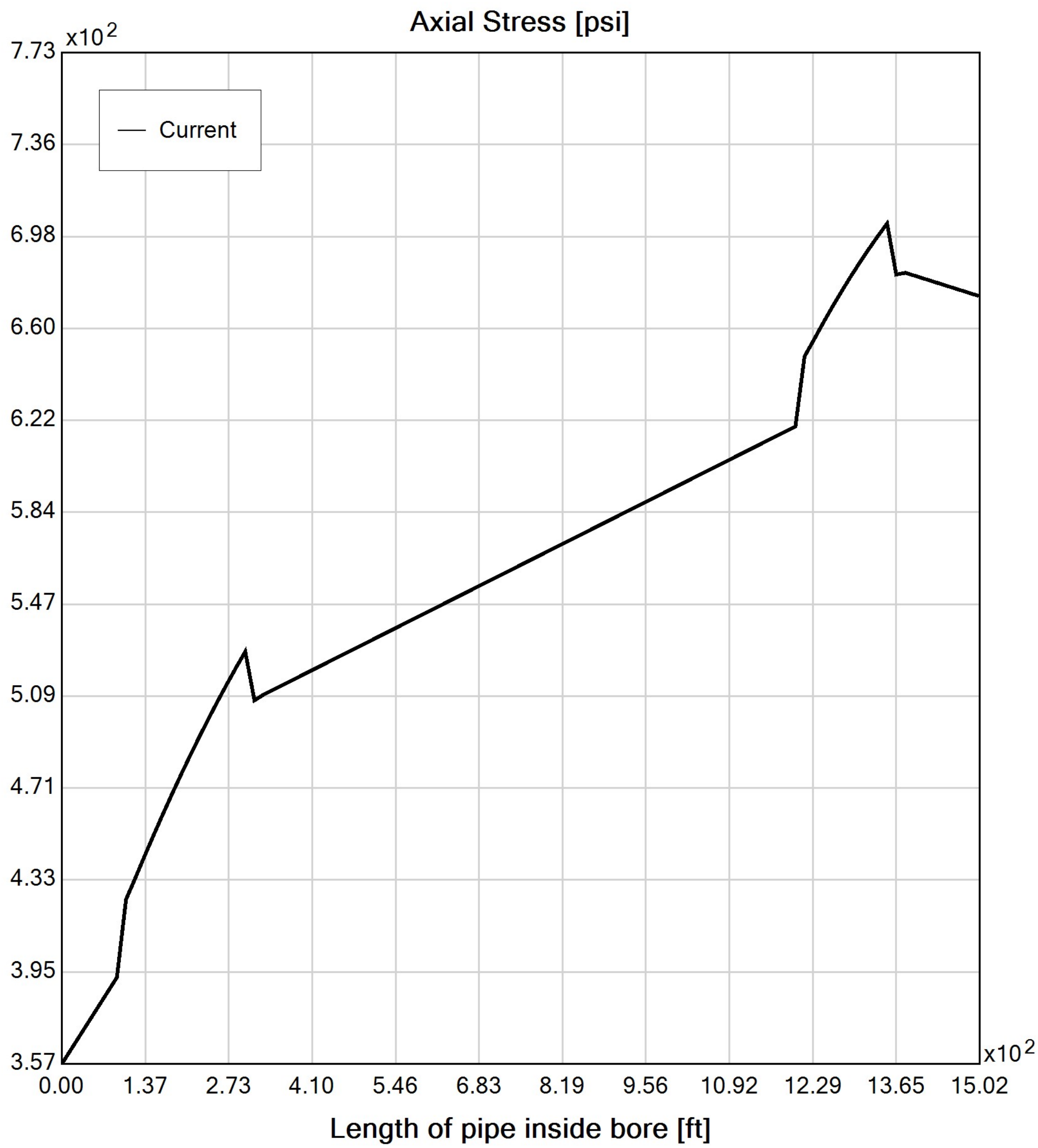
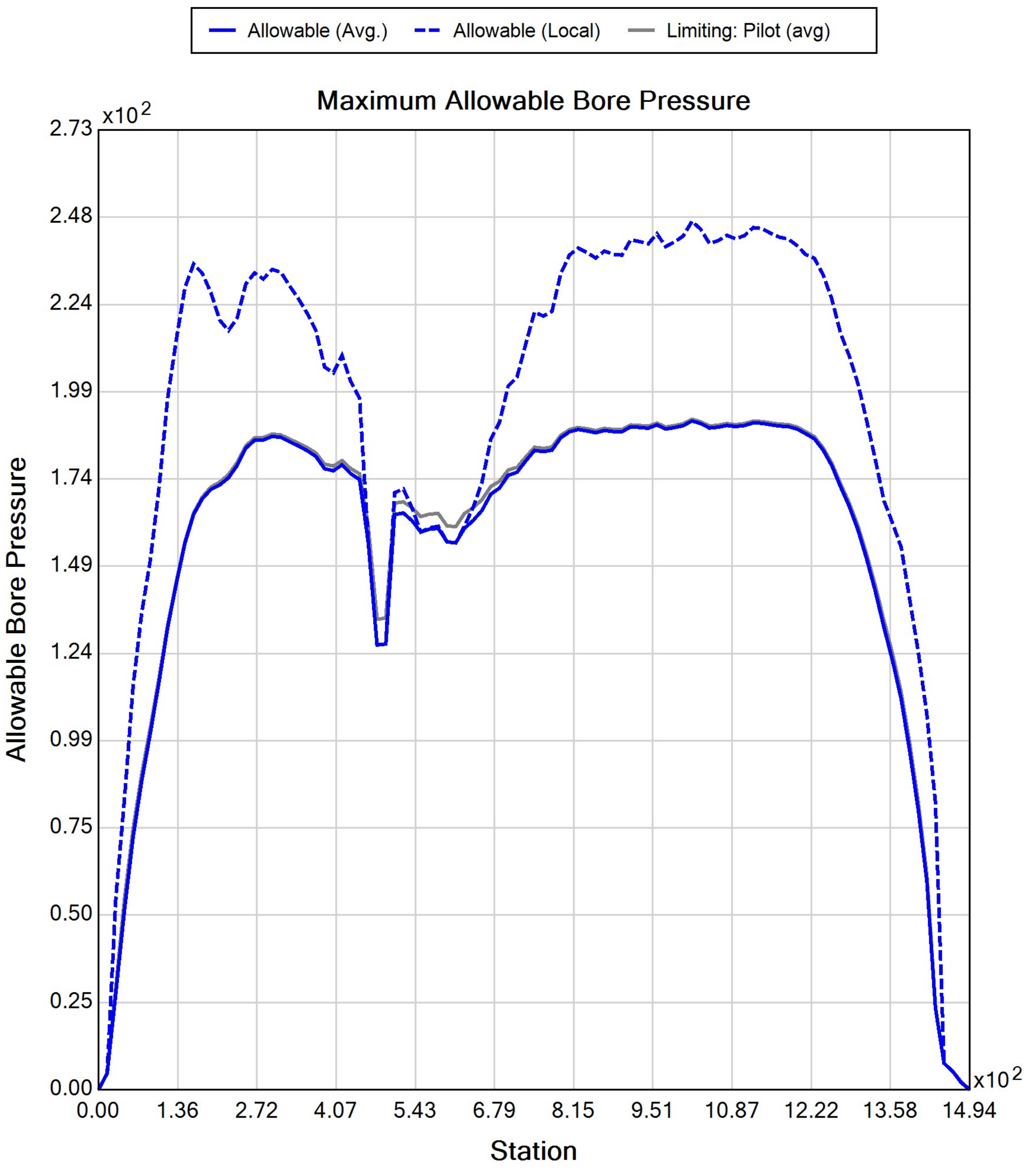

Pull Back Stress [psi]
x10 2
7.51
7.15
6.80
6.44
6.08
5.72
5.36
5.01
4.65
4.29
3.93
3.57
Current
x10 2
0.00
1.37
2.73
4.10
5.46
6.83
8.19
9.56
10.92
12.29
13.65
15.02
Length of pipe inside bore [ft]


Bending Stress [psi]
x10 1
2.83
2.58
2.32
2.06
1.80
1.55
1.29
1.03
0.77
0.52
0.26
0.00
Current
x10 2
0.00
1.37
2.73
4.10
5.46
6.83
8.19
9.56
10.92
12.29
13.65
15.02
Length of pipe inside bore [ft]


Axial Stress [psi]
x10 2
7.73
7.36
6.98
6.60
6.22
5.84
5.47
5.09
4.71
4.33
3.95
3.57
Current
x10 2
0.00
1.37
2.73
4.10
5.46
6.83
8.19
9.56
10.92
12.29
13.65
15.02
Length of pipe inside bore [ft]



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