



HORIZONTAL DIRECTIONAL DRILLING (HDD)

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PART 1: GENERAL

1.01 SCOPE

- A. Furnish all labor, materials, tools and equipment as necessary to construct a pipeline crossing by the horizontal directional drilling method. Furnish all labor, equipment, materials and supplies and perform all work necessary to provide AW with a complete, finished water main crossing. The finished work includes proper installation testing, restoration of underground utilities and environmental protection and restoration.

1.02 QUALITY ASSURANCE:

- A. HDD equipment operators shall be trained to operate the specific Horizontal Directional Drilling equipment for AW's project with at least 3 years experience in directional drilling obtained within the last five years. All pipe and appurtenances of similar type and material shall be furnished by a single manufacturer.
- B. Perform HDD operations under the constant direction of a drilling supervisor who shall remain on site and be in responsible charge throughout the drilling operation. The Contractor's supervisor shall have supervised directional drilling of a minimum of 5,000 linear feet of pipe of a similar or greater diameter, of similar material, over similar lengths, and with similar subsurface conditions.
- C. The requirements set forth in this Specification specify a wide range of procedural precautions necessary to insure that the basic, essential aspects of a proper Directional Bore installation are adequately controlled. Strict adherence shall be required under specifically covered conditions outlined in this Specification.
- D. Perform the work in general conformance with ASTM F1962, current revision, "Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings."
- E. Adhere to the Specifications; any changes must be expressly approved by the AW Project Manager. Approval of any aspect of any Directional Bore operation covered by this Specification shall in no way relieve the Contractor of its ultimate responsibility for the satisfactory completion of the work authorized under the Contract.

1.03 PROFILES AND TOPOGRAPHY

- A. Contours, topography and profiles of the ground as may be shown on the Drawings are believed to be reasonably correct, but are not guaranteed to be absolutely so and are presented only as an approximation. It is the Contractor's responsibility to verify all elevations required to successfully complete the crossing.

1.04 SUBMITTALS

- A. Prior to beginning work, submit to AW copies of a report of schedules, calculations, procedures and any supplemental subsurface soil condition investigations performed along the path of the proposed crossing. Number of copies of the report shall be as specified in Section. The report will summarize the subsurface conditions that are known to the Contractor and that his proposed crossing procedure is based upon factual, best available information. If the subsurface conditions are known to the Contractor by previous work or geotechnical studies done in the immediate area, the information shall be recorded in the report along with any additional geotechnical studies performed by the Contractor. The report shall include the following:

1. Subsurface Information

- a. Record in the report subsurface conditions known to the Contractor by previous work or prior geotechnical studies performed in the immediate project area.
- b. Boring information obtained by AW, if any, is listed in the Supplementary Conditions section of these Specifications.
- c. Additional borings performed by the Contractor and analysis of soils along the path of the proposed crossing. The Contractor shall be responsible for obtaining and including in his bid price the cost of any additional borings along the pipe alignment which may be necessary to design the proposed directionally drilled crossing.
- d. At a minimum any supplemental borings performed by the Contractor shall include standard classification of soils, standard penetration tests, split spoon sampling and sieve analysis. Test borings shall be performed to a minimum depth of ten (10) feet below the proposed pipe invert unless rock is encountered in which case test borings shall penetrate at least two feet into the rock.

2. Drilling Equipment and Methods

- a. Submit information on equipment and written procedure with working drawings describing in detail the proposed boring method and the entire operation to be used. This shall include, but not be limited to, entry and exit pits; settlement pit; size, capacity and arrangement of drilling and pulling equipment; layout of carrier pipe; details and spacing of pipe rollers; type

of current head; method of monitoring and controlling line and grade; method of detection of surface movement; and layout of any proposed construction staging areas.

- b. In addition, submit for approval nameplate data for the drilling equipment, mobile spoils removal unit, and Material Safety Data Sheets (MSDS) information for the drilling slurry compounds. This must be submitted and reviewed by AW before work can proceed.

3. Piping

Submit shop drawings showing the pipe lengths, design details, joint details, etc. for AW Project Manager's review. Submittals shall include, but are not limited to, the following:

- a. All welding or fusion procedures to be used in fabrication of the different pipe materials and installation methods.
- b. Certified records for hydrostatic testing of all pipe materials to be used.
- c. An affidavit stating that all pipe materials furnished under this section have been manufactured in the United States and comply with all applicable provisions of referenced AWWA standards.

4. Proposed Alignment

Submit a graph in plan and profile plotting the pilot drilling hole alignment to AW for review, including entry/exit angles and radius of curvature. After completion of the crossing, submit a final pipe alignment.

5. Schedule

Time schedule for completing the Directional Bore, including any delays due to anticipated soil conditions.

6. Calculations

- a. Submit detailed design calculations for several representative loading conditions for the proposed crossing. If requested by AW, submit calculations to support the design of any particular location of pipe anywhere along the length of the crossing at no additional cost to AW.
- b. Design calculations shall be presented in a neat, readable format, with all figures, values and units included to facilitate ease of verification.

- c. Calculations shall be submitted to demonstrate that the pipe thickness design is sufficient to meet all design criteria specified.
- d. Calculations shall address the following loading conditions:
 - (1) Pre-installation:

Hoop and longitudinal stress during hydrostatic test; spanning stress with pipe full of water and supported on installation rollers, and maximum roller/support spacing.
 - (2) Installation/Post-Installation

Longitudinal stress from pulling force; longitudinal curvature stress at point of entry and in final position; external pressure from drilling fluid, overburden, and loads from the obstacle being crossed.
 - (3) Post-Installation/In-Service

Hoop and longitudinal stress during hydrostatic test; internal working and surge pressure; buckling with internal vacuum.
- e. Perform and submit to AW fluids pressure versus overburden strength calculations. These calculations shall be performed to determine minimum acceptable cover requirements and prevent drilling fluids from breakout to the ground surface.
- f. All calculations shall bear the seal of a Registered Professional Engineer. Licensure in the State in which the work is being performed is preferred.

B. Approval

No work shall commence without obtaining an approval from AW. Details and design calculations shall be submitted and approved well in advance of the drilling operation to prevent delays in work. All final layout work, including grades, shall be the Contractor's responsibility.

1.05 JOB CONDITIONS:

- A. Any nighttime work is strictly regulated and will be allowed only with prior approval granted by AW subject to regulatory agencies having jurisdiction. All crossing operations shall be accomplished during daylight hours, unless approved by AW. Crossing work shall not begin after the hour pre-established as the latest starting time that will allow completion during daylight hours, unless approved by AW. The Contractor shall provide a Work Plan submittal indicating its proposed hours of operation and length of work week. All work plans shall be subject in compliance with all applicable regulatory requirements for construction activities and any off site impacts.
- B. When hazards of nighttime work are carefully considered and determined to be insignificant, nighttime work may be allowed only to complete a properly planned crossing, and only if in the opinion of AW the delay was caused by reasonably unavoidable circumstances, and that such nighttime work is necessary to avoid placing an undue economic hardship on the Contractor. The Contractor shall be responsible for any additional cost associated with nighttime work.
- C. In emergency situations, or where delay would increase the likelihood of a failure, nighttime work may be allowed to complete a delayed crossing. All operations shall continue on a 24-hour per day basis during pipe pull back.

1.06 COORDINATION OF WORK

- A. Coordinate connections to existing pipelines that require shutdown of AW facilities. AW will designate the time for these connections that could involve work during evenings, nights, Saturdays, Sundays, or holidays. Method of connection and designated times are to cause the least amount of disruption to AW's water service to its customers. The cost for connections is to be included in the Contract Price. No contract price adjustment will be allowed for overtime, premium time, or other related costs.

1.07 USE OF EXISTING WATER SYSTEMS:

- A. All use of existing water systems during construction by the Contractor shall be allowed with the approval and direction of the AW Project Manager and AW's representatives. The Contractor shall be responsible for all permits, fees, temporary piping, temporary meter rental/provisions, temporary backflow preventer rental/provision and other water utility requirements for supplying water during construction. The Contractor shall use the existing water system only at locations, times and conditions as set forth by AW.
- B. If water is not readily available at the site or AW cannot provide the volume of flow required by the Contractor, provide potable water as needed from an off-site location at no additional cost to AW.

PART 2: PRODUCTS

2.01 PIPE

Unless otherwise specified in the Contract Documents, pipe installed by horizontal directional drilling shall either be high density polyethylene pipe (HDPE) or ductile iron pipe specifically designed for directional drilling. Unless otherwise specified in the Contract Documents, the water main pipe (carrier pipe) shall be installed without a casing pipe.

A. POLYETHYLENE PIPE

1. High Density Polyethylene (HDPE) Pipe, AWWA C906 compliant, NSF 61 Standard Listed, and furnished in fifty (50) foot lengths.
2. Polyethylene pipe shall be furnished with an outside diameter conforming to ductile iron pipe sizes. Minimum thickness of HDPE pipe shall be determined by the Contractor's calculations, but shall not be considering in-service loading shall not be less than DR 11 when measured in accordance with ASTM D2122.
3. All polyethylene pipe and fittings shall be made of a high-density polyethylene pipe compound with extra high molecular weight that meets the requirements for Type III, Grade P34 Polyethylene material as defined in ASTM D1248.
4. Pipes shall be jointed to one another and to polyethylene fittings by thermal butt-fusion or by socket fusion in accordance with ASTM D3261.
5. Joining of pipe sections shall be performed in accordance with the procedures recommended by the pipe manufacturer. Joints between pipe sections shall be smooth on the inside and internal projection beads shall not be greater than $\frac{3}{16}$ -inch.
6. The tensile strength at yield of the butt-fusion joints shall not be less than the pipe. A specimen of pipe cut across the butt-fusion joint shall be tested in accordance with ASTM D638.
7. Polyethylene pipe shall be joined to ductile iron pipe by the use of flange adapters and back-up rings. Flange adapters shall be butt fused to the polyethylene carrier pipe. The face of the flange adapter shall have a serrated sealing face to assist in holding the flange gasket in place. Flange gaskets shall be full-faced neoprene. Back-up rings shall be Class "D" steel ring flanges in accordance with AWWA C207. Flange bolts must span the entire width of the flange joint, and provide sufficient thread length to fully engage the nut.

B. DUCTILE IRON PIPE

1. Utilize DIP equipped with low profile flexible restrained joints such as Flex Ring or TR Flex. Gripping push-on joint gaskets, or restrained joint gaskets are not permitted.
2. All DIP shall be installed per DIPRA's Horizontal Directional Drilling with Ductile Iron Pipe Handbook to include strict adherence to maximum joint deflection allowances.

C. THICKNESS DESIGN

The following design criteria shall be used in calculating pipe thickness for HDPE, steel or ductile iron pipe:

- | | |
|---|--|
| 1. Working Pressure | **insert working pressure** PSI |
| 2. Test Pressure | **insert test pressure** PSI |
| 3. Surge Pressure | Working pressure + 100 psi |
| 4. Dead Load | Earth cover as shown on Drawings, but not less than 15 feet. |
| 5. Buckling Design | Considering dead load, internal vacuum, H-20 Wheel Loading and a hydrostatic load over top of pipe to grade. |
| 6. Max. Allowable | 3% |
| 7. Horizontal Deflection
Radius of Curvature | 90% of Actual Design Radius |
| 8. Downhole Friction Factor | 1.0 |
| 9. Factor of Safety for
Drilling Fluid Density | 1.5 |

D. The stresses in the pipe shall be calculated for the pre-installation, installation, and post installation loading conditions as specified in Part 1 of this Section. Thickness shall be selected so that stresses do not exceed the following under any of the loading conditions.

- | | |
|---|----------------------------|
| 1. All conditions except
internal surge pressure | 50% of minimum yield point |
| 2. Internal surge pressure
condition | 75% of minimum yield point |

E. The Contractor shall increase the minimum "in-service" thickness as necessary to support the expected stresses and loadings which are expected to be encountered during the installation of the HDD pipeline. The final selected thickness shall be supported by calculations as required herein. No

additional cost shall be considered by AW for pipe thickness greater than the specified minimum "in-service" thickness.

F. DEVIATIONS

Should the Contractor choose to submit a bid using material that does not meet all the requirements of these Specifications, include a description of the deviation with data showing the magnitude of the deviation. Acceptance of such deviations to these Specifications shall be subject to the review and approval of the AW Project Manager before a contract can be awarded.

2.02 EQUIPMENT

A. General: All equipment for the Directional Bore shall have the capacity, stability, and necessary safety features required to fully comply with the specifications and requirements of this section without showing evidence of undue stress or failure. It shall be the responsibility of the Contractor to assure that the equipment to be used in the Directional Bore is in sound operating condition. Backup equipment shall be required in the event of an equipment breakdown and where the condition of the equipment to be used indicates that routine component replacement or repair will likely be necessary during the Directional Bore.

B. Directional Drilling System: The directional drilling system shall consist of over-the-road-transportable field power unit, mud-mixing and recycling unit, a trailer or carriage-mounted drill unit, and all other support accessory vehicles and equipment. All system components shall be in sound operating condition with no broken welds, excessively worn parts, badly bent, or otherwise misaligned components. All drill pipe, reamers, pull back heads, swivels, drill heads and collars, pipe cradles, pipe rollers, ropes, cables, clamps, and other non-mechanical but essential items shall be in sound condition and replaced immediately when need is apparent. The equipment must be capable of drilling the specified length in a single bore.

1. Mud-Mixing and Recycle Units: The mud-mixing and recycle unit shall be a self-contained system designed to provide a supply of high-pressure bentonite-based cutting fluid to the drill unit. It shall contain a fluid storage tank and a complete bentonite and drilling fluid additive(s) mixing system. The cutting fluid is to be mixed on site. The cutting fluid shall be formulated for this specific project and anticipated conditions. It shall permit changes to be made to the bentonite and drilling fluid additive(s) concentrations during drilling in response to changing soil conditions. The field power unit shall contain the power-taken off-driven high pressure cutting fluid pumping system. The recycle units shall be of a capacity to minimize the production of new cutting fluid and maximize the reuse and recirculation of original cutting fluid produced.

2. Directional Drill System: A carriage-mounted version of the drill system shall include a thrust frame. Both the trailer-mounted and carriage-mounted drill system shall be designed to rotate and push 10-foot minimum hollow drill sections into the tunnel being created by the boring head. The drill sections shall be made of high strength S-

grade steel that permits them to bend to a 30-foot radius without yielding. Drill end fittings shall permit rapid makeup of the drill sections while meeting the torque, pressure and lineal load requirements of the system. The boring head itself shall be capable of housing a probe used by the Magnetic Guidance System (MGS) to determine tool depth and location from surface and to orient the head for steering. The MGS shall have a minimum accuracy of (+/-) 2 percent of the vertical depth.

The drilling equipment must be fitted with a permanent alarm system capable of detecting an electric current. The system will have an audible alarm to warn the operator when the drill head nears electrified cables. The drilling equipment shall be grounded, protected, and operated in accordance with manufacturer's requirements for electric strike safety.

The control console shall contain a calibrated display of inclination, azimuth, tool face location, mud pump rates, and torque pressures. The downhole steering system accuracy shall be (+/-) 1 percent of the horizontal bore length such that the difference between actual depth and machine calculated depth is not more than 1 foot per hundred feet.

3. Restrictions: Other devices or utility placement systems for providing horizontal thrust other than those previously defined in the preceding sections shall not be used unless approved by AW prior to commencement of the Work. The proposed device or system will be evaluated prior to approval or rejection on its potential ability to complete the pipe placement satisfactorily without undue stoppage and to maintain line and grade within the tolerances prescribed by the particular condition of the project. Water sluicing methods, jetting with compressed air, or boring or tunneling devices with vibrating type heads that do not provide positive control of the line and grade shall not be allowed.
- C. Spoils Equipment: The cutting fluid removal system shall include a self-contained vacuum truck which has sufficient vacuum and tank capacity to remove excess cutting fluid mixture and cuttings from the project site as required or as directed by AW. Spoils are not to be discharged into sewers or storm drains.

The Contractor will contain all drilling and pipe lubricating mud by taking special measures to prevent run-off onto adjacent properties and/or waterways. All surplus drilling and pipe lubricating mud will be removed from the site and properly disposed of by the Contractor at no cost to AW. The Contractor will also be responsible for all required erosion control measures at no cost to AW.

- D. Magnetic Guidance System: A Magnetic Guidance System (MGS) shall consist of a probe and a tracker that is capable of monitoring the location of the drill head during the drilling operation. The tracker shall be capable of tracking at all depths up to one hundred feet and in any soil condition, including hard rock. It shall enable the driller to guide the drill head by

providing immediate information on the tool face, azimuth (horizontal direction), and inclination (vertical direction). The tracker shall be accurate to +/-2% of the vertical depth of the borehole at sensing position at depths up to one hundred feet. Ferrous materials shall not influence or affect the MGS readings or accuracy.

Components: The Contractor shall supply all components and materials to install, operate, and maintain the MGS. This shall include, but is not limited to the following:

1. MGS Probe and Interface
2. Computer, Printer, and Software
3. DC Power Source, Current Control Box, and Coil/Tracking Wire.

The MGS shall be a Tensor TruTracker MGS, or other licensed and industry-approved wire guidance system. The Contractor is required to obtain an approval from AW for the equipment to be used. The Contractor is responsible for supplying all required information regarding the equipment and method to be used on the project. Work shall not commence until approval is obtained from AW. The Contractor is responsible for setting up and operating the MGS using personnel experienced with this system. "AWalk-over" tracking systems shall not be used, except as approved by AW. Contractor shall provide the AW Project Manager with current calibration certification of MGS in accordance with manufacturer's specifications.

- E. If equipment breakdown or other unforeseen stoppages occur and forward motion of the directional cutting head is halted at any time other than for reasons planned in advance (addition of drill stems, etc.), the boring path shall be filled with a proper bentonite solution immediately, or as directed by AW.
- F. The boring tool shall have steering capability and have an electronic tool detection system. The position of the tool during operation shall be capable of being determined accurately, horizontally within 1% of the horizontal distance of the borehole and vertically within 2% of the vertical depths of the borehole. The boring tool shall have a nominal steering radius of 30 feet.

2.03 DRILLING FLUIDS:

A. A mixture of Bentonite drilling clay, project specific cutting fluid additives, and potable water is to be used as the cutting fluid (MUD) and over ream hole filler for the Directional Bore. The drilling fluid mixture used shall have the following minimum viscosities as measured by a March Funnel:

- | | | |
|----|-------------|----------|
| 1. | Rock Clay | 60 sec. |
| 2. | Hard Clay | 40 sec. |
| 3. | Soft Clay | 45 sec. |
| 4. | Sandy Clay | 90 sec. |
| 5. | Stable Sand | 120 sec. |
| 6. | Loose Sand | 150 sec. |
| 7. | Wet Sand | 150 sec. |

These viscosities may be varied to best fit the soil conditions encountered as recommended by the drilling mud and fluid additive manufacturer, and as approved by AW.

- B. Where sandy or granular materials are encountered, a cement slurry or polymer supplement shall be considered for added strength and stability of the bore and over ream hole.
- C. No chemicals or polymer surfactant shall be used in the drilling fluid without written consent of AW, and after a determination is made that the chemicals to be added are not harmful or corrosive to the facility and are environmentally safe. Clay must be totally inert and contain no risk to the environment.
- D. Provide AW Project Manager and have on site at all times the Material Safety Data Sheets (MSDS) for all drilling compounds and chemicals.

2.04 TRACER WIRE

- A. Installation of tracer wire and tracer wire material shall conform to the requirements set forth in Specification Section 33 05 27.
- B. Tracer wire(s) shall be installed simultaneously with pullback of the pipe. Wire(s) shall either be wrapped around the pipe or taped to the pipe at 10-foot minimum intervals before installation.

PART 3: EXECUTION

3.01 SITE DISTURBANCE AND SOIL EROSION

- A. Sediment barriers shall be constructed as shown on the Drawings or where directed by AW. All soil erosion and sediment control work shall be done in accordance with the Standards for soil erosion and sediment control for the location where the work is performed. Contractor shall maintain sediment barriers until the project is deemed complete.
- B. The Contractor shall be responsible for the preservation of all existing trees, plants, and other vegetation that are to remain within or adjacent to the construction site and shall also be responsible for protecting existing concrete curb, fence, utilities, and other structures that are located within or adjacent to the construction site.
- C. The Contractor assumes all liability for environmental damage and cleanup due to inadvertent discharges of slurry or other causes. Slurry materials shall be selected based on the soil conditions encountered to minimize the risk of mud returns.

3.02 PERSONNEL REQUIREMENTS:

- A. Provide a competent and experienced supervisor representing the Drilling Contractor who must be present at all times during actual operations. A responsible representative, who is thoroughly familiar with the equipment and type work to be performed, must be in direct charge and control of the operation at all times. In all cases the supervisor must be continually present at the job site during the actual Directional Pilot Hole, over-reaming and pullback operations.
- B. Have a sufficient number of competent workers on the job at all times to insure the Directional Bore is made in a timely and satisfactory manner. Adequate personnel for carrying out all phases of the actual Directional Bore operation must be on the job site at the beginning of work.
- C. If HDPE is specified for the carrier pipe, HDPE pipe thermal butt fusion welding is to be completed by a welder certified by the manufacturer of the pipe or pipe welding equipment, in accordance with the Plastic Pipe Institute "Handbook of Polyethylene Pipe," Polyethylene Joining Procedures, and 49 CFR 192, Subpart F, latest edition.
- D. AW must be notified 48 hours in advance of starting each phase of the Work. The Directional Bore shall not begin until AW is present at the job site and agrees that proper preparations for the operation have been made. AW's approval for beginning the installation shall in no way relieve the Contractor of the ultimate responsibility for the satisfactory completion of the work as authorized under the Contract. It shall be the responsibility of AW to provide inspection personnel at such times as appropriate without causing undue hardship by reason of delay to the Contractor.
- E. If the Contractor fails to begin the Directional Bore at the agreed time, AW will establish the next mutually convenient time to begin. To avoid undue

hardship of either party, reasonable and mutual cooperation should be exercised where starting times are concerned. If one party fails to meet the agreed schedule, the other party is expected to consider a delayed start if the installation cannot be completed during daylight hours.

3.03 ALIGNMENT AND GRADE

- A. Determine and physically locate the depth, location, and size of all existing underground facilities in the vicinity of the proposed crossings and provide AW with a comprehensive report of these facilities before starting any construction. The Contractor shall be held completely and solely responsible for any damages incurred. The kinds, locations and sizes of the existing underground utilities which may be shown on the Drawings are intended only as a guide to the Contractor and are not guaranteed to be even approximately correct. Notify AW of all existing utilities along the route and in the vicinity of the crossing prior to the construction to include all test borings and excavations.
- B. If utilities of unknown depth or other obstructions require grade or alignment deviations from the Drawings, the grade and/or alignment may be adjusted with Engineer's approval. All adjustments shall permit gradual bends of the pipe to the original alignment beyond the directional bore section. At unusual site conditions, the Contractor may request a review of site conditions by AW for additional adjustment, and such determination shall be final. An adjustment in alignment, position, or elevation approved by the AW Project Manager shall not be cause for an adjustment of costs.
- C. Pipe entry and exit points are to be allowed no more than five (5) feet of deviation from the staked centerline. The entry point may be moved up to 25-feet further from the original entry point only with the AW Project Manager's approval. Exit point lengths greater than 25-feet from the original point require the AW Project Manager's approval. Entry and exit points normally will not be allowed closer to the banks of a waterway being crossed. Any installation that deviates from the plan may be rejected and any rejected installation shall be reconstructed at the Contractor's expense.
- D. The vertical profile as shown on the Drawings is the minimum depth to which the pipeline shall be installed. Contractor may, at his option and with the permission of AW, elect to install the pipe at a greater depth than shown on the Drawings, at no additional cost to AW.

3.04 INSTALLATION:

- A. The Contractor shall be responsible for providing a Maintenance of Traffic Plan to AW and local traffic law enforcement agency for review. The Maintenance of Traffic Plan shall show the location of all barricades, signs, devices and alternate routes for local traffic and pedestrian safety. Erection of the appropriate safety and warning devices in accordance with the USDOT "Manual of Uniform Traffic Control Devices" (MUTCD) shall be completed prior to beginning work and maintained until all construction is completed and the site restored.
- B. Specifically note in the Maintenance of Traffic Plan street intersections that are to remain open as required during the pipe pull-back operation, or traffic detours implemented. Install a temporary sleeve across the street intersections through which the pipe can be pulled or to construct a temporary bridge for the pipe over the intersections as required. No additional payment will be made for temporary structures required in order to permit access through street intersections or the implementation of traffic detours.
- C. The cost of restoring pavement, curb, sidewalk, driveways, lawns, storm drains, etc., and other landscaped facilities shall be borne by the Contractor unless otherwise noted.
- D. The following is a general outline of steps for the Directional Bore operation:
 - 1. Clear the right-of-way and temporary work space as shown on the Drawings. Contractor is responsible to install and maintain all soil erosion and sediment control devices, until project is completed and the approved permanent site stabilization is in place.
 - 2. Lay out the pipe crossing alignment using a qualified professional land survey team to confirm accurate horizontal distances, either physically measured or shot by Electric Distance Measurement. Entry and exit points shall be located and marked with survey hubs or markers. Payment for survey mark-out shall be included in the price bid under horizontal directional drilling.
 - 3. Haul, string, and assemble restrained pipe. Joint air test the section prior to installation and hydrostatically test the assembled pipeline section, unless otherwise approved by the AW Project Manager. If sufficient linear footage of lay down area for the pipe string is not available, the finished pipeline may be assembled in no more than two sections, with each section joint air tested separately and hydrostatically tested when fully assembled as one piece. The Contractor is responsible for ensuring that the drill rig has adequate pullback capacity to overcome the increased frictional resistance resulting from the stoppage of pipe pullback to perform the final weld or fusion of pipe sections. The Contractor is required to provide adequate site security. The Contractor shall be responsible for maintaining the integrity of the pipe until after the pullback, final test of the pipeline, and acceptance of the work by AW.

4. All assembled pipe sections shall be securely plugged at the end of each work day. The pipe interior is to be protected at all times against dirt, dust, drilling mud, pipe cuttings, debris, animal access, and other sources of contamination.
5. Provide adequate support rollers for the pipeline during pullback of the pipe string into the pre-drilled hole. The rollers and cradles shall be of a type that will prevent damage to the pipe and will be of sufficient number, as recommended by pipe manufacturer, to prevent over stressing due to sag bends during the pullback procedure. The pipe shall be supported at all times, including pullback, to maintain a free stress arc which limits pipe bending and internal hoop stresses to within manufacturer's limits.
6. Pipe which is not properly protected and supported and shows indications of excessive stressing, gouges, cuts, abrasions or other damage which may affect the operational performance intended for the pipe, as recommended by pipe manufacturer, shall be removed from the site and replaced at no additional cost as directed by AW.
7. Mobilize the drilling equipment, erect the rig, drill a pilot hole, enlarge the hole as necessary to a minimum diameter of 1.5 times the nominal diameter of the pipe, and pullback the prefabricated pipe string under the crossing.
8. Prior to beginning the Pilot Hole over-reaming, furnish to AW an as-built plan and profile of the actual crossing to confirm the installation is in compliance with the Contract Documents. Pilot hole alignment shall be accepted by AW in writing prior to reaming and pipe installation.
9. The Contractor shall be responsible for selecting the reaming process to be utilized, whether forward and/or back reaming will be undertaken, and the number of reaming passes to be made.
10. Supply portable mud tanks or construct temporary mud pits to contain excess drill fluids during construction and slurry material displaced by the pipe during installation. Mud pits are to be protected at all times against unauthorized access and be stabilized at all times against surface water runoff and containment berm failure. Pump, haul and dispose of any drill cuttings and excess drill fluids to a receiving site permitted to accept the spoils, all in a manner consistent with the local and State regulations, at no additional cost to AW.
11. Pull back the bore pipe in one continuous section. The Contractor shall use a swivel to minimize the rotation of the product pipe during pullback. Swivel shall utilize lubricated internal bearings which are fully protected from external contamination and over lubrication. Demonstrate the swivel operation to AW prior to pullback operation.
12. Use potable water and disinfect all piping and hoses used for water addition to the carrier pipe to counter the pipe flotation during pullback.

13. During pullback, maintain records for submission to AW indicating job, date, time, constant pipe footage progress, mud flow rates, pulling forces required and torque readings. Document the pull head location for each length of drill stem pipe for as build records.
14. Unless not permitted by the right-of-way owner, inject a low strength cement slurry into the bore hole for approximately 50 feet at each end of the drilled pipeline. Where cement slurry cannot be used, provide restraint at either end of the pipeline outside the bore to hold the pipe in place. The type of restraint shall be submitted to AW in advance of the Work and must be approved by AW prior to the start of construction.
15. AW shall have access at all times to any measuring or gauging devices used for the horizontal drill as well as any drilling logs maintained by the Contractor.
16. In the event that the Contractor must abandon the drill hole before completion of the crossing, the Contractor will seal the borehole with neat cement grout starting at the low point or end of the drill hole and redrill the crossing at no extra cost to AW.

3.05 PRESSURE TESTING AND LEAKAGE

- A. Prior to pullback, perform an allowable leakage test on the full length of pipe after all sections have been welded or fused in accordance with ANSI/AWWA C600, latest revision and as described in Section - Pressure and Leakage Tests. A hydrostatic pressure test shall also be performed on the installed pipe in accordance with ANSI/AWWA C600, and as described in Section - Pressure and Leakage Tests.

3.06 CONNECTION TO ADJOINING PIPE

- A. Install flange connections from the directionally-drilled pipe to adjacent pipe installed by open cut with support by backfill material as per Section - Excavation Backfill and Compaction for Utilities. Flange bolts shall be carefully tightened in increments, with a final torque value not exceeding the manufacturer's recommendations. Tightening torque increments shall not exceed 15 foot pounds.
- B. Polyethylene and flange gasket will undergo some compression set. Therefore, the flange bolts shall be retightened one hour after the initial assembly, and a second time at least four hours after the second tightening.

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