IRVING
TEXAS

CONTRACT DOCUMENTS
AND SPECIFICATIONS FOR

JAMISON 48-INCH WATER LINE REPLACEMENT

AUGUST 2019

CITY OF IRVING
825 W. IRVING BLVD.
IRVING, TEXAS 75060
P: (972) 721-2611

Prepared by:
HALFF
HALFF ASSOCIATES, INC.
12225 Greenville Ave., Suite 200
Dallas, Texas 75243
Tel (214) 572-2272
Fax (214) 739-0095
TBPE Firm #F-312

STATE OF TEXAS
PROFESSIONAL ENGINEER
JAYSON D. MELCHER
94839
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**SPECIFICATIONS AND CONTRACT DOCUMENTS FOR**

**JAMISON 48-INCH WATER LINE REPLACEMENT**

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**FOR**

**JAMISON 48-INCH WATER LINE REPLACEMENT**

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The specifications listed herein were prepared by or under the supervision of:

![Signature]

JAYSON D. MELCHER, PE
TEXAS P.E. #94839
HALFF ASSOCIATES, INC.
TBPE FIRM #F-312
DATE: 8/8/2019
The specifications listed herein were prepared by or under the supervision of:

STATE OF TEXAS

Alan L. Wilson
53669
PROFESSIONAL ENGINEER

8-12-19

ALAN L. WILSON, PE
TEXAS P.E. #53669
Baker Consulting Group, Inc.
DATE: 8/12/2019

CATHODIC PROTECTION

J. DEAN FLESSAS

8/8/2019

J. DEAN FLESSAS, NACE CP4
CP SPECIALIST #5928
DKC INTEGRITY, LLC.
DATE: 8/8/2019
DIVISION 02

SITE WORK
02200-J  PIPELINE EXCAVATION AND BACKFILL

1.00 GENERAL

1.01 WORK INCLUDED
   A. Scope of Work
      1. Furnish labor, materials, equipment and incidentals necessary to excavate and backfill as required for the construction of pipe to the lines, grades and extents indicated on the Drawings.
   
   B. Related Sections
      1. Section 02400-J – Trench Safety System
      2. Section 02402-J – Care of Water During Construction
      3. Section 15060-J – Bar Wrapped Concrete Cylinder Water Pipe and Fittings
   
   C. Measurement and Payment
      1. Except where specified elsewhere in the Contract Documents, the work included in this Section shall be considered subsidiary to the contract unit price for construction of 48-inch AWWA C303 Bar-Wrapped Concrete Cylinder Pipe to the lines, grades and extents indicated on the Drawings.

1.02 DEFINITIONS
   A. Owner: City of Irving
   B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants
   C. Owner’s Project Team (OPT): Representatives of the Engineer and/or Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

1.03 REFERENCES
   A. Except as modified or supplemented herein, the work included in this Section shall conform to the applicable requirements of the following standards, latest edition.
   B. ASTM International (ASTM):
      ASTM C33 Standard Specification for Concrete Aggregates
      ASTM C143 Standard Test Method for Slump of Hydraulic-Cement Concrete
      ASTM C150 Standard Specification for Portland Cement
      ASTM C260 Standard Specification for Air-Entraining Admixtures for Concrete
      ASTM C618 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
      ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (600 kN-m/m³))
      ASTM D1556 Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
      ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
Pipeline Excavation and Backfill

1.04 SUBMITTALS

A. Submittals shall be in accordance with TxDOT specifications and include the following:

1. Submittals required prior to the start of the Work:
   a. Contractor’s proposed method of backfilling and compaction to the Engineer for Review.
   b. A Dewatering Plan outlining how sufficient groundwater will be removed, if applicable.
      1) Dewatering Plan shall be prepared by and sealed by a Professional Engineer licensed in the State of Texas.
      2) Contractor shall assume all responsibility for the adequacy of the methods, materials, and equipment employed.
   c. Certified Test Reports for embedment material, crushed stone, and crushed concrete. Certified Test Reports shall be from an independent laboratory. Test reports shall include sieve analysis, Atterberg limits, and results of an Abrasion test.
   d. Trial mix design for flowable fill, if required, and Certified Test Reports for compressive strength tests.
   e. A 5-gallon bucket of proposed granular embedment material.

2. Test reports:
   a. Certified Test Reports for compaction tests.

1.05 JOB CONDITIONS

A. Classification of Excavation

1. Excavation shall be “unclassified” and involves removal of the necessary materials to provide the trench to the required width and depth. The Contractor, prior to submitting a proposal, must satisfy himself as to the actual sub surface conditions. No extra or separate payments shall be made for rock, dewatering, or any other condition.

B. Road Crossings

1. Work to be performed within the limits of the public or private right-of-way shall be in full accordance with the requirements of the easements and permits and as requested by the City, County, and/or private owner. Provide temporary access and detours for roads and driveways cut off during pipe laying operations.

C. Protection of Existing Structures and Utilities

1. Prior to the manufacture of pipe and start of construction, the Contractor shall communicate with the local representative of all utility companies including, but not limited to: oil, gas, electric, and telephone companies; water and sanitary sewer utilities; and any other public or private utility companies in the vicinity of the proposed...
construction; in order to obtain the assistance of the utility owners in locating utility lines and in the avoidance of conflicts with utility lines. The Contractor shall uncover and determine the elevation and location of conflicts well ahead of the manufacture of the pipe. The Engineer has shown the approximate location of existing utilities as determined from field surveys and record data received from utility companies. The fact that some utilities are not shown or are shown incorrectly in no way relieves the Contractor of his responsibility to locate all existing utilities.

2. The Contractor shall advise the OPT of any existing utilities that are not shown on the Drawings, or are shown incorrectly, that affect the pipe layout. The Contractor shall also propose a resolution to the utility conflict for the Engineer’s review. The Engineer will determine whether the utility will be relocated or the proposed pipeline location revised. If the pipeline location is revised, an adjustment to the Contract price will be made by adjusting the quantities for the various unit price pay items. If the proposed pipe grade is adjusted by 2 vertical feet or less, no Contract Price adjustment will be made.

3. Utilities that affect the pipe layout will be interpreted by the Engineer as follows:
   a. Utilities that conflict with the grade of the proposed pipe will be interpreted as affecting the pipe layout.
   b. Utilities that conflict with the operations and maintenance of the proposed pipe will be interpreted as affecting the pipe layout.

4. Where excavation endangers adjacent structures and utilities, the Contractor shall, at his own expense, carefully support and protect such structures and/or utilities so that there shall be no damage. Costs of temporarily or permanently relocating the conflicting utilities shall be borne by the Contractor without extra compensation from the Owner.

5. If in the opinion of the OPT, concrete backfill is necessary for the support of utility lines crossing trenches, the OPT may direct 2,000-psi concrete backfill to be used. Payment shall be made to the Contractor at the unit price bid for the installation of such quantity of the concrete backfill as directed by the Construction Manager.

1.06 SUBSURFACE CONDITIONS

A. Subsurface conditions have been investigated and documented in Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1) prepared by HVJ Associates (Geotechnical Investigation)

B. If necessary for the complete the work described in this Section, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

2.00 PRODUCTS

2.01 MATERIALS

A. Concrete Embedment, Backfill, Cradle, Cap, Blocking, and Encasement
   1. Where concrete embedment, backfill, cradle, cap, blocking, or encasement is indicated on the Drawings or requested by the OPT, it shall be 2,000-psi compressive strength Class B concrete as specified in TxDOT Item 421, Hydraulic Cement Concrete.
   2. Where concrete encasement is used to support manholes, it shall be 3,000-psi compressive strength Class A concrete as specified in TxDOT Item 421, Hydraulic Cement Concrete.

B. Flowable Fill / Controlled Low Strength Material (CLSM)
   1. Flowable fill shall consist of a mixture of sand, cement and/or fly ash, air-entraining admixture, and water which produces a minimum 28-day compressive strength of between 50 and 150 psi. The proportions of the mix shall be such as to produce material
that can be placed readily into the void area without spading or vibrating, and without segregation or undue accumulation of water or laitance to the surface.

a. Sand shall be clean natural sand in accordance with ASTM C33. The sand shall generally be of such size that all will pass a 3/8-inch sieve, minimum 95% will pass a 1/4-inch sieve, and minimum 80% will pass a No. 8 sieve. Minimum sand content, at saturated surface dry weight, shall be 2,720 lb/yd$^3$.

b. Cement shall be Type I Portland cement per ASTM C150. Minimum cement content shall be 50 lb/yd$^3$.

c. Fly ash shall be Class “C” fly ash per ASTM C618. Maximum fly ash content shall be 150 lb/yd$^3$.

d. Air-entraining admixture shall meet the requirements of ASTM C260. Minimum air content shall be 6%.

e. Water shall be clean and free from oil, acid, alkali, organic matter or other harmful impurities. Water that is suitable for drinking or for ordinary household use will be acceptable. Maximum water content shall be 290 lb/yd$^3$.

f. Concrete mix additive such as “Darafill” manufactured by GCP Applied Technologies or equal products may be used if required to meet the strength and flowability requirements of this Section.

2. Materials shall meet recommendations for mix design and placement, as published by National Ready Mixed Concrete Association.

3. Flowable fill shall have a minimum slump of 5 inches, and sufficient to allow the material to flow freely during placement, as determined in accordance with ASTM C143 with the following exceptions:

a. Do not rod the material.

b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.

4. Flowable fill shall have an initial set time (walkable surface) of 24 hours or less. The material, after set, shall provide full support to pipelines, adjacent earth walls, structures or other such facilities, but shall be of a low enough compressive strength after reaching final strength to allow future excavation with ordinary small excavation equipment.

5. The Contractor shall be responsible for the design of flowable fill material. A trial mix shall be designed by an independent testing laboratory, retained by the Contractor. The testing laboratory shall submit verification that the materials and proportions of the trial mix design meets the requirement of the Specifications. In lieu of trial mix design, the Contractor may submit a mix design used successfully in previous similar work, for similar materials for approval by OPT. The Contractor shall not make changes in materials gradation, source, brand, or proportions) of the mixture after having been approved, except by specific approval of the Engineer.

C. Crushed Stone

1. Where crushed stone is required for water drainage, restoration of trench foundation, or other uses, it shall be well-graded crushed stone or crushed concrete in accordance with TxDOT Item 247, Type A or D, Grade 1-2.

D. Geotextile Filter Fabric

1. Geotextile filter fabric used to separate crushed stone from in-situ soil shall be US 160NW nonwoven geotextile as manufactured by US Fabrics, Inc., or approved equal.

E. Crushed Stone Embedment

1. Crushed stone embedment material shall be well-graded crushed limestone in accordance with ASTM C33 gradation (3/8-inch to No. 8 sieve) as defined below:
### Sieve Size | Percent Passing
---|---
1/2-inch | 100%  
3/8-inch | 85%-100%  
No. 4 | 10%-30%  
No. 8 | 0%-10%  
No. 16 | 0%-5%

F. The embedment material shall be free flowing and shall be such that when wet, the fine material shall not form mud or muck. The embedment material shall be composed of angular, tough, durable particles, free from thin, flat and elongated pieces, of suitable quality to ensure permanence in the trench and have a percentage of wear of not more than 40% when tested in accordance with ASTM C131 or ASTM C535. The Plasticity Index of the fines shall not exceed 3 as measured by ASTM D4318. Light weight aggregate is not acceptable for embedment. Material used for embedment shall have a resistivity of not less than 500 ohms/cm as measured by ASTM G57.

Select Material
1. Select material shall be selected or processed excavated trench material free from rock fragments and clods larger than 2-inch in the greatest dimension. Select material shall be free of organic materials and excessive clay. Select material shall be free of sharp angular materials that could damage the pipe coating.

G. Ordinary Material
1. Ordinary material shall be excavated trench material free from rock fragments and clods larger than 6-inch in the greatest dimension. Ordinary material shall be free of organic materials.

H. Topsoil
1. Topsoil shall be soil material relatively free of stones or other objectionable debris, which have sufficient humus content to readily support vegetative growth. The suitability of soil for topsoil shall be subject to approval by the OPT.

### 3.00 EXECUTION

#### 3.01 TRENCH EXCAVATION

A. General
1. Excavate trenches to the alignment, width, and depth as indicated or as required for the proper installation of the pipe. Brace the trench and/or dewater the trench if necessary so that the workmen may work safely and efficiently. Comply with all applicable laws, ordinances, rules, regulations and orders of any public body having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss. Comply with the requirements of Section 02400-J - Trench Safety System.

2. The use of trench digging machinery is approved except in places where operations of same will cause damage to existing structures above or below ground, in which case employ hand methods. Pavement shall be cut with a saw, wheel, or pneumatic chisel along straight lines before excavating.

3. It is intended that the line be laid to the depth of cover shown on the Drawings. The minimum depth of cover shall be maintained at all locations unless shown otherwise. The approximate ground profile and the top of pipe profile show the relationship intended by the Engineer. The precise and detailed pipe layout is to be prepared by the Contractor and submitted to the Engineer for review. The responsibility for the workability of the detailed layout remains the responsibility of the Contractor.

4. Where unforeseen existing utilities or other conditions warrant a revision of the pipe grade or alignment, the Contractor shall submit a revised pipe layout to the Engineer for review. No intermediate high or low points will be allowed in the pipe grade without the approval of the Engineer.
B. Dewatering

1. Groundwater is anticipated to be encountered during the course of excavation and pipe installation. Refer to the Geotechnical Investigation for a summary of observed conditions and recommendations.

2. Perform dewatering in accordance with the approved Dewatering Plan and associated approved submittals. Keep the Owner’s Project team (OPT) advised of any changes made to accommodate field conditions.

3. Before dewatering is started, obtain all permits necessary for temporary construction dewatering and for the disposal of dewatering effluent. Comply with all applicable sampling, testing, monitoring, and reporting requirements.

4. Dewater excavations to provide a stable base for construction, preserve the strength of the foundation soil and to stabilize the excavation.

5. Dewatering should occur in advance of excavation by pump and sump arrangement, wells, well points, or other suitable dewatering means. Sufficient number and capacity of dewatering means shall be provided to ensure that once an excavation is made dry, the water is maintained below the excavation until that part of the Work under construction is completed. Dewatering means shall be subsidiary to the open cut pipe payment item.

6. Dewatering means that result in boils, loss of fines, softening of the subgrade, or excavation instability shall be ceased and replaced with means that do not result in these issues.
   a. If necessary, use coarse gravel instead of embedment material under the pipe to provide for the free drainage and flow of water in the pipe trench, where it is necessary, in order to keep the water level below the pipe barrel and bell holes for joints. Geotextile filter fabric shall be placed in the trench prior to placement of the crushed stone as a separation layer between the crushed stone foundation material and the in-situ soil. No additional compensation will be made for crushed stone and geotextile filter fabric for water drainage.

7. Dispose of Water in accordance with Section 02402-J - Care of Water During Construction. The water removed from trenches shall be conducted to natural drainage ways, drains, or storm sewers in such a manner as to prevent damage to adjacent property or to the public.

C. Pipe Trench

1. The “pipe zone” shall be defined as the zone from the bottom of the pipe trench to 3 inches above the top of the pipe.

2. The trench walls in the pipe zone shall be vertical. The trench width shall not be less than the pipe outside diameter plus 24-inches so that sufficient access is provided on each side of the pipe for bedding and backfill consolidation. Sufficient width shall also be provided for any necessary trench safety equipment. The maximum allowable trench width is shown on the trench detail. Should the actual trench width at the top of pipe exceed the maximum allowed, approved bedding and backfill materials and other measures to increase the pipe support to resist the resulting additional external load shall be provided at the contractor’s expense.

3. Trench walls above the pipe zone may be laid back or benched where room permits in accordance with OSHA requirements.

4. For flexible or semi-rigid pipe, where the character of the trench wall is loose, unstable, saturated soft clays, quicksand, or otherwise unable to provide adequate side support to maintain the required pipe deflection, the Contractor shall modify the backfill to keep the pipe within the limits of the specified pipe deflection.
   a. Contractor shall widen the trench excavation as necessary.
   b. Pipe shall be laid and trench backfilled with crushed stone to the top of the pipe zone. Crushed stone shall be compacted to 95% maximum density as measured by ASTM D698. Geotextile filter fabric shall be placed in the trench prior to placement of the
crushed stone as a separation layer between the crushed stone foundation material and the in-situ soil.

c. Contractor shall protect exterior pipe coating, and shall repair any damage caused by backfilling.

d. Concrete encasement, flowable fill, or some other method approved by the Engineer may be used in lieu of this procedure.

e. No additional compensation will be made for additional trench excavation, crushed stone, geotextile filter fabric, concrete encasement, flowable fill, etc., for stabilizing the trench walls.

D. Pipe Foundation

1. Excavate the trench to an even grade so that the full length of the pipe barrel is supported and joints match up properly. Excavate the trench to the line and grade indicated and as directed by the OPT. Grades shall be uniform between high points and low points to eliminate intermediate highs and lows.

2. The trench shall be rough-cut to a minimum of 4 inches below the bottom of the pipe. The rough-cut dimension shall be increased as necessary to provide a minimum clearance of 2 inches from the bottom of the trench to the bottom of the bells, flanges, valves, fittings, etc.

3. If unstable trench conditions are encountered, the contractor shall employ appropriate remedial measures to stabilize the condition.

4. The entire foundation area in the bottom of all excavations shall be firm, stable material. Loose material shall be removed, leaving a clean, flat trench bottom, and material shall not be disturbed below required subgrade except as hereinafter described. If the subgrade is soft, spongy, or disintegrated, or where the character of the foundation materials is such that a proper foundation cannot be obtained at the elevation specified, then when directed by the Owner, the Contractor shall deepen the excavation to a depth where a satisfactory foundation can be obtained. The subgrade shall then be brought back to the required grade with crushed stone, compacted to 95% maximum density as measured by ASTM D698. Geotextile filter fabric shall be placed in the trench prior to placement of the crushed stone as a separation layer between the crushed stone foundation material and the in-situ soil. No additional compensation will be made for crushed stone and geotextile filter fabric for pipe foundation.

E. Correcting Faulty Grade

1. If the trench is excavated to a faulty grade (at a lower elevation than indicated), correct the faulty grade as specified below:
   a. In uniform, stable dry soils, correct the faulty grade with granular embedment material thoroughly compacted to 95% maximum density measured in accordance with ASTM D698.
   b. In soft, spongy, disintegrated soils or where necessary to allow proper drainage, correct the faulty grade with crushed stone compacted to 95% maximum density as measured by ASTM D698. Geotextile filter fabric shall be placed in the trench prior to placement of the crushed stone as a separation layer between the crushed stone foundation material and the in-situ soil. No additional compensation will be made for crushed stone and geotextile filter fabric for correction of faulty grade.

F. Pipe Clearance in Rock

1. Remove ledge rock, rock fragments, or unyielding shale or marl to provide a clearance of at least 6 inches below the pipe, fittings, and valves. Provide adequate clearance for properly jointing pipe laid in rock trenches at bell holes. Refill the excavation to grade with granular embedment material.

G. Blasting Procedure

1. Blasting shall not be allowed.
H. Bell Holes
   1. Bell holes of ample dimension shall be dug in trenches at each joint of pipe to permit the jointing to be made properly, visually inspected, and so that the pipe will rest on the full length of the barrel.
   2. Pipe with field-applied exterior coatings shall have the joints excavated to sufficient depth to allow proper cleaning, application, testing, and inspection of the field-applied coating system.

I. Care of Surface Material for Reuse
   1. Surface materials such as topsoil in its natural state, suitable for reuse in restoring the excavated surface, shall be kept separate from the general excavation material. The top 12 inches of the trench backfill shall be considered topsoil. Save the topsoil to be used as backfill of the top 12 inches of the trench after pipe laying.

J. Manner of Piling Excavated Material
   1. Place excavated material so that Work is not endangered or interferes with public traffic. Do not place excavated material over buried pipelines or existing utilities unless adequate provisions are made to protect those pipelines and/or utilities. Roads and driveways must be kept open in every case. Keep drainage channels clear of obstructions or make other satisfactory provisions for drainage.

K. Open Trench
   1. The Owner’s representative shall have the right to limit the amount of trench that may be opened or partially opened at any time in advance of the completed line, and also the amount of trench left not backfilled.
   2. Not over 500 feet of trench in open country or pasture land shall be opened at any one time, and not more than 150 feet of trench in populated areas shall be left open unless otherwise permitted in writing by the Owner.
   3. Backfill and/or protect trenches as necessary to prevent injury to livestock, adjacent property, and the public.
   4. Trenches left open at night shall be fenced with adequate construction fencing. No trenches shall be left open at night in streets or populated areas.

3.02 BACKFILLING

A. General
   1. Backfill operations shall immediately follow pipe jointing, joint mortar application, and curing. Refer to Section 15060-J – Bar Wrapped Concrete Cylinder Pipe and Fittings.
   2. Remove any sheeting and shoring as backfilling operations progress. Incorporate methods so that a good bond is obtained between the backfill material and the undisturbed trench walls. All voids left after withdrawal of sheeting shall be immediately refilled with backfill. The Contractor shall engage a Professional Engineer licensed in the State of Texas to design the sheeting and bracing.
   3. Take the necessary precautions to protect the pipe during backfilling operations. Take care to prevent damage to the pipe or to the pipe coating, and repair any damaged pipe before it is covered up. Backfill the trench to prevent the deformation or otherwise deflection of the cylindrical shape of the pipe by more than the allowable pipe deflection as specified elsewhere. Use methods such as stulling or ellipsing as necessary.
   4. The backfilled grade at the top of the trench shall match that existing prior to construction, except where otherwise noted on the Drawings.

B. Backfill Procedure
   1. Place the first lift of granular embedment material (bedding layer) to a depth slightly above the bottom of pipe grade and do not compact. Lay pipe on this material to the
indicated grade. Provide bell holes to permit the pipe to rest on the full length of the barrel and to permit joint make-up.

2. Place subsequent lifts of granular embedment uniformly on both sides of the pipe to the top of the pipe zone. Compact using vibration or mechanical tamping to a minimum of 95% maximum density in accordance with ASTM D698 in lifts not exceeding 6-inch loose depth. Test embedment compaction per ASTM D1556 and ASTM D6938. Materials failing to meet the specified density shall be reworked as necessary to obtain the specified compaction. The Contractor shall take precautions to ensure no voids occur under the haunches of the pipe and to prevent disturbance of the pipe alignment.

3. Place and compact the backfill material above the pipe zone as shown on the Drawings. Mechanical compaction may be utilized above the pipe zone. The Contractor shall be responsible for any damage that may occur to the pipe using this alternative method of compaction.
   a. Place and compact native backfill material to a minimum of 97% maximum density in accordance with ASTM D4253 in lifts not exceeding 6-inch loose depth. Test embedment compaction per ASTM D1556 and ASTM D6938. Materials failing to meet the specified density shall be reworked as necessary to obtain the specified compaction.

C. Flowable Fill Placement

1. Flowable fill may be used in lieu of the specified embedment and/or backfill material in the following conditions if approved by the OPT:
   a. Congested areas where compaction is difficult to achieve.
   b. Areas beneath present or future structures, pavements, and similar facilities sensitive to expansive soil movements.
   c. Locations in which the use of a free draining granular material for embedment and/or backfill may cause the backfilled trench to become a French drain which might allow intrusion of surface or subsurface water beneath structures, pavements or similar facilities.
   d. Locations in which the groundwater level is above the proposed pipe invert elevation.
   e. Other locations where indicated on the Drawings or as directed by the OPT.

2. The Contractor shall give the OPT sufficient advance notice prior to placing material in any area to permit inspection of the area and to prepare for pouring.

3. Pre-job testing with actual equipment and intended configuration of the material sample may be required by the Owner to determine whether the material can be excavated. The testing equipment and configuration of the material shall be determined by the OPT.

4. All material shall be separately and accurately measured. The methods of measurement of materials shall be such that the proportions of water to cement can be closely controlled during the progress of the Work and easily checked at any time by the Owner's representative.

5. In the determination of the amount of water required for mix, consideration shall be given to the moisture content of the aggregate. The net amount of water in the mix will be the amount added at the mixer; plus the free water in the aggregate; and minus the absorption of the aggregate, based on a 30-minute absorption period. No water allowance shall be made for evaporation after batching.

6. When additive is contained in the mix, the additive ingredients, proportions, and placement shall be per the additive manufacturer's recommendations.

7. Maintain slump during placement at all times within ± 1 inch of that of the mixture design, as determined in accordance with ASTM C143 with the following exceptions:
   a. Do not rod the material.
   b. Place material in slump cone in one semi-continuous filling operation, slightly overfill, tap lightly, strike off, and then measure and record slump.
8. Flowable fill shall be placed against undisturbed trench walls and brought up uniformly to the elevation shown on the Drawings or directed by the OPT. Conduct the operation of depositing and compacting the material so as to form a compact, dense, impervious mass. The Contractor shall take appropriate measures to prevent pipe flotation during placement of flowable fill, including placement in lifts if necessary. Material shall be allowed to harden before placing next lift.

9. Flowable fill shall not be placed when the temperature is less than 40 °F.

10. Flowable fill shall be allowed to set before placing any overlying material and shall be protected from traffic for a minimum of 72 hours.

11. No additional compensation will be made for flowable fill used in lieu of the specified embedment and/or backfill.

D. Surface Material Replacement

1. In non-roadway areas, the top 12 inches of the trench backfill shall be composed of the original surface material or topsoil excavated from the trench. Place the topsoil over the consolidated trench backfill material and neatly round over the trench to a sufficient height to allow settlement to grade after consolidation. Grade the surface to allow drainage in the same manner as existing prior to construction.

2. Topsoil shall not contain rocks or clods larger than those adjacent to the trench in the undisturbed condition.

3.03 INSPECTION AND TESTING

A. Testing Laboratory

1. The Owner will provide the services of an independent recognized testing laboratory capable of performing a full range of testing procedures complying with the standards or testing procedures specified. The testing lab shall provide certified technicians that are trained and knowledgeable in in-trench nuclear density testing, sand cone, concrete sampling and testing, and ASTM D698 and D1557 proctors at a minimum.

B. Testing Frequency

1. Take a minimum of three in-trench/pipe zone nuclear density tests every 150 linear feet of installed pipe in populated areas and every 250 linear feet of installed pipe in unpopulated areas, pasture land, or cultivated fields. If less than 150 linear feet of pipe is installed in one day, a minimum number of three tests per day shall be performed.

2. Take a minimum of three nuclear density tests above the pipe zone for every 150 linear feet of installed pipe in populated areas and every 250 linear feet in unpopulated areas, pasture land, or cultivated fields. If less than 150 linear feet of pipe is installed in one day, a minimum number of three tests per day shall be performed.

3. Take a minimum of three in-trench/pipe zone nuclear density tests and a minimum of three above pipe zone nuclear density tests at all open cut road crossings.

4. Field record drawings shall be updated with test locations in the profile.

C. The Contractor shall accommodate Owner personnel during sample collection and testing.

D. The Contractor shall fully repair and rectify deficiencies found during testing.

3.04 MAINTENANCE OF SURFACES

A. Rock and Organic Material

1. Rock and organic material removed from the trench excavated material shall be removed from the right-of-way at the Contractor’s expense.
B. Deficiency of Backfill
   1. Any deficiency in the quantity of material for backfilling the trenches, or for filling depressions caused by settlement, shall be supplied by the Contractor at his expense. Make-up material shall be approved by the OPT.

C. Restoration of Surfaces
   1. Replace surface material and restore paving, shrubbery, fences, grass or turf, and other surfaces disturbed to a condition equal to that before the Work began.
   2. Provide seeding or sod as directed in the Contract Documents or by the OPT, in accordance with the Contract Documents.
   3. Restore public and private roadway paving and aggregate surfacing in accordance with the Contract Documents.

3.05 CLEAN-UP
   A. Remove surplus pipeline materials, tools, rubbish, and temporary structures, and leave the construction site clean, to the satisfaction of the OPT. Grade the surface, and reestablish drainage. Removal of rock and other excess excavated material and general leveling and grading of the right-of-way surface to a presentable appearance shall proceed so as to not be further than 2,500 linear feet behind the backfilling operations. The Contractor shall be responsible for location of sites for disposal of excess material and the Owner shall make no additional payment for expenses incurred in such disposal.

3.06 MEASUREMENT AND PAYMENT
   A. The work included in this Section shall be considered subsidiary to the contract unit price for construction of pipe to the lines, grades and extents indicated on the Drawings

END OF SECTION
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DEWATERING OF SHAFTS, TUNNELS AND PORTAL EXCAVATIONS

1.00 GENERAL

1.01 WORK INCLUDED

A. This Section is a specification for portal excavations and excavations for pits and shafts for shallow cased or lined tunnels for crossing highways, roads, railroads, creeks, and utilities only and includes materials, installation, maintenance, operation, and removal of temporary dewatering systems for the control and disposal of surface and ground waters. Perform site dewatering necessary to lower and control groundwater levels and hydrostatic pressures to allow excavation and construction to be performed properly under dry conditions or for sump and pump arrangements at the bottom of deep excavations for nuisance seepage in the soil or bedrock formations or at the seal between alluvium and bedrock.

B. Dewatering operations shall be adequate to ensure the integrity of the finished project. The responsibility for conducting the dewatering operation in a manner which will protect adjacent structures and facilities rests solely with the Contractor. The cost of repairing any damage to adjacent structures and restoration of facilities shall be the responsibility of the Contractor.

C. Measurement and Payment

1. Except where specified elsewhere in the Contract Documents, the work included in this Section shall be considered subsidiary to the contract unit price for installation of steel encasement.

1.02 DEFINITIONS

A. Owner: City of Irving

B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants

C. Owner’s Project Team (OPT): Representatives of the Engineer and Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

1.03 RELATED SECTIONS

A. The following Sections apply to the Work of this Section. Other Sections not referenced below shall also apply to the extent required for proper performance of this Work.


2. Section 02303-J Steel Jacked Casing, Steel Liner Plate and Expandable Liner by Tunneling.

1.04 DOCUMENTATION

A. Submittals shall be in accordance with TxDOT Specifications and shall include:

1. A detailed Dewatering Plan, schedule, and description of the dewatering of excavations. The Dewatering Plan shall include: the proposed type of dewatering system; the arrangement, location, and depths of system components; a complete description of the equipment and instrumentation to be used, with installation, operation and maintenance procedures; a description of the Contractor’s means and methods for measuring groundwater levels and piezometric water levels; and the methods for disposal of dewatering effluent and associated discharge permits. If a well
point system is to be used for dewatering, the dewatering plan submittal shall be signed and sealed by an engineer licensed in the State of Texas.

2. Copies of well installation permits.

3. Well decommissioning reports, as applicable.

4. Daily reports that includes the following information:
   a. Groundwater levels and piezometric water levels during the period the dewatering system is in operation.
   b. Changes in elevation of reference points to detect settlement in adjacent structures.
   c. The average dewatering flow rate.
   d. Water quality testing results as required by regulatory agencies and specified in discharge permits.

1.05 QUALITY ASSURANCE

A. Conduct a demonstration of proposed system and provide verification that adequate personnel, materials, and equipment are available.

B. Maintain adequate control to ensure that the stability of excavated and constructed slopes is not adversely affected by water, that erosion is controlled, and that flooding of excavations or damage to structures does not occur.

C. Where critical structures or facilities exist immediately adjacent to areas of proposed dewatering, establish reference points and shall observe the reference points at frequent intervals to detect any settlement which may occur.

1.06 SUBSURFACE CONDITIONS

A. Subsurface conditions have been investigated and documented in *Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1)* prepared by HVJ Associates (Geotechnical Investigation)

B. If necessary for the complete design and safe installation of necessary dewatering means, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

2.00 PRODUCTS

2.01 MATERIALS

A. Furnish all materials, tools, equipment, and facilities required for the necessary dewatering, including well points, deep wells, sump pumps, temporary pipelines for water disposal, rock or gravel placement, observation wells, and other means including standby pumping equipment maintained on the jobsite continuously.

B. Provide piezometers for monitoring groundwater levels along with other instruments and measuring devices as required.

3.00 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Groundwater is anticipated to be encountered during the course of excavation and pipe
installation. Refer to the Geotechnical Investigation for a summary of observed conditions and recommendations.

B. Perform dewatering in accordance with the approved Dewatering Plan and associated approved submittals. Keep the Owner’s Project team (OPT) advised of any changes made to accommodate field conditions.

C. Before dewatering is started, obtain all permits necessary for temporary construction dewatering and for the disposal of dewatering effluent. Comply with all applicable sampling, testing, monitoring, and reporting requirements.

D. Organize dewatering operations to lower the groundwater level in tunnel and shaft/portal excavations as required for prosecution of the Work, and to provide a stable, dry subgrade for the prosecution of construction operations. Maintain an adequate system to lower and control the groundwater to permit excavation, construction of structures, and placement of fill materials to be performed under dry conditions.

E. Dewatering equipment shall be installed to pre-drain water-bearing strata below the bottom of excavations and adjacent to tunnel openings. Dewatering systems shall be placed into operation before excavation below groundwater level is started. Dewatering shall be conducted to preserve the undisturbed bearing capacity of the subgrade soils at proposed bottom of excavation. Dewatering systems shall be operated continuously, 24 hours per day, 7 days per week, until construction is completed, concrete has achieved its required strength, backfill has been placed to a sufficient height to anchor the work against possible flotation, and dewatering is no longer required. Maintain the water level such that no danger to structures can occur because of buildup of excessive hydrostatic pressure. Remove systems upon completion of construction or when dewatering and control of surface or ground water is no longer required.

1. Maintain the water level a minimum of 2 feet below the subgrade and 5 feet below tunnel shaft bottom, unless otherwise permitted by the Engineer.

2. Maintain groundwater level a minimum of 5 feet below the prevailing level of backfill being placed.

3. Maintain water level below the tip elevation of all watertight ground support systems; i.e., sheet piling or soldier piles and sheeting, etc.

4. Provide a standby generator, fuel supply and pumps as required to assure 24/7 operations of the dewatering system. All fuel shall be stored in accordance with applicable laws and permits.

F. If foundation soils are disturbed or loosened by the upward seepage of water or an uncontrolled flow of water, the affected areas shall be excavated and replaced with drain rock at no additional cost to the Owner.

G. Modify dewatering procedures which cause, or threaten to cause, damage to new or existing facilities, so as to prevent further damage. The Contractor shall install settlement gauges, as necessary, to monitor settlement of critical structures or facilities adjacent to areas of dewatering. Control the rate of dewatering to avoid all objectionable settlement and subsidence.

H. The Work site shall be graded to facilitate drainage and runoff shall be diverted from the excavation. Surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to sumps, and pumped or drained by gravity away from the excavation.

I. If well points or wells are used, they shall be adequately spaced to provide the necessary dewatering and shall be sandpacked and/or other means shall be used to prevent pumping of fine sands or silts from the subsurface. A continuous check shall be maintained to ensure that the subsurface soil is not being removed by the dewatering operation.
J. The release of groundwater to its original level shall be performed in a manner that avoids disturbance of natural foundation soils, prevents disturbance of compacted backfill, and prevents flotation or movement of structures and pipelines.

K. Dispose of water in accordance with Section 02402-J – Care of Water During Construction.

END OF SECTION
02302-J EXCAVATION SUPPORT SYSTEMS FOR PORTALS AND SHAFTS

1.00 GENERAL

1.01 WORK INCLUDED

A. This Section specifies support of temporary open excavations by means of sheet pilings, soldier piles and lagging, structural steel wales and struts, tiebacks, and timber. In general, this Section applies to temporary support systems for portal excavations, and excavations for pits and shafts for short tunnels for crossing highways, roads, railroads, creeks, and utilities. The Contractor shall be responsible for the design and selection of methods in conformance with the design criteria specified herein and shown on the Drawings.

B. The Work of this Section applies to temporary excavation support systems for construction of jacking and receiving pits, and construction of portal headwalls and portal ramps.

C. Measurement and Payment

1. Except where specified elsewhere in the Contract Documents, the work included in this Section shall be considered subsidiary to the contract unit price for installation of steel encasement.

1.02 DEFINITIONS

A. Owner: City of Irving

B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants

C. Owner’s Project Team (OPT): Representatives of the Engineer and Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

1.03 RELATED SECTIONS

A. The following Sections apply to the Work of this Section. Other Sections not referenced below shall also apply to the extent required for proper performance of this Work.


2. Section 02303-J – Steel Jacked Casing, Steel Liner Plate and Expandable Liner by Tunneling.

3. Section 02400-J – Trench Safety Systems

4. Section 02402-J – Care of Water During Construction

1.04 REFERENCE CODE AND STANDARDS

A. The applicable provisions of the following standards and codes shall apply as if written here in their entirety:

ASTM A36  Structural Steel
ASTM A328  Steel Sheet Piling
ASTM A722  Standard Specification for Uncoated High-Strength Steel Bars for Prestressing Concrete
ASTM A615  Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
1.05 DOCUMENTATION

A. Submittals shall be in accordance with TxDOT Specifications and shall include:

1. The proposed excavation support system for each construction component (i.e. shaft or portal) where excavation support systems will be used. Include the following:
   a. Location of shafts by station and limits of working sites.
   b. Any geotechnical/boring undertaken by Contractor for whatever purpose connected to work.

2. Arrangement and details for each excavation support system, supporting design calculations, and construction methods to be used for the installation of each system. Clearly indicate allowable surcharge loads and restrictions on surcharge capacity, including live loads, on shaft construction drawings. Indicate thrust blocks or other reactions required for pipe jacking, when applicable.

3. Soldier pile installation methods, connection details, bracing preloading, and jacking procedures.

4. Depths below the main excavation bottom elevation to which the support system will be installed.

5. Elevations of ground surface and description of method of extending shaft above flood level, struts, and shores, as applicable.

6. Permissible depth to which excavation may be carried before supports must be installed and preloaded.

7. Full excavation depth load to be carried by various support system members.


9. Preloads as required.

10. Proposed sequence of strut and shore removal as applicable and as related to concrete placement and backfilling operations.

B. Submittals shall be coordinated with Work specified elsewhere in which support of excavation is required.

C. The proposed method of installing excavation support system shall include a description of the sequence of installation, template, and equipment to be used.

D. Contingency plans shall be submitted for alternative procedures to be implemented if the excavation support system is found to perform unfavorably.

1.06 QUALITY ASSURANCE
A. Supports for excavation shall be designed, signed and sealed by a Professional Engineer who is licensed to practice in the State of Texas and is experienced in the design of excavation support systems. Submittals and calculations shall be signed and sealed, and all design drawings and calculations shall be checked and initialed by a checker.

B. A competent person, trained and experienced in the use of shoring, trench shields, trenching and excavation procedures and soil identification shall direct and control the work. The competent person shall monitor all shoring, trenching and excavation operations, soil conditions and ground water conditions and remove all personnel immediately at any reasonable sign of distress. Shaft construction shall apply with local, state, and federal safety standards as applicable, including, OSHA Regulations: 29 CFR 1926, Subpart P – Excavation, Trenching, and Shoring [1926.652(c)(4)].

1.07 DESIGN CRITERIA

A. Excavation support systems shall be designed in accordance with the following criteria. Reference Geotechnical Investigation for soil profile and to obtain lateral loads required for shoring design:

1. Excavation support system and all components shall be designed to support the earth pressures, unrelieved hydrostatic pressures, utility loads, equipment, traffic, and construction loads including impact, and other surcharge loads in such manner that allows safe and expeditious construction of permanent structures, minimizes ground movement or settlement, and prevents damage to or movement of adjacent buildings, structures, roadways, and utilities.
   a. If necessary, design shaft cover for minimum 25 pounds per square foot distributed load plus 300 pound point load.
   b. Design to allow for HS-20 highway loading if located in the vicinity of paved area. Design steel plate deck, if such is required, for HS-20 loading.

2. Support members shall be designed to resist the maximum loads expected to occur during excavation and during the removal of supports.

3. Designs for staged removal shall conform to construction concrete placement and backfill sequence shown on the Drawings. Designs shall consider provisions for future construction, and limits on bracing level elevations as shown on the plans.

4. Where water flows from the face of excavation, the maximum height of unsupported excavation shall not exceed 15 inches.

5. In running sand and silt, a positive means for securing timber lagging to the soldier piles shall be provided to avoid shifting or falling off of the lagging, and a positive means for containing such material behind the lagging shall be provided.

6. Vertical support capacity shall be provided for wall systems and internal bracing elements, for loads due to vertical force components of tieback anchors, the weight of the structural systems themselves, and live load on any portion of the system.

7. Design shaft located within 100-year flood plain with water retaining liner extending 2 feet above 100-year flood elevation.

B. Steel Components: Design and fabricate steel components to meet the requirements of reference and codes cited in this Specification.

C. Timber Support Systems and Members: IBC Chapter 23, Wood, shall be used as the basis for determination of minimum allowable working stress. The minimum thickness of timber lagging between soldier piles spaced 5 to 7 feet center-to-center shall be 3 inches for excavations up to 25 feet in depth, and 4 inches for excavations deeper than 25 feet. For other conditions and types of lagging, design calculations shall be submitted.
1.08 PROJECT CONDITIONS

A. Utility agencies shall be notified and caution exercised while exposing utility facilities by hand or other methods approved by utility owner.

B. If existing utility facilities interfere with the proposed method of support, the method shall be modified in a manner that will protect the facility and accommodate the proposed Work. Submittals shall be revised and resubmitted along with design calculations required to account for the modified support method and to show the actual location of the existing utilities. Alternatively, the utility facility can be relocated as approved.

C. Provisions shall be made for contingencies as follows:
   1. The threshold warning and stop movement levels shall be provided by the Contractor's Engineer for temporary support systems as accepted by the Engineer.
   2. Monitor performance of support system components, for both vertical and horizontal movement.
   3. Provide contingency plan for alternative procedures to be implemented if unfavorable performance is evidenced.
   4. Keep on hand materials and equipment necessary to implement contingency plan.

D. Elements of the support system shall not be spliced except as detailed in an approved Submittal.

E. A dewatering system shall be provided, at locations where groundwater seepage is present, prior to excavation and until a steady state condition at least 5 feet below the proposed excavation bottom is achieved. The dewatering process shall continue until the excavation is backfilled. Water control measures shall be provided in accordance with the requirements specified in Section 02301-J Dewatering of Shafts, Tunnels and Portal Excavations.

1.09 SUBSURFACE CONDITIONS

A. Subsurface conditions have been investigated and documented in Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1) prepared by HVJ Associates (Geotechnical Investigation)

B. If necessary for the complete design and safe installation of excavation support systems, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

2.00 PRODUCTS

2.01 MATERIALS

A. Steel Sheet Piling: Steel sheet piling shall be continuous interlocking type ASTM A328 of appropriate shape and provided with at least one 2½-inch diameter handling hole on the centerline of the web located at least 6 inches from each end of the sheet pile.

B. Fabricated Connections: Fabricated connections and accessories, steel H-piles, WF shapes, and other structural steel shall conform to the requirements of ASTM A36, unless otherwise approved.

C. Concrete: For encasement of steel soldier piles below the final level of excavation, Class E Concrete shall be used with the exception of the 28-day minimum compressive
strength shall be increased to 2,500 psi. For encasement of soldier piles above the final level of excavation, Class E concrete shall be used.

D. Wood Lagging: Wood lagging shall be dimension lumber with minimum allowable stress of 1,100 psi. The stress grade of the lagging shall be in conformance with the allowable stresses of the UBC, Chapter 25. Lumber shall be grade marked by WWPA or WCLIB with species and grade conforming with those shown on approved submittals.

E. Tiebacks: Dywidag Bars or equivalent hot rolled and proof stressed alloy steel conforming to ASTM A722, Type II, deformed bars that produce a continuous thread pattern conforming to ASTM A615.

F. Steel Liner Plate: Steel liner plate shall be fabricated from one piece of metal and be flanged on 2 or 4 sides conforming to ASTM A1011, with minimum tensile strength of 42 ksi, minimum yield strength of 28 ksi, and elongation in 2 inches of 30% minimum.

3.00 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Ground support system shall:

1. Initial support elements, bracing and shoring structural members shall be installed at the locations and in the method, sequence and tolerances defined in this specification and on shaft construction drawings as the excavation progresses. A watertight impermeable barrier shall extend 42 inches above the surface for all shafts.

2. The support system shall extend the main excavation bottom elevation to a depth adequate to prevent lateral movement and to adequately support applied vertical loads. In areas where additional excavation is required below the main excavation subgrade provisions shall be made to prevent movement of main excavation supports. Damage to existing utilities during installation of excavation support system shall be avoided.

3. Install liner elements, bracing and shoring structural members at locations and in method sequence and tolerances defined on shaft construction drawings as excavation progresses. Shoring must always be used or installed in a manner that loose or falling soil cannot enter the excavation. Use end plates or shoring as required. Exposed surfaces of the shoring materials on the interior of the shaft shall be cleaned of loose debris as placement progresses, to minimize risk of worker injury from falling debris. Excavated material shall be stockpiled at least 15 feet away from the edge of the excavation.

4. Install supports as soon as possible after excavation and as close to the excavation face as work will permit.

5. Ensure bracing and shoring are in contact with casing or liner to provide full support as shown in shaft construction drawings. Evaluate and check modifications to bracing and shoring. Obtain approval from Contractor’s Engineer and submit to Owner.

6. Install seal slab as soon as final depth and stable bottom conditions have been reached and accepted by Owner. Construct seal slab capable of withstanding full piezometric pressure, either by pressure relief using under drains, or in case of more permeable ground condition, by use of structural reinforced slab. Construct seal slab in accordance with design provided by Contractor’s Engineer.

7. Special framing, bracing or shoring required around tunnel “eyes” or other penetrations shall be in-place according to shaft construction drawings before liner or any bracing or shoring at penetration is cut or removed.

8. Securely breast and shore face of starter or back tunnels to resist both soil and hydrostatic pressure.
9. When applicable, pressure grout voids or seepage paths around shafts and adjoining tunnels with 300 psi minimum grout or 350 psi minimum impervious cellular concrete. Pressure grout behind bolted steel liner plates as they are installed, unless otherwise approved by Owner. Perform secondary or ‘back grouting’ as ground measurement, voids or deformation of shaft liner are detected.

B. Install suitable thrust or reaction blocks as required for pipe jacking equipment.

C. Use appropriate dewatering techniques to maintain a stable working area. Water shall not be allowed to accumulate enough to require the use of a safety harness or lifeline. Provide drainage from shafts while work is in progress and until adjacent pipe joints have been sealed and shaft is backfilled.

D. Surface Water Control. Divert surface water runoff and discharge from dewatering system away from shaft. Protect shafts from infiltration or flooding.

E. Each surface work site is to be adequately and safely secured any time site is unattended by Contractor’s personnel.

F. Provide portable concrete traffic barriers at locations where work site is situated adjacent to highway, road, driveway, or parking lot. Angle traffic barriers in direction of lane flow. Do not place perpendicular to on-coming traffic.

G. Construct suitable guardrail barrier and warning system around periphery of shaft, meeting applicable safety standards. Properly maintain barrier throughout period shaft remains open. Repair broken boards, supports, and structural members. Provide ladder with safety cage, when required by OSHA, in each shaft.

H. Size of Shafts: Make size adequate for construction of permanent structures indicated on Drawings and to provide adequate room to meet operational requirements for tunnel construction and backfill.

3.02 SOLDIER PILES

A. Soldier piles shall be installed by pre-boring or other approved pre-excavation methods to tip elevation. Prevent pre-bored or other pre-excavated holes from collapsing.

B. Pre-bored hole shall be filled with lean concrete (2,500 psi) from bottom of hole to subgrade. A lesser strength concrete may be proposed dependent upon analysis of vertical support requirements prepared by the Contractor’s designer.

C. Remaining pile length shall be filled with lean concrete, completely encasing the pile.

D. Concrete shall be placed from the bottom of the hole upwards by means of a tremie pipe connected to a hopper.

3.03 LAGGING

A. Lagging shall be installed with no gap between the boards unless specifically approved. As installation progresses, the voids between the excavation face and the lagging or sheeting shall be backfilled with sand or soil rammed into place. Materials such as hay (excelsior) or burlap shall be used where necessary to allow drainage of groundwater without loss of soil or packing material. If gaps in the lagging are allowed, the gap width between lagging boards shall be limited to 1/2 inch maximum.

B. If unstable material is encountered, suitable measures shall be taken to retain it in place or to otherwise prevent soil displacement.

C. Extend lagging down to final subgrade.

D. A sufficient quantity of material shall be on hand for sheeting, shoring, bracing, and other operations for protection of work and for use in case of accident or emergency.
3.04 STEEL LINER PLATE

A. Fabricate uniform plates and those intended for one size shaft shall be interchangeable. Joints shall not allow inflow of ground where such conditions may exist.

B. Liner plate shall be fabricated to allow grouting and back grouting between liner plate and excavation face.

C. Bolts and nuts shall be quick acting coarse thread of material conforming to ASTM A449 with a minimum 5/8-inch diameter and length as required by the liner plate manufacturer.

D. Liner plate thickness tolerances shall conform to AASHTO specifications for Highway Bridges or comparable AREMA Manual for Railway Engineering.

3.05 STEEL SHEET PILING

A. Steel sheet piling may be used only where existing subsurface conditions are suitable for installation of sheet piling to the full depth of penetration required, and to proper alignment and plumbness, specified herein, without damage to the sheet piling or rupture of its interlocks. The use of steel sheet piling will not be permitted where sheeting would be required to penetrate boulders, rock or other materials which may prevent the proper installation of sheet piling.

B. Steel sheet piling shall be installed in plumb position with each pile interlocked with adjoining piles for its entire length so as to form a continuous diaphragm throughout the length of each run of wall, bearing tightly against original ground. Install sheeting to depth required for design. Exercise care during installation so that interlocking members can be extracted, if required, without injury to adjacent ground. The installation equipment shall be suitable to the type and nature of the subsurface materials anticipated to be encountered. The equipment, and methods of installation, cutting, and splicing shall conform to the approved submittals.

3.06 INTERNAL BRACING SUPPORT SYSTEM

A. All bracing support members shall be installed and maintained in tight contact with each other and with the surface being supported.

B. Bracing members shall be preloaded by jacking the struts and shores in accordance with loads, methods, procedures, and sequence as described on the approved submittals. Coordinate excavation work with bracing installation and preloading. Use steel shims and steel wedges welded or bolted in place to maintain the preloading force in the bracing after release of the jacking equipment pressure. Use procedures so as to produce uniform bracing member loading without appreciable eccentricities, over stressing, or support member distortion.

C. Struts shall be provided with intermediate bracing as needed to enable them to carry their maximum design load without distortion or buckling. Provide diagonal bracing as necessary to maintain the stability of the system. Web stiffeners, plates, or angles shall be provided as needed to prevent rotation, crippling, or buckling of connectors at points of bearing between structural steel members. Allow for eccentricities resulting from field fabrication and assembly.

D. Excavations shall be to a depth no more than 2 feet below the elevation of the support member about to be placed. The support member shall be installed and preloaded immediately after installation and prior to continuing excavation.

3.07 TIEBACKS
A. All tiebacks shall be installed with hardware and in a manner approved by the Manufacturer and the Engineer and as shown on the Drawings.

B. No tiebacks will be allowed to project outside the Limits of Construction or the Permanent Easement as shown in the Drawings.

3.08 REMOVAL OF SUPPORT SYSTEMS

A. Where removal is required wholly or in part, such removal shall be performed in a manner that will not disturb or damage adjacent new or existing construction or utilities. Fill all voids immediately with lean concrete, or other approved means.

B. All elements of support systems shall be removed to a minimum depth of 6 feet below final ground surface. However, when a structure poured against the sheeting system extends above the 6-foot limit, removal of the sheeting system shall be to the top of the structure.

C. All damage to property resulting from removal shall be promptly repaired at no additional cost to the Owner. The Engineer will be the sole judge as to the extent and determination of the materials and methods for repair.

D. All tiebacks shall be distressed, prior to backfill of excavations.

3.09 BACKFILL

A. Excavations within the right-of-way and not under hardened surfacing shall be backfilled and consolidated by tamping in 6-inch (maximum thickness) horizontal layers to 95% of maximum density as measured by ASTM D698. Surplus material shall be removed from the right-of-way and the excavation finished to original grades. Backfill shafts immediately after the installation of the carrier pipe and associated appurtenances is completed.

END OF SECTION
1.00 GENERAL

1.01 WORK INCLUDED

A. This Section specifies requirements for the subsurface investigation, design, procurement, and installation of tunnel casings or liners of either steel pipe (jacked) steel liner plate or expandable liner with either wood or steel lagging using a shield or boring machine that allows access to the excavation face. Excavation is accomplished by use of a Tunnel Boring Machine (TBM), shield, excavator, roadheader, or equal, or by hand-operated excavation tools and equipment. With a steel casing, the casing is jacked from a jacking pit where the jacks are situated. With tunnel liners, the liner plates/rings are assembled behind the tunnel boring machine/shield and the TBM/Shield is jacked against the tunnel liner. Hand excavation methods may be used to install tunnel liner or casing. In either method, excavated materials are transported to the jacking pit or shaft using either a short conveyor belt or muck apron at the face that empties excavated material into muck carts at the rear of the shield that are then transported by a track-mounted locomotive, or other mechanical means.

B. The Contractor shall furnish all labor, materials, and equipment required to install the casing or liner systems to the minimum dimensions and grades shown on the Drawings. The Contractor shall be solely responsible for providing equipment suitable for this job and for performing the Work in accordance with the Specification.

C. This Section also includes requirements for the design, procurement, installation, and operation of ventilation systems as necessary to maintain acceptable air quality and environmental conditions in the work area. An adequate lighting system shall be provided.

D. The Contractor shall furnish all material and labor to install and maintain pumps, piping, drains and other facilities for the control, collection and disposal of groundwater and construction related water from inside the casing or tunnel liner systems and shaft excavations.

E. The Contractor shall furnish and install all electrical equipment required to complete the casing or tunnel liner installation construction activities both on the surface and underground at the construction sites. The Contractor shall also furnish the electrical equipment for all of the auxiliary systems which shall include but not be limited to transformers, panel boards, security lighting, grounding, power for vent fans, sump pumps, disconnect switches, voice communication equipment, office trailers, etc.

F. In the performance of the work, comply with the lawful requirements of the affected roadway departments, railway companies, public agencies, and owners of public utilities or other facilities respecting the safeguarding of traffic and improvements which might be endangered by trenchless construction. The approach trenches in public roads will not be permitted to remain open for extended periods of time.

G. Measurement and Payment

1. Boring, jacking or tunneling pipe will be measured by the linear foot of pipe, complete in place. Such measurement will be made between the ends of the pipe along the central axis as installed. The work performed and materials furnished as prescribed by this item will be paid for at the total unit price bid per linear foot for Boring, Jacking or Tunneling Pipe, of the type, size, and class specified on the plans, which price shall be full compensation for furnishing all materials, liner materials required for tunnel operations, for all preparation, hauling and installing of same, and for all labor, tools, equipment and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material. The contract total unit price shall be the total compensation for furnishing and placing all materials including encasement pipe,
concrete embedment or grout backfill, concrete, clay or brick plugs, and for all labor, equipment and materials as required to complete the installation.

1.02 DEFINITIONS

A. Owner: City of Irving
B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants
C. Owner’s Project Team (OPT): Representatives of the Engineer and Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

1.03 DESIGN CRITERIA

A. Responsibility: The Contractor shall design, test, maintain, and monitor casing and liner systems based on the minimum criteria and requirements specified herein.

B. Loading Conditions: The Contractor shall refer to Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1 prepared by HVJ Associates (Geotechnical Investigation) for a description of anticipated geotechnical conditions. If necessary for the complete design and safe installation of the casings or liners, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

C. Casing or Liner Design: The Contractor shall design the casing or tunnel liner for all expected loading conditions, including: handling, installation, equipment, and other temporary static and dynamic stresses; loads imposed by subsequent construction operations; groundwater and ground loads; live loads; ground convergence control; and other conditions of service. Casing or liner shall be designed to support the ground safely and maintain its shape without encroaching inside the limits required for final lining (carrier pipe) construction or within the tolerances indicated in Section 02304-J Installation of Carrier Pipe in Tunnel. The Contractor shall design casing or liner plates in accordance with AISC and AASHTO or AREMA provisions, as applicable, with no more than a 25 percent increase in allowable stresses for temporary loading conditions. The Contractor shall select and design the casing or liner systems, methods and details to ensure safety to the public, adjacent property, and the completed work.

D. At railroad crossings, conform to locomotive loading distributions in accordance with AREMA specifications. In design, account for additive loadings due to multiple tracks. Provide steel encasement at railroad crossings as specified or as shown on the drawings.

E. For road crossings use HS-20 vehicle loading distributions in accordance with AASHTO.

1.04 RELATED SECTIONS

A. The following Sections apply to the Work of this Section. Other Sections not referenced below shall also apply to the extent required for proper performance of this Work.
4. Section 03610-J – Annular Backfill for Carrier Pipe in Tunnels.

1.05 REFERENCE CODE AND STANDARDS

A. The Work specified is the responsibility of the Contractor, subject to the approval of the Engineer. The Contractor shall perform the Work in accordance with all current applicable regulations and codes of Federal, State, and local agencies. In the event of conflict, the
Contractor shall comply with the strictest requirements. No part of this specification shall be construed as a relaxation of any of these rules, laws, and regulations.

B. The applicable provisions of the following standards and codes shall apply as if written here in their entirety:

   b. NFPA 70, National Electrical Code.
   b. Steel Casing: The steel casing pipe shall be in accordance with ASTM A 36, Grade C, unless indicated otherwise or approved equal. The casing wall thickness shall be designed to accommodate the maximum jacking load allowed, as well as expected earth and live loads. Thickness shall be no less than shown on the Drawings. The Contractor, however, shall be fully responsible for the sufficiency of the casing provided. Casing Section joints shall be of the interlocking type or butt welded, or welded using butt or banding straps in the field.
   c. ASTM A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

1.06 DOCUMENTATION

Submittals shall be in accordance with TxDOT Specifications and shall include:

A. Tunneling Plan. Within at least two months before the scheduled start of applicable activity, the Contractor shall submit detailed description, data, or calculation of proposed facilities, equipment to be used, and method of construction including but not limited to the following:

1. A detailed description of the equipment and procedures to be employed during casing or liner installation. Provide manufacturer’s literature describing in detail the equipment and the proposed tunneling system including machine type, excavation method, dimensions, weight, power, thrust, torque, cutterhead configuration, the maximum excavated diameter produced, and the articulation and steering capabilities.
2. Shop drawings showing general jacked casing or tunneling liner operation set-up, including locations of all equipment, pit or shaft details, staging and storage areas and emergency access around the jacked casing or tunnel operation, respectively.
3. Qualifications for Staff and Safety Officer, and welding certifications for welders employed for the Work.
5. Detailed Work plan for casings with sequence of excavation and support installation including number, location, direction, and timing of all casings.
6. Additional or supplementary geotechnical report, if necessary, signed and sealed by a qualified Engineer Registered in the State of Texas.
7. Material list including diameter, thickness, and class of casing.
8. Submit for review shop drawings, design criteria and design calculations established by Contractor’s Engineer for primary liner, including installation details, and certification by qualified Engineer Registered in the State of Texas that structural design of tunnel liner meets criteria and specified requirements for range of field conditions. Calculations shall include estimates of likely deflections or deformations of the supports and maximum tolerable values.
9. Detailed locations and sizes of all tunnel boring or jacking and receiving pits.
10. All permits associated with the tunnel boring or jacking operations.
11. Jacking lubrication materials and proportions of each ingredient.
12. Ventilation, lighting, communications, and draining systems plans.
13. Methods of controlling line and grade, and survey protocols.
14. Obstruction Removal Plan
15. Detailed list and description of all other equipment to be used.
16. Safety plan including an accident prevention program, a code of safe practices and an emergency plan. Safety Plan shall be prepared in accordance with all OSHA rules and regulations.
17. Submit surface settlement contingency plan outlining actions taken when threshold and limiting settlement values occur.

B. Ventilation Plan: Within at least two months before the scheduled start of applicable activity, the Contractor shall submit details of the ventilation fans and ducting and calculations showing that ventilation volumes meet the requirements specified herein or the requirements of 29 CFR 1926, whichever is greater. The calculations shall demonstrate that all rules, laws, and regulations are followed and that specification requirements will be met. The calculations shall include consideration of all effects and conditions indicated in the GDR, and all phases of casing or liner plate construction shall be considered. The Ventilation Plan shall also include details and procedures for gas detection/air quality monitoring, for Review by the Engineer of the Contractor’s proposed ventilation system does not relieve the Contractor of its responsibility to provide an adequate ventilation system in accordance with the Specification and 29 CFR 1926.

C. The Contractor shall maintain and submit shift records on a daily basis that include the following:
1. Starting and ending stations for each shift.
2. Crew size and allocations for each shift.
3. Starting and ending clock reading for each shift.
4. Type, quantity, and location of casing or liner plate installed.
5. Horizontal and vertical alignment from theoretical centerline at the end of each push.
6. Air quality reports of tests for dust, toxic and hazardous gases, and other atmospheric impurities in the working environment including the time, location and gas levels.
7. Record of water inflow.
8. Submit on a daily basis records of any unusual occurrences, including falls, unstable ground, groundwater problems, equipment malfunction, power outages, damage to casing ground support systems and the location and time of each such occurrence.
9. Other pertinent data as necessary.

1.07 QUALITY ASSURANCE
A. Project Manager: The Contractor shall identify an employee as the Project Manager who has at least five years of experience in jacked casing or tunnel liner construction with the methods specified.
B. Contractor’s Engineer: The Contractor shall either hire an independent Engineer or have an appropriate individual on staff for preparing construction submittals and shop drawings. The Contractor’s Engineer shall satisfy the following requirements:

1. Registration: Registered Professional Engineer in the State of Texas experienced in tunnel construction.

2. Duties of the Contractor’s Engineer shall include the following:
   a. Prepare plans and procedures for casing or tunnel liner installation.
   b. Assess ground conditions and make periodic field inspections to confirm that ground conditions are in agreement with the design criteria assumed for the design of the casing or liner.
   c. Interpret instrumentation readings and correlate them with observed ground conditions and excavation methods.
   d. Hold discussions as needed with the Owner’s Project Team (OPT) regarding ground and groundwater conditions, ground support requirements, instrumentation readings, and excavation and ground support procedures.
   e. Participate in all pertinent coordination meetings with the OPT.
   f. At the completion of each casing or liner systems installation a summary report shall be provided to the OPT, up-to-date drawings, results of tests performed and notes.

C. Each of the Contractor’s tunnel excavation operators shall have a minimum of two years experience in tunneling with the methods chosen. The Contractor’s Superintendent shall have a minimum of three years’ experience in the chosen method installation (i.e. jacked casing or liner systems).

D. Preconstruction Meeting: A preconstruction meeting shall be scheduled and conducted with the OPT between 15 and 30 days before beginning of operations.

E. The Contractor shall provide quality control, testing, and inspection as required herein, and in accordance with approved submittals.

F. The Contractor shall give the OPT a minimum of 3 days advance notice of the start of tunneling at any given location/crossing.

G. Welding Requirements: All welding procedures used to fabricate steel casings shall be prequalified under the provisions of ANSI/AWS D1.1. Welding procedures shall be required for, but not necessarily limited to, longitudinal and girth or special welds for pipe cylinders, casing joint welds, reinforcing plates and grout coupling connections.

H. All welding shall be done by skilled welders, welding operators, and tackers who have had adequate experience in the type of materials to be used. Welders shall be qualified under the provisions of ANSI/AWS D1.1 by an independent local, approved testing agency not more than 6 months prior to commencing work on the casing or pipeline. Machines and electrodes similar to those used in the work shall be used in qualification tests. The Contractor shall furnish all material and bear the expense of qualifying welders.

I. All welding shall conform to the applicable provisions of ANSI/AWS D1.1-80 Structural Welding Code, Section 3, Workmanship.

J. Tolerances on Line and Grade: Tolerances to line and grade for the casing construction shall be as follows:
   1. Horizontal Alignment: Maximum departure of 0.30-ft at any point along the theoretical casing centerline.
   2. Vertical Alignment: Maximum departure of 0.33-ft at any point along the theoretical casing grade line.
   3. Corrections to line and grade: No greater than 1 inch in 10 feet, or sufficient to prevent ponding, whichever is less.
1.08 JOB CONDITIONS

A. Excavated dimensions and arrangements, including depth, shown on the Drawings for the casing or tunnel liner systems are approximate dimensions. Subject to the approval of the Engineer and at no additional cost to the Owner, the Contractor shall select such dimensions as required to conduct the Work, based on space requirements for equipment, installation of components, handling of excavated material, methods of construction, and ancillary systems. The Contractor shall have the sole responsibility for sizing the outside diameter of the excavation. The size and depth of the excavation shall be adequate to prevent impacts to existing utilities and to reduce surface movements to within the limits specified, construct all structures required and to gain access to casing or tunnel liner systems installation operations for all materials, equipment, and personnel.

B. The Contractor shall maintain an adequate supply of casing or tunnel liner on site to prevent delays to the work.

C. The Contractor shall have the sole responsibility for maintenance and protection of existing utilities, structures, and facilities within the zone impacted by the access portals and tunnel. The zone of impact shall include the zone of ground movement in the vicinity of this work.

D. The Contractor shall allow the OPT's representative access to the access shafts, pits, or portals to inspect construction operations. This shall include, but is not limited to, visual inspection of installed casing or tunnel liner systems and verification of line and grade. The Contractor shall provide safe access in accordance with all safety regulations and furnish necessary assistance and cooperation to aid the OPT in observations and record keeping.

E. The Contractor shall furnish all material and labor to install and maintain pumps, piping, drains and other facilities for the control, collection and disposal of groundwater and construction related water from inside the casing or tunnel liner systems and shaft excavations. Water collected shall be directed to the access portals for disposal.

F. The Contractor shall furnish and install all electrical equipment required to complete the casing or tunnel liner installation construction activities both on the surface and underground at the construction sites. The Contractor shall also furnish the electrical equipment for all of the auxiliary systems which shall include but not be limited to transformers, panel boards, security lighting, grounding, power for vent fans, sump pumps, disconnect switches, voice communication equipment, office trailers, etc.
   1. Electric lines shall be sized for the loads and rated properly for the delivery voltage.
   2. Lighting shall be provided along the length of the tunnel, in the shaft areas, and in the vicinity of all operating equipment as required by OSHA requirements.
   3. Communication equipment shall be provided as required by OSHA requirements.

1.09 SUBSURFACE CONDITIONS

A. Subsurface conditions have been investigated and documented in Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1) prepared by HVJ Associates (Geotechnical Investigation).

B. If necessary for the complete design and safe installation of the casings or liners, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

1.10 SAFETY

A. All work shall conform to the requirements of OSHA. Perform all work in accordance with the current applicable regulations of the federal, state, and local agencies. In the event of conflict, comply with the more restrictive applicable requirements.
B. Methods of construction used by the Contractor shall ensure the safety of the work, project participants, the public, third parties, and adjacent property, whether public or private. The Work shall conform to the requirements of applicable Federal, State, and local laws and regulations. The Contractor is solely and completely responsible for maintaining safe work conditions at the site at all times.

C. The Safety Officer shall prepare and administer the Safety Plan. The Safety Officer shall be required to work full time on site during all aspects of tunnel construction. The Contractor shall hold safety meetings and provide safety instruction for new employees and training for all operations staff.

2.00 PRODUCTS

2.01 MATERIALS

A. Steel Casing Pipe

1. Steel Casing: Steel casing pipe shall be in accordance with ASTM A36, Grade C, with a minimum yield strength of 35,000 psi unless shown otherwise. Steel casing pipe shall be coated on the outside with two coats of medium consistency coal tar (Carboline “Bitumastic 50”, or Tnemec “46-465 HB Tnemecol”) or with coal tar epoxy (Ameron “Amercoat 78HB Coal Tar Epoxy”, Carboline “Bitumastic 300M”, or Tnemec “46H-HB Hi-Build Tnemco Tar”). Coating thickness shall be in accordance with coating manufacturer’s recommendations.

2. The casing pipe shall have the minimum capacity to withstand the maximum jacking load anticipated with a safety factor of 2.5. The casing shall also be designed to withstand anticipated long-term soil and groundwater loads with a safety factor of 1.5.

3. Casing wall thickness shall be determined by the Contractor. Minimum casing thicknesses shall be as shown on the Drawings.

4. Casing pipe shall be furnished with 2 inch minimum diameter grout holes which conform to ASTM Specification A53, Schedule 40, with threaded plugs. Holes shall be regularly spaced on 5-foot centers alternating at 45 degrees from plumb each side of the vertical centerline. Longitudinal spacing between grout holes may be decreased to provide more extensive grouting. Grout holes shall be fitted with countersunk, full face, rubber gaskets to prevent infiltration of displaced earth during the jacking process.

5. Welded steel casing joints shall be square cut with beveled ends, using a full-penetration butt weld. All welding shall conform to the applicable provisions of ANSI/AWS D1.1-80 Structural Welding Code, Section 3, Workmanship.

6. Interlocking steel casing joints shall be steel pipe utilizing an integral, machined press-fit connection method (Permalock or approved equal). Steel used in the manufacture of interlocking steel casing connections shall conform to ASTM A-36 as a minimum and be machinable. Steel casing pipe 30 inches or greater in diameter shall be manufactured by the rolled and welded cylinder method utilizing the DSAW process, with all welding to conform to the applicable provisions of ANSI/AWS D1.1-80 Structural Welding Code, Section 3, Workmanship.

7. Jacking lubrication shall consist of bentonite and/or polymers and potable water. Polymers shall be non-toxic and approved by the Engineer.

B. Steel Liner Plate and Related Accessories

1. Steel liner plate shall be designed to permit erection and assembly of the liner plate effectively from inside the tunnel. Fabricate uniform plates and those intended for one size tunnel shall be interchangeable. Material used for construction of plates shall be new, unused, and suitable for purpose intended,

2. Steel liner plate shall be fabricated from one piece of metal and be flanged on four sides conforming to ASTM A1011, with minimum tensile strength of 42 ksi, minimum yield strength of 28 ksi, and elongation in 2 inches of 30% minimum. Liner plate, bolts, and
nails shall be hot-dip galvanized.

3. Joints shall be such that when plates are bolted together no opening exists large enough to permit inflow of ground.

4. Steel liner plate shall be fitted with a minimum of one grout port for every three rings.

5. Liner plate thickness tolerances shall conform to AASHTO specifications for Highway Bridges or comparable AREMA Manual for Railway Engineering, Chapter 1, Section 4.15.

6. Bolts and nuts shall be quick acting coarse thread of material conforming to ASTM A449 with a minimum 5/8-inch diameter and length as required by the liner plate manufacturer. Welding of tunnel liner plate shall not be allowed.

7. The liner plate shall have tapped holes for grout nipples as shown on the plans.

C. Expandable liner plate (e.g. Ring Beam and Lagging)

1. Steel structural members shall be free of defects which may impair or reduce their structural integrity and have tapped holes minimum yield strength of 50,000 psi. Allowable bending stress shall be 75% of the yield strength.

2. Maximum spacing of steel ring structural members shall be 4 foot on center.

3. Use new and unused rough timber oak for lagging. Ensure ring spacing is sufficient for expected jacking loads.


2.02 PIPE JACKING SHIELD

A. The pipe jacking shield shall have closeable doors, louvers, or shield capable of supporting the entire area of the face at all times as needed, and for preventing the uncontrolled encroachment of both excavated and unexcavated materials into any part of the tunnel.

B. The pipe jacking shield shall be manned and operated at the front face of the tunnel excavation.

C. The pipe jacking shield shall have adjustable openings at the front face of the tunnel excavation to allow breaking up and extraction of material and objects.

D. The pipe jacking shield shall be steerable at the front face of the tunnel excavation and shall be capable of maintaining the specified line and grade of the tunnel within the specified tolerances.

E. The pipe jacking shield shall be guided using a laser and target. The position of the shield relative to the laser shall be tracked and recorded at least every five (5) feet.

F. A lubrication system shall be provided to inject pipe lubricant around the jacking pipe to decrease frictional resistance. See Paragraph 2.01 A. for requirements.

G. The pipe jacking shield shall be designed with adequate thrust capabilities to advance through the anticipated ground conditions without undue delay and without over-excavating beyond the shield overcut. The pipe jacking shield shall have a maximum allowable radial overcut of 1 inch.

H. The pipe jacking shield shall have an even number of thrust cylinders arranged symmetrically. Thrust cylinders shall have individual actuation, synchronized actuation, and individual maximum thrust control. Thrust cylinders shall not exert forces when idle, but shall resist displacements.

I. Control gauges shall be in satisfactory working order and accessible to allow observation of readings during excavation. Spare control gauges shall be on site and any defective gauge shall be replaced immediately.

J. The number of jacks, their capacity, and spacing shall be determined by the Contractor. The load distribution system shall ensure that the propulsion jacking load is applied evenly.
over an area sufficient to prevent damage to the jacked pipe.

K. Maximum thrust at any point and any time on the jacked pipe shall not exceed the safe jacking capacity of the pipe.

L. The jacking system shall be synchronized with load measurement capabilities to maintain loads within allowable limits.

M. The Contractor shall provide assistance to the OPT during tunnel alignment survey verifications.

N. Communications systems shall be continuously operated and maintained in good working order. Spares will be maintained on site to repair or replace defective components and ensure continuous operation.

O. Hard wired, electrically powered, amplified telephone or hand held, battery powered, rechargeable radio system shall be provided by the Contractor.

P. Advance telephone communication systems as the pipe jacking shield advances. Tunneling shall not continue at any time when communications are lost or communication systems are inoperative.

Q. The jacking equipment shall be equipped with dust suppression and environmental control facilities, which when combined with the ventilation system, are capable of meeting OSHA or Project requirements, or whichever is more rigorous.

2.03 TBM OR SHIELD FOR LINER PLATE CASING

A. TBM or shield shall conform to shape of tunnel with uniform perimeter that is free of projections that could produce over-excavation or voids. An appropriately sized over cutting bead may be provided to facilitate steering, but minimize settlement. In addition it shall:

1. Be capable of full directional guidance.
2. Be capable of full face closure, or permit ready installation of breasting boards.
3. Be equipped with appropriate tail in which casing is erected.
4. Be capable of correcting roll.
5. Be designed to handle adverse ground conditions including groundwater ingress.
6. Be equipped with visual display to show operator actual position of TBM or shield relative to design reference.

3.00 EXECUTION

3.01 GENERAL REQUIREMENTS

A. Construction methods used by the Contractor shall satisfy the requirements of this Section. The Contractor shall preserve the inherent strength of the ground surrounding the casing or tunnel liner systems. The Contractor shall minimize disturbance to the ground and shall minimize the surface effects of casing or tunnel liner systems installation.

B. Before starting tunnel excavation, the Contractor shall furnish all labor, materials, and equipment to initiate tunneling operations. Product delivery, storage, and handling shall conform to the requirements of these specifications. All equipment and materials necessary to control the excavations shall be on site, tested, and ready to use when needed.

C. Install tunnel casing or liner using method to control settlement, such as closed face tunnel boring machine or Engineer’s approved equal. See table for maximum allowable surface movement for each crossing type (where \( D \) = Excavated diameter of mined tunnel). Movements exceeding the thresholds shall be immediately reported to the Owner.
<table>
<thead>
<tr>
<th>Crossing Type</th>
<th>Movement (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Threshold</td>
</tr>
<tr>
<td>Railroad</td>
<td>0.25</td>
</tr>
<tr>
<td>Roads, Highways, and all other paved surfaces</td>
<td>0.50</td>
</tr>
<tr>
<td>Existing Pipelines</td>
<td>0.25</td>
</tr>
</tbody>
</table>

D. Install casings or tunnel liner at all locations shown on the Contract Drawings, using methods that include due regard for safety of workers, adjacent structures and improvements, utilities, and the public.

E. The Contractor shall perform tunnel excavation as shown on the Contract Drawings and as specified in this Section. Access shafts, portals, and pits shall be located where shown on the Plans. Where no such locations are given, the Contractor shall have the option of determining such locations subject to approval of the Engineer. In general, they shall not be located within road intersections.

F. All water entering the tunnels shall be removed by methods and equipment to prevent damage or ill effects to any portion of the work. The stability of the tunnel face shall be maintained at all times, including during shutdowns of the tunneling operations.

G. If not ready to place the pipe in the tunnel at the time of completion of casing or tunnel liner installation, the ends of the excavation shall be bulkheaded, and the approach trenches in public roads shall be backfilled, temporary surfacing placed thereon, and the affected portion of the road or paved area reopened to traffic.

H. Conduct all operations such that trucks and other vehicles minimize dust or noise nuisance in the roads and adjacent properties. Perform all work so as not to disturb adjacent structures, roadways, or existing utilities. Immediately repair any damage to the satisfaction of the agency or utility having jurisdiction.

I. All work shall conform to the requirements of OSHA. Perform all work in accordance with the current applicable regulations of the federal, state, and local agencies. In the event of conflict, comply with the more restrictive applicable requirements.

3.02 GROUND CLASSIFICATION AND GROUND SUPPORT

A. Use methods for tunneling operations, that minimizes ground settlement and are appropriate for existing ground conditions. Refer to Paragraph 3.01 B. of this Section for site specific settlement criteria.

B. Clean working conditions shall be maintained at all times inside the tunnel. Tunneling method shall control flow of water, prevent loss of soil into tunnel, and provide face stability.

C. Generally, the determination of tunnel type shall be made by the Contractor through its Engineer, in association with the Engineer.

D. Work shall be performed to minimize safety hazards and exposure of workers and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements.

E. In the event, methane or other flammable or toxic gases are encountered during tunnel construction, the Contractor shall notify the Owner and immediately take steps to control gas concentrations as described in 29 CFR 1926.

F. In case of emergency likely to endanger excavation or adjacent structures, the Contractor shall continuously maintain full work force 24 hours per day including weekends and holidays until emergency or hazardous conditions no longer jeopardize stability and safety of the work.
3.03 TUNNEL EXCAVATION

A. Prior to tunnel excavation the Contractor shall perform potholing or other utility verification locations to confirm or verify the presence of obstructions or utility conflicts not illustrated on the drawings or otherwise known. The OPT shall be notified of obstructions found.

B. Tunnel excavation shall not begin until the following have been completed:
   1. Required submittals have been made and the Engineer has reviewed and accepted them.
   2. Pit or shaft excavation and support have been completed.
   3. Groundwater control has been established.
   4. A safety meeting has been conducted as required by OSHA.
   5. Pre-construction survey documents have been submitted to the OPT.

C. The Contractor shall immediately notify the OPT, in writing, if any problems that would cause a schedule delay or a change to the submitted process/procedure are encountered with equipment or materials.

D. The Contractor shall continuously monitor, record, and control the rate of advance with the rate and volume of excavation to ensure that no over-excavation occurs. Promptly notify the OPT if the loose volume of excavated materials exceeds the theoretical excavation volume.

E. If the jacked casing and bored tunneling system is used, the Contractor shall:
   1. Apply lubrication under pressure using a manifold piping system from within the jacked pipe. The lubricant shall be continuously pumped throughout the pipe jacking operation.
   2. When approved by Engineer, insert an Intermediate Jacking Station when jacking forces reach 80% of the maximum safe jacking capacity of the pipe, or the thrust wall, or the capacity of the main jacks, whichever is lower.

F. The Contractor shall notify the OPT immediately if an obstruction is encountered. Upon written authorization by the Engineer, proceed with removal of the obstruction in accordance with the Contractor’s submitted obstruction removal plan.

G. All void space between the soil and the installed casing shall be grouted by the Contractor immediately upon completion of the casing installation with 300 psi minimum grout or 350 psi minimum impervious cellular concrete.

3.04 CASING OR TUNNEL LINER INSTALLATION

A. Provide method to ensure full bearing of soil against primary liner without significant settlement or movement of surrounding soil. Use grout to fill void behind non-expandable tunnel liner.

B. Install according to Contractor’s approved Work Plan and according to manufacturer’s recommendations following the general standard of care of the tunneling industry.

C. When using TBM or tunnel shield, advance equipment only far enough to permit construction of one tunnel liner set entirely within equipment shield. Tunnel liner installation shall proceed as closely as possible behind the excavation. Excavation shall at no time be more than 6” ahead of required space to install an individual primary liner segment. Use breast plates, poling boards, or other suitable devices to maintain accurate excavation with minimum amount of unsupported excavation at any time.

D. Line and grade shall be checked at the end of each work day and corrected before pressure grouting void space between outside of casing pipe or tunnel liner and excavation.

3.05 ANCILLARY SYSTEMS

A. Ventilation System
   1. The tunnel ventilation system shall be monitored and maintained to provide sufficient
quantities of fresh air to prevent dangerous accumulation of dusts, fumes, mists, gasses, or vapors, in accordance with the requirements of 29 CFR 1926. A supply of fresh air shall be furnished to effect the quick removal of fumes and dust generated by tunneling operations. Exhausted air shall be washed and filtered to remove excess dust particles resulting from excavation before discharge to the atmosphere.

2. The Contractor shall operate and maintain the ventilation system for the duration of the project. The ventilation system shall conform to specified safety requirements and those of jurisdictional authorities.

3. The Contractor shall provide air-testing devices for flammable, toxic, and carbon dioxide gases and shall keep written records of all readings. Testing frequency and location shall be determined according to 29 CFR 1926.55 and 1926.800.

4. The tunnel ventilation system shall be maintained in a good condition and shall be under the direction of an individual experienced in tunnel ventilation operation and maintenance. Experienced personnel who have worked on at least two projects of a similar magnitude shall operate the ventilation system.

5. Standby power shall be available at all times to supply full power to the ventilation system.

B. Tunnel Dewatering: If necessary to control or minimize the inflow of groundwater into the tunnel, the Contractor shall install, operate, and maintain a tunnel dewatering system in accordance with Section 02301-J - Dewatering of Shafts, Tunnels and Portal Excavations

C. Illumination: The Contractor shall illuminate working areas in accordance with the requirements of 29 CFR 1926.

3.06 SURFACE MONITORING POINTS

A. Surface Monitoring Points will be used to monitor surface vertical and horizontal movement of points located over the tunnel alignment area. The Contractor shall furnish a spray painted point or PK nail, or approved equal, one-foot outside of DART ROW on both sides at each tunnel crossing. An initial survey of the points shall be taken prior to any excavation of tunnel shafts.

B. Care shall be taken in Contractor’s operations to see that Monitoring Points are not damaged or dislodged. Damaged or dislodged instrumentation shall be replaced as soon as possible, within one day.

C. Regular measurements shall be taken, initially every day for 1st week once excavation starts for the tunnel shafts. Then, measurements shall be taken weekly thereafter if stable readings are recorded. Once tunnel excavation begins, measurements shall again be taken daily for 1st week. Then, measurements shall be taken weekly thereafter if stable readings are recorded. If some irregularity or an increase in displacements is observed, the interval of reading times should be increased based on OPT suggestions.

END OF SECTION
02304-J    INSTALLATION OF CARRIER PIPE IN TUNNEL

1.00    GENERAL

1.01    WORK INCLUDED
A. This Section specifies requirements for installing pipe in tunnels including preparatory
requirements. Pipe fabrication, placement of backfill around the pipe, and contact grouting
are specified elsewhere.
B. Measurement and Payment
   1. Except where specified elsewhere in the Contract Documents, the work included in
this Section shall be considered subsidiary to the contract unit price for installation of
steel encasement. The carrier pipe itself is measured and paid under the contract unit
price for construction of 48-inch AWWA C303 Bar-Wrapped Concrete Cylinder Pipe

1.02    RELATED SECTIONS
A. The following Sections apply to the Work of this Section. Other Sections not referenced
below shall also apply to the extent required for proper performance of this Work.
   2. Section 02303-J - Steel Jacked Casing, Steel Liner Plate and Expandable Liner by
Tunneling.
   5. Section 15060-J - Bar Wrapped Concrete Cylinder Pipe and Fittings
   6. Section 15240-J - Corrosion Protection Systems

1.03    TOLERANCE
A. Pipe Circularity: \( \frac{(D_h-D_v)}{D_v} \leq 0.005 \), where \( D_v \) is the pipe diameter measured vertically
and \( D_h \) is the pipe diameter measured horizontally, immediately before encasement in
grout.
B. Pipe Alignment in Tunnel:
   1. Line: Within 0.3 foot of theoretical alignment.
   2. Grade: Within 0.33 foot of theoretical grade.
   3. Corrections to line and grade: No greater than 1 inch in 10 feet, or sufficient to prevent
ponding, whichever is less.

1.04    SUBMITTALS
A. Submittals shall be in accordance with TxDOT Specifications and shall include:
   1. Pipe Installation Plan: Contractor shall submit a detailed Pipe Installation Plan showing
means and methods for transporting, handling, storing, protecting, installing, supporting and blocking the pipe in place at its final location. This plan includes
calculations demonstrating the pipe’s ability to handle transportation, handling, and
construction loads without damage; and shall be prepared and sealed by a
Professional Engineer licensed in the State of Texas. Integrate this information with submittal requirements specified in Section 15060-J - Bar Wrapped Concrete Cylinder
Pipe and Fittings, and Section 03610-J - Annular Backfill for Carrier Pipe in Tunnels.
Include the following:
      2. Preparations for installing pipe sections, including details of mock-up pipe section
assembly.
3. Methods for cleaning areas where pipe is to be placed, and methods for establishing and maintaining joint fit/reveal, line, and grade control.

4. Details of pipe carriers, prefabricated runners, cradles, internal supports, tie-downs, bracing, backfill concrete lift height, and other methods for preventing flotation while placing annular backfill.

5. Sequence and methods for installing pipe sections in the tunnel and fit up of joints.

6. Sequence and methods for encasing pipe sections in backfill. Coordinate with requirements of Section 03610-J - Annular Backfill for Carrier Pipe In Tunnels and show method, locations, and repair requirements for grout ports or other outlets in pipe that are used to monitor the advance of backfill.

7. Details for effecting tie-ins (if any) to buried pipeline reaches.

B. Shop Drawings: Pipe laying diagram showing for each pipe section: the length, deflection, pipe identification number, and special fittings. Integrate this information with submittal requirements specified in Section 15060-J - Bar Wrapped Concrete Cylinder Pipe and Fittings.

1.05 QUALITY CONTROL:

1. Installer’s Qualifications: The Contractor or subcontractor shall demonstrate experience installing similar pipe on at least three tunnels using similar methods and procedures proposed for this project. Submit project name and details, contract, and phone number for the three projects, completed within the last 5 years.

2. Manufacturer’s Certification: Certification that proposed pipe transportation, internal and external pipe supports, blocking details to prevent flotation, and backfilling procedures are in accordance with manufacturer’s recommendations and will not damage pipe. Provide calculations demonstrating that pipe will not be damaged during backfilling operations due to flotation. Calculations shall be prepared by and sealed by a Professional Engineer registered in the State of Texas.

3. Quality Control Plans:
   a. Methods for achieving minimum specified tolerances for line and grade, pipe ovalization to specified limits, and providing the minimum annular clearance.
   b. Welding procedures in accordance/integrated with Section 15060-J - Bar Wrapped Concrete Cylinder Pipe and Fittings

4. Record Keeping: Daily records submitted no later than the beginning of the following working day and integrated with the requirements of Section 03610-J - Annular Backfill for Carrier Pipe in Tunnels, including:
   a. Number and classification of men and equipment.
   b. Beginning and ending stations or elevations of pipe lining, and station or elevation where joint work has been completed.
   c. Testing, including time, location, and results of tests.
   d. Notation of any downtime or interruption to production, including length of time and reason.

1.06 OWNER ACCESS

A. Allow the Owner access to the work at all times.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Handle, transport, and store pipe sections in accordance with manufacturer’s recommendations and Section 15060-J - Bar Wrapped Concrete Cylinder Pipe and Fittings.

B. Do not use cables or chains to load or unload pipes.
C. Support stored pipe at a minimum on the quarter points along the pipe length.
D. Do not drag or skid pipe. Prefabricated runners are permitted provided coatings are not damaged.
E. Align pipe sections using jacks or other suitable devices without damaging the pipe.

2.00 PRODUCTS

2.01 MATERIALS
A. See Section 15060-J - Bar Wrapped Concrete Cylinder Pipe and Fittings
B. Blocking:
   1. Precast concrete.
   2. Untreated, hardwood timber conforming to requirements for stulls and braces.
   3. Steel shapes with appropriate measures to electrically isolate and protect the pipe and coating.

3.00 EXECUTION

3.01 GENERAL REQUIREMENTS
A. Install pipe in accordance with the project plans and specifications, approved submittals, and the manufacturer's recommended installation method. Piping shall have uniform alignment, grade, and bearing within the tolerances listed herein
B. Maintain ventilation, lighting, and other utilities in the tunnel throughout the pipe installation operations as required and per requirements of 29 CFR 1926 and 1910.
C. Electrical Isolation of Pipe: There shall be no electrical conductivity contact between the final carrier pipe and the casing or metallic tunnel liner component. Pipe bracing and saddles shall be made of inert non conductive material such as wood or rubber isolation bearing pads if bracing or saddles are made of steel or contain steel elements.

3.02 PREPARATION
A. Clean surfaces to receive backfill of muck, grout, debris, and other objectionable materials in each reach where pipe is to be installed.
B. The Contractor shall inspect the surfaces of tunnel support systems to identify voids, openings, blockouts, and depressions which could hinder the complete infilling of backfill behind the pipe, subject to specified criteria. The Contractor shall fill such voids, blockouts, and depressions using cementitious materials approved by the Engineer. Where the Engineer identifies voids, openings, blockouts, and depressions, and brings them to the attention of the Contractor, the Contractor shall fill them the same as if they had been identified by the Contractor.

3.03 INSTALLATION
A. Immediately before moving a pipe section into the tunnel:
   1. Inspect section, fittings, and appurtenances. Repair damaged pipe caused by the defects, delivery, or installation. Replace damaged pipe or other items that cannot be repaired as determined by the Engineer. Perform this work at no additional cost to the Owner.
   2. Verify that each section can be transported to its required location without interference
with or damage to initial tunnel support systems.

3. Check connections attached to the pipe section and equip with plugs. Remove dirt, debris, spills, and other objectionable material using cleaning materials that will not damage the pipe.

4. Remove foreign matter and contaminants from the pipe surfaces.

B. One casing spacer shall be placed within 2 feet of ends of casing. Place, align, and weld skid rails (reinforce weld) inside the casing or tunnel liner. Skid rails shall also be extended across the entire length of the bore pit and cement mortar shall be placed on both sides of the rails.

C. For BWCCP:
   1. Install flexible sealer, such as flexprotex, to outside of joints prior to engaging each pipe section inside casing or tunnel liner and making up joints. Clean and prime surfaces receiving sealer in accordance with manufacturer’s recommendations.
   2. Pull, push, or skid pipe into place inside casing or tunnel liner using a constant force method such as hydraulic cylinders. Use of construction equipment such as excavators for pulling or pushing pipe inside casing or tunnel liner will not be allowed. Lubricants such as flax soap or drilling mud may be used to ease pipe installation. Do not use petroleum products, oil or grease for this purpose.
   3. Install hold down jacks per project details.
   4. After installation of carrier pipe, verify electrical isolation between carrier pipe and casing or tunnel liner by performing casing electrical isolation testing as specified in Section 15240-J - Corrosion Protection Systems. If continuity exists, remedy the short prior to finishing inside joints.
   5. Mortar inside joints of carrier pipe.
   6. Completely fill annular space between carrier pipe and casing or tunnel liner with cellular grout in accordance with Section 03610-J - Annular Backfill for Carrier Pipe in Tunnels.

3.04 QUALITY TESTING FOR INSTALLED PIPE

   A. After pipe has been installed and grouted, the Contractor shall perform hydrostatic pressures tests in compliance with Section 15040-J - Hydrostatic Testing.

END OF SECTION
1.00 GENERAL

1.01 WORK INCLUDED
A. This Section consists of the basic requirements with which the Contractor must comply to provide for the safety and health of workers in a trench and to protect adjacent structures and slopes. This Section is for the purpose of providing minimum performance specifications. The Contractor shall develop, design, and implement the trench safety system. The Contractor shall bear the sole responsibility for the adequacy of the trench safety system and providing safe working conditions.
B. Should the trench safety protection system require wider trenches than specified elsewhere in the Contract Documents, the Contractor shall be responsible for the costs associated with determining adequacy of pipe bedding and class, as well as purchase and installation of alternate materials.
C. Measurement and Payment
   1. The measurement and payment shall be full compensation for all materials, equipment, fabrication, and incidental work to complete this item complete in place as shown on the plans, specified herein, or as directed by the Engineer. The separate pay item for trench safety shall be based on the linear feet of trench excavated. All excavated trenches shall be provided with trench safety measures including dewatering, as may be deemed necessary to provide adequate safety and protection of employees, regardless of the depth of the trench. Payment for all trenching and shoring requirements applicable to this protection shall be paid for at the total unit price shown in the bid proposal.

1.02 REFERENCES
A. The following standards, latest edition, shall be the minimum governing requirements of this Section and are hereby made a part of this Section as if written in its entirety.
   1. Occupational Safety and Health Administration (OSHA) 29 CFR Part 1926, Safety and Health Regulations for Construction
   2. H.B. 1569 of the 71st Regular Session of the State of Texas
B. Comply with all applicable Federal, State, and local rules, regulations, and ordinances.

1.03 SUBMITTALS
A. Submit a copy of the Trench Safety System Plan, signed and sealed by a Professional Engineer licensed in the State of Texas, for record purposes.

1.04 QUALITY ASSURANCE
A. The Contractor shall select an engineer based on competence and qualifications in accordance with Sec. 2254.004, Texas Government Code, and not on the basis of competitive bids and will certify to that effect with the Trench Safety System Plan submittal.
B. The Contractor shall be responsible for complying with state laws and federal regulations relating to trench safety, including those which may be enacted during the performance under this Contract.

1.05 SUBSURFACE CONDITIONS
A. Subsurface conditions have been investigated and documented in Geotechnical Investigation, 48-inch Water Line at SH 114 and Spur 482, City of Irving, Texas (Report No. DG-18-10117.1) prepared by HVJ Associates (Geotechnical Investigation)
B. If necessary for the complete design and safe installation of trench excavation support systems, the contractor shall be responsible for procuring the services of a qualified geotechnical professional Engineer, licensed in the state of Texas, to oversee additional subsurface investigations and provide additional geotechnical recommendations, which shall be subsidiary to the work performed in accordance with this Section.

2.00 PRODUCTS

2.01 GENERAL

A. All materials and products incorporated into the Trench Safety System shall be suitable for their intended uses; shall meet all design criteria and parameters used by the Trench Safety System designer; and shall meet all applicable OSHA standards.

3.00 EXECUTION

3.01 PROCEDURES

A. At least 10 Calendar Days prior to execution or any excavation operations, and not more than 30 Calendar Days following the execution date of the Construction Agreement, the Contractor shall submit a Trench Safety System Plan, signed and sealed by a Professional Engineer licensed in the State of Texas. The Trench Safety System Plan shall be in writing, site specific and sufficiently detailed and clear to be understandable and usable by all personnel who will be executing, supervising, and witnessing the trenching operations. A copy of the Trench Safety System Plan, they shall be available at the site of trenching operations at all times. A second copy shall be provided to the Owner for the Owner’s records.

B. The Trench Safety System Plan shall include a Conformance Affidavit stating that the operations will be conducted in full conformance with OSHA standards.

1. The Conformance Letter shall also describe the Trench Safety System techniques proposed to be used on the project.

2. Specific references to the applicable OSHA standards sections shall be included for each technique to be used.

C. If borings and/or detailed geotechnical analyses are required to develop the Trench Safety System Plan, they shall be executed by the Contractor at his cost.

D. For trenches having depths greater than the various limits given in the OSHA standards (8, 12 or 20 feet, depending on the techniques used), a site specific protective system shall be designed by a Professional Engineer licensed in the State of Texas experienced in soil mechanics and structural design. The design shall be signed, sealed and dated by the Professional Engineer, and it shall identify those specific locations where the design is applicable.

3.02 METHODS OF PROVIDING TRENCH SAFETY

A. Protective systems referenced in this Section shall be as defined and described in 29 CFR 1962.652, “Requirements for Protective Systems.”

B. It is the duty, responsibility, and prerogative of the Contractor to determine the specific applicability of a proposed Trench Safety System for each field condition encountered in the Work. The Contractor specifically holds the Owner, Engineer, and any of their designated representatives harmless in any actions resulting from the failure or inadequacy of the Trench Safety System used to complete the project.

C. Unless otherwise noted on the Drawings, Sloping/Benching, Trench Shielding with trench boxes, and/or Sheeting/Shoring/Bracing protective systems may be used.
3.03  INSPECTION DUTIES OF CONTRACTOR

A. Provide a Competent Person, as defined in the OSHA standards, to make frequent inspections of the trenching operations and the Trench Safety System in full conformance with the OSHA standards.

B. If evidence of a possible cave-in or landslide is apparent, all work in the trench shall immediately cease and not be resumed until all necessary precautions have been taken to safeguard personnel entering the trench.

C. In an emergency situation which may threaten or affect the safety or welfare of any persons or properties, the Contractor shall act at his discretion to prevent possible damage, injury or loss. Any additional compensation or time extension claimed for such actions shall be considered in view of the cause of the emergency and in accordance with the Agreement.

END OF SECTION
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CARE OF WATER DURING CONSTRUCTION

1.00 GENERAL

1.01 WORK INCLUDED

A. This Section sets for the requirements for care of water during construction. Requirements for dewatering of pipeline trenches are found in Section 02200-J - Pipeline Excavation and Backfill.

B. Furnish labor, materials, equipment and incidentals necessary to operate pumps, piping and other facilities to assist in the removal of surface water and ground water, and provide protection from flood waters. Build and maintain the necessary temporary impounding works, cofferdams, bypass pumping, channels, and/or other diversions as necessary to protect the work. Remove the temporary works, equipment, and materials after completion in strict accordance with this section of the specifications and the applicable drawings.

C. Measurement and Payment

1. The work included in this Section shall be considered subsidiary to the contract unit prices for construction of 48-inch AWWA C303 Bar-Wrapped Concrete Cylinder Pipe and installation of steel encasement.

1.02 DEFINITIONS

A. Owner: City of Irving

B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants

C. Owner’s Project Team (OPT): Representatives of the Engineer and Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

D. Project Construction Manager (PCM): TxDOT representative proving construction management services.

1.03 DOCUMENTATION

A. Provide Record Data in accordance with TxDOT Specifications, including:

1. Plans and procedures for handling flood flows and dewatering excavations. Modifications to these plans and procedures shall be submitted for approval.

2. A dewatering plan signed and sealed by an engineer licensed in the State of Texas if a well point system is used for dewatering.

2.00 PRODUCTS (NOT USED)

3.00 EXECUTION

3.01 FLOOD FLOWS AND OTHER WATER

A. The Contractor is responsible for handling and diverting any flood flows, stream flows, or any other water, including groundwater encountered during the progress of the work. Build, maintain, and operate cofferdams, channels, flumes, sumps, and other temporary works as
needed to pass floodwater or divert stream flow or pass other surface water through or around the construction site and away from construction work while it is in progress. Unless otherwise approved by OPT, a diversion must discharge into the same natural watercourse in which its headworks are located. Construct permanent work in areas free from water. Full responsibility for the successful dewatering of the work areas rests with the Contractor. Remove protective works, after they have served their purpose.

### 3.02 DEWATERING EXCAVATED AND OTHER FOUNDATION AREAS

A. The Contractor is responsible for dewatering foundations for all areas during construction of the works of improvement, including areas of required backfills. Lower the water table as needed to keep work areas free of standing water or excessive muddy conditions as needed for proper performance of the construction work. Furnish, prepare, and maintain drains, sumps, casings, well points, and other equipment needed to dewater areas for required construction work. Any dewatering method that causes a loss of fines from foundation areas shall not be permitted. Keep available standby equipment to assure the proper and continuous operation of the dewatering system. Provide continuous monitoring (24 hours per day) of the dewatering system to assure continuous operation.

B. Construction modifications in the dewatering system may be required by the PCM to provide adequate performance. In the event of failure of the system, flooding of the excavation may be ordered by the PCM until the system is operative.

### 3.03 DEWATERING BORROW AREAS

A. Unless otherwise specified on the drawings, maintain the borrow areas in drainable condition or otherwise provide for timely removal of surface waters that accumulate, for any reason, within the borrow areas.

### 3.04 WATER IN EXISTING UTILITIES

A. The Contractor is responsible for handling and diverting any water contained in or flowing through utilities altered during the progress of work. Furnish, prepare and maintain all works required to sustain construction progress including, but not limited to temporary piping, valves, plugs, drains, dikes, ditches and pumps. Full responsibility for the successful handling of utility water rests with the Contractor. Remove any temporary works, after they have served their purpose.

B. The Contractor is responsible for restoring utilities to full operating status unless specified otherwise. In the event a utility is temporarily removed from service or impaired, the Contractor shall work to restore the utility in a diligent and expeditious manner.

### 3.05 WATER DISPOSAL

A. Dispose of water in such a manner as to cause no injury, nuisance, or damage to public or private property, or be a menace to the public health.

1. Dispose of the water in accordance with applicable regulatory agency and permit requirements.

2. Do not drain trench water through the pipeline under construction.

3. Water and debris shall be disposed of in a suitable manner in compliance with permit requirements. No water shall be drained into work built or under construction.

4. Prevent disposal of sediments from the soils to adjacent lands or waterways by employing necessary methods, including settling basins. The Contractor shall locate settling basins away from watercourses to prevent
silt-bearing water from reaching the watercourse during flow regime.

5. Where excavations may obstruct the natural flow of a watercourse, implement measures to control and dispose of the surface water that will not adversely affect water quality or beneficial uses of the watercourse. The Contractor shall divert watercourse flows around excavation areas by constructing barriers, temporary culverts, new channels or other appropriate means.

6. Do not allow water containing mud, silt or other pollutants from aggregate washing or other construction activities to enter a watercourse or be placed in locations that may be subjected to high storm flows.

END OF SECTION
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DIVISION 03

CONCRETE
1.00 GENERAL

1.01 WORK INCLUDED
   A. This Section specifies requirements for developing and preparing mix designs, testing and verifying mixes, batching, transporting, and placing annular backfill between the casing or liner plate and the final carrier pipe as follows:
      1. Annular Backfill for Concrete Cylinder Pipe (PCCP) pipe shall be low density cellular concrete.
      2. Annular Backfill for Welded Steel Pipe (WSP) shall be conventional grout.
   B. Measurement and Payment
      1. The work included in this Section shall be considered subsidiary to the contract unit price for installation of steel encasement.

1.02 DEFINITIONS
   A. Owner: City of Irving
   B. Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants
   C. Owner’s Project Team (OPT): Representatives of the Engineer and Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.
   D. Project Construction Manager (PCM): TxDOT representative proving construction management services.

1.03 RELATED SECTIONS
   A. The following Sections apply to the Work of this Section. Other Sections not referenced below shall also apply to the extent required for proper performance of this Work.
      1. Section 02305-J - Steel Jacked Casing, Liner Plate, and Expandable Liner by Tunneling.
      2. Section 02304-J - Installation of Carrier Pipe in Tunnel.

1.04 REFERENCE CODE AND STANDARDS
   A. The applicable provisions of the following standards and codes shall apply as if written here in their entirety:
      1. American Concrete Institute (ACI):
         ACI 214 Recommended Practice for Evaluation of Strength Test Results of Concrete
         ANSI-B40.1 Gauge - Pressure, Indicating Dial Type - Elastic Element
         ASTM C33 Specification for Concrete Aggregates
         ASTM C94 Standard Specification for Ready-Mixed Concrete
         ASTM C117 Test Method for Material Finer than 75 µm (No. 200) Sieve in
1.05 DOCUMENTATION

Provide Shop Drawings in accordance with TxDOT Specifications.

A. Provide Working Drawings and Methods Statements for low density cellular concrete or conventional grout as applicable, including:
   1. Means and methods for proportioning, mixing, batching, and delivering concrete or grout, including the storage of raw materials.
   2. Details for transporting, placing, and consolidating concrete or grout. Integrate with and describe the sequencing of this work with the installation of pipe as specified in Section 02304-J - Installation of Carrier Pipe in Tunnel.
   3. Lift drawings showing details of delivery pipes, slicklines, injection ports, break between pour bulkheads, casing seals or tunnel end bulkheads, and other materials.
   4. Calculations for preventing flotation and deformation of the final lining (carrier pipe). Provide calculation for each lift planned to place backfill.
   5. Descriptions of labor, equipment and supplies required to perform the work.
   6. Cross-sections and profiles showing the arrangement of transportation, handling, and placing equipment including passing clearances.
   7. Details of pumping pressures and rates, placement sequences and volumes, lift thicknesses, including the theoretical quantity for each placement.
   8. Methods for diverting construction water and groundwater and protecting concrete or grout.

B. Mix Designs: The Contractor shall submit concrete or grout mix designs.

C. Quality Control:
   1. Qualifications: The Contractor shall provide information regarding the proposed
specialty firm for batching and pumping cellular concrete, the individuals responsible for
development of mix designs, the individuals overseeing placement of cellular concrete,
and field sampling and testing personnel, including qualifications of their employer.

2. Certifications:
   a. Certificates of compliance for materials incorporated into the Work.
   b. Calibration certificates for gauges, scales, and meters in accordance with
      ANSI B40.1.
   c. Written certification from the pipe manufacturer that the pipe is capable of
      handling the proposed pumping and hydrostatic pressures.

3. Written certification from the manufacturer of the foaming agent material
   manufacturer that: (1) ingredients used in cellular concrete or conventional grout are
   compatible, (2) the method whereby the cellular concrete foaming agent is introduced
   to the batching system is acceptable, and (3) that the concreting supervisor is
   knowledgeable in the formulation and adjustment of mix designs.

4. Quality Control Plans:
   a. Procedures for producing cellular concrete or conventional grout, including
      procedures for verifying mix ingredient quality and performing sampling, testing,
      and record keeping.
   b. Methods for controlling critical mix parameters, such as cellular concrete
      or conventional grout density.
   c. Methods for assuring that the annular spaces between the carrier pipe and
      the casings or liner plate are filled.
   d. Methods for assuring that injection pressures do not damage adjacent work or
      the carrier pipe.
   e. Method for determining when pipe bracing and supports may be removed.

5. Recordkeeping: Daily records shall be submitted no later than the end of each
   working day for the following:
   a. Delivery tickets.
   b. Daily reports and records of cellular concrete or conventional grout
      placement, including:
      1). Number and classification of men and equipment.
      2). Beginning and ending stations or elevations of placements, beginning
         and ending time for the pour, and volume.
      3). Test information, including times, locations, and results of tests.
      4). Notation of any downtime or interruption to production, including length of
         time and reason.

6. Notifications: Twenty-four hours in advance of (excluding non-work days)
   all placements.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Cellular Concrete Specialty Contractor: Minimum of 10 years of recent, successful
      experience in batching and placing cellular concrete for at least three tunnel projects
      of the general type, size, and diameter as required for this project.
2. Concreting Supervisor: Experienced in similar tunnel conditions and knowledgeable in the formulation and adjustment of mix designs.
3. Field Sampling and Testing Personnel: Qualified employees of an ACI-certified testing laboratory.

B. Acceptance Criteria:
2. Density: Within 15% percent of the design value.

C. Preconstruction Meeting:
1. Notify PCM two weeks before implementation of placement of concrete backfill.
2. Coordinate meetings with preconstruction meeting to review details of the backfill operation, including mixing, placement procedures and sequencing, and testing and inspection for each type of backfill.

D. Testing:
1. General: Test non-cellular concrete compressive strengthContractor shall take three 3-inch diameter cylinders for each sample to be tested.
2. General: Test cellular concrete compressive strength in accordance with ASTM C495, and mimicking in-situ pressures except that cylinders shall be cast using styrofoam molds. Plastic molds will not be permitted. Test specimen shall not be oven cured. Specimen shall be capped with plaster of Paris, not sulfur caps.
3. Pre-Production Testing: Take one set comprising four cylinders for each proposed mix. Perform compressive strength tests on one set of samples at 56 days.
4. Production Testing: Perform production testing at the batch plant and at the placement location as specified in this Section.

1.07 DESIGN CRITERIA
A. Low Density Cellular Concrete:
1. Cementitious content shall be no less than 200 lb/cy.
2. Water content shall be no more than 65 percent.
3. Wet density shall be no less than 45 lb/cubic ft.
4. Minimum compressive strengths shall be 100 psi after 7 days and 300 psi after 28 days.

B. Conventional (Mortar) Grout:
1. Conventional grout shall consist of a pumpable mix of 1 part cement, 2 parts clean sand, water free from organics and deleterious materials, and a small amount of bentonite for pumpability and stability. The unit weight shall not be less than 140 lbs per cubic ft.
2. Minimum 28 day unconfined compressive strength 1,500 psi.

C. Backfill Concrete Joints: Joints shall be oriented perpendicular to the longitudinal centerline of the pipe, at least 12 inches from pipe joints.

1.08 SEQUENCING AND SCHEDULING
A. The Contractor shall provide access at all times to the OPT to view and inspect the work specified herein.
2.00 PRODUCTS

2.01 MATERIALS

A. Foaming Agent: Foaming agent shall conform to the requirements of ASTM C869 when tested in accordance with ASTM C796. The foaming agent shall maintain stability until the cement sets to form a self-supporting matrix comprising closed cells and low water absorptive characteristics. Foaming agent shall be Mearl Geofoam Liquid Concentrate (the Mearl Corporation, Roselle Park, New Jersey); Rheocell 15 (Master Builders Inc., Cleveland, Ohio); WF 304 Foam Concentrate (Cellufoam Concrete Systems, Scarborough, Ontario); or MaxFlow Foaming Agent Concentrate (MaxFlow Environmental Corp., Black Mountain, North Carolina).

B. Admixtures: Admixtures shall not contain chlorides, substances that promote corrosion, and for cellular concrete, admixtures shall be certified for use with foaming agent by foaming agent manufacturer.

1. Air-entraining admixtures shall conform to ASTM C260, and shall be nontoxic after 30 days and shall contain no chlorides. Admixtures shall be Master Builders MB-AE 90 or Sika AER (Sikamix 104).

2. Water-reducing admixtures shall conform to ASTM C494, Type A or D, shall contain no chlorides, shall be nontoxic after 30 days, and shall be compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the Manufacturer’s recommendations. Admixtures shall be Master Builders Pozzolith polymer-type normal setting, Plastocrete (Sikamix 160) Normal Set, or Sika Chemical Corporation.

C. Retarder/Water Reducer: ASTM C494, Type D.

D. Plasticizer/Water Reducer: ASTM C494, Type A.

E. Cement: ASTM C150, Type II.

F. Fly Ash: ASTM C618, Class F, except that fly ash with carbon content greater than 6 percent may be used.


H. Water: ASTM C94, with a pH not less than 6.7.

2.02 EQUIPMENT

A. General: Equipment shall be of sufficient size and capacity to batch and pump required volumes of concrete backfill over the distance required and through injection ports at a uniform flow rate and under the required constant pressure in an underground environment. No trucking of concrete backfill is allowed. The system shall be capable of generating a non-foamed slurry unit weight within ±15 percent of the design unit weight. Equipment shall be maintained in good operating condition. An adequate inventory of spare parts and backup equipment shall be available on site.

B. Batching: Slurry shall be batched mechanically in a manner ensuring consistency of the mix.

C. Foam Generator for Cellular Concrete: Foam shall be generated by combining controlled quantities of air, water, and foaming agent under pressure in accordance with the foaming agent manufacturer’s recommendations. The temperature of water used in generating the foam shall be maintained below 80°F, or as recommended by the foaming agent manufacturer. Foam shall be discharged into the mixer and blended with the cement slurry.

D. Mixing: The mixer shall be configured for compatibility with the pump to ensure continuous and uniform flow at the point of placement. The mixer shall be capable of providing a super-wetted, homogenized mix. The mixer shall be fitted with a meter with an accuracy of ±1 gallon to measure the volume of water added to dry mix ingredients.
E. Pumping: Pumping equipment shall be capable of pumping concrete without pulsation or segregation. Pumping equipment shall be operated to convey a continuous, uniform stream of concrete without air pockets. Pumping equipment shall be equipped with a device to limit pumping pressure as required to prevent damage to steel pipe.

F. Piping, Injection Hoses, Ports, Valves, and Connections: Concrete shall be conveyed to placement points using steel piping or rubber hoses, with all components having an internal diameter of at least 2 inches. A system of valves shall be furnished in the line at or near the points of injection to facilitate sample collection. Suitable stop valves shall be furnished at injection points for use in venting air or maintaining pressure, as required.

G. Pressure Gauges: Pressure gauges shall display up to 150% of the maximum allowable pressure and be accurate to within 0.5% over the full range of the gauge. Pressure gauges shall be certified and calibrated in accordance with ANSI B40.1, Grade 2A. Pressure gauges shall be oil-filled type gauges attached to a saddle-type diaphragm seal.

2.03 SOURCE QUALITY CONTROL

A. The Contractor shall provide delivery and measurement of materials from batching equipment to within the accuracies specified in ASTM C94. Scales shall be tested periodically in a manner and at intervals set forth in the approved Quality Control Plan.

B. Fine aggregate, when used, shall be sampled and tested in accordance with ASTM C33 and at the frequency specified in the approved Quality Control Plan.

C. Fly ash shall be sampled and tested in accordance with ASTM C311 at least once daily.

D. Equipment to generate foam for cellular concrete shall be tested and calibrated each day for density and volume output.

E. The wet density of cellular concrete shall be sampled and tested in accordance with the following schedule, before the introduction of the foaming agent, noting the time and temperature every 30 minutes, after a change in the mix batched, and whenever compression test cylinders are made.

F. Mix design tickets shall be provided for cellular concrete backfill used each day, identifying the mix design criteria.

G. Delivery tickets for each load of backfill concrete shall be provided in accordance with ASTM C94.

3.00 EXECUTION

3.01 GENERAL REQUIREMENTS

A. The limits of each backfill placement shall be established based on size and capacity of batching and placing equipment, and mix parameters such as initial set time.

B. Lift heights shall be limited to avoid pipe flotation and to maintain cellular concrete parameters within specified limits.

C. Arrange and route utilities to provide ready and available services during backfill placement.

D. Temporary track systems used during tunnel construction may be left in place if the minimum indicated clearances are maintained and timber ties are removed.

3.02 PREPARATION

A. General: Verify that locations where backfill is to be placed are clean and free of standing or running water. If conditions warrant, operate dewatering systems until grouting operations are complete and grout has reached initial set. Where used, seal or otherwise
protect sheeting, panning, and drainage systems from infiltration by backfill. Verify that the pipe has been installed as specified in Section 02304-J Installation of Carrier Pipe in Tunnel.

B. Bulkheads: Erect full-height vertical bulkheads snug between excavated rock surface or tunnel support system and pipe no closer than 12 inches from the leading edge of the pipe. Provide an opening in the crown in addition to other required vent outlets. Provide an opening for the tunnel invert drain and at the casing invert to facilitate draining water away from the work during backfilling operations.

3.03 PLACEMENT OF ANNULAR BACKFILL

A. General: Methods employed shall completely fill the annular space behind the pipe with concrete. Where water inflows or zones of water seepage exceed 2 gallons per minute, erect panning to divert groundwater inflows away from backfill placement.

B. Lift Placement Requirements:

1. Use methods as required to avoid pipe flotation and damage to the pipe. Inject concrete on either side of the pipe simultaneously. Complete each lift for a particular section of tunnel being backfilled before starting the next lift in that length of tunnel being backfilled and before starting the first lift of a succeeding length of tunnel being backfilled.

2. Unless specified otherwise, install pressure grouting through grout fittings/ports for the casing pipe or tunnel liner plate. Grout fittings/ports shall be fabricated into casing pipe or tunnel liner plate per Section 02303-J-Steel Jacked Casing, Steel Liner Plate and Expandable Liner by Tunneling. After grouting, all grout ports shall be sealed with a threaded plug (using thread compound or tape), and grouted over to provide a continuous smooth interior surface of the pipe.

3.04 FIELD QUALITY CONTROL

A. General: Collect samples of fresh cellular concrete at the injection point or discharge point, as the case may be. Measure and record the volume of backfill placed. Compare actual volume placed for each length of tunnel being backfilled with the theoretical volume for that length of tunnel being backfilled. Use grout hole connections in the pipe to monitor the backfill placement operations.

B. Compression Tests: Take two sets of two cylinders for every 200 cubic yard batched, but no less than two sets per day, two sets per annulus between carrier pipe and tunnel liner/casing grouted, or two sets per lift. Test two cylinders at 28 days and test the additional two cylinders at 56 days.

C. Heat of Hydration Monitoring: Monitor the temperature rise during curing of backfill materials to confirm that the specified criteria have been achieved. Measure the temperature of the pipe after placement of each lift of backfill at the following times: immediately after placement, 30 minutes, 1 hour, 2 hours, and 4 hours.

D. Wet Density Test for Cellular Concrete: Sample at the injection point every 30 minutes, after a change in the mix batched, and whenever compression test cylinders are made.

END OF SECTION
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DIVISION 15

MECHANICAL
1.00 GENERAL

1.01 WORK INCLUDED
A. Perform a hydrostatic pressure test on each valved or plugged section of newly laid pipe after the pipe has been backfilled. Perform hydrostatic pressure test by raising the pressure in the pipe section to the required test pressure for the duration defined in Paragraph 3.02.

B. Plugs may be installed in concrete cylinder or steel pipe at intermediate locations for the purpose of testing shorter lengths of pipe with Owner approval. No additional compensation will be paid to the Contractor for testing at intermediate locations if Contractor uses this option.

C. Obtain water from the Owner for filling the pipeline for the hydrostatic test as shown on the Drawings. Provide the necessary piping, connection, pressure reducing and backflow prevention equipment required to conduct the test. Fill the new pipeline through a backflow prevention device. Leave the pipeline full of water upon completion of the hydrostatic test, unless internal test plugs must be removed to allow construction to continue or where pipe will gravity drain.

D. The Jamison water line is a transmission main that delivers water to the Cities of Irving and Grand Prairie. The total transmission main is approximately 14 miles long. Due to the amount of time that the transmission main will be removed from service for the construction of the relocated section, the entire transmission main shall be flushed, disinfected and pass the required bacteriological tests. Flushing, disinfection and testing shall be in accordance with AWWA C651 and this Section.

E. Water for a success test will be provided by Irving at no cost to the Contractor. Water required for failed tests must be purchased from Irving at published rates.

F. Dechlorinate all water drained from potable water mains in accordance with Irving Standard Specification Section 15043 – Water Dechlorination.

G. Measurement and Payment
   1. The work included in this Section shall be considered subsidiary to the contract unit price for construction of 48-inch AWWA C303 Bar-Wrapped Concrete Cylinder Pipe.

1.02 SUBMITTALS
A. Detailed Testing Plan - Provide an installation and testing plan with a detailed schedule for the period of time beginning with the first instance that the existing pipeline will need to be removed from service through reinstatement of service through the new pipe. The time of year and duration of service disruptions shall meet the requirements specified herein.
   1. The plan shall indicate how the pipe will be will be isolated, drained, flushed and filled for hydrostatic testing and disinfection, whether in segments or in total. Flushing points and means of dechlorination shall be indicated.
   2. The plan shall indicate when steps lead by the OPT are anticipated, such as inspections or valve operation beyond the limits of pipe replacement.

B. Prior to testing, submit calibration certificates for meters and pressure gauges used for testing.

C. Submit Hydrostatic Pipe Test Reports.

1.03 STANDARDS
A. American Water Works Association
   AWWA M9 Concrete Pressure Pipe
1.04 MEASUREMENT AND PAYMENT
   A. The work included in this Section shall be considered subsidiary to the contract unit price for construction of pipe to the lines, grades and extents indicated on the Drawings.

2.00 PRODUCTS (NOT USED)

3.00 EXECUTION

3.01 HYDROSTATIC TESTING
   A. General
      1. Perform hydrostatic test on bar wrapped concrete cylinder pipe in accordance with AWWA M9 and the pipe Supplier’s recommendations.

   B. Test Conditions
      1. Test pipe at 100% of the specified pipe working pressure as measured at the lowest pipe elevation.
      2. Test duration shall be 4 hours.

   C. Procedure
      1. Hydrostatically test the pipe after backfill over the test section of pipe has been completed for seven days. Check that all air valves are operational, all outlets are plugged and blowoff valves are closed tight. Install calibrated pressure gauges – one each at the lowest point of pipe being tested and one at the pressure source.
      2. Slowly fill the line with water and vent all air from the pipeline during filling. Provide backflow preventer on connection to potable water system.
      3. Allow the pipe to stand under a slight pressure for at least 48 hours to allow the mortar lining to become saturated and/or to allow the escape of remaining air trapped in the line. Examine bulkheads, valves, manholes, flanges, and connections for leaks during this period.
      4. Any observed leak shall be repaired before continuing with the test.
      5. Meters measuring make-up water and pressure gauges shall be calibrated prior to testing. Furnish all necessary equipment and include the cost for this effort in the Contract Price.
      6. Expel all air from the pipe before applying the specified test pressure. Provide taps in the line to expel air from high points where air valves are not provided. These taps must be made by the pipe manufacturer and approved by the Engineer. Tightly plug the tap after tests are complete. Include the cost for these taps in the Contract Price.

   D. Examination Under Pressure
      1. Inspect the pipe during the test to locate any leaks or breaks, defective joints, cracked or defective pipe, fittings, or valves. Correct defective Work identified during the pressure test.
      2. Correct all identified leaks even if leakage is within the parameters for permissible make up water per Paragraph 3.05.
      3. Test the pipe again after defective Work has been corrected. Repeat the test and correction of defective Work until satisfactory test results are obtained.

   E. Permissible Makeup Water
      1. Measure make up water required for the section of pipe being tested. Makeup water is the volume of water pumped into the test section of pipe necessary to maintain the specified test pressure after the pipe has been filled with water and the air expelled.
2. The maximum acceptable volume of makeup water for steel or bar-wrapped pipe installations is 10 gallons per inch of pipe diameter per mile of pipe tested per 24 hours. Calculate the maximum acceptable volume of makeup water using the following equation:

\[ V_m = \frac{10 \times D \times L}{5280} \]

Where:
- \( V_m \) is the maximum acceptable volume of makeup water in gallons for 24 hours
- \( D \) is the nominal pipe diameter in inches
- \( L \) is the length of the pipe test section in feet

As an example, the allowable amount of makeup water for a test section of 2,500 feet of 60 inch diameter pipe would be: \( 10 \times 60 \times 2500 / 5280 = 284 \) gallons

3.02 STERILIZATION

A. After the hydrostatic testing has been successfully completed and accepted, the pipe shall be cleaned, flushed and sterilized in accordance with AWWA C651, Section 4.

B. Contractor will be responsible for sterilization of the entire Jamison line from the Jamison meter vault to the Grand Prairie delivery point (approximately 14 miles).

C. Chlorine injection shall be set-up at the Jamison meter vault at a point directed by the OPT.

D. After removal of test plugs used for hydrostatic testing, the pipeline will be filled by opening the isolation valve at the Jamison meter vault. Any water flushed from the pipe during filling shall be dechlorinated.

E. Water that remains in downstream portions of the transmission main during the tie-in of the new main shall be flushed out of the pipe. Any water flushed from the pipe during filling shall be dechlorinated.

F. The concentration of disinfect and the duration of the test shall be in accordance with AWWA C651 depending on the method selected. If disinfection concentrations are high, the contractor shall provide dechlorination as directed by the OPT before water is allowed into storage tanks.

3.03 TESTING

A. Verification that the entire pipeline has been adequately sterilized shall be performed in accordance with AWWA C651, Section 5 and applicable TCEQ requirements.

B. Samples for verification shall be collected at least every 1,000 feet along newly laid pipe, and at Irving’s and Grand Prairie’s Points-of-Entry (two for Irving and one for Grand Prairie).

C. Samples shall be tested for coliform bacteria, HPC bacteria, chlorine residual, ammonia, pH, alkalinity, and turbidity.

D. Results shall be certified by a TCEQ-approved laboratory.

E. Water will be provided at no cost to the Contractor for a successful test. Water required for failed tests must be purchased from Irving at published rates.

END OF SECTION
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15044-J ABANDONMENT OF WATER MAINS

1.00 GENERAL

1.01 WORK INCLUDED

A. Abandonment in place of existing water mains and appurtenances using impervious cellular concrete fill.

B. Measurement and Payment

1. Filling of the existing water line to be abandoned shall be measured per cubic yard of fill material and paid for at the Total Unit Price as shown in the proposal. All additional necessary operations such as providing additional access to assure complete filling or installation of plugs shall be considered subsidiary to that price.

1.02 SUBMITTALS

A. All submittals shall be in accordance with TxDOT Specifications and this Section.

B. Submit product data for proposed plugs for approval.

C. Submit technical information for equipment and operational procedures including projected slurry injection rate, grout pressure, method of controlling grout pressure, bulkhead and vent design, and number of stages of grout application.

D. At least 15 days prior to commencing abandonment activities, submit plan for abandonment, describing proposed grouting sequence, bypass pumping requirements and plugging, if any, and other information pertinent to completion of work.

2.00 PRODUCTS

2.01 PLUGS

A. Grout Plugs: Cement-based dry-pack grout conforming to ASTM C1107, Grade B or C.

B. Manufactured Plug: Commercially available plug or cap specifically designed and manufactured to be used with pipe being abandoned.

2.02 IMPERVIOUS CELLULAR CONCRETE FILL

A. Type II in accordance with Irving Standard Specification Section 03601 – Impervious Cellular Concrete Fill

B. Placement characteristics: self-leveling.

C. Shrinkage characteristics: non-shrink.

D. Water bleeding for fill to be placed by grouting method in sewers: not to exceed 2 percent according to ASTM C940.

2.03 BALLAST

A. Ballast Material: Natural rock or concrete pieces with minimum size equal to at least 10 times maximum aggregate size of flowable fill and maximum size of 24 inches. Maximum dimension shall not be more than 20 percent of minimum dimension of space to be filled.

B. Ballast Composition: Free of regulated waste material.
3.00 EXECUTION

3.01 CUTTING AND CAPPING OF MAINS
A. Do not begin plug and abandonment operations until replacement main has been constructed and tested, all service connections have been installed, and main has been approved for use.
B. Install plug, clamp, and concrete reaction block and make cut at location shown on Drawings and/or as directed by the Owner.
C. Main to be abandoned shall not be valved off and shall not be cut or plugged other than as shown on Drawings.
D. Plug or cap ends or opening in abandoned main in manner approved by the Owner.
E. Remove and dispose of surface identifications such as manhole frames and valve stack lids.
F. Backfill excavations in accordance with Section 02200-J - Pipeline Excavation and Backfill.
G. Mark location of abandoned service connections on Drawings and provide to the Owner.

3.02 PREPARATION FOR ABANDONMENT
A. Have fill mix design reports and other submittals required by Paragraph 1.02 accepted by the Owner prior to start of placement. Notify the Owner at least 24 hours in advance of grouting.
B. Select fill placement equipment and follow procedures with sufficient safety and care to avoid damage to existing underground utilities and structures. Operate equipment at pressure that will not distort or imperil portion of work, new or existing.
C. Drain existing water main prior to starting fill placement. Dispose of water in accordance with Section 02402-J - Care of Water During Construction.

3.03 EQUIPMENT
A. Batching, mixing, and placing equipment shall be capable of producing a homogeneous mixture that meets the requirements of this specification. Cement, water, and foaming agent shall be mixed at the jobsite. Materials premixed and delivered to the jobsite will not be accepted.
B. Use concrete or grout pumps capable of continuous delivery at planned placement rate.

3.04 INSTALLATION OF FILL
A. The cellular concrete fill installer shall be certified and approved in writing by the foam agent manufacturer. The installer’s foreman shall have experience of installing a minimum of five (5) successful cellular concrete projects within the past 2 yrs. Filling operation shall be performed by experienced crews with equipment to monitor density of fill and to control pressure.
B. Abandon existing water main removed from service to the extents shown on the Drawings by completely filling water main with CCF.
C. Remove manholes, valve stacks, and other structures along the section of pipeline being abandoned in accordance with Irving Standard Specification Section 02020 – Manhole Abandonment or Manhole Removal.
D. Continuously place CCF from intermediate pour points. Pour points shall be spaced at a maximum of 600 feet apart so as to not exceed pours of 300 feet in length.
E. Pump CCF through bulkheads constructed for placement of two 2-inch PVC pipes or use other suitable construction methods to contain CCF in lines to be abandoned. These pipes will act as injection points or vents for placement of flowable fill.
F. Place CCF under pressure flow conditions into properly vented open system until fill emerges from vent pipes. Pump fill with sufficient pressure to overcome friction and to fill water main from low end, to discharge at high end.

G. Inject fill through replaced ballast using grouting equipment and series of grout pipes discharging at bottom of placement, allowing fill to rise through ballast effectively filling all voids. Alternatively, sequentially place individual pieces of ballast at same time as flowable fill is placed. Do not fill with ballast more than 50 percent of volume at any level, to prevent nesting and void formation.

H. Remediate placement of flowable fill which does not fill voids in water main, or in manholes or other structures, or where voids develop due to excessive shrinkage or bleeding of fill, by using pressure grouting either from inside sewer or from surface.

I. Clean inside surface of main at least 12 inches from ends to achieve firm bond and seal grout plug or manufactured plug to pipe surface. Similarly, clean and prepare exterior pipe surface if manufactured cap is to be used.

J. When using grout plug, place temporary plug or bulkhead approximately 12 inches inside pipe. Fill pipe end completely with dry-pack grout mixture.

K. When using manufactured plug or cap, install fitting as recommended by manufacturer’s instructions, to form water tight seal.

L. Backfill to surface, above pipe or structures left in place, with flowable fill in restricted areas, compacted bank run sand in unrestricted areas to be paved or select fill in unrestricted areas outside of pavement. Place and compact backfill, other than flowable fill, in compliance with Section 02200-J Pipeline Excavation and Backfill.

M. Collect and dispose of excess fill material and other debris in accordance with local requirements or as directed by the Owner.

3.05 PROTECTION OF PERSONS AND PROPERTY

A. Provide safe working conditions as required by OSHA and applicable State and local laws for employees throughout demolition and removal operations. Observe safety requirements for work below grade.

B. Maintain safe access to adjacent property and buildings. Do not obstruct roadways, sidewalks or passageways adjacent to Work.

3.06 TESTING

A. During placement of the initial batches, check the wet density and adjust the mix as required to obtain the specified cast density at the point of placement.

B. At hourly intervals during placing, monitor and log the density and adjust as necessary to maintain the specified cast density.

C. Conduct the compressive strength tests in accordance with ASTM C 495. Provide a CCF compressive strength at 28 days as specified in Table I of Irving Standard Specification Section 03601 – Impervious Cellular Concrete Fill

D. Penetrometer readings shall be taken with a Soiltest Mortar Penetrometer, model CT-421A, or approved equal. The upper three inches of the area of the cured CCF mixture tested shall be removed prior to taking the penetrometer readings. The test value of record shall be the average of three tests.

3.07 PAYMENT AND MEASUREMENT

A. The contract unit price per linear foot of water main to be abandoned shall be the total compensation for furnishing all material, labor, equipment, tools and superintendence necessary to complete the work in accordance with the Contract Documents, including but not limited to:
1. Furnishing, delivery and installation of abandonment materials.
2. Excavation, stockpiling, and backfilling of spoil.
3. Excavation sheeting, shoring and bracing.
4. Dewatering.
5. Site clean-up.
6. Other incidental work required by the Contract Documents.

END OF SECTION
1.00  GENERAL

1.01  WORK INCLUDED

A.  Scope of Work

1. Furnish labor, materials, equipment, and incidentals necessary to manufacture, deliver, install, test, and ready for operation bar wrapped concrete cylinder pressure pipe, fittings, and specials as shown on the Drawings and as specified herein, including concrete or cement mortar lining, cement mortar coating, additional special linings and coatings, joints, connections, and appurtenances, for potable water applications.

2. Lining and coating shall be shop applied except as necessary for field repairs and joint protection.

B.  Measurement and Payment

1. The installation of pipe shall be measured per linear foot and will be paid for at the total unit price as shown in the bid proposal for the size, class, and type specified. This item includes furnishing and placing the pipe, including: joint connections as specified; bends; bevels; outlets; test fittings and access manholes; other fittings as shown on the plans; barricading; relocation of power and light poles as shown on the plans; replacement of landscaping; excavation; all embedment and backfill materials, placement, compaction and testing; temporary plugs and fittings; cleaning, disinfection, flushing, dichlorination and/or disposal of heavily chlorinated water; and all specified pipe testing; in accordance with the specifications and plans. This item includes all labor, materials, tools, equipment, and incidental items necessary to complete the work. This item also includes all required permitting for the pipe construction, including fees, insurance requirements, training, flag men, and other permit contingencies required by DART. This item consists of all work associated with the relocation of the 48-inch Jamison water line exclusive of items listed separately.

C.  Related Sections

1. Section 02200-J – Trenching and Backfilling
2. Section 02304-J – Installation of Carrier Pipe in Tunnel
3. Section 15040-J – Hydrostatic Testing
4. Section 15086-J – Slow Closing Combination Air Release and Vacuum Relief Valves
5. Section 15087-J – Blowoff Valves for Water Service
6. Section 15101-J – Butterfly Valves
7. Section 15150-J – Miscellaneous Pipeline Valves and Appurtenances
8. Section 15240-J – Corrosion Protection Systems

1.02  DEFINITIONS

A.  Owner: City of Irving

B.  Engineer: Unless referencing the Contractor’s Engineer, Halff Associates, Inc. or its subconsultants

C.  Owner’s Project Team (OPT): Representatives of the Engineer and/or Owner, including Owner’s utility and inspection staff, and others as may be designated by the Owner.

1.03  REFERENCES

Except as modified or supplemented herein, the work included in this Section shall conform to the applicable requirements of the following standards, latest edition.
A. American Society of Mechanical Engineers (ASME):

ASME BPVC IX  Boiler and Pressure Vessel Code, Section IX: Welding, Brazing, and Fusing Qualifications

B. ASTM International (ASTM):

ASTM A193  Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194  Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A307  Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength
ASTM A370  Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A563  Standard Specification for Carbon and Alloy Steel Nuts
ASTM C33  Standard Specification for Concrete Aggregates
ASTM C144  Standard Specification for Aggregate for Masonry Mortar
ASTM C150  Standard Specification for Portland Cement
ASTM C497  Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile
ASTM E165  Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709  Standard Guide for Magnetic Particle Testing
ASTM E1417  Standard Practice for Liquid Penetrant Testing
ASTM E1444  Standard Practice for Magnetic Particle Testing
ASTM F593  Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

C. American Welding Society (AWS):

AWS D1.1  Structural Welding Code – Steel

D. American Water Works Association (AWWA):

AWWA C206  Field Welding of Steel Water Pipe
AWWA C207  Steel Pipe Flanges for Waterworks Service – Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm)
AWWA C217  Petrolatum and Petroleum Wax Tape Coatings for the Exterior Connections and Fittings for Steel Water Pipelines
AWWA C303  Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
AWWA M9  Manual: Concrete Pressure Pipe

E. International Organization for Standardization (ISO):

ISO 9001  Quality Management Systems – Requirements

F. NSF International (NSF):

NSF 61  Drinking Water System Components – Health Effects

1.04 SUBMITTALS

Submittals shall be in accordance with TxDOT specifications and include the following.

A. Pipe Installation Schedule and Detailed Testing Plan

1. Provide an overall project schedule for the pipeline relocation indicating:
a. Pipe production and delivery
b. Mobilization and site prep
c. Tunneling operations, including anticipated work time crossing DART right-of-way
d. Anticipated working time on FedEx property
e. Anticipated working time requiring the existing pipeline to be removed from service
f. Testing and startup of the new installation
g. Abandonment of the existing pipeline
h. Surface restoration, cleanup and demobilization

2. Detailed Testing Plan – Refer to Section 15040-J – Hydrostatic Testing and Disinfection

B. Shop Drawings and Product Data

The following data and information shall be submitted and approved prior to pipe fabrication.

1. Anticipated production and delivery schedule.

2. Design calculations for the pipe showing methods and processes used to satisfy the pipe and fittings design criteria specified in the Contract Documents, including:
   a. Design specification data sheets listing all parameters used in the pipe design.
   b. Calculations for pipe and fittings design, fittings reinforcement design, material thicknesses, thrust restraint, shop and field welds, linings, and joint dimensions. Calculations shall show maximum design pressure, surge pressure, hydrostatic test pressure, deflection, and buckling.
   c. All calculations shall be signed and sealed by a Professional Engineer licensed in the State of Texas.

3. Pipe Manufacturer’s fabrication and lay drawings, including:
   a. Fabrication and lay drawings showing a schematic location with profile and a tabulated layout schedule, both of which shall reference the stationing and invert elevations of the proposed pipeline as shown on the Drawings.
   b. Full details and dimensions of joints, pipe, and fittings, and locations and details for the fabrication of all fittings and specials.
   c. Provisions for thrust restraint as shown on the Drawings, incorporating the limits of each reach of restrained and/or welded joints and including field welded joint restraint calculations.
   d. Where welded joints are required, location of all outlets required by the Contractor to conduct welding operations, provisions for thermal stress control, and provisions for control of coating damage.
   e. Locations and details of bulkheads for hydrostatic testing of the pipeline, including method of attachment to the pipeline and methods to prevent excessive pipe wall stresses.
   f. Stulling plan showing size, number, and location of stulls to be placed in the pipe.
   g. Mix design for concrete or cement mortar lining and cement mortar coating.
   h. All shop drawings shall be based on the Contract Documents and shall be updated during construction as required to incorporate changes necessary to avoid conflicts with existing utilities and structures.

4. Pipe Manufacturer’s documentation, including:
   a. Pipe Manufacturer’s Welding Procedure Specifications in accordance with AWWA C206, and AWS D1.1 or ASME BPVC IX.
   b. Welding certificates and Welder Qualification Records in accordance with AWWA C206, and AWS D1.1 or ASME BPVC IX for all factory welders.
   c. Inspection procedures to be used by Pipe Manufacturer for quality control and assurance for materials and welding. Submit standard repair procedures that describe in detail shop and field work to be performed.
d. Certification showing calibration within the last 12 months for equipment such as scales, measures devices, and calibration tools used in manufacture of pipe. Each device used in manufacture of pipe is required to have a tag recording the date of last calibration. Devices are subject to inspection by Owner.

5. Product data for flexible joint couplings, joint wrappers, flanges, nuts, bolts, gaskets, and bonding agents.

6. Contractor’s proposed field Welding Procedure Specifications in accordance with AWWA C206 and AWS D1.1.

7. Contractor’s mix design for cement mortar for joints and field patching.

C. Certifications and Test Reports

The following data and information shall be submitted prior to pipe shipment.


2. Certified affidavit of compliance from the Pipe Manufacturer that all pipe, fittings, and specials for this Contract were manufactured, inspected, and tested in accordance with the applicable AWWA standards and meet or exceed the requirements of the Contract Documents. Affidavit shall certify that all pipe and fittings are new and not supplied from inventory.

3. Pipe Manufacturer’s test reports, including:
   a. Mill certificates, including chemical and physical test results for each heat of steel, Charpy v-notch tests, and elongation tests.
   b. Welding inspector certificates and certified test reports for factory welds of fittings from a Certified Welding Inspector provided by the Pipe Manufacturer.
   c. Copies of results of factory hydrostatic tests for pipe sections and fittings.
   d. Certified test reports for concrete and cement mortar tests.
   e. Copies of results of Pipe Manufacturer’s factory quality control tests.

4. Pipe Manufacturer’s recommended procedures for field patching of lining and coating and installation of joint wrappers.

5. Welding certificates and Welder Qualification Records in accordance with AWWA C206 and AWS D1.1 for all of the Contractor’s proposed field welders.

6. Gasket certification in accordance with AWWA C207.

7. Any other certified test reports for materials as specified in applicable AWWA standards.

D. Record Data

1. Record data showing stations and top-of-pipe elevations at each pipe joint shall be submitted weekly.

2. Daily welding reports for field welding showing welder and joint welded shall be submitted monthly.

3. Submit welding inspector certificates and certified test reports for field welds from a third party Certified Welding Inspector retained by the Contractor.

4. Reports showing deflection measurements and calculated deflection for each location measured shall be submitted no later than 21 days after backfill to final grade.

5. Submit copies of results of field pressure/leakage tests.

6. After construction, the Contractor shall submit red-lined Drawings showing all changes made during construction.

7. After construction, the Pipe Manufacturer shall provide the pipe plan and profile layout drawings showing each joint of pipe and all fittings, specials, and appurtenances, incorporating any changes made during construction, using the same coordinate system as used on the Drawings.
1.05 QUALITY ASSURANCE

A. Pipe Manufacturer Qualifications

1. Pipe and fittings shall be the product of one manufacturer with at least five years successful experience manufacturing pipe of the particular type, size, and quantity of pipe specified for this project. Pipe manufacturing operations (including pipe, fittings, specials, linings, and coatings) shall be performed at one location unless otherwise approved by the Engineer. Only the following manufacturers will be considered: Thompson Pipe Group and Northwest Pipe Company.

2. Pipe Manufacturer shall be certified under the American Concrete Pressure Pipe Association (ACPPA) Compliance Audit and Certification Program for concrete pressure pipe and accessory design and manufacturing.

3. Pipe Manufacturer shall have a quality control program certified under ISO 9001 for concrete pressure pipe and accessory manufacturing.

B. Welder Qualifications

1. The Pipe Manufacturer’s factory welders shall be skilled certified welders that are performance qualified per the requirements of AWWA C206, and AWS D1.1 or ASME BPVC IX.

2. The Contractor’s field welders shall be skilled certified welders that are performance qualified per the requirements of AWWA C206 and AWS D1.1. Welders, welding operators, and tackers shall have adequate experience in the methods and materials to successfully perform all welding required for the installation of the proposed pipe, fittings, and specials. All welders shall have been certified within the last six months or shall provide a welding continuity log to be allowed to weld on the pipe line. Field welding shall be provided by one of the following firms:
   a. Fuller Services, Barry Fuller, 817-946-5458
   b. Rangeline Pipeline and Services, Ryan Alumbaugh, 682-250-2153
   c. Thompson Pipe Group
   d. Eddie's Welding Services, Eddie Pierce, 817-909-6089
   e. National Welding Corporation, Nash Williams, 801-255-5959
   f. No others will be accepted

3. The Contractor shall furnish all material and bear the expense of qualifying welders. Machines and electrodes similar to those to be used in the work shall be used in qualification tests.

C. Certified Welding Inspectors

1. The Pipe Manufacturer shall provide for the services of a Certified Welding Inspector to ensure all factory welding of fittings meets the requirements of this Section and other referenced welding specifications.

2. The Owner shall retain the services of a Certified Welding Inspector, certified in accordance with AWS D1.1, for inspection of all field welded joints.

D. Owner Testing and Inspection

1. Pipe, fittings, and specials may be subject to inspection at the manufacturing plant by an independent testing laboratory selected and retained by the Owner. The OPT and/or representatives of the independent testing laboratory shall have free access to the work whenever it is in preparation or progress, and the Pipe Manufacturer shall provide proper facilities for access and inspection.

2. The Pipe Manufacturer shall provide written notice to the Owner a minimum of two weeks prior to pipe fabrication as to fabrication schedule so that the Owner may determine and advise the Pipe Manufacturer as to the Owner’s decision regarding tests to be performed by an independent testing laboratory. Materials used in the manufacturing of the pipe
may be tested by the independent testing laboratory in accordance with the provisions of AWWA C303 and this Section.

3. In the event the Owner elects to retain an independent testing laboratory to make material tests and weld tests, it is the intent that the tests be limited to one spot testing of each category unless the tests do not show compliance with the standard. If these tests do not show compliance, the Owner reserves the right to have the laboratory make additional tests and observations.

4. Pipe, fabricated parts, and materials which are discovered to be defective or not in conformance with the requirements of the Contract Documents shall be subject to rejection at any time prior to Owner’s final acceptance of the product.

5. The inspection and testing by the independent testing laboratory anticipates that production of pipe will be done over a normal period of time and without “slow downs” or other abnormal delays. In the event that an abnormal production time is required due to delays by the Contractor or the Pipe Manufacturer, and the Owner is required to pay any excessive costs for inspection, then the Contractor shall be required to reimburse the Owner for such laboratory costs over and above those which would have been incurred under a normal schedule of production.

E. Field Representative

1. During the construction period, the Pipe Manufacturer shall furnish the services of a qualified, factory-trained, job-experienced field representative to advise and assist the Contractor in his pipe laying operations and instruct construction personnel in proper joint assembly and inspection procedures.

2. The field representative shall be on site full-time during installation of the first two pipe joints by each of the Contractor’s crews and thereafter as requested by the OPT or Contractor. The field representative shall also be subject to call by the Contractor and/or Owner to advise and assist with the solution of field problems.

3. During his site visits, the field representative shall observe all phases of the installation including pipe stockpiling and handling, trench conditions, pipe installation, bedding and backfill, and joint assembly. If, in the opinion of the field representative, any phase of the installation is unsatisfactory and jeopardizes the performance of the pipe, he shall so advise the Contractor and Owner.

4. The field representative shall be required to return to the project site at no additional cost to the Owner if, in the opinion of the Engineer, the pipe, fittings, or specials, or Contractor’s construction methods involving these materials do not comply with the Specifications.

1.06 DELIVERY AND STORAGE

Deliver, handle, and store all pipe in accordance with this Section, AWWA M9, AWWA C303, and the Pipe Manufacturer’s recommendations to protect the pipe, lining, and coating.

A. Packing and Shipment

1. The pipe shall be prepared for shipment to afford maximum protection from normal hazard of transportation and allow pipe to reach the project site in an undamaged condition. Pipe damaged in shipment will not be accepted at the site until it is satisfactorily repaired. Damaged pipe that cannot be repaired shall be returned to the Pipe Manufacturer’s facility and properly repaired.

2. After the completed pipe, fittings, and specials have been removed from the final cure at the manufacturing plant, the shop applied concrete or cement mortar lining shall be protected from drying by means of plastic end covers banded to the pipe ends. Covers shall be maintained over the pipe ends at all times until ready to be placed in the trench. Moisture shall be maintained inside the pipe by periodic addition of water as necessary.

3. Prior to shipment, pipe shall be visually inspected for damage to the shop applied pipe lining and coating and repaired as necessary.
4. Pipe shall be carefully supported during shipment, storage, and installation. Pipe, fittings, and specials shall be separated so that they do not bear against each other, and the whole load shall be securely fastened to prevent movement in transit. Ship pipe on padded bunks with tie-down straps located approximately over stulling. Store pipe on padded skids, sand or dirt berms, sand bags, tires, or other suitable means to protect pipe from damage.

5. All pipe, fittings, and specials 36 inches in diameter or larger shall be internally supported and braced with stulls as soon as practical after fabrication to maintain a true circular shape.
   a. Internal stulls shall be located at each end of each length of pipe, fitting, and special and the middle of each pipe joint. Additional stulls shall be provided if required to protect the pipe, lining, or coating from damage as determined by the Pipe Manufacturer or if they will be greater than 15 feet apart.
   b. Internal stulls shall consist of timber or steel firmly wedged and secured so that the stulls remain in place during storage, shipment, and installation. Pipe and lining shall be protected from damage from stulls using shaped wood pads or similar devices as necessary. Pipe shall be rotated so that one stull remains vertical during storage, shipment, and installation. Stulls shall not be removed until pipe is laid, set to grade, and backfilled.

B. Marking for Identification
   1. Each joint of pipe and each fitting shall be marked on the inside of each end with the following information:
      a. Class for which it is designed
      b. Date of manufacture
      c. Project name
      d. Identification number as shown on the Shop Drawings
      e. Beveled pipe shall be marked with the amount of bevel
   2. Markings should be visible from inside the pipe after installation during and after field welding, joint grouting, and inspection. Markings should be applied a minimum of 3 inches in height with a waterproof paint or dye resistant to fading due to UV exposure.
   3. The outside top centerline shall be marked on all fittings and specials.

C. Point of Delivery
   1. The pipe shall be delivered direct from pipe plant to the project site and strung along pipeline route, thus avoiding re-handling of the pipe and the possibility of damage thereto. Where fully loaded truck and trailer cannot operate along the pipeline route, pipe may be unloaded at access points along the route and brought to the trench side by approved methods; however, the Contractor shall be responsible that pipe is undamaged at the time of laying the pipe in the trench. The Contractor is responsible for securing and maintaining a location to store the pipe.
   2. Prior to shipment, pipe shall be visually inspected for damage to the shop applied pipe lining and coating and repaired as necessary.
   3. Reject or repair the damage in accordance with this Section before placing into the trench.
   4. The Contractor shall visually inspect all pipe, fittings, and specials for damage upon arrival at the project site. Upon delivery of the pipe, notify the Owner so that inspection may be made.
      a. The lining and coating of all pipe, fittings, and specials shall be checked for cracking. Reject or repair the damage in accordance with this Section.
      b. If excessive cracking is found, exceeding the allowance in AWWA C303, modify shipping procedures to reduce or eliminate cracking.
c. Pipe damaged in shipment shall not be delivered to the project site until such
damaged pipe is properly repaired by the Pipe Manufacturer in accordance with
AWWA C303 repair procedures.
d. Under no circumstances will a dropped pipe be used unless inspected and approved
by the Owner and pipe manufacturer.

2.00 PRODUCTS

2.01 MATERIALS

A. General

1. All pipe and fittings shall be new and not supplied from inventory. All pipe and fittings
shall be manufactured in the continental U.S.A. using materials made in the U.S.A.
Shipping manufactured pipe and fittings over salt waterways will not be allowed.

2. All material used for manufacturing pipe, fittings, and specials shall be in accordance with
AWWA M9 and AWWA C303 unless otherwise specified herein.

B. Cement

1. Cement used in concrete and mortar shall be ASTM C150 Type I or II.

C. Aggregates

1. Aggregates used in concrete and mortar for pipe lining and coating shall conform to
ASTM C33.

D. Sand

1. Sand used in mortar for pipe joints shall be of silica base, conforming to ASTM C144.

E. Steel

1. Steel shall meet the requirements of AWWA C303. Steel shall be homogenous and shall
be suitable for field welding.

F. Joint Wrappers

1. Joint wrappers shall be fiberglass reinforced or burlap cloth, 9 inches wide for pipe 36
inches and larger, and 7 inches wide for pipe smaller than 36 inches, hemmed on each
side.

2. Joint wrappers shall be as manufactured by MarMac Construction Products, Inc. or
approved equal.

G. Pipe Flanges, Nuts, Bolts, and Gaskets

1. Furnish all bolts, nuts, flange gaskets, and insulation kits.

2. Flanges shall be in accordance with AWWA C207, class equal to or greater than the
pressure class of the adjacent pipe. Coordinate dimensions and drilling of flanges with
flanges for valves, pumps, and other equipment to be installed in the piping system.

3. All buried hardware shall be ASTM F593 Type 316 stainless steel with sufficient strength
to meet the strength required for the service conditions.

4. Fastener hardware at Class B and D flanges exposed inside buildings, vaults, or
manholes shall be ASTM A307 Grade B bolts with ASTM A563 Grade A heavy hex nuts.

5. Fastener hardware at Class E and F flanges exposed inside buildings, vaults, or
manholes shall be ASTM A193 Grade B7 bolts with ASTM A194 Grade 2H heavy hex
nats.

6. All bolts shall be long enough that a minimum of three threads are exposed beyond the
nut. Use an anti-seize compound on bolt threads during installation.

7. Non-insulating gaskets shall meet the requirements in AWWA C207. Gaskets shall be
full-face, minimum 1/8 inch thick. Finished gaskets shall have holes punched by the
manufacturer and shall match the flange pattern in every respect. Frayed cut edges resulting from job site gasket fabrication are not acceptable.

H. Buried Ferrous Metal Coatings
   1. Coatings for buried ferrous metal such as flanges, nuts, bolts, and dresser couplings shall be Densyl Tape system manufactured by Denso, consisting of Densyl Mastic, Densyl Paste, and Densyl Tape, or approved equal.

I. Threaded Outlets
   1. Where outlets or taps are threaded, furnish and install brass bushings and plugs for the outlet size indicated.

J. Outlets for Weld Leads
   1. The Contractor may use factory manufactured outlets for access for weld leads, in addition to outlets for appurtenances. Outlets for weld leads may be flanged or threaded. Outlet configuration shall be as shown in the Shop Drawings and shall be approved by the Engineer. Spacing of outlets shall be as determined by the Contractor and Pipe Manufacturer.
   2. Outlets for weld leads shall be welded closed after use. Procedure for welding of outlets for weld leads shall be approved by the OPT prior to application.

K. Flexible Joint Couplings
   1. Flexible joint couplings shall be Dresser Style 38, Smith-Blair Style 411, or approved equal.

L. Test Plugs
   1. The Contractor shall furnish test plugs in accordance with the Drawings and as needed to perform field hydrostatic tests. Additional test plugs not shown in the Drawings but requested by the Contractor will be paid for by the Contractor.
   2. Each test plug shall be designed to withstand the test pressure on either side with only atmospheric pressure on the opposite side.

2.02 MIXES
A. Cement Mortar
   1. Cement mortar used for pipe joints shall consist of 1 part Portland cement to 2 parts clean, fine, sharp silica sand, mixed with water.
   2. Interior joint mortar shall be mixed with as little water as possible so that the mortar is very stiff, but workable.
   3. Exterior joint mortar shall be mixed to the consistency of thick cream.
   4. Water for cement mortar shall be treated and suitable for drinking water.
   5. In cold weather, joint mortar shall be protected from freezing. Mortar which has been allowed to freeze shall be rejected and disposed.
   6. Cement mortar used for patching shall be mixed as per cement mortar for interior joints.
   7. Cement mortar used for protection of exposed metal shall be mixed as per cement mortar for interior joints.
   8. Bonding agent for interior joint mortar and pipe patching shall be Probond Epoxy Bonding Agent ET-150 parts A and B, Sikadur 32 Hi-Mod, or approved equal.

2.03 MANUFACTURED PIPE
A. General
   1. All pipe, fittings, and specials shall be designed, manufactured, and tested in accordance with AWWA M9, AWWA C303, and the criteria specified herein.
2. All products and manufacturing shall comply with applicable federal, state, and local environmental control regulations for air pollution, worker exposure, surface preparation, blast cleaning, disposition of spent aggregate and debris, and lining and coating applications.

3. Nominal pipe sizes and pressure classes shall be as shown on the Drawings. The inside pipe diameter, including the concrete or cement mortar lining, shall be at a minimum the nominal pipe diameter as shown on the Drawings. Fittings, specials, and connections shall be the same pressure class as the associated pipe.

4. Fittings and specials shall be fabricated from hydrostatically tested pipe or welded steel sheets or plates. Ends of fittings and specials shall be compatible with the type of joint or coupling specified for the pipe.

5. All pipe, fittings, and specials shall meet the requirements of NSF 61.

6. Trench depths indicated shall be verified by the Contractor after existing utilities are located. Vertical alignment changes required because of existing utility or other conflicts shall be accommodated by an appropriate change in pipe and embedment design. In no case shall the pipe and embedment system be installed deeper than its design allows. If additional depth is required, the Contractor shall submit calculations and provide additional wall thickness as required at no additional cost to the Owner.

B. Pipe Design Criteria

1. Internal Pressure
   a. Working pressure shall be the pressure class specified on the Drawings.
   b. Transient (surge) pressure plus working pressure shall be 150% of the pressure class specified on the Drawings.
   c. Internal field test pressure shall be 100% of the pressure class specified at the lowest pipe elevation.

2. External Loading
   a. Earth (dead) load shall be based upon the following parameters:
      1) Construction Conditions: Trench
      2) Trench Width: As shown on Drawings
      3) Trench Depth: As shown on the Drawings
      4) Bedding Conditions: As shown on Drawings
      5) Unit Weight of Fill (\(w\)): 130 pcf
      6) Coefficient (\(K_{U}\)): 0.150
      7) Deflection Lag Factor (\(D_{l}\)): 1.0
      8) Coefficient (\(k\)): 0.090
      9) Modulus of Soil Reaction (\(E'\)): 600 psi
      b. Live load shall be based upon the following parameters:
         1) AASHTO HS-20 loading, unpaved condition, at all locations except railroads
         2) AREMA Cooper E-80 loading at railroads
      c. Maximum steel stress at working pressure: 18,000 psi
   d. Minimum steel tensile yield strength: 36,000 psi
   e. Maximum allowable deflection (\(D_y = D_o\)): 1%

3. Surcharge Loading
   a. For pipe not inside encasement, the pipe design shall account for the following additional future surcharge loading conditions:
      1) Additional earth (dead) load equivalent to the depth shown on the Drawings plus an additional 7 feet of fill over the pipe.
      2) Transient (live) line loading produced by construction equipment that will be over the pipeline for short durations, equivalent to a fully loaded Link Belt Model 238 Hylab 5 crane (150-ton capacity).
   b. Maximum allowable deflection with any or all of the specified additional future surcharge loadings taken into account: 1.2%
C. Provisions for Thrust

1. Thrust at bends, tees, plugs, valves, or other fittings shall be resisted by restrained joints as shown on the Drawings. Restrained joints shall be used a sufficient distance from each side of each bend, tee, plug, valve, or other fitting to resist the thrust that develops at 150% of the pressure class specified.

2. Restrained joints shall consist of welded joints unless other types of joint restraint are shown on the Drawings. Thrust collars will only be permitted for temporary pipe plugs.

3. Thrust at bends adjacent to casing shall be restrained by welding joints through the casing and a sufficient distance each side of the casing. No thrust restraint contribution shall be allowed for pipe in casing.

4. In areas where restrained joints are used for thrust restraint, the pipe shall have adequate cylinder thickness to transmit the thrust forces. For welded joints, if the thickness of the steel cylinder adjacent to the welded joint is greater than or equal to 0.1875 inch, the joints to be welded shall be prepared by trimming the spigot in the shop.

5. The Pipe Manufacturer shall submit thrust calculations with the fabrication and lay drawings verifying that the thrust restraint system is adequate to meet the Pipe Manufacturer’s minimum standards, AWWA M9, or the Contract Documents, whichever is more stringent.

6. The length of pipe with restrained joints, pipe cylinder thickness, and all other provisions necessary to resist thrust forces shall be determined by the Pipe Manufacturer in accordance with AWWA M9 and the following parameters:
   a. The length of pipe with restrained joints shall not be less than the minimum required length shown on the Drawings.
   b. The water table shall be assumed to be above the pipe.
   c. Soil Cover: Minimum depth from ground surface to top of pipe over restrained area as shown on Drawings
   d. Soil Type: As indicated in the Geotechnical Investigation
   e. Buoyant Unit Weight of Fill: 60 pcf
   f. Coefficient of Friction (μ): 0.30

D. Pipe Ends

1. The standard pipe ends shall have a shop applied primer and shall include steel joint rings with a continuous solid rubber ring gasket as per AWWA M9 and AWWA C303.

2. Welded joints shall be provided as required for thrust restraint.

3. Harnessed joints and flanged joints shall be provided where indicated on the Drawings.

4. Harnessed joints may be used in lieu of welded joints adjacent to structures, if approved by the OPT.

5. Butt Strap Closure Joints
   a. Closure joints will be allowed where necessary to make closure to pipe previously laid or for applications requiring field adjustments. Closure joints shall be installed using butt strap joints in accordance with AWWA C206 and applicable provisions of this Section. Closure joints shall be coated with a shop-applied primer.
   b. Closure sections and other short sections of pipe shall be furnished by the Pipe Manufacturer. The Contractor shall make all field measurements necessary for fabrication of these sections and shall be responsible for their accuracy.
   c. Butt strap closure joints which cannot be hydrostatically tested in the field with the main pipeline shall be welded inside and outside as detailed in the Drawings and shall be air tested. Provide 1/4-inch NPT threaded fittings between the weld areas to accommodate the air tests.

6. Flanged Joints
   a. Flanged joints shall be provided at connections to valves and where indicated on the Drawings. No slip-on flanges will be allowed. Pipe flanges shall be shop welded and
welding of flanges to pipe shall conform to the requirements of AWWA C206 and AWWA C207.

b. Pipe flanges shall be designed for the same pressures as the adjacent pipe. Flanges shall match the fittings or appurtenances which are to be attached. Provide insulation kits in locations shown on the Drawings.

E. Shop Applied Lining and Coating

1. Concrete or cement mortar lining of pipe shall be centrifugally cast to leave a smooth lining. All rough spots shall be ground down with a rubbing stone or other approved method.

2. Concrete or cement mortar lining and cement mortar coating at joints intended to be welded shall be held back a sufficient distance from the weld location to allow for a full magnetic particle test or dye penetrant test to be performed on the weld.

3. Pipe to be installed in casing shall have two built-up mortar rings, each approximately 2 feet long and slightly higher than the pipe bell, to prevent the pipe from being supported by the pipe bell. Mortar bands shall be built-up at the pipe length form each pipe end section.

F. Curves and Bend Fittings

1. Curves may be made by deflecting the joints, by use of beveled joints, or by a combination of the two methods, unless otherwise indicated on the Drawings or permitted by the OPT.
   a. Maximum joint opening and deflection shall not exceed 75% of that recommended by the Pipe Manufacturer.
   b. Beveled pipe sections used in curved alignment shall each be substantially of standard length except when shorter sections are required to limit the radius of curvature, in which case all sections throughout the curve shall be of substantially equal length. No bevel shall be greater than 5 degrees.

2. Bend fittings shall be long radius (minimum radius of 2.5 times the inside pipe diameter) to allow passage of cleaning pigs. The maximum miter angle on each section of the bend shall not exceed 11-1/4 degrees (one cut bend up to 22-1/2 degrees).

2.04 FACTORY TESTING

The Pipe Manufacturer shall perform all tests as required by AWWA C303 and as listed herein.

A. Mill Certification

1. The Owner will require the manufacturer to furnish mill test certificates on steel coil, steel plate, reinforcing steel or wire, and cement. The manufacturer shall perform the tests described in AWWA C303 for all pipe, fittings, and specials.

B. Charpy V-Notch Test

1. Each heat of steel for plates or coil 0.25 inch and thicker shall be tested to verify minimum full-size sample impact values of 25 foot-pounds at 30 °F in accordance with ASTM A370, except that tests are not required for small heats used for fittings. Minimum Charpy values for sub-size samples shall be as defined in ASTM A370.

C. Elongation

1. For the tensile test specified in ASTM A370, 2-inch test specimens shall show elongations not less than 22% for each heat of steel.

D. Hydrostatic Pressure Testing

1. Each pipe cylinder, with joint rings welded to its ends, shall be hydrostatically tested prior to application of lining or coating. The internal test pressure shall be that which results in a fiber stress equal to 75% of the minimum yield strength of the steel used. Each pipe
cylinder tested shall be completely watertight under maximum test pressure. The test pressure shall be held for sufficient time to observe the weld seams.

2. As a part of testing equipment, the Pipe Manufacturer shall maintain a recording pressure gauge and the reference number of each pipe cylinder tested. The pipe shall be numbered in order that this information can be recorded.

3. All welds on fittings not previously hydrostatically tested shall be tested by hydrostatic test, air test, ultrasonic test, magnetic particle test, or dye penetrant test. Air test shall be made by applying air to the welds at 10 psi pressure and checking for leaks around and through welds with a soap solution as described in AWWA C206. In addition, 10% of welds for fittings shall be checked with x-ray or ultrasonic testing by a third party Certified Welding Inspector paid for by the Pipe Manufacturer.

E. Cement Mortar Lining

1. Shop applied concrete or cement mortar linings shall be tested in accordance with AWWA C303.

F. Cement Mortar Coating

1. Absorption Test
   a. Shop applied cement mortar coatings shall be tested for absorption in accordance with AWWA C303 and ASTM C497 Method A.

2. Strength of Coating
   a. Tests shall be made of cured mortar coating for the purpose of qualifying the mortar coating machine and the mortar mix design. 1-inch cubes shall be tested in accordance with ASTM C109. The equivalent cylinder compressive strength of the mortar (0.74 times the cube strength) shall be not less than 5,500 psi in 28 days.

3.00 EXECUTION

3.01 INSTALLATION

A. Work Time Requirements. Work shall be performed to minimize the amount of time in which operation of the 48-inch Irving Jamison Pipeline is disrupted.

1. Allowable Down-Time
   a. The Owner shall be notified of all disruptions in the operation of the pipeline at least five business days prior to the planned disruption. A detailed schedule of work to be performed and an estimate of the total duration of the disruption shall be provided with the request.
   b. Disruptions to the water pipeline service shall be limited to November 1 through February 28.
   c. The maximum duration of a single service disruption shall be forty-two(42) calendar days. The pipe shall be purged, cleaned and pass bacteriological tests in accordance with City of Irving standard specifications prior to reinstating service.

2. The OPT will operate valves on the existing pipeline to isolate, dewater and fill the line. The Contractor shall provide all other means for dewatering, disinfecting, dechlorinating and testing the pipe after installation.
   a. Approximately three miles of the pipeline, from the Jamison meter vault to an isolation valve on Texas Plaza Drive, are estimated to be isolated for construction of the tie-ins for the new pipeline.

B. General

1. Install bar wrapped concrete cylinder pipe, fittings, specials, and appurtenances as specified and required for the proper functioning of the completed pipe line. Install pipe,
fittings, and specials in accordance with AWWA M9 and the Pipe Manufacturer’s recommendations.

2. All products and installation shall comply with applicable federal, state, and local environmental control regulations for air pollution, worker exposure, surface preparation, disposition of spent aggregate and debris, and lining and coating applications.

3. Lining and coating applications, including joint completion and lining and coating repairs, shall be performed in conditions that meet or exceed the written environmental application requirements of the Pipe Manufacturer. The Contractor shall provide adequate environmental controls as required to permit work to proceed within the Pipe Manufacturer’s environmental limitations.

4. The requirements of Section 02200-J – Pipeline Excavation and Backfill shall govern for the excavation and backfilling of trenches for laying all pipe, fittings, and specials. Conformance with pipe deflection requirements shall be as described herein. At the location of each joint, dig bell holes in the bottom of the trench and at the sides as necessary to permit completion and visual inspection of the entire joint. After pipe installation and backfill, remove sheeting and shoring in a manner such that a good bond is achieved between the backfill material and the undisturbed trench walls.

5. Restrain pipe to be placed in casing as necessary to prevent flotation during installation.

6. Reject, plainly mark, and promptly remove from the Site any pieces that are determined to be damaged and not suitable for repair according to the OPT. If any damaged piece is discovered after having been installed, it shall be removed and replaced with a sound piece at no additional cost to the Owner.

7. Keep the pipe clean during and after the laying operation and free of debris, dirt, animals, and trash. Effectively seal the open end of the pipe against the entrance of water using a gasketed night cap at the close of each operating day. Do not lay pipe in water. Provide for drainage at low points.

C. Line, Grade, and Cover over Top of Pipe

1. Pipe shall be laid to the lines and grades as specified or shown on the Drawings. Cover shall be defined as the distance from the top of the pipe barrel to the natural ground surface.

2. The grades shall be constructed so as to provide a uniform grade between high points and low points, and intermediate high and low points shall be eliminated to avoid abrupt changes in elevation. No additional compensation shall be made for extra trench depth required to meet these conditions.

3. Runs intended to be straight shall be laid straight, within the tolerance specified herein. Curves may be made by deflecting the joints, by use of factory-mitered beveled joints, or by a combination of the two methods, unless otherwise indicated on the Drawings or permitted by the Engineer. Maximum joint opening and deflection shall not exceed 75% of that recommended by the Pipe Manufacturer. No bevel shall be greater than 5 degrees.

4. Use survey equipment to indicate alignment and grade. Take at least one elevation reading on each length of pipe. Make periodic elevation measurements with surveying instruments to verify accuracy of grades. Verify survey set up daily using an independent benchmark or temporary benchmark.

5. Alignment and Grade Tolerances
   a. Pipe shall be laid such that the horizontal centerline alignment is within ± 0.50 feet of that shown on the Drawings.
   b. Pipe shall be laid such that the invert elevations are within ± 0.10 feet of the elevations shown on the Drawings. High and low points will not be acceptable, except where indicated on the Drawings.
   c. Observe stricter tolerances than specified above as necessary to maintain minimum cover, maintain required clearances, make pipe connections to existing pipe,
maintain the correct slope in the run, or prevent high or low points along the pipeline other than those locations indicated on the Drawings.

D. Pipe Handling

1. Handle pipe, fittings, specials, and appurtenances with care at all times to avoid damage. Do not drop or roll pipe into trenches under any circumstances.

2. Stullsing shall be kept in place until after pipe backfilling and compaction operations are completed or until grouting of the annular space between tunnel or casing and the pipe is completed, depending on which pipe installation condition is involved. Any stulls that are temporarily removed to facilitate interior joint welding shall be re-installed before continuing backfilling operations. The re-installation shall be done in a manner that will not compromise or damage lining.

3. Provide the proper implements, tools, equipment, and facilities for safe and convenient performance of the Work. Lower pipe, fittings, specials, and appurtenances into the trench by means of a crane or other machine. The crane shall be of a sufficient size for handling the pipe, and shall lift and lower the pipe at a slow rate of speed. The crane shall be capable of stopping the lifting operation at any point without producing a shock or otherwise jerking or vibrating the pipe.

4. Pipe shall be handled at all times with a minimum of two wide non-abrasive slings, belts, or other equipment designed to prevent damage to the coating. The equipment shall be kept in such repair that its continued use is not injurious to the coating. All pipe shall be handled with a spreader bar. The spacing of pipe supports required to handle the pipe shall be adequate to prevent cracking or damage to the lining or coating. Repair of any damaged lining or coating shall be in accordance with this Section.

5. Pipe, fittings, and specials shall be inspected for lining and coating damage just prior to placing into the trench. Reject or repair the damage in accordance with this Section before placing into the trench.

6. The pipe shall be lowered into the trench using the equipment and slings as noted above. The pipe shall not be dragged on the bottom of the trench but shall be supported by the slings while being fitted to the adjacent pipe section.

E. Pipe Jointing

1. General

a. Thoroughly clean the bell and spigot rings of foreign matter, rust, and scale before laying each joint of pipe by brushing and wiping. If any damage to the protective coating on the metal has occurred, repair the damage before laying the pipe.

b. Lubricate the gasket and the inside surface of the bell with an approved non-toxic, water soluble lubricant (flax soap) which will facilitate the telescoping of the joint. Tightly fit together sections of pipe and exercise care to secure true alignment and grade.

c. When a joint of pipe is being laid, place the gasket on the spigot ring. Equalize the tension in the gasket by inserting a smooth, round rod under the gasket and moving it completely around the circumference of the joint.

d. The spigot end of the pipe shall be centered with bell of the last length of previously laid pipe and pushed into position. Following assembly, the entire circumference of the pipe joint shall be checked with a feeler gauge to ensure the gasket remains seated in the spigot groove. If the gasket is found to be displaced, the joint shall be removed, the gasket inspected, the joint relaid, and the gasket position rechecked.

e. The interior joint space between the ends of the pipe sections shall have an opening within the tolerances as recommended by the Pipe Manufacturer.

f. No "blocking up" of pipe or joints will be permitted. If the pipe is not uniformly supported or the joint not made up properly, remove the joint and properly prepare the trench.
g. After joining, check the position of the gasket with a feeler gauge. If the gasket is out of position, disassemble the joint and repeat the joint laying procedure.

h. For interior welded joints, complete backfilling before welding. After welding, apply the interior joint mortar.

i. For exterior welded joints, provide adequate working room under and beside the pipe.

2. Pipe Bonding
   a. Connect each joint of pipe with bonding wires to maintain continuity of current. Provide bonding wires free of foreign material. Joint bonding wires shall be used to bond across mechanical joints in the newly installed piping where the joints are not welded for thrust restraint unless otherwise indicated on Drawings.

b. Electrically isolate main line from other connections. Use insulating type joints or provide flange adapter with insulating kit as required when connecting new piping to existing piping.

3. Exterior Joints
   a. Make the exterior joint by placing a joint wrapper around the pipe and secure in place with two metal straps. The wrapper shall encircle the pipe, leaving enough opening between ends to allow the mortar to be poured inside the wrapper into the joint.

b. Fill the joint with cement mortar from one side in one continuous operation until the mortar has flowed entirely around the pipe. During the filling of the joint, rod or agitate the grout at the wrapper opening. Pat or manipulate the sides of the wrapper to settle the mortar and expel any entrapped air. Leave wrappers in place undisturbed until the mortar has set up, 15 minutes minimum.

c. More grout shall be added to refill the joint completely, if necessary.

d. The gap at the top of the grout band must be protected from penetration of backfill into the grout by:
   1) Filling the joint completely and allowing the grout to stiffen,
   2) Capping with a stiff mortar mix, or
   3) Covering with a structurally protective material.

e. The grout band shall not be removed from the joint.

f. Additional bedding or backfill shall not be placed on either side of the pipe or joint until after the grout band has been filled and the grout has mechanically stiffened.

4. Interior Joints
   a. Upon completion of joint welding and testing, where required, and completion of backfilling of the pipe trench, clean out dirt or trash that has collected in the joint, and moisten the concrete surfaces of the joint space by spraying or brushing with a wet brush.

b. Where the mortar joint opening is 1 inch or wider, such as where trimmed spigots are required, apply a bonding agent to mortar and steel surface prior to placing joint mortar.

c. Fill the interior joint recess with a stiff cement mortar. Ram or pack the stiff mortar into the joint space and take extreme care to ensure that no voids remain in the joint space.

d. After the joint has been filled, level the surfaces of the joint mortar with the interior surfaces of the pipe with a steel trowel so that the surface is smooth.

e. Interior joints of pipe 24 inches and smaller shall have the bottom of the bell buttered with cement mortar, prior to inserting the spigot, such that when the spigot is pushed into position it will extrude surplus mortar from the joint. The surplus mortar shall be struck off flush with the inside of the pipe by pulling a filled burlap bag or an inflated ball through the pipe with a rope.

f. All interior joints shall be carefully inspected after mortar is cured. Each joint shall exhibit a smooth, continuous interior surface.
F. Welded Joints

1. General
   a. Joints shall be welded in accordance with AWWA M9, AWWA C206, and AWS D1.1. Unless otherwise specified, welds shall be full circle fillet welds.
   b. The Contractor shall provide adequate ventilation and a safe environment for welders and welding inspectors.
   c. Furnish labor, equipment, tools, and supplies, including shielded type welding rod, to construct the work as required in the Contract Documents. Protect welding rod from any deterioration prior to its use. If any portion of a box or carton is damaged, reject the entire box or carton.
   d. Adequate provisions for reducing temperature stresses shall be the responsibility of the Contractor.
   e. Use only competent, skilled workmen qualified in accordance with this Section. After each welder has qualified in accordance with this Section, a check inspection shall be made of joints in the line welded by each respective welder. After the welding is completed, hand or power wire brush welds and clean them before the welding inspector makes the check inspection. Inspect welds for defects exceeding tolerances allowed by code under which the weld was made. Repair all defects exceeding tolerance. Any welder making defective welds shall not be allowed to continue to weld.
   f. Furnish each welder employed with a steel stencil for marking the welds, so that the work of each welder may be identified. Each welder shall stencil the pipe adjacent to the weld with the stencil assigned to him. In the event any welder leaves the job, his stencil shall be voided and not duplicated if another welder is employed.
   g. Daily welding reports shall be maintained which identify the welder’s name and the joint welded. Joints must be shown on the daily welding reports with the identification number assigned in the lay drawings (example: ID#1 – ID#2). Submit three copies of all daily welding reports to the Owner monthly.

2. Welding Procedure
   a. Pipe 36 inches and smaller shall be welded on the exterior using the following procedures:
      1) Telescope together the joints to be welded with a rubber gasket as specified above and align perfectly with the adjacent section of pipe. Accomplish welding by laying a filler rod between the steel bell of one section and the steel spigot of the other, and welding the bell to the outside of the spigot. Use no less than three complete passes to make the weld. When the joint weld is completed, pour the exterior joint with mortar as specified above. After all sections are in final position, fill the interior joint with mortar as specified above.
   b. Pipe 42 inches and larger shall be welded on the interior using the following procedures:
      1) Joint spigots shall be trimmed where the stress in the gasket groove exceeds 12,000 psi due to axial thrust load. Trim the joint ring behind the gasket groove. After the adjacent pipe sections are aligned and tack welded, weld the bell to the spigot with a full fillet weld. When the joint weld is completed, fill the interior joint and pour the exterior joint with mortar as specified above.
   c. After the pipe has been joined and properly aligned and prior to the start of the welding procedure or the placing of pipe embedment, the spigot and bell shall be made essentially concentric by jacking, shimming, or tacking to obtain a clearance tolerance around the periphery of the joint. In no case shall the clearance tolerance be permitted to accumulate.
   d. Before welding, thoroughly clean pipe ends. Weld pipe by machine or by the manual shielded electric arc process. Welding shall be performed so as not to damage shop applied lining or coating. Cover the coating as necessary to protect from welding.
e. In all hand welding, the metal shall be deposited in successive layers. For hand welds, not more than 1/8 inch of metal shall be deposited in each pass. Each pass except the final pass, whether in butt or fillet welds, shall be thoroughly bobbed or peened to relieve shrinkage stresses and to remove dirt, slag, or flux before the succeeding bead is applied. Each pass shall be thoroughly fused into the plates at each side of the welding groove or fillet and shall not be permitted to pile up in the center of the weld. Undercutting along the side shall not be permitted.

f. All welds shall be free from pin holes, non-metallic inclusions, air pockets, undercutting, and any other defects disallowed by AWWA C206 and/or AWS D1.1.

g. If the ends of the pipe are laminated, split, or damaged to the extent that satisfactory welding contact cannot be obtained, the pipe shall be removed and replaced at no additional cost to the Owner and the defective joint removed from the site.

3. Weld Testing
   a. Visual tests and either magnetic particle tests or dye penetrant tests in accordance with AWWA C206, ASTM E165, ASTM E709, ASTM E1417, ASTM E1444, and AWS D1.1 shall be performed by a Certified Welding Inspector retained by the Owner on all field welded joints. Welds that are defective shall be replaced or repaired, whichever is deemed necessary by the OPT, at the Contractor’s expense. The Contractor shall cooperate with the welding inspector to allow efficient inspections.

b. If Contractor disagrees with OPT interpretation of welding tests, test sections may be cut from the joint for physical testing. The Contractor shall bear the expense of repairing the joint, regardless of the results of physical testing. The procedure for repairing the joint shall be approved by OPT before proceeding.

c. Welded butt strap joints which cannot be hydrostatically tested in the field with the main pipeline shall be air tested in accordance with AWWA C206. Following successful completion of the test, seal weld the threaded test fittings.

G. Flanged Joints
   1. Flanged joints shall be made and completed in accordance with procedures given in AWWA M9.

   2. Provide insulating flanged joints where shown on Drawings and in accordance with Section 15240-J – Cathodic Protection Systems.

H. Deflection Testing
   1. The OPT will perform deflection testing of each joint. The contractor shall accommodate the Owner personnel performing the tests.

   2. Sections of pipe that exceed one percent (1%) deflection shall be remedied at no additional cost to the Owner until the pipe passes the deflection test. At a minimum, the pipe shall be excavated and the backfill shall be recompacted. Pipe replacement may be required at the discretion of the Owner. Damage to the pipe lining or coating on segments that fail the deflection tests shall be repaired or the segment must be replaced in accordance with the requirements of Section 3.02.

I. Protection of Ferrous Metal
   1. Buried Metal
      a. Protect buried ferrous metal such as flanges, nuts, bolts, and dresser couplings by applying two wraps of wax tape and dense profiling mastic in accordance with AWWA C217 and Section 15150-J – Miscellaneous Pipeline Valves and Appurtenances, and encasing it with flowable fill, unless otherwise specified in the Drawings.

      b. Exposed Metal
         1) Protect exposed ferrous metal by a minimum 1-inch coating of cement mortar as specified herein for interior joints, unless otherwise specified in the Drawings.

         2) Exposed large flat surfaces such as flanges, bolts, caulked joints, threaded outlets, and closures shall have coating reinforced with galvanized wire mesh.
3) Thoroughly clean and wet the surface receiving a cement mortar coating with water just prior to placing the cement mortar coating. After placing, take care to prevent cement mortar from drying out too rapidly by covering with damp earth or burlap. Cement mortar coating shall not be applied during freezing weather.

3.02 REPAIRS

A. Field Patching of Lining and Coating

1. Carefully observe the pipe and check the lining and coating for cracking. Should cracking occur, take immediate steps to protect the pipe.

2. Any joint of pipe with cracks exceeding the following dimensions shall be repaired by the Pipe Manufacturer by an approved method:
   a. Shrinkage cracks with a width of 1/16 inch or greater in the interior lining.
   b. Cracks larger than 0.005 inch (a hairline) in the exterior coating.

3. Excessive field patching of lining or coating shall not be permitted. Removal and replacement of a pipe joint will be required if required patching of lining or coating will exceed 100 square inches or has dimensions greater than 12 inches in any direction. Removal and replacement of a pipe joint will be required if more than one patch is required on either the lining or coating.

4. Wherever necessary to field patch the lining or coating, make patch with cement mortar as specified herein for interior joint mortar. Apply a bonding agent to a clean, dry surface prior to cement mortar patch. Do not install patched pipe until the patch has been properly and adequately cured and approved for laying by the OPT.

5. Remove, replace, or reject any disbonded lining or coating. Apply bonding agent to patch area. A patch larger than 100 square inches or 12 inches in the greatest dimension shall not be accepted and will require the joint of pipe to be removed and replaced. Adequately cure patches.

3.03 CLEANING

A. General

1. Prior to hydrostatic testing of the pipeline, thoroughly clean all of the newly constructed pipes and fittings to remove all dirt, stones, pieces of wood, or other materials and obstructions which may have entered the pipeline during the construction period. Debris cleaned from the pipeline shall be removed from the lowest available pipeline access point.

2. The Contractor shall be responsible for the transporting and disposal of all debris removed from the pipeline at an approved off-site location and for the proper disposal of any water used for flushing the line.

B. Sterilization and Testing

1. Cleaning, disinfection, and bacteriological testing of the newly constructed pipeline shall be performed in accordance with Section 15040-J – Hydrostatic Testing and Disinfection.

3.04 FIELD TESTING

A. Perform Weld Testing in accordance with Part 3.01 of this Section

B. Perform hydrostatic testing in accordance with Section 15040-J – Hydrostatic Testing.
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1.00 GENERAL

1.01 WORK INCLUDED
A. This Section specifies the materials, manufacture, and construction of manholes. All manhole construction shall be performed in accordance with this Section or as shown on the Drawings.
B. The Contractor is advised that the top of manhole elevations shown in the Drawings are approximate, based on current pavement and natural ground conditions as determined from survey data. No additional payment will be made if the final elevation of the manhole ring and cover is higher or lower than that specified in the Drawings due to the requirements of finished grade and/or the replaced pavement surface.
C. Measurement and Payment
   1. The work included in this Section shall be considered subsidiary to the contract unit price for other items.

1.02 REFERENCES
A. The following standards, latest edition, shall be the minimum governing requirements of this Section and are hereby made a part of this Section as if written in its entirety.
   1. Occupational Safety and Health Administration (OSHA) 29 CFR Part 1926, Safety and Health Regulations for Construction
   2. H.B. 1569 of the 71st Regular Session of the State of Texas
B. Comply with all applicable Federal, State, and local rules, regulations, and ordinances.

1.03 SUBMITTALS
A. All submittals shall be in accordance with TxDOT Specifications and this Section.
B. Submit mix design, aggregate test reports, and 7-day and 28-day compressive strength test reports for cast-in-place concrete.
C. Submit manufacturer's catalog sheets and technical information for steel reinforcement, precast manhole sections, joint connections, manhole frame and cover, and other pertinent products.
D. All structural designs submitted by Contractor shall be sealed and signed by a Professional Engineer registered in the State of Texas.

1.04 QUALITY ASSURANCE
A. The Contractor shall be responsible for complying with state laws and federal regulations relating to trench safety, including those which may be enacted during the performance under this Contract.

2.00 PRODUCTS

2.01 PRECAST CONCRETE MANHOLE RISERS
A. Manhole risers shall be constructed with precast concrete rubber gasket sections in accordance with ASTM C76, C443 and C478 using the following materials.
   1. Concrete shall conform to the requirements of NCTCOG Standard Specifications for Public Works Construction Item 502.1
2. Steel reinforcement shall be ASTM A615, Grade 60, deformed. Provide a minimum concrete cover of 3 inches over reinforcing steel on the inside of precast manholes.

3. Non-Shrinking Grout: Material shall be a non-shrink cement-base grout. "Five Star Grout" as manufactured by U. S. Grout Corporation or "Supreme" grout as manufactured by Hanson Pipe and Products shall be permitted.

4. Rubber Gaskets: Flexible, watertight, rubber compression gasket of the round O-Ring design in accordance with ASTM C443. The Contractor is advised that the top of manhole elevations shown in the Drawings are approximate, based on current pavement and natural ground conditions as determined from survey data. No additional payment will be made if the final elevation of the manhole ring and cover is higher or lower than that specified in the Drawings due to the requirements of finished grade and/or the replaced pavement surface.

B. Cast-in-place concrete manhole risers will not be allowed, unless approved in writing by Owner.

C. Sections: Sections shall be as manufactured by a company listed in Irving Standard Specification Section 01005 – Approved Products Listings.

D. The concrete manhole riser sections, with the exception of the grade rings, shall be formed with male and female ends, and installed with bell ends turned down.

2.02 PRECAST CONCRETE FLATTOP SECTIONS

A. Precast concrete flattop sections shall conform to the requirements of ASTM C478 and shall be one continuous structure.

B. Precast concrete flattop sections shall have a 36-inch diameter opening and a minimum thickness of 12 inches or as necessary to support H-20 loading.

2.03 TRAFFIC RATED MANHOLE COVERS

A. Frames and covers for access manholes on test fittings shall be watertight, and in conformance with Irving Standard Specification Section 02016 – Wastewater Manholes and Section 1005 – Approved Products Listings. Covers shall be 40-inches in diameter and stamped "Water", unless shown otherwise on the Drawings.

2.04 GRADE RINGS

A. Precast Grade Adjustment Rings

1. Precast grade adjustment rings shall be reinforced concrete meeting the requirements of ASTM C478. To accommodate steep surface grades, non-uniform precast adjustment rings may be used in accordance with the original manufacturer recommendation.

2. Flexible, watertight, rubber compression gaskets in accordance with ASTM C443 shall be used below each grade adjustment ring.

3. Precast grade adjustments shall provide a structural capacity equal to or greater than the existing or specified manhole frame, and shall not affect the opening size or surface appearance.

4. Cracked or multiple piece (defective) precast grade adjustment rings will not be accepted.

5. When grade rings are used to adjust final elevation of the frame and cover, they shall be traffic rated and shall not exceed 18” in height unless approved in writing by the Engineer.

2.05 WAX TAPE

A. Provide wax tape in accordance with AWWA C217 on all outlets and fasteners that are to be mortar-coated as indicated in the Drawings.

B. Apply wax tape prior to mortar coating. Clean and dry the surface to be coated of all foreign matter and scrub with a wire brush. Apply one wrap of wax tape primer, then two wraps of
wax tape, in accordance with the manufacturer's instructions. Press on primer and tape to conform to the surface.

C. Wax tape system shall consist of Trenton Wax-Tape Primer and Trenton Wax-Tape #1, or approved equal.

2.06 METAL COATINGS

A. All metal surfaces inside manhole other than stainless steel and bronze shall receive two coats of bitumastic coating applied in accordance with the manufacturer's instructions. Coating shall be Koppers 50 or approved equal.

3.00 EXECUTION

3.01 INSTALLATION

A. When necessary, the excavation must be adequately dewatered until the backfilling operation is complete to prevent the manhole and base from floating.

B. Frames and covers shall be furnished and installed as required and indicated on the Drawings and as specified.

C. Manholes shall be built up so that the cover, when placed, shall be at the designated elevation. Grade rings shall be used to bring the frames to grade.

D. Excavate the pit for a manhole structure no wider than the manhole diameter plus 4 feet, allowing 2 feet around the structure. Manhole pit excavation is unclassified.

E. Manhole barrel sections shall have O-ring joints as specified or shown on the Drawings.

F. Foundation: The manhole shall rest on concrete encasement placed around the pipe or on a concrete foundation, as shown on the Drawings. Concrete Encasement shall be in conformance with Section 02200-J – Pipeline Excavation and Backfill.

G. Grade Adjustment Risers: Final grade adjustment of access covers and frame assemblies may be made using adjustment risers as specified herein. The minimum number of risers required of the type specified shall be used. Tapered adjustment risers may be used to match final grade. The annular space between risers and cone basin, between risers and cover frame, and between multiple risers shall be sealed using an approved sealant. Installed grade adjustment risers and riser assemblies shall fit within the existing casting without interference, cause no binding to the manhole lid, and be immobile and watertight. Manhole lids shall have bearing on all of the surface of the inner ring(s).

3.02 MANHOLE TESTING

A. Manholes shall be tested for leakage by hydrostatic exfiltration testing, vacuum testing, or other methods acceptable to the 30 Texas Administrative Code (TAC) 217.58 and as set forth in these Contract Documents.

END OF SECTION
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15086-J  COMBINATION AIR RELEASE AND VACUUM RELIEF VALVES

1.00  GENERAL

1.01  WORK INCLUDED
A. Furnish labor, materials, equipment and incidentals necessary to install slow closing combination air release/vacuum relief valves of the sizes and types indicated. Furnish the necessary isolating valves and piping.

B. Measurement and Payment
1. Installation of air and vacuum relief valves shall be measured per each installed complete in place and will be paid for at the Total Unit Price as shown in the bid proposal of the specified item. This item includes all labor, materials, tools, equipment, and incidental items necessary to complete the work in accordance with the specifications, details and addenda thereto.

1.02  DOCUMENTATION
A. Provide Shop Drawings including:
2. Certified Test Reports at least 7 days prior to the shipment of the valve. Certified Test Report shall indicate compliance with factory hydrostatic tests.

B. Provide Operations and Maintenance Manuals.

1.03  STANDARDS
A. The following standards shall apply where applicable.
1. AWWA C512  Standards for Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service
2. ANSI B16.1  Cast Iron Pipe Flanges and Fittings

2.00  PRODUCTS

2.01  GENERAL
A. Each air valve shall have a cast or ductile iron body, bronze or stainless steel trim, and stainless steel float, as appropriate. Float shall be baffled to prevent air from blowing valve closed until air is exhausted.

B. Valve body, float, etc., shall be designed for a 150 psi working pressure and shall seat at a minimum pressure shown in the valve schedule at the end of this Section.

C. Air valves shall be manufactured by DeZurik/APCO, Crispin-Multiplex Manufacturing Company, or Cla-Val and shall meet AWWA C512.

D. Top of valve assembly shall be fitted to attach a hood, unless otherwise indicated. Valve inlet shall be N.P.T. for 2" and smaller valves. Valve inlets 3" and larger shall be drilled according to ANSI B16.1 for a 125 psi pattern. Flange pressure rating shall equal or exceed the maximum working pressure.

E. Contractor shall coordinate drilling patterns between pipe and valves.

F. A 1" pipe outlet shall be provided at the bottom of the valve's housing for valves 3" and larger. A 1" gate valve and ell shall be provided as shown on the Drawings.

G. Valve Coating - Manufacturer-applied standard internal and external coating.
2.02 COMBINATION AIR VALVES (CAV)

A. Combination air valves shall be heavy duty air and vacuum valves with air release. Air release valves shall be designed to automatically release accumulated air pockets within the pipeline while in operation and under pressure. Air release maximum orifice shall be sized for 150 psi.

B. Combination air valves shall be designed to release accumulations of air at high points within a pipeline by controlled venting of large volumes of air as the pipeline is being filled and by releasing accumulated pockets of air while the pipeline is in operation and under pressure.

C. Combination air valves shall also be designed to permit large volumes of air to enter the pipeline during pipeline drainage. The large float shall have a guided stem.

D. Each CAV shall be equipped with a surge check device to control the venting of air out of the pipe while preventing slam. The disc of the surge check shall have drilled orifices to throttle water flow. Air and vacuum valves with surge check shall be APCO Series 1700, or Crispin Model VR/PL Series.

2.03 GATE VALVES

A. Gate valves shall be used to isolate blow off piping from the water pipeline outlet. Gate valves shall be resilient seated with non-rising stem in accordance with AWWA C509 and shall be designed for a working pressure of 150 psi or the design working pressure of the waterline on which it is installed, whichever is greater.

B. Valve manufacture shall be in conformance with Irving Standard Specification Section 15101 – Gate Valves and Butterfly Valves and Irving Standard Specification Section 01005 – Approved Products Listings

C. Valve inlet shall be N.P.T. for 2-inch and smaller valves. Valve inlets 3-inch and larger shall be flanged-end and drilled according to ANSI B16.1. Contractor shall coordinate drilling patterns between pipe and valves. Flange pressure rating shall equal or exceed the maximum working pressure.

D. The non-rising stem shall be ASTM B584 or ASTM B763 bronze with an inside screw. Shaft seal shall employ Buna-N rubber O-rings or V-type packing.

E. Operators shall turn counterclockwise to open the valve. Valve shall have a 2-inch square nut operator unless otherwise shown. Operators shall be enclosed grease lubricated bevel gear.

F. Valve shall be equipped with a 1-inch carbon steel solid one-piece extension stem to within 4 inches of the top of the manhole. Extension stem shall encapsulate and be pinned to the operating nut. Provide Trumbull Model 367 stem guides at maximum 5-foot spacing, two minimum. Stem guides shall be secured to the manhole wall using stainless steel anchor bolts.

3.00 EXECUTION

3.01 INSTALLATION

A. General: Valves and accessories shall be installed in accordance with the manufacturer’s written instructions and as indicated. Gates shall be adequately braced to prevent warping and bending under the intended use. Valves shall be firmly supported to avoid undue stresses on the pipe.

B. Carefully handle and install valves vertically in such a manner as to prevent damage to any part of the valves. Provide nuts, bolts, and gaskets where applicable.

C. Access: Valves shall be installed with easy access for removal and maintenance, and to
avoid interference between gate valve operator and structural members, handrails, or other equipment.

3.02 PERMANENT TAGGING
A. Valves shall be permanently tagged with brass tags showing the station and working pressure rating.

3.03 SCHEDULES
A. Schedule is not guaranteed to be complete. It is the Contractor’s responsibility to supply all valves specified in the Contract Documents. This schedule is given with the intention to facilitate description of the various valves and as an aid to plan take-off.

Table 02643-A: Valve Schedule

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<th>Station Location</th>
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<th>Pipe Size (in)</th>
<th>Type</th>
<th>Valve Working Pressure Rating (psi)</th>
<th>Min Pressure (psi)</th>
<th>Flange Pressure Rating (psi)</th>
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END OF SECTION
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1.00 GENERAL

1.01 WORK INCLUDED
   A. Furnish labor, materials, equipment, and incidentals necessary to install blow off valve assemblies of the sizes and types indicated. Furnish the necessary isolating valves, piping, and other equipment necessary for each valve assembly as indicated on the Drawings.
   B. Measurement and Payment
      1. Installation of blow off valve assembly shall be measured per each installed complete in place and will be paid for at the Total Unit Price as shown in the bid proposal of the specified item. This item is complete and includes the manhole and reinforced concrete base; gate valves with operators, valve stems and guides; ductile iron pipe and fittings; concrete splash pad and bollard; manhole frame and cover and valve box with cover; labor, materials, fittings, barricading, and incidentals as detailed on the plans and details.

1.02 RELATED SECTIONS
   A. Specification Section 15061-J Water Main Access Manholes
   B. Irving Standard Specification Section 01005 – Approved Products Listings
   C. Irving Standard Specification Section 15101 – Gate Valves and Butterfly Valves

1.03 SUBMITTALS
   A. Submittals shall be in accordance with TxDOT Specifications and shall include:
      1. Shop drawings showing standard cut sheets, materials of construction, and valve weights.
      2. Certified Test Reports indicating compliance with standards referenced and required factory hydrostatic tests.
   B. Provide Operation and Maintenance Manuals

1.04 STANDARDS
   A. Except as modified or supplemented herein, the work included in this Section shall conform to the applicable requirements of the following standards, latest edition:
      1. NSF/ANSI 61, Drinking Water System Components – Health Effects
      2. AWWA C110, Ductile-Iron and Gray-Iron Fittings
      3. AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
      4. AWWA C115, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
      5. AWWA C150, Thickness Design of Ductile-Iron Pipe
      6. AWWA C151, Ductile-Iron Pipe, Centrifugally Cast
      7. AWWA C509, Resilient-Seated Gate Valves for Water Supply Service
      8. ASME/ANSI B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

1.05 DELIVERY, STORAGE, AND HANDLING
   A. Provide adequate protection during transport to prevent damage to the equipment.
   B. Store and handle equipment in accordance with the manufacturer’s instructions.
1.06 WARRANTY

A. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced and the unit(s) restored to service at no expense to the Owner.

B. Warranty shall be for a period of two years after Final Acceptance.

2.00 PRODUCTS

2.01 GATE VALVES

A. Gate valves shall be used to isolate blow off piping from the water pipeline outlet. Gate valves shall be resilient seated with non-rising stem in accordance with AWWA C509 and shall be designed for a working pressure of 150 psi or the design working pressure of the waterline on which it is installed, whichever is greater.

B. Valve manufacture shall be in conformance with Irving Standard Specification Section 15101 – Gate Valves and Butterfly Valves and Irving Standard Specification Section 01005 – Approved Products Listings

C. Valve inlet shall be N.P.T. for 2-inch and smaller valves. Valve inlets 3-inch and larger shall be flanged-end and drilled according to ANSI B16.1. Contractor shall coordinate drilling patterns between pipe and valves. Flange pressure rating shall equal or exceed the maximum working pressure.

D. The non-rising stem shall be ASTM B584 or ASTM B763 bronze with an inside screw. Shaft seal shall employ Buna-N rubber O-rings or V-type packing.

E. Operators shall turn counterclockwise to open the valve. Valve shall have a 2-inch square nut operator unless otherwise shown. Operators shall be enclosed grease lubricated bevel gear.

F. Valve shall be equipped with a 1-inch carbon steel solid one-piece extension stem to within 4 inches of the top of the manhole. Extension stem shall encapsulate and be pinned to the operating nut. Provide Trumbull Model 367 stem guides at maximum 5-foot spacing, two minimum. Stem guides shall be secured to the manhole wall using stainless steel anchor bolts.

2.02 PIPE AND FITTINGS

A. Install pipe and fittings as indicated on the Drawings. Piping shall be Class 53 mortar-lined ductile iron, with flanged joints except where otherwise indicated. Pipe and fittings shall conform to AWWA C110, AWWA C111, AWWA C115, AWWA C150, and AWWA C151 as applicable.

B. Piping within manhole shall have factory-applied asphaltic coating.

C. Buried piping shall have factory-applied asphaltic coating and shall be wrapped in the field with polyethylene encasement per AWWA C105.

D. Above-ground piping shall be factory-primed and painted silver.

E. Insulating gaskets shall be provided where indicated on the Drawings. Insulating gaskets shall be full-face Type E with O-ring.

2.03 FASTENERS

A. All fasteners shall be 316 stainless steel.

2.04 MANHOLES

A. Access manholes for blow off valves shall comply with the Drawings and Section 15061-J - Water Main Access Manholes.
2.05 SPLASH PAD
A. Concrete for splash pad shall comply with the Drawings
B. Provide bollards where necessary as indicated in the Drawings.

3.00 EXECUTION

3.01 INSTALLATION
A. Carefully handle and install valves vertically in such a manner as to prevent damage to any part of the valves. Valves and accessories shall be installed in accordance with the manufacturer's written instructions. Valves shall be firmly supported to avoid undue stresses on the pipe. Provide nuts, bolts, and gaskets where applicable.
B. Valves shall be installed with easy access for removal and maintenance, and to avoid interference with valve operators and structural members, handrails, or other equipment.

3.02 FIELD QUALITY CONTROL
A. Upon completion of installation of the equipment, an acceptance test shall be conducted to verify the satisfactory operation of each unit. The test shall be conducted in a manner approved by and in the presence of the Owner or his representative. Each unit shall be checked for general operation and leakage. Each unit must perform in a manner acceptable to the Owner before final acceptance will be made.

3.03 MEASUREMENT AND PAYMENT
A. The contract unit price per EACH shall be the total compensation for furnishing all material, labor, equipment, tools and superintendence necessary to complete the work in accordance with the Contract Documents

END OF SECTION
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1.00 GENERAL

1.01 WORK INCLUDED

A. Furnish labor, materials, equipment and incidentals necessary to install butterfly valves and appurtenances, including valve boxes, operators, bolts, nuts, and gaskets.

B. Valves proposed shall be suitable for direct-bury service installation with operator in a manhole.

C. The Manufacturers of the valve and operator shall coordinate with each other to meet all specified operation and performance requirements.

D. Measurement and Payment

1. Installation of butterfly valve assemblies shall be measured per each installed complete in place and will be paid for at the Total Unit Price as shown in the bid proposal of the specified item. This item is complete and includes the butterfly valve with operator; spool pieces with valve bypass pipe, fittings and 12-inch gate valve; all valve stems and guides; manhole and reinforced concrete base; 12-inch gate valves with operators; ductile iron pipe and fittings; concrete splash pad and bollard; manhole frame and cover and valve box with cover; labor, materials, fittings, barricading, and incidentals as detailed on the plans and details.

1.02 RELATED SECTIONS

A. Specification Section 15061-J - Water Main Access Manholes

1.03 QUALITY ASSURANCE

A. Acceptable Manufacturers:

1. Butterfly Valves:
   a. Mueller
   b. Kennedy
   c. Pratt-Groundhog

B. Experience Requirements: The Manufacturer shall have had at least ten years’ successful experience in manufacturing tight-closing, rubber-seated butterfly valves for this service type and sizes specified.

C. Factory Inspection and Testing:

1. Valve Testing:
   a. Butterfly valves, 3-inch through 72-inch, and actuators shall be tested in accordance with AWWA C504.
   b. Butterfly valves, 78-inch and larger, and actuators shall be tested in accordance with AWWA C516.
   c. Valves actuators and limit switches (where specified) shall be completely assembled and wired at the factory, adjusted for correct seating, and fully tested at the manufacturer’s facility to verify proper design and operation. Prior to shipment, factory operational tests and adjustments shall be performed on each valve. The valve shall be tested in the same orientation (shaft horizontal or vertical) as the field installation. Correct seating of each valve disc shall be certified. The valve will be
opened 10 percent, then closed and tested in the orientation in which the valve will be installed. Repeat test for both sides of valve seat. To test the actuator, conduct one opening test with the maximum pressure differential in order to test the actuator. Factory operational testing and adjustment shall be performed on each valve prior to shipment. Provide certification before shipping valves. A completed, dated, and signed copy of the detailed test procedure shall be shipped with each valve.

d. Limit switches, seat adjustments, stops, and functions shall be set and checked at the factory. Provide Certified Test Reports.

e. The manufacturer shall perform thorough visual inspection and ultrasonic tests on all castings before assembly.

f. The manufacturer shall conduct ultrasonic testing of each valve disc and valve body in accordance with the following test procedures, and certify there are no defects within the ductile iron material.

1). Perform testing using a hand-held ultrasonic velocity/thickness gage that uses pulse-echo techniques to measure material thickness and velocity. The gage will be used as a velocimeter by coupling the transducer to a ductile iron sample of known thickness and performing a velocity calibration. The ductile iron sample will conform to ASTM A536, Grade 65-45-12.

2). Take a minimum of 16 measurements per body and disc, for valve sizes 42 through 96 inches. Take a minimum of eight measurements for valves sizes 24 through 36 inches. Valves less than 24 inches do not require ultrasonic testing. The points of measurement should be equally spaced and represent the entire body and disc casting and not be limited to one specific area.

3). Read the velocity off the gage display, record, and include as a Certified Test Report. Components with measured velocities of less than 0.21 in/µS (5,300 m/S) will be rejected. The gage will also be used as an ultrasonic thickness gage to confirm the minimum body shell thickness meets the requirements of the latest revision of AWWA C504 for 3-inch through 72-inch valves and AWWA C516 for valves 78-inch and larger.

g. The operator and butterfly valves shall be assembled and fully tested at the manufacturer’s facility to verify proper mechanical, electrical and control design, operation, and coordination.

h. Provide Certified Test Reports for factory testing.

2. Valve Coating Adhesion Test - The coating adhesion to the substrate shall exceed cohesion of the coating film as demonstrated by the following test:

a. Prepare test panel and apply coating per manufacturer’s recommendation.

b. After sample has properly cured per manufacturer's recommendation, scribe an "X" using a sharp knife or scalpel through the coating to the metal substrate.

c. With the point of the knife at the juncture of two scribes, attempt to lift off coating. Coating should not lift off substrate or between coats readily, but should break up leaving coating material on the substrate of this damaged area.

d. No disbondment of the film shall be noted as tested above after immersion in tap water for 1500 hours at 100 degrees Fahrenheit.

3. A falling sand abrasion test using ASTM D968 shall produce an abrasion coefficient of 25-30 liters/mil. As an alternative, a Taber Abrader Test should find 3.5 - 3.7 milligrams coating loss per 100 cycles when using a CSF 10 Wheel (1000 gram weight).

4. Manufacturer's Representative for Installation, Startup, and Testing:
a. The services of a competent factory technician shall be provided for whatever period is required to ensure proper installation, testing, start-up, and Owner training. The technician shall be factory trained and have a minimum of five years of experience in the installation and adjustment of valves. The technician shall instruct the Owner’s personnel in the proper care, maintenance, adjustment, and operation of the equipment.

b. The technician shall be onsite during field hydrostatic pressure testing and startup of valves. The minimum time required to be on-site for 8 hours, not including travel time, is as follows:
   1) Valve and system installation: 2 days (1 trip minimum)
   2) Valve and system start-up: 2 days (1 trip minimum)
   3) Owner training: 1 day (1 trip minimum)

c. Prior to start-up of the equipment, the Manufacturer’s technician shall certify to the Owner, in writing, that the equipment has been properly installed and adjusted for satisfactory operation.

1.04 SUBMITTALS

A. Submit Shop Drawings, Certificate of Adequacy of Design, and Operation and Maintenance Manuals for the material included in this Section. Copies of those submittals will be provided to Installation Contractor.

B. All submittals, including cut-sheets, drawings, and operation and maintenance data, shall have text written in English, and all numerical data shall be in the foot-pound-second system of units.

C. Submittals shall be in accordance with TxDOT Specifications and shall include:
   1. Shop Drawings:
      a. Catalog Data showing seat orientation, actuator and extension stem orientation, materials of construction, and assembly drawings. For valves with extension stems, indicate the provisions for supporting the valve, gearing, and extension stem.
      b. Weight and dimensions of valves and actuators.
      c. Description of valve body seats and disc seats with appropriate ASTM, AWWA, or ANSI material specification.
      d. Valve flange pressure rating, bolt diameter, and bolt orientation.
      e. A description of the components that will be shipped separately and will require field assembly.
      f. Project specific motor actuator control schematic / wiring diagrams.
      g. Motor operator motor data sheet showing voltage horsepower, full-load amps, locked rotor amps, valve opening/closing times, etc.
      h. Valve torque calculations.
      i. Motor actuator torque.
      j. Provide torque calculations through the full range of operations for all motor operated valves.

   2. When the product submittal differs from the specified requirements and/or catalog description, each point of difference shall be clearly stated.
3. Provide an electronic, 3D model file of the valve. File shall be compatible with AutoCAD, Inventor, or Revit software and will be used for inclusion in the project model.

4. Factory testing procedures.

5. Certificate of Adequacy of Design: Show compliance with AWWA, ANSI, and ASTM standards including hydrostatic tests, operational tests, and all other tests required by the applicable standards.

6. Copy of the Manufacturers’ warranties for the valve and actuator. Include all provisions and exclusions.

7. Operation and Maintenance Manuals:
   a. Manuals shall be prepared by the Manufacturers and shall include storage instructions, installation and adjustment procedures, troubleshooting procedures, operation and maintenance procedures, appropriate final certified shop drawings, and parts listings and final wiring diagrams. Manual may be the Manufacturer’s standard instructions but shall be supplemented as necessary to cover any special features not included in standard material. Submit preliminary manuals for review prior to delivery of the equipment.

8. Certified Test Reports:
   a. Factory hydrostatic tests.
   b. Operational tests.
   c. Seat tests.
   d. Ultrasonic tests.
   e. Coating adhesion tests.

9. Equipment Installation Report:
   a. From the valve supplier, for all valves.
   b. From the operator supplier, as required.

1.05 STANDARDS

A. The applicable provisions of the following standards shall apply as if written here in their entirety:

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<thead>
<tr>
<th>American National Standards Institute (ANSI)/NSF International (NSF)</th>
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<tr>
<td>ANSI B16.1</td>
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<td>ANSI/NSF 61</td>
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<th>ASTM International (ASTM)</th>
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<td>ASTM A48</td>
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<td>ASTM A126</td>
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<td>ASTM A240</td>
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1.06 WARRANTY

A. Manufacturer shall warrant the equipment furnished for a period of two years against defects in materials and workmanship, equipment design, and operational failure. The warranty period shall be interpreted as the 24-month period following the installation, adjusting, and acceptance testing, and the start of actual operation of the equipment, or 36 months after complete delivery, whichever occurs first.

B. Manufacturer shall provide all parts, labor, and incidental cost for making repairs; shipping of the equipment to the site; and startup services. If it is necessary to return the equipment to the manufacturer for correction of defects during the warranty period, Owner will remove and load the equipment onto a vehicle provided by the Equipment Manufacturer. Owner will reinstall the equipment when it is returned to the Site after defects have been corrected.

2.00 PRODUCTS

2.01 MANUFACTURED PRODUCTS

A. General:

1. Butterfly valves shall be tight-closing, rubber-seated type, with rubber seats that are cemented and clamped into the valve disc or body. Valve class shall be suitable for the pressure class of the adjacent pipe. Pressure class of valve shall be permanently marked on the valve. Valves shall be bubble-tight at rated pressures with flow in either direction and shall be satisfactory for applications involving valve operation after long periods of inactivity.

2. All valves shall be a class 250B unless otherwise shown in the plans. Valves shall be designed for a maximum full-open fluid velocity of 16 ft/sec based on nominal valve size.

3. Valve discs shall set at 90 degrees to the axis of the valve and revolve through 90 degrees from full open to closed.
4. Butterfly valves shall be furnished in strict accordance with the applicable requirements of AWWA C504, latest edition.

5. All valves for water service shall comply with NSF 61 standards.

B. Butterfly Valves:

1. Body: close-grained cast iron, ASTM A126, or ductile iron ASTM A536, Grade 65-45-12, with integrally cast hubs for shaft bearings.

2. Disc: Valve discs shall be of one piece cast alloy iron per MIL Specification MIL-G-858A, Class 1, or ductile iron per ASTM A536, Grade 65-45-12. The seating edge of the disc shall be 18-8 stainless steel. Adjustable mechanical stops shall be provided to limit rotation.

3. Shafts: Valve shafts shall be of one piece design, projecting completely through valve disc and made of stainless steel Type 302, 303, 304, or 316. Each valve shaft shall be securely attached to valve disc by means of tapered pins extending through disc and shaft. Valve shafts may also be of the “stub shaft” type as per AWWA Standard C-504, the latest edition.

4. Seats: Valve seat shall be Buna N rubber securely cemented and clamped into valve body or to the disc for complete immobility under all operating conditions. Mechanical clamping means used to clamp valve seat shall be of non-corrosive construction.

5. Bearings: Shaft bearings shall be of the sleeve type self lubricated material that will not have a harmful effect on rubber. An adjustable 2-way thrust bearing shall be provided to keep disc centered, regardless of valve position. Stuffing boxes shall be provided with depth not less than the diameter of the shaft and the design shall be such that packing can be easily adjusted or replaced without disturbing valve operator. Gland follower shall be bronze one piece construction.

6. Shaft Seals: Where shafts project through the valve bodies for actuator connection, a split-V or O-ring type shaft seal shall be provided.


8. Factory Surface Preparation and Shop Coating:

   a. The exterior ferrous surfaces of the valve shall be thoroughly cleaned of all scale, dirt, grease, or other foreign matter, and thereafter primed at the shop.

   b. All butterfly valves shall be spray coated with a two component epoxy to cover all interior ferrous surfaces that come in contact with water. Interior coating shall be factory applied to a nominal thickness of 3-4 mils. Exterior coatings shall be in accordance with AWWA Standard C-504 for buried service valves.

   c. The interior coating shall be a two part thermosetting epoxy protective coating and shall function as a physical, chemical and electrical barrier between the base metal to which it is applied and the surroundings.

   d. The coating shall be non-toxic and shall not impart taste to water. The coating must be formulated from materials deemed acceptable per the Food and Drug Administration Document Title 21 of the Federal Regulations on Food Additives, Section 121.2514 entitled, Resins and Polymeric Coatings.

   e. The coating shall have a satin finish and shall be suitable for field overcoating and touchup with same coating material without standing or special surface preparation, or application of heat in excess of room temperature.

   f. The coating shall have a successful record of performance in valves, pipes or other allied equipment for a minimum of two years.
g. Ferrous surfaces that are not to be painted shall be given a shop coat of grease, slush oil, or other suitable rust resistant coating.

h. Special care shall be taken to protect uncoated items and plastic items from environmental damage.

9. Connections:
   a. Bell Ends: Not allowed.
   b. Flanged Ends: Valves shall have 125-pound flanged ends faced and drilled in accordance with ASTM Standards. All flanges shall be rated to meet the valve pressure rating.
   c. Acceptable valve flanges must be compatible with pipe flanges.

C. Manual Operator:
   1. Valve operator shall be designed and manufactured in accordance with the applicable requirements of AWWA C504 and shall be arranged for horizontal or vertical valve shaft installation.
   2. Manual operators shall be the worm-gear or traveling nut type, having permanently grease-lubricated totally enclosed gearing with operating nut and gear ratio design to require not more than 80 pounds pull at the valve. Operator shall be provided with adjustable limit stops on the input shaft to the operator. Limit stops on output shaft of operator will not be permitted. Operator shall be designed for direct burial service and a valve manhole shall be provided over the valve operator as shown in the plans.
   3. Actuators shall turn counterclockwise to open the valve.
   4. Operators for buried valves shall have an extended stem with a 2-inch square operating nut. Provide bevel gear for vertical operation of the nut. Provide a handwheel where indicated.

D. Valve Extension Stems and Stem Guides: Extension stem shall be 1 inch, carbon-steel, solid shaft. Valves in manholes shall include two adjustable Trumbull 367 stem guides, minimum; one at each end of extension stem. Supports shall be provided at 10-foot maximum spacing.

E. Precast concrete manholes shall be constructed over the gear boxes of butterfly valves in accordance with Section 15061-J – Water Main Access Manholes.

3.00 EXECUTION

3.01 INSTALLATION

A. Install valves in piping with valve shaft horizontal and with the disc seat adjustment facing the thrust harness, unless otherwise indicated.

B. Valve actuators shall be stored in an environmentally protected area until installed. Space heaters shall be energized during storage as materials on hand, and upon installation of the valve.

C. Installation shall be in accordance with the manufacturer’s instructions. Carefully handle valve while lowering into position to prevent damage to any part of the valve. Place the valve in position with the stem oriented as shown in the Drawings and securely hold until connections have been made.

D. Install and test precast concrete manholes in accordance with Section 15061-J – Water Main Access Manholes.
E. For buried valves without manholes, the Installation Contractor shall adjust the valve box so it is flush with the surrounding ground surface and construct a 30-inch by 30-inch concrete pad with brass marker around the valve box flush with the ground surface.

3.02 FIELD QUALITY CONTROL

A. Upon completion of installation, an acceptance test to verify the satisfactory operation of each valve shall be conducted. Tests shall be conducted in a manner approved by and in the presence of the Owner or Owner’s Representative. The valve must perform in a manner acceptable to the Owner before final acceptance.

3.03 CLEAN AND ADJUST

A. Adjustments shall be in accordance with the valve manufacturer’s instructions.

END OF SECTION
15150-J MISCELLANEOUS PIPELINE VALVES AND APPURTEINANCES

1.00 GENERAL

1.01 WORK INCLUDED

A. Furnish labor, materials, equipment and incidentals necessary to install the equipment specified herein. See other Sections for piping and appurtenances associated with heating, ventilation, air condition, and plumbing systems.

B. Measurement and Payment
   1. The work included in this Section shall be considered subsidiary to the contract unit price for other items.

1.02 DOCUMENTATION

A. Provide Shop Drawings in accordance with TxDOT Specifications including cut sheets, assembly drawings, weight of valves and a list of spare parts and tools.

B. Provide Operations and Maintenance.

2.00 PRODUCTS

2.01 GENERAL

A. All valves 2” and larger shall open in the counter-clockwise direction.

2.02 MANUFACTURED PRODUCTS

A. Corporation Stops: Corporation stops shall be bronze with tapered plug and flat key operator. Unless otherwise indicated, stops shall be equal to Mueller H-10046 with iron pipe thread on inlet and outlet, of the size indicated.

B. Hose Faucet (Hose Bibb): Hose faucet shall be stainless steel with 3/4” pipe thread and standard garden hose 50 feet long with threaded outlet with wheel handle equal to Mueller H-8260.

2.03 WAX TAPE

A. Wax tape shall be Trenton No. 1 wax tape as manufactured by the Trenton Corporation or approved equal, and shall meet AWWA C217. Clean and dry the surface of all foreign matter and scrub with a wire brush. Apply a thin film of Trenton Wax Tape Primer, then apply two wraps of wax tape. Press on primer and tape to conform to the fitting surface. Backfill around fitting with flowable fill per Section 02200-J - Pipeline Excavation and Backfill (Flowable Fill) or 2000 psi concrete, as indicated.

2.04 STEEL BOLTED (DRESSER) COUPLING FOR PLAIN-END PIPE

A. Where dresser couplings are indicated, furnish and install a gasketed, sleeve-type coupling meeting AWWA C219, with a pressure rating as indicated on the Drawings.

B. The pipe couplings shall be of a gasketed, sleeve-type with diameter to properly fit the pipe. Each coupling shall consist of one steel middle ring, two steel followers, two rubber-compounded wedge section gaskets and sufficient trackhead steel bolts to properly compress the gaskets. Field joints shall be made with this type of coupling. The middle...
ring and followers of the coupling shall be true circular sections free from irregularities, flat spots, or surface defects. They shall be formed from mill sections with the follower-ring section of such design as to provide confinement of the gasket. After welding, they shall be tested by cold expanding a minimum of 1% beyond the yield point.

C. The coupling bolts shall be of the elliptic-neck, track-head design with rolled threads. The Supplier shall supply information as to the recommended torque to which the bolts shall be tightened. All bolt holes in the followers shall be oval for greater strength.

D. The gaskets of the coupling shall be composed of a crude or synthetic rubber base compounded with other products to produce a material that will not deteriorate from age, from heat, or exposure to air under normal storage conditions. It shall also possess the quality of resilience and ability to resist cold flow of the material so that the joint will remain sealed and tight indefinitely when subjected to shock, vibration, pulsation and temperature or other adjustments of the pipeline.

E. The couplings shall be assembled on the job in a manner to ensure permanently tight joints under all reasonable conditions of expansion, contraction, shifting and settlement, unavoidable variations in trench gradient, etc. The coupling shall be Dresser, Style 38, Smith Blair, Style 41, or Baker, Series 200.

2.05 INSULATED (DRESSER) COUPLINGS FOR PLAIN-END PIPE

A. Couplings shall meet the basic requirements specified in paragraph 2.04 of this Section.

B. Insulated Dresser couplings shall be Dresser Style 39, or equivalent Smith Blair or Baker. Insulated coupling shall include boots for both pipe ends, and shall insulate each end from electrical current flow. The middle sleeve ring shall be sized to fit over the insulation boots and properly seal the connection. Where sleeve couplings are restrained using a thrust harness (similar to Detail 02626-007) with bolts, over drill the bolt holes and install insulating sleeves and washers similar to Section 15240-J Corrosion Protection Systems.

2.06 VICTAULIC RESTRAINED FLEXIBLE COUPLING FOR PLAIN-END PIPE

A. General:
   1. Couplings shall be bolted, split-sleeve type and consist of four basic components: a one or two-piece housing, gasket assembly, bolts and nuts, and restraint rings as required for pipe or coupling restraint.
   2. Couplings shall be Victaulic Restrained Flexible Couplings as manufactured by Victaulic, or an approval equal.
   3. Couplings type shall be as indicated on the Drawings. Couplings size and working pressure shall be the same as the adjacent pipe as shown on the Drawings.
   4. Where flexible couplings are indicated, furnish and install couplings meeting AWWA C219. The coupling shall be capable of sustaining the full thrust load at 2.0 times the minimum pressure rating minimum. Coupling shall pass an insulation test of 5,000 mega ohms.

B. Products:
   1. Housing:
      a. The housing shall be one or two-piece with a double arch cross section that closes around pipe ends that are smooth for joint flexibility or expansion and contraction requirements or pipe ends with steel restraint rings affixed for pipe end restraint requirements.
      b. The housing shall be sized so that the inside diameter fits the outside diameter of
the pipe. The coupling housing thickness shall be sufficient to handle the service loads.

c. As the coupling closes, it confines the elastomeric gaskets beneath the arches of the sleeve to create the radial seal. The axial seal is effected by the sealing pad at the closure plates as the bolts pull the coupling snug around the pipe ends.

d. Victaulic ExE couplings are flexible, unrestrained pipe joints. FxE couplings are flexible, expansion joints. FxF couplings are flexible, restrained joints. Flexibility, contraction and expansion and joint restraint are as specified in the Supplier’s latest literature.

e. Bolts or studs and nuts shall secure the closure plates.

1). Bolts and studs shall conform to the requirements of ASTM A325 Type 1 and ASTM A193 Class 1 Grade B7 (HDG) respectively. Stainless steel bolts and studs shall conform to the requirements of ASTM F593 Alloy Group 2 and ASTM A193 Class 2 Grade B8M respectively.

2). Nuts shall conform to the requirements of ASTM A194 Grade 2H and stainless steel nuts shall comply with the requirements of ASTM F594 Alloy Group 2.

f. Housing and closure plates shall be manufactured from carbon steel conforming to ASTM A36 or stainless steel conforming to ASTM A240 type 316L.

g. Sealing plates shall be manufactured from ASTM A240 type 316L stainless steel.

2. Gaskets:

a. The sealing members are comprised of two O-Ring gaskets and an elastomer-sealing pad bonded to the sealing plate. Internal pressure is not required to effect the seal.

b. Gaskets and the sealing pad bonded to the sealing plate supplied shall be of the proper rubber compound for the service intended. Gasket material properties shall meet or exceed the appropriate requirements of ASTM D2000.

c. Gaskets for water service shall be Isoprene, EPDM or Buna-N for water and sewerage service within the temperature range of –20 to 190º F.

3. Restraint Rings:

a. FxE couplings shall allow for thermal expansion and contraction at the pipe joint. One (or two) restraint ring(s) affixed to one end of pipe keeps the flexible coupling in the proper location. FxF couplings provide a restrained pipe joint. FxF Type 2 Modified couplings provide a restrained pipe joint and allows for slight Expansion/Contraction or Angular Rotation of the joint. One restraint ring welded to each of the pipe ends fits beneath the coupling and is protected by the coupling. Follow Supplier’s recommendation for size and amount of welding required to attach the restraint rings to the plain end pipe.

b. The restraint rings shall be furnished with the couplings and shall be of the same material as the coupling housings.

4. Spare Parts:

a. Provide all special tools and appliances as may be needed to adjust, maintain, and retain the products provided under this Section.

5. Coating of Carbon Steel Couplings:

a. Prior to installation, carbon steel couplings shall be completely coated on the I.D. and O.D. with liquid epoxy paint per the requirements of AWWA C210
C. Execution:

1. Protective Coatings:
   a. Couplings installed underground shall receive additional protection against corrosion.
      
   1). Heat Shrink Sleeves by Canusa-CPS, a ShawCor Company. 2). Cold applied tape per AWWA C209.
   b. Bolts, Studs and nuts utilized on buried couplings are to be stainless steel.

2. Installation:
   a. Installation of couplings shall be in accordance with Supplier’s written instructions.

2.07 FLANGE INSULATION KITS

A. See Section 15240-J – Corrosion Protection Systems

2.08 FLANGED COUPLING ADAPTERS

A. Flanged coupling adapters shall be restrained. Tie rods shall be able to handle 150% of the working pressure of the adjacent pipe. Acceptable Suppliers: Dresser, Smith-Blair, or Baker.

2.09 ADJUSTABLE PIPE SUPPORTS

A. Galvanized pipe supports for floor mounted piping. Pipe supports shall be manufactured by Piping Technologies or approved equal, comprising a saddle, threaded nipple, and reducer assembly with extra strength steel pipe and floor flange. Where required, saddle shall be fabricated steel to fit valve or piping appurtenance. Entire unit shall be hot dipped galvanized after fabrication.

2.10 FLAP VALVES

A. Flap valves shall be circular flange framed, with machined back flange for attachment to a flanged wall thimble. Body and flap shall be cast iron, ASTM A126-B. Resilient seat shall be neoprene or Buna-N bonded in a groove machined in the body. Hinge arms shall be high-tensile bronze, ASTM B584-CA865 with two pivot points, an adjustable lower pivot with limited rotation and a threaded upper hinge post to adjust flap valve sensitivity. A lubrication fitting shall be supplied for each pivot. Hinge pins shall be silicon bronze, ASTM B98-CA655 or Type 304 Stainless Steel.

B. Flap valve shall be designed to open when differential head across the flap is 0.3’ or less.

C. Flap valve shall be Rodney Hunt Series FV-AC, Waterman Equal Model, or equal.

2.11 STAINLESS STEEL BALL VALVES

A. Full port stainless steel valves shall be manufactured of 316 stainless steel. The valve shall have an adjustable stem packing, reinforced PTFE seats, PTFE stem packing, thrust washer and body seal. Pressure rating shall be no less than 250 psi. Valve shall conform to MSS-SP 110.

B. Valve shall be a Watts Regulator Company Series S-FBV-1 or approved equal.
2.12 DISMANTLING JOINT

A. The dismantling flange shall have a flanged adapter body made of carbon steel per ASTM A53, ASTM A512, ASTM A283 GRC, ASTM A36 or having a minimum yield of 30,000 PSI.

B. It shall have a follower flange made of ductile iron per ASTM A536, steel section per ASTM A576GR1020HR, or carbon steel having a minimum yield of 30,000 PSI. The flanges shall be carbon steel per AWWA C207 Class D.

C. The dismantling joint shall have a spigot made of carbon steel per ASTM A53, ASTM A512, or carbon steel having a minimum of 30,000 PSI. The tie rods shall be made of carbon steel per ASTM A193 B7. The gaskets shall be Nitrile (Buna N) NSF 61. The dismantling joint shall be a Smith-Blair, Inc., 971, 972, 975 or approved equal.

3.00 EXECUTION

3.01 INSTALLATION

A. Install valves and appurtenances in accordance with the Supplier's instructions.

END OF SECTION
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PART 1 - GENERAL

1.1. DESCRIPTION
This SPECIFICATION pertains to the implementation of a corrosion protection system for the new bar wrapped concrete cylinder pipe water main and carbon steel casing pipes. The primary purpose of the system is to provide mitigation of stray current generated by DART. The proposed system shall include, but not be limited to, test stations, galvanic anodes, bond cables, electrical isolation, testing and all associated cable hardware required to complete the installation, as well as site clean up and surface restoration.

1.2. CORROSION PROFESSIONAL
The OWNER shall provide the services of a corrosion professional to oversee the installation and testing of the corrosion protection system components. The corrosion professional shall be a Corrosion or Cathodic Protection Specialist certified by NACE International and shall demonstrate practical experience in at least five previously completed projects of a similar nature.

1.3. SYSTEM ARRANGEMENT
System Arrangement: The DRAWINGS indicate the locations of the corrosion protection system components to be installed.

The CONTRACTOR may propose modifications upon review of the project SPECIFICATIONS and site verifications. These changes shall be limited to component installation locations and will only be considered if documented that they will result in benefits to the OWNER. Any proposed modification must be fully described and submitted by the CONTRACTOR and approved by the Owner’s Representative. Modifications or additional materials shall be at no additional cost to the OWNER. Any modifications shall incorporate all requirements of this SPECIFICATION.

1.4. MEASUREMENT AND PAYMENT
The installation of the corrosion protection systems shall be as a lump sum pay item for the supply, installation and commissioning as described in this section and the project plans.

1.5. RELATED WORK DESCRIBED ELSEWHERE
Section 02200 – Pipeline Excavation and Backfill
Section 02303 – Steel Jacked Casing, Steel Liner Plate and Expandable Liner by Tunelling
Section 02394 – Installation of Carrier Pipe in Tunnel
Section 02400 – Trench Safety Systems
Section 15060 – Bar-Wrapped Concrete Cylinder Pipe and Fittings

1.6. SUBMITTALS
Submit the following information for approval:

A. Bill of Materials: Prepare a bill of materials indicating quantities, detailed descriptions and manufacturers.

B. Catalog Cuts:
   1. Anode Lead Wire
   2. Test Leads
   3. Sacrificial Anodes
   4. Test Stations
   5. Exothermic Welds
   6. Backfill Shields
   7. Bond Cable
   8. Crimp Connectors
9. Splice Tape
10. Anode Header Cable
11. Insulating Flange Kits

C. Engineer’s Qualifications: A copy of the corrosion engineer’s resume complete with references for at least five completed previous projects of a similar nature.

PART 2 - PRODUCTS

2.1 GENERAL
All pipe used in conjunction with this section shall conform to and be approved in the current "APPROVED PRODUCTS LISTINGS" list which is on file with the CITY OF IRVING PUBLIC WORKS DEPARTMENT. UV faded pipe will not be accepted and pipe with extrusion defects such as, but not limited to, internal rippling or external grooves shall be grounds for rejection at the discretion of the Engineer.

2.2 SACRIFICIAL ANODES – ZINC

2.2.1 High Purity Zinc Anode:
A. Provide 30# – ASTM B418, Type II high purity zinc anodes. Anodes shall be cast with an ingot length of 30" and effective diameter of 2".
B. The metallurgical composition of the zinc anodes shall comply with ASTM B418, Type II as listed below:

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<thead>
<tr>
<th>Element</th>
<th>Percent Composition</th>
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<tbody>
<tr>
<td>Aluminum</td>
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<tr>
<td>Cadmium</td>
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</tr>
<tr>
<td>Iron</td>
<td>0.0014 Maximum</td>
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<tr>
<td>Lead</td>
<td>0.003 Maximum</td>
</tr>
<tr>
<td>Copper</td>
<td>0.002 Maximum</td>
</tr>
<tr>
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<td>Balance</td>
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</table>

C. Anode Current Capacity: Zinc anodes require a current capacity of no less than 335 amp-hours per pound and a current efficiency of 90%.

2.2.2 Anode Backfill Material:
A. Use chemical backfill material around all galvanic anodes. Backfill provides a reduced contact resistance to earth, provides a uniform environment surrounding the anode, retains moisture around the anode, and prevents passivation of the anode.
B. All galvanic anodes come prepacked in a backfill material conforming to the following composition:

| Ground hydrated gypsum: 75 percent |
| Powdered bentonite: 20 percent |
| Anhydrous sodium sulfate: 5 percent |

C. Have a grain size backfill such that 100 percent is capable of passing through a 20-mesh screen and 50 percent is retained by a 100-mesh screen.
D. Completely surround the anode with the backfill mixture within a cotton bag.
E. The required weight of backfill is 37# for a total weight if the packaged anode of 67#.
2.2.3 Anode Lead Wires:
   A. Use a 20-foot length of No. 12 AWG solid copper wire equipped with TW or THW insulation for standard lead wires for a sacrificial anode.
   B. Label and install cable lug connectors all anode lead wires as shown on drawings when terminated in test stations.

2.2.4 Lead Wire Connection to Zinc Anode:
   A. Cast anodes with a galvanized steel core with the weight of the core not to exceed 0.10 pounds per linear foot.
   B. Recess one end of the anode to expose the core for the lead wire connection.
   C. Silver-solder the lead wire to the core and fully insulate the connection by filling the recess with an electrical potting compound.

2.3 TEST STATION LEAD WIRES, ANODE COLLECTOR CABLE AND JOINT BONDING WIRES
   A. Test station lead wires shall be #6 AWG, stranded copper with THWN or THHN insulation. The color of the lead wire shall be as shown on the DRAWINGS – Black to the pipe and white to casing pipes.
   B. Anode collector cable shall be #6 AWG, stranded copper with UHMWPE insulation. The color of the lead wire shall be red.
   C. Label and install cable lug connectors all anode lead wires as shown on drawings when terminated in test stations.
   D. Joint bonding wires shall be used to bond across mechanical joints in the newly installed piping where the joints are not welded for thrust restraint.
   E. Bond wires shall be #6 AWG, stranded copper with TW, THW or THHN insulation. Color is not critical as the connections will be buried.

2.4 SPLICE CONNECTOR
   Anode lead wire to anode collector cable shall be made using solid copper crimp, Burndy Y series or equal.

2.5 SPLICE SEALING TAPE
   Anode lead wire to anode collector cable splices shall be encapsulated using a combination of two half lapped layers of rubber electrical tape, 3M Type 23 or equivalent, covered by two half lapped layers of plastic electrical tape, 3M Super 33+ or equivalent.

2.6 CORROSION CONTROL TEST STATIONS
   A. At test station locations indicated on the drawings, a flush to grade test station shall be used, and placed such that possible damage from vandalism, traffic, etc. is minimized and access for corrosion monitoring is easily accomplished.
   B. The flush to grade test station body shall have a cast iron, locking lid with “CP TEST” cast in place. The test station body shall be model NM from CP Test & Valve Products, Bingham and Taylor or equivalent.
   C. The test station terminal board shall be a seven terminal as manufactured by Cott Manufacturing or approved equal.
D. Test Stations which will include anodes shall be provided with a calibrated shunt rated at 0.01 ohm and a maximum current of 8 amperes.

E. All terminal boards shall be wired by the installer as shown on the drawings. NOTE: Not all test stations include galvanic anodes. See Test Station Table for a list of required test station configurations.

F. Where required to offset the test station out of the traffic lanes of a roadway, test and anode leads will be protected in Schedule 80 PVC conduit meeting NEMA TC6 requirements.

2.7 REFERENCE ELECTRODE

A. The electrode shall be equipped with No. 14 AWG stranded copper wire with blue HMW/PE insulation of suitable length to extend from near the pipe (see drawings) to the test station without splicing.

B. The reference electrode shall be copper/copper sulfate, double membrane and ceramic cell in a geomembrane package, as manufactured by Permacell Plus by Corrpro or equivalent.

2.9 THERMITE WELD EQUIPMENT

A. Charges and Molds- Thermite molds and charges shall be used. Charges and mold size shall be as specified by Erico or Thermoweld for the specific surface configuration.

B. Weld Coating- Coating for welds shall be Kop-Coat as manufactured by Carboline or Royston Handy Caps (caps prefilled with mastic)

C. Weld Cap- The coated weld shall be covered with a plastic weld cap.

2.10 FLANGE INSULATING KITS

A. The flange insulating materials and special gasket diameters specified hereinmay not be stock items and shall be ordered early to allow time for manufacture. Ordering information should include nominal pipe diameter and pipe flange pressure class.

B. Flanges shall be as specified in pipe specifications, except bolt holes shall be enlarged as required to accept bolt insulating sleeves.

C. Insulation kits shall be as manufactured by PSI Industries, Advance Products, Central Plastics or as approved by the Engineer. Insulated flange kits shall be available for inspection by the Engineer prior to installation.

D. Sealing Gaskets shall be Type “E”, 1/8 inch thick NEMA G-10 retainer (gasket) with special Nitrile ring seat. Seams will not be permitted in the G-10 retainer at intervals less than 4 feet and seams must be finished to provide a uniform retainer thickness. The retainer inside diameter shall be 1/8 inch less than the inside diameter of the flange. Provide gaskets suitable for exposure to water under the specified field test pressure.

E. Bolt Insulating Sleeves shall be NEMA G-10, full length of bolt, 1/32 inch thick.

F. Insulating Washers shall be NEMA G-10, 1/8 inch thick, two for each flange bolt.

G. Backing and Fronting Washers shall be Steel, 1/8 inch thick, four for each flange bolt, one on each face of the insulating washers (double, double, steel). The backing and fronting washer outside diameter shall not be larger than the outside diameter of the insulating washer.
2.11 WAX TAPE COATING

A. Insulating flanges and all other buried metallic components that are not mortar coated shall be encapsulated with a cold applied petrolatum (wax) tape. Wax tape shall be in accordance with AWWA C-217. Tapes shall be Trenton Corp Tape #1 or Denso North America Densyl Tape or A/E approved equal.

PART 3 - INSTALLATION

3.1. GENERAL
The CONTRACTOR shall furnish all labor, equipment, material and all appurtenances to make the installation and perform the work in a workman-like manner. The CONTRACTOR shall rely upon the Corrosion Professional to train field personnel on the proper installation of the corrosion protection system components.

3.2. BONDING

A. Provide two (2) #6 AWG bond cables across each slip or mechanical joint on the new water main and associated new laterals. Bond all fittings including elbows, tees, reducers and valves. Welds shall be no less than 3” apart and shall be made in areas where the mortar coating on the pipe has been recessed by the manufacturer or bond plates were provided.

B. Make the bond wire attachment to the steel pipeline cylinder using an exothermic weld connection. Clean the steel surface with a ceramic grinding wheel, rasp or coarse file prior to welding the bond cable in place. The use of resin impregnated wheels or discs will not be permitted. The cable shall be welded to the pipeline or fitting with only sufficient insulation removed from the cable to allow placement into the weld mold. After the weld has cooled, all slag shall be removed, and the weld shall be tested with a sharp hammer blow to assure a proper metallurgical bond. All defective welds shall be removed and replaced. All exposed surfaces of the copper bond cable and steel shall be covered with a bitumastic filledplastic shield encapsulating the connection.

C. Repeat the weld procedure on both sides of each joint.

D. The importance of properly bonding the pipeline joints cannot be over emphasized. Take care to ensure each weld is in place and not damaged when backfilled. Any missing or loose bonds will be excavated and repaired as a part of this project.

3.3 PIPELINE ANODES

A. Install anode beds as indicated on project DRAWINGS. All anode beds shall be connected to the pipeline through a test station.

B. Auger the hole, 8” diameter to a depth where the top of the anode is close to the same depth as top of pipe.

C. Do not lift or support anode by the lead wire. Exercise care to preclude damaging the anode and the lead wire insulation.

D. Place prepackaged magnesium anode in hole. Backfill the annulus between the anode and the earthen hole with stone-free native soil compacting in 6” layers. Pour 5 gallons of water in the hole to saturate the anode backfill.

E. Connect the anode collector cable to the anode lead wire using a copper crimp. Coat the connection with two layers of rubber tape followed by two layers of vinyl tape. Half lap each tape wrap.
F. Trench the anode cable back to the test station to a depth of 24 inches. Carefully lay the cable in the bottom of the trench, ensuring the cable does not rest on sharp edges and is free of kinks. Completely fill trench using stone-free native soil. Leave at least 18 inches of excess cable in the test station.

3.4 TEST LEAD CONNECTION

A. Test lead connections shall be made using exothermic welding in locations where the mortar coating was left off in the factory from the pipe surface over an area sufficient to make the connection. The steel surface shall be cleaned to white metal with a ceramic grinding wheel, rasp, or coarse file prior to welding the conductor. Use of resin impregnated wheels or discs will not be permitted. The conductor shall be welded to the pipeline by the exothermic process with only sufficient insulation removed from the conductor to allow placement in the welding mold. After the weld has cooled, all slag shall be removed, and the weld shall be tested with a sharp hammer blow to assure a proper metallurgical bond. All defective welds shall be removed and replaced. All exposed surfaces of copper and steel shall be covered with a bitumastic filled shield encapsulating the connection.

B. Trench cables to a depth of 24 inches. Carefully lay structure wire in bottom of trench, ensuring the cable does not rest on sharp edges and is free of kinks. Connect the lead wires to the test station terminals and backfill leaving at least 18 inches of excess cable length.

3.5 TEST STATIONS

A. Install test stations at locations as indicated on project DRAWINGS. Typical spacing is 1,000 feet between stations.

B. Install test stations directly over the pipe and provide a 24” x 24” concrete pad. Terminate test leads and calibrated shunts as indicated. Install test station labels.

C. Extreme care must be taken to avoid damaging lead wires.

3.6 INSULATING FLANGE KITS

A. Flange insulating kits shall be installed in pipe flanges where indicated and as shown on the DRAWINGS.

B. Bolting at insulated flanges shall consist of studs and nuts with sufficient stud length to allow at least one full stud thread protruding through each nut. Sleeves shall extend into the insulating washers. After installation, but before burial, all insulated flanges shall be tested as specified in the subsection titled Testing, included in this section.

C. All flange insulation kit installations on 36 inches and larger piping shall be fully assembled and tested before connection to the line pipe.

D. All insulating components of the insulating flanged gasket set shall be cleaned of all dirt, grease, oil, and other foreign materials immediately prior to assembly. Bolt holes in mating flanges shall be properly aligned before bolts and insulating sleeves are inserted to prevent damage to the insulation.

E. Flange bolts shall be prevented from rotating while nuts are being tightened to avoid damaging bolt sleeve insulation. After flange bolts have been tightened, each insulating washer shall be inspected for cracks or other damage. All damaged washers shall be replaced.

F. After assembly, resistance between each bolt and flange shall be measured with an approved insulation checker; minimum resistance shall be 50,000 ohms or greater.
G. After each insulated flange meets the insulation test criteria, the insulating flange joints shall be coated with the wax tape as specified in this section. Wax tape shall be installed in full accordance with the manufacturer’s recommendations.

PART 4 - TESTING

All field tests shall be witnessed by the ENGINEER or Owner’s Representative. Advise the ENGINEER at least 5 days prior to conducting final test.

4.1 INSULATING FLANGE TEST

A. The CONTRACTOR shall test each assembled insulating flange kit prior to burial to verify acceptable installation and performance of the insulated flanges. If tests indicate that defects exist in materials, equipment, or installation, which are the sole responsibility of the CONTRACTOR, these defects shall be immediately corrected. Tests and repairs shall continue until the materials, equipment, and installations are in accordance with the Specification requirements. Corrective action shall include the restoration of all other construction and facilities disturbed by the repair work.


C. Use Model 601 insulation checker to verify acceptable insulated pipe flange installation as defined by the manufacturer. This tool tests to identify ineffectively insulated pipe flanges, and tests to identify ineffectively insulated components of insulated flanges using a specified high frequency test. The specified high frequency insulation checker is not designed for testing buried insulated flanges through attached lead wires.

4.2 BONDING

The evaluation of the pipe bonds shall be conducted by the CONTRACTOR on all sections of bonded ductile iron and carbon steel pipeline. The tests are not required for welded joints. The tests shall be conducted using a portable rectifier, the tracer wires installed above the pipeline, a voltmeter, and the pipe test leads provided within the test stations. The tests shall be conducted between consecutive test stations to evaluate the pipe bonds. Using the #8 AWG tracer, connect the portable test rectifier in circuit with the pipe. Attach the #8 AWG cable to one of the lead wires within each test station. Then connect the #12 test wire to the free test station lead wires with a voltmeter in circuit. Once the test leads are connected, energize the rectifier and adjust the current output to 25 amperes. Measure and record the voltage drop between test stations with the current applied. Calculate the pipeline resistance by dividing the voltage drop by the current applied. The maximum allowable resistance between test stations is computed as follows:

\[ R = (1.5) \left[ \left( \frac{r}{L} \right) \left( \frac{OD^2-ID^2}{NJ} \right) + (NJ \times 0.00026) \right] \]

where:

- \( R \) = the maximum allowable resistance for test section
- \( r \) = electrical resistance of iron or steel
- \( L \) = total length of pipe tested
- \( OD \) = outside diameter of pipe
- \( ID \) = inside diameter of pipe
- \( NJ \) = number of bonded joints in test section

Any sections of pipe exhibiting a resistance higher than this level are assumed to have a high resistance or missing bond cable. Locate and repair the damaged or missing bond. The results of each resistance test shall be recorded and submitted for review by the ENGINEER or Owner’s Representative. Record the test station numbers and stationing for each test. Incorporate the resistance test data in the final report on the corrosion protection system.
4.3 CORROSION PROTECTION SYSTEM COMMISSIONING

A. All post installation testing shall be witnessed by the Owner's Representative.

B. The tester shall first verify that all dielectric flange gaskets are installed, and the joints are totally isolated. The tester shall also verify the steel casing pipes are electrically isolated from the new water line. Electrical isolation shall be verified by measuring structure to soil potentials of each component with a fixed reference. Equal potentials identify shorted conditions. Isolation shall be corrected if components are found to be shorted.

C. The tester shall collect GPS coordinates for all test stations and buried insulated connections to the pipeline.

D. Prior to connecting the anode leads to the pipe or casing, the tester shall obtain native AC and DC potentials at each test station, on 100 foot centers along the entire pipeline, and across each insulated flange.

E. Once the native readings have been recorded, the tester can connect the anode leads through the calibrated shunts in each test station and record the current output of each anode bed.

F. The system shall be allowed to operate for at least two weeks and a follow up potential survey shall be performed collecting data at the same locations as defined in task D of this section.

G. A datalogger shall be used to collect current output and local potential measurements for a period sufficient to allow two DART trains to pass in each direction.

H. All field data shall be tabulated and presented in a typed report. The report must include an evaluation of the field data, AS-BUILT DRAWINGS and operation and maintenance instructions.

G. The AS-BUILT DRAWINGS must include the exact stationing of each test station and anode.

END OF SECTION
APPENDIX A

GEOTECHNICAL ENGINEERING REPORT
GEOTECHNICAL INVESTIGATION
48-INCH WATER LINE AT SH 114 AND SPUR 482
CITY OF IRVING, TEXAS

SUBMITTED TO
HALFF ASSOCIATES
12225 GREENVILLE AVE, SUITE 200
DALLAS, TEXAS 75243

BY
HVJ ASSOCIATES®
DALLAS, TEXAS
OCTOBER 8, 2019

REPORT NO. DG-18-10117.1
October 8, 2019

Ben Stephens, PE, ENV SP
Senior Project Manager
Halff Associates, Inc.
12225 Greenville Ave., Ste. 200,
Dallas, Texas 75243

Re: Geotechnical Investigation
48-inch Water Line at SH 114 and Spur 482,
Irving, Texas
Owner: City of Irving
HVJ Associates® Project No. DG-18-10117.1

Dear Mr. Stephens:

Submitted herein is the final report of our geotechnical investigation for the above referenced project. The study was performed in accordance with the proposal number DG-18-10117.1, 2nd Revision, dated February 6, 2019 and is subject to the limitations presented in this report.

We appreciate the opportunity of working with you on this project. Please read the entire report and notify us if there are questions concerning this report or if we may be of further assistance.

Sincerely

HVJ NORTH TEXAS - CHELLIAH CONSULTANTS, INC.
Texas Firm Registration No. F-17942

[Signatures]

Robert H. Lawrence, PE
Project Manager

Saif Bin Salah, EIT
Assistant Project Manager

The seal appearing on this document was authorized by Robert H. Lawrence, PE 120422 on October 8, 2019.
Alteration of sealed document without proper notification to the responsible engineer is an offence under the Texas Engineering Practice Act.

The following lists the pages which complete this report:

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- Appendix A – 4 pages
- Appendix B – 20 pages
- Appendix C – 6 pages
- Appendix D – 12 pages
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</tbody>
</table>
EXECUTIVE SUMMARY

HVJ Associates® was retained by Halff Associates to provide a geotechnical investigation for the realignment of the existing Jamison 48-inch Water Line between SH 114 and Spur 482 in the City of Irving, Texas. The existing waterline consists of approximately 4,760 linear feet of 48-inch bar-wrapped concrete cylinder water main located within TxDOT right-of-way. The existing 48-inch water line will need to be relocated due to conflicts with the TxDOT proposed improvements along SH 114 and the Diamond Interchange. The proposed realignment crosses SH 114, the Spur 482 frontage road and the DART rail in two locations and will be approximately 4,725 linear feet of bar-wrapped concrete cylinder pipe. Furnished information from the client indicate that these lines are proposed to be installed at invert depths of 15 to 20 feet below existing ground surface along most of the proposed alignment. At the location where the proposed waterline crosses the DART rail near the Diamond Interchange, the invert depth is about 40 feet from existing ground surface. The planned boring depths were provided by Halff Associates during early planning stages. Based on the invert depths provided after the field investigation was complete, it should be noted that borings B-8 and B-9 may only provide information up to the depth of the pipeline invert. While we do not anticipate significant variation within 5 feet of the termination depth of borings B-8 and B-9, conditions could vary below the termination of our borings and warranted additional investigation prior to construction.

The purpose of this study is to perform a geotechnical investigation to understand the soil/rock stratigraphy along the proposed realignment, identify groundwater depth and provide design and construction recommendations for the proposed pipeline. Geotechnical investigation includes open-cut and trenchless recommendations for installation of the water line.

Subsurface conditions were evaluated by drilling nine (9) borings (B-1 to B-9) to depths ranging from 25 to 40 feet below the existing ground surface.

1. Subsurface conditions encountered during our field activity in the borings are summarized in the following table.

<table>
<thead>
<tr>
<th>Stratum Types Encountered</th>
<th>Boring ID</th>
<th>B-1</th>
<th>B-2</th>
<th>B-3</th>
<th>B-4</th>
<th>B-5</th>
<th>B-6</th>
<th>B-7</th>
<th>B-8</th>
<th>B-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Thickness (inches)(1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Base Thickness (inches)(2)</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>6</td>
<td>11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fill(3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Fat Clay(4)</td>
<td>0.28</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lean Clay(5)</td>
<td>-</td>
<td>-</td>
<td>1.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.21</td>
<td>-</td>
</tr>
<tr>
<td>Clayey Sand(6)</td>
<td>-</td>
<td>5.9</td>
<td>8.14</td>
<td>0.5-14</td>
<td>1.3</td>
<td>0.5</td>
<td>0.8-4</td>
<td>3.7</td>
<td>13-28</td>
<td>-</td>
</tr>
<tr>
<td>Sandy Clay(7)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.9</td>
<td>5.18</td>
<td>-</td>
<td>7.18</td>
<td>3.13</td>
</tr>
<tr>
<td>Sandy with Clay (SP-SC)(8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>9.19</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Shale(10)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>29-40(11)</td>
<td>35-40(11)</td>
<td>-</td>
</tr>
</tbody>
</table>

Notes:
1. 1-inch Asphalt Pavement encountered in B-5 and B-7.
2. Sandy gravel, loose, moist, light brown to brown.
3. Sandy clay/clayey sand, soft, loose, moist
4. Sandy, soft to very stiff, moist, tannish brown to dark brown.
5. With sand, stiff, moist, tannish brown to brown
(6) Loose to dense, moist, light brown to brown.
(7) Very soft to very stiff, moist, light brown to dark brown.
(8) Slightly compact, tan to brown, poorly graded.
(9) Clayey, soft, dark gray, severely fractured.
(10) Very soft to soft, dark gray
(11) Boring termination depth.

2. Groundwater was observed during drilling in the borings at this site. A summary of the borings where groundwater was encountered is presented in the table below.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth of Groundwater (feet)</th>
<th>Boring No.</th>
<th>Depth of Groundwater (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>18</td>
<td>B-6</td>
<td>15</td>
</tr>
<tr>
<td>B-2</td>
<td>Dry</td>
<td>B-7</td>
<td>11</td>
</tr>
<tr>
<td>B-3</td>
<td>9</td>
<td>B-8</td>
<td>16</td>
</tr>
<tr>
<td>B-4</td>
<td>9</td>
<td>B-9</td>
<td>22</td>
</tr>
<tr>
<td>B-5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, groundwater may also be encountered through fissures and fractures of rock with seasonal variations. It is anticipated that groundwater levels will fluctuate due to seasonal variations in climatic conditions. Groundwater information is included on the boring logs on Plates 4 to 12.

3. Selected soil samples were tested in the laboratory to determine applicable physical and engineering properties. Tests were generally performed according to the relevant ASTM Standards. These tests consisted of moisture contents, Atterberg limits, percent passing #200 sieve, unconfined compressive strength, dry unit weight, free swell, sulfates, chlorides, pH, lime series, Standard Proctor and CBR tests. The test results are included on the boring logs presented on Plates 4 through 12. A laboratory summary table is included in Appendix A.

4. Sulfates, chlorides and pH tests were performed on select soil samples and the test results are included in Appendix B. Measured sulfates test results ranged between 49.5 and 1200 ppm, pH ranged from 7.23 to 8.77 and chlorides between 4.89 and 59.7 ppm.

5. Lime series pH tests were performed on select soil samples. Based on the test results we recommend a minimum lime content of 6% used. The test results are included in Appendix C.

6. Free swell tests were performed on select soil samples and the test results are included in Appendix D. Maximum measured swell percent is approximately 2.41%.

7. Standard Proctor tests were conducted on bulk samples collected from near borings B-3 and B-6. Three-point CBR tests along with Standard Proctor tests were also conducted on bulk samples collected from borings B-1 and B-8. The Standard Proctor and CBR test results are presented in Appendices F and G, respectively.

8. We understand that the water pipelines will be installed using open cut excavation and/or trenchless techniques. The recommendations are included in sections 6 and 7 of this report.

Please note that this executive summary does not fully relate our findings and opinions. Those findings and opinions are only presented through our full report.
1 INTRODUCTION

1.1 General

HVJ Associates® was retained by Halff Associates to provide a geotechnical investigation for the realignment of the existing Jamison 48-inch Water Line between SH 114 and Spur 482 in the City of Irving, Texas. The existing waterline consists of approximately 4,760 linear feet of 48-inch bar-wrapped concrete cylinder water main located within TxDOT right-of-way. The proposed realignment crosses SH 114, the Spur 482 frontage road and the DART rail in two locations and will be approximately 4,725 linear feet of bar-wrapped concrete cylinder pipe. Furnished information from the client indicate that these lines are proposed to be installed at invert depths of 15 to 20 feet below existing ground surface along most of the proposed alignment. At the location where the proposed waterline crosses the DART rail near the Diamond Interchange, the invert depth is about 40 feet from existing ground surface. The planned boring depths were provided by Halff Associates during early planning stages. Based on the invert depths provided after the field investigation was complete, it should be noted that borings B-8 and B-9 may only provide information up to the depth of the pipeline invert. While we do not anticipate significant variation within 5 feet of the termination depth of borings B-8 and B-9, conditions could vary below the termination of our borings and warranted additional investigation prior to construction.

The purpose of this study is to perform a geotechnical investigation to understand the soil/rock stratigraphy along the proposed realignment, identify groundwater depth and provide design and construction recommendations for the proposed pipeline. Geotechnical investigation includes open-cut and trenchless recommendations for installation of the water line.

1.2 Geotechnical Study Program

The primary objective of this study is to perform a geotechnical investigation and testing and provide design and construction recommendations for the proposed pipeline.

The objectives were accomplished by:

1. Drilling nine (9) borings (B-1 to B-9) to depths ranging from 25 to 40 feet below the existing ground surface.

2. Performing laboratory tests on selected samples to determine physical characteristics of the soils.

3. Performing engineering analyses to develop design recommendations for the proposed pipelines.

Subsequent sections of this report contain descriptions of the field exploration, laboratory testing program, general site and subsurface conditions, design recommendations, and construction considerations.

2 FIELD EXPLORATION

2.1 General

The field exploration program was performed between March 18 and March 27, 2019. Subsurface conditions were evaluated by drilling nine (9) borings (B-1 to B-9) to depths ranging from
approximately 25 to 40 feet below the existing ground surface. The approximate boring locations are presented on the Plan of Borings, on Plates 3A to 3C.

2.2 Sampling Methods

Samples were obtained continuously to a depth of 10 feet and at 5-foot intervals thereafter to the maximum termination depth of borings. Cohesive soil samples were obtained with a three-inch thin-walled (Shelby) tube sampler in general accordance with ASTM D-1587 standard. Each sample was removed from the sampler in the field, carefully examined and then classified. The shear strength of the cohesive soils was estimated by a hand penetrometer in the field. Suitable portions of each sample were sealed and packaged for transportation to our laboratory.

Rock encountered was cored continuously to the maximum termination depth in borings B-8 and B-9. The coring method employed consisted of a wire-lined NX core barrel with an inside diameter of 2 inches and length of 5 feet. Water was used as the drilling fluid to facilitate the coring process. The core samples were retrieved from the borehole and the percent recovery (REC) and the Rock Quality Designation (RQD) were recorded for each 5-foot run. The REC value was obtained by dividing the total length of core recovered by the total length of the core run. The RQD value was obtained by dividing the total length of intact core with a minimum length of 4 inches by the total length of the core run. The core samples were visually examined for rock type and features, which were properly documented on boring logs along with the REC and RQD values. The samples were then wrapped and secured in core boxes for transportation to our laboratory.

Detailed descriptions of the soils encountered in the borings are given on the boring logs presented on Plates 4 through 12. Keys to the terms and symbols used for soil and rock classification on the boring logs are presented on Plates 13A and 13B.

2.3 Groundwater Observations

Groundwater was observed during drilling in the borings at this site. A summary of the borings where groundwater was encountered is presented in the table below.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Depth of Groundwater (feet)</th>
<th>Boring No.</th>
<th>Depth of Groundwater (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>18</td>
<td>B-6</td>
<td>15</td>
</tr>
<tr>
<td>B-2</td>
<td>Dry</td>
<td>B-7</td>
<td>11</td>
</tr>
<tr>
<td>B-3</td>
<td>9</td>
<td>B-8</td>
<td>16</td>
</tr>
<tr>
<td>B-4</td>
<td>9</td>
<td>B-9</td>
<td>22</td>
</tr>
<tr>
<td>B-5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, groundwater may also be encountered through fissures and fractures of rock with seasonal variations. It is anticipated that groundwater levels will fluctuate due to seasonal variations in climatic conditions. Groundwater information is included on the boring logs in Plates 4 to 12.

2.4 Borehole Completion

The project borings were backfilled with soil cuttings upon completion of drilling. Borings located on the pavement was patched with concrete at surface.
3 LABORATORY TESTING

Selected soil samples were tested in the laboratory to determine applicable physical and engineering properties. Tests were generally performed according to the relevant ASTM Standards. These tests consisted of moisture contents, Atterberg limits, percent passing #200 sieve, unconfined compressive strength, dry unit weight, free swell, sulfates, chlorides, pH, lime series, Standard Proctor and CBR tests.

The Atterberg limits and percent passing No. 200 sieve tests were utilized to verify field classification by the Unified Soil Classification System. Unconfined compressive strength and hand penetrometer were utilized to obtain the undrained shear strength of the soil. The type and number of tests performed for this investigation are summarized below.

Table 3-1 – Type and Number of Laboratory Tests

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Number of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Content (ASTM D2216)</td>
<td>82</td>
</tr>
<tr>
<td>Atterberg Limits (ASTM D4318)</td>
<td>19</td>
</tr>
<tr>
<td>Percent Passing No. 200 Sieve (ASTM D1140)</td>
<td>22</td>
</tr>
<tr>
<td>Unconfined Compression Soil (ASTM D2166)</td>
<td>13</td>
</tr>
<tr>
<td>Unconfined Compression Rock (ASTM D7012)</td>
<td>3</td>
</tr>
<tr>
<td>Free Swell (ASTM D4546)</td>
<td>12</td>
</tr>
<tr>
<td>Sulfates (SW-846 9038)</td>
<td>9</td>
</tr>
<tr>
<td>Chlorides (SW 9056)</td>
<td>9</td>
</tr>
<tr>
<td>pH (EPA 9045C)</td>
<td>9</td>
</tr>
<tr>
<td>Lime Series (pH)</td>
<td>6</td>
</tr>
<tr>
<td>Standard Proctor Test</td>
<td>4</td>
</tr>
<tr>
<td>CBR Test</td>
<td>2</td>
</tr>
</tbody>
</table>

The summary of laboratory test results are presented in Appendix A.

Sulfates, chlorides and pH tests were performed on select soil samples. Measured sulfates test results ranged between 49.5 and 1200 ppm, pH ranged from 7.23 to 8.77 and chlorides between 4.89 and 59.7 ppm. The test results are included in Appendix B.

Lime series pH tests were performed on select soil samples. Based on the test results, we recommend using a minimum lime contract of 6% for lime treated soil. Note that additional lime content may be recommended based on experience and local criteria in the following sections. The test results are included in Appendix C.

Free swell test were performed on select soil samples and the test results indicate the subgrade soils have a maximum swell percentage of up to 2.41%. The test results are included in Appendix D.

Standard Proctor and CBR tests are conducted on bulk samples collected from near borings B-1, B-3, B-6 and B-8. The Standard Proctor and CBR test results are included in Appendices E and F, respectively.

4 SITE CHARACTERISTICS

4.1 General Geology

According to the University of Texas at Austin, Bureau of Economic Geology 1987 Geologic Atlas of Texas, Dallas Sheet indicates that the project site area is located in the Eagle Ford formation.
(map symbol Kef), overlain by the Alluvial (map symbol Qal) and Fluviatile Terrace Deposits (map symbol Qt).

The Eagle Ford Group consists of shale, sandstone and/or limestone but is mainly synonymous with shale within the area. Eagle Ford shale is characteristically bituminous and selenitic with calcareous concretions and large cracks in which it is not uncommon to find other minerals.

Alluvium is flood plain deposits from rivers and streams and represents erosion or reworked materials from upstream and uphill primary formation. These deposits consist of active clays, silts, or sands and gravels.

The Fluviatile Terrace Deposits consists of mainly gravel, sand, silt and clay, continuous terraces of different ages separated by a solid line. A Geology Map of the project site is presented in Plate 2.

4.2 Soil Stratigraphy

Our interpretation of soil and groundwater conditions at the project site is based on information obtained at the boring locations only. This information has been used as the basis for our conclusions and recommendations. Significant variations at areas not explored by the project borings may require reevaluation of our findings and conclusions. Based on our field investigation, the subsurface soils observed are presented below.

<table>
<thead>
<tr>
<th>Table 4-1 - Stratum Types Encountered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring ID</td>
</tr>
<tr>
<td>Pavement Thickness (inches)&lt;sup&gt;(1)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Base Thickness (inches)&lt;sup&gt;(2)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Approximate Depths to Strata Encountered (feet)</td>
</tr>
<tr>
<td>Fill&lt;sup&gt;(3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat Clay&lt;sup&gt;(4)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lean Clay&lt;sup&gt;(5)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Clayey Sand&lt;sup&gt;(6)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sandy Clay&lt;sup&gt;(7)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sand with Clay (SP-SC)&lt;sup&gt;(8)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Highly Weathered Shale&lt;sup&gt;(9)&lt;/sup&gt;</td>
</tr>
<tr>
<td>Shale&lt;sup&gt;(10)&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Notes:
1. 1-inch Asphalt Pavement encountered in B-5 and B-7.
2. Sandy gravel, loose, moist, light brown to brown.
3. Sandy clay/clayey sand, soft, loose, moist.
4. Sandy, soft to very stiff, moist, tannish brown to dark brown.
5. With sand, stiff, moist, tannish brown to brown.
6. Loose to dense, moist, light brown to brown.
7. Very soft to very stiff, moist, light brown to dark brown.
8. Slightly compact, tan to brown, poorly graded.
9. Clayey, soft, dark gray, severely fractured.
10. Very soft to soft, dark gray.
5 PIPELINE DESIGN CRITERIA AND RECOMMENDATIONS

5.1 General

The project will involve realignment of existing Jamison 48-inch Water Line between SH 114 and Spur 482 in the City of Irving, Texas. The proposed realignment crosses SH 114, the Spur 482 frontage road and the DART rail in two locations and will be approximately 4,725 linear feet of bar-wrapped concrete cylinder pipe. Furnished information from the client indicate that these lines are proposed to be installed at invert depths of 15 to 20 feet below existing ground surface along most of the proposed alignment. At the location where the proposed waterline crosses the DART rail near the Diamond Interchange, the invert depth is about 40 feet from existing ground surface. The planned boring depths were provided by Halff Associates during early planning stages. Based on the invert depths provided after the field investigation was complete, it should be noted that borings B-8 and B-9 may only provide information up to the depth of the pipeline invert. While we do not anticipate significant variation within 5 feet of the termination depth of borings B-8 and B-9, conditions could vary below the termination of our borings and warranted additional investigation prior to construction.

The proposed water pipeline will be installed using open-cut and/or trenchless techniques. Our analyses and recommendations for open cut and/or trenchless techniques are presented below.

5.2 Geotechnical Parameters

Geotechnical design parameters are presented in Table 5-1 below. These design parameters are based on field and laboratory test data obtained from the corresponding boring locations and at the approximate invert depths only. Please note that, because of the nature of the soil stratigraphy at this site, parameters at locations that deviate from the boring locations may vary substantially from values reported in the following table:

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Approximate Depth (feet)</th>
<th>Soil Description</th>
<th>Total Unit Weight (pcf)</th>
<th>Undrained Shear Strength (psf)/Friction Angle (Deg.)</th>
<th>Allowable Bearing Pressure (psf)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>5-18</td>
<td>Stiff fat clay</td>
<td>125</td>
<td>1,000 psf</td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td>18-28</td>
<td>Stiff sandy fat clay</td>
<td>125</td>
<td>1,400 psf</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>28-35</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td>B-2</td>
<td>5-8</td>
<td>Dense clayey sand</td>
<td>125</td>
<td>33 Deg.</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>8-35</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td>B-3</td>
<td>5-8</td>
<td>Stiff lean clay with sand</td>
<td>125</td>
<td>1,400</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>8-14</td>
<td>Medium dense clayey sand</td>
<td>125</td>
<td>30 Deg.</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>14-25</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td>B-4</td>
<td>5-14</td>
<td>Loose clayey sand</td>
<td>125</td>
<td>27 Deg.</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>14-25</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td>B-5</td>
<td>5-9</td>
<td>Stiff sandy clay</td>
<td>125</td>
<td>1,400</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>9-19</td>
<td>Medium dense sand with clay</td>
<td>125</td>
<td>30 Deg.</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>19-25</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td>B-6</td>
<td>0-5</td>
<td>Loose clayey sand</td>
<td>125</td>
<td>27 Deg.</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>5-18</td>
<td>Soft sandy clay</td>
<td>125</td>
<td>800 psf</td>
<td>1,100</td>
</tr>
<tr>
<td>Boring No.</td>
<td>Approximate Depth (feet)</td>
<td>Soil Description</td>
<td>Total Unit Weight (pcf)</td>
<td>Undrained Shear Strength (psf)/Friction Angle (Deg.)</td>
<td>Allowable Bearing Pressure (psf)*</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------</td>
<td>------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>B-7</td>
<td>18-25</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>5-21</td>
<td>Stiff lean clay with sand</td>
<td>125</td>
<td>1,400 psf</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>21-25</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>N/A</td>
<td>2,500</td>
</tr>
<tr>
<td>B-8</td>
<td>5-7</td>
<td>Loose clayey sand</td>
<td>125</td>
<td>27 Deg.</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>7-18</td>
<td>Stiff sandy clay</td>
<td>125</td>
<td>1,400 psf</td>
<td>2,000</td>
</tr>
<tr>
<td></td>
<td>18-29</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>29-40</td>
<td>Shale</td>
<td>130</td>
<td>-</td>
<td>4,500</td>
</tr>
<tr>
<td>B-9</td>
<td>5-13</td>
<td>Soft sandy clay</td>
<td>125</td>
<td>700 psf</td>
<td>1,000</td>
</tr>
<tr>
<td></td>
<td>13-28</td>
<td>Medium dense clayey sand</td>
<td>125</td>
<td>30 Deg.</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>28-35</td>
<td>Highly weathered clayey shale</td>
<td>130</td>
<td>2,000 psf</td>
<td>3,000</td>
</tr>
<tr>
<td></td>
<td>35-40</td>
<td>Shale</td>
<td>130</td>
<td>-</td>
<td>4,500</td>
</tr>
</tbody>
</table>

Note: *The allowable bearing pressure includes a factor of safety of 3 and the values are limited to minimum allowable bearing pressure below a given layer.

The values shown in the above table represent our interpretation of the soil or rock properties at invert depths and below, based on the available laboratory and field test data. Use of the soil properties shown above may or may not be appropriate for a particular analysis, since choice of design parameters often depends on whether total or effective stress analysis is used, rate of loading, duration of loading, geometry of loaded area, and other factors. The total unit weight values shown above represent our interpretation of soil unit weight at natural moisture content. The undrained shear strength and allowable bearing pressure values represent our interpretation of the shear strength in clay soils based primarily on the results of unconfined compressive strength tests, hand penetrometer tests and experience with similar soils.

5.3 Open Cut Pipe Installation Recommendations

Pipe Design. The loads imposed on underground pipes depend principally upon the method of installation, the weight of overburden soils, roadway traffic load, and loads due to existing surface structures. For design of rigid pipes installed using open-cut excavation methods, loads due to overburden and traffic can be determined from Plate 15.

The traffic load applied to the pipe can be calculated using 85% of wheel load with an impact factor of 1.5 for one foot of soil cover, 50% of wheel load with an impact factor of 1.35 for 2 feet of cover, and 30% of wheel load with an impact factor of 1.15 for 3 feet of cover. This results in a total design traffic load on the pipe of about 1.28, 0.68 and 0.35 times the wheel load for 1, 2 and 3 feet of cover, respectively. For pipes with four or more feet of cover, the traffic loads may be taken as a surcharge equivalent to 250 psf. This load depends on both the axle load and the axle spacing.

The design of flexible pipes requires the modulus of soil reaction of the native soil (E’n) in the trench wall as input. The E’n values are based on empirical relationships to the soil consistency as defined by unconfined compression tests for cohesive soils. E’n values for the native soils are presented in the following table. The E’n values for short-term conditions in cohesive soils may be assumed to be 1.5 times the long-term values. These values are based on the soil data obtained at the boring locations only and may be used for the noted invert depth zone. Note that the native E’ value should be used with the embedment E’ value to calculate a composite E’ value when used in deflection calculations.
Pipe Bedding and Backfill. Based on the soil borings, it can be expected that fat clays, sandy fat clay, clayey sand and clayey shale (highly to moderately weathered) may be encountered within the bedding zone. We recommend that pipe bedding be in accordance with Item 504.2.2 and backfill be in accordance with Item 504.6 of North Central Texas Council of Governments (NCTCOG) standard specification.

Compact bedding and backfill material should be laid in 6-inch lifts and compacted to at least 95% of the maximum density as measured by Standard Proctor tests (ASTM D 698) for areas influenced by vehicular traffic and at least 90% of the maximum dry density for the areas not influenced by vehicular traffic. The bottom of the excavation should be dry before the placement of the pipe. Based on groundwater measurements during drilling, we recommend groundwater control be implemented, to achieve stable trench conditions and a satisfactory foundation base.
The excavations should be performed with equipment capable of providing a relatively clean bearing area. Stable soils are essential to provide a strong base during construction. In addition, stable soils enhance trench bottom stability, support for bedding compaction, and minimize possible pipe settlement. Whenever soft or unsuitable foundation soils are encountered during trench excavation we recommend over-excavating below the base of the excavation and replacing with on-site soils compacted to at least 95% of maximum dry density in loose lifts not exceeding 6 inches. HVJ Associates® should be contacted to recommend appropriate depth of the excavation when soft or unsuitable foundation soils are encountered.

The pipes should be installed in a bedding envelope. Bedding materials selected for the project may include pea gravel, uncrushed gravel, crushed gravel, crushed stone, stone screenings, and natural/manufactured sand. Based on ASTM C1479M, these materials are expected to fall in category I consisting of well graded sand (SW), poorly graded sand (SP), well graded gravel (GW), or poorly graded gravel (GP).

ASTM C 1479 categorizes soil into four different groups to evaluate the suitability of soil for use as bedding, embedment or backfill material for rigid and/or semi-rigid pipes. This information is presented in table below.

<table>
<thead>
<tr>
<th>Soil Category</th>
<th>USCS Classifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I</td>
<td>SW, SP, GW, GP</td>
</tr>
<tr>
<td>Category II</td>
<td>GM, GC, SM, SC with more than 12% fines CL, ML, CL-ML with more than 30% retained on 75 µm sieve</td>
</tr>
<tr>
<td>Category III</td>
<td>CL, ML, CL-ML with less than 30% retained on 75 µm sieve</td>
</tr>
<tr>
<td>Category IV</td>
<td>MH, CH, OL, OH, PT</td>
</tr>
</tbody>
</table>

If these Category I soils are used for bedding, Category II soils are recommended for embedment to prevent particle migration between different size of soil particles. Category II, Category III or Category IV can be used for backfilling the trenches. Native Soils encountered in the borings can be considered as Category IV.

The bedding material must be compatible with the materials in the trench bottom, walls, and backfill so that particle migration from, into, or through the bedding is minimized. Particle migration can occur when open-graded material is placed adjacent to a finer material. Under the action of hydraulic gradient from groundwater flow, fines may migrate into the coarser material. The gradation and relative size of the embedment and adjacent materials must be compatible in order to minimize migration.

**Trench Backfill.** For pipes that will be located under streets or within one foot of streets and curbs, pipe embedment should extend to a minimum of six (6) inches above the top of pipe. Trench zone backfill is that portion of trench backfill that extends vertically from the top of pipe embedment up to pavement subgrade or up to final grade when not beneath pavement. Trenches that are located partially within the limit of one foot from streets or curbs should be uniformly backfilled according to the paved area criteria. Backfill material may consist of in-situ soils or imported flexible base materials. Fill material should be placed in loose lifts not exceeding eight (8) inches, and should be compacted to 95% of the standard proctor maximum dry density as determined by ASTM D 698. However, the backfill up to twelve (12) inches above the top of the pipe should be compacted so as to prevent structural damage to the pipe.
It is common practice to use the material excavated from the trench as trench backfill regardless of the plasticity index of the soil excavated from the trench. We recommend that for trench backfill with a PI greater than 20, that the loose lift thickness of fill be limited to a maximum of six (6) inches. This should provide for better compaction of higher plasticity backfill that will reduce problems for pavement constructed above this fill. For native soil reusability, plasticity indices are presented in Appendix A with depths.

6 CONSTRUCTION CONSIDERATIONS

6.1 General

This section is intended to address issues that might arise during construction. Our recommendations are intended for use as guidelines in dealing with particular soil conditions. The topics addressed in this section include trench excavation stability, groundwater control, open-cut construction and trenchless technique construction considerations.

The recommendations contained herein are not intended to dictate construction methods or sequences. Instead they are provided solely to assist designers in identifying potential construction problems related to excavation, based upon findings derived from sampling. Depending upon the final design chosen for the project, the recommendations may also be useful to personnel who observe construction activity.

Prospective contractors for the project must evaluate potential construction problems on the basis of their review of the contract documents, their own knowledge of and experience in the local area, and on the basis of similar projects in other localities, taking into account their own proposed methods and procedures.

6.2 Open-Cut Excavation Considerations

We understand that part of the pipeline may be installed using open-cut excavations. Excavations should satisfy two requirements. First, the soils above final grade must be removed without disturbing the soil below excavation grade, which will support constructed facilities. Second, the sides of the excavation must be stable to prevent damage to adjacent streets and facilities as a result of either vertical or lateral movements of the soil. In addition, a satisfactory excavation procedure must include an adequate construction dewatering system to lower and maintain the water level at least a few feet below the lowest excavation grade.

Excavation Stability. Excavations shall be shored, laid back to a stable slope or some other equivalent means may be used to provide safety for workers and adjacent structures. Earth pressures for braced excavations are presented on Plate 14. Assessment of the need for excavation sloping, use of trench boxes or other measures required providing a stable excavation and the use of appropriate construction practices and/or equipment is the contractor’s responsibility. The following comments are intended to represent common solutions to stability problems encountered in similar soil conditions in the North Texas area, and may not be construed as excavation system design recommendations. The excavation operations shall be performed in accordance with 29 CFR Part 1926 subpart P, as amended, including rules published in the Federal Register, Vol. 54, No. 209, dated October 31, 1989, as a minimum. In addition, the provisions of legislation enacted by the Texas Legislature should be satisfied.

Excavations. Trenches that are deeper than five feet deep should be appropriately sloped and protected in accordance with Table B-1 of 29 CFR Part 1926 subpart P, and shoring may be constructed in accordance with Table C-1.1, Table C-1.2 and Table C-1.3 of 29 CFR Part 1926. Soil types required by Table C-1.1, Table C-1.2 and Table C-1.3 (Trench Shoring - Minimum Timber Requirements) are given in Table 6-1 below:
Table 6-1 – OSHA Soil Types

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>OSHA Soil Type Depth of Trench (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5</td>
</tr>
<tr>
<td>B-1</td>
<td>B</td>
</tr>
<tr>
<td>B-2</td>
<td>B</td>
</tr>
<tr>
<td>B-3</td>
<td>B</td>
</tr>
<tr>
<td>B-4</td>
<td>C</td>
</tr>
<tr>
<td>B-5</td>
<td>C</td>
</tr>
<tr>
<td>B-6</td>
<td>C</td>
</tr>
<tr>
<td>B-7</td>
<td>C</td>
</tr>
<tr>
<td>B-8</td>
<td>C</td>
</tr>
<tr>
<td>B-9</td>
<td>C</td>
</tr>
</tbody>
</table>

* Definitions of Types A, B and C soils are presented in the following table.

Table 6-2 – Soil Type Definitions

Definitions of Types A, B and Type C Soils

Type A

a. Cohesive soil with an unconfined compressive strength of 1.5 tsf (144 kPa) or more; or

b. Clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam

c. No soil is Type A if it is fissured, is subject to vibration of any type, has previously been disturbed, is part of a sloped, layered system where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (4H:1V) or greater, or has seeping water.

Type B

a. Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

b. Granular cohesionless soils including: angular gravel (similar to crushed rock), silt, silt loam, sandy loam and, in some cases, silty clay loam and sandy clay loam.

c. Previously disturbed soils except those which would otherwise be classed as Type C soil.

d. Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

e. Dry rock that is not stable; or

f. Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.
Type C
a. Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
b. Granular soils including gravel, sand, and loamy sand; or
c. Submerged soil or soil from which water is freely seeping; or
d. Submerged rock that is not stable, or
e. Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H: 1V) or steeper.

Table B-1 of 29 CFR Part 1926 subpart P presents maximum allowable slopes and configurations based on the soil types, and they are presented in the following table.

Table 6-3 – Slope Configurations

<table>
<thead>
<tr>
<th>Excavations made in Type B soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.</td>
</tr>
<tr>
<td>2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions shown in Appendix E.</td>
</tr>
<tr>
<td>3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.</td>
</tr>
<tr>
<td>4. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excavations made in Type C soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.</td>
</tr>
<tr>
<td>2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.</td>
</tr>
<tr>
<td>3. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Excavations made in Layered Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as shown in Appendix E.</td>
</tr>
</tbody>
</table>

* Diagrams for slope configuration depending on soils types are presented in Appendix E.

In general, it is our opinion that the pressure distribution (for braced walls) should be used for design of sheeting or trench boxes. To reduce the potential for ground movement adjacent to the top of the excavation, the bracing should be preloaded in stages as the excavation is deepened. The detailed earth pressure diagrams are presented on Plate 14.
The planned construction will be performed along alignments near existing utility installations (either crossing or paralleling the new alignments). The contractors should be aware of potential excavation stability problems while working in the vicinity of old trenches and the excavation system should be designed to accommodate this weak material (trench backfill).

The vertical walls of excavations should be located a safe distance from existing utilities in order to prevent movement in the soil mass behind the excavation that may adversely affect the utilities. We recommend that the horizontal distance should be 4 feet between the existing pipeline and any other utilities, and vertical depths should be determined based on the slope configurations in OSHA Table B-1 of 29 CFR Part 1926 subpart P depending on soil types.

The difficulty of excavation will increase with depth. Soft weathered rock can generally be ripped with backhoes fitted with rock teeth. However, rock excavation methods may be required in the Shale encountered in the borings. These methods could include hoe rams, backhoes with rock excavation buckets, and pneumatic hammers. Excavation of the hard rock is expected to be difficult and time consuming.

6.3 **Tunnelman’s Ground Classification for Soils**

Based on the Tunnelman’s Ground Classification for Soils, the following classifications can be expected:

- **Raveling:** this applies to residual soils or sand with small amounts of clay, stiff fissured clays. The clayey sand soils encountered in borings B-2 through B-9 between depths of 0-28 feet can be considered as Raveling soil.

- **Flowing:** this applies to sand or gravel material, without significant cohesion and plasticity, below the water table. Such soils were encountered in borings B-3, B-4, B-5 and B-9 between depths of 8-28 feet from the ground surface.

- **Squeezing:** this applies to soils with low friction strength. Squeezing occurs at shallow to medium depth in clay of very soft to medium consistency. Such soils were encountered in borings B-1, B-6, B-7 and B-9 between depths of 0-28 feet from the ground surface.

6.4 **Lateral Earth Pressure-Temporary Excavation Supporting System**

If construction involves incorporating the temporary excavation sheeting as part of a permanent structure, then the walls of the structure should be designed using parameters given below in order to resist the lateral earth pressures.

The soil parameters are presented below:

- Unit weight of water = 62.4 pcf
- Wet unit weight of on-site soil = 135 pcf
- Coefficient of earth pressure for clays (long-term condition) = 1.0
- Coefficient of earth pressure for clays (short-term condition) = 0.5
- Coefficient of earth pressure for sands (long-term condition) = 0.5
- Coefficient of earth pressure for sands (short-term condition) = 0.3

Lateral pressures resulting from surcharge conditions must be taken into account.
6.5  Boring, Jacking, or Tunneling Construction Considerations

We understand part of that the pipeline may be installed using trenchless techniques. Three basic criteria exist for satisfactory construction. First, construction must be feasible which means that it is possible to advance the bore safely and to maintain the integrity of the bore opening at least temporarily. Second, the construction should not result in excessive damage to adjacent or overlying structures, streets, or utilities. Third, the long-term design objectives of the facility must be achieved. A summary of the construction conditions for the project is given below.

Pipe Design. For pipes to be installed by trenchless techniques, whereby sections of pipe are jacked forward against the surrounding soil, pipes should be designed to resist significant bending moments, along with the jacking forces exerted on the pipe during installation. These loads generally exceed the overburden pressures that are typically determined based on the prism earth load to the ground surface, plus hydrostatic pressure and surcharge loads as shown on Plate 15. Therefore, pipes designed to resist construction loads during trenchless installation should have adequate strength for most long-term overburden and traffic loads.

During design, allowance should be made for any external loads, other than soil and rock loads, which may be exerted on the pipe. These include loads from foundations for structures located approximately 15 to 40 feet on either side of the water line and any possible future excavation to be performed within the same distance near the water line. Much of the stability of the water lines is due to the presence of relatively uniform stress conditions in the soil around the pipe. Relief of the earth loads on one side of the water line due to subsequent adjacent excavation could cause an overstress of the pipe.

Alignment. Constructability is determined to a large extent by the type of soil or rock. The best conditions are full-faced conditions. Situations that are more difficult are mixed face conditions where two different types of soil and rock, or two different types of rock are encountered in the excavation face simultaneously. These tunneling conditions should be avoided whenever possible.

We anticipate mixed face conditions may exist in the areas of borings at the project site depending on the depth of the tunnel alignment. Where mixed face conditions are encountered, control of the grade of the face of excavation is more difficult to control, and local instability of the face of the excavation is more likely at and near locations where the boundary between two strata is exposed in the excavation.

Face of Excavation Stability. The stability of the face is a function of the shear strength and stress-strain characteristics of the soil or rock, the overburden pressure, the geometry of the cross section, the time-dependent loss of strength, the delayed deformation of some soils, and the construction procedures. When the face consists of more than one kind of soil or rock, the stability of such a face may be assessed by analyzing the different materials independently.

For the cohesive soil materials that may be encountered the stability of a face is determined by its existing undrained shear strength. The stability of the unsupported face of the excavation may be evaluated by a ratio of the overburden pressure divided by the undrained shear strength of the soil assuming atmospheric air pressure in the tunnel. This ratio is referred to as the Overload Factor, OF. Based on the measured soil properties, OF values were 3.0 or less.

Generally, a design value for the overload factor of 4 or less is desirable in cohesive soils. Higher OF values will frequently lead to large deformations of the soil around and ahead of the excavation, with the associated problem of increased subsidence and possible deformations. It should be noted; however, that exposure time of the face is the most important. At the moment of excavation, negative pore pressures are generated. If the soil is left under the same conditions, the pore pressures will dissipate resulting in a reduction of shear strength. Thus, if a slow rate of advance is
expected, a higher value of the OF must be used (or a reduced corrected value for the undrained shear strength).

Fill material were encountered in borings B-8 and B-9 at a depth of 0 to 3 feet. However, fill material from road grading or in old utility trenches may also be encountered. A potential for face instability exists where weak fill soils are encountered. The contractor should be aware of these conditions and make provisions to avoid loss of ground where fill is encountered.

**Loss of Ground.** A properly designed and controlled operation can eliminate or reduce immediate soil movement and subsidence to a tolerable level. Nevertheless, some ground loss should be expected during trenchless operation. With good construction techniques, ground loss can be held to acceptable levels. Generally, pipes bored or jacked beneath pavement and buried utilities can be expected to create a loosened subgrade or bedding condition which may lead to subsequent deformations. Advance rate and excavation rate should be compatible to avoid over excavation or loss of ground in order to minimize deformations.

Groundwater was encountered in the borings while drilling and may be encountered in all segments along the proposed waterline route during tunneling operations. We recommend that equipment providing positive support to the face, such as earth pressure balance equipment, be used when constructing this project.

Large ground loss can result from uncontrolled flowing ground. The potential for such ground loss exists wherever water-bearing sands or silts are encountered along the alignment. Careful dewatering of such layers will reduce the potential for development of flowing conditions. **These conditions were encountered in some of the borings depending on the depth of tunneling operation.** If these conditions are encountered during construction, tunneling should be halted and measures need to be taken to dewater the area.

**Ground Surface Movements.** The zone of influence of a trenchless crossing extends a distance equal to the invert depth on each side of the centerline of the alignment. No building structures are anticipated to be in the zone of influence. However pavement, rail line, and utilities are expected adjacent to or crossing the alignment and may experience movement caused by trenchless excavation. Settlement of these structures should be within acceptable limits provided good construction practices are followed. Long-term vertical movements caused by consolidation of the ground above the tunnel will occur if leakage into the liner impacts groundwater levels in the project area.

We recommend that settlement monitoring points be established and monitored along these structures located within 100 feet of tunneling operations during construction. Limits of movements for each structure should be agreed upon by the owner of that structure prior to construction.

### 6.6 Groundwater Control

Assessment of the need for groundwater control and installation of appropriate dewatering equipment is the contractor's responsibility. The following comments are intended to represent common solutions to groundwater control problems encountered in similar soil conditions in the North Texas area, and may not be construed as dewatering system design recommendations.

A conventional pump and sump arrangement may be adequate if water bearing cohesive soils are encountered during trench excavations. Well points or eductors may be utilized to lower the groundwater level to at least three feet below the excavation level where water bearing cohesionless soils are encountered. Well points are generally not effective below about 15 feet beneath the top of the well point, and deeper dewatering requires deep wells with submersible pumps and eductors. Based on the subsurface soils encountered, we anticipate groundwater to be controlled using a
combination of pump and sump arrangement and well points. If necessary, coarse gravel should be used instead of embedment material under the pipe to provide for the free drainage and flow of water in the trench. In any case, the groundwater control system used must provide a relatively dry, stable base for construction. However, it should be noted that groundwater conditions will change due to rainfall and seasonal changes.

Control of groundwater should be accomplished in a manner that will preserve the strength of the foundation soils; will not cause instability of the excavation; and will not result in damage to existing structures. Where necessary to this purpose, the water will be lowered in advance of excavation by pump and sump arrangement, wells, well points, or similar methods. Open pumping should not be permitted if it results in boils, loss of fines, softening of the subgrade, or excavation instability. Discharge should be arranged to facilitate sampling by the owner's representative or engineer.

6.7 **Thrust Force Design Recommendations**

Unbalanced thrust forces will be developed in water lines due to changes in direction, cross-sectional areas, or when the pipe is terminated. These forces may cause joints to disengage if not adequately restrained. There will be a slight loss of hydraulic head due to the development of turbulence in bends in the pipes. This loss will cause a pressure change across the bend, but it is usually small enough to be neglected. The thrust force acting on bend is shown in Plate 16.

The thrust force may require more reaction than is available just from the pipe bearing against the backfill. In order to prevent intolerable movement and overstressing of the pipe, suitable buttressing should be provided. In general, thrust blocks, concrete encasement, restrained joints and tie rods are common methods of providing reaction for the thrust restraint design. The thrust restraint design provisions described in this section are based on the American Water Works Association Manual M9 (1979).

7 **MONITORING**

7.1 **Excavation Safety**

As required under OSHA regulations, the contractor should provide a “competent person” to inspect trench excavations daily before the start of work, as needed during the shift, and after every rainstorm or other hazard increasing occurrence. When the competent person finds evidence of a hazardous condition, exposed workers should be removed from the hazardous area until the necessary precautions have been taken to ensure their safety. A competent person means one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous or dangerous to workers, and who has authorization to take prompt corrective measures to eliminate them.

7.2 **Construction Materials Testing**

We recommend that backfill be monitored by an accredited testing laboratory to verify that construction is performed in conformance with project specifications. HVJ Associates® routinely provides these services and would be pleased to do so for this project.
8 DESIGN REVIEW

HVJ Associates® should review the design and construction plans and specifications prior to release to make certain that the geotechnical recommendations and design criteria presented herein have been properly interpreted.

9 LIMITATIONS

This investigation was performed for the exclusive use of Halff Associates for the realignment of the existing Jamison 48-inch Water Line between SH 114 and Spur 482 in the City of Irving, Texas. HVJ Associates® has endeavored to comply with generally accepted geotechnical engineering practice common in the local area. HVJ Associates® makes no warranty, express or implied. The analyses and recommendations contained in this report are based on data obtained from subsurface exploration, laboratory testing, the project information provided to us and our experience with similar soils and site conditions.

The methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Samples cannot be relied on to accurately reflect the strata variations that usually exist between sampling locations. Should any subsurface conditions other than those described in our boring logs be encountered, HVJ Associates® should be immediately notified so that further investigation and supplemental recommendations can be provided.
PLATES
SITE VICINITY MAP
48-INCH WATER LINE AT SH 114 AND SPUR 482

Project Location

Image obtained from Google Earth Pro, April 2019
Legend
Qt: Fluviatile Terrace Deposits
Qal: Alluvium Deposit
Kef: Eagle Ford Formation
Kau: Austin Chalk

Image obtained from Geologic Atlas of Texas, Dallas Sheet
Approximate Boring locations

Image obtained from Google Earth Pro, April 2019
Approximate Boring locations

Image obtained from Google Earth Pro, April 2019
Approximate Boring locations

Image obtained from Google Earth Pro, April 2019
**LOG OF BORING**

Project: 48" Waterline at SH 114  
Boring No.: B-1  
Groundwater during drilling: 18 feet  
Groundwater after drilling: 24 feet  
Date: 3/18/2019  
Nothing: 32.846284  
Easting: -96.896063  
Elevation: N/A  
Station: --  
Offset: --  
Project No.: DG-18-10117.1

**SOIL SYMBOLS**  
**DEPTH, FEET**  
**SOIL/ROCK CLASSIFICATION**  
**% PASSING NO. 200 SIEVE**  
**DRY DENSITY, PCF**  
**SHEAR STRENGTH, TSF**  
**PLASTIC LIMIT**  
**LIQUID LIMIT**  
**CONTENT, %**  

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>SOIL SYMBOLS</th>
<th>DEPTH, FEET</th>
<th>SAMPLER SYMBOLS</th>
<th>AND FIELD TEST DATA</th>
<th>SOIL/ROCK CLASSIFICATION</th>
<th>% PASSING NO. 200 SIEVE</th>
<th>DRY DENSITY, PCF</th>
<th>SHEAR STRENGTH, TSF</th>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
<th>CONTENT, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FAT CLAY (CH), soft to stiff, moist, dark brown, trace gravel and calcareous deposits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FAT CLAY (CH), sandy, stiff to very stiff, moist to wet, brown to light brown, with ferrous stains</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-with gray shaley clay seams at 23 feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>SHALE, clayey, soft, dark gray to tan, highly weathered, severely fractured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Boring terminated at 35 feet below ground surface.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>25</td>
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<td></td>
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<td>30</td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

Shear Types:  
- = Hand Penet.  
■ = Torvane  
▲ = Unconf. Comp.  
★ = UU Triaxial  

See Plate 3 for boring location.
## LOG OF BORING

**Project:** 48" Waterline at SH 114  
**Boring No.:** B-2  
**Date:** 3/18/2019  
**Project No.:** DG-18-10117.1  
**Groundwater during drilling:** ---  
**Groundwater after drilling:** ---  
**Northing:** 32.845709  
**Easting:** -96.897554  
**Elevation:** N/A  
**Station:** --  
**Offset:** --

### SOIL/SOIL CLASSIFICATION

<table>
<thead>
<tr>
<th>ELEV. FEET</th>
<th>SOIL SYMBOLS</th>
<th>SOIL/ROCK CLASSIFICATION</th>
<th>DRY DENSITY, PCF</th>
<th>% PASSING NO. 200 SIEVE</th>
<th>SHEAR STRENGTH, TSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>FAT CLAY (CH), sandy, stiff, dark brown to brown, with intermixed light brown sand seams</td>
<td>62</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>10-3-18</td>
<td></td>
<td>CLAYEY SAND (SC), dense, light brown, with trace gravel</td>
<td>27</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>15-21-35</td>
<td></td>
<td>SHALE, clayey, soft, dark gray to tan, highly weathered, severely fractured</td>
<td>80</td>
<td>104</td>
<td></td>
</tr>
</tbody>
</table>

**Boring terminated at 35 feet below ground surface.**

**Shear Types:**  
○ = Hand Penet.  
■ = Torvane  
▲ = Unconf. Comp.  
★ = UU Triaxial

**See Plate 3 for boring location.**

**PLATE 5**
**SOIL/ROCK CLASSIFICATION**

- **BASE**, sandy gravel, loose, moist, brown
- **LEAN CLAY (CL)**, with sand, stiff, moist, tanish brown to brown, with calcareous deposits, sand pockets
- **CLAYEY SAND (SC)**, medium dense, moist, brown to light brown, fine grained, with calcareous deposits
- **SHALE**, clayey, soft, dark gray, highly weathered, severely fractured

Boring terminated at 25 feet

---

**SOIL SYMBOLS**

<table>
<thead>
<tr>
<th>ELEV. DEPTH, FEET</th>
<th>SOIL SYMBOLS</th>
<th>SOIL/ROCK CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Base</td>
<td>sandy gravel, loose, moist, brown</td>
</tr>
<tr>
<td>5</td>
<td>Lean Clay (CL)</td>
<td>with sand, stiff, moist, tanish brown to brown, with calcareous deposits, sand pockets</td>
</tr>
<tr>
<td>10</td>
<td>Clayey Sand (SC)</td>
<td>medium dense, moist, brown to light brown, fine grained, with calcareous deposits</td>
</tr>
<tr>
<td>15</td>
<td>Shale</td>
<td>clayey, soft, dark gray, highly weathered, severely fractured</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LOG OF BORING**

Project: 48" Waterline at SH 114
Boring No.: B-3
Groundwater during drilling: 13 feet
Groundwater after drilling: 9 feet

Date: 3/27/2019
Project No.: DG-18-10117.1
Northing: 32.844587
Easting: -96.899065
Station: --
Offset: --

See Plate 3 for boring location.
**LOG OF BORING**

Project: 48" Waterline at SH 114  
Boring No.: B-4  
Groundwater during drilling: 9 feet  
Groundwater after drilling: ---

Date: 3/18/2019  
Northing: 32.843628  
Easting: -96.900270  
Station: --  
Offset: --

**SOIL SYMBOLS**  
**DEPTH, FEET**  
**SOIL/ROCK CLASSIFICATION**  
**SAMPLER SYMBOLS**  
**AND FIELD TEST DATA**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>SOIL SYMBOLS</th>
<th>SOIL/ROCK CLASSIFICATION</th>
<th>% PASSING NO. 200 SIEVE</th>
<th>DRY DENSITY PCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>BASE, sandy gravel, light brown</td>
<td>0.5 1.0 1.5 2.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>CLAYEY SAND (SC), loose, light brown to tan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>SHALE, clayey, soft, dark gray to tan, highly weathered, severely fractured</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
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<tr>
<td>25</td>
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<td>30</td>
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<td></td>
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<tr>
<td>35</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Plate 3 for boring location.

---

**PLATE 7**
LOG OF BORING

Project: 48" Waterline at SH 114
Date: 3/19/2019
Project No.: DG-18-10117.1
Boring No.: B-5
Elevation: N/A
Groundwater during drilling: 10 feet
Station: --
Groundwater after drilling: ---
Offset: --

SOIL/ROCK CLASSIFICATION

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>SOIL SYMBOLS</th>
<th>SAMPLER SYMBOLS</th>
<th>ELEV. DEPTH, FEET</th>
<th>DRY DENSITY PCF</th>
<th>% PASSING NO. 200 SIEVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-13-12</td>
<td>PAVEMENT, 1 inches of Asphalt over 11 inches of Base</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-26-27</td>
<td>CLAYEY SAND (SC), loose, moist, light brown</td>
<td></td>
<td></td>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>SANDY CLAY (SC), stiff to very stiff, moist, dark brown, with light brown sand pockets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SAND WITH CLAY (SP-SC), medium dense, tan to gray, poorly graded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>-becomes brown with gravel below 13 feet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SHALE, clayey, soft, dark gray, highly weathered, severely fractured</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Boring terminated at 25 feet below ground surface.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Plate 3 for boring location.
**LOG OF BORING**

<table>
<thead>
<tr>
<th>Project: 48&quot; Waterline at SH 114</th>
<th>Date: 3/19/2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring No.: B-6</td>
<td></td>
</tr>
<tr>
<td>Groundwater during drilling: 15 feet</td>
<td></td>
</tr>
<tr>
<td>Groundwater after drilling: ---</td>
<td></td>
</tr>
<tr>
<td>Project No.: DG-18-10117.1</td>
<td></td>
</tr>
<tr>
<td>Elevation: N/A</td>
<td></td>
</tr>
<tr>
<td>Station: --</td>
<td></td>
</tr>
<tr>
<td>Offset: --</td>
<td></td>
</tr>
</tbody>
</table>

**SOIL/ROCK CLASSIFICATION**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH, FEET</th>
<th>SOIL SYMBOLS</th>
<th>SAMPLER SYMBOLS</th>
<th>SOIL/ROCK CLASSIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6-5-8</td>
<td></td>
<td></td>
<td>CLAYEY SAND (SC), loose, moist, brown to light brown, with trace gravel and calcareous deposits</td>
</tr>
<tr>
<td>5</td>
<td>7-13-19</td>
<td></td>
<td></td>
<td>SANDY CLAY (CL), very soft to soft, brown, with light brown sand pockets</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>-becomes gray and brown below 13 feet</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>SHALE, clayey, stiff, dark gray, highly weathered, severely fractured</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>Boring terminated 25 feet below ground surface.</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
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<tr>
<td>35</td>
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<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Shear Types:**
- ● = Hand Penet.
- □ = Torvane
- ▲ = Unconf. Comp.
- ★ = UU Triaxial

See Plate 3 for boring location.

PLATE 9
PAVEMENT, 1 inch of Asphalt
CLAYEY SAND (SC), loose, moist, brown to gray, with gravel
LEAN CLAY (CL), with sand, stiff, moist, brown to gray
SHALE, clayey, soft, dark gray to brown, highly weathered

Boring terminated 25 feet below ground surface.

Shear Types:  ● = Hand Penet.  ■ = Torvane  ▲ = Unconf. Comp.  ★ = UU Triaxial

See Plate 3 for boring location.
**LOG OF BORING**

Project: 48" Waterline at SH 114  
Boring No.: B-8  
Groundwater during drilling: 16 feet  
Groundwater after drilling: 16 feet

Date: 3/20/2019  
Northing: 32.841309  
Easting: -96.906555  
Station: --  
Offset: --

**SOIL/ROCK CLASSIFICATION**

- **FILL**, sandy lean clay, soft, moist, brown, with gravel
- **CLAYEY SAND (SC)**, loose, moist, brown to gray
- **SANDY CLAY (CL)**, stiff to very stiff, moist to wet, brown to dark brown
- **SHALE**, clayey, soft, dark gray, highly weathered
- **SHALE**, very soft, dark gray

**SOIL SYMBOLS**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>SOIL SYMBOLS</th>
<th>DEPTH, FEET</th>
<th>SAMPLER SYMBOLS</th>
<th>AND FIELD TEST DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

**LOG OF BORING**

- Compressive Strength at 35.25 feet = 9.8 tsf
- Compressive Strength at 39 feet = 11.48 tsf

Boring terminated at 40 feet below ground surface.

**PLATE 11**
**LOG OF BORING**

Project: 48" Waterline at SH 114  
Boring No.: B-9  
Groundwater during drilling: 22 feet  
Groundwater after drilling: ---  

**Date:** 3/21/2019  
**Project No.:** DG-18-10117.1  
**Elevation:** N/A  
**Northing:** 32.840367  
**Easting:** -96.908008  
**Station:** --  
**Offset:** --  

<table>
<thead>
<tr>
<th>ELEV., FEET</th>
<th>SOIL SYMBOLS</th>
<th>SOIL/ROCK CLASSIFICATION</th>
<th>% PASSING NO. 200 SIEVE</th>
<th>DRY DENSITY PCF</th>
<th>MOISTURE CONTENT, %</th>
<th>PLASTIC LIMIT</th>
<th>LIQUID LIMIT</th>
<th>SHEAR STRENGTH, TSF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td><strong>FILL</strong>, clayey sand, very loose, moist, brown to tan, with gravel</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td><strong>SANDY CLAY (CL)</strong>, very soft to stiff, moist, brown, with gravel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td><strong>CLAYEY SAND (SC)</strong>, medium dense, moist, tan to brown</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-- (wet at 23.5 feet)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td><strong>SHALE</strong>, clayey, very soft to soft, dark gray, highly weathered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td><strong>SHALE</strong>, very soft to soft, dark gray</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td>- Compressive Strength at 37 feet = 12.5 tsf</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>Boring terminated at 40 feet below ground surface.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Shear Types:**  
- = Hand Penet.  
■ = Torvane  
▲ = Unconf. Comp.  
★ = UU Triaxial  

See Plate 3 for boring location.

PLATE 12
### SOIL SYMBOLS

<table>
<thead>
<tr>
<th>Soil Types</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>🌱</td>
</tr>
<tr>
<td>Silt</td>
<td>🌱</td>
</tr>
<tr>
<td>Sand</td>
<td>🌱</td>
</tr>
<tr>
<td>Gravel</td>
<td>🌱</td>
</tr>
<tr>
<td>Clayey</td>
<td>🌱</td>
</tr>
<tr>
<td>Silty</td>
<td>🌱</td>
</tr>
<tr>
<td>Sandy</td>
<td>🌱</td>
</tr>
<tr>
<td>Fill</td>
<td>🌱</td>
</tr>
</tbody>
</table>

### Sampler Types

- Thin Walled Shelby Tube
- Split Barrel
- Auger
- THD Cone Penetration Test
- Jar Sample
- No Recovery

### WATER LEVEL SYMBOLS

- Groundwater measured after drilling operations
- Groundwater measured during drilling operations

### SOIL GRAIN SIZE

<table>
<thead>
<tr>
<th>Classification</th>
<th>Particle Size</th>
<th>Particle Size or Sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>&lt; 0.002 mm</td>
<td>0.002 - 0.075 mm</td>
</tr>
<tr>
<td>Silt</td>
<td>0.075 - 4.75 mm</td>
<td>0.002 mm - #200 sieve</td>
</tr>
<tr>
<td>Sand</td>
<td>4.75 - 75 mm</td>
<td>#200 sieve - #4 sieve</td>
</tr>
<tr>
<td>Gravel</td>
<td>75 - 200 mm</td>
<td>#4 sieve - 3 in.</td>
</tr>
<tr>
<td>Boulder</td>
<td>&gt; 200 mm</td>
<td>&gt; 8 in.</td>
</tr>
</tbody>
</table>

### DENSITY OF COHESIONLESS SOILS

Descriptive Term | Penetration Resistance “N” * Blow/Foot
--- | ---
Very Loose       | 0 - 4
Loose            | 4 - 10
Medium Dense     | 10 - 30
Dense            | 30 - 50
Very Dense       | > 50

### CONSISTENCY OF COHESIVE SOILS

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Undrained Shear Strength (tsf)</th>
<th>Penetration Resistance “N” * (Blows/ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Soft</td>
<td>0 - 0.125</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Soft</td>
<td>0.125 - 0.25</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Firm</td>
<td>0.25 - 0.5</td>
<td>4 - 8</td>
</tr>
<tr>
<td>Stiff</td>
<td>0.5 - 1.0</td>
<td>8 - 15</td>
</tr>
<tr>
<td>Very Stiff</td>
<td>1.0 - 2.0</td>
<td>15 - 30</td>
</tr>
<tr>
<td>Hard</td>
<td>&gt; 2.0</td>
<td>&gt; 30</td>
</tr>
</tbody>
</table>

### PENETRATION RESISTANCE

- **# - # - #**: Blows required penetrating each of three consecutive 6-inch increments per ASTM D-1586
- **50/4”**: If more than 50 blows are required, driving is discontinued and penetration at 50 blows is noted
- **4/6”**: Texas Cone Penetration blows required penetrating each of two consecutive 6-inch increments per TEX-132-E

* The N value is taken as the blows required to penetrate the final 12 inches

### TERMS DESCRIBING SOIL STRUCTURE

- **Slickensided**: Fracture planes appear polished or glossy, sometimes striated
- **Fissured**: Breaks along definite planes of fracture with little resistance to fracturing
- **Inclusion**: Small pockets of different soils, such as small lenses of sand scattered through a mass of clay
- **Parting**: Inclusion less than 1/4 inch thick extending through the sample
- **Seam**: Inclusion 1/4 inch to 3 inches thick extending through the sample
- **Layer**: Inclusion greater than 3 inches thick extending through the sample
- **Laminated**: Soil sample composed of alternating partings of different soil type
- **Stratified**: Soil sample composed of alternating seams or layers of different soil type
- **Intermixed**: Soil sample composed of pockets of different soil type and laminated or stratified structure is not evident
- **Calcareous**: Having appreciable quantities of calcium carbonate
- **Ferrous**: Having appreciable quantities of iron
- **Nodule**: A small mass of irregular shape

### KEY TO TERMS AND SYMBOLS USED ON BORING LOGS

**PROJECT NO.:** DG-18-10117.1  **DRAWING NO.:** Plate 13A
Information on each boring log is a compilation of subsurface conditions and soil and rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.

**SOLUTION AND VOID CONDITIONS**

<table>
<thead>
<tr>
<th>Void</th>
<th>Interstice; a general term for pore space or other openings in rock.</th>
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<tbody>
<tr>
<td>Cavities</td>
<td>Small solutional concavities.</td>
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<tr>
<td>Vuggy</td>
<td>Containing small cavities, usually lined with a mineral of different composition from that of the surrounding rock.</td>
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<tr>
<td>Vesicular</td>
<td>Containing numerous small, unlined cavities, formed by expansion of gas bubbles or steam during solidification of the rock.</td>
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<tr>
<td>Porous</td>
<td>Containing pores, interstices, or other openings which may or may not interconnect.</td>
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<tr>
<td>Cavernous</td>
<td>Containing cavities or caverns, sometimes quite large. Most frequent in limestones and dolomites.</td>
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**HARDNESS**

- **Friable**: Crumbles under hand pressure
- **Low Hardness**: Can be carved with a knife
- **Moderately Hard**: Can be scratched easily with a knife
- **Very Hard**: Cannot be scratched with a knife

**WEATHERING GRADES OF ROCKMASS**

1. **Fresh**: No discoloration, loss of strength, or other effect of weathering.
2. **Slightly**: Discoloration indicates weathering of rock material and discontinuity surfaces.
3. **Moderately**: Discoloration indicates weathering of rock material and discontinuity surfaces.
4. **Highly**: Less than half of the rock material is decomposed or disintegrated to a soil.
5. **Extremely**: All rock material is decomposed and/or disintegrated into soil. The original mass structure is still largely intact.
6. **Residual Soil**: All rock material is converted to soil. The mass structure and material fabric are destroyed.

**JOINT DESCRIPTION**

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<tr>
<th>SPACING</th>
<th>INCLINATION</th>
<th>SURFACES</th>
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<td>Very Close</td>
<td>0-5</td>
<td>Slickensided</td>
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<td>Close</td>
<td>5-35</td>
<td>Polished, grooved</td>
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<td>Medium Close</td>
<td>35-65</td>
<td>Smooth</td>
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<td>Wide</td>
<td>65-85</td>
<td>Planar</td>
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<td>85-90</td>
<td>Irregular</td>
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<td>Undulating or granular</td>
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<td>Rough</td>
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<td>Jagged or pitted</td>
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**BEDDING THICKNESS**

1. **Very Thick**: >4'
2. **Thick**: 2'-4'
3. **Thin**: 2"-2'
4. **Very Thin**: 1/2"-2"
5. **Laminated**: 0.08"-1/2"
6. **Thinly Laminated**: <0.08"

**REFERENCES**

**H** (ft) = Depth to Excavation Bottom

**S** (psf) = Surcharge loading adjacent to Excavation wall

**Dw** (ft) = Depth to groundwater below Existing grade

  - Zero for temporary excavation

**Hs** (ft) = Equivalent Depth of surcharge loading

\[
Hs = \frac{S}{120}
\]

Note: The pressure diagram shown is not appropriate for design of cantilever walls.

**K** = Lateral Earth Pressure coefficient

- Clay: 0.5 for short term (K_a), 1.0 for long term condition (K_o)
- Sand: 0.3 for short term (K_a), 0.5 for long term condition (K_o)

\[
\delta_w, (pcf) = \text{Total unit weight above water table or submerged unit weight below groundwater level}
\]

\[
\delta_w, (pcf) = \text{Unit weight of water} = 62.4 \text{ pcf}
\]
For

\[ D_w \leq H \]

\[ P_1 = 7D_w + (H-D_w)(7-\gamma_w)+P_s + (H-D_w)\gamma_w \]

\[ P_2 = [7D_w + (H-D_w)(7-\gamma_w)+P_s]K_o + (H-D_w)\gamma_w \]

\[ P_3 = [7D_w + (H+D_w)(7-\gamma_w)+P_s]K_o + (H+D_w)\gamma_w \]

\[ P_4 = 7D_w + (H+D_w)(7-\gamma_w)+P_s + (H+D_w)\gamma_w \]

For

\[ H < D_w < H+W \]

\[ P_1 = H+P_s \]

\[ P_2 = (7H+P_s)K_o \]

\[ P_3 = [7D_w + (H+D_w)(7-\gamma_w)+P_s]K_o + (H+D_w)\gamma_w \]

\[ P_4 = 7D_w + (H+D_w)(7-\gamma_w)+P_s + (H+D_w)\gamma_w \]

Where

\[ P_1, P_2, P_3 = \text{Pressure imposed on pipe, psf} \]

\[ D_w = \text{Depth of groundwater, feet} \]

\[ H = \text{Depth of top of pipe from ground surface, feet} \]

\[ W = \text{Diameter of pipe, feet} \]

\[ \gamma = \text{Total Unit weight of soil, pcf} \]

\[ \gamma_w = \text{Unit weight of water, pcf} \]

\[ P_s = \text{Surcharge load, psf} \]

\[ K_o = \text{Coefficient of earth pressure, (1.0 for clays and 0.5 for sands)} \]
\[ T_x = PA \left( 1 - \cos \theta \right) \]
\[ T_y = PA \sin \theta \]
\[ T = 2 PA \sin \frac{\theta}{2} \]
\[ \Delta = \left( 90 - \frac{\theta}{2} \right) \]

Where:

- \( T \) is the resultant force on the bend.
- \( T_x \) is the component of thrust force in x-direction.
- \( T_y \) is the component of thrust force in y-direction.
- \( P \) is the maximum sustained pressure.
- \( A \) is the pipe cross-sectional area.
- \( \theta \) is the bend deflection angle.
- \( \Delta \) is the angle between \( T \) and X-axis.
- \( V \) is the fluid velocity.
- \( D \) is the inside diameter of conduit.

Sample Calculation:

Given: \( P = 150 \text{ psi}, D = 1.0' = 12'' \)
\( A = \left( \frac{\pi D^2}{4} \right) = 113.1 \text{ in}^2 \)

Find:
\( T = 2 PA \sin \frac{\theta}{2} = 2 \times 150 \times 113.1 \times \sin \left( \frac{90}{2} \right) \)
\( = 23,239 \text{ lb} = 24.0 \text{ kips} \)
\( T_x = PA \left( 1 - \cos \theta \right) = 150 \times 113.1 \times \left( 1 - \cos 90^\circ \right) \)
\( = 16,969 \text{ lb} = 17.0 \text{ kips} \)
\( T_y = PA \sin \theta = 150 \times 113.1 \times \sin \left( 90^\circ \right) \)
\( = 16,969 \text{ lb} = 17.0 \text{ kips} \)
APPENDIX A

SUMMARY OF LABORATORY TEST RESULTS
<table>
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<tr>
<th>Boring#</th>
<th>Depth</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>PI</th>
<th>Percent Finer Than #200 Sieve</th>
<th>Moisture Content (%)</th>
<th>Dry Unit Weight (pcf)</th>
<th>Shear Strength Soil (UC) (tsf)</th>
<th>Compressive Strength Rock (UC) (tsf)</th>
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APPENDIX B

SULFATES, CHLORIDES AND PH TEST RESULTS
Analytical Report  619634

for
HVJ North Texas-Chelliah Consultants Inc.

Project Manager: Saif Salah

48 In Waterline

DG18-10117.1

08-APR-19

Collected By: Client

9701 Harry Hines Blvd
Dallas, TX 75220

Xenco-Houston (EPA Lab Code: TX00122):
Texas (T104704215-18-28), Arizona (AZ0765), Florida (E871002-24), Louisiana (03054)
Oklahoma (2017-142)

Xenco-Dallas (EPA Lab Code: TX01468):
Texas (T104704295-18-17), Arizona (AZ0809), Arkansas (17-063-0)

Xenco-El Paso (EPA Lab Code: TX00127): Texas (T104704221-18-14)
Xenco-Lubbock (EPA Lab Code: TX00139): Texas (T104704219-18-18)
Xenco-Midland (EPA Lab Code: TX00158): Texas (T104704400-18-18)
Xenco-San Antonio (EPA Lab Code: TNI02385): Texas (T104704534-18-4)
Xenco Phoenix (EPA Lab Code: AZ00901): Arizona (AZ0757)
Xenco-Phoenix Mobile (EPA Lab Code: AZ00901): Arizona (AZM757)
Xenco-Atlanta (LELAP Lab ID #04176)
Xenco-Tampa: Florida (E87429), North Carolina (483)
Xenco-Lakeland: Florida (E84098)
Saif Salah:

We are reporting to you the results of the analyses performed on the samples received under the project name referenced above and identified with the XENCO Report Number(s) 619634. All results being reported under this Report Number apply to the samples analyzed and properly identified with a Laboratory ID number. Subcontracted analyses are identified in this report with either the NELAC certification number of the subcontract lab in the analyst ID field, or the complete subcontracted report attached to this report.

Unless otherwise noted in a Case Narrative, all data reported in this Analytical Report are in compliance with NELAC standards. The uncertainty of measurement associated with the results of analysis reported is available upon request. Should insufficient sample be provided to the laboratory to meet the method and NELAC Matrix Duplicate and Matrix Spike requirements, then the data will be analyzed, evaluated and reported using all other available quality control measures.

The validity and integrity of this report will remain intact as long as it is accompanied by this letter and reproduced in full, unless written approval is granted by XENCO Laboratories. This report will be filed for at least 5 years in our archives after which time it will be destroyed without further notice, unless otherwise arranged with you. The samples received, and described as recorded in Report No. 619634 will be filed for 45 days, and after that time they will be properly disposed without further notice, unless otherwise arranged with you. We reserve the right to return to you any unused samples, extracts or solutions related to them if we consider so necessary (e.g., samples identified as hazardous waste, sample sizes exceeding analytical standard practices, controlled substances under regulated protocols, etc).

We thank you for selecting XENCO Laboratories to serve your analytical needs. If you have any questions concerning this report, please feel free to contact us at any time.

Respectfully,

Kalei Stout

Laboratory Manager

Recipient of the Prestigious Small Business Administration Award of Excellence in 1994.
Certified and approved by numerous States and Agencies.
A Small Business and Minority Status Company that delivers SERVICE and QUALITY
Houston - Dallas - Midland - San Antonio - Phoenix - Oklahoma - Latin America
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Sample receipt non conformances and comments per sample:

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Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-1  
Lab Sample Id: 619634-001  
Date Received: 04.01.19 15.55

Date Collected: 04.01.19 00.00  
Sample Depth: 13 - 15

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B
Tech: SDK  
% Moisture: 
Analyst: SDK  
Basis: Wet Weight
Seq Number: 3084204

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Analytical Method: Soil pH by EPA 9045C
Tech: SDK  
% Moisture: 
Analyst: SDK  
Basis: Wet Weight
Seq Number: 3084389

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Analytical Method: Sulfate by SW-846 9038
Tech: SDK  
% Moisture: 
Analyst: SDK  
Basis: Wet Weight
Seq Number: 3084855

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Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-2
Lab Sample Id: 619634-002

Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 18 - 20

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI- B
Tech: SDK
Analyst: SDK
Seq Number: 3084204

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Analytical Method: Soil pH by EPA 9045C
Tech: SDK
Analyst: SDK
Seq Number: 3084389

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Analytical Method: Sulfate by SW-846 9038
Tech: SDK
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Seq Number: 3084855

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Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: **B-3**  
Lab Sample Id: 619634-003  
Date Received: 04.01.19 15.55  
Sample Depth: 13 - 14.5

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B
Tech: **SDK**  
Analyst: **SDK**  
Seq Number: **3084204**

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Analytical Method: Soil pH by EPA 9045C
Tech: **SDK**  
Analyst: **SDK**  
Seq Number: **3084389**

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Analytical Method: Sulfate by SW-846 9038
Tech: **SDK**  
Analyst: **SDK**  
Seq Number: **3084855**

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Page 7 of 20  Final 1.000
Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-4
Lab Sample Id: 619634-004
Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 13 - 14.5

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B

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Analytical Method: Soil pH by EPA 9045C

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Analytical Method: Sulfate by SW-846 9038

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<th>Dil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>14808-79-8</td>
<td>427</td>
<td>249</td>
<td>mg/kg</td>
<td>04.04.19 10.30</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-5
Lab Sample Id: 619634-005
Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 18 - 20

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI- B

<table>
<thead>
<tr>
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<th>Cas Number</th>
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<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
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<tbody>
<tr>
<td>Chloride</td>
<td>16887-00-6</td>
<td>19.9</td>
<td>4.99</td>
<td>mg/kg</td>
<td>04.02.19 10.00</td>
<td>1</td>
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Analytical Method: Soil pH by EPA 9045C

<table>
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<th>Result</th>
<th>RL</th>
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<th>Analysis Date</th>
<th>Flag</th>
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</thead>
<tbody>
<tr>
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<td>12408-02-5</td>
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<tr>
<td>Temperature</td>
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<td></td>
<td>Deg C</td>
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Analytical Method: Sulfate by SW-846 9038

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<tr>
<th>Parameter</th>
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<th>Units</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>14808-79-8</td>
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</table>
Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-6
Lab Sample Id: 619634-006
Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 13 - 15

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI- B
Tech: SDK
Analyst: SDK
Seq Number: 3084204

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cas Number</th>
<th>Result</th>
<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>16887-00-6</td>
<td>&lt;4.97</td>
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<td>mg/kg</td>
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Analytical Method: Soil pH by EPA 9045C
Tech: SDK
Analyst: SDK
Seq Number: 3084389

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cas Number</th>
<th>Result</th>
<th>RL</th>
<th>Units</th>
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<th>Flag</th>
<th>Dil</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
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<tr>
<td>Temperature</td>
<td>TEMP</td>
<td>22.9</td>
<td></td>
<td>Deg C</td>
<td>04.03.19 10.30</td>
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Analytical Method: Sulfate by SW-846 9038
Tech: SDK
Analyst: SDK
Seq Number: 3084855

<table>
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<tr>
<th>Parameter</th>
<th>Cas Number</th>
<th>Result</th>
<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
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<tbody>
<tr>
<td>Sulfate</td>
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<td>89.0</td>
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</table>
Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-7
Lab Sample Id: 619634-007

Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 13 - 15

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B
Tech: SDK
Analyst: SDK
Seq Number: 3084204

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cas Number</th>
<th>Result</th>
<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>16887-00-6</td>
<td>14.9</td>
<td>4.98</td>
<td>mg/kg</td>
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Analytical Method: Soil pH by EPA 9045C
Tech: SDK
Analyst: SDK
Seq Number: 3084389

<table>
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<th>RL</th>
<th>Units</th>
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<th>Flag</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
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<tr>
<td>Temperature</td>
<td>TEMP</td>
<td>22.3</td>
<td></td>
<td>Deg C</td>
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Analytical Method: Sulfate by SW-846 9038
Tech: SDK
Analyst: SDK
Seq Number: 3084855

<table>
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<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>14808-79-8</td>
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</table>
# Certificate of Analytical Results 619634

**HVJ North Texas-Chelliah Consultants Inc., Dallas, TX**

**48 In Waterline**

Sample Id: **B-8**  
Lab Sample Id: 619634-008  
Date Received: 04.01.19 15.55  
Sample Depth: 28 - 29.5

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B  
Tech: SDK  
Analyst: SDK  
Seq Number: 3084204

<table>
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<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Chloride</td>
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Analytical Method: Soil pH by EPA 9045C  
Tech: SDK  
Analyst: SDK  
Seq Number: 3084389

<table>
<thead>
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<th>Parameter</th>
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<tbody>
<tr>
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<tr>
<td>Temperature</td>
<td>TEMP</td>
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<td>Deg C</td>
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Analytical Method: Sulfate by SW-846 9038  
Tech: SDK  
Analyst: SDK  
Seq Number: 3084855

<table>
<thead>
<tr>
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<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
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</tbody>
</table>
Certificate of Analytical Results 619634

HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: B-9
Lab Sample Id: 619634-009
Date Received: 04.01.19 15.55
Date Collected: 04.01.19 00.00
Sample Depth: 13 - 15

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B
Tech: SDK
Analyst: SDK
Seq Number: 3084204

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
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</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>16887-00-6</td>
<td>&lt;4.97</td>
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Analytical Method: Soil pH by EPA 9045C
Tech: SDK
Analyst: SDK
Seq Number: 3084389

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<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
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<td>SU</td>
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</tr>
<tr>
<td>Temperature</td>
<td>TEMP</td>
<td>22.3</td>
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<td>Deg C</td>
<td>04.03.19 10.30</td>
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</table>

Analytical Method: Sulfate by SW-846 9038
Tech: SDK
Analyst: SDK
Seq Number: 3084855

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cas Number</th>
<th>Result</th>
<th>RL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>14808-79-8</td>
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<td>49.5</td>
<td>mg/kg</td>
<td>04.04.19 10.30</td>
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Sample Id: 3084204-1-BLK  
Lab Sample Id: 3084204-1-BLK  

Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI- B  
Prep Method:  
Tech: SDK  
Analyst: SDK  
Seq Number: 3084204  
Date Prep:  

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<tr>
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<th>RL</th>
<th>MDL</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
<th>Dil</th>
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</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>16887-00-6</td>
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</table>
HVJ North Texas-Chelliah Consultants Inc., Dallas, TX
48 In Waterline

Sample Id: 3084855-1-BLK
Lab Sample Id: 3084855-1-BLK

Matrix: SOLID

Analytical Method: Sulfate by SW-846 9038
Prep Method:

Tech: SDK
Analyst: SDK
Seq Number: 3084855

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cas Number</th>
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<tr>
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</table>
## QC Summary 619634

### HVJ North Texas-Chelliah Consultants Inc.

#### 48 In Waterline

### Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MB Result</th>
<th>Spike Amount</th>
<th>LCS Result</th>
<th>LCS % Rec</th>
<th>LCSD Result</th>
<th>LCSD % Rec</th>
<th>Limits</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
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<td>49.3</td>
<td>100</td>
<td>49.7</td>
<td>100</td>
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<td>25</td>
<td>mg/kg</td>
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</tr>
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</table>

### Analytical Method: Chloride, Mercuric Nitrate Method by SM4500-CI-B

<table>
<thead>
<tr>
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<th>Parent Result</th>
<th>Spike Amount</th>
<th>MS Result</th>
<th>MS % Rec</th>
<th>MSD Result</th>
<th>MSD % Rec</th>
<th>Limits</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
</tr>
</thead>
<tbody>
<tr>
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<td>&lt;4.86</td>
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<td>120</td>
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<td>25</td>
<td>mg/kg</td>
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### Analytical Method: Soil pH by EPA 9045C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parent Result</th>
<th>MD Result</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
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</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.09</td>
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<td>SU</td>
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<tr>
<td>Temperature</td>
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<td>23.1</td>
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<td>25</td>
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### Analytical Method: Soil pH by EPA 9045C

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>MD Result</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
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<tbody>
<tr>
<td>pH</td>
<td>8.13</td>
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<tr>
<td>Temperature</td>
<td>22.3</td>
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<td>2</td>
<td>25</td>
<td>Deg C</td>
<td>04.03.19 10:30</td>
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### Analytical Method: Sulfate by SW-846 9038

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MB Result</th>
<th>Spike Amount</th>
<th>LCS Result</th>
<th>LCS % Rec</th>
<th>LCSD Result</th>
<th>LCSD % Rec</th>
<th>Limits</th>
<th>% RPD</th>
<th>RPD Limit</th>
<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
<td>&lt;16.6</td>
<td>199</td>
<td>198</td>
<td>99</td>
<td>191</td>
<td>97</td>
<td>80-120</td>
<td>4</td>
<td>20</td>
<td>mg/kg</td>
<td>04.04.19 10:30</td>
<td></td>
</tr>
</tbody>
</table>

### MS/MSD Percent Recovery

[D] = 100*(C-A) / B

### Relative Percent Difference

RPD = 100 | (C-E) / (C+E) |

### LCS/LCSD Recovery

[D] = 100 * (C) / B

### Log Difference

Log Diff. = Log(Sample Duplicate) - Log(Original Sample)

---

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Final 1.000
### QC Summary 619634

**HVJ North Texas-Chelliah Consultants Inc.**  
48 In Waterline

**Analytical Method:** Sulfate by SW-846 9038  
**Matrix:** Soil  
**Seq Number:** 3084855  
**Parent Sample Id:** 619496-001  
**MS Sample Id:** 619496-001 S  
**MSD Sample Id:** 619496-001 SD

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parent Result</th>
<th>Spike Amount</th>
<th>MS Result</th>
<th>MS %Rec</th>
<th>MSD Result</th>
<th>MSD %Rec</th>
<th>Limits</th>
<th>%RPD</th>
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<th>Units</th>
<th>Analysis Date</th>
<th>Flag</th>
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</thead>
<tbody>
<tr>
<td>Sulfate</td>
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<td>197</td>
<td>244</td>
<td>73</td>
<td>264</td>
<td>83</td>
<td>75-125</td>
<td>8</td>
<td>20</td>
<td>mg/kg</td>
<td>04.04.19 10:30</td>
<td>X</td>
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</tbody>
</table>

**Parameter Calculations:**
- **MS/MSD Percent Recovery**  
  \[ D = 100 \times \left( \frac{C-A}{B} \right) \]
- **Relative Percent Difference**  
  \[ RPD = 200 \times \left| \frac{C-E}{C+E} \right| \]
- **LCS/LCSD Recovery**  
  \[ D = 100 \times \left( \frac{C}{B} \right) \]
- **Log Difference**  
  \[ \text{Log Diff.} = \text{Log(Sample Duplicate)} - \text{Log(Original Sample)} \]

**Notes:**
- LCS = Laboratory Control Sample  
- MS = Matrix Spike  
- A = Parent Result  
- B = Spike Added  
- C = MS/LCS Result  
- D = MSD/LCSD % Rec  
- E = MSD/LCSD Result
Flagging Criteria

X In our quality control review of the data a QC deficiency was observed and flagged as noted. MS/MSD recoveries were found to be outside of the laboratory control limits due to possible matrix/chemical interference, or a concentration of target analyte high enough to affect the recovery of the spike concentration. This condition could also affect the relative percent difference in the MS/MSD.

B A target analyte or common laboratory contaminant was identified in the method blank. Its presence indicates possible field or laboratory contamination.

D The sample(s) were diluted due to targets detected over the highest point of the calibration curve, or due to matrix interference. Dilution factors are included in the final results. The result is from a diluted sample.

E The data exceeds the upper calibration limit; therefore, the concentration is reported as estimated.

F RPD exceeded lab control limits.

J The target analyte was positively identified below the quantitation limit and above the detection limit.

U Analyte was not detected.

L The LCS data for this analytical batch was reported below the laboratory control limits for this analyte. The department supervisor and QA Director reviewed data. The samples were either reanalyzed or flagged as estimated concentrations.

H The LCS data for this analytical batch was reported above the laboratory control limits. Supporting QC Data were reviewed by the Department Supervisor and QA Director. Data were determined to be valid for reporting.

K Sample analyzed outside of recommended hold time.

JN A combination of the "N" and the "J" qualifier. The analysis indicates that the analyte is "tentatively identified" and the associated numerical value may not be consistent with the amount actually present in the environmental sample.

** Surrogate recovered outside laboratory control limit.

BRL Below Reporting Limit.

RL Reporting Limit

MDL Method Detection Limit SDL Sample Detection Limit LOD Limit of Detection

PQL Practical Quantitation Limit MQL Method Quantitation Limit LOQ Limit of Quantitation

DL Method Detection Limit

NC Non-Calculable

SMP Client Sample BLK Method Blank

BKS/LCS Blank Spike/Laboratory Control Sample BKSD/LCSD Blank Spike Duplicate/Laboratory Control Sample Duplicate

MD/SD Method Duplicate/Sample Duplicate MS Matrix Spike MSD: Matrix Spike Duplicate

+ NELAC certification not offered for this compound.

* (Next to analyte name or method description) = Outside XENCO's scope of NELAC accreditation
| Sample Identification | Matrix | Sample Date | Time Sampled | Time Collected | Total Containers | # of Containers | Correlation Factor: | Temperature (°C): | Corrected Time: | Corrected Factor: | Sampled Using: | Barcode #/Session: | Temp. Intake: |
|-----------------------|--------|-------------|---------------|---------------|----------------|----------------|-----------------|----------------|---------------|----------------|--------------|----------------|-------------|-------------|
|                      |        |             |               |               |                |                |                 |                |               |                |              |                |             |             |

**Sample Comments:**

- Lab's Name: [Name]
- Lab's Address: [Address]
- Lab's Phone: [Phone]
- Lab's Fax: [Fax]
- Lab's Email: [Email]

**Work Order Notes:**

- [Notes]

**Chain of Custody:**

- [Details]
Client: HVJ North Texas-Chelliah Consultants Ir  
Date/ Time Received: 04/01/2019 03:55:00 PM  
Work Order #: 619634  

Acceptable Temperature Range: 0 - 6 degC  
Air and Metal samples Acceptable Range: Ambient  
Temperature Measuring device used: XDA  

<table>
<thead>
<tr>
<th>Sample Receipt Checklist</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 *Temperature of cooler(s)?</td>
<td>21.6</td>
</tr>
<tr>
<td>#2 *Shipping container in good condition?</td>
<td>Yes</td>
</tr>
<tr>
<td>#3 *Samples received on ice?</td>
<td>No</td>
</tr>
<tr>
<td>#4 *Custody Seals intact on shipping container/ cooler?</td>
<td>No</td>
</tr>
<tr>
<td>#5 Custody Seals intact on sample bottles?</td>
<td>No</td>
</tr>
<tr>
<td>#6 Custody Seals Signed and dated?</td>
<td>N/A</td>
</tr>
<tr>
<td>#7 *Chain of Custody present?</td>
<td>Yes</td>
</tr>
<tr>
<td>#8 Any missing/extra samples?</td>
<td>No</td>
</tr>
<tr>
<td>#9 Chain of Custody signed when relinquished/ received?</td>
<td>Yes</td>
</tr>
<tr>
<td>#10 Chain of Custody agrees with sample labels/matrix?</td>
<td>Yes</td>
</tr>
<tr>
<td>#11 Container label(s) legible and intact?</td>
<td>Yes</td>
</tr>
<tr>
<td>#12 Samples in proper container/ bottle?</td>
<td>Yes</td>
</tr>
<tr>
<td>#13 Samples properly preserved?</td>
<td>Yes</td>
</tr>
<tr>
<td>#14 Sample container(s) intact?</td>
<td>Yes</td>
</tr>
<tr>
<td>#15 Sufficient sample amount for indicated test(s)?</td>
<td>Yes</td>
</tr>
<tr>
<td>#16 All samples received within hold time?</td>
<td>Yes</td>
</tr>
<tr>
<td>#17 Subcontract of sample(s)?</td>
<td>No</td>
</tr>
<tr>
<td>#18 Water VOC samples have zero headspace?</td>
<td>N/A</td>
</tr>
</tbody>
</table>

* Must be completed for after-hours delivery of samples prior to placing in the refrigerator

Analyst:  
PH Device/Lot#:  

Checklist completed by: Whitney Capps  
Date: 04/01/2019  

Checklist reviewed by: Kalei Stout  
Date: 04/03/2019
APPENDIX C

LIME PH TEST RESULTS
LIME SERIES-pH

PROJECT: 48 inch Water Line at SH 114

REPORT NO.: DG-18-10117.1

LOCATION: Boring B-1 (2-4 feet)

LIME CURVE
(Soil pH vs Percent of Lime)

<table>
<thead>
<tr>
<th>Percent of Lime</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>8.7</td>
<td>13.1</td>
<td>13.2</td>
<td>13.3</td>
<td>13.4</td>
</tr>
</tbody>
</table>

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**LIME SERIES-pH**

**PROJECT:** 48 inch Water Line at SH 114

**REPORT NO.:** DG-18-10117.1

**LOCATION:** Boring B-2 (2-4 feet)

---

**LIME CURVE**

(Soil pH vs Percent of Lime)

<table>
<thead>
<tr>
<th>Percent of Lime</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>8.9</td>
<td>13.4</td>
<td>13.5</td>
<td>13.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

---

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PROJECT: 48 inch Water Line at SH 114

REPORT NO.: DG-18-10117.1

LOCATION: Boring B-4 (2-4 feet)

LIME SERIES-pH

LIME CURVE
(Soil pH vs Percent of Lime)

<table>
<thead>
<tr>
<th>Percent of Lime</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>10.1</td>
<td>13.3</td>
<td>13.4</td>
<td>13.5</td>
<td>13.5</td>
</tr>
</tbody>
</table>

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LIME SERIES-pH

PROJECT: 48 inch Water Line at SH 114

REPORT NO.: DG-18-10117.1

LOCATION: Boring B-5 (1-3 feet)

LIME CURVE
(Soil pH vs Percent of Lime)

<table>
<thead>
<tr>
<th>Percent of Lime</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>8.5</td>
<td>13.2</td>
<td>13.3</td>
<td>13.4</td>
<td>13.4</td>
</tr>
</tbody>
</table>

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PROJECT: 48 inch Water Line at SH 114
REPORT NO.: DG-18-10117.1
LOCATION: Boring B-8 (2-4 feet)

LIME SERIES-pH

Our letters and reports are for the exclusive use of the client. The use of our name must receive our prior written approval. Our letters and reports apply only to the material(s) tested and/or inspected and are not necessarily indicative of the qualities of apparently identical or similar material(s). This report may not be reproduced, except in full, without consent of HVJ.
LIME SERIES-pH

PROJECT: 48 inch Water Line at SH 114

REPORT NO.: DG-18-10117.1

LOCATION: Boring B-9 (2-4 feet)

LIME CURVE
(Soil pH vs Percent of Lime)

<table>
<thead>
<tr>
<th>Percent of Lime</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>9.3</td>
<td>13.3</td>
<td>13.4</td>
<td>13.4</td>
<td>13.4</td>
</tr>
</tbody>
</table>

Our letters and reports are for the exclusive use of the client. The use of our name must receive our prior written approval. Our letters and reports apply only to the material(s) tested and/or inspected and are not necessarily indicative of the qualities of apparently identical or similar materials(s). This report may not be reproduced, except in full, without consent of HVJ.
APPENDIX D

FREE SWELL TEST RESULTS
### Swell Test Data

<table>
<thead>
<tr>
<th>Sample Height (in)</th>
<th>Initial</th>
<th>Final</th>
<th>Wet + Ring (g)</th>
<th>229.45</th>
<th>230.95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter (in)</td>
<td>2.037</td>
<td>2.037</td>
<td>Dry + Ring (g)</td>
<td>203.37</td>
<td>203.37</td>
</tr>
<tr>
<td>Volume (cc)</td>
<td>53.083</td>
<td>52.729</td>
<td>Ring Wt. (g)</td>
<td>120.62</td>
<td>120.62</td>
</tr>
<tr>
<td>Height of Solids (in)</td>
<td>0.574</td>
<td>0.574</td>
<td>Moisture Data (Trimmings)</td>
<td>LL</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.70</td>
<td>2.70</td>
<td>Wet + Tare (g)</td>
<td>126.30</td>
<td></td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>31.5</td>
<td>33.3</td>
<td>Dry + Tare (g)</td>
<td>103.38</td>
<td>PI</td>
</tr>
<tr>
<td>Wet Density (pcf)</td>
<td>127.9</td>
<td>130.6</td>
<td>Tare (g)</td>
<td>31.09</td>
<td></td>
</tr>
<tr>
<td>Dry Density (pcf)</td>
<td>97.3</td>
<td>97.9</td>
<td>Moisture Content (%)</td>
<td>31.7</td>
<td></td>
</tr>
</tbody>
</table>

### Swell Sample Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time (min)</th>
<th>Swell Void Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/2/2019</td>
<td>0.1088</td>
<td>0.0000</td>
<td>0.9940</td>
<td>0.7320</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>0.0910</td>
<td>0.0178</td>
<td>0.9762</td>
<td>0.7010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>0.0</td>
<td>0.0910</td>
<td>0.0000</td>
<td>0.7010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>1.00</td>
<td>0.0915</td>
<td>0.0005</td>
<td>0.7019</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>2.00</td>
<td>0.0917</td>
<td>0.0007</td>
<td>0.7022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>4.00</td>
<td>0.0917</td>
<td>0.0007</td>
<td>0.7022</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>8.00</td>
<td>0.0924</td>
<td>0.0014</td>
<td>0.7035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>15.00</td>
<td>0.0930</td>
<td>0.0020</td>
<td>0.7045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>30.00</td>
<td>0.0942</td>
<td>0.0032</td>
<td>0.7066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>60.00</td>
<td>0.0947</td>
<td>0.0037</td>
<td>0.7075</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>250.00</td>
<td>0.0975</td>
<td>0.0065</td>
<td>0.7123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/3/2019</td>
<td>1440.0</td>
<td>0.0991</td>
<td>0.0081</td>
<td>0.7151</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/4/2019</td>
<td>2880.0</td>
<td>0.1004</td>
<td>0.0094</td>
<td>0.7174</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/5/2019</td>
<td>4320.0</td>
<td>0.1009</td>
<td>0.0099</td>
<td>0.7183</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/6/2019</td>
<td>5760.0</td>
<td>0.1022</td>
<td>0.0112</td>
<td>0.7205</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/7/2019</td>
<td>7200.0</td>
<td>0.1021</td>
<td>0.0111</td>
<td>0.7204</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Over Burden Pressure= 375 psf
Calculated by: SBN Sample Height before inundation= 0.9762 in
Calculated by: SBN Change in Height after Swell= 0.0111 in
Checked by: SG Percent Free Swell= 1.14 %
### HVJ ASSOCIATES®
**SWELL TEST ASTM D-4546**
**METHOD B**

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>48 IN WATERLINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boring No.:</td>
<td>B-2</td>
</tr>
<tr>
<td>Project No.:</td>
<td>DG 18-10117.1</td>
</tr>
<tr>
<td>Sample Depth.</td>
<td>13-15</td>
</tr>
<tr>
<td>Date Tested:</td>
<td></td>
</tr>
<tr>
<td>Ring No.:</td>
<td>10</td>
</tr>
<tr>
<td>Technician:</td>
<td></td>
</tr>
</tbody>
</table>

#### Swell Sample Data

<table>
<thead>
<tr>
<th>Swell Sample Data</th>
<th>Initial</th>
<th>Final</th>
<th>Test Data</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Height (in)</td>
<td>1.017</td>
<td>1.020</td>
<td>Wet + Ring (g)</td>
<td>228.08</td>
<td>234.43</td>
</tr>
<tr>
<td>Diameter (in)</td>
<td>2.049</td>
<td>2.049</td>
<td>Dry + Ring (g)</td>
<td>208.60</td>
<td>208.60</td>
</tr>
<tr>
<td>Volume (cc)</td>
<td>54.927</td>
<td>55.089</td>
<td>Ring Wt. (g)</td>
<td>115.58</td>
<td>115.58</td>
</tr>
<tr>
<td>Height of Solids (in)</td>
<td>0.638</td>
<td>0.638</td>
<td>Moisture Data (Trimmings)</td>
<td>LL</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.70</td>
<td>2.70</td>
<td>Wet + Tare (g)</td>
<td>125.96</td>
<td></td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>20.9</td>
<td>27.8</td>
<td>Dry + Tare (g)</td>
<td>109.22</td>
<td>PI</td>
</tr>
<tr>
<td>Wet Density (pcf)</td>
<td>127.8</td>
<td>134.6</td>
<td>Tare (g)</td>
<td>109.22</td>
<td>31.38</td>
</tr>
<tr>
<td>Dry Density (pcf)</td>
<td>105.7</td>
<td>105.4</td>
<td>Moisture Content (%)</td>
<td>21.5</td>
<td></td>
</tr>
</tbody>
</table>

#### Sample Description

| Hand Penetrometer (tsf) |       |

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time (min)</th>
<th>Swell Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/2/2019</td>
<td></td>
<td>0.0317</td>
<td>0.0000</td>
<td>1.0170</td>
<td>0.5943</td>
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<tr>
<td>4/2/2019</td>
<td></td>
<td>0.0107</td>
<td>0.0210</td>
<td>0.9960</td>
<td>0.5614</td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>0.0</td>
<td>0.0107</td>
<td>0.0000</td>
<td>0.9960</td>
<td>0.5614</td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>1.0</td>
<td>0.0134</td>
<td>0.0027</td>
<td>0.9987</td>
<td>0.5656</td>
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</tr>
<tr>
<td>4/2/2019</td>
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<td>0.0039</td>
<td>0.9999</td>
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<tr>
<td>4/2/2019</td>
<td>4.0</td>
<td>0.0150</td>
<td>0.0043</td>
<td>1.0003</td>
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<tr>
<td>4/2/2019</td>
<td>8.0</td>
<td>0.0170</td>
<td>0.0063</td>
<td>1.0023</td>
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<tr>
<td>4/2/2019</td>
<td>15.0</td>
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<td>0.0075</td>
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<tr>
<td>4/2/2019</td>
<td>30.0</td>
<td>0.0210</td>
<td>0.0103</td>
<td>1.0063</td>
<td>0.5775</td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>60.0</td>
<td>0.0213</td>
<td>0.0106</td>
<td>1.0066</td>
<td>0.5780</td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>250.0</td>
<td>0.0213</td>
<td>0.0106</td>
<td>1.0066</td>
<td>0.5780</td>
<td></td>
</tr>
<tr>
<td>4/3/2019</td>
<td>1440.0</td>
<td>0.0323</td>
<td>0.0216</td>
<td>1.0176</td>
<td>0.5952</td>
<td></td>
</tr>
<tr>
<td>4/4/2019</td>
<td>2880.0</td>
<td>0.0332</td>
<td>0.0225</td>
<td>1.0185</td>
<td>0.5967</td>
<td></td>
</tr>
<tr>
<td>4/5/2019</td>
<td>4320.0</td>
<td>0.0335</td>
<td>0.0228</td>
<td>1.0188</td>
<td>0.5971</td>
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</tr>
<tr>
<td>4/6/2019</td>
<td>5760.0</td>
<td>0.0340</td>
<td>0.0233</td>
<td>1.0193</td>
<td>0.5979</td>
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<tr>
<td>4/7/2019</td>
<td>7200.0</td>
<td>0.0341</td>
<td>0.0234</td>
<td>1.0194</td>
<td>0.5981</td>
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</tr>
<tr>
<td>4/8/2019</td>
<td>8640.0</td>
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<td>0.0239</td>
<td>1.0199</td>
<td>0.5988</td>
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<tr>
<td>4/9/2019</td>
<td>10080.0</td>
<td>0.0347</td>
<td>0.0240</td>
<td>1.0200</td>
<td>0.5990</td>
<td></td>
</tr>
</tbody>
</table>

**Over Burden Pressure:** 1750 psf

**Calculated by:** SBN
**Sample Height before inundation:** 0.9960 in

**Computed by:** SBN
**Change in Height after Swell:** 0.0240 in

**Checked by:** SG
**Percent Free Swell:** 2.41 %
### Swell Sample Data

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<th>Test Data</th>
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<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
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**Over Burden Pressure:** 875 psf

**Calculated by:** SBN

**Sample Height before inundation:** 1.0078 in

**Computed by:** SBN

**Change in Height after Swell:** 0.0002 in

**Checked by:** SG

**Percent Free Swell:** 0.02 %
### Swell Sample Data

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### Swell Void Deformation

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Calculated by: SBN

Sample Height before inundation: 0.9808 in
Change in Height after Swell: 0.0083 in

Computed by: SBN

Over Burden Pressure: 2375 psf
Percent Free Swell: 0.85 %
### SWELL TEST ASTM D-4546
#### METHOD B

**Project Name:** 48 IN WATERLINE  
**Boring No.:** B-4  
**Project No.:** DG 18-10117.1  
**Sample Depth:** 18.20  
**Date Tested:**  
**Ring No.:** 36  
**Technician:**  
**Date Calculated:**  

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<th>Test Data</th>
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<td>Wet + Tare (g)</td>
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</table>
| Moisture Content (%) | 21.2 | 28.3 | Dry + Tare (g) | 111.51  | PI  
| Wet Density (pcf) | 133.8   | 142.7 | Tare (g) | 32.17   |  
| Dry Density (pcf) | 110.4   | 111.2 | Moisture Content (%) | 19.8 |  

**Sample Description**  
Hand Penetrometer (tsf)

<table>
<thead>
<tr>
<th>Date</th>
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<th>Elapsed Time (min)</th>
<th>Swell Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
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**Over Burden Pressure:** 2375 psf

**Calculated by:**  
**Sample Height before inundation:** 0.9601 in

**Computed by:**  
**Change in Height after Swell:** 0.0199 in

**Checked by:**  
**Percent Free Swell:** 205 %
**HVJ ASSOCIATES®**

**SWELL TEST ASTM D-4546**

**METHOD B**

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<th>Boring No. B-5</th>
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<td>Date Calculated:</td>
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<th>Final</th>
<th>Test Data</th>
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<th>Final</th>
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<table>
<thead>
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<th>Date</th>
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<th>Elapsed Time (min)</th>
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<th>Deformation (in)</th>
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Over Burden Pressure= 750 psf
Calculated by: SBN
Sample Height before inundation= 0.9927 in
Computed by: SBN
Change in Height after Swell= 0.0058 in
Checked by: SG
Percent Free Swell= 0.58 %
**HVJ ASSOCIATES®**  
**SWELL TEST ASTM D-4546**  
**METHOD B**

<table>
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<th>48 IN WATERLINE</th>
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### Swell Sample Data

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### Swell Void

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<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
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Calculated by:  
- Over Burden Pressure: 1125 psf  
- Sample Height before inundation: 0.9457 in  
- Change in Height after Swell: -0.0019 in  

Computed by:  
- Percent Free Swell: -0.20 %

Checked by:  
- SG
# HVJ ASSOCIATES®

**SWELL TEST ASTM D-4546**

**METHOD B**

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## Swell Sample Data

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<th>Sample Height (in)</th>
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## Sample Description

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## Elapsed Swell Void

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<th>Deformation</th>
<th>Void Ratio</th>
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## Hand Penetrometer (tsf)

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## HVJ ASSOCIATES®
### SWELL TEST ASTM D-4546
#### METHOD B

**Project Name:** 48 IN WATERLINE  
**Boring No.:** B-8  
**Project No.:** DG 18-10117.1  
**Sample Depth:** 6-8  
**Date Tested:**  
**Ring No.:**  
**Technician:**  
**Date Calculated:**

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### Swell Data

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</tbody>
</table>

- **Over Burden Pressure:** 875 psf
- **Calculated by:** SBN
- **Sample Height before inundation:** 0.9981 in
- **Computed by:** SBN
- **Change in Height after Swell:** 0.0033 in
- **Checked by:** SG
- **Percent Free Swell:** 0.33 %
**Swell Test ASTM D-4546**  
**Method B**

**Project Name:** 48 IN WATERLINE  
**Boring No.:** B-8  
**Project No.:** DG 18-10117.1  
**Sample Depth:** 8-10

**Date Tested:**  
**Ring No.:** 21  
**Technician:**  
**Date Calculated:**

### Swell Sample Data

<table>
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<tr>
<th>Sample Height (in)</th>
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<th>Final</th>
<th>Wet + Ring (g)</th>
<th>239.26</th>
<th>240.91</th>
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<tbody>
<tr>
<td>Diameter (in)</td>
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<td>2.040</td>
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<tr>
<td>Volume (cc)</td>
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<td>Height of Solids (in)</td>
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<td>Moisture Data (Trimmings)</td>
<td>LL</td>
<td></td>
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<tr>
<td>Specific Gravity</td>
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<td>Wet + Tare (g)</td>
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<tr>
<td>Moisture Content (%)</td>
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<tr>
<td>Wet Density (pcf)</td>
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<td>Tare (g)</td>
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<tr>
<td>Dry Density (pcf)</td>
<td>122.3</td>
<td>123.8</td>
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### Sample Description

<table>
<thead>
<tr>
<th>Sample Height before inundation</th>
<th>Hand Penetrometer (tsf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9958 in</td>
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</tr>
</tbody>
</table>

### Swell Void Measurements

<table>
<thead>
<tr>
<th>Date</th>
<th>Time (min)</th>
<th>Elapsed Time (in)</th>
<th>Swell Void Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/2/2019</td>
<td>0.1045</td>
<td>0.0000</td>
<td>1.0105</td>
<td>0.3775</td>
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<td></td>
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<td>0.0898</td>
<td>0.0147</td>
<td>0.9958</td>
<td>0.3574</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/2/2019</td>
<td>0.0990</td>
<td>0.0002</td>
<td>0.9960</td>
<td>0.3577</td>
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<tr>
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<td>0.0006</td>
<td>0.9964</td>
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<td>0.0006</td>
<td>0.9964</td>
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<td>0.0023</td>
<td>0.9981</td>
<td>0.3605</td>
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- **Over Burden Pressure:** 1125 psf
- **Calculated by:** SBN
  - Sample Height before inundation: 0.9958 in
- **Computed by:** SBN
  - Change in Height after Swell: 0.0023 in
- **Checked by:** SG
  - Percent Free Swell: 0.23 %
### HVJ ASSOCIATES®
#### SWELL TEST ASTM D-4546
##### METHOD B

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>48 IN WATERLINE</th>
<th>Boring No.</th>
<th>B-9</th>
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<td>DG 18-10117.1</td>
<td>Sample Depth.</td>
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#### Swell Sample Data

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<tr>
<th>Sample Height (in)</th>
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<th>Final</th>
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<th>Initial</th>
<th>Final</th>
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<tbody>
<tr>
<td>Wet + Ring (g)</td>
<td>236.23</td>
<td>237.55</td>
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<td></td>
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<tr>
<td>Dry + Ring (g)</td>
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<td>216.72</td>
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<td></td>
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| Diameter (in)      | 2.048   | 2.048 |
| Ring Wt. (g)       | 118.11  |       |
| Moisture Data (Trimmings) | LL | |

| Moisture Content (%) | 19.8    | 21.1   |
| Wet Density (pcf)    | 136.1   | 136.6  |
| Dry Density (pcf)    | 113.6   | 112.7  |
| PI                  | 32.39   | 17.8  |

#### Hand Penetrometer (tsf)

<table>
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<tr>
<th>Date</th>
<th>Time</th>
<th>Elapsed Time (min)</th>
<th>Swell Void Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio (in)</th>
</tr>
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<td>1.0035</td>
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<td>1.0093</td>
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</table>

#### Sample Description

- Over Burden Pressure: 875 psf
- Sample Height before inundation: 1.0086 in
- Change in Height after Swell: 0.0024 in
- Percent Free Swell: 0.24%
### HVJ ASSOCIATES®
**SWELL TEST ASTM D-4546**
**METHOD B**

**Project Name:** 48 IN WATERLINE  
**Boring No.:** B-9  
**Project No.:** DG 18-10117.1  
**Sample Depth:** 13-15  
**Date Tested:**  
**Ring No.:**  
**Technician:**  
**Date Calculated:**

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<tr>
<th>Swell Sample Data</th>
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<tr>
<td>Sample Height (in)</td>
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<td>Wet + Tare (g)</td>
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<td>PI</td>
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<tr>
<td>Dry Density (pcf)</td>
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<td>114.1</td>
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**Sample Description**

<table>
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<th>Date</th>
<th>Time (min)</th>
<th>Elapsed Time (in)</th>
<th>Swell Void Readings (in)</th>
<th>Change (in)</th>
<th>Deformation (in)</th>
<th>Void Ratio</th>
<th>Over Burden Pressure=</th>
<th>Calculated by:</th>
<th>Sample Height before inundation=</th>
<th>Computed by:</th>
<th>Change in Height after Swell=</th>
<th>Checked by:</th>
<th>Percent Free Swell=</th>
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<tr>
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<td>0.0000</td>
<td>0.9915</td>
<td>0.4673</td>
<td></td>
<td></td>
<td></td>
<td>SBN</td>
<td>0.9967 in</td>
<td>SBN</td>
<td>0.0012 in</td>
<td>SG</td>
<td>0.12 %</td>
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APPENDIX E

OSHA TABLE SLOPE CONFIGURATIONS
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

   SIMPLE SLOPE

2. All bench excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

   SINGLE BENCH

   MULTIPLE BENCH

DATE: 5/02/2019
PROJECT NO.: DG-18-1017.1
DRAWING NO.: Plate E-1

PREPARED BY: SBS
APPROVED BY: RL
B-1.2 Excavations Made in Type B Soil (CONT...)

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

Support or shield system

20' Max.

18" Min.

VERTICALLY SIDED LOWER PORTION

4. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).
B-1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.

```
\[\text{SIMPLE SLOPE}\]
```

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

```
\[\text{VERTICAL SIDED LOWER PORTION}\]
```

3. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).
B-1.4 Excavations Made in Layered Soils

1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below:
2. All other sloped excavations shall be in accordance with the other options permitted in § 1926.652(b).
APPENDIX F

STANDARD PROCTOR TEST RESULTS
**Report On:** Moisture Density Relationship  
**Project No:** 190064F  
**Cust No:** 00295  
**Lab No:** 19-3410-1  
**Report No:** 190064F-0003  
**Page:** 1 of 1

**Client:** HVJ North Texas  
Saif Bin Salah  
8701 John W. Carpenter Fwy.  
Suite 250  
Dallas, TX 75247

**Project:** CBR and Std Proctor - FM4 Grandview

**Report Date:** 04/16/2019  
**Sample Date:** 04/03/2019

**Location:** 48" Waterline Boring B-1

**Material:** Soil

<table>
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<th>% Moisture</th>
<th>Dry Density Lbs./Cu.Ft.</th>
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</thead>
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<tr>
<td>16.2</td>
<td>93.60</td>
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<td>19.1</td>
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<td>22.2</td>
<td>98.50</td>
</tr>
<tr>
<td>25.0</td>
<td>93.70</td>
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</tbody>
</table>

19.7 Optimum 100.7 Maximum

Color: Dark Brown  
Description: Sandy Clay with Organics

**Desc of Rammer:** Mechanical  
**Preparation Method:** Dry

**Test Method (As Applicable):** ASTM D-698 Method-B

---

Orig: HVJ North Texas Attn: Saif Bin Salah  
(1-cc copy)  
1-cc Laboratory

Respectfully Submitted,  
TSIT Engineering & Consulting, LLC

**Signature:** Sana Sarama,
Proctor Report

Client: Halff Associates, Inc.
Project: 48-inch Water Line at SH 114 and Spur 482

Sample Details
Sample ID: Boring B-3
Date Sampled: 5/2/2019
Tested By:

Test Results
ASTM D 698
Maximum Dry Unit Weight (lbf/ft³): 114.6
Optimum Water Content (%): 12.5
Method: A
Preparation Method: Dry
Specific Gravity (Fines): 2.65
Retained Sieve No 4 (4.75mm) (%): 18
Passing Sieve No 4 (4.75mm) (%): 82
Tested By:
Date Tested:

ASTM D 4718
Corrected Maximum Dry Unit Weight (lbf/ft³): 119.1
Corrected Optimum Water Content (%): 12.5
Specific Gravity (Oversize): 2.35
Sieve Size (Oversize): No 4
Oversize Particles (%): 18

ASTM D 4318
Liquid Limit (%): 18
Plastic Limit (%): 12
Plasticity Index (%): 6

Dry Unit Weight - Water Content Relationship

Comments
Passing #200 = xx%
Proctor Report

Client: Halff Associates, Inc.

Project: 48-inch Water Line at SH 114 and Spur 482

Sample Details

Sample ID: Boring B-6

Tested By:

Date Sampled:

Test Results

ASTM D 698

Maximum Dry Unit Weight (lbf/ft³): 114.2

Optimum Water Content (%): 13.0

Method: A

Preparation Method: Dry

Specific Gravity (Fines): 2.65

Retained Sieve No 4 (4.75mm) (%): 16

Passing Sieve No 4 (4.75mm) (%): 84

Tested By:

Date Tested:

ASTM D 4718

Corrected Maximum Dry Unit Weight (lbf/ft³): 118.4

Corrected Optimum Water Content (%): 13.0

Specific Gravity (Oversize): 2.35

Sieve Size (Oversize): No 4

Oversize Particles (%): 16

Tested By:

Date Tested:

ASTM D 4318

Liquid Limit (%): 19

Plastic Limit (%): 8

Plasticity Index (%): 11

Tested By:

Date Tested:

Dry Unit Weight - Water Content Relationship

0% Air Voids

0% Air Voids

Comments

Time Left Lab:  Time Arrived Site:  Time Left Site:  Time Arrived Lab:  Lunch Hours:  Total Hours:

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Report On: Moisture Density Relationship

Lab No: 19-3410-2
Report No: 190064F-0004

Project No: 190064F  Cust No: 00295
Page 1 of 1

Client: HVJ North Texas
Saif Bin Salah
8701 John W. Carpenter Fwy.
Suite 250
Dallas, TX 75247

Project: CBR and Std Proctor - FM4 Grandview

Report Date: 05/03/2019

Location: 48" Waterline Boring B-8
Sample Date: 04/03/2019

Sampled By: Sana S.
By Order Of: 

Material: Soil

% Moisture  Dry Density Lbs./Cu.Ft.

9.4  107.9
12.4  113.8
15.6  113.5
18.4  107.5

13.9  Optimum  114.7  Maximum

Color: Brown to Dark Brown
Description: Sandy Clay with Gravel

Desc of Rammer: Mechanical
Preparation Method: Dry

Test Method (As Applicable): ASTM D-698 Method-B

Orig: HVJ North Texas Attn: Saif Bin Salah
(1-cc copy)
1-cc Laboratory

Respectfully Submitted,
TSIT Engineering & Consulting, LLC

Sana Sarama,
APPENDIX G

CBR TEST RESULTS
<table>
<thead>
<tr>
<th>Date Sampled:</th>
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<th>April 13, 2019</th>
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**CBR Test: ASTM D 1883**

**Stress Versus Penetration**

**Project: FM4 Grandview**

![Stress Versus Penetration Graph]
<table>
<thead>
<tr>
<th>Penetration, in</th>
<th>Load (lbs)</th>
<th>Stress on Piston, lb/in²</th>
<th>CBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
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<th>Stress on Piston, lb/in²</th>
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# LAB CBR PER ASTM D1883-99

## PROJECT: NTE-WEST SEGMENT

### CBR @ 0.1-inch penetration

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<th># of Blows</th>
<th>Swell [%]</th>
<th>CBR</th>
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### CBR @ 0.2-inch penetration

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<tbody>
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<td>0</td>
<td>10</td>
<td>see CBR @ Optimum</td>
<td>0.7</td>
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<tr>
<td>0</td>
<td>25</td>
<td>see CBR @ Optimum</td>
<td>1.4</td>
</tr>
<tr>
<td>0</td>
<td>56</td>
<td>see CBR @ Optimum</td>
<td>1.7</td>
</tr>
</tbody>
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## Pre-Soaking Conditions @ 10 Blows

<table>
<thead>
<tr>
<th>Dry Density [pcf]</th>
<th>Moisture [%]</th>
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## Post-Soaking Conditions @ 10 Blows

<table>
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## Pre-Soaking Conditions @ 25 Blows

<table>
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## Post-Soaking Conditions @ 25 Blows

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## Pre-Soaking Conditions @ 56 Blows

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## Post-Soaking Conditions @ 56 Blows

<table>
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<th>Moisture [%]</th>
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<tbody>
<tr>
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LAB CBR PER ASTM D1883-99
PROJECT: NTE-WEST SEGMENT

Date Sampled: April 3, 2019  Date Tested: April 13, 2019
Project No: 190064F/19-3410-2  Location: 48" waterline-Boring B-8
Material Description: Brown to Dark brown sandy clay w/ gravel  USCS Classification:
Liquid Limit [LL]:  Plasticity Index [PI]:
Testing Remarks:

CBR Test: ASTM D 1883
Stress Versus Penetration
Project: FM4 Grandview

Stress on Piston [lb/in²]

Penetration [inches]

- 10 Blows - 25 Blows - 56 Blows
### 10 blows

<table>
<thead>
<tr>
<th>Penetration, in</th>
<th>Load (lbs)</th>
<th>Stress on Piston, lb/in²</th>
<th>CBR</th>
</tr>
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<tbody>
<tr>
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<td>0.0</td>
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<td>0.025</td>
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<tr>
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<tr>
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### 25 blows

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<tbody>
<tr>
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<tr>
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### 56 blows

<table>
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<th>CBR</th>
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### CBR @ 0.1-inch penetration

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<th>CBR</th>
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### CBR @ 0.2-inch penetration

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<tr>
<td>0</td>
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**Pre- Soaking Conditions @10 Blows**
- Dry Density [pcf]: 86.7
- Moisture [%]: 13.8

**Post- Soaking Conditions @10 Blows**
- Dry Density [pcf]: 78.4
- Moisture [%]: 25.9

**Pre- Soaking Conditions @25 Blows**
- Dry Density [pcf]: 99.1
- Moisture [%]: 13.8

**Post- Soaking Conditions @25 Blows**
- Dry Density [pcf]: 93.0
- Moisture [%]: 21.2

**Pre- Soaking Conditions @56 Blows**
- Dry Density [pcf]: 114.9
- Moisture [%]: 13.7

**Post- Soaking Conditions @56 Blows**
- Dry Density [pcf]: 113.3
- Moisture [%]: 15.3