CHAPTER 21
TUNNELING AND ENCASEMENT

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Miscellaneous Steel
2. Concrete
3. High Density Polyethylene (HDPE) Pipe

1.2 RELATED DOCUMENTS

A. All other requirements and provisions of the CHARLOTTE WATER, Water and Sewer Design and Construction Standards, apply to this section.

1.3 DEFINITIONS AND ABBREVIATIONS

A. See Sections iii and iv of the CHARLOTTE WATER Water and Sewer Design and Construction Standards for common abbreviations and definitions.

1.4 SUBMITTALS

A. Required submittals for product approval include, but are not limited to, the following:

1. Product brochures
2. Catalog cut sheets
3. Shop drawings including dimensions and part/material lists
4. Certification of compliance
5. Prior product acceptance test reports
6. Reference contact data
7. Shipping tickets and purchase invoices

B. Provide product data for the following:

1. Miscellaneous Steel
2. Concrete
3. High Density Polyethylene (HDPE) Pipe

C. Shop Drawings

D. Product Certificates: Required for all products.

E. Qualification Data: For qualified testing agency.

F. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to ASTM D 698.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall be responsible for the safe storage of materials furnished by or to them, and accepted by them and intended for the work, until they have been incorporated in the completed project. Handling and storage of all project materials are to be in compliance with the manufacturer's recommendations for handling and storage. The interior of all pipes, manholes and other accessories shall be kept free from dirt and foreign materials at all times.

B. Transportation of Materials and Equipment: The Contractor and their Suppliers are directed to contact the North Carolina Department of Transportation to verify axle load limits on State maintained roads (and bridges) which would be used for hauling of equipment and materials for this project. The Contractor and their Suppliers shall do all that is necessary to satisfy the Department of Transportation requirements and will be responsible for any damage to said roads which may be attributed to this project. All materials required to construct this project shall be furnished by the Contractor and shall be delivered and distributed at the site by the Contractor or their material supplier.

C. Loading and Unloading Materials: All pipe and accessories shall be loaded and unloaded by lifting with hoists or skidding so as to avoid shock or damage. Under no circumstances shall such materials be dropped. Pipe handled on skidways shall not be skidded or rolled against pipe already on the ground.

D. Responsibility for Materials on Site: In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench. Each piece shall be redundantly chocked at each end to prevent movement or rolling. Pedestrian or vehicular traffic shall not be unduly inconvenienced in placing of material along the streets or right-of-way, as applicable.

The Contractor will string in advance no more than the amount of pipe and material that can be installed within two (2) weeks unless approved by the Engineer. All the materials shall be placed in such a manner as not to hinder access, endanger or impede traffic, create a public nuisance or endanger the public.

Materials strung through residential areas (or any area with maintained lawns) shall be placed in such a manner as not to restrict normal lawn maintenance and must either be installed within two (2) weeks or removed to an approved storage yard, as required by the Engineer.

E. Material and Equipment Storage Sites: Unless otherwise shown on the plans, the Contractor will be responsible for locating and providing storage areas for construction materials and equipment. Unless prior written consent from the owner of the proposed storage area is received by CHARLOTTE WATER, the Contractor will be required to store all equipment and materials within the limits of the project site, or the limits of the sanitary sewer right-of-way and temporary construction easement provided. The materials and equipment storage shall comply with all local and state ordinances throughout the construction period. Material and equipment may only be stored within road right-of-way if approved by the controlling agency. Bulk storage of stacked materials shall not be permitted in or along road rights-of-way.

Storage sites shall be fenced with adequate protection to reasonably prevent the public from entering the site. The Contractor shall be responsible for the safeguarding of materials and equipment against fire, theft, and vandalism and in a manner which does not place the public at risk and shall not hold the City responsible in any way for the occurrence of same.

PART 2 - PRODUCTS

2.1 MISCELLANEOUS STEEL

A. Steel Encasement Pipe

1. Steel Encasement Pipe: Steel pipe shall be fully welded or seamless, smooth wall or spiralweld, consisting of Grade "B" steel as specified in ASTM A-139.
2. Minimum yield strength shall be 35,000 PSI; and pipe thickness shall be as specified for each individual job.
3. Pipe design shall be in accordance with AWWA M11 considering the following:
    a. Internal pressure
    b. External pressure
    c. Special physical loading
    d. Practical requirements
    e. Minimum wall thickness of 0.25 inch
4. All pipe shall be furnished with push-on joint pipe, or beveled ends prepared for field welding of circumferential joints. All burrs at pipe ends shall be removed.
5. Encasement pipe must be approved by the appropriate controlling agency (D.O.T., R.R., etc.) and the Engineer prior to ordering.
6. Permalok steel casing pipe may be used as an alternative steel casing pipe joining system. All steel used in the manufacture of Permalok steel pipe shall conform to the requirements of ASTM A-36, ASTM A515, grade 60 or ASTM A572, grade 42. All welding shall be performed by qualified welding operators in accordance with the requirements of ANSI/AWS D1.1. One reduced section tension test specimen shall be evaluated for each lot of 1000’ of each size and wall thickness, and shall show a tensile strength not less than 95% of the minimum strength specified for the grade of steel used, unless waived by the purchaser. All Permalok pipe shall be clearly marked with the manufacturers’ name, manufacturer’s job number, customer name, O.D., wall thickness, and weight per foot.
7. Casing Spacers
    a. Bands: Casing spacer bands shall be made of High-Density Polyethylene (HDPE), UV resistant non-metallic virgin polypropylene, heavy duty two-piece #304 Stainless Steel (minimum 14 gauge), or Carbon Steel.
    b. Risers: HDPE, UV resistant non-metallic virgin polypropylene, #304 Stainless Steel, #10 gauge, or Carbon Steel.
    c. Liner: Ribbed PVC extrusion or Thermoplastic Rubber (TPR).
    d. Runners: Integrally molded solid core, ultra-high molecular weight polymer, or glass reinforced plastic. All spacers shall have full length, integrally molded skids extending beyond the bell or mechanical joint of the carrier pipe.
    e. Applicable Standards: The following standards apply as applicable: ASTM D-695, ASTM D-621, ASTM D-638, ASTM D-149/61, ASTM 149/64, ASTM B117.

f. Acceptable Manufacturers:

1) Raci Spacers of North America

2) CCI Pipeline Systems, LLC

3) BMW Company

4) Cascade Waterworks Mfg

5) GPT

6) Approved equal

8. End Seals

a. Provide one of the following end seals, as required by the project specific plans and construction documents:

1) Masonry Seals: Ensure drainage of encasement by leaving a 1-inch diameter weep hole in the seal of the lower end of the encasement. Clay or shale masonry shall meet the requirements of ASTM C62 Grade SW. Concrete brick masonry shall meet the requirements of ASTM C55 for Grade S-II, except that absorption of brick shall not exceed 10 lbs./cf. All masonry units shall be free from cracks and flaws with straight and parallel sides and square corners burned hard and true. Brick masonry mortar shall be Type S masonry cement meeting ASTM C270.

2) Watertight Rubber Seals: Provide wrap around or pull-on rubber end seals. Provide end seals by one of the following:

a) CCI Piping Systems, LLC

b) Garlock

c) Konex International

d) Approved equal

B. Structural Steel Tunnel Liner Plates

1. The tunnel liner plates shall be either the four (4) flange type (as approved for use within D.O.T. right-of-way) or the lap seam type (as approved for use within railroad right-of-way) fabricated to permit assembly of a continuous steel support system as the tunnel is excavated. Tunnel liner plates shall be fabricated from structural quality hot rolled, carbon steel sheets or plates conforming to the specifications of ASTM A-569.

The tunnel liner shall be designed in accordance with the requirements of Section 16- Division I and constructed to conform to Section 25-Division II of the current or interim AASHTO Standard Specifications for Highway Bridges.

Liner plates shall be galvanized in accordance with AASHTO M167 and fully bituminously coated in accordance with AASHTO M190. All hardware necessary to the tunneling operation shall be hot-dip galvanized in accordance with ASTM A-153 prior to bituminous coating application. Hardware shall conform to ASTM SpecificationA-307, Grade A.

The minimum mechanical properties of the flat steel plate before cold forming used forthe design of the tunnel liner shall be:

a. Minimum Tensile Strength of Liner Plates: 42,000 P.S.I.

b. Minimum Yield Strength of Liner Plates: 28,000 P.S.I.

c. Steel Liner Plates must be approved by the appropriate controlling agency (DOT, Railroad, etc.) and the Engineer prior to ordering. In case of conflict between design criteria of the appropriate controlling agency and Section 2.8.C of these technical specifications, the more stringent criteria of the requirements will apply. Gauge or thickness of liner plates will be as noted on the plans and elsewhere in these specifications.

d. Elongation, 2-inches = 30 percent

e. The moment of inertia shall be .042 inches to the 4th power per inch of width for four flange 12 gage liner plate.

C. Stainless Steel Straps and Anchors

1. Straps for concrete piers, inside drops, and outside drops: Stainless Steel ASTM A240 Type 304 or Type 304L.

2. Straps or painted carbon steel straps for vent pipes. Stainless Steel ASTM A240 Type 304 or Type 304L.

3. For stainless steel anchors, bolts, and washers (hardware): Stainless Steel ASTM A240 Type 316 or Type 316L.

4. Epoxy Adhesive Anchorage: Adhesive anchors shall consist of a two-component structural epoxy injection gel meeting the requirements of ASTM C881, stainless steel screen tubes of hollow base materials. Minimum adhesive anchor embedment shall be 4-inches (5-inches minimum for frame and cover) unless otherwise indicated. Provide epoxy adhesive anchors by Hilti Corporation HIT-HY 200, ITW Red Head A7+ Quick-Dure Adhesive, Powers Fasteners Pure 150-Pro Epoxy, or pre-approved equal.

a. Cartridge Injection Adhesive Anchors

1) Threaded steel rod, inserts or reinforcing dowels, complete with nuts, washers, polymer or hybrid mortar adhesive injection system, and manufacturer's installation instructions. Type and size as indicated on Drawings.

2) Interior and Exterior Use: As indicated on the Drawings, provide stainless steel anchors. Stainless steel anchors shall be AISI Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. All nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.

3) When indicated on the project drawings, or specified by the Standard Details, deformed reinforcing dowels shall be A615 Grade 60.

b. Capsule Anchors

1) Threaded steel rod, inserts and deformed reinforcing dowels with 45-degree chisel point, complete with nuts, washers, glass or foil capsule anchor system containing polyvinyl or urethane methacrylate-based

resin and accelerator, and manufacturer's installation instructions. Type and size as indicated on Drawings.

2) Interior and Exterior Use: As indicated on the Drawings, provide chisel-pointed stainless steel anchors. Stainless steel anchors shall be AISI Type 316 stainless steel provided with stainless steel nuts and washers of matching alloy group and minimum proof stress equal to or greater than the specified minimum full-size tensile strength of the externally threaded fastener. All nuts shall conform to ASTM F594 unless otherwise specified. Avoid installing stainless steel anchors in contact with galvanically dissimilar metals.

3) Deformed reinforcing dowels shall be A615 Grade 60, with 45-degree chisel-points at embedded end.

5. Anti-seize/anti galling lubricant: Apply anti-seize/anti-galling lubricant on all bolt and nut threads as recommended by manufacturer for each application. Install nuts and bolts on process piping using an anti-seize/anti-galling lubricant. Minimize seizing and galling by installing nuts at slow speeds to reduce friction heat and using clamps, not bolts, to pull joints together. If nut begins to bind before tightening the joint down, stop immediately. Wait a minute or two to allow any heat to dissipate and then back the fastener off. Inspect the threads for damage and remove any debris before proceeding with a new nut. Anti-seize/anti-galling lubricant shall be MRO Solutions LLC Solution 1000; Permatex Anti-Seize Lubricant, Finish Line Anti-seize Assembly Lube, USS Ultra Tef-Gel, Loctite Heavy Duty Anti-Seize, Loctite LB 771 by Henkel or pre-approved equal.

D. Steel Reinforcing For Concrete:

1. Bars: All reinforcement bars shall conform to the Standard Specifications for billet-steel bars for concrete reinforcement, ASTM A-615, or low alloy steel deformed and plain bars for concrete reinforcement, ASTM A-706. All bars shall be deformed and of structural Grade 60.

2. Wire: All reinforcement wire fabric shall conform to the Standard Specifications for welded steel wire fabric for concrete reinforcement, ASTM A-185 and steel wire, plain, for concrete reinforcement, ASTM A-82. Minimum yield strength shall be 65,000 PSI and minimum tensile strength shall be 75,000 psi.

E. Casing Vent Pipe

1. Vent Pipe: Unless otherwise specified, shall be located at each end of the casing pipe as shown on the Standard Details. The vent pipe shall be galvanized steel per ASTM A-53, Type E, Grade "B", Schedule 40.

2. All steel shall be Grade "B" only, with a minimum yield strength of 35,000 P.S.I.

3. Pipe design shall be in accordance with AWWA M11 considering the following:

a. Internal pressure

b. External pressure

c. Special physical loading

d. Practical requirements

e. Minimum wall thickness of 0.25 inch

4. The steel pipe shall have an inside lining - minimum 20 mils dry film thickness of Induron Protecto 401, Tnemec Perma-Shield PL Series 431, or approved equal, or shall have fusion-bonded epoxy coating in accordance with AWWA C213. Surface preparation and supplication shall be as recommended by Induron or Tnemec. Lining applicator shall be an Induron or Tnemec approved certified applicator.

5. Outside surface of the pipe exterior coating shall be fusion-bonded epoxy coating in accordance with AWWA C213 as per Induron or Tnemec or approved equal. Surface preparation and application shall be as recommended by Induron or Tnemec or approved equal. The coating applicator shall be an Induron or Tnemec or approved equal certified applicator.

   a. Exterior coating shall be forest green or olive green, as approved by the Engineer.

6. Vent pipe shall be equipped with a screen to guard from insects, debris, and animals as indicated on the Standard Details. Screen shall be sized to fit and installed securely inside the hub or coupling of the vent pipe. Screen shall be constructed of 0.009" thick 316 stainless steel 18 x 18 mesh with 0.047" openings.

2.2 CONCRETE

A. Portland Cement: All concrete shall conform to the Standard Specifications for READY MIXED CONCRETE, ASTM C-94. An air-entraining admixture, conforming to ASTM C-260, shall be added to either Type II, or Type III Portland Cement. Fly Ash conforming to ASTM C-618 for Class F Fly Ash may be added to the concrete mix but shall not be considered as replacement for more than 25% of the cement therein (strengths shall not be less than hereinafter required). Type IL Portland-limestone cement, meeting ASTM C-595, shall be allowed in lieu of Type II Portland-cement.

   1. Types III and IIIA Portland Cement shall only be used for manhole inverts, concrete encasement, concrete blocking, and/or as directed by the Engineer and shall conform to ASTM C-150.

   2. Types II and IIA Portland Cement shall be used in precast manholes, cast in place structures, reinforced concrete piers and concrete as directed by the Engineer, and shall conform to ASTM C-150 except that Tricalcium Aluminate content shall not exceed 8%. Portland-limestone cement Type IL(MS), conforming to ASTM C-595, shall be allowed in lieu of Types II and IIA.

B. Aggregates: All aggregates used for concreting shall conform to ASTM C-33 and shall be checked daily for any variances in moisture content. Said variances shall be corrected and/or taken into consideration for each batch.

   1. Coarse Aggregates: Shall be uniformly and evenly graded for each application in accordance with A.C.I. Standard 318. Unless otherwise approved, aggregate shall be sound, crushed, angular granitic stone. Flat or elongated aggregate or smooth round stones shall not be acceptable.

   2. Fine Aggregates: Shall consist of natural sand, manufactured sand or a combination thereof. Fine aggregates shall conform to the sieve analysis as specified in paragraph 4.1 of ASTM C-33 except that the percent passing a No. 50 sieve shall not exceed 5% and the percent passing a No. 100 sieve shall be 0% as provided for in paragraph 4.2 of ASTM C-33.

C. Mix Design: Concrete shall be watertight, resistant to freeze-thaw cycles and moderate sulfate attack, abrasion resistant, workable, and/or finishable. These qualities may be met through the use of admixtures (if and only if approved in the mix design as hereinafter specified) conforming to the appropriate ASTM with the exception of the use of calcium chloride, which shall be limited to no more than 1% by cement weight - thoroughly mixed to insure uniform distribution within the mix. If the concrete is used with reinforcing steel, no calcium chloride will be allowed. The Contractor shall assume responsibility for concrete mixture. When required by the Engineer, and prior to beginning construction, the Contractor, at their expense, shall obtain from an approved commercial testing laboratory a design for a suitable concrete mix and submit same with their list of materials and material suppliers for approval. The concrete shall be proportioned to meet the following requirements: (Note: This mix does not apply "in total" to precast manhole or reinforced concrete pipe).

1. Compressive Strength: Minimum 3,600 psi
2. Water-Cement Ratio By Weight: Maximum 0.50
3. Slump: Minimum 3”, Maximum 5”
4. Superplastercizer Slump: 6” – 8”
5. Air Content (Entrained and Entrapped): Minimum 4%, Maximum 6%
6. Coarse Aggregate: ¾” - 1 ½” (as required by the application)

D. Curing Compound: All concrete curing compounds shall conform to the standard specifications for LIQUID MEMBRANE - FORMING COMPOUNDS FOR CURING CONCRETE, ASTM C-309, Type 2. Curing compounds shall be applied if forms are stripped when concrete is to remain exposed to atmosphere.

E. Grouts: All grouts shall be of a non-shrink nature (as may be achieved through additives or proportioning) and depending upon application range from plastic to flowable cement water paste. Testing as specified above for concrete may b e required for acceptance of grouts to include frequent checks for consistency by a time- of-flow measurement. Expansion grouts shall be either MasterFlow 648 epoxy grout by BASF, or 1428HP Grout by W.R. Meadows, or approved equal. Grouts shall be mixed (if applicable) and placed in accordance with the manufacturer's current recommendations, for each specific application. Expansion grouts shall be used only as directed by the Engineer. Acceptable range of testing requirements:

1. Compressive Strength: 10,500 psi to 12,500 psi.
2. Bond Strength: 1,350 psi to 1,700 psi.
3. Percent Expansion: + 0.025% to + 0.75%

F. Mortar: Mortar used in sanitary sewer manholes shall be hydraulic cement mortar in accordance with ASTM C-398. Mortar used in sewer manholes shall be Type M mortar in accordance with ASTM C-270.

G. Lightweight Cellular Concrete Fill: For Use In Annular Spaces Inside Casing Pipe And Tunneling Pipes.

1. Qualifications: The Contractor must be capable of developing a mix design, batching, mixing, handling, and placing cellular concrete. The Contractor shall be certified by the manufacturer of the foaming agent and regularly engaged in the production and placement of cellular concrete. The Contractor shall have fully

qualified workers who are thoroughly trained and experienced in the production, placement and quality control of cellular concrete. Certificates verifying their qualifications and training will be required as part of the submittal for approval.

2. Conformance: Cellular concrete supplier must provide independent, third-party testing that confirms the proposed cellular concrete meets:

   a. ASTM C495, Standard Test Method for Compressive Strength of Lightweight Insulating Concrete.

      1) Slump: 10” to 11”
      2) Air Content: 75%
      3) Unit Weight: 28 - 35 PCF
      4) Design Compressive Strength of 150 psi at 28 days or 80 psi at 56 days.

   b. ASTM C666, modified Procedure B as per ACI 523.1 - Standard for freeze thaw cycles with relative dynamic modulus of elasticity (E) not less than 70% of its original value after 120 cycles.

3. Materials: Blast furnace slag shall conform to ASTM C 989. The percentage of blast furnace slag, if used, shall range from 20% to 30% depending on application. Fly ash, if utilized, must conform to ASTM C 618.

4. Foaming agents shall conform to the requirements of ASTM C 869 when tested in accordance with the provisions of ASTM C 796.

H. Flowable/Excavatable Fill (CLSM): Contractor shall furnish and place flowable fill i.e. controlled low strength (CLSM) backfill where shown in the drawings.

1. Cement: All cement used shall be Type II Portland cement which shall conform to the requirements of ASTM C150.

2. Fly Ash: ASTM C618, Class F.

3. Aggregates: Fine aggregate shall conform to the grading and quality requirements of ASTM C33. Coarse aggregate shall conform to the grading and quality requirements of ASTM C33 for size No. 476, No. 57, or No. 67.

4. Water: The batch mixing water and mixer washout water shall conform to the requirements of ASTM C94.

5. Flowable Fill Properties:

   a. CLSM shall have a maximum fifty-six (56) day compressive strength of one hundred and fifty (150) psi when molded and cured as in conformance with ASTM D4832.

   b. CLSM shall have a minimum cement content of fifty (50) pounds per cubic yard. The water-cementitious materials ratio of the mix shall not exceed three and one-half to one (3.5:1).

   c. CLSM shall be air entrained to a total air content of approximately five percent (5%).

   d. The minimum slump shall be six (6) inches and the maximum slump shall be eight (8) inches when tested in accordance with ASTM D6103.

   e. Fine aggregate shall be between fifty percent (50%) and sixty percent (60%) by volume of the total aggregates in the CLSM mix.

f. The consistency of the CLSM slurry shall be such that the material flows easily into all openings between the pipe and the lower portion of the trench. When trenches are on a steep slope, a stiffer mix of slurry may be required to prevent excavatable flowable fill from flowing down the trench. When a stiffer mix is used, vibration shall be performed to ensure that the excavatable flowable fill slurry completely fills all spaces between the pipe and the lower portion of the trench.

2.3 HIGH DENSITY POLYETHYLENE (HDPE) PIPE

A. HDPE pipe, for open cut casing applications, 8-inch thru 30-inch in diameter shall be manufactured in accordance with AWWA C906 and ASTM F714. Polyethylene pipe shall be OD based Iron Pipe Size – IPS and Dimension Ratio (DR) 9.

B. Product Standard: AWWA C906 and ASTM F714.

C. Pipe Compound: PE 4710 resin conforming to ASTM D3350 with cell classification 445574C/E.

D. Pipe markings shall be as required by AWWA C906. Product markings shall be at intervals of not more than 5 feet. The minimum pipe markings shall be as follows:
   1. Manufacture's Name or Trademark and product record.
   2. Nominal pipe size.
   3. IPS
   4. Dimension Ratio ("DR 9") and pressure class.
   5. AWWA C906.
   6. Seal of testing agency that verified the suitability of the pipe.
   7. Resin type/material code.
   8. ASTM standard
   9. Production date.
   10. Color Identification requirements:
      a. Sewer: HDPE pipe shall be identified by a green stripe on exterior. Striping material shall be the same as the piping material.
      b. Water: HDPE pipe shall be identified by a blue stripe on exterior. Striping material shall be the same as the piping material.

E. Manufacturers: Performance Pipe, GF Piping Systems, JM Eagle, Driscoplex, WL Plastics or approved equal.

PART 3 - EXECUTION

3.1 TUNNELING OPERATIONS USING STRUCTURAL STEEL LINER PLATES

A. All plates shall be formed to provide circumferential flanged joints. Longitudinal joints may be flanged or offset lap seam type. All plates shall be punched for bolting on both longitudinal and circumferential seam or joints. Bolt spacing in circumferential flanges shall be in accordance with the manufacturer's standard spacing and shall be multiples of the plate length so that plates having the same curvature shall be interchangeable to permit staggering of the longitudinal seam. Bolt spacing at flanged longitudinal seams shall be in accordance with the manufacturer's standard spacing. For lapped longitudinal seams, bolt size and spacing shall be in accordance with the manufacturer's standard but not less than

that required to meet the longitudinal seam strength requirements of the design specifications. All liner plates for the full length of a specified tunnel shall be either the flanged or the lapped seam type. The two types shall not be mixed in the same tunnel.

B. Liner plates shall be assembled in accordance with the manufacturer's instructions. Galvanized and coated plates shall be handled in such a manner as to prevent bruising, scaling, or breaking of the coating. Any plates that are damaged during handling or placing shall be replaced, except that small areas with minor damage may be repaired to the satisfaction of the Construction Engineer or their representative.

C. Galvanized surfaces shall be repaired by thoroughly wire brushing the damaged areas and removing all loose cracked coating, after which the cleaned areas shall be painted with two (2) coats of zinc rich paint as approved, and an acceptable bituminous coating restored.

D. When tunneling has proceeded a distance sufficient for placing one section of the tunnel liner, that section of liner will be placed before excavating further. Excavation shall be controlled so that the space outside the liner plate shall be held to a minimum of 2-inches. All voids between the liner plate and the tunnel wall shall be filled with 1:3 Portland cement grout, containing no more water than necessary, placed under sufficient pressure to fill all voids. Grout shall be placed through the grout holes provided in the top of the tunnel liner plates. Grout holes 2-inch in diameter shall be provided at no more than 4.5-foot centers or every third ring of plates to permit grouting as the erection of the tunnel liner progresses. At no time will the grouting operations be further than 10' from the front end or head of the tunnel construction.

E. At the end of each day's operations, the voids outside installed liner plates shall be grouted whether 10' or less. Grout will be forced into each grout hole. If the grout from one hole should flow along the liner plates so as to plug the next hole, the plug shall be opened by punching through the grout so that each hole may be used for grouting. The grouting operation will be continued at each hole until all spaces outside the liner plates are filled and no grout will flow.

F. The tunnel shall be constructed to the limits, grade and alignment shown on the Construction Plans. Excavation, without the use of jetting, shall be done in such a manner as to protect public and/or private property from damage. Prior to beginning any construction, the Contractor shall submit pit shoring and tunnel liner details for approval, and no tunneling may begin prior to approval of these details by the appropriate Controlling Agency. After approval of tunnel liner and pit shoring details, a five (5) day notice to the Controlling Agency, through the Construction Engineer, shall be provided as previously specified.

G. No blasting will be done without prior written approval of CHARLOTTE WATER and then only in strict accordance with all Federal, State, and Local laws, ordinances, rules, or regulations governing the storage and use of explosives.

H. The charges for the initial series of blasts should be placed in the triangle method. The second series should be placed in the radial method a minimum distance from the desired diameter of the tunnel. The triangular charges shall be set to go off first, with the radial charges to go off following a short interval or using the time-lag method.

I. Where rock is encountered before approaching the shoulder or pavement, the first four series of charges will be used in determining the amount of controlled blasting to be used before beginning any blasting beneath the railway or shoulders or pavement of the highway as applicable. If rock is encountered after tunneling progresses beneath the pavement or

railway, the charges will initially be set at very low levels and increased in small increments until the proper amount of charge is determined.

J. In no case will an overshoot be permitted. If a boulder is encountered and removed by blasting or by other methods, a bulkhead will be formed immediately after removal of the boulder and the area filled with grout before proceeding with the tunneling operations.

K. If there is any indication of a vertical split in the rock formation, or any indication of settlement of the roadway or railway fill, all operations shall be stopped, and the Controlling Agency notified immediately. If the vertical split is not determined to be of too great a magnitude or too close to the rails/pavement, the split shall be filled with grout at a pressure specified by the Controlling Agency, allowed to set and tunneling operations may be continued.

L. If it is determined that the vertical split is too great of a magnitude or too close to the pavement or railway, the Controlling Agency shall determine the method to be used to correct the split. If settlement of the roadway or railway occurs, the Controlling Agency will advise the Owner and their Contractor of the proper steps to be taken to correct the settlement. If deemed necessary by the Controlling Agency, adequate warning devices (signs, flashers, etc.) accompanied by responsible flagmen shall be placed at a distance allowing any and all traffic time to stop safely before reaching the questionable area. At the option of the Controlling Agency, it may provide the necessary flagmen, warning devices, etc., at the Contractor's expense. Traffic shall be allowed over the questionable area only as directed by the Controlling Agency.

M. The Controlling Agency shall have full authority to inspect entire tunnel operation, require disposition of remedial measures, and to stop all work if, in its opinion, the work will cause any damage to the roadway/railway section or endanger traffic. In all instances the Controlling Agencies reserve the right to sample, test, and approve all materials used.

N. The completed liner shall consist of a series of structural steel liner plates assembled with staggered longitudinal joints. Liner plates shall have been fabricated to fit the cross section of the tunnel. All plates shall be connected by bolts on both longitudinal and circumferential seams or joints.

O. After tunneling operations have been completed the Contractor will install the carrier pipe in a manner approved by the Engineer. Cellular grout (maximum compressive strength less than 150 psi) or excavatable fill (maximum compressive strength less than 150 psi) will then be placed after completing installation of the pipe within the tunnel liner as directed by the Engineer and end enclosure walls installed as shown on the Construction Plans or Standard Details. Ends of the tunnel liner will be sealed with a twelve-inch (12”) masonry wall on each end. Weep holes will be provided on the downstream end for drainage - See Standard Detail #18. The Contractor shall then remove the vertical shoring for pits (if ground conditions allow), surplus spoils, and material from the site. If ground conditions prevent the safe removal of the pit shoring, as determined by the pit design engineer or the Controlling Agency, the shoring shall remain in place. The top of the shoring shall be removed to a distance 2-feet below finish grade.

P. The site shall then be returned to its original condition, seeded, mulched, or restored as specified and left in a neat and satisfactory condition. Shoring material shall be removed in such a manner so as to avoid collapse and to allow proper backfill. The backfill shall be placed in accordance with these Specifications or the requirements of the Controlling Agency.

Q. The Contractor shall notify the Controlling Agency through the Engineer and acknowledgement shall be received a minimum of five (5) working days prior to beginning any work within roadway or railway rights-of-way. If required, 24-hours notice will be given prior to completion to allow the controlling agency to inspect the installation prior to backfill operations.

R. The Contractor will notify CHARLOTTE WATER, in writing, upon completion of the tunnel liner installation. Notification of completion of the tunnel operation will then be forwarded to the Controlling Agency. When the Controlling Agency is NCDOT, the Engineer will notify the Division Engineer, in writing, by letter with a copy to the attention of the State Design Services Engineer, North Carolina Department of Transportation, Division of Highways, Raleigh, North Carolina 27611.

S. The Contractor shall reimburse CHARLOTTE WATER and CHARLOTTE WATER shall reimburse the Division of Highways, or other Controlling Agency, should any settlement or damage result to the roadway within a period of one (1) year after completion of the tunneling operations.

3.2 DRY BORE WITHOUT STEEL ENCASEMENT

A. Bore Pits (or Tunnel Pits): Bore or tunnel pits shall be safed-up, shored, well marked, lighted, and not left unattended except as approved by the controlling agency. Requirements for stabilization and dewatering of bore pits shall be as specified in Sections 3.6 and 3.7 herein. The angle of repose method (sloping pit walls) for creating a safe working area shall not be used.

B. Installation: Continuous checks shall be made as to the elevation, grade and alignment of each successive section of encasement as well as the tracks (rails) upon which the boring rig travels.

C. Boring operations shall be continuous to their completion, and unnecessary or prolonged stoppages shall not be allowed.

D. In the event an obstruction is encountered during the boring and jacking operations, the auger is to be withdrawn and the bored hole stabilized before reapplying to the Controlling Agency for permission to open cut, bore at an alternate location, or install a tunnel.

E. Installation shall be to the limits specified by the Controlling Agency and/or as delineated in their encroachment issued to the City. (Copy of the encroachment agreement must be kept at the site throughout boring operations).

F. The Controlling Agency shall have full authority to require remedial measures and/or to stop all work if, in its opinion, said work will cause any damage to the roadway/railway section or endanger traffic. In all instances the Controlling Agencies reserve the right to sample, test, and approve all materials and methods used.

G. The Contractor shall notify the Controlling Agency through the Construction Engineer and acknowledgement shall be received a minimum of five (5) working days prior to beginning any work within roadway or railway rights-of-way. If required, 24-hours notice will be given prior to completion.

3.3 DRY BORE WITH STEEL ENCASEMENT

A. Bore Pits (or Tunnel Pits): Bore or tunnel pits shall be safed-up, shored, well marked, lighted, and not left unattended except as approved by the controlling agency. Requirements for stabilization and dewatering of bore pits shall be as specified in Sections

3.6 and 3.7 herein. The angle of repose method (sloping pit walls) for creating a safe working area shall be prohibited.

B. Pits adjacent to roadways shall be protected using interlocking precast concrete traffic barrier walls. Subject to approval of the Engineer, pits protected by existing traffic barrier walls or steel guardrails may not require temporary concrete traffic barrier walls.

C. Pits within the 1:1 slope distance from the edge of pavement, or greater than 20 in depth, or when required by the Engineer or the Controlling Agency shall be designed by a geotechnical/structural Professional Engineer. The Contractor shall be responsible for providing a pit design and details signed and sealed by a Professional Engineer licensed in North Carolina, and subject to approval of the Controlling Agency.

D. The pits and shoring shall be removed (if ground conditions allow) at the conclusion of construction. If ground conditions prevent the safe removal of the pit shoring, as determined by the pit design engineer or the Controlling Agency, the shoring shall remain in place. The top of the shoring shall be removed to a distance 2-feet below finish grade.

E. Installation: Smooth wall or spiral weld steel pipe may be jacked through dry bores slightly larger than the pipe, bored progressively ahead of the leading edge of the advancing pipe as spoil is mucked by the auger back through the pipe. As the dry boring operation progresses, each new section of encasement pipe shall be fully and completely butt-welded to the section previously jacked into place. Continuous checks shall be made as to the elevation, grade and alignment of each successive section of encasement as well as the tracks (rails) upon which the boring rig travels.

1. Steel encasement pipe shall have minimum thickness as provided below as specified by the controlling agencies. The actual thickness required must be calculated based on site conditions and actual depth of cover.

PIPE DIMENSIONS, INCHES PIPE TYPE - STEEL STANDARD - ASTM A 53 AND A 139				
Carrier Pipe Size (inches)	Casing Pipe Minimum Thickness (inches)			Minimum Tunnel Size (inches)
	Casing Pipe Size (inches)	NCDOT	Rail Roads	
4	12	0.250	0.250	36
6	12	0.250	0.250	36
8	18	0.250	0.312	48
10	20	0.250	0.344	48
12	24	0.250	0.375	48
16	30	0.312	0.469	48
18	30	0.312	0.469	48
24	36	0.375	0.532	54
30	48	0.500	0.750	60
36	54	0.500	0.781	72
42	60	0.500	0.844	84
48	66	0.625	0.938	90
54	72	0.625	1.000	96

F. If voids are encountered or occur outside the encasement pipe, grout holes shall be installed in the top section of the encasement pipe at ten (10) foot centers and the voids filled with Portland Cement grout at sufficient pressure to prevent settlement in the roadway/railway. The water-cementitious materials ratio of the mix shall not exceed three and one-half to one (3.5:1).

G. Boring operations shall be continuous, around the clock, to their completion, and unnecessary or prolonged stoppages shall not be allowed.

H. In the event an obstruction is encountered during the boring and jacking operations, the auger is to be withdrawn and the excess pipe is to be cut off, capped, and filled with 1:3 Portland Cement Grout at sufficient pressure to fill all voids before reapplying to the Controlling Agency for permission to open cut, bore at an alternate location, or install a tunnel.

I. Installation shall be to the limits specified by the Controlling Agency and/or as delineated in their encroachment issued to the City. (Copy of the encroachment agreement must be kept at the site throughout boring operations).

J. The completed casing installation shall be such as to prevent the formation of a waterway under the road or railbed. Ends of the casing shall be sealed with eight-inch (8”) solid brick

masonry walls. Weep holes will be provided on the downstream end for drainage. Ends of casing may also be sealed with synthetic rubber end seals.

K. The Controlling Agency shall have full authority to require remedial measures and/or to stop all work if, in its opinion, said work will cause any damage to the roadway/railway section or endanger traffic. In all instances the Controlling Agencies reserve the right to sample, test, and approve all materials and methods used.

L. The Contractor shall notify the Controlling Agency through the Engineer and acknowledgement shall be received a minimum of five (5) working days prior to beginning any work within roadway or railway rights-of-way. If required, 24-hours notice will be given prior to completion to allow the controlling agency to inspect the installation prior to backfill operations.

M. Casing Spacers/Isolators: Upon completion of the installation of the steel casing pipe, casing spacers/isolators shall be installed on any carrier pipe passing through the steel casing pipe. They shall be designed to support and protect the carrier pipe, and electrically isolate the carrier pipe from the casing. Casing spacers shall be installed at each end of the pipe, within 2 feet of the joint, and at intervals not greater than seven (7) feet, as determined by the spacer manufacturer, based on pipe diameter and loads.

3.4 STEEL CASING INSTALLATION BY TUNNEL AND JACK METHOD

A. The Contractor will provide all materials equipment and labor necessary to guarantee the complete installation of a steel casing as shown on the construction plans. The Contractor will provide an installation method acceptable to the Controlling Agency based on the conditions encountered. The Contractor shall be responsible for determining the site conditions based on his own investigations prior to construction. See Dry Bore With Steel Encasement – Bore Pits, above, for pit requirements.

B. The casing shall be installed by jacking, with simultaneous removal of spoil. The spoil removal shall not proceed more than 18-inches ahead of the casing. The diameter of the excavated hole shall be no larger than necessary to keep the casing moving freely and lubricant may be used to reduce the jacking forces. Casing sections shall be joined by full and complete butt welds. The butt weld shall be watertight and shall develop 100 percent of the strength of the steel pipe wall. Permalok steel casing pipe may be used as an alternative steel casing pipe joining system.

C. The completed casing installation shall be such as to prevent the formation of a waterway under the road or railbed. Ends of the casing shall be sealed with eight-inch (8-inch) solid brick masonry walls. Weep holes will be provided on the downstream end for drainage. Ends of casing may also be sealed with synthetic rubber end seals - See Standard Details.

D. The Controlling Agency shall have full authority to inspect entire operation, require disposition of remedial measures, and to stop all work if, in its opinion, the work will cause any damage to the roadway/railway section or endanger traffic.

E. The Contractor shall notify the Controlling Agency through the Engineer and acknowledgement shall be received a minimum of five (5) working days prior to beginning any work within roadway or railway rights-of-way. If required, 24-hours notice will be given prior to completion to allow the controlling agency to inspect the installation prior to backfill operations.

F. After the casing is jacked in place, 2-inch grout holes shall be used to pump a 1:3 Portland cement grout to fill the void outside the casing. Sufficient pressure should be applied to force grout out of the adjacent grout hole. Grout holes shall be a maximum of ten feet apart at the top of the casing.

The casing size and thickness shall be as shown on the Plans or Special Provisions.

G. Casing Spacers/Isolators: Upon completion of the installation of the steel casing pipe, casing spacers/isolators shall be installed on any carrier pipe passing through the steel casing pipe. They shall be designed to support and protect the carrier pipe, and electrically isolate the carrier pipe from the casing. Casing spacers shall be installed at each end of the pipe, within 2 feet of the joint, and at intervals not greater than 7 feet, as determined by the spacer manufacturer, based on pipe diameter and loads.

H. Casing End Seals: The ends of the casing pipe shall be sealed with synthetic rubber casing end seals or solid brick masonry walls, as specified, as shown on the Standard Details, and as approved by the Controlling Agency.

3.5 STEEL ENCASEMENT

A. Casing installation within NCDOT Rights-of-Way shall conform to provisions of approved utility encroachment agreements for the project. Unless specifically indicated otherwise by the encroachment agreement, the annular void between carrier pipes and casing pipes 24 inches in diameter or larger shall be pumped with flowable fill; grout; or Class III, Class IV or Class V select materials in accordance with NCDOT Standard Specifications for Roads and Structures Section 1540 Encasement 1540-3 (E).

B. Interpretation of soil investigation reports and data, investigating the site and determination of the site soil conditions prior to bidding is the sole responsibility of the Contractor. Any subsurface investigation by the Bidder or Contractor must be approved by the appropriate authority having jurisdiction over the site. Rock and/or water, if encountered, shall not entitle the Contractor to additional compensation.

C. Casing construction shall be performed so as not to interfere with, interrupt or endanger roadway surface and activity thereon, and minimize subsidence of the surface, structures, and utilities above and in the vicinity of the casing. Support the ground continuously in a manner that will prevent loss of ground and keep the perimeters and face of the casing, passages and shafts stable. The Contractor shall be responsible for all settlement resulting from casing operations and shall repair and restore damaged property to its original or better condition at no cost To CHARLOTTE WATER.

D. Face Protection: The face of the excavation shall be protected from the collapse of the soil into the casing.

E. Casing Design: Design of the bore pit and required bearing to resist jacking forces is the responsibility of the Contractor. The excavation method selected shall be compatible with expected ground conditions. The lengths of the casing shown on the Drawings are the minimum lengths required. The length of the casing may be extended for the convenience of the Contractor, at no additional cost to CHARLOTTE WATER.

F. Groundwater Control

1. See requirements for Dewatering in the Excavation and Backfill specifications of the CHARLOTTE WATER, Water and Sewer Design and Construction Standards.

2. The Contractor shall control the groundwater throughout the construction of the casing.

3. Methods of dewatering shall be at the option and responsibility of the Contractor. Maintain close observation to detect settlement or displacement of surface facilities due to dewatering. Should settlement or displacement be detected, notify the Engineer immediately and take such action as necessary to maintain safe conditions and prevent damage.

4. When water is encountered, provide and maintain a dewatering system of sufficient capacity to remove water on a 24-hour basis keeping excavations free of water until the backfill operation is in progress. Dewatering shall be performed in such a manner that removal of soil particles is held to a minimum.

G. Safety

1. Provide all necessary bracing, bulkheads and shields to ensure complete safety to all traffic, persons and property at all times during the work. Perform the work in such a manner as to not permanently damage the roadbed or interfere with normal traffic over it.

2. Observe all applicable requirements of the regulations of the authorities having jurisdiction over this site. Conduct the operations in such a manner that all work will be performed below the level of the roadbed.

3. Perform all activities in accordance with the Occupational Safety and Health Act of 1970 (PL-596), as amended, applicable regulations of the Federal Government, OSHA 29CFR 1926.650, 29CFR 1926.651, 29CFR 1926.652, and 29CFR 1926.800, and applicable criteria of ANSI A10.16 (latest edition), "Safety Requirements for Tunnels, Shafts, and Caissons".

H. Boring and Jacking

1. Bore Pits and Receiving Pits

a. Conduct boring and jacking operations from a pit excavated at one end of the section to be bored. Where conditions and accessibility are suitable, place the pit on the downstream end of the bore.

b. The pit shall be rectangular and excavated to a width and length required for ample working space.

c. The walls of the pit shall be properly shored on all sides in compliance with OSHA requirements. Pit sheeting shall be timber or steel piling of ample strength to safely withstand all structural loadings of whatever nature due to site and soil conditions. Keep preparations dry during all operations. Perform pumping operations as necessary.

d. The bottom of the pit shall be firm and unyielding to form an adequate foundation upon which to work. In the event the pit bottom is not stable, excavate to such additional depth as required and place a gravel sub-base or a concrete sub-base if directed by the Engineer due to soil conditions.

2. Jacking Rails and Frame

a. Set jacking rails to proper line and grade within the pit. Secure rails in place to prevent settlement or movement during operations. The jacking rails shall

cradle and hold the casing pipe on true line and grade during the progress of installing the casing.

b. Place backing between the heels of jacking rails and the rear of the pit. The backing shall be adequate to withstand all jacking forces and loads.

c. The jacking frame shall be of adequate design for the magnitude of the job. Apply thrust to the end of the pipe in such a manner to impart a uniformly balanced load to the pipe barrel without damaging the joint ends of the pipe.

3. Boring and jacking of casing pipes shall be accomplished by the dry auger boring method without jetting, sluicing or wet-boring.

4. Auger the hole and jack the casing through the soil simultaneously.

5. Bored installations shall have a bored-hole diameter essentially the same as the outside diameter of the casing pipe to be installed.

6. Execute boring ahead of the casing pipe with extreme care, commensurate with the rate of casing pipe penetration. Boring may proceed slightly in advance of the penetrating pipe and shall be made in such a manner to prevent any voids in the earth around the outside perimeter of the pipe. Make all investigations and determine if the soil conditions are such as to require the use of a shield.

7. As the casing is installed, check the horizontal and vertical alignment frequently. Make corrections prior to continuing operation. For casing pipe installations over 100 feet in length, the auger shall be removed, and the alignment and grade checked at minimum intervals not greater than 60 feet.

8. Any casing pipe damaged in jacking operations shall be repaired, if approved by the Engineer, or removed and replaced at Contractor's own expense.

9. Lengths of casing pipe, as long as practical, shall be used except as restricted otherwise. Joints between casing pipe sections shall be Permalok® joints or full circumference butt joints with complete joint penetration, single groove welds, for the entire joint circumference, in accordance with the American Welding Society (AWS) recommended procedures. Prior to welding the joints, the Contractor shall ensure that both ends of the casing sections being welded are square.

10. The Contractor shall prepare a contingency plan allowing the use of a casing lubricant, such as bentonite, in the event excessive frictional forces jeopardize the successful completion of the casing installation.

11. Once the jacking procedure has begun, it should be continued without stopping until completed, subject to weather and conditions beyond the control of the Contractor.

12. Care shall be taken to ensure that casing pipe installed by boring and jacking method will be at the proper alignment and grade.

13. The Contractor shall maintain and operate pumps and other necessary drainage system equipment to keep work dewatered at all times.

14. Adequate sheeting, shoring and bracing for embankments, operating pits and other appurtenances shall be placed and maintained to ensure that work proceeds safely and expeditiously. Upon completion of the required work, the sheeting, shoring and bracing shall be left in place, cut off or removed, as designated by the Engineer.

15. All surplus material shall be removed from the right-of-way and the excavation finished flush with the surrounding ground.

16. Grout backfill shall be used for unused holes or abandoned pipes.

I. Ventilation and Air Quality: Provide, operate and maintain for the duration of casing project a ventilation system to meet safety and OSHA requirements.

J. Installation of Pipe

1. After construction of the casing is complete, and has been accepted by the Engineer, install the pipeline in accordance with the Drawings and Specifications.

2. Check the alignment and grade of the casing and prepare a plan to set the pipe at proper alignment, grade and elevation, without any sags or high spots.

3. The pipe shall be supported within the casing by use of casing spacers sized to limit radial movement to a maximum of 1-inch. Provide a minimum of three (3) casing spacers per nominal length of pipe. Casing spacers shall be attached to the pipe at maximum seven (7) foot intervals. Casing spacers shall also be provided within two feet of each end of the carrier pipe within the casing.

K. End Seals

1. Masonry/Brick End Seals

a. Close the ends of the casing pipe with masonry brick and mortar seal, minimum 8-inches thick, at both ends of casing.

b. Leave a weephole opening at the bottom of the lowest bulkhead end for drainage of the annular space.

2. Lightweight Cellular Concrete Fill (For casings only)

a. Prior to installation, the ground surface shall be cleared of organic top soils, debris, sharp objects, and trees. Tree stumps shall be either removed or cut to the level of the ground surface. All wheel tracks or ruts in excess of 3 in. (75 mm) in depth shall be graded smooth or otherwise filled with soil to provide a reasonable smooth surface.

b. The lightweight cellular concrete fill shall be placed according to the approved installation procedures provided by the manufacturer.

c. There shall be no standing water in the area to be filled. If necessary, dewatering shall be continuous during the time the lightweight cellular concrete fill is constructed. Lightweight cellular concrete fill shall not be placed during or when periods of precipitation are expected unless placed in an enclosed, covered area and the ground water is diverted away from the lightweight cellular concrete fill.

d. If any items are to be encased in the fill, the items shall be set to the final location both horizontally and vertically prior to installation of the lightweight cellular concrete fill.

e. Mixing and placement of the lightweight cellular concrete fill shall be done as follows:

1) After mixing, the materials shall be promptly placed in the final location.

2) No mechanical vibration of the lightweight cellular concrete fill shall be permitted.

3) The material shall be placed to prevent segregation. Intermediate lifts shall be placed horizontal while only the top lift shall be sloped to grade. The final surface elevation of the lightweight cellular concrete fill shall be within ±1.5 inches of the plan elevation.

4) Limit the area of placement to the volume that can be placed within 1 hour, up to the maximum lift height. Stagger placements such that the vertical joints are at least 10 ft (3 m) apart.

5) The cellular concrete shall be placed with a hose. The discharge hose length shall not exceed 800 ft (244 m) in length. Discharge from the hose shall not be allowed to flow more than 30 ft (9 m) from where it is deposited to its final position.

6) Heavy construction equipment or other unusual loading of the lightweight cellular concrete fill shall not be permitted.

7) Construction activities on any recently placed lift will not be permitted until at least 12 hours has elapsed and a minimum compressive strength of 8 psi has been achieved. However, if any work on the recently placed lightweight cellular concrete fill resulting in cracking or indentations of more than an 0.125 inch, the contractor shall discontinue construction, revise their wait time, mix strength or equipment used and submit to the Engineer for approval.

8) Sawing or ripping of the lightweight cellular concrete fill for utilities, drains or other conflicts will be by methods approved by the Engineer of Record and lightweight cellular concrete fill Manufacturer.

f. Where required, formwork should be designed and installed to withhold cellular concrete and may require lining with poly sheeting or similar impermeable membrane to prevent leakage.

g. Cellular concrete may be placed during freezing conditions, provided measures are taken to prevent damage to the cellular concrete until sufficient strength has been attained. Care should be taken to avoid freezing before initial set. Cellular concrete must not be placed during heavy or prolonged precipitation.

h. Concrete can be placed with a maximum slope of 1%. Slopes greater than 1% will require profiling by creating steps for the Cellular Concrete with formwork or can be mechanically graded to slopes in excess of 1% by means of grader, bulldozer or milling machine.

L. Sheeting Removal: Remove sheeting used for shoring from the shaft and off the job site. The removal of sheeting, shoring and bracing shall be done in such a manner as not to endanger or damage either new or existing structures, private or public properties and also to avoid cave-ins or sliding in the banks.

M. Coatings: Unless otherwise shown on the construction plans, casing pipe installed under State and/or City maintained roadways shall not require a protective coating.

3.6 CONCRETE PLACEMENT

A. Ready mix concrete will not be accepted without the inspector receiving the plant dispatch ticket.

B. Before placing concrete, verify that installation of formwork, reinforcement, and embedded items is complete and that required inspections have been performed.

C. Do not add water to concrete during delivery, at Project site, or during placement unless approved by the Engineer.

D. Before test sampling and placing concrete, water may be added at Project site, subject to limitations of ACI 301. Do not add water to concrete after adding high-range water-reducing admixtures to mixture.

E. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete will be placed on concrete that has hardened enough to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as indicated. Deposit concrete to avoid segregation.

1. Deposit concrete in horizontal layers of depth to not exceed formwork design pressures and in a manner to avoid inclined construction joints.

2. Consolidate placed concrete with mechanical vibrating equipment according to ACI 301.

3. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

F. Forms: Forms may be made of wood, plywood, metal, or any other material approved by the Engineer. Forms shall be mortar tight, of material strong enough to resist noticeable deflection or bulging between supports, and the interior dimensions of the forms shall be such that the finished concrete shall be of the form and dimensions shown on the Plans. The design of the forms shall take into account the effect of vibration of concrete as it is placed and also the rate of speed at which the forms will be filled. Forms shall be coated with a lubricant as approved by the Engineer. Mechanical vibrators, of an approved type, and continuous spading and/or rodding of concrete shall be used to produce proper contact of concrete with forms and reinforcing steel in piers and with forms and pipe in monolithic inverts insuring a compact, dense and impervious artificial stone of uniform texture.

G. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When average high and low temperature is expected to fall below 40 deg F for three successive days. Maximum temperature in concrete after placement shall not exceed 160°F (70°C). Maximum temperature difference between center and surface of placement shall not exceed 35°F (19°C).

2. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.

4. Do not place concrete until the foundation, the adequacy of the forms, the placing of reinforcement and other embedded items have been inspected and approved.

5. Place concrete in daylight unless an approved lighting system is provided.

6. Remove all debris from the interior of forms in preparation for placing concrete. Moisten earth or base course surfaces on which concrete is to be placed immediately before placing concrete. Do not place concrete on excessively wet or frozen surfaces.

7. Place concrete in its final position in the forms within the time stipulated in Subarticle 1000-3(E) of NCDOT'S 2024 Standard Specifications for Roads and Structures.

ELAPSED TIME FOR PLACING CONCRETE		
Air or Concrete Temperature, whichever is higher.	Maximum Elapsed Time	
	No Retarding Admixture Used	Retarding Admixture Used
90°F or above	30 minutes	1 hr. 15 minutes
80°F through 89°F	45 minutes	1 hr. 30 minutes
79°F or below[A]	60 minutes	1 hr. 45 minutes
70°F through 79°F[B]	60 minutes	1 hr. 45 minutes
69°F or below[B]	1 hr. 30 min	2 hr. 15 minutes

8. Place concrete to avoid segregation of the materials and the displacement of the reinforcement. Thoroughly work the concrete during placement. Bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets or honeycombs.

9. Do not place concrete when the air temperature, measured at the location of the concrete operation in the shade away from artificial heat, is below 35°F unless permission is otherwise granted by the Engineer. When such permission is granted, uniformly heat the aggregates and water to a temperature no higher than 150°F. Place the heated concrete at a temperature of at least 55°F and no more than 80°F.

10. All concrete shall be protected from freezing by the Contractor during the initial 7 days of curing. The Contractor shall submit an anti-freezing plan for review. Frozen concrete shall be removed and replaced at the Contractor's expense.

H. Hot-Weather Placement: Comply with ACI 301 and as follows:

1. Maintain concrete temperature below 90 deg F at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

I. Finishing: Provide the type of finish required by the contract directly applicable to the work being constructed

1. Ordinary Surface Finish: Remove all form ties or metal spacers to a depth of at least 1 inch below the surface of the concrete and clean and fill the resulting holes or depressions with grout. Metal devices with exposed cross-sectional area not exceeding approximately 0.05 sq. inches on surfaces permanently in contact with earth fill may be broken off flush with the surface of the concrete.

Remove all fins caused by form joints and other projections. Remove stains and discoloration. Clean all pockets and fill with grout as directed. Thoroughly soak the surface of all concrete with water before the application of a grout repair.

Use grout consisting of one part cement and two parts sand. Use cement from the same source as originally incorporated in work. Cure the grout for at least 3 days. After the grout has thoroughly hardened, rub the patch with a carborundum stone as required to match the texture and color of the adjacent concrete.

On surfaces that are to be backfilled or surfaces that are enclosed, the removal of form marks, fins and pockets; the rubbing of grouted areas to uniform color; and the removal of stains and discoloration will not be required.

2. Sidewalk Finish: Strike off fresh concrete and compact until a layer of mortar is brought to the surface. Finish the surface to grade and cross section with a float, trowel smooth and finish with a broom.

3. Rubbed Finish: After the ordinary surface finish has been completed, thoroughly wet and rub the entire surface. Use a coarse carborundum stone or other equally good abrasive to bring the surface to a smooth texture and remove all form marks. Carefully stroke the surface with a clean brush to finish the paste formed by rubbing. Alternatively, spread the paste uniformly over the surface and allow it to take a reset. Finish by floating with a canvas, carpet-faced or cork float or rub down with dry burlap.

4. Float Finish: Finish the surface with a rough carpet float or other suitable device leaving the surface even but distinctly sandy or pebbled in texture.

J. Curing: Cure concrete according to ACI 308.1, by one or a combination of the following methods:

1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:

a. Water.

b. Continuous water-fog spray.

c. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

2. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive.

Cure for not less than seven days. Immediately repair any holes or tears during curing period using cover material and waterproof tape.

a. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive floor coverings.

b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating liquid floor treatments.

c. Cure concrete surfaces to receive floor coverings with either a moisture-retaining cover or a curing compound that the manufacturer certifies will not interfere with bonding of floor covering used on Project.

3. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

a. Removal: After curing period has elapsed, remove curing compound without damaging concrete surfaces by method recommended by curing compound manufacturer.

4. Curing and Sealing Compound: Apply uniformly to floors and slabs indicated in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.

K. Flowable Fill

1. Use straps, soil anchors or other approved means of restraint to ensure correct alignment when flowable fill is used as backfill for pipe or where flotation or misalignment may occur.

2. Protect flowable fill from freezing for a period of 36 hours after placement.

3. Place flowable fill to the designated fill line without vibration or other means of compaction.

4. Flowable fill may be placed during freezing conditions, provided measures are taken to prevent damage to the cellular concrete until sufficient strength has been attained. Care should be taken to avoid freezing before initial set. Cellular concrete must not be placed during heavy or prolonged precipitation.

5. Take all necessary precautions to prevent any damages caused by the hydraulic pressure of the fill during placement prior to hardening. Provide the means to confine the material within the designated space.

L. Testing: The following tests will be performed by a Testing Laboratory selected by CHARLOTTE WATER to ensure the concrete quality. The costs for performing the tests will be paid for by CHARLOTTE WATER when the test results are in conformity with the specifications below. For Developer Donated projects, testing shall be performed by a third party and paid for by the developer. However, those which show no conformity, or a failure will be paid for by the Contractor. It shall be the responsibility of the Contractor to properly inform the Testing Laboratory as to when the concrete will be placed into the forms. For developer projects, the testing laboratory shall be approved by the Engineer, and shall be a sub consultant to the developer’s consulting engineer. All cost of testing shall be paid by the developer.

1. Compressive strength in accordance with ASTM C-31 and ASTM C-39. Test cylinders which are formed in the field will be left in the field until compression testing (7-day, 14-day, 28-day) is completed thereby more closely approximately the curing conditions of the field placed concrete.
2. Slump Test in accordance with ASTM C-143.
3. Air Content Test in accordance with either ASTM C-173 or ASTM C-231.
4. A strength test shall be the average of the strengths of at least two 6 x 12 in. cylinders or at least three 4 x 8 in. cylinders made from the same sample of concrete and tested at 28 days or at test age designated for f'c.
5. Cellular concrete unit weight testing shall be in accordance with ASTM C496, ASTM C796 and ASTM C869.
6. The testing agency performing acceptance testing shall comply with ASTM C1077.
7. Samples for preparing strength test specimens of each concrete mixture placed each day shall be taken in accordance with (a) through (c):
    a. At least once a day.
    b. At least once for each 150 CY of concrete.
    c. At least once for each 5,000 SF of surface area for slabs or walls.
8. Engineer shall be consulted if exemption from testing is requested.

3.7 OPEN CUT HDPE CASING PIPE

A. HDPE Pipe (Open Cut Installation of Casing Pipe Only): HDPE pipe shall be installed with a minimum of 3.0 feet of cover and a maximum of 20 feet of cover. Buried HDPE pipe and fittings shall be installed in accordance with ASTM D2321 or ASTM D2774 for pressure systems and AWWA Manual of Practice M55 Chapter 7.

1. Trenching:
    a. Trench Length: The length of open trench required for fused pipe sections should be such that bending and lowering the pipe into the ditch does not exceed the manufacturer's minimum recommended bending radius and result in kinking.
    b. Trench Width: Trench widths shall be in accordance with Section 3.2 per Chapter 11 Gravity Sanitary Sewer Specifications of the CHARLOTTE WATER Water and Sewer Specifications.
    c. The trench width at pipe grades for pipes 24-inch diameter and greater shall be sized to accommodate the butt-fusion equipment necessary to fuse the HDPE pipe size as shown on the plans.
    d. Open cut installation of HDPE casing pipe shall be installed with Type III or greater stone bedding.
2. When HDPE SDR 9 casing pipe is used for open cut casing installations, the minimum thickness and clearances shall be as shown in the following table:

Minimum Requirements for Open Cut HDPE Casing Pipe			
Carrier Pipe Size (inches)	Casing Pipe Size (OD, inches)	Casing Pipe Minimum Thickness (inches)	Casing Pipe Average ID (inches)
6	18	2.000	13.760
8	20	2.222	15.289
12	26	2.899	19.875

3. Repairs:

   a. Defective or damaged pipe including leaking joints shall be removed and replaced with sound new pipe. Pipe re-connections shall be made, and joint leaks repaired, using repair sleeves pre-approved by the Engineer.

   b. Pipe that is sound and otherwise acceptable, but will not pass the deflection test, will be exposed and the bedding materials removed and replaced. Re-rounding of the pipe by mechanical means, without uncovering the pipe shall typically not be approved. If re-rounding is approved by the Engineer, any device used for re-rounding shall be subject to approval by the Engineer. Over-deflection of the pipe near the joint will be corrected by excavation only.

   c. Repairs shall be limited to one repair between manholes. Deficiencies in excess of these limitations shall be corrected by relaying the section of pipe.

END OF SECTION