SECTION 7200
WASTEWATER FORCE MAINS
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7210 GENERAL

1. These Specifications apply to all force mains that are to be owned, operated, and maintained by Cary. Design of private pump stations and force mains and associated facilities is not covered by these Specifications or otherwise herein, and the applicant should look for guidance from other appropriate agencies (NCDENR, NC Plumbing Code, etc.).

2. All aspects of the design of wastewater force mains, and associated facilities shall, at a minimum, meet the requirements of the latest version of the NCDENR "Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains". Requirements presented in Cary Standard Specifications hereunder that are more restrictive or go above and beyond the requirements of the Minimum Design Criteria are required by Cary.

3. All aspects of the design of pump stations, force mains, and associated facilities shall be submitted for review and approval to Cary's Utilities Department.

4. Wastewater force main interconnections shall be prohibited. All wastewater force mains shall extend to the nearest gravity sewer or pump station wet well that has sufficient long-term capacity.

5. All utility crossings within Cary streets shall be made by trenchless methods. State maintained streets within the Cary ETJ should also be crossed using trenchless methods. In cases where utility conflicts, rock, or other obstructions prevent trenchless crossings, Cary may consider approving other methods.

7220 WASTEWATER FORCE MAINS

A. DESIGN

1. Force mains shall be installed with a minimum cover of 4 feet measured from the top of the pipe to the finished grade.

2. Force mains shall be installed in dedicated public right of way or in dedicated utility easements as follows. When wastewater force mains are constructed adjacent to gravity sewer mains or for construction of parallel wastewater force mains, the minimum horizontal clearance shall be at minimum 7-ft from pipe edge to pipe edge when the depth of installation is 8-ft or less. Otherwise, the minimum horizontal separation between pipelines shall be 10-ft up to installation depth of 10-ft. Clearances for pipelines greater than 10-ft depth shall be designed by Engineer of Record and approved by Cary's Utilities Department. Easement widths outlined below shall be widened by at least the clearance

between the pipelines when constructing a shared gravity sewer and wastewater force main corridor.

Standard Easement Width for Sewer Force Mains

Pipe Size (diameter)	Pipe Depth (feet)	Easement Width (feet)
8-inch to 12-inch	10-ft or less	20-ft
8-inch to 12-inch	10-ft – 12.5-ft	25-ft
8-inch to 12-inch	12.5-ft – 15-ft	30-ft
8-inch to 12-inch	15-ft to 17.5-ft	35-ft
8-inch to 12-inch	17.5-ft to 20-ft	40-ft
12-inch to 24-inch	15-ft or less	30-ft
12-inch to 24-inch	15-ft – 17.5-ft	35-ft
12-inch to 24-inch	17.5-ft – 20-ft	40-ft
Greater than 24-inch	Any Depth	Specified by the Director of Utilities
Any Size	Deeper than 20-ft	

3. Dedicated easements for force mains and appurtenances shall be recorded as “Cary Utility and Pipeline Easement”. Cary force main easements shall contain only Cary utilities unless otherwise approved by the development plan or an encroachment agreement.

4. Access easements to allow sufficient means of gaining entrance to proposed Utility and Pipeline Easements may be required by the Utilities Department where conventional access from the public right-of-way is limited or infeasible.

5. Wastewater force main discharge manholes and intermediate air release locations that require odor control shall be provided with sufficient easement area to accommodate the odor control systems as designed by the Engineer of Record, whether utilizing passive, forced air or chemical treatment for odor control. The maintenance easement for odor control systems shall be sized based on site specific conditions and shall provide sufficient area for routine maintenance operations, such as refilling media, chemicals, replacing equipment, etc.

6. Force mains shall discharge at the invert of the receiving manhole and shall be as close as possible to 180 degrees from the outlet pipe.

7. Force main design shall facilitate cleaning and inspection. The use of 90-degree bends is prohibited.

8. Force mains shall be constructed with a pigging/emergency connection located within 50-ft of the pump station valve vault.

9. Force main minimum design velocity shall not be less than 2-ft per second throughout the length of the force main. As a design preference, force main systems when operating at higher flows shall reach velocities of 3 to 5 ft/s to re-suspend any settled solids.

10. Force main systems shall be of adequate sizing and design to effectively convey the ultimate peak flows as applied by the connected pump station to the discharge point.

11. The force main route shall be such that the number of high points requiring combination air valves is minimized to the extent possible. Combination Air Valves rated for use with raw wastewater shall be installed at all the high points or runs exceeding 3000-ft on all force mains in accordance with the Standard Details. A high point shall be determined as any location where the vertical separation between the adjacent low point and high point in the force main is greater than or equal to 10 vertical feet.

12. Restraint:
    a) General: All valves and fittings shall be restrained. Pipe joints shall also be restrained an adequate length away from valves and fittings in accordance with AWWA manual M41 (or the latest edition of *Thrust Restraint Design for Ductile Iron Pipe* as published by the Ductile Iron Pipe Research Association). In all cases, **there must be a pipe restraint plan with the method of restraint to be used and the length of pipe to be restrained clearly identified on the plans at all necessary locations**. The pipe restraint plan shall be included under the design responsibility of the NC Professional Engineer sealing the plan drawings.

    b) Pipe Joints: The standard joint restraint method shall be to use manufacturer provided restrained joint pipe. Pipe up to and including 12-inches in diameter may also utilize mechanical joint pipe with approved wedge action retainer glands (for the specified distance). All joint restraint products that include the means of restraint within the joint gasket shall be prohibited.

    c) Valves: Valves shall be restrained in a manner consistent with operation as a dead end. This includes restraining the valve to the pipe and restraining a sufficient number of pipe joints on both sides of the valve to accommodate dead end restraint.

13. A plug valve shall be installed at least every 3000 feet of force main length.

14. All air release valves, plug valves greater than 12-inches, or other appurtenances that have moving or operating parts and require maintenance and routine access shall have a manhole placed over them or over the operating portion of the device.

15. Construction Involving Existing Force Mains
    a) The existing wastewater force main must remain active and protected during all phases of construction. The contractor must provide a plan for the structural protection of the existing wastewater force main.

    b) A proposed construction sequence must be submitted for any demolition of a portion of existing wastewater force main. The plan must be reviewed and approved by Utilities and Public Works

16. Separation Requirements

	Water	Storm water	Sewer (Gravity and Forcemain)	Reclaimed
Water	18-inches vertical	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation
Storm water	**Parallel Installations**: 10-feet horizontal **Crossings**: 18 inches vertical		24-inches vertical	Min. 18-inches vertical.
Sewer (Gravity & Forcemain)	**Parallel Installations:** 10 feet horizontally **Crossings:** 18-inches vertical separation water main over sewer	24-inches vertical	7-feet horizontal separation, increasing with depth	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes)**: 18-inches
Reclaimed	**Parallel Installations**: 10-feet horizontal and water line at least 18-inches above reclaimed **Crossings (water main over reclaimed water pipeline)**: Min. 18-in vertical separation	Min. 18-inches vertical.	**Parallel Installations:** 10-feet horizontal **Crossings (reclaimed water pipes over sewer pipes)**: 18-inches	18 inches vertical

Separation between Sewer Force Main and Storm Water Pipes:
Sewer force mains shall have a minimum vertical separation of 24 inches between storm pipes when the horizontal separation is 5 feet or less. Where sanitary and storm sewers cross with a vertical separation of less than 24 inches, the entire leg of sanitary sewer shall be made of standard ductile iron pipe with joints rated for water main service and the void space between the pipe crossing shall be backfilled with 3000-psi concrete or minimum 500-psi, quick setting, non-excavatable flowable fill that meets or exceeds NCDOT Specifications.

Separation between Sanitary Sewer and Sewer Force Main:
There shall be a minimum 7-foot horizontal separation between parallel gravity and/or force mains in outfall locations when the depth of installation is 8-ft or less. Otherwise, the minimum horizontal separation between pipelines shall be 10-ft in outfalls.

Separation between Sewer Force Main and Water Main
Parallel Installations: 10-ft lateral separation (pipe edge to pipe edge) unless local conditions or barriers prevent a 10-ft lateral separation, in which case:

- A minimum 5-ft lateral separation and water line laid in a separate trench, with the elevation at least 18-inches above sanitary or storm sewer line measured vertically from top of sewer pipeline to bottom edge of water main.
- A minimum 5-ft lateral separation and water line laid in the same trench as the sanitary or storm sewer, with the water main located at one side on a bench of undisturbed earth and with the elevation of the bottom of the water main at least 18-inches above the top of the sanitary or storm sewer.
- In unique cases where the sewer force main and the water main are installed with at least 5-ft of lateral separation but less than 10-ft of horizontal separation, and less than 18-inches of vertical separation, the design engineer shall submit justification of deviation per section 6010.A.12.c to be approved on a case-by-case basis by Cary. At a minimum both the water main and sewer force main shall be constructed of ductile iron pipe with joints in full compliance with water main standards.

Crossings (Water Main over Sewer Force Main): All water main crossings of sewer force mains shall be constructed in conformance with Cary Specifications. At a minimum, 18-inches of clearance shall be maintained between the bottom edge of the water main and the top edge of the sewer force main. If 18-inches of clearance is not maintained, the crossing shall be reviewed and allowed only on a case-by-case basis with justification of deviation provided by the design engineer per section 6010.A.12.c. At a minimum, the water main and sewer force main shall both be constructed of ductile iron pipe with joints in conformance with water main construction standards. The ductile iron sewer force main shall extend 10-ft on both sides of the crossing. When the separation between pipelines is 18-inches or less, the void space between the pipes shall be filled

with minimum 500-psi, quick setting, and non-excavatable flowable fill extending 3-ft on both sides of the crossing. Regardless of pipe material, at least 12-inches of vertical separation is required for sewer force main crossings of potable water mains.

Crossings (Water Main under Sewer Force Main: Allowed only as approved by Cary with justification of deviation provided by the design engineer per section 6010.A.12.c, when it is not possible to cross the water main above the sewer force main. At a minimum, 18-inches of separation shall be maintained, (measured from pipe edge to pipe edge) and both the water main and sewer force main shall be constructed of ductile iron in conformance with water main construction standards to a minimum of 10-ft on both sides of the crossing. If local conditions prevent providing 18-inches of clearance, then at least 12-inches of clearance shall be provided and the void space between the pipes shall be filled with minimum 500-psi, quick setting, and non-excavatable flowable fill extending at least 3-ft on both sides of the crossing. In all cases the water main pipe shall be centered at the point of crossing with joints equally spaced from the point of crossing.

Separation between Sewer Force Main and Reclaimed Water:
Sewer force mains and reclaimed water mains shall be laid with at least 10 feet of horizontal separation, measured laterally edge to edge unless the elevation of the bottom of the reclaimed water main is at least 18 inches above the top edge of the sewer force main, with a horizontal separation of at least 3 feet.

Where a reclaimed water main and a sewer force main cross, the crossing shall be constructed at a 90-degree angle and the sewer force main shall cross at least 18-inches below the reclaimed water line. Because all reclaimed water mains in the Cary municipal system are constructed to fully comply with water system testing and integrity standards as described by 15A NCAC 18C, when the minimum separation cannot be met, at least 12-inches of clearance shall be maintained, the sewer force main shall be provided in ductile iron pipe in full compliance with water main standard joints, and the void space between the pipes shall be filled with minimum 500-psi, quick setting, non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

If the sewer force main crosses above the reclaimed water line, the clearance shall be at least 18-inches. Because all reclaimed water mains in the Cary municipal system are constructed to fully comply with water system testing and integrity standards as described by 15A NCAC 18C, when the minimum separation cannot be met, at least 12-inches of clearance shall be maintained, the sewer force main shall be provided in ductile iron pipe in full compliance with water main standard joints, and the void space between the pipes shall be filled with minimum 500-psi, quick setting, non-excavatable flowable fill extending at least 3-ft on both sides of the crossing. In all cases the reclaimed water main pipe shall be centered at the point of crossing with joints equally spaced from the point of crossing.

Sanitary Sewer Force Main and Stream Crossings:

The top of the sewer force main shall be at least one foot below the stream bed. Concrete encasement and ductile iron pipe shall be required when the cover between the top of the pipe and the stream bed is less than 3 feet.

Sewer force mains shall not be installed under any part of water impoundments.

The following minimum horizontal separations shall be maintained:

i. 100 feet from any private or public water supply source, including wells, WS-1 waters or Class I or Class II impounded reservoirs used as a source of drinking water (except as noted below)

ii. 50 feet from any waters (from normal high water) classified WS-II, WS-III, B, SA, ORW, HQW or SB (except as noted below)

iii. 10 feet from any other stream, lake, or impoundment (except as noted below)

iv. 25 feet from private wells (with no exceptions)

v. 50 feet from sources of public water supply (with no exceptions)

Where the required minimum separations cannot be obtained, ductile iron sewer force main pipe with joints equivalent to water main standards shall be used.

B. MATERIALS

1. Pipe Materials

a) The minimum wastewater force main size shall be 4-inches in diameter.

b) Ductile Iron Pipe shall be required for all wastewater force mains. Ductile iron pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 20-ft lengths. The minimum requirements for ductile iron pipe and required laying conditions are tabulated below. For all other installations other than specified, the laying condition, bedding requirements or the minimum pressure class rating and/or thickness class shall be increased in accordance with AWWA C151. A pipe thickness design shall be submitted for external loading in all cases where the pipe depth exceeds the specified range of depths outlined in the following table.

Pressure Class, Max. Depth and Laying Condition for DI Wastewater Force Mains

Pipe Diameter	AWWA C-150, Laying Condition	Pressure Class	Maximum Depth of Cover
4-8 -inch	type 1	350 psi	3-16 feet
4-8 -inch	type 4	350 psi	16-20 feet
10-12 -inch	type 1	350 psi	3-10 feet
10-12 -inch	type 4	350 psi	10-20 feet
14-20 -inch	type 4	350 psi	3-28 feet
24 -inch	type 4	350 psi	3-25 feet

Note: For cases not specified, a ductile iron pipe and bedding design certified by a Professional Engineer licensed in the State of North Carolina shall be required in compliance with AWWA C150 and the Ductile Iron Pipe Research Association.

All ductile iron pipe shall be marked in conformance with ASTM A-746.

c) All ductile iron wastewater force mains and fittings for sewer construction shall receive an interior ceramic epoxy coating, consisting of an amine cured novalac epoxy containing at least 20% by volume of ceramic quartz pigment, as manufactured by a manufacturer listed on Cary's Approved Products List. The interior coating shall be applied at a nominal dry film interior thickness of 40-mils. All DIP bells and spigots shall be lined with 8-mils of coating joint compound applied by brush to ensure full coverage. All pipe supplied with approved interior lining shall be provided free of holidays. Pipe installed with defects in the lining will be rejected. Patching of coating defects after installation shall not be approved. Lined pipe must be installed within one year of the application date on the pipe.

d) Pipe fittings shall be made of ductile iron designed and manufactured per AWWA C110 or C153. All fittings up to and including 24 inches in diameter shall be designed for a minimum internal pressure of 350 psi, unless otherwise approved by Cary. Fittings shall be mechanical joint or proprietary manufacturer provided restrained joint. Gaskets shall be in accordance with AWWA C111. All fittings shall be interior coated with coating listed on Cary's Approved Products List and as specified herein for ductile iron pipe.

e) Restrained Joint Ductile Iron Pipe shall be the boltless type unless otherwise approved. For installations requiring welded locking rings, the rings shall be factory welded. The restrained joints shall provide a minimum of 4-degrees of deflection for pipe sizes, 4-inches through 12-inches in diameter.

All proprietary pipe restraint systems shall be approved by Cary and provided in compliance with all standards for coatings, linings, pressure classes, etc. as required for ductile iron pipe. All restrained joint pipe shall be installed based on laying conditions, pressure class, etc. as required for typical ductile iron pipe.

2. Manhole Materials:

a) All sewer force main manholes shall be installed according to Section 7000 of Cary's Standard Specifications when design and installation criteria are not otherwise covered herein.

b) All force main discharge locations and other manholes for wastewater force mains (excluding those housing large diameter plug valves) shall be either epoxy coated at minimum 80-mils thickness or a polymer concrete manhole meeting the specifications of section 7000.

c) Force Main Manhole Epoxy Coating: Sewer force main receiver manholes, sewer force main combination air valve manholes and other concrete structures subject to high levels of hydrogen sulfide gas shall be provided with an approved monolithic epoxy coating system consisting of a 100% solids, solvent-free, two-component epoxy resin that meets the following Specifications for up to 100 mils of coating with a manufacturer approved set time of 6-hours or less.

i. Material Providers and Installers: Approved coating manufacturers and corresponding installers are identified in Cary's Approved Product List.

ii. Surface Preparation: Concrete manholes must be well cured prior to application of the protective epoxy coating. Generally, 28 days is adequate cure time for standard Portland cement. If earlier application is desired, compressive or tensile strength of the concrete can be tested to determine if acceptable cure has occurred. (Note: Bond

strength of the coating to the concrete surface is generally limited to the tensile strength of the concrete itself. An Elcometer pull test to determine suitability of concrete for coating may be required).

Surface preparation shall be based on the requirements of the manufacturer of the epoxy coating and applicable NACE International standards.

iii. Installation: A minimum 80-mils thickness shall be applied to new manholes (120-mils for existing manholes). During application a wet film thickness gage, meeting ASTM D4414 - Standard Practice for Measurement of Wet Film Thickness of Organic Coatings by Notched Gages, shall be used to ensure a monolithic coating and uniform thickness during application.

The temperature of the surface to be coated should be maintained between 40° F and 120° F during application. Prior to and during application, care should be taken to avoid exposure of direct sunlight or other intense heat source to the structure being coated. Where varying surface temperatures do exist, care should be taken to apply the coating when the temperature is falling versus rising or in the early morning. The humidity should also be observed to ensure compliance with the epoxy manufacturers' recommendations.

Manufacturer approved heated plural component spray equipment shall be used in the application of the specified protective epoxy coating. The spray equipment shall be specifically designed to accurately ratio and apply the specified protective coating materials and shall be regularly maintained and in proper working order.

If necessary, subsequent topcoating or additional coats of the protective coating should occur as soon as the basecoat becomes tack free, ideally within 12 hours but no later than the recoat window for the specified products. Additional surface preparation procedures will be required if this recoat window is exceeded.

d) Force Main Receiver Manholes: Sewer force mains shall not discharge directly into existing gravity sewer lines. Sewer force mains shall discharge into a receiver manhole that has been epoxy coated as specified herein or a Polymer Concrete Manhole as specified in section 7000. The receiver manhole shall be provided in the typical eccentric tapered design at minimum 5-ft diameter. The bench shall be sloped up to 8-inches from the invert channel to the manhole wall. The invert shall be provided with a gradual upsloping alignment from the force main entry to the gravity transition point. Sufficient grade shall be placed on the invert such that wastewater falls back into the force main when the pumps are not in operation creating a vapor lock

between the force main and the manhole. Drop connections into force main receiver manholes shall be prohibited.

e) Combination Air Valve Manholes: Manholes for combination air valve installation shall be provided in flat top configuration to accommodate the excess length of wastewater combination air valves. In cases where the combination air valve assembly shall be located in a paved area, provide typical eccentric, tapered manhole design with typical manhole frame and cover for paved areas. The minimum manhole diameter for combination air valve assemblies shall be 5-ft. Minimum 6-ft diameter manholes shall be used with force mains 20-inches and larger and when an odor control system is required. Any manholes located in NCDOT or street right-of-way shall be provided flush with finished grade.

3. Encasement Pipe

a) Encasement pipe shall be new and manufactured of grade 'B' steel with minimum yield strength of 35,000-psi in accordance with ASTM A139 and A283.

b) All casing pipe shall have machine cut, bevel ends that are perpendicular to the longitudinal axis of the casing.

c) Size and minimum wall thickness of smooth wall or spiral welded steel encasement pipe shall be as shown in the below table. Actual wall thicknesses shall be determined by the casing installer based on their evaluation of the required forces to be exerted on the casing when it is installed.

Minimum Wall Thickness of Steel Encasement Pipe

Encasement Pipe Outside Diameter *(inches)*	Minimum Wall Thickness *(inches)*
12-3/4	0.188
14	0.250
16	0.250
18	0.250
20	0.250
24	0.250
26	0.312
28	0.312
30	0.312
36	0.375
42	0.500
48	0.500
54	0.500
60	0.500
66	0.625

d) Encasement pipe installed for railroad bores shall meet the requirements of the American Railway Engineering Association (AREA) for boring under railroads.

e) Encasement pipe shall have the following minimum sizes:

Minimum Allowable Steel Encasement Diameter Per Carrier Size

Carrier Pipe Size Inside Diameter (inches)	Carrier Pipe Outside Bell Diameter Typ. (inches)	Steel Encasement Nominal Diameter (inches)
6	9.19	12-3/4
8	11.33	16
10	13.56	18
12	15.74	20
14	19.31	24
16	21.43	26
18	23.70	28
20	25.82	30
24	29.88	36
30	36.34	42
36	42.86	48
42	49.92	60
48	56.36	66

4. Casing Pipe Spacers and End Closures

a) The carrier pipe shall rest on steel pipe alignment spacers. The spacers shall have either a bituminous or epoxy coating. A minimum of 2 steel spacers per joint shall be required on carrier pipe less than 36-inches. Carrier pipe greater than or equal to 36-inches shall have a third spacer. The steel spacers shall be located evenly along the carrier pipe alignment in such a manner that each spacer supports the same unit weight of carrier main. The spacing interval of the steel spacers shall assure the necessary grade, clearance, and support of the carrier main. The spacers shall be manufactured for the specific carrier pipe and casing pipe diameters being used such that the risers do not allow the pipe to float within the casing.

b) In cases where the encasement pipe is installed near facilities with stray current, such as gas lines, high voltage power transmission lines, petroleum lines, railroad tracks, etc., the steel spacers shall be provided with composite contacts on the runners such as an EPDM rubber liner or an ultra-high molecular weight polyethylene plastic skid to prevent transmitting the stray current to the carrier pipe.

c) The carrier pipe bells shall not be allowed to contact the interior of the encasement pipe under any circumstances.

d) No blocks or temporary spacers shall be wedged between the carrier pipe and the top of the encasement pipe.

e) The ends of the encasement pipe shall be sealed using 8-inch bricks and a non-shrink grout.

f) A 2-inch galvanized vent pipe shall be provided on the upper end of the casing on all stream and railroad crossings.

C. INSTALLATION

1. Excavation and Preparation

a) Ductile iron pipe shall be installed in accordance with the requirements of AWWA C600 and the Ductile Iron Pipe Handbook published by the Ductile Iron Pipe Research Association. Materials at all times shall be handled with mechanical equipment or in such a manner to protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

b) Pipe and fitting interiors shall be protected from foreign matter and shall be inspected for damage and defects prior to installation. In the event foreign

matter is present in pipe and fittings, it shall be removed before installation. Open ends of pipe shall be plugged or capped when pipe laying is not in progress.

c) All pipe shall be constructed with at least 48 inches of cover below the finished surface grade. Pipe shall be laid on true lines as directed by the Engineer. The wastewater force main shall be installed at a grade which will allow air to migrate to a high point where the air can be released through an air valve. A minimum pipe slope of 1 foot in 500 feet should be maintained and there shall be no intermediate high points in the line.

d) Trenches shall be sufficiently wide to adjust the alignment. Bell holes shall be dug at each joint to permit proper joint assembly. The pipe shall be laid and adjusted so that the alignment with the next succeeding joint will be centered in the joint and the entire pipeline will be in continuous alignment both horizontally and vertically. Pipe joints shall be fitted so that a thoroughly watertight joint will result. All joints will be made in conformance with the manufacturer's recommendations for the type of joint selected. All transition joints between different types of pipe shall be made with transition couplings approved on shop drawings showing the complete assembly to scale.

e) Trenching for pipelines (water, sewer, pressure, natural gas and liquid petroleum), communication and power lines and drainage and irrigation pipes shall be excavated to the required depth to permit the installation of the pipe (inclusive of pipes, wires, cables, ducts, and conduit) along the lines and grades shown on the construction drawings.

f) Prior to trenching for the construction of any utility mains or connections, the Contractor shall locate all existing utilities within the construction zone. This may include at a minimum contacting the North Carolina One Call Center at 811 or 1-800-632-4949. Where critical Cary water and sewer utilities cannot be located by traditional means, specialized utility locating, such as vacuum excavation or ground penetrating radar (GPR) may be required to locate existing utilities before excavating.

g) In all cases where trenchless methods are planned to cross an existing utility corridor with water, sewer, force main, reclaimed water and/or other Cary maintained pipelines, an SUE (subsurface utility exploration) services firm shall be contracted to verify the depths of existing utilities prior to boring. Where SUE involves survey work, the survey shall be in accordance with the requirements of Section 10050 of these Standard Specifications.

h) The Contractor shall be responsible for implementing all required safety provisions for trenching in compliance with the Occupational Safety and Health Administration (OSHA) regulations and all other applicable safety requirements and procedures.

i) Trench Dimensions

i. The minimum trench width at the top of the pipe shall be at least 24-inches greater than the outside diameter of the pipe. Rock shall be removed to a depth of at least 6-inches below the bottom of the pipe and the trench backfilled with suitable material.

ii. Open trenches shall not exceed 100-feet.

iii. All trenches shall be confined to the limits of the right-of-way or utility easement. Trenches in paved areas shall not be sloped.

iv. All trenches in or along roadways shall be properly backfilled at the end of each working day.

j) Trench Protection

i. Wet trenches shall be stabilized with a base layer of #78 M or #57 stone. The bottom of the trench shall be shaped to provide uniform support along the entire length of the pipeline. Severely unstable trench bottoms requiring undercut excavation shall receive a foundation support system for the pipeline designed by a registered Geotechnical Engineer licensed in the State of NC.

ii. A space shall be excavated at each bell to provide ample space to join the pipes with no misalignment.

iii. The Contractor shall take all necessary measures to prevent water from entering the trench.

2. <u>Pipe laying and backfilling</u>

a) Open ends of pipe shall be plugged when pipe laying is not in progress to prevent trench water, soil, and debris from entering.

b) All pipe shall be laid in accordance with the manufacturer's recommendations and all applicable Cary Standards, Specifications and Details.

c) Pipe laying shall be accomplished in a manner and with the required resources to provide a properly aligned and sealed pipeline and joints.

d) Pipe deflection limits shall not be exceeded in accordance with manufacturer requirements.

e) All gravity mains shall be installed beginning with the downhill section at the lowest elevation, and advanced upgrade to the terminus of the main. All bell ends shall be oriented facing the uphill direction.

f) Backfill material shall be free from construction material, frozen material, organic material, or unstable material. Backfill with a high clay content or high shrink-swell potential that cannot meet compaction requirements shall be deemed unsuitable and replaced as directed by a professionally licensed Geotechnical engineer.

g) Backfill materials that have been allowed to become saturated or with moisture contents non-conducive to meeting compaction requirements shall be deemed unsuitable and replaced.

h) When original excavated materials have been deemed unsuitable, granular material must be imported to the site to backfill utility trenches and meet compaction requirements. The following materials shall be acceptable forms of granular backfill: aggregate base course, soil type base course, select backfill material, sand or screenings in accordance with NCDOT Specifications.

i) In all open utility trenches, backfill shall be compacted to 95% maximum dry density as measured by AASHTO method T99. The Contractor shall be responsible for verifying that compaction requirements have been met or exceeded by providing soils testing data from an approved Geotechnical Firm. The soil test results shall be certified by a licensed Geotechnical Engineer.

j) Backfill for utility trenches shall be placed in 8-inch lifts or less of uncompacted soil and compacted with a mechanical tamp before placing additional layers.

3. Pavement repairs

a) All pavement cuts shall be repaired within a maximum of three (3) days from the date the cut is made. If conditions do not permit a permanent repair within the given time limit, permission to make a temporary repair must be obtained from the Infrastructure Field Technician.

b) Pavement repairs shall be made in accordance with Cary Standard Details.

c) All asphalt pavement utilized to repair open trenches shall comply with all applicable Cary asphalt pavement material and installation Specifications.

d) All pavement patches shall be provided in such a manner that a uniform and smooth driving surface free of depressions and/or bumps is obtained. Pavement patches not meeting this standard shall be milled and replaced.

4. Trenchless pipe installation

a) The preferred trenchless method shall be auger boring. Alternate trenchless methods including microtunneling, guided boring, conventional tunneling, horizontal directional drilling or hand tunneling may be approved after thorough evaluation by the Utilities Department.

b) In addition to meeting or exceeding all Cary requirements, all trenchless crossings shall be approved by and meet the requirements of all controlling legal authorities, such as NCDOT, Norfolk Southern Railway and CSX Corporation.

c) Direct bores may be made without a casing pipe on pipelines 6-inches in diameter and smaller.

d) Encasement pipe shall be installed with all trenchless construction methods (excluding horizontal directional drilling when it is approved and as noted above). There shall be a minimum cover of 4-ft between the pavement subgrade and the top of the casing pipe. Under no circumstances shall the pavement subgrade be disturbed.

e) Permanent easements (UPE) shall be provided at all trenchless pits to allow for future access to casing pipes.

f) All carrier pipe shall be manufacturer provided restrained joint ductile iron pipe except for reclaimed water mains in which restrained PVC C900 or C905 pipe in compliance with Section 6500 is utilized.

g) As the trenchless operation progresses, each new section of encasement pipe shall be joined using full penetration seal welds prior to installation of the casing. Joints shall be electric-fusion welded by operators qualified in accordance with the American Welding Society's standard procedure for arc welds. The welds shall be capable of transmitting all thrust and other loads across the joints.

h) If voids are encountered while installing encasement pipe thirty (30) inches and larger, 2-inch or larger grout holes shall be installed at ten (10) foot centers in the top section of the encasement pipe. The grout holes shall be used to fill the void spaces with 1:3 Portland cement grout at sufficient pressure to prevent settlement of the roadway, unless NCDOT approval stipulates otherwise. Other grout mixtures may be submitted for approval.

i) In the event that an obstruction is encountered during the trenchless operations, the equipment shall be withdrawn. The pipe shall be cut off, capped, and filled with 1:3 Portland cement grout at a sufficient pressure to fill all voids before moving to another boring site.

j) Restrained joint ductile iron carrier pipe shall be pulled into the casing pipe.

k) For all trenchless operations of 100-ft or more, the ground surface elevations shall be recorded prior to beginning work.
    i. At a minimum, survey points shall be identified with a nail or hub located as follows:
        - Road crossings: Centerline and each shoulder/curb
        - Utility and Pipeline Crossings: Directly above and 10-ft each side of the crossing
        - All locations: Points shall not exceed 50-ft spacing.
    ii. Elevations at each point shall be recorded with an accuracy of 0.01-feet.

l) Settlement observations shall be made each day until the pipe/casing is fully installed.

m) Readings shall be reported to the Infrastructure Field Technician.

n) In the case of observed settlement, the monitoring points and observation frequency shall be increased as determined by Cary.

5. <u>External corrosion protection</u>

a) External corrosion can occur at an accelerated rate in metallic pipelines such as steel and ductile iron when they are installed in aggressive soils or when they are installed near other structures or utilities that carry impressed currents. Such facilities that typically utilize impressed current cathodic protection are gas pipelines, such as owned by Colonial Pipeline, Cardinal Pipeline and Dixie Pipeline. Other potential sources that may create stray currents that contribute to accelerated pipeline corrosion are high voltage power transmission lines and railroad crossings.

b) In cases where metallic steel and ductile iron pipelines or encasement pipes are planned for installation in close proximity to any potential sources of stray current or aggressive soils, zinc coated pipe shall be specified and a field analysis consisting of stray current evaluation and soil testing shall be conducted by an experienced technician, as certified by the National Association of Corrosion Engineers, (NACE), to determine the potential for external corrosion and the need for additional protection measures. In cases where stray current conditions and/or aggressive soils are prevalent, a

corrosion specialist certified by the NACE or other applicable certification board shall be consulted regarding the design of pipeline protection measures.

c) At a minimum, all stray current protection systems should include bonded joints and sacrificial anodes with a 50-year or longer design life and test facilities in lieu of polyethylene encasement, unless otherwise approved by Cary. The cathodic protection element of the pipeline design package shall be sealed by Professional Engineer licensed in the State of NC.

d) Full impressed current cathodic protection shall only be utilized when extreme corrosion potential has been proven and/or as otherwise directed by the Utilities Department and the certified corrosion engineer of record.

6. Embedment Material

Bedding and embedment material classifications shall be defined as follows:

- CLASS I - Angular, (1/4 to 1-1/2 inch) graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, crushed gravel, and crushed shells.

- CLASS II - Coarse sands and gravels with maximum particle size of 1-1/2 inch, including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW and SP are included in this class.

- CLASS III - Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures, Soil Types GM, GC, SM, and SC are included in this class.

- CLASS IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types MH, ML, CH and CL are included in this class. These materials shall not be used for embedment.

Class I foundation material consisting of ¼-inch to 1½ -inch graded stone shall be required in addition to standard bedding and embedment for all sewer installations, regardless of pipe material, when the trench bottom is unstable due to water, rock, infiltration or soil type.

All bedding, embedment and backfill materials shall be compacted to a minimum of 95% Standard Proctor density regardless of material. In instances where compliance with compaction requirements is questionable as determined by the Infrastructure Field Technician, testing shall be provided by the Contractor and a reputable licensed Geotechnical Engineer to verify compliance.

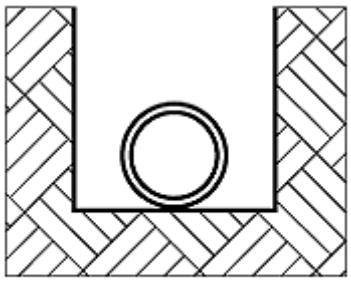
In any area where the pipe will be installed below existing or future ground water levels or where the trench could be subject to inundation, additional Class I material shall be used for bedding.

If hydraulic jack shoring is utilized for trench walls, it shall be restricted to the area just above the top of the pipe. This will ensure the embedment materials and pipe will not be disturbed when the shoring is removed.

7. Laying Conditions

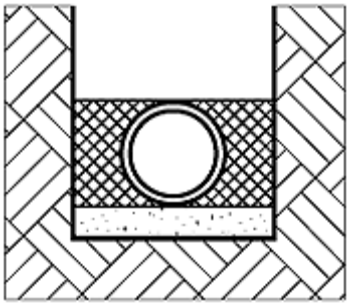
Pipe shall be installed at laying conditions as specified by the plans. Laying conditions for ductile iron pipe shall be as described in AWWA C151 and the Ductile Iron Pipe Research Association. Laying conditions shall be defined as follows:

Type 1: Flat Bottom Trench with Pipe Resting on Stable Undisturbed Earth. Unstable conditions such as wet trench bottoms, intermediate rock layering, partially weathered rock, and other unsuitable soil conditions shall require utilizing more stringent laying conditions. At a minimum, Type 4 laying condition shall be utilized with a minimum of 4-inches of bedding to overcome unstable conditions. For severe unstable soil conditions, undercut excavation and an engineer designed foundation plan shall be provided prior to pipeline installation.



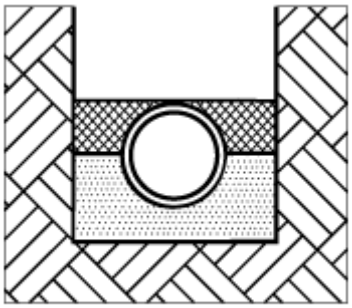
Type 1*

Type 4: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to a depth of 1/8 pipe diameter or a minimum of 4-inches. Embedment material, consisting of Class 1, Class 2 or Class 3 materials, shall be compacted greater than 95% Proctor to the top of the pipe. Careful attention must be allocated to compacting embedment material under the bottom edges of the pipe.



Type 4

Type 5: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone to the center of the pipe and extending a minimum of 4-inches under the pipe. Granular or select embedment, consisting of Class 1 or Class 2 materials, compacted to greater than 95% Proctor installed to the top of the pipe.



Type 5

8. Installation Below the Water Table

   For installations below the water table, a single layer of engineering fabric shall be installed between the pipe and trench floor/trench wall. The fabric shall fully encapsulate the force main, bedding, and embedment material with a minimum of 12-inch overlap at the top of the embedment material.

9. Utility Coordination

   Prior to beginning construction, the Contractor shall contact local utility companies and verify the location of existing utilities. The Contractor shall be completely and solely responsible for locating all existing buried utilities inside the construction zone before beginning excavation. The Contractor shall be solely responsible for scheduling and coordinating the utility location work. When an existing utility is in conflict with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

D. PIPE IDENTIFICATION AND MARKING

1. Marking Tape
   a) Installation: Marking tape shall be installed continuously and longitudinally along all sewer force mains for new construction and for any repair or retrofit construction using open trench methods. Marking tape shall be installed directly above the center of the pipe and at least 24-inches deep from final grade to a maximum depth of 36-inches below final grade.

      Any sections where tape cannot be accurately placed at time of backfilling sufficient survey data shall be collected to reestablish location for tape installation.

   b) Specifications: The sewer force main marking tape shall be an approved product identified in Cary's Approved Products List. The marking tape shall be made of polyethylene (or approved equivalent) material, 6-inches wide and a minimum of 6 millimeters thick. The marking tape shall have detectable markers embedded in the tape and spaced adequately to provide continuous detection along the tape from above the buried pipe at final grade. The tape shall be green in color and shall be marked with words that read "CAUTION SEWER LINE BURIED BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

2. Marker Balls
   a) Installation: Non-programmable marker balls are required at the ends of all casing pipe, fittings and reducers. Marker balls shall be used in addition to marking tape within thoroughfares and within 100-ft of a signalized intersection. Through signalized intersections, marker balls shall be spaced at 25-ft intervals. They shall also be installed along and directly above all force mains in conditions where marking tape cannot be installed due to restrictions or conflicts. In these conditions, non-programmable marker balls shall be placed at all vertical and horizontal deflection points, at all tees and crosses and at a spacing along the main no greater than 100 feet apart. Each marker ball shall be installed directly above the center of the pipe and at least 24-inches deep from final grade to a maximum depth of 36-inches below final grade. A table of marker ball locations, with description, must be submitted as part of the record drawing.

   b) Specifications: The Marker Ball is a non-programmable ball and shall be an approved product identified in Cary's Approved Products List. The marker ball shall be green in color for wastewater and conform to APWA standards. It shall have a minimum detectable depth of 5 feet.

E. VALVES AND APPURTENANCES

1. General: The rated working pressure of all valves and appurtenances shall meet the maximum design pressure of the pump station and pipeline.

2. Check Valve: Check valves shall be iron bodied, fully bronze mounted with bronze clapper disc and bronze seat ring and shall have a spring-loaded lever arm capable of being mounted on either side of the valve.

3. Plug Valve: Plug valves shall be non-lubricating, eccentric action and resilient plug facing with heavy duty Type 316 stainless steel bearings. Plug valves shall be designed for a minimum working pressure of 175 psi for valves 12" and smaller, 150 psi for valves 14" and larger. Valves shall be bi-directional and meet the pressure rating in both directions of flow. The plug valve body shall be cast iron ASTM A126 Class B with welded-in overlay of 90% nickel alloy content on all surfaces contacting the face of the plug. Sprayed, plated, nickel welded rings or seats screwed into the body are not acceptable.

   All plug valves 12" and smaller shall have round port design that provides a minimum 80% port area. The valve plug shall be ductile iron ASTM A536 Grade 65-45-12 up to 20-inches in diameter, with EPDM, Buna N, or Neoprene resilient seating surface to mate with the body seat. Valves 24-inches and larger may have plugs made of cast iron in accordance with ASTM A126 class B. Large plug valves with rectangular plugs shall provide clean passage for a solid sphere of at least 67% of the adjoining pipe diameter to facilitate pigging of the force main. Force main plug valves with rectangular port shall be "full-port" cross-sectional area perpendicular to the flow of at least 100% of the adjoining pipe.

   All buried plug valves shall be provided with worm gear actuators. All plug valves shall be buried and provided with a 2-inch operator nut and valve box as shown in Cary Standard Details. Plug valves greater than 12-inches shall be installed such that the actuator and gearing is accessible in a manhole as shown in the Cary Standard Details. All plug valves shall be provided with typical mechanical joint end connections and restrained with wedge action retainer glands on both ends of the valve assembly as described herein.

   Valves shall be installed according to the manufacturer's recommendations. Typically for wastewater this means installing the seat side toward the pump station so that the flow is against the face of the plug in the closed position. In the open position, the plug should rotate up to the top of the pipeline which may require installing the valve on its side.

4. Rubber Seated Ball Valve: For larger diameter force mains where plug valves are not available, rubber seated ball valves shall be of the tight-closing, shaft-mounted type that fully comply with AWWA Standard C507 to provide a full port unobstructed waterway with no additional pressure drop. Design pressure ratings

shall be 150 psi or greater and provide tight shutoff against flow. With the valve in the closed position, the rubber seated valve shall be bubble tight at rated pressure. All ball valves shall be provided in an epoxy coated manhole or Polymer Concrete Manhole with worm gear actuators and a handwheel.

5. Valve Box Covers: Force main plug valves or ball valves shall have valve box covers and/or manhole lids with the word "Sewer" cast into them.

6. Combination Air Valves shall be provided to purge air from the system at startup, vent small pockets of air while the system is being pressurized and running and prevent critical vacuum conditions during draining. Combination air valves approved for use in wastewater force main installations shall be installed at all high points of wastewater force mains 6 inches in diameter or larger and at other locations, such as major changes in slope, as directed by Cary. A high point shall be determined as any high location where the difference between the high elevation and adjacent low elevation exceeds 10-ft unless otherwise determined by the Director of Utilities based on special circumstances. The combination air valve shall automatically exhaust large volumes of air from the system when it is being filled and allow air to re-enter the pipe when the system is being drained. The wastewater force main shall be installed at a continuous grade between low and high points without intermediate high points unless an air release valve is being installed. A minimum pipe slope of 1 foot in 500 feet should be maintained. Combination air valves shall be sized by the Engineer and approved by Cary.

   a) Combination air valves shall be of the single housing style with Type 304 or 316 stainless steel body that combines the operation of both an air/vacuum and air release valve. The valve must meet the requirements of AWWA C512 and be installed in accordance with Cary Standard Details. The valve shall have a minimum 145-psi working pressure unless the pipeline design requires a higher-pressure rating.

   b) The valve shall have a minimum 2-inch male NPT inlet for a 2-inch valve assembly. Combination air valves sized from 3-inches to 8-inches shall be provided with studded inlet connectors or flanged connections. The combination air valve shall be provided with cylindrical shaped floats and anti-shock orifice made of high-density polyethylene. Combination air valves with spherical floats shall not be accepted. All combination air valves shall be installed in accordance with Cary Standard Details.

   c) Installation of Combination Air Valve Assembly:

      i. The Engineer of Record shall provide ample depth of installation to accommodate the extended height of combination air valves for wastewater force mains. All combination air valves shall be connected to the main by an MJ x FLG tee with the branch diameter equal to at least half of the main diameter.

ii. The 2-inch combination air valve shall be provided with male NPT threads and isolated with a 2-inch gate valve. The isolation valve shall be provided with NPT threads and connected with brass or bronze piping.

iii. Combination air valves 3-inches and greater shall be connected by flange or studs. If needed due to a larger diameter tee, a flanged reducer shall be provided between the tee and the isolation valve. Gate valves shall be used for 3-inch assemblies. Combination air valves 4-inches and larger shall be isolated with a plug valve. In all cases the isolation valve shall be sized equal to the combination air valve.

7. Pigging Station: Force mains shall be constructed with a pigging/emergency connection located within 50-ft of the pump station valve vault. This pigging leg shall consist entirely of approved epoxy coated ductile iron pipe of the same diameter as the main. A restrained MJ wye shall be provided in the main line and valved on each branch. The pigging leg shall extend out of the ground and be closed with a bauer type connection. The protruding pipe shall be protected by concrete bollards spaced 6-ft apart.

8. Emergency Connection Assembly: On some wastewater force mains, an additional emergency connection assembly may be required. The size, criticality and proximity to a downstream manhole will be important factors in the need for this connection. The emergency connection assembly shall include either a ball valve or plug valve assembly for isolation from the primary wastewater force main. Additionally, the primary force main shall be provided with a main line plug valve or ball valve on the upstream side of the emergency connection assembly to prevent bypass flow from draining back to the pump station. The emergency connection assembly shall be brought to the final graded surface with a visible blind flange assembly for connection by an outside pumping contractor.

9. Force Main Odor Control Systems: Force main odor control shall be included in the design plans for any proposed force main at discharge locations, intermediate air release locations and otherwise as directed by Cary's Utilities Department. In limited cases, air release valves located in isolated areas may be approved without odor control systems. The suggested odor control technology shall be designed by the Engineer of Record to achieve 95% or greater hydrogen sulfide removal. All systems, including those utilizing activated carbon, shall be manufactured specifically for addressing hydrogen sulfide gas. Forced air systems should be avoided due to the need to include provisions for electrical power to the odor control system. For all odor control systems, the Engineer of Record shall provide sufficient easement area for long term maintenance of the system.

7230 INSPECTIONS, TESTING, AND TRAINING

A. INSPECTIONS

1. All materials and equipment used in the construction of the wastewater pumping system must be verified for compliance with the Specifications (or other approval granted by Cary) by the Inspector prior to installation. Non-conforming materials or equipment shall be immediately removed from the job site.

2. Compliance with plans and Specifications shall be verified on a regular basis by the Inspector.

B. TESTING

1. General

   a) The Contractor shall furnish all materials, labor, and equipment to perform all testing. Water for testing purposes may be obtained from Cary. The Contractor shall reimburse Cary for all water used at Inside Utility Rates.

   b) All water or wastewater used during testing of the pump station, force main, or any of the systems described in this section, must be returned to Cary's sanitary sewer system after proper coordination with Cary's Departments of Public Works and Utilities.

   c) All on-site testing and/or installation verification shall be performed in the presence of the Inspector or other representative authorized by Cary.

2. Force main Testing

   a) The force main shall be completely filled with water, all air shall be expelled from the pipe, and the discharge end of the pipeline shall be plugged and adequately blocked before the hydrostatic test begins.

   b) The force main shall be tested to a pressure of 150 psi or three times the rated Total Dynamic Head of the pumps in psi, whichever is larger, as measured at the lowest elevation of the pipeline, for a duration of 2 hours. The pressure gauge used in the hydrostatic test shall be calibrated in increments of 5 psi or less. At the end of the test period, the leakage shall be measured with an accurate water meter.

   c) All leaks shall be located and repaired regardless of the amount of leakage. If the force main does not pass the leakage test requirements, the cause of the failure shall be identified and repaired. Testing shall be repeated until the force main passes.

$$\text{Allowable Leakage, } L = \frac{S \times D \times \sqrt{(P)}}{133{,}200}$$

Where: L = leakage (gph)
S = length of pipe (feet)
D = nominal diameter of pipe segment tested (inches)
P = test pressure (pounds per square inch)

d) All forcemain piping, including pigging station and emergency bypass connections shall be pigged prior to substantial completion with a foam pig matching diameter of the pipe.

3. Marker Ball and Marker Tape Testing

Testing of the marker balls and marker tape shall be performed by the Contractor at the completion of the project to assure they are all working properly. It is the Contractor's responsibility to provide the necessary equipment to test the markers. Any defective, missing, or otherwise non-locatable units shall be replaced at the contractor's expense.

END OF SECTION 7200