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701 Gravity Sewer

A. Design

1. Main Location

- a) All public sanitary sewer mains shall be installed in dedicated street right of way or in dedicated utility easements. Mains within easements shall be centered within the easement. Mains located along NCDOT roads shall be placed outside of NCDOT right of way.
- b) In preparing engineering design plans, all elevations shall be tied to NC grid system and the benchmark shall be described on the plans. A field survey of all waterways and waterbodies within project area must be performed, including but not limited to: creeks, streams, rivers, lakes, ponds, ditches, and culverts. Survey must include adequate points to accurately represent the cross section of the waterway/waterbody, i.e. top of bank, toe, centerline, etc.
- c) Construction Drawings shall be prepared by or under the direct supervision of a professional engineer, licensed in North Carolina. Design shall conform to all standards and guidelines established by the Town and NCDEQ. Any design that does not meet minimum requirements set forth by NCDEQ and 15A NCAC 02T rules shall require a variance approval from NCDEQ. Plans shall indicate deflection angles at all manholes.
- d) All private sewer collection mains inside the Town service area that will connect or are planning to discharge into the Apex sewer system shall comply with all Town of Apex design, siting and installation criteria outlined herein. The Owner of the private sewer collection system shall meet all State design requirements and obtain a State permit to operate the private system.
- e) Gravity mains shall be installed in dedicated public right of way (not alleys or roundabouts) or in dedicated utility easements as follows:

<u>Pipe Depth*</u>	<u>Permanent Easement Width</u>	<u>Town Road R/W</u>
8-ft or less	20-ft	Allowed
8-ft – 15-ft	30ft	As Specified by the WR Department
15-ft – 20-ft	40-ft	Not Allowed
Deeper than 20 ft	As Specified by the WR Department	Not Allowed

*Depth of the sewer main shall be measured from the top of the pipe to the final grade or road subgrade at the deepest point between manholes.

Dedicated easements for sewer mains and appurtenances shall be recorded as “Town of Apex Public Sanitary Sewer Easement”. Town of Apex sewer easements shall contain only Town of Apex utilities unless otherwise approved by the site plan or an encroachment agreement. Sewer mains shall be centered in the easement. Easements shall be acquired by the Developer (unless utility is designed as part of a Capital Improvement Project) prior to construction approval.

Easements must be clearly labeled as “public” or “private”.

If the sewer main is located within the road right-of-way, a clear width equal to or greater than the easement width required must be available. If adequate width is not available within the right-of-way, additional easement outside of the right-of-way must be maintained. For example, if a sewer main normally requiring a 20 foot easement is installed 5 feet inside of the right-of-way, an additional 5 feet of easement must be obtained outside of the right-of-way to provide a clear total width of 10 feet on each side of the pipe.

- f) The minimum width of a permanent easement that contains sanitary sewer and storm sewer shall be 30 feet. There must be a separation of 10 feet between the outside of each pipe and 10 feet from the centerline of the pipe to the easement line.
- g) The minimum width of a permanent easement that contains sanitary sewer and greenway shall be 15 feet in addition to the width required in the table above. There must be a separation of 10 feet between the sewer main and the edge of pavement and at least 10 feet from the centerline of the pipe to the easement line.
- h) No structures, equipment, retaining walls, embankments, impoundments, pavement, landscaping, fill, or other elements that would inhibit maintenance operations shall be constructed within a sewer main easement as outlined in Section 200. Fences may be allowed across easements provided that appropriate access gates or removable panels have been installed to allow utility maintenance. Fences shall not be installed parallel within utility easements. In all cases, Town of Apex Operations Staff shall have access to secured access gates. Fill or cut slopes are not allowed to extend into easements without full development plan approval or an approved encroachment agreement from the Town of Apex, see Section 200 for further information. All such pre-existing or planned conditions as noted herein that would impact operations and maintenance within the noted sewer main easement shall be noted and disclosed during the site plan approval process. Pre-existing conditions that are not disclosed during

the site plan review may nullify the approval and require relocating the sewer easement where there are no existing conflicts.

- i) Where public sanitary sewer mains are installed within easements crossing private property, the Town's Water Resources Department shall have the right to enter upon the easement for purposes of inspecting, repairing, or replacing the sewer main and appurtenances. Where paved private streets, driveways, parking lots, etc. have been installed over public sewer mains, the Town of Apex shall not be responsible for the repair or replacement of pavement, curbing, landscaping, etc. which must be removed to facilitate repairs. The Water Resources Department shall excavate as necessary to make the repair, and shall backfill the disturbed area to approximately the original grade. Replacement of privately owned pavement, curbing, walkways, etc. shall be the responsibility of the property owner and/or Homeowner's Association.
- j) Easements shall be accessible from public rights-of-ways. If easement is not accessible perpendicular from right-of-way due to steep slope, environmental feature, or other obstacle, additional easement may be necessary.
- k) Sewer line easements shall be graded smooth, free from rocks, boulders, roots, stumps, and other debris, and seeded and mulched upon the completion of construction. Easements across sloped areas shall be graded uniformly across the slope to no steeper than a 4 to 1 ratio.
- l) Mains paralleling a creek shall be of sufficient depth to allow lateral connections below the stream bed elevation. The top of the sewer main and laterals shall be at least three feet 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.
- m) Mains shall not be installed under any part of water impoundments or area to be impounded. Sewer mains shall not be installed through, above, or below any retained earth structure. Sewer main location and depth shall not be within the theoretical 1:1 slope of any impoundment dam or structure, or shall maintain a minimum of 10' horizontal separation from the toe of slope, whichever is greater. The entire easement shall be outside of the toe of slope, unless prior approval is obtained from the Water Resources Director.
- n) Sewer profile shall follow natural topography and road grade. Sewer designed against natural grade or road grade shall only be allowed if

approved by the Water Resources Director and no practical alternative is available.

- o) The following minimum horizontal separations shall be maintained:
1. 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)
 2. 50 feet from wetlands and any waters (from normal high water) classified WS-II, WS-III, B, SA, ORW, HQW or SB (except as noted below)
 3. 20 feet from any other stream, lake, or impoundment (except as noted below)
 4. With approval directly from PERCS, the following separations may be acceptable when water main standards are implemented:
 - a. All appurtenances shall be outside the 100 foot radius of wells.
 - b. 50 feet from private wells (with no exceptions)
 - c. 50 feet from public water wells (with no exceptions)
 - d. Where the required minimum separations cannot be obtained, ductile iron pipe shall be used with joints equivalent to water main standards.
- p) Sewer mains shall always be extended along any and all natural drainage courses/draws that are located within the property line boundaries of the proposed development. This sewer shall be extended to all adjacent upstream property lines.
- 1) Sewer design shall account for future upstream development based on the current land use plan.
 - 2) Project shall include evaluation of existing downstream sewer capacity. This evaluation shall address the capacity of all sewer collection and truck sewer systems that will be impacted downstream of the new development and/or redevelopment. If any downstream sewer segments exceed 50 percent full, but are less than 65% full, the Town will evaluate and determine if upsizing is required. If any downstream sewer segments exceed 65 percent full, the

sewer main must be upsized or re-installed at a greater slope to allow for greater flow through the pipe. All improvements must be made the full length, from manhole to manhole.

- 3) The most upstream manhole shall be designed and located so that all upstream properties will have access to connect with future sewer mains. Depths shall be evaluated so that streams, roads, culverts, and any other features that must be crossed by future upstream sewer mains can do so and still achieve the required minimum cover on top of the sewer main.
- q) Gravity sewer mains shall be deep enough to serve the adjoining properties and allow for sufficient slope in lateral lines. Gravity sewer pipe shall have the following minimum covers:
 - 1) 3 feet from the top of pipe to finished subgrade in roadways.
 - 2) 3 feet from the top of pipe to finished grade outside roadways.
 - r) Sewer mains that do not meet minimum cover stated above or the table in section A.1.e) are required to be ductile iron for the entire run between manholes. Steel casing and/or concrete may also be required for protection, at the direction of the Water Resources Director.
 - s) In all cases where fill material is added above existing sewer mains, the Engineer of Record shall prepare a structural analysis of the existing pipeline and determine if it is capable of supporting additional loading. If the additional fill material exceeds AWWA, DIPRA, UNIBELL and/or manufacturer standards for loading, the pipeline shall either be reinforced to adequately support the additional loading or replaced with a ductile iron pipe rated to support the added loading.
 - t) Separation Between Sanitary Sewer and Storm Water Pipes:

Sewer mains shall have a minimum vertical separation of 24 inches between storm pipes when the horizontal separation is 3 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 quick setting, minimum 500-psi, non-excavatable flowable fill that meets or exceeds NCDOT Specifications.
 - u) Separation Between Sanitary Sewer and Sewer Force Main:

There shall be a minimum 7 foot horizontal separation between parallel gravity and force mains when the depth of installation is 8-ft

or less. Otherwise, the minimum horizontal separation between pipelines shall be 10-ft up to 10-ft depth of installation.

v) Separation Between Sanitary Sewer and Water Main

- 1) Parallel Installations: 10-ft lateral separation (pipe edge to pipe edge) or minimum 5-ft lateral separation, and water line at least 18-inches above sanitary sewer line measured vertically from top of sewer pipeline to bottom edge of water main.

Crossings (Water Main Over Sewer): All water main crossings of sewer lines shall be constructed over the sewer line in conformance with Town of Apex 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 main. If 18-inches of clearance is not maintained, the water main and sanitary sewer main shall:

- a. Both lines shall be constructed of ductile iron pipe with joints in conformance with water main construction standards.
 - b. The sanitary sewer pipe shall be ductile iron the entire run from manhole to manhole.
 - c. The void space between the pipes shall be filled with minimum 500-psi, quick setting 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 sanitary sewer crossings of potable water mains.
- 2) Crossings (Water Main Under Sewer Line): Allowed only as approved by Town of Apex, when it is not possible to cross the water main above the sewer line. At a minimum, 18-inches of separation shall be maintained, (measured from pipe edge to pipe edge) and the sanitary sewer shall be constructed of ductile iron in conformance with water main construction standards the entire run from manhole to manhole. 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, non-excavatable flowable fill extending at least 3-ft on both sides of the crossing.

- w) Where concentrated sources of runoff (e.g., SCM discharge, FES discharge outlets, natural drainage ways, etc.) convey across existing or proposed Town of Apex Sanitary Sewer Easements, the applicant must design a rip rap lined channel across the full width of the easement.

2. Main Size, Slope and Design Criteria

- a) Public gravity mains shall be a minimum of 8 inches in diameter.
- b) Major interceptors shall be sized in accordance with the "Town of Apex Sewer Master Plan". In areas not included in the master plan, interceptors shall be designed based on the proposed land use (according to the Town's Comprehensive Growth Plan), using the following flow factors. At a minimum, all gravity sewer mains shall be designed and sized to serve the ultimate tributary buildout of the drainage basin.

Residential flow rates:

Land Use	Flow Factor
Single Family Residential	300 gpd per dwelling unit
Multi-Family Residential	250 gpd per dwelling unit

Non-residential flow rates:

Use flow factors as required by the North Carolina Department of Environmental Quality (at the time of this Specification revision, these flow rates are contained in 15A NCAC 02T .0114).

For all other flow rates not listed in Section ii above, use:

Land Use	Flow Factor
Office and Institutional	0.09 gpd/sq.ft bldg. space
Commercial	0.12 gpd/sq.ft bldg. space
Industrial	0.20 gpd/sq.ft bldg. space

- c) The ratio of peak to average daily flow shall be 2.5.
- d) Sanitary sewers shall be designed to carry the projected average daily flow at no more than 1/2 full. The minimum velocity for sanitary sewer lines shall be 2.5-fps.
- e) Sanitary sewers shall be sized based on the Manning's Equation with Manning's roughness coefficient "n" = 0.013 or greater. Pipe diameter sizes used in the calculation of Manning's Equation shall be nominal pipe sizes.

- f) The minimum grades for public sanitary sewers shall be as follows:
Minimum Slopes for Gravity Sewer Mains

Main Size (diameter in inches)	Minimum Slope V=2.5ft/s, depth 1/2 full (feet per 100 feet) {standard required velocity}
8	0.52
10	0.39
12	0.30
14	0.25
15	0.23
16	0.21
18	0.18
21	0.15
24	0.12
27	0.11
30	0.09
36	0.07
42	0.06
48	0.05

Note1: All minimum slopes based on Manning's Equation

Note2: Manning's coefficient n = 0.013 used for all computations

- g) The minimum grade for the uppermost reach of a sanitary sewer line shall be 1% regardless of sewer line size.
- h) The maximum grade for sanitary sewers is 10%. The maximum velocity in sanitary sewers is 15 ft/sec. These limits may only be exceeded with the approval of the Director of Water Resources and the incorporation of the following provisions, which apply to all sewers either designed or installed at grades equal to or exceeding 10%:
- 1) All sewers with a grade of 10% or higher must have the downstream run of pipe installed with ductile iron pipe.
 - 2) High velocity manholes shall be used on all sewers with a grade of 10% or higher. High velocity lines cannot tie directly to an existing line and must proceed 180° through the invert into the downstream line.
 - 3) Concrete thrust collars shall be installed on all sewers designed at grades of 10% or higher. The anchors shall be installed at the following spacing:
 - a. Not over 36' center to center on grades from 10% to 25%
 - b. Not over 24' center to center on grades from 25% to 40%
 - c. Not over 16' center to center on grades exceeding 40%

- 4) The Town reserves the right to require all high velocity requirements outlined herein for sewer lines either designed or installed at grades of 10% or greater, regardless of the flow velocity. In cases where the design grade established on the sewer design plan is exceeded during construction and the 10% threshold is exceeded, all high velocity requirements shall apply without waiver.
- i) Sewer extensions shall be designed for projected flows, even when the diameter of the receiving sewer is less than the diameter of the proposed extension.
 - j) All pipe diameter changes shall occur only in manholes, with the invert of the larger pipe lowered sufficiently to maintain the same energy gradient. An approximate method of obtaining this result is to place the crown of the incoming pipes may be designed for an elevation at or above the crown of the outgoing pipe.
 - k) All transitions of pipe material, pipe separations, grade changes, pipe thicknesses and all angular deflection changes shall occur only at manholes.
 - l) Pipe trench excavation and backfilling shall be performed in accordance with Section 0450 of these Specifications.
 - m) Gravity sewer downstream from a connection point with a force main shall be lined with 401-type ceramic epoxy for a minimum of 1,200 linear feet.
 - n) The minimum angle between inlet and outlet pipes in a manhole shall be 90 degrees.

B. Materials

Materials specified herein are acceptable for sewer service as described. Sanitary sewer mains shall conform to the following criteria:

Diameter (in)	Depth (ft)*	Material
Any	≤ 4	DIP
8 – 15	4 ≤ 13	PVC SDR 35 or C900 DR 18
8 – 15	13 < D ≤ 16	PVC C900 DR 18 or DIP
> 15	Any	DIP
Any	> 16	DIP

*Depth of the sewer main shall be measured from the top of the pipe to the final grade or road subgrade at the deepest point between manholes.

1. Ductile Iron Pipe

Material Specifications

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 DIP
Sewer Mains

Pipe Diameter	AWWA C-150, Laying Condition	Pressure Class	Maximum Depth of Cover
8 -inch	type 1	350 psi	3-16 feet
8 -inch	type 4	350 psi	> 16 feet
10-12 -inch	type 1	350 psi	3-16 feet
10-12 -inch	type 4	350 psi	16-20 feet
10-12 -inch	type 5	350 psi	> 20 feet
14-20 -inch	type 4	250 psi	3-20 feet
14-20 -inch	type 5	250 psi	> 20 feet
14-20 -inch	type 5	350 psi	As Directed
24-30 -inch	type 4	250 psi	3-20 feet
24-30 -inch	type 5	300 psi	> 20 feet
24-30 -inch	type 5	350 psi	As Directed
36-42 -inch	type 4	300 psi	3-20 feet
36-42 -inch	type 5	350 psi	> 20 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.

In cases where thickness class designation of ductile iron pipe is specified, the corresponding thickness class designations are as outlined in the following table.

The following table lists approved manufacturers of DIP and DIP fittings that are allowable for installation within the Town's system.

Product Category	Approved Manufacturer	Model/Series	Pressure/Load Rating	Reference Standard	Requirements
Ductile Iron Pipe 8-inch & 10-inch Diameter (and 4-inch and 6-inch services) Cement Mortar Lined	US Pipe	Tyton Joint	350 psi	AWWA C150 and C151	Cement mortar lined with exterior bituminous coating. McWane pipe stamped "McWane by Atlantic States or Clow" only
	American (ACIPCO)	Fastite Joint			
	McWane	Tyton Joint			
Ductile Iron Pipe 12-inch and Larger Diameter Protecto 401 Lined	US Pipe	Tyton Joint	250-350 psi	AWWA and DIPRA Standards	40-mils of Protecto 401 Lining (lining must be less than 1 year old); McWane pipe stamped "McWane by Atlantic States or Clow" only
	American (ACIPCO)	Fastite Joint			
	McWane	Tyton Joint			
Ductile Iron Fittings 8-inch & 10-inch Diameter (and 4-inch and 6-inch services) Cement Mortar Lined	Sigma	Mech. Joint	350 psi	AWWA C110/C111 and AWWA C153	Shall always meet or exceed pipe pressure rating
	Tyler Union	Mech. Joint			
	SIP Industries	Mech. Joint			
	Star	Mech. Joint			
	American	Mech. Joint			
Ductile Iron Fittings 12-inch and Larger Diameter Protecto 401 Lined	Sigma	Mech. Joint	250-350 psi	AWWA and DIPRA Standards	Shall always receive interior Protecto 401 Lining to meet or exceed main line pipe standards. (401 lining must be < 1yr old)
	Tyler Union	Mech. Joint			
	SIP Industries	Mech. Joint			
	Star	Mech. Joint			
	American	Mech. Joint			

Ductile Iron Pipe Thickness Class

Pipe Diameter	Pressure Class	Nominal Thickness (inches)	Minimum Corresponding Thickness Class
8	350	0.25	50
10	350	0.26	50
12	350	0.28	50
14	250	0.28	50
16	250	0.30	50
18	250	0.31	50
20	250	0.33	50
24	250	0.37	50
24	300	0.40	51
30	250	0.42	51
30	300	0.45	52
36	300	0.51	52
36	350	0.56	53
42	300	0.57	52
42	350	0.63	53

Pipe joints shall be of the push-on type as per AWWA C111.

For 10-inch diameter and smaller gravity sewer mains, pipe lining shall be cement mortar with a seal coat of bituminous material, all in accordance with AWWA C104.

For 12-inch diameter and larger gravity sewer mains, all ductile iron pipe 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 Protecto 401. 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 joint compound by Protecto 401 or approved equal applied by brush to ensure full coverage. All pipe supplied with Protecto 401 interior lining shall be provided free of holidays. Pipe installed with defects in the lining will be rejected and required to be replaced. Patching of Protecto 401 coating defects after installation shall not be approved. Protecto 401 lined pipe must be installed within one year of the application date on the pipe.

All buried DIP and fittings shall have bituminous coating on the exterior surface in accordance with AWWA C151/ANSI A21.51. The seal coat

shall be a coal tar epoxy lining and shall be Indurall Coating, Inc. "Ruff-Stuff", Kopper's Company, Inc. "Bitumastic No. 300-M" or approved equal. Pipe shall be supplied in minimum 20-ft lengths.

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

Pipe material and manufacturer must have a supplier within 200 miles of the Town of Apex.

2. Solid Wall PVC Pipe

Material Specifications

PVC Pipe shall be solid wall and made of PVC plastic having a cell classification of 12454 or 12364 (with minimum tensile modulus of 400,000 psi) as defined in Specification D1784. PVC pipe shall have integral wall bell and spigot joints for the conveyance of domestic sewage and shall be supplied in 20 ft lengths. Fittings shall be made of PVC plastic having a cell classification of 12454-B, as defined in ASTM D1784.

All PVC gravity sewer pipe and PVC fittings up to 15-inches in diameter shall be manufactured in accordance with the latest version of ASTM D3034. All solid wall PVC pipe installed at diameters from 18-inches to 27-inches in diameter shall be manufactured in conformance with ASTM F679 and provided at minimum pipe stiffness of 115-psi. Fittings must be manufactured by pipe supplier or approved equal, and have bell and/or spigot configurations compatible with that of the pipe. PVC pipe shall be installed in accordance with the requirements of this Specifications manual and ASTM D2321.

All PVC pipe up to and including 15 inches in diameter shall have a maximum Standard Dimension Ratio (SDR) of 35 for depth of installation no shallower than 4-ft of cover from the pipe crown and no deeper than 13-ft measured from the bottom of the pipe. All solid wall PVC pipe for depth of installation greater than 13-ft shall be C900 DR18. Solid wall PVC pipe shall not be approved for depths of installation greater than 20-ft. All solid wall PVC pipe shall be marked and certified in conformance with ASTM D3034 or ASTM F679 and all AWWA standards.

C. Sewer Main Installation

1. General Requirements

- a) Pipe trench excavation and backfilling shall be performed in accordance with Section 0450 of these Specifications.
- b) Transitions of pipe material, pipe separations, grade changes and all angular deflection changes shall occur only at manholes. Pipe crowns shall be matched for changes in pipe sizes.
- c) All sewer mains installed with less than 4 ft of cover or deeper than 20-ft shall be ductile iron pipe.
- d) 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 covered and protected when pipe laying is not in progress to prevent debris from entering the pipe.
- e) Pipe shall be laid on true lines as directed by the Engineer. 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.
- f) 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.
- g) No bells or connections shall be within any waterway crossing area.
- h) Sewer mains shall not be installed within roundabouts.

702 Manholes

A. Design

1. Manhole Location, Siting and Design
 - a) Manholes shall be spaced at a maximum distance of 400 feet.
 - b) Manholes shall be installed at each deflection of line and/or grade. The flow channel through manholes shall have a uniform and smooth finish free of irregularities or obstructions. The invert channel shall conform to the shape and slope of the entering/exiting sewer line. Either pre-cast or brick and mortar inverts may be used. Mortar shall be mixed in a clean, tight mortar box, or in an approved mechanical mixer and used within 45 minutes of mixing.
 - c) A minimum drop of 0.2 feet must be maintained between the invert into and out of the manhole. The benches shall be sloped so as to prevent sedimentation. The inverts from intercepted cross lines shall be tied into the main flow line wherever possible, so as to provide a smooth transition. Wherever such cross lines tie-in at a substantially higher elevation than that of the downstream invert, the connecting line shall extend into the manhole a sufficient distance to enable the flow to spill into the flow line rather than onto the invert bench.
 - d) On dead-end manholes receiving service connections, the invert must be constructed and the invert flow line shall extend through the manhole so that all flow entering the manhole shall be readily conveyed downstream.
 - e) Free falls of wastewater flow into the manhole invert from incoming sewer mains shall not be allowed, except under limited circumstances.
 - f) In certain isolated circumstances standard free drops may be allowed, not exceeding 24-inches, when pipe diameter changes occur at a manhole. In these cases, the smaller diameter pipe crown shall be positioned no higher than the larger diameter pipe crown to limit the drop. When free drops are necessary due to pipe size changes, the Contractor shall take preventive measures to prevent free drops into the manhole invert, such as building a flume or trough up to the incoming invert, or piping the flow to the primary invert flow channel.
 - g) Drop manholes are not allowed without the written approval of the Water Resources Department. While certain physical constraints may dictate the need for drop manholes, they may not be used merely to decrease

trenching depth. Upstream slope changes shall be used to avoid the need for drop manholes.

- h) Manholes shall not be obstructed from view or access. It is illegal to bury or obstruct access to manholes. Manholes shall not be installed within roundabouts.
- i) Manhole covers shall be elevated as follows:
 - 1) Roadways: Manholes installed in roadways and road shoulders shall be installed with the cover flush with the top of pavement.
 - 2) Outside of Roadways: Manholes installed outside of roadways shall be elevated at least 12 inches above the surface grade and/or at the same elevation of the road travel lane unless otherwise approved by the Water Resources Director.
 - 3) Wooded Outfalls: All manholes installed in wooded, forested or brushy areas shall be elevated at least 24 inches above the surface elevation.
 - 4) 100-Year Flood Zone: All manholes located within the 100-year flood elevation shall be elevated at least 24 inches above the 100-year flood elevation or specify watertight covers and vents that extend at least 24 inches above the 100-year flood elevation.
 - 5) 100-Year Culvert Headwater Depth: All manholes located within a 100-year culvert headwater staging area shall be elevated at least 24 inches above the 100-year flood elevation or specify watertight covers and vents that extend at least 24 inches above the 100-year flood elevation.
 - 6) Well Maintained Areas: All manholes installed in well maintained areas, such as yards, sidewalks or otherwise inside an improved right-of-way shall be installed flush with the finished surface.
- j) Manholes used in outfalls and other non-traffic bearing areas shall be constructed with a flat top and outside steps.
- k) Manholes shall be provided without interior steps.
- l) When connecting a new sewer main to an existing main, the connection shall be established with a “Doghouse” type of manhole inserted over the existing main. Doghouse manholes shall only be installed on existing DIP or PVC mains.

m) Grade rings shall not exceed 6 inches.

2. Manhole Sizing

a) Manholes shall be sized as shown in the following table. The next larger size shall be required if the pipe size, depth, or number of main line connections warrants a larger size. In consideration of main line connections, all will be considered regardless of type, whether inside drop, outside drop, force main or standard connection.

Manhole Sizing Guide

Manhole Size	Maximum Allowable Pipe Size, Single In	Maximum Allowable Pipe Size, Multiple In	Maximum Depth with Extended Base
<i>(diameter)</i>	<i>(diameter)</i>	<i>(diameter)</i>	<i>(invert to rim)</i>
4-ft	8-12 inches		12-ft ¹
5-ft ⁴	14-24 inches	8-12 inches	12-ft to 18-ft
6-ft ⁴	30-36 inches	14-24 inches	18-ft to 24-ft
8-ft ⁴	≥42 inches	30-36 inches	24-ft to 30-ft
10-ft ⁴		≥42 inches	>30-ft

¹Depths beyond 14-ft in roadways shall require a 5-ft diameter manhole with extended base.

⁴Due to the limited manhole wall area that could exist between the invert in and out, some manholes may require upsizing as directed by the Water Resources Department.

All manholes 5-ft in diameter shall be extended to surface elevation with no further reduction in diameter until the eccentric cone section.

Manhole transitions for 6-ft and larger diameter manholes are only allowed in the top 5-ft of the manhole. In no case shall the smallest barrel size be less than 5-ft diameter. At least 5-ft of vertical clearance shall be maintained above the pipe crown before transitioning to a smaller diameter riser, or transition shall not be utilized. An eccentric flat slab reducer from 6-ft diameter or larger manhole base sections to 5-ft diameter risers (non-paved areas) or eccentric cones (paved areas) shall be used to make any transition.

Manholes outside of paved areas that are 6-ft in diameter and greater and are too shallow to maintain 5-ft of vertical clearance above the crown of the pipe shall maintain the full manhole diameter up to the design surface elevation and be provided with a flat top slab cover with eccentric hole.

Manholes inside of paved areas that are 6-ft in diameter and greater shall be constructed with an eccentric, flat top reducer to 5-ft diameter and provided with a 5-ft diameter eccentric, tapered cone at the finished grade.

When the depth of the manhole is too shallow to maintain 5-ft of vertical clearance above the crown of the pipe a 3-ft tall eccentric, tapered cone shall be used without any additional 5-ft diameter risers.

B. Materials

1. Concrete Manholes

- a) Manholes shall be precast concrete with a minimum compressive strength of 4000-psi and utilize minimum grade 60 rebar in compliance with ASTM C478. All 4-ft and 5-ft diameter manholes and all 6-ft diameter manholes in paved areas shall be provided with eccentric cone sections. Flat top manholes are required in outfall areas and for 6-ft and larger diameter manholes.
- b) Precast concrete manholes shall meet all design and manufacturing requirements of ASTM C478 and all H-20 loading requirements. Minimum wall thickness shall be 5-inches and shall increase with depth and diameter in accordance with ASTM standards. The standard joint shall be sealed with a plastic cement putty meeting Federal Specification SS-S-00210, such as Ram-Nek or a butyl rubber sealant. All lift holes must be plugged with non-shrinking grout after installation.
- c) All manholes greater than 5-ft diameter shall have minimum 8-inch (6-inch for 4-ft diameter manholes), 4,000-psi concrete bottoms resting on a minimum of 12 inches of #57 stone. Sewer mains shall enter and exit radially through the manhole. Inverts shall be constructed with a width equal to the effluent pipe and a height equal to 1/2 that of the effluent pipe. Inverts shall be so finished with sufficient drop across the manhole to compensate for all resulting energy loss across the invert. Flat invert channels shall not be allowed. At each inlet and outlet of 8 inches or greater, resilient connectors or manhole boots shall be provided in conformance with ASTM C923. Rings and clamps are to meet standards of ASTM A167 and/or ASTM C923.
- d) Precast manhole components shall not be installed, transported, or removed from the casting yard prior to reaching the minimum compressive strength of 4,000-psi and at least 7 days have elapsed since casting.
- e) Manhole flat slab, eccentric reducers provided for 6-ft diameter and larger manholes shall be provided with minimum slab thickness of 12-inches. Flat slab, eccentric reducers shall not be allowed for manhole diameters less than 6-ft.

- f) Manhole flat top slab covers for outfall manholes 6-ft diameter and greater shall be designed and manufactured for H-20 loading and provided in minimum slab thickness of 8-inches. Manhole flat top covers shall be provided with a minimum clear opening of 36-inches when utilized with a 36-inch clear span manhole frame and cover.
- g) Manhole benches shall slope upwards from the spring line of the pipe to the projected level of the pipe crown at the manhole wall, or 8-inches above the spring line, whichever is less. Bowl type inverts recessed inside of precast benches shall not be accepted.

2. Manhole Frame and Cover Materials

- a) Manhole Frames and Covers shall be Class 35 gray iron with "Sanitary Sewer" and the Town symbol forged into the cover as indicated in the details. Ring and cover shall be stamped with make and model. All manhole frames and covers shall be domestically made and manufactured in the USA from domestic iron.

b) Types

- 1) Manhole Frames and Covers in Paved Areas and some Unpaved Areas: For all installations in roadways or within the right of way, use Type 1 ring and cover, and place sufficient depth of concrete below the pavement around the ring to ensure contact with manhole. Type 1 covers shall be provided with 1 vent hole. Type 1 covers shall be designed for a proof load of 40,000 lbs. and be provided in Class 35B gray iron in conformance with ASTM A48. At a minimum, Type 1 manhole rings shall weigh 190 lbs. and the cover shall weigh 120 lbs.
- 2) Manhole Frames and Covers for Outfalls: For installation in outfall areas, with 4-ft and 5-ft diameter manholes use Type 2 ring and covers. Type 2 covers shall not be installed in areas subject to traffic loading. Type 2 covers shall be provided with an integrated frame and cover assembly in which the cover rotates away from the frame for access. The rotating assembly shall be provided with a cast in stainless steel rod assembly. Type 2 covers shall be provided with a minimum 24-inch clear span opening along the axis with the stainless steel rod assembly. Security shall be provided by 3 exterior cast lugs at $\frac{3}{4}$ -inch thickness that allow padlock installation or bolting with 3 stainless steel bolts with stainless steel zinc plated nuts. Type 2 covers shall be made of Class 35B iron in conformance with ASTM A48 and designed for a proof load of 12,000 lbs. The frame and cover weight shall not be less than 60-lbs for the cover and 80-lbs for

the ring. The Type 2 frame and cover assembly shall be provided with a gasket that makes the cover assembly watertight when bolted at all three lugs. Type 2 covers shall be provided inside the 100-year flood elevation or other areas subject to flooding.

- c) All castings shall be machined to give even and continuous bearing on the full length of the frame. Castings shall be free of porosity and blow holes. All manhole frames shall be bolted to the manhole, except in paved streets.
- d) Manhole ring and cover shall be made by East Jordan Iron Works, US Foundry, Neenah Foundry Company, or approved equal.
- e) Where deemed necessary in low areas of streets, solid manhole covers may be required to prevent surface water inflow into the sewer.

C. Installation

1. General Requirements

- a) The downstream side of the last manhole(s) of a sanitary sewer line extension under construction shall be plugged by constructing a brick/block wall to prevent the passage of groundwater, runoff and sediment into the sanitary sewer system. All water upstream of the wall shall be pumped out of the sanitary sewer line and all sediment and solids shall be removed and properly disposed of by the Contractor. Water, sediment, and solids shall be removed every 30 days, or sooner if necessary, for the duration of the project. The wall shall not be removed until the line has been inspected by the Town to ensure that all possible points of inflow or infiltration have been eliminated. Failure to meet these requirements will be deemed a violation with fines up to \$1,000.00 per day.
- b) Manholes shall not be buried or hidden, which is a violation and subject to penalty by fines.
- c) All manhole penetrations, whether sewer main or service lateral, shall be cored with a concrete coring machine. All pipe connections must be made with flexible watertight couplings or boots.

For new manholes, there shall be a minimum of 9-inches or $\frac{1}{2}$ the pipe outside diameter (OD), whichever is greater, between the pipe hole openings. (Pipe hole opening is typically 4" greater than the pipe OD.) When the adjacent pipes are different sizes, the OD of the smaller pipe shall be used to determine the spacing requirement, but shall never be less than 9-inches.

For connections to existing manholes, there shall be a minimum of 9-inches or 3.5-inches plus $\frac{1}{2}$ the OD of the existing pipe, whichever is greater, between the pipe hole openings.

- d) All manhole sections shall be standard tongue and groove with rubber "O" ring or butyl rope sealant. All external manhole joints shall be wrapped with an approved joint seal material.
- e) Each connection to a manhole shall be sealed watertight by means of a flexible sleeve or gasket type sealing system. The flexible sleeve type system, if used, shall be equal to Flexible Manhole Sleeve as manufactured by the Interpace Corporation. The gasket type system, if used, shall be equal to the PSX system as manufactured by the Press Seal Gasket Corporation. The sealing system shall be furnished by the manhole manufacturer.
- f) Manholes shall be set on a base of 57 stone that is a minimum of eight (8) inches thick for four (4) foot diameter manholes and twelve (12) inches for five (5) foot diameter.
- g) Backfill around manholes shall be placed uniformly in shallow layers and thoroughly compacted with mechanical tampers and with care taken to ensure against displacement of the structure.
- h) All manhole rings shall be set in full mortar beds and bolted down. The rings with covers shall be set to the final grade indicated on the plans or as may be directed by the Town. Any rings and covers not conforming to the correct grade shall be adjusted by the Contractor as required. The exterior surface of all manholes shall be thoroughly cleaned of all grease, dirt, etc. All lifting lugs shall be removed and holes patched thoroughly with non-shrink mortar, color to match that of the manhole where such patches are exposed.

2. Manholes Subject to Inundation

- a) Manholes subject to flooding shall be watertight and vented 24 inches above the 100-YR flood elevation. In flood prone areas, the manholes shall be vented at least every 1000-ft or every other manhole, whichever is greater.
- b) The exterior of all manholes within the 100-year flood elevation and in wetland areas shall receive an exterior coating of an approved bitumastic coal tar epoxy or an approved epoxy coating at 40-mils to prevent weepage or attack by acidic soils. Individual joints shall be

wrapped with Conwrap, Conseal, or approved equal and approved by the Town prior to backfilling.

- c) Anti-flotation design measures shall be implemented as required in flood prone areas.

3. Manholes Located on Large Collection Mains

The Town reserves the right to require all manholes located on interceptor or outfall mains 24-inches in diameter and larger to have the manhole interior and bench coated with an approved epoxy coating at 80-mils thickness. The epoxy coating shall be field applied and tested as described herein.

4. Force Main Discharge Manholes

All manholes located on gravity mains that serve or will serve as discharge points for sanitary sewer force mains shall receive an interior epoxy coating at 80-mils thickness. In addition to the receiver manhole, the Town reserves the right to require epoxy coating of the next two consecutive manholes downstream of the receiver manhole or all downstream manholes within 1200-lf of the receiver manhole,—See Section 800 for further information on force main discharge manholes.

5. Epoxy Coating

- a) 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.

- b) Installation: A minimum 80-mils thickness shall be field 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.

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 top coating 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.

6. Labeling

- a) The interior of each manhole shall be labeled during construction. Labels can be from the manufacturer (stencil, tag, etc.) or by the contractor (tag, permanent marker, paint pen, etc.). Label must include the manhole number according to the record drawings and must consist of letters at least 3 inches tall and must be located approximately 12 inches above the shelf of the manhole.

703 Service Connections

A. Design

1. General Requirements

- a) All residential subdivision lots shall be served by gravity unless otherwise approved. If a pump is approved, it shall be privately maintained and must pump into either a service connection placed on the lot. The pump and force main (if needed) must have a note on the recorded plat indicating the following: "Privately maintained sewer pump and force main is required to serve this lot".
- b) Service connections to the main lines shall be perpendicular to the main line and shall extend to the edge of the right of way or easement line. Direct taps shall be within the top quarter of the main, or within a

manhole. All single family residences and businesses shall have individual connections to the public sewer main. Sewer services may not cross private property if the Development is subject to UDO requirements.

- c) Multiple service connections located outside public right of way or public easements are for private use only and will not be maintained by the Town. A private sewer permit from NCDEQ shall be required on all private collection systems prior to construction plan approval. A cleanout or manhole shall be installed within each serviced lot's right of way or easement for the Town's use, and shall extend a minimum of 6 inches above the finished grade.
- d) Cleanouts are required on all services with a maximum spacing of 50 feet for four (4) inch lines and 100 feet for six (6) inch lines. The first cleanout from the main/manhole shall be maintained by the Town and shall be installed one (1) foot inside the right of way line or edge of easement. All cleanouts shall extend a minimum of 6 inches above finished grade with brass caps or meet the optional cleanout method requirements in accordance with the Standard Details. Town maintenance of sewer services shall terminate at the first cleanout.
- e) Sewer cleanouts located in paved areas, which bear vehicle loading, must have ductile iron risers, ductile iron fittings and a traffic rated cast iron cover assembly.
- f) All 4 inch services shall connect directly into a public sewer main or manhole, in the fronting street or into an easement within the property. All 6 inch service connections shall be into a manhole.
- g) Service lines connected to manholes shall not be through the cone section or manhole joints. Service lines shall be installed 6" above, but no more than 30 inches above the invert or shall be installed with a standard drop. Multiple service connections shall not be maintained by the Town. For 6-ft diameter and larger manholes no service is allowed in the reduced diameter riser sections of the manhole.
- h) The use of in-line wyes for service connections shall be required for all new construction. When connecting to existing sewer mains, service saddle taps will be allowable. Taps shall be at the 10 or 2 o'clock position, and shall not be top taps.
- i) Service connections to mains at depths of 14-ft and greater shall utilize ductile iron pipe between the main and the cleanout, including a ductile iron wye for the cleanout stack. Location and angle of fittings shall be as shown in the standard detail drawings.

- j) Where the flood level rims of plumbing fixtures are below the elevation of the manhole cover of the next upstream manhole in the public sewer, such fixtures shall be protected by a backwater valve installed in the *building drain, branch of the building drain or horizontal branch* serving such fixtures. Plumbing fixtures having flood level rims above the elevation of the manhole cover of the next upstream manhole in the public sewer shall not discharge through a backwater valve.

B. Materials

1. Pipe Materials

- a) PVC Pipe shall be C900, schedule 40, or greater supplied in minimum 20-ft lengths. Schedule 40 PVC pipe shall be manufactured with a cell classification of 12454 in conformance with ASTM D1784. Schedule 40 pipes shall be manufactured to dimensional tolerances as specified in ASTM D1785 and rated for service conditions up to temperatures of 140-degrees Fahrenheit. The pipe may be joined by solvent weld in conformance with ASTM D2564.

Schedule 40 PVC pipe may be used for sewer services between 4 and 13 feet and shall require 4-inches of stone bedding extended to the springline.

PVC pipe and fittings for sewer laterals shall conform to ASTM D2665 "PVC Plastic Drain, Waste & Vent Piping" and shall be NSF approved. Laying lengths may be 10 or 20 feet with solvent weld type joints for Schedule 40 pipe or gasketed joint for PVC C900 DR18 pipe.

PVC C900 pipe shall be used in depths between 13 and 20 feet and shall require 6-inches of stone bedding extended 6-inches above the pipe crown.

- b) Ductile Iron Pipe may be used for any depth sewer service but must be used for sanitary sewer services with less than 4 feet of cover or in excess of 20 feet of cover. Ductile iron services shall also be used in all cases where a well is located within 100-ft of the sewer service line. Ductile iron service piping shall be provided in conformance with the ductile iron piping standards outlined herein including cement mortar lining.
- c) Any sewer service lateral deeper than 20 feet shall be pre-approved by the Director of Water Resources.

2. Sewer Service Fittings, New Construction

a) DIP Main with DIP Service

In-line wye fittings for ductile iron main lines joined with ductile iron service lines shall be typical ductile iron mechanical joint fittings as specified herein. In this case all fitting sizes shall conform to AWWA C153. Wye fittings through 10-inches in diameter shall be provided with cement mortar lining in accordance with AWWA C104 and provided with exterior asphaltic coating per AWWA C151. Wye fittings for lines larger than 10-inches in diameter shall be provided with Protecto 401 lining as specified herein for ductile iron pipe of the same sizing.

b) DIP Main with PVC Service

For ductile iron sewer mains to be joined with PVC service lines, the in-line wye fittings shall be slip joint ductile iron with an IPS sized branch for PVC schedule 40 service lines. Ductile iron fittings for connecting PVC service lines shall be deep bell, gasketed joint and air test rated. Gasket grooves shall be machined. Bell depths shall meet the minimum socket depth requirements of ASTM D3034 and ASTM F1336. Wall thickness shall meet the requirements of AWWA C153. Ductile iron wye fittings through 10-inches in diameter with IPS connections shall be provided with cement mortar lining in accordance with AWWA C104 and provided with exterior asphaltic coating per AWWA C151. Ductile iron wye fittings for PVC lines larger than 10-inches in diameter shall be provided with Protecto 401 lining as specified herein.

c) PVC Main with PVC Service

For PVC sewer mains to be joined with PVC service lines, PVC in-line wye fittings shall be provided. Typical Schedule 40 PVC fittings shall be provided at the cleanout wye and stack.

d) PVC Main with DIP Service

A ductile iron tee/wye shall be provided when the service line is required to be ductile iron due to a crossing or other obstruction. The fitting shall be specifically manufactured for ASTM 3034 PVC pipe such that a smooth flow way exists on the main line through the fitting. The branch shall be gasketed to receive the 4-inch DIP service line without additional fittings. The ductile iron tee/wye fitting shall be Protecto 401 lined.

3. Service Saddle Connections, Existing Sewer Mains

- a) PVC service saddles shall be of the same material as the main, 45 degree deflection, and shall be solvent welded and fastened with single stainless steel bands. The saddle service branch shall be stubbed

slightly into the sewer main so that when installed, the saddle shall not slip or rotate.

- b) For existing DIP main lines, ductile iron service saddles shall be used. The saddle assembly shall consist of a virgin SBR or NBR gasket compounded for sewer service, a ductile iron saddle casting, a 304 stainless steel adjustable strap for fastening the gasket and the saddle casting to the sewer main and a 304 stainless steel adjustable circle clamp for securing the service line into the rubber gasket. The saddle shall be furnished with adapters as required to properly receive the service pipe.

C. Installation

1. General Requirements

- a) Sewer laterals shall not be located in easements when gravity service can be provided to the property frontage at the street.
- b) Each separately owned structure requires a separate tap to a public sewer.
- c) Four inch lines shall have a minimum slope of $\frac{1}{4}$ inch per foot and 6 inch lines shall have a minimum slope of $\frac{1}{8}$ inch per foot.
- d) Service connections to new mains shall include the use of wye (not tee) connections. Saddle taps onto new lines shall not be allowed.
- e) Saddle taps into existing PVC mains shall be made at the 10 o'clock or 2 o'clock position of the main with the wye saddle angled 45-degrees towards the direction of flow in the main. Taps shall only be made by a mechanical circular cutting saw providing a smooth and uniform cut for the saddle installation.
- f) Service connections shall be made using an approved sewer saddle when the existing sewer line is 8", 10", or 12" in diameter. This service connection shall not be used when the sewer main material is truss sewer pipe. The opening in the sewer main for the sewer saddle shall be cut with a hydraulically or pneumatically driven circular tapping saw of the same nominal diameter as the sewer service line.
- g) Service laterals to be maintained by the Town shall not be located beneath a driveway or curb, nor shall a clean-out be located in a sidewalk area without prior written approval from the Director of Water Resources.

704 Testing and Inspections

A. General

The Contractor shall furnish all materials, labor, and equipment to perform all testing. The Contractor may arrange to obtain water for testing purposes from the Town. The Contractor shall reimburse the Town for all water used for construction at current inside utility rates.

B. Sewer Main and Service Connection Testing

1. Visual Testing and Observation

- a) All materials used must be approved by the Town prior to installation. Rejected materials shall be immediately removed from the job site.
- b) Gravity sanitary sewer lines shall be clean and free from obstructions, and shall be visually inspected from every manhole. Lines which do not exhibit a true line and grade or which have structural defects shall be corrected. Sanitary sewer service connections shall be visually inspected prior to backfilling.

The Town may re-inspect the line at any time prior to final acceptance if any damage or displacement is suspected to have occurred subsequent to the initial inspection

2. Air Testing

- a) Low-pressure air testing in accordance with ASTM F1417 shall be performed on all sewer mains before the laterals or stubs are installed on the line, and after the trench has been backfilled to finished grade. Plugs shall be installed at each manhole to seal off the test section. Prior to testing, the sewer line shall be clear of debris and flushed with water as necessary. The line will be pressurized with a single hose and monitored by a separate hose connection from the plug. Air then shall be slowly introduced into the sealed line until the internal air pressure reaches 5.0 psig. The air pressure shall then be allowed to stabilize for a minimum of 2 minutes. The line shall be "acceptable" if the pressure does not drop in the time prescribed for the test in the table below.

		Nominal Pipe Diameter (in)									
		8	12	15	16	18	21	24	30	36	42
Length of Test Section (ft)	50	7:33	11:20	14:10	15:11	17:00	19:48	22:40	28:19	34:00	39:40
	100	7:33	11:20	14:10	15:11	17:00	19:48	22:47	35:37	51:17	69:48
	150	7:33	11:20	14:10	15:12	19:14	26:10	34:11	53:25	76:55	104:42
	200	7:33	11:24	17:48	20:16	25:39	34:54	45:35	71:13	102:36	139:36
	250	7:33	14:15	22:16	25:20	32:03	43:37	56:58	89:02	128:12	174:30
	300	7:35	17:06	26:43	30:23	38:28	52:21	68:22	106:48	153:54	209:25
	350	8:52	19:57	31:10	35:27	44:52	61:05	79:46	124:42	179:30	244:19
	400	10:07	22:48	35:37	40:31	51:17	69:48	91:10	142:30	205:06	279:13
	450	11:23	25:39	40:04	45:35	57:42	78:31	102:36	160:18	230:48	314:07
	500	12:39	28:30	44:31	50:39	64:06	87:15	114:00	178:06	256:24	349:02

- b) If the section fails to meet these requirements, the source of leakage shall be repaired and the pipe section re-inspected
- c) The Contractor shall furnish all plugs, compressors, hoses, gauges, and any other equipment necessary to conduct the low-pressure test.

3. Infiltration Tests

- a) Portions of the sewer lines, which exhibit a higher ground water table during construction, shall be tested for infiltration. The portions of the line to be infiltration tested shall be determined by the Town.
- b) The portion of the sewer line designated by the Town shall be tested for infiltration by installing a V-notch measuring weir or other suitable measuring device in the downstream end of the pipe to be tested. When a steady flow occurs over the weir, the rate of flow (infiltration) shall be measured. The rate thus measured shall not exceed 100 gallons per 24 hours per inch of sewer pipe diameter per mile of pipe. The Contractor shall furnish weirs and other equipment required for infiltration tests and the tests shall be performed in the presence of the Town.
- c) Should the infiltration tests reveal leakage in excess of the allowable, the leaking joints shall be re-laid if necessary or other remedial construction shall be performed by and at the expense of the Contractor. The section of sewer thus repaired shall then be retested to determine compliance with the Specifications.

4. Deflection Testing for Flexible Pipe

a) The mandrel (go/no-go) deflection test shall be performed on each line prior to acceptance and no sooner than 30 days after installation. The pipeline shall be thoroughly clean and free of debris and/or sediment prior to testing. The Contractor shall supply the mandrel used for this performance test. The mandrel device shall be cylindrical in shape having 9 or 10 possible contact points with the pipe. The mandrel's length and diameter (ID of proving ring) shall be in accordance with the following tables, and shall be subject to the Town's approval.

b) For flexible pipes (such as PVC), the following shall apply:

Nominal Diameter (inches)	Pipe Class	Average Inside Pipe Diameter (inches)	5% Deflection Mandrel Diameter (inches)	Length of Mandrel (inches)	Minimum Fins Included with Mandrel
8	C900	7.98	7.58	10	9
8	SDR 35	7.891	7.496	10	9
10	C900	9.79	9.30	10	9
10	SDR 35	9.864	9.371	10	9
12	C900	11.65	11.07	10	9
12	SDR 35	11.737	11.150	10	9
15	SDR 35	14.374	13.655	10	9
16	C900	15.35	14.58	10	9
18	C900	17.20	16.34	24	9
24	C900	22.76	21.62	24	9

Note: Calculated 5% deflection allowance does not include additional manufacturing tolerances provided by pipe manufacturers. For the purposes of testing, 5% deflection shall be calculated from standard pipe inside diameter as published in ASTM D3034 and ASTM F679.

c) The mandrel shall be advanced through the pipeline to determine if bedding and embedment has been provided in compliance with ASTM D2321 to assure joint deflection of less than 5%. If the mandrel becomes obstructed for any reason while being pulled through the line with less than 100-lbs of force, the location of the defect shall be noted and the mandrel shall be removed from the pipeline. Under no circumstances shall heavy equipment be utilized to force the mandrel through the pipeline. Deflection testing may be done concurrently with sewer televising inspections, provided the mandrel is kept within visible range of the camera. The mandrel diameter shall have a tolerance of +/- 0.01 inch. Contact length shall not be less than 2 inches.

Any lines not meeting this test shall be corrected by the Contractor and the test repeated. The Town shall approve the mandrel. The Contractor shall furnish drawings of the mandrel with complete dimensions to the Town upon request.

5. Video Assessment and Cleaning

- a) As a final measure required for acceptance, the Contractor shall clean and televise all newly installed sewer mains prior to acceptance by the Town. A 3rd party CCTV Contractor shall televise the sewer main and all lateral connections installed from the upstream to downstream manhole with no reverse setups or cutaways. This shall be done at the Contractor's expense. Throughout shooting, the camera shall be panned and tilted for a complete view of the main. Lighting shall be adequate to view the entire sewer main and service connections from beginning to end. The video inspection shall be submitted to the Town on a CD/DVD and formatted with software compatible and readable by the Town. The Town shall not be responsible for purchasing additional software necessary to view the CD/DVD.
- b) The camera shall be advanced at a uniform rate not to exceed 20 feet per minute that allows a full and thorough inspection of the new sewer main. The camera shall be a color, pan and tilt camera capable of producing a five hundred line resolution picture. Lighting for the camera shall be sufficient to yield a clear picture of the entire periphery of the pipe. The picture quality shall be acceptable and sufficient to allow a complete inspection with no lapses in coverage. The length of the sewer main shall be measured and recorded on the video screen. The distance counter shall be calibrated before shooting the inspection video.
- c) The Contractor shall clean the sewer mains ahead of video inspection with a high-velocity water jet. The video inspection shall take place within 2-hours of cleaning operations as witnessed by the Town. All construction debris shall be collected in the downstream manhole and shall not be released into the sewer system. No other work shall be performed on the Sewer lines after cleaning and prior to video inspection
- d) The Town shall be present throughout the cleaning and televising of the sewer mains to verify that the video work complies with the Specifications. The camera operator shall stop, reverse, pan, and tilt the camera to view any area of interest during the inspection as directed from the Town.
- e) It is recommended that all site grading and all utilities must be installed and complete prior to final inspection to ensure that damages to the sewer main do not occur. Damages found after final inspection would requiring re-inspection by the Town.

- f) CCTV inspection date must be acknowledged and approved by the Water Resources Department prior to inspection. All structures must be physically labeled by the contractor with number shown on the video. Punch list items from the inspection must be submitted on the Town's approved 3rd Party CCTV Report form and all video files uploaded to One Drive (flash drives and CD/DVDs are not acceptable).
- g) The contractor may not perform CCTV inspections on any utilities that they have installed.

6. Marker Tape Testing

Testing of the marker tape shall be performed by the Contractor at the completion of the project to assure it is working properly and completely detectable. It is the Contractor's responsibility to provide the necessary equipment to test the markers. Any defective, missing, or otherwise non-locatable segments shall be replaced.

C. **Manhole Testing**

1. Vacuum Testing

- a) All newly installed manholes shall pass a vacuum test in accordance with ASTM C 1244. The Contractor shall supply all equipment and materials necessary to vacuum test the manholes.
- b) Vacuum Testing shall be completed prior to any specified coating and lining materials being installed.
- c) The Town shall be present and witness all vacuum testing.
- d) The following vacuum testing criteria shall apply for compliance with the testing procedure.
 - 1) A vacuum of 10-inches of mercury shall be drawn with an approved vacuum testing unit.
 - 2) The testing time shall not be measured until after the vacuum pump has been shut off.
 - 3) The time required for the vacuum to drop from 10-inches to 9-inches of mercury shall meet or exceed the values listed in the following table.

Manhole Vacuum Testing Time

Depth (feet)	Manhole Diameter (inches)		
	48	60	72
Time (seconds)			
8	20	26	33
10	25	33	41
12	30	39	49
14	35	48	57
16	40	52	67
18	45	59	73
20	50	65	81
22	55	72	89
24	59	78	97
26	64	85	105
28	69	91	113
30	74	98	121

2. Holiday Testing of Lined Manholes

All manholes that require an epoxy coating shall undergo discontinuity testing. This shall be a high-voltage spark test conducted in accordance with NACE International Standard Practice 0188. All areas of the manhole coated shall be tested. The spark tester shall be set at a minimum of 100 volts per mil of coating thickness applied. The Contractor shall supply the spark tester and all testing equipment and labor needed to perform this test.

All holidays identified must be repaired. The epoxy coating must be abraded and cleaned prior to re-coating. All touch-up work shall be in accordance with the epoxy manufacturers guidelines.

705 Aerial Crossings

A. Design

Aerial crossings shall only be utilized in cases where buried crossings are not feasible due to stream crossings, compliance with riparian buffer standards, minimizing impacts to wetlands, preventing excessive depth of installation, or as otherwise directed by the Town of Apex. All aerial crossings shall have prior approval by the Water Resources Director and will only be considered if there are no practical alternatives available, cost shall not be considered justification for aerial crossings

In cases where aerial crossings are utilized to cross streams, the bottom of the pipe shall be installed above the 25-year flood elevation of the stream. Piers shall generally be located at a uniform spacing of 20-ft or 1 pier for every joint of pipe. Piers shall be provided in accordance with the standard details or as otherwise designed by a licensed NC Professional Engineer.

All pier footings shall be designed by a licensed NC Professional Engineer and the assumptions provided in the footing design shall be included on the plans. At a minimum, the footing design shall include: 1) the allowable soil bearing capacity, 2) design concrete compressive strength, 3) plan for reinforcing steel with sizing and location of bars, 4) force diagram including buoyant forces, stream velocity impacts 5) depth of installation to prevent frost heaving, 6) bedding design to prevent differential settlement and 7) factors of safety for unanticipated loads such as trees falling across the aerial crossing.

At a minimum all pier foundations shall be constructed on a base of 12-inches of washed stone. The soil conditions under the pier shall be evaluated by a licensed NC Geotechnical Engineer to determine if the allowable soil bearing capacity meets or exceeds the design assumptions included in the structural design. If the soil conditions fail to meet the specified bearing capacity requirements, a pile foundation shall be provided or the soils shall be undercut and replaced in conformance with the recommendations of the geotechnical engineer of record.

Piers installed in stream beds shall be avoided in lieu of spanned crossings. Spanned pipe crossings greater than 20-ft shall be provided in accordance with the pipe manufacturer's specifications and shall not exceed 40-ft for ductile iron pipe. Spanned pipe crossings shall be designed such that all flanges and exterior pipe connections are located above the 25-year flood elevation.

Spanned crossings greater than 40-ft without piers shall be provided in a steel encasement pipe and the entire crossing including piers, foundation, truss and/or beam supports and pipe thickness design shall be provided by a licensed NC Structural Engineer.

B. Pipe Materials

1. **Ductile iron pipe** for aerial crossings shall be interior lined with Protecto 401 at 40-mils regardless of pipe diameter from manhole to manhole. All joints for ductile iron pipe utilized in aerial crossings shall be restrained with a US Pipe Mech-Lok joint, American MJ Coupled joint, or other as approved by the pipe manufacturer, the Water Resources Department and the Engineer of Record. Ductile iron pipe utilized for spanned crossings greater than 20-ft without a pier shall typically be provided with flanged connections. All bolts and fasteners for flanged or bolt locking restraining systems shall be provided in stainless steel and installed in a manner to prevent seizing.
2. **PVC pipe** shall not be approved for aerial crossings.

3. **Steel pipe** provided for aerial crossings shall be fabricated with grade B steel that has minimum yield strength of 35 KSI in accordance with ASTM A139. Steel pipe for aerial crossings shall be provided with minimum wall thickness consistent with a pressure class of 200-psi or greater. Steel pipe for aerial sewer crossings shall be provided with 40-mils of interior ceramic coating, such as Ceramaline and provided with an exterior tape wrap approved by the manufacturer. All steel pipe joints shall be welded in conformance with manufacturers' specifications.

C. Installation

Aerial crossings are often utilized to span sensitive environmental areas and installation shall be consistent with plans to preserve the sensitive areas.

Joints of bolt lock or coupled restrained pipe shall be located within 2-ft of each pier as outlined by the detail drawings. Contractor shall ensure the length of pipe joints allows for this spacing.

Pipe shall be secured to each pier with 1/4-inch by 2-inch width steel straps fastened to 4; 1/2-inch stainless steel lugs anchored and adhered with epoxy to the concrete pier. The steel straps shall receive a weather resistant painted finish to prevent long term corrosion.

Precast piers may be submitted for approval provided the footing and foundation designs are completed by licensed structural and geotechnical engineers.

In cases where soil conditions cannot be sufficiently stabilized to provide an adequate foundation for concrete piers, a pile foundation designed by a licensed NC structural engineer and approved by the Town shall be provided.

Reinforcing steel for concrete piers shall be grade 40 and shall be constructed in conformance with the latest edition of the "Recommended Practice for Placing Reinforcing Bars" or other documentation as published by the Concrete Reinforcing Steel Institute.

In cases where rock exists at the foundation elevation, the footing shall be drilled and connected with dowels into the rock layer.

706 Repairs, Modifications, and Abandonment

A. Sewer Main Repairs

1. Vitrified Clay Pipe - replace damaged section with DIP and install a Fernco coupling at each end encased in concrete.

2. PVC Pipe - replace damaged section with PVC Pipe and install a Fernco coupling at each end encased in concrete.
3. ABS/PVC Truss Pipe - replace damaged section with DIP and install a Fernco coupling at each end encased in concrete.
4. Asbestos Cement Pipe - Replace damaged section with DIP and couplings encased in concrete.

B. Installation

1. All repairs to damaged sanitary sewer lines in paved areas shall be backfilled with ABC stone (crusher run) to a density of 95 percent Standard Proctor.
2. All repairs to damaged sanitary sewer lines shall be bedded with 6-inches of washed stone and compacted to a minimum of 95% Standard Proctor density before installing the new joint of ductile iron or PVC pipe.

C. Draining Sewer Mains

A detailed bypass pumping and emergency plan shall be required for any sewer line draining event.

All sanitary sewer mains and sewer force mains 20-inches and larger, active, inactive, or abandoned shall begin to be drained by tapping the bottom half of the pipe. A corporation stop or other valve shall be provided to control flow. All effluent shall be pumped to a downstream manhole (when available) or other containment tank utilizing continuous piping. The use of a sump pit on lines 20-inches and larger is not allowed.

In sensitive environmental areas and in other various scenarios the Water Resources Department may require lines less than 20-inches also be tapped in order to be drained.

D. Abandonment of Existing Sewer Mains

1. Existing sewer mains and casings located outside of road sections shall be removed, unless otherwise directed by the Town. All materials and labor shall be provided by the contractor.
2. Grout filling and abandoning in place may be allowed with prior approval from the Director of Water Resources.