LEXINGTON
NORTH CAROLINA

SANITARY SEWER AND WATER DISTRIBUTION DESIGN MANUAL

APRIL, 2024

City of Lexington

Engineering Services

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PREFACE

This document is a guide for the design and construction of Sanitary Sewer and Water Distribution Systems within the City of Lexington utilities service areas. In addition to using this manual, the design engineer should use sound engineering judgement in the design of each individual site.

Lexington Engineering Services will use these design standards as well as sound engineering principles to review the detailed engineering drawings for development projects. All engineers are encouraged to take these design standards into consideration in the preliminary layout of infrastructure (streets, storm drainage, etc.) so changes can be held to a minimum when the detailed construction drawings are reviewed.

The design criteria in this manual applies to all projects within the City of Lexington utilities service areas and should be used in conjunction with the latest versions of the LIDS Manual and NCDEQ Water and Sewer Regulations.

THIS IS THE ORIGINAL VERSION

Periodic updates occur to this document. For the latest version, please contact the City of Lexington Engineering Department at EngineeringServices@LexingtonNC.gov

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SECTION 1 – GENERAL

1.1 Applicability

The following wastewater and water design and construction standards shall apply to all extensions of the City of Lexington wastewater collection system and water distribution system and all service connections to Lexington's public mains.

If approved by the City of Lexington, private sanitary sewer or water systems inside the City's utility service area requesting to connect to the City of Lexington public mains shall comply with the City's standards and specifications. The Owners of the private systems shall meet all NC requirements and obtain NC Division of Water Quality and/or Public Water Supply Section permit(s) to operate the private system(s).

Backflow Prevention and Cross Connection Control standards shall apply to all temporary and permanent connections to the City's public water system.

SECTION 2 – UTILITY TRENCHES

2.1 Excavation and Preparation

2.1.1 General Requirements

Trenching for pipelines (water, sewer, storm drainage, irrigation, natural gas), communication, and power lines shall be excavated to the required depth to permit the installation of the utility line and all proposed utilities (inclusive of pipes, wires, cables, ducts, and conduit) along the lines and grades shown on the construction drawings.

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 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.

In all cases where trenchless methods are planned to cross an existing utility corridor with water, sewer, force main, natural gas, and/or other City maintained lines, an SUE (subsurface utility exploration) services firm shall be contracted to verify the depths of existing utilities prior to boring.

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.

2.1.2 Trenching

2.1.2.1 – Trench Dimensions

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.

Trenches shall be excavated only to the depth required for the required pipe bedding. Unauthorized excavation below the specified trench grade line shall be refilled with washed stone to the proper elevation at the Contractor's expense.

Open trenches shall not exceed 100-feet. Trenching activities shall not be started, nor continue, during rainfall and anticipated or forecasted precipitation. At the onset of rainfall, snow, or other precipitation, backfilling must be completed diligently to obtain proper compaction of backfill materials.

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

All trenches in or along roadways and within City utilities easements shall be properly backfilled at the end of each working day. Any trenches outside of roadways and public easements that are to remain open at the end of the workday must be provided with appropriate trench shoring to prevent wall collapse, and sturdy construction barriers must be properly placed around the opening to prevent unauthorized entry.

Equipment, stockpiled backfill, stone, and stored construction materials shall be confined to approved storage & staging areas. Encroachment of private property, public roadways and utilities easements will not be permitted.

2.1.2.2 – Trench Protection

Wet trench bottoms shall be stabilized with a base layer of #78 M or #67 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.

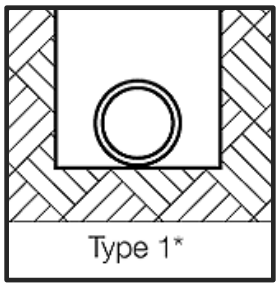
A space shall be excavated at each bell to provide ample space to join the pipes with no misalignment.

The Contractor shall take all necessary measures to prevent water from entering the trench. Water shall not enter the pipeline at any time.

2.2 Pipe Laying and Backfilling

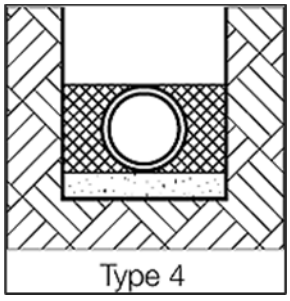
2.2.1 Pipe Laying Conditions

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.



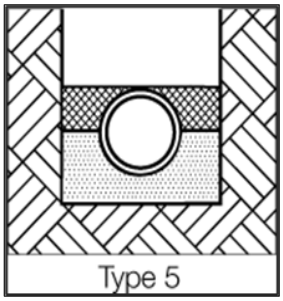
Type 1 pipe laying requires excavation of earth below pipe bell so the pipe bears uniformly upon undisturbed native earth. Soil is backfilled and tamped by hand around the pipe (and completely under the pipe haunches) in uniform layers not exceeding six inches in depth.

Type 4: Pipe bedded in Class 1 material, No. 67 or No. 78 crushed stone at least $^{1}/_{8}$ the pipe diameter, minimum of 6-inches, of bedding shall be installed below the pipe. Embedment material consisting of Class 1A or 1B, Class 2 or Class 3 materials shall be compacted to the top of the pipe greater than 95% Proctor. Careful attention must be allocated to compacting embedment material under the bottom edges of the pipe.



At a minimum, Type 4 laying condition shall be utilized with a minimum of 6-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 5: Pipe bedded in Class 1 material, No. 67 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 laying condition shall be utilized for gravity sewer and pipelines greater than 8 -inch diameter with >14 feet to 20 feet of cover and where rock or other hard, angular materials are encountered. The City Inspector may require Type 5 in other cases to overcome unstable conditions.

2.2.2 Pipe Installation

2.2.2.1 – General Requirements

a) Open ends of pipe shall be plugged water-tight by mechanical plug 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 City 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 sewer 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.

2.2.2.2 – Backfill

a) Backfill material shall be free from large rocks & debris, construction materials, frozen material, organic matter, and 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.

b) All gravity sewer pipe shall be bedded with a minimum of four (4) inches of #57 washed stone below the pipe and backfilled with #57 washed stone to the springline. Refer to the Bedding and Backfill for Sanitary Sewer Pipe Installation Detail (6001).

c) A minimum of six (6) inches of #57 washed stone shall be required for both water and sewer main bedding where rock or unstable material is encountered.

d) 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.

e) When original excavated materials have been deemed unsuitable for backfill, acceptable material must be imported to the site and properly installed to meet compaction requirements. Acceptable materials include

ASTM 2321 Class II or Class III (or Class 1A or 1B) soils.

f) 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.

g) 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.

2.3 Open Trench Pavement Repairs

All roadway pavement cuts shall be repaired within the time limit directed by the City Engineer or the NCDOT representative, as appropriate. If conditions do not permit a permanent repair within the given time limit, permission to make a temporary repair must be obtained from the City Engineer or NCDOT, as appropriate.

Pavement repairs shall be made in accordance with City Standards and Specification or NCDOT Standards, as appropriate. All lane and roadway closures shall follow City or NCDOT notification requirements. Signage and other controls shall comply with MUTCD.

All asphalt pavement utilized to repair open trenches shall comply with all applicable City or NCDOT pavement material and installation specifications.

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 as instructed by the City Inspector. Refer to City Standard Detail 1024 A, B & C for approved utility cut pavement repairs.

2.4 Trenchless Pipe Installation

2.4.1 General Requirements

2.4.1.1 – Installations Within the Streets and Easements

Utility crossings within City streets shall be made by trenchless methods unless otherwise approved in advance of the construction by the City Engineer. State maintained streets within the City shall also be crossed using trenchless methods unless otherwise approved in advance by the City and NCDOT. Right-of-way encroachment permits shall be submitted to the City and NCDOT with the proposed plan of improvements.

Where conditions necessitate trenchless pipe installations within existing City utilities easements, all City utilities shall be located, and the contractor shall verify existing pipeline crossing elevations by vacuum excavation or other approved methods prior to construction. The City shall require dedication of additional easement area for future maintenance of City infrastructure where access and entry

points are limited by horizontal and/or vertical impediments.

Notifications of impending construction shall be provided to the City and coordinated with the City Inspector prior to the start of construction in street rights-of-way and easement areas.

Trenchless methods including micro-tunneling, guided boring, boring and jacking, conventional tunneling, horizontal directional drilling or hand tunneling may be approved after thorough evaluation by the City Engineer.

2.4.1.2 – Installations In Other Rights-of-Way

In addition to meeting or exceeding all City requirements, all trenchless crossings shall be approved by and meet the requirements of all controlling legal authorities such as NCDOT, Duke Energy, Norfolk Southern Railway, CSXT, and WSSB.

2.4.2 Materials

2.4.2.1 – Encasement Pipe

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

Pipe shall have machine cut, bevel ends that are perpendicular to the longitudinal axis of the casing.

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.

Table 2-1: Steel Encasement Pipe Diameters*

Outside Diameter (inches)	Minimum Wall Thickness (inches)
12.75	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
66	0.500

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

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.

Encasement pipe shall have the minimum dimensions per Table 2-2 below.

Table 2-2: Minimum Steel Encasement Pipe Diameter Per Carrier Pipe Size

Carrier Pipe Inside Diam. (inches)	Carrier Pipe Outside Bell Diam. Typ. (inches)	Steel Encasement Nominal Diameter (inches)
6	9.19	12.75
8	11.33	16
10	13.56	18
12	15.74	26
14	19.31	26
16	21.43	28
18	23.70	28
20	25.82	30
24	29.88	36
30	36.34	42
36	41.37	48
48	54.71	66

2.4.2.2 – Casing Spacers and End Closures

The carrier pipe shall rest on 304 stainless steel pipe alignment spacers. A minimum of 2 stainless steel spacers per joint shall be required on carrier pipe less than 20-inches. Carrier pipe greater than or equal to 20-inches shall have a third spacer. The 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 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.

All spacers shall be provided with dielectric insulated contacts on the runners such as ultra-high molecular weight polyethylene plastic skids to eliminate friction at pipe installation/removal and prevent transmitting stray current to the carrier pipe in cases where other pipelines, railways, or electric infrastructure in proximity may convey current.

The carrier pipe bells shall not be allowed to contact the interior of the encasement pipe under any circumstances. No blocks or temporary spacers shall be wedged between the carrier pipe and the top of the encasement pipe.

The ends of the encasement pipe shall be sealed using high-tensile strength stainless steel pipe bands/clamps and min. 1/8 thickness EPDM or nitrile casing seals sized for the specific casing and carrier pipes outer diameters. In cases where pipe depth is less than 10 feet and ground water is absent, the City may authorize the use of 8" concrete block (ASTM C90) and high-quality non-shrink grout with two 1-inch weep holes for condensation drainage at the lowest end.

A 2-inch powder coated steel vent pipe shall be provided on the upper end of the casing on all stream and railroad crossings.

2.4.2.3 – Carrier Pipe

All carrier pipe shall be manufacturer-provided restrained joint ductile iron pipe. Push-on pipe with restraining gaskets shall not be allowed.

2.4.3 Installation

2.4.3.1 – General Requirements

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.

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.

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

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

2.4.3.2 – Settlement Surveying

For all trenchless operations of 100 ft or more, the ground surface elevations shall be recorded prior to beginning work.

a) 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.

b) Elevations at each point shall be recorded with an accuracy of 0.01 feet.

Settlement observations shall be made each day until the pipe/casing is fully installed. Readings shall be reported to the City inspector.

In the case of observed settlement, the monitoring points and observation frequency shall be increased as determined by the City Inspector.

2.4.4 External Corrosion Protection

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 Lexington Utilities, Colonial Pipeline, Williams Transco Pipeline, and Piedmont Natural Gas. Other potential sources that may create stray currents that contribute to accelerated pipeline corrosion are high voltage power transmission lines and railroad crossings.

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.

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 the City Engineer. The cathodic protection element of the pipeline design package shall be sealed by Professional Engineer licensed in the State of NC.

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

The City may require specific pipe wrapping or coating materials to prevent pipeline corrosion for pressure sewer mains where corrosive soil characteristics are known or anticipated.

SECTION 3 – SANITARY SEWER

3.1 Gravity Sewer Mains

3.1.1 Design

3.1.1.1 – Sewer Main Location

Sewer mains within the public right of way shall range from 3 to 8 feet of depth to the top of the installed pipe, standard depth. Occasional sewer main depths may reach up to 12 feet in the City's right-of-way, or future City right-of-way, where no other alternatives exist such as at connections to existing outfalls or at crossings of existing utilities pipelines.

Sewer mains outside the right of way may exceed 12 feet of depth as needed for a specific project. New gravity sewers shall not exceed 20 feet of depth as installed unless the City authorizes the excessive depth to provide for planned expansion of the public wastewater system. Gravity sewers shall not be designed or installed with less than 2 feet of cover unless the segment of pipe is part of an approved aerial sewer crossing.

In preparing engineering design plans for sanitary sewer mains, all elevations shall be tied to NC grid system and the benchmark shall be described on the approved plans.

All public sanitary sewer mains shall be installed in a dedicated street right-of-way or in dedicated public sanitary sewer easements. Public mains installed in the City's rights-of-way shall be located at or near the center of pavement. Sewer mains within easements shall be centered within the easement. Mains located within NCDOT rights-of-way shall be placed in accordance with NCDOT standards.

Gravity mains shall be provided utility easements based upon pipe diameters and depths according to Table 3-1 below.

Table 3-1. Standard Easement Width for Sanitary Sewer Mains

Pipe Size (diameter)	Pipe Depth (feet)	Total Easement Width (feet)
8-inch to ≤12-inch	Up to 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	As Approved for a Specific Project

Any Size	Deeper than 20’	As Approved for a Specific Project
8 to 12-inch between buildings[1]	3 to 10-ft	30-ft or greater

[1]Where public sewer mains must traverse between buildings with less than 60 feet of horizontal distance between the closest external building points, the minimum sewer easement width shall be 30 feet and the cover over the sewer main shall be at least 3.0 feet and no more than 10.0 feet from finished grade to top of pipe.

Sewer easements must be centered on the pipe and structures as installed. Dedicated easements for public sewer mains and appurtenances shall be recorded as public sanitary sewer easements (PSSE). City sewer easements shall contain only City utilities unless otherwise approved by an encroachment agreement.

Access easements to allow sufficient means of gaining entrance to proposed public sanitary sewer easements may be required by the Water Resources Department where conventional access from the public right-of-way is limited.

Easements across sloped areas shall be graded uniformly across the slope to no steeper than 20% longitudinal grade. Cross slopes shall not exceed 10% grade.

No permanent structures, utility system structures/appurtenances, equipment, catch basins or other storm drainage structures, retaining walls, embankments, impoundments, or other elements that would restrict access and/or inhibit maintenance operations shall be constructed within a public sanitary sewer easement. Fences may be allowed across easements provided that an encroachment agreement is approved by the City of Lexington and the appropriate access gates have been installed to allow utility maintenance.

Mains paralleling a creek shall be of sufficient depth to allow lateral connections to manholes below the stream bed elevation. The top of the sewer main shall be at least three (3) feet below the stream bed. Restrained joint ductile iron carrier pipe with steel encasement shall be required for all stream crossings. Refer to City Standard Details.

Mains and appurtenances shall not be installed under any part of temporary or permanent water impoundments, including, but not limited to, ponds, erosion control impoundments such as skimmer basins and sediment traps, and stormwater control measures.

The following minimum horizontal separations shall be maintained:

a) 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)

b) 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)

c) 20 feet from other streams, lakes, or impoundments (except as noted below)

d) With approval directly from PERCS, the following separations may be acceptable when water main standards are implemented (ductile iron pressure class pipe required):

- zero horizontal separation/intersections at streams with encased pipe crossings
- 25 feet from private wells
- 50 feet from public water wells
- appurtenances located outside 100-ft radius of wells

Gravity sewer mains shall be deep enough to serve the first-floor elevation of homes and buildings, adjoining properties, and allow for sufficient slope in lateral lines. Public sewer mains and/or dedicated public sanitary sewer easements shall be extended to adjoining properties to allow for expansion of public sewer system.

Sewer mains 10 or more feet deep to the top of the pipe shall be ductile iron (uniform pipe material required from manhole to manhole). The maximum depth of sewer within City roadways shall be 12 feet. The maximum depth of sewer in NCDOT rights-of-way shall be 14 feet, unless otherwise approved due to unavoidable existing conditions. Pipe depths shall not exceed AWWA, DIPRA, UNIBELL, and/or the pipe manufacturers' standards for loading.

Separation Between Sanitary Sewer, Water, Drainage Pipes & Other Utilities:

Sanitary Sewer (gravity & pressure) - when sanitary sewer crosses

- <u>over water main</u>	- <u>under water main</u>
18 inches of vert separation is required and both pipes shall be water main quality DIP (center of each pipe located at crossing)	18 inches of vert separation is required
- <u>over storm drain</u>	- <u>under storm drain</u>
18 inches of vert separation is required; 12 inches vert separation at critical crossings may be authorized if sanitary sewer is DIP	18 inches of vert separation is required; 12 inches vert separation at critical crossings may be authorized if sanitary sewer is DIP
- <u>gravity or pressure sewer</u>	- <u>other linear utilities</u>
12 inches min vert separation at crossings & both shall be DIP	12 inches min vert separation

Sanitary Sewer (gravity & pressure) - when sanitary sewer is parallel to

- water main	- other pipelines & linear utilities
a minimum of 10 feet of horizontal separation shall be maintained	horizontal separation shall be maintained such that excavation of the lower utility shall not compromise the upper utility with a slope of 1:1; minimum of 5 feet horizontal separation (in no case shall storm drains or other utilities be installed parallel to public sewer mains within a public sanitary sewer easement)

Alternatives to minimum pipe separations may only be allowed by the City on a case-by-case basis where existing pipelines, grades, and structures are outside of City and/or developer control. Reduced separations or other modifications shall not be approved for new development areas unless no alternatives exist. In no case shall pipe separations, pipe materials, and pipeline design diverge from the restrictions set forth by NC DEQ.

3.1.1.2 – Main Size, Slope, and Design Criteria

Public gravity mains shall be a minimum of 8-inch diameter. Private gravity mains shall be minimum 6-inch diameter.

Major interceptors shall be designed based on the City land use plan, using the following flow factors. At a minimum, all gravity sewer mains shall be designed and sized to serve the ultimate tributary build-out of the drainage basin.

Residential flow rates:

Land Use	**Minimum Flow Factor**
Single Family Residential*	75 gpd per bedroom
Multi-Family Residential	100 gpd per bedroom

*A 4-bedroom minimum shall be assumed for each home unless verified otherwise.

Non-residential flow rates shall be as established by the North Carolina Department of Environmental Quality (at the time of this Specification, these flow rates are contained in 15A NCAC 02T .0114).

Sanitary sewers shall be sized based on the Manning's Equation with Manning's roughness coefficient "n" = 0.011 or greater. Pipe diameter sizes used in the calculation of Manning's Equation shall be nominal pipe sizes.

Sanitary sewers shall be designed to carry the average daily flow at no more than ½ full and projected peak flow at no more than $^2/_3$ full. The minimum velocity for sanitary sewer lines shall be 2 fps. The ratio of peak to average daily flow shall be 3.0.

The minimum slopes for public sanitary sewers are provided below in Table 3-2.

Table 3-2. Minimum Slopes for Gravity Sewer Mains

Main Size *(diameter, inches)*	Minimum Slope *(feet per 100 feet)*
8	0.50
12	0.36
14	0.29
15	0.27
16	0.25
18	0.21
21	0.17
24	0.14
27	0.13
30	0.11
36	0.09

Min. Velocity =2.0ft/s, Manning's coefficient n = 0.011 used for all computations

The maximum grade for sanitary sewers is 10%. The maximum velocity in sanitary sewers is 15 ft/sec. These limits may only be exceeded if approval is granted by the City on a case-by-case basis where existing pipelines, grades, and structures are outside of City and/or developer control. Pipe grades exceeding 10% shall not be approved for new development areas.

The following provisions apply to all sewers either designed or installed at grades equal to or exceeding 10%:

a) All sewers with a grade of 10% or higher must be ductile iron pipe.

b) High velocity manholes shall be used on all sewers with a grade >10%. High velocity lines cannot tie directly to an existing line and must proceed 180o through the invert into the downstream line.

c) 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:

- Not over 36' center to center on grades from 10% to 25%
- Not over 24' center to center on grades from 25% to 40%
- Not over 16' center to center on grades exceeding 40%

d) The City 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.

The engineer shall submit velocity calculations for all sewers at minimum or maximum pipe grades and as requested by the City.

All transitions in pipe diameter, pipe material, pipe separations, grade changes and all angular deflection changes shall occur only at manholes. For pipe diameter

changes from manhole inlet to outlet, the invert of the larger pipe shall be lowered sufficiently to maintain the same energy gradient.

3.1.1.3 – Construction Involving Existing City Mains:

a) The existing sewer main must remain active and protected during all phases of construction. The contractor must provide a plan for the structural protection of the existing sewer main.

b) A proposed construction sequence and bypass pumping plan must be submitted for any demolition, flow restriction, or modification of a portion of existing sanitary sewer. The plan must be reviewed and approved by the City prior to the work.

3.1.2 Materials

All pipe, fittings, manholes, valves, cast iron frames & lids, sealants, gaskets, restraint systems, and all other materials supplied for construction shall be new materials provided for the specific project. Materials shall be handled & stored properly to prevent damage, and at the time of installation must be free from fading, crazing, deep scratches, cracks, and all other defects.

3.1.2.1 – Ductile Iron Pipe

Ductile Iron Pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 20-ft lengths. A pipe thickness design shall be submitted for external loading in all cases where depths exceed manufacturers recommended depths for type 5 laying conditions.

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

Table 3-3. Ductile Iron Pipe Thickness Class

Pipe Diameter (inches)	Pressure Class (psi)	Nominal Thickness (inches)	Minimum Corresponding Thickness Class
4	350	0.25	51
6	350	0.25	50
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 12-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 except a minimum thickness of 1/8" shall be provided (double thickness).

Restrained joint ductile iron pipe shall be of the boltless restrained joint type unless approved otherwise for a specific application. For installations requiring welded locking rings, the rings shall be factory welded. All proprietary pipe restraint systems shall be approved by Water Resources 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. Push-on pipe with restraining gaskets alone shall not be allowed as restrained pipe installations.

All buried DIP and fittings shall have bituminous coating on the exterior surface in accordance with AWWA C151. All ductile iron pipes shall be marked in conformance with ASTM A-746.

In cases where unusual waste age or other corrosive environments may exist, the City may require specific pipe linings and exterior coatings appropriate for the conditions. All pipe coatings and linings shall be applied by the manufacturer.

3.1.2.2 – Solid Wall PVC Pipe

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 minimum 14 or 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 12-inches in diameter shall be manufactured in accordance with the latest version of ASTM D3034 (SDR 35) or ASTM F679 (SDR 26 with PS115). All solid wall PVC pipe installed at diameters from 18-inches to 24-inches in diameter shall be SDR 26 and manufactured in conformance with ASTM F679, 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. Pipe and fitting gaskets shall be manufacturer-installed and shall comply with ASTM F477. PVC pipe shall be installed in accordance with the requirements of this Specifications manual and ASTM D2321.

All PVC pipe up to and including 12-inches in diameter shall have a maximum Standard Dimension Ratio (SDR) of 35 for depth of installation no shallower than 3-ft of cover from the pipe crown and no deeper than 10-ft measured from the top of the pipe. Regardless of pipe diameter, solid wall PVC pipe shall not be approved for

depths of installation greater than 10-ft measured from finished grade to the top of the pipe. All solid wall PVC pipe shall be marked and certified in conformance with ASTM D3034 or F679.

Table 3-4. SDR 35 PVC Pipe Sizing and Min. Wall Thickness

Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Minimum Wall Thickness (inches)
4	4.215	0.120
6	6.275	0.180
8	8.400	0.240
10	10.500	0.300
12	12.500	0.360

Table 3-5. SDR 26 PVC Pipe Sizing and Min. Wall Thickness

Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Minimum Wall Thickness (inches)
4	4.215	0.162
6	6.275	0.241
8	8.400	0.323
10	10.500	0.404
12	12.500	0.481
18	18.701	0.671
21	22.047	0.791
24	24.803	0.889

PVC pipe shall be the appropriate color signifying sanitary sewer. Each pipe section supplied shall be easily identified and must be plainly and permanently marked with the following data:

- Manufacturer name or trademark
- Date of manufacture
- Pipe classification
- Nominal pipe size
- Dimension ratio/SDR
- Applicable ASTM/ANSI/NSF pipe specifications

3.1.3 Sewer Main Installation

3.1.3.1 – General Requirements

Transitions of pipe material, pipe separations, grade changes and all angular deflection changes shall occur only at manholes.

All sewer mains installed with less than 3 ft of cover or deeper than 10-ft to top of pipe shall be ductile iron pipe.

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 and protected when pipe laying is not in progress to prevent debris from entering the pipe.

All sewer cleanouts shall be protected during construction by installation of tree protection fencing or City approved material. Material will be adequately maintained throughout the construction period to prevent damage and contamination of the sewer system.

All pipes shall be constructed with at least 36 inches of cover below the finished grade. 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.

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 conflicts with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

3.1.3.2 – Embedment Materials

Bedding and embedment material classifications shall be defined as follows:

a) 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, crushed stone, crushed gravel, and crushed shells.

b) 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.

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

d) CLASS IV - Silt, silty clays, and clays, including inorganic clays and silts of medium to high plasticity and liquid limits. Soil Types Of 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 95% maximum dry density as measured by AASHTO method T99 regardless of material. In instances where compliance with compaction requirements is questionable as determined by the City's inspector, testing shall be provided by the Contractor and a reputable licensed Geotechnical Engineer to verify compliance.

The minimum trench width shall be one pipe diameter plus 12 inches on each side of the pipe. 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.

3.1.3.3 – DIP Specific Requirements

Ductile iron pipe 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 trenches. Any fittings or segments of pipe exhibiting damage to pipe, pipe coatings, and/or linings shall not be installed and must be removed from the site.

Pipe shall be installed at laying conditions as specified herein and identified by the plan drawings. Refer to standard detail "Bedding and Backfill for Sanitary Sewer Pipe Installation" (6001).

3.1.3.4 – PVC Specific Requirements

The installation of PVC Pipe shall satisfy the requirements of the manufacturer, and the following, whichever is more restrictive.

The pipe shall be produced with bell and spigot end construction. Joining shall be accomplished with manufacturer's installed rubber gasket. Flexible watertight elastomeric seals in accordance with ASTM D3212-1 may also be used.

Standard Bedding for PVC Gravity Sewers shall consist of minimum of 4-inches of No. 67 stone installed under the pipe and up to the springline (center) of the pipe, Type 5 laying condition. Embedment shall extend to the top of the pipe. The bedding and embedment materials shall be installed from trench wall to trench wall. Bedding and embedment shall be compacted to 95% maximum dry density as measured by AASHTO method T99. Careful attention shall be placed on compacting embedment

under the haunches of the pipe to prevent any potential voids. Refer to Standard Detail 6001.

PVC sewer mains require the installation of a continuous 12-gauge solid copper tracer wire attached to the main, extending from manhole to manhole. Access to the tracer wire shall be provided at each manhole frame. All services regardless of material shall have the same quality solid copper tracer wire connected at the sewer main tracer, running the full extent of the service, and terminating at finished grade at the City's clean out stack.

The maximum allowable deflection after installation shall BE LESS THAN 5% for PVC pipe. Deflection testing of each segment from manhole to manhole may not be started until 30 days following the installation of the last pipe section.

All PVC pipe shall be stored properly to prevent UV damage prior to installation. Any PVC pipe with visible fading caused by UV radiation from sunlight shall be rejected. All PVC pipe shall be free from nicks, scratches, and gouges at the time of installation. Such defects can impact the strength of PVC pipe and all pipes with visible gouges and deformations shall be rejected.

3.1.4 Marking and Tracing Materials and Installation

3.1.4.1 – Marking Tape

Marking tape shall be installed continuously and longitudinally along all sanitary sewer mains for new construction and for any repair or retrofit construction using open trench methods. For service connections, the marking tape shall extend from the main line to the cleanout at the right-of-way/easement. Marking tape shall be installed directly above the center of the pipe and at least 18-inches deep from final grade to a maximum depth of 24-inches below final grade.

The sanitary sewer main marking tape shall be detectable and shall be made of polyethylene (or approved equivalent) and aluminum, minimum 3-inches wide and a minimum of 5 mils thick. The tape shall be green in color and shall be marked with words "CAUTION SEWER LINE BURIED BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

3.1.4.2 – Tracer Wire

All sanitary sewer mains and services shall be installed with a continuous, longitudinal copper tracer wire attached to the pipeline and each manhole and clean out. Wire shall be solid copper minimum 12 AWG with 30 mil HDPE jacketing (green).

Corrosion proof wire connectors shall be installed at all splices and wyes to prevent disconnection of wire and inhibit corrosion. Wires shall be extended to finished grade and must be accessible at all manholes and clean outs.

Each segment of tracer wire for sanitary sewer mains and all services from manhole to manhole shall be tested for continuity by the contractor prior to final backfilling and at the completion of the sanitary sewer construction. It is the Contractor's responsibility to provide the necessary equipment to generate the traceable signal and locate the wire. Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense.

3.2 Manholes

3.2.1 Design

3.2.1.1 – Manhole Location, Siting, and Design

a) The maximum length of sewer main from manhole to manhole shall be 375 feet.

b) Sewer manholes shall be located outside of ditches and flow paths.

c) 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.

d) The minimum drop from invert in to the manhole outlet is 0.20 feet.

e) The maximum flow deflection angle in a manhole shall be dependent upon pipe size as shown in the following table. Sufficient drop shall be provided in the manhole to compensate for energy loss caused by the change of alignment. A minimum drop of 0.25-ft is required for a change of alignment greater than 45-degrees.

Table 3-6. Max. Allowable Flow Deflection

Pipe Size (largest pipe controls)	Maximum Deflection Angle per Manhole
8 to 10 inch diameter	90 degrees
12 to 20 inch diameter	75 degrees
>20-inch diameter	60 degrees

f) Free falls of wastewater flow into the manhole from incoming sewer mains shall not be allowed. In some instances, drops not exceeding 24-inches may be acceptable.

g) Where pipe diameter increases at the outlet of the manhole, 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.

h) Upstream slope changes shall be used whenever possible to avoid the need for drop manholes. If drop manholes are necessary, they shall be constructed with an inside drop connection within a minimum 5-ft. diameter manhole. Outside drop manholes shall only be allowed when unalterable site conditions prevent preferred installations. Drops shall be constructed in accordance with the Standard Details.

i) Manholes shall not be obstructed from view or access. It is illegal to bury or obstruct access to manholes.

j) Manholes shall be restricted to less than 40 inches in height at the cover/rim.

k) All watertight manholes shall be constructed with a flat top (vent pipe installed in slab).

l) When connecting a new sewer main to an existing main where an existing manhole not readily accessible, the connection shall be established with a "Doghouse" type of manhole inserted over the existing main. Refer to Standard Details.

m) When manholes are installed with the roadway, they shall be located either in the center of the roadway or in the center of the travel lane.

n) Manhole covers shall be elevated as follows:

- Roadways: Manholes installed in roadways and road shoulders shall be installed with the cover flush with the top of pavement or finished grade.
- Outside of Roadways: Manholes installed outside of roadways shall be elevated at least 18 inches above the surface grade unless otherwise noted.
- Wooded Outfalls: All manholes installed in wooded, forested or brushy areas shall be elevated at least 18 inches above the surface elevation.
- 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.
- Manholes installed within the floodplain (1% chance zone) and flood prone areas shall have rim elevations a minimum of 2 feet above the base flood elevation (BFE), or 2 feet above the estimated BFE approved by the City where no BFE has been established on the Flood Insurance Rate Map.

3.2.1.2 – <u>Manhole Sizing</u>

a) Manholes shall be sized as shown in the following table. The next larger size shall be required if the pipe size, depth, drop connection 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.

Table 3-7. Manhole Sizing

Manhole Size *(diam.)*	Maximum Allowable Pipe Size *(diam.)*	Maximum Depth of Cover *(invert to surface)*	Maximum Depth with Extended Base* *(invert to surface)*	Frame & Cover Size - outside of paved areas *(diam.)*	Maximum Sewer Main Connections *(quantity)*
4-ft	8-16 inches	12-ft[1]	25-ft	24-inches	3
5-ft	18-24 inches	14-ft	35-ft	24-inches	2[2]
6-ft	27-42 inches	16-ft	35-ft	36-inches	2[2]
8-ft	48 inches	18-ft	35-ft	36-inches	2[2]
10-ft	54 inches	20-ft	35-ft	36-inches	2[2]

[1]Depths beyond 12-ft in roadways may require installation of a 5-ft diameter manhole with extended base.

[2]Additional smaller diameter connections that meet the spacing requirements in Subsection 3.2.3, Installation, below may be approved if deemed appropriate.

[*]Additional depths necessary to facilitate planned public wastewater expansion may be considered by the City.

b) Manhole transitions: 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 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.

3.2.2 Materials

3.2.2.1 – 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. 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 for water-tight applications (rim less than two feet above B.F.E.) and for 6-ft and larger diameter outfall 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. Minimum manhole base thickness shall be six (6) inches and shall increase to meet soil and ground water loads/pressures and buoyancy forces.

c) The standard joint shall be sealed with an approved rubber o-ring gasket or butyl rubber sealant. Joints shall be wrapped with butyl adhesive tape a minimum of six (6) inches wide. All lift holes must be plugged with non-shrink grout after installation.

d) All standard manholes shall rest on a minimum of six (6) inches of #57 stone. Flat top manholes require a minimum of eight (8) inches of #57 stone below the manhole base.

e) Sewer mains shall enter and exit radially through the manhole. Inverts shall be cast in manhole sections by the manufacturer to match the approved design. Inverts shall be 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 flexible connectors or manhole boots shall be provided in conformance with ASTM C923. Stainless steel rings, clamps, and tighteners shall be installed to form a watertight seal at the manhole and at the connecting sewer pipe.

f) 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 3 days have elapsed since casting.

g) Manhole flat top slab covers for outfall manholes 6-ft diameter and greater shall be designed and manufactured for H-20 loading. In no case shall slab covers be less than six (6) thick.

h) Manhole benches shall slope upwards a minimum of ¼ inch/ft. 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.

3.2.2.2 – Manhole Frame and Cover Materials

a) Manhole Frames and Covers shall be made of Class 35B gray iron in conformance with ASTM A48 and shall have "Sanitary Sewer" cast into the cover as indicated in Standard Details. Frame and cover shall be stamped with manufacturer and model number. All manhole frames and

covers shall be manufactured in the USA from domestic iron unless otherwise approved. Frames and covers installed within NC DOT rights-of-way shall meet City of Lexington and NC DOT standards.

b) Types:

- Type 1 Manhole Frames and Covers for Paved Areas: For all installations in pavement, roadway shoulders, or at grade within well-maintained areas, use Type 1 frame and cover. In pavement, place asphalt and properly compact around the frame exterior to ensure contact and seal to prevent water infiltration. Type 1 frames shall be 7-1/2" height with minimum clear opening of 22". Manhole covers shall be 23½-inch diameter and have 2 (two) one-inch vent holes and (one) 1-inch radius non-penetrating pick holes. Each frame within the road right-of-way and/or flow path shall have a removable stainless-steel insert to prevent inflow. Type 1 covers shall be H20 traffic rated. See Standard Detail.

- Type 2 Manhole Frames and Covers outside of Paved Areas: For installation outside of pavement and in outfall areas. Type 2 frames and covers shall have the same vent and pick hole(s) and be of the same minimum dimensions and weights as Type 1 above. The frame shall be secured to the cone with four stainless steel anchors and nuts. Covers shall be bolted to frames with four stainless steel bolts.

  Rim elevation of outfall manholes shall be at least 18" above finished grade. The Type 2 frame and cover assembly shall be at least 24 inches above the base flood elevation in the floodplain (1% chance zone) or other flood prone areas. Where the rim elevation would be 40 or more inches above grade to achieve minimum height above base flood elevation, provide Flat Top Manhole (vented) with Type 3 frame and cover per below.

- Type 3 Manhole Frames and Covers for Flat Top Manholes: All watertight vented manholes shall be flat top manholes with Type 3 frame and cover. Minimum frame height shall be 4". The Type 3 cover shall be solid and be minimum 23½-inch diameter. See Standard Detail.

  The frame shall be formed into the slab or made watertight at the precast slab opening with bituminous sealant and secured with four stainless steel anchors and nuts. The cover shall be bolted to frame with four stainless steel bolts. The slab opening shall be eccentric and the top of the slab ranging from 18" and 38" above finished grade.

  The frame and cover assembly shall have a neoprene gasket for a watertight seal for areas within the floodplain or other areas subject to flooding. All watertight manholes shall be vented with the vent opening installed a minimum of 24" above the base flood elevation, or the estimated base flood elevation approved by the City.

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.

d) All manhole frames and covers shall have a manufacturer-applied bituminous and/or epoxy coating to prevent corrosion for the specific application as approved by the City.

3.2.3 Installation

3.2.3.1 – General Requirements

a) The invert(s) in of the lowest installed manhole(s) of a sanitary sewer line extension under construction shall be plugged to prevent the passage of groundwater, runoff, and sediment into the public sanitary sewer system. All water upstream of the plug shall be pumped out of the sanitary sewer line and all sediment and solids shall be removed and properly disposed of by the Contractor. The plug will not be removed until the line has been inspected by City to ensure that all possible points of inflow or infiltration have been eliminated. Failure to meet these requirements will be deemed a violation of the Sewer Use Ordinance for which fines shall be assessed according to the magnitude of the violation.

b) 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 connectors or boots.

For new manholes, there shall be a minimum of 9-inches or ½ 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 ½ the OD of the existing pipe, whichever is greater, between the pipe hole openings.

c) All external manhole joints shall be sealed and wrapped with six (6) inch wide butyl tape or an approved equal.

3.2.3.2 – Manholes Subject to Inundation

a) Manholes subject to flooding shall be watertight and vented 24 inches above the base flood elevation, or 24 inches above the estimated base flood elevation approved by the City.

b) The exterior of all manholes within the floodplain and in wetland areas shall receive an exterior coating of an approved bitumastic epoxy at 40 mils to prevent weepage or attack by acidic soils.

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

3.2.3.3 – Manholes Located on Large Collector Mains

The City 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. An approved polymer concrete manhole may be installed in lieu of epoxy coating the manholes.

3.2.3.4 – 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 cases where acute waste age or other highly corrosive conditions are anticipated, downstream manholes within 1000-lf of the receiver manhole shall require epoxy coating.

3.2.3.5 – Epoxy Coating

Coating manufacturers and corresponding installers shall be reviewed and approved by the City prior to applications. Submittals for materials shall be detailed and include product performance consistent with the proposed use.

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.

3.3 Service Connections

3.3.1 Design

3.3.1.1 – General Requirements

a) Direct sewer service taps shall not be allowed on sewer interceptor or outfall mains fifteen (15) inches or greater, except by manhole connection.

b) All residential subdivision lots shall be served by gravity unless otherwise approved. If a pump is required for a given property, it shall be privately maintained and must pump to a gravity service connection on the City's gravity main.

c) 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.

d) Cleanouts are required on all services. Clean outs shall be located at the right of way line or edge of easement. All cleanouts shall extend to finished grade with a four (4) inch ferrule and three (3) inch brass plug. Sewer cleanouts shall not be installed in paved areas. Refer to Standard Detail 6003.

e) All 6-inch and 8-inch service connections shall be into a manhole.

f) 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. For 6-ft diameter and larger manholes no service is allowed in the reduced diameter riser sections of the manhole.

g) 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 may be allowable with City inspection and approved materials. Taps shall be at the 10 or 2 o'clock position and shall not be top taps.

h) Service connections to mains at depths of 10-ft or more shall be DIP and shall be authorized when no alternatives exist.

i) 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 at the service connection to the public main.

3.3.2 Materials

3.3.2.1 – Pipe Materials

a) PVC Pipe shall be SDR35 or greater, supplied in minimum 18-ft lengths. PVC pipe shall be manufactured with a cell classification of 12454 in conformance with ASTM D1784. Pipes shall be manufactured to dimensional tolerances as specified in ASTM D1785 and rated for service conditions up to temperatures of 140-degrees Fahrenheit.

   PVC pipe for sewer services shall require minimum 4-inches of stone bedding extended from the trench bottom to the pipe springline. If rock or unstable material is encountered at the trench bottom, 6 or more inches of additional material shall be removed and replaced with washed stone tamped to min. 95% Standard Proctor density.

b) Ductile Iron Pipe shall be used for sanitary sewer services with less than 3 feet of cover or more than 10 feet of cover and when separations with other pipelines measure less than 12” vertically at crossings. 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.

DIP Service Pipe Sizing Nominal Pipe Diameter (inches)	Outside Diameter (inches)	Inside Diameter (inches)	Thickness (inches)
4	4.80	4.30	0.25
6	6.90	6.40	0.25

3.3.2.2 – Sewer Service Fittings, New Construction

Sewer services on the sewer main shall be connected to the main at in-line wye fittings. The service branch shall be 4-inches in diameter.

a) DIP Main with DIP Service: In-line wye fittings for ductile iron main lines shall be joined with ductile iron service lines, standard push-on ductile iron, with mechanical joint fittings as specified herein. All fitting sizes shall

conform to AWWA C153. Wye fittings through 12-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 mains larger than 12-inches in diameter shall be provided with a City approved coating and lining according to the specific application and quality of wastewater received or anticipated.

b) PVC Main with PVC Service: For PVC sewer mains to be joined with PVC service lines, heavy duty gasketed PVC in-line wye fittings (same material as sewer main) shall be provided. Typical SDR 35 and SDR 26 PVC fittings and pipe shall be provided up to and include the clean out stack and tail pipe.

c) PVC Main with DIP Service: PVC main line wyes shall be provided when the service line is ductile iron. A gasketed PVC transition adapter fitting manufactured for the specific main line wye and service pipe diameters shall connect the wye service branch to the DIP service line and provide a smooth flow way from the main line through the fitting. In cases where 4-inch SDR 35 or SDR 26 transition fittings are unavailable, a transition coupling (Romac 501 or approved equal) may be used to connect 4-inch SDR 35 or SDR 26 to the ductile iron service.

All services shall be installed with solid copper tracer wire from the sewer main to the City's cleanout.

3.3.2.3 – Service Saddle Connections, Existing Mains

PVC service saddles shall be of the same material as the main and shall be solvent welded and fastened with double stainless-steel bands.

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.

3.3.3 Installation

3.3.3.1 – 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 on a public street requires a separate tap to a public sewer.

c) All service lines with less than 3-ft of cover or deeper than 10-ft shall be made of ductile iron pipe.

d) 4-inch lines shall have a minimum slope of 1.0-ft/100 feet and 6-inch lines shall have a minimum slope of 0.60-ft/100 feet.

e) All service connections to existing sanitary sewer mains shall be made by City unless otherwise approved by the City in advance of construction. Right-of-way encroachment(s) must be approved in writing by the right-of-way or easement owner prior to commencement of work.

f) Service connections to new mains may be made by the Contractor but shall include the use of wye (not tee) connections. Saddle taps onto new lines shall not be allowed.

g) Saddle taps into existing 8" 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.

h) Service connections shall be made using an approved sewer saddle when the existing sewer line is 8" or 10" 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.

i) Service connections to all food service establishments shall require a City-approved grease interceptor. Grease interceptors shall not be located within the public right-of-way or within public easements.

3.4 Aerial Crossings

3.4.1 General Requirements

Aerial crossings shall only be utilized in cases where buried crossings are prohibited due to stream crossing depth limitations, compliance with stream buffer standards, minimizing impacts to wetlands, preventing excessive depth of installation, or as otherwise directed by the City.

3.4.2 Design

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 and designed by a licensed NC Professional Engineer with foundations and structural components, including concrete reinforcements, designed by a licensed Structural Engineer. Aerial crossings are subject to City floodplain regulations and stream buffer restrictions.

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 subbase scour and 7) factors of safety for unanticipated loads such as trees falling across the aerial crossing. At locations inundated by the 100-year design storm shall include foundation anchor design.

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 and subbase stability. If the soil conditions fail to meet the specified bearing capacity and stability 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. The carrier pipe shall be epoxy-lined DIP installed in a casing meeting the requirements of the standard specifications. The carrier pipe shall be epoxy-lined DIP between the upstream and downstream manholes. The entire crossing including piers, reinforcement, foundation, truss and/or beam supports, pipe anchor straps, and pipe thickness design shall be provided by a licensed NC Structural Engineer. Spanned pipe crossings shall be designed such that all flanges and exterior pipe connections are located above the 25-year flood elevation.

Each pier exposed to the 100-year design storm shall be protected by the appropriately size rip rap and extends 6-feet beyond the pier radially. Stream bank slopes beneath the aerial crossing shall be protected by appropriately sized rip rap and extend a minimum of 6-feet beyond the centerline of the pipe up and downstream. Rip rap shall not be allowed in the stream.

3.4.3 Materials

3.4.3.1 – Pipe

a) Ductile Iron Pipe:

Ductile iron pipe for aerial crossings shall be flanged pipe, minimum pressure class 250. Refer to Subsection 3.1.2.1 above.

b) Steel Pipe:

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 250-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.

3.4.4 Installation

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

Pipe shall be secured to each pier with minimum1/4-inch by 2-inch width steel straps fastened to a minimum 4; ½-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. All pipe securing methods shall be designed by a NC licensed Professional Engineer.

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 City 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 or potential scour elevation, the footing shall be drilled and connected with dowels into the rock layer.

3.5 Gravity Main and Manhole Testing

3.5.1 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 Water Resources Department. The Contractor shall reimburse the City for all water used for construction at current inside utility rates.

3.5.2 Sewer Main and Service Connection Testing

3.5.2.1 – Inspection and Testing

a) All materials used must be approved by the City Inspector prior to installation. Rejected materials shall be immediately removed from the site.

b) Gravity sanitary sewer lines shall be clean and free from obstructions and shall be visually inspected by lamping and camera inspection from manhole to manhole. Lines which do not exhibit a true line and grade, or which have structural defects shall be repaired. Sanitary sewer service connections and tracer wire connectivity shall be inspected prior to backfilling.

3.5.2.2 – 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.

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 4.0 psig. The air pressure shall then be allowed to stabilize for a minimum of 2 minutes at no less than 3.5 psig (plus groundwater pressure, if any). When the pressure reaches 3.5, the time required for the pressure to drop 1.0 psi will be observed and recorded. The line shall be "acceptable" if the pressure does not drop more than 1.0 psi in the time prescribed for the test in the Sanitary Sewer Air Test table found in the Standard Details. An abbreviated version of the air test table is shown below.

Table 3-8. ASTM F1417 Low Pressure Air Test

Pipe Diameter, in.	Minimum Time, min:s	Length for Minimum Time, ft	Time for Longer Length, s	Specification Time for Length (L) Shown, min:s							
				100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
4	3:46	597	0.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	0.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.520 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

b) If the section fails to meet these requirements, the source of leakage shall be repaired and the pipe section re-inspected.

The City inspector may require that an infiltration test be performed that shall not exceed 100 GPD/inch/mile.

3.5.2.3 – 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 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 City Inspector’s approval.

b) For flexible pipes (SDR 35 To 12”) & (SDR 26 from 18” To 24”), the following or the manufacturer’s recommendations, whichever is more restrictive, shall apply:

Table 3-9. Deflection Testing for Flexible Pipe

Nominal PVC Pipe Diameter (inches)	Average Inside Pipe Diameter (inches)	5% Deflection Mandrel Diameter (inches)	Length of Mandrel (inches)	Minimum Fins Included with Mandrel
8	7.891	7.20	10	9
10	9.864	9.00	10	9
12	11.737	10.70	12	9
18	17.177	15.68	18	9
21	20.249	18.50	24	9
24	22.781	20.80	24	9

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.

3.5.2.4 – Video Assessment and Cleaning

a) As a final measure required for acceptance, the Contractor shall clean and televise all newly installed sewer mains and laterals from the demarcation cleanout to the main and shall be clearly identifiable as to the lot of building serviced prior to acceptance by City. The Contractor shall televise the sewer main, and all lateral connections installed from the upstream to downstream manhole with no reverse setups or cutaways. Throughout shooting, the camera shall be panned and tilted for a complete view of the main and laterals. 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 City inspector on a City approved media type. The City shall not be responsible for purchasing additional software necessary to view the submission.

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 from manhole to manhole.

The distance counter shall be calibrated before shooting the inspection video.

c) The Contractor shall clean the sewer mains and laterals ahead of video inspection with a high-velocity water jet. All construction debris shall be collected in the downstream manhole and shall not be released into the sewer system.

The video inspection shall take place immediately following cleaning operations. The City Inspector shall be present throughout the cleaning and televising of the sewer mains and laterals to verify that the video work complies with the Specifications.

Prior to providing the inspection media to City's inspector the Contractor shall label the submission with the following information:

- Name of the Project/Development
- Name and contact information of responsible party
- Date of televising
- Manhole identification as shown on the plans

3.5.2.5 – Tracer Wire Testing

Testing of the tracer wire shall be performed by the Contractor at the completion of the project to assure continuity and functionality. It is the Contractor's responsibility to provide the necessary equipment to complete testing. Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense and shall be retested.

3.5.3 Manhole Testing

3.5.3.1 – Vacuum Testing

a) All newly installed manholes shall pass a vacuum test. 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 City inspector shall be present and witness all passing vacuum tests.

d) The following vacuum testing criteria shall apply for compliance with the testing procedure.

- A vacuum of 10-inches of mercury shall be drawn with an approved vacuum testing unit.
- The testing time shall not be measured until after the vacuum pump has been shut off.

- 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.

Table 3-10. Manhole Vacuum Testing

Depth (feet)	MH Diameter (inches)		
	48	60	72
	Time (seconds)		
8	60	75	90
10	60	75	90
11	75	90	105
15	75	90	105
16	90	105	120
20*	90	105	120

* >20 ft depth shall be as specified by the City Inspector

3.5.3.2 – 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.

3.6 Force Mains

3.6.1 General Requirements

These Specifications apply to all force mains that are to be owned, operated, and maintained by the City and any private wastewater collection & pumping systems approved to discharge to the City's wastewater collection system. Design of individual pumping systems and pressure lines and associated facilities to serve a single residence or business is not covered by these Specifications, and the applicant should look for guidance from other agencies, such as the City of Lexington Business & Community Development Office (building permits), NC Office of State Fire Marshal (NC Plumbing Code) and NC Division of Water Quality (permitted, or deemed permitted, residential wastewater systems).

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". The standards and specifications hereunder that are more restrictive than requirements of the NC Minimum Design Criteria shall apply.

Private connections to City of Lexington force mains shall be prohibited unless specifically approved in advance as part of the City's economic development program or a future public collection system expansion. All other wastewater force mains shall extend to the nearest gravity sewer or wastewater pump station that has sufficient long-term capacity for the anticipated wastewater discharge.

3.6.2 Design

3.6.2.1 – Minimum Cover

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

3.6.2.2 – Horizontal and Vertical Separations

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.

For depths greater than 8 feet, pipelines and other linear utilities shall be located with a minimum horizontal separation distance such that excavation of the lower utility shall not compromise the upper utility with a slope of 1:1 (horizontal to vertical separation ratio). In no case shall storm drains or other utilities be installed parallel to public sewer mains within a public sanitary sewer easement.

3.6.2.3 – Location within Right-of-Way or Easements

Public force mains shall be installed in a dedicated public right-of-way with sufficient space for the pipeline installation and future maintenance or centered within a dedicated public sanitary sewer easement. Refer to minimum easement width requirements in table below.

Table 3-11. Easement Widths for Force Mains

Pipe Size (diameter)	Pipe Depth (feet)	Min. Easement Width (feet)
4-inch to 12-inch	≤ 12.5-ft	25-ft
4-inch to 12-inch	>12.5-ft – 15-ft	35-ft
16 to 24-inch	≤ 15-ft	35-ft
4-inch to 24-inch	>15-ft to 17.5-ft	40-ft
4-inch to 24-inch	>17.5-ft to 20-ft	60-ft
Greater than 24-inch	Any Depth	As approved for a specific project
Any Size	> 20-ft	As approved for a specific project

Dedicated easements for force mains and appurtenances shall be recorded as "Public Sanitary Sewer Easement". City force main easements shall contain only City utilities unless otherwise approved by the development plan or an encroachment agreement.

Access easements to allow sufficient means of gaining entrance to proposed Public Sanitary Sewer Easements shall be required where conventional access from the public right-of-way is limited or infeasible.

Wastewater force main discharge manholes and air release locations that require odor control shall be provided with sufficient easement area to accommodate the odor control systems, 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 materials storage and routine maintenance operations, such as refilling media, chemical deliveries, equipment replacement.

3.6.2.4 – Horizontal Alignment and Location

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

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, runs exceeding 3000-ft on all force mains. 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.

All air/vacuum release valves, gate/plug valves, and other structures shall be installed at or near the center of the dedicated easement. Appurtenances that have moving or operating parts and require maintenance and routine access shall be installed with an approved manhole. Tracer wire access points shall be marked with and shall be accessible at grade within a cast iron valve box.

3.6.2.5 – Design Flow

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. 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 resuspend any settled solids.

3.6.2.6 – 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 Engineer of Record.

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 either mechanical joint pipe with approved wedge action retainer glands (for the specified distance) or reaction blocking at fittings as an alternative. All joint restraint that includes the means of restraint only 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.

3.6.2.7 – Pigging or Emergency Connections:

If required by the City for a specific project, force mains shall be constructed with a pigging/emergency connection located within 50-ft of the pump station valve vault.

3.6.2.8 – 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 and/or encroachment agreement must be reviewed and approved in writing by the City of Lexington prior to any associated work.

3.6.2.9 – Separation Requirements:

Separation Between Sanitary Sewer, Water, Drainage Pipes & Other Utilities:

Sanitary Sewer (gravity & pressure) - when sanitary sewer crosses

- over water main	- under water main
18 inches of vert separation is required and both pipes shall be water main quality DIP (center of each pipe located at crossing)	18 inches of vert separation is required
- over storm drain	- under storm drain
18 inches of vert separation is required; 12 inches vert separation at critical crossings may be authorized if sanitary sewer is DIP	18 inches of vert separation is required; 12 inches vert separation at critical crossings may be authorized if sanitary sewer is DIP

- gravity or pressure sewer	- other linear utilities
12 inches min vert separation at crossings & both shall be DIP	12 inches min vert separation

Sanitary Sewer (gravity & pressure) - when sanitary sewer is parallel to

- water main	- other pipelines & linear utilities
a minimum of 10 feet of horizontal separation shall be maintained	horizontal separation shall be maintained such that excavation of the lower utility shall not compromise the upper utility with a slope of 1:1 horizontal to vertical spacing ratio (in no case shall storm drains or other utilities be installed parallel to public sewer mains within a public sanitary sewer easement)

Alternatives to minimum pipe separations may only be allowed by the City on a case-by-case basis where existing pipelines, grades, and structures are outside of City and/or developer control. Reduced separations or other modifications shall not be approved for new development areas unless no alternatives exist. In no case shall pipe separations, pipe materials, and pipeline design diverge from the restrictions set forth by NC DEQ.

3.6.2.10 – Stream Crossings

Steel encasement and restrained joint ductile iron pipe shall be required. The top of the force main shall be at least three feet below the stream bed. Refer to Standard Details.

Sewer force mains shall not be installed under any part of water impoundments, including temporary impoundments such as skimmer basins and sediment traps.

The following minimum horizontal separations shall be maintained:

a) 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)

b) 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)

c) 20 feet from other streams, lakes, or impoundments (except as noted below)

d) With approval directly from PERCS, the following separations may be acceptable (water main/pressure class standards are implemented):

   - zero horizontal separation/intersections at streams with encased pipe crossings

- 25 feet from private wells
- 50 feet from public water wells
- appurtenances located outside 100-ft radius of wells

3.6.3 Materials

3.6.3.1 – Pipe Materials

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

b) All force mains shall be constructed of ductile iron pipe. Ductile iron pipe and pipe joints shall meet public water main standards. Ductile iron pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 20-ft lengths. All ductile iron pipe shall be marked in conformance with ASTM A-746.

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.

Table 3-12. Pressure Class, Max. Depth & Laying Condition For Ductile Iron Force Main

Diameter	Laying Condition	Pressure Class	Maximum Depth of Cover
4-8 -inch	type 1	350 psi	3-14 feet
4-8 -inch	type 4	350 psi	14-20 feet
12 -inch	type 1	350 psi	3-10 feet
12 -inch	type 4	350 psi	10-14 feet
12 -inch	type 5	350 psi	14-20 feet
16-24 -inch	type 4	250 psi	3-14 feet
16-24 -inch	type 5	250 psi	14-20 feet

c) All ductile iron wastewater force mains and fittings for sewer construction shall receive an appropriate pipe lining and coating approved by the manufacturer for the specific application. At minimum, force mains conveying residential wastewater shall be cement mortar lined with a seal coat of bituminous material, in accordance with AWWA C104. Special linings and coatings which inhibit and prevent pipeline degradation shall be applied by the manufacturer for all pipelines conveying aged/septic, commercial, and industrial wastewaters. Such materials must be tested and certified by the manufacturer for the conditions and must be approved by the City.

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 City. 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 City'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.

f) All proprietary pipe restraint systems shall be approved by City 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.

3.6.3.2 – Manhole Materials

a) All sewer force main manholes shall be installed according to the City's gravity sewer manhole specifications, Section 3.2 above, when design and installation criteria are not otherwise covered in this section.

b) Force Main Manhole 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 (80 mils minimum) of coating with a manufacturer approved set time of 6-hours or less.

- Coating manufacturers and corresponding installers shall be reviewed and approved by the City prior to applications. Submittals for materials shall be detailed and include product performance consistent with these specifications.

- 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.

- 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.

3.6.3.3 – Force Main Receiving 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 Wastewater Collection Systems above. 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.

3.6.3.4 – 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.

3.6.4 Installation

3.6.4.1 – General Requirements

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 shall be handled with mechanical equipment or in such a manner to always protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

Pipe trench excavation and backfilling shall be performed in accordance with these Specifications.

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.

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 provided in the City-approved drawings. Reaction blocking for all fittings or components subject to hydrostatic thrust shall be securely anchored using poured-in-place concrete thrust blocks and/or other measures identified on construction drawings. No concrete shall interfere with the removal of fittings. Material for reaction blocking shall be 3000 psi concrete.

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.

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.

3.6.4.2 – Embedment Materials

Bedding and embedment material classifications shall be defined as follows:

a) 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.

b) 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.

c) 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.

d) 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. The Contractor shall secure services of a reputable NC-licensed Geotechnical Engineer to verify compliance with compaction requirements in locations where compaction results warrant substantiation as identified by the City inspector.

The minimum trench width shall be one pipe diameter plus 12 inches on each side of the pipe.

Refer to Installation Below the Water Table section below for any area where the pipe will be installed below existing or future ground water levels or where the trench could be subject to inundation.

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.

3.6.4.3 – Laying Conditions

Refer to Utility Trenches, Section 2.2, Pipe Laying and Backfilling, above.

3.6.4.4 – Installation Below the Water Table

In cases where no other alternatives exist, installations below the water table shall require a single layer of approved engineering fabric 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.

3.6.4.5 – 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 line conflicts with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

3.6.5 Marking and Tracing Materials and Installation

3.6.5.1 – Marking Tape

Marking tape shall be installed continuously and longitudinally along all 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 18-inches deep from final grade to a maximum depth of 24-inches below final grade.

The marking tape shall be detectable and shall be made of polyethylene (or approved equivalent) and aluminum, minimum 3-inches wide and a minimum of 5 mils thick. The tape shall be green in color and shall be marked with words "CAUTION: BURIED FORCE MAIN LINE BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

3.6.5.2 – Tracer Wire

All force mains shall be installed with a continuous, longitudinal copper tracer wire attached to the pipeline, each air/ vacuum release manhole, valve boxes and all tracer wire access points. Wire shall be solid copper minimum 12 AWG with 30 mil HDPE jacketing (green).

Corrosion proof wire connectors shall be installed at all splices to prevent disconnection of wire and inhibit corrosion. Wires shall be extended to final grade and must be accessible at all air/vacuum release manholes, tracer wire access points and valve boxes.

Each segment of tracer wire shall be tested for continuity by the contractor prior to final backfilling and at the completion of the construction. It is the Contractor's responsibility to provide the necessary equipment to generate the electrical signal and locate the wire. Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense.

3.6.6 Valves and Appurtenances

3.6.6.1 – General

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

3.6.6.2 – Check Valves

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.

3.6.6.3 – Resilient Wedge Gate Valves

Gate valves with 2 -inch operating nut shall be open- left, non-rising stem, and shall be tight-closing. The operating nut shall be marked indicating the direction to open with the word "OPEN" and an arrow.

Valves shall fully comply with AWWA Standard C509 or C515 and provide a full waterway. Waterway shall be smooth and free of cavities, pockets, depressions, and other restrictions in the seat area to prevent the build-up of solids.

Valves shall have an iron body, bonnet, and O-ring plate. The wedge shall be fully encapsulated with rubber that is permanently bonded to the wedge per ASTM D249. Main line valves shall be provided with typical mechanical joint end connections and restrained with wedge action retainer glands on both ends of the valve assembly.

Valves shall be supplied with O-ring seals at all pressure retaining joints. No flat gaskets shall be permitted. All non-rising stem valves shall have two O-rings located above thrust collar and one below. The upper O-rings shall be replaceable with valve fully opened and subjected to full pressure. Valves shall have a low torque thrust bearing located both above and below the stem collar to reduce friction during operation.

Valve stem shall be cast copper-alloy (high-strength, non-corrosive) with integral collars in full compliance with AWWA C509 or C515. Valves shall be approved by the manufacturer for wastewater and corrosive applications. All stems shall operate with copper alloy stem nuts independent of the wedge.

All valves shall be coated with a corrosion resistant fusion bonded epoxy coating, conforming to AWWA C550, which protects the interior and the exterior of the valve.

Valves must be rated at 200 psi or greater and pass hydrostatic testing to 500 psi by the manufacturer. All valves shall provide tight shutoff against flow. With the valve in the closed position, the valve shall be bubble tight at rated pressure. Each valve shall have the manufacturer's name, the pressure rating, country of origin and the year in which it was manufactured cast on the body. Prior to shipment from the factory, each valve shall be hydrostatically pressure tested according to the requirements of AWWA C509.

Gate valves smaller that 16 inches shall be installed with stem and 2 inch operating nut within a cast iron valve box. Operating nut shall be accessible at no more than 30" below final grade. Valve box shall be centered on valve stem.

All valves 16 -inch diameter and larger shall be provided in an epoxy coated manhole with worm gear actuators and 2-inch nut, or hand wheel, operable from manhole frame at 90º to the rim.

3.6.6.4 – Plug Valves

If approved for use, 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 within 30" of final grade. Plug valves 12 inches and smaller shall be installed with operating nut accessible through a cast iron valve box centered on the valve stem. Plug valves greater than 12-inches shall be installed such that the actuator and gearing is accessible in a manhole as shown in the City 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.

3.6.6.5 – Pipe Fittings

Fittings shall be mechanical joint ductile iron designed and manufactured as per AWWA C110. Sizes of fittings up to and including 12 inch shall be designed for an internal pressure of 250 psi; larger size fittings shall be designed for an internal pressure of 150 psi.

3.6.6.6 – Valve Box and Manhole Covers:

Force main gate valves and plug valves 12 inches and smaller, shall have valve stem and operating nut installed within a cast iron valve box. Cast iron valve box covers and manhole lids shall have the word "Sewer" cast into them.

3.6.6.7 – Combination air/vacuum valves:

Comb. Air/vacuum 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 four (4) inches in diameter or larger and at other locations, such as major changes in slope, as directed by City. 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 City 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 City.

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 City 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 City Standard Details.

c) Combination Air Valve Assembly Installation:

- 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.

- 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.

- 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 gate valve. In all cases the isolation valve shall be sized equal to the combination air valve.

3.6.6.8 – Pigging Stations

If required by the City, force mains shall be constructed with a pigging 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.

3.6.6.9 – Emergency Connection Assembly:

Some wastewater force mains may require an emergency connection assembly in more remote locations. The capacity, criticality and proximity to a downstream manhole will be important factors to determine the need for this connection. The decision for the emergency connection shall be at the sole discretion of the City's wastewater collection system Operator in Responsible Charge.

3.6.6.10 – Force Main Odor Control System:

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 the City. 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.

3.7 Force Main Inspections and Testing

3.7.1 Inspections

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 City) by the City Inspector prior to installation. Non-conforming materials or equipment shall be immediately removed from the site.

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

3.7.2 Testing

3.7.2.1 – General

a) The Contractor shall furnish all materials, labor, and equipment to perform all testing. Water for testing purposes may be obtained from City. The Contractor shall reimburse City 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 City's sanitary sewer system after proper coordination with Water Resources.

c) All on-site testing and/or installation verification shall be performed in the presence of the City Inspector.

3.7.2.2 – Hydrostatic 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.

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

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

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.

3.7.2.3 – Tracer Wire Testing

a) Testing of the tracer wire shall be performed by the Contractor at the completion of the project to assure continuity and functionality. It is the Contractor's responsibility to provide the necessary equipment to complete testing.

b) Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense and shall be retested.

3.8 Sewer Main Repairs and Modifications

3.8.1 Sewer Main Pipe Repairs

The Water Resources Department and City Inspector shall be notified of damage made to public sewer infrastructure at the time the damage occurs. City Inspection of the repairs shall be required. The City may authorize repairs to begin prior to arrival of the City Inspector if emergency conditions warrant immediate repair.

3.8.1.1 – Vitrified Clay, ABS, or Asbestos Cement Pipe

Replace damaged section with D.I.P. and install an approved solid body transition coupler at each end of repair.

3.8.1.2 – PVC or PVC Truss Pipe

Replace damaged section with PVC Pipe and install an approved solid body coupler at each end of repair.

3.8.1.3 – Ductile Iron (Gravity Mains)

Replace damaged section with DIP and install solid body coupler at each end of repair.

3.8.1.4 – Ductile Iron (Pressure Mains)

Replace damaged section with pressure-rated solid body coupler at each end of repair or install an approved repair clamp at small leaks (appropriate pressure-rated fittings for pressure range) used as directed by the City.

3.8.2 Installation

All repairs to damaged sanitary sewer lines shall be bedded with min. 6-inches of #67 washed stone and compacted to a minimum of 95% Standard Proctor density before installing the new joint of pipe. Washed stone shall be installed to springline of pipe or above. Embedment and backfill shall be placed as required in Section 2.2, Pipe Laying and Backfilling, above.

All repairs to sanitary sewer lines in paved areas and City streets require pavement repairs in accordance with City Standards and Specifications. Refer to City Standard Detail 1024 A, B & C for approved utility cut pavement repairs.

3.8.3 Abandonment

3.8.3.1 – Draining Sewer Mains

A detailed by-pass/pumping plan shall be required for all active wastewater system flow interruptions and any sewer line abandonment. The plan shall be submitted for review and approval with the civil drawings for the proposed wastewater extension, modification, and/or line abandonment.

Prior to modifications or abandonment, all sanitary sewer mains and sewer force mains active, inactive, or abandoned shall be drained by plugging the furthest downstream manhole outlet and providing suction apparatus to remove all materials from the manhole invert or by tapping the bottom half of the pipe at sumps and installing suction equipment to empty the pipeline. A corporation stop or other valve shall be provided to provide flow control.

All effluent shall be pumped to an active downstream manhole or other containment tank utilizing continuous piping. Wastewater pumped to a containment tank shall be hauled to the City's wastewater treatment plant by a permitted hauler for disposal at the contractor's expense.

3.8.3.2 – Disconnecting & Abandoning Mains, Manholes & Services

Sewer service laterals shall be abandoned by removing and replacing the saddle with a 360-degree stainless steel sleeve. At in-line wyes, the service lateral shall be cut within 12" of the wye and a mechanical cap installed on DIP/cast services or glued to PVC services and the abandoned wye encased with 1 cubic foot of concrete.

Gravity and pressure sewer mains to be abandoned shall be filled with flowable fill concrete or removed as directed by the City. Manhole cones and risers shall be removed, and base sections filled with flowable fill concrete, unless otherwise directed by the City for the specific project.

3.9 Wastewater Pump Stations

3.9.1 Design Requirements

These Specifications apply to all pump stations and associated facilities that are to be owned, operated, and maintained by the City and any private wastewater collection & pumping systems approved to discharge to the City's wastewater collection system. These Specifications apply to all force mains that are to be owned, operated, and maintained by the City and any private wastewater collection & pumping systems approved to discharge to the City's wastewater collection system. Design of individual pumping systems and pressure lines and associated facilities to serve a single residence or business is not covered by these Specifications, and the applicant should look for guidance from other agencies, such as the City of Lexington Business & Community Development Office (building permits), NC Office of State Fire Marshal (NC Plumbing Code) and NC Division of Water Quality (permitted, or deemed permitted, residential wastewater systems).

All aspects of the design of pump stations, and associated facilities shall, at a minimum, meet the requirements of the latest version of NCDENR's or NCDEQ's "Minimum Design Criteria for the Fast-Track Permitting of Pump Stations and Force Mains". Requirements presented in City's Standard Specifications herein that are more restrictive than the Minimum Design Criteria are required by the City.

All aspects of the design of pump stations, and associated facilities shall be submitted for review and approval to Water Resources. This review may be more extensive than the typical development site plan process. Materials necessary for the review and requiring approval include complete plans, Specifications, design reports, and specific equipment submittals for the specific pump station, as described herein.

If required by the City, a detailed economic analysis consisting of minimum 20-year present worth evaluation shall be submitted by the Engineer-of-Record comparing alternatives such as modifications to existing public sewer systems and/or extension of gravity sewers versus the construction of a pump station and force main alternative. Gravity

sewer systems shall always be preferred over pump station and force main construction. The City reserves its right to consider economic evaluations, service area configuration, operating costs, and other external factors before approving pump station plan submittals in lieu of gravity sewer extensions.

All equipment, except for the generator, included in this Specification shall be designed for a sound rating of 55 dB (A) or less at a distance of 23 feet (7 m) from the operating equipment. The generator shall include a sound attenuating enclosure and hospital grade silencer. The generator shall have a sound rating of less than 71 dba for generators rated below 150KW and less than 73 dba for generators, rated between 150KW and 250KW, at a distance of 23 feet (7 m) from the operating equipment. Warning horns and sirens have no sound restrictions.

The pump station design shall incorporate ways to minimize the sound levels leaving the site property. Factors to consider include equipment layout, cumulative sound levels, and walls that reflect the sound. Equipment submittals that include the sound ratings for the major equipment to be installed at the pump station shall be supplied to and approved by the Water Resources prior to ordering the equipment.

The pump station shall not be approved for routine operation until sound testing has demonstrated that the noise levels are in accordance with the requirements of this section. All sound testing shall be performed by reputable personnel and testing equipment to assure accuracy. The City reserves the right to require certified sound engineers in cases when the accuracy of the testing equipment is uncertain. The City may also require sound testing to be repeated prior to the end of the corrections period to further demonstrate that the pump station, including the generator, is performing as designed. Generator auto start and operation, other than for power outages, shall occur during the time periods of Monday through Friday between the hours of 9:00 a.m. and 4:00 p.m., not including holidays which are observed by the State of NC.

Pump station facility design plans shall evaluate surge and water hammer and incorporate sufficient surge suppression based on the range of flows, pressure and other variables included in the pump station design.

Pump station facility design plans shall include an emergency by-pass pumping connection downstream of the valve vault and must permit sufficient space to accommodate equipment movements and staging.

Pump station facility design plans shall include provisions for any odor control/ chemical facilities identified by the City.

3.9.2 Warranty

All equipment, materials, and systems supplied under this Specification shall be provided in new and in unused condition with a warranty from the manufacturer to City that the subject equipment, materials, and systems shall be free of defects in workmanship and material, and shall operate as intended under the known conditions, for a minimum period of one year. The warranty shall be in printed form and made applicable to City (as Warrantee) at the time of acceptance for maintenance by City.

3.9.3 Submittals

3.9.3.1 – Design Report

A design report signed and sealed by an NC Professional Engineer is required with the submittal of plans and Specifications for any facilities covered under this section that are proposed for construction. This design report shall contain, at a minimum, the following design criteria:

a) Pump station calculations which verify capacity for the immediate service area and the reserve capacity provided or expandability for future tributary flows.

b) Total dynamic head calculations for all applicable pumping situations.

c) System curve and pump curve analysis used to determine pump selection and operating point. Pump family of curves shall be provided.

d) Pump station cycle and pump run times covering the high, low, and average flows over the entire expected operating period of the pump station.

e) Response time available in event of an emergency (time between the high-water alarm and the first system overflow at average design flow and peak design flow).

f) Pump station flotation/buoyancy calculations.

g) Minimum velocity within the force main, including an analysis of the capabilities of the pumps to completely flush any depressed sections of the force main in a single pumping cycle.

h) Maximum detention times within the pump station and force main covering the low flows over the entire expected operating period of the pump station.

i) An evaluation of the capability of the receiving sewer to handle the peak flow discharge from the proposed facility in addition to the existing or planned peak flows currently handled by the receiving sewer or sewage facility.

j) Airflow calculations and chemical dosing calculations for all odor control/ chemical facilities.

k) Calculations for the sizing of the backup power generator.

3.9.3.2 – Project Review Submittals

a) Project Review Submittals shall be submitted to the City for review and approval prior to application for a permit for the pump station and/or force main, and prior to entering construction contracts or purchasing any equipment for the pump station or force main. Obtaining permits, entering construction contracts, or purchasing any equipment in no way obligates

the City to accepting designs or equipment that do not meet the specified standards or other City requirements.

b) The Project Review Submittals shall include, at a minimum, complete plans and Specifications, a design report as described above, and manufacturer's information on specific major equipment listed in this Specification section.

The information submitted for equipment shall include, at a minimum, the name of the manufacturer and the specific model being supplied, fabrication and assembly drawings, detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished. It shall also include any system hydraulic schematics, electrical wiring diagrams, and control panel schematics. Additional detailed information that may be required for submittal for specific equipment is listed in the appropriate equipment section.

3.9.3.3 – Pre-Approved Equal Submittals

a) Equipment and systems other than those listed in the Approved Manufacturers List must receive approval from the City prior to application for a permit for the pump station or force main, and prior to entering construction contracts or purchasing any equipment or systems for the pump station or force main. Purchasing equipment in no way obligates the City to accepting equipment that does not meet the specified standards or other City requirements.

b) Pre-Approved Equal packages shall include the following information as a minimum:

- Current catalog data sheets and complete technical data to support Specification compliance.
- A point-by-point list clearly stating all differences between the named item and the proposed alternate and a separate list clearly stating all exceptions to the Specifications. If no exceptions are listed, then no exceptions to the Specifications will be allowed.
- Installation list with name, address, and phone number of contact person for each of at least five (5) installations where the proposed equipment has been in similar service and satisfactory operation for at least two (2) years. The date of placing equipment in service at each listed installation shall be provided.
- Three (3) copies of Pre-Approved Equal information shall be submitted.

c) Equipment that meets the Pre-Approved Equal submittal requirements, the technical Specification requirements, and all other requirements of the City, will be approved by the City via letter within 30 calendar days of receipt of a complete package.

3.9.3.4 – Testing Results Submittals

a) The results of all testing shall be submitted to Water Resources for review prior to continuing progress on the particular equipment. If shop testing is required, results shall be submitted prior to delivery of the equipment. If installation verification is required, results shall be submitted prior to start-up and testing of the equipment. If final start-up tests are required, results shall be submitted prior to final acceptance of the equipment.

b) Three printed copies of all test results are required to be submitted for review.

c) A final, compiled summary of all testing done on all equipment shall be provided to City upon completion of the project prior to project closeout and final acceptance. This final, compiled summary shall consist of a single bound printed copy and an electronic copy on approved media device.

3.9.3.5 – Operation and Maintenance (O&M) Manuals

a) Operation and Maintenance (O&M) manuals are required for all equipment and systems furnished under this Specification section. Three (3) copies shall be supplied to the City in printed format prior to startup of the subject equipment or systems. The O&M manuals shall contain all the necessary information for proper operation and maintenance of the subject equipment and systems. At a minimum, the O&M manuals shall contain the following:

- Final approved shop drawings.
- Design data including certified pump curves and system curves.
- Wiring diagrams and control schematics.
- Detailed inventory of installed equipment, including its functional description, and manufacturer name, address, and phone number (and the same for a local representative of the manufacturer).
- Operating instructions.
- Troubleshooting techniques.
- Spare parts list.
- Maintenance schedules.
- Assembly and disassembly instructions.
- Instructions for start-up and shutdown, as well as calibration and adjustment.
- Annotated hard copy and downloadable electronic copy of application program for all field programmable equipment (eg PLCs, operator interfaces, etc.)

b) Final, Operation and Maintenance (O&M) manual covering all equipment and systems supplied shall be provided to the Cit\y upon completion of the project prior to project closeout and final acceptance. This document shall consist of two bound printed copies and an electronic copy in City approved format.

3.10 Pump Stations Site and Structures

3.10.1 General

Pump stations shall be located on a parcel or an easement that is dedicated to the City. The site shall be directly connected to a dedicated public right-of-way or have a dedicated access easement to a public right-of-way.

Reliable on-site backup power for all public wastewater pump stations shall be provided. Odor control facilities are required for all pump stations of 0.5 MGD or greater capacities. Sizing of these items will be based on expected flow volumes and characteristics.

All stations shall have a minimum of 2 pumps of equal capacity. The pumps shall be solids handling, submersible, centrifugal pumps each capable of pumping flows equal to the expected peak hourly flow. Vacuum priming, suction lift, submersible grinder pump, or above grade pumping units shall not be allowed.

The City requires a 3.0 peaking factor. Higher peaking factors may be warranted and required by the City to meet watershed future build out or other factors. Wet well/dry well pumping systems shall be required when peak flows exceed 1- MGD. Where 3 or more pumps are required, they should be of such capacity that with the largest unit out of service, the remaining units shall have capacity to handle the peak hourly flows. Pumps and force mains shall be sized to provide a minimum velocity in the force main of 2.5 fps and a maximum velocity of 10 fps.

Pump stations shall remain fully functional, operational, accessible, and free from physical damage during a 100-year flood event.

3.10.2 Site Work

3.10.2.1 – Stormwater Controls and Ground Cover

For sites not subject to post-construction stormwater regulations, the site shall be graded to manage stormwater in a manner that inhibits concentrated and erosive discharges to slopes and downstream areas. Storm drainage conveyances shall be designed to permit infiltration and dissipate energy to the maximum extent practicable. Hydraulic calculations may be required to verify the extent of stormwater impacts to downstream areas and public infrastructure.

For sites subject to Low-Density or High-Density post-construction stormwater regulations, all built-upon-area associated with the pump/lift station (including any gravel/stone) must be treated by a primary or secondary stormwater control measure, as required by the City of Lexington Stormwater Administrator.

The site shall be stabilized by crushed stone, low maintenance vegetative ground cover or other suitable materials. No vegetative ground cover is allowed within the fenced area. Visual screening and landscaping shall be provided in accordance with the approved site plan.

3.10.2.2 – Fence and Gates

The site shall be secured by a 6-ft high aluminum coated chain link fence. It shall have 3-wire galvanized barb arms, set at an outward facing 45-degree angle and located at the top of each post. Each wire to be 3 strand barb wire class III galvanized or aluminized. The outer barb wire shall hold a load of 250-lbs. The 6- ft height does not include the barb arms. Minimum 9 gauge galvanized "easy twist" fence ties for binding fence shall be installed on each 2", 3", or 4" post at a minimum vertical spacing of 2 feet.

Fencing shall be provided around the entire perimeter of the pump station property maintaining an offset of 6 to 8 feet from the property boundary. All line posts, top and bottom rails, and gate posts shall be hot-dipped galvanized steel.

Both small and large pump stations shall provide a minimum of two manual 180-degree opening access gates that provide a min. opening of twelve (12) feet. Gates shall be located to provide vehicle accessibility for lifting the pumping units and unobstructed fuel and chemical deliveries. All gate posts and corner posts shall be minimum 4-inch diameter.

3.10.2.3 – Service Vehicle Access

The pump station site shall permit the delivery, loading, unloading, and removal of all equipment and materials (pumps, generators, structures, tanks, chemicals, etc.) from the pump station site with a full-sized service truck and crane. The site shall feature adequate turn around areas for a WB-40 service vehicle and provide a minimum 12-foot-wide access road within a minimum 20 ft right-of-way, or 20 ft dedicated access easement, to the site with grades not to exceed 10%. Sites shall be properly designed for the delivery of chemicals if required for the station, and in some cases, larger than a WB-40 vehicle. Additional turning radius may be required.

3.10.2.4 – Lighting

An LED light equivalent to a high-pressure sodium vapor light with a minimum 600-watt capacity is required. The light shall be mounted on a suitable utility pole that retracts or pivots for bulb maintenance from ground level. The light shall be at a height of 30 feet and shall be controlled by a photocell. All area lighting shall be provided in a downward projecting fixture, such as shoe box type light or approved equal. Open globe lighting shall be prohibited on all pump station sites.

3.10.2.5 – Water Service

All wastewater pump stations shall have a metered water service connection (minimum 1-inch service) to a public water system. Pump stations within 200 feet of City of Lexington water mains shall have a metered water connection to the City's distribution system (extension of the public water main may be required at no

expense to the City) and be provided with sufficient volume and pressure for operations including wash downs and other site-specific maintenance activities. For stations with capacities over 0.5 MGD, a 2-inch water service may be required to accommodate larger wash down and service needs. The supply shall have a City-approved reduced pressure principle, RPZ, backflow prevention assembly and hotbox with weatherproof electrical outlet on the downstream side of the water meter.

A minimum of one (1) freeze proof yard hydrant is required within the fenced area. Emergency shower and eye washing basin shall be provided in pump stations with chemical odor control facilities. Separate reduced pressure principle, RPZ, backflow preventers shall be required as necessary to protect eye wash and/or emergency shower stations from potential chemical contamination within the pump station site. As required by ANSI Z358.1, the shower and eye wash stations shall be provided with a tepid water system and be able to operate simultaneously.

3.10.2.6 – Force Main By-Pass

All wastewater pump stations shall be equipped with a force main emergency by-pass pumping connection downstream of the valve vault. The emergency connection shall tie to the force main via restrained MJ joint fittings, restrained MJ gate valve, and RJ ductile iron pipe, ending with an accessible aluminum quick connect adapter. The emergency connection assembly shall be located inside of the pump station fence at a location accessible to City personnel and equipment. Refer to Standard Detail 6021.

3.10.3 Structures

3.10.3.1 – General

The submersible pump station structures shall consist, at a minimum, of a wet well, and a valve vault. Large, integrated structures are permissible, however, there shall be walls separating the portions of the structure listed above. Pump station structures other than the wet well shall be provided with a means to remove accumulated water and wastewater from the structure. Hinged and corrosion resistant access hatches with metal grate style fall protection for equipment and personnel shall be provided for all structures, shall be certified for H-20 loading, traffic rated, and sized appropriately.

Stations with capacities of 0.5 MGD or greater shall have mechanical bar screen units. Bar spacing to be ½” wide. Where required by the City for a specific project or anticipated wastewater characteristics, stations less than 0.5 MGD shall have a removable 316 stainless steel or aluminum basket strainer installed within a manhole immediately upstream of the wet well. Basket strainers shall be easily accessed and removed via crane/hoist and stainless-steel cable through a lockable access hatch.

Any portion of a pump station that may allow floodwater entry into the wastewater system shall be built with a top elevation a minimum of 2 feet above the nearest Base Flood Elevation (current FIRM). Where no BFE is identified on the FIRM, the

top elevation of openings shall be a minimum of 3 feet above the elevation at the floodplain limit (1% chance zone boundary) nearest to the site.

3.10.3.2 – Wet Well

The wet well shall have a minimum diameter of 6-feet and shall be large enough to easily accommodate the removal of each pump.

The wet well shall be designed to have an operating volume sufficient to provide pump operating cycles to match the manufacturer's recommendations. The pump operating cycles must be between two and eight times per hour at design daily flow without being excessively deep.

The wet well shall be constructed of precast reinforced concrete manhole sections conforming to ASTM C-478, latest revision. Extended bases or another foundation shall be used to provide adequate bearing surface and flotation protection if conditions warrant their use. All concrete shall have a minimum 28-day compressive strength of 4000 psi.

Manhole section joints shall be of a durable mastic sealing material. The exterior of manhole wet wells shall have a factory applied bitumastic or asphaltic coating. The exterior of wet well joints shall be overlapped by an approved material. The interior side of the joints shall be plastered smooth with Portland hydraulic cement grout.

Cast-in-place wet wells shall be properly designed by a NCPE and include appropriate structural support, waterproofing, exterior coating, structure covers, access hatches, etc.…

At a minimum, wet wells shall have a vent made from ductile iron with flanged joint pipe fittings cast within the slab top. A stainless-steel insect screen shall be installed at the exposed end of the vent pipe. Forced air venting is also allowed and will be required on individual pump stations in conjunction with odor control measures, depending on circumstances.

Wet wells and wet well piping shall be coated with at least 80-mils of an approved monolithic epoxy coating system consisting of a 100%-solids, solvent-free, two-component epoxy resin for up to 100 mils of coating with a manufacturer approved set time of 6-hours or less. The epoxy coating system shall be installed in no more than 2 applications with no runs and no holidays. High voltage holiday testing shall be utilized to verify there are no voids in the coating. Epoxy coatings shall only be applied to adequately cured concrete structures that have been sufficiently washed and prepared for epoxy coating installation. Properly applied coating shall provide a smooth finish at 80-mils or greater and fill all pores in concrete substrate. Care will be taken to ensure no epoxy coating is applied to the pump coupling face, the guide rails, or any other part that needs to allow movement or replacement on a regular basis.

3.10.3.3 – Crane and Hoist

All pump stations less than 0.3 MGD shall be supplied with a removable stainless-steel or powder coated steel Davit crane-hoist combination of minimum 800-pound

capacity. Crane shall be installed with pedestal base shall be mounted to wet well slab top or an adjoining concrete foundation to provide 360-degree rotation and direct access over pump hatch for pump removals.

Crane have adjustable boom length and angle and be supplied with either an electric winch or manual winch with a drill motor drive adapter installed. Cable supplied with crane shall be stainless-steel wire rope (min. ¼ inch diameter) of adequate capacity for pump removal weights.

Pump stations with 0.3 MGD or greater shall be supplied with a fixed base jib crane for pump removals (min. 1,000-pound capacity) and installed on an engineered concrete foundation. Crane shall be capable of 360-degree rotation and have motorized electric hoist with mechanical load brake and a friction clutch. Hoist shall be supplied with chain collector and corrosion resistant chain of adequate length and capacity for lifting and removing pumps (min. 3/8-inch diameter).

3.10.3.4 – Valve/Meter Vaults

The valve/meter vault shall, at a minimum, consist of a precast reinforced concrete manhole base section at least 6 feet in diameter or a precast reinforced concrete rectangular structure at least 6 feet square. The valve/meter vault shall be complete with a drain that discharges to the wet well. The drainpipe between the valve vault and the wet well shall have a back water valve at the wet well end.

The access cover for the valve vault shall be from a manufacturer listed on City's Approved Products List and shall be a square hatch of 1/4 inch aluminum diamond pattern plate on an extruded aluminum frame cast in place in the cover slab.

All access covers shall be centered over all equipment to accommodate service and removal and shall include a recessed lifting handle, stainless steel hinges, slam lock w/ removable key, a hold-open arm with release handle, compression spring assist, and a removable metal grate style fall protection guard. Hinges and all access hatch hardware shall be 316 stainless-steel. Pipe stands shall be stainless steel to support valves and other appurtenances requiring support.

3.10.3.5 – Manholes

Any manholes installed on the pump station site need to meet the City's standard specifications. All manholes installed on the pump station site shall receive an interior coating of an approved epoxy resin, as previously specified for the pump station wet well.

3.10.3.6 – Buildings

Building systems to house chemical feed facilities shall be adequate to provide sufficient storage, clearance, and 100% containment of chemicals in the event of a chemical tank or other failure. In addition to providing the required spill containment, chemical tanks shall be double wall, crosslinked polyethylene tanks. A removable roof or roof sections shall be required to allow sufficient access to all equipment and tanks within the building. Buildings shall be heated to avoid the freezing of chemicals.

All supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be designed and sealed by a NC Professional Engineer. Chemical feed delivery lines will be chemical resistant and of a flexible material routed through oversized schedule 80 conduit.

On a case-by-case basis, a building may be required to house all electrical and control equipment. This building shall be of precast, prefabricated, or built in place construction.

All buildings located on a pump station site shall have the first-floor elevation a minimum of 3 feet above the elevation of the nearest floodplain (SFHA) boundary.

3.10.4 Piping and Valves

3.10.4.1 – Piping

Suction and discharge piping shall be minimum Class 50 ductile iron flanged pipe in accordance with AWWA C 115. Type 304 stainless steel discharge piping and transition couplers may be required for wet well piping to the connection upstream of the valve vault, where wastewater age or future tributary flow characteristics are questionable. All hardware installed in the wet well shall be 316 stainless-steel.

Discharge piping and valves shall produce a minimum head loss while maintaining a minimum velocity of 2.5 feet per second. All exposed piping shall have adequately sized and located restraint and blocking systems as approved by the City. Bolts and gaskets for flanged pipe shall be provided by the pipe manufacturer or meet/exceed the pipe manufacturer's specifications.

3.10.4.2 – Pump Piping

The discharge connection elbow shall be a straight through fitting with no flap valve and shall be permanently installed in the wet well along with the discharge piping. The pumps shall be automatically connected to the discharge connection elbow when lowered into place. The entire weight of the pump shall bear upon the guides and base support with no part of the pump bearing directly on the floor of the wet well. A stainless-steel chain shall be provided for lifting each pump from the wet well. All hardware used shall be 316 stainless-steel.

3.10.4.3 – Check Valves and Gate Valves

An external lever and weight swing check valve and a gate valve shall be provided within a valve vault for the discharge pipe of each pump. Check valves shall be ductile iron bodied, fully bronze mounted with bronze clapper disc and bronze seat ring and shall have the lever arm capable of being mounted on either side of the valve. Gate valves shall be resilient wedge open left with non-rising stem. Isolation gate valve(s) of the resilient wedge type shall also be provided upstream of the valve vault to isolate the wet well and vault from the emergency by-pass pumping connection.

3.10.4.4 – Plug Valve

Plug valves approved for use shall be 1/4 turn, eccentric action and resilient plug

facing with heavy-duty stainless-steel bearings and welded-in corrosion resistant nickel seat. Pump station plug valves shall be "full-port" cross-sectional area perpendicular to the flow of at least 100% of the adjoining pipe.

3.10.4.5 – Pressure Gauges

A +/- 2% accuracy pressure gauge with a 3 inch or larger liquid filled dial, stainless steel case, and graduated to 150% of force main static pressure shall be provided on each discharge pipe. The gauge shall be installed between the check and gate valves. Isolation seals and cut-off ball valve shall be provided between the gauge and force main. The gauge shall be oriented so that it is easily visible and legible from the valve vault hatch opening. The gauge shall also be capable of delivering an electronic remote signal compatible with the City's SCADA system. A separate manual read pressure gauge shall also be provided.

3.10.4.6 – Anchor Bolts

Anchor bolts and nuts shall be furnished as required for each item of equipment. Anchor bolts, together with templates or setting drawings, shall be delivered sufficiently early to permit setting the anchor bolts when the structural concrete is placed. Anchor bolts shall be at least 3/4 inch in diameter. Anchor bolts and associated hardware shall be 316 stainless steel.

Anchor bolts shall be accurately located and centered in pipe sleeves having an inside diameter approximately 2.5 times the bolt diameter and a length approximately 8 times the bolt diameter. A square anchor plate with thickness of approximately 0.5 the bolt diameter and side dimensions 4 times the bolt diameter shall be welded to the bottom of each sleeve, with the anchor bolt extended through the plate and welded thereto. Two nuts and a washer shall be furnished with each anchor bolt.

Anchor bolts shall be long enough to accommodate 1.5 inches of grout beneath the baseplate and to provide adequate anchorage into structural concrete. Bolts shall have a "J" bend or wedge and epoxy anchoring system securing them into the concrete.

Anti-seize compound will be applied to the threads of all stainless-steel bolts before assembly.

3.10.5 Electrical- General

3.10.5.1 – General

All electrical systems associated with any of the items covered under this section shall meet all applicable electrical standards and code requirements, including, but not limited to: ANSI, ASTM, NEMA, IEEE, DEMA, EEI, HEI, ISO, NFPA, SAE, NEC, UL508, as well as any other federal, state, or local codes.

3.10.5.2 – Electrical Service

Electrical service to all pump stations shall be appropriately sized three phase power,

240 VAC with automatic transfer switches to automatically starting on-site emergency generators. The electrical power entrance shall be through a meter base, followed by a NEMA 3R heavy duty, single throw, and fusible safety switch. This shall be followed by a heavy-duty automatic transfer switch that transfers between the utility power and the on-site generator. This shall be followed by a NEMA 3R heavy duty, double throw, three pole safety switch which feeds the control panel from one side and heavy duty, circuit breaking 4 wire, 4 pole male receptacle assembly as manufactured by Crouse-Hinds or other approved equal from the other side. There shall be a NEMA 3R heavy duty single throw fusible safety switch between the generator and the automatic transfer switch.

3.10.5.3 – Electrical Equipment Class and Isolation from Gases

Electrical equipment inside the wet well shall meet the requirements for Class I, Division I, and Group C/D service. All these electrical components shall be suitably sized to be capable of service with all electrically powered equipment running.

All electrical components, including panels, shall be sealed off from the wet well in accordance with the N.C. Electrical Code requirements for electrical service to class 1 division 1.

3.10.5.4 – Conduits

The use of rigid conduits is required. Generally, PVC shall be used below ground and PVC coated galvanized steel shall be used above ground. Conduits that lead to a control panel shall be air gapped a minimum of 3-feet from the panel or seal-offs shall be provided.

3.10.5.5 – Weather and Flood Protection

Pump station electrical and control equipment shall be in a building as described above, or under a weather hood. An aluminum weather hood with a clear height of 7 feet, an overhang of at least 4 feet and a thickness of 3/16 inch shall be provided for control equipment exposed to the weather. The back panel and side panel shall also be 3/16-inch-thick aluminum. The support structure for the weather hood shall be made from structural steel members assembled to provide individual, direct support to the control equipment panel, transfer switch, safety switches, meter base and the weather hood. The steel frame shall be painted with a two component, high build epoxy polyamide paint system designed for severe service. All weather hoods shall be provided with a light and GFI protected 120V outlet.

Exposed outlet boxes for outdoor and indoor wet process areas used for lighting fixtures, switches, and receptacles shall be aluminum provided with rubber neoprene gasketed covers of similar metal. Junction and pull boxes shall be NEMA 4X construction and of ample size to house the required devices. Boxes shall be provided with hasps.

All electrical equipment, including non-submersible motors, electrical panels, control panels, alarm/telemetry systems, backup generators, etc., shall be located a minimum of 4 feet above the nearest floodplain boundary elevation. Weather hoods

shall be installed to eliminate runoff to the front side. All electrical enclosures shall have hinged doors/covers.

3.10.5.6 – Junction Boxes and Wiring Enclosures

An intermediate terminating explosion proof junction box is to be supplied and installed mid-way from the wet well and the pump control panel. This box shall be NEMA type 4X suitably sized to house all pump power and control wiring. Rigid metal conduit shall be utilized with the necessary seal-off fittings. Terminal strips shall be provided to properly split the power termination to facilitate pump removal from the junction box and not the pump control panel.

The minimum size of boxes shall be according to the NEC. No box shall be filled to more than 40% of capacity.

Where control wires must be interconnected in a junction box, terminal strips consisting of an adequate number of screw terminals shall be installed. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected. Approximately 20 % of the terminals provided shall consist of spare terminals. Terminals shall be lettered and/or numbered to conform to the wiring diagram.

3.11 Pump Stations Equipment

3.11.1 Pumps

3.11.1.1 – General

a) Pumps, motors, and major accessories shall be supplied by a single manufacturer as listed in City's Approved Manufacturer's List.

b) Each pumping unit shall be complete with a close-coupled, submersible electric motor, and all other appurtenances specified, or otherwise required for proper operation.

c) The equipment provided under this section shall be suitable for the service conditions and shall be capable of meeting all operating requirements of the pumping system.

d) Each pumping unit including motor and all integral controls shall be rated and labeled for use in a Class 1, Division 1, Group C/D area as defined by the National Electric Code.

e) Each item of equipment and each part shipped separately shall be identified with indelible markings for the intended service. Tag numbers shall be clearly marked on all shipping labels and on the outside of all containers.

f) Abbreviations. Reference to standards and organizations herein shall be as indicated by the following designations:

- AFBMA Antifriction Bearing Manufacturers Association
- AGMA American Gear Manufacturers Association

- AISI American Iron and Steel Institute
- ANSI American National Standards Institute
- ASME American Society of Mechanical Engineers
- ASTM American Society of Testing and Materials
- NPT National Pipe Thread
- SAE Society of Automotive Engineers

3.11.1.2 – Submittals

a) Complete fabrication and assembly drawings, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section. The data and specifications for each unit shall include, but not be limited to, the following:

- Pumps
  - Name of Manufacturer
  - Type and model
  - Rotating speed
  - Direction of rotation
  - Size of suction elbow inlet
  - Size of discharge elbow outlet or nozzle
  - Net weight (mass) of pump and motor only
  - Complete performance curves showing capacity versus head, bhp (brake kW), NPSH required, and efficiency
  - Data on shop painting
- Motors
  - Name of manufacturer
  - Type and model
  - Type of bearings and method of lubrication
  - Rated size of motor, hp (kW), and service factor
  - Insulation class and temperature rise
  - Full load rotative speed
  - Net weight
  - Efficiency at full load and rated pump condition
  - Full load current
  - Locked rotor current

b) Operation and Maintenance Manuals shall include, at a minimum, the following information:

- Equipment function, normal operating characteristics, and limiting conditions.
- Assembly, installation, alignment, adjustment, and checking

instructions.

- Operating instructions for startup, routine and normal operation, regulation and control, shutdown, and emergency conditions.
- Lubrication and maintenance instructions.
- Guide to troubleshooting.
- Parts lists and predicted life of parts subject to wear.
- Outline, cross-section, and assembly drawings; engineering data; and wiring diagrams.
- Test data and performance curves.

3.11.1.3 – Quality Assurance

Performance and Balance Requirements:

a) All specified conditions shall be at rated speed unless otherwise indicated.

b) Overall (wire-to-water) efficiency for constant speed pumps shall include losses in the pump and motor. Overall (wire-to-water) efficiency for variable speed pumps shall include losses in the pump, motor, adjustable frequency drive, and any transformers supplied as part of the adjustable frequency drive equipment.

c) The minimum hydrostatic test pressure shall be 1.5 times shutoff head plus max suction pressure.

d) Pump performance shall be stable and free from cavitation and noise throughout the specified operating head range at minimum suction submergences. The design running clearance between the impeller inlet and the casing wearing ring (if provided) shall be not less than 0.01 inch or 1 mil per inch of casing wearing ring diameter, whichever is greater.

e) When required, pumping units shall be designed so that maximum reverse rotation due to reverse flow at the head as required will not cause damage to any component. Pump supplier shall coordinate this provision with the motor supplier.

f) All rotating parts shall be accurately machined and shall be in as nearly perfect rotational balance as practicable. Excessive vibration shall be sufficient cause for rejection of the equipment. The mass of the unit and its distribution shall be such that resonance at normal operation speeds is avoided. In any case, the unfiltered vibration velocity, as measured at any point on the machine including top of motor, shall not exceed the maximum velocity as indicated for vertical, end suction, solids handling pumps. At any operating speed, the ratio of rotative speed to the critical speed of a unit or its components shall be less than 0.8 or more than 1.3.

3.11.1.4 – Materials

a) Stator housing, oil chamber housing, impeller casing, and impeller shall be cast iron, ASTM A48.

b) Casing wearing ring shall be bronze, ASTM B62, rubber, or martensitic stainless steel, Brinell 300+.

c) Bottom wearing plate shall be cast iron, ASTM A48 with spiral grooves.

d) Impeller wearing plate shall be martensitic stainless steel, Brinell 200-250.

e) Shaft shall be alloy steel, hard chrome plated, or martensitic stainless steel, AISI type 416.

f) Mechanical seals shall be 2 tandem single type, oil lubricated with silicon or tungsten carbide seal rings at all points, except the upper rotating seal, which shall be carbon.

g) Discharge base shall be cast iron or fabricated steel.

h) Guiderails shall be stainless steel pipe, ASTM A312, Schedule 40S.

i) Upper guiderail bracket, cable hooks, and chain hooks shall be AISI type 304 stainless steel.

j) Pedestal base shall be cast iron or fabricated steel.

3.11.1.5 – Pumps

a) Pumps shall be submersible, non-clog centrifugal sewage pumps capable of passing a 3-inch sphere. Pumps shall be capable of handling raw, unscreened sewage. Major pump components shall be of gray cast iron devoid of burrs, pits, or other irregularities.

b) The impeller casing shall have well-rounded water passages and smooth interior surfaces free from cracks, porosity, blowholes, or other irregularities. The discharge nozzle shall be flanged, with dimensions and drilling conforming to ANSI B16.1, Class 125. The discharge nozzle shall be flanged and sufficiently rigid to support the pumping unit under all operating conditions.

c) The impeller shall be a semi-open and enclosed recessed one-piece casting with not more than two non-clog passages with the impeller completely out of the flow path. The interior water passages shall have uniform sections and smooth surfaces and shall be free from cracks and porosity. The impeller shall be dynamically balanced and securely locked to the shaft by means of a key and self-locking bolt or nut.

d) For pumping units 20 hp and larger, renewable wearing rings shall be provided in the casing and on the impeller. The rings shall be positively locked in place. For pumping units less than 20 hp a renewable wearing ring or axially adjustable wearing plate shall be provided in the casing. Casing wearing ring shall be securely fastened to the impeller casing front cover to provide either an axial or radial running clearance. Axially adjustable wearing plate shall be arranged to permit adjustment of the axial running clearance between the impeller and plate.

The wearing plate shall have an outward spiraling groove designed to force stringy solids outward and away from the impeller.

e) The oil chamber shall contain a drain plug and a vent plug. Food grade oil shall be used.

f) Each pump shall be provided with two mechanical rotating shaft seals arranged in tandem and running in an oil chamber. Each interface shall be held in contact by an independent spring system designed to withstand maximum suction submergence. The seals shall require neither maintenance nor adjustment and shall be readily accessible for inspection and replacement. Shaft seals lacking positively driven rotating members or conventional double mechanical seals which utilize a common single or double spring acting between the upper and lower units and requiring a pressure differential to offset external pressure and effect sealing, will not be acceptable. The seals shall not rely upon the pumped media for lubrication and shall not be damaged if the pumps are run unsubmerged for extended period while pumping under load.

g) All mating surfaces of major components shall be machined and fitted with O-rings where watertight sealing is needed. Sealing shall be accomplished by O-ring contact on four surfaces and O-ring compression in two planes, without reliance on a specific fastener torque or tension to obtain a watertight joint. The use of elliptical O-rings, gaskets, or seals requiring a specific fastener torque value to obtain and maintain compression and watertightness will not be acceptable. The use of secondary sealing compounds, gasket cement, grease, or other devices to obtain watertight joints will not be acceptable.

3.11.1.6 – Pump Motors

a) The pump motors shall be sealed submersible type, and shall be appropriately sized three phase power, 60 Hertz motors with a maximum speed of 1800 RPM. The motors shall meet the U.S. requirements of Class I, Division I, and Group C/D for hazardous locations, and shall be sized to non-overloading throughout the entire operating range of the pump.

b) A heat sensor thermostat shall be attached to and embedded in the winding and be connected in series with the motor starter contactor coil to stop motor if temperature of winding is more than 220 degrees F. Thermostat shall reset automatically when motor cools to safe operating temperature. The common pump motor shaft shall be of 416 stainless-steel. (See 4e above)

c) The motor shall be protected by mechanical seal system as described above. A double electrode shall be mounted in the seal chamber to detect any water entering the chamber through the lower seal. Water in the chamber shall cause a red light to turn on at the control panel. This signal shall not stop the motor but shall act as a warning only.

d) Power cables to pumps shall be minimum 8 AWG Hypalon jacketed type SPC cable a minimum of thirty (30) feet in length.

e) Motors shall be provided by the pump manufacturer and shall be air-filled, totally submersible. Motor nameplate rating shall exceed the maximum power required by the pump in the operating head range. Each motor shall have a voltage, frequency, and phase rating as required and shall have a service factor of 1.15. The stator housing shall be an air-filled, watertight casing. A cooling jacket shall encase the motor housing for each pump where needed to maintain adequate cooling. Cooling jacket shall require no external source of cooling water. Motor insulation shall be moisture resistant, Class F, 180 degrees Celsius. Each motor shall be NEMA Design B for continuous duty at 40 degrees Celsius ambient temperature and designed for at least 10 starts per hour.

f) Each motor housing shall be provided with a moisture detection system provided by the motor manufacturer and per the manufacturer's requirements, complete with all sensors, control power transformer, intrinsically safe control modules, and relays. The moisture detection system shall be rated for a 120V AC supply. The moisture detection system shall provide two normally open dry output contacts rated 5 amps at 120 volts AC. The contacts shall close when moisture is detected in the motor housing and an alarm relay energized. The pump shall not be shut down. All moisture detection system components shall be furnished by the pump supplier and shall be shipped loose for installation into the motor controller enclosure, or if required to be mounted separately all components shall be mounted in a NEMA 4 stainless steel enclosure.

g) The motor bearings shall be antifriction, permanently lubricated type. The lower bearing shall be fixed to carry the pump thrust and the upper bearing free to move axially. The bearings shall have a calculated AFBMA L10 Live Rating of 40,000 hours when operating at maximum operating head. Maximum shaft runout at the mechanical seals shall not exceed 2 mils at any point in the operating head range.

h) Thrust bearings shall be protected by bearing temperature switches. The switches shall be normally closed automatic reset type rated 5 amps at 120V AC.

i) Each motor shall be capable of continuous operation in air (unsubmerged) for at least 24 hours under pump full load conditions, without exceeding the temperature rise limits for the motor insulation system.

j) Each pump shall be equipped with one or more multiconductor cable assemblies for power and control. Each multiconductor assembly containing power cables shall be provided with a separate grounding conductor. Each cable assembly shall bear a permanently embossed code or legend indicating the cable is suitable for submerged use. Cable sizing shall conform to NEC requirements.

k) All cables shall be of sufficient length to terminate in a junction box outside the wet well as indicated on the drawings, with 10 feet of slack that shall be

coiled on a cable hook at the top of the wet well. Each cable shall be supported by AISI Series 300 corrosion-resistant PVC Style woven Kellems Grips type woven grips to prevent damage to the cable insulation. Mounting of cable supports in the wet well shall be coordinated to prevent damage to the cable.

l) The cable entry water seal shall include a strain relief and a grommet type seal designed so that a specific fastener torque is not required to ensure a watertight submersible seal. The cable entry junction box and motor shall be separated by a stator lead sealing gland or a terminal board. The junction box shall isolate the motor interior from moisture gaining access through the top of the stator housing.

m) Motors with an adjustable frequency type speed controller shall be derated to compensate for harmonic heating effects and reduced self-cooling capability at low-speed operation so that the motor does not exceed Class B temperature rise when operating in the installed condition at load with power received from the adjustable frequency drive. All motors driven by adjustable frequency drives shall be supplied with full phase insulation on the end turns and shall meet the requirements of NEMA MG 1, Part 31. In addition to the requirements of NEMA MG 1, Part 31, motors shall be designed to be continually pulsed at the motor terminals with a voltage of 1600 volts ac.

n) Adjustable Speed Drives: Adjustable frequency drives shall be provided as specified by the pump stations designer or if the projected flow is 0.3 MGD or higher.

o) Station pumps between 15-30 hp shall have a 30 hp rated reduced voltage soft starter (RVSS). Stations with pumps greater than 30 hp shall utilize variable frequency drives with appropriately sized RVSS.

3.11.1.7 - Appurtenances

a) The lift out systems shall consist of a straight elbow that bolts to the bottom of the basin, a combination disconnect assembly with a seal flange that mounts to the pump, rail support guides that fasten to the wall of the basin and guide and support brackets that mount to the pump. The guide rails shall be type 316 stainless steel.

b) Guiderail Mounted Base. A discharge base and discharge elbow shall be furnished by the pump manufacturer. The base shall be sufficiently rigid to firmly support the guiderails, discharge piping, and pumping unit under all operating conditions. The base shall be provided with one or more integral support legs or pads suitable for bolting to the floor of the wet well. The face of the discharge elbow inlet flange shall be perpendicular to the floor and shall make contact with the face of the pump discharge nozzle flange. The diameter and drilling of the elbow outlet flange shall conform to ANSI B16.1, Class 125. The pump and motor assembly shall be automatically connected to and supported by the discharge base and guiderails so that the

unit can be removed from the wet well and replaced without the need for operating personnel to enter the wet well.

c) Sliding Bracket. Each guiderail mounted pumping unit shall be provided with an integral, self-aligning guiderail sliding bracket. The bracket shall be designed to obtain a wedging action between flange faces as final alignment of the pump occurs in the connected position. The bracket shall maintain proper contact and a suitably sealed connection between flange faces under all operating conditions. The sliding bracket shall be non-sparking.

d) Guiderails. Each guide rail mounted pumping unit shall be equipped with one or more guiderails. Guiderails shall be sized to fit the discharge base and the sliding bracket and shall extend upwards from the discharge base to just below the bottom of the access hatch. An upper guiderail bracket shall be provided at the pump access opening. Guiderails shall be made of 316 stainless steel.

e) Lifting Chain. Each guide rail mounted pumping unit shall be provided with a chain suitable for removing and installing. The chain shall be 316 stainless- steel with 4x6 lifting eyes at 10ft intervals starting at the top. A suitable chain hook shall be provided at the top of the wet well. A stainless-steel cable is not an acceptable alternative to a lifting chain.

f) Special Tools and Accessories. Equipment requiring periodic repair and adjustment shall be furnished complete with all special tools, instruments, and accessories required for proper maintenance. Equipment requiring special devices for lifting or handling shall be furnished complete with those devices.

3.11.1.8 – Shop painting

a) All iron and steel parts which will be in contact with pumped liquid or submerged after installation, including the inside of the casing, the impeller, and the discharge elbow, shall be shop cleaned in accordance with the coating manufacturer's recommendations and painted with the epoxy coating system specified. The coating shall have a dry film thickness of at least 10 mils and shall consist of a prime coat and one or more finish coats. At least 1 quart of the finish coat material shall be furnished with each pump for field touchup.

b) All other iron and steel surfaces, except stainless steel and machined surfaces, shall be protected with suitable protective coatings applied in the shop. Surfaces of the equipment that will be inaccessible after assembly shall be protected for the life of the equipment. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. Electric motors, speed reducers, starters, and other self-contained or enclosed components shall be shop primed or finished with an oil resistant enamel or universal type primer suitable for

top coating in the filed with a universal primer and aliphatic polyurethane system.

c) Surfaces to be coated after installation shall be prepared for painting as recommended by the paint manufacturer for the intended service, and then shop painted with one or more coats of the specified primer.

3.11.2 Pump Control Systems

3.11.2.1 – General:

All components of the Pump Control Systems shall be properly designed and installed to meet all NEC and other industry standards, as well as all federal, state, and local requirements.

3.11.2.2 – Submittals:

Complete fabrication and assembly drawings, together with detailed specifications and data covering materials, parts, devices, and accessories forming a part of the equipment furnished, shall be submitted in accordance with the submittals section. The data and specifications for the Control Panel and Components shall include, but not be limited to, the following:

a) Name of manufacturer

b) Type and model

c) Enclosure rating

d) Dimensions of complete panel

e) Electrical schematics and wiring diagram

f) Liquid level sensors with mounting details and cable lengths, and pump controls

g) Published descriptive data on each item of equipment and all accessories, indicating all specific characteristics and options.

3.11.2.3 – Enclosure:

Enclosure shall be a NEMA type 4X and be of suitable size to house all components. A locking hasp shall be provided with no screw clamp type latches. Enclosure shall be fabricated from 14-gauge steel. The top of the enclosure shall serve as a drip shield and the seam free sides shall prevent rain and sleet from entering. Inner panel shall be made of 12-gauge steel and shall be painted white. The enclosure and interior panel shall be painted with heat fused modified polyester powder, electrostatically applied over a phosphatized base. Enclosure shall be ASA 61 gray.

3.11.2.4 – Hinged Inner Door:

An inner door shall be furnished. Overload reset push buttons, circuit breakers, switches, pilot lights, and hr. meters shall be the only components accessible with door closed. Door shall be hinged and may be opened when service is required.

3.11.2.5 – Lined Terminal Block:

A terminal block shall be furnished with properly sized line lugs to accept the main power source entering the control panel. Load lugs shall be adequate to accept all required load side wiring requirements. All live parts shall be fully shielded.

3.11.2.6 – Motor Circuit Breaker (440-480 VAC):

A properly sized, molded case, thermal hydraulic-magnetic circuit breaker or motor protector shall be provided for each pump motor. Line and load sides shall be equipped with lugs properly sized for the horsepower and current rating of the motor(s). The interrupting rating shall be 5,000 RMS symmetrical amps.

3.11.2.7 – Transformer Primary Circuit Breaker:

A properly sized, two pole, molded case circuit breaker shall be furnished ahead of the control power 120-VAC power transformer for short circuit protection and disconnecting power to the transformer. The circuit breaker shall conform to the Specifications for the motor circuit breaker(s).

3.11.2.8 – Control Power Transformer:

An industrial quality control transformer shall be furnished to provide control voltage. The transformer shall be furnished to provide more than adequate KVA rating to provide 120-VAC power for all items required in the control and alarm circuits. Transformer shall be protected in its secondary by properly sized supplemental circuit breaker(s).

3.11.2.9 – Magnetic Contactors and Overload Relays:

A magnetic contactor shall be furnished for each motor. A separate, panel mounted, 3 leg (three phase) overload relay or motor protector shall be supplied for each motor. Each leg of the overload relay shall be equipped with a properly sized overload heater. Electronic overloads are not acceptable. Contactor and overload relay shall be properly sized for the required horsepower, voltage, and phase.

3.11.2.10– Elapsed Time Meters:

Six-digit, non-resettable elapsed time meters shall be mounted in the control panel enclosure inner door to record the running time of each pump.

3.11.2.11– Condensation Strip Heat with Thermostat

A strip heater shall be furnished to prevent condensation within the control panel enclosure. The heater shall be controlled by a panel mounted, adjustable thermostat.

3.11.2.12- Phase & Voltage Monitor:

A phase failure, reversal and under voltage monitor shall be supplied to prevent the motors from running under low voltage, phase loss, or phase reversal conditions. The monitor shall lock out the control circuit until the problem is corrected and automatically reset. The phase and voltage monitor shall be adjustable.

3.11.2.13– Lightning and Surge Arrestor:

Suitable lightning and surge arrestors shall be provided to protect motors and control equipment from lightning induced or other line surges. Surge arrestor shall meet current UL standards.

3.11.2.14- Thru - Door Overload Reset Push Buttons:

Overload reset push buttons shall be provided for each overload relay. Push buttons shall be mounted so that with inner door closed, overload relays may be reset without entering high voltage compartment.

3.11.2.15– Switches:

Heavy-duty industrial grade oil-tight 22mm switches shall be provided for each pump for "Hand/Off/Automatic" operation selection. All switch components shall be made of corrosion resistant metals and polyesters. Contact blocks shall be made of see-through polycarbonate for simplified inspection of contacts. Cams and strokers shall be Teflon impregnated for abrasion free service without lubrication. The switches required shall be as follows:

Switch Function (Name Plate)	Voltage
Manual-Off-Automatic	120 VAC

3.11.2.16– Pilot Lights:

Full voltage, push to test, heavy-duty industrial grade oil-tight pilot lights shall be provided. All pilot light components shall be made of corrosion resistant metals and polyesters. An insulated socket shall be furnished to eliminate the possibility of shock during bulb change. Bulb change shall not require removal of the socket. Bulbs shall be “super bright” LED type. Lens shall be 22mm and made of Lexan. The pilot lights required shall be as follows:

Pilot Light Function (Name Plate)	Voltage	Lens Color
PUMP 1	120 VAC	GREEN
PUMP 2	120 VAC	GREEN

3.11.2.17– Seal Fail Alarm Circuit with Test Push Button (all submersible pumps):

The control panel shall be equipped with a conductance actuated control relay that shall respond to current from a moisture sensor in the pump seal chamber. Relay contacts shall be rated at 10 amps minimum. All molded structural parts shall be of high mechanical and dielectric strength, structural dimensionally stable, arc resistant, thermosetting plastic. Base plate shall be high strength, diecast aluminum alloy. Solid state type relays shall not be considered acceptable for seal fail monitoring

applications. An amber alarm pilot light shall illuminate upon alarm condition. Each pilot light shall include contacts that shall allow testing of the seal failure circuit and pilot light bulb by pushing. Bulb change shall not require removal of the socket. Bulbs shall be "super bright" LED type.

3.11.2.18– Seal Failure Circuit Test Push Button (illuminated):

Heavy-duty industrial grade oil-tight push buttons shall be provided for each submersible pump motor. All push button components shall be made of corrosion resistant metals and polyesters. An insulated socket shall be furnished to eliminate the possibility of shock during bulb change. Bulb change shall not require removal of the socket. Bulbs shall be "super bright" LED type. Lens shall be 22mm and made of Lexan. The push buttons required shall be as follows:

Push Button Function (Name Plate)	Voltage	Lens Color
P1 SEAL FAIL	120 VAC	AMBER
P2 SEAL FAIL	120 VAC	AMBER

3.11.2.19– Pump Alternator Circuit (duplex operation):

The electro-mechanical alternator relay shall be of industrial design specifically for use in pump applications. It shall have single-pole double-throw heavy-duty 10-amp silver cadmium oxide contacts enclosed in a transparent cover. The snap action contacts shall transfer when the unit is de-energized. The circuit shall never be closed or opened while current is being conducted. The alternator circuit shall alternate the lead pump position between the pumps and shall allow the lag pump to start in response to a rising water level in the wet well. A four-position switch shall be provided on the exterior of the pump control panel inner door. The switch shall have a position for: Pump 1, Pump 2, or Both.

3.11.2.20– Control Relays:

Plug-in control relays with 120-VAC coils shall be provided as required. Contact rating shall be 5-amps (minimum). Sockets shall be of the same manufacture as the relays and hold-down clips shall be furnished to prevent relay from sliding out of the socket. Relays shall have indicator lights showing when they are engaged.

3.11.2.21– High Wet Well Level Alarm:

The control panel shall be provided with a suitable alarm circuit, activated by a separate level control. This alarm shall signal a high- water condition in the wet well. Terminals shall be furnished in the control panel for connection of externally mounted alarm devices. A red flashing light shall be provided as a visual alarm of the high water in the wet well condition. A continuous sounding alarm shall also be provided as an audible alarm of the high water in the wet well condition.

3.11.2.22– Liquid Level Controls:

Float-actuated mercury level control switches shall be provided for pumps off, lead

pump on, lag pump on, and for low level alarm and high-level alarm functions. The mercury switch shall be encapsulated in polyurethane foam for corrosion and shock resistance. Level switches shall be weighted to hold desired position in the wet well. The cord connection to the control shall be numbered 16-2, rated for 13-amps, and shall be type SJTO. To ensure optimum longevity contacts shall be rated for 20-amps at 115-VAC and shall be sealed in a heavy-duty glass enclosure. No junction boxes or cable splices of any kind will be allowed in the wet well.

3.11.2.23 – High Temperature Shutdown Circuit(s):

The pump motor high temperature circuit shall provide terminals for connection of the leads from the temperature sensor provided in the pump motor windings. Upon a high temperature condition in the pump windings, the control power to the pump motor contactor shall be disconnected, thus stopping the pump motor. The pump shall automatically restart when the pump motor temperature returns to an acceptable level.

3.11.2.24– Ground Lug(s):

Equipment ground lug(s) shall be provided for grounding the enclosure. The ground lug(s) shall be suitable for the service provided the enclosure sized per table 250-95 of the N.E.C. In all cases, the enclosure must be adequately grounded per article 250 of the N.E.C.

3.11.2.25– Terminals:

Terminals shall be provided for connecting mercury float switch leads, temperature sensor and seal fail sensor leads. Terminal blocks shall be rated for 600 volts use and accept a wire range of #22-8. Block shall be constructed of nylon. All live parts shall have insulating walls on all sides of the lug. Blocks must be U.L. recognized.

3.11.2.26– Construction Standards:

Subpanel shall be drilled and tapped to accept machine thread bolts (self-tapping screws are not acceptable). All control wiring shall be 16- AWG machine tool wire, Carol type 76512 or equal. All control wire shall be color coded or numbered in accordance with applicable standards. Power (motor) shall be in accordance with the current National Electrical Code. Major groups of wires shall be contained in plastic wiring trough equal to Panduit type E.

3.11.2.27– Nameplates:

All indicator lights, alarms, selector switches, pushbuttons and major control system components shall be identified with engraved phenolic plastic nameplates, white lettering on a black background.

3.11.3 Alarm Dialer/SCADA

The pump station shall be provided with an alarm dialer in a lockable NEMA 4 enclosure. Hard line dialer units shall have a minimum of eight inputs and capable of additional expansion with battery backup and be the ANTX Dialer Scout or approved equal. The

operating environment shall withstand from –5° Fahrenheit to 130° Fahrenheit with a 90% relative humidity, non-condensing. The alarm dialer shall operate on 120-VAC and shall have a rechargeable battery backup capable of providing 4 hours of standby power with surge protectors on the power and telephone lines. The alarm dialer shall monitor power, high water, and low water conditions through normally open/normally closed contacts, shall have the capability of dialing four phone numbers, and shall work on a standard telephone service. The dialer shall be provided by a manufacturer listed in City's Approved Manufacturers List. Seal failure and high temperature signals from all pumps shall be combined into a common "pump trouble" alarm to be transmitted from the dialer.

The pump station telemetry units shall be compatible with City's current SCADA system. City shall not be required to purchase additional software to operate the telemetry unit.

3.11.4 Generators

3.11.4.1 – General

a) Backup power shall be provided by an automatically starting on-site generator controlled by an automatic transfer switch. The generator shall be capable of supplying all necessary electrical power for complete operation of the pump station in the event of a failure of the electrical feed supplied by the local grid.

b) The entire generator set, switchgear, and accessories necessary to provide a fully functional backup power system, shall be supplied and warranted by a single manufacturer. The list of acceptable manufacturers is provided in City's Approved Manufacturers List.

c) Each engine-generator unit shall be new and a standard product of the manufacturer and shall be a packaged-type unit, fully shop assembled, wired and tested, requiring no field assembly of critical moving parts.

d) The generator shall be sized to start and continuously run all pumps, motors, and other electrical equipment at the pump station site. The pump starting conditions (including delay timers, VFDs, soft starts, reduced voltage starters, etc.) should be verified for the particular site. The kW rating needed for a particular pump station shall be calculated by a licensed professional engineer by the generator manufacturer.

e) The voltage, amps, phase, etc., shall be coordinated with the design of the electrical equipment for the particular site. Generators will be 3 phase, 60 hertz, and capable of multiple voltages through re-strapping.

f) The engine generator set will have a complete and separate control panel mounted inside the generator enclosure providing all settings, monitoring, and control options required, as well as the ability to send alarm signals back to the alarm dialer and telemetry system.

g) Each unit of equipment shall be provided with a corrosion resistant substantial metal nameplate, securely affixed in a conspicuous place.

Nameplate information shall include equipment model number, serial number, manufacturer's name and location, and important performance data.

h) Reference Sound section above.

3.11.4.2 – Submittals

The Contractor shall submit to Water Resources, complete shop drawings for assembly and installation, together with detailed specification and data covering materials, drive unit, parts, devices, and accessories forming a part of the equipment furnished, with the submittals section. The data and specifications for each unit shall include, but shall not be limited to, the following:

a) Manufacturer, model, and type: engine, alternator, enclosure, battery charger and battery, silencer, switchgear, transformer, etc.

b) Listing of standard and optional accessories.

c) Engine output horsepower and efficiency curves at specified conditions.

d) Engine mechanical data including heat rejection, exhaust gas emission data (maximum values at loads of 1/4, 1/2, 3/4, and full for: carbon monoxide (CO) (lb/hr), nitrogen oxides (NOx)(lb/hr), temperature (F), flow (ACFM)), combustion air and ventilation air flows, and fuel consumption at specified conditions.

e) Generator electrical data including temperature and insulation data, winding pitch, cooling requirements, excitation ratings, voltage regulation, voltage regulator, efficiencies, waveform distortion and telephone influence factor.

f) Ratings at specified conditions: engine (net horsepower), engine (maximum performance horsepower bare engine), generator kW at specified power factor, volts, amperes.

g) Overall dimensions (length, width, height) and net weight.

h) Concrete pad recommendation (including size, length, and spacing of all necessary supports and anchor bolts) and layout/stub-up locations for electrical conduits.

i) Wiring diagrams and schematics for the entire system, including the engine control panel, generator breaker, automatic transfer switch, auxiliary transformer, and remote alarm indicators.

j) Calculations or test results showing compliance with specified motor starting and voltage dip requirements.

k) Line circuit breaker rating.

l) Control panel layout, identifying location of all instrumentation being supplied.

m) Operation instructions.

n) Letter from the engine-generator manufacturer confirming that the unit will provide the specified minimum kW rating at the specified design conditions and time duration.

o) Battery sizing calculations.

p) Battery charger sizing calculations.

q) Maximum output short circuit kvA available.

r) A certificate of compliance, when required.

s) Manufacturer's and dealer's written warranty.

3.11.4.3 – Quality Control

Quality Standards. Except where modified or supplemented by these Specifications, all equipment and materials shall be designed and constructed in accordance with the latest applicable requirements of the standard Specifications and codes of ANSI, ASTM, NEMA, IEEE, DEMA, EEI, HEI, ISO, NFPA, SAE, NEC, UL508, and other such regularly published and accepted standards as well as state and local codes.

3.11.4.4 – Generator Equipment

a) Engine

- Engine shall be compression ignition type diesel powered, 4 stroke, liquid cooled, American made, with a minimum of 130 HP, or equal.
- Engine shall operate at an RPM of no more than 1800.
- The engine will be equipped with an electronic governor to maintain 4% drop from no load to full load and +/-0.25% steady state. The electronic governor control shall be furnished as a complete governor and control package.
- Engine shall have a dry type air cleaner, coolant, fuel filters, and oil filters with replaceable elements.
- Engine shall have a lube oil cooler and a fuel lift pump.

b) Generator

- The synchronous generator shall be a single bearing, self- ventilated, drip-proof design in accordance with NEMA MG 1 and directly connected to the engine flywheel.
- Voltage regulation shall be within +/-0.5% at steady state from no load to full load. The momentary voltage drop shall not exceed the specified percent without starter coils dropping out or stalling the engine at any time when applying or starting the specified loads. Recovery to stable

operation shall occur within 2 seconds. Unit shall be capable of adjusting voltage under varying load conditions within 16 milliseconds.

- The voltage regulator shall be a totally solid-state design, and include electronic voltage buildup, volts per hertz regulation, overexcitation protection, shall limit voltage overshoot on startup, and shall be environmentally sealed.
- The insulation material shall meet NEMA standards for Class H insulation and be fungus resistant.
- The generator shall be a self-excited generator type. The excitation system shall be of brushless construction.
- The generator shall be supplied with a 240V single phase anti-condensation heater protected by a circuit breaker inside the main control panel. When the generator set is not running the heater is automatically connected to the AC supply through a power relay mounted in the control panel. Upon receiving a start signal the AC supply is automatically disconnected by the power relay and automatically reconnected when the start signal is removed, and the engine has stopped. A temperature set point shall determine the start and stop signal.

c) Fuel System.

- Each engine-generator unit shall be furnished with a complete diesel fuel system, including an integral fuel tank, fuel filter, fuel shut off valve, and all accessories as required for proper operation. All items shall be suitable for the specified fuel and located inside the enclosure above the base plate and serviceable from inside the enclosure.
- The fuel tank shall have the capacity to provide fuel for a minimum run time of 48 continuous hours at 100% prime load.
- The fuel tank shall be double walled with a rupture basin of 110% capacity. It shall be pressure tested for leaks prior to shipment and have all necessary venting per US142 standards. A locking fill cap, a mechanical reading fuel level gauge, low fuel level alarm contact, and fuel tank rupture alarm contact shall be provided. The fuel system shall require a polishing/filtration system for larger units if stipulated by the City. Any drain lines associated with the generator shall include brass plugs. Plastic plugs will not be accepted.
- Where access to a Lexington natural gas line is available within 200 LF of the pumping station, a natural gas service shall be provided and a natural gas-fueled engine-generator shall be required. The gas service shall be properly sized for continuous service at 100% prime load.

d) Lubrication

- Equipment shall be adequately lubricated by systems which require attention no more frequently than weekly during continuous operation. Lubrication systems shall not require attention during startup or shutdown and shall not waste lubricants.
- Lubricants shall be provided in sufficient quantities to fill all lubricant reservoirs and to replace all consumption during testing, startup, and operation prior to acceptance of equipment. Unless otherwise specified or permitted, the use of synthetic lubricants will not be acceptable.
- Lubrication facilities shall be convenient and accessible. Oil drains and fill openings shall be easily accessible from the normal operating area or platform. Drains shall allow for convenient collection of waste oil in containers from the normal operating area or platform without removing the unit from its normal installed position.

e) Exhaust System

- Each engine-generator unit shall be furnished with a complete exhaust system including an exhaust silencer, exhaust piping, expansion joints, and accessories as required for a complete operating system.
- A rain cap shall be provided to prevent rain from entering the exhaust pipe. The rain cap shall open from exhaust pressure from the engine and shall close when exhaust flow tops. The cap shall be stainless steel counterbalancing with vertical discharge.

f) Starting System

- Each engine-generator unit shall be furnished with a complete electric motor start system including starting motors, battery pack with rack, cables, and battery charger.
- The engine starter shall be a 12-volt DC or 24-volt DC, solenoid shaft, electric starting system with positive engagement.
- The batteries shall be of the high rate, diesel starting, lead acid type. The batteries shall be sized for five 10 second cranks with battery and engine oil temperature of 30 degrees F and a battery end voltage of 70 percent of system voltage.
- The battery charger shall be current limiting and shall be furnished to automatically recharge the batteries. The charger shall be dual charge rate with automatic switching to the boost rate when required. Output voltage regulation shall not exceed 1%. The charger shall include temperature compensation, NEMA 2 corrosion resistant enclosure, overload protection, silicon diode full wave rectifiers, voltage surge suppressor, DC ammeter, DC voltmeter, and fused AC input, on/off switch, remote annunciation of loss of AC power, low battery voltage, and high battery voltage, AC input and DC output circuit breakers or

fuses, floating voltage equalization, equalizing timer. AC input voltage shall be 120 volts or 240 volts, single phase.

- The battery charger shall have a DC output suitable to supply power for all continuous loads and to recharge the batteries from a full discharge state to normal operating voltage within 8 hours.
- The batteries, battery rack, and battery charger shall be located within the engine-generator enclosure. The battery rack frame shall be constructed of corrosion resistant material.
- The engine-generator shall automatically supply power to the battery charger when it is operating, and utility power is not available.

g) Cooling System.

- Each engine-generator unit shall be cooled with unit-mounted radiator cooling system complete with radiator, expansion tank, water pump, belt-driven fan, fan guard, thermostatic temperature control, high-water temperature cutout, and all accessories as required for proper operation.

  The radiator shall be sized to provide sufficient capacity for cooling of the engine and all other accessories required for proper operation at an ambient temperature of 125 degrees F and considering the enclosure static pressure restriction. The fan shall draw air over the engine and discharge through the radiator.
- The cooling system shall be filled with a permanent antifreeze mixture of the ethylene glycol type with rust inhibitor.
- The engine generator unit shall have a 240V coolant heater protected by a safeguard breaker inside the main control panel. A controller shall be included to regulate the output temperature to within safe limits. When the generator set is not running the heater is automatically connected to the AC supply trough a power relay mounted in the control panel. Upon receiving a start signal the AC supply is automatically disconnected by the power relay and automatically reconnected when the start signal is removed, and the engine has stopped.

h) Enclosure

- The engine-generator unit, fuel system, control panel, battery rack, battery charger, power panel, exhaust silencer, and other ancillary equipment, shall be housed in a weatherproof enclosure.
- The enclosure shall consist of a roof, side walls, and end walls, and shall be weatherproof and sufficiently sealed to prevent the entry of rodents.
- The enclosure shall be constructed of 12 gauge or heavier metal panels that can be easily removed, or doors.

- Doors shall be lockable with stainless steel hardware for access to the engine-generator, controls, and accessories. Doors shall also provide easy accessibility for maintenance. Doors shall have lock arm to prevent swinging when open.
- The enclosure shall be provided pre-wired, requiring only external connection to the power panel and ATS.
- Lube oil and coolant drains shall be extended to the exterior of the enclosure and terminated with drain valves.
- All moving parts inside of enclosure, including cooling fan and charging alternator, shall be fully guarded to prevent injury.
- Lifting points shall be provided on base frame suitable for lifting combined weight of base tank, engine generator unit, and enclosure.
- An LED floodlight shall be provided inside the enclosure to illuminate the generator equipment located within the interior of the enclosure. The floodlight shall be provided with a switch mounted on the generator control panel.

i) Control System

- Provide a generator set mounted control panel for complete control and monitoring of the engine and generator set functions. Critical components shall be environmentally sealed to protect against failure from moisture and dirt. Components shall be housed in a NEMA 1/IP22 enclosure with hinged door secured with a twist lock latch. The panel door will have a voltage shunt switch. The panel itself shall be mounted on a separate support stand shall be mounted inside the enclosure such that the face of the panel faces outward and is isolated from vibrations of the engine/generator arrangement. Panel/breaker arrangements shall be mounted in such a manner as to not restrict access to the generator, engine, or other parts of the system that need periodic maintenance or repair.
- The control panel shall be automatic and safety type and shall include at least all items required by NFPS 110 Level 1.
- Panel shall include the following instrumentation and controls (at a minimum): voltmeter, ammeter, frequency/tachometer, engine running hours, coolant temperature gauge, lube oil pressure gauge, battery condition voltmeter, run/off/auto switch, emergency stop push-button, lamp test pushbutton, 7 position voltmeter phase selector switch, 4 position ammeter phase selector switch, 3 attempt start timer, and cool down timer.
- Panel shall include the following emergency shutdowns with individual warning lamps (at a minimum): fail to start, high coolant temperature, low lube oil pressure, and overspeed.

- Panel shall include the following alarms with individual warning lamps (at a minimum): approaching low oil pressure, approaching high engine temperature, low/high battery voltage, battery charger failure, control switch not in auto mode.
- Panel shall have at least 2 spare shutdown channels and 1 spare alarm channel and 4 additional fault channels for shutdown or alarm programming.
- Panel shall have the ability to send up to 8 channels back to the existing SCADA system at the pump station.
- Engine generator unit shall be provided with a fuel level gauge indicating relative fuel tank level in % values.
- The panel shall be provided with a switched light that illuminates the panel face.

j) Circuit Breaker. Provide a generator mounted, molded case or insulated case construction, UL rated, 3 pole, and circuit breaker, sized as required. Breaker shall utilize a thermal magnetic trip. Breaker shall be housed in a steel NEMA 1 enclosure mounted on a separate support stand vibration isolated from the engine/generator arrangement. Bus bars, sized for the cable type shown on drawing, shall be supplied on the load side of breaker.

k) Receptacles. The engine generator will be supplied with two 120V, 20-amp duplex receptacles and two 120V, 20-amp twist lock receptacles. Receptacles will have individual circuit breakers and will be placed inside the enclosure or will have weatherproof covers.

l) Shop Painting

- All steel and iron surfaces shall be protected by suitable coatings applied in the shop. Surfaces which will be inaccessible after assembly shall be protected for the life of the equipment. Coatings shall be suitable for the environment where the equipment is installed. Exposed surfaces shall be finished, thoroughly cleaned, and filled as necessary to provide a smooth, uniform base for painting. Electric motors, engine, alternator, enclosure, piping, and valves shall be shop primed and finish painted prior to shipment to the site.
- Stainless steel, nonferrous, and nonmetallic surfaces shall not be painted.

m) Power Transformer

An externally mounted power transformer shall be supplied to provide required 240V single phase power to the coolant heater and anti-condensation heater for each engine generator unit. The amp load shall be calculated by a licensed engineer or the generator manufacturer.

3.11.5 Automatic transfer Switch (ATS)

An automatic transfer switch (ATS) shall be provided on all pump stations for switching power to the onsite backup generator when normal grid power fails. The ATS shall be provided by the same manufacturer as the generator and included under the same warranty as the generator.

3.11.5.1 – General

a) The ATS shall be rated for the voltage and ampacity as shown on the plans and shall have 600-volt insulation on all parts in accordance with NEMA standards.

b) The current rating shall be a continuous rating when the switch is installed in an unventilated enclosure and shall conform to NEMA temperature rise standards. Designs which require cabinet ventilation are unacceptable and do not meet this Specification.

c) The unit shall be rated based on all classes of loads, i.e., resistive, tungsten, ballast, and inductive loads. Switches rated 400 amperes or less shall be UL listed for 100% tungsten lamp load.

d) As a precondition for approval, all transfer switches complete with accessories shall be listed by Underwriters Laboratories, under Standard UL 1008 (automatic transfer switches) and approved for use on emergency systems.

e) The withstand current capacity of the main contacts shall not be less than 20 times the continuous duty rating when coordinated with any molded case circuit breaker established by certified test data. Refer to required withstand and close ratings as detailed in this Specification.

f) Temperature rise tests in accordance with UL 1008 shall have been conducted after the overload and endurance tests to confirm the ability of the units to carry their rated currents within the allowable temperature limits.

g) Transfer switches shall comply with the applicable standards of UL, CSA, ANSI, NFPA, IEEE, NEMA, and IEC.

h) The transfer switches shall be supplied with a microprocessor-based control panel as detailed further in these Specifications.

i) The transfer switch shall be capable of detecting if the source switch was successful and if the pump station is receiving power. It shall also be capable of transmitting a failure signal if it was not successful in switching sources and the pump station is not receiving power.

3.11.5.2 – Sequence of Operation

a) The ATS shall incorporate adjustable three phase under-voltage sensing of the normal source and emergency source.

b) When the voltage of any phase of the normal source is reduced to 80% of nominal voltage, for a period of 0-10 seconds (programmable) a pilot contact shall close to initiate starting of the engine generator.

c) When the emergency source has reached a voltage value within 10% of nominal voltage and achieved frequency within 5% of the rated value, the load shall be transferred to the emergency source after a programmable time delay.

d) When the normal source has been restored to not less than 90% of rated voltage on all phases, the load shall be re-transferred to the normal source after a time delay of 0-30 minutes (programmable). The generator shall run unloaded for 5 minutes (programmable) and then automatically shut down. The generator shall be ready for automatic operation upon the next failure of the normal source.

e) If the engine generator should fail while carrying the load, retransfer to the normal source shall be made instantaneously upon restoration of proper voltage (90%) on the normal source.

f) The transfer switch shall be equipped with a microprocessor-based control panel. The control panel shall perform the operational and display functions of the transfer switch. The display functions of the control panel shall include ATS position and source availability.

g) The front panel display shall include indicators for timing functions, capability to bypass the TD on transfer or retransfer, and an ATS test switch and afford on-board diagnostic capability.

h) The control panel shall be provided with calibrated pots (accessible only by first opening the lockable cabinet door) to set time delays, voltage and frequency sensors. Designs which make use of DIP switches to render such adjustments are not acceptable. The ATS shall be capable of being adjusted while the controls are energized and the unit in automatic mode. Designs which force a "programming mode" or require the controls be de-energized during adjustment are unacceptable.

i) The control panel shall be opto-isolated from its inputs to reduce susceptibility to electrical noise and provided with the following inherent control functions and capabilities:

- An LED display for continuous monitoring of the ATS functions.
- Built-in diagnostic display.
- Capability to support external communication and network interface through an optional RS 485 port.
- Mechanical test switch to simulate a normal source failure.

- Time delay to override momentary normal source failure prior to engine start. Field programmable 0-10 minutes (continuously adjustable via a calibrated potentiometer factory set at 3 minutes).
- Time delay on retransfer to normal source, continuously adjustable 0-30 minutes, factory set at 15 minutes. If the emergency source fails during the retransfer time delay, the transfer switch controls shall automatically bypass the time delay and immediately retransfer to the normal position.
- Time delay on transfer to emergency, continuously adjustable 0–15-minute, factory set at 1 minute.
- An in-phase monitor shall be provided. The monitor shall compare the phase angle difference between the normal and emergency sources and be programmed to anticipate the zero-crossing point to minimize switching transients.
- An interval-type automatic clock exerciser shall be incorporated within the microprocessor.
- Provide a momentary pushbutton to bypass the time delays on transfer and retransfer.

3.11.5.3 – Construction and Performance

a) The automatic transfer switch shall be of double throw construction operated by a reliable electrical mechanism momentarily energized. There shall be a direct mechanical coupling to facilitate transfer in 6 cycles or less.

b) The normal and emergency contacts shall be mechanically interlocked such that failure of any coil or disarrangement of any part shall not permit a neutral position.

c) For switches installed in systems having ground fault protective devices, and/or wired to be designated a separately derived system by the NEC, a 4th pole shall be provided. This additional pole shall isolate the normal and emergency neutrals. The neutral pole shall have the same withstand and operational ratings as the other poles and shall be arranged to break last and make first to minimize neutral switching transients. Add-on or accessory poles that are not of identical construction and withstand capability are not acceptable.

d) The contact structure shall consist of a main current carrying contact, which is a silver alloy with a minimum of 50% silver content. The current carrying contacts shall be protected by silver tungsten arcing contacts on all sizes above 400 Amps.

e) The transfer switch manufacturer shall submit test data for each size switch, showing it can withstand fault currents of the magnitude and the

duration necessary to maintain the system integrity. Minimum UL listed withstand and close into fault ratings shall be as follows:

Any molded case breaker:	
Size (Amps)	(RMS Symmetrical)
Up to 200	10,000
201-260	35,000
261-400	35,000
401-1200	50,000
1201-4000	100,000
Specific coordinated breakers:	
Size (Amps)	(RMS Symmetrical)
Up to 150	30,000
151-260	42,000
261-400	50,000
401-800	65,000
801-1200	85,000
1201-4000	100,000
Current limiting fuse:	
Size (Amps)	(RMS Symmetrical)
Up to 4000	200,000

*All values 480 volt, RMS symmetrical, less than 20% power factor.

f) A dielectric test at the conclusion of the closing tests shall be performed.

g) The automatic transfer switch manufacturer shall certify sufficient arc interrupting capabilities for 50 cycles of operation between a normal and emergency source that are 120 degrees out of phase at 480 volts, 600% of rated current at 0.50 power factor. This certification is to ensure that there will be no current flow between the two isolated sources during switching.

h) All relays shall be continuous duty industrial type with wiping contacts. Customer interface contacts shall be rated 10 amperes minimum. Coils, fuses, relays, timers, and accessories shall be readily front accessible. The control panel and power section shall be interconnected with a harness and keyed disconnect plugs for maintenance.

i) Main and arcing contacts shall be visible without major disassembly to facilitate inspection and maintenance.

j) A manual handle shall be provided for maintenance purposes with the switch de-energized. An operator disconnect switch shall be provided to defeat automatic operation during maintenance, inspection, or manual operation.

k) The switch shall be mounted in a NEMA 3R enclosure unless otherwise indicated on the City-approved plans.

l) Switches composed of molded case breakers, contactors or components thereof not specifically designed as an automatic transfer switch will not be acceptable.

3.11.6 Odor Control Systems

Odor control measures shall be evaluated for all possible sources of odor related to wastewater pumping systems. Source locations to be analyzed shall include, but not be limited to, the wet well at the pump station, the force main discharge location, and force main air release valves. Odor control measures to be analyzed shall include, but not be limited to, oxidizing agent added to the wastewater, odor masking agents added to the air, activated carbon treatment, biofilter treatment, and wet scrubber treatment. Final determinations of appropriate odor control measures shall be made by the City. Solutions that include chemical feed must consider the feasibility of chemical delivery to the site, provide appropriate chemical storage facilities including secondary containment.

Odor control facilities not located on the pump station site (air release valves and discharge points, for instance) shall be constructed in underground vaults or shall be house inside an above-grade structure. Appropriate consideration shall be given to changing media or supplying chemical at the remote locations, as well as the safety of the maintenance staff while servicing the systems.

3.12 Pump Station Inspections, Testing and Training

3.12.1 Inspections

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 City) by City personnel prior to installation. Non-conforming materials or equipment shall be immediately removed from the job site.

Compliance with plans and Specifications shall be verified on a regular basis by the City utilities inspector and the Engineer of Record or the engineer's direct report.

3.12.2 Testing

3.12.2.1 – General

a) The Contractor shall furnish all materials, labor, and equipment to perform all testing. Water for testing purposes may be obtained from City at City-approved fire hydrants with a proper hydrant meter-backflow preventer combination where City water mains are available. The Contractor shall reimburse the City at Inside Utility Rates. Where water must be obtained from another public water supply, contractor shall adhere to proper water purchasing and dispensing requirements as dictated by the water supplier.

b) All water used during testing of the pump station, force main, or any of the systems described in this section, must be disposed of in accordance with City ordinances and NC DWQ regulations. Testing water may be discharged to City's sanitary sewer system if approval by the Wastewater Treatment Plant Supervisor is granted in writing prior to testing.

c) Before the operational tests are conducted, the required copies of the Operation and Maintenance Manuals shall be delivered to City.

d) Before the operational tests are conducted, the startup/testing procedures shall be reviewed with all involved parties and approved by Water Resources.

e) City reserves the right to require further testing, as necessary, to assure that all components and infrastructure are performing in accordance with the manufacturer recommendations and City Specifications. All testing, repairs and/or readjustments, and necessary re-testing, shall be at no additional cost to City.

f) All on-site testing and/or installation verification shall be performed in the presence of the City personnel and the Engineer of Record.

g) All testing, installation verification, and training shall be performed in the presence of, or by, an experienced, competent, and authorized manufacturer's representative.

h) Factory testing shall consist of testing all operating functions of the equipment under varying operating conditions to assure that it will perform as specified. Any specific testing that may be required is discussed under the individual equipment items below. Results of factory testing shall be presented to City prior to delivery of the equipment.

i) Installation Verification shall consist of a visit to the site by a manufacturer's representative to inspect, check, adjust if necessary, and approve the equipment installation. The manufacturer's representative shall certify that the equipment has been properly installed and lubricated, is in accurate alignment, and is free from any undue stress imposed by connecting piping or anchor bolts. Any specific verification requirements are discussed under the individual equipment items below. Results of the installation verification shall be presented to City prior to start-up of the equipment.

j) On-Site Testing shall consist of all manual and automatic operating functions under various operating conditions, including full load conditions. The equipment shall also be tested under adverse or emergency conditions. All alarms and remote signals shall also be tested. Any specific testing that may be required is discussed under the individual equipment items below. Results of the on-site testing shall be presented to City prior to final acceptance of the project.

k) All functions and systems of the pump station, even those not specifically listed below, shall be tested to ensure proper operation under normal and emergency situations.

l) All defective equipment or malfunctioning systems shall be replaced or corrected, and the full system placed in a fully operational condition to the satisfaction of the City Inspector.

m) Results of all factory testing, installation certifications, and on-site operational testing shall be provided to City in the final construction documents as described in the Submittals portion of this Specification section.

3.12.2.2 – Pump Testing

a) Each pump shall be tested at the factory for capacity, power requirements, and efficiency at specified rated head, shutoff head, operating head extremes, and at as many other points as necessary for accurate performance curve plotting. All tests and test reports shall conform to the requirements and recommendations of the Hydraulic Institute Standards. Acceptance testing shall be Level A, with no minus tolerance or margin allowed. The test result report shall include data and test information as stipulated in the Hydraulic Institute Standards, copies of the test log originals, test reading to curve conversion equations, and certified performance curves. The curves shall include head, bhp (brake kW), pump efficiency, and shop test NPSH available, plotted against capacity. The curves shall be easily read and plotted to scales consistent with performance requirements. All test points shall be clearly shown.

b) All pumps shall receive installation verification.

c) On-site testing shall be performed to the maximum extent possible. All pumps shall be exercised separately to verify proper pump rotation and tested for wet well draw-down of one foot to test pump discharge rate in GPM in the presence of the pump supplier. Each pump shall be tested from the same water level at least twice for discharge rate verification.

3.12.2.3 – Generator Testing

a) Each engine generator set shall be fully assembled with its control panel and factory tested to demonstrate that the equipment conforms to specified requirements for load capacity. The tests shall consist of repeated starts and stops operation under a load bank at specified capacity for a minimum of 4 continuous hours, and tests to demonstrate that each safety shutdown device is working properly.

b) Each engine generator set shall receive installation verification.

c) Each engine-generator set shall receive on-site testing to demonstrate that the equipment conforms to specified requirements for load capacity and starting duty. The complete system (engine, generator, control panel, and automatic transfer switch) shall be field tested together by the manufacturer or manufacturer's representative as a complete system to assure compatibility. A resistive load bank with temporary connections shall be provided to complete the field testing. Each unit shall be mechanically checked for proper operation. Each alarm and safety shutdown shall be checked by artificially simulating an alarm condition. The testing shall consist of repeated starts and stops, a "cold start", normal operation under

full load conditions at the specified power rating for a minimum of four continuous hours, and a one-step rated load pickup test in accordance with NFPA 110. The following items shall be measured, recorded, and submitted in a field test report: outdoor ambient temperature, barometric pressure, kW output, engine speed (RPM), engine jacket water temperature, engine oil pressure, start time, completion time. Test reports shall verify that the specified tests have been performed and shall state results.

3.12.2.4 – Automatic Transfer Switch Testing

a) Each automatic transfer switch shall receive field verification.

b) Each automatic transfer switch shall receive on-site testing in conjunction with the engine generator. At a minimum, the main power supply from the commercial power grid shall be cut and the switch shall automatically properly transfer the power feed to the standby generator.

3.12.2.5 – Control System Testing

All electrical, instrumentation, control, and telemetry systems shall receive on- site testing to ensure complete operation of all systems. At a minimum the testing shall include the following:

a) Pump automatic control and operation

b) Level-sensing equipment operation

c) Alarm and telemetry system automatic operation

d) Backup power generation automatic control and operation

e) Vibration testing of all rotating equipment

3.12.2.6 – Structure Testing

a) Wet wells and other wastewater containing structures at the pump station shall be inspected and tested for watertightness. Structures shall be thoroughly cleared of dirt, mud, gravel, and other foreign debris prior to testing.

b) The watertightness test shall be performed in accordance with ACI 350.1R "Testing Reinforced Concrete Structures for Watertightness". If the structure is a small diameter precast manhole, a vacuum test in accordance with ASTM C1244 "Standard Test Method for Concrete Sewer Manholes by Negative Test Pressure (Vacuum) Test" may be used in lieu of the hydrostatic test.

c) Watertightness testing shall not commence until the structure is fully assembled and backfilled.

d) Any structure that fails to meet the requirements of the watertightness test shall be inspected, made watertight, and retested until passing results are achieved or the structure is replaced and achieves a passing test.

3.12.3 Operator Training

Suppliers of major equipment packages shall provide training to City staff as to the proper operation and maintenance of their equipment. Training shall be performed by an experienced, competent, and authorized manufacturer's representative. Training shall be at no additional cost to City.

Training shall be provided for, but not limited to, the equipment listed in the table below. The training times presented below for Operation Training and Maintenance Training are the minimum required. Complicated systems can require more than the minimum requirements.

Table 3-13. Systems Training Hours

Equipment System	Operation Training (hours)	Maintenance Training (hours)
Pumps and Pump Control Systems	2	4
Engine Generator and Automatic	2	4
Chemical or Odor Control	1	2
Alarm Dialer/ SCADA	1	0

3.12.3.1 – Operational Training

Operational training shall include, but not be limited to, the following procedures or information: normal startup of the unit, normal shutdown of the unit, emergency shutdown of the unit, normal operation of the unit (typical temperature, pressures, signals, rpm, etc., for gauges and instruments which are displayed on the panel), a presentation of all operational features (alternative run modes, bypasses, other features not typically used in day-to-day operation, etc.), presentation of all alarm signals, etc.

3.12.3.2 – Maintenance Training

Maintenance training shall include, but not be limited to, the following procedures or information: standard lubrication procedures and schedules, removal and replacement of equipment, disassembly and re-assembly, replacement of wear parts or common replacement parts, standard troubleshooting procedures, etc.

3.12.3.3 – Instructions

Simplified operation instructions shall be submitted for review in accordance with the submittals section of this Specification. When the review is complete, the instruction sheets shall be printed on heavy paper or cardboard stock and laminated with clear plastic. Two copies of the laminated instructions shall be furnished with the unit. One copy shall be located or displayed at the control panel for the unit. The reserve copy shall be delivered to City. The instructions specified here are in addition to the required operation and maintenance manuals.

SECTION 4 – WATER DISTRIBUTION

4.1 Water Mains

4.1.1 Design

4.1.1.1 – General

The following Standard Specifications and associated Standard Details shall apply to all public water system connections and extensions, and all private water systems planning to connect to the City distribution system.

All utility extension permits must be obtained and an authorization to construct granted by NC Public Water Supply Section and the City of Lexington prior to all water system construction.

4.1.1.2 – Location

All public water mains shall be located under pavement within City street rights-of-way, within roadway shoulders inside NCDOT rights-of-way, or in dedicated public utilities easements with a minimum width of 20 feet. City utility and pipeline easements shall contain only City utilities unless otherwise approved by way of formal encroachment agreement with the City.

4.1.1.3 – Easement Areas

No permanent structures, equipment, retaining walls, embankments, impoundments, or other elements that would inhibit maintenance operations shall be constructed within a City utility and/or pipeline easement. Fences may be allowed across easements provided that appropriate access gates have been City-approved and are properly installed to allow utility maintenance. Fill or cut slopes greater than 4:1 are not allowed to extend into easements

4.1.1.4 – Sizing

Sizing: Major transmission lines shall be sized as directed by the City. Six (6) inch mains may be used on a case-by-case basis only when the Water Resources Operator in Responsible Charge has determined that the proposed improvements and existing distribution network supports using six (6) inch mains. If fire hydrants are not required on a main, up to 400 linear feet of two (2) inch water main may be permitted on residential cul-de-sacs. Where the existing network is lacking connectivity, lines shall be upsized to provide adequate fire flow as directed by the City Engineer or City Fire Marshal.

4.1.1.5 – Second Connection Required

A second connection shall be made to the City's distribution system for any development proposing 30 or more residences (or 30 or more service connections), and as required by the City Engineer or City Fire Marshal due to anticipated water quality and/or hydraulic deficiencies indicated by the City's water model.

4.1.1.6 – Hydrant Legs

Hydrant legs and fire hydrants shall be connected to the water main at or near street intersections within new development areas and as approved by the City Fire Marshal. Fire hydrants shall be placed at or near the right-of-way limit facing the street. Service taps are not allowed on fire hydrant legs.

4.1.1.7 – Construction Involving Existing Mains

a) The existing water main and services must remain active and protected during all phases of construction.

b) The contractor must provide a plan for the structural protection of the existing water main and proper isolation of the public water system from any possible contamination for all proposed water main connections and/or extensions.

c) A proposed construction sequence must be submitted for any demolition and/or relocation of a portion of existing public water main. The plan must be reviewed and approved by the City and all required NC DEQ permits issued prior to any construction and demolition activities.

d) All water main extensions shall remain separated from the existing public water system until final testing and disinfection have been approved by the City Inspector. Contractors shall purchase all filling and flushing water from the City of Lexington by way of a City-approved hydrant meter and backflow prevention assembly. The cost for hydrant meter rental and public water use shall be assessed according to the City's current Schedule of Fees.

4.1.1.8 – Restraint:

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). The standard joint restraint method shall be to use manufacturer provided restrained joint pipe and fittings. Pipe up to and including 12-inches in diameter may utilize mechanical joint pipe with approved wedge action retainer glands and reaction blocking at fittings as an alternative.

Projects with pipe diameters greater than 8-inches, poly-wrapped pipe, or combined bends must have an engineer-sealed 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 must be calculated 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). The plan must also account for the actual soil types that exist at the project site.

All MJ cap and plug fittings, including tapped caps, shall be restrained with approved wedge action retainer glands. Reaction blocking shall not be used to restrain caps and plugs unless approved by the City.

4.1.1.9 – Depth of Installation:

All water mains shall have a minimum cover of 3.0 feet measured from the top of the pipe to the finished grade unless otherwise approved by the City.

When water lines are installed along a roadway, they shall be installed at sufficient depth to maintain four (4) feet of cover to the subgrade of any future road improvements including potential vertical alignment changes. Maximum depths permitted for new water mains shall be as approved by the City.

4.1.1.10 – Relation to Sanitary Sewer, Storm Sewers, and Other Utilities:

Water mains-when a water main crosses:

water main 12 inches of vert separation is required	**small conduits/ linear utilities** (electric/telecom) 12 inches of vert separation is required
over storm drain 12 inches of vert separation is required	**under storm drain** 12 inches of vert separation is required
over gravity or pressure sewer 18 inches of vert separation is required	**under gravity or pressure sewer** 18 inches vert separation at crossings & both shall be water main quality DIP (center of each pipe located at crossing)

Water main-when water is installed parallel to:

sewer mains or storm drains a minimum of 10 feet of horizontal separation shall be maintained	**all other pipelines and linear utilities** horizontal separation shall be maintained such that the excavation of the lower utility shall not compromise the upper utility with a slope of 1:1 horizontal to vertical separation ratio. In no case shall storm drains or other utilities lines be installed parallel to water mains within a public water main easement

Alternatives to minimum pipe separations may only be allowed by the City on a case-by-case basis where existing pipelines, grades, and structures are outside of City and/or developer control. Reduced separations or other modifications shall not be approved for new development areas unless no alternatives exist. In no case shall

pipe separations, pipe materials, and pipeline design diverge from the restrictions set forth by NC DEQ.

4.1.2 Materials

4.1.2.1 – General

All water main distribution pipe greater than 2" diameter shall be ductile iron and comply with NSF/ANSI 61- latest revision. Any newly installed ductile iron water mains larger than 12-inch in diameter shall be zinc-coated ductile iron pipe.

The zinc-coated ductile iron pipe shall be sprayed with an arc-sprayed zinc per ISO 8179 zinc coating on the outside of the pipe and covered with an asphaltic topcoat. The mass of the zinc applied shall be 200 g/m2 of pipe surface area. A finishing layer topcoat shall be applied to the zinc. The coating system shall conform in every respect to ISO 8179-1 "Ductile iron pipes – External zinc-based coating – Part 1: Metallic zinc with finishing layer. Second edition 2004-06-01".

4.1.2.2 – Ductile Iron Pipe

a) Ductile iron pipe shall be designed and manufactured in accordance with AWWA C150 and C151 and provided in nominal 18-ft or 20-ft lengths. The minimum required pressure rating for ductile iron pipe 6" through 12" is 350 PSI.

b) Pipe joints shall be mechanical joint or push-on type as per AWWA C111. Gaskets shall be supplied by the pipe manufacturer for the specific pipe joint configuration and diameter. Gaskets shall be either EPDM or SBR and must be NSF/ANSI 61 compliant.

c) Pipe lining shall be cement mortar in accordance with AWWA C104. All buried ductile iron pipe shall have a bituminous exterior coating in accordance with AWWA C151.

4.1.2.3 – Ductile Iron Fittings

All ductile iron fittings shall be provided in conformance with AWWA C110 for standard ductile iron fittings and AWWA C153 for compact ductile iron fittings. All fittings shall be pressure rated for a minimum 350-psi through 24-inches in diameter and 250-psi for fittings greater than 24-inches in diameter. In cases where minimum pressure standards are less than the pipe specification, fittings shall always be pressured rated to meet or exceed the pressure ratings for the specified pipe. All fittings for potable water service shall be provided with cement mortar linings and asphaltic seal coats in accordance with AWWA C104. All ductile iron fittings shall have an asphaltic exterior coating in accordance with AWWA C151. All ductile iron fittings shall be provided with mechanical joint end connections or proprietary restrained joints from an approved manufacturer. Gaskets shall be provided in conformance with AWWA C111 with EPDM rubber gaskets preferred over SBR.

4.1.2.4 – Restrained Joint Ductile Iron Pipe

All restrained joint ductile iron pipe unless otherwise specified shall be of the boltless restrained joint type. 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 6-inches through 12-inches in diameter.

All proprietary pipe restraint systems shall be approved by the City 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.

4.1.2.5 – PVC Pipe

2-inch diameter SDR 17 PVC shall meet or exceed the requirements of ASTM D1784 cell class 12454 and be NSF/ANSI 61 certified for potable water. Pipe dimensions shall meet ASTM D2241. Joint design shall be in accordance with the requirements of ASTM D3139. Pipe end connections must be bell & spigot and have manufacturer-installed gaskets at bell end. Gaskets must conform to ASTM F477 with EPDM rubber gaskets preferred over SBR.

Pipe shall be pressure rated at 250-psi and provided in minimum 20-ft lengths. SDR 17 may only be approved for residential cul-de-sacs and other residential dead-end lines where future extension is impracticable.

All PVC pipe shall be stored properly to prevent UV damage prior to installation. Any PVC pipe with visible fading caused by UV radiation from sunlight shall be rejected. PVC pipe shall be free from nicks, scratches, and gouges at the time of installation. All pipe segments with visible gouges shall be rejected.

PVC pipe shall be the appropriate color signifying potable water. Each pipe section supplied shall be easily identified and must be plainly and permanently marked with the following data:

a) Manufacturer name or trademark

b) Date of manufacture

c) Pipe classification/ pressure rating

d) Nominal pipe size

e) Dimension ratio/SDR

f) Applicable AWWA/ANSI/NSF pipe specifications

4.1.3 Installation

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 shall be handled with mechanical equipment or in such a manner to always protect them from damage. At no time shall pipe and fittings be dropped or pushed into ditches.

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 water-tight when pipe laying is not in progress.

All pipe shall be constructed with at least 36 inches of cover below the finished surface grade. Pipe shall be laid on true lines as directed by the Engineer. Trenches shall be sufficiently wide to adjust the alignment with a minimum of 12 inches clear on each side of the pipe. 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.

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 are provided in the Utility Trenches, Pipe Laying and Backfilling Section above.

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 conflicts with construction, it shall be exposed prior to beginning construction to prevent damage to the existing utility.

All valves that are under the ownership and acceptance of Lexington’s municipal water system shall be operated only by trained City personnel. Existing valves in the City’s water system will not be operated without a minimum notice of 72 hours to the Engineer and City Inspector. New water mains under construction shall remain fully disconnected from the City’s water distribution system or shall be indirectly connected through use of a Reduced Pressure Principle Assembly (RP) approved by the City’s Backflow Prevention Program ORC to supply water to the water main extension. At such time when the valves in new construction areas are connected with the municipal water supply, the valves shall only be operated by City personnel.

All water discharged or dispensed for construction of water mains or other development activities shall be purchased from the City at connections to or locations on the municipal water system which are approved in advance by the City. All temporary water use shall be measured by a City-approved metering device and backflow prevention assembly. Contractor’s billing accounts for water use shall be established at City Customer Service before construction begins.

4.1.4 Pipe Identification and Marking

4.1.4.1 – Marking Tape

a) Installation: Marking tape shall be installed continuously and longitudinally along all water mains and water services for new construction and for any repair or retrofit construction using open trench methods. For service connections, the marking tape shall extend from the main line to the water meter. Marking tape shall be installed directly above the center of the pipe and at least 12-inches deep from final grade.

b) Specifications: Marking tape shall be made of polyethylene (or approved equivalent) and aluminum material, 3-inches wide and a minimum of 6 millimeters thick. The tape shall be blue in color and shall be marked with words "CAUTION WATER LINE BURIED BELOW" (or an approved equivalent wording). The wording shall be repetitive along the full length of the tape.

4.1.4.2 – Tracer Wire

All water mains shall be installed with a continuous, longitudinal copper tracer wire attached to the pipeline, fittings and each valve box. Wire shall be solid copper minimum 12 AWG with 30 mil HDPE jacketing (blue).

Corrosion proof wire connectors shall be installed at all splices, tees, and crosses to prevent disconnection of wire and inhibit corrosion. Wires shall be extended to finished grade and must be accessible at all valve boxes, blow-offs, and hydrants.

Each segment of tracer wire shall be tested for continuity by the contractor prior to final backfilling and at the completion of the water main construction. It is the Contractor's responsibility to provide the necessary equipment to generate the signal and locate the wire. Any defective, missing, or otherwise non-locatable segments shall be replaced at the Contractor's expense.

4.2 Fire Protection

4.2.1 Fire Hydrants

4.2.1.1 – Location

All fire hydrants shall be installed on a minimum 6-inch public water line. Only one fire hydrant may be installed when the line is served by a 6-inch tap and is not looped to another main. There shall be at least one fire hydrant at each street intersection.

The maximum distance between hydrants, measured along street centerlines, shall be 500 feet. When residential intersections are less than 700 feet apart, a hydrant is not required between the intersections. Additional fire hydrants may be required for specific development projects. Any deviation from this section must be approved by the City Fire Marshal.

4.2.1.2 – Specifications

Hydrants shall conform to AWWA C502 with a minimum valve opening of 4 ½-inches. Hydrants shall be furnished with a 5-inch Storz connection (manufacturer installed as part of the hydrant assembly) and double 2 ½-inch hose connections with caps and chains, dry top, National Standard threads, mechanical joint, 1 ½-inch pentagon operating nut, open left, painted silver and yellow bonnet, bronze to bronze seating, Traffic type with min. 3'6" bury. Fire hydrant caps shall be attached to the body of the hydrant with a minimum 2/0 twist link, heavy duty, non-kinking, machine chain. All fire hydrants shall be designed and rated for a working pressure of 200-psi or greater. No adapters for Storz connections shall be permitted. See City's Approved Products List for manufacturers.

4.2.1.3 – Installation

Hydrants shall be set plumb, properly located with the pumper nozzle facing the closest curb of a fire lane or street, but not a parking space. The back of the hydrant opposite the pipe connection shall be firmly blocked against the vertical face of the trench with 1/3 cubic yard of concrete for blocking. All joints between the tee and the hydrant shall be mechanical joints restrained with wedge action retainer glands. A minimum of 8 cubic feet of stone shall be placed around the drains. The backfill around the hydrants shall be thoroughly compacted and closely match the elevation on the approved plans. Hydrant installation shall be in accordance with Standard Detail 6104.

4.2.1.4 – Depth of Bury

The maximum depth of bury for all new fire hydrants shall be 5-ft from the breakaway flange connection. The breakaway flange or safety coupling shall be oriented vertically just above finished grading and bolted directly to the fire hydrant in compliance with manufacturer standards. The breakaway flange or safety coupling shall not be buried.

4.2.2 Water System Hydraulics

The minimum acceptable flow for fire hydrants is 1000-gpm at minimum 20-psi residual in residential areas and 1500-gpm at minimum 20-psi residual in other districts, or as specified by the City Fire Marshal for a specific location. Designers shall be required to provide water system hydraulic calculations incorporating current fire flow testing results from hydrants in the vicinity of water main extension to verify the adequacy of the design.

Fire flow testing must be scheduled in advance with the City for the City personnel to operate system and hydrant valves for the designer or the designer's representative conducting the fire flow tests. The designer shall be charged for services according to the City's current Schedule of Fees.

4.3 Valves and Appurtenances

4.3.1 Valves

Valves shall be installed on all branches from feeder mains and hydrants according to the following schedule: 4 valves at crosses; minimum 2 valves at tees; one valve on each hydrant branch and elsewhere as directed by the City. When a loop section of water line is connected back into the feeder main within 200 feet or less, only one valve will be required in the feeder main. In all cases where new water mains are connected to an existing water distribution line, valves shall be located at all end points and at intermediate points throughout the new system extension to assure testing requirements can be met without interfering with the operation of the existing system.

Where no water line intersections are existing, a main line valve shall be installed at a maximum distance of 600 feet from the previous valve.

Valves shall be properly located, operable and at the correct elevation. The maximum depth of the valve nut shall be 4 feet without an extension kit. When valve extension kits are used, they must be manufactured by the same company which manufactured the valve.

4.3.2 Air Valves/Combination Air Valves

Air valves and combination air vacuum relief 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. Air valves or combination air vac. relief valves rated for potable water use shall be installed at all high points of water lines 8 inches in diameter or larger and at other locations such as major changes in grade as directed by the City. A high point shall be determined as any high location where the difference between the high elevation and adjacent low elevation exceeds 8-ft.

All air/combination valves shall be provided in conformance with AWWA C-512. The water main shall be installed at a grade which will allow the 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.

The combination air valve shall be sized by the Engineer and approved by the City. 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 shall be rated for minimum 230 PSI working pressure. 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 Standard Details.

2-inch air/combination valves shall be installed in a standard 4-foot diameter eccentric manhole. The 2-inch valve shall have a 2-inch male NPT inlet. Connection to the main shall be with a direct tap in the same sizing as the air/combination valve assembly. The isolation valve shall be rated for 200-psi service or greater. Refer to Standard Detail.

Combination air valves 3-inches and greater shall be installed in a flat top manhole sized according to the water main diameter. Mains less than or equal to 20” shall utilize a 5-foot diameter manhole and larger mains shall utilize a minimum 6-foot diameter manhole. All connections shall be by flange joints. Connection to the main shall be by an MJ x FLG tee with the branch diameter equal to at least half of the main diameter. If needed due to larger diameters, a flanged reducer shall be provided prior to the flanged gate valve sized equally to the flanged combination air valve.

Precast concrete manholes shall be provided in accordance with Standard Details.

4.3.3 Valves, Small Diameter

Valves for blowoff installations sized smaller than 4-inches, may be brass curb stops or resilient seated wedge type gate valves with a non-rising stem and a 2-inch operating nut in compliance with AWWA C509. 2-inch gate valves shall be provided with triple O-ring seals and threaded end connections in compliance with ANSI B2.1. 4-inch gate valves for blow-offs shall be resilient wedge gate valves the same specifications as the 2-inch diameter. The valves shall be rated for a minimum pressure rating of 200-psi.

4.3.4 Gate Valves, 6 to 16-inches

All valves for potable water applications, 16-inches in diameter and smaller shall be resilient seated wedge gate valves in conformance with the requirements of AWWA C509, (grey or ductile iron body) or AWWA C515, (reduced wall ductile iron body). All coating materials used in the construction of gate valves for potable water applications must comply with NSF 61 to assure lead free construction. All gate valves shall be designed for a working pressure of 250-psi with a minimum UL listing and FM approval rating of 200-psi. Gate valves shall be fusion bonded epoxy (FBE) coated both interior and exterior at a nominal thickness of 6-8-mils and the FBE coating shall be provided in conformance with AWWA C550. All gate valves shall be assembled with stainless steel bolts.

All gate valves 16-inches in diameter and smaller shall be installed in the vertical position and shall be provided with mechanical joints. The exception is the tapping valve where a flanged end connects to the tapping sleeve. Gate valves shall be restrained by wedge action retainer glands or other approved manufacturer provided restraining systems. All gate valves shall open left with a non-rising stem (NRS) and be provided with a 2-inch square operating nut. All gate valves shall be constructed with triple O-ring seals in which 2 O-rings are located above the thrust collar and 1 O-ring is located below the thrust collar. The two upper O-rings shall be replaceable with the valve fully open and subjected to full rated working pressure.

The gate valve wedge shall be fully encapsulated in rubber. All valves shall be rated for bi-directional flow. All sealing gaskets shall be made of EPDM rubber materials.

4.3.5 Valve Boxes

Valve Boxes shall be cast iron, screw type, with a 5 1/4-inch opening, and "water" stamped on the cover. The cover shall be 6-inches in depth. All valve box assemblies and

covers shall be cast from Class 30B or 35B gray iron and domestically made and manufactured in the USA.

Valve box ring adjustments will not be allowed. The valve box shall be centered over the wrench nut and seated on compacted backfill without touching the valve assembly. All valve boxes in pavement shall be flush with the top of the pavement or flush with the finished grade. Outside of paved areas precast concrete valve box encasements or a trowel finished 2' x 2' x 6" pad of 3000-psi concrete may be used for valve box encasement provided the assembly is buried flush with the surface grade and compacted properly to prevent movement of the precast encasement.

4.3.6 Actuators

All valves shall be provided with standard 2-inch operating nuts. Unless otherwise specified, the direction of rotation to open the valves shall be to the left, (counterclockwise), when viewed from the top. Each valve body or actuator shall have cast thereon the word “OPEN” and an arrow indicating the direction to open.

4.3.7 Blow-offs

Blowoffs shall be a minimum of 2 inches and installed at the end of all dead-end water lines. Where there is not sufficient pressure or fire hydrants to thoroughly flush the system, a larger blowoff shall be required. Blowoff Assemblies shall be constructed as shown in City Standard Details. A full-size gate valve is required on water mains that are planned or anticipated to be extended.

4.3.8 Reaction Blocking

Material for reaction blocking shall be 3000 psi concrete, poured in place. The reaction areas are shown in the Standard Details. A minimum 8 mil plastic shall cover the fitting to ensure that no concrete will interfere with removal of the fitting.

4.3.9 Wedge Action Retainer Glands

All wedge action retainer glands shall be manufactured as a one-piece retainer gland for use with mechanical joints and shall be rated to provide restraint up to 350-psi pressure rating for sizes through 16-inches. For sizing above 16-inches, the wedge action retainer gland shall be rated to provide restraint up to 250-psi. Approved wedge action retainer glands shall be made of ductile iron, coated with a manufacturer applied epoxy coating or polyester powder coating.

In cases where wedge action retainer glands are approved for pipe restraint of fire hydrant supply lines or other applications, the entire hydrant supply line shall be restrained.

4.4 Taps and Services

4.4.1 Design

Individual water services shall be provided from the main to each water meter for single family residences in accordance with the Standard Details. All connections shall be made

by direct tap. Service connections shall be made as perpendicular to the main as possible and shall run straight to the meter.

Individual taps to the main shall be provided for the domestic service, irrigation service, and fire service in accordance with the Standard Details.

No taps shall be made within 3-feet of the bell or spigot end of the pipe.

All water service lines shall be installed at a minimum depth of cover of 18-inches.

All water meter boxes and vaults shall be located at the edge of the serviced lot's right-of-way or easement. Water meter boxes shall not be placed in streets, sidewalks, driveways, paved areas or obstructed by fencing, buildings, or electrical infrastructure.

All meter boxes shall be protected during construction by installation of tree protection fencing or some other acceptable material. Material will be adequately maintained throughout the construction period to prevent damage and contamination of the water system.

The water meter shall be sized based on water demand. All single-family residential water service lines shall be minimum ¾-inch diameter. Refer to the Standard Details. A single water service line may provide 2 water services for a single-family residence (separate domestic and irrigation) but shall not be less than 1-inch in diameter.

Service taps to new water lines shall be made by the Contractor in accordance with the Specifications after obtaining applicable permits and paying all associated fees.

4.4.2 Materials

4.4.2.1 – Stainless Steel Tapping Sleeves, 6-inch through 12-inch mains

Stainless steel tapping sleeves are preferred for ductile iron or asbestos cement water mains through 12-inches in diameter with branch sizing as shown in the following table. All stainless-steel tapping sleeves shall be manufactured in conformance with AWWA C223. All stainless-steel tapping sleeves shall have a stainless-steel flange and be provided in a two-piece assembly with a full circumferential gasket with tabbed gasket holding assembly and ¾-inch test plug. The back band shall be a minimum 14-gauge stainless steel and the front band (where the outlet is located) shall be a minimum 12-gauge stainless steel. The bolt bars shall be a minimum 7-gauge stainless steel. All stainless-steel tapping sleeves shall be manufacturer rated for a working pressure of 200-psi or greater and hydrostatically tested to 150-psi before a tap is made. Stainless steel tapping sleeves shall not be air tested.

Table 4.1. Stainless Steel Tapping Sleeve Diameters

Nominal Main Size (inches)	Nominal Branch Size (inches)
6	6
8	6
8	8
10	8

12	6
12	8
12	12

4.4.2.2 – Ductile Iron Tapping Sleeves

If approved by the City for a specific application, mechanical joint tapping sleeves for water mains to 12" diameter may be fabricated of ductile iron construction in a two-piece assembly with mechanical joint connections to the main line and flanged connection to the tapping valve. All MJ tapping sleeves shall be rated for a working pressure of 200-psi or greater and provided with a ¾-inch test plug for testing. All tapping sleeves shall be hydrostatically tested up to 150-psi before a tap is made. Tapping sleeves shall not be air tested. Refer to Standard Details.

All mechanical joint tapping sleeves shall be manufacturer fabricated and approved for installation on the specific main line pipe material, whether ductile iron, plastic, cast iron or asbestos cement.

Unless otherwise approved by the City, the tapping of City water mains larger than 16" diameter will be completed by City forces or the City's contractor. All costs for such taps shall be paid in advance by the person requesting to connect or extend the City's water distribution system.

4.4.2.3 – Service Tap Diameters

The maximum size of direct taps for ductile iron water mains 6-inches to 12-inches without a fitting, tapping sleeve or saddle shall be 1-inch. Any taps larger than 1-inch or any size tap on mains larger than 12-inches shall be provided with a tapping sleeve and valve.

4.4.2.4 – Corporation Stops

Corporation Stops shall be ball type, made of "no lead" brass (meeting UNS C89833 as per ASTM B584). Corp stops shall be complete with a compression coupling and AWWA Standard threads as per AWWA C800. Taps shall be located at 10:00 or 2:00 o'clock on the circumference of the pipe. Service taps shall be staggered alternating from one side of the water main to the other and at least 12 inches apart. The taps must be a minimum of 24 inches apart if they are on the same side of the pipe. All corporation stops shall be rated for a working pressure of 300-psi.

No burned taps will be allowed, and each corporation stop will be wrapped with Teflon tape. No taps are allowed on a fire hydrant line. No tapping shall be made where rodding is placed.

4.4.2.5 – Copper Service Tubing

Copper service tubing for ¾-inch & 1-inch services shall be type K soft copper tubing per ASTM B88. No union shall be used in the installation of the service connection of 100-feet or less. Service lines more than 100 feet shall use a three (3) piece compression coupling. Only one (1) compression coupling shall be used for each 100 feet or fraction thereof.

4.4.2.6 – Meter Boxes for ¾-incha and 1-inch Services

Meter boxes shall be cast iron per ASTM A48 Class 25 or ASTM A126 Class B. Meter boxes shall provide a cover opening of 8 X 18 1/8 inches and boxes shall measure at least 12.5 inches in depth. Lids shall also be cast iron and have the words "Water Meter" cast into them. They shall also be lockable. Lids shall be provided with a 2 inch (maximum) diameter hole to accommodate a transmitter. All meter boxes and lids shall be installed as shown in the Standard Details and have a black E-coating.

Meter boxes shall have 45-degree compression connections outside the box on the inlet side. There shall be a lockable ball valve inside the box on both the inlet and outlet which shall be permanently affixed to ensure proper spacing and alignment for the meter. Meter boxes shall also be provided with an ASSE 1024 approved inline, dual check valve located behind the meter. All fittings and connections shall be "no lead" brass conforming to UNS C89833 as per ASTM B584.

4.4.2.7 – No Lead Brass Curb Stop

Curb stop shall be no lead brass with compression connections shall be installed within 2 feet of the inlet connection. The curb stop may be buried without a box above it.

4.4.2.8 – One 2-inch or 6-inch grade adjuster

Grade adjuster may be used when needed to meet final grade, however, no grade adjusters are permitted on new construction projects. Grade adjusters shall be cast iron. Grade adjuster and box shall be by the same manufacturer.

4.4.2.9 – 1-½ and 2-inch Water Services

½-inch and 2" meter boxes shall be light weight polymer concrete as indicated in the Standard Details. Meter boxes for 1 ½ and 2-inch water services shall provide a cover opening of 24 X 36 inches and boxes shall measure at least 30-inches in depth and provided in straight wall arrangement. Standard meter box covers shall be provided in solid configuration with a 2-inch diameter transmitter hole, and with the words, "Water Meter" in the lid. To ensure positive discharge, the box shall have an open bottom to allow drainage through a 6-inch stone base.

Coppersetter piping and fittings for 1 ½ and 2-inch water meters shall be constructed from "no lead" brass (meeting UNS C89833 as per ASTM B584) and copper tubing and shall be equipped with angle check valve outlets and by-pass flanged valve or by-pass flanged ball valve inlets as furnished by Ford 70 Series (VBB77-XXB-11-7-NLSTYLE).

If directed by the City's Backflow Prevention Program Operator in Responsible Charge, the service shall have a privately owned and installed City-approved backflow preventer on the private side of the meter.

4.4.2.10 – Services Greater Than 2-inches

Water services greater than 2-inches: Water services greater than 2-inches shall have the meter and bypass line located within a precast concrete vault. All piping and valves shall be ductile iron flanged pipe. There shall be isolation gate valves on both sides of the meter as well as one on the bypass line. Gate valves within the vault shall meet the above requirements of AWWA C509 for non-rising stem gate valves but shall be provided with hand wheel operators. A standard buried gate valve with 2-inch nut shall be provided between the main and the vault. Link seals shall be used where the pipe enters and exits the vault.

If directed by the City's Backflow Prevention Program Operator in Responsible Charge, the service shall have a privately owned and installed City-approved backflow preventer on the private side of the meter.

4.4.2.11 – Meter Vaults

Meter vaults and access doors shall meet HS-20 loading requirements and shall be located outside of travel areas. Pedestrian rated covers shall not be used regardless of where they are located. The access double doors shall be aluminum with a flush drop lift handle, stainless steel hinges and bolts, a stainless-steel slam lock, an automatic hold open arm, and compression springs to allow for easy opening. Vaults for 3- and 4-inch meters shall be approximately 8-feet by 10-feet in size. Six-inch meter vaults shall be approximately 9-feet by 12-feet. To ensure positive drainage, the vault shall be tied into the existing storm drainage system. If positive drainage is unobtainable, a sump pump shall be located and operated in the vault.

4.5 Testing and Inspections

4.5.1 General

All water mains shall be flushed, meet hydrostatic testing limits, and be properly disinfected prior to being placed into service by the City.

All filling and flushing water for water main extensions shall be obtained from the City through a City-approved hydrant meter and backflow prevention assembly connected to an existing City fire hydrant. In cases where a fire hydrant is not readily available, the developer may be required to purchase a fire hydrant assembly to be installed prior to construction of the water main extension.

The public utilities contractor shall purchase all flushing and test water from the City of Lexington at current rates.

The engineer of record shall have a representative under his/her direct supervision in attendance to observe the full duration water main testing and document test results for the engineer's certification.

The City Inspector must be in attendance for the full duration of final passing tests. Connection to the existing public water system and activation of the water main extension shall be scheduled with the City Inspector a minimum of three (3) business days prior to tie-in. The City inspector must be on site for tapping existing water mains and tie-ins.

4.5.2 Flushing

All water main filling and flushing activities shall be coordinated in advance with the City Inspector. City valves and hydrants shall be operated only by City personnel unless authorization has been granted in wiring by the City Inspector for a specific operation.

Distribution system flushing shall be accomplished with sufficient water velocity (minimum of 2.5 fps) to thoroughly clean the main of soil, debris, and pipe lubricant following construction and prior to disinfection and hydrostatic testing.

Flushing may not begin until the last of the concrete blocking has cured a minimum of seven days.

4.5.3 Hydrostatic Testing

The pipeline designer shall submit testing plan to the City Inspector for review a minimum of three (3) days prior to water main testing. The testing plan must include required hydrostatic pressures for highest and lowest elevations of water main test segments, allowable pressure loss, and make-up water volume for the stated test duration. Testing pressures shall not exceed maximum limits for pipe, valves, sleeves, hydrants, and fittings.

All newly constructed water mains shall be filled with potable water and hydrostatically tested at minimum 200 psi for a duration of at least two hours unless alternative testing procedures are authorized within the City-stamped and approved civil drawings.

Test pressures shall be at least 1.25 times the working pressure of the pipeline at the highest elevation of the test section and at least 1.5 times the working pressure at the lowest elevation of the test section. The test pressure may not exceed the thrust restraint design pressures or 1.5 times the pressure rating of the pipe or joint, whichever is less (as specified by the manufacturer). Test pressures for sections that include gate valves at the test section boundary must not exceed the rated working pressure of the valves.

The hydrostatic test pressure must not vary more than $\pm$ 5 psi for the duration of the test and make-up water required to restore to the starting test pressure for the section tested must not exceed the quantity determined by the formula:

$$L = \frac{SD\sqrt{P}}{148{,}000}$$

Where, L = the allowable leakage, in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
P = average test pressure for section during the leakage test, in psi

For a 2-hour test, multiply L by 2 for allowable leakage for test duration.

All visible leakage must be repaired regardless of test results.

Each tapping sleeve and valve shall be hydrostatically tested at 150 PSI for 15 minutes with zero pressure loss at installation unless otherwise approved in advance of testing.

4.5.4 Disinfection

The mains shall be disinfected using a chlorine concentration equal to or greater than 50 milligrams per liter (50 ppm). The chlorine solution shall remain in the mains for a minimum of 24 hours.

When disinfection is complete and approved by the City Inspector, the contractor shall flush the new lines sufficiently so that the chlorine concentration level in the new lines does not exceed existing public water line concentrations. (AWWA C651).

Bacteriological test samples shall be collected by City Inspector for biological testing immediately following flushing of the disinfection water.

Highly chlorinated water (water with chlorine levels greater than the public water system) must be dechlorinated per methods acceptable to the Lexington Stormwater Administrator prior to release to the environment.

SECTION 5 – BACKFLOW PREVENTION

5.1 Application

For the protection of the public water supply, all industrial and commercial customers are required to install and maintain backflow prevention assemblies (BPAs) at water service connections to the City of Lexington water system. This includes all domestic, irrigation, and fire line services. Residential customers requesting irrigation services must also install and maintain an approved BPA.

5.2 Design

The design, performance, and configuration of all backflow prevention assemblies must be approved by the University of Southern California FCCCHR at the time the BPA is installed. Refer to the USC FCCCHR List of Approved Backflow Prevention Assemblies (https://fccchr.usc.edu/list.html).

The appropriate backflow prevention device for each service connection shall be determined based upon the hazard(s) associated with use of the water connection and the site/property. Backflow prevention assemblies shall be installed prior to all taps, tees, branches, and any other connections to the water lateral. The preferred location for BPAs is immediately downstream of the city water meter or vault (private side of the City's water meter). The BPA type required for each water service and its location shall be at the sole discretion of the City's Backflow Prevention Program Operator in Responsible Charge (BPPORC).

Temporary water service or fire hydrant connections used for filling tanks, flushing/filling new water main extensions, temporary construction water, or other uses must be provided with a metering device and backflow prevention assembly approved in advance by the Backflow Prevention Program ORC.

5.3 Materials

All materials used in the construction of BPAs must comply with NC plumbing code. Materials used for domestic water BPAs shall be NSF 61 certified no lead and be approved for potable water use. Refer to City Standard Details for additional information.

5.4 Testing and Inspections

The City of Lexington Backflow Prevention Program ORC shall be notified a minimum of three business days prior to all BPA installations to allow Water Resources Department staff opportunity to inspect the assembly/ies. Property owners are responsible for all repairs and testing of BPAs.

All backflow prevention assemblies must pass testing after installation/modification and then every twelve months following installation. Reports must be submitted to the City's Backflow Prevention Program ORC within 30 days of testing.

All BPA testers must be NC certified with current certification at the time testing is performed. Testing kits used to conduct BPA testing shall have valid certification at the time of BPA testing.

APPENDIX

City of Lexington

Approved Product List

1. **Ductile Iron Pipe (4" to 12") – Domestic, Pressure Class 350, AWWA C-151/ANSI A21.51, ANSI C-111/AWWA A21.11, AWWA C104 / ANSI 21.4, AWWA C-150/ANSI A21.50, ASTM A536:**
   American Cast Iron Pipe Co.
   McWane Ductile
   US Pipe

2. **Ductile Iron RJ Pipe (4" to 12") – Domestic, Pressure Class 350, AWWA C-151/ANSI A21.51, AWWA C111/ ANSI A21.11, AWWA C104 / ANSI 21.4, AWWA C-150/ANSI A21.50, ASTM A536:**
   American Cast Iron Pipe Co.
   McWane Ductile
   US Pipe

3. **Ductile Iron Mechanical Joint Fittings – Domestic, Pressure Class 350, AWWA C-153/ANSI A21.53, AWWA C-111/ANSI A21.11, AWWA C-104/ANSIA A21.4, AWWA C110 / ANSI 21.10, ASTM A536:**
   American Cast Iron Pipe Co.
   McWane Ductile/Tyler Union
   US Pipe

4. **2" PVC Pipe & Fittings – Pressure Rated Water Distribution, ASTM D-1784, ASTM D-3139, NSF/ANSI-61, SDR 17, 250 psi:**
   JM Eagle
   National Pipe
   Diamond Plastics

5. **Gate Valves - Resilient Seated, NRS, (3" - 16") 200 PSI Rating, (Open Left), AWWA C509/515:**
   Clow Series F-6100 (with Slotted Bolt Holes at 11:00 & 1:00 position)
   Mueller Series 2360 (with Slotted Bolt Holes at 11:00 & 1:00 position)

6. **Tapping Valves - Resilient Seated, NRS (4" - 16") Flange x M.J. Min. 200 PSI Rating, (Open Left):**
   Clow F-6114 (No Slots on Flange side)
   Mueller T-2360 (No Slots on Flange side)

7. **Tapping Sleeves (4" through 12") Stainless Steel, Min. 200 PSI Rating:**
   Romac SSTIII
   Smith-Blair 665
   Mueller H-304 SS

8. **Cast Iron Valve Boxes - Two-Piece, Water or Sewer on Lid as appropriate:**
   Tyler Union Series 6850 Screw-type with 5-1/4" Drop Lid
   Star Pipe Products VB-0001 Screw-type w/ 5-1/4" Drop Lid
   Bingham & Taylor 15B Screw-type w/ 5-1/4" Lid

9. **Fire Hydrants (Hydrant Tee Required) - ANSI/AWWA C502, Traffic Type, Dry Top, 6" M.J. Shoe, 4-1/2" Main Valve Opening (Open Left), (2) 2-1/2" Hose & (1) 5" factory-installed Storz pumper connection, 200 PSI Min. Rating, UL 246 Listed & FM 1510 Approved:**
   Clow Medallion
   Mueller Super Centurion 250

10. **Curb Stops - Full Port Ball Valve, NSF/ANSI 61 certified:**
    Ford B11W & B41W

11. **Corporation Stops - Ball Valve, (3/4" – 1", Brass, AWWA/CC Thread Inlet x Copper Tube Compression Nut Outlet), NSF/ANSI 61 compliant:**
    Mueller B-25008N
    Ford FB1000G

12. **Corporation Stops - Ball Valve, (1-1/2" – 2", Brass, AWWA/CC Thread Inlet x Copper Tube Pack Nut Outlet), NSF/ANSI 61 compliant:**
    Ford FB1000
    Mueller P-25008

13. **Copper Meter Setter, NSF/ANSI 61 certified low lead brass (5/8" X 3/4", 9" Riser Ht., w/lock wing ground key angle meter stop):**
    Mueller H1404N (w/ H-14222N & H-15428N end pieces)
    Ford V72-9W-MM-33-NL (w/CSSUN1-33-NL & C84-33-Q-NL end pieces)

14. **Copper Tubing, Type "K" soft, ASTM B-88, NSF/ANSI 61 certified**

15. **Miscellaneous 2" or 3" Fittings/Threaded Pipe/Nipples, Brass, NSF/ANSI 61 certified:**
    Ford
    Mueller

16. **Meter Boxes (3/4" & 1"):**
    Sigma MBX-1 w/ touch reader hole (Item # MB-382T)

17. Retainer Gland Joint Restraint:
EBAA Megalug 1100 Series for DI/CI Pipe
Romac Grip Ring DI/CI Pipe
Ford Uni-flange1400 (U domestic) Series for DI/CI Pipe

18. Cast Iron Pipe Couplings, Straight and Transition:
Ford FC1 & FC2A
Romac 501
Smith-Blair 441

19. DCVA, DCDA, & RP Backflow Prevention Assemblies – University of Southern California FCCC&HR Approved & NSF/ANSI-61 certified:
Watts Febco Wilkins

20. Type 1 & Type 2 Manhole Frame (7 ½") & Cover Gray Iron Castings Conform to ASTM-A48 Class 35B,"Sewer" or "Water" Cast in Cover as Appropriate, NCDOT 840.54 Standard:
U.S. Foundry 669 HD w/ KL cover (Type 2 Frame and Cover are bolted w/ 316SS hardware)

21. Type 3 Water-tight Manhole Frame (4") & Bolted Cover, Gray Iron Castings Conform to ASTM-A48 Class 35B, Lettering Cast into Cover "Sewer" or "Water", as Appropriate, Frame & Cover include Factory Machined Seating w/ Continuous Nitrile Gasket, 4 receiving lugs at opening:
U.S. Foundry 1261 HD Slab-type Ring w/ Bolted KL Cover (incl. four 316SS Hex Head Bolts)

22. PVC Pipe & Fittings (4" to 12" diam.) – Gravity Sewer, ASTM D-1784, ASTM D-3034, ASTM D-3212, ASTM F-477 (Gaskets), SDR 35 (PS46) or SDR 26 (PS115):
National Pipe
Diamond Plastics
JM Eagle

23. PVC Pipe & Fittings (18" to 24" diam.) – Gravity Sewer, ASTM D-1784, ASTM F-679, ASTM D-3212, ASTM F-477 (Gaskets), SDR 26 (PS115):
National Pipe
Diamond Plastics
JM Eagle

24. 4" Sewer Solid Transition Adapter SDR 35/SDR 26 to DIP Service:
Harco #35-3920404
Multi Fittings Corp. P/N 273965 or 130031

25. Sewer Saddle Wye, SDR 35 or SDR 26, ASTM D3212 & ASTM F477:

Harco 8 x 4 MSB w/ SS straps or FBNS

26. **Solid Tracer Wire, Copper, 12 AWG, min. break load of 197 lbs. Casing min. 30 mil HMWPE (ASTM D1248), direct burial rated:**
    Pro-Line Safety CU HDPE 30 MIL Tracer Wire- P/N 7400402xx (blue) or 7400405xx (green)

27. **Locking Tracer Wire Connector, Submersible, Water & Corrosion Proof, anti-oxide compound filled, direct burial rated:**
    Pro-Line Safety Tracer-Lock Connector #TL-LUG-SS

28. **Air Release Valve (Potable Water), ANSI/AWWA C512, NSF 61 & NSF 372, NPT inlet:**
    Crispin PL20

29. **Comb. Air/Vacuum Valve (Wastewater), ANSI/AWWA C512, Includes backflush components (all brass fittings):**
    Crispin Universal (US Series)

30. **Casing Spacers (min. 14 ga. 304 Stainless Steel), spacer lining shall be min. 1/8 -inch-thick Neoprene/EPDM, min. four (4) welded legs per spacer w/Dielectric Polymer skids, all hardware shall be 304 or 316 SS:**
    Spider Manufacturing, Inc. Black Widow, Prod. Code BWS(8) or BWS(12)

31. **Manhole Frame Insert (min. 18 ga. 304 Stainless Steel) Neoprene gasketed, w/ Eccentric Gas Relief Valve (release at 0.5 to 1.5 PSI) and Handle:**
    Rainstopper
    Parson Environmental

32. **Wastewater Pumps, submersible non-clog (passing 3-inch sphere or greater):**
    Tsurumi
    Piranha
    Pentair-Myers

For consideration of materials not included on the most recently approved materials list, please contact Engineering Services at 336-248-3970. All requested shop drawings, test records, certifications, and other supporting information must be provided at no cost to the City for a determination to be made. Developers/contractors shall allow a minimum of 45 calendar days for evaluations of new materials.