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SECTION 3

STORMWATER DRAINAGE SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Work under this section includes, but is not limited to piping and appurtenances for a complete storm drainage system.

1.02 DESIGN CRITERIA

A. General

1. The City of Claremont recognizes that there are numerous methods and computer models available to calculate peak flows, generate and route hydrographs to determine peak discharges, and to size pipes/culverts, drainage ways and emergency spillways. It is the responsibility of the design engineer to select the appropriate methods suitable for the site to design the stormwater system needed to meet the requirements of this section and the City's Ordinances.
2. In general the City recognizes and accepts the methodologies outlined in the publication entitled "Elements of Urban Stormwater Design" by H. Rooney Malcom, P.E.

B. Collection System

1. A collection system includes the inlets and pipes used to collect stormwater runoff from a parking area, street and/or a subdivision. It also includes ditches or channels constructed to convey runoff to inlets or pipes and to existing natural drainage features.
2. All collection system components shall be sized to adequately pass the 10-year recurrence interval storm. However, pipes or larger drainage structures crossing collector or arterial streets, shall be sized to accommodate the 25-year recurrence interval storm.

C. Stormwater Detention

1. Permanent detention facilities shall conform to the requirements stated herein and to the City's Ordinances.
2. The facility shall be designed such that the 10-year peak discharge after development is no greater than the 10-year discharge from the same area prior to development. The detention pond shall be of adequate size/volume to detain the excess runoff volume.
3. Unless otherwise approved by the City, all detention facilities shall be "dry ponds".
4. A pipe or weir may be used as the primary outlet device.
5. An emergency by-pass spillway will be provided that will pass the runoff generated by the 50-year storm, after the impoundment area has reached its capacity.

6. Emergency by-pass shall be open, broad-crested weirs. Spillways constructed or earthen fill embankments must be asphalt or concrete lined with sufficient approach and exit sections provided to prevent any possible erosion. Earthen embankments constructed in cut areas will require only a vegetated spillway.
7. Structures shall be designed not to fail during the 100-year storm.

D. Easements

1. All storm sewers shall be constructed in dedicated street rights-of-way or permanent easements. Minimum width of easement shall be as follows:
 - a. 15-inch thru 36-inch pipe..... 20 feet
 - b. 42-inch thru 72-inch pipe..... 30 feet
 - c. >72-inch pipe To Be Determined by City
 - d. Constructed Drainageways To Be Determined by City

1.03 REFERENCES

A. Publications are referred to in the text by basic designation only.

1. American Society for Testing and Materials (ASTM)
 - a. A48 Standard Specification for Gray Iron Castings
 - b. A536 Standard Specification for Ductile Iron Castings
 - c. C55 Standard Specification for Concrete Building Brick
 - d. C76 Reinforced Concrete Culverts, Storm Drain and Sewer Pipe (latest)
 - e. C443 Flexible Watertight Joints for Circular Concrete Pipe and Precast Manhole Sections (latest)
 - f. C478 Precast Reinforced Concrete Manhole Sections (latest)
 - g. C858 Underground Precast Concrete Utility Structures (latest)
 - h. C890 Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures (latest)
 - i. C913 Precast Concrete Water and Wastewater Structures (latest)
 - j. C923 Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (latest)
 - k. C990 Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants (latest)
 - l. D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft³ (600 kN-m/m³))
 - m. D1248 Polyethylene Plastics Molding and Extrusion Materials (latest)
 - n. D1586 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
2. American Association of State Highway and Transportation Officials (AASHTO)
 - a. M 170 Standard Specifications for Reinforced Concrete Culverts, Storm Drain, and Sewer Pipe (latest)

- b. M 294 Standard Specifications for Corrugated Polyethylene PipeUNI-BELL Plastic Pipe Association (UNI)
- a. B-6 Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe (latest)
- 4. NCDOT Standard Specifications for Roadway and Structure and Standard Details.
- 5. Elements of Urban Stormwater Design; H. Rooney Malcom, P.E. (available from N.C. State Industrial Extension Service).

1.04 SUBMITTALS

- A. All related Design Calculations must be sealed by a N.C. Professional Engineer.
- B. Submit the following to the City of Claremont and obtain approval from the City's Public Works Department prior to beginning work:
 - 1. Affidavit of Compliance: Affidavit shall attest that supplied products conform to the referenced standard and this specification and that tests set forth in each applicable referenced publication have been performed and that test requirements have been met. Submit for each of the following materials:
 - a. Pipe
 - 1) Pipe Reinforced Concrete Pipe
 - 2) Corrugated Polyethylene (HDPE)
 - b. Pre-cast concrete manholes
 - c. Pre-cast concrete boxes
 - d. Concrete blocks
 - 2. Catalog Data: Submit manufacturer's standard drawings or catalog cuts for the following. Clearly indicate equipment to be furnished for the Project including options to be provided.
 - a. Pipe
 - 1) Reinforced Concrete Pipe
 - 2) Corrugated Polyethylene (HDPE)
 - b. Pre-cast Concrete Manholes and the following appurtenances:
 - 1) Manhole steps
 - 2) Pipe connectors
 - 3) Joint material
 - 4) Frames and covers
 - 5) Castings
 - c. Pre-cast Concrete Boxes and the following appurtenances:
 - 1) Manhole Steps
 - 2) Pipe Connectors
 - 3) Joint material
 - 4) Frames and covers
 - 5) Castings

3. Prior to Final Acceptance submit the following report:
 - a. Field test report for each section of pipe for the following:
 - 1) Low-pressure air test for storm drain piping.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. All materials and equipment shall be handled and stored in accordance with the manufacturer's recommendations.

1.06 QUALITY ASSURANCE

- A. All parts and materials incorporated into a project shall be new and unused.
- B. Contractors must be licensed by the N.C. Licensing Board for General Contractors and have a classification and a cost limitation appropriate for the work to be performed.

1.07 WARRANTY

- A. Line Work
 1. All materials and workmanship shall have a one-year warranty from the date of final acceptance by the City. A warranty inspection will be made jointly by the City and Contractor/Developer approximately eleven (11) months after acceptance to identify needed repairs. All labor, equipment and materials needed to make these repairs shall be the responsibility of the Contractor.

PART 2 ALLOWABLE PRODUCTS AND MATERIALS

2.01 REINFORCED CONCRETE PIPE

- A. Reinforced Concrete Pipe shall conform to ASTM C76, AASHTO M170, and to the following requirements:
 1. Pipe lengths shall be not less than 8 feet.
 2. Pipe shall be Class III minimum per ASTM C76.
 3. Pipe shall be designed for a Type 2 laying condition at the design depth of cover.
 4. Storm Sewer Mains:
 - a. Joint shall be modified tongue and groove.
 - b. Use flexible plastic joint material
- B. Concrete Flared End Sections shall be reinforced and meet all applicable requirements of ASTM C76.

2.02 CORRUGATED POLYETHYLENE (HDPE) PIPE

- A. Pipe shall be manufactured by sources participating in the N.C. Department of Transportation's HDPE Pipe QC/QA Program.
- B. Pipe shall meet AASHTO M 294 for Type S or Type D.
- C. Pipe shall be double-wall.
- D. Pipe shall have smooth inside wall.

E. Pipe shall be supplied in manufacturer's standard length.

2.03 MANHOLES

A. Provide manholes made of precast concrete sections in conformance with ASTM C478, NC Department of Transportation, and the following requirements:

1. General

a. Manhole inside diameter shall conform to the following for various size pipes:

- 1) 15 inch – 18 inch pipe..... 4' diameter
- 2) 24 inch – 36 inch pipe..... 5' diameter
- 3) 42 inch – 48 inch pipe..... 6' diameter
- 4) 54 inch pipe 8' diameter
- 5) >54 inch pipe As Approved by City

b. Precast concrete manholes shall be as manufactured by Adams Concrete, Carolina Precast Concrete, Inc., D & M Concrete Specialties, Inc., N. C. Products Corp., Stay Right Tank, Tindall Concrete Products, Inc. or approved substitute.

2. Precast Concrete Sections

a. Minimum wall thickness shall be 5-inches.

b. Base: Cast monolithically without construction joints or with an approved PVC waterstop in the cold joint between the base slab and the walls. The width of the base extensions on Extended Base Manholes shall be no less than the base slab thickness.

c. Riser: Minimum lay length of 16-inches.

d. Eccentric Cone: Top inside diameter shall be 24-inches. Width of the top ledge shall be no less than the wall thickness required for the cone section.

e. Transition Cone: Provide an eccentric transition from 60-inch and larger manholes to 48-inch diameter risers, cones, and flat slab top sections. Minimum slope angle for the cone wall shall be 45 degrees.

f. Flat Slab Top: Designed for HS-20 traffic loadings as defined in ASTM C890. Items to be cast into Special Flat Slab Tops shall be sized to fit within the manhole ID and the top and bottom surfaces. Provide a float finish for exterior slab surface.

g. Precast or core holes for pipe connections. Diameter of hole shall not exceed outside diameter of pipe by more than 3-inches.

h. Grade Rings: May be used to adjust frame and cover to finished grade. Grade Rings shall be no less than 4-inches in height.

i. Lifting Devices: Devices for handling precast components shall be provided by the precast manufacturer and comply with OSHA Standard 1926.704.

3. Joints

a. Manufacturer in accordance with tolerance requirements of ASTM C 990 for butyl type joints.

- b. Minimize number of joints. Do not use riser section for manholes up to 6 feet tall and no more than one riser for each additional 4 feet in height.
 - c. Flexible Joint Sealants: Preformed butyl rubber based sealant material conforming to Federal Specification SS-S-210A, Type B and ASTM C990.
 - d. External Seal: Polyethylene backed flat butyl rubber sheet no less than 1/16-inch thick and 6-inches wide.
4. Inverts
- a. Brick and mortar or precast concrete invert.
 - b. Form and finish invert channel to provide a consistent slope from inlet(s) to outlet up to 4-inches.
 - c. Channel walls shall be formed to 3/4 of the height of the outlet pipe diameter.
 - d. Finish benches with a minimum uniform 1.5:12 slope. Provide a 1/4-inch radius at the edge of bench and trough.
5. Flexible Pipe Connectors: Provide flexible connectors for pipe to manhole that conform to ASTM C923 and as recommended by the pipe manufacturer. Provide stainless steel pipe clamp type band around flexible connection to sewer pipe.
6. Manhole Steps
- a. Steps shall be in accordance with ASTM C478 and made of 1/2-inch grade 60 steel encapsulated by co-polymer polypropylene and have serrated tread and tall end lugs.
 - b. Secure steps to the wall with compression fit in tapered holes or cast-in-place. Align steps along a vertical wall and shall not be located over a pipe opening. First step shall be a maximum of 26-inches from the bottom.
 - c. Steps shall be by American Step Co., Inc., Bowco Industries, Inc., M. A. Industries, Inc. or approved substitute.

2.04 CASTINGS

A. General

- 1. Made of gray iron, ASTM A-48 - Class 30, or ductile iron, ASTM A536, grade 65-45-12.
- 2. Castings shall be free from imperfections not true to pattern. Casting tolerances shall be plus or minus 1/16-inch per foot of dimension. Top shall set neatly in frame, with edges machined for even bearing and proper fit to prevent rattling and flush with the edge of frame.
- 3. Castings shall be as manufactured by Neenah Foundry Co., U.S. Foundry & Manufacturing Corp., or Vulcan Foundry.

B. Manhole Ring and Cover:

- 1. Minimum clear opening shall be 22-inches.
- 2. Minimum weight for frame and cover shall be 310 pounds and suitable for Heavy Duty Highway Traffic Loads of H-20.
- 3. Frame shall have four 1-inch anchor bolt holes equally spaced.

4. "Storm Sewer" shall be cast on the cover as appropriate. Casting shall bear the name of the manufacturer and the part number.
 5. Provide cover with two 1-inch perforated holes.
- C. Grate and Frame:
1. Grate and Frame shall be NCDOT Standard.
 2. Grate and Frame shall be suitable for Heavy Duty Highway Traffic Loads of H-20.
 3. Casting shall bear the name of the manufacturer and the part number.

2.05 PRECAST BOXES

- A. Provide precast concrete boxes made of precast concrete sections in conformance with ASTM C913 and the following requirements.
1. General
 - a. Precast boxes include:
 - 1) Square/Rectangular catch basin boxes and drop inlets.
 - 2) Non-round manhole structure.
 - b. Precast manufacturer shall have a professional engineer registered in the State of North Carolina on staff. Provide a certification signed and sealed by the North Carolina Professional Engineer that the boxes provided for the Project are in conformance with the reference standards and these specifications and are structurally sufficient (i.e., adequate wall thickness and reinforcing). The boxes shall be adequate for the existing site conditions as described in the soils reports provided in these Project specifications.
 - c. Precast concrete boxes shall be manufactured by Adams Concrete, Carolina Precast Concrete, Inc., D & M Concrete Specialties, Inc, N. C. Products Corp., Stay Right Tank, Tindall Concrete Products, Inc. or approved substitute.
 2. Precast Concrete Sections
 - a. General: Concrete compressive strength shall be 4,000 psi minimum and rated for H-20 loading.
 - b. Base: Cast monolithically without construction joints or with an approved PVC waterstop in the cold joint between the base slab and the walls. The width of the base extensions shall be no less than the base slab thickness and shall be as indicated on the Details.
 - c. Riser: Minimum lay length of 16-inches.
 - d. Flat Slab Top: Designed for HS-20 traffic loadings as defined in ASTM C890. Items to be cast into Special Flat Slap Tops shall be sized to fit within the top and bottom surfaces. Provide a float finish for the exterior slab surface and a 1-inch chamfer on all exposed edges.
 - e. Lifting Devices: Devices for handling precast components shall be provided by the precast manufacturer and comply with OSHA Standard 1926.704.

3. Joints
 - a. Manufacturer in accordance with tolerance requirements of ASTM C 990 for butyl type joints.
 - b. Minimize number of joints.
 - c. Flexible Joint Sealants: Provide preformed butyl rubber based sealant material conforming to Federal Specification SS-S-210A, Type B - Butyl Rubber or O-ring rubber gasket conforming to ASTM C443.
 - d. External Seal: Provide a polyethylene backed flat butyl rubber sheet no less than 1/16-inch and 6-inches wide applied to outside perimeter of joint.
4. Flexible Pipe Connectors: Provide flexible connectors for pipe to box that conform to ASTM C923.

2.06 CONCRETE BRICK MASONRY UNITS

- A. Concrete brick masonry units shall be solid units meeting the requirements of ASTM C55, Grade S-11.
- B. Clay brick shall not be permitted for any drainage structure.
- C. Concrete and mortar shall meet the requirements of the NCDOT's Standard Specifications for Roads and Structures.

PART 3 EXECUTION / INSTALLATION

3.01 PIPE AND ACCESSORIES

- A. General
 1. Provide erosion control measures as required. Erosion control measures including seeding and mulching shall be designed, installed and maintained in accordance with the N.C. Department of Environment and Natural Resources, Land Quality Section's "Erosion and Sediment Control Planning and Design Manual". The Developer/Engineer is responsible for securing all required permits.
 2. Pipe installation shall meet the following general guidelines:
 - a. Handle pipe and accessories in accordance with manufacturer's recommendations.
 - b. Carefully inspect pipe immediately prior to laying. Do not use defective pipe. Replace pipe damaged during construction.
 - c. Lay pipe to design grade and alignment.
 - d. Provide proper equipment for lowering pipe into trench.
 - e. Provide tight closure pipe ends when work is not in progress.
 - f. Keep pipe interior free of foreign materials.
 - g. Do not lay pipe in water or when the trench or weather conditions are unsuitable for the work.
 - h. Clean bell and spigots before joining. Make joints in accordance with pipe manufacturer recommendation.

B. Trenching for Underground Pipe Installation

1. Definitions

a. **Backfill:** A specified material used in filling the excavated trench and placed at a specified degree of compaction.

1) **Materials:** Materials listed herein include processed materials plus the soil classifications listed under the Unified Soil Classification System, (USCS) (Method D2487 and Practice D2488). The soil materials are grouped into five broad categories according to their suitability for this application.

i. **Class I:** Angular, 6 to 40-mm (1/4 to 1-1/2-in.), graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shell.

ii. **Class II:** Coarse sands and gravels with maximum particle size of 40 mm (1-1/2 in.), including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class.

iii. **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.

iv. **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 bedding, haunching, or initial backfill.

v. **Class V:** This class includes the organic soils OL, OH, and PT as well as soils containing frozen earth, debris, rock larger than 40 mm (1 1/2 in.) in diameter, and other foreign materials. These materials shall not be used for bedding, haunching, or initial backfill.

2) **Backfill Zones:** Each backfill zone shall extend the full width of the trench bottom.

i. **Foundation:** Extending down from the bottom of bedding zone as defined below.

ii. **Pipe Embedment**

1. **Bedding:** Extending from 4-inches below the pipe bottom to the pipe bottom for 30-inch diameter and smaller and 6-inches below the pipe bottom for pipes larger than 30-inches in diameter.

2. **Haunching:** Extending from the bedding (bottom of the pipe) to the pipe spring line.

3. **Initial Backfill:** Extending from the haunching (pipe spring line) to 1 foot above the top of the pipe.

iii. **Final Backfill:** Extending from the initial backfill to the finish ground elevation.

- b. Laying Conditions:
 - 1) Type 1: Flat bottom trench with loose backfill.
 - 2) Type 2: Flat bottom trench with backfill lightly consolidated to centerline of pipe.
 - 3) Type 3: Pipe bedded in 4-inches minimum of loose soil and backfill lightly consolidated to top of pipe.
 - 4) Type 4: Pipe bedded on Class I material to 1/8 pipe diameter (4-inch minimum) Backfill compacted to top of pipe a minimum of 80 percent of standard proctor.
 - 5) Type 5: Pipe bedded in compacted Class I material to pipe centerline with 4-inch minimum under pipe. Backfill to top of pipe with Class I, II, or III and compact to 90 percent of standard proctor.
- c. Compaction: Process of mechanically stabilizing a material by increasing its density at a controlled moisture condition. "Degree of compaction" shall be expressed as a percentage of the maximum dry density obtained by the test procedure presented in ASTM D698 (Standard Proctor).
- d. Excavation: The removal of soil or rock to obtain a specified depth or elevation.
- e. Hard Material: Solid, homogeneous material which is not included in the definition of "rock" but which may require the use of heavy excavation equipment with ripper teeth. Amount must exceed 1 cubic yard in volume. Material having a standard penetration resistance as determined by ASTM D1586 between 60 and 150 blows per foot is defined as "hard material."
- f. Lift: Layer of soil placed on top of a previously prepared or placed soil.
- g. Rock: Solid, homogeneous material which cannot be removed without the systematic drilling and blasting exceeding 1 cubic yard in volume. Material having a standard penetration resistance as determined by ASTM D1586 greater than 150 blows per foot is defined as "rock." Removal of "hard material" will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.
- h. Pipe Springline: A line running horizontally through the center of the pipe.
- i. Topsoil: Natural, friable soil, representative of productive soils in the vicinity of the site. Topsoil shall be free from roots, stones larger than 1-inch, objectionable weed seeds, toxic substances, and materials that hinder grading, planting, and maintenance operations.

2. Products

- a. Stone
 - 1) Class I material shall be #67 or #78M stone in accordance with NCDOT specifications Section 1005, General Requirements for Aggregate.
- b. Warning and Identification Tape
 - 1) Tape shall be a minimum 3-inch wide polyethylene plastic tape manufactured specifically for identification of buried utilities with

means of enabling detection by a metal detector to a minimum depth of 3 feet. Tape shall be color coded and continuously imprinted with warning and identification markings in bold black letters to read "CAUTION - BURIED (utility) LINE BELOW." Color and printing shall be permanent, unaffected by moisture or soil and shall be as follows:

<u>UTILITY</u>	<u>COLOR</u>	<u>MARKING</u>
Water	Blue	Caution - Buried Water Line Below
Storm/Gravity Sewer.....	Green	Caution - Buried Sewer Line Below
Force Main	Green	Caution - Buried Force Main Below
Electric	Red.....	Caution - Buried Electric Line Below
Gas.....	Yellow.....	Caution - Buried Gas Line Below
Telephone	Orange	Caution - Buried Telephone Line Below
SCADA.....	Orange	Caution - Buried SCADA Line Below

2) Tape shall be by Blackburn Manufacturing, Joseph G. Pollard Co., or Reef Industries Inc.

c. Tracer Wire

- 1) Tracer wire shall be #12 solid copper wire. All connections shall be by wire nuts and taped.
- 2) Splices in tracer wire are to be kept to a minimum and joined with copper split nuts of appropriate size.

3. Project Safety

- a. Contractor is responsible for Project safety.
- b. Perform work in conformance with applicable State and Federal safety regulations including, but not limited, to the following:
 - 1) North Carolina Safety and Health Standards for the Construction Industry (29CFR 1926 Subpart P).
 - 2) NC OSHA Industry Guide No. 14, Excavations.
 - 3) NC OSHA Industry Guide No. 20, Crane Safety.
- c. Provide barriers, warning lights, and other protective devices at excavations as necessary for safety of workers and the public.
- d. Provide sloping of bank, shoring, sheeting, or other means of maintaining the stability of the trench in accordance with the requirements of the Associated Contractor's Manual of Accident Prevention OSHA, Part 1926.P.

4. Protection of Underground Facilities

- a. Investigate underground facility location prior to start of construction.
- b. Installer is required to contact North Carolina 811 prior to start of construction.
- c. Repair damage to any existing facilities.

5. Water Control
 - a. Prevent surface water from entering the trench.
 - b. When trench bottom is below the existing ground water table, install a dewatering system to maintain water table 1 foot below trench bottom. Provide a man experienced in dewatering work at the job site.
 - c. Maintain dewatering until backfilling has proceeded above the existing ground water level.
 - d. Dispose of water from dewatering operations in accordance with the North Carolina Sedimentation Pollution Control Act.
6. Use of Explosives
 - a. Explosives may not be used on any excavation unless specifically approved by the City.
7. Excavating
 - a. Excavation shall be by open cut method. Short sections of trench may be tunneled or direct bored with the approval of the City.
 - b. Stockpile excavated material in such a manner that it will not obstruct the flow of runoff, streams, endanger Work, impair the use or appearance of existing facilities, or be detrimental to the completed Work.
 - c. Contractor shall segregate excavated material so as to maintain material suitable for backfill separate from material that is unsuitable.
 - d. Trench dimensions at the pipe embedment and foundation zone unless noted otherwise shall be as follows:
 - 1) Minimum width: Pipe outside diameter plus 18-inches.
 - 2) Maximum width: Pipe outside diameter plus 24-inches.
 - 3) Sides shall be vertical to a minimum of one foot above the top of pipe.
 - e. Shape trench bedding to provide uniform bearing for the full pipe length. Bottom shall be free of protrusions that could cause point loading on pipe. Provide bell holes as required for properly making pipe joint.
 - f. Do not over excavate. Excavation below grade shall be backfilled with Class I material.
 - g. Undercut soils that become unsatisfactory by construction activity or by being left exposed to the weather and backfill with Class I material.
 - h. Remove shoring, bracing, and sheeting, unless otherwise noted, as the trench is backfilled.
 - i. Excavation of trench shall not advance more than 200 feet ahead of the installation. In no case should the excavation extend beyond that which can be backfilled by the end of the workday.
 - j. Correct unstable soil conditions encountered at trench foundation by one of the following methods:
 - 1) Excavate below grade as approved by Engineer and backfill with Class I material or approved substitute material.

- k. Rock and Hard Material
 - 1) Excavate rock and hard material to a minimum depth of 4-inches below the pipe for pipes smaller than 30-inches and 6-inches for pipes 30-inches and larger.
 - l. Gravity Lines:
 - 1) Excavate trench to the design alignment and grade.
 - m. Utility Structures: Provide a minimum of 12-inches below subgrade and backfill with Class I material compacted to 95 percent maximum density. If the soil conditions are found to be unsuitable for structural stability of the manhole, City may require additional depth of Class I material.
8. Backfilling
- a. General
 - 1) Temperature must be above freezing and rising.
 - 2) In windy, hot, or arid conditions with a high rate of evaporation add moisture to the material to maintain the optimum moisture content.
 - 3) Do not proceed in rain or on saturated subgrade.
 - 4) Do not place material on surfaces that are muddy, frozen, or contain frost.
 - 5) Maintain backfill operation within 200 feet from pipe laying operation.
 - 6) Backfill trench to existing ground surface with select excavated material at the specified compaction.
 - 7) If excavated material is unsuitable to obtain specified compaction, provide suitable off-site borrow material for backfill.
 - 8) Re-excavate trenches improperly compacted. Backfill and compact as specified.
 - 9) Provide appropriate tamping equipment, and water to obtain proper moisture content, to achieve specified compaction of backfill.
 - 10) Conduct operation of heavy equipment above pipe installation as to prevent damage to pipe.
 - 11) Install warning / identification tape over utilities. Bury tape one foot below finished grade above the utility.
 - b. Backfill in pipe embedment zone (bedding, haunching, and initial backfill).
 - 1) General
 - i) Backfill with material as specified below. Material shall be free from objects larger than 2-inches.
 - ii) Where rock and hard material has been excavated below pipe bottom, backfill and compact bedding with Class I material. Class II or III material may be used for bedding with Engineer's approval.
 - iii) Place backfill material to assure placement of material under pipe haunches.

- iv) Take care during placement and compacting of material to avoid movement of pipe.
- 2) Place backfill in bedding and haunching zones in 6-inch maximum lifts and compact to 90 percent density. Provide backfill material in pipe embedment zone as specified below.
 - i) Storm Sewer Lines, Rigid Pipe
 - 1. Excavation in Class I, Class II, Class III, and stable Class IV soils suitable for bedding, the bedding surface shall provide a firm foundation of uniform density. Backfill with select excavated material.
 - 2. Excavation in Class V, unstable Class IV soils, running water, and other unstable soil conditions, excavate a minimum of 4-inches below pipe bottom and provide Class I material for bedding and haunch zone. Backfill with Class I, II, or III material in initial backfill.
 - ii) Storm Sewer Lines, Flexible (HDPE)
 - 1. Depth 0 to 14 ft: Provide Class I material for bedding and haunching. Backfill with Class I, II, or III material in initial backfill.
 - 2. Depth over 14 ft: Provide Class I material for bedding, haunching, and initial backfill.
- c. Final Backfill
 - 1) Backfill with materials free of stones and free of debris larger than 6-inches in dimension. Place backfill in lifts not exceeding the thickness and compacted to the minimum density specified below.
 - 2) Trench backfilled with non-cohesive materials may be compacted with water flooding; except under roadways, shoulders of roadways, and other areas subject to vehicular movement, provided the method of compaction is approved by the City and provides the degree of compaction required.
 - 3) Lifts and density:
 - i) Undeveloped areas (i.e., forests, fields, and, croplands): Trench may be filled with bulldozer blade provided material fall will not damage pipe. Mound soil over the trench area sufficiently to settle level over time. Degree of compaction shall be 85 percent.
 - ii) Lawns: Backfill in 12-inch lifts and compact to 90 percent. Top 12-inches shall be free of material with a dimension over 2-inches.
 - iii) Roads (including Rights-of-way), drives, parking areas (including areas within 20 feet), and adjacent to existing utilities: Backfill in 6-inch lifts compact to 95 percent.
 - iv) Within 20 feet of foundations: Backfill in 6-inch lifts compacted to 95 percent.
- d. Utility Structures: Bring backfill to grade in even lifts on all sides. Lift depths and compaction densities shall be as specified according to area

of installation for pipe above. Backfill against cast-in-place concrete structure only after concrete has attained the specified 28-day compressive strength.

3.02 MANHOLES

A. General

1. Set base plumb and level. Align manhole invert with pipe invert.
2. Secure pipe connectors to pipe in accordance with manufacturer's recommendation.
3. Clean bells and spigots of foreign material that may prevent sealing. Unroll the butyl sealant rope directly against base of spigot. Do not stretch. Follow manufacturer's instructions when using O-ring seals.
4. Set precast components so that steps align.
5. Plug lift holes using a non-shrink grout. Cover with a butyl sealant sheet on the outside and seal on the inside with an application of an epoxy gel 1/8-inch thick extending 2-inches beyond the opening.
6. Set manhole frames to grade with grade rings. Seal joints between cone, adjusting rings, and manhole frame with butyl sealant rope and sheet.
7. Apply external seal to the outside of joint.
8. Finish the interior by filling fractures greater than 1/2-inch in length, width or depth with a sand cement mortar.
9. Cement mortar shall be installed completely around frames to prevent water and soil from entering between manhole and frame.
10. Clean the interior of the manhole of foreign matter
11. Ring and Cover shall be installed in accordance with Standard Details.

3.03 PRECAST BOXES

- A. Catch basins and drop inlet shall receive 12-inches of No. 67 stone base to extend 6-inches beyond the base.
- B. Set base plumb and level. Align box invert with pipe invert.
- C. Secure pipe connectors to pipe in accordance with manufacturer's recommendation.
- D. Clean bells and spigots of foreign material that may prevent sealing. Unroll the butyl sealant rope directly against base of spigot. Do not stretch.
- E. After joining box sections, apply the butyl sealant sheet around the outside perimeter of the joint.
- F. Plug lift holes using a non-shrink grout. Cover with a butyl sealant sheet on the outside and seal on the inside with an application of an epoxy gel 1/8-inch thick extending 2-inches beyond the opening.
- G. Cement mortar shall be installed completely around frames to prevent water and soil from entering between box and frame.
- H. Finish the interior by filling fractures greater than 1/2-inch in length, width or depth with a sand cement mortar. Do not fill the joints between the precast components.
- I. Clean the interior of the structure of foreign matter.

3.04 CONCRETE MASONRY UNITS BOX

- A. Construct in accordance with Standard Details.

3.05 TESTING

A. General

1. City will determine if, and to what level, testing is required.
2. Clean and flush pipe system of foreign matter prior to testing.
3. Notify City a minimum of 48 hours prior to testing.
4. Perform tests in the presence of City.
5. Length of line to be tested at one time shall be subject to approval of City.
6. Pipe sections shall not be accepted and placed into service until specified test limits have been met.
7. Repair defects in the pipe system. Make repairs to the same standard as specified for the pipe system.
8. Retest repaired sections until acceptance.
9. Repair visible leaks regardless of the test results.

B. Storm Drainage

1. Test gravity lines between manholes or junction boxes.
2. Light Testing: Mains will be checked by City for displacement after the trench has been filled to two feet above the pipe and tamped as specified, and upon completion of the project. Test will be as follows:
 - a. A light will be flashed between the ends of the pipe section being tested.
 - b. If the illuminated interior shows any misalignment, or other defects as designated by City, defects shall be repaired.
3. General
 - a. Infiltration shall not exceed 100 gallons per inch of diameter, per mile of pipe, per 24 hours. City may require flow measurement for verification of infiltration.
 - b. Verify that maximum infiltration rate shall not be surpassed by air testing as follows.
4. Low Pressure Air Test:
 - a. Air testing of sewer mains shall conform to UNI-B-6 and the following requirements:
 - b. Perform initial air test when each section of main is complete, but prior to installation of service wyes. Test as construction proceeds.
 - c. Wet interior surfaces of porous pipe material prior to testing.
 - d. Safety
 - 1) Provide a superintendent who has experience in low-pressure air testing of gravity sewer mains.
 - 2) Follow safety recommendations of air testing equipment manufacturer.
 - 3) Properly brace sewer plugs during testing. Test plugs prior to use in air testing.

- 4) No one shall be allowed in manhole or trench when pipe is under pressure.
 - 5) Pressurizing equipment shall include a regulator and a pressure relief valve, which are set no higher than 9 psig. Monitor gauges continuously to assure that the pressure does not exceed 9 psig.
- e. Equipment
- 1) Sewer plugs shall be specifically designed for low pressure air testing.
 - 2) Use two separate air hoses.
 - i) One to connect the control panel to the sealed line for introducing the air.
 - ii) One from the sealed line to the control panel to provide constant monitoring of the air pressure in the line.
 - iii) If Pneumatic plugs are used a separate line shall be used to inflate the plugs.
 - 3) As a minimum the above ground air testing equipment shall include a shutoff valve, pressure regulating valve, pressure relief valve, input pressure gauge, and a continuous monitoring pressure gauge having a pressure range from 0 to at least 10 psig.
 - 4) Continuous monitoring pressure gauge shall be at least 4-inches in diameter with minimum divisions of 0.10 psi and an accuracy of +/- 0.04 psi.
 - 5) Monitoring gauges shall be subject to calibration as deemed necessary.
 - 6) Air used for testing shall pass through a single above ground control panel.
- f. Testing
- 1) Groundwater Determination: Immediately prior to each air test, determine groundwater level by a method acceptable to the Engineer. Adjust pressure used in air test in accordance with groundwater level.
 - 2) Apply air slowly to the test section until the pressure reached is 4.0 psi plus an adjustment of 0.433 psi for each foot of ground water above the crown of the pipe. Internal air pressure, including adjustment for ground water, should never exceed 9.0 psi.
 - 3) When the above-required pressure is reached, throttle air supply to maintain internal pressure for at least two minutes to permit stabilization.
 - 4) When pressure has stabilized at required pressure, shut off air supply.
 - 5) While observing the continuous monitoring pressure gauge, decrease pressure approximately 0.5 psi from required pressure.
 - 6) At this reading timing shall commence with a stopwatch and allowed to run until pressure has dropped 1.0 psi or allowable time has lapsed. Line shall be "Acceptable" if the pressure drop does not exceed 1 psig in the time prescribed for the test in Standard Detail, Low Pressure Air Testing for Gravity Sewer Mains.

3.06 "AS-CONSTRUCTED" DRAWINGS

A. General

1. Maintain on-site a full set of project drawings for purpose of recording as-constructed conditions.
2. Information should be legibly recorded as construction progresses.
3. Clearly and completely identify any field changes from the original drawings.
4. Actual, as-constructed elevations shall be obtained on all structures such as manholes, wet well, etc. Invert depths shall be recorded at each structure. All elevations shall be referenced to NAVD 88.
5. Show horizontal and vertical location of any existing underground utilities encountered during construction.
6. Submit document to the City prior to final acceptance.
7. All new features shall be surveyed utilizing survey grade GPS equipment and digital file with all surveyed information shall be provided to the City.
8. A digital CADD file shall be provided to the City that contains all the features constructed with the updated as-built information along with survey data.
9. The City shall have the right to employ an independent survey firm to verify the "As-Constructed" Drawings submitted by the Developer at the end of the project. If components or the drawings are determined to be incorrect, the Developer shall have all items corrected to obtain final approval by the City. Developer will also be responsible for reimbursing the City for all associated costs related to verification, review, and other costs arising from any corrections having to be made in order to provide correct plans and files to the City.

◆ END OF SECTION ◆