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## **SECTION 02400**

### **STORM DRAINAGE**

#### **PART 1 – PRODUCTS**

##### **1.01 PIPE:**

- A. Round Concrete Pipe – Shall be reinforced Class III and shall conform to ASTM Specification C -76 or AASHTO Specification M 170.
  - 1. Joints – Shall be water tight flexible rubber gasket and shall meet ASTM Specification C-443
  - 2. Filter Fabric – Mirafi 140N or equivalent.
  - 3. Concrete pipe shall be designed with no lifting holes. The lifting holes will jeopardize the structural integrity and hydraulic capacity of the pipe once installed.
  - 4. A minimum depth of 12 inches cover is required for RCP Class III.
  
- B. Reinforced Concrete Elliptical Culvert and Storm Sewer Pipe – Shall be reinforced Class He-III, or VE-III, and shall conform to ASTM Specification C -507 or AASHTO Specification M-207.
  - 1. Joints – Shall be water tight flexible rubber gasket and shall meet ASTM Specification C-443
  - 2. Filter Fabric – Mirafi 140N or equivalent.
  - 3. Concrete pipe shall be designed with no lifting holes. The lifting holes will jeopardize the structural integrity and hydraulic capacity of the pipe once installed.
  - 4. A minimum depth of 12 inches cover is required for RCP Class III.
  
- C. Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe – Shall be reinforced Class A-III, and shall conform to ASTM Specification C -506 or AASHTO Specification M-206.
  - 1. Joints – Shall be water tight flexible rubber gasket and shall meet ASTM Specification C-443

2. Filter Fabric – Mirafi 140N or equivalent.
  3. Concrete pipe shall be designed with no lifting holes. The lifting holes will jeopardize the structural integrity and hydraulic capacity of the pipe once installed.
  4. A minimum depth of 12 inches cover is required for RCP Class III.
- D. Plastic Pipe - To be used for subgrade drainage shall be rigid heavy duty corrugated polyethylene perforated pipe manufactured by Advance Drainage Systems (ADS), or accepted equivalent, and shall conform to AASHTO M-252. The use of coiled tubing is not permitted and will be rejected.

## **1.02 DRAINAGE STRUCTURES:**

- A. Details – See Plans.
- B. Concrete – Reinforced and non-reinforced.
1. Shall have a compressive strength of 3,000 PSI in 28 days. Concrete shall be ready mixed conforming to ASTM-C-94.
  2. Reinforcing steel shall conform to ASTM A-615, Grade 60. Mesh reinforcing shall conform to ASTM-A1064. Reinforcing shall be covered by a minimum 1" of concrete for covers and 1 ½ "for walls and flooring and 3" where concrete is deposited directly against the ground.
  3. Preformed Expansion joint filler materials shall conform to ASTM Specification D-1751, or shall be resin impregnated fiberboard conforming to the physical requirements of ASTM Specification D-1752.
- C. Mortar:
1. Mortar used at connections of pipe and drainage structures shall be composed of one part by volume of Portland cement and two parts of sand. The Portland cement shall conform to ASTM C-150, Type I or II. The sand shall conform to AASHTO Standard M-45 and shall be of an accepted gradation. Hydrated lime shall conform to ASTM C-141, Type A. The quantity of water in the mixture shall be sufficient to produce a workable mortar, but shall in no case exceed

7 gallons of water per sack of cement. Water shall be clean and free of harmful acids, alkalis and organic impurities. The mortar shall be used within 30 minutes from the time the ingredients are mixed with water.

- D. Brick Masonry – Brick shall conform to ASTM Specification C-62, Grade SW or C-55, Grade P-I or P-II. Mortar for jointing and plastering shall consist of one part Portland cement and two parts fine sand. Lime may be added to the mortar in the amount not more than 25% of the volume of cement. The joints shall be completely filled and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with ½ -inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course, and for round structures, brick shall be laid radially with every sixth course a stretcher course.
- E. Pre-cast – Shall be constructed in accordance with ASTM C-478 and conform to the details on the project drawings.
  - 1. Joints – Shall be tongue and groove sealed with flexible gaskets or mastic sealant. Gaskets shall be O-Ring or Type A or B “Tylox” conforming to ASTM C-443 and mastic shall be “Ram-nek”, or equivalent, with primer. The primer shall be applied to all contact surfaces of the manhole joint at the factory in accordance with the manufacturer’s instructions.
  - 2. Steps – Shall be aluminum alloy equivalent to Neenah R-1982-W or polypropylene equivalent to M.A. Industries PS-1-PF. The steps shall be installed at the manhole factory and in accordance with the recommendations of the step manufacturer. Manholes will not be acceptable if steps are not installed accordingly, and properly aligned vertically.
  - 3. Leaks – No leaks in the manhole will be acceptable. All repairs made from inside the manhole shall be made with mortar composed of one part Portland cement and two parts clean sand; the mixing liquid shall be straight bonding agent equivalent to “Acryl 60”.

### **1.03 DRAINAGE CASTINGS:**

- A. General - This specification is applicable for gray and ductile iron construction castings. All castings shall be manufactured in the United States of America by Neenah Foundry Company, U.S. Foundry &

Manufacturing Corporation, East Jordan Iron Works, Inc. or approved equal. All manufacturers shall be approved suppliers and be able to demonstrate that there is an acceptable quality control program at the producing foundry, prior to supplying castings.

- B. Material - Gray iron castings for heavy duty applications shall be manufactured from iron conforming to ASTM A48, Class 35B of AASHTO M306, or as requested by the purchaser. Gray iron castings for sidewalk or pedestrian applications shall be manufactured from iron conforming to ASTM A48, Class 30B or 35B, or as requested by the purchaser. Ductile iron castings shall conform to ASTM A536.
- C. Manufacture - Castings shall be of uniform quality, free from sand holes, gas holes, shrinkage, cracks and other surface defects. Castings shall be ground smooth and well cleaned by shot blasting. Bearing surfaces between manhole rings and covers or grates and frames shall be cast or machined with such precision to prevent rocking. As-cast dimensions may vary within accepted foundry tolerances as outlined in the Iron Castings Handbook published by the American Foundry Society. Nominally, casting dimensional tolerances shall be +/- 1/16" per foot. All published casting weights are average and approximate values and shall vary +/- 5%. Castings shall be furnished painted or unpainted as specified by the purchaser.
- D. Proof Load Testing - Traffic service castings shall have a first article proof load test conducted and the results of that proof load shall be made available upon request. The proof load shall be conducted in accordance with the method and procedure that is outlined in AASHTO M306. The casting shall be tested on a suitable and calibrated load testing machine and the casting shall hold a 40,000 pound proof load for one minute without experiencing any cracks or detrimental permanent deformation.
- E. Inspection - Inspections shall be in accordance with AASHTO M306. Results of these tests shall be furnished to the purchaser upon request. The heat or production date and product numbers shall be cast on the casting. This information shall be used for casting traceability and testing.
- F. Marking - All castings shall be identifiable and show, at a minimum, the following: name of the producing foundry, "Made in USA" as country of origin, ASTM material designation, individual part number, cast or heat date. In addition, at a minimum, the top or traffic side of all castings shall be clearly marked "Storm" and "City of Savannah" with "Dump No Waste Drains to River" or "Waterways" or "Drains to River" in flush cast letters. This includes all manhole covers, grates, and similar castings.

Refer to casting specifications and details as found in the City of Savannah's *Standard Details for Drainage*.

Note: Particular attention should be made to the specific "Savannah Coastal" casting image required on Inlet Manhole Covers.

- G. Sampling - Random checks on the castings may be conducted. These random checks would be conducted in accordance with AASHTO M306.
- H. Records - Test results for each lot of castings shall be maintained by the foundry for a minimum of seven years and shall be made available upon request.

Certification/Standards Compliance

ASTM A48 Material

ASTM A536 Material

AASHTO M306 Product Performance/Quality

ISO 9001:2008 Quality Assurance

- I. Quality Assurance - System of manufacturing quality assurance must conform to the requirements of ISO 9001:2008 and be certified by a third party.

#### **1.04 PRE-CAST BOX CULVERTS:**

- A. Pre-cast box culvert sections shall conform to ASTM specification C1577.
- B. Details – See Plans.
- C. Concrete - Mix design shall have a minimum compressive strength of 5,000 psi. The concrete mix design shall conform to ASTM C150 for cement and ASTM C33 for aggregates.
- D. Reinforcing Steel - shall conform to ASTM A185/A or A497/A.
- E. Joints and Gaskets - shall be watertight and conform to ASTM C1677-09.
- F. Filter Fabric – Mirafi 140N or equivalent.
- G. Box culvert sections shall be designed with no lifting holes.

**1.04 STONE BACKFILL:**

- A. Shall be graded crushed granite with the following gradation:

<u>Square Opening Size</u>	<u>Weight</u>	<u>Percent Passing By</u>
1"		100%
3/4"		90% to 100%
3/8"		0% to 65%
No. 4		0% to 25%
No. 100		0% to 10%

**1.05 SAND BACKFILL:**

- A. Shall be clean sand free from clay and organic material as described in Section 02200-1.01-D. Not more than 10% shall pass the No. 100 sieve.

**1.06 BORROW:**

- A. Where it is determined by the Engineer that sufficient suitable material is not available from the site to satisfactorily backfill the pipe to at least 2 feet above the top of the pipe, the Contractor shall furnish suitable sandy borrow material to accomplish the requirements. The material shall not have more than 60% passing the No. 100 sieve, nor more than 20% passing the No. 200 sieve.

**PART 2 – EXECUTION & TESTING**

**2.01 LOCATION AND GRADE:**

- A. The vertical and horizontal location of the sewer and ditches and the position of all manholes and other structures are shown on the drawings. The grade line as given on the profile or mentioned in these specifications means the invert or bottom of the inside of the pipe or bottom of ditch.

The Contractor shall be responsible for the proper location and grade of drainage pipe, culverts and other structures. Pipe and box culvert lines shall be straight and show a uniform gradient between manholes. The following descriptions of pipe related work shall also apply to all drainage structures including manholes, inlets, box culverts, junction boxes and other underground features.

## **2.02 EXCAVATIONS:**

- A. Excavated material shall be piled a sufficient distance from the trench banks to avoid overloading to prevent slides or cave-ins, following OSHA trench safety techniques and requirements.
- B. Remove from site all material not required or suitable for backfill.
- C. Grade as necessary to prevent water from flowing into excavations.
- D. Remove all water accumulating in the excavation from surface flow, seepage or otherwise, by pumping or other accepted method.
- E. Provide bracing and shoring as necessary for the protection of the work and safety of personnel.

## **2.03 TRENCHING:**

- A. The width of trenches at any point below the top of the pipe shall not be greater than the outside diameter of the pipe, plus 2' – 0" for pipes measuring through 30-inches, and 3' 0" for pipes greater than 30-inches box culverts and other structures, to permit satisfactory jointing and through tamping of the bedding material under and around the structures. Shoring and bracing where required shall be placed within the trench width as specified. Care shall be taken not to over-excavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures shall be necessary. Cost of this re-design and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the owner.
- B. Removal of Unstable Material – Where wet or otherwise unstable soil, incapable of supporting the pipe, as determined by the Owner, is encountered in the bottom of the trench, such material shall be removed to the depth required and replaced to the proper grade with select material, compacted as provided in Paragraph 2.08, "BACKFILLING", hereinafter.

## **2.04 BRACING AND SHORING:**

- A. The sides of all trenches and other excavations shall be securely held by skeleton or solid sheeting and bracing, as required to protect the adjoining property and for safety.



## **2.05 BEDDING:**

- A. The bedding surface for pipe and other structures shall provide a firm foundation of uniform density throughout the entire length of pipe or extent of structure. The excavation bottom shall be dewatered by whatever means and methods are necessary before installing pipe or other structures. Depending on the nature of the soil and other conditions, Contractor shall use well points or other means such as sumps and sump pumps to remove all water from the bedding surface. Pipe shall be carefully bedded in a soil foundation that has been accurately shaped and rounded to conform to the lowest one-fourth (1/4) of the outside portion of circular pipe, or to the lower curved portion of arch pipe for the entire length of the pipe. When necessary, the bedding shall be tamped to compact it to 95% modified proctor density (ASTM 1557). Bell holes and depressions for joints shall be only of such length, depth and width as required for properly making the particular type joint.
- B. Stone Backfill – Where, in the opinion of the Engineer, the subgrade of the pipe trench is unsuitable material, the Contractor shall remove the unsuitable material a minimum of six inches (6”) deep and furnish and place stone backfill in the trench to stabilize the subgrade. The stone shall be ¾-inch graded but variations in the gradation will be permitted upon acceptance by the Engineer. Attention is invited to the fact that the presence of water does not necessarily mean that stone backfill is required. If well points or other types of dewatering will remove the water, the Contractor shall be required to completely dewater the trench in lieu of stone backfill. Stone backfill will be limited to areas where well pointing and other conventional methods of dewatering will not produce a dry bottom. Pipe shall be carefully bedded in the stone as specified above. Crushed concrete or other aggregates cannot be substituted for natural stone.
- C. Sand Backfill - Where in the opinion of the Engineer, the character of the soil is such that the material even though dewatered is unsuitable for pipe bedding, an additional foot of excavation shall be made and replaced with clean sand furnished by the Contractor.

## **2.06 PLACING PIPE AND PRE CAST BOX CULVERT SECTIONS:**

- A. Each pipe shall be carefully examined before being laid, and defective or damaged pipe shall not be used. Pipe lines shall be laid to the grades and alignment indicated. Proper equipment shall be provided for lowering sections of pipe into trenches. Under no circumstances shall pipe be laid when trench conditions or weather are unsuitable for such work.

Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. All pipe in place shall have been checked before backfilling. When storm drain pipe terminates in a new ditch, the headwall or end section together with ditch pavement, if specified, shall be constructed immediately as called for on the plans. Ditch slopes and disturbed earth areas shall be grassed and mulched as required.

The Contractor will be responsible for maintaining these newly constructed ditches and take immediate action subject to acceptance to keep erosion of the ditch bottom and slopes to a minimum during the life of the contract. No additional compensation will be given to the Contractor for the required diversion of drainage and/or dewatering of trenches. Grassing of the completed earth surface of the trench backfill shall conform to the technical specification for Grassing.

- B. Concrete Pipe – Laying shall proceed upgradient with the spigot ends of bell and spigot pipe pointing in the direction of the flow.
- C. Each box culvert section shall be carefully examined before being laid, and defective or damaged sections shall not be used. Box culvert lines shall be laid to the grades and alignment indicated. Proper equipment shall be provided for lowering sections of box culvert into trenches. Under no circumstances shall box culverts be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary.
- D. Pre-cast Box Culverts – Installation shall proceed upgradient with tongue ends of tongue and groove box culverts pointing in the direction of the flow.

## **2.07 JOINTS IN PIPES AND BOX CULVERTS:**

- A. Concrete Pipe – Flexible watertight joint shall be made with rubber-type gaskets for concrete pipe. The design of joints and the physical requirements for rubber-type gaskets shall conform to ASTM Specification C-443.
  - 1. Installation of Filter Fabric at Joint – After each joint is joined together; the Contractor shall place two layers of Mirafi 140N or equivalent filter fabric around the joint a minimum width of four feet, centered on the joint.
- B. Pre-cast Box Culverts – Flexible watertight joint shall be made with rubber-type gaskets for concrete box culverts. The design of joints and

the physical requirements for rubber-type gaskets shall conform to ASTM Specification C1677-09.

1. Installation of Filter Fabric at Joint – After each joint is joined together; the Contractor shall place two layers of Mirafi 140N or equivalent filter fabric around the joint a minimum width of four feet, center on the joint. The two layers of fabric shall wrap around all four sides of the box culvert joint.

## **2.08 BACKFILLING:**

- A. After the bedding has been prepared and the pipe installed, select material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of the pipe in layers not exceeding six-inches (6”) in compacted depth. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to insure thorough compaction of the fill under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compaction shall continue until the fill has reached an elevation of at least 12-inches above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical tampers or rammers in layers not exceeding 8-inches. Soil density relations tests and moisture density relations tests may be performed by a testing firm or laboratory and shall be taken as directed in conformance with the compaction requirements specified in subparagraph “COMPACTION” hereinafter. Deficiencies shall be corrected by the Contractor without additional cost to the owner, any sheeting and/or portions of bracing used shall be left in place. Untreated sheeting shall not be left in place beneath structures or pavements.
- B. For pipe placed in fill sections, the backfill material and the placement and compaction procedures shall be as specified above and in subparagraph “COMPACTION” hereinafter. The fill material shall be uniformly spread in layers longitudinal on both sides of the pipe, not exceeding six inches (6”) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 12-inches above the top of the pipe shall extend a distance of not less than twice the outside diameter on each side of the pipe or 12 feet, whichever is less. After the backfill has reached at least 12-inches above the top pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 8-inches.

- C. In compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert at any stage of the construction shall be at the Contractor's risk. Any pipe damaged thereby shall be repaired or replaced at the expense of the Contractor.

**2.09 DETECTION TAPE:**

- A. Metal Detectable Tape – Marking tape shall be a corrosion resistant, detectable marking tape designed for use in the protection and location of nonmetallic or low metal content underground piping. The tape shall consist of solid aluminum foil which is incased in chemically inert polyethylene plastic that will not degrade when exposed to acid, alkalies and other destructive surfaces commonly found in soil. The solid foil core shall be encased in a protective jacket that allows the visual inspection of the aluminum core on one side to ensure continuity. The tape shall be 6.0 mil thick total thickness (the aluminum portion of the tape is only 0.35 mil thick) and 3 inches wide with tensile strength of 2800 PSI. A continuous warning message repeated every 24" to 36" shall be imprinted on the tape surface. The tape shall contain an opaque color concentrate designating the color code appropriate to the line being buried. Safety precaution green with "Caution – buried storm sewer below" or similar markings on tape. The contractor shall place the tape over the installed drainage pipes at a depth not to exceed 18 inches below the finished surface. The metallic tape shall be equivalent to terra-tape by Griffolyn Co. Inc of Houston Texas.

**2.10 COMPACTION:**

- A. Soil and compaction tests shall be made by a testing laboratory accepted by the Owner and shall be made at the Owner's direction and expense. Failed tests shall be rescheduled at the Owner's direction, and retesting shall be paid for by the Contractor. Laboratory compaction characteristics of the soil shall be made in accordance with ASTM D-1557. In-place density tests shall be made in accordance with ASTM D-1556, D-2922 or D-5195. Results of the tests shall be furnished to the Owner by the testing laboratory.

The minimum number of tests required shall be:

Backfill in traffic areas . . . . . 1 per 100 lf or less for each 2' of depth or portion thereof. (Minimum of 2 for any line segment.)

Backfill in non-traffic areas . . . . 1 per 200 lb or less for each 6 feet of depth or portion thereof.

The minimum percent of compaction of the backfill material (in accordance to ASTM D-1557) shall be the following:

In traffic areas . . . . . 98% for the top 12" of backfill under the pavement base; 95% below the 12" line.

In non-traffic areas . . . . . 95%

**2.11 DRAINAGE STRUCTURES:**

- A. Drainage structures shall be constructed of the materials specified for each type and in accordance with the details shown on the drawings.

**2.12 MANHOLES:**

- A. Manholes shall be constructed where shown on the drawings or where directed by the Owner. The channel in the bottom of the manholes shall be smooth and properly shaped. Special care must be exercised in laying the channel in adjacent pipes to grade. The tops of manholes shall be built to grades designed by the Owner. Manhole sections with either honeycomb defects; exposed reinforcing; broken/fractured tongue or groove; or cracked walls will be subject to rejection by the Engineer for use on the project. When mastic sealant is used, improperly applied primer will also be cause for rejection.

**2.13 LEAKAGE:**

- A. All visible leaks shall be repaired, regardless of the amount of leakage.

**2.14 CONNECT PIPE TO EXISTING STRUCTURES:**

- A. The Contractor shall connect the system to the existing structure where indicated. A hole not more than 4-inches larger than the outside diameter of the new pipe shall be cut neatly in the structure and the new pipe laid so that it is flush with the inside face of the structure. The annular space around the pipe shall be filled with a damp, expanding mortar or grout, combined with bricks and/or brick fragments, as necessary to make a watertight seal.

**2.15 CLOSING PIPE:**

- A. When the work or pipe laying is suspended, either for night or at other times, the end of the sewer must be closed with a tight cover. The Contractor will be held responsible for keeping the sewer free from obstructions.

**2.16 REGRADE EXISTING DITCH:**

- A. Designated existing ditches shall be regarded and shaped to provide a bottom with a uniform slope, without depressions that hold water, and that conforms to the plan grades. The side slopes shall be smooth and uniform, dressed by hand if necessary, conforming to the indicated slopes.

**2.17 CONSTRUCT NEW DITCHES:**

- A. New ditches as shown on the construction drawings shall be graded and shaped to provide a bottom with a uniform slope, without depressions that hold water, and that conforms to the plan grades. The side slopes shall be smooth and uniform, dressed by hand if necessary, conforming to the indicated slopes. Ditches with side slope greater than 3:1 (Horizontal: Vertical) shall be stabilized by means of woven jute fabric engineered for erosion control and soil stabilization, or approved equal.

**2.18 CLEANING:**

- A. Prior to televising and before acceptance of the storm systems, all storm lines shall be cleaned to the satisfaction of the Engineer. Where any obstruction occurs, the Contractor will be required to clean the lines by means of flushing and rods and swabs or other instruments.

**2.19 TELEVISIONING:**

- A. After the completion of cleaning, all constructed storm lines must be televised prior to acceptance. Accordingly, all storm lines that are installed within accepted public right-of-ways and easements will be televised, including the first section of private lines between manholes that are connected to the public lines. In addition, storm lines from stormwater detention basins to the City system shall be televised. No lines shall be televised within 30 days of installation. If televising is performed by City personnel, contractors will be charged a standard fee, and will be responsible for preparing the lines to insure that they are cleaned and free of debris prior to televising. Details and procedures of this program are included in the "Televising Procedures Manual"

developed by the City's Water Quality Control Department who will be providing the television services. Contractors will be responsible for becoming familiar with this manual.

**2.20 RECORD DATA:**

- A. As required under Section 1500, Paragraph 54, of the General Conditions, the Contractor is required to keep accurate, legible records of the vertical and horizontal location of all new storm lines and structures during construction. These records shall be made available to the Engineer before his final review for incorporation into Record Drawings. Final payment to the Contractor will be withheld until all such information is received and accepted.

**END OF SECTION**