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5.01 Design

Storm drainage facilities shall be designed to dispose of storm water generated upon or passing through the project location. The determination of the quantities of water which must be accommodated will be based upon peak flows from storms having the following

return periods:

<i>Drainage Structure</i>	<i>Storm Event - Return Frequency</i>
Curb Inlet, Roadside Ditches	2-year storm
Storm Sewer Collector	10-year storm
Cross Street Storm Drainage	25-year storm
Greenways	25-year storm
Structures in Flood Plain	100-year storm*

*Drainage structures in the flood plain should pass 100-year storm without over-topping the roadway -- or in the alternative, the structures may be designed to pass only the 25-year event, in which case, the downstream roadway embankment shall be fully protected from the residual flow which may overtop the roadway during a 100-year event.

Prediction of the peak flow rates shall be calculated using the procedure in the USDA Soil Conservation Service Method, the Rational Method, or other acceptable calculation procedures as determined by the TOWN. The size of storm water conduits shall be determined by utilizing the standard energy equation for inlet control or outlet control and headwater nomographs as published by various federal agencies – US FHWA - H.E.C. #5, Soil Conservation Service, etc. The minimum pipe size to be used shall be 15-inch diameter Reinforced Concrete Pipe (RCP). All pipes should be designed utilizing a Manning’s roughness coefficient of 0.013 (n-value).

All storm sewers shall be installed in dedicated street rights-of-way or easements. Minimum widths of storm sewer easements shall be as follows:

<i>Pipe Diameter</i>	<i>Easement</i>
15" -- 36"	20'
42" -- 72"	30'
> 72"	to be determined by the Town of Apex

No structures such as buildings, fences, playsets, etc. shall be placed within any public easement.

Where multiple pipes are installed, the edges of the easement shall be a minimum of 10 feet from the centerline of the outside pipe with a 3' clearance between the exterior of the

parallel storm sewer pipes. Pipes shall not outfall in the front yard of a lot, but should extend to the rear third of the lot or property line in residential subdivisions.

Discharge from the drainage systems shall not be of such a velocity as to cause damage after leaving the pipe. Maximum allowable outlet velocity will be 2.5 feet per second (refer to "Code of Ordinances, Town of Apex, North Carolina" enacted December 20, 2005; Chapter 5, Article X, Sec. 5-149). Exiting velocities shall be in conformance with the sedimentation and erosion guidelines and outlet protection used whenever the velocity exceeds the allowable limit. Pipe outlets, flared end sections and head walls shall be provided, with rip-rap aprons designed to reduce velocity and dissipate energy so that downstream damage from erosion does not occur. Calculations shall be submitted with plan review.

Manholes or structures shall be installed at each deflection of line or grade. Acute angle junctions (angles less than 90°) between pipe runs should be avoided. No inaccessible junction boxes shall be permitted. The maximum distance between access openings shall not exceed 400 feet for pipes 30" and smaller. For pipes 36" and larger, the maximum distance between access openings may be increased to 500 feet.

Manhole base diameters shall conform to the following for the various storm sewer pipe sizes:

<i>Storm Sewer Pipe Size</i>	<i>Manhole Base Diameter</i>
15" - 36"	5'0"
42" - 48"	6'0"
54"	8'0"

For pipes greater than 54", manhole base sections shall be sized as required and shall be approved by the ENGINEER.

Joints between sections of pipe shall be constructed utilizing a watertight gasket, o-rings, or bitumastic impregnated rope-type joint material for the full circumference of the joint. For pipes 36-inches in diameter or larger, each interior joint shall also be filled with a Portland cement grout and troweled smooth for the circumference of the pipe.

Pipe may enter the corner of all structure material types except precast concrete "waffle" type boxes.

The minimum cover shall be 2 feet from finish subgrade to the top of pipe under roadways, and 1 foot under a non-roadway area.

Storm water shall not generally be allowed to flow across the roadway. Any deviation shall

require pre-approval by the ENGINEER. Drainage shall be provided to intercept the flow prior to the radius of an intersection, or the design of the roadway shall indicate a continuous grade around the radius to allow the flow to continue down the intersecting street. Water shall be picked up before the spread into the roadway exceeds eight feet for curb and gutter roadways. No catch basin shall be installed in the radius of a curve.

Piped storm water that originates within or passes through the public ROW shall be conveyed through a contiguous public storm drain easement, from the ROW. through points downstream, to the point of open discharge. Private storm drainage systems will be permitted, provided that: (1) such systems collect and discharge impounded storm water wholly within the same lot or (2) such systems collect water from one single lot and discharge into the public storm drain system. Private storm drain systems that connect to the public storm drain system shall have the connecting leg of such a system, which crosses into the public ROW. or easement, constructed in accordance with Town Specifications, including but not limited to: the necessary easements, piping, inlets and junction boxes. Piped private storm drainage systems may not cross property lines or convey storm water from one lot to another. Where permitted by topography and site conditions, storm drain systems that serve a single non-residential lot (i.e., parking lots, private streets, vehicular use areas), shall be privately maintained.

5.02 Pipe Materials

a. General:

All storm sewer pipes to be installed in projects within the jurisdictional limits of the Town of Apex shall be reinforced concrete pipe (RCP) conforming to the specifications presented herein. In special cases where material other than RCP may be required, the applicant's plan submittal must contain a formal request to use other material and complete background data to justify its use. Approval to use other material may only be granted by the Public Works Department.

b. Reinforced Concrete Pipe (RCP):

RCP shall be as per ASTM C76 (or the latest revision), Class III or Class IV with a minimum 15-inch diameter as furnished by NC Products or Gray Concrete Pipe Company or an approved equal. Joints shall be wiped with mortar or sealed with a plastic cement putty meeting Federal Specification SS-S-00210 such as "Ram-Nek." Mortar shall be applied to the outside of all pipe joints and to both the inside and outside of joints of pipes 36" or larger.

5.03 Materials - Storm Drainage Structures

a. General:

All structures (manholes, curb inlets, catch basins, junction boxes, etc.) shall be

constructed of concrete brick masonry units, cast-in-place reinforced concrete, or pre-cast concrete.

Curb inlets in streets with curb and gutter shall be DOT type standard frame, grate, and hood. Yard inlets and area drains shall utilize a grate and frame, 4 feet by 8 feet size, minimum.

b. Concrete Brick Masonry Units:

Concrete brick masonry units shall be solid units meeting the requirements of ASTM C55, Grade S-II. Clay brick shall not be permitted for any drainage structure.

c. Precast Concrete Manholes:

Pre-cast concrete manholes shall meet the requirements of ASTM C478. Manholes shall have joints sealed with a pre-formed rope-type gasket per Federal Specifications SS-S-00210. Manholes shall have 5-foot diameter for storm drains with a diameter 15-inch through 36-inch, 6-foot diameter for storm drains with a diameter 42-inch through 48-inch, and 8-foot diameter for storm drains 54" in diameter. All pipes greater than 54" shall have manholes sized as required and approved by the ENGINEER.

Transition reducing slabs may be used to enable the use of 4' diameter eccentric cones at the top. All pre-cast manholes for storm sewers shall be of the eccentric type for ease of access.

d. Mortar:

Mortar shall be proportioned as shown below for either Mix No. 1 or Mix No. 2. All proportions are by volume. Water shall be added only in the amount required to make a workable mixture.

MIX NO. 1	1 part Portland Cement 1/4 part Hydrated Lime 3 3/4 parts Mortar Sand (maximum)
MIX NO. 2	1 part Portland Cement 1 part Masonry Cement 6 parts Mortar Sand (maximum)

Portland cement shall be ASTM C-150, Type 1. Hydrated lime shall conform to ASTM C207, Type S. Masonry cement shall meet the requirements of ASTM C91. Mortar sand shall be standard size 4S, per requirements of the NCDOT.

e. Castings:

- 1) General – All castings shall meet the requirements of ASTM A48, Grade 35B iron and shall be manufactured in the USA. Country of origin shall be embossed on each casting.

At a minimum, manufacturers shall submit the following to substantiate to the ENGINEER that castings meet the minimum criteria:

- a. Bar tensile test reports from an independent testing laboratory. The results must confirm that the material meets ASTM A48 Class 35B.
 - b. Casting proof load test report on the subject casting. Proof load tests shall be conducted in accordance with AASHTO M306, Section 7.0. During proof load testing, castings shall maintain a 40,000 lb proof load for one minute without experiencing any cracking or detrimental deflection.
 - c. A written statement of certification by a qualified licensed engineer, employed by the producing foundry, that castings meet these specifications.
- 2) Curb Inlet - Grates, frames, and hoods shall be in accordance with NCDOT Standard 840.02 and 840.03. Curb inlet hoods shall be embossed with "Dump No Waste! Drains to Waterways".
 - 3) Grates & Frames - Cast iron grates and frames for yard inlets shall be of the size indicated on the approved plans. Grates and frames shall be in compliance with NCDOT Standards for a 2' X 2' masonry opening, or its equivalent with comparable features for other larger size openings as may be required.

Grates and frames shall only be used outside of street rights-of-way.

- 4) Manhole Rings & Cover - Cast iron manhole rings and covers shall be in compliance with Detail 7.06 of these specifications with the words "STORM SEWER" cast on the cover. Covers shall have two 1-inch holes. Manhole castings shall be machined to provide a continuous bearing around the full periphery of the frame.

f. Portland Cement Concrete:

Portland cement concrete used for storm drainage structures, end walls, etc. shall conform to the technical requirements presented in Section 2.07 of these Specifications, and shall have a minimum compressive strength of 3,000 psi at 28 days. Primary structures, such as box culverts, may require concrete having a compressive strength greater than 3,000 psi, and may require the submission of mix designs and testing of the concrete by an independent laboratory. These special requirements may be imposed by the ENGINEER for all such structures where deemed necessary.

g. Reinforcing Steel:

Reinforcing steel shall be new billet steel conforming to ASTM A615 for grade 60. Reinforcing steel shall be deformed per current ASTM standards.

5.04 Miscellaneous Materials

a. Rip Rap:

Riprap shall be large aggregate of the size and class shown on the approved drawings. Storm water calculations shall be submitted with plan review.

5.05 Inlets and Outlets

a. Headwalls, Endwalls, and Flared End Sections:

Headwalls, Endwalls, and Flared End Sections shall be constructed of structural cast-in-place concrete or pre-cast concrete in accordance with NCDOT specifications and shall be installed at all discharge points and inlets where there is not a structure. Details and design of headwalls, endwalls, and flared end sections shall be in accordance with NCDOT Standard Detail requirements. Details shall be shown on all plan submissions.

Flared End Sections shall be installed on single pipe culverts up to and including 60 inches in diameter, and on multiple pipe culverts less than 30 inches in diameter. Flared End Sections shall also be installed at the outlet point of all storm drainage systems.

Headwall and Endwalls shall be installed on single pipe culverts greater than 60 inches in diameter, and on multiple pipe culverts greater than and including 30 inches in diameter.

b. Dissipaters and Scour Protection:

Energy dissipaters shall be installed at all discharge points and shall be properly sized to ensure that stormwater is released at a non-erosive velocity.

Scour protection shall be provided for all drainage ways where, in the opinion of the Engineer, erosive velocities or other factors require the use of protective measures. All protective measures shall be shown on all plan submissions.

Additional information on the impact of stormwater discharge onto adjacent properties may be required by the Engineer.

5.06 Structural BMP's Within The Primary and Secondary Watershed Protection Overlay Districts

Structural Best Management Practices (BMP's) shall be designed and constructed per the guidelines and minimum design criteria presented in the State of North Carolina Department of Environmental and Natural Resources (DENR) BMP Manual, latest revisions. These structures shall be designed to meet all stormwater requirements presented in Section 6.1 of the Town of Apex Unified Development Ordinance.

In addition to the guidelines and minimum design criteria presented in DENR's BMP Manual, the following design criteria shall be used for inlet and outlet control devices in *all* Structural BMP's:

- The invert elevation for the inlet to the Structural BMP shall be set no lower than the normal/permanent pool elevation controlled by the water quality orifice(s).
- The outlet device shall be constructed of either precast Reinforced Concrete Pipe or CMP material. No masonry structures will be approved.

Prior to the approval of a final plat (with respect to a subdivision), issuance of a certificate of occupancy (with respect to a site plan), or commencement of a use for any development upon which a Structural BMP is required, the applicant shall certify that the completed project is in accordance with the approved stormwater management plans and designs, and shall submit actual "as-built" plans for all Structural BMP's.

The "as-built" plans shall show the final design specifications for all Structural BMP's and practices and the field location, size, elevations, and planted vegetation of all measures, controls, and devices, as installed. The designer of the Structural BMP's shall certify, under seal, that the as-built Structural BMP's, controls, and devices are in compliance with the approved plans and designs as required by the Town of Apex UDO.

A final inspection and approval by the Town of Apex Environmental Programs Manager or his/her designee must occur before the release of any performance securities

5.07 Construction Methods

a. Trenching & Bedding for Storm Sewers:

The trench shall be excavated to the line and grade indicated on the drawings. The trench bottom shall provide a firm and uniform support for the pipe. Where bell and spigot type pipe is used, recesses shall be excavated to receive the pipe bell.

Where the foundation is found to be of poor supporting value, the pipe foundation shall be conditioned by undercutting the unacceptable material to the required depth as directed by the ENGINEER, and backfilling with stone or other approved material. Where necessary, surface water shall be temporarily diverted in order to maintain the pipe foundation in a dry condition. The flow of water from such temporary diversions shall be directed into suitable

erosion control devices.

b. Pipe Laying:

Concrete pipe culverts shall be laid carefully with bells or grooves upgrade and ends fully and closely jointed. Joints of concrete pipe shall be made with cement mortar or with rope-type gasket joint meeting ASTM C 443 and C 361 materials as specified.

Where mortar is used, the joint shall be thoroughly wetted before making the mortar joint. Before succeeding sections of pipe are laid, the lower portions of the bell or groove of the pipe shall be filled on the inside with cement mortar of sufficient thickness to bring the inner surface of the abutting pipes flush and even. After the pipe is laid, the remainder of the joint shall be solidly filled with mortar and sufficient additional mortar used to form a bead or ring around the outside of the joint. The inside of the joint shall be wiped and finished smooth. Pipe which is not true to alignment, or which shows any settlement after installation, shall be taken up and re-laid.

c. Backfilling:

The storm sewer trench shall be backfilled with selected earth or approved material free from large stones or clods. The material shall be compacted in 6-inch lifts (loose measurement) to the top of the pipe and compacted to 95% of maximum dry density (Standard Proctor). The backfilling shall be done on both sides of the pipe simultaneously to prevent displacement of the pipe. If the pipe is within an area to be paved or where the trench is immediately behind the curb, the backfill material shall be placed on top of the pipe with an initial lift of twelve (12) inches followed by six (6) inch lifts to the top of the trench. If the pipe is outside of the paved area and is not located directly behind the curb, the backfill material shall be placed on top of the pipe in twelve (12) inch lifts to the top of the trench. The backfill materials shall be moistened when necessary in the opinion of the INSPECTOR to obtain maximum compaction. Water setting or puddling shall not be permitted.

All trash, forms, debris, etc., shall be cleared from the backfill material before backfilling. Backfilling around structures shall be done symmetrically and thoroughly compacted in 6-inch layers with mechanical tampers to the specified 95% density (Standard Proctor).

d. Masonry Structures:

Excavations shall be made to the required depth, and the foundation, on which the brick masonry is to be laid, shall be approved by the TOWN. The brick shall be laid so that they will be thoroughly bonded into the mortar by means of the "shove-joint" method. Buttered or plastered joints will not be permitted. The headers and stretchers shall be so arranged as to thoroughly bond the mass. Brickwork shall be of alternate headers and stretchers with consecutive courses breaking joint. All mortar joints shall be at least 3/8 inches in thickness. The joints shall be completely filled with mortar. No spalls or bats shall be used

except for shaping around irregular openings or when unavoidable to finish out a course. All details of construction shall be in accordance with approved practice and to the satisfaction of the ENGINEER.

Steps as shown on the plans shall be placed in all catch basins and inlets when they are greater than five feet in depth. The steps shall be set in the masonry as the work is built up, thoroughly bonded, and accurately spaced and aligned.

Inverts in the structures shall be shaped to form a smooth and regular surface free from sharp or jagged edges. They shall be sloped adequately to prevent sedimentation. The castings shall be set in full mortar beds. All castings when set shall conform to the finish grade shown on the drawings. Any castings not conforming shall be adjusted to the correct grade.

e. Concrete Construction:

The forming, placing, finishing, and curing of portland cement concrete shall be performed in strict accordance with all applicable requirements as contained in the Standard Specifications for Road & Structures latest edition, as published by the NCDOT and pertinent ACI (American Concrete Institute) codes and guidelines.

f. Installation of Precast Concrete Structures:

Pre-cast concrete manholes, junction boxes, etc. shall be installed level and upon a firm, dry foundation, approved by the ENGINEER. Structures shall be backfilled with suitable materials, symmetrically placed and thoroughly compacted so as to prevent displacement. Castings shall be set in full mortar beds to the required finished grade. Refer to Detail 5.05.

Waffle boxes shall be allowed only to a depth of 5 feet. All pre-cast boxes deeper than 5 feet shall be solid boxes.