City of Raleigh Stormwater

STORMWATER DESIGN MANUAL

Last Edited June 20, 2024

Presented to City Council September 3, 2024

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INTRODUCTION

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1.1 INTRODUCTION

This manual shall be used to assist in the design of stormwater infrastructure and to aide in regulatory compliance of development projects within the City of Raleigh (City) and its extraterritorial jurisdiction (ETJ). The audience for this manual is technical professionals, including:

- Designers associated with development projects
- Designers hired by the City for project design
- City staff conducting plan review or project management

This manual and its contents are fully incorporated into the City's Unified Development Ordinance (UDO) under UDO Sections 1.1.12, 9.2.1.B, and 9.4.2, and all development activity shall be subject to these requirements. Unless otherwise stated, these requirements apply to all projects including development, redevelopment, and public projects.

1.2 LIMITATIONS

The manual provides a compilation of readily available literature regarding stormwater management in the Raleigh area. Although it is intended to establish uniform design practices, it does not replace the need for sound professional judgment. Because materials presented were obtained from numerous publications and have not been duplicated in their entirety, the applicant must obtain original or additional reference materials, as appropriate.

Any web links/URLs provided in this manual were current at the time of Manual completion. If the links have changed, documents and other resources may need to be searched by name.

1.3 CITY STORMWATER REGULATIONS

The City's stormwater plan review team reviews the requirements in the stormwater areas listed below and issues the associated permits.

With each regulatory section, the applicable qualified design professional has been added. This varies between requirements based on State and Federal laws in addition to the requirements of the UDO and this Manual.

1.3.1 Watercourse Buffers

Watercourse buffers, also known as riparian buffers, help protect water quality. Buffer rules protect vegetated areas adjacent to intermittent and perennial streams, lakes, reservoirs, ponds, estuaries, and modified natural streams. The Neuse buffer rules specifically protect buffers for their nutrient removal abilities. All areas of the City may require buffers associated with the

Neuse River Basin. Areas within a watershed protection and other overlay districts may have additional buffer requirements.

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
9.2.3. Watercourse Buffers	NA	Watercourse Buffer (WCB)

Design Professional: NA

Permit Information:

Watercourse Buffer permits are issued for all projects that have a regulated watercourse buffer on site per UDO Section 9.2.3.E. If the project falls in a watershed overlay district with watercourse buffer requirements (Falls, Swift Creek, and Urban Watershed Protection Overlay Protection Districts, Conservation Management Districts, and the Metro-Park Overlay District), buffers apply to all watercourses, not only those that may appear on the United States Geological Survey (USGS) 7.5 Minute Quadrangle Map or published Wake or Durham County Soil Survey Map.

Watercourse Buffer permits are also issued for project sites that have streams or waterbodies subject to the Neuse River riparian buffer rules. If streams depicted on the USGS 7.5-Minute Quadrangle Map or published Wake or Durham County Soil Survey Map have had a stream/buffer determination from North Carolina Department of Environmental Quality (NCDEQ), include the determination and applicable map in an appendix of the Stormwater Compliance Report (SCR), which is described in Chapter 2.

If stream buffer impacts are proposed, the following information must be submitted to the City based on the designation in the Table of Uses in the Neuse Buffer Rules (15A NCAC 02B .0714):

- If Deemed Allowable impacts are proposed, provide a narrative listing the applicable section of the Table of Uses and provide any associated data such as impact width or area.
- If Allowable Upon Authorization impacts are proposed, provide the application to NCDEQ – including maps – and the approval letter from NCDEQ.

Underlying Regulations:

- North Carolina (NC) Neuse Buffer Rules (15A NCAC 02B .0714)
- NC Water Supply Watershed Regulations 15A NCAC 02B .0624
- Falls Lake Nutrient Strategy 15A NCAC 02B .0277

Required Reference Material:

- NC Neuse Buffer Rules (15A NCAC 02B .0714), including the Table of Uses
- NCDEQ Resources for Stream Identification, Buffer Authorization, Buffer Variance
- USGS Maps, in one of the following formats:
    - USGS 7.5-Minute Quadrangle Maps
    - National Map Viewer
- The most recent version of the published manuscript of the soil survey map prepared by the Natural Resources Conservation Service (NRCS) (Wake County Soil Survey 1970 and Durham County Soil Survey 1976)

  OR

  The following digital versions of the most recent NRCS Soil Survey maps (excluding Web Soil Survey)

    - https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soil/soil-surveys-by-state
    - https://archive.org/details/usda-soil-surveys
- Both the USGS 7.5-Minute Quadrangle maps and the most recent NRCS Soil Survey maps are currently available on a NCDEQ Map Viewer:
    - NCDEQ Map Viewer for USGS and Soil Maps

1.3.2 Stormwater Conveyance System

Stormwater Conveyance infrastructure includes pipes, inlets, junctions, swales, roadway gutters, culverts, and bridges. Requirements are related to both hydraulic design and to materials. Information regarding as-built and inspection submittals are also in Chapter 4 of this Manual.

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
NA	**Chapter 4 Stormwater Conveyance Design** Chapter 3 Hydrology Chapter 7 Easements	Stormwater Conveyance (SCON)

Design Professionals:

- Conveyance design in general: Qualified, registered professional engineers in NC and registered landscape architects in NC, as allowed by law.
- Inspection certification in Section 4.8: Qualified, registered professional engineers in NC.

Permit Information:

- A Stormwater Conveyance System permit is required for the construction, reconstruction, replacement, extension, renovation, alteration, demolition or abandonment of stormwater conveyance systems that are specified in Section 4.8.1 of this Manual. Any project requiring a Stormwater Conveyance System permit will be required to submit an electronic file of the approved stormwater conveyance system in a format specified in the plan review checklist and prior to permit issuance. Stormwater conveyance systems also require inspection and as-built certification submittal to and acceptance by the Stormwater Division in the City of Raleigh's Engineering Services Department (Raleigh Stormwater) prior to final inspection approval and Certificate of Occupancy issuance.

Underlying Regulations:

- For NCDOT roads, NCDOT standards must be met.
- For City roads and other areas in the City and ETJ, this Manual contains the requirements.

Required References:

- City of Raleigh Standard Detail Drawings
- NCDOT Standard Details – most recent version
- AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specification, Section 12
- NCDOT "Guidelines for Drainage Studies and Hydraulic Design" - most recent version
- FHWA "Hydraulic Design of Highway Culverts", "Hydraulic Design of Energy Dissipators for Culverts and Channels" & "Hydraulic Design of Safe Bridges"
- HEC-22 Urban Drainage Design Manual
- ASTM C76, C1479, C1628, C507, C923, C1478, F2510, F2881, F477, D3212, & D2321
- AASHTO M330 & M294
- NCDEQ "Erosion and Sediment Control Planning and Design Manual"

- NASSCO “Pipeline Assessment and Certification Program”

1.3.3 Stormwater Management

Also referred to as post-construction stormwater management, stormwater management includes compliance with regulations for water quality (nutrients) and runoff rate (peak discharge). This includes design requirements for traditional stormwater control measures (SCMs) and green stormwater infrastructure (GSI).

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
9.2.2. Active Stormwater Control Measures	**Chapter 5 Stormwater Management Calculations** **Chapter 6 SCM Design** Chapter 3 Hydrology Chapter 7 Easements	Stormwater Control (SC) Stormwater Control 2 (SC2)

Design Professionals:

Qualified registered North Carolina professional engineer, surveyor, soil scientist or landscape architect, as detailed in UDO Section 9.2.2.D.1.a.

Permit Information:

Stormwater Control permits are issued for properties that are increasing or substituting impervious area per UDO Section 9.2.2.C. Properties fall into two categories of requirements:

- ***Exempt Property Requirements:*** UDO Section 9.2.2.A provides exemptions for some properties that, dependent on age, size, or use, do not have to comply with the full Active Stormwater Control Measure rules contained in UDO Sections 9.2.2 B through H. Instead, those properties are to comply with the impervious surface limitations defined in UDO Section 9.2.2.A. However, these impervious surface limitations may be exceeded by (a) choosing to comply with the Full Stormwater Requirements or (b) the methods described in UDO Section 9.2.2.A.4.b.
- ***Full Stormwater Requirements:*** UDO Sections 9.2.2.B through H require full stormwater calculations prepared by a qualified licensed professional as described in UDO Section 9.2.2.D.1.a. These rules address water quality (UDO Section 9.2.2.B Nitrogen Reduction) and runoff control (UDO Section 9.2.2.E Stormwater Runoff Controls). Typically, a development constructs one or more SCM to meet those requirements. Calculations are documented in the SCR.

Underlying Regulations:

- City of Raleigh NPDES MS4 Permit
- NC Neuse Nutrient Strategy Rules 15A NCAC 02B .0711
- NC DEQ Stormwater Minimum Design Criteria (MDC)
- Local requirements related to localized flooding as stated in the UDO and this Manual.

Required Reference Material:

- NCDEQ Stormwater Design Manual - Required reference for SCM Design
- NCDEQ Stormwater Control Measure Credit Document - Needed reference to determine if a SCM is considered a Primary SCM.
- NCDEQ SNAP Tool - Required tool for Nutrient Calculations.
- City of Raleigh Standard Detail Drawings - Optional Details for SCMs.

1.3.4 Erosion and Sediment Control (ESC)

ESC requirements protect the environment and property from erosion and sediment runoff during active construction. The temporary control devices are removed once the site is stabilized.

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
9.4 Erosion and Sediment Control	**Chapter 8 Erosion and Sediment Control** Chapter 3 Hydrology	Land Disturbance – Grading (LDG)

Design Professionals:

Qualified, registered professional engineers in NC and registered landscape architects in NC unless otherwise allowed by law.

Permit Information:

Land Disturbance Grading (LDG) permits are required for all projects that disturb 12,000 square feet (0.275 acres) or more of land area per UDO Section 9.4.6.

Underlying Regulations:

- NC Sedimentation Pollution Control Act of 1973
- City of Raleigh NPDES MS4 Permit

Required Reference Material:

- NCDEQ Erosion and Sediment Control Planning and Design Manual

1.3.5 Floodplain Management

The City requires management of floodplains delineated by Federal Emergency Management Agency (FEMA) mapping and local requirements to delineate floodplains upstream of the FEMA mapping limits.

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
9.3 Special Flood Hazard Area Regulations	**Chapter 9 Floodplains** Chapter 3 Hydrology Chapter 7 Easements	Floodplain (FL): • FL (FEMA) • FL (non-FEMA)

Design Professionals:

Some requirements in UDO Article 9.3 and Chapter 9 of this Manual must be signed and sealed by a qualified, registered North Carolina professional engineer.

Permit information:

Flood permits are required for all development activities conducted on property that contains floodplain, as defined in UDO Section 9.3.2 and Chapter 9 of this Manual.

Underlying Regulations:

- FEMA Floodplain Regulations
- Local requirements, as stated in the UDO and this Manual, that extend floodplain protections upstream of the limits studied by FEMA.

Required Reference Material:

- FEMA Floodplain delineations
  - North Carolina Flood Risk Information System
- Flood Hazard Soils

  - The last paper copy of the NRCS Soil Survey maps including the Wake County 1970 maps and Durham County 1976 maps, which may be found on the USDA Natural Resources Conservation Service website and USDA NRCS archive.
- FEMA Technical Bulletins

1.3.6 Water Supply Watersheds

Water Supply Watershed Protection Overlay Districts and the Metro-Park Overlay District are in place to ensure the availability of public water supplies at a safe level of water quality for residents of the City and surrounding areas.

UDO SECTION(S)	DESIGN MANUAL CHAPTER(S)	PERMIT(S)
9.5. Watershed Protection Areas	Chapter 5 Stormwater Management Calculation Chapter 6 SCM Design Chapter 3 Hydrology Chapter 7 Easements	Water Supply Watershed (WSWP)

Design Professionals:

When stormwater management calculations or SCM design is required, a qualified registered North Carolina professional engineer, surveyor, soil scientist or landscape architect, as detailed in UDO Section 9.2.2.D.1.a, is to be used but only in their area of competence.

Permit Information:

Water Supply Watershed permits are issued for projects within the following regulated overlay districts:

- Urban Watershed Protection Overlay District
- Falls Watershed Protection Overlay District
- Swift Creek Watershed Protection Overlay District.

Underlying Regulations:

- NC Water Supply Watershed Regulations 15A NCAC 02B .0624
- Falls Lake Nutrient Strategy 15A NCAC 02B .0277
- Swift Creek Land Management Plan Inter-Local Agreement

Required Reference Material:

See the required reference materials listed in Section 1.3.1, “Watercourse Buffers,” and Section 1.3.3, “Stormwater Management,” of this Manual.

1.4 State and Federal Regulations

It is the responsibility of the applicant to be fully aware of all applicable Federal and State government laws and regulations. The City has the delegated authority for review of some State and Federal regulations. Those are as follows:

- NC Water Supply Watershed Regulations 15A NCAC 02B .0624
- City of Raleigh NPDES MS4 Permit
- Falls Lake Nutrient Strategy 15A NCAC 02B .0277
- NC Neuse Nutrient Strategy Rules 15A NCAC 02B .0711
- NC Sedimentation Pollution Control Act of 1973
- FEMA Floodplain Regulations

The following regulations are not directly implemented by the City. Applicants must apply for permits directly with the applicable State and/or Federal agency. The City will request confirmation that applicable permits or authorizations have been obtained.

- NC Neuse Buffer Rules (15A NCAC 02B .0714)
- Federal Clean Water Act Sections 401 & 404 for temporary and permanent impacts to streams, wetlands and waterways, which includes:
  - 401 Water Quality Certifications (WQC) by NCDEQ
  - 404 Permits from the US Army Corps of Engineers (USACE)
- NC State Dam Safety Regulations

The information above is not intended to be a comprehensive list of required permitting. It is the applicant’s responsibility to obtain necessary permits.

1.5 SUBMITTAL REQUIREMENTS

Project submittal requirements are stated throughout the Manual. Designers are responsible for thorough review and adherence to all applicable Manual and UDO requirements. The City has development checklists as an additional resource for ensuring compliance with all applicable requirements; checklists are available on the City’s Stormwater website.

1.6 ABBREVIATIONS

The following abbreviations are used frequently in this document:

AASHTO	American Association of Highway and Transportation Officials
ASTM	American Society for Testing and Materials
BFE	Base Flood Elevation
BUA	Built Upon Area
CCTV	Closed-circuit television
DIS	Disconnected Impervious Surface
EPA	Environmental Protection Agency
ESC	Erosion and Sediment Control
FEMA	Federal Emergency Management Agency
HW/D	Headwater to Pipe Diameter Ratio
NFIP	National Flood Insurance Program
FHWA	Federal Highway Administration
FRO	Financially Responsibility/Ownership Form
GIS	Geographic Information System
GSI	Green Stormwater Infrastructure
HDPE	High-density polyethylene
HGL	Hydraulic Grade Line
LGP	Lot Grading Plan (City-specific)
LOD	Limits of Disturbance
LOMR	Letter of Map Revision
LS-FS	Level Spreader – Filter Strip
MDC	Minimum Design Criteria
MS4	Municipal Separate Storm Sewer System
NC	North Carolina
NCAC	North Carolina Administrative Code
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCFMP	North Carolina Floodplain Mapping Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PE	Professional Engineer
PP	Polypropylene
PVC	Polyvinyl Chloride
RFPE	Regulatory Flood Protection Elevation
RLA	Registered Landscape Architect
ROW	Public Street Right-of-Way
RCP	Reinforced Concrete Pipe
SCM	Stormwater Control Measure
SCR	Stormwater Compliance Report (City-specific)
SFHA	Special Flood Hazard Area
SNAP	Stormwater Nitrogen and Phosphorus, a tool from NCDEQ
TN	Total Nitrogen
UDO	Unified Development Ordinance
USACE	United States Army Corps of Engineers

WSEL	Water Surface Elevation
WSWP	Water Supply Watershed Program
WQv	Water Quality Volume

1.7 DEFINITIONS

Applicant
The Owner or Owner's Representative submitting required materials to the City for review and potential approval.

Built Upon Area (BUA)
Defined in UDO Section 9.2.1.F.

City Standards
Requirements for design, construction, and maintenance of stormwater infrastructure. These standards include the Raleigh Stormwater Design Manual, the Raleigh City Code, including its UDO and all City Standard Details.

Culvert
A structure that conveys any flow collected in an open-ended pipe and can be utilized as a cross-drain.

Freeboard
An additional depth (added to the top of a basin, pond, ditch, dam or roadway embankment, etc.) regarded as a safety factor, above the peak design storm water surface elevation.

Frequency
The average time interval between equal magnitude storm events. For example, a 25-year storm event has the probability of being equaled or exceeded once every 25 years, or a 4% chance of being equaled or exceeded in any given year.

Green Stormwater Infrastructure (GSI)
Defined in UDO Section 12.2.

Gutter
A depression along the edge of the roadway, attached to the inside part of the curb, used to convey stormwater runoff, typically directing it to a curb opening inlet.

Hydraulic Grade Line (HGL)
In open-channel flow, the HGL is equal to the water surface elevation in the channel or partially full pipe. In pressure flow (full-pipe flow), the HGL denotes the level water will rise to if unconstrained.

Hydrograph
A graph of runoff over time for a given storm and watershed.

Impervious Surface
Defined in UDO Section 12.2.

Infiltration
A complex process of allowing runoff to penetrate the ground and flow through the upper or lower soil surface.

Invert
The lowest point inside of a pipe, channel, or structure.

Limits of Disturbance (LOD)
See Chapter 8, Section 8.2 of this Manual.

Lot Grading Plan (LGP)
See Chapter 2 of this Manual.

Peak Discharge
The maximum rate of flow for water passing a given point during or after a rainfall event. Also referred to as peak flow.

Person
Any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, interstate body or other legal entity.

Post-Development
The condition of a property following any development activity.

Pre-Development
The existing condition of a property before development occurs.

Public Runoff
Runoff that comes from a City or NCDOT maintained public street ROW or from parcels owned by the City of Raleigh.

Raleigh Stormwater
The Stormwater Division within the City of Raleigh Engineering Services Department.

Runoff
The portion of rainfall that is not part of the initial abstraction (evaporation, infiltration, surface depression storage).

Spread
The width of flow measured perpendicularly from the roadway pavement edge or the face of curb towards the center of the roadway.

Stage
The elevation of the water surface above a given elevation datum.

Stormwater Compliance Report (SCR)
See Chapter 2 of this Manual.

Time of Concentration (Tc)
The time required for water to flow from the most hydraulically remote point of the watershed to the location being analyzed. Thus, the time of concentration is the maximum time for water to travel through the watershed, which is not always the maximum distance from the outlet to any point in the watershed.

Unified Development Ordinance (UDO)
Part 10 of the Raleigh City Code that contains regulations applicable to the city limits of the City of Raleigh and its ETJ concerning the use and development of land and buildings, including zoning, subdivision, stormwater, and natural resource conservation.

Water Quality Volume (WQv)
The design volume for a nutrient treatment SCM as defined by NCDEQ in General MDC 1.

Chapter 2

SITE DEVELOPMENT REQUIREMENTS

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2.1 LOT GRADING PLAN (LGP)

A LGP is required as detailed in Section 2.1.1. below. It addresses possible off-site stormwater impacts for projects that are not subject to the Full Stormwater Requirements (UDO Sections 9.2.2.B through H). The LGP is required at site or building permit review, whichever comes first.

2.1.1 LGP Applicability

A LGP is required for development projects that are adding impervious area or performing grading or changing how flow leaves property, and meet one of the following criteria:

- Less than or equal to 1 acre (one and two unit detached residential) OR
- Less than or equal to 0.5 acre (all other development types) OR
- Over 1 acre (one and two unit detached residential) with impervious area of 5% or less.

LGP are not required for the following situations:

- Projects adding less than or equal to 800 square feet of impervious area
- Interior-only projects
- Deck-only projects
- Projects that do not increase impervious area, do not conduct grading, and do not change how flow leaves the property.
- Projects subject to the Full Stormwater Requirements in UDO Sections 9.2.2.B through H.

Note that Planning and Development may require a plot plan in situations where a LGP is not required.

2.1.2 LGP Design Requirements

2.1.2.1 Concentrated Flow

For the purposes of the LGP, concentrated flow means flow that has been combined into a channel, pipe, or downspout. Each point where flow is being concentrated within a development project must address the potential impacts in one of the following ways:

A. Discharge to an existing pipe or swale in the ROW.

B. Discharge overland flow from up to 19,000 square feet of impervious area into the ROW. This meets the 3 cubic feet per second (cfs) limit in Section 4.2.7 of this Manual.

C. Discharge to a stream buffer on the property, meeting the applicable buffer rules.

D. Vegetated Area: Demonstrate that the flow can be redistributed in a vegetated area by meeting the following criteria:

a. Discharge to a vegetated receiving area on the parcel that is a minimum of 10 feet in length or 0.04 times the drainage area in square feet, whichever is greater. The width shall be one half the length of the receiving area.

b. The vegetated receiving area shall have a slope of 8% or less and shall be planted with a non-clumping, deep-rooted grass species and/or native plants appropriate for rain gardens.

E. Surface Infiltration Pits: Construct surface infiltration pits, sized based on the following chart or formula:

Impervious Square Footage (SF)	Surface Infiltration Pit Size (length x width x depth in feet)
<=100	3.5 x 3.5 x 2.5
Greater than 100 and <=200	4 x 4 x 3.5
Greater than 200 and <=400	6 x 6 x 3.5
Greater than 400 and <=600	9 x 5 x 4
Greater than 600 and <=800	9 x 7 x 4
Greater than 800 and <=1000	9 x 9 x 4

As an alternative to the above table, the size can be determined with this formula:
Minimum Volume (cubic feet) = 0.3 x Impervious Area (square feet)

Per NC rules about injection wells, downspouts must discharge to the surface and not be piped into the stone within the pit. One surface dimension must be greater than the depth of the pit, and the bottom of the pit must be at least 2 feet above the seasonal high-water table.

F. Rain Gardens: Construct rain gardens using the following sizing table or the formula below. The amended soil depth shall be a minimum of 18 inches under the entire ponding area. Rain gardens must be mulched and planted.

Impervious Square Footage (SF)	Rain Garden Size (SF) Assumes 6" ponding depth
<=100	16
Greater than 100 and <=200	33
Greater than 200 and <=400	67
Greater than 400 and <=600	100
Greater than 600 and <=800	133
Greater than 800 and <=1000	167

As an alternate to the above table, the ponding area shall be sized based on capturing the first 1 inch of runoff from the impervious area.

G. Easement: Tie-into a stormwater conveyance system on adjacent property. If this conveyance system does not have an existing private drainage easement, obtain a private drainage easement from the downstream property owner, as presented in Section 7.2 of this Manual. Provide calculations that demonstrate the downstream system has capacity per Chapter 4 of this Manual.

H. For options A-F above, no site-specific calculations, soil tests, or design drawings need to be submitted to the City. The applicant may need to make simple calculations as listed in items D, E, F, but those calculations do not need to be submitted to the City. No easement, maintenance agreement, or annual inspection is needed if the sole purpose of installation is to meet this Section 2.1.2.1.

2.1.2.2 Impervious Limits

A. Determining Impervious Surface Limits

The impervious surface limits for the site are based on UDO Section 9.2.2.A, on limits established on previously recorded maps, or on watershed overlay districts. Contact stormwater.impervious@raleighnc.gov for assistance determining the limit for a specific property.

B. Exceeding Impervious Surface Limits

Whether a site may exceed the impervious surface limit is based on the underlying regulations.

- For sites with impervious surface limits based on UDO Section 9.2.2.A, the methods for exceeding the limits are given in UDO Section 9.2.2.A.4.b.
    - For the method in UDO Section 9.2.2.A.4.b.i, the calculations shall be based on the Volume Reduction method in Chapter 5 of this Manual.
    - For the method in UDO Section 9.2.2.A.4.b.ii., the calculations shall be based on Section 5.2 of this Manual, Rate of Runoff Control Requirements.
- For sites with impervious surface limits established by a previous subdivision plan, increasing the impervious surface limit will require modifying the subdivision-wide plan.
- For sites with impervious surface limits based on a watershed overlay district, available methods are listed in UDO Section 9.5.

2.1.2.3 Other Requirements

- No flooding or impounding of water against an insurable structure shall be permitted during the 100-year storm event, except for properly floodproofed non-residential structures.
- Proposed reverse slope driveways must identify the flow route for the driveway runoff. Flow shall not pond against the building structure in the 10-year storm.

2.1.4 LGP Submittal Requirements

Lot grading plans shall contain the following information at minimum. These requirements are in addition to the Planning and Development requirements for a site plan.

- Existing and proposed topography at a minimum of 2-foot intervals.
- Top and bottom elevations for proposed retaining walls.
- First floor elevation for every primary structure and accessory dwellling unit when floodplain is present on a property.
- Existing and proposed stormwater conveyance system infrastructure.
- Proposed downspout flow directions (Indicate which property line(s) the downspout(s) will flow towards).
- Swale typical cross-sections.
- Adjacent street and sidewalk elevation(s).
- Locations of septic tank(s) and drainfield(s).
- Location of porches, decks, swimming pools, AC pads, doorways, sheds, and other accessory structures.
- Drainage Easements (existing and proposed).
- Limits of disturbance.
- Existing environmental features, including: special flood hazard areas, wetlands, streams, watercourse buffers.
- Indicate the method(s), as listed in Section 2.1.2.1 of this Manual, that will be used on the lot. If flow drains towards multiple property lines, indicate which method will be used in each flow direction.
- Provide a table on the lot grading plan indicating the flow direction at a minimum of four points and the selected discharge option from section 2.1.2.1.
- Attach the associated standard detail if selecting discharge options D - Vegetated Area; E - Surface Infiltration Pit; or F - Rain Garden.

After a LGP has been submitted to and approved by the City, any modification(s) to the proposed development that change the method(s) of compliance with Section 2.1.2.2. above, shall require revision(s) to the approved LGP. Modifications to the discharge option as required in Section 2.1.2.1 above may be made during construction and reported to the stormwater inspector at the time of final inspection.

2.2 STORMWATER COMPLIANCE REPORT (SCR)

Prior to the approval of any preliminary or permitting submittal (whichever comes first), the applicant shall submit to the City a Stormwater Compliance Report (SCR) that complies with the requirements set forth in the UDO and this Manual.

The list below provides an overview of the SCR format. Additional detailed requirements are contained in the applicable chapters of this Manual.

2.2.1 SCR Applicability

A SCR, with applicable sections, is required for development projects that meet any one of the following:

- Greater than 1 acre (one and two unit detached residential) or more than 0.5 acre (all other development types).
- Less than or equal to 1 acre (one and two unit detached residential) or 0.5 acre or less (all other development types) AND seeking to exceed established impervious surface limits.
- Located in a Watershed Protection Overlay District or Metro-Park Overlay District.
- Requiring a flood study per Chapter 9 of this Manual.
- If a stormwater conveyance system, as defined in Chapter 4 of this Manual, is installed, replaced, or hydraulically altered as part of the development project.

2.2.2 SCR Components

A completed package, sealed by a North Carolina licensed design professional, shall be provided with each plan or permit submittal. The report shall contain a main body (narrative) and appendices.

1. **Cover** – The cover of the report shall contain the project name, the package revision date, and the case number (once provided by Planning and Development). It shall be signed and sealed by a North Carolina licensed design professional.
2. **Project Data –** The following project data shall be provided at the beginning of the SCR:
    a. A map fitting on 8.5” x 11” paper showing project area, aligning with parcel boundaries, so that it is clear what area is covered by the SCR.
    b. The following information, in a table format as shown on the City’s website:
        i. Floodplain – Presence, Type, Impacts
        ii. Neuse Buffers – Presence, Impacts
        iii. Streams – Presence, Impacts
        iv. Wetlands – Presence, Impacts
        v. Watershed Protection Overlay – Presence, Compliance Method
        vi. Active Stormwater Controls Compliance Method

1. Subject to Exempt Property Requirements (UDO Section 9.2.2.A) OR Full Stormwater Requirements (UDO Sections 9.2.2.B to H) OR Exempt (specify UDO subsection within UDO Section 9.2.2.A.3)
2. Meeting Existing Impervious Surface Allocation
3. Will stormwater compliance be on a lot-by-lot basis (only allowed when all lots > 1 acre) or shared between multiple lots
4. Full Stormwater Requirements (UDO Sections 9.2.2.B to H), Nitrogen Rules Calculation Method – SNAP or Runoff Volume Match

vii. Documented Downstream Structural Flooding

viii. Rezoning Conditions

ix. Site Use – Previous and Proposed

x. Zoning

3. Streams, Wetlands and Buffers

a. Any streams subject to the Neuse River riparian buffer rules on the property must be shown on the plans. If there are streams depicted on the USGS 7.5-Minute Quadrangle Map or published NRCS Wake or Durham County Soil Survey map(s) that are not subject to the buffer rules throughout the project limits include the NCDEQ buffer determination letter and applicable map in an appendix of the SCR.

b. If stream buffer impacts are proposed, include the applicable information in the SCR based on the Neuse Buffer Rules (15A NCAC 02B .0714):

   i. If Deemed Allowable impacts are proposed, provide a narrative listing the applicable section(s) of the Table of Uses and provide any associated data such as impact width or area.

   ii. If Allowable Upon Authorization impacts are proposed, provide in an appendix to the SCR a copy of the application to NCDEQ – including impact maps – and a copy of the approval letter from NCDEQ.

   iii. If Mitigation is required, provide in an appendix to the SCR documentation that the mitigation requirements have been completed.

c. If jurisdictional wetlands and streams are present, provide the jurisdictional determination from the USACE in an appendix to the SCR.

d. If impacts to jurisdictional wetlands and streams are proposed, provide in the SCR the following documents:

   i. 401 Water Quality Certification from NCDEQ with impact map.

   ii. Approval by the USACE or documentation that a Nationwide Permit

applies.

iii. If a Nationwide Permit applies, list the permit number and name and provide an active web link to the document.

iv. Include copies of the submitted pre-construction notification application (PCN) and associated maps providing the wetland and stream reference labels. Also include copies of any revised submittals to NCDEQ or USACE.

e. If the project falls within a watershed overlay district with watercourse buffer requirements (Falls, Swift Creek, and Urban Watershed Protection Overlay Protection Districts, Conservation Management Districts, and the Metro-Park Overlay District), indicate the buffer width(s) that apply to the project. Note that these buffers apply to all watercourses in the project area, not only those that may appear on the USGS 7.5-Minute Quadrangle Map or published Wake or Durham County Soil Survey map(s). For disturbance of any city-regulated riparian buffer, documentation of how the buffer disturbance complies with UDO Section 9.2.3 must be provided.

f. The narrative shall explain how **diffuse flow**, if applicable, is being maintained for stormwater discharge from the proposed project into a riparian or watercourse buffer.

4. Drainage Design

a. Methodology - A thorough description of all methodologies, procedures, and data sources used in the calculations shall be included in the narrative, as well as a detailed record of all assumptions.

b. See Chapter 4 of this Manual for additional requirements.

5. Active Stormwater Controls

a. Exemptions based on UDO Section 9.2.2.A

i. State any applicable impervious surface limits with reference to UDO Section 9.2.2.A.

ii. State any other exemption being claimed with reference to UDO Section 9.2.2.A.

b. Meeting Existing Impervious Surface Allocation - The following shall be provided in the main body of the SCR.

i. State the source of the allocation, including the case number (assigned by Planning and Development) that established the impervious surface limit and the applicable Wake or Durham County Register of Deeds reference (book and page) for the associated recorded map.

ii. List the maximum allowable impervious surface area and the proposed impervious surface area.

c. Nitrogen Compliance

   i. Provide a table in the main body/narrative of the SCR showing the following items:

      1. %BUA
      2. WQv needed and WQv provided
      3. For SNAP, show the target export in pounds/year, the export after SCMs are applied, and the buy-down needed.
      4. For runoff volume match, summarize the pre- and post-development volumes of runoff leaving the site for the 90th percentile storm event

   ii. Methodology – in narrative

      1. Summarize which methodology used (SNAP versus runoff volume match).
      2. State any deviations from the City's guidance on SNAP input and explain these inputs.
      3. Describe the method used for runoff volume match.

   iii. PDF of City's SNAP input summary tables in an appendix to the SCR.

   iv. PDF of SNAP worksheets or Runoff Volume Match calculations as an appendix to the SCR.

   v. WQv calculations as applicable

d. Runoff Rate Compliance

   i. In the narrative:

      1. Provide a table showing the pre- and post-development peak discharge for the regulated storms for each point of analysis. Indicate the % change.
      2. Methodology - A thorough description of all methodologies, procedures, and data sources used in the calculations shall be included in the narrative, as well as a detailed record of all assumptions.

   ii. In appendix:

      1. Development of input data (e.g. CN, C, Tc, etc)
      2. PDF sheets from the software used showing the following:

         a. Model configuration/Routing Schematic/Node Diagram - e.g. how do drainage areas combine, what drainage area is routed through a channel or a SCM.

         b. Input data such as drainage area, coefficients, time of

concentration, time step.

c. Input data for SCMs such as stage-storage tables, outlet elevations, and shapes.

d. Output hydrograph from each step.

e. Establishing Impervious Surface Allocation

i. Provide a table showing the maximum impervious surface area per lot.

6. Stormwater Control Measure Summary

a. In the narrative:

i. List each SCM used in the project with a unique identifier to include the SCM type and the regulation(s) the SCM is being used to satisfy (e.g. Nitrogen only, Nitrogen and Runoff Rate, Watershed Overlay, Diffuse Flow, etc.).

b. See Chapter 6 of this Manual for additional requirements.

7. Erosion and Sediment Control Design

a. Methodology - A thorough description of all methodologies, procedures, and data sources used in the calculations shall be included in the narrative, along with a detailed record of all assumptions.

b. See Chapter 8 of this Manual for additional requirements.

c. This section is not required at preliminary review. It is required at permitting review.

8. Floodplain Compliance

a. If SFHA areas are present on the project site, show the 100-year flood elevation, 100-year floodway, and future 100-year flood elevation on the project's existing condition and stormwater/grading plans.

b. If fill in the floodplain fringe is allowed and pursued for this site, provide a figure showing the floodplain boundaries, the fill areas, and the percent of the floodplain being filled.

c. If floodproofing is allowed and pursued, indicate the floodproofing strategy.

d. If floodplain is present on the site, state that an elevation certificate is needed.

e. If a flood study is needed, state the type of flood study needed (based on Chapter 9 of this Manual) and indicate the case number for the study, as assigned by Planning and Development, and the Flood Study (FS) number, as assigned by the City's stormwater reviewer.

9. Overlay Districts

If the project falls in an overlay district with watercourse buffer requirements (Falls, Swift Creek, and Urban Watershed Protection Overlay Districts, Conservation Management Districts, and the

Metro-Park Overlay District), indicate in the narrative how those requirements apply to the project and how they will be met.

a. State in the SCR the maximum allowable impervious surface area permitted in the specific district and the proposed impervious surface area for the site.

b. Documentation of all additional requirements (e.g. impervious surface area, built area, nutrient loading, buffer, retention, detention), as applicable, to the respective Watershed Protection Overlay District, as detailed in UDO Article 9.5.

10. Rezoning Conditions

List the applicable rezoning case number issued by the City and any stormwater-related zoning conditions included with that approved rezoning. For each stormwater-related zoning condition, state in the narrative of the SCR how compliance is achieved. This description may reference other sections of the SCR or plans for details.

11. Figures/Maps

a. Pre- and Post- Development Land Cover, per Chapter 5 of this Manual.

b. Drainage Areas for Runoff Rate Analysis, per Chapter 5 of this Manual.

c. Drainage Areas for SCMs.

d. Drainage Areas for Drainage Design, per Chapter 4 of this Manual.

12. SCM Construction Cost Estimate(s)

A construction cost estimate shall be provided for each SCM. This section is not required at preliminary review. It is required in the O&M Manual at permitting review.

The cost estimate shall contain the following information:

- Quantities for cost items.
- Unit costs adjusted to the current year's dollars.
- Total cost.

The following cost items shall be included:

- Structures and their appurtenances.
- Pipe within the SCM or embankment.
- Excavation and grading.
- Fill material, including specialized material for embankments.
- Rip rap.
- Geotextiles.
- Plantings.

- Soil media.
- Soil preparation.
- Retaining walls, as required in Chapter 6 of this Manual.

2.3 ADDITIONAL SITE CRITERIA

2.3.1 Restoration of pervious areas

Pervious surface areas compacted during construction shall be restored to continue being considered pervious surface area. Areas that were impervious in the existing condition that are proposed to be pervious in the final condition must be made pervious in accordance with the requirements of this section.

The following requirements apply to all pervious surface areas compacted during construction or that are proposed in place of previously existing impervious surface areas:

- Till the area to a depth of 12 inches below the top of the compacted subgrade.
- Provide soil amendments, as needed, in accordance with soil tests. If lime and/or fertilizer are to be used, it shall be applied uniformly during seedbed preparation and mixed well in the top four to six inches of soil or applied as recommended in the planting specifications for proposed landscaping.

These requirements must be reflected in the project's plans and in the project's construction sequence.

2.3.2 Substitution of Impervious Area

To obtain credit for existing impervious surface area under the substitution of impervious surface credit, one of the following must be true:

- The impervious surface area must not be removed more than one year prior to the plan submittal claiming substitution.
- The demolition permit must be open at the time of plan submittal.

If a plan has been approved with substitution of impervious surface area, the work to substitute the impervious surface area with pervious surface area must take place prior to the expiration of a valid building permit or the sunsetting of an approved subdivision or site plan.

2.3.3 Maximum Slopes

The maximum slope of a newly graded vegetated area shall be 3:1 unless an alternate stabilization method is approved.

2.3.4 Vehicle and Equipment Cleaning Requirements

2.3.4.1 All Facilities

- All wash water must be discharged to the sanitary sewer collection system.
- Grading and drainage shall be provided so that wash water does not bypass the sanitary sewer collection system and enter the storm drain system.
- These requirements do not negate the need to meet Raleigh Water's requirements about discharges to the sanitary sewer collection system.

2.3.4.2 City Properties

These requirements shall apply to new or renovated City of Raleigh facilities.

The City of Raleigh has specific requirements in its NPDES permit pertaining to vehicle and equipment cleaning measures. These projects must **clearly demonstrate and describe measures that prevent/minimize contamination of stormwater from all areas used for vehicle and equipment cleaning**.

- New or renovated City facilities shall have a designated wash station if vehicle and/or equipment maintenance or cleaning occurs at the site.
- Approved measures include performing cleaning operations indoors, cover cleaning operations, ensure wash water drains to the sanitary sewer collection system, collect stormwater run-on from the cleaning area and provide treatment or recycling.
- If sanitary sewer facilities are not available and cleaning operations must take place outdoors, the cleaning operations must take place on, or drain directly to, a grassed or graveled area.
- If none of the above measures can be achieved, then storm drain(s) must be covered with portable drain covers during cleaning activities, and any standing water present after the cleaning activities have been completed are to be removed and properly handled before the storm drain(s) are uncovered.

Chapter 3

HYDROLOGY

TABLE OF CONTENTS

3.1 Introduction

This chapter addresses hydrologic methods that are approved for use in the required calculations detailed in subsequent chapters of this Manual.

3.2 Drainage Area Delineation and Analysis

The drainage area for a watershed must be determined from topographic maps and field surveys within the project area. The vertical datum associated with the topographic information must be stated in the plan set.

3.2.1 Analysis Points

For runoff rate control, the selection of analysis points is described in Chapter 5 of this Manual, “Stormwater Management Calculations”.

For storm drainage design, analysis is needed for:

- every new inlet
- any existing inlet with a drainage area that has been modified
- upstream flows that will enter the pipe system(s) being analyzed

For floodplain analysis, the designer will determine the number of drainage areas needed for the analysis. Analysis points for flow change locations can be established at the upstream end of the site, the downstream end of the site, and the entrances of tributaries. If only one drainage area is used for the analysis, it must be the discharge at the downstream end of the site.

3.2.2 Drainage Area Maps

Pre-development (existing) and post-development (proposed) drainage area maps shall be provided in the SCR. Pre-development maps must depict existing conditions including topography, natural channels, stormwater conveyance infrastructure, impoundments, SCMs, and impervious area. Post-development maps shall depict existing features to remain, changes in topography, proposed stormwater conveyance infrastructure, proposed SCMs, and proposed impervious area.

Delineated drainage areas shall be clearly depicted on the pre-development and post-development drainage area maps. All drainage areas must be labeled consistently between pre- and post- development with the total area (acres) provided for each. Each drainage area shall accurately represent the areas contributing to the selected points of analysis, which may include off-site areas contributing stormwater runoff.

When using the NRCS method for time of concentration, segmented flow paths are to be clearly depicted on both pre-development and post-development drainage area maps. The differing flow path segments and their transitions from one to another shall be depicted and labeled (e.g., sheet flow to shallow concentrated flow). Additional information on time of concentration is provided in Section 3.6, below.

3.3 Hydrologic Design Methods

Hydrology involves the estimation of flow peaks, volumes, and time distributions of stormwater runoff. The analysis of these parameters is fundamental to the design of stormwater management infrastructure, such as stormwater conveyance systems and SCMs.

It is the designer's responsibility to be knowledgeable about hydrologic methodologies and apply them on a site-specific basis within the limitations of specific methods.

3.3.1 Watershed Characteristics

The approved methods listed in Table 3.1 consider some or all of the following characteristics:

- Rainfall amount and storm distribution
- Drainage area size and/or shape
- Groundcover and soil type
- Slopes of terrain and stream channel(s)
- Antecedent moisture condition
- Rainfall abstraction rates (initial and constant)
- Storage potential (e.g., floodplains, ponds, wetlands, reservoirs, channels)
- Watershed development potential
- Characteristics of the local drainage system

3.3.2 Channel Routing

Some aspects of stormwater design require routing hydrographs through channels. Methods for performing routing calculations include:

- Muskingum
- Muskingum–Cunge
- Lag and K
- Kinematic Wave
- Modified Puls

3.3.3 Impoundment Routing

Some calculations require consideration of routing through SCMs or other impoundments. The approved method for this type of routing is:

- Storage-Indication Method

3.3.4 Approved Methods

Hydrologic design methods vary by application and have method-specific constraints. This is addressed in Table 3.1, where the methods with check marks are approved for use for those pertinent design applications and those methods without a check mark cannot be used for those pertinent design applications. Approved methods are:

- Rational Method – Applicable for drainage areas under 100 acres.
- NRCS Method as detailed in *TR-55 Urban Hydrology for Small Watersheds* and the *National Engineering Handbook*, Part 630, Hydrology, NEH-630.10 and 630.16.

- HEC-HMS – Applicability varies based on selected method within the model. This is the Hydrologic Modeling System (HMS) from the USACE's Hydrologic Engineering Center (HEC).
- Stormwater Management Model (SWMM) - This method was developed by the United States EPA.

TABLE 3.1
APPROVED USES OF HYDROLOGIC METHODS

Design Application	Manual Chapter	Rational	NRCS	SWMM	HEC-HMS
Stormwater Conveyance Systems: • Closed Systems • Open Systems • Culverts <= 72" dia.	4	✓	✓	✓	
Stormwater Conveyance Systems: • Inlets and Gutters	4	✓	✓	✓	
Stormwater Conveyance Systems: • Bridges • Culverts > 72" dia.	4		✓	✓	✓
SCM Design	5		✓	✓	
Erosion Controls	8	✓	✓		
Flood Studies	9		✓	✓	✓

Many software programs use the methods listed above. Software that uses those methods without alteration are approved for hydrology calculations. Some examples of software approved for hydrologic analysis are listed below in alphabetical order:

- CivilStorm
- EPA SWMM
- HEC-HMS
- Hydraflow
- HydroCAD
- Hydrology Studio
- InfoDrainage
- Infoworks ICM
- PC SWMM
- PondPack
- Stormwater Studio
- WinTR-20

- WinTR-55
- XP SWMM

Approved methods for flood studies can be found in Chapter 9 of this Manual, “Floodplain Management”.

3.3.5 Methods Not Allowed

The following hydrologic design methods are not allowed for hydrologic analysis unless specifically noted elsewhere in this Manual:

- Chainsaw Routing Method
- Modified Rational Method
- Simple Method for Runoff Volume

3.4. Rainfall Data

While traditionally NOAA Atlas 14 has been used for Rainfall-Intensity-Duration data, several projects were underway to update or replace NOAA Atlas 14 at the time of this Manual’s adoption. To keep pace with advances in the science and engineering around current and future rainfall data, the City will post effective rainfall data on the City’s stormwater website. The website will list the effective date for each rainfall data update. Projects must use the Rainfall-Intensity-Duration data effective at the time of the project’s first submittal.

3.5 Land Cover and Infiltration Characteristics

Sections 3.5.3 and 3.5.4., below, give additional detail on the Rational and NRCS methods. This does not preclude the use of other methods shown as approved in Section 3.3., above.

3.5.1 Antecedent Moisture Conditions

Average antecedent soil moisture conditions shall be used for all hydrologic analysis.

3.5.2 Land Use/Land Cover

All stormwater modeling must be designed based on fully developed (future) land use conditions or existing land use, whichever generates the higher stormwater runoff rate.

Approved sources for future land use are:

- The current City of Raleigh Zoning Map
- The current Future Land Use Maps or Zoning Maps for adjacent jurisdictions when those areas are part of the drainage area to the analysis point.

Values for Rational C and NRCS CN that align with Raleigh’s zoning districts are included in the tables below.

Regardless of method chosen, the development of inputs related to land cover and infiltration characteristics shall be shown in the SCR. For example, if the NRCS Method is used, the calculation of the composite CN value will be shown for each drainage area, including the hydrologic soil groups, land cover category, and condition.

3.5.3 Rational Method Runoff Coefficient (C)

If the Rational Method is selected, the Runoff Coefficient will be calculated based on the C values found in Table 3.2, below. These are adapted from the 2013 update to the FHWA Hydraulic Engineering Circular No. 22, otherwise known as HEC-22 *Urban Drainage Design Manual*.

TABLE 3.2
RATIONAL METHOD COEFFICIENTS

Description Of Area	Runoff Coefficient (C)
Impervious Areas (BUA):	
Compacted Gravel Areas	0.95
Drives, Walks, and Roofs	0.95
Asphalt and Concrete	0.95 to 1.00
Woodlands	0.25
Playgrounds	0.35
Lawns:	
Sandy Soil, Flat, 2%	0.10
Sandy Soil, Average, 2 – 7%	0.15
Sandy Soil, Steep, >7%	0.20
Clay Soil, Flat, 2%	0.17
Clay Soil, Average, 2 – 7%	0.22
Clay Soil, Steep, >7%	0.35
Graded or No Plant Cover (Including during construction):	
Sandy Soil, Flat, 0 – 5%	0.30
Sandy Soil, Average, >5 and <10%	0.40
Clay Soil, Flat, 0 – 5%	0.50
Clay Soil, Average, >5 and <10%	0.60
Zoning:	
Single-Family (R – 1) and (R – 2)	0.40
Single-Family (R – 4)	0.55
Single-Family (R – 6)	0.75
Multi-family (R – 10)	0.75
Residential Mixed Use (RX-)	0.85
Office Park (OP-)	0.90
Office Mixed Use (OX-)	0.90

Neighborhood Mixed Use (NX-)	0.95
Commercial Mixed Use (CX-)	0.95
Downtown Mixed Use (DX-)	0.95
Industrial Mixed Use (IX-)	0.80
Conservation Management (CM)	0.15
Agriculture Productive (AP)	0.30
Heavy Industrial (IH)	0.90
Manufactured Housing (MH)	0.75
Campus (CMP)	0.60
Planned Development (PD)	Custom number based on actual impervious area

3.5.4. NRCS Curve Number (CN)

The NRCS method uses a combination of soil conditions and land use (groundcover) to assign a stormwater runoff factor to an area. These runoff factors, CN, indicate the stormwater runoff potential of an area.

CN values shall be based on NRCS Technical Release 55 (TR-55), *Urban Hydrology for Small Watersheds* publication, Table 2-2.

Typically, the most recent version of the Web Soil Survey Map is used to determine the hydrologic soil group (HSG). Soils assigned to a dual hydrologic group (A/D, B/D or C/D) shall be considered to be in the least infiltrative soil group. Alternatively, a site-specific geotechnical or soil survey may be used to determine the hydrologic soil group classification, using the least-permeable soil layer within six inches of the surface to determine the HSG. A legible map, clearly delineating and labeling the site boundary and soil types, shall be provided to substantiate the chosen classification.

If the site is making use of disconnected impervious area as a stormwater runoff reduction strategy, the “Urban impervious area modifications” described in TR-55, pages 2-9 and 2-10, may be used. Designers must demonstrate that the impervious area would remain disconnected, either through use of the Disconnected Impervious Surface SCM or by demonstrating there is no potential for connecting the impervious area in the future.

TABLE 3.3 NRCS CURVE NUMBERS (CN) FOR FUTURE CONDITIONS	
Raleigh Zoning District	**Equivalent TR-55 Land Cover Description**
R-1	Residential districts by average lot size – 1 acre
R-2	Residential districts by average lot size – 1/2 acre
R-4	Residential districts by average lot size – ¼ acre
R-6	Residential districts by average lot size – 1/8 acre
R-10	Residential districts by average lot size – 1/8 acre
Residential Mixed Use (RX-)	Residential districts by average lot size – 1/8 acre
Office Park (OP-) and Office Mixed Use (OX-)	Commercial and business
Neighborhood Mixed Use (NX-)	Commercial and business
Commercial Mixed Use (CX-)	Commercial and business
Downtown Mixed Use (DX-)	Commercial and business
Industrial Mixed Use (IX-)	Industrial
Conservation Management (CM)	Open space
Agriculture Productive (AP)	Other agricultural lands
Heavy Industrial (IH)	Industrial
Manufactured Housing (MH)	Residential districts by average lot size – 1/8 acre
Campus (CMP)	Residential districts by average lot size – 1/8 acre
Planned Development	Custom number based on actual impervious area

3.6 Time of Concentration

The time of concentration (Tc) is a concept used in hydrology to measure the response of a watershed to a storm event based on the 2-year, 24-hour precipitation value. It is defined as the time needed for water to flow from the most hydraulically distant point in a watershed to the watershed outlet. Time of concentration is a function of topography, soil properties, and land use within the watershed and varies depending on these factors. Time of concentration is only applied to surface runoff and shall be no less than 5 minutes for hydrologic analysis.

This Manual follows the standard set by NCDOT and requires the NRCS method.

3.6.1 NRCS Method

The NRCS Method of time of concentration is an approved method to use for either the Rational Method or the NRCS Unit Hydrograph Method. For sheet flow, maximum lengths are limited to 100 feet in forested or meadow conditions and 50 feet in developed areas, after which sheet flow becomes concentrated flow. These maximum lengths may need to be shortened if steep slopes or other land cover conditions that would result in a flow depth of greater than 0.1 foot are present. Shallow concentrated flow follows the sheet flow condition. The travel time for shallow concentrated flow is based on a velocity to slope relationship based on land cover type. Open channel flow is assumed to begin where flow enters a roadway gutter pan, an open

channel, or an USGS blue-lined stream. Additionally, flow within pipes and culverts not under pressure is considered to be closed channel flow. Manning's n values for use in this method are found in TR-55.

3.7 Peak Flow Development

Information is provided below on the two most common methods used for peak flow development. This does not preclude use of the other approved methods in Section 3.3 of this Manual.

3.7.1 Rational Method

The Rational Method estimates the peak rate of runoff at any location in a watershed as a function of the drainage area, runoff coefficient, frequency factor, and mean rainfall intensity for a duration equal to the time of concentration.

The Rational Method is expressed as follows:

[EQ 3.1] $Q = C \times i \times A$

Where,

Q = maximum rate of runoff (cfs)

C = runoff coefficient representing a ratio of runoff to rainfall

i = average rainfall intensity for a duration equal to the time of concentration or calculated travel time (in/hr)

A = drainage area contributing to the design point location (ac)

3.7.2 NRCS Unit Hydrograph Method

The NRCS hydrologic method requires data such as drainage area, runoff factor, time of concentration, and rainfall. The NRCS approach also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during a storm event. Details of the methodology can be found in TR-55 and the NRCS National Engineering Handbook, Section 4.

CHAPTER 4
STORMWATER CONVEYANCE DESIGN

TABLE OF CONTENTS

4.1 INTRODUCTION

The stormwater conveyance system encompasses pipes, culverts, bridges, structures, gutters, and constructed channels conveying runoff from public and private lands. Note that roof drainage and building foundation drainage systems are considered building systems until they are connected to a structure (i.e. manhole, junction, inlet) or channel (gutter, swale, ditch) that is part of the stormwater conveyance system. Building systems are subject to building codes, not this Manual.

For guidance related to specific hydraulic design and calculations, please refer to the most recent version of the NCDOT manual "*Guidelines for Drainage Studies and Hydraulic Design*" and the FHWA manuals "*Hydraulic Design of Highway Culverts-HDS 05*" and *"HEC-22 Urban Drainage Design Manual"*. Where discrepancies exist among the manuals, this Manual shall govern.

4.2 REQUIREMENTS FOR ALL STORMWATER CONVEYANCE

4.2.1 Overland Flow Path Required

While stormwater conveyance systems do not need to convey the 100-year storm, an overland flow path shall be provided for the 100-year storm. This means that all sites shall be designed so that no building floods, or has water impounded against it during the 100-year storm event.

If the water surface is altered on parcels that are not part of the development project, the 100-year storm ponding elevations and areas shall be shown and labeled on the preliminary or permitting submittal, whichever occurs first.

4.2.2 Gravity Design Required

All stormwater conveyances must flow by gravity. No pumping will be allowed for any stormwater system on public or private property except as allowed in Section 6.3.1 of this Manual.

4.2.3 Flow Leaving the Site

For sites greater than 1 acre used for one or two unit dwellings or greater than 0.5 acre for all other uses, flow from the development site that has been newly concentrated into pipes or swales shall leave the site in one of the following methods:

- Approved discharge to a jurisdictional stream or stream buffer.
- Connection to the ROW
- Discharge to an existing or proposed public or private drainage easement

4.2.3 Existing Systems

Existing stormwater conveyance systems on the site or in the half of City ROW adjacent to the

property (and parallel to the lanes) shall be analyzed with any Tier 3 site plan. Stormwater conveyance systems that do not meet the requirements of this chapter for capacity or condition as identified by the project's visual pipe inspection (on site) or by the City (in City ROW) shall be replaced or improved to meet the criteria.

4.2.4 Location Relative to Buildings and Other Structures

Stormwater conveyance systems shall not be placed under or within 10 feet of any permanent structure or associated foundation, including retaining walls. Additionally, buildings are not allowed within drainage easements, as defined in Chapter 7 of this Manual. The only stormwater conveyance system that may be placed under or within a building is the discharge from a SCM and it must follow the requirements for SCMs, which can be found in Section 6.3.4.of this Manual.

4.2.5 Public Versus Private Infrastructure

Structures and pipes sized 15 inches and greater located within the ROW are considered publicly-maintained stormwater infrastructure; this excludes driveway culverts, which are private. Structures and pipes located within a parcel are maintained by the parcel owner unless a drainage easement indicates otherwise. See Chapter 7 of this Manual for drainage easement requirements.

4.2.6 Decreased Capacity Downstream

If a proposed stormwater conveyance system has a higher capacity than the offsite stormwater conveyance system component immediately downstream, the applicable SCR must contain the following information:

- Narrative description of why this design is necessary and what special maintenance will be required.
- Map identifying locations where new surcharging will occur.
- Analysis of the impacts of the surcharging, including delineation of flow paths and identification of any buildings to be impacted between the site and the next floodplain studied by FEMA or the City.

4.2.7 Flow into the ROW

Flow from pipes, swales, or gutters in excess of 3 cfs shall not flow from a parcel onto a sidewalk, multi-use path, greenway, or street.

Flow from any piped stormwater conveyance system, building drainage system, or landscape drain shall not be discharged directly onto sidewalks. Conveyance under the sidewalk is required.

4.2.8 Connecting to Conveyance System in City ROW

Connecting a private stormwater conveyance system to a stormwater conveyance system in the City ROW requires a Stormwater Conveyance System permit. This can be obtained under a building permit or site permit case type, whichever applies. A modified version of the as-built process will be required as described in Section 4.7 of this Manual.

Connections to storm structures (e.g. inlets, manholes) and to the gutter through the curb shall be performed in accordance with City of Raleigh details.

4.2.9 Easements

See Chapter 7 of this Manual, “Easements”.

4.3 SIZING CRITERIA

4.3.1 Closed Conveyance Systems Sizing Criteria

Closed stormwater conveyance systems, designed for either public or private projects, shall be sized based upon the criteria listed in Table 4.1, below.

TABLE 4.1
SIZING CRITERIA FOR CLOSED STORMWATER CONVEYANCE SYSTEMS

DRAINAGE AREA	DESIGN STORM	DESIGN CRITERIA
≤ 25 acres	10-year 25-year	HGL for the entire system is to be at or below the crown of all pipes. HGL shall not exceed the top of inlet structures or gutter elevations.
> 25 acres	25-year 100-year	HGL for the entire system is to be at or below the crown of all pipes. Outside the ROW, inundation does not exceed the limits of the drainage easement.

HGL calculations shall consider all head losses, friction factors, and bypass flows. The downstream HGL at the outlet end of the stormwater conveyance system shall begin at a known water surface elevation or at the downstream crown of pipe, whichever is greater.

HGL calculations shall be provided in the SCR at building or site permitting submittal, whichever comes first. Include the following data in the report:

- Drainage area maps.
- Profiles showing HGLs.
- Calculation tables listing the input and output values.

4.3.2 Open Channel Conveyance Systems Sizing Criteria

For purposes of this Manual, open channel conveyance systems refer to ditches, swales, and other constructed channels used as part of the overall stormwater conveyance system. These requirements do not apply to jurisdictional streams.

Open channel conveyance systems shall be sized based upon the criteria listed in Table 4.2., below.

TABLE 4.2
SIZING CRITERIA OPEN CHANNEL CONVEYANCE SYSTEMS

DRAINAGE AREA	DESIGN STORM	DESIGN CRITERIA
< 25 acres	10-year 25-year	Water surface elevation for the entire system is at or below top of banks. Outside the ROW, inundation does not exceed the limits of the drainage easement.
≥ 25 acres	25-year 100-year	Water surface elevation for the entire system is at or below top of banks. Outside the ROW, inundation does not exceed the limits of the drainage easement.

The channel design calculations shall be included in the SCR at the building or site permitting submittal, whichever comes first. Include the following data in the report:

- Drainage area maps.
- Calculations showing inputs and outputs.

See Section 4.5.2 of this Manual regarding channel lining.

4.3.3 Bridge And Culvert Sizing Criteria

Bridges and culverts shall be sized based upon the criteria listed in Table 4.3., below, and the following criteria.

- All bridges and culverts shall be designed so that no building, either proposed or existing, floods or has water impounded against it during the 100-year storm event, unless the building structure is a properly permitted, floodproofed, non-residential structure as provided in UDO Section 9.3.5.B.2.
- For road crossings serving 10 acres or more, the maximum depth of the water impounded during the 100-year storm event must not exceed 15 feet, as measured from the upstream invert of the culvert to the water surface elevation. Should the maximum depth be exceeded, a Design Exception shall be submitted along with engineering calculations that verify the stability of the embankment against slope failure and seepage effects.

- Bridges 25 feet or less in span along the centerline of the structure will require approval by the City's Transportation Director.
- Timber elements of substructures and superstructures will not be eligible for City acceptance.
- For culverts in an existing or proposed City ROW, culverts that span 18 feet shall be upsized to exceed 20 feet to meet the requirements of Federally-Qualifying Culverts per the Code of Federal Regulation 23 CFR 650.31. The spacing between barrels must not exceed half the diameter of the barrel of the culverts.
- The requirements in UDO Sections 9.3.8 and 9.3.9 shall be met in addition to the criteria in this Manual.

TABLE 4.3
FREEBOARD CRITERIA FOR CULVERTS AND BRIDGES

SYSTEM	DESIGN STORM	DESIGN CRITERIA
Road crossings with drainage area ≤ 25 ac	25-yr 100-yr	12 in to top of road[1] with HW/D ≤ 1.2 or 12 in from the low chord.[2] Outside the ROW, no increase in inundation shall occur outside the limits of the drainage easement.
Road crossings with drainage area > 25 ac	50-yr 100-yr	24 in to top of road[1] with HW/D ≤ 1.2 or 12 in from the low chord.[2] Outside the ROW, no increase in inundation shall occur outside the limits of the drainage easement.
Road crossings over regulated floodways	100-yr 100-yr	24 in to top of road[1] with HW/D ≤ 1.2 or 24 in from the low chord.[2] No project proposing expansion of the floodplain shall be approved without approved floodplain map revisions.

[1]Culvert Freeboard is measured from the top of the road and is defined as the lowest adjacent point where roadway overtopping would occur.
[2]Bridge freeboard is measured from the low chord, which is the bottom of the bridge structure that defines the waterway opening.

For guidance related to Bridges and Culverts, please design per the most recent version of NCDOT manual *Guidelines for Drainage Studies and Hydraulic Design* and the FHWA Hydraulic Design Series Number 7, *Hydraulic Design of Safe Bridges.* Where discrepancies exist among the manuals, this Manual shall govern.

4.3.4 Inlet And Gutter Sizing Criteria

Inlets and gutters shall be designed based on Table 4.4., below. These requirements apply to roads and driveways located as follows:

- In the ROW
- In a public drainage easement
- On a City-owned parcel

TABLE 4.4
INLET AND GUTTER SIZING CRITERIA

TOPIC	DESIGN CRITERIA
Design storm	• 10-year storm.
Maximum spread	• Half the width of one travel lane on two- or three-lane streets and one-lane width on wider streets. • When the typical section includes a full shoulder (four feet or greater), parking lane, or bike lane, no encroachment into the travel lane will be allowed.
Additional Inlet locations	• Sags* • Upgrade of intersections, including intersection of a non-residential driveway or private road with a public road. • Upgrade of superelevation crossovers. • Any location where more than 3 cfs will reach a ROW from a private site during the 10-year storm.
	•
Inlet blockage	• Inlets shall be designed assuming 50% blockage for locations where grate inlets are required. In combination inlets, only the grate portion must be shown as 50% blockage.

*In sag areas where relief by curb overflow is not provided, inlet capacity shall be designed for:

- One dry eight-foot travel lane in the 25-year event on two- or three-lane streets.
- Two dry eight-foot travel lanes (one in each direction) in the 50-year event on four-lane or more streets.

Gutter spread calculations shall be provided for all proposed public and private streets with such calculations to be included in the SCR for the building or site permitting submittal, whichever is submitted first. Gutter spread calculations shall include the following:

- All flow rates in cfs to the nearest hundredth.
- Calculation table(s) listing the input and output values.

- Tables shall include structure number, bypass structure, spread, allowable spread, and a column indicating whether spread requirements were met.

4.3.5 Maximum Ponding Depth

The following requirements about maximum ponding depth apply to the ROW and to parcels.

- Yard Inlets: Ponding at yard inlets outside the ROW shall be limited to a maximum of one foot above an inlet elevation for the 10-year storm. No water may be ponded against structures and no structures shall be flooded as a result. Ponding shall not extend into the ROW.
- Fire Lanes: Ponding in fire lanes shall not exceed 7 inches depth at the 10-year storm. This requirement is assumed to be met in areas with a 6 inch curb that allows overtopping. In situations where flow could not overtop the curb, calculations will be required.

4.4 STORMWATER PIPES

This section applies to stormwater conveyance pipes located:

- Fully and partially within City ROW.
- Downstream of City or NCDOT ROW, when the pipes convey public roadway runoff.

The requirements in this Section apply to pipes that are part of closed conveyance systems and to culverts.

For pipes located within NCDOT ROW, NCDOT details and specifications shall apply.

4.4.1 Overall Criteria

TABLE 4.5 OVERALL STORMWATER PIPE CRITERIA	
TOPIC	**DESIGN CRITERIA**
Diameter	• Minimum of 15 in. • See material-specific sections of the Manual for maximum diameter.
Cover	• Minimum cover is 2 feet from the outside wall of the pipe to grade unless manufacturer's specifications require additional cover. • See material-specific sections of the Manual for maximum cover.
Slope	• Minimum slope is 0.5%. • Maximum slope is 10%.
Installation Trench Width	• Pipe outside diameter plus 3 feet, unless otherwise specified in City Standard Details.
Tie-Ins	• All tie-ins of pipe must occur at a structure. No "break-ins" or taps to pipes allowed.
Bedding details	• See material-specific sections of the Manual.
Joint type	• See material-specific sections of the Manual.
Approved pipe materials:	• Reinforced concrete pipe (RCP). • Double wall Polypropylene (PP). • Double wall high-density polyethylene (HDPE).

All pipes shall be supplied by a manufacturer of the subject pipe material that is listed on the NCDOT Approved Producer/Supplier List.

4.4.2 Reinforced Concrete Pipe (RCP)

RCP may be installed in the City ROW, in City public drainage easements, and on private property.

- Pipe shall be installed per a City standard detail.
- Pipe shall be manufactured to meet ASTM C76 and shall be installed per ASTM C1479.
- Unless otherwise specified in this Manual or in City Standard Details, all RCP shall be Class III or greater. Greater pipe strength class and maximum cover requirements shall

be based on the Indirect Design Method as found in Section 12 of the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specification.

- Unless otherwise specified in this Manual or in City Standard Details, all joints shall use a single offset joint that consists of a non-circular rubber (profile type) gasket.
    - In lieu of non-circular rubber (profile type) gasket, butyl sealant may be used with either tongue and groove pipe or single offset joint pipe provided each joint utilizing butyl sealant must be wrapped with a 3-foot strip of filter fabric centered on the joint, with minimum 18” overlap. Filter fabric shall conform to Type 4 requirements in Section 1056 of the NCDOT Standard Specifications.
    - Confined groove o-ring gasket pipe utilizing rubber or neoprene o-ring gaskets, can be used in lieu of all other joint types with no additional approval if specified in the plans.
    - All joints and gaskets shall conform to the requirements of ASTM C1628.
- Locations where pipe material changes shall require a structure that meets the standards of Table 4.6, except for repairs of existing stormwater conveyance systems. For repairs of existing stormwater conveyance systems, any transition of RCP to PP or HDPE shall have a dissimilar materials adapter (ASTM C877 Type II Band) incorporating a geotextile coupler with mastic coating and stainless-steel straps.
- Stormwater conveyance pipes must be specified to meet the following requirements:
    - Adhere to AASHTO R-73 for acceptance of pipe at time of delivery and until backfill is placed.
    - Concrete pipe, when delivered to the job site, shall have cured and reached the design strength as required by ASTM C76 for non-pressurized pipe or ASTM C507 for Elliptical Pipe and at least seventy-two (72) hours shall have elapsed since time of manufacture.
    - Acceptance of the pipe at point of delivery shall not relieve the contractor of full responsibility for any defects in materials due to workmanship.
- Lifting holes: one lifting hole per pipe length will be allowed for stormwater pipes. Lifting holes must be facing up, not sideways or down. Lifting holes must be filled in one of the following ways:
    - Fully grouted using a non-shrink grout after installation and before backfilling the pipe.
    - Filled with a lifting-hole-specific cap.

4.4.3 Polypropylene

Polypropylene (PP) may be used for stormwater conveyance pipes to be installed within private property and in City ROW for “Local” streets, “Sensitive Area Residential Street” and “Alley,

Residential" streets as each is defined in the City of Raleigh "Street Design Manual", provided the stormwater conveyance pipes are installed according to all of the following requirements:

- Pipe shall be double wall with a smooth interior pipe (Type S) and shall conform to AASHTO M330 or ASTM F2881.
- Maximum pipe diameter is 48 inches.
- Maximum cover is 20 feet.
- Double Gasketed Bell and spigot joints with O-ring gasket (on spigot end) shall be installed on all pipes. Bells shall cover two full corrugations on each section of pipe. Gaskets shall conform to ASTM F477. Joint performance shall meet the watertight joint performance requirements of ASTM D3212.
- PP shall be backfilled per City standard details.
- Locations where pipe materials change shall require a structure that meets the standards of Table 4.6, except for repairs of existing stormwater conveyance systems. For repairs of existing stormwater conveyance systems, any transition of PP to RCP shall have a dissimilar materials adapter (ASTM C877 Type II band) incorporating a geotextile coupler with mastic coating and stainless-steel straps.
- Connections to structures shall be made with a resilient watertight connector. Resilient connectors shall meet ASTM C923, ASTM C1478, and ASTM F2510. In situations where resilient watertight connectors will not work, non-shrink grout shall be used at the structure interface in conjunction with bituminous coating or other approved adhesive then wrapped with 4-oz geotextile fabric on the exterior connection of the structure. Filter fabric and coating must extend for a minimum length of 12-inches along the pipe and 12-inches up the structure wall.
- Mandrel testing or laser profiling results shall be submitted with the Inspection Submittal per Section 4.7.4, below.

4.4.4 High Density Polyethylene

Double Wall High-Density Polyethylene (HDPE) may be used for stormwater conveyance pipes to be installed on parcels, provided the stormwater conveyance pipes are installed according to all of the following requirements:

- Corrugated exterior/smooth interior pipe (type S) shall conform to AASHTO M294.
- Maximum pipe diameter is 48 inches.
- Maximum cover is 17 feet.
- Bell and spigot joints with O-ring gasket (on spigot end) shall be installed. Bells shall cover two full corrugations on each section of pipe. Gaskets shall conform to ASTM F477. Joint performance shall meet the watertight joint performance requirements of ASTM D3212.

- Installation trench minimum width shall be per City details..
- HDPE shall be backfilled with six inches of #57 stone bedding under the pipe and to the top of pipe. Nonwoven Geotextile fabric six (6) ounces or greater shall be used to separate the #57 stone from the remaining backfill. Remaining backfill shall be installed in accordance with City standard details.
- Locations where pipe materials change shall require a structure that meets the standards of Table 4.6, except for repairs of existing stormwater conveyance systems. For repairs of existing stormwater conveyance systems, any transition of HDPE to RCP shall have a dissimilar materials adapter (ASTM C877 Type II band) incorporating a geotextile coupler with mastic coating and stainless-steel straps.
- Mandrel testing or laser profiling results shall be submitted with the Inspection Submittal per Section 4.7.4, below.

4.5 OPEN CHANNELS AND ENERGY DISSIPATION

Open channel conveyance systems shall be designed per UDO Section 9.4.4.G, unless otherwise specified below.

4.5.1 Channel Configuration

The maximum allowable side slopes for vegetated conveyance shall be 3H:1V with a minimum longitudinal slope of 1%.

4.5.2 Channel Lining

Channel lining shall be determined per UDO Section 9.4.4.G.2.

Vegetated conveyances shall be sodded, not seeded (fully stabilized before operational with permanent stabilization).

A table with channel segment, slope, drainage area, proposed velocity, proposed discharge, channel lining, and maximum channel lining velocity shall be provided either on the plans or in the SCR.

4.5.3 Energy Dissipation At Pipe Outlets

Energy dissipation calculations shall be provided with the preliminary or permitting submittal, whichever occurs first. The following outlet protection and energy dissipators are approved:

- Plunge pools.
- Riprap apron.
- Baffled outlets.

Calculations shall be in accordance with the NCDEQ *"Erosion and Sediment Control Planning and Design Manual"* or the FHWA manual, *"Hydraulic Engineering Circular No. 14 Hec-14: Hydraulic Design of Energy Dissipators for Culverts and Channels"*.

4.6 DRAINAGE STRUCTURES

NCDOT or City standard structures shall be used for all City of Raleigh streets. Other details will be allowed if they meet the minimum design criteria for all structures, as listed below, and have been sealed by a North Carolina licensed structural engineer.

4.6.1 Minimum Criteria for Drainage Structures

The following criteria apply to enclosed drainage structures, including manholes, junctions, inlets, and catch basins.

TABLE 4.6
DRAINAGE STRUCTURE DESIGN CRITERIA

TOPIC	DESIGN CRITERIA
Access	• All drainage structures shall allow for access to the stormwater conveyance system with a grate, manhole cover, or a lid. • The lid must be capable of being removed for immediate maintenance concerns (capable of being removed manually). • Access opening must be a minimum of 2' in diameter.
Interior dimensions	For the area below the access opening, extending to the structure invert: • Minimum dimension is 2.5 feet in any direction. • For drainage structures less than 4 feet deep, the minimum area is 6 square feet. • For drainage structures greater than or equal to 4 feet in depth and less than 12 feet deep, the minimum area is 12 square feet. • For drainage structures greater than or equal to12- feet in depth and less than 20-feet in depth, the minimum area is 18 square feet. • For drainage structures greater than or equal to 20-feet in depth, the minimum area is 25 square feet.
Invert drop	• Minimum invert drop at drainage structures is 0.5% slope or 0.1 feet, whichever is greater. • Minimum invert drop at drainage structures for pipe size increases is based on matching crown elevations.
Labeling	• All drainage structures shall be labeled with the following language or its approved equivalent: "Dump No Waste. Drains to River."
Loading	• Drainage structures and access lids must withstand HL-93 loading.
Location	• For stormwater conveyance pipe systems with a 48-inch pipe (or equivalent cross-sectional area) or larger, there must be a maximum spacing of 300 feet. • For stormwater conveyance pipe systems with an equivalent size of less than a 48-inch pipe, there must be a maximum spacing of 250 feet. • A drainage structure shall be provided wherever there is a change in

	pipe size, pipe material, pipe slope, or flow direction within a stormwater conveyance network. This requirement does not apply to pipe sections used as underground storage SCMs. For SCM access locations, see Chapter 6 of this Manual. • Inlets shall not be located in driveways with valley curbs.
Pipe angles	• Any change in pipe direction which results in an angle less than 90° between the inflow and outflow pipe will require a detailed study and a drop equal to or greater than the diameter of the pipe out.
Steps	• Required for all structures deeper than 3'-6". • Steps must be positioned such that they can be used by personnel to access the structure.

4.6.2 End Treatments

End treatment is required for all stormwater conveyance pipes.

- Flared End Sections shall be placed on stormwater conveyance pipes smaller than 36 inches. These must be reinforced concrete. No polypropylene or HDPE end treatments are allowed.
- Cast-in-place or pre-cast concrete headwalls and endwalls are required for all stormwater conveyance pipe system outfalls 36 inches or larger.

End treatments shall be designed in accordance with NCDOT standards and design details except when those standards conflict with the above criteria in this Section 4.6.2 of the Manual.

4.7 STORMWATER CONVEYANCE SYSTEM PERMITTING AND CERTIFICATIONS

4.7.1 Permit Applicability

A Stormwater Conveyance System permit is required for the construction, reconstruction, replacement, extension, renovation, alteration, demolition, or abandonment of stormwater conveyance systems that meet at least one of the following:

- Is located in the ROW.
- Is located on public or private property and is greater than or equal to 12 inches in diameter.
- Is located on public or private property and conveys public runoff.

The following situations do not require a Stormwater Conveyance System permit:

- A stormwater conveyance system private pipe less than 12 inches in diameter that is outside of ROW and does not connect to ROW.

- Repairing or replacing in-kind private pipes that do not convey public runoff. This applies only when the hydraulic performance is not altered – e.g. the same pipe size and pipe material are used. (Note that other permitting may be required, such as buffer or land disturbance permitting.)

4.7.2 Permitting Submittal

4.7.2.1 Calculations

Calculations, as described in multiple sections of this Chapter, must be submitted for new stormwater conveyance pipes (including replacements) and repairs, if the pipe installation or repair will alter hydraulic performance.

Calculations are not needed for private pipes less than 12 inches in diameter connecting to the public system.

4.7.2.2 Electronic File

Projects requiring a Stormwater Conveyance System permit will be required to submit an electronic CAD file of the approved stormwater conveyance system in a format specified in the plan review checklist prior to permit issuance.

4.7.3 As-built Submittal

4.7.3.1 As-built Applicability

As-built submittals are required for new, repaired, abandoned, or replaced pipes >= 12 inches diameter.

4.7.3.2 As-built Submittal Requirements

As-built documentation, and certification for both public and private stormwater conveyance systems, must be submitted to Raleigh Stormwater. At a minimum the following items shall be included/documented with the as-built submittal:

- *Stormwater Conveyance As-Built Submittal Checklist* – A completed copy of this checklist including the signed and sealed statement provided by a qualified North Carolina licensed PE or RLA which certifies that the as-built stormwater infrastructure (both public and private) complies with the approved plans and meets all UDO requirements.
- *As-Built Drawings* – A certified set of as-built drawings that redline the approved storm drainage plans. These drawings shall be signed and sealed by a North Carolina licensed PE or RLA, for stormwater infrastructure only.
- *As-Built Survey Documents*
    - As-Built Survey – A certified post construction as-built survey, signed and sealed by a North Carolina Professional Land Surveyor (NCPLS), for stormwater infrastructure only.

  - Survey File – An electronic file of the NCPLS-certified post-construction as-built survey in format specified in the *Stormwater Conveyance As-Built Submittal Checklist* for stormwater infrastructure only.
  - Survey Point File – A file of the NCPLS-certified post construction as-built survey in the format specified on the *Stormwater Conveyance As-Built Submittal Checklist* for stormwater infrastructure only.
  - All recorded public or private drainage easements properly labeled and provided as polygons in the format specified on the *Stormwater Conveyance As-Built Submittal Checklist*.
- *Recorded Map(s)* – Copies of the recorded map(s) depicting required drainage easements.
- *Deed(s) of Easement* – Copies of the recorded easement instrument(s) for required drainage easements.

4.7.4 Inspection

4.7.4.1 Inspection Applicability

The following table states the inspection applicability:

TABLE 4.7 INSPECTION APPLICABILITY				
	INSPECTION TYPE			
	CCTV	**Mandrel or Laser Profiling**	**NBIS**	**Still Photo of Connection**
New pipes in City ROW or conveying public runoff >= 12” diameter	**YES**	**If PP or HDPE**	**If >= 72”**	NO
Repair of pipe >=12” in City ROW or conveying public runoff	**YES**	**If PP or HDPE**	**If >= 72”**	NO
Driveway culverts in ROW	NO	NO	NO	NO
New private pipes *not* conveying public runoff that are less than 20 feet in length	NO	NO	NO	NO
Pipes <12” connecting to City stormwater conveyance system in City ROW	NO	NO	NO	**YES**

4.7.4.2 Required Inspections

A. Stormwater conveyance pipes must be clear of sediment and debris as verified by City staff.

B. CCTV Inspection

- CCTV inspection shall be performed in accordance with the latest testing

requirements set forth by the National Association of Sewer Service Companies (NASSCO) Pipeline Assessment & Certification Program (PACP).

C. Mandrel Testing for flexible pipe (PP and HDPE)
- The deflection test must be completed no sooner than 30 days after installation and backfill of flexible pipes.
- A 9-vane mandrel sized for 7.5% deflection must be used to complete the test.
- The mandrel shall be pulled by hand through the pipe sections.
- Full length laser profiling may be substituted for mandrel testing.

D. Bridge Inspection
- Applies to any infrastructure with openings 72 inches or greater in any direction.
- The bridge inspector shall be prequalified by NCDOT to perform municipal bridge inspections.
- Inspection shall be completed in compliance with the National Bridge Inspection Standards (NBIS).

4.7.4.3 Acceptance Standards

A. CCTV
- Pipes that have NASSCO PACP structural and O&M scores of 1 will be accepted.
- Pipes that have NASSCO PACP structural or O&M defects with a score of 2 or greater must submit a repair plan.

B. Mandrel Testing or Laser Profiling
- Pipes with deflection less than or equal to 7.5% will be accepted.
- Pipes with deflection of greater than 7.5% must be included in the repair plan for replacement.

C. Bridge Inspections
- Inspection shall be compliant with NBIS

4.7.4.4 Inspection Submittal Requirements

The inspection results must be submitted to and accepted by Raleigh Stormwater to verify there are no defects in the stormwater conveyance system in the ROW or on private parcels. The following items shall be included/documented with the pipe inspection submittal:

- Stormwater Conveyance Pipe Inspection Checklist, completed, signed and sealed by a qualified North Carolina-licensed PE.
- Repair plan when defects are present, signed and sealed by a qualified North Carolina-licensed PE.
- CCTV videos and reports, when applicable.
- Mandrel Test Report or Full-Length Laser Profiling for all Flexible Pipe, when applicable.
- North Carolina-licensed PE sealed NBIS-Compliant Bridge Inspection Report, when

applicable.

4.7.5 Summary

The stormwater conveyance system pipe inspection submittal and as-built documentation must be reviewed and accepted by the Raleigh Stormwater prior to:

- Issuance of a Certificate of Occupancy/Certificate of Compliance.
- Final approval of the Stormwater Conveyance System permit inspection.
- Project Closeout and Certificate of Completion.

Raleigh Stormwater's acceptance of the stormwater conveyance system pipe inspection and as-built certifications does not constitute acceptance of the system for maintenance by the City, unless the stormwater conveyance system is one the City has had constructed and is located within City-maintained ROW or City-held public drainage easements. When the stormwater conveyance system is located on private property it is the responsibility of the property owner and/or property owner's association to maintain.

For maintenance purposes, stormwater conveyance systems within City-maintained ROW shall also be accepted by the City's Transportation Department.

Chapter 5

STORMWATER MANAGEMENT CALCULATIONS

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5.1 INTRODUCTION

This chapter provides additional information and requirements for compliance with the Full Stormwater Requirements contained in UDO Sections 9.2.2.B through 9.2.2.H. Additional information about compliance with the Exempt Property Requirements in UDO Section 9.2.2.A. can be found in Chapters 1 and 2 of this Manual.

The term Built Upon Area (BUA) as described in Article 9.2 of the UDO is synonymous with impervious area and will be used throughout this chapter.

5.2 RATE OF RUNOFF CONTROL REQUIREMENTS

Sites subject to active stormwater control measures as specified in UDO Section 9.2.2.E are required to meet runoff limitations and shall not have any increase in peak stormwater runoff leaving the site at each point of discharge between pre- and post-development conditions for the 2- and 10-year storm events unless meeting an exemption in UDO Section 9.2.2.E.2.

Note that additional runoff control measures may be required if:

- Runoff from a site could cause adverse impacts on other properties as provided in UDO Section 9.2.2.E.3.
- Rezoning has resulted in a specific zoning condition related to rate of runoff control.

Requirements for rate of runoff control calculations are found in Chapter 3 of this Manual, “Hydrology”, and in this chapter of the Manual. The same method of calculating peak stormwater runoff leaving the site must be used for pre-development (existing) and post-development (proposed) conditions.

SCMs, as detailed in Chapter 6 of this Manual, “Stormwater Control Measure (SCM) Design”, shall be implemented as needed to comply with the rate of runoff control requirements.

5.2.1 Defining the Regulated Area

The regulated site area includes:

- Entire parcel(s) area.
- Newly dedicated ROW.
- Existing ROW where BUA is added, or fee-in-lieu is paid (e.g. for sidewalks).
- Greenways - if a new greenway easement is being dedicated to the City, applicants shall account for greenway built upon area in their compliance calculations for the project.

The drainage areas to the points of analysis must incorporate the entire regulated area.

5.2.2 Points of analysis (POA)

For runoff rate control, selected points of analysis shall be located at each point where flow leaves the parcel being developed. This includes a separate POA for each tie-in to a pipe system, even if those pipe systems combine further downstream. Additionally:

- For added BUA in the ROW, flow will be analyzed either at the edge of the limits of disturbance or where flow leaves the existing ROW.
- For project sites with an on-site stream, a point of analysis shall be provided where concentrated runoff enters the stream. In this context, concentrated runoff shall be flow that has been concentrated into a stormwater conveyance system.

- For existing sheet flow conditions, the property line may be treated as the POA, but a separate drainage area must be delineated for flow to each adjacent property.

The physical locations and labels for points of analysis shall remain consistent between pre-development and post-development exhibits and associated calculations to show compliance with pre-development (existing) and post-development (proposed) runoff conditions. If the POA needs to be relocated due to a change in site conditions, the reason for that change shall be explained in the SCR narrative.

5.2.3 Additional Runoff Control Requirements

To determine if a project site is subject to additional runoff controls per UDO Section 9.2.2.E.3., contact a stormwater plan reviewer.

To demonstrate compliance with UDO Section 9.2.2.E.3.d, delineate the drainage area to the location of downstream flooding provided by the stormwater plan reviewer . Calculate the total drainage area to that downstream point. Next, calculate the acreage of the project site within the drainage area. Divide the acreage of the project site within the drainage area by the total drainage area to find the percentage of the drainage area composed of the project site.

For rezoning cases, applicants will be asked to provide a map showing the point at which the project site becomes less than 5% of the drainage area. The steps to develop this map are as follows:

i. Determine whether the project site drains to just one stream or stormwater conveyance system or if it drains to multiple streams or stormwater conveyance systems.
ii. If the project site drains to more than one stream or stormwater conveyance system, delineate the drainage divide between the streams on the project site.
iii. Calculate the acreage of those portions of the project site that drain to each stream.
iv. For Stream A, take the acreage of the project site that drains to Stream A and multiply it by 20.
v. Now, find the first point downstream of the project site where the drainage area is greater than or equal to 20 times the acreage from the site draining to Stream A. Sometimes the point may be immediately downstream of the site (e.g. when the site is adjacent to a large watercourse).
vi. Repeat steps iv and v for each stream.
vii. Submit a map that shows the project site and the drainage areas delineated.

Examples of the above procedure can be found on the City's stormwater website.

5.3 NITROGEN REDUCTION REQUIREMENTS

Sites subject to active stormwater control measures as specified in UDO Article 9.2 must meet nitrogen export targets that are tied to the Neuse Nutrient Strategy. The current version of these rules was adopted by the City effective May 1, 2023 and can be found in UDO Section 9.2.2.B. These rules are based on 15A NCAC 02B .0711, were drafted based on the Model Ordinance and Local Program Development Guide from NCDEQ, and were approved by the State of North Carolina prior to adoption by the City.

There are two methods of demonstrating compliance:

- Match Runoff Volume for the 90th percentile storm (1.34") as demonstrated through Storm-EZ or equivalent method.
- Meet the 3.6 lb/ac/yr target as demonstrated through the NCDEQ Stormwater Nitrogen and Phosphorus (SNAP) Tool.

For both methods, Sections 5.3.1 through 5.3.6 and 5.3.10, of this Manual, shall apply. For the Runoff Volume method requirements, Section 5.3.7 of this Manual also applies. To meet the 3.6 lb/ac/yr target through the SNAP tool, see also Sections 5.3.8 through 5.3.10 of this Manual.

5.3.1 Common Plan of Development

For the purposes of Nitrogen Reduction Rules compliance, 'Common Plan of Development' means a site where multiple separate and distinct development activities may be taking place at different times on different schedules but governed by a single development plan regardless of ownership of the parcels. Information that may be used to determine a 'Common Plan of Development' include plats, blueprints, marketing plans, contracts, building permits, public notices or hearings, zoning requests, and infrastructure development plans.

This definition is taken from Common Plan of Development Definition in 15A NCAC 02H .1002(8) and is included in UDO Section 9.2.1.F.2.

The following example situations fall under a 'Common Plan of Development':

- Projects submitted under one application to the City.
- Adjacent parcels (including those separated by ROW) that are managed as one project.

The following example situations do not fall under a 'Common Plan of Development' for the purpose of Nitrogen Reduction Rules compliance:

- Two residential lots sharing a driveway, when those lots are used for any detached house or tiny house used for single-unit living or any attached house, tiny house or two-unit townhouse development used for two- unit living, including accessory uses.

Please contact a stormwater plan reviewer if you are unclear about whether a project meets the definition of 'Common Plan of Development'.

5.3.2 Existing BUA

The treatment of existing BUA in the Nitrogen Reduction Rules varies based on the date the BUA was permitted and/or constructed. The timeframes of significance are addressed below.

5.3.2.1 **BUA placed or permitted before May 1, 2001**

Existing BUA that was in place before May 1, 2001 or was permitted before May 1, 2001:

- Will not be counted towards the percent BUA for the site, unless desired by the applicant.
- Will not be included as part of the project's regulated site area.

- Will not be required to be treated by a SCM.
- Will not require additional nutrient offset credit purchases.

Designers may use historic aerial photographs, which are available in iMaps, or sealed surveys to demonstrate that BUA was in place prior to May 1, 2001.

5.3.2.2 **Unpermitted BUA placed after May 1,2001**

If BUA was placed on or after May 1, 2001 but did not receive a stormwater control permit, it will be considered new BUA for the purposes of Nitrogen Reduction Rules compliance.

5.3.2.3 **BUA permitted under previous Nitrogen Reduction Rules (2001-2023)**

The previous Nitrogen Reduction Rules were in effect in the City of Raleigh from May 1, 2001 to April 30, 2023. The associated calculation requirements for the previous version of the rules can be found in the archived version of the City of Raleigh Stormwater Design Manual, dated 2002. BUA that was permitted under the previous rules was either permitted or submitted for permitting between May 1, 2001 and April 30, 2023.

Existing BUA permitted under the previous Nitrogen Reduction Rules (2001-2023):

- Will count towards the percent BUA for the site.
- Will be included in the project's regulated site area.
- Will not be required to provide additional SCM treatment beyond what was required at the time of permitting for this BUA.
- May require additional nutrient offset credit purchases based on the results of the nutrient analysis.

Designers have two options for showing the calculations for BUA permitted under the previous Nitrogen Reduction Rules. In either method, credit will be given for the previous nutrient offset credits associated with the parcel area and for the previously constructed SCMs.

- **Method A**: Put information in SNAP, recalculating with the new method.
- **Method B**: Use first generation calculation method for the existing BUA permitted 2001 and later, which requires recalculation because the pervious area decreases. If the drainage area to the existing SCMs is altered, the credit associated with the existing SCMs will need to be recalculated. Use SNAP for the new BUA. Show the overall compliance in a spreadsheet. See the City's website for an example spreadsheet documenting Method B.

5.3.2.4 BUA previously permitted under Nitrogen Reduction Rules effective May 1, 2023

Previously placed BUA that was permitted under the rules effective May 1, 2023:

- Will be counted towards the percent BUA,
- Will be included as part of the project's regulated site area.
- Will not be required to provide additional SCM treatment beyond what was required at the time of permitting,
- May require additional nutrient offset credit purchases.

Any BUA permitted under the rules effective May 1, 2023 must use the SNAP tool or Runoff Volume Match to demonstrate compliance.

5.3.3 Defining the Regulated Site Area

The site used for the nitrogen calculations may be different than the site as defined for runoff rate control. It is not necessary to separate the calculations by drainage area for nitrogen calculations. In the case of multi-phase subdivisions, the Nitrogen calculations must be separated for each phase or group of phases that will individually comply with the requirements.

The regulated site area includes:

- Entire parcel(s) area minus the BUA that was placed or permitted prior to May 1, 2001, as defined above. The removal of this BUA from the calculation in the 2023 Nitrogen Reduction Rules methodology replaces the previous apportioning method.
- Newly dedicated ROW
- Existing ROW where BUA is added or fee-in-lieu is paid (e.g. for sidewalks)
- Greenways - If a new greenway easement is being dedicated to the City, applicants shall account for greenway built upon area in their compliance calculations for the project.

These areas will be detailed in the City Nutrient Summary Sheets (The City Nutrient Summary Sheets are available in PDF form along with a contact for obtaining the Excel version.)

5.3.4 Determine Compliance Method

Each project must determine if the Nitrogen requirements will be met through Runoff Volume Match or by meeting the Nitrogen Target. See Table 5.1, below.

TABLE 5.1 COMPARISON OF NITROGEN COMPLIANCE METHODS		
	Runoff Volume Match	**Nitrogen Target**
Design Storm	1.34”	1”
Pre-Development Condition	Impervious = Impervious Pervious = Forest	Impervious = Impervious Pervious = Managed Pervious
Target Nitrogen Loading	NA	3.6 lb/ac/yr
Nutrient Offset Credit Threshold	NA – No nutrient offset credits allowed	If %BUA <= 24%, nutrient offset credits-only allowed. If %BUA >24%, primary SCM required before use of nutrient offset credits.
SCM Required	SCMs not automatically required but are typically needed to meet the standards of the Runoff Volume Match method.	If %BUA <= 24%, SCM is not required but may be used. If %BUA >24%, primary SCM required.
WQv to be Treated	No minimum threshold.	If %BUA >24%, primary SCM required to treat 100% of WQv associated with the new BUA.
Calculation Method	Storm-EZ or custom spreadsheet	SNAP

Some considerations for determining the method:

- Sites with high existing infiltration rates (e.g. HSG A or B) may find it easier to meet infiltration requirements than sites with clayey soils (e.g. HSG C and D).
- Sites with greater amounts of pervious areas and greater disconnected impervious areas will find it easier to meet runoff match requirements than high density sites.
- Sites that cannot meet the full Runoff Volume Match requirements will still see benefits from using volume reduction practices, as the infiltration rate is considered in the SNAP tool, effectively allowing for a partial infiltration method.

5.3.5 Using Volume Reduction to Meet Nutrient Loading Requirements

Volume Reduction practices are a subset of SCMs that closely align with Green Stormwater Infrastructure (GSI) practices. However, not all GSI practices achieve Volume Reduction. Volume Reduction practices are intended to minimize stormwater impacts of development by matching the volume of water leaving each site before and after construction, thereby, preserving the existing hydrology of the area. These practices address the difference in volume of runoff, not just peak discharge, by infiltration, evapotranspiration, or rainwater harvesting.

Practices approved for Volume Reduction are identified in Chapter 6 of this Manual, “Stormwater Control Measure (SCM) Design”. To meet nutrient loading requirements for either the Nitrogen Reduction Rules or any overlay district, applicants are required to adhere to NCDEQ guidance provided in the May 13, 2014 memorandum “*Procedure for Meeting the Requirements for Nutrient Sensitive Waters Stormwater Management Programs by*

Implementing Low Impact Development" and *"Calculating Runoff Volume Using the SCS Method as a Voluntary Alternative to the Simple Method"* from March 2014 or any future updates to that procedure as issued by NCDEQ.

For new development, the pre-development land cover must be assumed to be forested for the entire development site. For redevelopment of sites with existing BUA, a modified calculation may be performed. For the purposes of this modified calculation, any BUA added as part of the redevelopment must be assumed to be forested in the predevelopment condition.

For the runoff volume match requirements, the State of North Carolina requires use of the 1.34 inch storm, as opposed to the 1 inch storm used in the water quality volume requirements.

Calculations for showing Volume Reduction must be based on either the Storm-EZ tool or the same methodology, which includes:

- NRCS (SCS) Discrete Curve Number Method, which is used to generate inflow hydrographs. This involves running the CN calculation in TR-55 twice: first for connected impervious area and secondly for the remaining site area.
- The runoff fates described in the Stormwater Control Measure Credit Document, which are applied to the inflow hydrograph.

5.3.6 Required On-site Treatment

For sites with a BUA greater than 24%, a primary SCM shall be required on-site before off-site credits can be purchased.

The percentage BUA for the project is calculated based on the proposed total impervious area on the project.

- For a Greenfield Site, the formula is:
  [EQ 5.1]

$$\left[\frac{Proposed\ BUA}{Regulated\ Project\ Area}\right] * 100 = \%BUA$$

- For sites with Existing BUA, either Equation 5.1 or the following the formula may be used:
  [EQ 5.2]

$$\left[\frac{[(Proposed\ Total\ BUA) - (Existing\ BUA\ placed\ or\ permitted\ prior\ to\ May\ 1, 2001)]}{[(Regulated\ Project\ Area) - (Existing\ BUA\ placed\ or\ permitted\ prior\ to\ May\ 1, 2001)]}\right] * 100 = \%BUA$$

If the BUA is greater than 24%, then a Primary SCM is required for nutrient treatment. If the BUA is less than or equal to 24%, a SCM may be used but it is not required for water quality purposes. A SCM might be needed to meet peak discharge requirements, however. Primary SCMs are defined by NCDEQ; the Primary versus Secondary designations can be found in the *Stormwater Control Measure Credit Document* in table A-2.

5.3.7 Determining Water Quality Volume

UDO Section 9.2.2.B.1.g states, "Stormwater control measures shall be designed to control and treat the volume of runoff generated from all built-upon area by one inch of rainfall or equivalent

runoff volume". Per NCDEQ clarifications via e-mail, this means that all new BUA (or an equivalent amount of previously untreated BUA) must drain to the SCMs on the site and that the SCMs must provide at least 100% treatment for that BUA.

Calculate the required WQv based on all the newly proposed BUA on site.

Treat that volume of WQv in one or more SCMs on site.

The amount of actually treated WQv will be based on:

- Determining the WQv associated with the actual land cover draining to each SCM.
- Existing BUA on the site may be treated in lieu of the newly proposed BUA if that existing BUA is not currently treated by another SCM.
- ROW that drains to the SCM may be given credit for treatment if that ROW BUA is not currently treated by another SCM.
- Credit will be given for the WQv associated with pervious areas draining to the SCM.

5.3.8 Calculations in the SNAP Tool

As of the adoption date of this Manual, the SNAP tool is the required calculation method for compliance with the Nitrogen Reduction Rules. The most recent version of the SNAP tool shall be used. If NCDEQ changes the required calculation method, that NCDEQ directive will supersede this subsection of the Manual.

5.3.8.1 SNAP Project Info Worksheet

On the Project Info worksheet, the following fields must be filled in:

- Project Name.
- Nutrient Management Watershed, Sub-watershed, Delivery Zone.
- Nitrogen Export Rate Target = 3.6 lb/ac/yr.

For additional guidance, see the City's stormwater website.

5.3.8.2 SNAP Land Cover Characteristics Worksheet

On the Land Cover Characteristics worksheet, the following criteria apply:

- Precipitation Station will be Raleigh.
- The category "Roof" will be used for any impervious surface elevated above the surrounding ground and not used for vehicular traffic. Slatted decks will be included in this category at 50% or 30% according to the UDO definition of "impervious surface."
- The category "Roadway" will be used for road surface impervious area in the ROW.
- The category "Parking/Driveway/Sidewalk" will be used for all impervious area outside the ROW that is located at ground level. It encompasses miscellaneous impervious areas such as HVAC pads, retaining walls, plazas, patios, compacted gravel, synthetic turf/sports courts, and other similar surfaces that do not meet the infiltrating permeable

pavement SCM criteria. It also includes private roads and non-roadway BUA in the ROW.

- "Protected Forest" refers to Permanently Protected Undisturbed Open Space (PPUOS) as defined in the UDO. This area must be depicted on a recorded plat, permanently fenced, and treated like a SCM, requiring an Operations and Maintenance (O&M) Manual and annual inspections. Note that Tree Conservation Area (TCA), as defined by UDO Article 9.1, is not automatically Protected Forest.
- "Managed Pervious/Landscaping" will be used for all pervious area that is not PPUOS. This also applies to existing conditions.
- "Offsite or Existing" categories will not be used in the City of Raleigh. This is because SNAP does not give nutrient credit for these areas.
- Pools and Open water will be entered as "Custom Land Cover" with values of Impervious Value =0, TN EMC = 1.18, TP EMC = 0.11.
- Zone 1 of riparian buffers, when forested, will be treated as "Protected Forest" for both existing and proposed conditions.
- For Existing BUA, reference the section on Existing BUA above.

5.3.8.3 SCM Characteristics Worksheet

- The hydrologic soil group at SCM location, means the HSG specifically where the SCM is sited, not the HSG for the project site. If the SCM location falls on the line between two HSGs then the less infiltrating HSG must be chosen.
- The SCM Description will align with the SCR and the plan set. For example: if SCMs are labeled A, B, and C, those labels will be used in SNAP.
- The Design Storm size for all SCMs in Raleigh is 1 inch.
- All SCMs shall be designed to a minimum of 100% sizing if they are used for regulatory purposes.

Note that comparison between existing TN load and proposed TN load is not used for compliance outside of Watershed Protection Overlay Districts.

5.3.9 Nutrient Offset Credit Eligibility and Calculations

Sites that have a BUA percentage less than or equal to 24% may meet the nutrient target through nutrient offset credits only. The thresholds of 6 lb/ac/yr and 10 lb/ac/yr from the previous Nitrogen Reduction Rules are no longer in use. Sites that have more than 24% BUA, may purchase nutrient offset credits after the requirement to treat BUA in Section 5.3.6 of this Manual has been satisfied for the parcel.

5.3.10 Nitrogen Compliance Submittal Requirements

The signed and sealed SCR shall contain the following items related to the nutrient calculations and runoff volume match:

- Existing Conditions and Post-Development maps showing the project site land cover with SNAP categories.
- PDF versions of the following SNAP tool worksheets:
    - Project Info.
    - Land Cover Characteristics.

  - SCM Characteristics.
  - Nutrient Export Summary.
  - Nutrient Offset.
- PDF versions of “City Nutrient Summary Sheets” (“City Nutrient Summary Sheets” are available on the City’s stormwater website in PDF form along with a contact for obtaining the Excel version).

Additionally, the Excel file of the SNAP tool shall be submitted as part of the permitting case with the City assigned case file number in the file name prior to issuance of the Stormwater Control permit.

5.4 WATER SUPPLY WATERSHED PROGRAM REQUIREMENTS

The State of North Carolina requires cities and counties statewide to implement watershed protection programs for areas where drinking water is supplied by surface impoundments or by direct withdrawal from streams. These requirements include limitations for BUA, required use of SCMs on lots exceeding certain specified BUA limitations, and the incorporation of GSI for volume control. The Water Supply Watershed Program Area requirements are specific to the watershed protection areas which can be found in the UDO as follows:

- Urban Watershed Protection Overlay District – UDO Section 9.5.1
- Falls Watershed Protection Overlay District – UDO Section 9.5.2
- Swift Creek Watershed Protection Overlay District – UDO Section 9.5.3

5.4.1 SNAP Calculations for WSWP

To comply with the Watershed Protection Area nutrient requirements, the NCDEQ SNAP tool must be used for calculating the Nitrogen and Phosphorus loading rates. Projects within a watershed overlay district need to meet both the Nitrogen Reduction Rules and the Watershed Rules. The more stringent requirements must be shown in the SNAP tool. The SNAP input on the Land Cover Characteristics and SCM Characteristics must follow the guidance in Section 5.3.8 above.

On the Project Info worksheet, the following fields must be filled in:

- Project Name.
- Nutrient Management Watershed, Sub-watershed, Delivery Zone.
- Nitrogen and Phosphorus Export Rate Targets.

For additional guidance, see the City’s stormwater website.

5.4.2 WSWP Nutrient Calculation Submittal Requirements

The submittal requirements for nutrient calculations are the same as the Nitrogen submittal requirements in Section 5.3.10, above.

5.5 NCDOT WORK UNDERTAKEN BY THE CITY

Projects in the NCDOT ROW undertaken by the City may either fulfill the Nitrogen Reduction requirement for linear transportation projects per the requirements found in 15A NCAC 02H .1001(1)(c) or fulfill the City’s requirements. Find more information about the NCDOT requirements in the NCDOT Stormwater BMP Toolbox.

Chapter 6

STORMWATER CONTROL MEASURE (SCM) DESIGN

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6.1 INTRODUCTION

Stormwater Control Measures (SCMs) improve water quality and detain peak runoff to meet the City's Active Stormwater Control requirements set forth in UDO Section 9.2.2. and described in the previous chapter of this Manual.

All SCMs used for regulatory compliance must follow the design requirements in this Manual. SCMs used to comply with the Nitrogen Reduction requirements must also comply with the NCDEQ Stormwater MDC that were established in Rule 15A NCAC 2H and can be found in NCDEQ's Stormwater Design Manual. For each SCM, this includes compliance with:

- MDCs applicable to all SCMs.
- Section 6.3 (of this Manual) design requirements applicable to all SCMs.
- The device-specific MDC.
- The device-specific design requirements in Section 6.4 of this Manual.

If the MDCs are updated after the effective date of this Manual, then the updated MDC requirements shall govern in projects submitted to Planning and Development after the new MDC effective date. If a new device-type is added to the MDCs, then it may be used for Nitrogen Reduction per the criteria established by NCDEQ.

6.2 SELECTING A SCM

The City encourages the use of GSI as a best practice for stormwater management. GSI practices contribute to managing, treating, and reducing stormwater runoff as close as possible to the runoff's source, by preserving natural landscape features and/or by mimicking natural processes through installation and maintenance of structurally engineered devices. The majority of stormwater treated through GSI practices is designed to infiltrate or evapo-transpire rather than leave the property as stormwater runoff. Thus, in comparison to conventional stormwater management practices, GSI practices can provide additional water quality benefits.

Additionally, GSI practices can enhance site aesthetics, improve air quality, reduce urban heat island impacts, create wildlife habitat, reduce energy consumption, reduce infrastructure costs, and increase property values. More information and resources for implementing GSI in the City of Raleigh, including special programs and incentives, can be found on the City of Raleigh's Stormwater website. Additionally, standard details for GSI can be found on the City's Standard Details website.

6.3 DESIGN REQUIREMENTS FOR ALL SCMS

6.3.1 Pumping Restrictions

No pumping of stormwater shall be allowed as a necessary component of any SCM except for rainwater harvesting. This does not preclude the use of a temporary pump for maintenance drawdown.

6.3.2 Clarifications on General MDCs

The following requirements apply to the design of all regulatory SCMs:

A. The requirements specified in Chapter A-5, “Common Structures and Materials”, of the NCDEQ Stormwater Design Manual must be followed.

B. General MDC 2 regarding contaminated soils shall apply to all brownfield or contaminated sites, including those sites that have not entered into a Brownfields Agreement with NCDEQ. This includes sites identified by NCDEQ as having Underground Storage Tanks (UST), Hazardous Waste (active or inactive), or Pre-Regulatory Landfills.

C. General MDC 3 regarding side slopes indicates that “Side slopes of SCMs stabilized with vegetated cover shall be no steeper than 3:1 (horizontal to vertical). Retaining walls, gabion walls, and other engineered surfaces may be steeper than 3:1. Steeper vegetated slopes may be considered on a case-by-case basis if the applicant demonstrates that the soils and vegetation shall remain stable.” Notwithstanding the last sentence of General MDC 3, vegetated slopes steeper than 3:1 will not be considered on a case-by-case basis.

6.3.3 Embankments and Freeboard

The following freeboard requirements apply to constructed embankments for SCMs of all types where the design depth of water to be impounded is 3 feet or greater.

Constructed embankments are those that are created by placing compacted fill above the original grade. For the definitions of constructed embankments versus excavated ponds and for further definition of depth of water impounded, refer to NRCS Conservation Practice Standards Pond Code 378 for NC.

A. There must be 1-foot of freeboard between the largest storm with peak discharge requirements and the crest of an emergency spillway.

B. Flow from the 100-year storm event shall not flow through the emergency spillway and must be safely conveyed through the primary outlet control structure.

C. The freeboard to the top of an embankment must be a minimum of 1 foot above the elevation of the highest stage calculated for the 100-year storm.

D. Embankments shall be designed per the standards in NRCS Conservation Practice Standards Pond Code 378 for NC for all design components, except when the NCDEQ Stormwater Design Manual or this Manual have more stringent requirements.

E. Embankments shall comply with North Carolina Dam Safety Regulations.

F. The only penetration through the embankment shall be the outflow barrel. Seepage associated with the barrel shall be minimized through the use of anti-seep collar or filter and drainage diaphragms.

6.3.4 Proximity to Buildings

All SCMs shall be located a minimum of 10 feet from any building unless all of the following criteria are met:

A. The SCM is watertight.

B. Plastic tanks molded as one piece are assumed to be watertight. Other materials must include leak testing specifications.

C. The specified leak rate in the testing must be acceptable to the design professionals responsible for geotechnical recommendations and structural design.

D. A signed and sealed letter from a North Carolina-licensed structural engineer is required with the SCR at the time of permitting review. This letter must specify that the structural engineer is aware of the location of the SCM per dated plans and has approved a specific acceptable leak rate.

E. If a SCM is located in or under a building, SCM approval also will require a signed letter from the applicable property owner or party responsible for maintaining and repairing the SCM acknowledging the increased long-term maintenance costs associated with the SCM location. This shall be submitted with the SCR at the time of permitting review.

F. Adequate access is provided for maintenance. If access by maintenance vehicles such as pump trucks is not directly available, a letter from a maintenance company indicating that are willing to maintain the SCM shall be required. This also may require a hose pull diagram. These shall be submitted with the SCR at the time of permitting review.

6.3.5 Use of Retaining Walls

Retaining walls may be used to contain ponded water associated with the SCM treatment volume if all of the following requirements are met:

A. A leak rate associated with the wall must be established. The leak rate must be used in conjunction with the outlet structure hydraulic design to demonstrate compliance.

B. For walls over 5 feet in height, a signed and sealed letter by the North Carolina-licensed structural engineer responsible for the retaining wall must be submitted with the SCR, indicating that the engineer is aware of the saturated soil conditions as shown on the dated plans.

C. Wall design details must be submitted with the permitting drawings prior to permit approval that demonstrate no short circuiting of the SCM will occur through drainage systems associated with the retaining wall.

D. Retaining walls within a SCM are considered an element of the SCM and must be included in the drainage easement for SCM access, the SCM O&M Manual, and the SCM construction cost estimate.

E. If retaining walls are within a wet pond or stormwater wetland, the lowest grade adjacent to a retaining wall must be above the water quality volume elevation.

Permitting for disciplines other than stormwater may be required. For example, building permits may be required. Retaining wall designs must meet the requirements for other disciplines, such

as providing railings at the top of walls.

6.3.6 Plantings

The following requirements apply to all SCMs:

A. Proposed plantings in the SCM or on its side slopes shall not include any species listed as an "Invasive Plant Species" in the North Carolina Extension Gardener Plant Toolbox.

B. No woody vegetation shall be planted on embankments.

C. Vegetation shall not impede sight distance on any public road. Per the *Raleigh Street Design Manual* (2018), this means that no foliage shall be present between 24 inches and 8 feet above the curb line elevation.

D. Woody vegetation shall not be planted within 3 feet of the inflow.

E. Woody, deep-rooted vegetation (e.g., trees) must not be planted directly over buried underdrains.

6.3.7 Infiltration Testing

When infiltration testing is required, the following are approved tests:

a. Double-ring Infiltrometer (ASTM D3385-18)

b. Modified Philip-Dunne Infiltrometer (ASTM D8152-18)

c. Constant head permeameter (also known as the Amoozemeter) (ASTM D2434-22)

6.3.8 Maintenance Access

See Section 7.4 of this Manual, "SCMs", for requirements to access the SCM.

6.3.9 Location relative to ROW

SCMs owned and maintained by the City are allowed within City ROW. Privately owned and maintained SCMs are not allowed in the ROW.

6.3.10 Outlet Design

When designing the outlet of a SCM, all of the following apply:

A. Inlets and outlets of SCMs shall be designed/located to avoid short circuiting of the measure.

B. The outlet structure must be designed with maintenance in mind by ensuring access for cleaning, inspection, and repair. Specifically, the following shall be shown on the plans:
   1. Outlets shall be accessible by foot in the storm for which the SCM has been designed.
   2. Outlet structures deeper than 3.5 feet must be designed with internal ladders for maintenance access.

C. Outlet size and shape shall prevent blockages or clogging of the outlet. Also, the outlet must be designed to ensure the safety of people and wildlife in the surrounding area.
   1. This may include the use of a trash rack on a riser structure to prevent debris or wildlife from entering the outlet. If a trash rack is used, the maximum opening size shall be 4 inches, and there shall be a method of latching the rack closed.

2. All drawdown orifices shall include a method for preventing clogging. Approved methods include:
    - Trash rack.
    - Upturned elbow in the outlet structure.
    - Downturned elbow in a permanent pool.

D. For outlet structure calculations:
    1. Pipes smaller than or equal to 12 inches in diameter shall be analyzed as a submerged orifice if HW/D is greater than 1.5. When incorporating an orifice into an outlet structure design, the orifice discharge coefficient must be based on the type of orifice proposed and must be documented in the SCR.
    2. Pipes greater than 12 inches in diameter must be analyzed as a discharge pipe with headwater and tailwater effects considered. The outlet hydraulics for pipe flow can be found in the NCDOT manual, *"Guidelines for Drainage Studies and Hydraulic Design"*.
    3. When using weirs, the weir discharge coefficient must be based on the edge treatment of the proposed weir and must be documented in the SCR.

E. The outlet must be designed to control the velocity of water flowing out of the SCM to prevent erosion and other issues caused by high-velocity stormwater using the 10-year storm.

F. Wet ponds and wetlands shall include an emergency draw down feature that is operable above the 100-year water surface. The draw down shall not exceed the flow rate of the 10-year storm.

G. Principal outlet barrels passing through an embankment as described in Section 6.3.2, above, shall be composed of concrete pipe.

The following shall be required for all City-maintained SCMs:

H. Non-corrosive material and mounting hardware shall be implemented to extend device longevity, ease operation, and reduce the cost of maintenance.

I. Locking of trash racks and other elements is prohibited due to potential maintenance issues.

6.3.11 Requirements for All Underground SCMs

A. Underground SCMs shall provide access in accordance with OSHA standards and requirements, such as those for confined space entry.

B. Underground SCMs must meet structural requirements for HL-93 loading.

C. A minimum of two access points shall be required.

    1. Access points shall be reachable by a pump truck.

    2. Access points shall not be impeded by vehicular or pedestrian traffic. If traffic control will be required for maintenance access, a traffic control plan shall be provided in the O&M Manual.

3. Access manways shall meet the access, interior dimensions, labelling, loading, and steps criteria from Table 4.6 of this Manual.

D. Each chamber of the underground SCM shall be reachable by a pump truck suction hose.

E. Access provided also shall meet manufacturer's requirements.

6.3.12 Maintenance Requirements for all SCMs

A. Temporary pumps may be used for drawdown of water for SCM maintenance. However, the discharge rate for the temporary pump shall not exceed the 10-year peak discharge rate for the SCM.

6.3.13 Emergency Spillway

For SCMs with embankments as defined in Section 6.3.2, an emergency spillway is required to prevent failure of the embankment structure during large storm events.

A. The barrel of the principal spillway or outlet shall not be under the emergency spillway.

B. Ensure the emergency spillway is modeled in the outlet definition of the routing analysis.

6.3.14 City-Maintained SCMs

All City-maintained SCMs shall use the Standard Specifications for SCM components, available from Raleigh Stormwater.

6.4 SUBMITTAL REQUIREMENTS

The following sub-sections describe the SCM-related SCR components.

6.4.1 Stormwater Compliance Report (SCR)

All calculations associated with SCM design must be included in the signed and sealed SCR. This includes all of the following which apply to the SCM type under design:

A. SCM Drainage Area map(s).

B. Water quality volume provided, based on the drainage area to each specific SCM.

C. Infiltration Testing report, if applicable.

D. Infiltration Calculations.

E. Soil testing report for Seasonal High Water Table (SHWT) and depth to confining layer, if applicable.

F. Draw-down rate calculations for the water quality orifice.

G. Underdrain calculations, if applicable.

H. Information related to building proximity, if applicable.

I. Information related to retaining walls, if applicable.

J. Routine calculations that include the primary outlet structure and emergency spillway.

K. Anti-flotation measure calculations, if applicable.

L. Outlet protection calculations.

M. Hydraulic calculations for flow splitters.

N. For ***Sand Filters***, hydraulic calculations for the connection between the sediment chamber and filter chamber.

O. For ***Sand Filters***, minimum size calculations for the sediment and filter chambers.

P. For ***Wetlands***, area calculations for the zones.

6.4.2 SCM Plan View

The plans must clearly show the following items in plan view. Depending on the scale of the project, these items may either be shown on the Grading/Drainage plan or on a Separate SCM plan view.

A. Outlet location.

B. Outlet control structures, labeled.

C. Existing and proposed drainage easements. See Chapter 7, "Easements", for drainage easement requirements for SCM access.

D. Dimensions for the distance between the SCM and adjacent structures (buildings) if they are closer than 20 feet.

E. Emergency spillway showing proposed contours and dimensions and identifying spillway liner, if applicable.

F. Underdrains with clean-out locations, if applicable.

G. Outlet protection, shown to scale in plan view with the dimensions, depth, and class of stone.

H. For plans with retaining walls, the top of wall and bottom of wall elevations along the length of the retaining wall must be labeled at least every 20-feet.

I. ***Swales*** appropriately labeled and showing contours. The width, side slopes, longitudinal slope, and any proposed liners must be specified. If check dams are present along the swale alignment, they must be shown to scale and be labeled with all applicable dimensions.

J. ***Wetlands*** with zones hatched and labeled including the percentage of each zone proposed. This may be provided as an exhibit in the SCR in lieu of providing it in the plan set.

K. ***Level Spreader – Filter Strips (LS-FS)*** and ***Disconnected Impervious Surface (DIS)*** must show the associated vegetated area with dimensions and slope.

6.4.3 SCM Plan Sheet Notes

A. The SCM plans must reference the landscaping plan sheets by number if plantings are not shown on the SCM plan.

B. The specifications for proposed liners and geotextiles must either be included as notes on the SCM plans or referenced in the detail sheets. If the designer is relying on specifications rather than notes, the specification sections for liners or geotextiles must be provided in the SCR for the City stormwater reviewer to see.
C. All media and stone types associated with a SCM must be included on the plans.
D. ***Bioretention*** media must reference the composition, P-Index, and infiltration rate per the Bioretention MDCs on the plans..

6.4.4 SCM and SCM Component Details

6.4.4.1 Cross-Section Through SCM

The following information shall be shown in the cross-section of the SCM plan detail:

A. Calculated water surface elevations appropriately labeled for the water quality, 2-year, 10-year and 100-year storms. If treatment was required for other design storms, those elevations also shall be shown. The water quality elevations shall be shown correctly in reference to the elevation of the SCM components.
B. Labeled design freeboard per the freeboard requirements in Section 6.3.2. above, if applicable.
C. Labeled elevation of the top of embankment and embankment width, if applicable.
D. SHWT elevation, if applicable for the SCM type.
E. Liner location and reference to the location of the liner specifications or details, if applicable.
F. Labeled geotextiles, if applicable.
G. Dimension of SCM media depth, if applicable.
H. All underdrain systems and clean-outs or observation wells with callouts indicating pipe material, size, perforations (if applicable), and slope.
I. Outlet protection, to scale, indicating the surface slope.

6.4.4.2 Outlet Structure Detail

The following information shall be shown in the outlet structure detail on the SCM plan:

A. Outlet control structure that contains all needed components including weirs, orifices, emergency draw-down valves, pipes in and out, anti-flotation measures, and anti-clogging measures.
B. Labeled invert elevations, structure dimensions, pipe/weir/orifice sizes and elevations, and any other components.
C. Calculated water surface elevations labeled for the water quality, 2-year, 10-year and 100-year storms. If treatment was required for other design storms, those also shall be shown.

6.4.4.3 Flow Splitters

A. Show all flow splitters in plan view and in a cross-section detail. The elevations must be labeled according to the cross-section through SCM section above. This detail may be a part of the SCM cross-section or a stand-alone detail.
B. Show calculated water surface elevations in each chamber for the water quality, 2-year, 10-year and 100-year storms. If treatment was required for other design storms, those shall also be shown in the cross-section detail.

6.4.4.4 Outlet Protection

- Provide an installation detail for outlet protection in the SCM plans.

6.5 SCM TYPE-SPECIFIC DESIGN REQUIREMENTS

6.5.1 Infiltration System

DESCRIPTION AND APPLICATIONS:
Infiltration practices consist of an area that intercepts and temporarily stores runoff until it infiltrates into the underlying and surrounding soils. They may also be classified as runoff-reducing, GSI practices. Varieties: Infiltration Trenches, Infiltration Basins
ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS
A. The drainage media is required to be composed of medium or coarse sand, or crushed stone (with a uniformity coefficient of two or smaller). The media shall be hard, durable, inert particles, free from slate, shale, clay, silt, and organic matter. Media shall be washed until it is free of fines. B. Permeable, non-woven geotextiles shall enclose drainage media on all sides of the infiltration system and shall be in contact with the in-situ soil. C. Infiltration trench media shall be a minimum depth of 1.5 feet. D. A minimum 12-inch cover is required from the top of all piping to the finished grade. E. A minimum of 12 inches of head is required to promote infiltration. F. Infiltration practices shall not be used over occupied structures (buildings). G. One infiltration test shall be provided for every 7,000 square feet of infiltration surface area.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-1 Infiltration System

6.5.2 Bioretention

DESCRIPTION AND APPLICATIONS:

Bioretention consists of a vegetated depression over special filtration media. After passing through the media, water infiltrates or is collected in underdrains.

Varieties: Planter Boxes, Curb-side Bioretention, Bump-out Bioretention, Median Bioretention, Transit Stop Bioretention, Pedestrian Refuge Bioretention

ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:

A. Pretreatment is required. The most commonly used pretreatment devices are:
    a. A *grass and gravel combination:* 8 inches of gravel followed by 3 to 5 feet of sod perpendicular to slope.
    b. A forebay: 18 to 30 inches deep where the water enters and shallower where water exits in order to dissipate hydraulic energy. The forebay must be lined to ensure that water will not flow into the underdrain without first flowing through the treatment area of the bioretention cell. Lining material shall allow for removal of sediment and debris with a shovel or vac-truck.
    c. *Vegetated Swale*: maximum longitudinal slope of 5%, 2% preferred. Non-porous check dams with a minimum height of 6 inches shall be placed as needed to provide ponding behind them. Minimum swale bottom width of 2 feet.
B. Flow shall enter a bioretention cell via dispersed flow with a velocity less than 1 foot per second (fps) for mulched cells or 3 fps for sodded cells to prevent erosion. If inflow enters via a pipe or swale, then a rip-rap lined entrance, a forebay, or another energy-dissipation device shall be used.

REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS):

C. Clean-out pipes shall extend upwards from the underdrain pipe to an elevation 3 inches above the water quality ponding. They shall be located at the end of the bioretention surface, near the toe of slope. Underdrain pipes shall have a minimum slope of 0.5%.
D. The minimum width of a bioretention cell shall be 18 inches.
E. The surface of the bioretention shall not slope more than 0.5% in any direction. Installation in multiple cells is allowed and shall be considered at sloped sites.
F. Bioretention adjacent to public or private roads or sidewalks have the following additional criteria:
    1. All features including vegetation must ensure clear sightlines for pedestrians and drivers per the City of Raleigh Street Design Manual.
    2. Pedestrian access shall not be impacted by the bioretention design.
    3. For drop offs greater than 12 inches, pedestrian and vehicle safety measures shall be installed.

4. There must be a location adjacent to the bioretention area for a maintenance truck to park safely. This may be a parking spot or a grassed area.
5. Gutter spread requirements must be met.

G. Bioretention shall not prevent the placement of residential trash, recycling, and yard waste bins for pick-up. The minimum width of embankment is 5 feet. This allows for mowing access.

H. A flow splitter shall be used to route flows above WQv away from the bioretention area.

I. The minimum maintenance vehicle parking area for median bioretention is 12 feet by 18 feet.

IMPORTANT LINKS:

NCDEQ Stormwater Design Manual Chapter C-2 Bioretention Areas
City of Raleigh Standard Details
City of Raleigh Street Design Manual

Bioretention is approved in many configurations, including:

- Planter Boxes – Planter boxes may be installed as part of streetscapes, site landscaping, or adjacent to structures.
- Curb-side Bioretention or Bump-out Bioretention – This may function as traffic calming or street-scaping.
- Median Bioretention.
- Transit Stop Bioretention - A transit bump-out is designed to accommodate bus stops. It extends the curb into the street to create a wider boarding area for passengers, and may also include shelter, seating, and other amenities.
- Pedestrian Refuge Bioretention - A pedestrian refuge bump-out is designed to provide a safer crossing for pedestrians by extending the curb into the street and creating a shorter crossing distance. It typically includes a painted crosswalk, a raised curb or planter, and may also include seating or other amenities.

Figure 6.1, below, gives multiple examples of installation locations in the ROW.

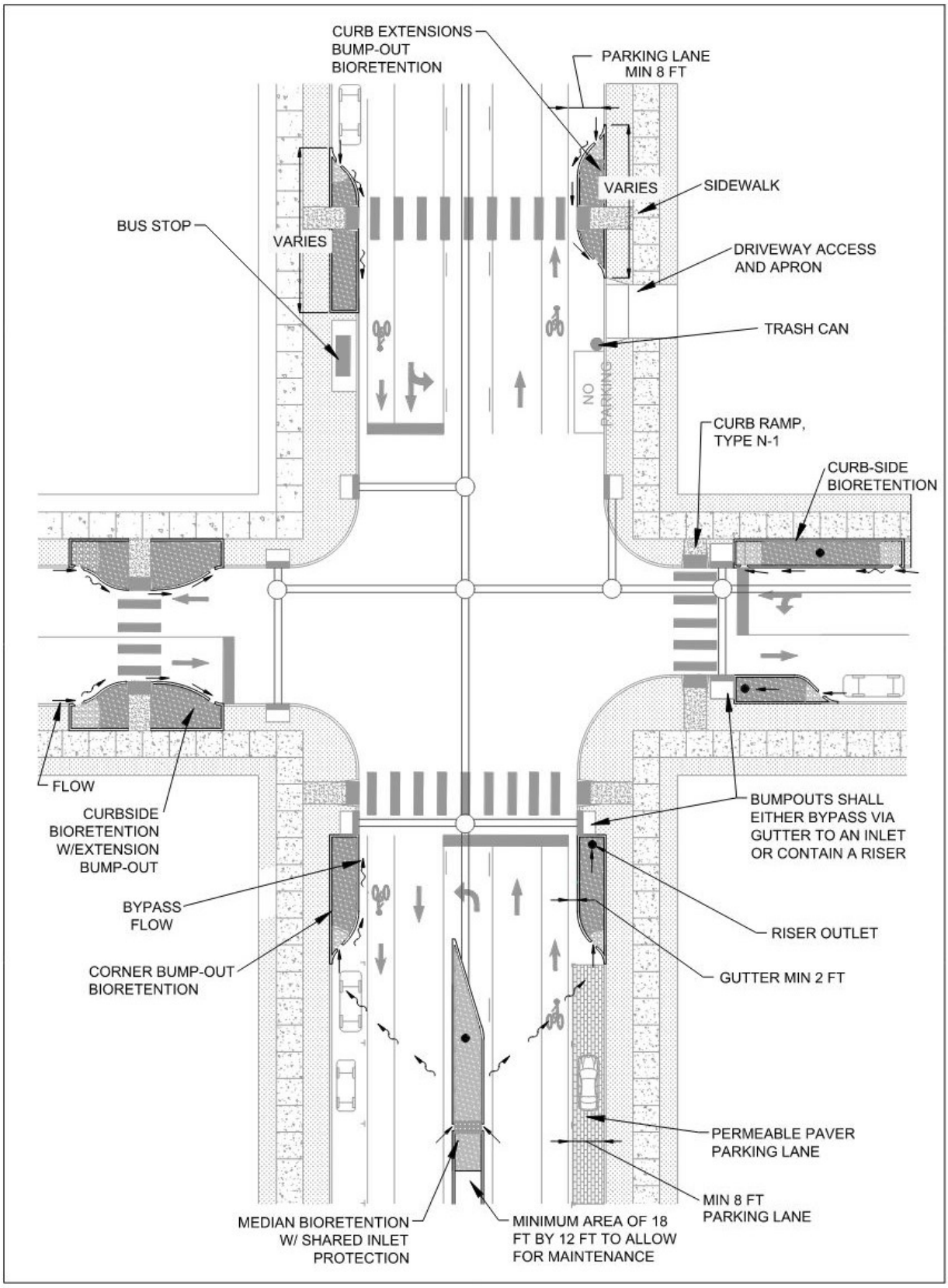

Figure 6.1 Bioretention Example Configuration

6.5.3 Wet Pond

DESCRIPTION AND APPLICATIONS:
A stormwater wet pond is an excavated basin that captures and detains stormwater runoff, releasing it slowly over a period of 2 to 5 days. Pollutants are removed through sedimentation in the permanent wet pool. Older Names: Detention Basin
ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:
A. An impermeable liner must be included if the permanent pool design elevation is not within 6 inches of the SHWT. B. Wet ponds shall have the ability to sustain a wet pool by one of the following mechanisms: 1. Permanent pool elevation within 6 inches of the SHWT. 2. Impermeable liner and with a minimum drainage area of 25 acres. 3. Site specific measurements and water balance calculations showing there is sufficient inflow to the pond to sustain the permanent pool with or without a liner.
REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS):
C. As part of design, a geese management strategy shall be designed for the period of plant establishment.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-3 Wet Pond

6.5.4 Stormwater Wetland

DESCRIPTION AND APPLICATIONS:
Stormwater wetlands combine the detention and settling of a wet pond with the vegetated benefits of a wetland. Other Names: Constructed Wetland
ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:
A. Stormwater wetlands shall have the ability to sustain the permanent pool by one of the following mechanisms: 1. Permanent pool elevation within 6 inches of the SHWT. 2. Impermeable liner and with a minimum drainage area of 10 acres. 3. Site specific measurements and water balance calculations showing there is sufficient inflow to the pond to sustain the permanent pool with or without a liner. B. A minimum flow length to width ratio (L:W) shall be 3:1.
REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS)
C. As part of design, a geese management strategy shall be designed for the period of plant establishment.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-4 Stormwater Wetland

6.5.5 Permeable Pavement System

DESCRIPTION AND APPLICATIONS:

Permeable pavement systems have a surface layer that allows rainfall to pass through to the underlying gravel layer. Water stored in the gravel layer is either infiltrated (Infiltration Design) or slowly released (Detention Design).

Types of permeable pavement systems: Permeable Interlocking Concrete Pavers (PICP), Permeable Concrete, Permeable Asphalt, Concrete Grid Pavers, Plastic Turf Reinforcing Grid.

The following may also be designed as permeable pavement systems, using the same standards as permeable pavement: Permeable Sports Courts, Synthetic Turf

ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:

A. In an infiltration design, geotextiles (permeable and non-woven) shall line the sides of the aggregate base to prevent migration of adjacent soils into it and subsequent permeability and storage capacity reduction.
B. Geotextiles are not allowed under the aggregate base in an infiltration design because they can accumulate fines and inhibit infiltration.
C. In a detention design, geomembranes shall be used to provide a barrier on the sides and bottom of the aggregate base to prevent infiltration into the subgrade. Geomembranes also shall be used to line the sides of the aggregate base when structures or conventional pavement is within 20 feet or less.
D. The slope of permeable surfaces shall be less than 6%.
E. The designer shall ensure that the pavement meets its structural design requirements by involving a North Carolina-licensed design professional with expertise in pavement design.
F. The system shall be accessible for the surface maintenance technique(s) specified by the manufacturer or trade association. Permeable asphalt, permeable concrete, and PICP shall be accessible by a regenerative air street sweeper.

REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS)

G. Signage shall be posted that indicates permeable pavement is present and that materials storage and sanding/salting the area is prohibited.
H. Permeable surface materials other than those listed in the NCDEQ Stormwater Design Manual shall provide maintenance procedure information during permitting review. The unlisted permeable surface material must be approved by the City's Stormwater SCM and Dams Asset Manager, or his/her designee, prior to permitting approval.
I. The minimum width of a section of permeable pavement confined on 3 sides shall be 50 feet. This equates to 6 parking spots width. This is for maintenance access by a street sweeper.

IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-5 Permeable Pavement

6.5.6 Sand Filter

DESCRIPTION AND APPLICATIONS:

A sand filter consists of a settling area (sediment chamber) and a sand filter (sand chamber) area. Flow through the sand either infiltrates or is collected in underdrains. Sand filters may be located above ground or underground.

ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:

A. The flow distribution system between the sediment chamber and the sand chamber shall be sized for the water quality storm. While storage above the sand may be counted for peak flow attenuation per MDC 4, the higher incoming flows shall be otherwise routed to avoid erosion of the sand layer.
B. The sediment chamber shall be separate from any chambers used for detention. This allows for easier sediment removal.

REQUIREMENTS FOR CITY FUNDED PROJECTS

(RECOMMENDED FOR OTHER PROJECTS)

C. All of the following apply to underground sand filters:
    1. A minimum of 4 feet of vertical space shall be provided between the surface of the sand and the “ceiling” of the sand chamber.
    2. Access shall be provided to every sand chamber.

IMPORTANT LINKS:

NCDEQ Stormwater Design Manual Chapter C-6 Sand Filter

6.5.7 Rainwater Harvesting (RWH)

DESCRIPTION AND APPLICATIONS:

Rainwater harvesting systems capture water runoff and store the water in a cistern. The system must include a passive drawdown or a dedicated non-potable use such as irrigation or toilet flushing.

ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:

A. Pumping is allowed as part of a rainwater harvesting system only when it serves as part of a distribution system to a non-potable use.
B. Systems other than those on a one- or two-unit residential property must be designed to prevent accidental consumption of non-potable water. Therefore, for systems other than those on a one- or two-unit residential property, spigots and hose bibs shall be lockable or opened only by use of a special tool.
C. The soil or foundation upon which the cistern will be placed must be sufficient to support the weight of the cistern when full.

REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS)

D. A passive drawdown is required for residential-scale, above ground systems. The passive drawdown shall discharge over two to five days to another SCM, which may include DIS. Passive drawdowns shall discharge by gravity.
E. Cisterns over 500 gallons that utilize passive drawdown and are intended for nutrient treatment shall direct the drawdown to another SCM that has been sized to receive that rate of runoff.
F. Any passive drawdown shall be installed in such a way to prevent easy breakoff of pipes or fittings by people or by-passing equipment.
G. Signage for passive drawdown shall be installed and the passive drawdown shall be locked or require the use of a special tool
H. Because the orifice for passive drawdown is often very small, the passive release mechanism shall be equipped with a filter or other device, located on the inside of the tank, to prevent clogging.
I. Above ground systems shall include a draw down method.
J. Above ground systems shall include a first flush diverter that is accessible by a person standing on the ground or on a ladder.
K. On residential-scale above ground systems, screens shall be installed to prevent access to the water by mosquitoes.

IMPORTANT LINKS:

NCDEQ Stormwater Design Manual Chapter C-7 Rainwater Harvesting

6.5.8 Green Roof

DESCRIPTION AND APPLICATIONS:
Green roofs layer drainage material, soil media, and plants over waterproofing and insulation layers.
REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS)
A. The stormwater designer shall ensure that the roof meets its structural goals by involving a North Carolina-licensed design professional with expertise in roof design. The roof must be designed to support the loads associated with the green roof layers, the designed rainwater storage, and maintenance activities in addition to standard roof loading design. B. A nonwoven, permeable geotextile layer and a drainage layer shall be placed beneath the growing media for roofs with slopes of less than 2%. Granular or aggregate materials may also be used for a drainage layer. The drainage layer shall drain to the roof gutters and downspouts. C. The roof shall be equipped with a waterproof membrane to protect against leaks. D. Fall protection shall be in the form of permanent installed barrier systems. Personal fall protection systems such as cable-based lifelines are not approved as these increase the cost and difficulty of maintenance. E. The green roof shall be accessible to maintenance staff from the building floor serviced by an elevator. Ladder access is not approved. F. An irrigation source shall be provided for plant establishment. If irrigation is desired after plant establishment, this must be considered in the green roof design as it will impact the stormwater management function. G. The use of a leak detection system shall be discussed with the owner or the applicable City department responsible for the City project for which the green roof is being installed. H. The desired vegetation shall be considered when planning the soil depth.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-8 Green Roof

6.5.9 Level Spreader – Filter Strip (LS-FS)

DESCRIPTION AND APPLICATIONS:
LS-FS are designed to slow down and distribute the flow of stormwater over a vegetated strip, allowing for natural filtration and pollutant removal. These practices consist of a collection area, a hardened level spreader, and a vegetated filter strip.
REQUIREMENTS FOR CITY FUNDED PROJECTS (RECOMMENDED FOR OTHER PROJECTS)
A. Pretreatment via a forebay is required when this device is not downstream of another SCM. The forebay shall be designed to "Recommendation 1: Pretreatment" in the NCDEQ Stormwater Design Manual, Chapter C-9. B. Soil amendment is required to promote plant growth per "Recommendation 2: Soil Amendment" in the NCDEQ Stormwater Design Manual, Chapter C-9. The FS and side slopes shall be covered with at least six inches of stockpiled topsoil, imported topsoil, or a combination of the two. A one-time fertilizer application to the topsoil shall be specified on the plans. C. Non-clumping, native, deep-rooted grasses shall be specified on the plans. See "Recommendation 3: Grass Specification for FS" in the NCDEQ Stormwater Design Manual, Chapter C-9. D. The depth to the SHWT shall be a minimum of 12 inches measured from the lowest ground surface elevation. E. The angle of entry from the point of discharge to the level spreader shall be parallel and must not be less than 45 degrees. See Figure 6.2 below.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-9 Level Spreader-Filter Strip

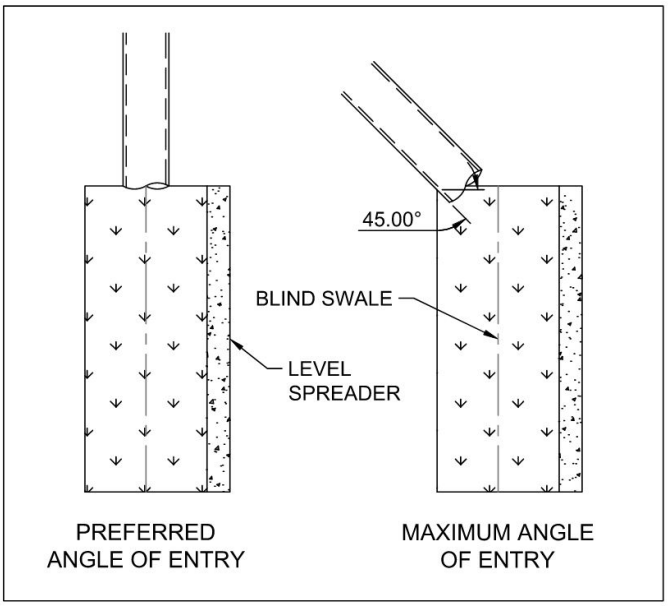

Figure 6.2 Pipe Entry into Blind Swale for Level Spreader

6.5.10 Disconnected Impervious Surface (DIS)

DESCRIPTION AND APPLICATIONS:
DIS can mitigate the impacts of stormwater runoff from impervious surfaces in urban and developed areas by directing water that would traditionally be conveyed to stormwater conveyance systems to vegetated areas where water can be slowed down and encouraged to infiltrate. DIS can also reduce the size and/or number of other site-required SCMs through their reduction of peak flow rate and volume.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-10 Disconnected Roofs (DR) and Disconnected Pavement (DP)

6.5.11 Treatment Swales

DESCRIPTION AND APPLICATIONS:
Treatment swales are vegetated, open channels that are explicitly designed and constructed to capture and treat stormwater runoff within dry or wet cells formed by check dams or other means.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-11 Treatment Swale

6.5.12 Dry Pond

DESCRIPTION AND APPLICATIONS:
Dry ponds hold water immediately after a storm event and drain to be dry between storm events. Other Names: Dry Detention Basin
ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:
A. If designing for nutrient removal credit, the flow length to pond width ratio (L:W) shall be 3:1. B. If not designing for nutrient removal credit, maximum drawdown time is 2 days.
IMPORTANT LINKS:
NCDEQ Stormwater Design Manual Chapter C-12 Dry Pond

6.5.13 Proprietary SCMs

DESCRIPTION AND APPLICATIONS:
Proprietary SCMs are manufactured treatment systems available from commercial vendors. These systems are designed to treat stormwater runoff and/or provide peak runoff control. Only NCDEQ approved Proprietary SCMs will be approved by the City for compliance with nutrient treatment requirements.
ADDITIONAL REQUIREMENTS BEYOND MDC, APPLICABLE WHEN SCM IS USED FOR RUNOFF RATE REQUIREMENTS:
A. SCMs must have a NCDEQ approved $EMC_{effluent}$ for Total Nitrogen to be used for meeting Nitrogen requirements. This can be found in the NCDEQ *Stormwater Control Measure Credit Document.* B. SCMs that can meet the MDC for Silva Cell Suspended Pavement With Bioretention may be used in lieu of the Silva Cell.
IMPORTANT LINKS:
NCDEQ Stormwater Control Measure Credit Document NCDEQ Stormwater Design Manual Part D

6.5.14 Underground Detention

DESCRIPTION AND APPLICATIONS:
Underground detention storage is in subsurface tanks, pipes, or vaults designed to provide peak runoff control.
DESIGN REQUIREMENTS:
A. Joint sealing specifications shall be included in the plans or specifications. If in specifications, the joint sealing specification sections shall be included in the SCR. B. Leak testing procedures and the "acceptable leak rate", as referenced in Section 6.3.3, above, shall be included in the plans or specifications. If in the specifications, the leak testing specification sections shall be included in the SCR. C. If the underground detention does not have other SCMs upstream, a separate sediment sump or chamber shall be provided for pretreatment. This shall be sized to 0.1 inches of depth per acre of contributing drainage area. The minimum depth of the sump shall be 3 inches. The sediment sump or chamber does not count towards the storage volume for underground detention. D. A high-flow bypass shall be included to safely pass the 100-year storm.

Minimum Maintenance Requirements:

TYPICAL MAINTENANCE ACTIVITIES FOR UNDERGROUND DETENTION SYSTEMS	
Activity	**Schedule**
Remove any trash/debris and sediment buildup in the underground vaults or pipe/tank systems	Annually
Perform structural repairs to inlet(s) and outlet(s)	As needed, based on inspection
Maintain groundcover and stability of overall site to reduce incoming sediment loads	As needed, based on inspection

6.5.15 Permanently Protected Undisturbed Open Space (PPUOS)

DESCRIPTION AND APPLICATIONS:
PPUOS ensures that vegetated areas will remain in a forested state. This reduces the required nutrient treatment and runoff control at a site.
DESIGN REQUIREMENTS:
A. Permanent fencing of the PPUOS is required. This requirement is waived within stream buffers and floodways. The outer edge of Zone 2 of a stream buffer shall be fenced when Zone 2 is PPUOS. B. PPUOS must be depicted on a map recorded in the Wake County Register of Deeds office or the Durham County Register of Deeds office, whichever shall apply.

TYPICAL MAINTENANCE ACTIVITIES FOR PPUOS	
Activity	**Schedule**
Inspect the perimeter of the PPUOS for encroachments of unallowed activities.	Annually
Inspect the fencing.	Annually

6.6 SCM OPERATIONS & MAINTENANCE REQUIREMENTS

Operations and maintenance (O&M) refer to the performance and ongoing upkeep of a SCM after construction has finished. An O&M Manual, a recorded drainage easement for the purposes of SCM access, and an Operation and Maintenance Agreement shall be completed as part of the permitting process to ensure proper long-term maintenance of each SCM.

6.6.1 Operations and Maintenance Manual

To provide stormwater treatment as designed, SCMs must be properly operated and maintained. Therefore, a site-specific Operations and Maintenance Manual (O&M Manual) that specifies all upkeep necessary for the function of all SCM components is required. The O&M Manual shall be submitted with the permitting submittal and an updated version of the O&M Manual shall be submitted with the SCM as-built submittal. If the O&M procedures associated with a SCM must be changed, an updated O&M Manual shall be submitted to the City with the Annual Inspection documentation.

One O&M Manual shall be provided for each project or phase of development and shall address each SCM to be constructed for that particular project or phase of development.

The O&M Manual shall cover maintenance requirements for the stormwater conveyance system, perimeter of the applicable SCM, inlet(s), pretreatment measures, main treatment area, outlet, vegetation, and discharge point.

All SCM O&M Manuals must incorporate the elements and O&M tasks found in the following sources at a minimum:

- UDO Section 9.2.2.D.2.
- NCDEQ Stormwater Design Manual, Part A-7, SCM Operation and Maintenance.
- NCDEQ Stormwater Design Manual, SCM-specific chapters dealing with maintenance items.

Note that the NCDEQ items are summarized in the Storm EZ O&M Supplement.

Components of an O&M Manual shall include all of the following:

A. A cover page with the project name, City case file number, and the name and seal of a qualified North Carolina-licensed PE, land surveyor, or landscape architect.

B. A table listing each SCM name(s)/identification, device-type, brief description, and purpose (e.g. Nitrogen only, Nitrogen and Runoff Rate, Watershed Overlay, Diffuse Flow).

C. An exhibit, sized to 8.5” x 11”, showing the SCM(s)’ locations, identifiers, and identifying the parcels that achieve compliance under this stormwater control plan.

D. Exhibit(s) showing the drainage areas to each SCM, such exhibit(s) sized to no more than 11”x17,” and showing parcel boundaries.

E. Plan sheets or exhibits that show the plan view and details (cross-section, profile, flow-splitter, outlet control structures) of each SCM, with the plat sheets or exhibits sized to no more than 11”x17”.

F. A description of the maintenance access procedures. If confined entry will be required, this shall be included.

G. Planting plan and schedule of plantings.

H. SCM or SCM component manufacturer information, if applicable.

I. SCMs that serve to meet stormwater runoff compliance requirements for multiple lots are shared in their entirety among all lots within a subdivision, regardless of which lots drain to each SCM in the subdivision. Each O&M Manual for a shared SCM shall include a description of which lots are served by the SCM (UDO Section 9.2.2.D.2.d).

J. An inspection checklist including frequency of inspection and SCM items/components to be inspected.

K. Maintenance instructions including (UDO Section 9.2.2.D.2.e):

   1. Maintenance tasks listed in the NCDEQ Stormwater Design Manual and this Manual.
   2. SCM manufacturer specified maintenance procedures.
   3. Quantitative triggers for when maintenance or repair actions must be taken.
   4. Expectations for documenting maintenance.
   5. Inspection of the maintenance access route.
   6. Special equipment needed for maintenance.
   7. The maximum pumped draw down rate of the SCM for maintenance, given in gallons per minute (gpm).
   8. The party that shall perform each action.

L. A list of the steps that shall be taken to restore a SCM to the design specifications in the event of a failure (UDO Section 9.2.2.D.2.f).

M. A statement about the expected repair life of the SCM (UDO Section 9.2.2.D.2.g).

N. A replacement cost schedule, derived by dividing the initial construction cost of the SCM by the expected life of the SCM and its components. (UDO Section 9.2.2.D.2.g).

O. A budget to include annual costs, such as routine maintenance, repair, periodic sediment removal, replenishment of rip-rap, insurance premiums associated with the SCM, , mowing and reseeding, replacing vegetation as necessary, and required inspections (UDO Section 9.2.2.D.2.j).

6.6.2 Recorded Easement Requirements

See Chapter 7 of this Manual, Section 7.4, for drainage easement requirements for SCM access.

6.6.3 Operation and Maintenance Agreements

To ensure proper long-term maintenance, an Operation and Maintenance Agreement shall be required for any site containing one or more SCMs. These agreements shall be signed, notarized, and recorded. The Agreement will reference the O&M Manual.

6.7 AS-BUILT CERTIFICATIONS AND SURVEYS

Upon completion of the permitted SCM work, the City requires submittal of certifications and as-built information to verify compliance with all applicable stormwater regulations. City acceptance of the as-built certifications and/or impervious or built area surveys is required prior to final approval of one or more of the following for a project or building: the Stormwater Control permit, the Certificate of Compliance, the Certificate of Occupancy, or the Partial Certificate of Occupancy (commercial only). An exception is where multiple units are served by the stormwater control measure(s), in which case the City may elect to withhold a percentage of permits or certificates of occupancy until as-built plans are submitted and approved by the City.

6.7.1 Stormwater Control Measures

All SCMs require certification by a licensed professional qualified in SCM design as detailed in UDO Section 9.2.2.D.1.a., verifying that the actual construction of the SCM conforms to the approved plans and provides the required level of stormwater treatment and/or peak flow control. Refer to the As-Built Checklist on the City's Stormwater website.

As-built submittals shall include all of the following:

A. Form 503, signed by the City stormwater inspector.

B. Completed checklist and certification by a licensed professional qualified in SCM design as detailed in UDO Section 9.2.2.D.1.a. Reference to the recorded map showing private drainage easements for SCM access (reference Register of Deeds book and page).

C. Narrative summary of any deviations from approved development plans.

D. Surveyed elevations of SCM components.

E. Redlines of approved SCM plans, details, and planting plans.

F. Shop Drawings (when applicable).

G. Updated SCR reflecting any hydrologic and hydraulic changes from the approved development plans to the as-built conditions.

H. Updated O&M Manual, including any changes to the O&M Manual to reflect as-built conditions.

I. Photos of the following SCM components:

1. Above Ground SCMs: All orifices (where flow enters and exits), inside of the riser structure, all inlets and outlets (including flared end section, pipe interior, and dissipater pads), outlet discharge area, earthen berms/weirs, emergency spillways, dam embankments, and all slopes (interior and exterior). Photos shall be dated and must be taken within 7 days of the initial as-built submittal to the City.
2. Underground SCMs: All orifices (where flow enters and/or exits), inlet structures (interior/exterior), weir walls, interior of SCM (for example, detention pipes, sand filter chambers, sediment chambers, flow splitters), interior of outlet piping, outlet dissipator, and discharge area. Photos shall be dated and must be taken within 7 days of the initial as-built submittal to the City.
3. Some SCMs require photographs taken during construction to verify that they were constructed in accordance with the approved development plans (permeable pavers, underground SCMs, and any SCM that includes underdrains, anti-seep collars, or filter diaphragms). SCMs that require underdrains must be photographed during construction to show that capping has been provided to prevent bypass. Any during-construction photographs submitted must be dated. These photos shall be included with the as-built submittal to the City.
4. Photos of plantings in the SCM shall be dated and must be taken within 7 days of the initial as-built submittal to the City.

J. Receipt/invoice/bill of sale with list of plants purchased.

K. Documentation of any required testing or materials certification with respect to the applicable SCM.

Once the as-built plans and certification are accepted by the City, the SCM will enter the maintenance phase and will be maintained and inspected by the responsible party in perpetuity.

6.7.2 Impervious Area or Built Area Surveys

Submittal of as-built impervious surveys to the site's stormwater inspector is required if impervious restrictions are a condition of the Stormwater Control permit for the project. The submitted impervious area or built area survey shall be sealed by a North Carolina-licensed professional land surveyor. An as-built impervious survey must depict all areas considered impervious per the UDO. The requirement applies to:

- New single-family dwellings and additions/improvements to single-family lots when the total impervious area is within 10% or 400 SF of the maximum impervious area limit, whichever is greater.
- Re-development that proposes no change in total impervious area but includes over 500 SF of substitution of impervious area.
- Any non-residential site with an impervious area limit as part of its conditions of development or Stormwater Control permit approval.

Chapter 7

EASEMENTS

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7.1 INTRODUCTION

Several types of drainage easements are required with development in the City of Raleigh. These shall include drainage easements for the purposes of:

- Upstream discharge where concentrated flow enters a private property at a location other than a stream. See Section 7.2 of this Manual.
- Conveyance systems, including new and existing open and closed conveyance systems such as pipes, channels, structures, culverts, and bridges. These easements shall include the stormwater conveyance system as well as access from the ROW for maintenance and repair purposes. See Section 7.3 of this Manual.
- SCMs, including both the SCM and access from the ROW for maintenance and repair purposes. See Section 7.4 of this Manual.
- Dams not considered part of SCMs. See Section 7.5 of this Manual.
- Flood storage where development results in an increase in flood levels. See Section 7.6 of this Manual.

A specific drainage easement may serve several of the purposes described above.

Drainage easements shall be deemed to be either public drainage easements or private drainage easements as described in this Chapter. Public and private drainage easements shall not overlap.

Proposed drainage easement locations shall be shown on the preliminary and permitting submittals. See Section 7.7 of this Manual regarding recording drainage easements.

7.2 UPSTREAM DISCHARGE

Site plans in the review process will be evaluated to determine if existing flow from upstream properties enters the site. Establishment of a drainage easement on the property being developed shall be required, as follows:

- If flow enters in a stream, then no drainage easement is required.
- If flow enters in an existing or proposed pipe or swale, then drainage easements (public or private) shall be provided per Section 7.3 of this Manual.
- If flow enters via sheet flow, then one 20’ wide drainage easement (public or private) will be required for each entering drainage area of one acre or more.

7.3 CONVEYANCE SYSTEMS

Drainage easements for open or closed stormwater conveyance systems are required for proposed conveyance systems carrying runoff from:

- More than one parcel
- An upstream conveyance system in a drainage easement
- SCMs

- ROW

7.3.1 Easement Widths

Minimum easement widths are determined based on maintenance needs. Drainage easements shall allow for access of construction equipment, taking into consideration the limitations that may be imposed by embankment slopes or other obstacles. Drainage easements for conveyance systems shall be centered over the pipe or channel/swale. Proposed off-center easement locations shall demonstrate to City Stormwater staff that the infrastructure can be accessed, maintained, and replaced using the proposed easement configuration. The access portion of a drainage easement does not need to be centered over the structure.

TABLE 7.1
MINIMUM EASEMENT WIDTHS FOR PIPES

Pipe Scenario	Easement Width
Single Pipe	20 ft OR 10 ft + pipe diameter + (2x the deeper invert depth) *whichever is greater*
Multiple Pipes	20 ft OR 10 ft + outside pipe widths + (2x the deeper invert depth) *whichever is greater*

TABLE 7.2
MINIMUM EASEMENT WIDTHS FOR OPEN CHANNELS OR SWALES*

Drainage Area	Easement Width
< 5 ac	5 ft on each side from centerline
5 ac to <25 ac	10 ft on each side, from top of bank
25 ac and larger	50 ft on each side, from top of bank

*Applies to channels and swales that are not jurisdictional waters or regulated streams with riparian buffers.

TABLE 7.3 MINIMUM EASEMENT WIDTHS FOR BRIDGES AND CULVERTS	
Equivalent Size	**Easement Configuration**
Up to 36” dia.	The drainage easement must contain the upstream and downstream inverts of the conveyance structure + minimum 10’ offset from the structure(s) including headwalls and wingwalls
36” and greater diameter	The drainage easement must contain the upstream and downstream inverts of the conveyance structure + minimum 10’ offset from the structure(s) including headwalls and wingwalls. AND Provide a 25’ wide drainage easement for access to the structure invert from ROW where the drainage easement does not involve traversing laterally across slopes that exceed 3:1. The configuration of this portion of the drainage easement will vary based on site conditions.

Where other utilities are involved, such as water and sewer, additional easement widths for the combined easements shall be provided according to guidelines in the Public Utilities Handbook, but in no case shall the easement widths be less than those listed above.

7.3.2 Public versus Private Drainage Easements

Unless otherwise specified in this Manual, all required drainage easements for conveyance shall be private drainage easements.

The following drainage easements are public drainage easements:

- Drainage easements identified by NCDOT as drainage easements held by NCDOT.
- Drainage easements associated with culverts or bridges serving City ROW will be held by the City and shall be labeled as City of Raleigh Permanent Drainage Easement.
- Drainage easements for the purposes of stormwater conveyance that convey public runoff shall be held by the City and shall be labeled as City of Raleigh Permanent Drainage Easement. Such easements shall exclude areas required to be in private drainage easements for SCMs.
- Drainage easements held by public entities other than the City or NCDOT, when identified as such by those entities.

7.4 SCMs

Stormwater control measures, conveyance systems transporting stormwater runoff from a SCM, space for maintaining the SCM, and access to the SCM from the ROW all shall be placed in a private drainage easement.

This includes:

- The entire footprint of the SCM system plus an additional 10 feet or more around the SCM to provide adequate room for construction equipment and activities necessary to complete maintenance, repair, or replacement tasks.
- Direct maintenance access to each component of the SCM requiring maintenance activities. This includes components such as the forebay, riser structure, plantings, embankment, outlet, and emergency spillway.
- For constructed ponds and wetlands, the required easement shall be 25 feet off the edge of the SCM at points where forebay and main pool sediment removal will be performed.
- A private drainage easement for the stormwater conveyance system applied to each outflow from the SCM, beginning at the SCM and extending to a point where the flow reaches a ROW, a jurisdictional water body, or another public or private drainage easement following the minimum easement width requirements in Section 7.3 of this Manual.
- Drainage easements for maintenance of and access to SCMs shall have a minimum width of ten feet, shall extend to a public ROW, and shall not include longitudinal or cross slopes that exceed 3:1 (horizontal to vertical). These are the requirements of General MDC 8.

Drainage easements for SCM facilities, including for conveyance systems transporting stormwater runoff from the SCM facilities, shall be held by the entity responsible for the operation and maintenance of the SCM facility, whether an individual, a corporation, a property owners' association, or a government. See the requirement in UDO Section 9.2.2.G.2 that drainage easements are required for all SCMs. Easements for SCMs that are not publicly maintained require provisions that allow the City to access the device for inspections and to perform maintenance and repair activities in the event the responsible party is failing to do so. In no case shall the recorded drainage easement confer an obligation on the City to assume responsibility for a private SCM or a public SCM that is the responsibility of a public entity other than the City.

7.5 DAMS

For existing or proposed dams that are not considered part of SCMs, the primary and emergency dam spillways shall be placed in drainage easements. The drainage easement shall include access to the dam from the ROW and the accompanying access shall not include longitudinal or cross slopes that exceed 3:1 (horizontal to vertical).

The type of drainage easement shall be as follows:

- Private property with privately maintained dam = private drainage easement
- Private property with publicly maintained dam = public drainage easement held by the public entity responsible for maintenance
- Public property with publicly maintained dam = no easement needed

The drainage easement shall grant rights to the parties considered owners of the impoundment. It also shall allow the City to access the device for inspections and to perform maintenance and repair activities in the event the responsible party is failing to do so. Such easement shall not confer an obligation on the City to assume responsibility of the dam.

7.6 FLOOD STORAGE

No increased ponding or conveyance depth shall be permitted on adjacent properties for the 100-year storm event, unless the increase is located within a drainage easement granted by the impacted property owner(s) to the owner(s) responsible for the increased ponding.

A backwater analysis will be required to be submitted to the City for new culverts to show possible impacts to flood levels both on site and on neighboring properties. If the backwater analysis shows there is an impact on neighboring properties for the 100-yr storm event, a drainage easement will be required.

For regulated floodplain areas, Chapter 9 of this Manual and UDO Article 9.3 may have more stringent requirements.

If development creating the increased ponding is on private property, a private drainage easement is required. If the development creating the increased ponding is on City property or in a City ROW, then a public drainage easement benefitting the City is required.

7.7 RECORDING DRAINAGE EASEMENTS

Drainage easement recordation on maps will take place via the City's Recorded Map process at the timeline specified in the project's conditions of development approval or in the UDO. Proposed maps depicting drainage easements are required to show metes and bounds for the drainage easement(s). Maps must label all drainage easements as "Private Drainage Easement", "City of Raleigh Permanent Drainage Easement", or "NCDOT Permanent Drainage Easement" or as public easement held by a public entity other than the City or NCDOT. The applicant may choose to include a parenthetical sub-label, but that is not a requirement of the City.

An instrument establishing the rights and obligations associated with private drainage easements associated with SCMs also shall be recorded in the Wake County Register of Deeds Office or the Durham County Register of Deeds Office, whichever shall apply. This can be accomplished through completion and recording of one of the City's locked templates for drainage easements, either the "Declaration of Maintenance Covenant and Grant of Protection Easements for Stormwater Control Facilities" (Maintenance Covenant) which applies to off-site SCMs that are shared devices among multiple lots, with the recording of the Maintenance Covenant required by UDO Section 9.2.2.G.2, or the [new document to be named].

7.8 RELEASE OF DRAINAGE EASEMENTS

There are specific cases where drainage easements may be relocated or removed.

- If a site relocates stormwater infrastructure, then the associated existing drainage easement(s) shall be released once the stormwater infrastructure has been relocated, with new drainage easement location(s) to be proposed during the development review process.
- If the existing drainage easement does not meet one of the purposes listed in this chapter and does not preserve a wider stream or channel buffer, then drainage easement release may occur through the City's Recorded Map process. Potential applicants are advised to discuss the property with a stormwater reviewer prior to application.

7.9 IMPROVEMENTS IN DRAINAGE EASEMENTS

This section defines what improvements are allowed and disallowed in private drainage easements and City of Raleigh Permanent Drainage Easements.

When evaluating proposed improvements to be constructed or installed within a drainage easement, the purpose of the drainage easement is evaluated. The following principles are applied:

A. The work must not permanently limit access for maintenance, repair, and replacement of the drainage infrastructure contained in the drainage easement.
B. The work must not increase the cost to the easement holder for conducting maintenance, repair, or replacement of the stormwater conveyance infrastructure or SCM contained in the drainage easement.
C. The work must not impede the flow of water through the drainage easement.
D. The work must not directly damage the drainage infrastructure contained in the drainage easement.
E. The work must not increase the loading on the drainage infrastructure beyond the load originally contemplated in the stormwater design.

The table below applies these principles to common situations. This table does not negate the need for other required permitting. Please contact a stormwater reviewer if there are questions about what improvements are allowed in a drainage easement.

Table 7.4 IMPROVEMENTS IN DRAINAGE EASEMENTS		
Proposed Item	**Allowed?**	**Conditions or Exceptions:**
Accessory Structures (e.g. Sheds, Garages, Carports, Coops, etc.)	Not Allowed	N/A
Buildings	Not Allowed for Residential, including the overhang of these structures. Conditional for Non-Residential.	Not allowed for residential structures. For Non-Residential structures: Underground SCMs may be placed under buildings when the specific requirements in Section 6.3.3 of this Manual have been met.
Decks/porches	Not Allowed, including the overhang of these structures.	N/A
Driveways	Conditional	- Allowed if stormwater conveyance pipes and SCMs meet City requirements for cover and loading per Chapters 4 and 6 of this Manual. - Not allowed in open conveyance systems unless perpendicular to the open conveyance system.
Fences	Conditional	Fences are allowed if they meet the following criteria, as demonstrated on the plot plan: - Crossing a conveyance system drainage easement perpendicular to the easement. - When running parallel to a conveyance system or SCM drainage easement, footings need to be a minimum of 5' from the pipe centerline/SCM edge or at a 1:1 slope away from the pipe or SCM invert, whichever is larger. AND - Not impeding flow AND - Not over a drainage structure AND - Posts in the easement will be hand dug. AND - A gate is provided for equipment to access any SCM or stormwater conveyance structure. The minimum gate width is 10 feet. If the gate is the primary access point for a SCM, then the gate width must accommodate the largest equipment needed for maintenance.
Headwalls, Endwalls and Wingwalls	Allowed	These structures are directly related to stormwater infrastructure.

Proposed Item	Allowed?	Conditions or Exceptions:
HVAC or Other Equipment	Conditional for Residential Not Allowed for Non-Residential	Allowed on residential lots if the conditions for fences are met. Not allowed on non-residential projects.
Patios and Private Pathways	Conditional	Allowed if the conditions for driveways are met.
Play Equipment	Conditional for Residential Not Allowed for Non-Residential.	Allowed on residential lots if the conditions for fences are met. Not allowed on non-residential projects.
Pools	Not Allowed	N/A
Retaining walls	Conditional	- In drainage easements around SCMs, retaining walls are allowed if Section 6.3.4 of this Manual is met. - Retaining walls with perpendicular intersections with drainage pipes are allowed if designed and permitted at the same time. - An application for new retaining wall(s) in an existing drainage easement containing stormwater conveyance infrastructure or SCM(s) must contain an analysis that addresses principles A through E at the start of this Section 7.9.
Signs	Conditional	- Signs on posts less than 6” in width or depth must follow the criteria for fences in this table. - Signs with larger footers are not allowed.
Vegetation - Planting (Trees, Shrubs, Landscape Beds)	Conditional	In general plants complement stormwater functions. Plants are allowed in drainage easements when the following are met as demonstrated on the plans: - Vegetation other than grass is not allowed within those portions of drainage easements that provide access to SCMs located within the drainage easements. - Plants cannot change the topography in a way that redirects flow outside the drainage easement. - Trees may not be planted directly over stormwater infrastructure that has less than five (5) feet of cover.
Vegetation - Planting (Grass)	Allowed	
Vegetation - Removal	Conditional	- Removal of vegetation shall not change the topography in a way that redirects flow to areas outside the drainage easement. - Removal of vegetation within SCMs must be performed according to the SCM design and O&M documents.

Chapter 8
EROSION AND SEDIMENT CONTROL

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8.1 INTRODUCTION

Erosion and sedimentation control devices and best practices are imperative in the protection of waterways, downstream properties, and infrastructure. This chapter describes the erosion and sedimentation control (ESC) requirements for the City. Adherence to this chapter, the City's UDO, City ESC Standard Detail Drawings, as well as to NCDEQ's *"Erosion and Sediment Control Planning and Design Manual"* is required.

Land Disturbance Grading (LDG) permits are required for all projects that disturb 12,000 square feet (0.275 acres) or more of land area. Prior to the issuance of a LDG permit, an ESC plan must be designed/submitted to and approved by the City. The approved plan must include ESC measures that shall be installed on the site prior to any land-disturbing activities. See UDO Article 9.4 for when permitting is required for less than 12,000 square feet of land disturbance.

All land-disturbing activities undertaken within the City shall provide ESC measures to protect public and private property from erosion and sediment damage as a result of the land-disturbing activity, regardless of the amount of land disturbed. Whether a LDG permit is required or not, ESC measures are required to be installed to protect from erosion and sediment as necessary for water quality and natural resource protection in our communities.

8.2 SELECTED DESIGN CRITERIA

All ESC measures shall be designed to the standards in NCDEQ's *"Erosion and Sediment Control Planning and Design Manual"*, the City's ESC Standard Detail Drawings, the City's UDO, or this Manual, whichever is more stringent.

8.2.1 Limits of Disturbance

The LOD shall include all land disturbing activity, as defined in UDO Article 12.2, and encompass all construction activities including, but not limited to, the following:

- Construction Access (minimum of 10 feet around structures or extended to the property line if the property line is less than 10 feet away from the structure)
- Equipment and Vehicle Parking
- Equipment and Vehicle Maneuverability
- Demolition
- Clearing and Grubbing
- Erosion Control Measures
- Material Staging and Storage
- Earthen Stockpiling
- Excavating and Filling
- Fine Grading

- Change of Cover (i.e. draining a pond)
- Dredging

8.2.2 Clean Water Diversions

Offsite runoff that naturally enters the disturbed area can be directed around the disturbed area as “clean water” via stabilized ditch or pipe/culvert. A stable diversion ditch shall be designed to the same standards as a temporary diversion ditch. However, when utilizing a ditch as a “clean water” diversion, seed and straw alone shall not be used for stabilization. A stable outfall shall be designed in combination with a ditch or piped conveyance. Treatment or detention of “clean water” runoff is not required and silt fence shall not be placed upslope of the “clean water” diversion.

8.2.3 Dewatering

When de-watering of an erosion control measure by pumping is required, the outflow of the pump shall be connected to a silt bag. The silt bag shall be installed per the City’s ESC Standard Detail Drawing, as the same may be amended from time to time, shall be placed on a flat area, and silt fence/silt fence outlet shall be placed at the downslope side of the bag. A City inspector shall be notified prior to dewatering.

8.2.4 Stockpile Requirements

Earthen stockpiles shall be shown on the ESC plan and setback from adjacent property lines to allow for construction access and installation and maintenance of surrounding ESC measures. Stockpile slopes shall be 2:1 or flatter. At no time shall a stockpile exceed a height of 35-feet. Stockpiles shall be removed prior to the end of the project and closeout of LDG permit.

8.2.5 Work in or Over Watercourses

Temporary bridges or culverts shall be employed when construction equipment is required to cross natural or constructed channels. These structures must be identified on the approved ESC plan and include the applicable City ESC Standard Detail Drawing. Prior to installing bridges or culverts, authorization may be required by State and/or Federal agencies.

When permitted work is required within an active watercourse, work must be conducted in the dry or a means of diverting the watercourse must be provided. All components of the diversion plan must be shown on the ESC plan with associated details provided. This includes grading for diversion channels, silt bag placement, impermeable berm locations, pump intakes, pump outlet and energy dissipation, and any other physical elements as applicable.

8.2.6 Sites One Acre or Larger

The NPDES General Construction permit, NCG010000 (NCG01), requires that land-disturbing activities disturbing one acre or more, or that are part of a larger common plan of development (as defined in the NCG01 permit), obtain NCG01 coverage under the NCG01 permit. An approved ESC plan and subsequent submission of electronic Notice of Intent (e-NOI) to NCDEQ with supporting information is required in order for the NCG01 permit to be issued by NCDEQ.

8.2.7 Sites 20 Acres or Larger

If 20 acres or more are included in the LOD, the following shall be required in the ESC plan submittal:

- Demonstrate how time of exposure and amount of exposed area is limited.
- Cut/fill analysis with an exhibit that shows where soil will ultimately be moved from one area of the tract to another between the pre-development and post-development conditions, which must include pre- and post-construction contours. When earthen material is proposed to be hauled off-site, the ESC plan must include the address(es) of the off-site location(s) where material is to be hauled, including applicable project name and permit number (when required).
- The construction sequence on the ESC plan shall detail phasing to justify the time and amount of exposure.

8.3 SINGLE-FAMILY RESIDENTIAL CONSTRUCTION AND LOTS WITH LOD UNDER 12,000 SF

8.3.1 Common Plan of Development and Permit Requirements

A LDG permit is required when 12,000 square feet or more of land disturbance will occur within a new proposed residential development (including demolition), on a single residential lot, or on multiple residential lots by the same person within the same residential subdivision. A person conducting land-disturbing activity is any individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, interstate body or other legal entity. A Subdivision is defined by one of the following: an active subdivision case or a subdivision as demonstrated by a map or other land record recorded in the applicable Register of Deeds office. Staff also will review the applicable county GIS parcel data and the subdivision layer in iMaps.

When determining the area of land disturbance, the square footage of disturbance shall be aggregated, regardless of:

- Whether the lots are under single or diverse ownership.
- Whether the lots are adjoining or not.
- The date of the subdivision.

The NCG01 permit requires a Certificate of Coverage from NCDEQ if a single-family lot(s) is within a common plan of development that disturbs one acre or more.

Unless otherwise required in Article 9.4 of the UDO, if a person disturbs less than 12,000 square feet within a common plan of development disturbing one acre or more, the City will not require a LDG Permit. However, a NCG01 permit must be obtained from NCDEQ which also requires ESC plan approval through NCDEQ

If a person disturbs 12,000 square feet or more within a common plan of development disturbing

one or more acre, the City requires a LDG permit. The LDG permit submittal to the City must include the items noted below in Section 8.4.5 of this Manual.

8.3.2 Requirements if LOD is under 12,000 sf

For all lots with a proposed LOD under 12,000 square feet that do not require a LDG permit, ESC measures are required to be installed per City ESC Standard Detail Drawing specifications and must be installed at or within the LOD shown on the City-approved plot plan. These measures must be appropriate for site and topographic conditions and include, but are not limited to, the following:

- Construction entrance for each point of access measuring, at a minimum, 12 feet in width by 20 feet in length and composed of two- to three-inch railroad ballast or at least six inches of surge stone per the City ESC Standard Detail Drawing. When existing paved driveways remain, the construction entrance shall extend from the point of entrance onto the site from the existing driveway.
- Silt fence/silt fence outlets on the low sides of the lot.
- ESC measures on high sides of lot to prevent off-site sedimentation and to restrict access to the construction entrance.
- Inlet protection if a catch basin or yard inlet is located within the limits of disturbance.

8.3.3 Groundcover/Stabilization Requirements for Lots with LOD under 12,000 sf

Projects on different lots will vary in size and the amount of land disturbance associated with each such project will also vary.

- For projects that result in a LOD of less than 400 square feet, permanent groundcover must be applied over 100% of the disturbed area prior to approval of final inspection of the Stormwater Control permit and issuance of Certificate of Occupancy. See Section 8.7.1, below, for groundcover specifications.
- For projects that result in a LOD of 400 square feet or more, permanent stabilization must be achieved prior to approval of final inspection of the Stormwater Control permit and issuance of Certificate of Occupancy. See Section 8.7.2, below, for stabilization specifications.

8.4 SUBMITTAL REQUIREMENTS

The following items are required for LDG permit approval.

8.4.1 Financial Responsibility/Ownership (FRO) Form

The original FRO form must be submitted to the City prior to LDG permit issuance. See the UDO for the FRO requirements and the City's stormwater website for specific submittal procedures.

8.4.2 Surety

A surety, as required in Section 9.4.4.A.1.c. of the UDO, must be supplied to the City for the area of land disturbance prior to LDG permit issuance. See the UDO for the surety requirements and the City's stormwater website for specific submittal procedures.

8.4.3 ESC Calculations

Design calculations associated with the ESC measures either shall be shown on the ESC plans or included in the SCR. Calculations must be sealed by a North Carolina licensed engineer, landscape architect, or land surveyor. The following shall be included as applicable:

- Sizing for sediment basins.
- Sizing for skimmers or other surface draw down devices.
- Sizing temporary diversion ditches or clean water diversions.
- Calculations for outlet protection.
- Calculations and a summary table for construction detention compliance per UDO Section 9.2.2.E.1.b. See Chapter 3 of this Manual for approved methods of analysis.
- Drainage area maps associated with the ESC measures.
- Narrative statements about assumptions and methodology.
- Cut/fill analysis as described in this Chapter 8 for sites over 20 acres.
- Any other calculations required by NCDEQ's *"Erosion and Sediment Control Planning and Design Manual"*.

8.4.4 Plan Requirements

All ESC plans required for land-disturbing activities, as identified in this Chapter 8, shall meet all of the following requirements:

- ESC plans shall clearly show existing and proposed site features, drainage features, jurisdictional streams, wetlands, and buffers, as well as any SFHAs.
- ESC plans shall clearly depict the proposed ESC measures including applicable City ESC Standard Detail Drawings and areas of required vegetative stabilization.
- ESC plans shall include notes, details, and a construction sequence (See Section 8.5, below) for the ESC measures proposed and sequence of installation.
- A copy of the approved ESC plan shall be maintained on the job site.
- The signature and seal of the North Carolina licensed engineer, landscape architect, or land surveyor who prepared the plan must be on each sheet of the ESC plan.
- Primary point of contact for the project, including name, address, email and phone number shall be included in the ESC plan.
- Total acreage for the property/site shall be provided in the ESC plan.
- Total proposed LOD on each ESC plan view sheet. Round to hundredths of an acre. Place the LOD in the ESC plan view sheet in a clearly visible box outlined in black.

- A note included in each ESC plan indicating that prior to commencing land-disturbing activities, the approved limits of land disturbance shall clearly and accurately be demarcated on the ground with stakes, ribbons, or other approved means, and shall be demarcated on the ground for the duration of the construction activity and no land disturbance shall occur outside the limits indicated on the approved ESC plan.

8.4.5 NPDES Plan Requirements

Although NCDEQ provides NCG01 coverage, to meet the requirements of the NCG01 permit, all of the following must be included in the ESC plan that is submitted to the City:

- The most recently approved detail sheets provided by NCDEQ (NCG01 Ground Stabilization and Materials Handling Plan sheet and the NCG01 Inspection, Recordkeeping and Reporting Plan sheet).
- A separate plan sheet titled “NPDES Stabilization Plan” to include required ground stabilization timeframes based on site areas as outlined in the NCG01 permit. The critical areas which require more stringent stabilization requirements must be hatched and an associated legend must be included.
- Drainage areas of one acre or more shall include the use of outlet structures that withdraw from the surface. These structures shall be included on the ESC plan.
- A statement block with the following standard language must be included on each NPDES Stabilization Plan sheet:
    - This page is submitted to comply with NPDES General Stormwater Permit NCG010000.
    - This page can be approved by the City pursuant to NPDES General Stormwater Permit NCG010000 only.
    - This page of the approved plans is enforceable exclusively pursuant to NPDES General Stormwater Permit NCG010000.
    - The City is not authorized to enforce this page of the plans and it is not a part of the approved plans for purposes of enforcement action under the City Code.

8.4.6 Plan Revisions

Changes to construction sequence on approved ESC plans must be discussed with a City stormwater inspector and noted on approved ESC plans. Changes to the sequence that result in a lack of installation, delay of installation, or change in ESC measures will require an ESC plan revision. In addition, if the measures installed are not functioning and/or do not meet applicable City requirements, City stormwater inspections staff will require an ESC plan revision.

8.5 CONSTRUCTION PHASING AND SEQUENCING

All land-disturbing activities must be planned and conducted to prevent erosion on-site, which could result in off-site sedimentation. To meet these objectives, ESC plans require multiple

phases as construction progresses. The number of phases necessary for a project will be site-specific and based on the complexity and/or sequencing of the site development.

Once LDG permits are issued, the construction sequence is part of the approved ESC plans and must be followed.

8.5.1 Initial Phase of Construction

An erosion control construction sequence shall be included with all ESC plans, broken out by phase as necessary. The construction sequence provided in an ESC plan for the initial phase of construction shall include, at a minimum, all of the following items:

1. *After obtaining a Land Disturbance Grading permit but prior to beginning construction, schedule an on-site pre-construction meeting with the City Stormwater Inspections Regional Coordinator (Inspector Name) at (Inspector's Phone Number). (See map of Regional Coordinators) The project's limits of disturbance shall be demarcated on-site.*
2. *Install all perimeter erosion and sedimentation control measures including silt fence, silt fence outlets, and construction entrances as well as sediment basins. Limit clearing and land disturbing activity to only the area necessary to install the permitted measures. After construction of temporary diversions, berms, and basins, groundcover shall be installed immediately.*
3. *Schedule an initial Land Disturbance Grading permit inspection through the City Permit and Development Portal.*
4. *Upon approval of the Land Disturbance Grading permit initial inspection, commence bupermitted land disturbing activity.*
5. *For sites greater than one acre, erosion control measures shall be inspected by the financially responsible party and maintained at least once per week and after every rainfall event.*

★ *Modify and add sequencing for site specific details (for example, stream crossing sequencing, installation of clean water diversions) as necessary.*

8.5.2 Intermediate Phasing of Construction

One common error in ESC plan design is a failure to provide adequate intermediate phasing to address evolving construction activities. Phasing must follow changes to the site during construction, both in topography and development/construction activities. Some of these intermediate phasing activities may include, but are not limited to:

- Bypass of off-site and on-site water.
- Stream crossings.
- Rough grading of the site.
- Installation of infrastructure including stormwater conveyance system.
- Fine grading.

- Installation of pavement.
- Building construction.

Intermediate phasing and associated construction sequencing may also need to address the relocation or resizing of specific erosion control measures. This intermediate phasing must be clearly addressed in the construction sequence and shown on the ESC plans with notes/callouts notating the sequential nature.

Later phase(s) of the ESC plan must include a plan to keep sediment from the building site from being washed onto the pavement and tracked off-site. The ESC plan must include ESC measures around the building's LOD with controlled openings/access points for construction access. These ESC measures help prevent tracking of sediment from un-sodded/non-stabilized areas around active building construction onto the newly paved surfaces and then off the site.

The construction sequence provided in the ESC plan for the intermediate phase of construction shall include, at a minimum, all of the following items:

1. *All erosion and sedimentation control measures shall be inspected and maintained throughout construction.*
2. *Stabilization is required within 14 calendar days of completion of any phase of grading or inactivity on the project site.*
3. *Install additional erosion and sedimentation control measures when instructed by a City stormwater inspector.*

★ *Modify and add sequencing for site specific details (for example, basin removal/relocation/sizing, silt fence installation around buildings) as necessary.*

If the site requires a Stormwater Conveyance System permit, the following also will be added to the intermediate construction sequence in an ESC plan:

- *As stormwater infrastructure is installed, install inlet protection or other approved ESC measures as shown on the ESC plan.*
- *After all stormwater infrastructure is installed, submit a red-lined approved ESC plan to the City with as-built conditions of the stormwater conveyance system.*

8.5.3 Final Phase(s) and Project Close-Out

All ESC plans shall have a final phase that includes permanent stabilization of the site and removal of ESC devices. This is required even if the owner/developer has submitted separate plans for further development on the site.

The construction sequence provided in the ESC plan for the final phase of construction shall include, at a minimum, all of the following items:

1. *Site stabilization is required prior to final approval of Land Disturbance Grading permit and issuance of Certificate of Occupancy. [Insert site specific stabilization requirements, see Section 8.7, below]*
2. *No temporary erosion and sedimentation control measures shall be removed without*

prior approval by a City stormwater inspector.

3. *Once approved, remove remaining temporary erosion and sedimentation control measures. All permanent erosion control measures [for example, permanent ditch stabilization, riprap outlet protection] must be installed and functioning at this time.*
4. *Schedule a final Land Disturbance Grading permit inspection through the City Permit and Development Portal.*

★ *Modify and add sequencing for site specific details (for example, basin conversion, pipe flushing) as necessary.*

If the site requires a Stormwater Conveyance System permit, the following also will be added to the final construction sequence in an ESC plan:

Stormwater Conveyance System As-built Certification

- *Once the stormwater conveyance system has been installed, prepare a surveyed as-built of the stormwater conveyance system.*
- *Submit the Stormwater Conveyance As-built Submittal Checklist and required checklist items to the City.*

Stormwater Conveyance System Pipe Inspection Certification

- *After the stormwater conveyance system as-built certification has been accepted by the City and when the area draining to the stormwater conveyance system is at least 70% stabilized, consult with a City stormwater inspector and, upon approval, flush sediment from conveyance system.*
- *Flushing the conveyance system shall not result in sediment laden water in the downstream system, stream, and/or wetland.*
- *The contractor shall coordinate and provide closed-circuit television (CCTV) inspection of all stormwater infrastructure 12" or greater and less than 72" (both public and private).*
- *For stormwater conveyance infrastructure 72" or greater, a Bridge Inspection Report, in compliance with National Bridge Inspection Standards (NBIS), must be sealed by a North Carolina-licensed professional engineer.*
- *If defects are identified during pipe inspection, submit a repair plan to the City, correct the defects, and conduct additional pipe inspection(s) to confirm defect correction.*
- *When the stormwater conveyance system (both public and private) is free of defects, submit the Stormwater Conveyance Pipe Inspection Checklist and required checklist items to the City. This must be submitted a minimum of 7 days prior to scheduling the Final Stormwater Conveyance System Permit Final Acceptance inspection.*

If the site includes conversion of ESC measures to permanent, post-construction SCMs (See Section 8.6, below), all of the following shall be addressed in the final construction sequence in an ESC plan:

- *When the area draining to the SCM is at least 70% stabilized, consult with a City stormwater inspector and, upon approval, install and/or convert the erosion control measures to the permanent SCM.*

ESC plans shall address conversion of ESC devices within the construction sequence. Reference Section 8.6, below, for guidance regarding conversion to post-construction SCMs.

- *As-built certifications of all post-construction SCMs on-site must be provided/approved by the City a minimum of seven calendar days prior to scheduling the final inspection. Refer to the Stormwater Control Measure (SCM) As-Built Submittal Checklist for required items and submittal process. As-built device certifications must be approved in writing prior to a Certificate of Occupancy or Certificate of Compliance being issued.*

The construction sequence in the ESC plan for the final phase of construction also shall include any information or certifications that are required prior to final approval of permits and/or Certificates of Occupancy, as detailed below:

- *As-built impervious surveys are required if impervious restrictions are a permit condition of approval for a project and shall be sealed by a North Carolina-licensed surveyor.*

For any projects subject to the NPDES NCG01 permit, include the following:

- *Projects subject to the NPDES NCG010000 permit also may apply to NCDEQ for termination of coverage of this permit after the City's approval of the final Land Disturbance Grading permit inspection and issuance of Certificate of Completion.*

8.6 POST-CONSTRUCTION SCM

For post-construction stormwater designs that include stormwater ponds, wetlands, or similar SCMs, it is common practice for the SCM to be installed initially as a temporary sediment/skimmer basin. The timing of conversion from temporary to permanent control measure depends on the exposed areas and continued land disturbance. **Table 8.1.**, below, provides general guidance (not device-specific) for the planning and conversion of ESC measures to post-construction SCMs. The ESC plan must account for these items and provide a site- and device-specific phasing plan for the conversion of any ESC measures to post-construction SCMs in the construction sequence.

TABLE 8.1
CONVERTING ESC MEASURES TO POST-CONSTRUCTION SCMS

Topic	Conversion Guidance
Drainage Areas	Drainage areas shall be limited by the applicable post-construction SCM design specifications, even if construction phase drainage areas could be larger. This means that sites may have to be divided into smaller drainage areas with the use of multiple ESC basins and other ESC measures.
Grading to Blend into Topography	Some temporary ESC measures are graded into slopes, have steep embankments or side slopes, and otherwise do not blend well into the surrounding topography. These types of ESC measures are not good candidates to convert to post-construction SCMs, unless regrading is part of the conversion plan. A sounder approach is to design the temporary ESC measure so that this type of regrading is not necessary, which may include changing the footprint, grading, slopes, and other features of the ESC measure.
Stabilizing the Drainage Area	Ensure that the contributing drainage area is stabilized prior to conversion. This is a positive aspect to using ESC basins because they cannot be removed until their erosion control function is complete. Therefore, the tendency to prematurely install post-construction SCMs is lessened. The conversion can proceed when City stormwater inspectors indicate that the drainage area is properly stabilized. In addition to drainage area stabilization, other supplemental ESC measures may be warranted, such as diverting flow around an ESC measure during the conversion process and using silt fence or matting/sod on the side slopes of an ESC measure.
Removing Construction Sediment	All construction sediment shall be removed as the first step in the conversion process. This requires flushing all stormwater infrastructure of sediment and dewatering the ESC measure using an approved dewatering and sediment capture method (e.g. silt bags). All notification requirements of applicable permitting agencies shall be met prior to and during dewatering the basin for conversion.
Excavating Below the ESC Measure Bottom Elevation	The bottom of the post-construction SCM shall be at least one foot lower than the temporary ESC measure bottom elevation. It is important that the bottom of the post-construction SCM will be in undisturbed soils that have not been impacted by construction activities. During excavation to the post-construction design elevation, scarify or rip the underlying soil to promote infiltration.
Installing Underdrains	It is recommended that a permanent riser be installed while the ESC device is temporary if it will have underdrains as a permanent SCM. During the conversion to a permanent measure, the underdrains then will be installed.
Post-Construction SCM Installation	Install the SCM per the approved construction plans. Sequencing items specific to the proposed SCM design must be detailed. Some minor grading or adjustments to the footprint may be needed to meet the post-construction

Easement/SCM Location Awareness	Because the post-construction SCM must be located within a permanent drainage easement, it is very important to make sure the final SCM is within the specified area of the permanent drainage easement to avoid costly relocation of the SCM or re-recordation of the required permanent drainage easement.

8.7 GROUNDCOVER VS. STABILIZATION

NCDEQ surface stabilization standards and specifications found in its *"Erosion and Sediment Control Planning and Design Manual"* and the groundcover/stabilization requirements of this Manual shall be adhered to throughout construction. Whenever they are in conflict, the more stringent shall apply.

8.7.1 Groundcover

When a land-disturbing activity occurs, the person undertaking the activity shall install groundcover, devices, or structures sufficient to restrain erosion and always retain sediment within the approved LOD.

The City approves the use of many types of groundcover, including but not limited to, seed/straw, seed/straw/tackifier, hydroseed, rolled erosion control products (e.g. matting), pine or hardwood mulch, and tarps and landscaped areas (e.g. shrubs, trees, pine straw). It is important to identify what type of groundcover(s) is suitable for a site. Aspects to consider include landscape position, slope, sun/shade exposure, soil type, duration of groundcover application, and/or stabilization requirements at project completion.

Groundcover is required on any portion of a site upon which further land-disturbing activity has ceased (temporarily or permanently). When demolition is complete and prior to building commencement, groundcover must be applied. It is important to comply with timeframes for groundcover application. These timeframes must be clearly identified in the construction sequence on the approved ESC plans. Refer to UDO Article 9.4. for the City's most current groundcover requirements. If more stringent, state and/or federal timeframe requirements for groundcover application shall be followed.

When land-disturbing activities have ceased but final grade has not yet been established, temporary groundcover may be used. However, when final grade has been met, permanent groundcover must be installed, and permanent stabilization must be achieved.

8.7.2 Stabilization

The application of groundcover is intended to counteract the erosive influences of rain and wind on bare soil and is effective at preventing erosion until permanent stabilization has been achieved.

Stabilization of soil can be achieved using one or a combination of the following methods:

- Grass – permanent groundcover must be applied over 100% of the disturbed area. Permanent stabilization is achieved when there is 100% growth and 80% density of permanent groundcover with no evidence of erosion.
- Sod – when seed is applied to a site and is unable to germinate, sod may be utilized to

achieve permanent stabilization. Sod must be installed so that it does not move and/or create voids that could cause areas of accelerated erosion. Sod is considered permanent stabilization when roots have been established. If environmental or mechanical conditions prevent the installation of sod this will result in delay of Certificate of Occupancy and/or Certificate of Compliance.

- Artificial/Synthetic Turf – when artificial/synthetic turf is utilized for stabilization, it must be approved/permitted by the City prior to installation and will be considered 100% impervious unless permitted as a stormwater control device.
- Gravel, Concrete, or other Impervious Surface (See definition in UDO Article 12.2)/ Built Upon Area (See definition in UDO Section 9.2.1.F.1) – When using impervious surface/built upon area for stabilization, it must be approved/permitted by the City prior to installation and may include parking lots, buildings, gravel, and rip rap.
- Landscaping – shrubs, trees, pine straw, and/or mulch must be used in combination with any of the above methods and cannot be the sole method to stabilize a site. When utilizing mulch, triple-shredded hardwood mulch must be applied at a depth of six inches to prevent movement.
- Native plants – the use of native plants is encouraged to stabilize sites. When temporary wetland, riparian buffer, and/or stream bank impacts have been approved by the appropriate agency, stabilization shall include installation of permanent native grasses/trees/shrubs/plugs. This permanent vegetation must be applied to 100% of the disturbed area and is not considered permanently stabilized until 100% growth and 80% density is achieved with no evidence of erosion.

8.7.2.1 Stabilization for Permit Close Out/Certificate of Occupancy

Permanent stabilization is required prior to closing out LDG permits, closing out Stormwater Control permits with 400 square feet or more of land disturbance, and/or prior to issuance of Certificates of Occupancy or Certificates of Compliance.

Chapter 9

FLOODPLAIN MANAGEMENT

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9.1 INTRODUCTION

The City is a participating community in FEMA's National Flood Insurance Program (NFIP). The City, the North Carolina Floodplain Management Program (NCFMP), and FEMA have identified more than 23 square miles of floodplain, otherwise known as flood-prone areas or Special Flood Hazard Areas (SFHA), within the City's ETJ. The implementation and enforcement of the City's Floodplain Management Program has far-reaching effects, including but not limited to the ability for our residents to obtain flood insurance under the NFIP.

9.2 TYPES OF SPECIAL FLOOD HAZARD AREAS

The City currently recognizes four types of floodplains as SFHAs: those identified as FEMA-designated, those identified by a drainage basin study, those identified by a flood study, and those identified by flood hazard soils. Any development within any of these three areas is subject to the City's SFHA regulations (UDO Article 9.3).

9.2.1 FEMA-Designated SFHA

FEMA mapping includes only areas with a contributing drainage area of at least one square mile (640 acres).

9.2.2 SFHA Based on Drainage Basin Study Maps

The City completes drainage basin studies that produce mapped flood hazard areas to supplement FEMA's Digital Flood Insurance Rate Maps (DFIRMs). The City Drainage Basin Study Maps use the same criteria as DFIRMs to illustrate SFHAs with a contributing drainage area that is typically at least 100 acres but less than one square mile (640 acres). A list of all completed drainage basin studies may be found on the City's stormwater website. The City performs drainage basin study updates periodically.

9.2.3 SFHA Based on Flood Study

The City requires that a flood study be completed to determine base flood elevations for any stream located on or intersecting a development site that has a drainage area of 25 acres or more. Sites containing, or adjacent to, streams that drain greater than or equal to 25 acres and less than 100 acres must complete a Simple Flood Study. Sites that drain 100 acres or more must complete a Comprehensive Flood Study. See Section 9.5.1, below, for the details about these study types and their requirements.

Additional information about flood studies can be found in the NCDOT Guidance for Drainage Studies and Hydraulic Design.

9.2.4 SFHA Based on Flood Hazard Soils

Flood hazard soils are soil types defined in UDO Article 12.2. and are illustrated on the most recent paper copy of the Wake County or Durham County Soil Survey map, whichever shall apply.

There are several options for how to establish the SFHA and the Regulatory Flood Protection Elevation (RFPE) for flood hazard soils:

- Use the delineation from the published Wake County or Durham County Soil Survey map, whichever shall apply, as the SFHA. Determine the RFPE as described in UDO Article 9.3.4.
- A North Carolina-licensed soil scientist may establish the presence, highest elevation, and extent to which the flood hazard soils exist on the project site.
- A flood study may be used as is detailed in Section 9.5.1, below.

9.3 FLOODPLAIN DEVELOPMENT REQUIREMENTS

To reduce vulnerability during future flood events, the SFHA regulations set forth by the City exceed FEMA minimum floodplain management standards. Adoption of these higher standards reduces the risk of loss of life and decreases the amount of damage in future floods.

Specific requirements for SFHA regulations can be found in UDO Article 9.3.

9.4 PERMIT APPLICATION

The submittals for a site in the floodplain shall adhere to the requirements in UDO Sections 9.3.2 and 9.3.11 and the requirements below.

- Certification with supporting technical data by a registered PE licensed in the State of North Carolina is provided to the City's Floodplain Administrator and/or his or her designee. Exclusions are determined based on FEMA-480 Floodplain Management Requirements. Floodway realignments must be approved by the City. If a floodway realignment is being requested, the applicant shall submit all necessary data for review, as per the *Flood Study Submittal Checklist*.
- See Section 9.5, below, for the requirements for flood studies, including Conditional Letter of Map Revision (CLOMR) and No-Rise/No Impact studies.
- On sites that create or reconfigure parking, the parking lots must be elevated to ensure the elevation of the lowest parking space is no more than 6 inches below the RFPE. This provision does not apply to single-family lots.
- For sites that require elevation certificates and/or floodproofing certificates:
    - The applicant submits required certifications upon the completion of the project.
    - The applicant schedules the final floodplain inspection through the City Permitting and Development Portal, once the required elevation certifications are approved by the City.
    - The City closes out the flood permit (UDO Section 9.3.2). If the flood permit is not closed out, then a Certificate of Occupancy will not be issued.

- For sites that require a Letter of Map Revision (LOMR), the applicant must submit a LOMR to the City within 6 months of the Certificate of Occupancy being issued or completion of construction, whichever occurs first, per FEMA's LOMR requirements.

9.5 FLOOD STUDY REQUIREMENTS

Flood study requirements are found in the *Flood Study Submittal Checklist* on the City's stormwater website. Flood studies shall be submitted as indicated on the website and in this Manual.

9.5.1 Local Flood Study Requirements

Flood study requirements are broken into two categories. Note that when a Simple Flood Study is required, a Comprehensive Flood Study may be performed instead.

TABLE 9.1
LOCAL FLOOD STUDY REQUIREMENTS

Location of Development	Study Requirement
Flood hazard soil areas that drain 5 acres or less	No study required
Flood hazard soil areas that drain more than 5 acres and less than 100 acres	Simple Flood Study required
Non-flood hazard soils that drain between 0 and 25 acres	No study required
Sites containing or adjacent to any stream that drains greater than or equal to 25 acres and less than 100 acres	Simple Flood Study required
Flood hazard soil areas or sites containing or adjacent to any stream that drain 100 acres or more	Comprehensive Flood Study required

- Simple Flood Study
  - Establishes the 100-year future conditions water surface elevation for the cross-section locations.
  - Shall be used to establish the RFPE.
  - Floodway determination not required.
  - Approved methods include: HEC-RAS, Manning's equation, or NCDOT standard headwater analysis.
  - If there is a structure on the property or downstream that influences the WSEL on the property, then a method (see Table 3.1 of this Manual) that accounts for backwater from that structure is required.

- Comprehensive Flood Study
    - Establishes the 100-year future conditions water surface elevation for the cross-section locations.
    - Shall be used to establish the RFPE.
    - Delineates the Floodway versus Floodway Fringe.
    - Approved methods include: One-Dimensional or Two-Dimensional Steady Flow Models capable of modeling ineffective flow areas and developing a floodway that is listed by FEMA as “Hydraulic Numerical Models Meeting the Minimum Requirement of National Flood Insurance Program”.

For both types of studies, analysis must be performed, at a minimum, along the following locations (i.e. cross-sections)

- Upstream and downstream property lines.
- Upstream and downstream of every structure with hydraulic impacts (e.g. dams, bridges, culverts, weirs).
- Representations of each change in channel and floodplain shape, slope, or roughness.
- Flow change locations (e.g. tributary or pipe inflow locations).

Flood study submittal process:

- Flood studies shall be submitted to the City as a separate development review case.
- See the City stormwater website for the checklist, submittal process, and review turnaround times.

9.5.2 FEMA Flood Map Changes

To make changes to the adopted maps within FEMA flood-prone areas, an applicant must complete an application to FEMA for a CLOMR, LOMR, Letter of Map Revision based on Fill (LOMR-F), or Letter of Map Amendment (LOMA), where appropriate. All of these map change documents are issued by FEMA and individual submittal requirements can be found at www.fema.gov.

A CLOMR is required when a proposed project will, upon construction, affect the hydrologic or hydraulic characteristics of a flooding source, thus resulting in the modification of the existing regulatory floodway, the effective Base Flood Elevation (BFE), or extents of the SFHA. The CLOMR does not revise an effective DFIRM; however, it indicates that the project, if built as proposed, will revise the effective DFIRM. City staff approval of the change is required prior to an applicant submitting a CLOMR application to FEMA (UDO Section 9.3.4.B). A public hearing must be held for the City Council to approve the flood map change associated with a CLOMR. This public hearing cannot be scheduled until after obtaining approval from City stormwater review staff. City Council and FEMA approval can run concurrently, and the project can be approved once all three approvals have been obtained. Each CLOMR must be followed by a LOMR (issued by FEMA) confirming that the project was built as designed, with the LOMR to be submitted to the City no later than 6 months after completion of the project per FEMA requirements. In cases where the City is not requiring the modification of the existing regulatory floodway (i.e., required road or utility crossing), all three approvals must come

before the first City approval of the project.

A LOMR is FEMA's official modification to an effective DFIRM and shall be submitted by the applicant within 6 months of the project's completion of construction or issuance of a Certificate of Occupancy, whichever occurs first.

A LOMR-F is FEMA's official modification to the effective DFIRM outside of the regulated Floodway. This shall be submitted to FEMA within 6 months of the modification.

A LOMA is a letter that reflects an official revision and/or an amendment to an effective DFIRM. If a property owner thinks its property has been mapped in an SFHA in error, it may submit a request to the City and FEMA for a LOMA. Note that a LOMA may not necessarily need a flood study and may be based on surveyed data.

9.5.3 No-Rise/No Impact

A No Impact study may be submitted to show the project will have no effect on the characteristics of the floodplain. This may be required by UDO Article 9.3 or can be submitted to show encroachment into the FEMA Floodway without going through the CLOMR process. If there is no impact to the published flood elevations, then City stormwater review staff can administratively approve the project with a detailed engineering analysis. The No Impact Study must be submitted and approved by City stormwater review staff before a flood permit can be issued (submittal guidelines can be found on the City's stormwater website). The City's flood permit file must have a record of the results of this analysis, which shall be in the form of a No-Impact Certification. This No-Impact Certification must be supported by technical data and signed and sealed by a North Carolina-licensed PE . The supporting technical data shall be based on the standard step-backwater computer model used to develop the 100-year annual floodplain shown on the DFIRM or Flood Boundary and Floodway Map (FBFM).

9.6 ELEVATION CERTIFICATE PROCESS

The following certifications, if required by UDO Article 9.3, must be received, reviewed, and approved by City stormwater staff prior to the final flood permit inspection. All required documentation shall be submitted to the City prior to scheduling final floodplain inspection and issuance of a Certificate of Occupancy.

9.6.1 FEMA Elevation Certificate

For structures located within FEMA-designated floodplain areas, the current effective FEMA Elevation Certificate form must be used. Find more information on the Elevation Certificate Form.

9.6.2 City of Raleigh Lowest Floor Certificate

For structures located within non-FEMA-delineated floodplains, a Lowest Floor Certificate form must be used; this form can be found on the City's stormwater website.

9.7 FLOODPROOFING CERTIFICATE

New construction or substantial improvement of nonresidential or residential accessory structures located in SFHA areas may utilize floodproofing measures. Residential buildings are not allowed to floodproof.

Applicants must use the current FEMA Floodproofing Certificate. A link may be found on the City's stormwater website.

9.8 SUBSTANTIAL IMPROVEMENT OR SUBSTANTIAL DAMAGE

If the cumulative cost of improvements and repairs to an existing structure in a SFHA is greater than or equal to 50% of the market value of the structure over any five-year period, that structure is considered substantially impacted and must be brought fully into compliance with current City SFHA regulations (UDO Section 9.3.5.B.6). Market value will be determined by the tax value of the structure, per the Wake County Real Estate records, if the applicant does not provide the City with an appraisal of the structure's value signed and sealed by a North Carolina-licensed general appraiser (building only, no land value). See Equation below for calculating substantial improvement or substantial damage.

[EQ] $$\frac{\mathbf{5}-\textit{year Cumulative Cost of Improvements and Repairs}}{\textit{Pre}-\textit{Improvement or Pre}-\textit{Damage Market Value Condition of Building}} \geq \mathbf{50}\%$$

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