**City of Raleigh Stormwater**

# STORMWATER DESIGN MANUAL

Version 3 Draft – September 5, 2023

## Chapter 1

# 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 and 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 relevant to stormwater management activities in the Raleigh area. Although it is intended to establish uniform design practices, it neither replaces the need for sound engineering judgment, nor precludes the use of information not presented. 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.

### 1.3.1 Watercourse Buffers

Watercourse buffers, also known as riparian buffers, help protect water quality. These 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) |

**Permit Information:**

Watercourse Buffer permits are issued for all projects that have a regulated watercourse buffer on site. 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 USGS 7.5 Minute Quadrangle Map or published Wake or Durham County Soil Survey Map.

Watercourse Buffer permits are also issued for projects 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 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 relevant 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

**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:
    - United States Geological Survey (USGS) 7.5-Minute Quadrangle Maps
    - National Map Viewer
- The digital version of the last paper copy of the NRCS Soil Survey maps including the Wake County 1970 maps and Durham County 1976 maps. The paper copies depict streams, which are not depicted on the current digital maps (Web Soil Survey). Steams on these maps are used for surface water and buffer identification purposes.
    - 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 last paper copy of the 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 closed-circuit television (CCTV) submittals is also in Chapter 4.

| UDO Section(s) | Design Manual Chapter(s) | Permit(s) |
|---|---|---|
| NA | **Chapter 4 Stormwater Conveyance Design**<br>Chapter 3 Hydrology<br>Chapter 7 Easements | Stormwater Conveyance (SCON) |

**Permit Information:**

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

- Is located in the public right-of-way.
- 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.

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 systemsrequire CCTV inspection and as-built certification submittal to and acceptance by 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
- ASCE 15-17 “Standard Practice for Direct Design of Buried Precast Concrete Pipe using Standard Installations (SIDD)” 2017.
- 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, 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 considers 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**<br>**Chapter 6 SCM Design**<br>Chapter 3 Hydrology<br>Chapter 7 Easements | Stormwater Control (SC)<br>Stormwater Control 2 (SC2) |

**Permit Information:**

Stormwater control permits are issued for properties that are increasing or substituting impervious area. Properties fall into two categories of requirements:

- ***Exempt Property Requirements:*** UDO 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 9.2.2 B through H. Instead, those properties can meet the impervious surface limitations defined in 9.2.2.A. These impervious surface limitations may be exceeded with constructed stormwater controls or engineering studies prepared by a qualified licensed professional as described in the UDO and in Chapter 5.
- ***Traditional Stormwater Requirements:*** UDO 9.2.2.B through H requires full stormwater calculations prepared by a qualified licensed professional. These rules address water quality (UDO 9.2.2.B Nitrogen Reduction) and runoff control (UDO 9.2.2.E Stormwater Runoff Controls). Typically, the development constructs one or more stormwater control measure (SCM) to meet those requirements. Calculations are documented in the SCR.

**Underlying Regulations:**

- NPDES MS4 Permit
- NC Neuse Nutrient Strategy Rules.
- North Carolina Department of Environmental Quality (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**<br>Chapter 3 Hydrology | Land Disturbance – Grading (LDG) |

**Permit Information:**

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

**Underlying Regulations:**

- NC Sedimentation Pollution Control Act of 1973
- 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 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**<br>Chapter 3 Hydrology<br>Chapter 7 Easements | Floodplain (FL):<br>FL (FEMA)<br>FL (non-FEMA) |

**Permit information:**

Flood permits are required for all development activities conducted on a property that contains floodplain, as defined in the UDO and this Manual.

**Underlying Regulations:**

- Federal Emergency Management Agency (FEMA) Floodplain Regulations
- Local requirements, as stated in the UDO and this Manual, that extend floodplain protections upstream of the limits studied by FEMA.
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**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 and Metro-Park Overlay District

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<br>Chapter 6 SCM Design<br>Chapter 3 Hydrology<br>Chapter X Easements | Water Supply Watershed (WSWP) |

**Permit Information:**

Watershed permits are issued for projects within a regulated overlay district.

**Underlying Regulations:**

- NC Water Supply Watershed Regulations
- Swift Creek Land Management Plan

**Required Reference Material:**

See 1.3.1 Watercourse Buffers and 1.3.3 Stormwater Management for the required reference materials.

## 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:

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- NC Water Supply Watershed Regulations
- NPDES MS4 Permit
- NC Neuse Nutrient Strategy Rules.
- NC Sedimentation Pollution Control Act of 1973
- Federal Emergency Management Agency (FEMA) Floodplain Regulations

The following regulations are not directly implemented by the City. Applicants must apply for permits directly with the 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 404 & 401 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 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 |
| EPA | Environmental Protection Agency |
| ESC | Erosion and Sediment Control |
| FEMA | Federal Emergency Management Administration |
| 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 |
| MDC | Minimum Design Criteria |
| MS4 | Municipal Separate Storm Sewer System |
| 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 |
| PP | Polypropylene |
| PVC | Polyvinyl Chloride |
| RFPE | Regulatory Flood Protection Elevation |
| ROW | Right-of-Way |
| RCP | Reinforced Concrete Pipe |
| SCM | Stormwater Control Measure |
| SCR | Stormwater Compliance Report (City-specific) |
| SFHA | Special Flood Hazard Area |
| UDO | Unified Development Ordinance |
| USACE | United States Army Corps of Engineers |
| WSEL | Water Surface Elevation |
| WSWP | Water Supply Watershed Program |
| WQv | Water Quality Volume |

## 1.8 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 9.2.1.F.

**City Standards**
Requirements for design, construction, and maintenance of stormwater infrastructure. These standards include the City Stormwater Management Design Manual, City Code, 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.

**Lot Grading Plan (LGP)**
See Chapter 2.

**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.

**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.

**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)**
City document that contains most local regulations 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 Lot Grading Plan (LGP) is required as detailed in Section 2.1.1. below. It serves as a visual summary of drainage information related to a development. The LGP will be required at site or building permit review, whichever comes first.

Preparation of the LGP requires familiarity with this Manual, particularly the following chapters:

- Chapter 4 – Stormwater Conveyance Design
- Chapter 7 - Easements

### 2.1.1 LGP Applicability

An LGP is required for projects that meet the following:

- Under 1 acre (one and two unit detached residential) or 0.5 acre (all other development types) or over 1 acre (one and two unit detached residential) with impervious area of 5% or less.

AND

- Adding impervious area or performing grading or changing how flow leaves the property.

LGP are not required for the following situations:

- 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 traditional stormwater requirements in UDO 9.2.2.B through H and include grading and drainage plans.

Note that there may be other plot plan requirements even in situations where an LGP is not required.

### 2.1.2 LGP Submittal Requirements

Lot grading plans shall contain the following information at minimum:

- Existing and Proposed Topography at a minimum of 2-foot intervals
- Flow patterns represented by arrows
- Arrows showing where flow leaves the lot
- Top and bottom elevations for retaining walls

- First floor elevation for every building
- Existing and proposed stormwater conveyance system infrastructure
- Proposed downspout connections to the existing or proposed storm drain system
- Proposed downspout flow path when discharging within 10 feet of the property line.
- Swale typical cross-sections
- Adjacent street and sidewalk elevation(s)
- Locations of proposed septic tank(s) and drainfield(s)
- Location of porches, decks, swimming pools, AC pads, doorways, sheds, and other accessory structures
- Easements (existing and proposed) and building setbacks (per Stormwater Management Design Manual, Chapter 2, Section 2.9)
- Limits of disturbance
- Existing environmental features, including: Special Flood Hazard Areas, Wetlands, Streams, Watercourse Buffers

After an LGP has been submitted and approved, any changes to the proposed development that may impact the lot grading and/or stormwater flow patterns will require a new LGP submittal for review and approval.

### 2.1.3 LGP Design Considerations and Requirements

Below are the considerations and requirements that shall be taken into account during design of the LGP for both single-lot and multi-lot development:

- When placing fill on a single-lot development, existing flow patterns and concentrated stormwater discharge locations shall be maintained to the maximum extent practical. Where that is not possible and new concentrated flow discharge locations are created, the lot shall drain to an available drainage swale or system (with appropriate easement). Calculations shall be submitted to demonstrate adequate conveyance capacity of the swale or system. When existing swales are not available, a swale may be placed entirely on the applicant's property or along the property line of the adjacent property with the impacted property owner(s) approval and easement recordation, as appropriate.
- 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.
- When roof drains are proposed as surface drainage, provisions shall be included to

discharge roof drain flows away from the building foundation and to control erosion at the discharge point.

- Reverse slope driveways without associated engineered drainage design will not be allowed as they would likely fail to drain during major rainfall events.
- Any downspouts or other concentrated discharge shall be offset from the property line by a minimum of 10 feet (or at the building setback line, whichever is less) a City right-of-way (ROW), or public/private drainage easement.
- If newly concentrated stormwater discharge locations are created by the proposed development, then stormwater flows from these new discharge locations shall be conveyed through an offsite drainage easement as detailed in Chapter 7.

## 2.2 STORMWATER COMPLIANCE REPORT (SCR)

Prior to the approval of any preliminary or permitting submittal (whichever comes first), the applicant shall submit 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 relevant chapters of this document.

### 2.2.1 SCR Applicability

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

- Larger 1 acre (one and two unit detached residential) or 0.5 acre (all other development types).
- Under 1 acre (one and two unit detached residential) or 0.5 acre (all other development types) AND changing how flow leaves the property OR Seeking to exceed established impervious surface limits.
- Located in a Watershed Protection or Metro Park Overlay.
- Requiring a flood study per Chapter 9.
- If a stormwater conveyance system, as defined in *Chapter 4* is installed, replaced, or hydraulically altered.

### 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 known). It shall be signed and sealed by a licensed 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 the area covered by the SCR
    b. The following information, in a table format as shown on the City's website (Table will be added to website before final Manual version):
        i. Floodplain – Presence, Type, Impacts
        ii. Neuse Buffers – Presence, Impacts
        iii. Streams – Presence, Impacts
        iv. Wetlands – Presence, Impacts
        v. Watershed Overlay – Presence, Compliance Method
        vi. Active Stormwater Controls -
            1. Subject to Exempt Property Requirements (UDO 9.2.2.A) OR Traditional Stormwater Requirements (UDO 9.2.2.B to H) OR Exempt per (specify Code section within 9.2.2.A.3)
            2. Meeting Existing Impervious Allocation
            3. *Will stormwater compliance be on a lot-by-lot basis (only allowed when all lots > 1ac) or shared between multiple lots*
            4. Traditional Stormwater Requirements (UDO 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, that have had a stream/buffer determination from NCDEQ, include the determination 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 of tTable of Uses and providing any relevant data such as impact width or area.

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

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

c. If jurisdictional wetlands and streams are present, provided the jurisdictional determination from the US Army Corps of Engineers (USACE) in an appendix of the SCR.

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

i. Approval of 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 the submitted pre-construction notification application (PCN) and associated maps providing the wetland and stream reference labels. Also include any revised submittals.

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), indicate the buffer width(s) that apply to the project. Note that these buffers apply to all watercourses, not only those that may appear on the USGS 7.5-Minute Quadrangle Map or published Wake or Durham County Soil Survey Map. 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**

i. 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. See chapter 4 for additional requirements.

**5. Active Stormwater Controls**

a. **Exemptions based on 9.2.2.A**

i. Applicable impervious limitations as detailed in

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

i. State the source of the allocation including the case number that established the limit and the reference (book and page) for the associated recorded map.

ii. List the limit and the site impervious area.

c. **Nitrogen Compliance –**

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

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 90$^{th}$ 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 summary tables in an appendix.

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

v. WQv needed calculations

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 POI. Indicate the % change.

2. Methodology - A thorough description of all methodologies,

procedures and data sources used in the calculations shall be included, 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, etc

d. Output hydrograph from each step.

e. **Establishing Impervious Allocation**

1. Provide a table showing the maximum impervious area per lot.

**6. Stormwater Control Measure Summary**

a. In narrative

i. List each SCM with a unique identifier fused in the project with the SCM type and the regulation(s) the SCM is meeting. (e.g. Nitrogen only, Nitrogen and Runoff Rate, Watershed Overlay, Diffuse Flow)

b. See Chapter 6 for additional requirements.

**7. Erosion and Sediment Control Design**

i. 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.

ii. See Chapter 8 for additional requirements.

**8. Floodplain Compliance**

a. If fill in the floodplain fringe is allowed for this site, indicate why. Provide a figure showing the floodplain boundaries, the fill areas, and the percent of the floodplain being filled.

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

c. If floodplain is present on the site and an elevation certificate is needed.

d. If a flood study is needed, state the type of flood study needed (based on Chapter 9) and indicate the case number for the study and the FS number, once

assigned.

**9. Overlay Districts**

If the project falls in an 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 how those requirements apply to the project and how they will be met.

a. Impervious limitations specific to the overlay district. Limit and the site impervious.

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

**10. Rezoning Conditions**

List the rezoning case number and the stormwater-related conditions. For each condition, state 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.

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

c. Drainage Areas for SCMs

d. Drainage Areas for Drainage Design, per Chapter 4.

**12. SCM Construction Cost Estimate(s)**

A construction cost estimate shall be provided for each SCM. The cost estimate will contain the following information:

- Quantities for cost items
- Unit costs adjusted to the current year 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

## 2.3 ADDITIONAL SITE CRITERIA

### 2.3.1 Restoration of pervious areas

Pervious areas compacted during construction shall be restored to continue being considered pervious area. Similarly, any areas that were impervious in the existing condition that are proposed to be pervious in the final condition must be restored.

The following requirements apply to all pervious areas compacted during construction or that are proposed in place of previously existing impervious 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 should be reflected in the plans and the construction sequence.

### 2.3.2 Substitution of Impervious Area

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

- The impervious 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, the work 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.

### 2.3.4 Vehicle and Equipment Cleaning Requirements

#### 2.3.4.1 All Facilities

- All wash water must be discharged to sanitary sewer.
- Appropriate grading and drainage shall be provided so that wash water does not bypass

the sanitary sewer collection system.

#### 2.3.4.2 City Properties

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

The City of Raleigh has specific BMP requirements within the 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 will have a designated wash station if vehicle and/or equipment maintenance or cleaning occurs at the site, .
- Acceptable measures include performing cleaning operations indoors, cover cleaning operations, ensure wash water drains to the sanitary sewer, collect stormwater run-on from the cleaning area and provide treatment or recycling.
- If sanitary sewer is 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, direction needs to be provided that storm drain must be covered with portable drain covers during cleaning activities, and any standing water present after the activities are completed are to be removed and properly handled before the drain is uncovered.

Chapter 3

# HYDROLOGY

## TABLE OF CONTENTS

## 3.1 Introduction

This chapter addresses hydrologic methods that are acceptable for use in the required calculations detailed in subsequent chapters.

## 3.2 Drainage 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.

### 3.2.1 Points of Analysis

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

For storm drainage design, points of analysis are needed for every new inlet, for any inlet whose drainage area that has been modified, and for upstream flows entered 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, downstream end of the site, and the entrances of tributaries. If only one drainage area is used, it must be the flow to the downstream end of the site and applied throughout the site.

### 3.2.2 Drainage Area Maps

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

Delineated drainage areas shall be clearly displayed. All drainage areas should be labeled consistently between pre- and post- development with the total area (acres) provided for each. Each drainage area provided shall accurately represent the areas contributing to the selected points of analysis which may include off-site areas that contribute runoff to the selected point of analysis.

When using the SCS method for Time of Concentration, segmented flow paths are to be clearly displayed on both pre- 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.

Acceptable methods will 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, etc.)
- Watershed development potential
- Characteristics of the local drainage system

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

Some calculations require consideration of routing through SCMs or other impoundments. Acceptable methods for this type of routing include:

- Storage-Indication Method

Acceptable hydrologic design methods vary by application and have method-specific constraints. This is addressed in table 3.x. Overall, acceptable methods include:

- 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 United States Army Corps of Engineers Hydrologic Engineering Center's (HEC).
- Stormwater Management Model (SWMM) - This method was developed by the United States Environmental Protection Agency (EPA).

| TABLE 3.1<br>ACCEPTABLE APPLICATIONS OF PEAK FLOW HYDROLOGIC METHODS | | | | | |
|---|---|---|---|---|---|
| *Design Application* | *Manual Chapter* | *Rational* | *NRCS* | *SWMM* | *HEC-HMS* |
| Stormwater Conveyance Systems:<br>• Closed Systems<br>• Open Systems<br>• Culverts <= 72” dia. | 4 | ✓ | ✓ | ✓ | |
| Stormwater Conveyance Systems:<br>• Inlets and Gutters | 4 | ✓ | ✓ | ✓ | |
| Stormwater Conveyance Systems:<br>• Bridges<br>• 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 deemed acceptable for hydrology calculations. Some examples of acceptable software for hydrologic analysis are listed below in alphabetical order:

- CivilStorm
- EPA SWMM
- HEC-HMS
- Hydraflow
- HydroCAD
- Hydrology Studio
- Infoworks ICM
- PC SWMM
- PondPack
- Stormwater Studio
- WinTR-20
- WinTR-55
- XP SWMM

Acceptable methods for flood studies can be found in Chapter 9 – Floodplain Management.

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

- Simple Method for Runoff Volume
- Chainsaw Routing Method

## 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 that reference at the time of this manual's writing. To keep pace with advances in the science and engineering around current and future rainfall data, the City will post the effective rainfall data on the City's Stormwater website. Release dates will be provided for use in determining the effective data at the time of a project's submittal. Use of the Rainfall-Intensity-Duration data specified by the City is required.

[LINK LOCATION TO BE ADDED IN FINAL VERSION]

## 3.5 Land Cover and Infiltration Characteristics

### 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 should be designed based on fully developed (future) land use conditions or existing land use, whichever generates the higher runoff rate.

Acceptable 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 Stormwater Compliance Report (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 the Table 3.2 below. These are adapted from the 2013 update to the Federal Highway Administration (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 – 10% | 0.40 |
| Clay Soil, Flat, 0 – 5% | 0.50 |
| Clay Soil, Average, 5 – 10% | 0.60 |
| | |
| Zoning: | |
| Single-Family (R – 1) and (R – 2) | 0.40 |
| Single-Family (R – 4) | 0.55 |
| Single-Family (R – 6) | 0.55 |
| Multi-family (R – 10) | 0.75 |
| Residential Mixed Use (RX-) | 0.85 |
| Office Park (OP-) | 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 |
| Agricultural Productive (AP) | 0.30 |
| Heavy Industrial (IH) | 0.90 |
| Manufactured Homes (MH) | 0.75 |
| Campus (CMP) | 0.60 |

### 3.5.4. NRCS Curve Number (CN)

The NRCS method uses a combination of soil conditions and land use (groundcover) to assign a runoff factor to an area. These runoff factors, CN, indicate the 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 determination 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 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 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-) | 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 |
| Agricultural Productive (AP) | Other agricultural lands |
| Heavy Industrial (IH) | Industrial |
| Manufactured Homes (MH) | Residential districts by average lot size – 1/8 acre |
| Campus (CMP) | Residential districts by average lot size – 1/8 acre |

## 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 a valid 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 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 ft. Shallow concentrated flow follows the sheet flow condition and may not be considered shallow concentrated flow if in a well-defined channel. The travel time for shallow concentrated flow in 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 closed channel flow. Manning's n values for use in this method are found in TR-55.

## 3.7 Hydrograph Development

### 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)

### 3.7.3 NRCS Unit Hydrograph Method

The NRCS hydrologic method requires data l 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 North Carolina Department of Transportation (NCDOT) manual "*Guidelines for Drainage Studies and Hydraulic Design"* and the Federal Highway Administration's (FHWA) manual "Hydraulic Design of Highway Culverts-HDS 05" and *"HEC-22 Urban Drainage Design Manual"*. Where discrepancies exist, 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.

See Chapter 7 - Easements for the requirements for downstream conveyance easements and flood storage easements.

### 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.

### 4.2.3 Existing Systems

If the existing stormwater conveyance systems on the site or in the half of a City right-of-way (ROW) adjacent to the property do not comply with the current design criteria, the existing systems shall be replaced or improved to meet the criteria.

### 4.2.4 Location Relative To Structures

Stormwater conveyance systems shall not be placed under or within 10' of any permanent structure or the associated foundation, including retaining walls. Additionally, buildings are not

allowed within the stormwater conveyance easements, as defined in Chapter 7. The only stormwater conveyance system that may be placed under or within a building is the discharge from a stormwater control measure and it must follow the requirements for stormwater control measures, which can be found in Chapter 6.2.

### 4.2.5 Public Versus Private Infrastructure

The first structure within the ROW delineates the city-maintained system and the privately maintained infrastructure. Any infrastructure that crosses into the ROW that is connected to a ROW structure is privately owned starting at the structure.

[GRAPHIC TO BE ADDED IN FINAL VERSION]

### 4.2.6 Decreased Capacity Downstream

If a proposed system has a higher capacity than the system component immediately downstream, the Stormwater Compliance Report (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

Concentrated runoff from stormwater pipes or swales in excess of 3 cfs shall not flow across or onto sidewalks.

### 4.2.8 Connecting to Conveyance System in City ROW

Connecting to stormwater conveyance system in the City ROW requires permitting. This can be obtained under a building permit or site permit. A modified version of the as-built process will be required – See Section 4.8.

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

## 4.3 SIZING CRITERIA

### 4.3.1 Closed Conveyance Systems Sizing Criteria

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

| TABLE 4.1<br>SIZING CRITERIA FOR CLOSED STORMWATER CONVEYANCE SYSTEMS | | |
|---|---|---|
| *DRAINAGE AREA* | *DESIGN STORM* | *DESIGN CRITERIA* |
| ≤ 25 acres | 10-year<br><br>25-year | Hydraulic Grade Line (HGL) for the entire system is to be at or below the crown of all pipes.<br><br>HGL shall not exceed the top of inlet structures or gutter elevations. |
| > 25 acres | 25-year<br><br>100-year | HGL for the entire system is to be at or below the crown of all pipes.<br><br>Inundation does not exceed the limits of the easement or ROW. |

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 the permitting submittal. Include the following data in the report:

- Drainage area maps
- Profiles showing HGL's
- 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.

| TABLE 4.2<br>SIZING CRITERIA OPEN CHANNEL CONVEYANCE SYSTEMS | | |
|---|---|---|
| *DRAINAGE AREA* | *DESIGN STORM* | *DESIGN CRITERIA* |
| < 25 acres | 10-year<br><br>25-year | Water surface elevation for the entire system is at or below top of banks.<br><br>Inundation does not exceed the limits of easement/ROW |

| | | |
|---|---|---|
| ≥ 25 acres | 25-year<br><br>100-year | Water surface elevation for the entire system is at or below top of banks.<br><br>Inundation does not exceed the limits of easement/ROW |

The channel design calculations shall be included in the SCR at the permitting submittal. Include the following data in the report:

- Drainage area map
- Calculations showing inputs and outputs

See section 4.5.2 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. All bridges and culverts shall be designed so that no building [unless the structure(s) is a properly floodproofed, non-residential structure(s)], either proposed or existing, floods or has water impounded against it during the 100-year storm event.

TABLE 4.3
FREEBOARD CRITERIA FOR CULVERTS AND BRIDGES

| *SYSTEM* | *DESIGN STORM* | *DESIGN CRITERIA* |
|---|---|---|
| Road crossings with drainage area ≤ 25 ac | 25-yr<br><br>100-yr | 12 in to top of road[1] with HW/D ≤ 1.2 or 12 in from the low chord[2]<br>No increased inundation shall exceed the limits of easement/ROW |
| Road crossings with drainage area > 25 ac | 50-yr<br><br>100-yr | 24 in to top of road[1] with HW/D ≤ 1.2 or 12 in from the low chord[2]<br>No increased inundation shall exceed the limits of easement/ROW |
| Road crossings over regulated floodways | 100-yr<br><br>100-yr | 24 in to top of road[1] with HW/D ≤ 1.2 or 24 in from the low chord[2]<br>No increased inundation 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 road crossings serving 10 acres or more, the maximum depth of the water impounded during the 100-year storm event should not exceed 15 feet, as measured from the upstream invert of the culvert to the water surface elevation. Should the maximum depth be exceeded, appropriate engineering calculations shall be submitted to verify the stability of the embankment against slope failure and seepage effects.

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, this manual will govern.

### 4.3.4 Inlet And Gutter Sizing Criteria

Inlets and gutters shall be designed based on Table 4.4.

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<br>• 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*<br>• Upgrade of intersections, including intersection of a non-residential driveway or private road with a public road.<br>• Upgrade of superelevation crossovers<br>• Any location where more than 3 cfs would reach a public ROW from a private site during the 10-year storm. |
| Yard inlets | • Ponding at yard inlets outside the roadway shall be limited to a maximum of one foot above an inlet elevation for the 10-year storm if no structures are flooded as a result. Ponding may not extend into the ROW. |

| | |
|---|---|
| Inlet blockage | • Inlets shall be designed assuming 50% blockage for locations where grate inlets are required |

*In sag areas where relief by curb overflow is not provided, the system standard design level (25- or 50-year storm events) is to be used for analysis to ensure traffic flow is not interrupted. Guidance for sag area calculations can be found in the NCDOT *"guidelines for drainage studies and hydraulic design"*. In a sag condition where relief by overflow for a typical roadway cross section is not provided, inlet capacity and the stormwater conveyance system must 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 the SCR for the permitting submittal. 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.

## 4.4 ALL MATERIALS

All pipe and fittings shall be delivered to the site and unloaded with handling that conforms to the manufacturer's instructions for reasonable care. The Contractor shall take necessary precautions to ensure the method used in lifting or placing the pipe does not induce undue stress fatigue in the pipe or other item by following manufacturer or industry-wide standards.

As newer materials are accepted by the City, the City's website will post these materials and associated design criteria.

## 4.5 STORMWATER PIPES

This section applies to stormwater conveyance pipes in the City ROW or outside of City ROW that connect to the City stormwater infrastructure or convey public runoff. This applies to pipes that are part of closed conveyance systems and to culverts.

All proposed pipes within the City of Raleigh shall follow the manufacturers minimum cover specifications unless otherwise noted below in Table 4.5.

### 4.5.1 Overall Criteria

| TABLE 4.5<br>OVERALL STORMWATER PIPE CRITERIA | |
|---|---|
| *TOPIC* | *DESIGN CRITERIA* |
| Diameter | • Minimum of 15 in<br>• See site specific materials for maximum diameter |
| Cover | • Minimum cover is 1.5 ft from the outside wall of the pipe to grade unless manufacture specifications require additional cover<br>• See site specific materials for maximum cover |
| Velocity | • Minimum flow velocity is 3 fps |
| Slope | • Minimum slope is 0.5%<br>• Maximum slope is 10% |
| Installation Trench Width | • Follow manufactures' specifications or NCDOT 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 |
| Joint type | • See material-specific sections |
| Accepted pipe materials: | • Reinforced concrete pipe (RCP)<br>• Double wall Polypropylene (PP)<br>• Double wall high-density polyethylene (HDPE) |

### 4.5.2 Reinforced Concrete Pipe

- Reinforced-Concrete Pipe (RCP) shall be Class III or greater.
- Pipe shall be installed per a COR or NCDOT detail.
- Pipe shall be manufactured to meet ASTM C76 and shall be installed per ASTM C1479.
- Joints shall meet one of the following requirements:
    - Use single offset joints - Bell and spigot pipe using a single offset joint shall consist of a -profile gasket and shall conform to the requirements of ASTM C1628.
    - Use Conseal and Wrap Joint Externally with geotextile
- Pipe cover shall meet the requirements in ASCE 15-17 "Standard Practice for Direct Design of Buried Precast Concrete Pipe using Standard Installations (SIDD)" 2017.

- In addition to any deficiencies not covered by ASTM C76 for non-pressurized pipe, concrete pipe, which has any of the following visual defects, will not be accepted.
    - Pipe, which has been patched to repair porous spots, cracks, or other defects, when such patching was not approved by ENGINEER.
    - Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.
    - Pipe that has been damaged during shipment or handling even when previously approved before shipment.
    - Concrete pipe, at delivery 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 be at least three (3) days (seventy-two [72] hours) shall have elapsed since time of manufacture.
    - Acceptance of the pipe at point of delivery shall not relieve CONTRACTOR of full responsibility for any defects in materials due to workmanship.
- Lifting holes: one lifting holes per pipe length will be allowed for stormwater pipe. Lifting holes must be filled in one of the following ways:
    - pFully grouted using a non-shrink grout after installation and before backfilling the pipe.
    - Filled with a lifting-hole-specific cap.

### 4.5.3 Polypropylene

Polypropylene (PP) may be used on private property and on “Local” streets, “Sensitive Area Residential Street” and “Alley, Residential” as defined in the City of Raleigh “Street Design Manual”, provided it is installed according to the following requirements:

- Double Wall with a smooth interior pipe (Type S) shall conform to the American Association State Highway and Transportation Officials (AASHTO) M330 or ASTM F2881 and is the only allowed type within the ROW.
- Maximum pipe diameter is 60” and maximum cover is 15’.
- Certification shall be provided by Plastic Pipe Institute 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.
- Installation trench minimum width shall be per manufacturer’s specifications.

- PP shall be backfilled per manufacturers specification with a minimum of ASTM D2321 Class II or AASHTO A1 or A3 granular fill with minimum 6" bedding and fill to top of pipe. Remaining backfill shall be installed in accordance with City, NCDOT, or manufacturer details. Transition of PP to RCP shall have a dissimilar materials adapter incorporating a geotextile coupler with mastic coating and stainless-steel straps.
- Connections to structures shall be blocked and grouted with non-shrink grout.
- Mandrel testing results shall be submitted with the As-built Certification. See Section 4.9

### 4.5.4 High Density Polyethylene

Double Wall High-Density Polyethylene (HDPE) may be used on private property and other areas outside the ROW provided it is installed according to the following requirements:

- Corrugated exterior/smooth interior pipe (type S) shall conform to AASHTO M294.
- Maximum pipe diameter is 48" and the maximum cover is 12'.
- Certification shall be provided by Plastic Pipe Institute (PPI).
- 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 manufacturer's specifications.
- 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 current City standards.
- Transition of HDPE to RCP shall have a dissimilar materials adapter incorporating a geotextile coupler with mastic coating and stainless-steel straps.
- Mandrel testing results shall be submitted with the As-built Certification. See Section 4.9

## 4.6 OPEN CHANNELS AND ENERGY DISSIPATION

Open channel conveyance systems shall be designed per the City's Unified Development Ordinance (UDO) section 9.4.4.G.

### 4.6.1 Channel Configuration

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

### 4.6.2 Channel Lining

Channel lining shall be determined per UDO Sec. 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.

### 4.6.3 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 allowable:

- Plunge pools
- Riprap apron
- Baffled outlets

Calculations shall be in accordance with the North Carolina Department of Environmental Quality (NCDEQ) *"Erosion and Sediment Control Planning and Design Manual"* and the FHWA manual *"Hydraulic Engineering Circular No. 14 Hec-14: Hydraulic Design of Energy Dissipators for Culverts and Channels"*.

## 4.7 DRAINAGE STRUCTURES

NCDOT or COR 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, listed below, and have been sealed by a structural engineer.

### 4.7.1 Minimum Criteria For Structures

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

TABLE 4.6
DRAINAGE STRUCTURE DESIGN CRITERIA

| *TOPIC* | *DESIGN CRITERIA* |
|---|---|
| Access | • All structures shall allow for access to the stormwater conveyance system with a grate, manhole cover or a lid capable of being removed. |

| | |
|---|---|
| | • The lid must be capable of being removed for immediate maintenance concerns (capable of being removed manually).<br>• Access opening must be a minimum of 2' in diameter |
| Interior dimensions | For the area below the access opening, extending to the structure invert:<br>• Minimum dimension is 2.5 feet in any direction.<br>• Minimum area is 9 square feet.<br>• For structures greater than x depth, the minimum area is xxx. |
| Invert drop | • Minimum invert drop at structures is 0.5% slope or 0.1 feet whichever is greater.<br>• Minimum invert drop at structures for pipe size increases is based on matching crown elevations. |
| Labelling | • All structures shall be labelled with the following language or its approved equivalent: "Dump No Waste. Drains to River." |
| Loading | • Structures and access lids must withstand HL-93 loading. |
| Location | • For pipe systems with a 48-inch pipe (or equivalent cross-sectional area) or larger, there should be a maximum spacing of 300 feet<br>• For pipe systems with an equivalent size of less than a 48-inch pipe, there should be a maximum spacing of 250 feet<br>• A structure shall be provided wherever there is a change in pipe size, slope, or direction within a stormwater conveyance network |
| 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"<br>• Steps must be positioned such that they can be used by personnel to access the structure. |

### 4.7.2 End Treatments

End treatment is required for all pipes.

- Flared End Sections shall be placed on pipes smaller than 36 inches. These must be reinforced concrete. No polypropene end treatments shall be allowed.
- Cast-in-place or pre-cast concrete headwalls and endwalls shall be required for all 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.

## 4.8 STORMWATER CONVEYANCE SYSTEM CERTIFICATIONS

The City shall require certifications of closed-circuit television (CCTV) inspection data and as-

built documentation of stormwater conveyance systems that require a Stormwater Conveyance System Permit (see Chapter 1 when a permit is required). The CCTV inspection shall be performed in accordance with the latest testing requirements set forth by the NASSCO Pipeline Assessment & Certification Program (PACP). This inspection must be certified by a professional engineer and must be submitted to and accepted by Raleigh Stormwater to verify there are no defects in the stormwater conveyance system both on public and private property. At a minimum the following items shall be included/documented with the CCTV inspection submittal:

- Completed, signed and sealed *Stormwater Conveyance CCTV/Inspection Checklist*
- Repair plan when defects are present including associated CCTV videos
- Storm drainage video of final inspection showing all pipes are free of obstruction, defects, surface damage, structural deterioration, infiltration and inflow sources, and/or deposits, etc.
- All CCTV Report(s)
- All CCTV Videos
- All CCTV Inspection Database Files
- Mandrel Test Report for all Flexible Pipe
- Engineer Certified WIGINS Report for pipes or box culverts of 72" or greater with open channel on both sides

Once the CCTV inspection has been accepted by Raleigh Stormwater and, when applicable, the last inch of asphalt has been applied to the project, as-built documentation, and certification for both public and private stormwater conveyance systems must be submitted to Raleigh Stormwater. The as-built submittal must be certified by a professional engineer or landscape architect that the infrastructure has been installed per the approved plan. The as-built submittal must be accepted by 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 sealed statement provided by a qualified North Carolina (NC) licensed design professional which certifies that the as-built stormwater infrastructure (both public and private) complies with the approved plans and meets all Unified Development Ordinance (UDO) requirements.
- As-Built Drawings – A certified set of as-built drawings, signed and sealed by a North Carolina PE or RLA, for stormwater infrastructure only.
- As-Built Survey Submittals
    - As-Built Survey – A certified post construction as-built survey, signed and sealed by an 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 and private drainage easements properly labeled and provided as

polygons in the format specified on the *Stormwater Conveyance As-Built Submittal Checklist*.

- Recorded plat(s) files

The CCTV and as-built documentation must be reviewed and accepted by 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 acceptance of the stormwater conveyance system CCTV inspection and as-built certifications does not constitute acceptance of the system for maintenance by the City.

- 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.
- Acceptance of stormwater conveyance systems within the public ROW for maintenance purposes shall be made by City Transportation Department.

Chapter 5

# STORMWATER MANAGEMENT CALCULATIONS

## TABLE OF CONTENTS

## 5.1 INTRODUCTION

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

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 the City's Unified Development Ordinance (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. Note that additional runoff control measures may be required if:

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

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

Stormwater Control Measures (SCMs), as detailed in Chapter 6 – Stormwater Control Measure 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 right-of-way (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, 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

For runoff rate control, selected points of analysis shall be located at each point where flow leaves the parcel being developed. 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. 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-developed (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 Stormwater Compliance Report (SCR) narrative.

### 5.2.3 Additional Runoff Control Requirements

To determine if a site is subject to additional runoff controls per UDO Section 9.2.2.E.3., contact a stormwater plan reviewer, as the mapping associated with downstream flooding is not available in a public mapping application.

To demonstrate compliance with UDO Section 9.2.2.E.3.d, delineate the drainage area to the location of downstream flooding. 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 subject site. Provide the calculations and the drainage area map with your submittal.

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

i. Determine whether the site drains all to one stream or if it drains to multiple streams.
ii. If the site drains to more than one stream, delineate the drainage divide between the streams on the subject site.
iii. Calculate the acreage of the site that drains to each stream.
iv. For Stream A, take the acreage of the site that drains to Stream A and multiply it by 20.
v. Now, find the first point downstream of the site where the drainage area is greater than or equal to 20 times the acreage from the site draining to Stream A. If the site is adjacent to a large watercourse, this point could be immediately downstream of the site.
vi. Repeat steps iv and v for each stream.
vii. Submit a map that shows the subject site and the drainage areas delineated.

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

## 5.3 NITROGEN REDUCTION REQUIREMENTS

Sites subject to active stormwater control measures as specified in the City's 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 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 5.3.11 of this document apply. For the Runoff Volume requirements, Section 5.3.7 also applies. To meet the 3.6 lb/ac/yr target through the SNAP tool, also see Sections 5.3.8 to 5.3.10 of this document.

### 5.3.1 Common Plan of Development

'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 the UDO 9.2.1.F.2.

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

- Projects submitted as one case to the City of Raleigh.
- Adjacent parcels (including those separated by ROW) that are managed as one entity. E.g. Multiple apartment buildings managed by one entity.

The following example situations do not fall under a Common Plan of Development for the purpose of the Nitrogen Reduction Rule 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 Stormwater Staff at raleighstormwater@raleighnc.gov 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 % BUA for the site,
- Will not be included as part of the project's regulated site area.
- Will not be required to be treated by an 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 permit, it will be considered new BUA for the purposes of the Nitrogen Reduction Rule 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 total proposed BUA.
- 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 be required to complete additional nutrient offset credits 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 all information in SNAP, recalculating all areas with the new method.

**Method B**: Use first generation calculation method for the existing BUA, which requires recalculation because the pervious area decreases. If the drainage area to the SCMs is altered, the credit associated with the 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 %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 credits.

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, 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.

TABLE 5.1
COMPARISON OF NITROGEN COMPLIANCE METHODS

| | *Runoff Volume Match* | *Nitrogen Target* |
|---|---|---|
| **Design Storm** | 1.34” | 1” |
| **Pre-Development Condition** | Impervious = Impervious<br>Pervious = Forest | Impervious = Impervious<br>Pervious = Managed Pervious |
| **Target Nitrogen Loading** | NA | 3.6 lb/ac/yr |
| **Nutrient Offset Credit Threshold** | NA – No credits allowed | If %BUA <= 24%, credits-only allowed.<br>If %BUA >24, primary SCM required before use of credits. |
| **SCM Required** | No, but will likely be needed for compliance | If %BUA <= 24%, SCM is not required.<br>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 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 the increase in runoff from pre-development to post-development.

Practices suitable for Volume Reduction are identified in Chapter 6 – Stormwater Control Measure Design. To meet nutrient loading requirements for either theNitrogen Reduction Rule 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 built upon area, a modified calculation may be performed. For the purposes of this calculation, any built upon area added as part of the redevelopment must be assumed to be forested in the predevelopment condition.

For the runoff volume match requirements, the State requires use of the 1.34" storm, as opposed to the 1" 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 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 are applied to the inflow hydrograph.

### 5.3.6 Required On-site Treatment

For sites with a BUA% over 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 parcel.

- For a Greenfield Site, the formula is:
  (Proposed BUA/Regulated Project Area)*100=%BUA

- For sites with Existing BUA, the formula is:
  [(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)]*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%, an SCM may be used but it is not required for water quality purposes. An SCM might be needed to meet peak discharge requirements.
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

The UDO Article 9.2.2.B.1.g states “Stormwater control measures shall be designed to control and treat volume of runoff generated from all built-upon area by one inch of rainfall or equivalent runoff volume in one or more primary stormwater control measure.” Per NCDEQ, 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. After the City’s webinar on 4/20/2023, NCDEQ clarified that 100% of the BUA must drain to the SCMs – it is not acceptable to provide treatment >100% in lieu of sending BUA to SCMs.

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 writing 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 this 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:

- Precipitation Station will be Raleigh.
- The category "Roof" may be used for any impervious surface elevated above the surrounding ground and not used for vehicular traffic. Slatted decks may 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 public ROW.
- The category "Parking/Driveway/Sidewalk" will be used for all impervious area outside the ROW that is located at ground level. So, 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 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). This area must be recorded on the plat, permanently fenced, and treated like an SCM – requiring an O&M Manual and annual inspections. Note that Tree Conservation Area (TCA) 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 when submitting to 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, may 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 site. If the SCM location falls on the line between two HSG's then the less infiltrating HSG must be chosen.

- The SCM Description will align with the Stormwater Compliance Report (SCR) and plans. E.g. if SCMs are labeled A, B, and C, those labels would be used here.
- 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.

### 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.

Credits bought will now be in lb/yr rather than lb. The annual load of lb/yr will no longer be multiplied by 30 years. Thirty years was assumed to be the lifespan in the past; we now know that we should assume the credits will be in effect in perpetuity. Therefore, the perpetual credits will be sold in lb/yr. Per NCDEQ, mitigation banks will offer credits in both formats for some period of time.

### 5.3.10 Nitrogen Compliance Submittal Requirements

The sealed and signed Stormwater Compliance Report (SCR) shall contain the following items related to the nutrient calculations and runoff volume match:

- Existing Conditions and Post-Development Maps showing the land cover with SNAP categories.
- PDF version of the following SNAP Tool worksheets:
    - Project Info
    - Land Cover Characteristics
    - SCM Characteristics
    - Nutrient Export Summary
    - Nutrient Offset
- PDF version of City Nutrient Summary Sheets (The City Nutrient Summary Sheets are available on the City's website in PDF form along with a contact for obtaining the Excel version.)

Additionally, the Excel file of the SNAP tool shall be submitted with the City's Case number in the file name.

## 5.4 WATERSHED SUPPLY WATERSHED PROGRAM REQUIREMENTS

Under this program, the state 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 built upon area,

required use of SCMs on lots exceeding certain specified built upon area limitations, and the incorporation of green stormwater infrastructure (GSI) for volume control. The requirements are specific to the watershed protection areas which can be found in the UDO as follows:

- Urban Watershed – UDO Section 9.5.1
- Falls Watershed – UDO Section 9.5.2
- Swift Creek Watershed – 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 with a watershed overlay need to meet both the Nitrogen Reduction Rule and the Watershed Rule. The more stringent requirements should be shown in the SNAP Tool. The SNAP input on the Land Cover Characteristics and SCM Characteristics should follow the guidance 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 are the same as the Nitrogen submittal requirements in Section 5.3.10 above.

## 5.5 NCDOT WORK UNDERTAKEN BY OTHER ENTITIES

Projects undertaken by an entity other than North Carolina Department of Transportation (NCDOT) may fulfill the Nitrogen Reduction requirement for linear transportation projects per 15A NCAC 02H .1001(1)(c). Find more information in the NCDOT Stormwater BMP Toolbox.

Chapter 6

# STORMWATER CONTROL MEASURE (SCM) DESIGN

## TABLE OF CONTENTS

## 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 the UDO and described in the previous chapter.

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 State's Minimum Design Criteria (MDCs) that were established in Rule 15A NCAC 2H and can be found in the NCDEQ Stormwater Design Manual. For each SCM, this includes compliance with:

- MDCs for All SCMs
- Section 6.3 Design Requirements for All SCMs
- The device-specific MDC
- The device-specific Section 6.4 subsection.

If the MDCs are updated after the effective date of the most recent revision of this Manual, the MDC requirements shall govern. 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 green stormwater infrastructure (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 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 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 adhered to.

B) No pumping of stormwater shall be allowed as a necessary component of any SCM except for rainwater harvesting.

C) 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.

D) 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." However, no vegetated slopes steeper than 3:1 will be allowed.

E) General MDC 5 "All measures shall include an overflow or bypass device for inflow volumes in excess of the treatment, or, if applicable, the peak attention volume." This shall be applied based on the design intent of the SCM. e.g. If an SCM is designed for solely Nitrogen Reduction, the treatment is the 1" storm. If the SCM is designed for Runoff Control of the 10-year storm, treatment is the 10-year storm. If the 25-year or higher storm is the design basis, then the 25-year or higher storm is the treatment.

### 6.3.2 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 may 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 NRCS Conservation Practice Standards Pond Code 378 for NC for all design components, except when the NCDEQ Stormwater Manual or this document have more stringent requirements.

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

### 6.3.3 Proximity to Buildings

All measures shall be located a minimum of 10 feet from any building unless 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 the licensed structural engineer is required. 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 an SCM is located in or under a building, SCM approval will also require a signed letter from the property owner acknowledging awareness of the increased long term maintenance costs associated with the SCM location.

F) Adequate access is provided for maintenance.

### 6.3.4 Use of Retaining Walls

Retaining walls may be used to contain ponded water associated with the SCM treatment volume if 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’ height, a signed and sealed letter by the licensed structural engineer responsible for the retaining wall must be submitted, indicating that the engineer is aware of the saturated soil conditions as shown on the dated plans.

C) Wall design details must be submitted 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 an SCM are considered an element of the SCM and must be included in the SCM easement, 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.

### 6.3.5 Plantings

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

No woody vegetation shall be planted on embankments.

### 6.3.6 Infiltration Testing

When infiltration testing is required, the following tests will be accepted:

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)

### 6.3.7 Maintenance Access

See Chapter 7.4 SCM Easements for the requirements for the access path to the easement.

### 6.3.8 Location relative to ROW

SCMs owned and maintained by the City are allowed in the ROW. As of the writing of this Manual, privately owned and maintained SCMs are not allowed in the ROW.

### 6.3.9 Outlet Design

When designing the outlet of a SCM the following apply:

- The outlet must be designed with maintenance in mind by ensuring access for cleaning, inspection, and repair.
- The outlet shall be placed such that it will be visible and accessible for maintenance purposes at all times.

- Risers shall be accessible by foot in the treatment storm.
- Riser structures must be designed with internal ladders for maintenance access.
- The outlet must be designed to ensure the safety of people and wildlife in the surrounding area. This may include the use of a trash rack on a riser structure to prevent debris or wildlife from entering the outlet. If a track rack is used, the maximum opening size shall be 4", and there shall be a method of latching the rack closed.
- Outlet size and shape shall prevent blockages or clogging of the outlet.
- 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.
- Inlets and outlets of SCMs shall be designed/located to avoid short circuiting of the measure.
- Pipes smaller than 12 inches in diameter may be analyzed as a submerged orifice if H/D is greater than 1.5. When incorporating an orifice into an outlet structure design, an appropriate orifice discharge coefficient must be used and documented for the type of orifice proposed.
- Pipes greater than 12 inches in diameter should 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"*.
- When using weirs, an appropriate weir discharge coefficient must be used and documented for the edge treatment of the proposed weir.
- Wet ponds and wetlands shall include an emergency draw down feature.

Recommendations:

- Non-corrosive material and mounting hardware should be implemented to extend device longevity, ease operation, and reduce the cost of maintenance.
- Locking of trash racks and other elements is discouraged due to potential maintenance issues.

### 6.3.10 Requirements for All Underground SCMs

Underground SCMs shall provide access in accordance with OSHA standards and requirements.
Underground SCMs must meet structural requirements for HL-93 loading.

## 6.4 SUBMITTAL REQUIREMENTS

The following sections describe the submittal components required to demonstrate compliance and appropriate design of SCM's. Include all applicable items for the analysis and SCM design being conducted.

### 6.4.1 Stormwater Compliance Report (SCR)

All calculations associated with SCM design must be included in the 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 required.

D) Infiltration Calculations.

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

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

G) Underdrain calculations, if required.

H) Information related to building proximity, if required.

I) Information related to retaining walls, if required.

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

K) Calculations are provided for anti-flotation measures, 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***, calculations for the minimum sizes of the sediment and filter chambers.

P) For ***Wetlands***, calculations of the zone areas.

### 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 structure location shown and labelled.

C) Maintenance easement. See Chapter 7 – Easements for maintenance access requirements.

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

E) Emergency spillway showing proposed contours and dimensions and calling out the spillway liner.

F) Underdrains with clean-out location, if applicable.

G) Outlet protection must be shown to scale in plan view and the dimensions, including depth and class of stone, must be called out.

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*** must be called out and display proposed 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*** require zone hatching and area labels including the percentage of each zone proposed.

K) For ***Level Spreaders, LS-VFS*** and ***DIS,*** show the associated vegetated area with dimensions and slope.

### 6.4.3 SCM Plan Sheet Notes

- The SCM plans must reference the Landscaping sheets if plantings are not shown on the SCM plan.
- Give the specifications or reference the location of specifications for liners and geotextiles. If the designer is relying on specifications rather than notes, the relevant specification sections must be provided in the SCR for the reviewer to see.
- All media and stone types associated with a SCM must be stated on the plans.
- ***Bioretention*** media must reference the composition, P-Index, and infiltration rate per the MDCs.

### 6.4.4 SCM-Related Details

6.4.4.1 Cross-Section Through SCM

- Show calculated water surface elevations 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.
- Label the freeboard provided per the freeboard requirements in Section 6.3.2. above.
- Label the elevation of the top of embankment and embankment width.
- Specify the SHWT elevation, if required for the SCM type
- If a liner is proposed, show the liner and refer to the location for specs or details.
- Geotextiles must be shown and called out as appropriate.
- Dimension or call out SCM media depth.
- All underdrain systems and clean-outs or observation wells with callouts indicating pipe material, size, perforations (if applicable), and slope.
- The outlet protection must be shown to scale and indicate the surface slope.

6.4.4.2 Outlet Structure Detail

- Provide a detail for the outlet control structure that includes all relevant components including weirs, orifices, emergency draw-down valves, pipes in and out, and anti-flotation measures.
- Label the invert elevations, structure dimensions, pipe/weir/orifice sizes and elevations, and any other components.
- Show calculated water surface elevations 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.

6.4.4.3 Flow Splitters

- Flow splitters must be called out in plan view and a cross section detail must be provided labeling all relevant elevations as described in the cross-section through SCM section above. This detail may be a part of the SCM cross-section or a stand-alone detail.
- 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.

6.4.4.4 Outlet Protection

- An installation detail must be provided on the plans.

## 6.5 SCM TYPE-SPECIFIC DESIGN REQUIREMENTS

### 6.5.1 Infiltration System

| DESCRIPTION AND APPLICATIONS: |
|---|
| Infiltration practices may also be classified as runoff-reducing, green stormwater infrastructure practices. They consist of an area that intercepts and temporarily stores runoff until it infiltrates into the underlying and surrounding soils.<br><br>Varieties: Infiltration Trenches, Infiltration Basins |
| **ADDITIONAL REQUIREMENTS BEYOND MDC:** |
| A. Medium or coarse sand, or crushed stone (with a uniformity coefficient of two or smaller) is required for the drainage media. The media shall be hard, durable, inert particles, free from slate, shale, clay, silt and organic matter. Media shall be double washed.<br><br>B. Trench geotextiles shall enclose drainage media on all sides of the infiltration system and shall be in contact with the in-situ soil.<br><br>C. Infiltration trench media shall be a minimum depth of 1.5 feet.<br><br>D. A minimum 12-inch cover is required from the top of all piping to the finished grade.<br><br>E. A minimum of 12 inches of head is required to promote infiltration. |

F. Infiltration practices shall not be used over occupied structures (buildings).

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:

A. Pretreatment is required. The most commonly used pretreatment devices are:
    a. A *grass and gravel combination:* eight inches of gravel followed by three to five 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" shall be placed as appropriate to provide ponding behind them. Minimum swale bottom width of 2'.
B. Flow shall enter a bioretention cell via dispersed flow with a velocity less than one foot per second (fps) for mulched cells or three fps for sodded cells to prevent erosion. If inflow is concentrated in a pipe or swale, then a rip-rap lined entrance, a forebay, or another energy-dissipation device shall be used.
C. Clean-out pipes shall extend upwards from the underdrain pipe to an elevation above the water quality ponding. They shall be located at the end of the bioretention surface, near the toe of slope.
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 percent in any direction. Installation in multiple cells is allowed and should be considered at slopes sites.

F. Bioretention adjacent to public or private roads or sidewalks have the following additional criteria:

   a. All features including vegetation must ensure clear sightlines for pedestrians and drivers per the City of Raleigh Street Design Manual.

   b. Pedestrian access shall not be impacted by the bioretention design.

   c. For drop offs greater than 12”, pedestrian and vehicle safety measures shall be installed.

   d. There must a location adjacent to the bioretention for a maintenance truck to safely park. This may be a parking spot or a grassed area.

   e. Gutter spread requirements must be met.

   f. Bioretention shall not prevent the placement of residential trash, recycling, and yard waste bins for pick-up.

RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):

A. The minimum width of embankment is 5 feet. This allows for mowing access.
B. A flow splitter shall be used to route flows above WQv away from the bioretention area.
C. The minimum maintenance vehicle parking area for median bioretention is 12 feet by 22 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 applicable 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.X Bioretention Example Configuration***

[Insert GSI Example Configuration AKA Detail GSI-06.1]

### 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 two to five days. Pollutants are removed through sedimentation in the permanent wet pool.<br><br>Older Names: Detention Basin |
| **ADDITIONAL REQUIREMENTS BEYOND MDC:** |
| A. The riser shall be near the embankment to facilitate maintenance and reduce flotation forces. All flotation force for any outlet design subject to flotation forces shall be calculated by the designer.<br>B. The orifice at the permanent pool must have a turned-down elbow in order to prevent trash or other material floating on the surface from clogging the pipe.<br>C. Measures such as anti-seep collars or similar shall be provided along the barrel of the principal spillway to prevent piping.<br>D. Durable materials, such as reinforced concrete, are required for the barrel of the principal spillway.<br>E. An emergency spillway is required to prevent failure of the embankment structure during large storm events. The barrel of the principal spillway shall not be under the emergency spillway.<br>F. An impermeable liner must be specified if the permanent pool elevation is not within 6” of the SHWT.<br>G. Wet ponds shall have the ability to sustain a wet pool by one of the following mechanisms:<br>a. Permanent pool elevation within 6 inches of the SHWT<br>b. Impermeable liner and with a minimum drainage area of 25 acres<br>c. 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.<br>H. The rate of drawdown for maintenance shall be non-erosive and no more than the design flow out of the pond for the 10-year storm. |
| **RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):** |
| 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 setting of a wet pond with the vegetated benefits of a wetland.<br><br>Other Names: Constructed Wetland |
| **ADDITIONAL REQUIREMENTS BEYOND MDC:** |
| A. Stormwater wetlands shall have the ability to sustain the permanent pool by one of the following mechanisms:<br>a. Permanent pool elevation within 6 inches of the SHWT<br>b. Lined and with a minimum drainage area of 10 acres<br>c. 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.<br>B. A minimum flow length to width ratio (L:W) shall be 3:1. |
| **RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):** |
| 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 than 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).<br><br>Types of permeable pavement systems: Permeable Interlocking Concrete Pavers (PICP), Permeable Concrete, Permeable Asphalt, Concrete Grid Pavers, Plastic Turf Reinforcing Grid.<br><br>The following may also be designed as permeable pavement systems: Permeable Sports Courts, Synthetic Turf |
| ADDITIONAL REQUIREMENTS BEYOND MDC: |
| • In an infiltration design, geotextiles (permeable) shall line the sides of the aggregate base to prevent migration of adjacent soils into it and subsequent permeability and storage capacity reduction. Geotextiles are not allowed under the aggregate base in an infiltration design because they can accumulate fines and inhibit infiltration.<br>• 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 should also be used to line the sides of the aggregate base when structures or conventional pavement is within 20 feet or less.<br>• The slope of permeable surface shall be less than 5 percent.<br>• The designer shall ensure that the pavement meets its structural design requirements by involving a North Carolina licensed design professional with appropriate expertise in pavement design.<br>• 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. |
| RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS): |
| • Signage shall be posted that indicates permeable pavement is present and that materials storage and sanding/salting the area is prohibited.<br>• Permeable surface materials other than those in the NCDEQ Manual shall provide maintenance procedure information prior to approval.<br>• The minimum width of a section of permeable pavement confined between curbs shall be 50 feet. Therefore, there must be at least 6 parking spots contiguous. This is for maintenance access by a street sweeper. |
| IMPORTANT LINKS: |
| NCDEQ Stormwater Design Manual Chapter C-5 Permeable Pavement<br>City of Raleigh Standard Details |

### 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:** |
| Maximum drainage area of five acres unless the width of the sand chamber is limited to 20 feet and the interface between the sediment chamber and sand chamber is proportionally increased.<br>A. |
| **RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):** |
| The following apply to underground sand filters:<br>• A minimum of 4’ of space should be provided between the surface of the sand and the “ceiling” of the chamber.<br>• Access should be provided to every sand chamber.<br>• Sediment chambers should not be oversized for detention purposes. This increases the effort for maintenance. |
| **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:** |
| A. A passive drawdown, designed to prevent clogging, is required for residential scale above ground systems. The passive drawdown should discharge over two to five days to a another SCM, which may include DIS. Passive drawdowns shall discharge by gravity.<br>B. 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.<br>C. 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.<br>D. Systems other than those on a one- or two-unit residential property must designed to prevent accidental consumption of non-potable water. Therefore, spigots and hose bibs shall be lockable or opened only by use of a special tool.<br>E. The soil or foundation upon which the cistern will be placed must be sufficient to support the weight of the cistern when full. |
| **RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):** |
| • Any passive drawdown shall be installed in such a way to prevent easy breakoff of pipes or fittings by people or by-passing equipment.<br>• Signage for passive drawdown.<br>• 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.<br>• Screens to prevent mosquitos for cisterns should be used on residential property. |
| **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. |
| **ADDITIONAL REQUIREMENTS BEYOND MDC:** |
| A. The stormwater designer shall ensure that the roof meets its structural goals by involving a North Carolina licensed design professional with appropriate 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 additional to standard roof loading design.<br>B. Permanent fall protection measures shall be provided for maintenance activities.<br>C. A 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 should drain to the roof gutters and downspouts.<br>D. The roof shall be equipped with a waterproof membrane to protect against leaks. Structural evaluation of the roof shall be sealed by a North Carolina licensed structural engineer. Sealed structural calculations shall be included in the calculation submittal package. |
| **RECOMMENDATIONS (REQUIRED FOR CITY FUNDED PROJECTS):** |
| • Fall protection shall be in the form of permanent installed barrier systems. Personal fall protection systems such as cable-based lifelines will not be accepted as these increase the cost and difficulty of maintenance.<br>• The green roof shall be accessible to maintenance staff from building floor serviced by an elevator. Ladder access will not be accepted.<br>• Irrigation source shall be provided for plant establishment. If irrigation is desired after establishment, this must be considered in the green roof design as it will impact the stormwater function.<br>• The use of a leak detection system shall be discussed with the owning department.<br>• The desired vegetation shall be when planning the soil depth. |
| **IMPORTANT LINKS:** |
| NCDEQ Stormwater Design Manual Chapter C-8 Green Roof |

### 6.5.9 Level Spreader – Filter Strip

| DESCRIPTION AND APPLICATIONS: |
|---|
| Level Spreader – Filter Strips (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. |
| ADDITIONAL REQUIREMENTS BEYOND MDC: |
| A. Pretreatment via a forebay is required when using this device is not downstream of another SCM. The forebay shall be designed to Recommendation 1: Pretreatment in the NCDEQ Stormwater Manual Chapter C-9.<br>B. Soil amendment is required to promote plant growth per Recommendation 2: Soil Amendment in the NCDEQ Stormwater 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 should be specified.<br>C. Non-clumping, native, deep-rooted grasses shall be specified. See Recommendation 3: Grass Specification for FS in the NCDEQ Stormwater Manual Chapter C-9.<br>D. The depth to the SHWT shall be a minimum of 12 inches measured from the lowest ground surface elevation.<br>E. The angle of entry from the point of discharge to the level spreader should be parallel and must be not less than 45 degrees.<br>F. The maximum slope of the Filter Strip shall be 8% in the direction of flow. |
| IMPORTANT LINKS: |
| NCDEQ Stormwater Design Manual Chapter C-9 Level Spreader-Filter Strip |

### 6.5.10 Level Spreader – Diffuse Flow (No Filter Strip)

| DESCRIPTION: |
| --- |
| A level spreader without a filter strip may be used to meet the Neuse Buffer rules diffuse flow requirement. It will not receive nutrient credit or infiltration credits. |

| DESIGN REQUIREMENTS: |
| --- |
| A. The Level Spreader-Filter Strip MDC criteria and guidance shall be utilized for this measure. The MDCs related solely to the Filter Strip will not apply.<br>B. Level Spreader shall be located at least 10 feet upstream from any property line or building and at least 50 feet upstream from streams.<br>C. The angle of entry from the point of discharge to the level spreader should be parallel and must be not less than 45 degrees.<br>D. If the land within the first 50 feet downstream of the Level Spreader has a slope greater than 5%, this practice may not be used as it will not result in diffuse flow. |
| IMPORTANT LINKS: |
| NCDEQ Stormwater Design Manual Chapter C-9 Level Spreader-Filter Strip |

### 6.5.11 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 concentrated drainage 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) |

### 6.5.12 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 |

### 6.5.13 Dry Pond

| DESCRIPTION AND APPLICATIONS: |
| --- |
| Dry ponds hold water immediately after a storm event and drain to be dry between storm events.<br><br>Other Names: Dry Detention Basin |
| **ADDITIONAL REQUIREMENTS BEYOND MDC:** |
| • If designing for nutrient removal credit, the flow length to pond width ratio (L: W) shall be 3:1.<br>• If not designing for nutrient removal credit, maximum drawdown is two days. |
| **IMPORTANT LINKS:** |
| NCDEQ Stormwater Design Manual Chapter C-12 Dry Pond |

### 6.5.14 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 SCMs will be accepted by the City for compliance with nutrient treatment requirements. |
| **ADDITIONAL REQUIREMENTS BEYOND MDCs:** |
| • 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.*<br>• Devices 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<br><br>NCDEQ Stormwater Design Manual Part D |

### 6.5.15 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 provided.<br>B. Leak testing procedures and the acceptable leak rate shall be specified.<br>C. Adequate maintenance access must be provided for all underground detention systems, and at a minimum, be provided over the inlet pipe and outflow structure. Access openings must meet the drainage structure requirements in Chapter 4.<br>D. 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 shall be X. The sediment sump or chamber does not count towards the storage volume for the practice.<br>E. The minimum orifice diameter is three inches. Outlets shall be adequately protected from clogging by trash rack. Adjustable gate valves can also be used to achieve smaller equivalent diameters.<br>F. 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 and outlets | As needed, based on inspection |
| Maintain groundcover and stability of overall site to reduce incoming sediment loads | As needed, based on inspection |

## 6.6 SCM OPERATIONS & MAINTENANCE REQUIREMENTS

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

### 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 that specifies all upkeep necessary for the function of all SCM components is required. The O&M Manual shall be submitted with permitting submittal and an updated version will be submitted with the as-built submittal. One O&M manual shall be provided for each project or phase and address each device, and shall be sealed by a qualified registered North Carolina licensed professional engineer, land surveyor or landscape architect.

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

All SCMs O&M Manuals must reflect the following sources as 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 maintenance items.
- The above items are summarized in the Storm EZ O&M Supplement

Components of an O&M Manual include:

- A cover page with the project name, City case number, name and seal of the North Carolina licensed design professional
- 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)
- An exhibit, sized to 8.5 x 11, showing the SCM(s) locations, identifiers and easement locations, and identifying the parcels that achieve compliance under this stormwater plan.
- Exhibit(s) showing the drainage areas to each SCM, sized to no more than 11”x17,” and showing parcel boundaries.
- Plan sheets or exhibits that show the plan view and details (cross-section, profile, flow-splitter, outlet control structures) of each SCM sized to no more than 11”x17”.

- A description of the maintenance access. If confined entry will be required, this shall be included.
- Planting plan and schedule of plantings.
- SCM or SCM component manufacturer information if applicable.
- SCMs that serve to meet compliance requirements for multiple lots are shared in their entirety among all lots within the subdivision , regardless of which lots drain to each device. , in each O&M manual for a shared SCM, the design professional shall provide a description of which lots are served by the device (UDO Section 9.2.2.D.2.d).
- An inspection checklist including frequency of inspection and items to be inspected.
- Maintenance Instructions including:
    - Minimum of the Steps in the NCDEQ Stormwater Manual and this document.
    - SCM Manufacturer Specified Steps
    - Quantitative triggers for when actions mush be taken.
    - Expectations for documenting maintenance
- An indication of which O&M actions are needed for the SCM(s), who will be responsible for those actions, and the specific, quantitative criteria that shall be used to determine when these actions will be taken (UDO Section 9.2.2.D.2.e)
- An indication of the steps that shall be taken to restore a device to the design specifications in the event of a failure (UDO Section 9.2.2.D.2.f)
- A statement about the expected life of the device (UDO Section 9.2.2.D.2.g)
- A replacement cost schedule, derived by dividing the initial construction cost of the SCM by the expected life of the device and its components. (UDO Section 9.2.2.D.2.g)
- A budget to include annual costs, such as routine maintenance, repair, periodic sediment removal, replenishment of riprap, insurance premiums associated with the device/SCM facilities, taxes levied against the device/SCM facilities, mowing and reseeding and required inspections (UDO Section 9.2.2.D.2.h)

### 6.6.2 Recorded Easement Requirements

See Chapter 7, Section 7.4 for SCM Easement requirements.

### 6.6.3 Inspection and Maintenance Agreements

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

## 6.7 AS-BUILT CERTIFICATIONS AND SURVEYS

Upon project completion, the City shall require 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 are required on a project or a building prior to final approval of the following: the Stormwater Control Permit, the Certificate of Compliance, the Certificate of Occupancy or the Partial Certificate of Occupancy (commercial only).

### 6.7.1 Stormwater Control Measures

All SCMs require certification by an appropriate design professional, verifying that the actual construction of the measure conforms to the approved plans and provides the required level of stormwater treatment and/or peak flow control. The as-built plans and certification must be signed and sealed by an appropriate design professional, and all applicable checklist items must be included. Refer to the As-Built Checklist on the City's website.

Submittals will include:

Form 503, signed by the Stormwater Inspector

- Completed checklist and certification by a professional qualified in stormwater design.
- Reference to the recorded map showing Easements (reference book and page)
- Narrative summary of SCMs and any deviations from approved plans.
- Surveyed elevations of key SCM components.
- Redlines of approved SCM plans, details, and planting plan
- Shop Drawings (when applicable)
- Updated calculations reflecting any hydrologic and hydraulic changes from the permitted plans to the as-built conditions.
- Updated O&M Manual, including any changes to the O&M Manual to reflect as-built conditions.
- Photos of key components of the SCM.
    - Above Ground SCMs: Including but not limited to 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, all slopes (interior and exterior), etc. Photos shall be dated and be taken within 7 days of the initial as-built submittal.
    - Underground SCMs: including but not limited to all orifices (where flow enters and/or exits), inlet structures (interior/exterior), weir walls, interior of SCM (ex: detention pipes, sand filter chambers, sediment chambers, flow splitters) interior of outlet piping, outlet dissipator and discharge area. Confined space training or specialized equipment may be required. Photos shall be dated and be taken

within 7 days of the initial as-built submittal.

- Some SCMs will require photographs taken during construction to verify that they were constructed in accordance with the approved plans (ex: permeable pavers, underground SCMs, or any SCM that requires underdrains or anti-seep collars). SCMs that require underdrains shall provide photographs of underdrains showing appropriate capping to prevent bypass. Any during-construction photographs submitted should be dated.
- Planting photos. Photos shall be dated and be taken within 7 days of the initial as-built submittal.

- Receipt/invoice/bill of sale with list of plants purchased.
- Documentation of any required testing or materials certification.

Once as-built is accepted, 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 is required if impervious restrictions are a permit condition of approval for a project and the submitted survey shall be sealed by a North Carolina licensed surveyor. An as-built impervious survey should include all areas considered impervious per the UDO. The requirement applies to

- New single-family dwellings and additions/improvements when the total impervious area is within 10% or 400 SF of the limit, whichever is greater.
- Re-development proposing no change in impervious area and substitution of impervious area over 400 SF.
- Any non-residential site with an impervious limit.

Chapter 7

# EASEMENTS

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## 7.1 INTRODUCTION

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

- Downstream Discharge where concentrated flow enters a private property at a location other than a stream. See Section 7.2.
- Conveyance Systems easements for new and existing open and closed conveyance systems, including pipes, channels, structures, culverts, and bridges. These easements include access for maintenance. See Section 7.3
- SCM Easements that encompass both the SCM and the access path. See Section 7.4.
- Dams not considered SCMs. See Section 7.5
- Flood storage easements, where development results in an increase in flood levels. See Section 7.6.

The described easements purposes may share the same easement space if all other requirements are met.

Easements shall be determined to be either Public Drainage Easements or Private Drainage Easements as described in Section 7.2.

Proposed easement locations shall be shown the preliminary or permitting submittal, whichever comes first. All easements, unless otherwise specified in the UDO, shall be recorded on a plat.

## 7.2 DOWNSTREAM DISCHARGE EASEMENTS

Private drainage easements shall be provided for the following on any new development or redevelopment when newly concentrated stormwater discharge locations are created by the proposed development, then the 10-year stormwater flows from these new discharge locations shall be conveyed through an offsite drainage easement that has been secured and recorded between the developer and all downstream, impacted property owner(s). Such easements are required until the point where stormwater flow reaches:

- a jurisdictional water body,
- a City or NCDOT right-of-way (ROW),
- Another public/private drainage easement.

“Newly concentrated flow” shall include any flow that is more concentrated than existing conditions even if it passes through a level spreader, plunge pool, dissipation pad or other engineered device.

Also note the requirements for a Flood Storage Easements (Section 7.6) and for an overland flow path for the 100-year storm.

## 7.3 CONVEYANCE SYSTEM EASEMENTS

Easements for open or closed conveyance systems are required for conveyance systems carrying runoff from:

- More than one parcel
- An upstream conveyance system in an easement.
- An SCM
- The Public ROW

Easements widths have been determined based on maintenance needs. Adequate easements shall be provided to allow access of construction equipment, taking into consideration the limitations that may be imposed by embankment slopes or other obstacles. Easements shall be centered over the pipe or channel/swale. Off-center easement locations shall be allowed when it can be demonstrated that the infrastructure could be accessed, maintained, and replaced using the proposed easement configuration. The access portion of an easement does not need to be centered over the structure.

**TABLE 7.1**
EASEMENT WIDTHS FOR PIPES

| *Pipe Scenario* | *Easement Width* |
|---|---|
| Single Pipe | 20 ft or 10 ft + pipe diameter + (2x the larger invert depth), whichever is greater |
| Multiple Pipes | 20 ft or 10 ft + outside pipe widths + (2x the larger invert depth), whichever is greater |

**TABLE 7.2**
EASEMENT WIDTHS FOR OPEN CHANNELS OR SWALES*

| *Drainage Area* | *Easement Width*[1] |
|---|---|
| < 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 |

*This applied to channels and swales that are not jurisdictional waters or regulated Neuse riparian buffer.

| TABLE 7.3<br>EASEMENT WIDTHS FOR BRIDGES AND CULVERTS | |
|---|---|
| *Equivalent Size* | *Easement Configuration* |
| Up to 36” dia. | The 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 Easement must contain the upstream and downstream inverts of the conveyance structure + minimum 10’ offset from the structure(s) including headwalls and wingwalls<br>And<br>Provide a 25’ width access path to the structure invert from a public ROW where the path does not involve traversing lateral or incline slopes that exceed 3:1. |

Where other utilities are involved, such as water and sewer, additional width 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.

## 7.4 SCM EASEMENTS

Stormwater control measures, conveyance transporting stormwater runoff from an SCM, space for maintaining the SCM, and access to the SCM from the ROW shall be placed in a Private Drainage Easement.

The entire footprint of the SCM system shall be included in the easement, plus an additional 10 feet or more around the SCM to provide adequate room for the equipment and activities necessary to complete maintenance, repair, or replacement tasks. If heavy equipment will be necessary to perform maintenance tasks, such as for devices with a forebay that will require sediment clean-out, **the required easement is 25 feet off the edge of the SCM.** Easements do not need to be centered on the SCM if it can be shown that adequate space for maintenance, repair, and replacement is provided.

Stormwater Conveyance easements will be applied to each outflow from the SCM from the SCM to a point where the flow reaches a ROW, a jurisdictional water body, or another easement.

Direct maintenance access shall be provided to each component of the SCM requiring maintenance activities. This includes components such as the forebay, riser structure, plantings, embankment, outlet, and emergency spillway.

Easements for maintenance and access of SCMs shall extend to a public right of way and shall not include lateral or incline slopes that exceed 3:1 (horizontal to vertical).

Easements shall be held by the entity responsible for the operation and maintenance of the SCM facility, whether an individual, a corporation or a government unless determined otherwise. Easements for SCMs that are not publicly maintained require provisions that allow the permitting entity to access the device for inspections and potential assessments. In no case shall the recorded easement confer an obligation on the City to assume responsibility for the SCM.

## 7.5 EASEMENTS FOR DAMS

For existing or proposed dams that are not considered SCMs, the primary and emergency dam spillways shall be placed in a drainage easement. The easement will include access to the dam from a public right of way and that access path shall not include lateral or incline slopes that exceed 3:1 (horizontal to vertical).

## 7.6 FLOOD STORAGE EASEMENTS

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

A backwater analysis will be required 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 flood storage easement will be required.

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

## 7.7 PUBLIC VERSUS PRIVATE DRAINAGE EASEMENTS

Unless otherwise specified, all required easements should be assumed to be Private Drainage Easements.

The following items should be Public Drainage Easements:

- Easements identified by NCDOT as easements to be held by NCDOT.
- Easements associated with the culverts or bridges serving a City Road will be held by the City.

## 7.8 RECORDING EASEMENTS

Easement recordation will take place via the City's Recorded Map process at the timeline specified in the project's conditions or in the UDO. Proposed maps depicting easements are required to show metes and bounds. Maps must label all drainage easements as "Private Drainage Easement", "Public Drainage Easement", or "Private Flood Storage Easement" as discussed above. The applicant may choose to include a parenthetical sub-label, but that is not required by the City.

A document establishing the rights and obligations associated with the easement shall also be recorded. This can be accomplished through completion of one of the City's locked templates for Easements, either the "Declaration of Maintenance Covenant and Grant of Protection Easements for Stormwater Control Facilities" or the "Private Drainage Easement".

## 7.9 ABANDONMENT OF EASEMENTS

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

- If a site redevelops, including relocating stormwater infrastructure, easement abandonment and new easement locations may be proposed during the development review process.
- If the easement does not meet one of the purposes listed in this chapter and does not provide additional flood protection and water quality benefits by preserving a wider stream or channel buffer, then abandonment may occur through the City's Recorded Map process. Potential applicants are advised to discuss the property with a stormwater reviewer prior to application.

## 7.10 WORK IN EASEMENTS

This section defines what is allowed and disallowed in Private Drainage Easements, Public Drainage Easements, and Private Flood Storage Easements.

When evaluating proposed work in an easement, the goals of the easement are evaluated. The following principles are applied:

- The work must not permanently limit access for maintenance, repair, and replacement to the infrastructure contained in the easement.
- The work must not increase the cost to the easement holder for conducting maintenance, repair, or replacement.
- The work must not impede the flow of water through the easement.
- The work must not directly damage the drainage infrastructure.
- The work must not increase the loading on the infrastructure beyond the load originally considered in the 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 is allowed in an easement.

Table 7.4
WORK IN STORMWATER EASEMENTS

| Proposed Item | Allowed? | Conditions or Exceptions: |
|---|---|---|
| Accessory Structures (e.g. Sheds, Garages, Carports, Coops, etc.) | Not Allowed | |
| Buildings | Not Allowed for Residential<br><br>Not Allowed, with 1 exception for Non-Residential. | Exception for Non-Residential structures: Underground SCMs may be placed under buildings when the specific requirements in Chapter 6.3.4 have reviewed and approved. |
| Decks/porches | Not Allowed, including the overhang of these structures. | |
| Driveways | Conditional | Allowed if conveyance pipes and structures meet current City requirements for cover and loading.<br>Not allowed for open conveyance. |
| Fences | Conditional | Fences are allowed if they meet the following criteria, as demonstrated on the plot plan:<br>- Crossing a conveyance easement perpendicular to the easement.<br>- If running perpendicular to the conveyance easement, footings need to be a minimum of 5' from the infrastructure centerline or at a 1:1 slope away from the pipe invert, whichever is larger.<br>AND<br>-Not impeding flow<br>AND<br>-Not over a drainage structure<br>AND<br>-Posts in the easement will be hand dug. |
| Headwalls, Endwalls and Wingwalls | Allowed | These structures are directly related to stormwater infrastructure. |

| | | |
|---|---|---|
| HVAC or Other Equipment | Conditional | Must demonstrate that the principles listed above this table are met. |
| Patios and Private Pathways | Conditional | Allowed if conveyance pipes and structures meet current City requirements for cover and loading.<br><br>Not allowed for open conveyance. |
| Play Equipment | Conditional | Must demonstrate that the principles listed above this table are met. |
| Pools | Not Allowed | |
| Retaining walls | Dependent on where the retaining wall and the fill are placed. | It is important to analyze the increased pressure any wall will add to the pipe, if additional fill is placed on the pipe or if the wall is located in close proximity to the pipe more analysis may be required |
| Signs | Conditional | Dependent on the type of sign, e.g.:<br>- Large sign with footers placed on top of pipe, would not be allowed<br>- Street sign would be allowed if followed the guidance for fence posts in this table. |
| Vegetation - Planting (Trees, Shrubs, Landscape Beds) | Conditional | In general plants complement stormwater functions. Plants are allowed in easements when the following is demonstrated on the plans:<br>• Plants other than grass are not allowed in access path portion of a SCM easement.<br>• Plants cannot change the topography in a way that redirects flow outside the easement.<br>• Trees may not be planted directly over stormwater infrastructure that has less than X feet of cover. |
| Vegetation - Planting (Grass) | Allowed | |
| Vegetation - Removal | Conditional | • Removal cannot change the topography in a way that redirects flow outside the easement.<br>• Removal with SCMs must be in line with the SCM design and O&M documents. |

# Chapter 8
# EROSION AND SEDIMENT CONTROL

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## 8.1 INTRODUCTION

Erosion and sediment control devices and best practices are imperative in the protection of waterways, downstream properties, and infrastructure. This chapter describes the erosion and sediment control (ESC) requirements for the City. Adherence to this chapter, the City's Unified Development Ordinance (UDO), City ESC Standard Detail Drawings, as well as to the North Carolina Department of Environmental Quality (NCDEQ) *"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. Appropriate measures must be designed, approved, permitted and installed on the site prior to any land-disturbing activities. See UDO Article 9.4 for cases that require permitting for less than 12,000 square feet of land disturbance.

All land-disturbing activities undertaken within the City shall provide adequate 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 the NCDEQ *"Erosion and Sediment Control Planning and Design Manual"* , the City's Standard Detail Drawings, the City's UDO, or this manual, whichever is more stringent.

### 8.2.1 Limits of Disturbance

The Limits of Disturbance (LOD) shall include all land disturbing activity, as defined in UDO Section 12.2, and encompass all construction activities including, but not limited to, the following:

- Construction Access (minimum of 10' around structures or extended to the property line if less than 10 feet away)
- 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, etc.)
- 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 may 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 Standard Detail Drawing, shall be placed on a flat area and silt fence/silt fence outlet shall be placed at the downslope side of the bag. The 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 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 relevant 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

Land-disturbing activities disturbing one acre or more, or that are part of a larger common plan of development disturbing one acre or more, are required to obtain coverage under National Pollutant Discharge Elimination System (NPDES) General Construction Permit, NCG010000 (NCG01). Coverage under the NCG01 Permit requires an approved ESC plan and subsequent submission of electronic Notice of Intent (e-NOI) to NCDEQ.

### 8.2.7 Sites 20 Acres or Larger

If 20 acres or more are included in the LOD, the following requirements apply:

- Method of limiting the time of exposure and amount of exposed area.
- 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 condition, which must include pre- and post-construction contours.
- The construction sequence shall detail phasing to justify the time and amount of exposure.

## 8.3 SINGLE-FAMILY RESIDENTIAL CONSTRUCTION

### 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 development plan (including demolition), on a single lot, or on multiple lots by the same person within the same 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. Subdivision will be defined by one of the following: an active subdivision case, a recorded subdivision as demonstrated by a recorded map or other land records information. Staff will also review the County GIS parcel data and the City's subdivisions 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.

If a person disturbs less than 12,000 square feet within a common plan of development, the City will not require a LDG Permit. However, a NCG01 Permit must be obtained from NCDEQ. Therefore, an ESC plan approval may be required by NCDEQ.

If a person disturbs 12,000 square feet or more within a common plan of development, the City will require a LDG Permit. The LDG Permit submittal to the City must include the items noted below in 8.4.5

### 8.3.2 Requirements if LOD under 12,000 sf

For single-family lots with an LOD under 12,000 square feet that do not require a LDG Permit, ESC measures are required to be installed per City Standard Detail Drawing specifications. These measures must be appropriate for site and topographic conditions include, but are not

limited to:

- 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 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 Single-Family Lots

Projects on single-family lots vary in size and the amount of land disturbance associated with each project also varies.

- For projects that results 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 8.7.1 below for groundcover specifications.
- For projects that results 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 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 website for specific submittal procedures.

### 8.4.2 Surety

A surety 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 website for specific submittal procedures.

### 8.4.3 ESC Calculations

Design calculations associated with the ESC measures shall be either shown on the design plans or included in the SCR. Calculations must be sealed by a North Carolina licensed professional 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 during construction detention compliance per UDO Section 9.2.2.E.1.b. See Chapter 3 of this manual for acceptable 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 for sites over 20 acres.
- Any other calculations required by the NCDEQ *"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, shall meet the following requirements:

- ESC plans shall clearly show existing and proposed site features, drainage features, jurisdictional streams, wetlands, and buffers, as well as any SFHA's.
- Plans shall clearly demonstrate the proposed ESC measures including applicable City Standard Detail Drawings and areas of required vegetative stabilization.
- Plans shall include notes, details, and a construction sequence (See Section 8.5 below) relevant to the ESC measures proposed and sequence of installation.
- A copy of the approved plan shall be maintained on the job site
- The signature and seal of the North Carolina licensed professional 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.
- Total acreage for the property/site.
- Total proposed LOD on each ESC plan view sheet. Round to hundreths of an acre. Place the LOD in a clearly visible box outlined in black.
- Note indicating that prior to commencing land-disturbing activities, the approved limits of land disturbance shall clearly and accurately be demarcated with stakes, ribbons or other appropriate means, and shall be demarcated for the duration of the construction activity and no land disturbance shall occur outside the limits indicated on the approved plans.

### 8.4.5 NPDES Plan Requirements

To meet the requirements of the NCG01, the following must be included in the E&SC plan:

- 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 should be hatched and an associated legend should be included.
- Drainage areas of one acre or more shall include the use of outlet structures that withdraw from the surface.
- 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 the construction sequence should be discussed with the stormwater inspector and noted on the plans. Major changes to the sequence will require a plan revision. If the measures installed are not functioning and/or do not meet applicable City requirements, Stormwater Inspections staff shall require a 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 permits are issued, the construction sequence is part of the approved plans and must be followed.

### 8.5.1 Initial Phase of Construction

An erosion control construction sequence shall be included with all ES&C plans, broken out by phase as necessary. The construction sequence for the initial phase of construction shall include, at a minimum, 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 Stormwater Inspections Regional Coordinator (Inspector Name) at (Inspector's Phone Number). (See map of Regional Coordinators) The limits of disturbance of the project shall be demarcated on-site.*

2. *Install all perimeter erosion and sediment 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. Groundcover shall be installed on temporary diversions, berms and basins immediately after construction.*
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 permitted land disturbing activity.*
5. *For sites greater than one acre, erosion control measures shall be inspected and maintained at least once per week and after every rainfall event.*

★ *Modify and add sequencing for site specific details (stream crossing sequencing, installation of clean water diversions, etc.) 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 should 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 should be clearly addressed in the construction sequence and shown on the plans with notes/callouts notating the sequential nature.

Later phase(s) of the erosion control plan should reflect a plan to keep sediment from the building site from being washed onto the pavement and tracked off-site. This may include silt fence around the building's limit of disturbance with controlled openings/access points for construction access. The silt fence will 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 for the intermediate phase of construction shall include, at a minimum, 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 the City Stormwater inspector.*

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

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

- *As stormwater infrastructure is installed, install inlet protection or other approved measure as shown on the plan.*
- *After all stormwater infrastructure is installed submit a red-lined approved 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 for the final phase of construction shall include, at a minimum, 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 8.7 below]*
2. *No temporary erosion and sedimentation control measures shall be removed without approval by the City Stormwater Inspector.*
3. *Once approved, remove remaining temporary erosion and sedimentation control measures. All permanent erosion control measures [permanent ditch stabilization, riprap outlet protection, etc.] should 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 (Basin conversion, pipe flushing, etc.) as necessary.*

If the site requires a Stormwater Conveyance System permit, the following will also be added to

the final construction sequence:

*CCTV Inspection Certification*

- *When the area draining to the stormwater conveyance system is at least 70% stabilized consult with 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" (both public and private) and larger.*
- *If defects are identified during CCTV inspection, submit a repair plan to the City, correct defects and conduct additional CCTV inspection(s) to confirm defect correction.*
- *When the conveyance system (both public and private) is free of defects, submit the Stormwater Conveyance CCTV/Inspection Checklist and required checklist items to the City.*

*As-built Certification*

- *Once the CCTV Inspection has been accepted by the City and the final inch of asphalt has been installed, prepare surveyed as-built of the Stormwater Conveyance System.*
- *At a minimum of 7 days prior to scheduling the Final Stormwater Conveyance System Permit Final Acceptance Inspection, Submit the Stormwater Conveyance As-built Submittal Checklist and required checklist items to the City.*

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

- *No conversion of erosion control measures to SCMs shall occur without the approval of the City Stormwater Inspector.*
- *[ESC plans shall address conversion of devices within the construction sequence. Reference 8.6 below for guidance regarding conversion to post-construction SCMs.]*
- *As-built certifications of all post-construction SCMs on-site shall be provided/accepted 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 accepted in writing prior to a Certificate of Occupancy or Certificate of Compliance being issued.*

The construction sequence for the final phase shall also include any information or certifications required prior to final approval of permits and/or Certificate 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 may also apply for termination of coverage of this permit from NCDEQ after approval of the final land disturbance permit inspection and issuance of Certificate of Completion by the City.*

## 8.6 POST-CONSTRUCTION SCM

For post-construction stormwater designs that include stormwater ponds, wetlands or similar control measures, it is common practice for the control measure 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 should account for these items and provide a site- and device-specific phasing plan for the conversion of any measures in the construction sequence.

| TABLE 8.1<br>**CONVERTING ESC MEASURES TO POST-CONSTRUCTION SCMS** | |
|---|---|
| *Topic* | *Conversion Guidance* |
| Drainage Areas | Drainage areas shall be limited by the appropriate 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 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 practice so that this type of regrading is not necessary, which may include changing the footprint, grading, slopes and other features of the ESC practice. |
| 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, and conversion may begin. In addition to drainage area stabilization, other supplemental ESC measures may be warranted, such as diverting flow around the practice during the conversion process and using silt fence or matting/sod on the side slopes of the practice. |
| 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 practice using an approved dewatering and sediment capture method (e.g. silt bags, etc.). All notification requirements by 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 are not 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 device is temporary if it will have underdrains as a permanent SCM. During the conversion to a permanent measure, the underdrains may then be installed. |
| Post-Construction SCM Installation | Install the SCM per the approved construction plans. Sequencing items specific to the proposed design must be detailed. Some minor grading or adjustments to the footprint may be needed to meet the post-construction design. |
| Easement/SCM Location Awareness | Because the post-construction SCM must be located within an easement, it is very important to make sure the final SCM is within the specified area to avoid costly relocation of the SCM or re-recordation of the required easement. |

## 8.7 GROUNDCOVER VS. STABILIZATION

NCDEQ surface stabilization standards and specifications found in the *"Erosion and Sediment Control Planning and Design Manual"* and the groundcover/stabilization requirements shall be adhered to throughout construction.

### 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 limits of disturbance.

The City supports 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, etc.), pine or hardwood mulch, and tarps and landscaped areas (e.g. shrubs, trees, pine straw, etc.). 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 applied. It is important to comply with timeframes for groundcover application. These timeframes should be clearly presented in the construction sequence on the approved plans. Refer to UDO Article 9.4. for the most current ground cover 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. If environmental or mechanical conditions prevent the installation of sod this will result in delay of Certificate of Occupancy and/or Certificate of Compliance.
- Mulch – triple-shredded hardwood mulch at a depth of six inches must be applied to

prevent movement of mulch.

- Artificial/Synthetic Turf – when artificial/synthetic turf is utilized for stabilization it must be permitted 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 UDO Article 9.2) – When using impervious surface/built upon area for stabilization, it must be permitted and may include parking lots, buildings, gravel, rip rap, etc.
- 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.

#### 8.7.2.1 STABILIZATION FOR PERMIT CLOSE-OUT/CERTIFICATE OF OCCUPANCY

Permanent stabilization is required prior to closing LDG Permits, closing out Stormwater Control Permits with 400 square feet or more land disturbance, and/or prior to issuance of Certificate of Occupancy(s) or Certificate of Compliance.

Chapter 9

# FLOODPLAIN MANAGEMENT

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## 9.1 INTRODUCTION

The City of Raleigh (City) is a participating community in Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP), The City, North Carolina Floodplain Management Program (NCFMP), and FEMA have identified more than 23 square miles of floodplain, otherwise known as flood-prone areas or the Special Flood Hazard Area (SFHA), within Raleigh's jurisdictional area. 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.

Any landowners and/or professionals planning any development activity within the SFHA shall have the knowledge and skills to plan, design, and construct their project in compliance with SFHA regulations. For purposes of floodplain management, "development" is defined in the UDO.

## 9.2 TYPES OF SPECIAL FLOOD HAZARD AREAS

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

### 9.2.1 FEMA-Designated SFHA

Note that 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 the DFIRMs. The City Drainage Basin Study Maps use the same criteria as DFIRMs to illustrate SFHAs with a contributing drainage area of 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 [TO BE DETERMINED]. The City performs drainage basin study updates periodically.

### 9.2.3 SFHA Based on Flood Hazard Soils

Guidance on flood hazard soils may be found in  Flood hazard soils are soil types defined in UDO Section 12 and are illustrated on the last paper copy of the Wake County or Durham County Soil Survey Map.

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 as the SFHA. Determine the RFPE as described in the UDO.
- 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 detailed in Section 9.5.1 below.

### 9.2.4 SFHA Based on Flood Study

In addition to the above requirements, the City requires that a flood study be completed for any stream on or adjacent to a development site that has a drainage area of 25 acres or more. Sites containing or adjacent to streams that drain greater than 25 and less than 100 acres must complete a Simple Flood Study. Sites drains 100 acres or more must complete a Comprehensive Flood Study. See Section 9.5.1 below for the detail about these study types and their requirements.

You can find additional information about flood studies in the NCDOT Guidance for Drainage Studies and Hydraulic Design.

## 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 guidance on 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 UDO and the requirements below.

- A sealed engineering report shall be required for projects within the floodway of any SFHA which add any new obstructions. 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 9.5 below for the requirements for Flood Studies, including 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 six 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 information upon the completion of the project.
    - The applicant schedules the final floodplain inspection through the City Permitting and Development Portal, once the required information (FEMA Elevation Certificate, Floodproofing Certificate, Lowest Floor Certificate, etc.) is approved by the City.
    - The City closes out the *Floodplain Development Permit*. If the *Floodplain Development Permit* is not closed the Certificate of Occupancy will not be issued.
- For sites that require a LOMR, the Applicant must submit a LOMR to the City within six months of the Certificate of Occupancy or completion of construction, whichever occurs first.

## 9.5 FLOOD STUDY REQUIREMENTS

Flood Study requirements may be found on the *Flood Study Submittal Checklist* on the City's website. Flood studies shall be submitted as indicated on the website and in this document.

### 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.

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 0-25 acres | No study required |
| Sites containing or adjacent to streams that drain greater than 25 and less than 100 acres | Simple Flood Study required |

| | |
|---|---|
| Flood hazard soil areas or areas 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
    - Can be used to establish the RFPE
    - Floodway determination not required
    - Acceptable 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 this property, then a method 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
    - Can be used to establish the RFPE
    - Delineates the Floodway versus Floodway Fringe
    - Acceptable methods include: One-Dimensional or Two-Dimensional Steady Flow Models capable of modeling ineffective flow areas and developing a floodway that are 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 of 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 as a separate development review case.
- See City 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 Conditional Letter of Map Revision (CLOMR), Letter of Map Revision (LOMR), Letter of Map Revision based on Fill (LOMR-F) or Letter of Map Amendment (LOMA), where appropriate.

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 approval of the change is required prior to submitting a CLOMR application to FEMA. 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 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 confirming that the project was built as designed within six months of the completion of the project. In cases where the City is not requiring the modification of the existing regulatory floodway (ie; 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 within six months of the completion of construction or Certification 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 six 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 their property has been mapped in an SFHA in error, they 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 the UDO 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 staff can administratively approve the project with a detailed engineering analysis. The No Impact Study must be conducted and approved by staff before a permit can be issued. The City’s 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 sealed by a North Carolina licensed professional engineer. 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, must be received, reviewed, and approved prior to the final inspection. All required documentation shall be submitted to the City prior to scheduling final floodplain inspection.

### 9.6.1 FEMA Elevation Certificate

For structures located within FEMA-designated floodplain areas, the current effective FEMA Elevation Certificate form must be completed and submitted prior to the final inspection and Certificate of Occupancy. 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 providing elevation and flood vent information shall be completed and submitted prior to the final inspection and Certificate of Occupancy. A mid-point construction inspection is required to confirm that the elevation of the structure and associated equipment is at or above the RFPE elevation. FEMA Elevation Certificate

## 9.7 FLOODPROOFING CERTIFICATE

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

Applicants must utilize the FEMA Floodproofing Certificate.

## 9.8 SUBSTANTIAL IMPROVEMENT OR SUBSTANTIAL DAMAGE

If the cumulative cost of improvements and repairs to a structure 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. 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 a North Carolina licensed real estate appraisal of the structure (building only, no land value). See Equation below for calculating substantial improvement or substantial damage

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

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## Disclaimer

*To the best of their ability, the authors have insured that material presented in this manual is accurate and reliable. The design of engineered facilities; however, requires considerable judgment on the part of designer. It is the responsibility of the designer to ensure that techniques utilized are appropriate for a given situation. The City of Raleigh therefore accepts no responsibility for any loss, damage, or injury as a result of the use of this manual.*