Appendix I: General Design Criteria and Guidelines

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I.1 Hydrology and Runoff Determination

I.1.1 Acceptable Hydrologic Methods and Models

The following are the acceptable methodologies and computer models for estimating runoff hydrographs before and after development. These methods are used to predict the runoff response from given rainfall information and site surface characteristic conditions. The design storm frequencies used in all of the hydrologic engineering calculations will be based on design storms required in this guidebook unless circumstances make consideration of another storm intensity criterion appropriate:

- Rational Method (limited to sites under 10 acres)
- Urban Hydrology for Small Watersheds TR-55 (TR-55)
- Storage-Indication Routing
- HEC-1, WinTR-55, TR-20, and SWMM Computer Models

These methods are given as valid in principle and are applicable to most stormwater management design situations in the Southern Lowcountry. Other methods may be used when the Southern Lowcountry reviewing authority approves their application.

Note: Of the above methods, TR-55 and SWMM allow for the easiest correlation of the benefits of retention BMPs used to meet the stormwater retention volume (SWRv) with peak flow detention requirements and are therefore strongly recommended.

The following conditions shall be assumed when developing predevelopment, pre-project, and post-development hydrology, as applicable:

- For new development sites the runoff conditions shall be computed independent of existing developed land uses and conditions and shall be based on "Meadow in good condition" or better, assuming good hydrologic conditions and land with grass cover (NEH, 2004).
- For infill and redevelopment sites the predeveloped condition is the condition at the time of project submittal.
- Post-development conditions shall be computed for future land use assuming good hydrologic and appropriate land use conditions. If an NRCS CN Method-based approach, such as TR-55, is used, this curve number (CN) may be reduced based upon the application of retention BMPs, as indicated in the General Retention Compliance Calculator (Appendix H). This CN reduction will reduce the required detention volume for a site, but it should not be used to reduce the size of conveyance infrastructure.
- The rainfall intensity - duration - frequency curve should be determined from the most recent version of the Hydrometeorological Design Studies Center's Precipitation Frequency Data Server (NOAA Atlas 14, Volume 2).
- Predevelopment Time of Concentration (Tc) shall be based on the sum total of computed or estimated overland flow time and travel in natural swales, streams, creeks and rivers, but never less than 6 minutes.
- Post-development Time of Concentration shall be based on the sum total of the inlet time and travel time in improved channels or storm drains but shall not be less than 6 minutes.
- Site drainage areas exceeding 10 acres that are heterogeneous with respect to land use, soils, RCN or Time of Concentration (Tc) shall require a separate hydrologic analysis for each sub-area.
- Hydrologic soil groups (HSGs) approved for use in the Town of Bluffton are contained in the US Department of Agriculture Web Soil Survey. Where the HSG is not available through the Soil Survey due to the listed soil type being "Urban Soils" or similar, an HSG of C shall be used.

I.1.1.1 Urban Hydrology for Small Watersheds TR-55

Chapter 6 of Urban Hydrology for Small Watersheds TR-55, Storage Volume for Detention Basins, or TR-55 shortcut procedure, is based on average storage and routing effects for many structures and can be used for multistage outflow devices. Refer to TR-55 for more detailed discussions and limitations.

Information Needed
To calculate the required storage volume using TR-55, the predevelopment hydrology, along with the post-development hydrology for the 2, 10 and 25-year, 24-hour storm events are needed. The predevelopment hydrology is based on natural conditions (meadow) and will determine the site's predevelopment peak rate of discharge, or allowable release rate, *qo*.

The post-development hydrology may be determined using the reduced CNs calculated in the General Retention Compliance Calculator or more detailed routing calculations. This will determine the site's post-development peak rate of discharge, or inflow for the 2, 10 and 25-year, 24-hour storm events, and the site's post-developed runoff in inches. Note that this method does not require a hydrograph. Once the above parameters are known, the TR-55 Manual can be used to approximate the storage volume required for each design storm.

Procedure

1) Determine the peak development inflows, q_i, and the allowable release rates, q_O, from the hydrology for the appropriate design storm.

Using the ratio of the allowable release rate (q_O) to the peak developed inflow (q_i)—or q_O/q_i—for the design storms, use Figure 1 to obtain the ratio of storage volume (V_S) to runoff volume (V_R)—for Type III storms.

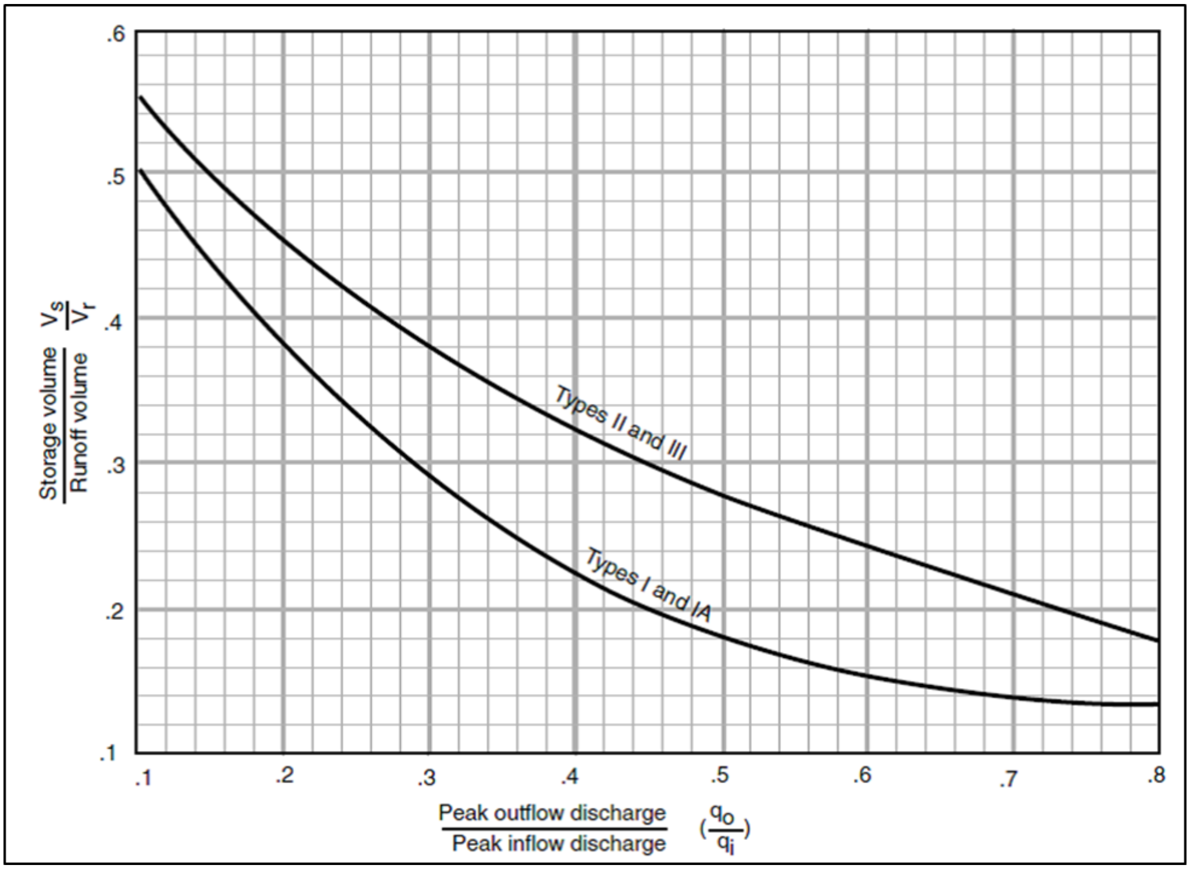

Figure 1. Approximate detention basin routing for rainfall Types I, IA, II, and III.

2) Determine the runoff volume V_R.

$$V_{\mathrm{R}} = \frac{Q}{12} \times SDA$$

where:

V_R = post-development runoff for the design storm (ft^3)

Q = post-development runoff for the design storm (in)

12 = conversion factor (inches to feet)

SDA = site drainage area (ft^2)

3) Multiply the V_S/V_R ratios from Step 1 by the runoff volume (V_R) from Step 2 to determine the required storage volumes (V_S) in acre-feet.

$$\left(\frac{V_S}{V_R}\right) V_R = V_S$$

The design procedure presented above may be used with Urban Hydrology for Small Watersheds TR-55 Worksheet 6a. The worksheet includes an area to plot the stage-storage curve, from which actual elevations corresponding to the required storage volumes can be derived. The characteristics of the stage-storage curve are dependent upon the topography of the proposed storage practice and the outlet structure, and it may be best developed using a spreadsheet or appropriate hydraulics software.

Limitations
This routing method is less accurate as the q_O/q_i ratio approaches the limits shown in Figure 1. The curves in Figure 1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (V_S) required is small, the shape of the outflow hydrograph is sensitive to the rate of the inflow hydrograph. Conversely, when V_S is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (q_O) approaches the peak inflow discharge (q_i) parameters that affect the rate of rise of a hydrograph, such as rainfall volume, CN, and Time of Concentration, become especially significant.

The procedure should not be used to perform final design if an error in storage of 25% cannot be tolerated. Figure 1 is biased to prevent under-sizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and storage indication routing will often pay for itself through reduced construction costs.

I.1.1.2 Storage-Indication Routing

Storage-Indication Routing may be used to analyze storage detention practices. This approach requires that the inflow hydrograph be developed through one of the methods listed in this appendix (TR-55, WinTR-55, SWMM, etc.), as well as the required maximum outflow, q_o. Using the stage-discharge relationship for a given combination outlet devices, the detention volume necessary to achieve the maximum outflows can be determined.

I.1.1.3 HEC-1, WinTR-55, TR-20, ICPR and SWMM Computer Models

If the application of the above computer models is needed, the complete input data file and print-out will be submitted with the Stormwater Management Plans (SWMPs). Submission of SWMPs shall include the following computer model documentation:

- For all computer models, supporting computations prepared for the data input file shall be submitted with the SWMPs.
- Inflow-outflow hydrographs shall be computed for each design storm presented graphically and submitted for all plans.
- Schematic (node) diagrams must be provided for all routings.

I.1.2 Stormwater Volume Peak Discharge

The peak rate of discharge for individual design storms may be required for several different components of water quality BMP design. While the primary design and sizing factor for most stormwater retention BMPs is the design Stormwater Retention Volume (SWRv), several design elements will require a peak rate of discharge for specified design storms. The design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales and water quality swale geometry, etc. all require a peak rate of discharge in order to ensure non-erosive conditions and flow capacity.

The peak rate of discharge from an SDA can be calculated from any one of several calculation methods discussed in this appendix. The two most commonly used methods of computing peak discharges for peak runoff calculations and drainage system design are NRCS TR-55 CN methods (NRCS TR-55, 1986) and the Rational Formula. The Rational Formula is limited to 10 acre drainage areas. It is highly sensitive to the Time of Concentration and rainfall intensity, and therefore should only be used with reliable Intensity-Duration-Frequency (IDF) curves or tables for the rainfall depth and region of interest (Claytor & Schueler, 1996).

The NRCS CN methods are very useful for characterizing complex sub-watersheds and SDAs and estimating the peak discharge from large storms (greater than 2 inches), but it can significantly underestimate the discharge from small storm events (Claytor and Schueler, 1996). Since the SWRv is based on smaller storm events, this underestimation of peak discharge can lead to undersized diversion and overflow structures, potentially bypassing a significant volume of the design SWRv around the retention practice. Undersized overflow structures and outlet channels can cause erosion of the BMP conveyance features that can lead to costly and frequent maintenance.

In order to maintain consistency and accuracy, the following Modified CN Method is recommended to calculate the peak discharge for the SWRv rain event. The method utilizes the Small Storm Hydrology Method (Pitt, 1994) and NRCS Graphical Peak Discharge Method (USDA, 1986) to provide an adjusted CN that is more reflective of the runoff volume from impervious areas within the SDA. The design rainfall is a NRCS Type III distribution, so the method incorporates the peak rainfall intensities common in the eastern United States, and the time of concentration is computed using the method outlined in TR-55.

The following steps describe how to calculate the SWRv peak rate of discharge (q_{pSWRv}) for the 85th percentile rain (1.16-inch) event.

1) **Calculate the adjusted CN for the site or contributing drainage area (CDA).**
The following equation is derived from the NRCS CN Method and is described in detail in the National Engineering Handbook Part 630 Chapter 10: Estimation of Direct Runoff from Storm Rainfall and NRCS TR-55 Chapter 2: Estimating Runoff:

$$CN = \frac{1{,}000}{10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{0.5}}$$

where:

CN = adjusted curve number

P = rainfall (in, 1.16 or 1.95 in)

Q_a = runoff volume (watershed inches), equal to SWRv/SDA

Note: When using hydraulic/hydrologic model for sizing a retention BMP or calculating the SWRv peak discharge, designers must use this modified CN for the CDA to generate runoff equal to the SWRv for the design rainfall event.

2) **Compute the site drainage area's time of concentration (*Tc*).**
TR-55 Chapter 3: Time of Concentration and Travel Time provides a detailed procedure for computing the Tc.

3) Calculate the stormwater retention volume peak discharge (q_{pSWRv}).
The q_{pSWRv} is computed using the following equation and the procedures outlined in TR-55, Chapter 4: Graphical Peak Discharge Method. Designers can also use WinTR-55 or an equivalent TR-55 spreadsheet to compute q_{pSWRv}:

- Read initial abstraction (I_a) from TR-55 Table 4.1 or calculate using I_a = 200/CN – 2
- Compute I_a/P (P = 1.16)
- Read the Unit Peak Discharge (q_u) from Exhibit 4-II using Tc and I_a/P
- Compute the q_{pSWRv} peak discharge:

$$qp_{SWRv} = q_u \times A \times Q_a$$

where:

q_{pSWRv} = stormwater retention volume peak discharge (ft^3/sec)
q_u = unit peak discharge (ft^3/sec/mi^2/in)
A = site drainage area (mi^2)
Q_a = runoff volume (watershed inches), equal to SWRv/SDA

This procedure is for computing the peak flow rate for the 85^{th} and 95^{th} percentile rainfall events. Calculations of peak discharge from larger storm events for the design of drainage systems, culverts, etc., should use published CNs and computational procedures.

I.2 Storm Sewer Collection System

I.2.1 Introduction

The focus of *the Southern Lowcountry Stormwater Design Manual* is to define standards and specifications for design, construction and maintenance of BMPs required to meet post construction stormwater performance objectives. Design of the conveyance of stormwater runoff within the public right-of-way (PROW) must follow the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009). These are incorporated by reference with the following notes pertinent to the Town of Bluffton.

I.2.2 Clearance with Other Utilities

- All proposed and existing utilities crossing or parallel to designed storm sewer systems must be shown on the plan and profile.
- Storm drain and utility crossings must not have less than a 45-degree angle between them.
- Minimum vertical and horizontal clearances, wall to wall, must be provided between storm drainage lines and other utilities as defined by the Beaufort-Jasper Water & Sewer Authority.

I.2.3 Pipe Systems

- The pipe sizes used for any part of the storm drainage system within the PROW must be designed in accordance with the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage. (SCDOT, 2009)

- The material and installation of the storm drain for any part of public storm sewer must be designed in accordance with the current requirements in SCDOT's Requirements for Hydraulic Studies, Part 2 Requirements for Roadway Drainage (SCDOT, 2009). An exception to the SCDOT list is spiral ribbed aluminum pipe (SRAP), which is not an acceptable pipe material for brackish waters. Materials shall be RCP, CAAP, HDPE or HP Storm per AASHTO standards for H20/H25 loading and installation per ASTM/AASHTO standards. Durability must be 100 years or greater per SCDOT standards.
- An alternative overflow path for the 100-year storm is to be shown on the plan view if the path is not directly over the pipe. Where applicable, proposed grading must ensure that overflow will be into attenuation facilities designed to control the 100-year storm.
- A pipe schedule tabulating pipe length by diameter and class is to be included on the drawings. Public and private systems must be shown separately.
- Profiles of the proposed storm drains must be shown on the drawings and indicate size, type, and class of pipe, percent grade, existing ground and proposed ground over the proposed system, and invert elevations at both ends of each pipe run. Pipe elevations and grades must be set to avoid hydrostatic surcharge during design conditions. Where hydrostatic surcharge greater than 1-foot of head cannot be avoided, a rubber gasket pipe is to be specified.

I.2.4 Hydraulic Grade Line

The existing grade line and proposed 25- and 100-year hydraulic grade lines (HGL) must be clearly indicated on the system profiles and identified with the initials HGL on the line and identified in the legend key. This grade line must take into consideration pipe and channel friction losses, computing structures losses, tailwater conditions and entrance losses. All pipe systems must be designed so that they will operate without building up a surcharged hydrostatic head under design flow conditions. It is recommended that the HGL be no more than 1 foot above the pipe crown. If pipes have a HGL more than 1 foot above the pipe crown, rubber gaskets are required. The 100-year HGL must not overtop the 6" curb of ingress/egress routes that would isolate interior parcels in the extreme flood event.

If the structural stormwater BMP discharges into a storm sewer, a detailed HGL analysis of the system including the receiving system must be submitted with the final Stormwater Management Plans (SWMPs) for 100-year storm event. Provide documentation supporting safe passage of the 100-yr post-development flow downstream and an analysis of the surrounding neighborhood area to identify any existing capacity shortfalls or drainage blockages based on the 10% rule in Section 3.8.

I.3 Open Channels

- Calculations must be provided for all channels, streams, ditches, swales, etc., including a typical section of each reach and a plan view with reach locations. In the case of existing natural streams/swales, a field survey of the stream (swale) cross sections may be required prior to the final approval.
- The final designed channel must safely pass the 100-yr storm event.
- If the base flow exists for a long period of time or velocities are more than 5 feet per second in earth and sodded channel linings, gabion or riprap protection must be provided at the intersection of the inverts and side slopes of the channels unless it can be demonstrated that the final bank and vegetation are sufficiently erosion-resistant to withstand the designed flows, and the channel will stay within the floodplain easement throughout the project life.

- Channel inverts and tops of bank are to be shown in plan and profile views.
- For a designed channel, a cross section view of each configuration must be shown.
- For proposed channels, a final grading plan must be provided.
- The limits of a recorded 100-year floodplain easement or surface water easement sufficient to convey the 100-year flow must be shown.
- The minimum 25-foot horizontal clearance between a residential structure and 100-year floodplain must be indicated in the plan.
- For designed channels, transition at the entrance and outfall is to be clearly shown on the site plan and profile views.

I.4 References

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