



City of Hendersonville
Stormwater Design Manual

November 14, 2011

Engineering Department

City Operations Center

305 Williams Street

Hendersonville, NC 28792

PURPOSE

The purpose of the City of Hendersonville Stormwater Design Manual is to provide the minimum standards for the design of stormwater systems and stormwater best management practices within the City of Hendersonville and its Extraterritorial Jurisdiction (ETJ). The guidelines presented shall be used in connection with the [Henderson County Erosion Prevention and Sediment Control requirements](#).

HYDROLOGY

This section describes recommended procedures to determine runoff flows and volumes for project sites within the City and ETJ. Utilizing the procedures described in this manual will provide the best available estimation for the existing and proposed conditions of the project site. The procedures will also provide a consistency for all designed stormwater elements within the City.

It is assumed that practicing Engineers and Landscape Architects preparing stormwater plans have a general understanding of the following procedures. This manual is not intended to be a step-by-step guide to stormwater design but rather a collection of applicable methodologies. Any issues concerning this manual should be brought to the attention of the City of Hendersonville Engineering Department.

Design Storm

The selection of the design storm is the fundamental requirement for any stormwater design. Each aspect of the stormwater system has a different design storm associated to provide a safe and functional system. The table below outlines each storm event applicable to certain stormwater analysis.

DESIGN STORM	
<i>Stormwater Element</i>	<i>Design Storm</i>
Stormwater Sewer	10 yr
Stormwater Ditch	10 yr
Roadway Cuvlert	25 yr
Detention BMP	2 & 10 yr (detention) 25 yr (pass)

Calculations

The calculation methods used for different design criteria are defined below. Other methodologies may be used but need to be approved by the City of Hendersonville Engineering Department prior to a stormwater submittal.

1. Rational Method

The rational method is the recommended runoff calculation for sites where:

- a. The drainage area is less than 200 acres; and
- b. Detention is **not** required.

Calculation

$Q=C*I*A$, where:

Q= Runoff, cfs

C= Runoff Coefficient

I= Rainfall Intensity, in/hr

A=Drainage Area

Rainfall intensity can be determined from [NOAA precipitation charts for Hendersonville.](#)

The time of concentration (T_c) is the time it takes a particle of water to travel from the most hydrological remote point in the drainage area. Acceptable methods to determine the T_c are the United States Department of Agriculture Natural Resources Conservation Service [Technical](#)

[Release – 55 \(TR-55\)](#) and the Kirpich equations (see equation below). Any other equation will need to be approved before submittal. The minimum T_c value used shall be 5 min. The City of Hendersonville Engineering Department reserves the right to review and reject any T_c values that it feels does not accurately reflect the drainage area and land use.

Kirpich Formula:

$$T_c = \frac{0.0078L^{0.77}}{S^{.385}}$$

L= Length in feet

S=Slope in feet per foot

The runoff coefficient must represent the land use of the drainage area to the point of analysis. An appropriate hydrologic soil group and land use shall be used to determine the appropriate C- factor. The City of Hendersonville Engineering Department reserves the right to review and reject any C coefficients that it feels does not accurately reflect the drainage area and land use.

2. TR-55 (Technical Release 55-Obtained from Nation Resources Conservation Service)

The TR-55 method is recommended runoff calculation for sites where:

- a. The drainage area is greater than 200 acres; or
- b. Detention is required.

Method

Detailed information, example calculations, and worksheets regarding the TR-55 method can be found in "[Urban Hydrology for Small Watersheds-Technical Release 55.](#)"

Rainfall depths can be determined from [NOAA precipitation charts for Hendersonville](#). A type II 24 hour storm distribution must be used in the analysis for this method.

The time of concentration is the time it takes a particle of water to travel from the most hydrological remote point in the drainage area. The minimum T_c value used shall be 5 min. The City of Hendersonville Engineering Department reserves the right to review and reject any T_c values that it feels does not accurately reflect the drainage area and land use.

The curve number values must represent the land use for the drainage area. An appropriate hydrologic soil group and land use shall be used to determine the appropriate CN. The City of Hendersonville Engineering Department reserves the right to review and reject any CN that it feels does not accurately reflect the drainage area and land use.

HYDRAULICS

This section provides recommended procedures for the design of stormwater systems and stormwater best management practices.

Design Flows

-Design flows must be calculated by the appropriate method outlined in the referenced Hydrology Section. Each stormwater element must be designed using the correct design storm.

Mannings “n”

-Typical allowable pipe material is HDPE and Concrete. Any other pipe material, the designer needs to get approval from the Engineering Department prior to submittal of the stormwater plans.

-Typical Mannings “n” values for ditches and pipes are shown below. Any values that differ from what is shown or not shown will need to be source documented for approval.

MANNING'S "n"	
<i>Material</i>	<i>"n"- value</i>
HDPE-Pipe	0.011
Concrete Pipe	0.012
Corrugated Metal Pipe	0.024
Earthen/ Sod Ditch	0.030
Rip-Rap Ditch	0.035

Stormwater Pipe/ Roadway Culverts

- Minimum pipe size for a stormwater pipe shall be 15”.
- Minimum slope for a stormwater pipe shall be 0.5%.
- All pipes shall have a rip-rap pad or velocity dissipater at the outlet adequately designed for the velocities exiting the pipe. Appropriate calculations shall be provided upon the submittal of the stormwater plan.
- The design of the stormwater system shall use the correct storm event outlined in the Hydrology section. Appropriate runoff method must be used to determine the runoff for the pipe. Systems where pipes are in a series, the drainage area shall be combined at the pipe. Manning’s equation should be used to determine the pipe size based on the slope and pipe material.
- Headwater values should be checked to ensure that no surcharges at junctions and catch basins will occur on site during the appropriate design storm for each stormwater element. Headwater for roadway culverts should be 12” below the shoulder elevation for the 25-year storm event.

Channels/ Ditches

- The design flow shall be the appropriate design storm as outline.
- Manning's equation should be used to determine the size of the channel for the design flow.
- Minimum slope of a grassed ditch shall be 1%. Minimum slope of a concrete lined ditch shall be 0.5%.
- Rip-rap lining shall be the last alternative and will be approved on a case-by-case basis.
- Determine the maximum possible shear stress for the selected lining and compare to the actual shear stress of the channel to ensure that the lining selected is acceptable. If the lining is not acceptable, choose a lining that will work for the actual shear stress.

Detention

- Detention structures shall use the appropriate runoff method and design storm outlined. All basins shall reduce the proposed design storm runoff to existing levels or below as required by the City of Hendersonville. All structures shall pass the 25-year storm event. If possible, an emergency spillway should be incorporated to assist or pass the 25-year storm event in case the main outlet becomes inoperable.
- All North Carolina Department of Environment and Natural Resources (NCDENR) Dam Safety regulations shall be incorporated in instances where a dam is used.
- One foot of freeboard shall be required unless the City of Hendersonville Engineering Department requires greater.
- If the detention structure is used as a water quality BMP then [NCDENR Stormwater Best Management Practices \(BMP\) Manual](#) shall govern the design of the structure. The structure shall still provide volume to reduce the proposed storm event to existing levels or below.

-If the project site has multiple drainage areas due to a topographic divide and/or multiple outlets/ swales, the designer must show the proposed condition will not increase stormwater runoff on the adjacent property owner. Any concern about detention of the project site should be brought to the Engineering Department's attention prior to the stormwater submittal.

Water Quality

-The City of Hendersonville requires water quality measures as stated in Hendersonville's [Stormwater Ordinance](#). Use [NCDENR Stormwater BMP Manual](#) to design appropriate measures for each site. All impervious areas of the site must be routed through a BMP.

-The City of Hendersonville Engineer Department requires 85% Total Suspended Solids (TSS) removal for each site. Proprietary measures can be used on a case-by-case basis as long as additional documentation is provided to show that the device provides 85% TSS removal.

