

City of Morristown

Stormwater Program Standard Operating Procedures

Stormwater Design Guidance Manual

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-Prepared By-

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1.0 Purpose and Scope

The purpose of this document is to establish consistent basic stormwater analysis and design criteria to be used for the design of stormwater infrastructure within the City of Morristown. In any case where the criteria set in this document is less stringent than other applicable criteria set by governing authorities having jurisdiction over the work, or less stringent than professional engineering judgment consistent with the Standard-of-Care associated with this type of work, the most stringent criteria shall apply.

1.1 Software

Proprietary and other software may be used for stormwater analysis provided:

1. The methodologies used in the alternative software are consistent with the methodologies specified in this document; and
2. Data sets or input data used by the alternative software are compatible with the software specified in this report, and the results of analysis using the alternative software must be equivalent to the results obtained using the software specified in this document.

1.2 Modifications

In some cases, modifications of the criteria set forth in this document may be necessary or desired. However, any departure from these criteria must be approved in writing by the City of Morristown. Requests for departures must be provided to the City in writing (email is acceptable). The request must describe the specific criteria for which a modification is requested, a description of why the departure is required or desired, and the specific modification requested. The City will follow internal procedures to obtain the City's review and disposition of the request.

2.0 Stormwater Management Plan (SWMP)

A Stormwater Management Plan (SWMP) is a set of drawings and other documents describing the proposed Stormwater Control Measures (SCMs) and Best Management Practices (BMPs) intended to maintain or restore quality and quantity of stormwater runoff to pre-development levels. The analysis and design of SCMs and BMPs shall be in accordance with the requirements of Stormwater Program Ordinance and the Adopted BMP Manuals (See Section 2.1).

A stormwater management plan (SWMP) is required:

1. For land disturbing activity, including New Development and Redevelopment that disturbs one acre or more of land
2. For land disturbing activity that disturbs less than one acre of land if:
 - a. The construction activities at the site are part of a larger common plan of development or sale that comprise at least one acre of land disturbance.
3. The project results in an increase of one half acre or more of impervious area.
4. The site is impacted by a water resource:
 - a. Any new development or redevelopment, regardless of size that proposes land disturbing activities within 100 feet of a water resource.
 - b. A Water Quality Buffer Zone is present on or adjacent to the project site or proposed land disturbance activity.
 - c. Stormwater discharges from the project site or land disturbance activity will discharge directly to a Water Resource.
5. The City Administrator or designee has determined:
 - a. that the stormwater discharge from a site or activity is causing, contributing to, or is likely to contribute to a violation of a state water quality standard;
 - b. that the stormwater discharge is, or is likely to be, a significant contributor of pollutants to Waters of the State;
 - c. that additional restrictions are needed to limit adverse impacts of the proposed land disturbance, development or redevelopment on water quality or channel protection.
6. The Division of Water Pollution Control of the State of Tennessee, Department of Environment and Conservation has determined that
 - a. the stormwater discharge from a site is causing, contributing to, or is likely to cause or contribute to a violation of a state water quality standard;
 - b. the stormwater discharge is, or is likely to be, a significant contributor of pollutants to waters of the state, or
 - c. changes in state or federal rules require sites of less than one acre that are not part of a larger common plan of development or sale to obtain a stormwater permit.

The information in this Stormwater Design Guidance Manual is intended to assist designers in preparing the SWMP and is intended to be general in nature. Other adopted BMP Manuals (See Section 2.1) provide specific details such as maximum side slope of a detention pond or vegetation requirements of a bioretention swale.

2.1 Adopted BMP Manuals

The default stormwater analysis and design guidelines adopted for use in the City of Morristown Stormwater Program are as set forth in the following documents.

1. City of Morristown Stormwater Design Guidance Manual, current edition as amended
2. Tennessee Erosion and Sediment Control Handbook, current edition as amended.
3. Northeast Tennessee Water Quality BMP Manual, 2008 edition.

3.0 Land Disturbance Permit

A City of Morristown Land Disturbance Permit is required for the following projects.

1. Land disturbance is greater than or equal to 1 acre, or when land disturbance is part of a larger common plan of development or sale greater than or equal to 1 acre
2. Impervious area is increased by more than 0.5 acre
3. Site is located within 100 feet of a water resource, regardless of size (See Section 8.2 for the definition of a water resource)
4. All sites which discharge directly to a water resource, regardless of the size
5. All sites where the City Administrator or his designee determines a site is contributing, or is likely to contribute, pollution to waters of the state or a violation of water quality standards, regardless of size

The following activities are exempt from obtaining a Land Disturbance Permit.

1. Any emergency activities that are immediately necessary for the protection of life, property, or natural resources;
2. Agricultural land management activities;
3. Additions or modifications to an existing single family residential structure or property that disturb less than one (1) acre, including residential gardens.

Note that the above activities must still be conducted in conformance with the Stormwater Program Ordinance (SPO).

This Stormwater Design Guidance Manual primarily addresses the design and construction of Stormwater Control Measures (SCMs). The Land Disturbance Permit may also require Erosion Prevention and Sediment Control Plans and/or Stormwater Pollution Prevention Plans (SWPPP). These documents should be prepared per the Adopted BMP Manuals (See Section 2.1).

The Land Disturbance Permit Review Packet contains detailed requirements for a plan submittal. The checklist must be completed and submitted with a Land Disturbance Permit Application.

4.0 General Drainage Design

Adequate drainage systems shall have the hydraulic capacity to accommodate the maximum expected storm water discharge, as described in the following sections. Adequate drainage systems shall be designed to accomplish the following.

1. Account for both off-site and on-site storm water.
2. Maintain natural drainage divides.
3. Convey storm water to a stream, channel, natural drainage way, or other existing facility.
4. Discharge storm water into the natural drainage way by connecting the drainage way at natural elevations, or by discharging the storm water into an existing facility of sufficient capacity to receive it, or by discharging into an approved injection well.

The following general guidelines should be followed.

1. Determination of the size and capacity of an adequate drainage system shall take into account the future development of the affected portion of the watershed.
2. The design must not adversely affect adjacent or neighboring properties.
3. Concrete curb and gutter with storm water drainage systems are required on all public right of ways.
4. In areas where there are known drainage problems, no future land use changes which will impact the runoff peak rate, timing, and volume will be allowed until it is convincingly established that no adverse on-site and off-site impacts will result.
5. A combination of storage and controlled release of storm water runoff shall be required for all development located in areas where there are inadequate man-made and/or natural drainage channels to accommodate the projected runoff. Alternative methods or proposals for accommodating the projected runoff may be submitted to the City for review and approval.
6. Storm sewers shall be piped completely from the street to the nearest natural drainage ditch with appropriate easements provided. However, open ditches or swales may be permitted if the hydraulic calculations show that a proposed ditch lining will prevent ponding or erosion in channel.
7. Stormwater management facilities must be designed, installed, and maintained in accordance with the Stormwater Program Ordinance.

8. Permanent easements must be provided as required by the Stormwater Program Ordinance and the criteria set forth in this document.

5.0 Hydrology

General requirements for performing calculations related to the hydrology of the proposed site are provided in the following sections.

5.1 Rainfall Data

Rainfall depth, duration and frequency relationships for use in analysis and design shall be determined based on the data contained in Atlas 14 developed by the U.S. National Oceanic and Atmospheric Administration. This data is available on-line at:

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=tn

Rainfall tables for both depth and intensity are available from the web site. The web site interface allows the user to select a location or enter the latitude and longitude of the point of interest. For analysis and design, a nearby location or the latitude and longitude of the approximate center of the major drainage area or watershed being analyzed (as applicable) shall be used. The Partial Duration Series option shall be selected.

The rainfall data provided by Atlas 14 are point rainfall depths and shall be used for drainage basins equal to or smaller than 10 square miles. For larger drainage basins, the total rainfall depth may be reduced using the areal reduction curves provided in Figure 15 of Technical Paper No. 40, published by the U.S. Weather Bureau (USWB, 1961). Alternatively, when using the HEC-HMS software, areal reductions may be made automatically by using the basin area option in the program.

For the previously described flow hydrograph methods, the following rainfall durations and distributions shall be used for design purposes:

1. NRCS/SCS, 24-hour, Type II, or
2. U.S. Army Corps of Engineers, 24-hour, Balanced Frequency Storm (as implemented in HEC-HMS)

In some cases, design storm events of different durations and/or distributions may be required or desired. For example, a long term simulation using an actual rainfall record may be useful for evaluating the performance of a proposed channel design subjected to an observed historic event. In that case, the analysis is supplemental to the base design and should be described in the analysis documentation.

5.2 Flows

Methods presented in the following sections shall be used to compute flows for use in analysis and design.

5.2.1 Rational Formula

The Rational Method as described in the TDOT Drainage Manual may be used to compute peak flows for projects with drainage areas equal to or less than 50 acres, and without significant detention effects. The method may not be used to compute hydrographs or to analyze storage effects.

5.2.2 NRCS WinTR-55

The Natural Resources Conservation Service WinTR-55 computer software (NRCS, 2009) may be used to compute flow hydrographs for project drainage areas greater than one acre provided that the drainage system can be reasonably represented by a dendritic stream network with minimal pressure pipe flow and backwater effects. The surface runoff shall normally be based on the default “484” peaking factor for the NRCS dimensionless unit hydrograph method. However, in some cases the use of an alternative peaking factor may be more appropriate when it is judged that the peak flows predicted using the standard factor are not reasonable and peaking should be adjusted. Note that the use of the U.S. Army Corps of Engineers HEC-HMS software is often more flexible and is recommended in lieu of WinTR-55.

5.2.3 HEC-HMS

HEC-HMS software from the US Army Corps of Engineers (USACE, 2010a) may be used to compute flow hydrographs for any project drainage areas provided that the drainage system can be reasonably represented by a dendritic stream network with minimal pressure pipe flow and backwater effects. The surface runoff shall normally be based on the Natural Resources Conservation Service (NRCS) dimensionless unit hydrograph method.

5.2.4 EPA SWMM

The U.S. Environmental Protection Agency SWMM model (EPA, 2010) may be used to compute flow hydrographs for any project drainage areas, including basins with significant non-dendritic patterns, pressure pipe flow, and backwater, provided that surface area hydrographs may be reasonably represented by the sheet flow runoff algorithms implemented within the software. The SWMM runoff algorithms are normally more applicable to urban setting and less applicable to undeveloped basins.

5.2.5 Regression Equations

Regional regression equations developed by the U.S. Geological Survey (USGS) as presented in the TDOT Drainage Manual may be used to compute peak flows when the size and nature of the

project drainage area falls within the limits specified by the USGS for the regression equations, when storage effects are not significant, and when runoff is not regulated.

5.2.6 Adjustment for Karst Topography

Watersheds and basins with significant sinkhole storage and/or that are underlain by karst may require adjustments to the hydrology methods specified in this document. Technical Bulletin No. 2, Hydrologic Modeling and Design in Karst, (Virginia Department of Conservation and Recreation), may be used as a general guideline. However, when significant sinkhole and/or karst conditions exist, consultation with the City regarding the appropriate approach to the analysis is required.

5.3 Runoff Coefficients

For the previously described flow hydrograph methods, appropriate runoff coefficients shall be used as indicated below.

5.3.1 Rational Method

For the Rational Method, area-weighted Runoff Coefficients shall be used. Coefficients shall be selected from the TDOT Drainage Manual or from a similar professionally accepted and published source.

5.3.2 NRCS Curve Number (CN) Method

For the CN method, Hydrologic Soil Groups (HSG) shall be determined from published mapping and data available from the U.S. Department of Agriculture (USDA). This data is available on-line at the “Web Soil Survey” site:

<http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>

Curve Numbers shall be derived based on Hydrologic Soil Groups (HSG) and land use and should be weighted by area. Acceptable sources include TDOT Drainage Manual, the tables presented in Chapter 2 of the USDA TR55 manual “Urban Hydrology for Small Watersheds” (NRCS/SCS, 1986), or other professionally accepted and published reference.

5.4 Time of Concentration

Time of Concentration calculations shall generally be based on the method described in the TR-55 manual. However, other methods may be used as appropriate as long as justification is included.

5.5 Routing

Routing the flows through storage (typically detention or retention) may be accomplished as follows.

5.5.1 Ponds and Reservoirs

Except when the SWMM model is used, flow through ponds and reservoirs shall be routed using the Modified Puls hydrologic method. Either the Modified Puls method or the hydraulic dynamic wave method may be used with SWMM.

5.5.2 Streams and Channels

Routing through streams and channels using WinTR-55 shall be performed using the Muskingum-Cunge method. Routing using HEC-HMS shall be performed using either the Muskingum-Cunge method or the Modified Puls method (developed from storage-discharge data for each routing reach). When SWMM is used, routing shall be performed using the hydraulic dynamic wave method.

6.0 Hydraulic Design

Methods of modeling conveyance flows are provided in the following sections.

Note that, in general, these requirements apply only when the infrastructure is to be constructed within City or TDOT ROW or in areas which will be dedicated to the City. In addition, calculations for stormwater conveyance systems are only required to be submitted in those situations.

6.1 Energy Losses

The following sections outline how to account for various energy losses in the hydraulic models.

6.1.1 Friction

Friction losses shall be based on Manning's roughness ("n") values, selected as appropriate from the TDOT Drainage Manual or other professionally accepted and published reference.

6.1.2 Coefficients of Expansion and Contraction

Coefficients for expansion and contraction must be estimated to account for water leaving and entering pipes, such as inside catch basins. Many software programs assign these values automatically based upon the geometry of the pipes and other factors. These assigned values are acceptable as long as the design engineer reviews and accepts them. In other cases, the TDOT Drainage Manual may be used.

6.2 Storm Sewers (Other than Culverts)

Storm sewers may flow under open channel conditions, pressure flow conditions, or a combination of those conditions. They shall be designed as follows.

6.2.1 Design Storms

Storm sewers for city streets shall be designed for the design storms as specified in the current TDOT Drainage Manual, as summarized in the table below.

Design Storms for Storm Sewer Systems		
Parameter	Road Type	
	Collector	Local Road
Inlet	10-year ^{1,3}	10-year ^{1,3}
Sewer	10-year ^{1,3}	10-year ^{1,3}
Roadway Freeboard ²	50-year	50-year
¹ 50-year in roadway sag sections ² The design high water elevation should be at or below the bottom of the roadway subgrade. ³ Storm sewers designed for a 10-year storm shall be checked for a 50-year storm to insure the HGL remains below the level of the castings. <i>Source: TDOT Drainage Manual, 2010</i>		

6.2.2 Capacity

Closed conduits shall be designed for the total flow intercepted by the inlets during the design storm event.

Storm drain systems should generally be designed as non-pressure systems. The hydraulic gradient for pressure flow systems shall not exceed the criteria for design storms as provided in Section 6.2.1.

In general, Manning's Equation shall be used for the hydraulic analysis or design of pipe systems, with parameters which meet the TDOT Drainage Manual. Other methods such as EPA SWMM may be used for the hydraulic analysis or design of pipe systems not adequately addressed by the Manning's Equation.

Additional design criteria include the following.

1. Minimum inside diameter of 18 inches
2. Minimum slope of 0.4%
3. Minimum flow velocity of 3 ft/sec and a maximum flow velocity of 12 ft/sec

6.2.3 Materials and Construction

In general, all storm drains shall:

1. Have a minimum inside diameter of 18 inches
2. Be gasketed Reinforced Concrete Pipe (RCP), as approved by TDOT
3. Be installed to the minimum standards of the City, Hamblen County Highway Department, Tennessee Department of Transportation, or manufacturer.
4. Have one foot of minimum cover, measured from the top of the pipe to finished subgrade
5. Be built on straight line and grade and be laid with the spigot end pointing in the direction of the flow
6. Have headwalls or structures at both ends of the pipe. On arterial streets and Tennessee State designated roadways, safety end-walls approved by TDOT are required.

6.3 Culverts

All culverts to be located in City or TDOT ROW must meet the following general criteria:

1. Culverts must be gasketed RCP.
2. Culverts must be a minimum of 18" inside diameter.
3. Culverts shall be installed per TDOT standard drawings and specifications.
4. Headwalls shall be required at both ends of the pipe in all cases. On arterial streets and Tennessee state designated roads, safety end-walls are required.

Culverts shall be hydraulically analyzed and designed per the TDOT Drainage Manual.

6.3.1 Design Storms

The design flow for culverts shall be based on the 50-year storm. The design shall be checked for the 100-year storm.

The design shall also insure that the design high water elevation is at all times at or below the bottom of the roadway subgrade.

6.3.2 Capacity

Culverts shall be sized per the methods provided in the TDOT Drainage Manual. Software which uses these methods is acceptable.

6.3.3 Driveway Culverts

Driveway culverts shall be a minimum of eighteen (18) inches Inside Diameter (ID) or as approved by the City. Driveway culvert material shall be gasketed Reinforced Concrete Pipe (RCP) if the culvert is located in City or TDOT ROW.

6.4 Gutters and Inlets

The hydraulics of gutters and inlets shall be analyzed based on the methods set forth in the TDOT Drainage Manual. Software may be used to design curbs and inlets as long as it is comparable to the methods in the TDOT Drainage Manual.

The following general criteria shall be met:

1. The design storm shall be the same as that specified for the storm sewer design.
2. The greatest spread shall be 8 feet. This shall be reduced if the height of the curb would be exceeded at this spread.
3. Spacing of inlets should not be more than 400 feet.
4. TDOT standard drawings shall be specified for construction of all drainage structures and piping.

6.5 Open Channels

Open channels are defined here as ditches, drainage ways and streams.

Channels shall be designed per the TDOT Drainage Manual.

6.5.1 Design Storms

Roadside ditches shall be designed for the 10-year storm. The design shall also insure that the design high water elevation is at all times at or below the bottom of the roadway subgrade.

6.5.2 Channel Lining

Open channels shall be designed to limit the flow velocity to the maximum allowable velocity for the selected lining.

Channel lining shall be required when the design velocity exceeds the allowable, non-erosive velocity for a given channel reach and no other erosion control measures provide adequate protection. The TDOT Drainage Manual shall be used to select an appropriate channel lining to insure the channel remains stable.

In general, riprap will not be allowed within the right-of-way unless specifically approved by the City.

6.5.3 Curved Channels

For channels and ditches, energy losses due to channel curvature may be significant. In addition, superelevation should be considered when establishing the design freeboard allowance.

Curved channel sections should be evaluated per the TDOT Drainage Manual.

6.6 Bridges

All spans which qualify as a “bridge” under TDOT regulations (length greater than 20 feet) shall be designed per TDOT requirements. Bridges may require additional approval from TDEC, TVA, US Army Corps of Engineers, FEMA, and/or other regulatory agencies.

7.0 Outlet Protection

The design discharge at the outlet of drainage systems shall not result in velocities that exceed the erosive velocity of the receiving channel unless energy dissipation and erosion protection measures are placed at the outlet. Energy dissipation and erosion control devices shall have no overfall at the terminal end and shall discharge onto a stable section. The terminal section shall be considered stable if the terminal section design velocity is less than the erosive velocity.

The need for energy management at the outfalls of culverts, pipes, pond spillways, ditches, and flumes shall be evaluated. The maximum velocities and shear stresses under design conditions at the outfalls shall be compared to the allowable shear stresses and velocities of the receiving stream or drainage way. When the allowable stresses or velocities are exceeded, outlet protection is required.

Acceptable design references include the BMP Manuals adopted by the City (See Section 2.1) and the TDOT Drainage Manual. Other sources such as FHWA materials may be acceptable as well.

Outfalls should generally be located at least 10 feet from the adjoining property line. If this cannot be accomplished, additional outlet protection measures must be provided to insure that the discharge does not cause erosion or other damage on the adjoining property.

8.0 Streams and Floodplains

Modifications to drainage ways, streams, in-stream structures (e.g., culverts and bridges), and floodplains are often subject to specific restrictions by governing authorities other than the City. All stormwater designs shall include an evaluation of these potential restrictions and address those restrictions in planning and design.

8.1 Floodplain Ordinance

The City of Morristown Municipal Floodplain Zoning Ordinance contains certain restrictions regarding work within a floodplain. Please consult the City for additional information about these restrictions when proposing work in floodplains.

The developer, property owner, or their designated representative will be responsible for the preparation, revision and approval of all studies and analyses (No-Rise, CLOMR, LOMR, LOMA, etc.) and any associated fees required for the City's submission of such documentation to FEMA for approval of encroachments into the regulated floodplain / floodway.

8.1.1 FEMA-Regulated ("Mapped") Waters

In accordance with the National Flood Insurance Program (NFIP), the ordinance regulates, among other items, construction activities within the floodplain. Floodplain mapping and Flood Insurance Studies (FIS), including flood profiles, for FEMA-regulated streams may be obtained from the FEMA Map Service Center at:

<https://msc.fema.gov/webapp/wcs/stores/servlet/StoreCatalogDisplay?storeId=10001&catalogId=10001&langId=-1&userType=G>

8.1.2 Unmapped Waters

The Floodplain Ordinance sets forth minimum stream setbacks from the stream banks for construction in floodplains of streams not mapped by FEMA.

8.2 Water Quality Buffer Zone

The City of Morristown Stormwater Program Ordinance requires a Water Quality Buffer Zone (WQBZ) along all water resources. A “water resource” is defined as streams, seeps, springs, wetlands, lakes, other surface waters and water resources that are not wet weather conveyances.

In general, the WQBZ is an undisturbed, vegetated strip of land which borders the stream and is limited to activities with minimal impact such as picnic areas, walking trails, greenways, minor landscaped areas, and utilities. The WQBZ shall remain undisturbed throughout perpetuity, and will be required to be maintained per an Inspection & Maintenance Agreement (See Section 13.2).

8.2.1 Width

The width of the WQBZ is measured from the top of bank, and shall be determined as follows.

1. Water Resources not listed as Impaired or Exceptional Tennessee Waters with drainage areas less than one (1) square mile shall have a buffer width of thirty (30) feet minimum.
2. Water Resources with drainage areas equal to or greater than one (1) square mile and/or are listed as Impaired or Exceptional Tennessee Waters shall have a buffer width of sixty (60) feet minimum.
3. A minimum buffer width of 30-feet shall be provided around the perimeter of a wetland, as measured from the outermost edge of the wetland as determined by USACE, NRCS, TDEC, or a Tennessee Qualified Hydrologic Professional (TN-QHP).
4. Water quality buffers are not required for
 - a. ponds and wetlands designed and constructed for the purposes of stormwater quality treatment and/or stormwater management.
 - b. ponds disconnected from other water resources.

Variances to the WQBZ widths may be granted. More information is available from City staff.

8.2.2 Signs

Permanent boundary markers, in the form of signage provided or approved by the City of Morristown, shall be installed prior to the completion of the development activities. Signage is to be posted at the coincidence of the water quality buffer zone edge, each lot line, and at a maximum spacing of one hundred fifty feet (150').

The signs shall contain the message, "Water Quality Buffer Zone: This area is reserved for the protection of water quality by limiting pollution, offering shade and bank stabilization, and providing wildlife habitat."

8.3 Other Regulatory Permits

Drainage ways with specific hydrologic and ecological characteristics are designated as "waters of the state" and subject to regulation by the Tennessee Department of Environment and Conservation (TDEC), the U.S. Army Corps of Engineers (USACE), and/or the Tennessee Valley Authority (TVA). In the initial planning and design phase of a project involving a drainage way with the potential of falling under the regulatory authority of these agencies, a determination by a Qualified Hydrologic Professional (QHP) shall be prepared and submitted to TDEC for their approval. This will consist of an inspection of the drainage way by the QHP, followed by a TDEC letter-of-determination. Alternatively, the water resource may be assumed to be under TDEC jurisdiction without obtaining a determination.

The USACE and TVA typically accept the TDEC determination, but this shall be verified directly with those agencies unless specifically advised otherwise by TDEC. If the stream is regulated, the following permits may be required, depending on the nature of the work to be done.

8.3.1 TDEC Aquatic Resource Alteration Permit (ARAP)

The ARAP permit also serves as the 401 Water Quality permit when a USACE 404 permit is required (see below). Information regarding the requirements of this permit is presented at:

<http://www.tn.gov/environment/permits/arap.shtml>

8.3.2 TVA 26A Permit and USACE 404

The TVA 26A permit application follows the same process as the USACE 404 permit. Information regarding the 26A and 404 permit requirements is presented at:

<http://www.tva.com/river/26apermits/regs.htm>, and
<http://www.spn.usace.army.mil/regulatory/nwp.html>

9.0 Sinkholes and Injection Wells

Discharge of stormwater to a sinkhole and/or injection well may be permitted if the following conditions are met.

1. All drainage systems discharging to sinkholes or injection wells shall be designed using the 100-year storm. Development must not occur within the area flooded by the 100-year storm.

2. The following information must be provided prior to the alteration or increase of the natural drainage for watershed discharging to such features as sinkholes and injection wells.
 - a. Proposed on-site and off-site drainage channels that are tributary to a sinkhole throat or injection well inlet shall be delineated, along with appropriate hydraulic calculations to define the existing and altered (if appropriate) 100-year flood plain and to confirm that off-site flooding will not be increased.
 - b. Detailed contours are to be shown for all sinkholes that are to receive storm water runoff from the site. These contours are to have a maximum interval of 2 feet and are to be verified by field surveys.
 - c. A geologic investigation of all sinkholes receiving storm water runoff from the site shall be performed by a licensed engineer with experience in geotechnical investigations.
 - d. TDEC must be contacted to determine if a Class V Injection Well permit is required. If so, TDEC approval must be provided before the site plans will be approved.

10.0 Post-Construction Stormwater Management

Information about required post-construction stormwater management is provided in the following sections.

10.1 Peak Flow Control

Stormwater management to control peak flow is mandated for all projects that result in over 0.5 acre of additional impervious area.

All hydrologic and hydraulic computations utilized in the design of stormwater control measures (SCMs) must be prepared and sealed by a registered engineer proficient in the field of hydrology and hydraulics and licensed in the State of Tennessee. The required hydrologic and hydraulic computations shall be in accordance with the procedures outlined in this manual and other adopted BMP Manuals (See Section 2.1) unless modifications are approved per Section 1.1.

10.1.1 Release Rate

The release rate from any detention facility should be less than or equal to that existing at the site prior to the proposed improvements for the 2, 5, 10, and 25-year storms, with emergency overflow capable of passing the 100-year discharge. Detention systems must be constructed during the first phase of major developments to eliminate damage to adjacent properties during construction. If siltation has occurred, detention systems must be restored to their design dimensions after construction is complete and certified as part of the Land Disturbance Permit Closure.

The discharge from any stormwater control facility shall be directed into the natural surface watercourse or drainage way that existed prior to development. Stormwater drainage may not be redirected from one natural watershed to another.

10.1.2 Volume

The required detention volume shall be that volume necessary to attenuate the post-development peak discharge to a level that does not exceed the pre-development peak discharge. This volume may be minimized by careful attention to outlet control structure design. Outlet control structures shall be designed to limit the outflow to the pre-developed peak for each of the return storms up to and including the design storm. In most cases, this will require multiple outlets or the use of some type of variable opening(s) such as multi-staged discharge outlet control boxes, or V-notch weir.

10.1.3 Drawdown

Drawdown is the emptying of the required storage volume. The storage volume may be the entire volume of the pond for a dry detention basin, or the volume above the normal pool level for a retention basin. Drawdown is typically accomplished with low release rates over an extended period of time, often by a small orifice or weir, or by infiltration.

Drawdown shall be complete within 72 hours.

10.1.4 Methods

Several methods of providing peak flow control are discussed below.

10.1.4.1 Detention Basins

The following guidelines shall be followed, along with those found in the City's adopted BMP Manuals (See Section 2.1), for designing detention ponds.

1. A minimum pipe size of eighteen (18) inches shall exit the outlet structure to the desired outfall point.
2. All detention ponds shall have an emergency spillway designed to pass the 100-year runoff if the storage capacity is exceeded. Emergency spillways shall be constructed in virgin soil material or may be incorporated into the outlet control structure's principal spillway.
3. All detention ponds shall have a minimum of one (1) foot of freeboard from the 100-year water surface elevation.
4. Detention ponds shall have side slopes of 2:1 or flatter. For ponds in areas accessible to small children and more than five (5) feet in depth, security fencing is strongly recommended.

5. Larger ponds which fall under the purview of the Safe Dams Act must comply with those regulations.

10.1.4.2 Retention Basins

As a minimum, retention ponds shall provide the required storage capacity above the permanent pool elevation to meet the requirements for detention. Slope, security and maintenance requirements are the same as for detention ponds.

10.1.4.3 Underground Storage

Underground detention is permitted, providing the requirements for peak flow control and drawdown are provided as required.

10.2 Pollutant Treatment

Projects which meet any of the following conditions must provide post-construction pollutant treatment, also sometimes called Permanent Stormwater Management.

1. Results in 1 acre or more of land disturbance, or is part of a larger common plan of development which results in land disturbance greater than or equal to 1 acre
2. The City Administrator or designee has determined that
 - a. the stormwater discharge from a site or activity is causing, contributing to, or is likely to contribute to a violation of a state water quality standard;
 - b. the stormwater discharge is, or is likely to be a significant contributor of pollutants to Waters of the State;
 - c. additional restrictions are needed to limit adverse impacts of the proposed land disturbance, development or redevelopment on water quality or channel protection.
3. The Division of Water Pollution Control of the State of Tennessee, Department of Environment and Conservation has determined that
 - a. the stormwater discharge from a site is causing, contributing to, or is likely to cause or contribute to a violation of a state water quality standard;
 - b. the stormwater discharge is, or is likely to be, a significant contributor of pollutants to waters of the state, or
 - c. changes in state or federal rules require sites of less than one acre that are not part of a larger common plan of development or sale to provide treatment.

Post-construction pollutant treatment is not required if the facility holds or will hold a TDEC Tennessee Multi-Sector General Permit (TMSP).

General guidelines for selecting and installing Stormwater Control Measures (SCMs) which remove pollutants from stormwater after construction is complete are provided below. Specific details and guidelines for a wide range of SCMs are found in the City's adopted BMP Manuals (See Section 2.1).

10.2.1 Requirements

Projects must provide SCMs which provide 80% total suspended solids (TSS) removal. The following sections provide options which may be selected to meet this standard.

Note that areas of a site may be "overtreated" to account for another area which may be difficult to treat. For example, a driveway which slopes away from the site could require an additional treatment device to treat the relatively small amount of flow. Instead, a proposed treatment device at another location at the site could provide additional treatment by having the area of the driveway included in its sizing calculations.

10.2.2 Methods

There are several acceptable methods for achieving the required post-construction stormwater treatment requirement.

10.2.2.1 BMP Manuals

One option for meeting this requirement is to select an appropriate Best Management Practice (BMP) from one of the City's adopted BMP Manuals, which are listed in Section 2.1. The manuals provide a wide variety of SCMs and an assigned TSS removal value. It is assumed that the BMP achieves the assigned TSS removal if the BMP is designed, constructed, and maintained according to the BMP manuals.

The manuals also provide design guidance for selecting and sizing appropriate BMPs.

10.2.2.2 Proprietary Devices

There are various BMPs produced by manufacturers which provide treatment for post-construction stormwater. The City of Knoxville, Tennessee, requires laboratory verification of manufacturer's TSS removal rates and grants approval for maximum flow rates at which the devices can achieve 80% TSS removal. The City of Morristown has adopted Knoxville's approved BMP list, which can be found on the City's Stormwater website:

www.mymorristown.com/departments/public_works/stormwater/index.php

In general, Proprietary Devices will be reviewed as follows:

1. The required treatment design flow is calculated per Section 3.3.7 of the Northeast Tennessee Water Quality BMP Manual.
 - a. The weighted curve number (CN) calculated for the site may be used instead of the formula given for CN.
2. This design flow is used to select an appropriate device from the approved City of Knoxville list (“Policy 25 List A - Sizing Guidelines” as of August 2012). The appropriate column to use depends on the following:
 - a. The “SPAP Flow” column may be used if the flow to be treated by the device also passes through an extended detention pond or equivalent BMPs which provide at least 60% TSS removal.
 - b. The “First Flush Flow” is used if the requirements of (a.) above are not met.
3. The calculated 10 year flow to the device is less than or equal to “The Bypass – 10yr flow” column

10.2.2.3 Catch Basin Inserts

Although their use is discouraged due to the significant maintenance required, catch basin inserts may be approved at small sites which have only a few inlets or to treat an isolated inlet. They shall meet the following requirements:

1. Inlet flow meets manufacturer’s capacity for both treatment and bypass (10-year flow)
2. Support is provided under the filter bag
3. Hydrocarbon treatment is provided
4. Curb inlet flows are treated or deflected through the treatment process

10.2.3 Channel Protection Volume

Retention of a channel protection volume is required to protect receiving streams, if the project also requires Pollutant Treatment. Specific details on sizing this volume can be found in Section 3.4 of the Northeast Tennessee Water Quality BMP Manual.

The channel protection volume is defined as the runoff volume from the 1-year frequency, 24-hour storm in Section 3.4.1. This volume should be used in the design. The method used in Section 3.4.2 may be used as an estimate to aid in preliminary design only.

Note that only the larger of the channel protection volume and water quality volume need be retained, not both.

10.3 Maintenance

Care must be taken to ensure that any required Stormwater Control Measures (SCMs) do not become nuisances or health hazards. Detention facilities should be designed to require minimal maintenance, and maintenance responsibility must be clearly stated on the plans and/or plan documents.

All projects which have SCMs for peak flow control or pollutant treatment will require an Inspection & Maintenance Agreement (See Section 13.2).

All detention facilities located in the City of Morristown shall be within storm drainage easements and maintained by the property owner or homeowners association.

10.4 Special Pollutant Abatement Plan (SPAP)

A Special Pollutant Abatement Plan (SPAP) is required for sites which are designed as “hot spots” per the Stormwater Program Ordinance.

“Hot Spots” are defined by the ordinance as any of the following.

1. By land use or type of business
 - a. Salvage yards and recycling facilities;
 - b. Vehicle service and maintenance facilities, including but not limited to vehicle, truck or equipment maintenance, fueling, washing or storage areas, gas stations, automotive dealerships, automotive repair shops, and car wash facilities;
 - c. Large impervious surfaces such as large parking lots, driveway, drive aisles and roofs.
 - d. Fleet storage areas (bus, truck, etc.);
 - e. Industrial sites (included on EPA Standard Industrial Classification code list);
 - f. Marinas (service and maintenance);
 - g. Public works storage areas;
 - h. Facilities that generate or store hazardous waste materials;
 - i. Commercial container nursery;
 - j. Restaurants and food service facilities;
 - k. Commercial facilities with outside animal housing areas including animal shelters, fish hatcheries, kennels, livestock stables, veterinary clinics, or zoos;

- l. Other land uses and activities as designated by the City Administrator or designee using information gathered through investigation, research, notification by regulatory agency, engineering analysis or scientific study.
2. A history of air or water pollution at a site;
3. A history of air or water pollution by an owner / operator at other sites;
4. The potential to impact environmentally sensitive areas, such as wetlands;
5. At the discretion of the City Administrator or designee as needed to address hotspots or pollutants of concerns on a case-by-case basis.

The SPAP documents Best Management Practices to be followed at the site after construction is complete. The required form is located in the Appendix C2 of the Northeast Tennessee Water Quality BMP Manual, 2008 edition.

The Contact Person designated in Section C is the person who is responsible for implementing the SPAP at the site, including conducting and documenting the inspections and training, and will sign the certification in Section D (“Acceptance of Responsibility for Plan Compliance”). This person would typically be the store manager or equivalent. If the appropriate person has not been designated, a technical person in the company with general environmental oversight may be named.

The “Certification and Signature” in Section D should be a president, owner, or ranking official. This person is responsible for updating the SPAP if the contact person changes.

10.5 Downstream Impact Analysis

A further evaluation of the impact of the detention / retention pond on the downstream watershed may be required if requested by the City.

11.0 Easements

Stormwater drainage easements must generally be provided for all stormwater systems, including pipes, channels, and culverts, if the systems convey water which originated off the property. These easements should be shown on the construction plans and on the as-builts.

Easements must remain free of fences or any other structures in order to provide access for maintenance.

11.1 Storm Sewers and Culverts

Minimum allowable easement width for storm drains, pipes and culverts shall be determined from the table below.

Minimum Easement Width for Storm Pipes and Culverts		
Pipe Size	Depth to Invert	Width of Drainage Easement
18 inches	3.5 feet	15 feet
24 inches	5.0 feet	20 feet
36 inches	6.0 feet	24 feet
54 inches	7.0 feet	30 feet
72 inches	9.0 feet	36 feet
Notes		
<ol style="list-style-type: none"> 1. For depths greater than shown, add two feet (2.0') for each additional foot to the invert. 2. For pipes sizes between those shown, values may be interpolated. 3. For larger pipe sizes and/or multiple lines of pipe, easement width shall be as determined by the City. 		

11.2 Open Channels

Minimum easement widths for open channels shall be determined from the table below.

Minimum Easement Width for Open Channels		
Top Width of Channel	Total Easement Width	Minimum Width on One Side
Less than 10 feet	15 feet greater than the top width of channel	10 feet
10 to 20 feet	20 feet greater than the top width of channel	15 feet
Greater than 20 feet	25 feet greater than the top width of channel	20 feet

11.3 Stormwater Control Measures

Access consisting of a 12' wide drivable path from the public ROW to each SCM is required. The path need not be paved, but should not have steep slopes or obstructions.

The maintenance and access easements to Stormwater Control Measures shall be conveyed by the Inspection & Maintenance Agreement (See Section 13.2).

12.0 Bonds

A performance bond is required for Land Disturbance Permits for projects which disturb one acre or more. The bond amount is 150% of the City's approved cost estimate including all erosion and sediment control, stormwater infrastructure and stormwater control measures at the site. The current bond format may be obtained from the City Planning Department.

Note that this bond is separate from the performance bond which may be required when the project contains infrastructure necessary to the project which will be dedicated to the City. This bond is administered by the Planning Commission.

Approval to combine the Land Disturbance Permit bond and the infrastructure bond may be granted. However, the infrastructure bond may only be reduced to a maximum of 50% of its value prior to project completion at the Planning Commission's discretion. The land disturbance bond may be reduced up to 100% by City staff.

12.1 Cost Estimate

The cost estimate for the performance bond shall include quantities and unit prices for the following items.

1. Stormwater control measures (detention ponds, treatment devices, etc.)
2. Stormwater conveyance systems (pipes, catch basins, channels, etc.)
3. Erosion prevention / sediment control practices (vegetation, sediment basins, inlet protection, etc.)

Unit prices shall be obtained from one of the following sources.

12.1.1 Knox County Bond Prices

Knox County Bond Prices are available on the City's Stormwater Program website:

www.mymorristown.com/departments/public_works/stormwater/index.php

When referencing the Knox County Bond Prices, please note the following:

1. Temporary construction entrances / exits and seeding / mulch are included in the “Grading” item.
2. Catch basin inserts are not considered to be “Water Quality Devices” on the Bond Prices list and may be estimated by the engineer.
3. The “Detention Basin Item” may overestimate the actual cost for large basins. The engineer may propose a lower cost along with documentation, such as contractor bids or other justification.

12.1.2 Contractor Bid

Unit prices as submitted in a bid for the project under review may be accepted if they are determined to be reasonable by City staff.

A copy of the actual bid must be submitted, along with a letter stamped by an engineer stating that the bid was received for the project in question and is reasonable.

12.2 Release

The bond will be released when the following conditions are met

1. Completion of land disturbing activity and stabilization of the site
2. City approval of the request for permit closure
3. City approval of the as-built post construction stormwater management survey and analysis
4. Recording of the Inspection and Maintenance Agreement (See Section 13.2) with the Hamblen County Register of Deeds

The bond may be eligible for a pro-rata reduction based on the amount of work remaining.

13.0 As-built Drawings

As-built drawings, showing the SCMs and infrastructure to be dedicated to the City as actually constructed, will be required prior to bond release and land disturbance permit closure. They must be prepared and sealed by a licensed surveyor and engineer.

Upon substantial completion of all stormwater management facilities, the applicant shall document the location, size, type, and appurtenances for each stormwater management facility, system, control, practice, measure, buffer zone, and conservation area designed to mitigate the quantity and quality of stormwater runoff on an as-built survey.

An analysis, certifying the function of the stormwater management system, will be required if the as-built drawings and/or field conditions indicate that the SCMs were not constructed in substantial conformance with the approved construction plans.

Refer to the “Land Disturbance Permit Closure Checklist” for specific requirements of the as-built drawings.

13.1 Tracking Data

The City’s NPDES General Permit for Discharges from Small Municipal Separate Storm Sewer Systems with the Tennessee Department of Environment and Conservation requires tracking of stormwater management infrastructure.

Therefore, as-built drawings which include Stormwater Control Measures (SCMs), also commonly referred to as Best Management Practices (BMPs) and including systems which provide peak flow control or pollutant treatment, must include the following information for each SCM.

1. Short description of each stormwater SCM to include the type, manufacturer, model number, and design or performance specifications
2. Latitude and longitude coordinates (decimal format to a minimum of 6 decimal places)
3. Maintenance requirements to include frequency of required maintenance
4. Name of person or entity executing the Inspection and Maintenance Agreement (See Section 13.2) for the SCMs at the site

13.2 Inspection & Maintenance Agreement

An Inspection & Maintenance Agreement is required for all projects which contain Stormwater Control Measures (SCMs) which provide peak flow control or pollutant treatment. This includes, but is not limited to, detention basins, water quality basins, proprietary devices, Water Quality Buffer Zones, Water Quality Volume Reductions, and infiltration features.

The Agreement allows access by the City should the City be required to maintain the SCMs in the absence of adequate maintenance by the property owner. The City may issue violations and civil penalties and/or recover costs associated with any such maintenance activities.

The Inspection & Maintenance Agreement will be recorded in the Hamblen County Register of Deeds Office and will be binding on the current property owners and all subsequent owners.

The owner shall submit the executed Inspection & Maintenance Agreement with the as-built drawings. The City will present the Agreement to City Council for approval. After approval by City Council, the City will record the Agreement upon payment of the recording fee by the applicant.

14.0 Plats

A plat will be required in the following situations:

1. As required by the City of Morristown Subdivision Regulations, and/or
2. If stormwater easements are required as per Section 11.0 and
 - a. if easements were not shown on a prior recorded plat, and/or
 - b. if easements were shown on a prior recorded plat, but stormwater infrastructure was not installed such that the required easements are correct

15.0 Plan Revisions

Revisions to the plans which affect the infrastructure addressed in this manual should be submitted to the City prior to changes being made. City staff will review the revisions to insure that all City requirements are still met.

16.0 Selected References

Chow, 1959. Open-Channel Hydraulics

City of Morristown, Adopted BMP Manuals (See Section 2.1)

City of Morristown, Municipal Floodplain Zoning Ordinance

City of Morristown, Stormwater Program Ordinance

EPA, 2009, 2010. U.S. Environmental Protection Agency, Stormwater Management Model, User's Manual and Software

FEMA, 2006. Federal Emergency Management Agency Flood Insurance, Hamblen County Tennessee and Incorporated Areas

FHWA, 1984. Federal Highway Administration, HEC-12, Drainage of Highway Pavements

FHWA, 2012a. Federal Highway Administration, Hydraulic Toolbox, Reference Guide and Software

FHWA, 2012b. Federal Highway Administration, HY8

FHWA, 2016. Federal Highway Administration, HEC-14, Hydraulic Design of Energy Dissipators for Culverts and Channels

NOAA, 2004. National Oceanic and Atmospheric Administration, Precipitation - Frequency Atlas of the United States, Atlas 14, Volume 2

USWB, 1961. U.S. National Weather Bureau, Technical Paper No. 40

TDOT, State of Tennessee Department of Transportation, Drainage Design Manual

TDOT, 2013. State of Tennessee Department of Transportation, Roadway Design Guidelines

USACE, 1991. U.S. Army Corps of Engineers, Water Surface Profiles, HEC-2, User's Manual and Software

USACE, 2010a. U.S. Army Corps of Engineers, Hydrologic Modeling System, HEC- HMS, User's Manual and Software

USACE, 2010b. U.S. Army Corps of Engineers, River Analysis System, HEC-RAS, Hydraulic Reference Manual and Software

NRCS, 1986. U.S. Department of Agriculture, Natural Resources Conservation Service/Soil Conservation Service, TR-55, Urban Hydrology for Small Watersheds

NRCS, 2002, 2009. U.S. Department of Agriculture Natural Resources Conservation Service, WinTR-55 User Manual and Software