Chapter 9 – Stormwater Detention

Stormwater detention facilities are a means of attenuating increases in peak flows caused by land development. In addition to providing flood control, stormwater detention facilities can protect downstream channels from increases in erosion. This chapter addresses general requirements for detention facilities as they relate to attenuating peak flows.

When a storm event occurs, stormwater runoff enters the detention facility. The outlet structure allows a portion of the stormwater runoff to discharge from the facility and the remainder of the stormwater runoff is temporarily stored. After the end of the storm, water continues to discharge from the facility until it is empty.

Stormwater detention facilities include:

- Detention Basin
- Retention Basin
- Extended Detention Basin
- Enhanced Extended Detention Basin
- Underground Detention

A detention basin is a pond that is normally dry. When a storm event occurs, it temporarily stores stormwater runoff, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system.

A retention basin is a stormwater pond which includes a permanent pool, even during non-rainfall periods. The pond includes storage above the normal pool elevation which temporarily stores stormwater runoff during storm events.

An extended detention basin is a pond which temporarily stores runoff for a specific time period following a storm event, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system. An extended detention basin is dry during non-rainfall periods. An extended detention basin provides more protection to the downstream channel from increases in erosion than a detention basin by releasing stored runoff at a lower rate over a longer time period. A typical plan and profile for an extended detention basin are detailed in the VA BMP Clearinghouse.

An enhanced extended detention basin is similar to an extended detention basin, but it also incorporates a shallow marsh in its bottom.

An underground detention facility consists of pipes or manufactured underground chambers used to temporarily store stormwater runoff following a storm event, discharging it at a controlled rate through a hydraulic outlet structure to a downstream conveyance system. An underground detention facility is dry during non-rainfall periods.

In addition to detention and retention basins, the design requirements specified by this chapter and the VA BMP Clearinghouse shall apply to ponds created as private property amenity features.

9.1 References

Except where more stringent requirements are presented in this Manual, the design and construction of stormwater detention facilities shall comply with VDOT and VA BMP Clearinghouse requirements. The primary design references are:

- VA SWM Handbook
- VDOT Drainage Manual
- VA E&SC Handbook
- VDOT Standards
- VA BMP Clearinghouse

9.2 Design Methodology and Criteria

9.2.1 Hydrology

See Chapter 4 for methodology used to determine design flows.

9.2.2 Design Flows and Storage Volumes

To properly design stormwater detention facilities, a flow routing program shall be used with an appropriate elevation – discharge - storage relationship for the design storm events.

9.2.3 Minimum Contributing Drainage Area

A stormwater retention basin, which contains a permanent pool, requires at least 10 acres of watershed drainage and/or a good source of base flow to maintain the permanent pool. A minimum drainage area of 20 acres shall be used when the basin is located in an area of high visibility to prevent unsightly drying of the permanent pool. Retention basins are best suited for regional and large drainage area projects.

9.2.4 Detention Facility Locations

Stormwater detention facilities should not be constructed within a Federal Emergency Management Agency (FEMA) designated 100-year floodplain. If this is unavoidable, the facility shall comply with all applicable regulations under the National Flood Insurance Program, 44 CFR Part 59.

The following factors shall be addressed when siting a stormwater detention facility:

- Geotechnical conditions including soil conditions;
- Groundwater levels and it's potential impacts;
- Karst topography;
- Existing and proposed utilities;
- Aesthetics on surrounding properties; and
- Environmental impacts including wetlands.

Stormwater basins shall be located to minimize the aesthetic impacts to the surrounding property. Basins shall be set back from property lines a distance equal to the minimum width of the applicable required buffer yard.

Locate stormwater detention facilities to avoid collecting significant amounts of drainage from offsite areas.

Stormwater basins shall be set back at least fifty feet from a residential dwelling structure as measured from the wall of the structure to the top of the basin embankment. In proposed single family residential subdivisions, the stormwater management facility shall be located in a single non-developed lot.

9.2.5 Basin Grading

Stormwater basins shall be graded to blend into the surrounding topography with the following conditions:

- Basin side slopes shall be no greater than 3:1.
- Provisions shall be made for the long-term maintenance of basin slopes and periodic access for maintenance of the outlet structure, emergency spillway, and removal of accumulated sediments.

- The maximum allowable depth of a stormwater detention basin shall be 15 feet, as measured from the top of the embankment to the lowest point in a basin.

- The bottom of the basin shall have a low flow or pilot channel to facilitate complete drainage. The pilot channel shall convey flows from a 2 year storm event and prevent standing water during dry-weather conditions. The pilot channel shall be sloped a minimum of 2% if it is a grass-lined channel and at a minimum of 1% if concrete-lined.

In addition to the above requirements, the follow standards of practice should be used when designing a stormwater basin to the extent possible:

- The length-to-width ratio of a stormwater basin should be a minimum of 2:1. A 3:1 ratio is desired where possible. This prevents short-circuiting of the basin's storage areas.

- To minimize cut and fill, the long dimension of a stormwater basin should run parallel to the contours.

9.2.6 Embankments and Emergency Spillways

Stormwater basin earthen embankments shall be designed and constructed to maintain structural integrity during the 100-year frequency storm event. When applicable, Virginia Dam Safety regulations shall apply.

The minimum top width of an embankment shall be 10 feet. Width may be greater based on the overall height. Embankment side slopes shall be no steeper than 3:1. Embankments with an emergency spillway must provide at least one foot of freeboard from the maximum 100 year storm water surface elevation to the top of the embankment. An embankment without an emergency spillway must provide at least two feet of freeboard from the maximum 100 year storm water surface elevation to the top of the embankment.

A geotechnical study shall be required for all stormwater basins with constructed embankments greater than 6 feet in height as measured from the base of the embankment. The geotechnical study shall be performed by a licensed geotechnical engineer or licensed geologist and the report submitted to the County.

9.2.7 Outlet Structures and Release Rates

A. Stormwater Release Rates

Stormwater detention facilities shall be designed with an outlet structure to control the release rate from stormwater being held in the facility. Design release rates shall meet the requirements set forth in Chapter 4, except that extended detention facilities shall be designed based on releasing the design storm runoff volume in a prescribed time as indicated in the VA BMP Clearinghouse.

All stormwater detention facilities shall be empty within 72 hours following the storm event.

Ponds created as private property amenity features, not being used as stormwater management, shall be exempt from release rate requirements.

B. Outlet Structure Criteria

Outlet structures generally include a principal spillway or outlet and an emergency overflow. An outlet structure may take the form of a drop inlet, pipe, weir, or orifice. The principal spillway or outlet is intended to release flow from the design storm events at the necessary controlled rate, without allowing flow to enter the emergency spillway or overflow. The sizing of the outlet structure shall be based on the results of the hydrologic routing calculations or model.

Outlets from stormwater detention facilities shall be designed to function without manual, electrical, or mechanical controls.

Where necessary, energy dissipaters shall be placed at the outfall to provide a non-erosive velocity from the facility to a channel. See Chapter 10 for the design of outfall protection.

The principal spillway is intended to convey the design storm without allowing flow to enter an emergency outlet. If site restrictions prevent the use of an emergency spillway, then the principal spillway should be sized to safely pass the 100-year design storm without overtopping the facility. The designer should consider partial clogging (50%) of the principal spillway during the 100-year design storm to ensure the facility would not be overtopped. For large storage facilities, selecting a flood magnitude for sizing the emergency outlet should be consistent with the potential threat to downstream life and property if the basin embankment were to fail. The minimum flood to be used to size the emergency spillway is the 100-year

design storm flood. The sizing of a particular outlet structure should be based on results of hydrologic routing and calculations.

When the primary spillway is less than 24 inches wide, it is considered inoperative during a 100-year frequency storm.

Where a stormwater basin with an earthen embankment has an emergency spillway included, two conditions should be evaluated. The routed 100-year WSEL should provide one foot of freeboard between the 100-yr WSEL and the top of the berm. Secondly, the spillway should be evaluated to show that the 100-year flow passes through the spillway without overtopping the berm. Both conditions should be evaluated and met. The ability to pass the 100-year flow through the spillway is typically evaluated by routing the flow through the spillway only with all other outlets ignored or by simply evaluating the 100-year flow through the dimensional equivalent weir using FlowMaster, similar software, or applicable weir equations.

Where a stormwater basin with an earthen embankment does not have an emergency spillway included, two conditions should be evaluated. The routed 100-year WSEL should provide two feet of freeboard between the 100-year WSEL and the top of the berm. Secondly, the principal outlet or spillway (riser weir or culvert outlet) should be sized to safely pass the 100-year frequency storm without overtopping the berm. For this condition, the evaluation should include a 50% clogging factor and is typically evaluated assuming a weir length (perimeter) or culvert (diameter) based on dimensions providing 50% of the design flow area. The principal spillway should be a minimum of 24 inches wide/diameter unless calculations show that the freeboard requirements and no overtopping conditions are met.

For examples of design calculations of outlet structure orifices and weirs, see the VDOT Drainage Manual and VA BMP Clearinghouse.

All riser structures shall be cast-in-place or precast concrete, unless a substitute material has been approved by the County. VDOT standards for riser structures may be found in the VDOT Standards.

Outlet pipes shall be reinforced concrete pipe with rubber gasket watertight joints, shall have appropriate seepage control, and shall be installed on a concrete cradle from the tie of the pipe to the riser for the entire length of the outfall pipe. Concrete cradle shall be in accordance with the requirements of the VDOT Standards.

C. Adequate Channel

Outflows from stormwater detention facilities shall be discharged to an adequate channel. For adequate channel requirements, see Chapter 5.

9.2.8 Omitted

9.2.9 Landscaping

Stormwater basin embankments shall be vegetated. Selection and plant installation shall be in accordance with the standards of the VA BMP Clearinghouse. Trees and shrubs shall not be planted within a stormwater detention basin, nor on a stormwater basin berm, dam, or emergency spillway.

The VA BMP Clearinghouse shall be utilized for guidance for landscaping in the marsh areas of enhanced extended detention basins.

Native plants will be used to the maximum extent possible.

9.2.10 Underground Detention

A. Materials

All materials used in underground detention facilities shall be corrosion resistant consisting of reinforced concrete, aluminized corrugated metal pipe, corrugated high density polyethylene pipe, or similar approved material.

B. Slope

Underground detention facilities shall be sloped to drain at a minimum floor slope of 0.5 percent.

C. Capacity

Underground detention facilities shall be sized such that the 100-year design storm may be routed through the facility with no damage to the surface property.

D. Accessibility and Maintainability

All underground detention facilities shall be designed to be readily accessible for periodic inspection and maintenance from the surface without the need to perform confined space entry.

Providing pre-treatment to remove sediments before or at the entrance of the underground detention facility to improve water quality and/or improve maintainability should be considered during the design.

9.2.11 Trash Racks

Outlet structures shall be equipped with an appropriate trash rack. The trash rack shall be in accordance with the VA BMP Clearinghouse.

9.3 Environmental Impacts

Environmental impacts shall be carefully considered when siting stormwater detention facilities. Siting basins in low lying areas with potentially environmentally sensitive areas requires careful consideration, coordination, approval, and permitting with local, state, and federal agencies to evaluate the suitability of constructing in these areas. Environmentally sensitive areas include, but are not limited to wetlands, shallow marshes, jurisdictional waters, natural watercourses, wildlife habitat, etc. and may be protected by state and/or federal laws. With careful planning, it may be possible to incorporate wetland mitigation into the basin design.

Construction of stormwater basins or modifications to existing basins shall comply with all applicable laws and regulations. The applicant is responsible for procuring all necessary permits, such as US Army Corps of Engineers and Virginia DEQ Wetland Permits, Virginia DEQ VPDES Permits, VSMP Permits, etc., prior to beginning construction. Copies of all permits shall be provided to Roanoke County prior to a land disturbing permit being issued. See Chapter 12 for more information.

Detention facilities shall be coordinated with a watershed or regional plan for managing stormwater runoff, if available.

9.4 Maintenance Requirements

For the post-construction maintenance of stormwater detention facilities, see Chapter 14.