10.11 Dry Detention Basin

10.11.1 Introduction

Dry detention basins are depressed areas that store runoff during wet weather and are dry the rest of the time. They are very popular because of their comparatively low cost; few design limitations; and ability to serve large as well as small watersheds. Dry detention basins are an impoundment made by constructing a dam or an embankment (embankment detention basin), or by excavating a pit or dugout (excavated detention basin). Basins resulting from both excavation and embankment construction are classified as embankment detention basins where the depth of water impounded against the embankment at emergency spillway elevation is 0.9m (3 ft) or more. Its purpose is to regulate the rate and amount of runoff from development sites during and after construction operations and to minimize the effects of downstream erosion and flooding. They should be considered when there is a need to control or prevent downstream erosion and flooding due to site development or from other land use changes.

10.11.2 Regulatory Considerations

Design the detention basin to be compatible with State floodplain management and storm water management programs as well as local regulations for controlling sediment, erosion and runoff. The basin shall properly regulate storm discharges from a site to a safe, adequate outlet. Consider the duration of flow as well as the peak discharge. Provide adequate erosion control measures and other water-quality practices. Plan and design the basin to ensure minimal impact on visual quality and human enjoyment of the landscape. Blend structures and materials aesthetically with their surroundings.

Attempt to locate detention basins where:

1. Failure of the detention basin would not, within reasonable expectations, result in loss of life, damage all-weather roads, railroads, homes, commercial and industrial properties or interrupt the use or service of utilities. (Dams which might fail and endanger life or property are regulated by the Commissioner of the Department of Environmental Protection under the sections 22a-401 through 22a-411, CGS as discussed in Section 10.5).

2. The effective height of the dam for an embankment detention basin should be 4.6m (15 feet) or less. The effective height of the dam is defined as the difference in elevation in meters (feet) between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no spillway, the top of the dam becomes the upper limit; and/or the product of the storage times the effective height of the dam should be less than 1,130,000 (3,000). Storage is the volume in m^3 (acre-feet) in the reservoir below the elevation of the crest of the emergency spillway.

Detention basins that exceed any one of the above conditions shall be designed to meet the criteria in Earth Dams and Reservoirs, Technical Release 60 (TR-60) (Rev. 10/85) by the Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (I).

10.11.3 Sizing Requirements

Stormwater Quality To design the basin for stormwater quality control, the water quality volume (WQV) must be routed through the basin. As described in the Connecticut Stormwater Quality Manual, "the water quality volume (WQV) is the amount of stormwater runoff from any given storm that should be captured and treated in order to remove a majority of stormwater pollutants on an average annual basis. The recommended WQV, which results in the capture and treatment of the entire runoff volume for 90 percent of the average annual storm events, is equivalent to the runoff associated with the first one-inch of rainfall." This runoff is typically referred to as the "first-flush".

The WQV is determined from the following equation:

$$\textbf{WQV} = \frac{(25.4mm)(R)(A)}{1000} \; or \; \frac{(1")(R)(A)}{12} \qquad \textbf{(10.31)}$$

where:

	WQV	=	Water Quality Volume, hectare meters (acre ft)
	R	=	Volumetric Runoff Coefficient=0.05+0.009(I)
	I	=	Percent of Impervious Cover (%)
	A	=	Site area, hectares (acres)

(Note: 1 hectare=10,000 m^2)

The WQV should be detained and released over a period of 24 h. The following equation may be used to obtain the average outflow from the basin:

$$\mathbf{Q_{avg}} = \frac{10{,}000(\mathrm{WQV})}{T} \; or \; \frac{43560(\mathrm{WQV})}{T} \qquad \textbf{(10.32)}$$

Where:

	Q_{avg}	=	average outflow from the basin, m^3/s (cfs)
	WQV	=	water quality volume, hectare meters (acre ft)
	T	=	detention time, s

Knowing the average outflow, one can use an appropriate orifice equation to determine the size of the outlet. To help prevent clogging, the minimum recommended size of the outlet should be 200mm (8 in). However, smaller diameters (minimum of 76 mm or 3 in) may be allowed if adequately protected from clogging by an acceptable external trash rack.

Although stormwater treatment basins presented in this chapter are sized based on WQV, some treatment practices such as grass drainage channels, hydrodynamic separators and flow diversion structures for off-line stormwater treatment practices, are more appropriately designed based on peak flow rate or Water Quality Flow (WQF). The WQF is the peak flow rate based on the WQV as defined above. The WQF is determined using the procedures outlined in Chapter 11, Appendix C of the Drainage Manual.

Stormwater Quantity For quantity purposes, the basin shall be designed to reduce the post-construction peak flow from a 2, 10, and 25-year storm (considered individually) to the preconstruction level, and it shall be able to pass a 100-year storm safely. To control these storms, the basin's storage shall be equal to the area between the pre- and post-construction hydrographs.

After a storage volume has been determined for each event, a 2, 10, and 25-year storm should be routed through the facility to ensure that the peak flows from the post-construction watershed are not greater than the corresponding preconstruction peak flows. Finally, a 100-year storm shall be routed through the facility to ensure that the embankment will not be damaged or fail during the passage of that storm. It is common to have several outlet configurations to control the different storms: one or more for the frequently occurring storms and an emergency spillway to control anything larger, including the 100-year storm, (Figure 10-25). To improve the efficiency of the outlet, it may be necessary to include an antivortex device for the riser overflow component (Figure 10-26).

If the primary purpose of the detention basin is to minimize flooding, the peak discharge from the 2-year, 10-year, 25-year and 100-year frequency, 24-hour duration, Type III distribution storms shall be analyzed.

No increase in peak flow from the 2-year, 10-year, and 25-year storms shall be allowed unless downstream increases are compatible with an overall floodplain management system. Check local requirement for additional criteria that may include larger storms. Some of the items to consider in determining if increased peak flows are compatible with an overall floodplain management system are:

1. the timing of peak flows from sub-watershed
2. the increased duration of high flow rates
3. the stability of the downstream channels
4. the distance downstream that the peak discharges are increased

Stormwater Quantity and Quality Combined Combining the two designs (quality and quantity) will yield a dual-purpose detention basin. Several other design variations may be considered to enhance the capabilities of the facility. One consideration is shaping the basin to improve its pollutant-removal capabilities. The length-to-width ratio should be at least 3:1, and a wedge-shaped basin (wider at the outlet) can also improve pollutant removal. The inlet, outlet and side slopes should be stabilized with riprap and/or vegetation to prevent erosion. The basin floor should also be vegetated to stabilize the soil and increase biological uptake. The pond floor should be sloped no less than 2% to prevent the ponding of stormwater, and the side slopes should allow for easy maintenance access. A marsh or wetland can be established on the pond floor to increase biological uptake, and a sediment forebay (a small sediment trap at the inlet of the basin, either a depressed area or a shallow area with a very flat slope where sediment is easily deposited) can be used to catch the sediment before it fills the basin (see Figure 10-29). Design guidance for sediment forebays is outlined in Section 10.12.2.

The basin can also have two stages: one to hold the smaller storms, and a second, which is rarely inundated and can be used for other purposes, to help store the larger storms. Safety considerations include reducing the chance of drowning by fencing the basin, reducing the maximum depth and/or including ledges and mild slopes to prevent people from falling in and facilitate their escape from the basin.

10.11.4 Outlets

The outlets for the basin shall consist of a combination of an outlet control structure (sometimes referred to as a principal spillway) and an emergency spillway. These outlets shall pass the peak runoff from the contributing drainage area for the design flood. If, due to site conditions and basin geometry, a separate emergency spillway is not feasible, the outlet control structure shall pass the entire routed peak runoff expected from the design storm. However, an attempt to provide a separate emergency spillway shall always be made. An emergency spillway shall be provided on all detention basins with a contributing drainage area equal to or exceeding 8 hectares (20 acres).

Outlet Control Structure (Principal Spillway) As previously indicated, these structures are sometimes referred to as principal spillways, however, outlet control structure will be used in this manual. Outlet control structures for detention basins can be designed in a wide variety of configurations. Most outlet control structures use riser pipes of concrete or corrugated metal. These risers can be designed to control different storms through the use of several orifices on the riser, for example, a small diameter to control the WQV, an orifice to control a 2-year storm, and larger openings to control the 10 and 25 year storms. Since the WQV outlet must be small to detain the WQV long enough, it can be easily clogged; thus, the minimum recommended size of the outlet should be 200mm (8 in). However, smaller diameters (minimum of 76mm or 3 in) may be allowed if adequately protected from clogging by an acceptable external trash rack. The larger flows are usually controlled by stormwater flowing in through the top of the riser, using the entire riser circumference. Under these circumstances an antivortex and trash rack design may be necessary to improve the flow characteristics into the structure and prevent blockage from floating debris.

The base of the structure shall be firmly anchored to prevent its floating. If the riser is greater than 3.0 m (10 ft) in height, computations shall be done to determine the anchoring requirements. As a minimum, a factor of safety of 1.25 shall be used (downward forces = 1.25 X upward forces).

The barrel of the outlet structure, which extends through the embankment, shall be designed to carry the flow provided by the riser with the water level at the crest of the emergency spillway. The connection between the riser and the barrel shall be watertight. The outlet of the barrel shall be protected to prevent erosion or scour of downstream areas. (See Chapter 8, Section 8.7, Outlet Protection.)

The outlet control structure and amount of storage shall be sized to prevent the emergency spillway from overtopping for a 25-year design storm. If no emergency spillway is used, the outlet control structure shall be designed to pass the entire routed peak flow expected from the 100 year storm.

The crest of the outlet control structure shall be set at the elevation corresponding to the storage volume required. If severe sedimentation is expected, the design volume should include provisions for sediment volume.

Emergency Spillway The emergency spillway shall consist of an open channel (earthen and vegetated) constructed adjacent to the embankment over undisturbed material not within the embankment fill. Where conditions require the construction of an emergency spillway on the embankment fill, a spillway shall be constructed of a non-erodible material such as riprap.

The minimum capacity of a natural or constructed emergency spillway shall be that required to pass the peak flow expected from a design storm of 100-year frequency, 24-hour duration, Type III distribution less any reduction creditable to conduit discharge and detention storage.

Elevations If the outlet control structure is used in conjunction with an emergency spillway, the crest of the outlet control structure shall be a minimum of 0.3 m (1 ft) below the crest of the emergency spillway. If no emergency spillway is used, the crest of the outlet control structure shall be a minimum of 0.9 m (3 ft) below the top of the embankment. In either case, a minimum freeboard of 0.3 m (1 ft) should be provided between the 100 year storm and the top of the embankment elevations.

10.11.5 Embankment Cross Sections

The fill material shall be clean mineral soil, free of roots, woody vegetation, oversized stones, rocks, or other unsuitable material. Areas on which fill is to be placed shall be scarified prior to the placement of fill. Fill material will be placed in 150- to 200-mm (6-8 in) continuous layers over the entire length of the fill. Compaction shall be obtained by routing the hauling equipment over the fill so that the entire surface of the fill is traversed by at least one wheel or tread track of the equipment, or by using a compactor.

The embankment shall have a minimum top width of 2.5 m (8 ft). The side slopes shall be 1V:2H or flatter. The embankment may have a maximum height of 3 m (10 ft) if the side slopes are 1V:2H. If the side slopes are 1V:2.5H or flatter, the embankment may have a maximum height of 4.5 m (15 ft). If there is a significant impoundment, a dam permit will be required. (See Section 10.5 for additional information.)

Table 10-5 Summary Of Considerations For A Dry Basin

Quality	Detain WQV for 24 h recommended minimum 200mm (8 in) orifice, 76mm (3 in) minimum with trash rack
Quantity	Control 2- and 10-, and 25-year peak flows and maintain non-erosive velocity
Shape	3:1 length-to-width ratio; wedge shaped (wider at outlet)
Maintenance	Inspect a minimum once a year, preferably during wet weather, mow as required; remove sediment (every 5-10 years, or as required)
Other considerations	Side slopes provide easy maintenance access (1V:4H); 2% bottom slope to prevent ponding; sediment forebay to reduce maintenance; safety requirements (depth and perimeter ledges)
Pollutant removal	Moderate

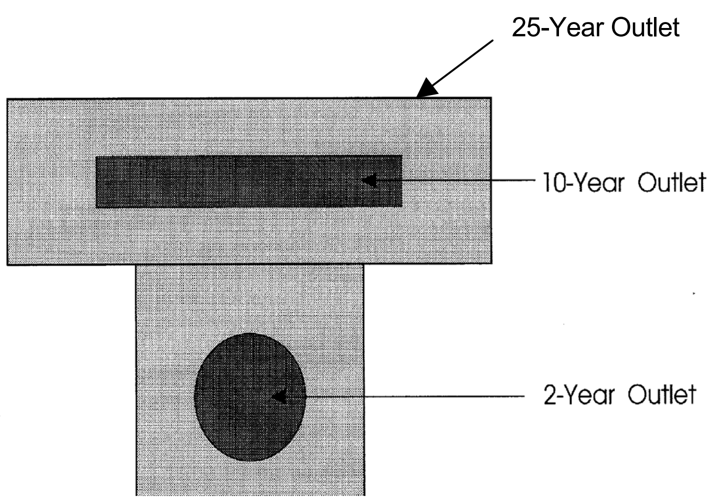

Figure 10-25 Concrete Riser

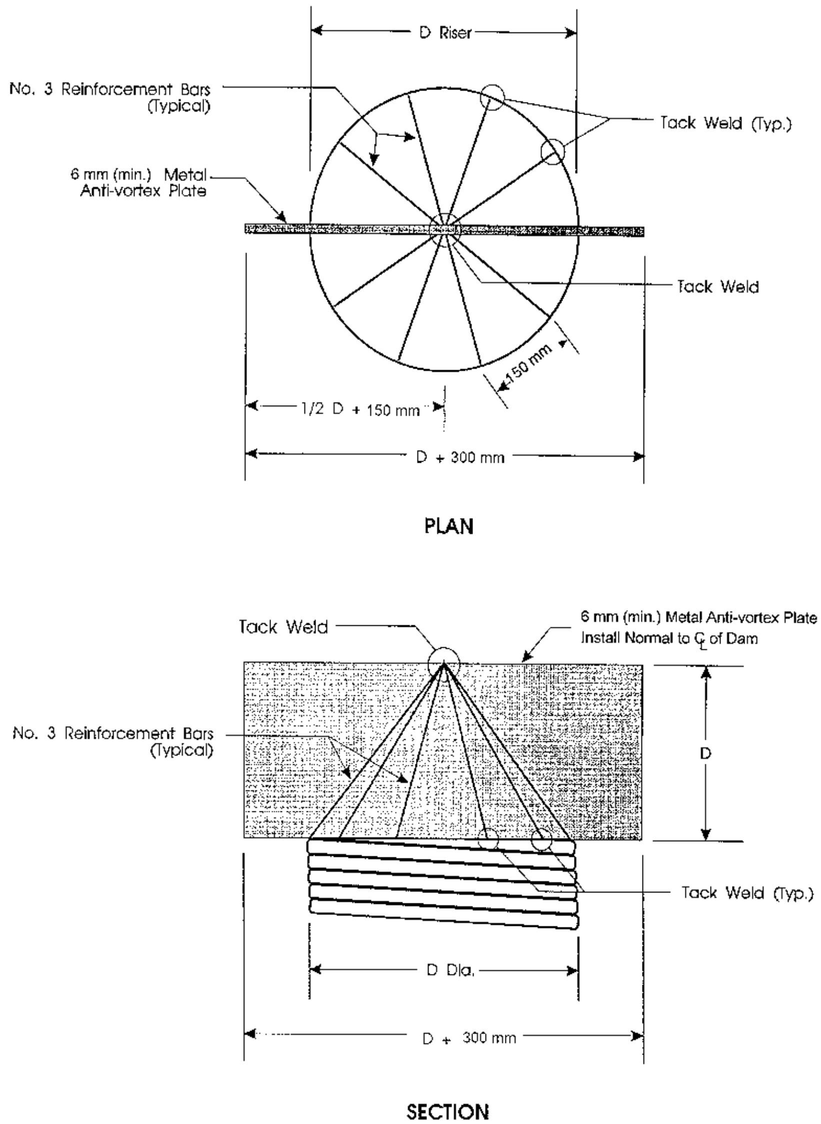

Figure 10-26 Antivortex Plate And Trash Rack
(Design of Urban Highway Drainage, FHWA TS 79-225)

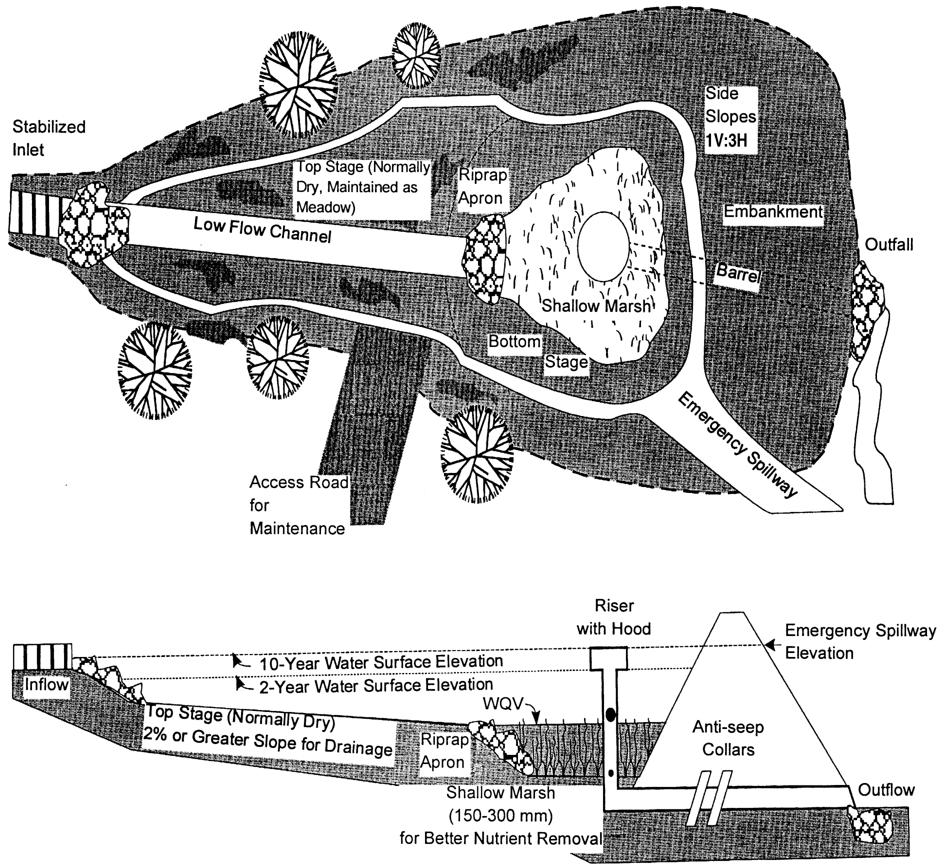

Figure 10-27 Dry Basin (after Schueler)