4.10 Dry Detention Practices

Introduction

Dry detention practices are explicitly designed to provide stormwater detention (2-year, 10-year, and 100-yr control).

Dry detention practices, also called dry ponds, are widely applicable for most land uses and are best suited for larger drainage areas. An outlet structure restricts stormwater flow so it backs up and is stored within the basin. The temporary ponding reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on the bed and banks of the receiving stream.

Detention vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. Detention tanks are underground storage facilities typically constructed with large diameter metal or plastic pipe. Both serve as an alternative to surface dry detention for stormwater quantity control, particularly for space-limited areas where there is not adequate land for a dry detention basin or multi-purpose detention area. Prefabricated concrete vaults are available from commercial vendors. In addition, several pipe manufacturers have developed packaged detention systems.

Dry detention practices are credited differently than other BMPs. In order to meet water quality requirements, they must store and release the first 1 inch of runoff over 24 hours. They may also be used solely for detention of larger storm events when water quality treatment is achieved by other BMPs.

Figure 4.10-1. Dry Extended Detention Pond (Photo: Center for Watershed Protection)

<table>
<tr><th colspan="2">KEY CONSIDERATIONS: DRY DETENTION PRACTICES</th></tr>
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DESIGN CRITERIA:

- Store and release the first 1 inch of runoff over 24 hours.
- Design with sufficient volume to detain design storms (typically the 2-, 10- and 100-year storms).
- Provide sufficient maintenance access.
- Provide freeboard and an emergency overflow for the 100-year storm event.

BENEFITS:

- Reduces post-construction stormwater runoff rates.
- Is a cost-effective flood control practice.

LIMITATIONS:

- Dry ponds are best suited to drainage areas greater than 10 acres.
- Does not reduce runoff volumes and provides less pollutant removal than other practices.

SITE APPLICABILITY:

- Rural Use
- Suburban Use
- Urban Use
- Construction Cost: low
- Maintenance: low
- Area Required: low

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STORMWATER MANAGEMENT PRACTICE PERFORMANCE:

Runoff Reduction Credit Approach
(applies to Shellfish Bed, SMS4, and infiltration credit approaches)

- 0% credit for runoff reduction

Coastal Zone Credit Approach

- 100% credit for storage volume of practice

Statewide Water Quality Requirement Credit Approach

- 1” of runoff must be stored and released over 24 hours

Pollutant Removal[1]
N/A - Total Suspended Solids
N/A - Total Phosphorus
N/A - Total Nitrogen
N/A - Metals
N/A - Pathogens

[1] Available data suggest minimal pollutant removal.

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Dry Detention Practice Feasibility Criteria

The following feasibility issues need to be evaluated when dry detention practices are considered as the final practice in a treatment train:

Space Required. A typical dry detention practice requires a footprint of 1% to 3% of its contributing drainage area, depending on the depth of the pond or storage vault (i.e., the deeper the practice, the smaller footprint needed).

Contributing Drainage Area. A contributing drainage area of at least 10 acres is preferred for dry ponds in order to keep the required orifice size from becoming a maintenance problem. Designers should be aware that small “pocket” ponds typically will:

1. Have very small orifices that will be prone to clogging
2. Experience fluctuating water levels such that proper stabilization with vegetation is very difficult
3. Generate more significant maintenance problems

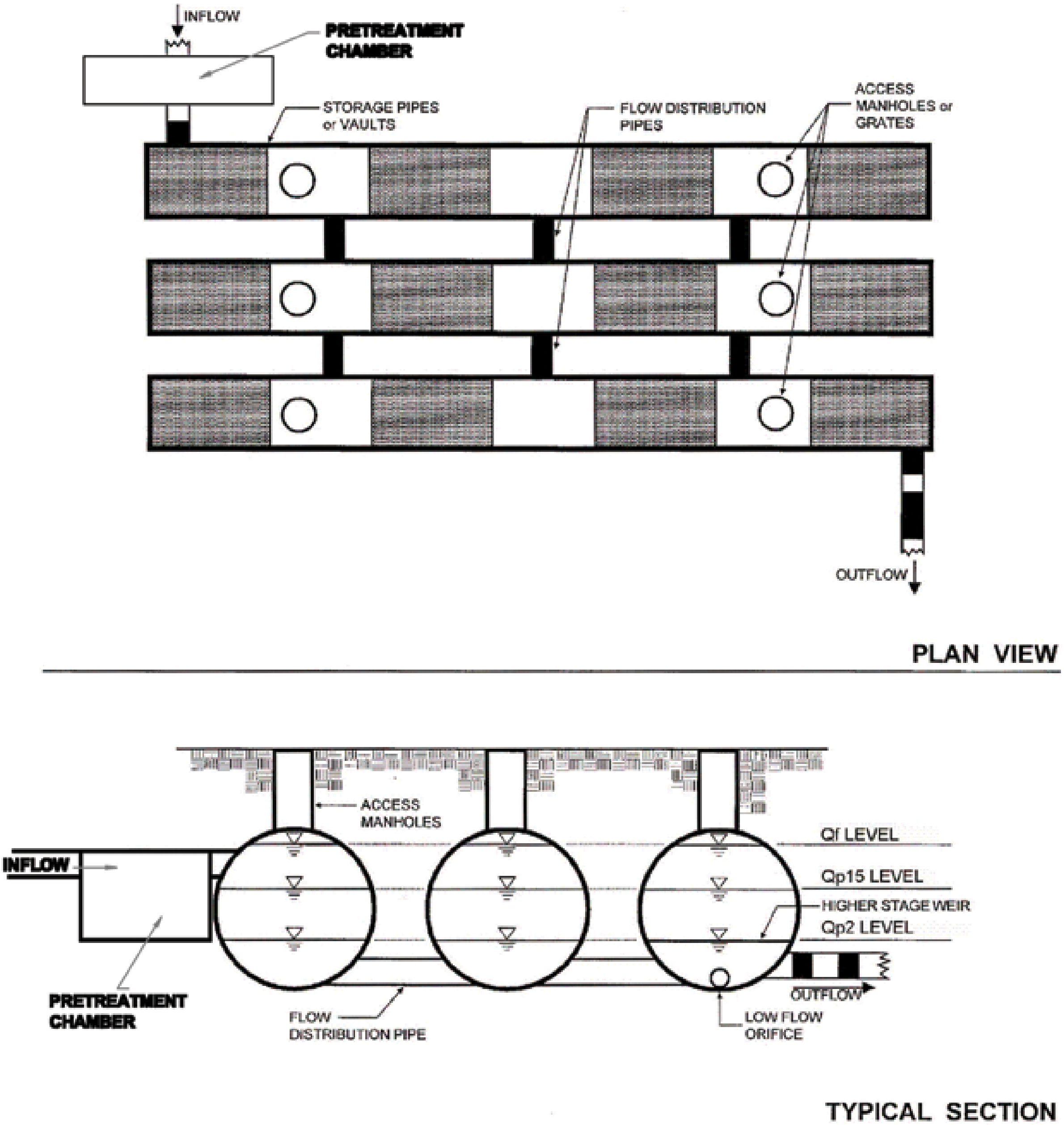
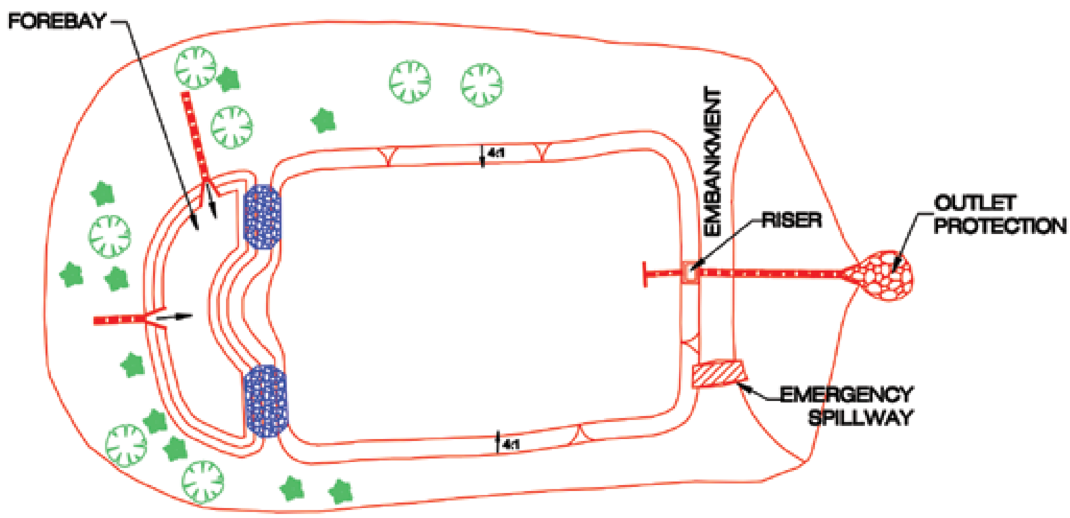
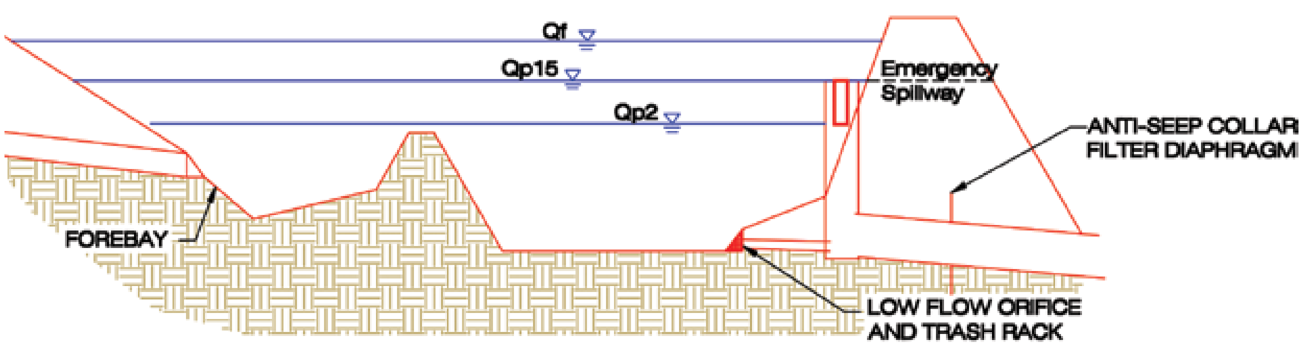


Figure 4.10-2. Example of an underground detention vault and/or tank



PLANVIEW



PROFILE

Figure 4.10-3. Example of a Dry Detention Pond

Underground detention systems can be located downstream of other structural stormwater controls providing treatment of the design storm. For treatment train designs where upland practices are utilized for treatment of the water quality volume (WQV), designers can use a site-adjusted Rv or CN that reflects the volume reduction of upland practices and likely reduce the size and cost of detention.

Available Hydraulic Head. The depth of a dry detention practice is usually determined by the amount of hydraulic head available at the site (dimension between the surface drainage and the bottom elevation of the site). The bottom elevation is normally the invert of the existing downstream conveyance system to which the dry detention practice discharges. Depending on the size of the development and the available surface area of the basin, as much as 6 to 8 feet of hydraulic head may be needed for a dry detention practice to function properly for storage. An underground practice will require sufficient head room to facilitate maintenance, at least 5 feet depending on the design configuration.

Minimum Setbacks. Generally, dry detention practices should be set back at least 10 feet from property lines, and 10 feet down-gradient from building foundations.

Depth-to-Water Table and Bedrock. Dry ponds are not allowed if the water table or bedrock will be within 0.5 feet of the floor of the pond. For underground detention facilities, an anti-flotation analysis should be performed to check for buoyancy problems in the high water table areas.

Tidal Impacts. The outlet of a dry detention practice should be located above the tidal mean high water elevation. In tidally impacted areas, detention practices may have minimal benefit, and requesting a variance for detention requirements may be an option.

Tailwater Conditions. The flow depth in the receiving channel should be considered when determining outlet elevations and discharge rates from the dry detention practice.

Soils. The permeability of soils is seldom a design constraint for dry detention practices. Soil infiltration tests should be conducted at proposed dry pond sites to estimate infiltration rates and patterns, which can be significant in Hydrologic Soil Group (HSG) A soils and some group B soils. Infiltration through the bottom of the pond is typically encouraged, unless it may potentially migrate laterally thorough a soil layer and impair the integrity of the embankment or other structure.

Structural Stability. Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate.

Geotechnical Tests. At least one soil boring should be taken at a low point within the footprint of any proposed dry detention practice to establish the water table and bedrock elevations and evaluate soil suitability. A geotechnical investigation is recommended for all underground BMPs, including underground storage systems. Geotechnical testing requirements are outlined in *Appendix C*.

Utilities. For a dry pond system, no utility lines should cross any part of the embankment where the design water depth is greater than 2 feet. Typically, utilities require a minimum 5-foot horizontal clearance from storage facilities.

Perennial Streams. Locating dry ponds on perennial streams will require both a Section 401 and Section 404 permit from the appropriate state or federal regulatory agency.

Economic Considerations. Underground detention can be expensive, but often allows for greater use of a development site. Dry detention ponds are generally inexpensive to construct and maintain. Depending upon the type of development, dry detention practices may be required to treat a larger volume of water than other BMPs. Dry detention practices must store 1 inch of runoff from the site, whereas infiltration practices and other LID BMPs must capture 1 inch of runoff from only the impervious cover on a site.

Dry Detention Practice Conveyance Criteria

Designers should use accepted hydrologic and hydraulic routing calculations to determine the required storage volume and an appropriate outlet design for dry detention practices. For management of the 2-year storm, a control structure with a trash rack designed to release the required pre-development discharge rate should be provided. Ideally, the channel protection orifice should have a minimum diameter of 3 inches in order to pass minor trash and debris. However, where smaller orifices are required, the orifice should be adequately protected from clogging by an acceptable external trash rack

For overbank flood protection, an additional outlet is sized for control of the 10-year storm event, and can consist of a weir, orifice, outlet pipe, combination outlet, or other acceptable control structure.

Riprap, plunge pools or pads, or other energy dissipaters should be placed at the end of the outlet to prevent scouring and erosion and to provide a non-erosive velocity of flow from the structure to a water course. The design must specify an outfall that will be stable for the 10-year design storm event. The channel immediately below the practice outfall may need to be modified to prevent erosion. This is typically done by calculating channel velocities and flow depths, then placing appropriately sized riprap, over filter fabric, which can reduce flow velocities from the principal spillway to non-erosive levels (3.5 to 5.0 fps depending on the channel lining material). The practice geometry and outfall design may need to be altered in order to yield adequate channel velocities and flow.

Flared pipe sections that discharge at or near the stream invert or into a step pool arrangement should be used at the spillway outlet. An outfall analysis should be included in the stormwater management plan showing discharge velocities down to the nearest downstream water course. Where indicated, the developer/contractor must secure an off-site drainage easement for any improvements to the downstream channel.

When the discharge is to a manmade pipe or channel system, the system must be adequate to convey the required design storm peak discharge.

If discharge daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance. Excessive use of riprap should be avoided.

The final release rate of the facility should be modified if any increase in flooding or stream channel erosion would result at a downstream structure, highway, or natural point of restricted streamflow.

The following ***additional*** conveyance criteria apply to underground detention:

- ✧ An internal or external high flow bypass or overflow should be included in the underground detention designs to safely pass the extreme flood flow.

The following ***additional*** conveyance criteria apply to dry ponds:

✧ **Primary Spillway.** The primary spillway should be designed with acceptable anti-flotation, anti-vortex, and trash rack devices. The spillway should generally be accessible from dry land. When reinforced concrete pipe is used for the principal spillway to increase its longevity, "O"-ring gaskets (ASTM C-361) should be used to create watertight joints, and they should be inspected during installation. The risk of clogging in outlet pipes with small orifices can be reduced by:

- Providing a micropool at the outlet structure.
    - Use a reverse-sloped pipe that extends to a mid-depth of the permanent pool or micropool.
    - Install a downturned elbow or half-round CMP over a riser orifice (circular, rectangular, V-notch, etc.) to pull water from below the micropool surface.
    - The depth of the micropool should be at least 4 feet deep, and the depth should not draw down by more than 2 feet during a 30 day summer drought.
- Providing an over-sized forebay to trap sediment, trash and debris before it reaches the dry pond's low-flow orifice.
- Installing a trash rack to screen the low-flow orifice.
- Using a perforated pipe under a gravel blanket with an orifice control at the end in the riser structure.

✧ **Emergency Spillway.** Dry ponds should be constructed with overflow capacity to safely pass the 100-year design storm event through either the primary spillway or a vegetated or armored emergency spillway.

✧ **Inlet Protection.** Inflow points into dry pond systems should be stabilized to ensure that non-erosive conditions exist during storm events up to the 10-year storm event.

Storage Pretreatment Criteria

Dry Pond Pretreatment Forebay. A forebay should be located at each major inlet to a dry pond to trap sediment and preserve the capacity of the main treatment cell. The following criteria apply to dry pond forebay design:

✧ A major inlet is defined as an individual storm drain inlet pipe or open channel serving at least 10% of the dry detention practice's contributing drainage area.

✧ The forebay consists of a separate cell, formed by an acceptable barrier. (e.g., an earthen berm, concrete weir, gabion baskets, etc.).

✧ The forebay should be sized to contain at least 0.1 inches of runoff.

✧ The forebay should be designed in such a manner that it acts as a level spreader to distribute runoff evenly across the entire bottom surface area of the main storage cell.

✧ Exit velocities from the forebay should be non-erosive or an armored overflow should be provided. Recommended non-erosive velocities are 4 feet per second for the two-year event, and 6 feet per second for the 10-year event.

✧ The bottom of the forebay may be hardened (e.g., concrete, asphalt, or grouted riprap) in order to make sediment removal easier.

- ✧ Direct maintenance access for appropriate equipment should be provided for each forebay.

Underground Detention Pretreatment. A pretreatment structure (sediment sump or vault chamber), sized to capture 0.1 inches of runoff should be provided at the inlet for underground detention systems.

Storage Design Criteria

Dry Pond Internal Design Features. The following apply to dry pond design:

- ✧ **No Pilot Channels.** Dry ponds must not have a low flow pilot channel, but instead must be constructed in a manner whereby flows are evenly distributed across the pond bottom, to avoid scour, promote attenuation and, where possible, infiltration. A pilot channel often allows runoff from small storms to pass quickly through a stormwater pond without receiving any treatment or peak flow attenuation. Without a pilot channel, runoff from even small storms will spread across the surface of the detention pond. For maintenance purposes, it should be noted that soils may stay wetter between storm events with this design.
- ✧ **Internal Slope.** The maximum longitudinal slope through the pond should be approximately 0.5% to 1%. The surface of the pond should be as flat as possible so as to allow runoff from even the smallest storms to spread out evenly across the entire pond surface.
- ✧ **Side Slopes.** Side slopes within the dry pond should generally have a gradient of 3H:1V to 4H:1V. The mild slopes promote better establishment and growth of vegetation and provide for easier maintenance and a more natural appearance. Ponds with side slopes steeper than 5H:1V should be fenced and include a lockable gate.
- ✧ **Long Flow Path.** Dry pond designs should have an irregular shape and a long flow path distance from inlet to outlet to increase water residence time, treatment pathways, pond performance, and to eliminate short-cutting. In terms of flow path geometry, there are two design considerations: (1) the overall flow path through the pond, and (2) the length of the shortest flow path (Hirschman et al., 2009):
  - The *overall flow path* can be represented as the length-to-width ratio OR the flow path ratio. These ratios should be at least 2L:1W (3L:1W preferred). Internal berms, baffles, or topography can be used to extend flow paths and/or create multiple pond cells.
  - The *shortest flow path* represents the distance from the closest inlet to the outlet. The ratio of the shortest flow to the overall length should be at least 0.4. In some cases – due to site geometry, storm sewer infrastructure, or other factors – some inlets may not be able to meet these ratios. However, the drainage area served by these "closer" inlets should constitute no more than 20% of the total contributing drainage area.

Safety Features. The following safety features should be considered for dry detention practices:

- ✧ The principal spillway opening should be designed and constructed to prevent access by small children.

- ✧ End walls above pipe outfalls greater than 48 inches in diameter should be fenced at the top of the wall to prevent a falling hazard.
- ✧ Dry detention practices should incorporate an additional 1 foot of freeboard above the emergency spillway.
- ✧ The emergency spillway should be located so that downstream structures will not be impacted by spillway discharges
- ✧ Underground maintenance access should be locked at all times.

Maintenance Access. All dry detention practices should be designed so as to be accessible to annual maintenance. A 5:1 slope and 15-foot wide entrance ramp is recommended for maintenance access to dry ponds. Also, adequate maintenance access must be provided for all underground detention systems. Access must be provided over the inlet pipe and outflow structure. Access openings can consist of a standard 30-inch diameter frame, grate and solid cover, or a hinged door or removable panel.

Outlets. Trash racks should be provided for low-flow pipes and for risers not having anti-vortex devices.

In order to reduce maintenance problems for small orifices, a standpipe design can be used that includes a smaller inner standpipe with the required orifice size, surrounded by a larger standpipe with multiple openings, and a gravel jacket surrounding the larger standpipe. This design will reduce the likelihood of the orifice being clogged by sediment.

Detention Vault and Tank Materials. All construction joints and pipe joints must be water tight. Cast-in-place wall sections should be designed as retaining walls. The maximum depth from finished grade to the vault invert should be 20 feet. Manufacturer's specifications should be consulted for underground detention structures.

Anti-floatation Analysis for Underground Detention. Anti-flotation analysis is required to check for buoyancy problems in the high water table areas. Anchors should be designed to counter the pipe and structure buoyancy by at least a 1.2 factor of safety.

Dry Detention Practice Sizing. For water quality purposes, the storage volume, *Sv*, for a dry detention practice is the volume of water that is stored, and released slowly over 24 hours – extended detention (The *Sv* does not include the 2-year or 10-year detention volumes.). To fully treat the water quality volume with at dry detention practice, the *Sv* must be equal to 1 inch of runoff from the site.

In the LID Compliance Calculator spreadsheet, dry detention practices are not assigned any runoff reduction credit. For projects in the Coastal Zone, the Sv for dry detention practices is given a 100% credit toward the storage requirement. For the statewide water quality requirements, dry detention practices are credited as a pond without a permanent pool, and at least 1 inch of runoff must be stored and released over 24 hours.

Dry detention practices should be sized to control peak flow rates from the 2-year and 10-year frequency storm event or other design storm. Design calculations must ensure that the post-development peak discharge does not exceed the pre-development peak discharge.

For treatment train designs where upland practices are utilized for treatment of the water quality volume, designers can use a reduced Rv or CN that reflects the volume reduction of upland practices to compute the peak flows from larger storm events.

Dry Detention Practice Landscaping Criteria

No landscaping criteria apply to underground dry detention practices.

For dry ponds, a landscaping plan should be provided that indicates the methods used to establish and maintain vegetative coverage within the dry pond. Minimum elements of a plan include the following:

- ✧ Delineating pondscaping zones within the pond
- ✧ Selecting corresponding plant species
- ✧ Developing the planting plan
- ✧ Establishing the sequence for preparing the wetland bed, if one is incorporated with the dry pond (including soil amendments, if needed)
- ✧ Identifying the sources of native plant material
- ✧ Executing the planting plan (e.g., keeping mowable turf along the embankment and all access areas, but may allow parts of the pond to include unmowed grasses, shrubs, and trees). The wooded wetland concept proposed by Cappiella et al., (2005) may be a good option for many dry ponds.
- ✧ Preventing woody vegetation from being planted or allowed to grow within 15 feet of the toe of the embankment nor within 25 feet from the principal spillway structure.
- ✧ Avoiding species that require full shade, or are prone to wind damage.

Dry Detention Practice Construction Sequence

Construction of underground storage systems must be in accordance with manufacturer's specifications. All runoff into the system should be blocked until the site is stabilized. The system must be inspected and cleaned of sediment after the site is stabilized.

The following is a typical construction sequence to properly install a dry pond. The steps may be modified to reflect different dry pond designs, site conditions, and the size, complexity and configuration of the proposed facility.

Step 1: Use of Dry Pond for Erosion and Sediment Control. A dry pond may serve as a sediment basin during project construction. If this is done, the volume should be based on the more stringent sizing rule (erosion and sediment control requirement vs. water quality treatment requirement). Installation of the permanent riser should be initiated during the construction phase, and design elevations should be set with final cleanout of the sediment basin and conversion to the post-construction dry pond in mind. The bottom elevation of the dry pond should be lower than the bottom elevation of the temporary sediment basin. Appropriate procedures should be implemented to prevent discharge of turbid waters when the basin is being converted into a dry pond.

Step 2: Stabilize the Drainage Area. Dry ponds should only be constructed after the contributing drainage area to the pond is completely stabilized. If the proposed dry pond site will be used as a sediment trap or basin during the construction phase, the construction notes should clearly indicate that the facility will be dewatered, dredged and re-graded to design dimensions after the original site construction is complete.

Step 3: Assemble Construction Materials on-site, make sure they meet design specifications, and prepare any staging areas.

Step 4: Clear and Strip the project area to the desired sub-grade.

Step 5: Install Erosion and Sediment Controls prior to construction, including temporary de-watering devices and stormwater diversion practices. All areas surrounding the pond that are graded or denuded during construction must be planted with turf grass, native plantings, or other approved methods of soil stabilization.

Step 6: Install the Spillway Pipe.

Step 7: Install the Riser or Outflow Structure and ensure the top invert of the overflow weir is constructed level at the design elevation.

Step 8: Construct the Embankment and any Internal Berms in 8 to 12-inch lifts and compact the lifts with appropriate equipment.

Step 9: Excavate/Grade until the appropriate elevation and desired contours are achieved for the bottom and side slopes of the dry pond.

Step 10: Construct the Emergency Spillway in cut or structurally stabilized soils.

Step 11: Install Outlet Pipes, including downstream riprap apron protection.

Step 12: Stabilize Exposed Soils. All areas above the normal pool elevation should be permanently stabilized by hydroseeding or seeding over straw.

Dry Pond Construction Inspection. Multiple inspections are critical to ensure that stormwater ponds are properly constructed. Inspections are recommended during the following stages of construction:

- Pre-construction meeting
- Initial site preparation (including installation of E&S controls)
- Excavation/Grading (interim and final elevations)
- Installation of the embankment, the riser/primary spillway, and the outlet structure
- Implementation of the pondscaping plan and vegetative stabilization
- Final inspection (develop a punchlist for facility acceptance)

If the dry pond has a permanent pool, then to facilitate maintenance the contractor should measure the actual constructed dry pond depth at three areas within the permanent pool (forebay, mid-pond and at the riser), and they should mark them on an as-built drawing. This simple data set will enable maintenance inspectors to determine pond sediment deposition rates in order to schedule sediment cleanouts.

Dry Detention Practice Maintenance Criteria

Typical maintenance activities for dry detention practices are outlined in Table 4.10-1. Maintenance requirements for underground storage facilities will generally require quarterly visual inspections from the manhole access points to verify that there is no standing water or excessive sediment buildup. Entry into the system for a full inspection of the system components (pipe or vault joints, general structural soundness, etc.) should be conducted annually. Confined space entry credentials are typically required for this inspection.

Table 4.10-1. Typical maintenance activities for dry detention practices

Maintenance Activity	Schedule
♦ Water dry pond side slopes to promote vegetation growth and survival.	As needed
♦ Remove sediment and oil/grease from inlets, pretreatment devices, flow diversion structures, and overflow structures. ♦ Ensure that the contributing drainage area, inlets, and facility surface are clear of debris. ♦ Ensure that the contributing drainage area is stabilized. Perform spot-reseeding where needed. ♦ Repair undercut and eroded areas at inflow and outflow structures.	Quarterly
♦ Measure sediment accumulation levels in forebay. Remove sediment when 50% of the forebay capacity has been lost. ♦ Inspect the condition of stormwater inlets for material damage, erosion or undercutting. Repair as necessary. ♦ Inspect the banks of upstream and downstream channels for evidence of sloughing, animal burrows, boggy areas, woody growth, or gully erosion that may undermine pond embankment integrity. ♦ Inspect outfall channels for erosion, undercutting, riprap displacement, woody growth, etc. ♦ Inspect condition of principal spillway and riser for evidence of spalling, joint failure, leakage, corrosion, etc. ♦ Inspect condition of all trash racks, reverse sloped pipes or flashboard risers for evidence of clogging, leakage, debris accumulation, etc. ♦ Inspect maintenance access to ensure it is free of debris or woody vegetation, and check to see whether valves, manholes and locks can be opened and operated. ♦ Inspect internal and external side slopes of dry ponds for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately. ♦ Monitor the growth of wetlands, trees and shrubs planted in dry ponds. Remove invasive species and replant vegetation where necessary to ensure dense coverage.	Annual inspection

Maintenance of dry detention practices is driven by annual inspections that evaluate the condition and performance of the practice. Based on inspection results, specific maintenance tasks will be triggered. An example maintenance checklist for dry detention practices is included in *Appendix F*.

Dry Detention Practice References and Additional Resources

1. Cappiella, K., Schueler, T., and T. Wright. 2005. Urban Watershed Forestry Manual. Part 1: Methods for Increasing Forest Cover in a Watershed. NA-TP-04-05. USDA Forest Service, Northeastern Area State and Private Forestry. Newtown Square, PA.
2. Hirschman, D., L. Woodworth and S. Drescher. 2009. Technical Report: Stormwater BMPs in Virginia's James River Basin: An Assessment of Field Conditions & Programs. Center for Watershed Protection. Ellicott City, MD.
3. Virginia Department of Conservation and Recreation (VA DCR). 2011. Stormwater Design Specification No. 15: Extended Detention (ED) Pond Version 1.8. Available at http://vwrrc.vt.edu/swc/april_22_2010_update/DCR_BMP_Spec_No_15_EXT_DETENTION_POND_Final_Draft_v1-8_04132010.pdf