VIRGINIA DCR STORMWATER DESIGN SPECIFICATION No. 15

EXTENDED DETENTION (ED) POND

VERSION 2.0
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SECTION 1: DESCRIPTION

An Extended Detention (ED) Pond relies on 24 to 36 hour detention of stormwater runoff after each rain event. An under-sized outlet structure restricts stormwater discharge so it backs up and is stored within the basin. The temporary ponding enables particulate pollutants to settle out and reduces the maximum peak discharge to the downstream channel, thereby reducing the effective shear stress on banks of the receiving stream. ED differs from stormwater detention as ED is designed to achieve a minimum drawdown time, rather than a maximum peak rate of flow. A design maximum peak rate of flow, or peak discharge, is commonly used to meet channel protection or flood control requirements and often only detains flows for a few minutes or hours. However, in some cases, detention designed for channel protection using the "energy balance" method described in the Virginia Stormwater Management Program (VSMP) regulations (4VAC50-60-66) may result in extended drawdown times. Therefore, designers are encouraged to evaluate the channel protection detention drawdown as compared to the ED requirements in order to optimize the design to meet both criteria.

ED ponds rely on gravitational settling as their primary pollutant removal mechanism. Consequently, they generally provide fair-to-good removal for particulate pollutants, but low or negligible removal for soluble pollutants, such as nitrate and soluble phosphorus. The use of ED alone generally results in the lowest overall pollutant removal rate of any single stormwater treatment option. Alternatively, an ED component is combined with wet ponds (Design Specification No 14) and constructed wetlands (Design Specification No 15) to help maximize pollutant removal rates of those practices.

Designers should note that an ED pond is typically the final element in the roof to stream pollutant removal sequence and provides limited volume reduction credit (Level 2 only), and **should therefore be considered *only* if there is remaining Treatment Volume or Channel Protection Volume to manage after all other upland runoff reduction practices have been considered and properly credited.**

SECTION 2: PERFORMANCE

Table 15.1. Summary of Stormwater Functions Provided by ED Ponds

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	0%	15%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	15%	15%
Total Phosphorus (TP) Mass Load Removal	15%	31%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	10%	10%
Total Nitrogen (TN) Mass Load Removal	10%	24%
Channel Protection	Yes; storage volume can be provided to accommodate the full Channel Protection Volume (CP_V)	
Flood Mitigation	Yes; flood control storage can be provided above the maximum extended detention volume	
[1] Change in event mean concentration (EMC) through the practice. The actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).		

Sources: CWP and CSN (2008); CWP (2007)

Leadership in Energy and Environmental Design (LEED®). The LEED® point credit system designed by the U.S. Green Building Council (USGBC) and implemented by the Green Building Certification Institute (GBCI) awards points related to site design and stormwater management. Several categories of points are potentially available for new development and redevelopment projects. **Chapter 6** of the 2013 *Virginia Stormwater Management Handbook* (2nd Edition) provides a more thorough discussion of the site planning process and design considerations as related to Environmental Site Design and potential LEED credits. However, VDCR is not affiliated with the USGBC or GBCI and any information on applicable points provided here is based only on basic compatibility. **Designers should research and verify scoring criteria and applicability of points as related to the specific project being considered through USGBC LEED resources.**

***Table 15.2. Potential LEED® Credits for Extended Detention Ponds*[1]**

Credit Category	Credit No.	Credit Description
Sustainable Sites	SS6.1	Stormwater Design: Quantity Control

[1] Actual site design and/or BMP configuration may not qualify for the credits listed. Alternatively, the project may actually qualify for credits not listed here. Designers should consult with a qualified individual (LEED AP) to verify credit applicability.

SECTION 3: LEVEL 1 AND 2 DESIGN TABLE

As the last practice in the treatment train, ED Ponds can serve the dual function of providing the final runoff volume and pollutant load reduction needed on the development site, while also providing the detention storage required to meet the channel protection and flood control requirements. Designers may therefore choose to go with the baseline design (Level 1) or may choose to maximize the volume and pollutant load reduction by incorporating an enhanced design (Level 2). To qualify for the higher nutrient reduction rates associated with the Level 2 design, ED ponds must be designed with a Treatment Volume (*Tv*) equal to $1.25(R_V)(A)$, as well as other specific design elements. **Table 15.3** lists the criteria for the Level 1 and 2 designs. See **Section 6** for more detailed design guidelines.

Table 15.3. Extended Detention (ED) Pond Criteria

Level 1 Design (RR:0; TP:15; TN:10)	Level 2 Design (RR:15; TP:15; TN:10)
Tv = [(1.0) (Rv) (A)] / 12 – the volume reduced by an upstream BMP	Tv = [(1.25) (R_V) (A)] / 12 – the volume reduced by an upstream BMP
A minimum of 15% of the Tv in the permanent pool (forebay, micropool) **Section 6.5**	A minimum of 40% of Tv in the permanent pool (15% in forebays and micropool, and 25% in constructed wetlands) **Sections 6.2 and 6.5**
Length/Width ratio *OR* flow path = 2:1 or more; Length of the shortest flow path / overall length = 0.4 or more. **Section 6.3**	Length/Width ratio *OR* flow path = 3:1 or more; Length of the shortest flow path / overall length = 0.7 or more. **Section 6.3**
Average Tv ED time = 24 hours or less. **Section 6.2**	Average Tv ED time = 36 hours. **Section 6.2**
Vertical Tv ED fluctuation may exceed 4 feet. **Section 6.3**	Maximum vertical Tv ED limit of 4 feet. **Section 6.3**
Turf cover on floor **Section 6.7**	Trees, shrubs, and herbaceous plants in upper elevations, and emergent plants in wet features **Section 6.7**
Forebay and micropool **Section 6.5**	Incudes additional cells or features (deep pools, wetlands, etc.) **Sections 6.2 and 6.5**

SECTION 4: TYPICAL DETAILS

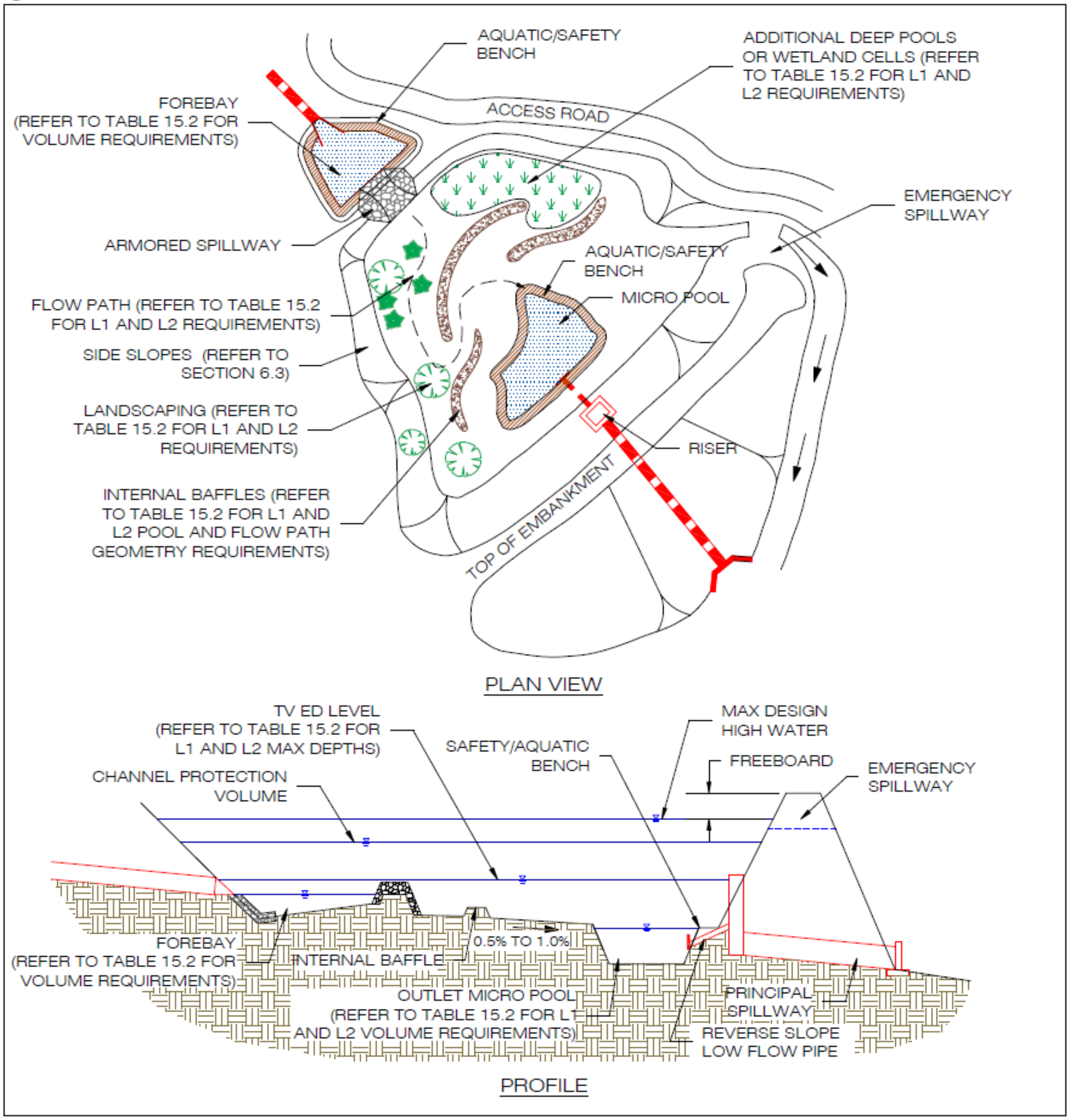

Figure 15.1. Typical Extended Detention Pond Plan and Profile

SECTION 5: PHYSICAL FEASIBILITY & DESIGN APPLICATIONS

The following feasibility criteria should be evaluated when ED ponds are considered as the final practice in a treatment train. Many of these items will be influenced by the type of ED Pond being considered (refer to Design Applications at the end of this section).

Space Required. A typical ED pond requires a footprint of 1% to 3% of its contributing drainage area, depending on the impervious cover, pond geometry, etc.

Contributing Drainage Area (CDA). A minimum contributing drainage area of 10 acres is recommended for ED ponds, in order to sustain a permanent micropool to protect against clogging. ED may still work with drainage areas less than 10 acres, but designers should be aware that these “pocket” ponds will typically (1) have very small orifices that will be prone to clogging, and (2) may generate more maintenance requirements.

Available Hydraulic Head. The depth of an ED pond is usually determined by the amount of hydraulic head available at the site. The bottom elevation is normally the invert of the existing downstream conveyance system to which the ED pond discharges. Typically, a minimum of 4 to 6 feet is needed for a water quality ED pond, and up to 10 feet of head (or more) may be needed for an ED pond to provide channel protection and flood control.

Minimum Setbacks. Local subdivision and zoning ordinances and design criteria should be consulted to determine minimum setbacks for impoundments to property lines, structures, and wells. Generally, ED ponds should be set back at least 10 feet from property lines, 25 feet from building foundations, 35 feet from septic system fields, and 50 feet from private wells.

Depth-to-Water Table and Bedrock. ED ponds are not allowed if the water table or bedrock will be within 2 feet of the floor of the pond. Refer to **Section 7** for design variations when encountering high water table, bedrock, or karst topography

Soils. The permeability of soils is seldom a design constraint for ED ponds. Infiltration through the bottom of the pond is encouraged unless it will impair the integrity of the embankment. Soil explorations should to be conducted at the proposed pond embankment to estimate infiltration rates and properly design the embankment cut-off trench.

An initial soil exploration should be conducted to rule out infiltration as a preferred practice and to rule out the presence of karst topography. The ED Basin should be the option of last resort if karst topography is present. Refer to **Section 7** for additional guidance when designing near karst topography. At a minimum, an impermeable clay or (preferably) geosynthetic liner in accordance with Stormwater Design Specification No. 13 (Constructed Wetlands) will be required.

Trout Streams. Pond practices have a tendency to raise the water temperature in receiving streams. Therefore, the use of ED ponds in watersheds containing trout streams is restricted to situations where upland runoff reduction practices cannot meet the full Channel Protection Volume requirement. In these instances, a an ED pond must (1) be designed with a maximum 12 hour detention time (to avoid excessive warming of runoff), (2) have a minimum outlet micro-pool volume sufficient to prevent clogging, (3) be planted with trees so it becomes fully shaded and (4) be located outside of any required stream buffers.

Perennial Streams. Locating ED ponds on perennial streams is typically not allowed and will require a Section 401 and Section 404 permit from the appropriate state or federal regulatory agency.

Design Applications

ED can be combined as a design element within other stormwater treatment practices (e.g., wet ponds, and constructed wetlands) to enhance their performance and appearance. Similarly, other design variations can be incorporated into the ED pond; e.g., bioretention, infiltration, sand filters, etc., located within the overall footprint but housed in a separate cell, where the maximum allowable CDA, among other design limitations as required by the criteria of that particular practice, can be addressed. In such cases, the designer should clearly document the design concept and "hybrid" performance credit (if applicable) for review by the plan approving authority (or the Virginia BMP Clearinghouse for broader application).

The traditional (and most common) design applications for ED include:

- Micropool ED
- Wet ED Pond (covered in Stormwater Design Specification No.14, Wet Ponds)
- Limited ED above Wetlands (covered Stormwater Design Specification No. 13, Constructed Wetlands)

Figure 15.1 above illustrates ED pond design variations. While ED ponds can provide for channel and flood protection, they will rarely provide adequate runoff volume reduction and pollutant removal to serve as a stand-alone water quality compliance strategy. Therefore, designers should always maximize the use of upland runoff reduction practices, (e.g., rooftop disconnections, small-scale infiltration, rainwater harvesting, bioretention, grass channels and dry swales) that reduce runoff at its source (rather than merely treating the runoff at the terminus of the storm drain system). Upland runoff reduction practices can be used to satisfy most or all of the runoff reduction requirements at most sites. However, an ED pond may still be needed to provide any remaining channel protection requirements. Upland runoff reduction practices will greatly reduce the size, footprint and cost of the downstream ED pond.

SECTION 6: DESIGN CRITERIA

6.1. Overall Sizing

The ED Pond is designed to hold the design *Tv* within the water volume below the normal pool elevation of any micropools, forebays and wetland areas (minimum of 15% for ED Level 1, and 40% for Level 2), as well as the temporary extended detention storage volume above the normal pool. To qualify for the higher nutrient reduction rates associated with the Level 2 design, the ED pond must be designed with a *Tv* that is 25% greater than the *Tv* for the Level 1 design [i.e., $1.25(R_v)(A)$], (additional Channel Protection Volume is not required).

Designers should use the BMP design treatment volume, Tv_{BMP} (defined as the treatment volume based on the contributing drainage area, Tv_{DA}, less any volume reduced by upstream runoff reduction practices) to size and design the wet features and extended detention volume. If additional detention storage is proposed for channel protection and/or flood control, designers should use the adjusted curve number reflective of the volume reduction provided by the upstream practices as well as the ED pond (Level 2) to calculate the developed condition energy balance detention requirements. (Refer to Chapter 11 of the Virginia Stormwater Handbook.

6.2. Treatment Volume Drawdown and Detention Design

Methods for calculating the required orifice size for achieving the target drawdown of the *Tv* for the Level 1 (24 hours) and Level 2 (36 hours) design can be found in the Engineering Calculations chapter of the current Virginia Stormwater Management Handbook. Similarly, the hydraulic design of the multi-stage riser to meet the channel protection and flooding protection design goals can also be found in the Virginia Stormwater Management Handbook.

Treatment Volume (water quality) Storage. The total *Tv* storage may be provided by a combination of the permanent pool (in the form of forebays, micropools, and wetland areas) and ED storage in accordance with the Level 1 and Level 2 design volume allocations. Refer to **Section 6.5** for forebays and micropools.

Constructed wetlands added to achieve a Level 2 design should be connected to the forebays or the micropool with a transition zone. Refer to **Design Specification No. 13: Wetlands** for criteria on the appropriate depth, side slopes, and other design features for the wetland pool component.

Vertical Extended Detention Limits. The maximum *Tv* ED water surface elevation may not extend more than 5 feet above the basin floor or normal pool elevation for a Level 1 design, or 4 feet for a Level 2 design. The maximum vertical elevation for ED and channel protection detention over shallow wetlands is 1 foot. The bounce effect is not as critical for larger flood control storms (e.g., the 10-year design storm), and these events can exceed the 5 foot vertical limit if they are managed by a multi-stage outlet structure.

6.3. Internal Design Geometry

Side Slopes. Side slopes leading to the ED pond should generally have a gradient no steeper than 4H:1V; or 3H:1V with safety bench. The mild slopes promote better establishment and growth of vegetation and provide for easier maintenance and a more natural appearance.

Long Flow Path. ED pond designs should have an irregular shape and a long flow path from inlet to outlet to increase water residence time, treatment pathways, and pond performance. 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):

- he overall flow path can be represented as the length-to-width ratio *OR* the flow path ratio (refer to Figure 2 of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site for additional information). These ratios must be at least 2L:1W for Level 1 designs and 3L:1W for Level 2 designs. 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 *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia

Stormwater BMP Clearinghouse web site). The ratio of the shortest flow to the overall length must be at least 0.4 for Level 1 designs and 0.7 for Level 2 designs. 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. Several design features of impounding structures are intended to provide elements of safety:

- **Safety Bench** is a minimum 10 foot wide bench with a minimal cross slope (2%) located immediately above the extended detention design high water; slopes below the safety bench should be no steeper than 3:1.
- **Aquatic Bench** is located on the perimeter of all wet features: forebays, micropools, wetland pools and graded from a depth of 0 to 18 inches (maximum). The width of the aquatic bench should be 4 to 6 feet for forebays and 6 to 10 feet for micropools. The width should increase accordingly for larger variations of these features.
- Safety benches and aquatic benches should be landscaped with vegetation that hinders or prevents access to the pool.
- The principal spillway opening must be designed and constructed to prevent access by small children.
- End walls above pipe outfalls greater than 48 inches in diameter must be fenced to prevent a safety hazard.
- An emergency spillway and associated freeboard must be provided in accordance with applicable local or state dam safety requirements. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.

6.4. Required Geotechnical Testing

Soil explorations should be conducted within the footprint of the proposed embankment, in the vicinity of the proposed outlet, and in at least two locations within the proposed ED pond treatment area. Soil boring data is needed to (1) determine the physical characteristics of the excavated material to determine its adequacy as structural fill or other use, (2) determine the need and appropriate design depth of the embankment cut-off trench, (3) provide data for structural designs of the outlet works (e.g., bearing capacity and buoyancy), (4) determine the depth to groundwater and bedrock and (5) evaluate potential infiltration losses (and the potential need for a liner).

Additional guidance on geotechnical criteria for impoundment facilities can be found in **Appendix A: Earthen Embankments** of the Introduction to the New Virginia Stormwater Design Specifications, as posted on the Virginia Stormwater BMP Clearinghouse web site:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Guidance on soil explorations in general can be found in **Appendix 8-A** of **Stormwater Design Specification No. 8 (Infiltration).**

6.5. Pretreatment Forebay and Micropool

Sediment forebays are considered to be an integral design feature to maintain the longevity of ED ponds. A forebay must be located at each major inlet to trap sediment and preserve the capacity of the main treatment cell.

Refer to **Appendix D: Sediment Forebays** of the Introduction to the New Virginia Stormwater Design Specifications, as posted on the Virginia Stormwater BMP Clearinghouse web site for design forebay design information, at the following web address:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Other forms of pre-treatment for sheet flow and concentrated flow for minor inflow points should be designed consistent with pretreatment criteria found in Design Spec No. 9: Bioretention.

6.6. Conveyance and Overflow

No Pilot Channels. Micropool ED ponds shall 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 promote the maximum infiltration possible.

Internal Slope. The maximum longitudinal slope through the pond should be approximately 0.5% to 1% to promote positive flow through the ED pond.

Principal Spillway. The principal spillway shall be designed with acceptable anti-flotation, anti-vortex, and trash rack devices. The spillway must generally be accessible from dry land. Refer to **Appendix B: Principal Spillways** of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Non-Clogging Low Flow Orifice. ED Ponds with drainage areas of 10 acres or less, where small diameter outlet pipes are typical, are prone to chronic clogging by organic debris and sediment. Orifices less than 3 inches in diameter may require extra attention during design to minimize the potential for clogging. Designers should always look at upstream conditions to assess the potential for higher sediment and woody debris loads. The risk of clogging in outlet pipes with small orifices can be reduced by:

- Providing a micropool at the outlet structure. The depth of the micropool should be at least 4 feet deep, and be equipped with an aquatic bench for safety purposes. The aquatic bench should be 4 to 6 feet wide and range from a depth of 0 to 18 inches below the water surface. The volume of the outlet micropool should be equal to (or larger) than the largest forebay. The depth of the micropool should not draw down by more than 2 feet during a 30 day summer drought (for a water balance calculation method, see **Section 6.2** of Stormwater Design Specification No 13: Constructed Wetlands). The following represent design options intended to improve the performance of the outlet structure:

    - Use a reverse-sloped pipe that extends to a mid-depth of the permanent pool or micropool; or
    - 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.
    -
- Providing an over-sized forebay to trap sediment, trash and debris before it reaches the ED pond's low-flow orifice.
- Installing a trash rack to screen the low-flow orifice.
- When a micropool is not feasible, perforated pipe(s) under a gravel blanket with an orifice control at the end in the riser structure can be used to control the outflow. Designers must verify the capacity of the perforated pipe and the orifice control, as well as the relative maintenance frequency, including visual indicators, for maintaining the design peak flows.

Emergency Spillway. ED ponds must be constructed with overflow capacity to pass the 100-year design storm event through either the Primary Spillway (with two feet of freeboard to the settled top of embankment) or a vegetated or armored Emergency Spillway (with at least one foot of freeboard to the settled top of embankment). **Appendix C: Emergency Spillways** of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Adequate Outfall Protection. The design must specify an outfall that will be stable for the maximum (pipe-full) design discharge (the 10-year design storm event or the maximum flow when surcharged during the emergency spillway design event, whichever is greater). The channel immediately below the pond outfall must be modified to prevent erosion and conform to natural dimensions in the shortest possible distance. Outlet protection should be provided consistent with state or local guidance.

Inlet Protection. Inlet areas should be stabilized to ensure that non-erosive conditions exist during storm events up to the overbank flood event (i.e., the 10-year storm event). Inlet pipe inverts should generally be located at or slightly below the forebay pool elevation.

On-Line ED Ponds must be designed to detain the required *Tv* and either manage or be capable of safely passing larger storm events conveyed to the pond (e.g., 1-year channel protection detention, 10-year flood protection, and/or the 100-year design storm event). Adequate design freeboard between the maximum design water surface elevation and the top of the embankment must be provided in accordance with Design Specification **Appendix A: Earthen Embankments** of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

Dam Safety Permits. ED ponds with high embankments or large drainage areas and impoundments may be regulated under the Virginia Dam Safety Act (§ 10.1-606.1 et seq., Code of Virginia) and the Virginia Dam Safety Regulations (4 VAC 50-20 et seq.). Refer to **Design Specification Appendix A: Earthen Embankments** for additional information.

6.7. Landscaping and Planting Plan

A landscaping plan must be provided that indicates the methods used to establish and maintain vegetative coverage within the ED pond and its buffer. Minimum elements of a plan include the following:

- Delineation of pondscaping zones within both the pond and buffer
- Selection of corresponding plant species
- The planting plan
- The sequence for preparing the wetland bed, if one is incorporated with the ED pond (including soil amendments, if needed)
- Sources of native plant material
- The landscaping plan should provide elements that promote diverse wildlife and waterfowl use within the stormwater wetland and buffers.
- The planting plan should allow the pond to mature into a native forest in the right places, but yet keep mowable turf along the embankment and all access areas. The wooded wetland concept proposed by Cappiella *et al*., (2005) may be a good option for many ED ponds.
- Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment nor within 25 feet from the principal spillway structure.
- A vegetated buffer of native plants that requires minimal maintenance should be provided that extends at least 25 feet outward from the maximum water surface elevation of the ED pond. Permanent structures (e.g., buildings) should not be constructed within the buffer area. Existing trees should be preserved in the buffer area during construction.
- The soils in the stormwater buffer area are often severely compacted during the construction process. The density of these compacted soils can be so great that it effectively prevents root penetration and, therefore, may lead to premature mortality or loss of vigor. As a rule of thumb, planting holes should be three times deeper and wider than the diameter of the rootball for ball-and-burlap stock, and five times deeper and wider for container-grown stock.
- Avoid species that require full shade, or are prone to wind damage. Extra mulching around the base of trees and shrubs is strongly recommended as a means of conserving moisture and suppressing weeds.

For more guidance on planting trees and shrubs in ED pond buffers, consult Cappiella et al (2006) and **Appendix E: Landscaping** of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site:.

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

6.8. Maintenance Features

Good maintenance access is needed so crews can remove sediments from the forebay, alleviate clogging and make riser repairs. The following ED pond maintenance items can be addressed during design, in order to make on-going maintenance easier:

- Adequate maintenance access must extend to the forebay, micropool, any safety benches, riser, and outlet structure and must have sufficient area to allow vehicles to turn around.

- The riser should be located within the embankment for maintenance access, safety and aesthetics. Access to the riser should be provided by lockable manhole covers and manhole steps within easy reach of valves and other controls.
- Access roads must (1) be constructed of materials that can withstand the expected frequency of use, (2) have a minimum width of 12 feet, and (3) have a profile grade that does not exceed 15%. Steeper grades are allowable if appropriate stabilization techniques are used, such as gravel or other material.
- A maintenance right-of- way or easement must extend to the ED pond from a public or private road.
- The designer should check to see whether sediments can be spoiled (deposited) on-site or must be hauled away.

6.9. ED Pond Material Specifications

ED ponds are generally constructed with materials obtained on-site, except for the plant materials, inflow and outflow devices (e.g., piping and riser materials), possibly stone for inlet and outlet stabilization, and filter fabric for lining banks or berms.

The basic material specifications for **Earthen Embankments**, **Principal Spillways**, **Vegetated Emergency Spillways** and **Sediment Forebays** shall be as specified in **Appendices A through D** of the *Introduction to the New Virginia Stormwater Design Specifications*, as posted on the Virginia Stormwater BMP Clearinghouse web site, at the following URL:

http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html

SECTION 7: REGIONAL & SPECIAL CASE DESIGN ADAPTATIONS

7.1. Karst Terrain

Karst regions are found in much of the Ridge and Valley province of the Virginia. The presence of karst complicates both land development in general and stormwater design in particular. Designers should always conduct geotechnical investigations in areas of karst terrain to assess this risk and rule out the presence of karst during the project planning stage. If these studies indicate that less than 3 feet of vertical separation exists between the bottom of the ED pond and the underlying soil-bedrock interface, ED ponds should not be used due to the risk of sinkhole formation and groundwater contamination, (see CSN Technical Bulletin No. 1, 2008, and Appendix 6-C of Chapter 6 of the Virginia Stormwater Management Handbook, 2010). If ED ponds are used, they must have an acceptable liner in accordance with the guidance provided in Section 7.1 of Stormwater Design Specification No. 13 (Constructed Wetlands).

7.2. Coastal Plain

The lack of sufficient hydraulic head and the presence of a high water table of many coastal plain sites significantly constrain the application of ED ponds. Excavating ponds below the water table creates what are known as dugout ponds where the water quality volume is displaced by groundwater, reducing the pond’s mixing and treatment efficiency and creating nuisance conditions. In general, ***shallow constructed wetlands are a superior alternative to ED ponds in coastal plain settings***.

7.3. Steep Terrain

The use of ED ponds is highly constrained at development sites with steep terrain.

7.4. Cold Climate and Winter Performance

Winter conditions can cause freezing problems within inlets, flow splitters, and ED outlet pipes, due to ice formation. The following design adjustments are recommended for ED ponds installed in higher elevations and colder climates:

- Do not submerge inlet pipes.
- Provide a minimum 1% slope for inlet pipes to discourage standing water and potential ice formation in upstream pipes.
- Place all pipes below the frost line to prevent frost heave and pipe freezing.
- Locate low flow orifices in the micropool so they withdraw at least 6 inches below the typical ice layer.
- Place trash racks at a shallow angle to prevent ice formation.
- If winter road sanding is prevalent in the contributing drainage area, increase the forebay size to 25% of the total *Tv* to accommodate additional sediment loadings.

7.5. Linear Highway Sites

ED ponds are poorly suited to treat runoff within open channels located in the highway right of way, unless storage is available in a cloverleaf interchange or in an expanded right-of-way. Guidance for pond construction in these areas is provided in VDOT’s annual stormwater management specifications, as reviewed and approved annually by DCR. Additional guidance can be found in Profile Sheet SR-5 in Schueler et al (2007).

SECTION 8: CONSTRUCTION

8.1. Construction Sequence

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

Step 1: Use of ED pond as an E&S Control. An ED 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

ED pond in mind. The bottom elevation of the ED pond should be lower than the bottom elevation of the temporary sediment basin.

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. Appropriate procedures should be implemented to prevent discharge of turbid waters when the basin is being converted into an ED pond.

Step 2: Stabilize the Drainage Area. Final grading and construction of ED pond components should only be constructed after the contributing drainage area to the pond is stabilized.

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

Step 5: Install E&S 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 4: Clear and Strip the project area to the desired sub-grade.

Step 6: Excavate the Core Trench and 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, or as directed by geotechnical recommendations, and compact as required with appropriate equipment.

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

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

Step 11: Install Outlet Protection, including emergency and primary outlet apron protection.

Step 12: Stabilize Exposed Soils with temporary seed mixtures appropriate for the pond buffer. All areas above the normal pool elevation should be permanently stabilized by hydroseeding or seeding over straw.

Step 13: Plant the Pond Buffer Area, following the pondscaping plan (see **Section 6.7**).

8.2. 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 punch list for facility acceptance)

A construction phase inspection checklist for ED Ponds can be accessed at the end of this specification.

In order to facilitate maintenance, the contractor should measure the actual constructed pond depth at three areas within the micropool or other water feature and mark and geo-reference 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.

Upon final inspection and acceptance, the GPS coordinates for all ED Ponds should be logged for entry into the VSMP Authority's maintenance tracking database.

SECTION 9: MAINTENANCE

9.1. Maintenance Agreements

The Virginia Stormwater Management regulations (4 VAC 50-60) specify the circumstances under which a maintenance agreement must be executed between the owner and the VSMP authority, and sets forth inspection requirements, compliance procedures if maintenance is neglected, notification of the local program upon transfer of ownership, and right-of-entry for local program personnel.

- Restrictive covenants or other mechanism enforceable by the VSMP authority must be in place to help ensure that ED ponds are maintained, as well as to pass the knowledge along to any subsequent property owners.
- Access to ED ponds should be covered by a drainage easement to allow access by the VSMP authority to conduct inspections and perform maintenance when necessary.
- All ED ponds must include a long term maintenance agreements consistent with the provisions of the VSMP regulations, and must include the recommended maintenance tasks and a copy of an annual inspection checklist.
- The maintenance agreement should also include contact information for owners to get local or state assistance to solve common nuisance problems, such as mosquito control, geese, invasive plants, vegetative management and beaver removal.

9.2. Maintenance Inspections

Maintenance of ED ponds is driven by annual inspections that evaluate the condition and performance of the pond, including the following:

- Measure sediment accumulation levels in forebay.

- Monitor the growth of wetlands, trees and shrubs planted. Record the species and their approximate coverage, and note the presence of any invasive plant species.
- Inspect the condition of stormwater inlets to the pond for material damage, erosion or undercutting.
- Inspect the banks of upstream and downstream channels for evidence of sloughing, animal burrows, boggy areas, woody growth, or gully erosion that may undermine embankment integrity.
- Inspect pond outfall channel for erosion, undercutting, rip-rap 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 woody vegetation, and check to see whether valves, manholes and locks can be opened and operated.
- Inspect internal and external side slopes of the pond for evidence of sparse vegetative cover, erosion, or slumping, and make needed repairs immediately.

Based on inspection results, specific maintenance tasks will be triggered. Example maintenance inspection checklists for ED Ponds can be accessed in Appendix C of Chapter 9 of the *Virginia Stormwater Management Handbook* (2010).

9.3. Common Ongoing Maintenance Tasks

ED ponds are prone to clogging at the ED low-flow orifice. This component of the pond's plumbing should be inspected at least twice a year. The constantly changing water levels in ED ponds make it difficult to mow or manage vegetative growth. The bottom of ED ponds often become soggy, and water-loving trees such as willows may take over. The maintenance plan should clearly outline how vegetation in the pond and its buffer will be managed or harvested in the future. Periodic mowing of the stormwater buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing only periodically to sustain healthy growth) or forest.

The maintenance plan should schedule a shoreline cleanup at least once a year to remove trash and floatables that tend to accumulate in the forebay, micropool, and on the bottom of ED ponds.

Frequent sediment removal from the forebay is essential to maintain the function and performance of an ED pond. For planning purposes maintenance plans should anticipate cleanouts every 5 to 7 years, or when inspections indicate that 50% of the forebay capacity has been filled. (Absent an upstream eroding channel or other source of sediment, the frequency of sediment removal should decrease as the drainage area stabilizes.) As noted above, the designer should also check to see whether removed sediments can be spoiled (deposited) on-site or must be hauled away. Sediments excavated from ED ponds are typically not considered toxic or hazardous, and can be safely disposed by either land application or land filling.

SECTION 10: COMMUNITY AND ENVIRONMENTAL CONCERNS

ED Ponds can generate the following community and environmental concerns that need to be addressed during design.

Aesthetics. ED ponds tend to accumulate sediment and trash, which residents are likely to perceive as unsightly and creating nuisance conditions. Fluctuating water levels in ED ponds also create a difficult landscaping environment. In general, designers should avoid designs that rely solely on *dry* ED ponds.

Existing Wetlands. ED ponds should never be constructed within existing *natural* wetlands, nor should they inundate or otherwise change the hydroperiod of existing wetlands.

Existing Forests. Designers can expect a great deal of neighborhood opposition if they do not make a concerted effort to save mature trees during pond design and construction. Designers should also be aware that even modest changes in inundation frequency can kill upstream trees (Wright *et al.,* 2007).

Stream Warming Risk. ED ponds have less risk of stream warming than other pond options, but they can warm streams if they are un-shaded or contain significant surface area in shallow pools. If an ED pond discharges to temperature-sensitive waters, it should be forested, contain the minimum pools to prevent clogging, and have a detention time of no longer than 24 hours. If a level 2 design with 36 hours is necessary, the additional detention time may be allowed if sufficient landscaping with an emphasis on shade is provided.

Safety Risk. ED ponds are generally considered to be safer than other pond options, since they have few deep pools. Maximum side-slopes and unfenced headwalls, however, can still create some safety risks. Gentle side slopes and safety benches graded near the water line of any water feature should be provided to avoid potentially dangerous drop-offs, especially where ED ponds are located near residential areas.

Mosquito Risk. The fluctuating water levels within ED ponds have potential to create conditions that lead to mosquito breeding. Mosquitoes tend to be more prevalent in irregularly flooded ponds than in ponds with a permanent pool (Santana *et al*., 1994). Designers can minimize the risk by combining ED with a wet pond or wetland.

Sample Construction Inspection Checklist for Extended Detention (ED) Ponds: The following checklist provides a basic outline of the anticipated items for the construction inspection of an ED pond. Inspectors should review the plans carefully, and adjust these items and the timing of inspection verification as needed to ensure the intent of the design and the inspection is met. Finally, users of this information may wish to incorporate these items into a VSMP Authority Construction Checklist format consistent with the format used for erosion and sediment control and BMP construction inspections.

Pre-Construction Meeting

☐ Pre-construction meeting with the contractor designated to install the ED pond has been conducted.

☐ Identify the tentative schedule for construction and verify the requirements and schedule for interim inspections and sign-off.

☐ Subsurface investigation and soils report supports the placement of an ED pond in the proposed location.

☐ Impervious cover has been constructed/installed and area is free of construction equipment, vehicles, material storage, etc.

☐ All pervious areas of the contributing drainage areas have been adequately stabilized with a thick layer of vegetation and erosion control measures have been removed.

☐ **Certification of Stabilization Inspection:** Inspector certifies that the drainage areas are adequately stabilized in order to convert the sediment pond or trap (if used for sediment control) into a permanent ED pond.

Construction of ED Pond Embankment and Principal Spillway

☐ Stormwater has been diverted around or through the area of the ED pond embankment to a stabilized conveyance; and perimeter erosion control measures to protect the facility during construction have been installed.

☐ Materials for construction of the embankment and principal spillway are available and meet the specifications of the approved plans.

☐ Construction of key trench, principal spillway, including the riser and barrel, anti-seepage controls, outlet protection, etc., is built in accordance with approved plans.

☐ Geotechnical analysis and approval of the core (if required) and embankment material has been provided, and the material has been placed in lifts and compacted in accordance with the approved plans.

☐ **Certification of Embankment and Principal Spillway Inspection:** Inspector certifies that each element of the embankment and principal spillway has been constructed in accordance with the approved plans.

Excavation of ED Pond

☐ Excavation of the ED pond geometry (including bottom shape and length:width ratio, side slopes, etc.) achieves the elevations in accordance with approved plans.

☐ Excavation of internal micro-topographic features: micro-pool outlet, forebays, etc., is in accordance with approved plans.

☐ Impermeable liner, when required, meets project specifications and is placed in accordance with manufacturers specifications.

☐ **Certification of Excavation Inspection:** Inspector certifies that the excavation has achieved all the appropriate grades, grade transitions, and ED pond geometry as shown on the approved plans.

Landscaping Plan and Stabilization

☐ Exposed soils on pond bottom, side slopes, and buffer areas are stabilized with specified seed mixtures, stabilization matting, mulch, etc., in accordance with approved plans.

☐ Appropriate number and spacing of plants are installed and protected on the aquatic bench and pond buffer in accordance with the approved plans.

☐ All erosion and sediment control practices have been removed.

☐ Follow-up inspection and as-built survey/certification has been scheduled.

☐ GPS coordinates have been documented for the ED pond installation.

SECTION 11: REFERENCES

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