13.0 Wet Ponds

Definition: Wet Ponds are stormwater storage practices that consist of a combination of a permanent pool, micropool, or shallow marsh that promote a good environment for gravitational settling, biological uptake and microbial activity. Wet Ponds are widely applicable for most land uses and are best suited for larger drainage areas. Runoff from each new storm enters the wet pond and partially displaces pool water from previous storms. The pool also acts as a barrier to re-suspension of sediments and other pollutants deposited during prior storms. When sized properly, Wet Ponds have a residence time that ranges from many days to several weeks, which allows numerous pollutant removal mechanisms to operate. Wet Ponds can also provide storage above the permanent pool to help meet stormwater management requirements for larger storms. Design variants include:

- 13-A Wet Pond
- 13-B Wet Extended Detention (ED) Pond

A Wet ED Pond differs from a typical Wet Pond in that a Wet ED Pond provides ~~24~~48-hour detention of all or a portion of the Resource Protection Volume (RPv). Optional internal baffles in the Wet ED Pond extend the flow path through the pond from the inflow point to the outlet. In addition, an undersized outlet structure restricts stormwater flow so it backs up and is stored within the Wet ED Pond. The temporary ponding enhances the ability of 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.

Wet Ponds should be considered for use after all other upland runoff reduction opportunities have been exhausted and there is still a remaining treatment volume or runoff from larger storms (i.e. Cv an Fv) to manage.

Wet Ponds do not receive any stormwater retention credit and should be considered only for pollutant removal efficiency and to manage flood events. Wet Ponds have both community and environmental concerns (see ***Section 13.3 Wet Pond Feasibility Criteria***) that need to be considered before applying them.

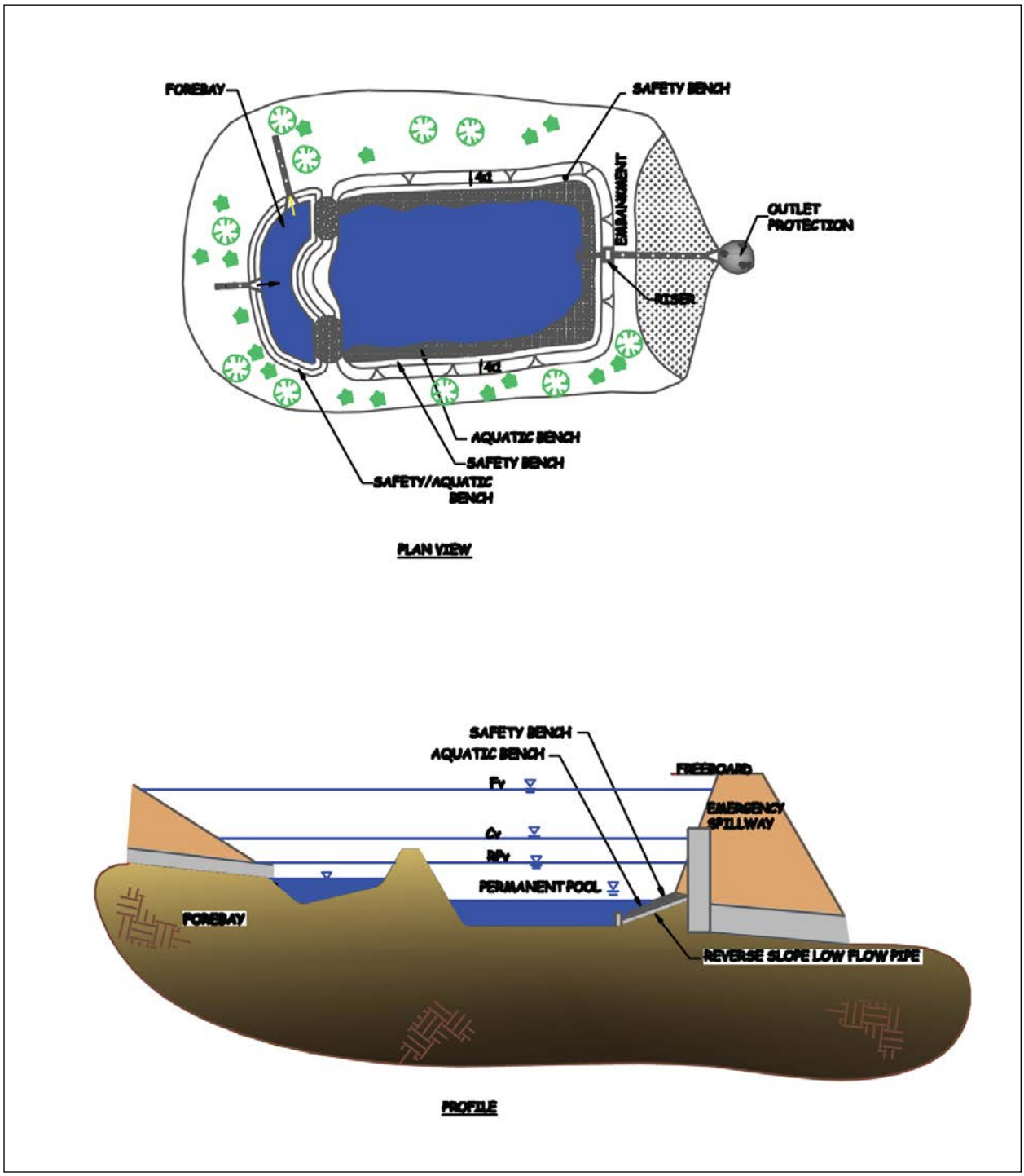

Figure 13.1. Wet Pond (13-A) Design Schematics.

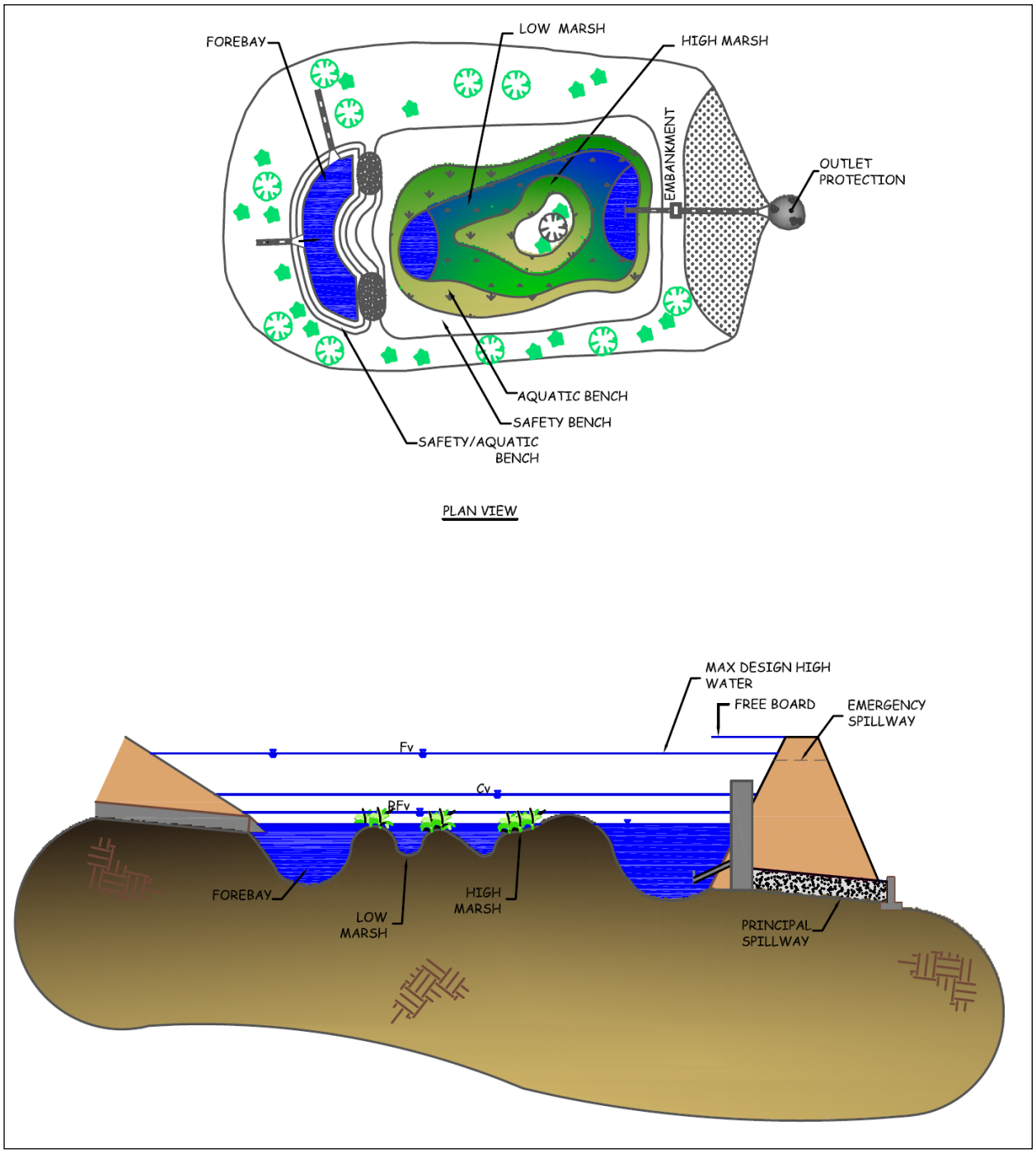

Figure 13.2. Typical Wet Extended Detention Pond (13-B) Details.

13.1 Wet Pond Credit Calculations

Wet Ponds used solely for quantity management receive 0% retention credit (~~R_v~~RPv) and 0% pollutant removals credit as outlined in **Table 13.1a**. ~~As a treatment practice, the Wet Pond must be sized according to the standards outlined in Section 13.6 to receive full pollutant removal credit.~~ Wet ED Ponds that provide 48-hour detention receive full credit for the portion of the RPv managed and pollutant reductions as outlined in **Table 13.1b**.

Table 13.1a Wet Pond ~~and Wet ED Pond~~ Performance Credits

Runoff Reduction	
Retention Allowance	0%
RPv	0%
Cv	0%
Fv	0%
Pollutant Reduction	
TN Reduction	~~20%~~0%
TP Reduction	~~45%~~0%
TSS Reduction	~~60%~~0%

Table 13.1b Wet ED Pond Performance Credits

Runoff Reduction	
RPv - Retention Allowance	7%
RPv – 48-HR Detention Allowance	100%
Cv	1%
Fv	0%
Pollutant Reduction	
TN Reduction	20%
TP Reduction	45%
TSS Reduction	60%

13.2 Wet Pond Design Summary

Wet Ponds constructed to meeting regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Small Pond Code 378 and this document. Table 13.2 summarizes design criteria for Wet Ponds. For more detail, consult Sections 13.3 through 13.7. Sections 13.8 and 13.9 describe practice construction and maintenance criteria.

Table 13.2 Wet Pond Design Summary

Feasibility Criteria (Section 13.3)	• Adequate groundwater, runoff or baseflow to support permanent pool • Recommended minimum Contributory drainage area (CDA) of 10 to 25 acres • Wet Pond surface area size allowance of 1% to 3% of CDA • Contributing slopes <15% • Wet Pond discharge point allows for gravity discharge • Setbacks in accordance with local codes • No utility may cross the embankment • Seasonal high water table < design permanent pool elevation • HSG C and D soils; HSG A and some HSG B soils may require a liner • Not located within jurisdictional waters, including wetlands or on perennial streams • Consider community and environmental concerns such as aesthetics, forests, safety, pollutants, mosquitoes and waterfowl
Conveyance Criteria (Section 13.4)	• Principal spillway must be accessible by dry land • Principal spillway must include trash racks and watertight joints • Small low flow orifices must be protected from clogging • Outfall channel designed to be stable for the Cv • Emergency spillway designed to safely convey the Fv • Emergency spillway must be in cut material or reinforced • Inflow points and forebays stable for the Cv • Secure necessary dam safety permits
Pretreatment Criteria (Section 13.5)	• Forebays at major inlets – those conveying >10% of runoff volume • Forebays sized for 10% of RPv • Non-erosive discharge from forebay to pond pool • Direct access provided to facilitate forebay maintenance
Design Criteria *Storage* (Section 13.6)	• Store RPv (2.7") within the permanent pool and extended detention • Storage >5' above permanent pool requires design enhancements • Water balance calculation if necessary • Detention time based on time of initial inflow to time of final outflow • Peak discharge < 5x average discharge
Design Criteria *Geometry* (Section 13.6)	• Minimum length to width ratio = 1.5:1 • ~~Maximum depth of permanent pool = 4.0 feet~~Minimum depth = 3'-4'; maximum depth = 6'-8' • Side slopes no steeper than 3H:1V • Ten foot wide safey bench constructed 1' above permanent pool • Ten foot wide aquatic bench constructed 1' below permanent pool
Design Criteria *Appurtenances* (Section 13.6)	• Soil borings / geotechnical tests will confirm need for a liner • Low Flow ED orifice protected from clogging • Riser structure must be accessible for maintenance • Trash racks provided on enclosed structure openings • Outlet pipe and pond drain equipped with adjustable gate valve

Table 13.2 Wet Pond Design Summary

	• Materials meet Small Pond Code 378 specifications
Design Criteria *Safety* (Section 13.6)	• Restrict entry to principal spillway • One foot of freeboard above the Fv elevation (2' if no emergency spillway) • Emergency spillway located to not impact downstream structures • Safety and aquatic benches landscaped to prevent access
Design Criteria *Maintenance* (Section 13.6)	• Provide access to forebays, safety bench, riser and outlet structure • Access roads built to withstand the expected frequency of use • Minimum width of access roads = 15', profile grade < 5:1 • Maintenance set aside area provided
Landscaping Criteria (Section 13.7)	• No woody vegetation within 15' of the embankment or 25' of principal spillway or inflow pipes • Detailed landscaping plan required

13.3 Wet Pond Feasibility Criteria

The following feasibility issues need to be considered when Wet Ponds are considered a final storm water management practice of the treatment train.

Adequate Water Balance. Wet Ponds must have enough water supplied from groundwater, runoff or baseflow so that the wet pools will not draw down by more than 2 feet after a 30-day summer drought. A simple water balance calculation ~~must be performed~~ using the **Equations 13.1** and **13.2** provided in **Water Balance Testing** can help determine the feasibility of the site to support a wet pond.

Contributing Drainage Area. A contributing drainage area of 10 to 25 acres is typically recommended for Wet Ponds to maintain constant water elevations. Wet Ponds can still function with drainage areas less than 10 acres, but designers should be aware that these "pocket" ponds will be prone to clogging, experience fluctuating water levels, and generate more nuisance conditions. When the contributing drainage area of the Wet Pond is less than 10 acres, alternative outlet configurations should be used to eliminate the possibility of clogging of the outlet.

Space Requirements. The surface area of a Wet Pond will normally be at least 1% to 3% of its contributing drainage area, depending on the pond's depth.

Site Topography. Wet Ponds are best applied when the grade of contributing slopes is less than 15%.

Available Hydraulic Head. The ultimate discharge point from the Wet Pond should be used to determine the minimum elevation of the permanent pool. The permanent pool elevation must be higher than the outlet elevation in order to have a gravity discharge. In situations where there is little relief on the parcel and the head differential between the permanent pool elevation and the discharge elevation is small, an option for the Wet Pond outlet is a weir and outlet channel configuration.

Minimum Setbacks. Local ordinances and design criteria should be consulted to determine minimum setbacks to property lines, structures, and wells. When not specified in local code, Wet Ponds should be set back at least 20 feet from property lines, 25 feet from building foundations, and 100 feet from septic system fields and 150 feet from public or private water supply wells.

Proximity to Utilities. For an open Wet Pond system, no utility lines shall be permitted to cross any part of the embankment of a wet pool.

Depth-to-Water Table. The depth to the seasonal high water table is an important consideration in planning of a Wet Pond. When the seasonal high water table elevation exceeds the proposed permanent pool elevation of the Wet Pond, the capacity planned for management of the Cv and Fv in the Wet Pond may be taken up by groundwater. Further, if the water table is close to the surface, it may make excavation difficult and expensive.

Soils. Highly permeable soils will make it difficult to maintain a healthy permanent pool. Underlying soils of Hydrologic Soil Group (HSG) C or D should be adequate to maintain a permanent pool. Most HSG A and B soils will not support a permanent pool without the use of a liner (See **Table 13.3** below). Geotechnical investigations must be conducted to determine the suitability of the soils to support a permanent pool. When soil borings confirm HSG A/B soils, an infiltration test should be conducted. If the infiltration test results in an infiltration rate greater than 1.0 inch/hour at the proposed Wet Pond invert, and the seasonal high groundwater table is two feet or more below the proposed Wet Pond invert, a stormwater management BMP other than a Wet Pond or Wet ED Pond should be designed.

Use of or Discharges to Natural Wetlands. Wet Ponds may not be located within jurisdictional waters, including wetlands, without obtaining a section 404 permit from the appropriate state or federal regulatory agency. In addition, the designer should investigate the wetland status of adjacent areas to determine if the discharge from the Wet Pond will change the hydroperiod of a downstream natural wetland (see Cappiella et al., 2006, for guidance on minimizing stormwater discharges to existing wetlands).

Perennial Streams. Locating Wet Ponds within perennial streams will require both a Section 401 and Section 404 permit from the appropriate state or federal regulatory agency.

Community and Environmental Concerns. Wet Ponds can generate the following community and environmental concerns that need to be addressed during design:

- **Aesthetic Issues.** Many residents feel that Wet Ponds are an attractive landscape feature, promote a greater sense of community and are an attractive habitat for fish and wildlife. Designers should note that these benefits are often diminished where Wet Ponds are under-sized or have small contributing drainage areas.
- **Existing Forests.** Construction of a Wet Pond may involve extensive clearing of existing forest cover. Designers can expect a great deal of neighborhood opposition if they do not make a concerted effort to save mature trees during Wet Pond design and construction.

- **Safety Risk.** Wet Pond safety is an important community concern, since both young children and adults have perished by drowning in Wet Ponds through a variety of accidents, including falling through thin ice cover. Gentle side slopes and safety benches should be provided to avoid potentially dangerous drop-offs, especially where Wet Ponds are located near residential areas.
- **Pollutant Concerns.** Wet Ponds collect and store water and sediment to increase residence time that will increase the likelihood for contaminated water and sediments to be neutralized. However, poorly sized, maintained, and/or functioning Wet Ponds can export contaminated sediments and/or water to receiving waterbodies (Mallin, 2000; Mallin et al., 2001; Messersmith, 2007). Further, designers are cautioned that recent research on Wet Ponds has shown that some Wet Ponds can be hotspots or incubators for algae that generate harmful algal blooms (HABs).
- **Mosquito Risk.** Mosquitoes are not a major problem for larger Wet Ponds (Santana et al., 1994; Ladd and Frankenburg, 2003, Hunt et al, 2005). However, fluctuating water levels in smaller or under-sized Wet Ponds could pose some risk for mosquito breeding. Mosquito problems can be minimized through simple design features and maintenance operations described in MSSC (2005).
- **Geese and Waterfowl.** Wet Ponds with extensive turf and shallow shorelines can attract nuisance populations of resident geese and other waterfowl, whose droppings add to the nutrient and bacteria loads, thus reducing the removal efficiency for those pollutants. Several design and landscaping features can make Wet Ponds much less attractive to geese, such as allowing the perimeter of the Wet Pond to grow up in tall grass and planting shrubs and grasses around the pond (see Schueler, 1992).

13.4 Wet Pond Conveyance Criteria

Wet Ponds, including their conveyance systems, constructed to meet regulatory stormwater management requirements in the State of Delaware shall be designed and constructed in accordance with the USDA NRCS Small Pond Code 378 and this document.

Internal Slope. The longitudinal slope of the Wet Pond bottom should be at least 0.5% to facilitate maintenance.

Principal Spillway. The principal spillway may be composed of a structure-pipe configuration or a weir-channel configuration. The principal spillway must be accessible from dry land. A structure-pipe spillway shall be designed with anti-flotation, anti-vortex and trash rack devices on the structure. The outfall pipe and all connections to the outfall structure shall be made watertight. When reinforced concrete pipe is used for the principal spillway pipe to increase its longevity, "O-ring" gaskets (ASTM C361) shall be used to create watertight joints. Anti-seep collars will decrease movement of water along the outside of the outfall pipe. When the principal spillway is composed of a weir wall discharging to a channel, the channel below the weir must be reinforced (with riprap, for example) to prevent scour of the channel.

Non-Clogging Low Flow Orifice. A low flow orifice must be provided that is adequately protected from clogging by either an acceptable external trash rack or by internal orifice protection that may allow for smaller diameters. Orifices less than 3 inches in diameter may require extra attention during design, to minimize the potential for clogging.

Adequate Outfall Protection. The design must specify an outfall that will be stable for the conveyance storm (Cv). The channel immediately below the Wet Pond outfall must be modified to prevent erosion and conform to natural dimensions in the shortest possible distance. This is accomplished by placing appropriately sized riprap over stabilization geotextile in accordance with HEC-14 Hydraulic Design of Energy Dissipators for Culverts and Channels and Delaware Erosion and Sediment Control Handbook Specification 3.3.10 Riprap Outlet Protection or 3.3.11 Riprap Stilling Basin, which can reduce flow velocities from the principal spillway to non-erosive levels (3.5 to 5.0 fps) based upon the channel lining material. Flared pipe sections, which discharge at or near the stream invert or into a step pool arrangement, should be used at the spillway outlet.

When the discharge is to a manmade pipe or channel system, the system must be adequate to convey the required design storm peak discharge. 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 rip-rap should be avoided. The final release rate of the facility shall be modified if any increase in flooding or stream channel erosion would result at a downstream structure, highway, or natural point of restricted streamflow.

Emergency Spillway. Wet Ponds must be constructed with overflow capacity to pass the maximum design storm event (Fv) if the Fv is being routed through the Wet Pond rather than bypassing. An emergency spillway designed to convey the Fv should be cut in natural ground or, if cut in fill, must be lined with stabilization geotextile and riprap. When the maximum design storm will be passing through the principal spillway, the principal spillway outlet pipe must have a minimum cross sectional area of 3 square feet.

Inflow Points Stabilization. Inflow points into the Wet Pond must be stabilized to ensure that non-erosive conditions exist during storm events up to the conveyance storm (i.e., the 10-year storm event). Inlet pipe inverts should generally be located at or slightly below the permanent pool elevation. A forebay (See **13.5 Wet Pond Pretreatment Criteria**) shall be provided at each inflow location, unless the inlet is submerged or inflow provides less than 10% of the total design storm inflow to the Wet Pond.

Dam Safety Permits. The designer should determine whether or not the embankment meets the criteria to be regulated as a dam by the Delaware Dam Safety Regulations. In the event that the embankment is a regulated dam, the designer should verify that the appropriate Dam Safety Permit has been approved by the Department's Dam Safety Program.

13.5 Wet Pond Pretreatment Criteria

Sediment forebays are considered to be an integral design feature to maintain the longevity of all Wet Ponds. A forebay must be located at each major inlet to trap sediment and preserve the capacity of the main treatment cell. The following criteria apply to forebay design:

- A major inlet is defined as an individual storm drain inlet pipe or open channel conveying at least 10% of the Wet Pond's contributing runoff volume
- The preferred forebay configuration consists of a separate cell, formed by an acceptable barrier such as a concrete weir, riprap berm, gabion baskets, etc. Riprap berms are the preferred barrier material.
- The forebay should be 3 to 4 feet deep. A safety bench is required at the pond shoreline for forebay depths greater than 3 feet. The safety bench need not continue around the entire forebay.
- The forebay must be sized to contain ten percent of the volume of runoff from the contributing drainage impervious area from the Resource Protection event. The relative size of individual forebays will be proportional to the percentage of the total inflow to the Wet Pond. The storage volume within the forebay may be included in the calculated required storage volume for the Wet Pond.
- The minimum length of the forebay is 10 feet. The forebay should have a length to width ratio of 2:1 or greater. Length is measured with the direction of flow into the Wet Pond.
- The forebay should be equipped with a metered rod in the center of the pool (as measured lengthwise along the low flow water travel path) for long-term monitoring of sediment accumulation. Metered wooden stakes will need to be replaced frequently in Wet Pond forebays; alternative materials should be considered for longevity.
- Vegetation should be included within forebays to increase sedimentation and reduce resuspension and erosion of previously trapped sediment.
- Exit velocities from the forebay shall be non-erosive or an armored overflow shall be provided. Direct maintenance access for appropriate equipment shall be provided to the each forebay.

13.6 Wet Pond Design Criteria

Wet Pond Sizing: In order to receive the credits outlined in Section 13.1, the permanent pool must be sized to store a volume equivalent to the Resource Protection storm (i.e., the runoff volume from the 1-year 2.7" Type II storm event). Further, Wet Ponds must provide ~~24~~ 48 hours extended detention of any remaining treatment volume up to the full water quality volume. Detention time shall be based on the time of initial inflow to time of final outflow from the facility. In order to simulate a baseflow condition to the extent practicable, the peak discharge for the outflow hydrograph shall not exceed 5X the average discharge rate.

Wet ED Ponds can be designed to capture and treat the remaining stormwater discharged from upstream practices to improve water quality. Additionally, Wet Ponds and Wet ED Ponds should be sized to control peak flow rates from the Conveyance Event and Flooding Event as required in accordance with the Delaware Sediment and Stormwater Regulations and accompanying Technical Document.

For treatment train designs where upland practices are utilized for treatment of the resource protection storm (RPv), designers can use a site-adjusted R_v or CN that reflects the volume reduction of upland practices to compute the Cv and Fv that must be treated by the Wet Pond.

Water Balance Testing: A water balance calculation ~~is~~ may be required to document that sufficient inflows to Wet Ponds and Wet ED Ponds exist to compensate for combined infiltration and evapo-transpiration losses during a 30-day summer drought without creating unacceptable drawdowns (see **Equation 13.1,** adapted from Hunt et al., 2007). The recommended minimum pool depth to avoid nuisance conditions may vary; however, it is generally recommended that the water balance maintain a minimum 24-inch reservoir.

Equation 13.1. Water Balance Equation for Acceptable Water Depth in a Wet Pond

$$DP > ET + INF + RES - MB$$

Where:

DP	=	Average design depth of the permanent pool (inches)
ET	=	Summer evapo-transpiration rate (inches) (assume 8 inches)
INF	=	Monthly infiltration loss (assume 7.2 @ 0.01 inch/hour)
RES	=	Reservoir of water for a factor of safety (assume 24 inches)
MB	=	Measured baseflow rate to the Wet Pond, if any (convert to inches)

Design factors that will alter this equation are the measurements of seasonal base flow and infiltration rate. The use of a liner could eliminate or greatly reduce the influence of infiltration. Similarly, land use changes in the upstream watershed could alter the base flow conditions over time (e.g., urbanization and increased impervious cover).

Translating the baseflow to inches refers to the depth within the Wet Pond. Therefore, **Equation 13.2** can be used to convert the baseflow, measured in cubic feet per second (ft^3/s), to pond-inches:

Equation 13.2. Baseflow Conversion Equation

$$\text{Pond inches} = (\text{MB in } ft^3/s) * (2.592E6) * (12"/ft) / \text{SA of Pond } (ft^2)$$

Where:

2.592E6	=	Conversion factor: ft^3/s to ft^3/month.
SA	=	surface area of Wet Pond in ft^2

Wet Pond Storage Design: The Wet Pond permanent pool, plus extended detention must store the Resource Protection volume (i.e., the runoff volume from the 1-year, 2.7" rainfall Type II storm event. Volume storage may be provided in multiple cells. Performance is enhanced when multiple treatment pathways are provided by using multiple cells, longer flow paths, high surface area to volume ratios, complex microtopography, and/or redundant treatment methods (combinations of pool, extended detention [ED], and marsh).

Maximum Extended Detention Levels: The maximum extended detention volume associated with

the Resource Protection volume should occur within the storage for the Conveyance storm (Cv). The total storage, including any ponding for larger flooding events (100-year storm) should not extend more than 5 feet above the permanent pool unless specific design enhancements to ensure side slope stability, safety, and maintenance are identified and approved.

Wet Pond Geometry: Wet Pond designs should have an irregular shape and a long flow path from inlet to outlet, to increase water residence time and Wet Pond performance. Greater flow paths and irregular shapes are recommended. The total length of the flow path compared to the linear length through the Wet Pond from inlet to outlet, must be a minimum ratio of 2:1. Internal berms, baffles, or vegetated peninsulas can be used to extend flow paths and/or create multiple pond cells.

In addition, the ratio of the shortest flow path through the system (due to an inlet located near the outlet) to the overall length must be at least 0.5:1. The drainage area served by any inlets located less than a 0.5:1 ratio shall constitute no more than 20% of the total contributing drainage area.

Permanent Pool Depth: The minimum recommended depth to prevent the normal pool area from being overtaken by undesirable vegetation is 3' to 4'. The maximum depth of the permanent pool should not exceed ~~four feet~~6' to 8' for safety reasons.

Side Slopes: Side slopes for Wet Ponds must be no steeper than 3H:1V. Mild slopes promote better establishment and growth of vegetation and provide for easier maintenance and a more natural appearance.

Wet Pond Benches:

- ***Safety Bench.*** When Wet Pond side slopes above permanent pool are steeper than 4H:1V, a 10 foot wide safety bench shall be constructed one foot above the permanent pool. The safety bench allows for maintenance access and reduces safety risks. The maximum slope of the safety bench is 5%.
- ***Aquatic Bench.*** An aquatic bench is a shallow area below the permanent pool that promotes growth of aquatic and wetland plants. The bench also serves as a safety feature, reduces shoreline erosion, and conceals floatable trash. Incorporate a 10 foot wide aquatic bench one foot below permanent pool.

Liners: Highly permeable soils will make it difficult to maintain a healthy permanent pool. When a geotechnical investigation recommends a liner, acceptable options include the following: (1) a clay liner following the specifications outlined in **Table 13.3** below; (2) a 30 mil poly-liner; (3) bentonite; (4) use of chemical additives; or (5) other acceptable measures as recommended by a qualified geotechnical professional. A clay liner should have a minimum thickness of 12 inches with an additional 12 inch layer of compacted soil above it, and it must meet the specifications outlined in **Table 13.3**. Other synthetic liners can be used if the designer can supply supporting documentation that the material will achieve the required performance.

Table 13.3. Clay Liner Specifications

Property	Test Method	Unit	Specification
Permeability	ASTM D-2434	Cm/sec	1×10^{-6}
Plasticity Index of Clay	ASTM D-423/424	%	Not less than 15
Liquid Limit of Clay	ASTM D-2216	%	Not less than 30
Clay Particles Passing	ASTM D-422	%	Not less than 30
Clay Compaction	ASTM D-2216	%	95% of standard proctor density
Source: VA DCR (1999).			

Required Geotechnical Testing: Soil borings should be taken below the proposed embankment, if applicable, in the vicinity of the proposed outlet area, and in at least two locations within the proposed Wet Pond bottom. Soil boring data is needed to (1) determine the physical characteristics of the excavated material, (2) determine its adequacy for use as structural fill or spoil, (3) provide data for structural designs of the outlet works (e.g., bearing capacity and buoyancy), (4) determine compaction/composition needs for the embankment (5) determine the depth to groundwater and bedrock and (6) evaluate potential infiltration losses (and the potential need for a liner).

Non-clogging Low Flow (Extended Detention) Orifice: The low flow ED orifice shall be adequately protected from clogging by an acceptable external trash rack. The preferred method is a hood apparatus over the orifice that reduces gross pollutants such as floatables and trash, as well as oil and grease and sediment.

Orifices less than 3 inches in diameter may require extra attention during design, to minimize the potential for clogging. As an alternative, internal orifice protection may be used (i.e., an orifice internal to a perforated vertical stand pipe with 0.5-inch ~~orifices~~ perforations or slots that are protected by wirecloth and a stone filtering jacket). Floating skimmers, seepage berms, French drains or other similar measures may be a better alternative to provide the 48-hour detention required for Wet ED Ponds if the orifice diameter is too small.

Riser: The riser must be located such that it is accessible from the pond side slope or safety bench for the purposes of inspection and maintenance. The riser may be located within the embankment for maintenance access, safety, and aesthetics. Access to the riser is to be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

Trash Racks: Trash racks shall be provided for low-flow pipes and for all riser structure openings. Open weirs without an upper enclosure will not require trash racks. Synthetic trash rack materials options are available and should be considered. All metal trash racks shall be coated with a rust inhibitor to increase longevity of the device.

Pond Drain: Wet Ponds should have a drain pipe that can completely or partially drain the permanent pool. In cases where a low level drain is not feasible (such as in an excavated Wet Pond), the Operation and Maintenance Plan should include requirements for dewatering the Wet Pond.

- The drain pipe should have an upturned elbow or protected intake within the Wet Pond to help keep it clear of sediment deposition, and a diameter capable of draining the Wet Pond within 24 hours.
- The Wet Pond drain must be equipped with an adjustable valve located within the riser, where it will not be normally inundated and can be operated in a safe manner.

Care should be exercised during Wet Pond drawdowns to prevent downstream discharge of sediments or anoxic water and rapid drawdown. The Department or the Delegated Agency shall be notified before a Wet Pond is drained.

Adjustable Gate Valve: If desired to adjust the pond permanent pool elevation, both the outlet pipe and the Wet Pond drain should be equipped with an adjustable gate valve (typically a hand wheel activated knife gate valve) or pump well and be sized one pipe size greater than the calculated design diameter. Valves should be located inside of the riser at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner. To prevent vandalism, the hand wheel should be chained to a ringbolt, manhole step or other fixed object.

Material Specifications: All materials used in construction of a Wet Pond or Wet ED Pond shall meet the material specifications in USDA NRCS Small Pond Code 378.

Safety Features:

- The principal spillway opening must be designed and constructed to prevent entry by small children.
- Wet Ponds must incorporate an additional 1 foot of freeboard above the emergency spillway, or 2 feet of freeboard if design has no emergency spillway, for the maximum design storm (e.g., Fv) unless more stringent Dam Safety requirements apply.
- The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges. The emergency spillway exit channel must be designed to direct runoff to a point of discharge without impact to downstream structures.
- Fencing of the perimeter of Wet Ponds is discouraged. The preferred method to reduce risk is to manage the contours of the Wet Pond to eliminate drop-offs or other safety hazards.
- Wet Pond side slopes above permanent pool shall be no steeper than 3H:1V. When Wet Pond side slopes above permanent pool are steeper than 4H:1V a 10-foot wide safety bench must be provided.
- The steepness of Wet Pond side slopes below permanent pool will be determined by soil type and influence of groundwater. The 10-foot wide aquatic bench located one foot below permanent pool is a requirement for all Wet Ponds and may not be waived.
- Both the safety bench and the aquatic bench must be landscaped to prevent personnel access to the pool. Perimeter landscaping shall be designed so as to not hinder maintenance access by equipment.
- Warning signs may be posted.

Maintenance Reduction Features: The following Wet Pond maintenance issues can be addressed during the design, in order to make on-going maintenance easier:

- **Maintenance Access.** All Wet Ponds must be designed so as to be accessible to annual maintenance. Good access is needed so crews can remove sediments, make repairs and preserve Wet Pond treatment capacity.
  - Adequate maintenance access must extend to the forebay, safety bench, riser, and outlet structure and must have sufficient area to allow vehicles to turn around.
  - The riser may 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 load-bearing materials or be built to withstand the expected frequency of use, (2) have a minimum width of 15 feet, and (3) have a profile grade that does not exceed 5:1.
  - A maintenance right-of-way or easement must extend to the Wet Pond from a public or private road.
- Maintenance Set-Aside Area: Adequate land area adjacent to the Wet Pond should be provided for in the Operation and Maintenance Plan as a location for disposal of sediment removed from the Wet Pond when maintenance is performed. The maintenance set-aside area is necessary on all sites adjacent to the Wet Pond to adequately dewater sediment removed from the pond prior to spreading and seeding or transporting from the site.
  - The maintenance set-aside area shall accommodate the volume of 0.1 inches of runoff from the Wet Pond's contributory drainage area.
  - The maximum depth of the set aside volume shall be one foot.
  - The slope of the set aside area shall not exceed 5%; and
  - The area and slope of the set aside area may be modified if an alternative area or method of disposal is approved by the Department or Delegated Agency.

13.7 Wet Pond Landscaping Criteria

Vegetated Perimeter: A vegetated area should be provided around the perimeter of the Wet Pond that extends at least 25 feet outward from the maximum water surface elevation of the Wet Pond. This vegetated perimeter provides enhanced water quality management of runoff through filtering, provides adequate setback from structures to allow for Wet Pond maintenance, and when the Wet Pond perimeter is allowed to grow up into meadow, this area aids in deterring waterfowl from inhabiting the Wet Pond. Permanent structures (e.g., buildings) should not be constructed within the vegetated perimeter area. Where it is possible to do so, existing trees should be preserved in the vegetated perimeter area during construction. The full width of the vegetated perimeter should be located in common open space, not within recorded lots.

The soils in the Wet Pond vegetated perimeter area are often severely compacted during the construction process, to ensure stability. 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

root ball for ball-and-burlap stock, and five times deeper and wider for container-grown stock. Organic matter such as locally generated compost may be used to amend compacted soil to improve soil structure, help establish vegetation, and reduce runoff.

For more guidance on planting trees and shrubs in Wet Pond vegetated perimeter areas, consult Cappiella et al (2006).

Woody Vegetation: Woody vegetation may not be planted or allowed to grow within 15 feet of the toe of the embankment. Woody vegetation may not be planted or allowed to grow within 25 feet of the principal spillway structure or any inflow pipes.

Landscaping and Planting Plan: A landscaping plan must be provided that indicates the methods used to establish and maintain vegetative coverage in the Wet Pond and its vegetated perimeter. The landscaping plan should provide elements that promote diverse wildlife and waterfowl use within the Wet Pond, wetland and vegetated perimeter areas. 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.

Minimum elements of a landscaping plan include the following:

- Delineation of pondscaping zones within both the Wet Pond and vegetated perimeter area
- Selection of corresponding plant species
- The planting plan
- The sequence for preparing the aquatic bench (including soil amendments, if needed)
- Sources of native plant material

13.8. Wet Pond Construction

Use of Wet Ponds for Erosion and Sediment Control. A Wet Pond may serve as a sediment basin during project construction. If this is done, the volume of the sediment basin must be based on the more stringent sizing rule (erosion and sediment control requirement vs. storage volume requirement). Installation of the permanent principal spillway 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 Wet Pond in mind. The bottom elevation of the temporary sediment basin should be set elevation minimum of six inches higher than the design bottom elevation of the final Wet Pond to allow for maintenance cleanout of accumulated sediment during pond conversion. Appropriate procedures must be implemented to prevent discharge of turbid waters when the sediment basin is being converted into a Wet Pond.

Approval from the Department or the appropriate Delegated Agency must be obtained before any planned Wet Pond or Wet ED Pond can be used as a sediment basin. The Sediment and Stormwater Plan must include conversion steps from sediment basin to permanent Wet Pond in the construction sequence. The Department or Delegated Agency must be notified and provide approval prior to

conversion from sediment basin to the final configuration of the Wet Pond or Wet ED Pond.

Construction Review. Multiple construction reviews are critical to ensure that Wet Ponds are properly constructed. Construction reviews are required during the following stages of construction, and noted on the plan in the sequence of construction:

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

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

Step 1: Stabilize the Drainage Area. Wet Ponds should only be constructed after the contributing drainage area to the Wet Pond is completely stabilized. If the proposed Wet 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 de-watered, dredged and re-graded to design dimensions after the original site construction is complete.

Step 2: Assemble Construction Materials on-site, make sure they meet design specifications, and prepare any staging areas. Ensure that appropriate compaction and dewatering equipment is available. Locate the project benchmark and if necessary transfer a benchmark nearer to the Wet Pond location for use during construction.

Step 3: Install Erosion and Sediment Controls prior to construction, including temporary de-watering devices and stormwater diversion practices. All areas surrounding the Wet 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 embankment area to the desired sub-grade.

Step 5: Excavate the Core Trench and Install the Principal Spillway Pipe in accordance with construction specification of NRCS Small Pond Code 378**.**

Step 6: Install the Riser or Outflow Structure, and ensure the top invert of the overflow weir is constructed level at the design elevation.

Step 7: Construct the Embankment and Any Internal Berms using acceptable material in 8- to 12-inch lifts, compact the lifts with appropriate equipment. Construct the embankment allowing for 10% settlement of the embankment.

Step 8: Excavate/Grade until the appropriate elevation and desired contours are achieved for the bottom and side slopes of the Wet Pond. Construct forebays at the proposed inflow points.

Step 9: Construct the Emergency Spillway in cut or structurally stabilized soils.

Step 10: Install Outlet Pipes, including any flared end sections, headwalls, and downstream rip-rap outlet protection underlain by stabilization geotextile.

Step 11: Stabilize Exposed Soils with the approved seed mixtures appropriate for the Wet Pond perimeter area. All areas above the normal pool elevation must be permanently stabilized in accordance with the vegetative stabilization specifications on the approved Sediment and Stormwater Management Plan.

Step 12: Plant the Wet Pond Benches and Vegetated Perimeter Area, following the pondscaping plan (see ***Section 13.7 Wet Pond Landscaping Criteria***).

Post Construction Verification. Following construction, the constructed Wet Pond depth at three areas within the permanent pool (forebay, mid-pond, and prior to the principal spillway) must be measured, marked, and geo-referenced on the post construction verification survey document. This simple data set will enable maintenance reviewers to determine sediment deposition rates in order to schedule sediment cleanouts.

13.9 Wet Pond Maintenance Criteria

Maintenance is needed so Wet Ponds continue to operate as designed on a long-term basis. Wet Ponds normally have fewer routine maintenance requirements than other stormwater control measures. Wet Pond maintenance activities vary regarding the level of effort and expertise required to perform them. Routine Wet Pond maintenance, such as mowing and removing debris and trash, is needed several times each year (See **Table 13.4**). More significant maintenance (e.g., removing accumulated sediment) is needed less frequently but requires more skilled labor and special equipment. Inspection and repair of critical structural features (e.g., embankments and risers) needs to be performed by a qualified professional who has experience in the construction, inspection, and repair of these features.

Sediment removal in the Wet Pond pretreatment forebay must occur when 50% of total forebay capacity has been lost. The owner can plan for this maintenance activity to occur every 5 to 7 years.

Sediment removed from the Wet Pond should be deposited in the designated maintenance set aside area for dewatering, prior to leveling and stabilization or removal from the site. Sediments

excavated from Wet Ponds are not usually considered toxic or hazardous. They can be safely disposed of by either land application or land filling. Sediment testing may be needed prior to sediment disposal if the wet pond serves a hotspot land use.

Community awareness can contribute to a properly maintained Wet Pond. Signs describing the function and/or minimum maintenance requirements for the Wet Pond may be posted at the Wet Pond location to increase community awareness.

Table 13.4. Typical Wet Pond Maintenance Items and Frequency

Frequency	Maintenance Items
During establishment, as needed (first year)	• Inspect the site after storm event that exceeds 0.5 inches of rainfall. • Stabilize any bare or eroding areas in the contributing drainage area including the Wet Pond perimeter area • Water trees and shrubs planted in the Wet Pond vegetated perimeter area during the first growing season. In general, water every 3 days for first month, and then weekly during the remainder of the first growing season (April - October), depending on rainfall.
Quarterly or after major storms (>1 inch of rainfall)	• Remove debris and blockages • Repair undercut, eroded, and bare soil areas
Twice a year	• Mowing of the Wet Pond vegetated perimeter area and embankment
Annually	• Shoreline cleanup to remove trash, debris and floatables • A full maintenance review • Open up the riser to access and test the valves • Repair broken mechanical components, if needed
One time –during the second year following construction	• Wet Pond vegetated perimeter and aquatic bench reinforcement plantings
Every 5 to 7 years	• Forebay sediment removal
From 5 to 25 years	• Repair pipes, the riser and spillway, as needed • Remove sediment from Wet Pond area outside of forebays

An Operation and Maintenance Plan for the project will be approved by the Department or the Delegated Agency prior to project closeout. The Operation and Maintenance Plan will specify the property owner's primary maintenance responsibilities and authorize the Department or Delegated Agency staff to access the property for maintenance review or corrective action in the event that proper maintenance is not performed. Wet Ponds that are, or will be, owned and maintained by a joint ownership such as a homeowner's association must be located in common areas, community open space, community-owned property, jointly owned property, or within a recorded easement dedicated to public use.

Operation and Maintenance Plans should clearly outline how vegetation in the Wet Pond and its vegetated perimeter area will be managed or harvested in the future. Periodic mowing of the Wet Pond vegetate perimeter area is only required along the maintenance access and the embankment. The remaining Wet Pond perimeter can be managed as a meadow (mowing every other year) or forest. The maintenance plan should schedule a shoreline cleanup at least once a year to remove trash and floatables.

Maintenance of a Wet Pond is driven by annual maintenance reviews that evaluate the condition and performance of the Wet Pond. Based on maintenance review results, specific maintenance tasks may be required.

13.10 References

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