# Chapter 4 – Wet Ponds

Wet Ponds have a permanent pool of water and have the capacity to temporarily store stormwater runoff and release it at a controlled rate; provide flood control; and provide water quality treatment. Properly sized and maintained, wet ponds can achieve high rates of removal for a number of urban pollutants, including sediment and the pollutants associated with sediment, such as trace metals, hydrocarbons, biological oxygen demand (BOD) , nutrients, and pesticides. They also provide some treatment of dissolved nutrients, through biological processes within the pond. The addition of an underdrained gravel trench in the bench area around the permanent pool allows for the slow, release of stormwater without risk of blockage and avoids thermal impacts. The underdrained gravel trench outlet is required when discharging to a stream, river or brook.

> ***IMPORTANT:***
> An underdrained gravel trench outlet is required for all discharges within the watershed of a stream, brook or river. The channel protection volume should be discharged solely through the underdrained gravel trench. A standard outlet structure may be provided if the discharge is to a lake, major river or tidal water.

**Permanent Pool Volume:** When designing a pond to meet General Standards of the DEP's Chapter 500 Stormwater Management Rules, the permanent pool must be sized in accordance with criteria provided below. When designing a pond to meet the Phosphorus Standard, the permanent pool volume must be adjusted using the equations found in Chapter 4 of Volume II. The permanent pool must have a storage volume below the permanent pool elevation at least equal to 2.0 inches times the subcatchment's impervious area plus 0.8 inch times the subcatchment's non-impervious developed area. If the total permanent pool volume is evenly distributed between two wet ponds in series, the total permanent pool volume may be reduced by 20%. If the permanent pool volume is evenly distributed between three ponds in series, the reduction may be 40%.

**Channel Protection Volume:** Wet ponds must detain, above the permanent pool, a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the landscaped developed area to be released over a 24 to 48 hour period. The outflow must be discharged through an underdrained gravel trench outlet if the basin is discharging to a stream, brook or river. When designing for flood control, the pond needs to control the peak flows from the 2, 10 and 25-year storms.

**Cooling:** When designed to meet the cooling standard, the underdrain trench outlet must be sized to provide effective cooling of the stormwater runoff to 60 degrees Fahrenheit. The underdrained outlet design should provide adequate cooling of stormwater runoff before discharging it.

**Location in Wetlands:** Wet ponds may not be located in wetlands without the appropriate permits from DEP and the Army Corps of Engineers. The DEP and Army Corps of Engineers should be contacted early in the design phase if any wet pond is proposed in a wetland.

**Wildlife Habitat:** If the pond will be used as new or enhanced wildlife habitat, a larger contributing watershed (>20 acres) may need to be considered so that flow is sufficient to maintain pool volume. Wet ponds for wildlife habitat located in watersheds less than 20 acres should have a reliable water source and a clay liner.

**Basin Siting:** The site for a wet pond should be suitable to prevent seepage, environmental impact or posing a hazard to downstream property or life.

- *Depth to Groundwater:* The elevation of the pond outlet should be at least 1 foot above the highest elevation of the seasonal high groundwater table in the area to be flooded by the pond. A wet pond

with its pool surface at the elevation of the groundwater table can be acceptable if the discharge outlet is an acceptable receiving channel and is stable under a constant discharge.

- *Depth to Bedrock:* A minimum separation of 1 feet is recommended from the bottom of the basin to the top of bedrock, or an impermeable barrier (clay layer or synthetic liner) should be provided. Wet ponds on fractured bedrock may seep into fractures and may discharge pollutants directly to the groundwater.
- *Stream Channels:* Wet ponds should not be located in stream channels because of the impact to aquatic life.
- *Slopes:* Interception of the seasonal groundwater table should be minimized to prevent creating a seasonal spring when placing a pond on a slope. Controlling seepage flow into a pond may be accomplished by the proper installation of a subsurface interceptor drainage system or by stabilizing the slope with riprap.
- *Access:* A maintenance access way should be at least 10 feet wide with a maximum slope of 15% and a maximum cross slope of 3%. This access should never cross the emergency spillway, unless the spillway has been designed for that purpose. An easement may be required.

**Soils:** Ponds in highly permeable soils may result in seepage, such that the permanent pool may be lost during a dry period from seepage. However, fine soil particles will eventually clog the bottom of the pool and stop runoff infiltration. There are two design options for ponds constructed in Hydrologic Soil Group A or B soils.

- *Pond Lining:* The bottom of the pond can be lined with a synthetic membrane or a compacted fine soil layer to prevent water loss.
- *Natural Clogging:* Infiltration occurs until clogging of the bottom with sediment and organic material and creates a wet pond. In this case, standards for separation from bedrock and seasonal high water table provided in Chapter 6 –Infiltration BMPs should be used in designing the pond.
- *Clay Soils:* The discharge of clay soil particles is a concern for phosphorus control in sensitive lake watersheds. If construction in clay soils is unavoidable, use erosion control matting on the sides and bottom of the pond, or line the pond with gravel (or a filter fabric) to contain the clay.

**Pond Shape:** Plug flow is accomplished when water entering the pond does not mix with the water in the pond but pushes it out. The following measures must be incorporated into the design to promote plug flow:

- *Flow Path:* The inlet and outlet should be as far apart as possible. Runoff should have to travel the longest distance possible through the pond before being discharged.
- *Inlet and Outlet Locations:* Provide one distinct area of inlet flow and one distinct area of outlet flow in the pond. The shallow and narrow end of the pond should be located near the inlet and the deeper and wider end near the outlet.
- *Basin Shape:* Provide a long and narrow basin shape, with a minimum 2:1 length to width ratio (3:1 is best). Runoff should travel the longest distance through the basin with the inlet and outlet as far apart as possible. The path of flow can be increased with an irregularly shaped basin or by using baffles. The basin should be shallow and narrow at the inlet, and deep and wide at the outlet.
- *Number of Ponds:* Provide two or more ponds in a series for the most effective treatment. The first pond experiences some mixing as incoming runoff meets still water, but water is pushed into subsequent ponds at a steady rate that minimizes mixing and promotes plug flow. Multiple ponds also restrict wind-generated mixing of the total volume of the ponds. Simple overflow outlets should be installed between ponds to ensure that water is released from the top of the pool. This upper layer of water contains less sediment than lower layer.
- *Permanent Pool Depth:* Wet ponds should have a mean depth of 3 feet or more to prevent turbulent re-suspension of sediments. The mean depth should be no more than 10 feet, and the maximum depth no greater than 15 feet to avoid thermal stratification and the release of phosphorus. Mean depth is defined as the pond volume (measured at one foot below permanent pool elevation) divided by the surface area at that elevation.

**Inlet Design:** Prevention of scour at the inlet will reduce maintenance problems and prevent damage to basin floor vegetation. Provide energy dissipation at the inlet in accordance with practices outlined in the Maine Erosion and Sediment Control Best Management Practices manual.

- *Inlet Protection:* The inlet should be protected with riprap or other energy dissipater, such as a baffle below the inflow structure, to remove sediment. A forebay should be designed with a minimum length to width ratio of 2:1.
- *Scour:* Energy dissipation should be provided at the inlet and outlet to prevent scour and reduce the velocity of stormwater. The velocity of flow through the inlet sediment control structure and basin should not exceed 2.5 feet per second.
- *Sediment Pretreatment:* A pretreatment device such as a forebay, grassed swale, filter strip, and sediment trap should be provided to minimize the discharge of sediment to the wetpond. The pretreatment structure should be sized to hold an annual sediment volume as follow:

Assuming an average of 10 storm events per year, the volume of a sediment trap should be calculated as follow:

$$\underset{\text{per year}}{10 \text{ storms}} \times \underset{\text{(acres)}}{\text{Sanded Area}} \times \frac{500 \text{ lbs.}}{\text{per acre-storm}} : \frac{90 \text{ lbs.}}{\text{ft}^3} = \underset{\text{of collected sediment}}{\text{annual cubic feet}}$$

**Emergency Spillways:** Emergency spillways should independently convey the runoff from the 25-year, 24-hour storm while maintaining at least one foot of freeboard between the peak storage elevation and the top of the embankment crest; and should safely convey the 100-year storm without overtopping the embankment. Overflow must discharge to a stable channel or stable area.

- *Location:* Emergency spillways should be located on undisturbed, non-fill soil. If the spillway must be located on fill soils, it should be horizontally offset at least 20 feet from the principal outlet; and be riprapped or reinforced with turf lining, or a non-flexible lining.
- *Exit channel:* The grade of the spillway's exit channel should not exceed 20% unless a non-flexible lining (concrete or asphalt) is provided. Vegetation, reinforced turf, riprap, and modular blocks are considered flexible linings. Large woody species growing in the emergency spillway will interfere with its function and must be removed.
- *Flow depth:* The design flow depth in the exit channel may not exceed one-half the $D_{50}$ stone size for channels lined with riprap and three inches for channels with vegetation. The channel should remain stable through the full range of design flows.

**Embankments:** Embankments must be designed by a professional engineer registered in the State of Maine and must be designed to meet engineering standards for foundation preparation, fill compaction, seepage control, and embankment stability. Basic standards for small basins can be found in the Maine Erosion and Sediment Control Best Management Practices manual. The design must include an investigation of the subsurface conditions at the proposed embankment location to evaluate the depth to bedrock and groundwater, settlement potential, and the need for seepage controls. The DEP may require a geotechnical report for any embankment over 10 feet in effective height or posing a hazard to downstream property or life.

- *Key:* Embankments must be keyed into undisturbed subsurface soils.
- *Safety Bench:* A safety bench should be designed into all embankments greater than 10 feet high.
- *Crest width:* The minimum crest width for any embankment must be as shown in Table 4.1.
- *Crest elevation:* The minimum elevation of the top of the settled embankment must be at least one foot above the peak water surface in the basin with the emergency spillway flowing at design depth for a discharge routed through the emergency spillway only.

***Table 4-1 - Crest Width***

| HEIGHT OF EMBANKMENT (feet) | CREST WIDTH (feet) |
|---|---|
| Less than 10 | 6 |
| 10-15 | 8 |
| 15-20 | 10 |
| More than 20 | 12 |

- *Fill Material:* Fill must be free of frozen soil, rocks over six inches, and sod, brush, stumps, tree roots, wood, or other perishable materials. Embankment fills less than 10 feet in fill height must be compacted using compaction methods that would guarantee a fill density of 90% of the maximum density as determined by standard proctor (ASTM-D698). All embankment fills more than 10 feet in fill height must be compacted to 90% of the maximum density and must have their density verified by field density testing.
- *Slopes:* The embankment's slopes should not be steeper than 2:1. Flatter slopes provide easier access for maintenance (mowing). At a minimum, one side slope, interior or exterior, should be 3:1, such that the combined interior and exterior embankments total 5:1 (2:1 + 3:1). Riprap should be installed around the edge of the pond if the embankment is steeper than 2:1.
- *Safety:* For safety reasons and to promote the growth of rooted aquatic plants, a gradually sloped bench of 10:1 slope around a pond perimeter is recommended. This bench should extend into the pool at least 10 feet (for 5 feet for very small ponds). The bench reduces the risk of accidental falls, and makes it easier to climb out. The underdrained gravel filter bench can also serve as the safety bench. If it is not possible for a shallow bench to extend around the pond, thorny bushes can be planted to discourage access.

***Table 4.2***
***MEDOT Specifications for Underdrains (MEDOT # 703.22)***

| Sieve Size | % by Weight |
|---|---|
| **Underdrain Type B** | |
| 1” | 90-100 |
| ½” | 75-100 |
| #4 | 50-100 |
| #20 | 15-80 |
| #50 | 0-15 |
| #200 | 0-5 |
| **Underdrain Type C** | |
| 1” | 100 |
| ¾” | 90-100 |
| 3/8” | 0-75 |
| #4 | 0-25 |
| 10 | 0-5 |

**Outlet:** The channel protection volume must be discharged solely through an underdrained gravel trench outlet having a single outlet with a diameter no greater than eight inches for all discharges to a river, stream or brook. Additional storage for flood control may be discharged through traditional pond outlets, flood control outlets, at an elevation above the permanent pool and channel protection volume storage.

- *Pond Outlet:* All pond discharges must outlet to a stable natural channel or an area capable of withstanding concentrated flows and saturated conditions without eroding.
- *Overflow:* If the pond is used for a project which does not need to provide peak flow control, the overflow from the pond may either be discharged uncontrolled through a broad crest weir or a standard outlet. If the pond needs to retain peak flows for flood control, then a standard outlet for peak control needs to be provided. Discharge from the pond needs to be directed to a stable channel or an area capable to withstand concentrated flows.

**Underdrained Gravel Trench:** The underdrain trench provides the slow release of the channel protection volume over a 24-48 hour period and cooling of the discharge.

- *Bench Elevation:* The bench should be set at the permanent pool elevation such that the channel protection volume will be stored between the bench surface elevation and the elevation of any flood control or emergency spillway outlets.
- *Pond Bench and Gravel Trench:* The pond bench must have a minimum width of 8 feet. The gravel trench is excavated into the pond bench. This trench should be at least 2 feet from the interior pond-side edge of the bench and should be located furthest from the inflow to the pond.
- *Trench Sizing:* The trench should have a length of 3 feet for every 1000 cubic feet of channel protection volume.
- *Trench Dimensions:* The gravel trench should be 4 feet wide and at least 3 feet deep. Gravel should cover the pipe underdrain by at least 2 feet and be 6 inches below the pipe.
- *Geotextile Fabric:* A geotextile fabric with suitable characteristics should be placed between the gravel and adjacent soil. The fabric will prevent the surrounding soil from clogging the outlet. Use a fabric that is compatible with the surrounding soil. Overlap seams should be a minimum of 12 inches.

- *Underdrain Pipe:* The underdrain piping should be 6 inch diameter with slotted, rigid schedule 40 PVC or SDR35 pipe.
- *Gravel Bed:* The gravel bedding should be clean, well-drained gravel. Recommended specification is the gravel meeting Maine DOT specification 703.22 Type B Underdrain Backfill as shown on Table 4.2 with at least 10% passing the # 50 sieve.
- *Orifice:* If the gravel does not provide 24 to 48 hours of maximum detention or the gravel (Maine DOT specification 703.22 Type B) does not have at least 10% passing the # 50 sieve or if the sieve analysis is unavailable, an orifice should be provided to control the release of flows. The orifice should be sized and modeled as a function of the required channel protection volume release rate. Table 4.3 shows examples of possible pond orifices for channel protection volumes; however the engineer is responsible for developing a design that meets the performance criteria based on the site specific characteristics and the required drainage time.

***Table 4.3***
***Pond Outlet Orifice Sizing for Pond Outflows***

| **CPV** (cu ft) | **Orifice Dia.** (in) | **CPV** (cu ft) | **Orifice Dia.** (in) |
|---|---|---|---|
| 8000-9500 | 1 3/8" | 24000-26500 | 2 3/8" |
| 9500-11000 | 1 ½" | 26500-29000 | 2 ½" |
| 11000-13000 | 1 5/8" | 29000-32000 | 2 5/8" |
| 13000-15000 | 1 ¾" | 32000-35000 | 2 ¾" |
| 15000-17000 | 1 7/8" | 35000-38000 | 2 7/8" |
| 17000-19000 | 2" | 38000-41500 | 3" |
| 19000-21500 | 2 1/8" | 41500-45000 | 3 1/8" |
| 21500-24000 | 2 ¼" | 45000-48500 | 3 ¼" |

- *Outlet clogging:* The pond outlet or orifice should be designed to prevent clogging and to allow access to the underdrain outlet for inspection and maintenance. This may be accomplished by having the underdrain discharge to a concrete sump outlet structure with the orifice built into this structure.
- *Alternative Outlets:* A 4-inch gate valve on the structure may be used in lieu of a standard orifice. This would allow for adjustment for site specific conditions. The engineer is responsible for designing an outlet structure that meets the release and cooling criteria previously presented.
- *Pond Drain:* If elevations allow, a manually controlled drain should be provided to dewater the pond over a 24 hour period without harming downstream water courses. This will facilitate the removal of accumulated sediment. The drain should be locked to prevent accidental draining of the pond.

**Flood Control Outlets:** If necessary, flood control outlets should be designed to control runoff from the 24-hour storms of the 2-year, 10-year, and 25-year frequencies such that the peak flows of stormwater from the project site do not exceed the peak flows of stormwater prior to undertaking the project. The elevation of the peak flow control structure must be above the elevation of the channel protection volume.

- *Discharge from Pond Surface:* The flood control outlet should be a simple overflow to discharge clarified water from near the surface of the pool.
- *Piping Materials:* Piping should be constructed of materials with a service life corresponding to the anticipated design life of the pond and its embankment. Reinforced concrete pipe is often recommended in a freshwater environment.
- *Trash Racks:* All outlets should have a trash rack to control clogging by debris and provide safety to the public. The surface area of each rack should be at least four times the outlet it is protecting. The spacing between rack bars can be no more than six inches or one-half the dimension of the smallest outlet opening behind it, whichever is less. Trash racks should be inclined to be self-cleaning.
- *Seepage Controls:* All pipes that extend through an embankment should have anti-seep collars or filter diaphragms to control the migration of soil materials and to prevent potential embankment failure from "piping" within the backfill along the conduit. All smooth outlet pipes greater than eight inches and all corrugated outlet pipes greater than 12 inches must have seepage controls to prevent migration of soil along the outside of the pipe.
- *Anti-floatation:* All riser structures must be designed to prevent the riser from floating.
- *Outlet Protection:* Outflow from the pond should be directed to a stable discharge point. A channel may need to be riprapped to prevent erosion. Riprap should be designed in accordance with the Maine Erosion and Sediment Control Best Management Practices manual.

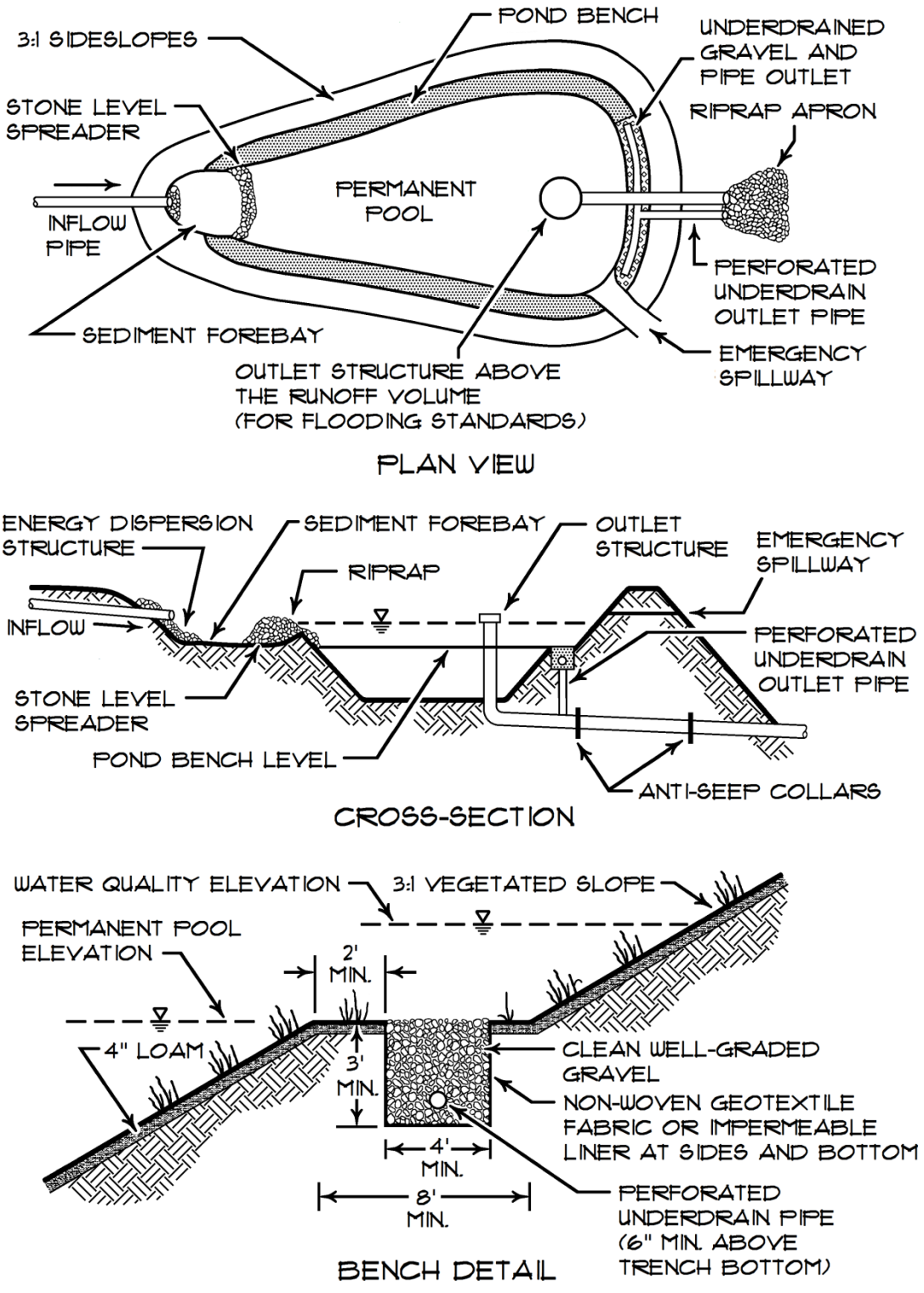


***Figure 4.1 – Wet Pond Design***

**Construction:** Construction of wet ponds should be started no later than September 1 or before June. If side slopes and banks cannot be revegetated or stabilized before winter, basin construction should be delayed to the following growing season. Seeding must occur by September 15 or other stabilization measures must be implemented before winter. Do not discharge stormwater to the basin until the basin is fully stabilized, or provide a sediment barrier at the outlet.

- *Sediment Disposal:* The disposal of construction sediments should be located such that water draining from the material could not flow directly to a water resource. For sensitive lake watersheds, DEP requires two sites to be reserved for on-site disposal of sediment excavated from the wet pond(s).

**Vegetation:** Appropriate species should be carefully selected for different sections of the pond. Appropriate plants should be chosen to stabilize the sides and bottom of the pond, as well as the safety bench. Prior to filling the ponds, side slopes and banks must be stabilized with grass or conservation mix seeding to prevent erosion. Creation of a marsh environment at the pond inlet will help to trap sediment. If the inlet has a sump, aquatic plants can be planted upstream of the sump to help retain sediments in the sump. Fertilizer should not be used in or around the pond except when necessary to establish new vegetation. Allowing for natural invasion along the safety bench or planting native species may encourage healthier growth than planting species not already found on site. Six inches of loam, composted wood waste or fine erosion control mix should be added to amend dry mineral soils. It is recommended that a qualified professional be consulted when planning the revegetation of a basin. *See Chapter 3:0, Detention Basins for Flood Control,* for more information on plant selection.

**Maintenance:** The wet pond should be inspected after every major storm to ensure proper functioning. Thereafter, the basin should be inspected at least once every six months. Inspections should include verification that the pond is slowly emptying through the gravel filter for a short time (12-24 hours) after a storm. It is important to design flow structures that can be easily inspected for debris blockage.

- *Maintenance Agreement:* A legal agreement should list specific maintenance responsibilities, establish the responsible party, and provide for the funding to cover long-term inspection and maintenance.
- *Inlets and Outlets:* The inlet and outlet of the pond should be checked periodically to ensure that flow structures are not blocked by debris. All ditches or pipes connecting ponds in series should be checked for debris that may obstruct flow.
- *Gravel Trench:* The gravel trench should be clear of clogging material (e.g., decaying leaves) so that discharge through the trench is not impeded. The top several inches of the gravel in the outlet trench should be replaced with fresh material when water ponds above the permanent pool for more than 72 hours. The sediments removed from the wet pond should be disposed of in accordance with application regulations.
- *Embankments:* Wet ponds should be inspected annually for erosion, side slopes destabilization, embankment settling or other signs of structural failure. Corrective actions should be taken immediately upon identification of a problem.