2.6 Water Quality Ponds

Wet extended detention pond

Description

Water quality ponds are stormwater ponds designed to treat runoff for pollutants and control increases in stream discharge and bedload transport. Water quality ponds may be predominantly dry between storm events, or have a permanent pool or even have wetland features. Water quality ponds remove pollutants by settling, chemical interaction and biological uptake by plants, algae and bacteria. The efficiency of settling suspended solids and the ability to treat dissolved pollutants is improved with the addition of wetlands and permanent pools. Water quality ponds are often designed to provide flood control by including additional detention storage above the volume specified in this practice.

Conditions Where Practice Applies

Water quality ponds are applicable to most urbanizing areas where pollutant loads are predominantly particulates and control is needed to address increased erosion potential in down stream channels.

Water quality ponds are appropriate for residential, commercial and industrial areas and are easily incorporated on sites where a stormwater pond is to be constructed to control potential flooding. Even where detention ponds are not necessary for flood control, water quality ponds can be used to address water quality and stream stability concerns.

Water quality ponds are most appropriate for larger sites, greater than 20 acres for wet or wetland ponds or greater than 10 acres for extended detention ponds. Ponds may be beneficial for smaller areas, yet have greater problems sustaining permanent pools, or issues of maintenance such as potential blocking of the outlet (due to small orifices) by trash and debris.

Existing flood control ponds may be retrofitted to meet the water quality and stream stability objectives of these stormwater ponds.

Planning Considerations

Water quality ponds may not be appropriate for ultra-urban areas where adequate space is not available or for heavy industrial areas that require extensive pollution treatment.

Water quality ponds may cause stream warming and may need additional design considerations or may not be appropriate for coldwater streams.

Ponds with dams are regulated under the Ohio Revised Code 1501: 21 Dam Safety Administrative Rules. A dam is exempt from the state's authority (ORC Section 1521.062) if it is 6 feet or less in height regardless of total storage; less than 10 feet in height with not more than 50 acre-feet of storage, or not more than 15 acre-feet of total storage regardless of height. Check with the Ohio Dept. of Natural Resources, Division of Water, for the most current requirements.

Additional upland practices may be needed to reduce nutrient loads that cause problems common to eutrophic ponds (excess algae, low oxygen levels, and odor).

For wet ponds, soils and site conditions must be appropriate to maintain a permanent pool during dry weather. Permanent pools may be difficult to maintain if the contributing watershed area is less than 20 acres and if the ratio of drainage area to water surface area is less than 6:1.

Suitable soils must be available for constructing the embankment and insuring sufficient impermeability to prevent seepage losses. A trained professional shall conduct an on-site evaluation of the proposed pond site and borrow areas prior to final design to characterize the adequacy of the site and the excavated soils for use as core trench or embankment fill. The evaluation should include a test pit at each abutment, along the centerline of the proposed embankment, the emergency spillway, the borrow area and the pool area. As a general rule, one test pit should be placed for every 10,000 square feet of area examined. All explorations shall be logged using the Unified Soil Classification System.

Treatment goals, watershed characteristics and site constraints should drive designs towards one of 3 main pond configurations:

1. *Extended Detention,*
2. *Wet Extended Detention*
3. *Wetland Extended Detention.*

Pond volume and depth characteristics depend on the type of pond being designed. In all instances, an extended detention volume (portion of the water quality volume, WQv) must be determined and treated.

Table 2.6.1 Pond types and appropriate characteristics and treatment goals

Pond Type	Minimum Drainage Area (acres) *	Drainage Area: Surface Area:	Suspended Solids Estimated Effectiveness	Dissolved Pollutants Estimated Effectiveness	Stream Warming Potential	Target Depth (apply % to surface area)
Extended Detention	≥10		Low to Moderate	Low	Moderate	3'
Extended Detention with Forebays and Micropool	≥10		Low to Moderate (improve over ED)	Low	Moderate	3'
Wet Extended Detention	≥20 or sufficient baseflow to support permanent pool	<6:1	Moderate-high	Moderate-High	High	Generally not deeper than 6-8'
Wet Extended Detention with wetland fringe	≥20 or sufficient baseflow to support permanent pool	<6:1	Moderate-high	Moderate-High	High	Generally not deeper than 6-8' – 20% at 6-8"
Wetland	≥20 or sufficient baseflow to support permanent pool	>50:1	Moderate-high	Moderate-High	Moderate	5-20% 1.5-6' wetland areas range from 0 – 18' with avg of 6 – 12"
Wetland (pocket)	Dependent upon baseflow	>100:1	Variable	Variable	Moderate	5-20% 1.5 – 6' Wetland areas range from 0 – 18" with avg of 6 –12"

*Note: Extended detention basins are appropriate for areas less than 10 acres, if the outlet is designed to prevent clogging.

Advantages of Wetland Features – Wetland vegetation, in addition to promoting settling, stabilizes deposited sediment. Wetlands can further treat stormwater in ways most other treatment practices cannot, by plant uptake, adsorption, physical filtration, microbial decomposition and shading. Wetland plants readily absorb heavy metals, and other toxic wastes.

Microorganisms that thrive in wetland plant root systems consume and decompose pollutants. These microorganisms that live among the plants are very good at breaking down poisonous organic compounds such as benzene, toluene and PCBs into harmless elements that the microorganisms and plants can digest.

Mosquito Concerns – Water quality ponds have extended detention times less than the time needed for common vector mosquitoes to hatch (generally 72 hours). But it is still important to design and maintain stormwater ponds in order to prevent conditions most favorable to mosquitoes. When designing and maintaining stormwater ponds apply the following considerations:

- Avoid stagnant water by assuring there is sufficient flow to support a wet or wetland ponds.
- Maintain the outlets so that detention does not occur beyond the extended detention period.
- Design wet ponds with wetland benches and wetlands with varying depths (mix of deeper water and wetland areas) in order to have improved habitats for natural mosquito predators like small fish, birds, dragonflies and aquatic insects.
- For areas that will have standing water without wave action or deeper water, consider aeration to prevent stagnation.

Design Criteria (Applicable to Each Pond Type)

Water Quality Volume (Applicable to all pond configurations)

The water quality volume (WQv) is the volume of runoff that is treated in a water quality pond. Depending upon the type of pond (dry extended detention, wet or wetland) all or a portion of this volume is stored above wetland or permanent pool features and drained over a 24-48 hour period. Detaining this volume has two stream protection objectives: reducing the pollutants suspended in the runoff and reducing the energy of common storm events responsible for most channel erosion. The water quality volume is calculated using equation 1 below, adapted from Urban Runoff Quality Management (ASCE/WEF, 1998). This is required by the Ohio EPA NPDES general permit (OHC00005 for construction activities.

$$WQv\ (ac\text{-}ft) = Rv * 0.90 * A / 12 \qquad \text{(Equation 1)}$$

Where:

Rv = volumetric runoff coefficient

A = area draining into the BMP in acres

The volumetric runoff coefficient, Rv, is calculated using the following equation or alternatively values provided in the Ohio EPA NPDES general permit (OHC00005) for construction activities.

$$Rv = 0.05 + 0.9\ (i) \qquad \text{(Equation 2)}$$

Where:

i = watershed imperviousness ratio, the percent imperviousness divided by 100

Note: The Ohio EPA NPDES stormwater general permit for construction activities requires that the water quality volume be increased by 20% for capacity lost over time due to sediment accumulation.

Pond Configuration

Configure the pond so that water quality treatment is optimized through pond shape and flow length. Improved settling of pollutants occurs as the flow length is maximized. Optimally, designs will avoid the problems of dead storage or incoming water short-circuiting through the pond and the resuspension of deposited sediments.

Forebays and micropools, pool water at the inlets and outlet of a pond in order to improve the effectiveness and ease of maintenance of water quality ponds. The shape and grade of pond side slopes also strongly influence pond effectiveness and potential safety.

1. Length to Width Ratio

Wedge shaped or ponds that are longer than wide will prevent flow from short-circuiting the main body of water. The ratio of flow length to pond width should be at least 3:1. To increase a pond's flow length, the contours of the pond may be configured to form baffles or an extended flow path. Constructing submerged aquatic benches to form cells will enhance flow routing (Figure 2.6.1).

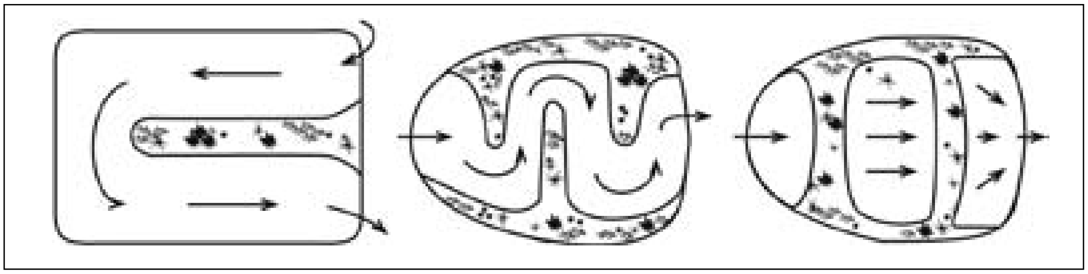

Figure 2.6.1 **Flow Routing to Enhance Water Quality Treatment**

2. Side Slopes

Varying the slope to create benches above and below waterlines increases safety and stability and can create water quality features such as wetland benches in permanent pools. Slopes should not be steeper than 3:1 or shallower than 12:1.

3. Forebay(s)

A forebay is a settling pool located at the inlet to a pond. It is separated from the rest of the pond by a level dike often planted with emergent wetland vegetation. Forebays are primarily used to improve the settling efficiency of a pond but they also reduce maintenance by promoting settling in a confined, easily accessible location.

Forebays promote settling by: segmenting or dividing the pond into cells which reduce mixing and promote plug flow; by converting the high velocity concentrated inflow from a pipe to a wide uniform slow flow to the normal pool area; and by dissipating flows through emergent vegetation. See Figure 2.6.2.

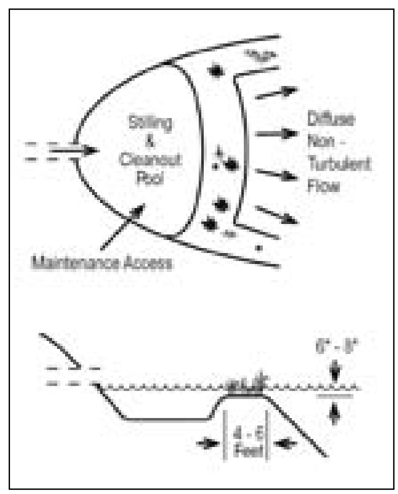

Figure 2.6.2 **Forebay**

Forebay Size – forebay for a single inlet should occupy from 8-25% of the normal pool area. Forebays should be large enough to avoid scour and resuspension of trapped sediment and sized for ease of construction and cleanout. Forebays should have a water depth of at least 3 ft.

Forebay Outlet – Provide an outlet to the main pond, consisting of a level spreader or submerged level dike. A submerged dike separating the forebay from the rest of a wet pool or wetland should be 6-12 in. below the normal water surface elevation and provide a non-erosive overflow. It should also be planted with hardy emergent wetland vegetation. See the wetland extended detention pond section below for more information on planting.

Forebay Maintenance Access – To accommodate relatively frequent sediment cleanout, easy equipment access should be provided to the forebay. This should include gradual slopes without obstructions and an access easement. Additionally a drain should be installed under the dike so that the forebay can be drained during maintenance operations.

4. Micropool

For wetland and predominantly dry extended detention stormwater ponds, a micropool is recommended in front of the outlet. The micropool allows a reverse slope pipe or other non-clogging outlet to be used. The micropool should be 4-6 feet deep and equal to 10% of the volume of the water quality volume.

5. Non-clogging Outlet

Extended detention outlets often require small orifices or controls and must be designed to be non-clogging. A reverse flow pipe is one way to configure an outlet to better trap floating pollutants and to be less clogging (see figure 2.6.3). Reverse flow pipes draw water from below the water surface to trap floating debris that would otherwise clog the outlet.

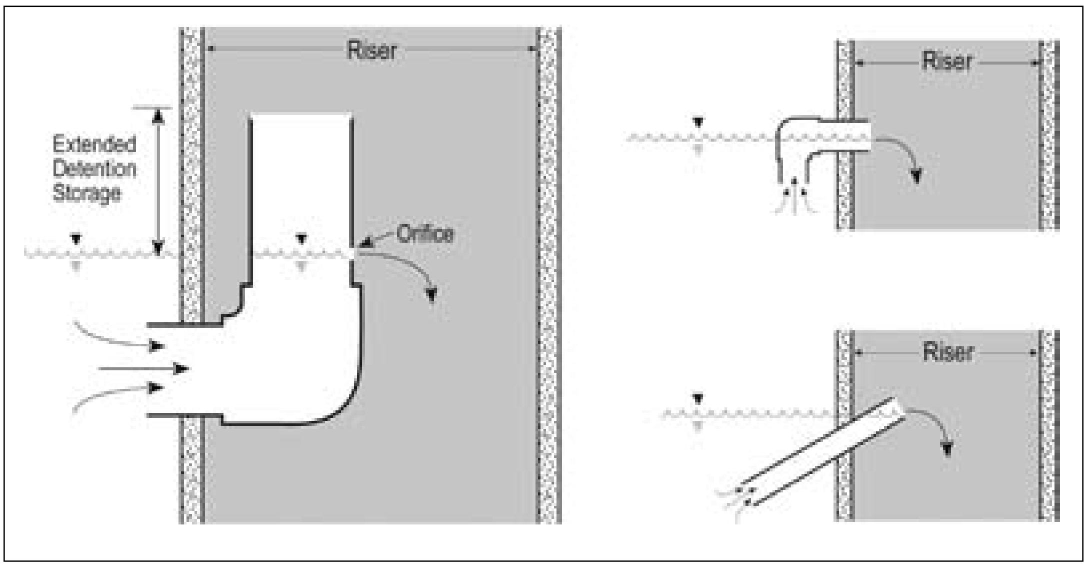

Figure 2.6.3 **Reverse Flow Structures Reduce Clogging and Trap Floating Pollutants**

A reverse flow pipe is designed to draw water below the pond's surface and above the midpoint of the normal permanent pool elevation. They may be constructed with a pipe on a negative slope or with a turned pipe elbow. Reverse flow outlets may be constructed with a straight pipe set on a negative slope. A pipe with a 90-degree elbow also may be used either inside the riser and facing upward or outside the riser facing down (see figure 2.6.3).

6. Pond Drain

It is recommended that a drain be installed such that the entire pond can be drained for maintenance or repair purposes.

7. Additional Specifications for Pond Construction

Embankment ponds must be well constructed and built according to NRCS Conservation Practice Standards 378 (Pond) addressing issues such as:

- Ponds must incorporate emergency spillways designed to safely convey flows exceeding design storm flows.
- Outlet structures should be built to withstand floatation and incorporate anti-vortex and debris or trash rack devices.
- Embankments and principal spillway shall utilize adequate soils and compaction, core trenches and anti-seep collars.

Dry Extended Detention Basin – Design Criteria

Detention Volumes

The extended detention volume is equal to the water quality volume (WQv) found in equation 1. An additional capacity of 20% must be provided within the water quality volume for sediment accumulation. This additional volume may be utilized in forebays at inlets and in a micropool at the outlet, which will improve the maintenance and efficiency of the pond.

Local government may require additional detention volumes for peak discharge control (flood control). Appropriate design procedures, including routing design storms through the basin, shall be used to insure the pond and outlet geometry meet local and state requirements. See the figure below.

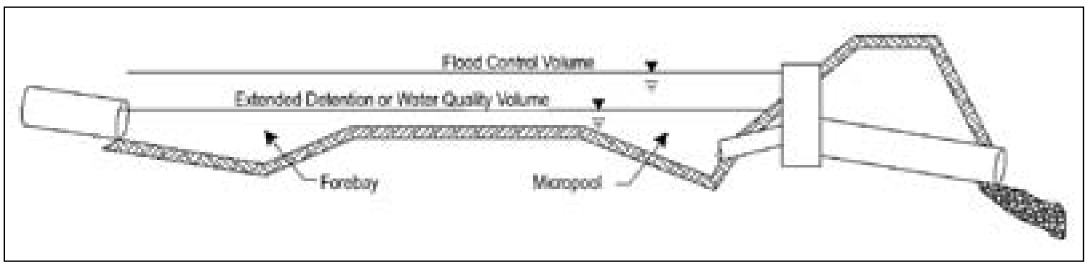

Fig 2.6.4 **Storm Water Pond with Extended Detention and Flood Control Volumes**

Outlet Design

Design the outlet structure (principal spillway) to draw down the extended detention volume over a 48-hour period. The outlet should empty less than 50% of this volume in the first 16 hours.

Peak discharge control (flood control) required by local government can be incorporated into the spillway with additional control devices (e.g. orifices or weirs) above the extended detention outlet. This type of multiple outlet spillway incorporates outlet controls for each attenuation goal.

Permanent Pool

Dry extended detention basins do not have a permanent pool except for the establishment of forebays at inlets and a micropool at the outlet. They increase the effectiveness of the pond and the ease of maintenance. More information is provided on these in the design criteria applicable to all ponds above.

Wet Extended Detention Basin – Design Criteria

Detention Volumes

Wet extended detention ponds detain a volume equal to the WQv found with equation 1 above a permanent pool.   See figure 2.6.5.

Local government may require additional detention volumes for peak discharge control (flood control). Appropriate design procedures, including routing design storms through the basin, shall be used to insure the pond and outlet geometry meet local and state requirements. See the figure below.

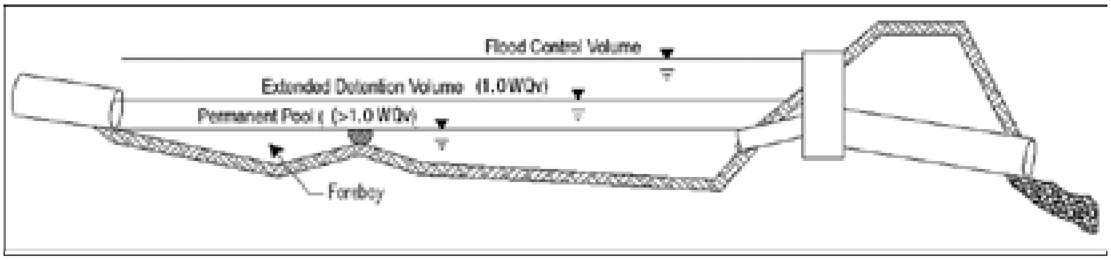

Figure 2.6.5   **Wet Storm Water Pond with Extended Detention and Flood Control Volumes**

Outlet Design

Design the outlet structure (principal spillway) to draw down the extended detention volume over a 24-hour period. The outlet should empty less than 50% of this volume in the first 8 hours.

Peak discharge control (flood control) required by local government can be incorporated into the spillway with additional control devices (e.g. orifices or weirs) above the extended detention outlet. This type of multiple outlet spillway incorporates outlet controls for each attenuation goal.

Permanent Pool Volume

The permanent pool of a wet extended detention pond is equal to the WQv found with equation 1 plus an additional volume equal to 20% of the WQv (0.2 WQv) added for sediment accumulation. Thus the original capacity of the permanent pool shall be equal to 1.2 times the water quality volume (1.2 WQv). This volume may include forebays, cells created within the permanent pool for increasing efficiency.

Permanent Pool Depth

The mean depth of the permanent pool should be between 3 and 6 feet in order to optimize settling of suspended particles. This is calculated by dividing the permanent pool's storage volume by the pool's surface area. A pool that varies in depth will allow diverse conditions for wetland vegetation and portions, which are deep enough for fish. If fish are to be maintained in the pool, approximately 25% of the pool should be at least 6 to 8 feet deep.

Overly shallow pools will have increased problems with algae and the re-suspension of deposited sediments by wind or as runoff enters the pond. Overly deep pools may encourage thermal stratification and anaerobic conditions at the bottom, which allow pollutants (e.g. metals and phosphorus) to be released from sediments. Deep pools are often associated with short flow paths from inlet to outlet, allowing runoff to short-circuit treatment provided by flow through the main volume of the pool.

Wetland Benches

Wet extended detention ponds may include wetland environments that greatly enhance water quality treatment by establishing a shallow aquatic bench around the main pool. These areas also improve safety by creating a vegetative barrier to discourage children from venturing into deeper water and reducing the hazard of steep grades at the pond edge.

When used as one water quality design feature within a wet extended detention pond, wetland vegetation should occupy at least 20% of the wet pool's water surface. It is also recommended that benches be at least 6 feet wide and have depths of 6 to 12 inches on average and not exceed 18 inches. See the Design criteria for wetland extended detention ponds for guidance on establishing wetland plants.

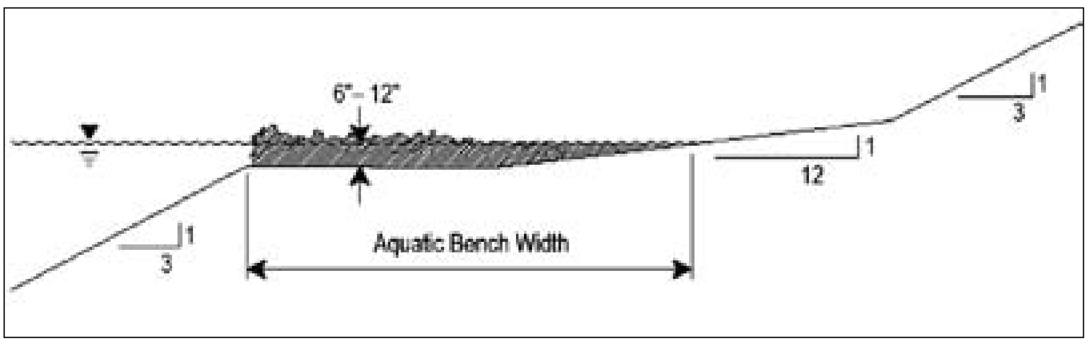

Figure 2.6.6 **Grading of Side Slope to form a Wetland Bench**

Reducing Thermal Impacts Through Shading

Warm water released from a permanent pool may adversely impact the thermal regime of receiving streams, particularly if the receiving water is a cold-water fishery. The pool acts as a heat sink between storm events during the summer months. Water released downstream from the pond can be as much as 10 F warmer than naturally occurring base flow. Large impervious surfaces also warm surface runoff significantly which can be critical to stream systems where fish and other aquatic life are threatened by high summertime water temperatures.

Add Shading – Shading a pond can significantly reduce thermal impacts. Trees planted around the pond, particularly on the south and west sides offer the most protection from the summer sun. Trees planted on islands or peninsulas should also be considered. Because tree roots can damage dams, trees must not be planted on the embankment itself. Wetland vegetation also contributes to shading and reduces thermal impacts.

Leaf litter introduces nutrients to the pond and adds to the accumulation of sediment. While nutrients and sediment are pollutants, nutrients in plant material or detritus are more readily utilized by aquatic insects and incorporated into the food chain. Fallen leaves are a vital part of aquatic environments, whereas soluble nutrients and nutrients attached to fine sediments easily wash through a pond system or promote algal growth.

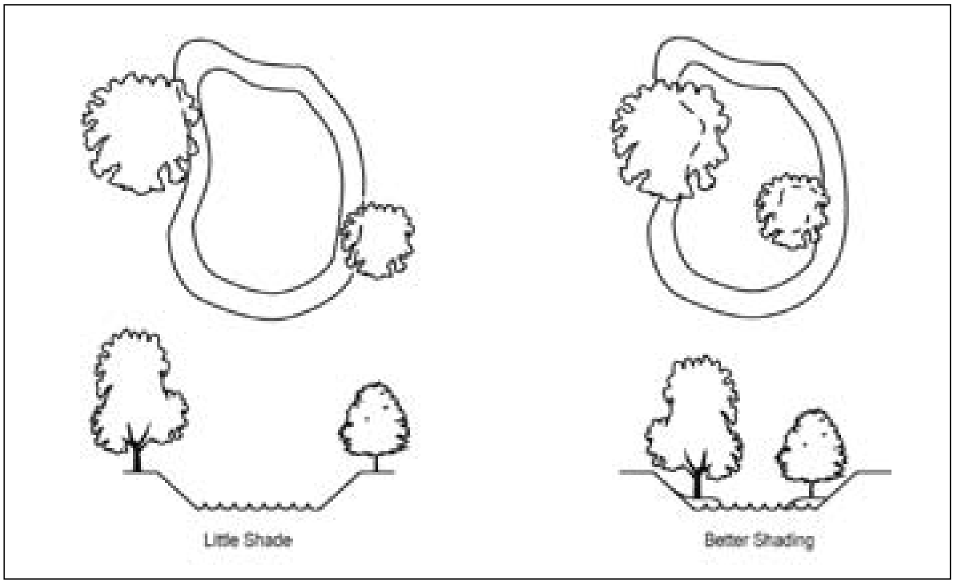

Figure 2.6.7 Tree Placement to Shade Ponds and Reduce Thermal Impacts

Wetland Extended Detention Basin – Design Criteria

Detention Volumes

Wetland extended detention ponds detain a volume equal to the water quality volume (1.0 WQv) found in equation 1 above the permanent wetland pool.

Local government may require additional detention volumes for peak discharge control (flood control). Appropriate design procedures, including routing design storms through the basin, shall be used to insure the pond and outlet geometry meet local and state requirements. See the figure below.

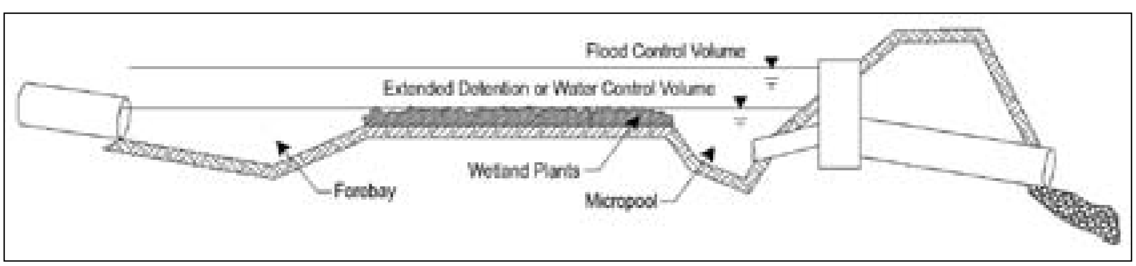

Figure 2.6.8 Wetland Storm Water Pond with Extended Detention and Flood Control Volumes

Outlet Design

Design the outlet structure (principal spillway) to draw down the extended detention volume over a 24-hour period. The outlet should empty less than 50% of this volume in the first 8 hours.

Peak discharge control (flood control) required by local government can be incorporated into the spillway with additional control devices (e.g. orifices or weirs) above the extended detention outlet. This type of multiple outlet spillway incorporates outlet controls for each attenuation goal.

Permanent Wetland Pool Volume

The permanent pool volume is based on the designer's assessment of sufficient runoff and base flow to sustain a wetland pool. The designer should assess the change in storage volume over time based on water entering and leaving the wetland. This water budget should include water entering from precipitation, runoff, base flow, and groundwater. Water leaving should include evaporation, expected plant transpiration, stormwater outflow, and seepage or percolation. Greater guidance on wetland creation and water budgets can be found in the Natural Resource Conservation Service Engineer Field Manual Chapter 13.

Add a volume equal to 20% of the water quality volume to the permanent wetland pool volume for accumulation of sediment over time. This total volume should include forebays, cells and micropools graded within the permanent pool for increasing efficiency.

Wetland Depth

Wetland pool depths should generally range between 6-18 inches. The average depth should be between 6 and 12 inches. This depth may vary but must accommodate 1) the depth appropriate for the type of wetland vegetation planted, and 2) adequate volume of runoff stored within the wetland. Wetland diversity and stability will be improved if a variety of depths are created with complex subsurface contours and irregular shapes to provide more edge effect.

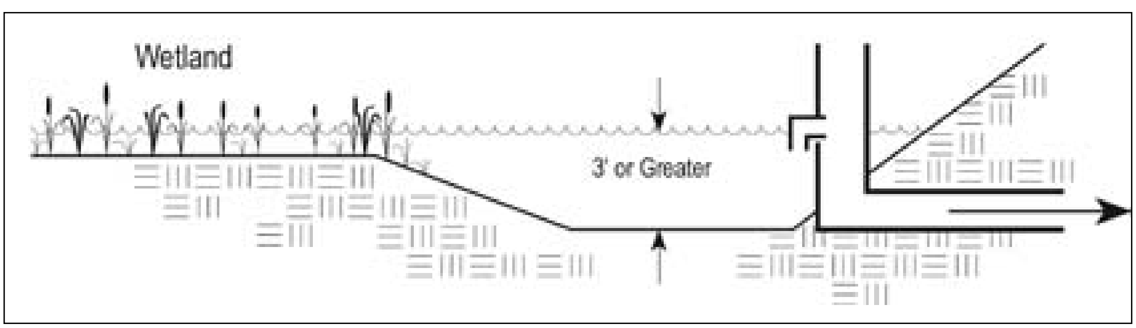

Figure 2.6.9 Micropool: Open Water Around Outlet Structure of Wetland

A micropool, that is a deep area, greater than 3 feet, should be created at the outlet structure so that vegetation and sediment buildup do not interfere with outflow from the basin. Incorporating a deep pool at the inlet to the pond may be used to promote initial settling and dissipate concentrated inflow.

Establishing Wetland Vegetation

Six to eight species of wetland plants should be planted. Species that have worked well in constructed urban wetlands include: common three square, arrowhead, soft stem bulrush, wild rice, pickerelweed, sweetflag, smartweeds, spike rush, soft rush, and a number of other sedges.

Vegetation may be established one or a combination of the following methods: planting nursery stock (plants or rhizomes), mulching with soils from an existing wetland or allowing volunteer establishment. Using only volunteer establishment is discouraged since it often leads to mono-typical stands of invasive or undesirable species.

Planting Layout – Initial planting should cover at least 30% of the wetland area, concentrated in several portions of the pond and have densities of four to five plants/square yard. Planting clusters of single species will improve the quality and diversity plantings. Plants should be planned for their appropriate depth within the permanent wetland pool.

Grading or Disking the Basin – The basin substrate should be soft enough to permit relatively easy insertion of the plants into the soil. If the basin has been recently graded or excavated, the soil should be sufficiently soft. However, if the basin soil is compacted or hard subsoil is encountered, planting will be difficult. In these cases, it is recommended that the basin soil be disked or otherwise loosened before planting.

Flood and Drain Prior to Planting – If nursery stock will be used, it is recommended that the wetland area be flooded for a period of time (6-9 monthes, USEPA) prior to draining and planting.

Treatment of Plant Material – For successful establishment of wetland vegetation the nursery stock must be correctly handled prior to planting. For growing plants, this consists of keeping the roots moist at all times, and in keeping the plants out of direct sunlight as much as possible. Vegetation should be planted as soon as possible to avoid damage during on-site storage. Dormant plant material should be stored under conditions similar to those under which the material was stored at the nursery.

When planting container plants dig holes about one third bigger to allow root systems an un-compacted area in which to develop.

Mulching with Wetland Soils – If an area is mulched with soil from an existing wetland, plants should be allowed to germinate and grow for a period prior to fully inundating the wetland pool. Care should be taken not to allow the newly germinated plants to dry out.

Transition from temporary sediment control basin to permanent stormwater quality pond.

Often permanent stormwater management ponds are used for sediment control during construction. In most cases, these facilities will need dewatering and sediment removal in order to insure that the pond has the appropriate volume for permanent stormwater design.

Maintenance of Water Quality Ponds

This includes removal of temporary risers used for sediment control and reseeding bare soil or establishing wetland vegetation in designated areas within the pond.

While maintenance is inevitable, the amount of maintenance required and its cost can vary considerably depending on the initial design of a pond. A number of design features are helpful in this regard:

Sediment Storage – Reduce the frequency of sediment cleanout easily by increasing the volume available for sediment storage. Increasing the permanent pool volume by 20% or according to the predicted sediment loads is recommended. Ponds used for sediment control during construction should be cleaned out when the site is stabilized, as the cost of cleanout will be considerably less expensive during construction than in the future.

On-Site Disposal – Transporting dredged sediment is often the largest cost associated with pond cleanout. This can be avoided by providing an area on-site for future sediment disposal. A disposal site should be designated during site design.

Forebay – Trapping most sediment in a confined, easily accessible forebay can reduce maintenance costs.

Maintenance Easements – Maintenance easements must be established to allow access to the pond, particularly to the forebays, embankment, outlet structure and sediment disposal areas.

Disposal of Pollutants – Water quality treatment practices are intended to trap pollutants. The fate of these pollutants must be considered. Trapped sediment is usually clean enough for on-site use. The large volume of sediment poses the most common disposal problem. Sediments may also have high concentrations of hydrocarbons, nutrients and heavy metals. Soil tests should be done if the pond has received spills, is in a highly industrial area, or if the watershed has intensive traffic.

Sediment should be spoiled in areas, which will keep pollutants bound in the sediment (e.g., metals and phosphorous). To avoid these pollutants from becoming soluble, acid and anaerobic conditions, such as wetlands, should be avoided.

Table 2.6.3 Typical Maintenance Activities For Water Quality Ponds (USEPA) Adapted from WMI, 1997 and SMRC

Schedule	Activity
Monthly	Mow embankment and clean trash and debris from outlet structure. Address any accumulation of hydrocarbons.
Annually	Inspect embankment and outlet structure for damage and proper flow. Remove woody vegetation and fix any eroding areas. Monitor sediment accumulations in forebay and main pool.
Semi-Annually	Inspect wetland areas for invasive plants.
3-7 years	Remove Sediment from forebays.
15-20 years	Monitor sediment accumulations in the main pool and clean as pond becomes eutrophic or pool volume is reduced significantly.

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