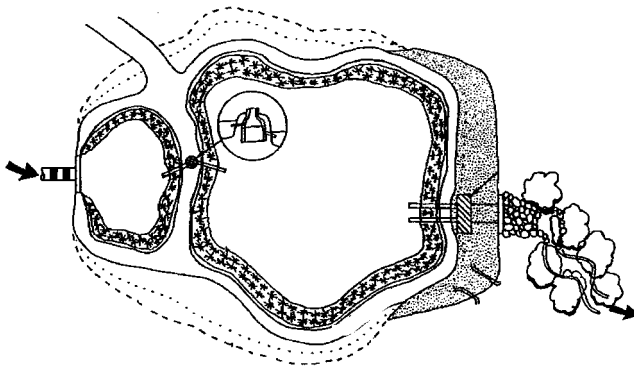


Retention Systems

Extended Storage Ponds



Description

Extended storage ponds (also known as extended detention ponds) are stormwater basins that are designed to provide temporary storage for runoff from multiple design events. Extended storage ponds are typically on-line, end-of-pipe BMPs. Extended storage ponds are not just flood-control measures, but are designed to use detention time as their primary method to allow the physical settling of pollutants. Extended storage allows particulate material and debris to settle out of the water column while drawing the pond down for additional storm event storage. Ponds that use this method can be dry, designed with a shallow marsh or have a permanent pool.

An extended storage pond is typically designed with three distinct stages:

- The top stage of the pond should have the capacity to regulate peak flow rates of large, infrequent storms (10-, 25- or 100-year), and will generally remain dry between storms. The volume in the stage is called the “flood storage volume”.
- The middle stage of the pond is designed to detain smaller storms for a sufficient period of time to remove pollutants from the runoff. The volume in this stage is called the “water quality volume”. The water quality volume is a design term that refers to the volume of water to be treated by the BMP. For extended storage ponds, the water quality volume is typically the runoff from the 0.3-year storm event, since a large fraction of the annual pollutant load is delivered by small, frequent storm events (like the 0.3-year storm).
- A third, bottom stage of extended storage ponds (below the outlet elevation) is optional. It can be designed to be managed in one of several ways. The lower stage can either have a permanent pool of water, have a shallow marsh, or be normally dry between

Purpose

	Water Quantity	Water Quality
Flow attenuation	■	
Runoff volume reduction	□	
Pollution prevention		
Soil erosion		N/A
Sediment control		N/A
Nutrient loading		N/A
Pollution removal		
Total suspended sediment (TSS)	■	
Total phosphorus (P)	■	□
Nitrogen (N)	■	□
Heavy metals	■	□
Floatables*	■	
Oil and grease	■	□
Other		
Fecal coliform		■
Biochemical oxygen demand (BOD)		■

■	Primary design benefit
■	Secondary design benefit
□	Little or no design benefit

* Only if a skimmer is incorporated into the outlet design.

Retention Systems

Extended Storage Ponds

Description (continued)

storm events (for the purpose of sediment storage). Only the first option (an extended storage pond that includes a permanent pool in its lower stage) is discussed in this document. A permanent pool in an extended storage pond functions like a wet pond (see the Wet Pond BMP Section for a more detailed description of wet ponds). Extended storage ponds with a permanent pool of water typically are more effective for pollutant removal than those that are normally dry. The permanent pool of water provides a much higher removal efficiency of suspended solids for very small runoff events by providing sediment storage and a relatively long residence time between storms for settling.

Figure 1 illustrates the difference between the flood storage volume, the water quality volume and the permanent pool in an extended storage pond. Figures 2 and 3 are examples of some typical extended storage pond designs.

For storms with a recurrence interval of about one year, the maximum bounce (water elevation increase) above the permanent pool usually should not exceed 3 ft. The extended storage volume should be drawn down in one to two days after a storm event to prevent destruction of adjacent vegetation by inundation, and to help assure the basin is ready for the next storm. In the Minneapolis-St. Paul area, the time between rainfall events is typically 87 hours.

It should be noted that the recommended drawdown time of 24 to 48 hours for a full pond is based on very limited laboratory data. A few extended storage ponds have been monitored and generally provide a TSS removal efficiency of 60 to 80% with a drawdown time of 24 hours. Forty hours is recommended in order to settle out the finer clay particles in runoff that typically adsorb toxic pollutants.

Sediment and its associated pollutants, such as trace metals and nutrients, are the pollutants most effectively controlled by extended storage ponds. If the pond's outlet is designed as a skimmer, floating debris and organic matter can also be effectively trapped. If a permanent pool or shallow marsh area is included in the design, some removal of fine sediment and soluble nutrients can be achieved.

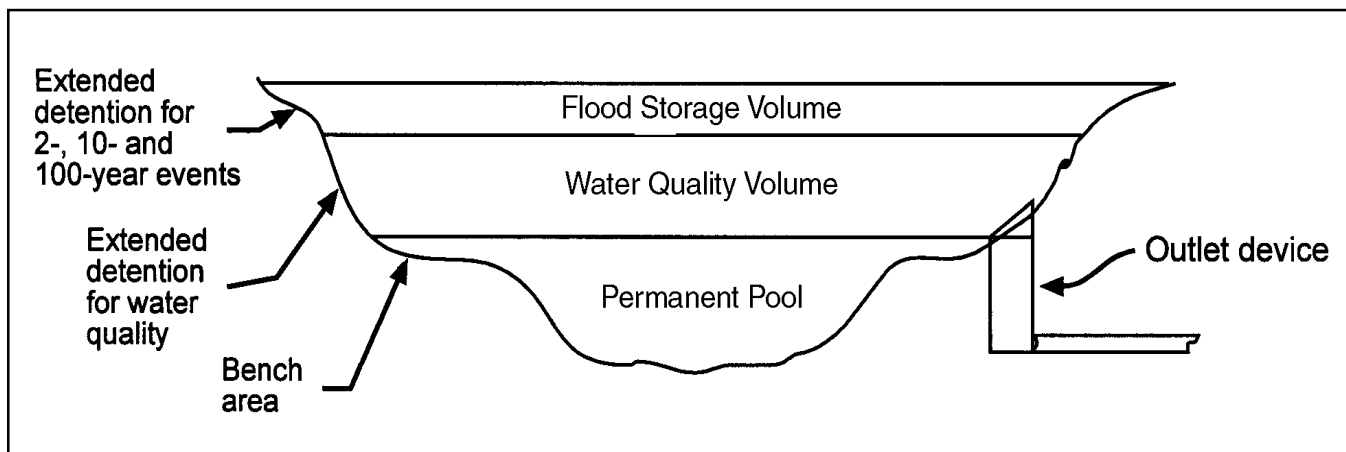


Figure 1: Extended Pond Cross-Section

Source: Adapted from Wet Detention Ponds, Pitt, 1998

Retention Systems

Extended Storage Ponds

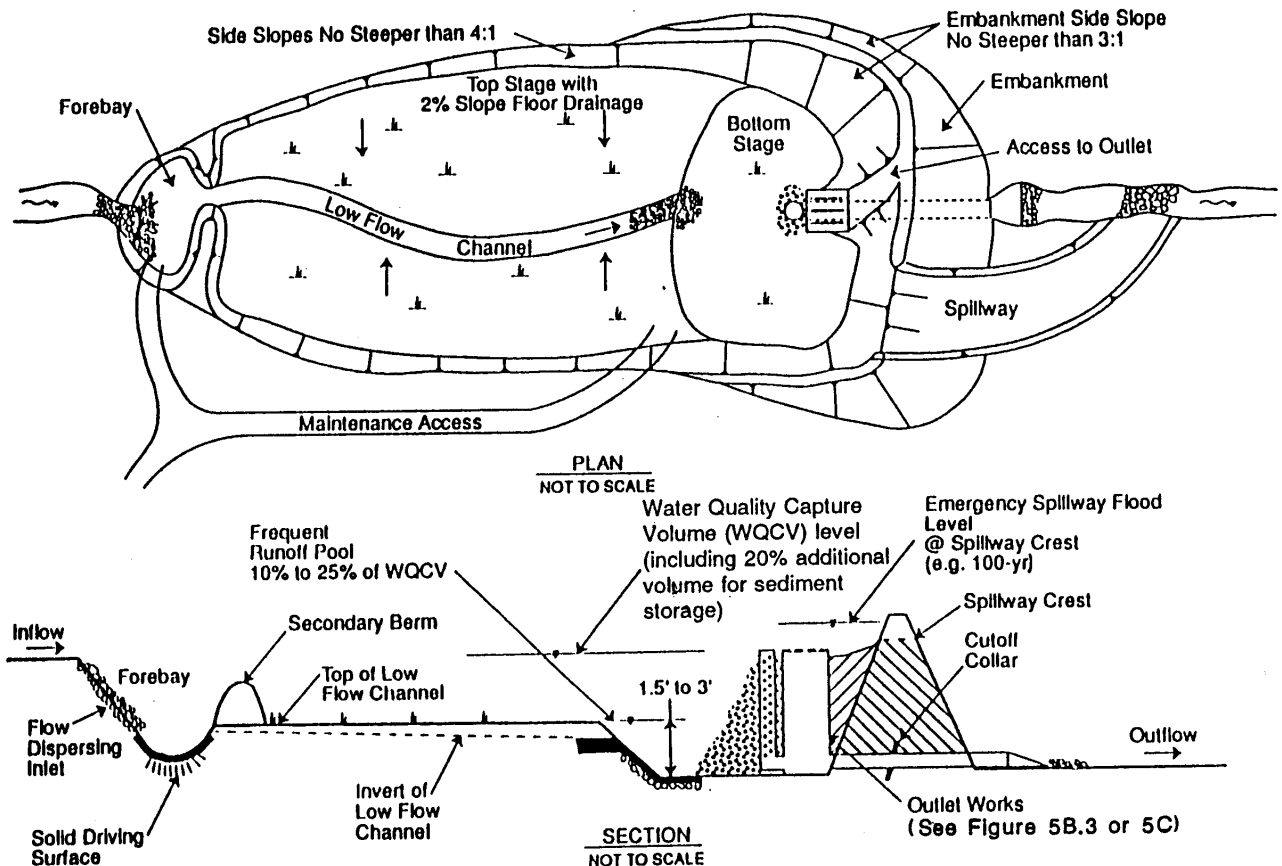


Figure 2: Schematic of an Extended Storage Pond

Source: **Used by Permission**, UDFCD, 1992*

Extended storage ponds are some of the best facilities for treating spring and winter runoff, because of the way that ice conditions effect the flows. Ponds without extended storage may have minimal storage above the ice surface; therefore, treatment could be bypassed. In addition, extended storage ponds are very effective in controlling peak discharges, an important factor in reducing downstream streambank erosion and sediment loads.

Generally, extended storage ponds are not practical if the contributing watershed area is less than 10 acres. Four acres of watershed area are recommended for each acre-foot of storage in the pond.

The efficiency of an extended storage pond depends largely upon the surface overflow rate (defined as the pond outflow rate divided by the pond surface area) (Barfield et al., 1986).

Retention Systems

Extended Storage Ponds

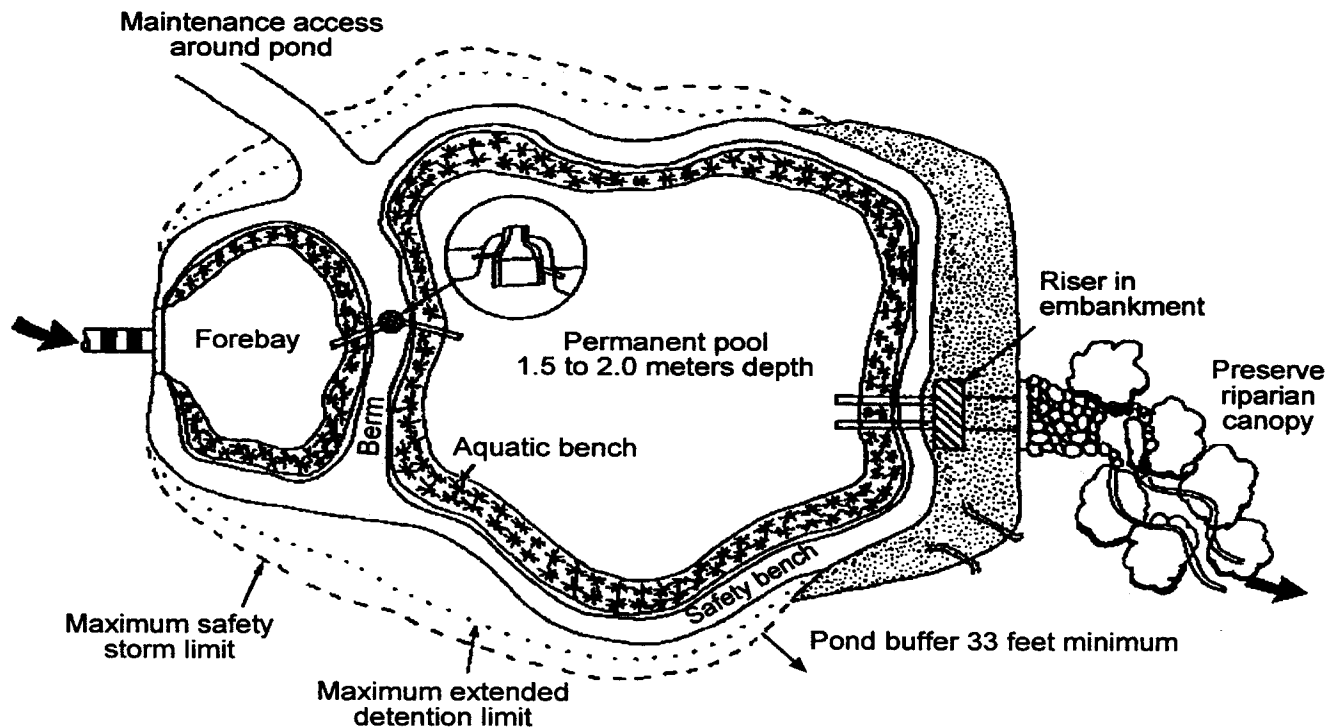


Figure 3: Schematic of an Extended Storage Pond with a Sediment Forebay

Source: Schueler, 1992

Enhancement Options

There are several common modifications that can be made to an extended storage pond to increase its pollutant removal effectiveness. These options are described below.

Adding a shallow wetland

Removal of soluble pollutants can be enhanced in the lower stage of the basin, if it is maintained as a shallow wetland. Establishing wetland vegetation in a shallow marsh component or on an aquatic bench in the lower stage of the detention basin will enhance removal of soluble nutrients, increase sediment trapping, prevent sediment resuspension, and provide wildlife and waterfowl habitat. Proper soils and surface or groundwater depth are needed to maintain wetland vegetation. The degree of removal by such wetlands appears to be dependent upon wetland size in relation to loading.

Sediment forebays

The settling area for incoming sediments can be increased through the addition of a sediment forebay. The use of a sediment forebay, however, is only recommended for wet ponds larger than 4,000 cubic feet. The forebay is an

Retention Systems

Extended Storage Ponds

excavated settling basin or a section separated by a low weir at the head of the primary impoundment. Forebays serve to trap sediments before the runoff enters the primary pool, effectively enhancing removal rates and minimizing long term operation and maintenance problems. Periodic sediment removal from the forebay is easier and less costly than removal from the primary wet pond pool. Sediment forebays should be designed for ease of maintenance. Hard bottom forebays make sediment removal easier, and forebays should be accessible by heavy machinery, if necessary. About 10 to 25% of the surface area of the wet pond should be devoted to the forebay.

The forebay can be distinguished from the remainder of the pond by one of several means: a lateral sill with rooted wetland vegetation, two ponds in series, differential pool depth, rock-filled gabions or retaining wall, or a horizontal rock wall filter placed laterally across the pond. Energy dissipation techniques should be used at the inlet to the sediment forebay to avoid erosion, to promote settling, and to minimize short-circuiting of flows. The length to width ratio of the forebay should be at least 2:1 to minimize short-circuiting.

Low flow channels

A low flow channel routes the last remaining runoff, dry weather flow and groundwater to the permanent pool and outlet. A low flow channel should be installed in the upper stage of the basin to ensure that the basin dries out completely. Low flow channels also serve to prevent erosion of the upper stage of the pond outside as runoff first enters the pond.

Pond shape

The inlet and outlet should be positioned in such a way that short-circuiting in the basin is minimized. Ponds that are considerably longer than wide (e.g. length equal to three times the width) will likely provide additional detention time for settling and biological treatment. Baffles and curved flow paths can also be used to increase settling efficiency.

Advantages

- Least costly BMP that controls both stormwater quantity and quality (in terms of construction costs).
- Can perform well in cold climates.
- Good retrofitting option for existing basins.
- Extended storage ponds that include a dead storage pool can remove significant levels of sediment and sorbed pollutants.
- Potential for beneficial terrestrial and aquatic habitat (depends on design).
- Less potential for hazards than deeper permanent pools
- Can provide excellent streambank erosion protection and treatment of stormwater when used in combination with other stormwater control practices such as wetlands or when retrofitted with permanent pools.

Limitations

- Generally not prescribed for drainage areas smaller than 10 acres.
- Requires relatively large land area.

Retention Systems

Extended Storage Ponds

- Removal of soluble pollutants is minimal if a permanent pool is not incorporated into the design.
- Discharges from ponds can consist of warm water, and thus their use may be limited in areas where warm water discharges will adversely impact a cold-water fishery.
- Sediment can be resuspended in the first stage of the pond after large storms if not removed.
- Cold winter climates may affect the biological removal of pollutants in the pond. (Lower temperatures decrease the rate of biological activity).
- Can often be considered unattractive by residents. Poorly maintained basins can create nuisance odors and collect trash.
- Erosion and resuspension of sediments may occur in the pond if the upper stage is not properly vegetated.
- Depending on their volume and depth, pond designs may require approval from dam safety authorities.

Requirements

Design

In determining the size of the basin, the two most critical parameters are the pond volume and the maximum rate of runoff released from the basin.

Pond Volume and Surface Area

Flood Storage Volume

The flood storage volume can be estimated in a number of ways. A typical approach is to limit the peak outflow rate to some predetermined level, such as the pre-development peak level. Local authorities may also have their own requirements that will dictate the magnitude of the flood storage volume. This volume must be situated above the groundwater table.

Water Quality Volume

When designing an extended storage pond, it's important to recognize that small storms (typically less than 1.25-inch events or 0.3-year return frequency events) that produce less than 0.5 inch of runoff) deliver the majority of the pollutants throughout an average year (Pitt, 1994 and 1998). If small storms are not considered in the design, their effects may not be adequately treated.

Therefore, the minimum recommended water quality volume for extended storage is the total volume of runoff from a 1.25-inch event (a storm with a return frequency of once in about 0.3 years). This should be calculated as an instant runoff volume. In other words, this volume should be considered to arrive at the pond all at once, rather than over the course of several hours or days.

In some urban areas, the water quality volume is often considered as 0.5 inch of runoff for all impervious areas in the watershed (MPCA, Construction Storm Water Permit). The 0.5-inch criterion is intended to be a simplified calculation of the runoff volume from the 1.25-inch event in residential areas. If you are required to meet other regulatory requirements, the MPCA recommends calculating both the 1.25-inch and other regulatory volumes, then using the larger measure for the water quality volume in the design. This volume must be situated above the groundwater table.

Retention Systems

Extended Storage Ponds

Permanent Pool Volume

The design requirements outlined in the Wet Ponds BMP section are pertinent to the design of the permanent pool in the lower stage of an extended storage pond. The only significant difference between a wet pond and the permanent pool in an extended storage pond is that the wet pond's volume must encompass the entire water quality volume (a wet pond design relies on only its permanent pool for treatment, whereas the permanent pool in an extended storage pond acts more like a "polishing" stage of the pond).

A minimum average depth of 3 feet is recommended in the permanent pool. The surface area of the permanent pool should be larger than 0.25 acres. Site constraints will likely play a role in determining the surface area of the permanent pool. Other sizing parameters will be determined by scour prevention requirements (see Scour Control, below).

Water Quantity Control Requirements:

Extended storage pond design must account for large, infrequent storm events for runoff quantity control, as well as small, frequent storm events for runoff quality control. This is usually achieved through the use of a multiple-stage outlet design. The Alternative Outlets BMP Section will cover the design of extended storage outlets in more detail.

Large storm events

Local authorities will likely have their own runoff control requirements for large storm events. Many watersheds require that the post-development peak runoff rate must equal the peak runoff rate from the 10- and 100- year pre-development events. In addition, low floor elevations of structures are typically required to be at least 0.3 to 3 feet above the 100-year flood elevation. These rates and elevations need to be considered in the pond-design phase, in addition to the water quality treatment and erosion control design.

Small storm events

Typically, the first flush of runoff contains the highest concentrations of pollutants. Thus, extended storage ponds should be designed to maximize the detention time for the most frequent storms. Routing calculations for a range of storms should provide the designer with the optimal basin size. Generally, most particulates settle within the first 12 hours of detention; however, additional time is required to settle finer particulates. Twenty-four hours is the minimum detention time necessary for optimal pollutant removal.

The design detention time can be achieved by adjusting the outflow rate from the basin. As the outflow rate is decreased, the detention time and the required temporary storage volume will be increased.

Although detention time is widely used in design, problems are often encountered in defining detention time in the case of intermittent stormwater flows. It is essentially impossible to define a detention time for stormwater flows (US EPA, 1983). To provide 90% overall removal, a design criterion has been established which will provide reasonable treatment given the assumptions about storm events, particle size distribution and settling velocities. To standardize design methods, the MPCA has selected an outflow rate of 5.66 cfs per surface acre of treatment pond. This outflow rate has been selected to provide 90% removal of TSS for a volume equal to the runoff from the 0.3-year return frequency event. This is about 1.25 inches of precipitation in the Minneapolis/St. Paul area.

Retention Systems

Extended Storage Ponds

Requirements

Design (continued)

The outlet device can therefore be designed to provide the desired outflow rate of 5.66 cfs per acre of pond surface area for the water quality volume (Pitt, 1994 and 1998) and appropriate rates for the two-, 10- and 100 year events

Pond Depth

Maximum depth of an extended storage pond may range from 3 to 12 feet (above the permanent pool). The depth of the basin may be limited by groundwater conditions or by soils. Extended storage ponds should be above normal groundwater elevation (i.e. should not intercept groundwater).

The depth of the permanent pool should be designed with other considerations in mind (see the Wet Pond BMP section for more detail).

Avoidance of Short-Circuiting and the Promotion of Plug Flow:

To prevent short-circuiting, water is forced to flow, to the extent practical, to all potentially available flow routes, avoiding "dead zones" and maximizing the time water stays in the pond during the active part of a storm. Design features that encourage plug flow and avoid dead zones are:

- Providing a broad surface for water exchange across cells rather than a constricted area.
- Maximizing the flowpath between inlet and outlet, including the vertical path, also enhances treatment by increasing residence time. Baffles or islands can be added within the permanent pool to increase the flow path.
- The ratio of flowpath length to width from the inlet to the outlet should be at least 3:1. The flowpath length is defined as the distance from the inlet to the outlet, as measured at mid-depth. The width at mid-depth can be found as follows: $\text{width} = (\text{average top width} + \text{average bottom width})/2$.
- All inlets should enter the first cell. If there are multiple inlets, the length-to-width ratio should be based on the average flowpath length for all inlets.
- Using a teardrop shape (as opposed to a rectangular one), as it minimizes dead zones caused by corners.

Pond Slopes

The side slopes of the permanent pool should be no steeper than 3:1. Flatter slopes help to prevent erosion of the banks during larger storms and make routine bank maintenance tasks, such as mowing, easier. Flat slopes also provide for public safety, and allow easier access. Furthermore, the sides of the pool that extend below the safety and aquatic benches to the bottom of the pool should be at a slope that will remain stable, usually no steeper than 2:1 (horizontal: vertical). Slopes leading to the wet pond should be no steeper than 3:1.

Sediment Management

Adequate sediment storage should be provided, usually to hold five to 25 years of sediment accumulation. A forebay at the inlet to the sediment basin can be used to trap coarse sediments, such as road sand, and large debris, such as leaves and branches. If sediment is removed from the forebay or the entire basin on a more frequent basis, the sediment storage volume in the basin may be reduced. A common (and recommended)

Retention Systems

Extended Storage Ponds

maintenance cycle is five years. Sediments can be resuspended by the incoming runoff. Therefore, it is recommended that there is either an additional plunge pool at the inlet (forebay) of the basin or sufficient measures such as riprap to dissipate the energy.

A sediment forebay or similar pretreatment device is highly recommended to enhance pollutant removal and to prolong pond effectiveness in larger (>4,000 cubic feet) facilities.

An access for maintenance, minimum width of 10 feet and a maximum slope of 15%, must be provided by public or private right-of-way. This access should never cross the emergency spillway, unless the spillway has been designed for that purpose.

An emergency drain (with a pipe sized to drain the pond in less than 24 hours) should be installed in all ponds to allow access for riser repairs and sediment removal (Schueler, 1987).

Sediment Storage Design

The original design volume of the wet pond should take into account gradual sediment accumulation. Sediment volume should be at least the MPCA permit requirement of 250 cubic feet (ft³) per acre of impervious surface. Another alternative is to design the permanent pool with a capacity for a certain number of years of storage. A detailed analysis of pond sediment storage volume may be helpful to determine cost-effective sediment control plans. Methods such as the NRCS use equations that address many of the sediment storage factors, but they should be evaluated by professionals on a site-specific basis. The basic equation and design considerations are:

$$\text{Vol} = A \times Y \times \text{DR} \times \text{TE} \times E / (217,800 \times G)$$

where: Vol = design sediment storage capacity,

E = average rate of erosion in the watershed in tons/acre/year,

A = area of the watershed in acres,

DR = sediment delivery ratio in percent,

G = estimated sediment density in the basin in pounds per cubic foot,

TE = trap efficiency, in percent, and

Y = design storage period in years.

Pond Inlet/Outlet Structures and Pipes

The pond should be designed in such a way that turbulence in the main treatment area is minimized. For example, inflow points should be designed with energy dissipaters to reduce inflow velocity. Reducing the turbulence will reduce the chance that previously deposited materials will be resuspended. It will also result in conditions more conducive to settling while the pond is filling.

The outlet area should be a deeper micropool to provide final settling and prevent resuspension of sediments. The outlet device should be carefully designed, since it is important to the operation of the entire pond system.

Several options that are available for pond outlets are discussed in the “Alternative Outlets” BMP Section.

In most cases, emergency spillways should be included in the pond design. Emergency spillways should be sized to safely pass flows that exceed the design storm flows. The spillway prevents pond water levels from overtopping

Retention Systems

Extended Storage Ponds

Requirements

Design (continued)

the embankment, which could cause structural damage to the embankment. The emergency spillway should be located so that downstream buildings and structures will not be negatively impacted by spillway discharges. The pond design should include an emergency drain to assist in pond maintenance. The drain pipe should be designed for gravity discharge and should be equipped with an adjustable gate valve. Embankments and spillways should be designed in conformance with the state Dam Safety regulations and criteria.

The design of the wet pond embankment is another key factor to be considered. Proper design and construction of the embankments will prolong the integrity of the pond structure. Subsidence and settling will likely occur after an embankment is constructed. Therefore during construction, the embankment should be overfilled by at least 5 percent (SEWRPC, 1991). Seepage through the embankment can also affect the stability of the structure. Seepage can generally be minimized by adding drains, anti seepage collars, and core trenches. The embankment side slopes can be protected from erosion by using minimum side slopes of 3:1 and by covering the embankment with vegetation or riprap. The embankment should also have a minimum top width of 2 meters (6 feet) to aid in maintenance.

Low-Flow Channels

A low flow channel routes the last remaining runoff, dry weather flow and groundwater to the permanent pool and outlet. A low flow channel should be installed in the upper stage of the basin to ensure that the basin dries out completely. Low flow channels also serve to prevent erosion of the upper stage of the pond outside as runoff first enters the pond. Pervious or impervious channel lining may be used. A pervious lining allows interaction of the runoff with the soil and grass, resulting in increased sorption of pollutants. Design velocities in pervious low flow channels should be high enough to prevent sedimentation and low enough to prevent scouring and erosion. No minimum low flow channel velocity is needed if a forebay is utilized prior to the low flow channel. The maximum flow velocity is dependent on the nature of the material used to line the channel.

Scour Control

Scour is the erosion of pond bottom or bank material due to high flow velocities. Scour control is important to maintain the function of the pond and reduce erosion, especially near the inlet. Inlet areas and inlet structures should be designed to control velocities at the inlet whether from large or small storm events.

Flow-diffusion devices, including plunge pools, directional berms or other specially created dissipation structures, are often recommended. For annual events, the velocity leaving the inlet area and entering the main treatment area should be less than 1 ft per second (fps). Decreasing velocity reduces scour and more importantly reduces mixing currents that reduce treatment efficiency.

The MPCA recommends that the following design storms be considered in the pond design (MPCA, 2000). Scour prevention can be achieved if velocities through the main treatment area are limited to the following maximums:

1 foot per second for the 1-year, 2.4-inch event:

3 feet per second for the 2-year, 2.8-inch event:

5 feet per second for the 10-year, 4.0-inch event and the 100-year, 6.0-inch event

Retention Systems

Extended Storage Ponds

Velocities are calculated as outflow divided by the area of the critical cross-section. All events are considered to be the 24-hour NRCS distribution event.

Design for Winter Runoff Conditions

During the winter period, the design volume of the wet pond can be less than desired. Ground freezing throughout the tributary watershed effectively increases the watershed's imperviousness, which increases the fraction of precipitation that reaches the pond. Moreover, the available volume in the permanent pool can be reduced by the formation of ice. Fortunately, winter rainfall and snowmelt events (as opposed to spring) typically produce lower volumes of runoff than summer storms and so most events will continue to be captured entirely (e.g. the volume of runoff will be less than the reduced volume of the wet pond). However, temperature regimes in the northern regions of Minnesota are such that ice cover may persist into the spring period when runoff rates and contaminant washoff rates are higher. In these areas, some authorities recommend that the wet pond volume be increased by an amount equal to the expected volume of the ice cover (Ontario Ministry of the Environment, 1999).

The thickness of ice can be estimated using Stefan's equation (Marsalek, 2000):

$$h = a (D_f)^{0.5}$$

Where: h is the ice thickness in mm

a is a coefficient of ice growth

D_f is the sum of freezing degree-days

The values for the coefficient for ice growth are shown below.

Condition	a (mm°C ^{-0.5} d ^{-0.5})
Theoretical Maximum	34
Windy Lake with No Snow	27
Average Lake with Snow	17-24
Average River with Snow	14-17
Shelter River with Rapid Flow	7-14

Work done a pond in Kingston, Ontario indicated that a coefficient value of 15 produced results close to measured values. The pond operated with a constant subsurface inflow, which tended to limit the buildup of ice. In general, it is expected that most ponds will be small enough and will receive sufficient inflow to behave more like a river (in terms of ice buildup) than a lake. Where possible however, the designer should consult with the local authorities concerning local knowledge on ice depths (Ontario Ministry of the Environment, 1999).

Snowmelt runoff events in Minnesota may convey high concentrations of urban runoff pollutants to stormwater ponds and other receiving waters. Recommendations to manage this potential influx of contaminated snow and ice melt include: incorporating extended storage (see the Extended Storage Ponds BMP Section) in the pond design, installing grass swales in the drainage system ahead of stormwater ponds, and storing contaminated snow and ice where debris and petroleum products are less likely to be transported to the pond (Oberts, 1991).

Retention Systems

Extended Storage Ponds

Requirements

Design (continued)

Water can flow over the ice in stormwater ponds during spring thaw, and may carry sediment directly out of the pond outlet. If this is a concern for a particular pond design, it is generally a good idea to incorporate extended storage capability of the pond. One can also increase the depth of the pond below the water quality spillway, thus allowing more room for the ice to collapse into the pond. If the pond is located in an area with a high water table, it may not be feasible to make this design modification.

Standpipe outlets may be destroyed by ice movement in winter. Standpipes are not recommended unless they are designed to withstand ice movement.

In Minnesota's urban areas, snow piles are often created in parking lots, along streets and elsewhere. Store snow where debris oil and other materials cannot readily enter waters of the state. Discharge of such materials directly to waters of the state is prohibited. So, snow-storage areas that minimize surface-water impacts should be planned.

Following the recommendations of this BMP section, by providing deep inlet and outlet zones or multiple pools, will usually result in designs that are robust enough to handle the winter and spring conditions without special considerations. However, runoff volume from spring snowmelt events can be very large, often the largest-volume event of the year. Ponds designed to function effectively in summer are often disrupted by winter and spring events. Inspection and maintenance during spring runoff should be a consistent feature of stormwater treatment systems in cold climates.

Sequencing

- Extended storage ponds may be constructed in the early phases of a development project, in order to treat site runoff during construction.
- If the basin is used as a sediment trap during construction, all sediment deposited during construction should be removed before normal operation begins.

Construction

- As with other stormwater BMPs, soils, depth to bedrock, and depth to water table must be investigated before designing an extended storage pond. At sites where bedrock is close to the surface, high excavation costs may make wet ponds infeasible. If the soils on site are relatively permeable or well drained, it will be difficult to maintain a permanent pool. In this situation, it may be necessary to line the bottom of the wet pond to reduce infiltration.
- All local, state and federal permit requirements should be established prior to initiating the pond design. Depending on the location of the pond, required permits and certifications may include wetland permits, water quality certifications, dam safety permits, sediment and erosion control plans, waterway permits, local grading permits, land use approvals, etc. (Schueler, 1992). Since many states and municipalities are still in the process of developing or modifying storm water permit requirements, the applicable requirements should be confirmed with the appropriate regulatory authorities.
- Pond systems can perform well in cold climates because many modification options are available to increase their effectiveness in frigid and snowy conditions. Many of these modifications address the problems associated with pipe freezing.

Retention Systems

Extended Storage Ponds

- To be effective in reducing peak runoff rates, the basin must be located where it can intercept most of the runoff from the site. Usually, this location is found at the lowest elevation of the site.

Maintenance

- Maintenance is required for the proper operation of extended storage ponds. Plans for extended storage ponds should identify owners, parties responsible for maintenance, and an inspection and maintenance schedule for extended storage ponds.
- Once constructed, the extended storage pond should be inspected after several storm events to confirm drainage system functions, bank stability, and vegetation growth. The outlet structure should be inspected for evidence of clogging or outflow release velocities that are greater than design flow. Problems should be addressed immediately.
- At least twice during the growing season, accumulated trash and debris should be removed from the side slopes, embankment, emergency spillway and outflow trash racks. Accumulated sediment in the forebay should be inspected at the same time.
- All extended storage outlet devices should be protected from clogging. All devices should have above-ground access for cleanout, should this be necessary.
- Extended storage ponds should be inspected at least once per year to ensure that they are operating as designed. Potential problems that should be checked include: subsidence, erosion, cracking or tree growth on the embankment; damage to the emergency spillway; sediment accumulation around the outlet; inadequacy of the inlet/outlet channel erosion control measures; changes in the condition of the pilot channel; and erosion within the basin and banks. Any necessary repairs should be made immediately. During inspections, changes to the extended storage pond or the contributing watershed should be noted, as these may affect basin performance.
- Sediment should be removed from the pond as necessary, and at least once every 5 to 25 years (usually more frequently than once every 25 years). The frequency of sediment removal depends on the years of sediment accumulation that were incorporated into the design of the volume of the wet pond's permanent pool and forebay.
- In most cases, no specific limitations have been placed on disposal of sediments removed from wet detention ponds. Studies to date indicate that pond sediments are likely to meet toxicity limits and can be safely landfilled. On-site sediment disposal is always preferable (if local authorities permit it) as long as the sediments are deposited away from the shoreline to prevent their re entry into the pond.
- Sediments should be tested for toxicants in compliance with current disposal requirements if land uses in the catchment include commercial or industrial zones, or if visual or olfactory indications of pollution are noticed.
- Mosquito control, if necessary.

Retention Systems

Extended Storage Ponds

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