2.6 Wet Extended Detention Basin

Description

A wet extended detention basin provides temporary storage for stormwater runoff above a permanent pool. The temporary storage volume is released over a period of at least 24 hours to give time for suspended solids to settle and to protect the receiving channel from erosive discharge. The permanent pool limits resuspension of sediment by subsequent storm events while promoting physical, biological, and chemical processes that remove pollutants in between runoff events. Forebays, aquatic benches, and other features foster these treatment processes.

A wet extended detention basin can provide secondary benefits such as flood control, wildlife habitat, water supply for fire protection, or serve as an aesthetic landscape feature, but these uses must not interfere with its primary water quality function.

Credits

Table 2.6.1 Credits for a Wet Extended Detention Basin Meeting the Criteria in this Chapter

Objective	Credit
Runoff Reduction Volume (RRv)	None.

Planning and Feasibility

A permanent pool is central to the function of a wet extended detention basin. Therefore this practice is best suited for locations where the contributing drainage area is sufficient to sustain a permanent pool during normal to dry weather patterns. A drainage area of at least six acres is recommended for surface runoff supported basins in urbanized areas.

A drainage area producing insufficient runoff or runoff with high nutrient load, as well as an improperly designed pool, may exhibit problems common to eutrophic basins such as excess algae and low dissolved oxygen levels. These conditions reduce treatment performance and create nuisances such as surface scum, fish kills, and odor.

Do not design a wet extended detention to receive natural stream flow (often described as in-line or side-saddle). These configurations interfere with the natural transport of channel bed load which can cause excessive sediment accumulation, limiting the functional life of the practice.

A wet extended detention basin may not be appropriate if the receiving water is a cold-water fishery. The permanent pool acts as a heat sink between storm events during the summer months such that discharges of warm water can impact the thermal regime of ecologically sensitive receiving waters.

Suitable soil must be available for constructing a stable embankment and ensuring sufficient impermeability. Prior to final design, a qualified professional should conduct an on-site soil evaluation to characterize the adequacy of the soil stratum of the proposed pool, embankment, and borrow areas. Do not rely solely on web soil survey data to characterize the engineering properties of soils for design purposes.

Dams are regulated under the Ohio Revised Code (ORC) 1501:21 Dam Safety Administrative Rules. A dam is exempt from the state's authority (ORC Section 1521.062) if it is six 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 Department of Natural Resources for the most current requirements.

Existing stormwater retention ponds that pre-date water quality requirements may be retrofitted to meet the criteria in this chapter.

Design Criteria

There are two principal aspects to the design of a wet extended detention basin. First, the hydrologic and hydraulic design ensures the proper volume of stormwater runoff is captured, stored, detained, and safely discharged. Second and sometimes overlooked, is design of the basin's geometry (shape and depth) and other features that maximize pollutant removal performance. To meet post-construction stormwater management objectives and maximize the functional life of the practice, design a wet extended detention basin according to the following criteria.

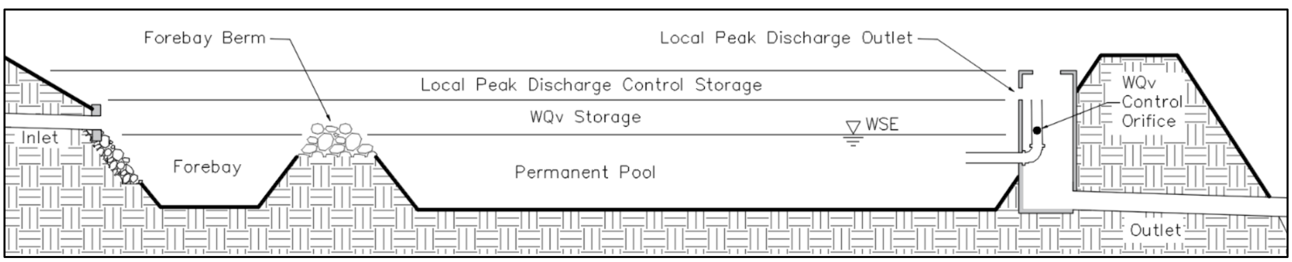

Figure 2.6.1 Typical wet extended detention basin section.

Water Quality Volume Storage

Provide a temporary or detention storage volume equal to the water quality volume (WQv) above the permanent pool and below to the invert of a local peak discharge control outlet or the auxiliary spillway (see Figure 2.6.1). Calculate the WQv for the drainage area to the basin as described in Chapter 2.16 and as required by Ohio EPA's NPDES general permit for construction activities.

Outlet Structure and Drawdown

Design an outlet structure to drain or draw down the WQv storage over a minimum 24-hour period with less than 50 percent of the WQv storage emptying within the first eight hours. Targeting a 24-hour drawdown period extends detention of the WQv long enough to provide treatment but short enough to provide storage for subsequent rainfall events. It also mitigates erosion of the receiving channel by reducing the outflow rates.

Extended detention of the WQv can require a small orifice or weir outlet that must be designed to minimize blockage by floatable debris, organic matter, ice, and sediment. The WQv outlet control must be constructed of durable materials in a manner that it will not easily be dislodged or damaged and must be accessible for inspection and maintenance.

Various outlet structure configurations (see Figure 2.6.2) can be used to protect a small orifice from clogging. Inlets designed to draw water from below the surface and away from the shoreline which, especially when coupled with a gravel filter and/or perforated intake pipe, can prevent debris and organic matter from clogging the small orifice. Locating the orifice within a larger riser is recommended to facilitate access and protect it from damage.

A well-designed outlet combined with reasonable maintenance activity can successfully sustain flow through an orifice under two inches in diameter, but the designer is encouraged to use professional judgement when specifying a smaller orifice. If the 24-hour drawdown necessitates an unreasonably small control orifice, a broader, shallower basin or a different post-construction stormwater management practice may be more appropriate.

In addition to the sizing and configuration of the water quality control outlet, design the outlet spillway to be structurally sound. The WQv outlet control must be constructed in a manner that it will not easily be dislodged or damaged and must be accessible for inspection and maintenance. Specify:

- durable pipe and other materials that will resist degradation under ultraviolet light, oxidation, and other forms of corrosion and
- proper grouting or sealing of any joints and pipe penetrations to prevent unintentional bypass of the orifice control.

An outfall to a stream or ditch must be stable for the maximum (pipe-full) design discharge. Use outlet protection consistent with state or local guidance to prevent erosion of the receiving channel bed or banks. Minimize any necessary modifications to the receiving stream.

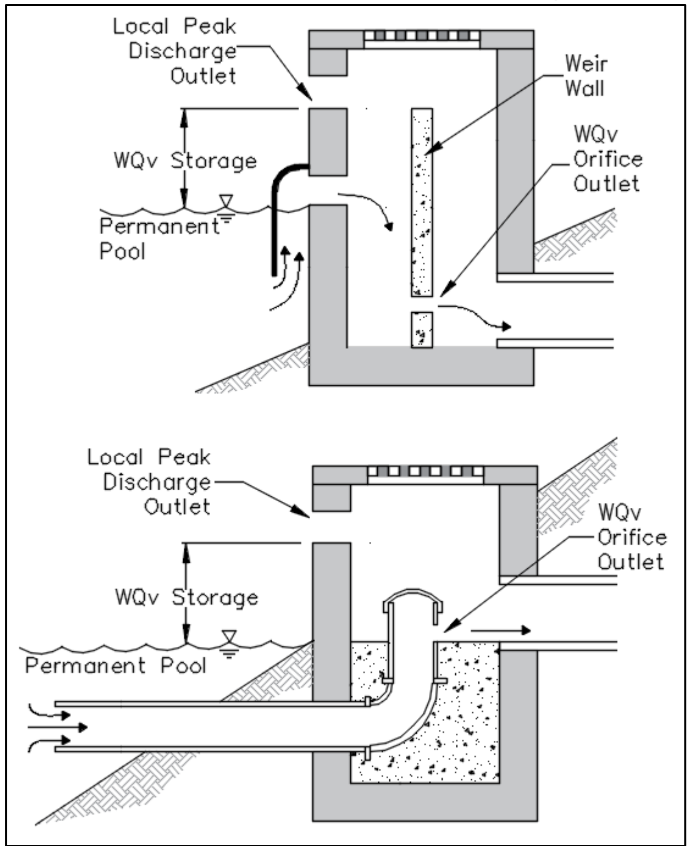

Figure 2.6.2 Conceptual illustrations of small orifice control protection (not to scale).

A wet extended detention basin shall have an auxiliary outlet to pass storm events that exceed the WQv.

Local Peak Discharge Control

Where local regulations require controlling the runoff peak discharge of moderate to large storm events using the critical storm or other method, a multi-stage storage volume and outlet may be needed. It is not necessary to stack the flood control storage volume above WQv except where required by local regulations. The WQv storage must be developed prior to activation of an upper peak discharge control.

Permanent Pool Volume

The permanent pool volume is the total volume of the basin up to the elevation of the water quality control outlet. In other words, the maximum volume of water that can be stored in the basin without discharging. The elevation of the permanent pool is referred to as the normal water surface elevation (WSE) or normal pool elevation, although the water surface may routinely be below this elevation during extended dry weather. The permanent pool volume of a wet extended detention basin, including the volume in forebays, must be at least 120 percent or 1.2 times the WQv. Twenty percent of this volume is considered a sacrificial volume for sediment accumulation.

Forebay(s)

A forebay is a small basin or plunge pool located at the inlet to a practice, separate from the main pool, and readily accessible for maintenance. It serves multiple functions: sedimentation, energy dissipation, and inflow dispersion. A forebay pool absorbs the energy of incoming concentrated runoff before distributing it throughout the primary pool as slow, uniform flow over a berm. This improves the mean water residence time and promotes the gravitational settling of finer particles within the main pool. A forebay also facilitates maintenance by capturing coarse solids that rapidly settle in a confined, accessible area.

Where feasible, locate a forebay at concentrated flow inlets that convey runoff from 10 percent or more of the basin's total drainage area or any inlet expected to contribute an excessive sediment load. Size the forebay for a single inlet to occupy at least 20 percent of the permanent pool surface area. Divide this area among multiple forebays if the basin has multiple inlets. A forebay may be designed to receive multiple inlets.

Image 2.6.1 Forebay with a rockfill berm.

The average depth of the forebay pool should be at least three feet to dissipate turbulent inflow without scouring and resuspending previously deposited sediment.

Separate the forebay from the main pool with a berm designed to distribute non-erosive overflow into the main pool. Recommended berm designs include: 1) a submerged earth berm capped with a stone dike (see Figure 2.6.1) or an aquatic (wetland) bench; 2) an earthen berm that extends above the permanent pool with an armored spillway; or 3) a rock check dam (see Image 2.6.1) extending above the permanent pool.

Design the forebay to ease sediment cleanout. Provide unobstructed equipment access to the forebay. If possible, include a graduated rod to better estimate sediment accumulation. A concrete forebay floor may also ease sediment removal.

Basin Layout

The layout or geometry of a wet extended detention basin may have a significant effect on its ability to capture sediment even when the volumetric requirements are met. Hydraulic inefficiencies such as short-circuiting of the pool and dead zones can reduce the effectiveness of the practice (Pitt, 2000) by shortening the water residence time during which gravitational settling and biological treatment processes function. To maximize effectiveness, lay out a wet extended detention basin to meet the following two objectives.

1. **Widely space the inlet(s) and outlet to minimize short-circuiting.** Lay out a long, narrow basin as illustrated in Figure 2.6.3.a or use internal baffles (extending above the temporary WQv storage) to develop a flow length between the inlet and outlet at least two times the average flow width (2L:1W) preferably up to five times the width.

   For basins with multiple inlets, the ratio of the shortest flow path to the overall flow path should be at least 0.5 as illustrated in Figure 2.6.3.b. The shortest flow path is the distance from the outlet to the closest concentrated flow inlet (excluding inlets collecting less than 10 percent of the drainage area) to the outlet.

2. **Shape the basin to avoid coves or corners that may be subject to stagnation.** In addition to reducing treatment efficiency, stagnant zones within the pool promote nuisances including algal growth, surface scum, and odor. Note that some shoreline irregularity may be desirable to create a more natural appearing water body.

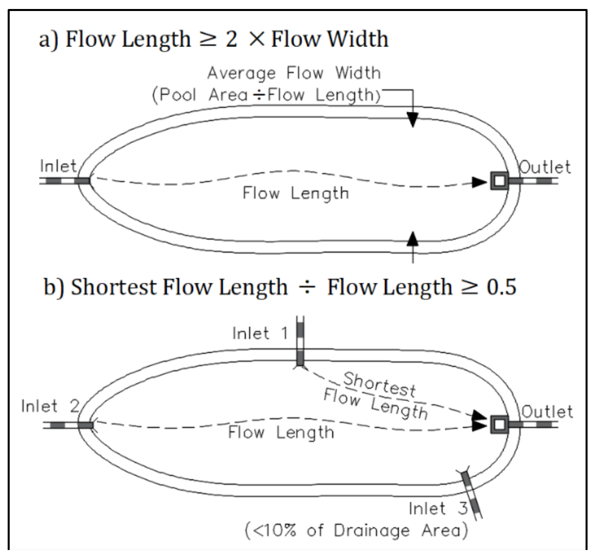

Figure 2.6.3 Illustrations of basin geometry (after Hirschman, 2009).

If site conditions prohibit shaping a basin to achieve these two objectives, other means to minimize short-circuiting and dead zones can include utilizing an internal baffle or extending the water quality volume outlet to a more distant intake point as illustrated in Figures 2.6.4a and 2.6.4b to lengthen the flow path. A forebay berm (see Figure 2.6.4c) may be used to disperse flow as previously discussed where the inlet and outlet are not exceptionally close. In some cases it may be possible to reorient the inlet and forebay such that the momentum from inflow promotes better circulation through the pool as illustrated in Figure 2.6.4d. Lastly, increase the basin surface area and permanent pool volume to compensate for anticipated dead zones and reduce energy in incoming stormwater with riprap. The increased surface area should produce in a WQv storage depth of 0.3 feet or less.

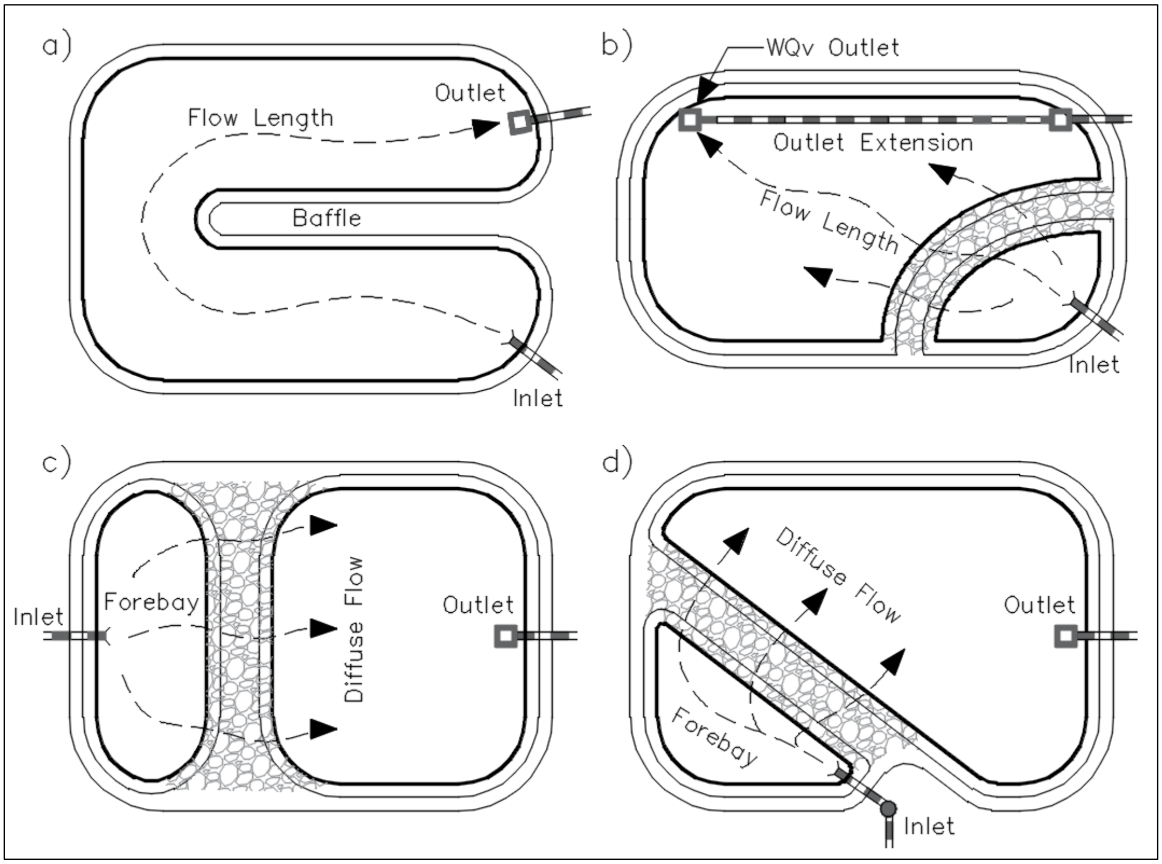

Figure 2.6.4 Conceptual illustrations of a) an internal baffle, b) the WQv outlet extended to a distant point, c) a forebay baffle to diffuse flow, d) directing the inlet away from the outlet.

Basin Depth

Basin depth is another important geometric design criterion. An overly shallow pool increases the potential for scour and re-suspension of previously captured sediment while an overly deep pool can present an imbalance between the pool volume and surface area resulting in a short flow path that allows runoff to short-circuit treatment.

The mean depth (storage volume divided by the surface area at the water quality outlet) of the permanent pool should be between three and six feet. Cattails and other nuisance vegetation are more likely to colonize pools less than three feet deep. If a high water table, bedrock, or other conditions limit the basin depth, an extended detention constructed wetland (Chapter 2.8) may be a more suitable practice.

A permanent pool depth of greater than 10 feet may develop thermal stratification resulting in anaerobic conditions that enable phosphorus and other pollutants to be released from benthic sediment back into the water column. Limiting the depth to 10 feet should be considered where the receiving waters have nutrient load limitation. Additionally, seasonal turnover in thermal stratified pools often causes fish kills.

Basin Side Slopes and Aquatic Benches

The side slopes of the basin shall be designed for stability and should not be steeper than 3:1. Incorporating benches or shelves in steep slopes can increase bank stability and improve safety.

A shallow bench below the normal pool, often referred to as an aquatic bench, may be used to create a wetland-like feature along the perimeter that, in addition to improving bank stability, can:

- provide additional pollutant removal mechanisms;
- improve safety by creating a vegetative barrier to discourage children from venturing into deeper water and reducing the hazard of steep grades at the basin edge;
- protect the shoreline from erosion due to wave action;
- create habitat for fish and other desired aquatic species; and
- deter geese habitation.

An aquatic bench should be six feet wide with variable depths of six to 18 inches. Overly wide aquatic benches and benches placed in stagnant areas may further short-circuiting by pushing flow toward the center toward the center of the pool. See Chapter 2.8 for guidance on establishing wetland vegetation.

Basin Liners

Minor seepage losses are normal with any water impoundment and can even provide beneficial circulation within the pool, however excessive seepage through overly permeable soils or fractured bedrock should not occur. In addition to destabilizing the normal pool elevation, the direct discharge to ground water presents the risk of its contamination by soluble pollutants in stormwater. Soil profiles consisting of clay, sandy clay, or silty clay to a depth of three feet below the pond typically provide sufficient impermeability under standard compaction. Soil borings are advised prior to locating a basin where sandy or loamy soil strata (plastic index < 12 and liquid limit < 25) are expected. Soil borings can confirm soil suitability and are used to determine compaction specifications or if a liner may be necessary. An infiltration basin (Chapter 2.11) may be a more suitable practice in moderately permeable soils.

If the drainage area contains a pollution hotspot or the basin is located in an area known to exhibit fractured bedrock (for example karst formations), soil borings must confirm a cover of in-situ soil with sufficient impermeability ($<10^{-7}$ cm/sec). If the in-situ soil or densification of it is not suitable, specify a clay or synthetic liner, or the use of a soil additive such as sodium bentonite or soda ash. Consult *NRCS Conservation Practice Standard - Pond Sealing or Lining*[1] (520, 521, or 522) for design guidance for each type of liner.

Consider a liner if the drainage area may not supply a sufficient volume of surface runoff to maintain a stable pool.

Basins in Series

Sizing criteria in this chapter apply to a singular basin serving as the primary practice. The overall TSS removal, runoff capture volume, and discharge rates of multiple basins placed in series (one basin discharges into another basin) must be shown to meet the NDPES construction stormwater general permit requirements through a stormwater management model (SWMM) such as U.S. EPA SWMM, PCSWMM, or winSLAMM.

Design Considerations

In addition to the proceeding design criteria that address the stormwater management function, other design considerations are necessary to ensure a sound and successful practice. Consider the following items when designing a wet extended detention basin and address them as appropriate.

Structural Integrity

Designers are encouraged to review both *Conservation Practice Standard Code 378 - Pond* and *Engineering Field*

Handbook Chapter 11 - Ponds and Reservoirs [1] for guidance the design of the spillways and embankment. In all cases:

- protect embankments from overtopping by designing an emergency spillway in native soil to bypass flow exceeding the outlet structure capacity in a non-erosive manner;
- design outlet pipes and risers to withstand flotation;
- install an anti-vortex device and trash rack on the outlet structure as necessary; and
- utilize proper soil compaction methods, a core trench, and anti-seep measures to reduce the risk of embankment failure.

Safety

Public safety is an inherent concern with any open water, temporary or permanent. Appropriate measures such as warning signs and personal flotation device stations should be planned. Fencing and shoreline vegetation may also deter access to open water for swimming or fishing. Outlet structures should be designed to prevent entry.

Slopes leading down to the permanent pool are recommended to be 4H:1V or flatter. A six- to 10-foot wide safety bench with a minimal cross slope located immediately above and adjacent to the permanent pool is recommended where steep slopes approach open water.

Fish

Fish may help balance the ecology of a wet extended detention basin by serving as top predators. If fish are to be maintained in the pool, 25 percent of the pool is recommended to be at least six to eight feet deep. Wetland benches or submerged features (for example, root wads) can also supply habitat.

Stormwater controls can provide a direct connection to our natural streams, rivers, and lakes. Non-native species that may reproduce in local waters, including koi or goldfish, should not be stocked. Although a common recommendation for mosquito control in ponds, western mosquitofish (Gambusia affinis) may lead to destructive ecological imbalances and is not recommended.

Mosquitoes

Many of the design criteria related to water quality also deter conditions favorable to mosquito reproduction such as stagnant pool areas. Consider designs with the necessary depth and habitat features to support natural predation by fish, birds, dragonflies, and aquatic insects. Proper maintenance including trash removal is also essential to mosquito population control.

Trees

Trees planted around the basin, particularly on the south and west sides, offer the shade from the summer sun which can reduce thermal impacts of the discharge waters and may benefit fish. Do not plant trees on the embankment itself. Wetland vegetation can also contribute to shading where trees are not desired.

Aeration

Fountains or bubblers used to minimize nuisances associated with stagnant water or to aerate the water column for fish must not lower the treatment efficiency of the basin by disrupting quiescent settling between storms, resuspending benthic sediment, or causing erosion. To minimize disruption of stormwater treatment functions:

- specify a fountain that draws water from a depth of two feet or less;
- avoid locating a fountain near the inlets, outlet, shoreline, or in normal pool depths less than four feet; and
- operate fountains on an intermittent or as-necessary basis (for example during dry periods).

[1] These documents are publicly available from the U.S. Department of Agriculture, Natural Resource Conservation Service on their website.

Construction Considerations

Transitioning from a Temporary Sediment Control

A wet extended detention basin temporarily used for sediment control during construction may require cleanout and/or re-grading to achieve the post-construction design volume prior to being placed into service as a permanent stormwater control. In most cases the basin will need dewatered to remove sediment that accumulated during construction. The cost of cleanout will be less expensive while the contactor is on site rather than in the future. Other transition tasks that may be required include:

- reseed any bare area along the shoreline;
- establish wetland vegetation in designated areas;
- remove any skimmer outlet devices; and
- complete any required outlet structure modifications (such as installing an orifice plate or patching temporary skimmer connections).

Maintenance Considerations

A wet extended detention basin must operate long-term with sustained performance. The designer must develop a detailed operation and maintenance plan for the owner that outlines the maintenance activities necessary and their expected schedule to ensure a consistent level of treatment occurs over the life of the practice.

While maintenance is inevitable, its frequency, level of effort, and cost can be minimized through good planning and design. The designer should consider the following measures to ease the owner's maintenance burden.

- Provide a georeferenced survey of the constructed basin depth elevations on an as-built drawing. This data establishes a baseline to determine sediment deposition rates and facilitate maintenance operations.
- Reduce the frequency of sediment cleanout by increasing the permanent pool volume available for sediment storage.
- A forebay can reduce maintenance costs and effort by trapping sediment in a confined, easily accessible location.

Accessibility

Where direct public access to a wet extended detention basin is not available, an easement to the basin must be established to allow access for maintenance activity, particularly to and around the forebay(s), embankment, outlet structure, and sediment disposal area(s).

Disposal of Dredged Post-Construction Sediment

A wet extended detention basin is intended to trap pollutants and the fate of these pollutants must be considered. Sediment collected in a wet extended detention basin is not typically considered toxic or hazardous unless the practice serves a hotspot land use or has received spills. In most cases, dredged sediment may be land applied and stabilized with vegetation. Soil tests may be conducted to verify whether dredged sediment must be hauled away when high concentrations of pollutants are suspected in the sediment.

Avoid the extra cost of transporting the sediment offsite by designating an area on-site for future sediment disposal.

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