MINIMUM STANDARD 3.06

RETENTION BASIN

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MINIMUM STANDARD 3.06

RETENTION BASIN

Definition

A retention basin is a stormwater facility which includes a permanent impoundment, or pool of water, and, therefore, is normally wet, even during non-rainfall periods. Inflows from stormwater runoff may be temporarily stored above this permanent pool.

Purpose

A retention basin provides for long-term water quality enhancement of stormwater runoff. Stormwater inflows may also be temporarily stored above the permanent pool for downstream flood control and channel erosion control. A retention basin is considered one of the most reliable and versatile BMPs available.

Water Quality Enhancement

High removal rates of particulate and soluble pollutants (nutrients) can be achieved in retention basins through *gravitational settling*, *biological uptake* and *decomposition*. When an even higher degree of pollutant removal efficiency is required, the basin can be ***enhanced*** by using various modifications relating to the size and design of the permanent pool.

Monitoring studies have shown sediment removal efficiencies to range from 50-90%, total phosphorus removal efficiencies to range from 30-90% and soluble nutrient removal efficiencies to range from 40-80%. (MWCOG, 1992). The design elements, physical characteristics, and monitoring techniques varied for each basin studied, which explains the wide range of efficiencies. The target pollutant removal efficiencies assigned to the different design options are presented in **Table 3.06-1**.

FIGURE 3.06 - 1
Retention Basin - Plan & Section

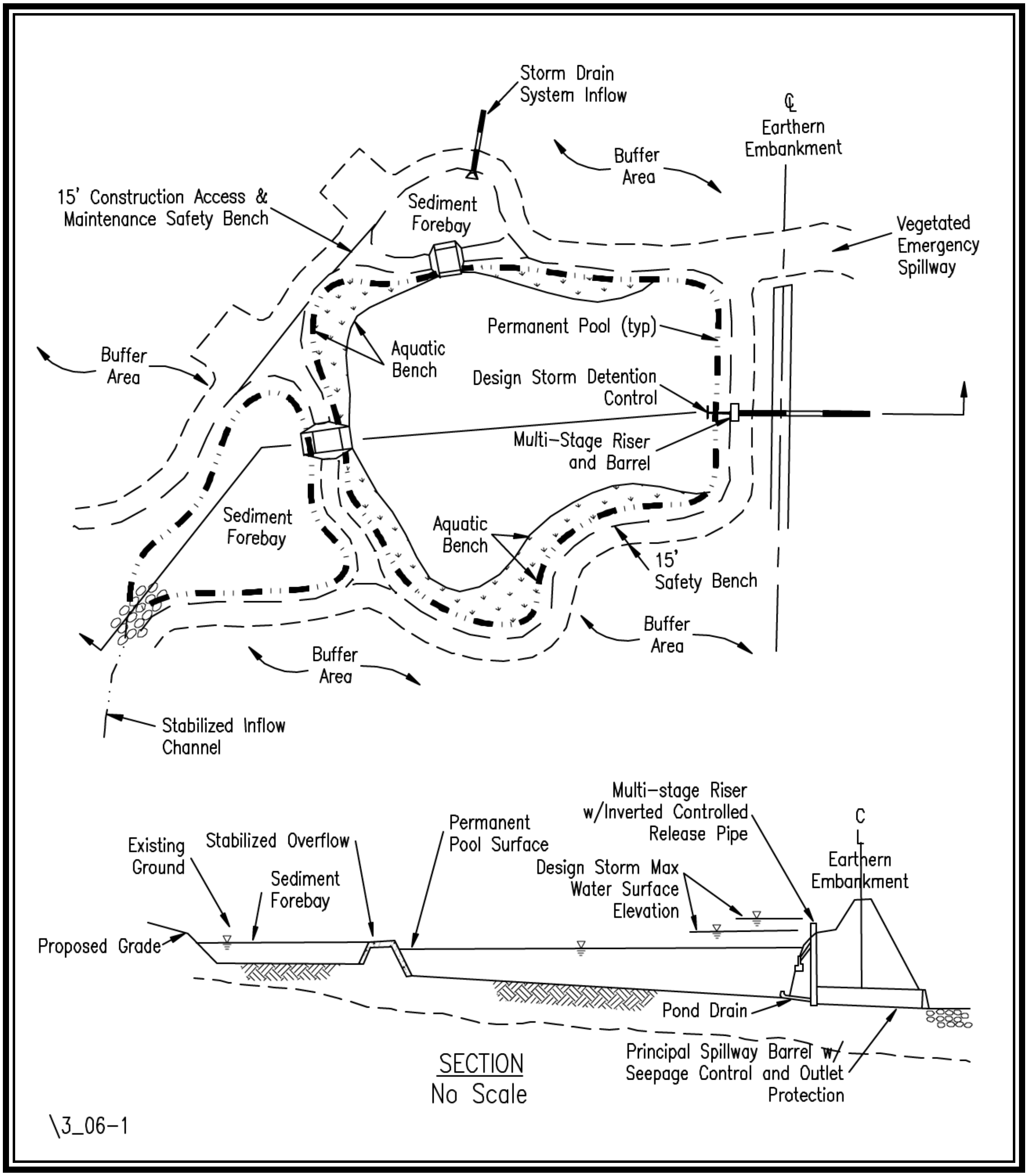

TABLE 3.06 - 1
Pollutant Removal Efficiencies for Retention Basins

Type	Sizing Rule	Target Phosphorus Removal Efficiency	Impervious Cover
Retention Basin I	3.0 x WQ Volume	40%	22-37%
Retention Basin II	4.0 x WQ Volume	50%	38-66%
Retention Basin III	4.0 x WQ Volume with Aquatic Bench	65%	67-100%

<u>Flood Control</u>

Retention basins which provide flood control are designed with "dry" storage above the permanent pool. This dry storage works in concert with a riser or control structure to reduce the peak rate of runoff from a drainage area. Typically, the design storms selected for flood control (i.e., 2-year, 10-year frequency, etc.) are specified by state and local ordinances, or are based on specific watershed conditions. In either case, the required volume to be stored above the permanent pool can be readily determined using the hydrologic methods discussed in **Chapter 4**. Similarly, a control or spillway structure can be designed using the engineering calculation procedures presented in **Chapter 5**.

<u>Channel Erosion Control</u>

The storage volume above the permanent pool can also be used to control or reduce channel erosion. Channel erosion protection can be accomplished by reducing the peak rate of discharge, similar to flood control, or by controlling the time over which the peak volume of discharge is released (extended detention), similar to water quality enhancement. **Chapter 5-11** provides a discussion on the design criteria for channel erosion control.

Conditions Where Practice Applies

<u>Drainage Area</u>

A contributing watershed of at least 10 acres and/or a good source of baseflow should be present for a retention basin to be feasible. Even with 10 acres of contributing watershed, the permanent pool may be susceptible to dry weather drawdowns due to infiltration and evaporation.

(Refer to **Chapter 5, Appendix 5C** for water balance calculation procedures.) Dry weather stagnation may result in aesthetic and odor problems for adjacent property owners. Therefore, for residential or high visibility applications, a minimum of 15 to 20 acres of contributing watershed may be more appropriate. Infiltration basins, trenches or extended-detention basins are more suitable for smaller sites.

A retention basin is recommended for use as a regional or watershed-wide stormwater management facility since its cost per acre treated is inversely proportional to the watershed size. Studies confirm that the most cost-effective application of a retention basin is on larger, more intensely developed sites (Schueler, et. al., 1985).

Note that excavated retention basins in areas of high groundwater, such as in Tidewater, Virginia, may be feasible with very small drainage areas. The groundwater elevation should be carefully monitored, however, to verify the design permanent pool elevation.

<u>Development Conditions</u>

Retention basins have the potential for removing high levels of soluble and particulate pollutants which makes them suitable for most types of development. They are appropriate for both high- and low- visibility sites. However, for high-visibility sites, care must be taken to avoid the aesthetic problems associated with stagnation or excessive infiltration of the permanent pool. Maintenance of the permanent pool is not necessarily critical to the retention basin's ability to remove pollutants, but maintenance **is critical** to ensure the BMP's acceptance by adjacent landowners. If adequate space is available, retention basins may also be used for both high and low density residential or commercial developments.

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A minimum 20-foot wide vegetated buffer should be provided around a retention basin to help filter out pollutants before they enter the basin. This requirement results in the need for more land, especially for those basins that may already be oversized to enhance their pollutant removal capabilities. It is for this reason that the use of large retention basins may not be a feasible option in developing watersheds where land is at a premium. This strengthens the argument for a regional or watershed approach to stormwater management. A regional retention or extended-detention basin is not only more cost-effective, it is also more likely to be installed on land that is not suitable for development. (It should be noted, however, that the environmental impacts and appropriate permits must still be considered for such an application.)

Planning Considerations

The success of a retention basin is dependent on the designer's ability to identify any site or downstream conditions that may affect the design and function of the basin. Above all, the facility should be compatible with both upstream and downstream stormwater systems, thus promoting a *watershed approach* in providing stormwater management.

Site Conditions

Existing site conditions should be considered in the design and location of a retention basin. Features such as topography, wetlands, structures, utilities, property lines, easements, etc., may impose constraints on the location or construction of the basin. Local government land use and zoning ordinances may also designate certain requirements.

All retention basins should be a minimum of 20 feet from any structure or property line (as required by local ordinances), and 100 feet from any septic tank/drainfield. (The designer should be aware that an impoundment of water may elevate the local water table which could adversely effect drainfields and structures.) Retention basins should be a minimum of 50 feet from any steep slope (greater than 15%). Alternatively, a geotechnical report must address the potential impact of any retention basin that is to be constructed on or near such a slope.

Additional considerations are as follows:

1. **Soils –**

   In the past, many designs were accepted based upon soils information compiled from available data, such as SCS soil surveys. While such a source may be appropriate for a pre-engineering feasibility study, final design and acceptance **should be based on an actual subsurface analysis and a permeability test**, accompanied by appropriate engineering recommenda- tions. The references listed at the end of this standard and at the end of **Minimum Standard 3.10, Infiltration Practices** provide more detailed information regarding the feasibility analysis of subsurface conditions for various soil types. Due to its complexity, this topic is not covered here. Note that the geotechnical study required for the embankment design (reference **Minimum Standard 3.01, Earthen Embankment**) will often provide adequate data to verify the soil's suitability for a retention basin.

   The goal of a subsurface analysis is to determine if the soils are suitable for a retention basin. The textural character of the soil horizons and/or strata units within the subsoil profile should be identified to at least 3 feet below the facility bottom. This information is used to verify the infiltration rate or permeability of the soil. For a retention basin, water inflow (base flow and groundwater) must be greater than water losses (infiltration and evaporation). If the infiltration rate of the soil is too high, then a retention basin may not be an appropriate BMP.

   Permeable soils are not suited for retention basins. The depth of the permanent pool can influence the rate at which water will infiltrate through the existing soil. The soil permeability may be such that the basin can support a shallow marsh or constructed wetland. However, as the depth of the permanent pool increases, the increased head or pressure on the soil may increase the infiltration rate. If necessary, a liner of clay, geosynthetic fabric, or other suitable material may be used in the basin (as specified by a geotechnical engineer). Refer to the design criteria for basin liners.

2. **Rock –**

A subsurface investigation should also identify the presence of rock or bedrock. Excavation of rock may be too expensive or difficult with conventional earth moving equipment, precluding the use of a basin. Blasting the rock for removal may be possible, but blasting may open seams or create cracks in the underlying rock, resulting in an unwanted drawdown of the permanent pool. Blasting of rock is not recommended unless a liner, as described above, is installed.

3. **Karst –**

In regions where Karst topography is prevalent, projects may require thorough soils investigations and specialized design and construction techniques. The presence of karst should be determined **<u>during the planning phase of the project</u>** since it may affect BMP selection, design, and cost.

4. **Existing Utilities–**

Most utility companies will not allow a permanent or temporary pool to be installed over their underground utility lines or right-of-ways. However, if such a site must be used, the designer should obtain permission from the utility company **before designing** the basin. The relocation of any existing utilities should be researched and the costs included in the overall basin cost estimate.

<u>Environmental Impacts</u>

1. **Wetlands –**

Large facilities and/or regional facilities naturally lend themselves to being placed in low lying, and usually environmentally sensitive, areas. Such locations often contain wetlands, shallow marshes, perennial streams, wildlife habitat, etc., and may be protected by state or federal laws. The owner or designer should investigate regional wetland maps and contact appropriate local, state, and federal agencies to verify the presence of wetlands, their protected status, and suitability for a retention basin at the location in question.

With careful planning, it may be possible to incorporate wetland mitigation into a retention basin design. This assumes that the functional value of the existing or impacted wetland can be identified and included, reconstructed, or mitigated for, in the basin. The Virginia Department of Environmental Quality should be contacted for more information regarding wetland mitigation.

2. **Downstream Impacts –**

A retention basin may have an adverse impact on downstream water quality by altering the biological oxygen demand (BOD), dissolved oxygen (DO), temperature, etc., of the water body. This is of special concern in cold water trout streams. The release depth of the control structure, overall pond depth, hydraulic residence time, and other design features can be manipulated to help meet the site specific needs of the downstream channel.

Urban detention and retention basin design should be coordinated with a watershed or regional plan for managing stormwater runoff, if available. In a localized situation, an individual basin can provide effective stream protection for the downstream property if no other areas contribute runoff in a detrimental way to that property. However, an uncontrolled increase in the number of impoundments within a watershed can severely alter natural flow conditions, causing combined flow peaks or increased flow duration. This can ultimately lead to downstream flooding and degradation.

3. **Upstream Impacts –**

The upstream channel must also be considered, especially when the retention basin is to be used to control downstream channel erosion. Erosive upstream flows will not only degrade the upstream channel, but will also significantly increase the maintenance requirements in the basin by depositing large amounts of sediment eroded from the channel bottom.

<u>Water Quality Enhancement</u>

A retention basin is typically selected for its water quality enhancement abilities and/or aesthetic value. The flexibility of providing for additional control components (channel erosion control, flood control, habitat, etc.) increases their value. The permanent pool of a retention basin serves to enhance the quality of the stormwater within it. Studies show that providing a larger permanent pool, and/or adding modifications such as an aquatic bench, sediment forebay, etc., will provide greater and more consistent pollutant removal benefits (refer to the **Design Criteria** section in this standard). Currently, no credit is given for any additional pollutant removal efficiency that may occur with an extended-detention volume stacked on top of the permanent pool of a retention basin. However, significant improvements in channel erosion control have been reported using extended-detention for the 1-year frequency design storm (Galli, MWCOG, 1992). Refer to **Minimum Standard 3.07, Extended Detention Basins**.

A concern in specifying a retention basin is how much land it will occupy. The size of the permanent pool will be based on the desired pollutant removal efficiency. The "dry" storage volume above the permanent pool will be sized for downstream channel erosion and/or flood control. The size of these two components together will determine the size of the basin.

Preliminary sizing estimates for the permanent pool and "dry" storage volume are recommended during the planning stages to evaluate the feasibility of using a retention basin.

If a retention basin is used to remove pollutants, the water quality within the basin will be lowered, thus possibly reducing its desirability for water supply, recreation, and aesthetic purposes. Therefore, the engineer should be aware of the site's specific runoff components and understand their possible effects on the quality of the stored water. Runoff from highways and streets can be expected to carry significant concentrations of heavy metals such as lead, zinc, and copper. These and other heavy metals may accumulate in the bottom of a facility, creating a potential health and environmental hazard. If a basin is in a watershed where a significant portion of the runoff is from highways, streets or parking areas, then access to the facility should be limited and warning signs should be posted. Proper disposal of the bottom sediments from these basins may require that they be hauled to an approved facility.

Further, retention basins in residential areas are subject to nutrients from lawn fertilizers and other urban sources. Excess nutrients can lead to algae and other undesirable vegetation which can diminish the aesthetic and recreational value of the basin.

<u>Flooding and Channel Erosion Control</u>

Flood control and downstream channel erosion are managed by providing additional storage volume, referred to as dry storage, above the permanent pool, and properly sizing a discharge opening in the riser structure.

When a retention basin is designed for channel erosion control and/or flood control, but **<u>not</u>** water quality enhancement, the permanent pool volume should be sized to address maintenance, aesthetic, and feasibility concerns (adequate drainage area, etc.).

<u>Sediment Control</u>

A stormwater retention basin may initially serve as a sediment control basin during the project's construction. A sediment basin is designed for the maximum drainage area expected to contribute to the basin during the construction process, while a permanent stormwater basin is designed based on post-developed land use conditions. When designing a facility to do both, the basin should be sized using the most stringent criteria, sediment control or stormwater management, which will result in the largest storage volume. The design elevations should be set with final clean out and conversion in mind. The bottom elevation of the permanent SWM basin should be lower than the design bottom of the temporary E&S basin. This allows for the establishment of a solid permanent bottom after sediment is removed from the facility.

The riser and barrel hydraulics and materials should be designed as the permanent stormwater control structure. However, the permanent riser may be temporarily modified to provide a sediment basin with wet and dry storage as required by the Virginia Erosion and Sediment Control Handbook, (VESCH), 1992 edition.

Safety

Basins that are readily accessible to populated areas should include all possible safety precautions. Steep side slopes (steeper than 3H:1V) at the perimeter should be avoided and dangerous outlet structures should be protected by enclosures. Warning signs for deep water and potential health risks should be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths. A notice should be posted warning residents of potential waterborne disease that may be contracted by swimming or diving in these facilities.

If the basin's surface area exceeds 20,000 square feet, an aquatic bench should be provided. (Refer to the **Design Criteria for Aquatic Bench**.)

A fence is **required** at or above the maximum water surface elevation **when a basin slope is a vertical wall**. Local governments and homeowner associations may also require appropriate fencing without regard for the steepness of the basin side slopes.

Maintenance

Retention basins have shown an ability to function as designed for long periods without routine maintenance. However, some maintenance is essential to protect the aesthetic and wildlife properties of these facilities.

Vehicular access to the permanent pool area and release structure must be provided to allow for long-term maintenance operations (such as sediment removal) and repairs, as needed. The incorporation of a *sediment forebay* at the inflow points into the basin will help to localize disturbance during sediment removal operations. An onsite area designated for sediment dewatering and disposal should also be included in the design. Care must be taken in the disposal of sediment that may contain an accumulation of heavy metals. **Sediment testing is recommended prior to sediment removal to assure proper disposal**.

A sign should be posted near the basin that clearly identifies the person or organization responsible for basin maintenance. Allowing participation by adjacent landowners or visitors is very helpful, especially if the facility serves as a recreational facility. Maintenance needs that are observed and addressed early will help to lower the overall maintenance costs. Routine maintenance inspections, however, should be conducted by authorized personnel. In all cases, access easements should be provided to facilitate inspection and maintenance operation.

Design Criteria

This section provides recommendations and minimum criteria for the design of stormwater retention basins intended to comply with the Virginia Stormwater Management program. It is the designer's responsibility to decide which aspects of the program apply to the particular facility being designed and if any additional design elements are required. The designer should also consider the long-term functioning of the facility in the selection of materials for the structural components.

Hydrology and Hydraulics

Chapter 4, **Hydrologic Methods** and **Chapter 5**, **Engineering Calculations** should be used to develop the pre- and post-developed hydrology for a basin's contributing watershed, to design and analyze the hydraulics of the riser and barrel system, and to design the emergency spillway.

The design of the riser and barrel system should take into account any additional storage provided above the permanent pool for peak discharge control. Generally, the 2-year storm should be used in *receiving channel adequacy* calculations and the 10-year storm should be used for *flood control* calculations. Alternative requirements such as 1-year extended detention for channel erosion control may be imposed by local ordinances.

The contributing drainage area should be a minimum of 10 acres with an adequate base flow. Fifteen to 20 acres is more appropriate to sustain a healthy permanent pool. Note that this requirement may preclude the use of the Modified Rational Method for the basin's design.

Embankment

The design of the earthen embankment for a retention basin should comply with **Minimum Standard 3.01, Earthen Embankment**. The requirements for geotechnical analysis, seepage control, maximum slopes and freeboard are particularly appropriate.

Principal Spillways

The design of the principal spillway and barrel system, anti-vortex device, and trash racks should comply with **Minimum Standard 3.02, Principal Spillway**.

Emergency Spillway

An emergency spillway that complies with **Minimum Standard 3.03, Vegetated Emergency Spillway** should be provided when possible, or appropriate.

Sediment Basin Conversion

When a proposed stormwater facility is used as a temporary sediment basin, the conversion to the permanent facility should be completed after final stabilization and approval from the appropriate erosion and sediment control authority.

In most cases the design criteria for the temporary sediment basin will require more storage volume (combined wet and dry) than that of a stormwater basin. In such cases, the extra volume should be allocated to the component of the facility that would derive the greatest benefit from the increased storage. This will depend on the primary function of the facility (i.e., water quality enhancement, flood control, or channel erosion control).

If modifications to the riser structure are required as part of the conversion to a permanent stormwater facility, they should be designed so that a) *the structural integrity of the riser is not threatened*, and b) *large construction equipment is not needed within the basin*. Any heavy construction work required on the riser should be completed during its initial installation. It is **NOT** recommended to install a temporary riser structure in the sediment basin and then replace it with a permanent riser after final stabilization. This may affect the structural integrity of the existing embankment and barrel.

The following additional criteria should be considered for a conversion:

1. Final elevations and a complete description of any modifications to the riser structure's geometry should be shown in the approved plans.
2. The wet storage area must be dewatered following the methods outlined in the VESCH, 1992 edition.
3. Sediment and other debris should be removed to a contained spoil area. Regrading of the basin may be necessary to achieve the final design grades and to provide an adequate topsoil layer to promote final stabilization.
4. Final modifications to the riser structure should be carefully inspected for watertight connections and compliance with the approved plans.
5. Final landscaping and stabilization should be per the VESCH, 1992 edition, and **Minimum Standard 3.05, Landscaping** in this handbook.

Permanent Pool

When designing a permanent pool for water quality benefits, certain physical and hydraulic factors can be manipulated to achieve a desired *pollutant removal efficiency*. These factors, which also influence the downstream water quality, include the permanent pool's *volume*, *depth*, *geometry*, *hydraulic residence time*, and *release depth*.

1. **Volume –**

Increasing the *volume* of the permanent pool increases the *residence time*, resulting in an increase in the pollutant removal efficiency of the permanent pool. **Table 3.06-1** provides the target pollutant removal efficiencies associated with different sizing rules.

2. **Depth –**

The *depth* of the permanent pool will affect several features of a retention basin including a) *aquatic plant selection*, b) *fish and wildlife habitat selection*, and c) *the rate at which nutrients are cycled*. Retention basins and artificial marshes built too shallow will not support fish populations year round. Basins built too deep may stratify, creating anaerobic conditions that may result in the resolubilizing of pollutants that are normally bound in the sediment. The release of such pollutants back into the water column can seriously reduce the effectivenes of the BMP and may cause nuisance conditions.

The depth of a stormwater management basin should vary to include as much diversity as possible, with an average depth of 3 to 6 feet. Approximately 15% of the basin area should be less than 18 inches deep. (Schueler, 1987). This can be accomplished by using an aquatic bench along the perimeter of the permanent pool as shown in **Figure 3.06-2**. **Table 3.06-2** below provides recommended surface area - pool depth relationships.

TABLE 3.06 - 2
Recommended Surface Area - Pool Depth Relationships for Retention Basins

BMP	**Pool Depth (*ft.*)**	**Surface Area (*as % of total BMP surface area*)**
Retention Basin	0 - 1.5 1.5 - 2 2 - 6	15% 15% 70%

Source: Washington State D.O.E.

3. **Geometry –**

The geometry of a stormwater basin and the associated drainage patterns are usually dictated by site topography and development conditions. However, the alignment of the incoming pipes should be manipulated relative to the release structure to the greatest extent possible to avoid *short-circuiting* of the incoming runoff. *Short-circuiting* is the condition where incoming runoff passes through the basin without displacing the old water. This can be avoided by maximizing the distance between the inlet and outlet structures. It can also be avoided by designing a *meandering* flow path through the basin, rather than a straight line flow path. In either case, a length-to-width ratio of 2:1 should be maintained. If site conditions prevent using the proper ratio, then baffles made from gabion baskets, earthen berms or other suitable materials may be used to lengthen the flow path (see **Figure 3.06-3**).

A retention basin should be multi-celled with at least two cells and preferably three. The first cell can be used as a sediment forebay to trap coarse sediments and reduce turbulence that may cause resuspension of sediments. This first cell should be easily accessible for maintenance purposes. The second (and third) cell provides for the further settling of pollutants and any biological processes.

4. **Hydraulic Residence Time –**

Hydraulic residence time is the permanent pool volume divided by the average outflow discharge rate. The longer the residence time, the higher the pollutant removal efficiency (Driscoll, 1983, Kulzer, 1989). A retention basin used for channel erosion control and flood control will usually achieve higher pollutant removal rates. This is due to the increased residence time associated with the peak discharge control above the permanent pool. The hydraulic residence time would be a factor in the design of a retention basin with a permanent pool volume based on an impervious area which is relatively small when compared to the contributory drainage area. In this case, the total drainage area discharge will turn over, or replace, the volume of the "undersized" pool volume before it has achieved an adequate residence time. Optimal pollutant removal efficiency is generally associated with a *mean annual hydraulic residence* time of 14 to 30 days (Driscoll, 1988; Kulzer, 1989; Schueler, 1987).

5. **Release Depth –**

The best water quality in a retention basin's permanent pool is usually at or near the surface (Galli, 1988; Redfield, 1983). Under normal dry weather conditions, the concentrations of total dissolved solids, phosphorus, and nitrogen generally decrease in the upper portions of the water column due to physical settling and algal and biological assimilation (Galli, 1992). This suggests that <u>subsurface</u> releases have high levels of nutrients and suspended solids. In addition, deeper basins usually have very low levels of dissolved oxygen in the bottom portions of the water column.

FIGURE 3.06 - 2
Varying Depth of Permanent Pool

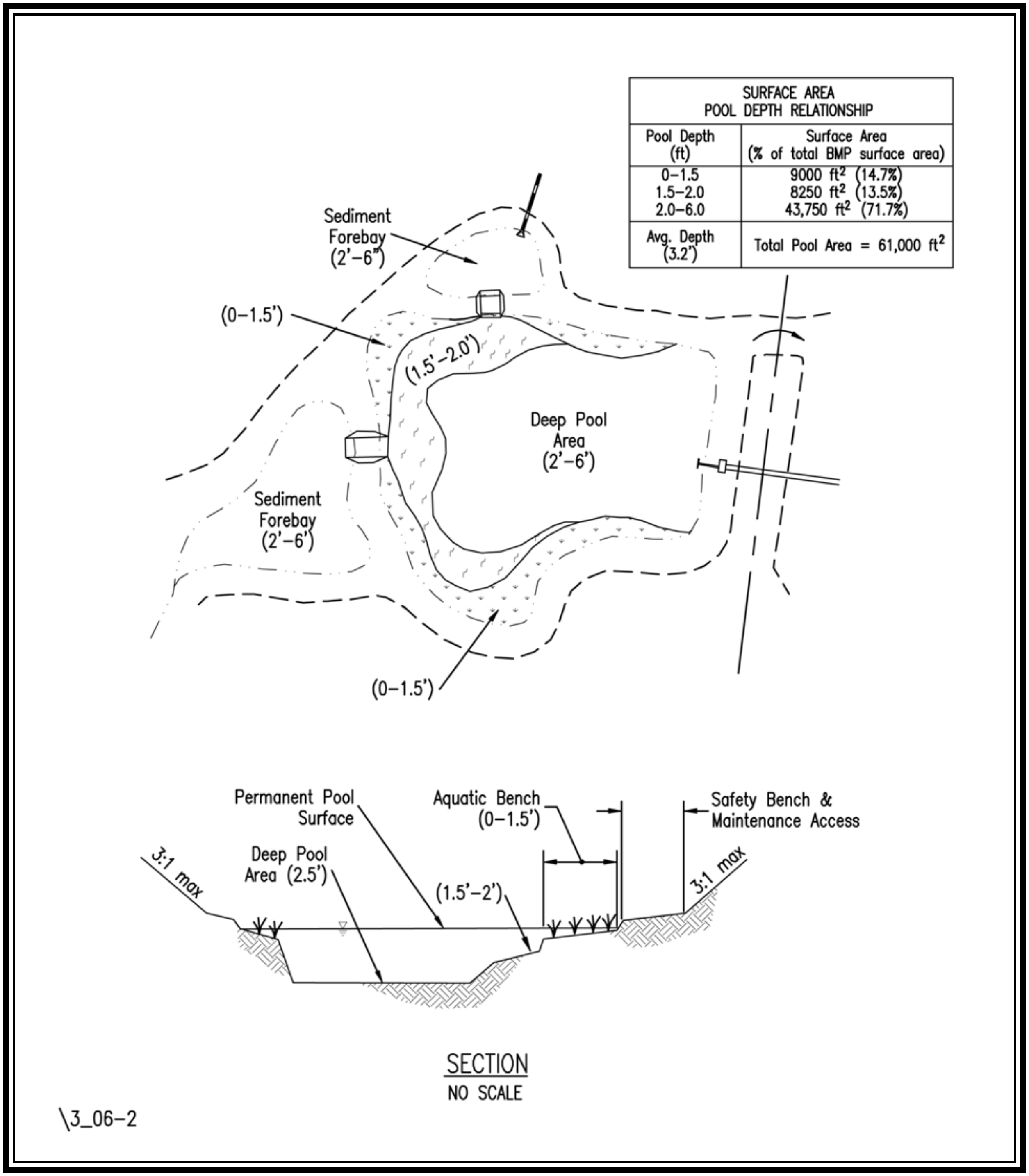
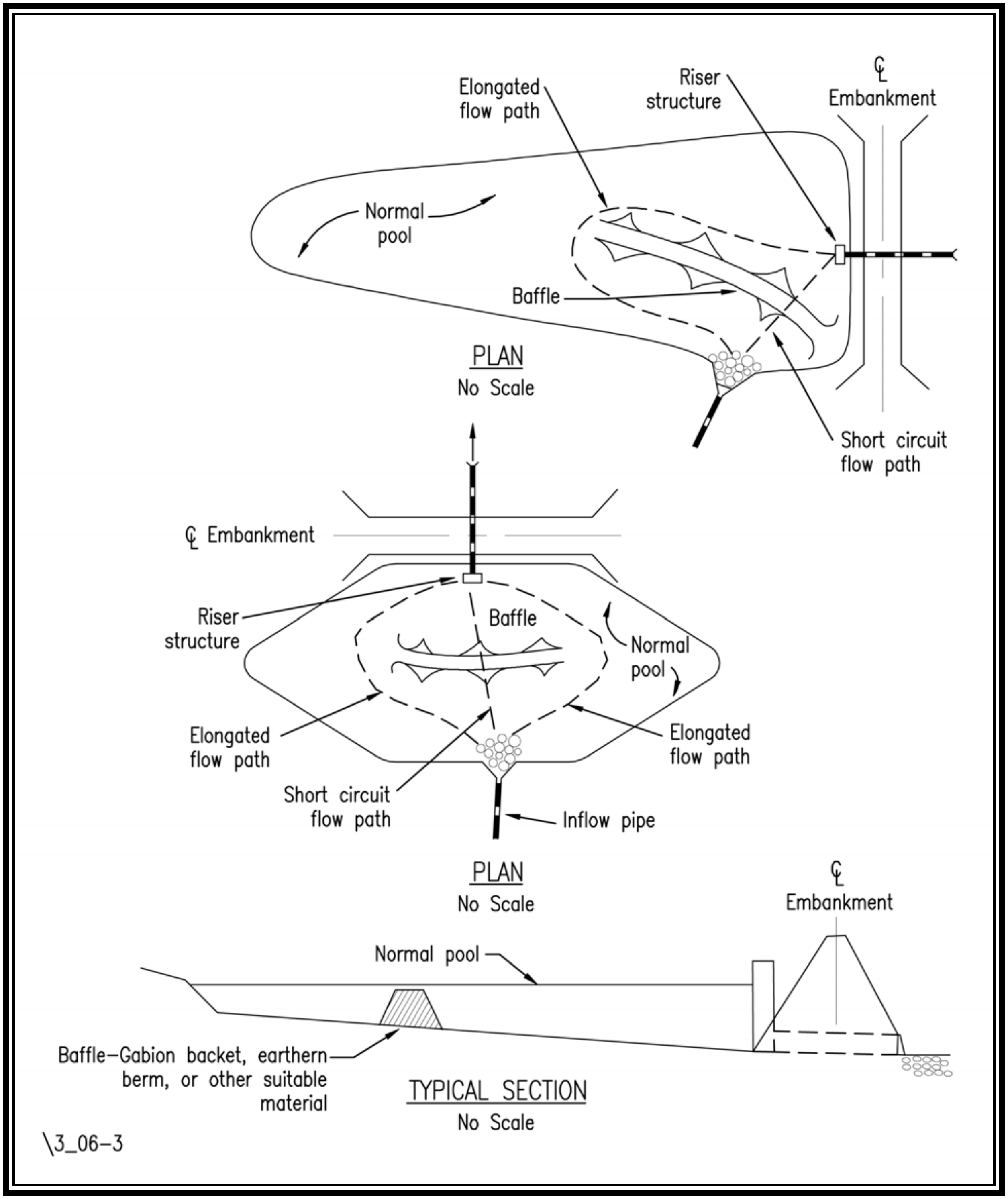


FIGURE 3.06 - 3
Short-Circuiting

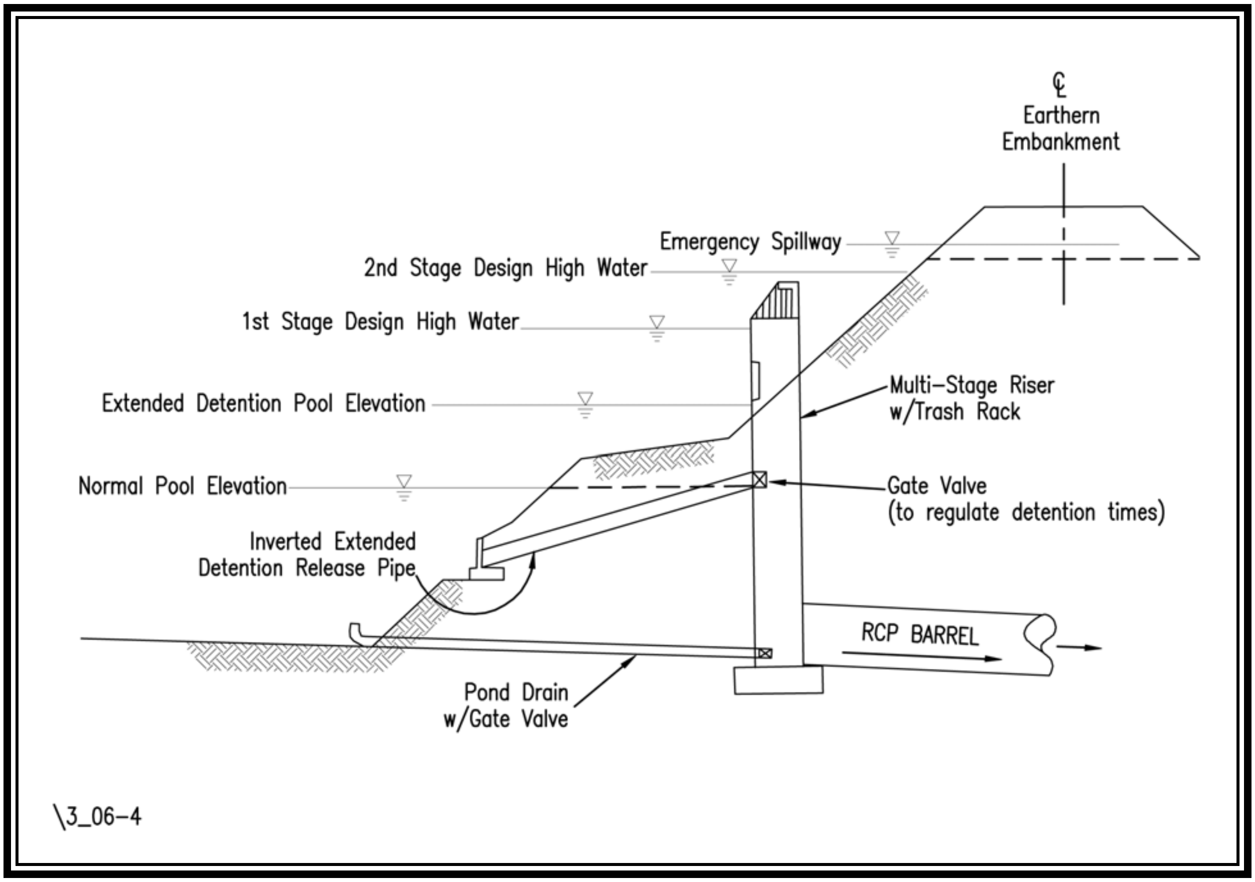


In contrast, the water at or near the surface of a retention basin is warmer because of solar heating of the basin and heated stormwater inflow. This resembles the cycling process of water in natural lakes and water bodies. However, the proximity of a retention basin to development (i.e., impervious surfaces) may lead to an excessive heat buildup from the incoming runoff during the warmer months. Therefore, a release depth of approximately 18 inches from the water surface is recommended (Galli, 1992) to avoid extremes in temperature, nutrient levels, and dissolved oxygen (see **Figure 3.06-4**).

It should be noted that inexpensive design modifications can be incorporated into the design of a retention facility to mitigate downstream impacts such as: a) *oversizing the barrel and adding surgestone or rip rap to the invert to help re-aerate the basin discharge* (Schueler, 1987), and b) *providing shade by planting (or saving) trees around the perimeter of the basin to help lower surface water temperature*.

If the receiving stream supports a trout population, the designer should contact the Department of Game and Inland Fisheries for additional measures to protect the downstream habitat.

FIGURE 3.06 - 4
Typical Retention Basin Control Structure



Aquatic Bench

The pollutant removal efficiency of a retention basin can be further enhanced by adding an *aquatic bench*. An aquatic bench is a 10 to 15 foot wide area that slopes from zero inches at the shoreline to between 12 and 18 inches deep in the basin (see **Figure 3.06-5**). This bench provides suitable conditions for a variety of aquatic plants and emergent vegetation. Specific landscaping requirements for an aquatic bench should be provided on the landscaping plan per **Minimum Standard 3.05, Landscaping**.

Most important, an aquatic bench augments the pollutant removal capabilities of a retention basin by providing an environment for aquatic vegetation and associated algae, bacteria and other microorganisms that reduce organic matter and nutrients (Schueler, 1987). In addition, aquatic bench vegetation provides an ideal habitat for wildlife, such as waterfowl and fish, and for predator insects that feed on mosquitoes and other nuisance insects.

An aquatic bench also serves to stabilize and protect the shoreline from erosion resulting from fluctuating water levels, and provides a safety feature by eliminating the presence of a steep submerged slope next to the shoreline.

The increase in pollutant removal efficiency associated with the establishment of an aquatic bench is **approximated** based on available information. Note that discharge monitoring may indicate much higher or lower values since many variables exist in any given stormwater basin design and the efficiencies are estimated.

Sediment Forebay

A *sediment forebay* will help to postpone overall basin maintenance by trapping incoming sediments at a specified location. The forebay should be situated and designed per **Minimum Standard 3.04, Sediment Forebays**. Usually, a sediment forebay is placed at the outfall of the incoming storm drain pipes or channels directed toward the basin and is situated to provide access for maintenance equipment.

A sediment forebay enhances the pollutant removal efficiency of a basin by trapping the incoming sediment load in one area, where it can be easily monitored and removed. The *target pollutant removal efficiency* of a retention basin, as listed in **Table 3.06-1**, is predicated on the use of sediment forebays at the inflow points to the basin.

Liner to Prevent Infiltration

A retention basin should have negligible infiltration through its bottom. Infiltration may impair the proper functioning of the basin and may contaminate groundwater. Where infiltration is anticipated, or in areas underlain by karst topography then a retention or detention facility should **not** be used unless an impervious liner is installed. When using a liner, the specifications provided in **Table**

3.06-3 for clay liners and the following recommendations apply:

1. A clay liner should have a minimum thickness of 12 inches.

2. A layer of compacted topsoil (minimum thickness 6 to 12 inches) should be placed over the liner before seeding with an appropriate seed mixture (refer to the VESCH, 1992 edition.)

3. Other liners may be used provided the engineer can supply supporting documentation that the material will achieve the required performance.

In many cases, the fine particulates and suspended solids in the water column of a new retention basin will settle out and quickly clog the the pores of the bottom soil. However, a geotechnical analysis should address the potential for infiltration and, if needed, specify liner materials.

Safety

The side slopes of a retention basin should be no steeper than 3H:1V and should be stabilized with permanent vegetation. If the basin surface exceeds 20,000 square feet, an aquatic bench should be provided to serve as a safety feature. Fencing may also be required by local ordinance.

Access

A 10 to 12-foot-wide access road with a maximum grade of 12% should be provided to allow vehicular access to both the outlet structure area and at least one side of the basin. The road's surface material should be selected to support the anticipated frequency of use and the anticipated vehicular load without excessive erosion or damage.

TABLE 3.06 - 3
Clay Liner Specifications

Property	Test Method (or equal)	Unit	Specification
Permeability	ASTM D-2434	*cm/sec*	1×10^{-6}
Plasticity Index of Clay	ASTM D-423 & D-424	%	Not less than 15
Liquid Limit of Clay	ASTM D-2216	%	Not less than 30
Clay Particles Passing	ASTM D-422	%	Not less than 30
Clay Compaction	ASTM D-2216	%	95% of Standard Proctor Density

Source: City of Austin, 1988

Landscaping

A qualified individual should prepare the landscape plan for a retention basin. Appropriate *shoreline fringe*, *riparian fringe* and *floodplain terrace vegetation* must be selected to correspond with the expected frequency and duration of inundation. Selection and installation guidelines should be per **Minimum Standard 3.05, Landscaping**.

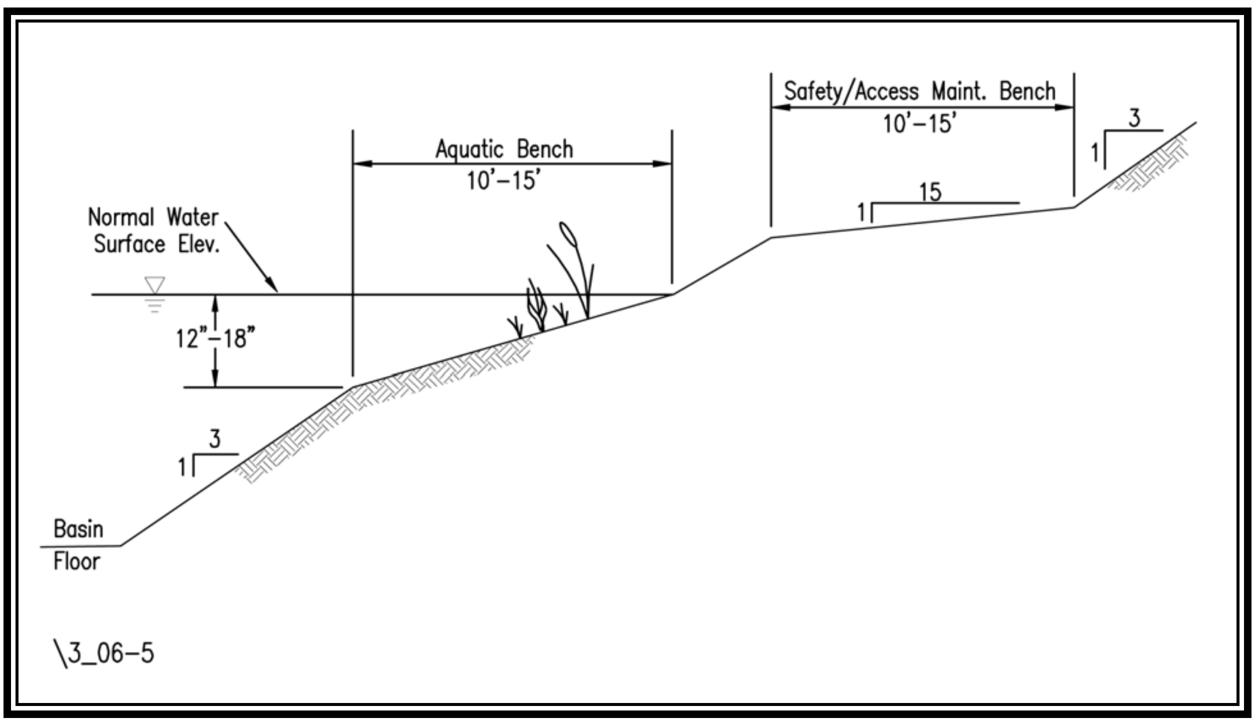
Vegetation should be planted in soil that is appropriate for the plants selected. Soil tests showing the adequacy of the soil or a soil enhancement plan should be submitted with the overall basin design.

The soil substrate must be soft enough to permit easy installation of the plants. If the basin soil has been compacted or vegetation has formed a dense root mat, the upper 6 inches of soil should be disked before planting. If soil is imported, it should be laid at least 6 inches deep to provide sufficient depth for plant rooting to occur.

Buffer Zones

A vegetated buffer strip should be maintained beside the basin. The strip should be a minimum of 20 feet wide, as measured from the maximum water surface elevation. Refer to **Minimum Standard 3.05, Landscaping**.

FIGURE 3.06 - 5
Typical Retention Basin Aquatic Bench - Section



Construction Specifications

The construction specifications for stormwater retention basins outlined below should be considered minimum guidelines. More stringent or additional specifications may be required based on individual site conditions.

Overall, widely accepted construction standards and specifications for embankment ponds and reservoirs, such as those developed by the USDA Soil Conservation Service or the U.S. Army Corps of Engineers, should be followed to build an impoundment.

Further guidance can be found in Chapter 17 of the Soil Conservation Service's Engineering Field Manual. Specifications for the work should conform to methods and procedures indicated for installing earthwork, concrete, reinforcing steel, pipe, water gates, metal work, woodwork and masonry and any other items that are apply to the site and the purpose of the structure. The specifications should also satisfy any requirements of the local plan approving authority.

The following minimum standards contain guidance and construction specifications for various components of retention basins: **3.01, Earthen Embankment**; **3.02, Principal Spillway**; **3.03, Vegetated Emergency Spillway**; **3.04, Sediment Forebay**; and **3.05, Landscaping**.

Maintenance and Inspections

The following maintenance and inspection guidelines are not intended to be all-inclusive. Specific facilities may require other measures not discussed here. The engineer is responsible for determining if any additional items are necessary.

Inspecting and maintaining the structures and the impoundment area should be the responsibility of either the local government, a designated group such as a homeowner's association or an individual. A specific maintenance plan should be formulated outlining the schedule and scope of maintenance operations.

Any standing water pumped during the maintenance operation must be disposed of per the VESCH, 1992 edition and any local requirements.

General Maintenance

Maintenance and inspection guidelines found in the following minimum standards apply: **3.01, Earthen Embankment**; **3.02, Principal Spillway**; **3.03, Vegetated Emergency Spillway**; **3.04, Sediment Forebay**; and **3.05: Landscaping**.

Vegetation

The basin's side slopes, embankment and emergency spillway should be mowed at least twice a year to discourage woody growth. For aesthetic purposes, more frequent mowing may be necessary in residential areas

Specific plant communities may require different levels of maintenance. Upland and floodplain terrace areas, grown as meadows or forests, require very little maintenance, while aquatic or emergent vegetation may need periodic thinning or reinforcement plantings. Note that after the first growing season, it should be obvious if reinforcement plantings are needed. If they are, they should be installed at the onset of the second growing season after construction.

Research indicates that for most aquatic plants the uptake of pollutants is stored in the roots, not the stems and leaves (Lepp 1981). Therefore, aquatic plants should not require harvesting before winter plant die-back. There are still many unanswered questions about the long term pollutant storage capacity of plants. It is possible that aquatic and emergent plant maintenance recommendations may be presented in the future.

Debris and Litter Removal

Debris and litter will accumulate near the inflow points and around the outlet control structure. Such material should be removed periodically. Also, as the water level rises during storm events, floatables accumulate around the grate or trash rack of the control structure. If a flat horizontal trash rack is used, floating debris will become lodged on the trash rack, which will remain clogged until it is manually cleaned. A significant accumulation can clog the riser structure. The use of an angled trash rack is recommended to allow any accumulated debris to slide off as the water level drops.

Sediment Removal

Sediment deposition should be continually monitored in the basin. Removal of any accumulated sediment, in the sediment forebay or elsewhere, is extremely important. A significant accumulation of sediment impairs the pollutant removal capabilities of the basin by reducing the permanent pool volume. The deposited sediment also becomes prone to resuspension during heavy flow periods. Unless unusual conditions exist, accumulated sediment should be removed from the sediment forebay and possibly other deep areas within the permanent pool every 5 to 10 years. The use of a sediment forebay with access for heavy equipment will greatly simplify the removal process. **During maintenance procedures, ensure that any pumping of standing water or dewatering of dredged sediments complies with the VESCH, 1992 edition, and any local requirements**.

Owners, operators, and maintenance authorities should be aware that significant concentrations of heavy metals (e.g., lead, zinc and cadmium) and some organics, such as pesticides, may be expected to accumulate at the bottom of a retention basin. Testing of sediment, especially near points of inflow, should be conducted regularly and **before disposal** to establish the leaching potential and level of accumulation of hazardous materials. Disposal methods must comply with applicable state and local regulations (e.g., for special waste).

Inspections

A retention basin and its components should be inspected annually, at a minimum, to ensure that they operate in the manner originally intended. Items in need of repair should be addressed promptly and as specified in the comprehensive maintenance program. Detailed inspections by qualified person(s) should address the following areas/concerns:

- Dam settling, woody growth, and signs of piping
- Signs of seepage on the downstream face of the embankment
- Condition of grass cover on the embankment, basin floor and perimeter
- Riprap displacement or failure
- Principal and emergency spillway meet design plans for operation
- Outlet controls, debris racks and mechanical and electrical equipment
- Outlet channel conditions
- Inlet pipe conditions
- Safety features of the facility
- Access for maintenance equipment
- Sediment accumulation
- Debris and trash accumulation
- Erosion of the embankment or side slopes

Design Procedures

1. Determine if the anticipated development conditions and drainage area are appropriate for a stormwater retention basin BMP.

   C Minimum drainage area of 10 acres and/or base flow

2. Determine if the soils (permeability, bedrock, Karst, embankment foundation, etc.) and topographic conditions (slopes, existing utilities, environmental restrictions) are appropriate for a stormwater retention basin BMP.

3. Determine any additional stormwater management requirements (channel erosion, flooding) for the project.

4. Locate the stormwater retention basin on the site.

5. Determine the hydrology and peak discharges of the contributory drainage area for each of the required design storms (**Chapter 4, Hydrologic Methods**).

6. Calculate the permanent pool volume and approximate storage volume requirements (**Chapter 5, Engineering Calculations**).

7. Design the embankment (**Min. Std. 3.01**), principal spillway (**Min. Std. 3.02**), emergency spillway (**Min. Std. 3.03**), sediment forebay (**Min. Std. 3.04**), landscaping plan (**Min. Std. 3.05**), and the permanent pool and other components of a stormwater retention basin BMP (**Min. Std. 3.06**) using **Chapter 5, Engineering Calculations**, and the Minimum Standards listed.

   - permanent pool depth
   - Permanent pool geometry
   - release depth
   - aquatic bench
   - pond drain

8. Design final grading of basin.

   - landscape plan
   - 20-foot buffer area
   - safety (3:1 slopes with bench)
   - access

9. Establish specifications for sediment control and sediment basin conversion (if required).

10. Establish construction sequence and construction specifications.

11. Establish maintenance and inspection requirements.

Checklists

Refer to **Appendix-3A** for **Design and Plan Review**, **Construction Inspection**, and **Operation and Maintenance** Checklists.

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Retention basin with small island.

Retention basin in ultra-urban setting (under construction).

Retention Basin

Chapter 3.06

Retention basin – Note flat slopes with "rough" edge and aquatic bench provided as safety and pollutant removal features.

Retention Basin