HARFORD COUNTY GOVERNMENT

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS & WATER RESOURCES

Excerpts from the Maryland 2000 Stormwater Design Manual

Harford County Government

Department of Public Works
Division of Highways & Water Resources
Stormwater Management

I. Introduction

The Maryland 2000 Stormwater Design Manual sets forth fourteen (14) performance standards that must be applied to any earth moving (construction) activity disturbing 5,000 or more square feet. Summaries of the standards are as follows:

Standard No. 1 Site designs shall minimize the generation of stormwater and maximize pervious areas for stormwater treatment.

Standard No. 2 Stormwater runoff generated from development and discharged directly into a jurisdictional wetland or waters of the State of Maryland shall be adequately treated.

Standard No. 3 Annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods. At a minimum, the annual recharge from post development site conditions shall mimic the annual recharge from pre development site conditions.

Standard No. 4 Water quality management shall be provided through the use of environmental site design practices.

Standard No. 5 Structural BMPs used for new development shall be designed to remove 80% of the average annual post development total suspended solids load (TSS) and 40% of the average annual post development total phosphorous load (TP).

Standard No. 6 Control of the two-year and ten-year frequency storm events is required if the local authority determines that additional stormwater management is necessary because historical flooding problems exist and downstream floodplain development and conveyance system design cannot be controlled. In addition, safe conveyance of the 100-year storm even through stormwater management practices shall be provided.

Standard No. 7 To protect stream channels from degradation, the channel protection storage volume (Cp_v) shall be based on the runoff from the one-year frequency storm event. Environmental site design practices shall be used to the maximum extent practicable to address Cp_v.

Standard No. 8 Stormwater discharges to critical areas with sensitive resources (e.g. cold water fisheries, shellfish beds, swimming beaches, recharge areas, water supply reservoirs, Chesapeake and Atlantic Coastal Bays Critical Area may be subject to additional performance criteria or may need to utilize or restrict certain BMPs).

Standard No. 9	All stormwater management practices shall have an enforceable operation and maintenance agreement to ensure the system functions as designed.
Standard No. 10	Every BMP shall have an acceptable form of water quality pretreatment.
Standard No. 11	Redevelopment, defined as any construction, alteration or improvement on sites where existing land use is commercial, industrial, institutional or multi-family residential and site impervious area exceeds 40%, is governed by special stormwater sizing criteria depending on the amount of increase or decrease in impervious area created by the redevelopment.
Standard No. 12	Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan and file a notice of intent (NOI) under the provisions of Maryland's Stormwater Industrial National Pollutant Discharge Elimination System (NPDES). The stormwater pollution prevention plan requirement applies to both existing and new industrial sites.
Standard No. 13	Stormwater discharges from land uses or activities with higher potential for pollutant loadings, defined as hotspots, may require the use of specific structural BMPs and pollution prevention practices. In addition, stormwater from a hotspot land use may not be infiltrated without proper pretreatment.
Standard No. 14	In Maryland, local governments are usually responsible for most stormwater management review authority. Therefore, prior to design, applicants should always consult with their local reviewing agency to determine if they are subject to additional stormwater design requirements. In addition, certain earth disturbances may require NPDES construction general permit coverage from MDE.

II. Stormwater Management Measures

Harford County Code 214-31 requires that the following stormwater management practices be designed according to the Maryland Design Manual. These stormwater BMP's are broken in the following categories:

- Stormwater management ponds
- Stormwater management wetlands
- Stormwater management infiltration
- Stormwater management filtering systems
- Stormwater management open channel systems

A. Stormwater Management Ponds

Facilities, which have a permanent pool, or a combination of shallow wetland with a permanent pool, store the entire water quality volume. Water quality volume is defined as the "storage needed to capture and treat the runoff from 90% of the annual rainfall".

Annual rainfall depth for Harford County:

2.6 inches for the 1 year – 24 hour storm event
3.2 inches for the 2 year – 24 hour storm event
5.1 inches for the 10 year – 24 hour storm event
7.2 inches for the 100 year – 24 hour storm event

Stormwater Ponds

- Wet Pond
- Micropool Extended Detention Pond
- Wet Extended Detention Pond
- Multiple Pond System
- Pocket Ponds
- Detention Ponds (pre-2000 Design Manual)

Retention Pond Characteristics

- Ponds with deep permanent pool areas (4' or greater in depth) shall be surrounded by 2 benches with a combined minimum width of 15 feet.

  Safety bench – extends outward from normal water edge to the toe of the pond side slope. The maximum slope of the safety bench is 6%.

  Aquatic bench – extends inward from the normal shoreline and has a maximum depth of 18 inches below the normal pool water surface elevation. An aquatic bench is not required in forebays.

- Principal spillway/riser with trash rack
- Anti-flotation
- Anti-vortex
- Anti-seep collar and/or filter diaphragm
- Low flow orifice/pipe – horizontal perforated pipe wrapped with hardware cloth; a geotextile wrap and gravel is not recommended
- Vertical standpipe – located in permanent pools; over-perforated and wrapped with hardware cloth and protected with a stone jacket
- Pond drain – can completely or partially drain the pond within 24 hours
- Valves – located inside the riser where they will not be inundated by water and can be operated in a safe manner (usually with a hand wheel or a gate valve)
- One (1) foot of freeboard above the design high water for the 10 year storm
- Emergency spillway
- Forebay for storm drain outfalls – exception is when the inlet provides less than 10% of the total inflow to the pond
- Sediment depth marker in forebay
- Minimum of a twelve (12) foot wide access right-of-way from public road
- Non-clogging low flow orifice with trash rack
- Endwalls – pipe outfalls greater than 48" diameter should be fenced to prevent injury
- Fence (if required)

- Pond buffer – extends 25 feet outward from the maximum water surface elevation. Woody vegetation may not be planted on nor allowed to grow within 15 feet of the toe of the embankment and 25 feet of the principal spillway structure.

Wet Pond, Multiple Pond System

Sediment forebay shall be located at the storm drain outfall into the pond and be sized to contain 0.1 inch per impervious area of contribution drainage. Multiple cells provide water quality storage.

Micropool Extended Detention

May have a pilot channel directing flow to a micropool. The purpose of the micropool is to allow sediments to settle and prevent clogging of the low flow orifice.

Q_f (extreme flood protection volume) – Storage to attenuate the post development 100 year, 24-hour discharge. This is the most expensive and stringent level of flood control. This criteria is generally not needed if the downstream development is located outside the 100-year flood plain.

Q_{p10} (overbank flood protection volume) – Conveyance to pond is designed on the discharge rate for the ten-year storm.

Wet Extended Detention Pond

Water quality is provided through a combination of permanent pool and extended detention (24 hour draw down of the water quality volume). The storage for Cp_v and WQ_v must be computed separately. WQ_v requirement cannot be met by using the Cp_v storage for the one-year storm.

Pocket Pond

Designed to accept small contributing drainage area that has little or no base flow to sustain water elevation during dry weather. Water elevation is maintained by a high water table.

Pond buffer – extends 25 feet outward from the maximum water surface elevation. Woody vegetation may not be planted on nor allowed to grow within 15 feet of the toe of the embankment and 25 feet of the principal spillway structure.

Detention Pond Characteristics

Ponds do not provide water quality benefits

- Principal spillway/riser with trash rack
- Anti-flotation
- Anti-vortex
- Anti-seep collar and/or filter diaphragm
- Low flow orifice/pipe – horizontal perforated pipe wrapped with hardware cloth; a geotextile wrap and gravel is not recommended
- Vertical standpipe – over-perforated and wrapped with hardware cloth and protected with a stone jacket
- One (1) foot of freeboard above the design high water for the 10 year storm

- Emergency spillway
- Pilot channel
- Minimum of a twelve (12) foot wide access right-of-way from public road
- Non-clogging low flow orifice with trash rack
- Fence (if required)

B. Stormwater Management Wetlands

Facilities must withstand a 30-day drought at summer evaporation rates without completely drawing down. Flow paths from inflow points to outflow points within stormwater wetlands are maximized (meanders).

- Shallow wetland
- ED shallow wetland
- Pond/wetland system
- Pocket wetland

Wetland Characteristics

- Design requirements same as stormwater management ponds
- Forebays shall be located at the inlet and a micropool shall be located at the outlet.
- Micropools – 3 to 6 foot deep pool used to protect the low flow pipe from clogging and prevent sediment resuspension
- Surface area of the entire wetland shall be at least 1% of the total drainage area and 1.5% for shallow wetland design
- Minimum 25% of WQ_v shall be in deep water zones with a minimum depth of 4' (forebay and micropool may be used to meet this criteria)
- Minimum 35% of the total surface area shall have a depth of 6" or less; and
- Minimum 65% of the total surface area shall be shallower than 18"

Wetland Extended Detention

Extended detention volume shall not be more than 50% of the total wetland design and the maximum water surface elevation shall not extend more than 3' above the normal pool elevation.

Rock beds, as a medium for wetland plants, may be used to promote greater nitrogen removal. Rocks should be 1-3 inches in diameter and placed up to normal pool elevation.

Wetland Establishment – Early April / Mid June

- Open wetland drain at least 3 days prior to planting date
- 3 to 6 inches of wetland soil or topsoil to be added 1' below normal pool to 6" above (provides nutrients and organic matter)
- ½ of wetland should be planted in first year
- Plants in clumps should be planted approx. 18" o.c.
- Individual plants should be spaced 12 – 14" o.c.
- Optimal depth for several common species of emergent wetland plants are often 6" or less

C. Stormwater Management Infiltration

Practices that capture and temporarily stores the WQ_v while allowing infiltration into the soil over a prescribed period.

- Infiltration trench
- Infiltration basin

Infiltration trench

The recharge volume (Re_v) and the WQ_v are in one location (e.g. stone filled trenches; pvc exfiltrators; rain storage grids).

Observation wells measure depth of accumulated sediments.

Infiltration Basin

WQ_v is retained and infiltrates through bottom of basin in a 2-day period

- Perforated low flow pipe is below the pond's bottom elevation
- Infiltration cannot be located on slopes greater than 15% or within fill soils
- The maximum contributing drainage area is generally less than 5 acres
- Basin must be located at a minimum 100' from a water supply well
- 25% of the WQ_v must be pretreated prior to entry to an infiltration facility. If the existing soils have an infiltration rate less than 2" per hour than 50% of the WQ_v must be pretreated

An infiltration trench must use (3) and a basin (2) of the following techniques:

- Grass channel
- Grass filter strip
- Bottom sand layer
- Upper sand layer (6" min) with filter fabric at the sand/gravel interface
- Washed bank gravel as an aggregate

D. Stormwater Management Filtering Systems

Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media. Filtered runoff may be collected and returned to the conveyance system or partially exfiltrate into the soil. These systems are not designed to met Cp_v or Q_p; they must be combined with a separate facility that provides those controls.

- Surface sand filter
- Underground sand filter
- Perimeter sand filter
- Organic sand filter
- Pocket sand filter
- Bioretention

Filtering Systems

Maximum drainage area is usually less than 10 acres. These facilities are normally applied to land uses with a high percentage of impervious surfaces.

- A minimum 4" perforated under drain (6" is preferred) in a gravel layer
- A permeable filter fabric shall be placed between the gravel layer and the filter media
- Filter bed is normally 18" in depth; sand filters must be a minimum depth of 12"

E. Open Channel Systems

Vegetated open channels designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or by other means. These systems are not designed to meet Cp_v or Qp_v; they must be combined wlth a separate facility that provides those controls. These systems may be used to meet the Re_v if designed to exfiltrate through the soil.

Grass channels (biofilters) must be designed in accordance with the Manual to be considered acceptable practice to meet WQv requirements.

Glossary

Portions of this glossary were adapted from the "*1994 Maryland Standards and Specifications for Soil Erosion and Sediment Control*" produced by the Maryland Department of the Environment, Water Management Administration.

ANTI-SEEP COLLAR – An impermeable diaphragm usually of sheet metal or concrete constructed at intervals within the zone of saturation along the conduit of a principal spillway to increase the seepage length along the conduit and thereby prevent piping or seepage.

ANTI-VORTEX DEVICE – A device designed and placed on the top of a riser or the entrance of a pipe to prevent the formation of a vortex in the water at the entrance.

AQUATIC BENCH – A bench which is located around the inside perimeter of a permanent pool and is normally vegetated with aquatic plants; the goal is to provide pollutant removal and enhance safety in areas using stormwater pond BMP's.

AQUIFER – A porous water bearing geologic formation generally restricted to materials capable of yielding an appreciable supply of water.

AS-BUILT – Drawing or certification of conditions as they were actually constructed.

BAFFLES – Guides, grids, grating or similar devices placed in a pond to deflect or regulate flow and create a longer flow path.

BANKFULL FLOW – The condition where stream flow fills a stream channel to the top of the bank and at a point where the water begins to overflow onto a floodplain.

BARREL – The closed conduit used to convey water under or through an embankment; part of the principal spillway.

BASE FLOW – The stream discharge from groundwater.

BERM – A shelf that breaks the continuity of a slope; a linear embankment or dike.

BEST MANAGEMENT PRACTICE (BMP) – A structural or non-structural device designed to temporarily store or treat stormwater runoff in order to mitigate flooding, reduce pollution and provide other amenities.

BIORETENTION – A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff by collecting it in shallow depressions before filtering through a fabricated planting soil media.

BUFFER – Zone of variable width located along both sides of a natural feature (e.g., stream or forested area) and designed to provide a protective area along a corridor.

CHANNEL – A natural stream that conveys water; a ditch or channel excavated for the flow of water.

CHANNEL PROTECTION VOLUME (CP_v) – A design criteria which requires 24 hour detention of the one year post-developed, 24 hour storm event for the control for stream channel erosion and is calculated according to Appendix D.11.

CHANNEL STABILIZATION – Erosion prevention and stabilization of velocity distribution In a channel using jetties, drops, revetments, structural linings, vegetation and other measures.

CHECK DAM – A small dam constructed in a gully or other small watercourse to decrease flow velocity (by reducing the channel gradient), minimize scour, and promote deposition of sediment.

CHUTE – A high velocity, open channel for conveying water to a lower level without erosion.

CLAY (SOILS) – 1. A mineral soil separate consisting of particles less than 0.002 millimeter in equivalent diameter. 2. A soil texture class. 3. (Engineering) A fine grained soil (more than 50 percent passing the No. 200 sieve) that has a high plasticity index in relation to the liquid limit. (Unified Soil Classification System)

COCONUT ROLLS – Also known as coir rolls, these are rolls of natural coconut fiber designed to be used for stream bank stabilization.

COMPACTION (SOILS) – Any process by which the soil grains are rearranged to decrease void space and bring them in closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength and reducing permeability.

CONDUIT – Any channel intended for the conveyance of water, whether open or closed.

CONTOUR – 1. An imaginary line on the surface of the earth connecting points of the same elevation. 2. A line drawn on a map connecting points of the same elevation.

CORE TRENCH – A trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

CRADLE – A structure usually of concrete shaped to fit around the bottom and sides of a conduit to support the conduit, increase its strength and, in dams, to fill all voids between the underside of the conduit and the soil.

CREST – 1. The top of a dam, dike, spillway or weir, frequently restricted to the overflow portion. 2. The summit of a wave or peak of a flood.

CRUSHED STONE – Aggregate consisting of angular particles produced by mechanically crushing rock.

CURVE NUMBER (CN) – A numerical representation of a given area's hydrologic soil group, plant cover, impervious cover, interception and surface storage derived in accordance with Natural Resources Conservation Service methods. This number is used to convert rainfall depth into runoff volume.

CUT – Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

CUT AND FILL – Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

CUTOFF – A wall or other structure, such as a trench, filed with relatively impervious material intended to reduce seepage of water through porous strata.

CZARA – Acronym used for the Coastal Zone Act Reauthorization Amendments of 1990. These amendments sought to address the nonpoint source pollution issue by requiring states to develop coastal nonpoint pollution control programs in order to receive federal funds.

DAM – a barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion, or for retention of soil, sediment or other debris.

DETENTION – The temporary storage of stormwater runoff in a BMP with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

DETENTION STRUCTURE – A permanent structure for the temporary storage of runoff that is designed to not create a permanent pool of water.

DIKE – An embankment to confine or control water, for example, one built along the banks of a river to prevent overflow to lowlands; a levee.

DISTRIBUTED RUNOFF CONTROL (DRC) - A stream channel protection criteria which utilizes a non-uniform distribution of the storage-stage-discharge relationship within a BMP to minimize the change in channel erosion potential from pre-developed to developed conditions.

DISTURBED AREA – An area in which the natural vegetative soil cover has been removed or altered, and, therefore, is susceptible to erosion.

DIVERSION – A channel with a supporting ridge on the lower side constructed across the slope to divert water to areas where it can be used or disposed of safely. Diversions differ from terraces in that they are individually designed.

DRAINAGE – 1. The removal of excess surface water or ground water from land by means of surface or subsurface drains. 2. Soil characteristics that affect natural drainage.

DRAINAGE AREA (WATERSHED) – That area contributing runoff to a single point measured in a horizontal plate, which is enclosed by a ridge line.

DROP STRUCTURE – A structure for dropping water to a lower level and dissipating surplus energy; a fall.

DRY SWALE – An open drainage channel explicitly designed to detain and promote the filtration of stormwater runoff through an underlying fabricated soil media.

EMERGENCY SPILLWAY – A dam spillway, constructed in natural ground, that is to discharge flow in excess of the principal spillway design discharge.

ENERGY DISSIPATOR – A designed device such as an apron of rip-rap or a concrete structure placed at the end of a conduit for the purpose of reducing the velocity, energy and turbulence of the discharged water.

EROSION – 1. The process by which the land surface is worn away by the action of water, wind, ice or other gravity. 2. Detachment and movement of soil or rock fragments by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

Accelerated erosion – Erosion much more rapid than normal, natural or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophes that expose base surfaces.

Gully erosion – The erosion process whereby water accumulates in narrow channels and removes the soil from this narrow area to considerable depths ranging from 1 to 2 feet to as much as 75 to 100 feet.

Rill erosion – An erosion process in which numerous small channels only several inches deep are formed. See rill.

Sheet erosion – The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not subsequently be removed by surface runoff.

EROSIVE VELOCITIES – Velocities of water that are high enough to wear away the land surface. Exposed soil will generally erode faster than stabilized soils. Erosive velocities will vary according to the soil type, slope, structural, or vegetative stabilization used to protect the soil.

EXFILTRATION – The downward movement of water through the soil; the downward flow of runoff from the bottom of an infiltration BMP into the soil.

EXTENDED DETENTION – A stormwater design feature that provides for the gradual release of a volume of water in order to increase settling of pollutants and protect downstream channels from frequent storm events.

EXTREME FLOOD VOLUME (Q_f) – The storage volume required to control those infrequent but large storm events in which overbank flows reach or exceed the boundaries of the 100-year floodplain.

FILTER BED – The section of a constructed filtration device that houses the filter media and the outflow pipe.

FILTER FENCE – A geotextile fabric designed to trap sediment and filter runoff.

FILTER MEDIA – The sand, soil, or other organic material in a filtration device used to provide a permeable surface for pollutant and sediment removal.

FILTER STRIP – A strip of permanent vegetation above ponds, diversions and other structures to retard the flow of runoff, causing deposition of transported material, thereby reducing sedimentation.

FINES (SOIL) – Generally refers to the silt and clay size particles in soil.

FLOODPLAIN – Areas adjacent to a stream or river that are subject to flooding or inundation during a storm event that occurs, on average, once every 100 years (or has a likelihood of occurrence of 1/100 in any given year).

FLOW SPLITTER – An engineered, hydraulic structure designed to divert a percentage of storm flow to a BMP located out of the primary channel, or to direct stormwater to a parallel pipe system or to bypass a portion of base flow around a BMP.

FOREBAY – Storage space located near a stormwater BMP inlet that serves to trap incoming coarse sediments before they accumulate in the main treatment area.

FREEBOARD (HYDRAULICS) – The distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditions.

FRENCH DRAIN – A type of drain consisting of an excavated trench filled with pervious material, such as coarse sand, gravel or crushed stone; water percolates through the voids in this material and flows to an outlet.

GABION – A flexible woven wire basket composed of rectangular cells filled with small stones. Gabions may be assembled into many types of structures such as revetments, retaining walls, channel liners, drop structures and groins.

GABION MATTRESS – A thin gabion, usually six or nine inches thick, used to line channels for erosion control.

GRADE – 1. The slope or finished surface of a road, channel, canal bed, roadbed, top of embankment, bottom of excavation, or natural ground; any surface prepared for the support of construction, like paving or laying a conduit. 2. To finish the surface of a canal bed, roadbed, top of embankment or bottom of excavation.

GRASS CHANNEL – An open vegetated channel used to convey runoff and to provide treatment by filtering pollutants and sediments.

GRAVEL – 1. Aggregate consisting of mixed sizes of ¼ inch to 3 inches which normally occur in or near old streambeds and have been worn smooth by the action of water. 2. A soil having particle sizes, according to the Unified Soil Classification System, ranging from the No. 4 sieve size, angular in shape, as produced by mechanical crushing.

GRAVEL DIAPHRAGM – A stone trench filled with small, river-run gravel used as pretreatment and inflow regulation in stormwater filtering systems.

GRAVEL FILTER – Washed and graded sand and gravel aggregate placed around a drain or well screen to prevent the movement of fine materials from the aquifer into the drain or well.

GRAVEL TRENCH – A shallow excavated channel backfilled with gravel and designed to provide temporary storage and permit percolation of runoff into the soil substrate.

GROUND COVER – Plants which are low-growing and provide a thick growth which protects the soil as well as providing some beautification of the area occupied.

GULLY – A channel or miniature valley cut by concentrated runoff through which water commonly flows during and immediately after heavy rains or snow melt. The distinction between gully and rill is one of depth. A gully is sufficiently deep such that it would not be obliterated by normal tillage

operations, whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage or grading activities.

HEAD (HYDRAULICS) – 1. The height of water above any plane of reference. 2. The energy, either kinetic or potential, possessed by each unit weight of a liquid expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various terms such as pressure head, velocity head, and head loss.

HERBACEOUS PERENNIAL (PLANTS) – A plant whose stems die back to the ground each year.

HIGH MARSH – A pondscaping zone within a stormwater wetland that exists from the surface of the normal pool to a six inch depth and typically contains the greatest density and diversity of emergent wetland plants.

HIGH MARSH WEDGES – Slices of shallow wetland (less than or equal to 6 inches) dividing a stormwater wetland.

HOTSPOT – Area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

HYDRAULIC GRADIENT – The slope of the hydraulic grade line. That includes static and potential head.

HYDRODYNAMIC STRUCTURE – An engineered structure to separate sediments and oils from stormwater runoff using gravitational separation and/or hydraulic flow.

HYDROGRAPH – A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

HYDROLOGIC SOIL GROUP (HSG) – A Natural Resource Conservation Service classification system in which soils are categorized into four runoff potential groups. The groups range from A soils, with high permeability and little runoff production, to D soils, which have low permeability rates and produce much more runoff.

HYDROSEED – An application of seed or other material applied with forced water in order to revegetate.

IMPERVIOUS COVER (I) – Those surfaces in the landscape that cannot infiltrate rainfall consisting of building rooftops, pavement, sidewalks, driveways, etc.

INDUSTRIAL STORMWATER PERMIT – A NPDES permit issued to an identified land use that regulates the pollutant levels associated with industrial stormwater discharges or specifies on-site pollution control strategies.

INFILTRATION RATE (*f*) – The rate at which stormwater percolates into the subsoil measured in inches per hour.

INFLOW PROTECTION – A water handling device used to protect the transition area between any water conveyance (dike, swale, or swale dike) and a sediment trapping device.

KARST GEOLOGY – Regions that are characterized by formations underlain by carbonate rock and typified by the presence of limestone caverns and sinkholes.

LEVEL SPREADER – A device for distributing stormwater uniformly over the ground surface as sheet flow to prevent concentrated, erosive flows and promote infiltration.

MANNING'S FORMULA (HYDRAULICS) – A formula used to predict the velocity of water flow in an open channel or pipeline:

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

Where V is the mean velocity of flow in feet per second; *r* is the hydraulic radius; s is the slope of the energy gradient or for assumed uniform flow the slope of the channel, in feet per foot; and *n* is the roughness coefficient or retardance factor of the channel lining.

MICROPOOL – A smaller permanent pool which is incorporated into the design of larger stormwater ponds to avoid re-suspension of particles and minimize impacts to adjacent natural features.

MICROTOPOGRAPHY – The complex contours along the bottom of a shallow wetland system, providing greater depth variation that increases the wetland plant diversity and increases the surface area to volume ratio.

MULCH – Covering on the soil surface to protect and enhance certain characteristics, such as water retention qualities.

MUNICIPAL STORMWATER PERMIT – A NPDES permit issued to municipalities to regulate discharges from municipal separate storm sewers for compliance with EPA regulations.

NPDES – Acronym for the National Pollutant Discharge Elimination System, which regulates point source discharges.

NON-STRUCTURAL BMPs – Stormwater runoff treatment techniques which use natural measures to reduce pollution levels, do not require extensive construction efforts and/or promote pollutant reduction by eliminating the pollutant source.

NITROGEN-FIXING (BACTERIA) – Bacteria having the ability to fix atmospheric nitrogen, making it available for use by plants.

NORMAL DEPTH – Depth of flow in an open conduit during uniform flow for any given conditions.

OUTFALL – The point where water discharges from a conduit, stream, or drain.

OFF-LINE – A management system designed to control a storm event by diverting a percentage of stormwater events from a stream or storm drainage system.

ON-LINE – A management system designed to control stormwater in its original stream or drainage channel.

ONE YEAR STORM – A stormwater event which occurs on average once every year or statistically has a 100% chance on average of occurring in a given year.

ONE HUNDRED YEAR STORM – An extreme flood event which occurs on average once every 100 years or statistically has a 1% chance on average of occurring in a given year.

OPEN CHANNEL – Also known as swale, grass channel, or biofilter. This system is used for the conveyance, retention, infiltration and filtration of stormwater runoff.

OUTLET – The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

OUTLET CHANNEL – A waterway constructed or altered primarily to carry water from man-made structures such as terraces, subsurface drains, diversions and impoundments.

OVERBANK FLOOD PROTECTION VOLUME (Q_p) – The volume controlled by structural practices to prevent an increase in the frequency of out of bank flooding generated by development.

PEAK DISCHARGE RATE – The maximum instantaneous rate of flow during a storm, usually in reference to a specific design storm event.

PERCENT AREA METHOD – Technique used to evaluate the compliance of a non-structural BMP for meeting recharge requirements by calculating the percent of impervious area effectively treated and comparing to a minimum recharge target percentage for the various soil groups.

PERCENT VOLUME METHOD – Procedure used with structural BMPs to evaluate compliance with recharge requirements by assuring that the volume of runoff treated by the practice exceeds the computer recharge volume.

PERMANENT SEEDING – The establishment of perennial vegetation which may remain for many years.

PERMEABILITY – The rate of water movement through a soil column under saturated conditions.

PERMEABLE COVER – Those surfaces in the landscape consisting of open space, forested areas, meadows, etc. that infiltrate rainfall.

PERMISSIBLE VELOCITY (HYDRAULICS) – The highest average velocity at which water may be carried safety in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. A safe, non-eroding or allowable velocity.

pH – A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. A pH of 7.0 denotes neutrality, higher values indicate alkalinity, and lower values indicate acidity.

PIPING – Removal of soil material through subsurface flow channels.

PLUGS – Pieces of turf or sod, usually cut with a round tube, which can be used to propagate the turf or sod by vegetative means.

POCKET POND – A stormwater pond designed for treatment of small drainage area (<5 acres) runoff and which has little or no base flow available to maintain water elevations and relies on groundwater to maintain a permanent pool.

POCKET WETLAND – A stormwater wetland design adapted for the treatment of runoff from small drainage areas (<5 acres) and which has little or no base flow available to maintain water elevations and relies on groundwater to maintain a permanent pool.

POND BUFFER – The area immediately surrounding a pond which acts as a filter to remove pollutants and provide infiltration of stormwater prior to reaching the pond. Provides a separation barrier to adjacent development.

POND DRAIN – A pipe or other structure used to drain a permanent pool within a specified time period.

PONDSCAPING – Landscaping around stormwater ponds which emphasizes using native vegetative species to meet specific design intentions. Species are selected for up to six zones in the pond and its surrounding buffer based on their ability to tolerate inundation and/or soil saturation.

POROSITY (*n*) – Ratio of pore volume to total volume.

PRETREATMENT – Techniques employed in stormwater BMPs to provide storage or filtering to help trap course materials and other pollutants before they enter the system.

PRINCIPAL SPILLWAY – The primary pipe or weir which carries base flow and storm flow through a dam embankment.

RECHARGE RATE – Annual amount of rainfall which contributes to groundwater as a function of hydrologic soil group.

RECHARGE VOLUME (Re_v) – The portion of the water quality volume (WQ_v) used to maintain groundwater recharge rates at development sites.

REDEVELOPMENT – Any construction, alteration, or improvement exceeding five thousand square feet of land disturbance performed on sites where existing land use is commercial, industrial, institutional, or multifamily residential.

RETENTION – The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

REVERSE-SLOPE PIPE – A pipe which draws from below a permanent pool extending in a reverse angle up to the riser and determines the water elevation of the permanent pool.

RIGHT-OF-WAY - Right of passage, as over another's property. A route that is lawful to use. A strip of land acquired for transport, conveyance or utility construction.

RIP-RAP – Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves); also applies to brush or pole mattresses or brush and stone, or similar materials used for soil erosion control.

RISER – A vertical pipe or structure which extends from the bottom of a pond and houses the control devices (weirs/orifices) to achieve the discharge rates for specified designs.

ROUGHNESS COEFFICIENT (HYDRAULICS) – A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

RUNOFF (HYDRAULICS) – That portion of the precipitation on a drainage area that is discharged from the area in the stream channels. Types include surface runoff, groundwater runoff or seepage.

SAFETY BENCH – A relatively flat area above the permanent pool and surrounding a stormwater pond designed to provide a separation to adjacent slopes.

SAND – 1. (Agronomy) A soil particle between 0.05 and 2.0 millimeters in diameter. 2. A soil textural class. 3. (Engineering) According to the Unified Soil Classification System, a soil particle larger than the No. 200 sieve (0.074mm) and passing the No. 4 sieve (approximately ¼ inch).

SEDIMENT – Soils or other surficial materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

SEEPAGE – 1. Water escaping through or emerging from the ground. 2. The process by which water percolates through soil.

SEEPAGE LENGTH – In sediment basins or ponds, the length along the pipe and around the anti-seep collars that is within the zone of saturation through an embankment.

SETBACKS – The minimum distance requirements for locating certain structures in relation to roads, wells, septic fields, or other structures.

SHEET FLOW – Water, usually storm runoff, flowing in a thin layer over the ground surface.

SIDE SLOPES (ENGINEERING) – The slope of the sides of a channel, dam or embankment. It is customary to name the horizontal distance first, as 1.5 to 1, or frequently, 1 ½:1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.

SILT – 1. (Agronomy) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter. 2. A soil textural class. 3. (Engineering) According to the Unified Soil Classification System a fine grained soil (more than 50 percent passing the No. 200 sieve) that has a low plasticity index in relation to the liquid limit.

SOIL TEST – 1. Physical analysis of soil properties such as grain size, plasticity, or texture. 2. Chemical analysis of soil to determine the need for fertilizers or amendments for species of plant being grown.

SPILLWAY – An open or closed channel, or both, used to convey excess water from a reservoir. It may contain gates, either manually or automatically controlled to regulate the discharge of excess water.

STABILIZATION – Providing vegetative and/or structural measures that will reduce or prevent erosion.

STAGE (HYDRAULICS) – The variable water surface or the water surface elevation above any chosen datum.

STILLING BASIN – An open structure or excavation at the foot of an outfall, conduit, chute, drop, or spillway to reduce the energy of the descending stream of water.

STORMWATER FILTERING – Stormwater treatment methods which utilize an artificial media to filter out pollutants entrained in urban runoff.

STORMWATER PONDS – A land depression or impoundment created for the detention or retention of stormwater runoff.

STORMWATER WETLANDS – Shallow, constructed pools that capture stormwater and allow for growth of characteristic wetland vegetation.

STREAM BUFFERS – Zones of variable width which are located along both sides of a stream and are designed to provided a protective natural area along a stream corridor.

STRUCTURAL BMPs – Devices which are constructed to provide temporary storage and treatment of stormwater runoff.

SUBGRADE - The soil prepared and compacted to support a structure or a pavement system.

TAILWATER – Water, in a river or channel, immediately downstream from a structure.

TECHNICAL RELEASE NO. 20 (TR-20) – A Soil Conservation Service (now NRCS) watershed hydrology computer model that is used to compute runoff volumes and provide routing for storm events through stream valleys and/or ponds.

TECHNICAL RELEASE NO. 55 (TR-55) – A watershed hydrology model developed by the Soil Conservation Service (now NRCS) used to calculate runoff volumes and provide a simplified routing for storm events through stream valleys and/or ponds.

TEMPORARY SEEDING – A seeding which is made to provide temporary cover for the soil while waiting for further construction or other activity to take place.

TEN-YEAR STORM – The 24 hour storm event which exceeds bank full capacity and occurs on average once every ten years (or has a likelihood of occurrence of 1/10 in a given year).

TIME OF CONCENTRATION (t_c) – Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to the outlet.

TOE (OF SLOPE) – Where the slope stops or levels out. Bottom of the slope.

TOE WALL – Downstream wall of a structure, usually to prevent flowing water from eroding under the structure.

TOPSOIL – Fertile or desirable soil material used for the preparation of a seedbed.

TOTAL PHOSPHORUS (TP) – The total amount of phosphorus that is contained within the water column.

TOTAL SUSPENDED SOLIDS (TSS) – The total amount of particulate matter that is suspended in the water column.

TRASH RACK – Grill, grate or other device installed at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversized debris from entering the structure.

TRUNCATED HYDROGRAPH – A method of computing the required design infiltration storage volume utilizing the differences from post-developed and pre-developed hydrograph volumes over a specific time frame.

TWO YEAR STORM – The 24 hour storm event which exceeds bank full capacity and occurs on average once every two years (or has a likelihood of occurrence of ½ in a given year).

ULTIMATE CONDITION – Full watershed built-out based on existing zoning.

ULTRA-URBAN – Densely developed urban areas in which little pervious surface exists.

VELOCITY HEAD – Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity (32.16 feet per second per second) [$v^2/2g$].

VOLUMETRIC RUNOFF COEFFICIENT (R_v) – The value that is applied to a given rainfall volume to yield a corresponding runoff volume based on the percent impervious cover in a drainage basin.

WATER QUALITY VOLUME (WQ_V) – The volume needed to capture and treat 90% of the average annual stormwater runoff volume equal to 1" (or 0.9" in Western Rainfall Zone) times the volumetric runoff coefficient (R_v) times the site area.

WATER SURFACE PROFILE – The longitudinal profile assumed by the surface of a stream flowing in a open channel; the hydraulic grade line.

WATER USE DESIGNATION – State of Maryland water use classification for the protection of resources (i.e. Use I - contact recreational use, Use II – shellfish harvest waters, Use IIII-natural trout waters, Use IV – recreational trout waters).

WEDGES – Design feature in stormwater wetlands that increases flow path length to provide for extended detention and treatment of runoff.

WET SWALE – An open drainage channel or depression, explicitly designed to retain water or intercept groundwater for water quality treatment.

WETTED PERIMETER – The length of the wetted surface of the channel.

WING WALL – Side wall extensions of a structure used to prevent sloughing of banks or channels.

Finally, people often plant exotic species for their ornamental value. While it is important to have aesthetic stormwater management facilities for public acceptance and the maintenance of property value, it is not necessary to introduce foreign species for this purpose. Many native species are aesthetically pleasing and can be used as ornamentals. For example, the following species are part of Maryland's natural heritage and provide high aesthetic value throughout the year: rhododendron, pink azalea, red maple, pin oak, sycamore, flowering dogwood, mountain laurel, willow, hemlock, white pine, bald cypress, atlantic cedar, american holly, black-eyed susan, sunflower, lobelia, pickerel weed, marsh hibiscus, and yellow pond lily. When selecting ornamentals for stormwater management facilities, planting preference should be given to native ornamentals. Please refer to the plant list in Section A.4 for a comprehensive list of native species available for stormwater management facility planting.

A.1 General Landscaping Guidance for All Stormwater BMPs

- Trees, shrubs, and/or any type of woody vegetation are <u>not</u> allowed on the embankment.
- Plant trees and shrubs at least 15 feet away from the toe of slope of a dam.
- Trees or shrubs known to have long taproots should not be within the vicinity of the earth dam or subsurface drainage facilities.
- Plant trees and shrubs at least 25 feet away from perforated pipes.
- Plant trees and shrubs at least 25 feet away from a principal spillway structures.
- Provide 15 foot clearance from a non-clogging, low flow orifice.
- Herbaceous embankment plantings should be limited to 10 inches in height.
- Use erosion control mats and fabrics in channels to reduce the potential for erosion.
- Stabilize all emergency spillways with plant material that can withstand strong flows. Root material should be fibrous and substantial but lacking a taproot.
- Sod channels that are not stabilized with erosion control mats.
- Divert flows temporarily from seeded areas until stabilized.
- Check water tolerances of existing plant materials prior to inundation of area.
- Stabilize aquatic and safety benches with emergent wetland plants and wet seed mixes.
- Do not block maintenance access to structures with trees or shrubs.
- To reduce thermal warming, shade inflow and outflow channels as well as southern exposures of ponds.
- Avoid plantings that will require routine or intensive chemical applications (i.e. turf area).
- Have soil tested to determine if there is a need for amendments.
- Native plant species should be specified over exotic or foreign species because they are well adapted to local on-site soil conditions and require little or no additional amendments.
- Decrease the areas where turf is used. Use low maintenance ground cover to absorb run-off.

Section 2.7 Acceptable Urban BMP Options

This section sets forth six acceptable groups of BMPs that can be used to meet the water quality and/or groundwater recharge volume criteria.

2.7.1 Urban BMP Groups

The dozens of different BMP designs currently used in the State of Maryland are assigned into six general categories for stormwater quality control (WQ_v and/or Re_v):

BMP Group 1 stormwater ponds
BMP Group 2 stormwater wetlands
BMP Group 3 infiltration practices
BMP Group 4 filtering practices
BMP Group 5 open channel practices
BMP Group 6 non-structural practices

Within each BMP group, detailed performance criteria are presented that govern feasibility, conveyance, pretreatment, treatment, environmental/landscaping and maintenance requirements (see Chapter 3).

To be considered an effective BMP for stand-alone treatment of WQ_v, a design shall be capable of:

1. capturing and treating the required water quality volume (WQ_v),
2. removing 80% of the TSS,
3. removing 40% of the TP, and
4. having an acceptable longevity rate in the field.

A combination of structural and/or non-structural BMPs are normally required at most development sites to meet all five stormwater sizing criteria. Documentation of the capability of the BMPs to remove TSS is provided in Appendix D.5. Guidance on selecting the most appropriate combination of BMPs is provided in Chapter 4.

BMP Group 1. Stormwater Ponds

Practices that have a combination of a permanent pool, extended detention or shallow wetland equivalent to the entire WQ_v include:

P-1 micropool extended detention pond
P-2 wet pond
P-3 wet extended detention pond

P-4 multiple pond system
P-5 pocket pond

BMP Group 2. Stormwater Wetlands

Practices that include significant shallow wetland areas to treat urban stormwater but often may also incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v include:

W-1 shallow wetland
W-2 ED shallow wetland
W-3 pond/wetland system
W-4 pocket wetland

BMP Group 3. Infiltration Practices

Practices that capture and temporarily store the WQ_v before allowing it to infiltrate into the soil over a two day period include:

I-1 infiltration trench
I-2 infiltration basin

BMP Group 4. Filtering Practices

Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media are considered to be filtering practices. Filtered runoff may be collected and returned to the conveyance system. Design variants include:

F-1 surface sand filter
F-2 underground sand filter
F-3 perimeter sand filter
F-4 organic filter
F-5 pocket sand filter
F-6 bioretention*

* may also be used for infiltration.

BMP Group 5. Open Channel Practices

Vegetated open channels that are explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by checkdams or other means include:

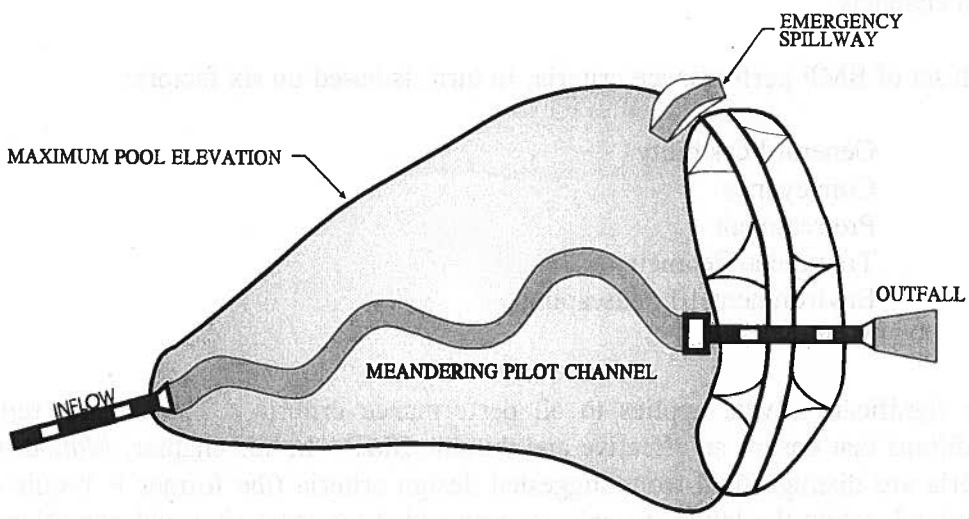
O-1 dry swale
O-2 wet swale

BMP Group 6. Non-structural BMPs

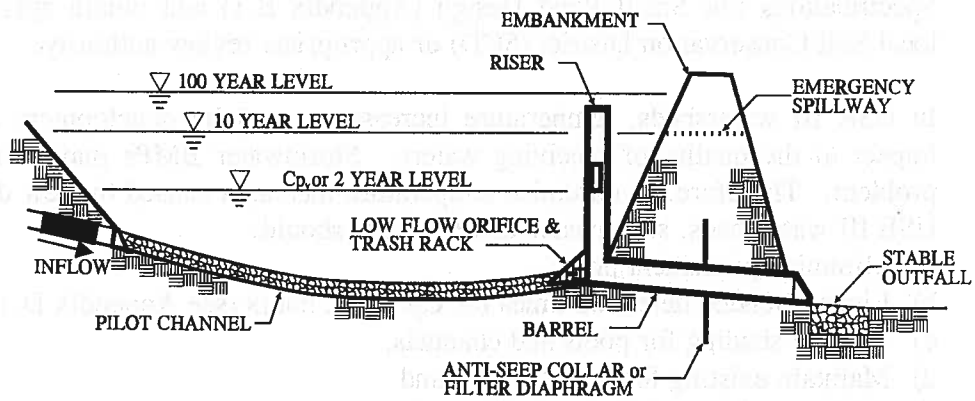
Non-structural BMPs are increasingly recognized as a critical feature of stormwater BMP plans, particularly with respect to site design. In most cases, non-structural BMPs shall be combined with structural BMPs to meet all stormwater requirements. The key benefit of non-structural BMPs is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of structural BMPs. In addition, they can provide partial removal of many pollutants. The non-structural BMPs have been classified into seven broad categories. To promote greater use of non-structural BMPs, a series of credits and incentives are provided for developments that use these progressive site planning techniques in Chapter 5.

- natural area conservation
- disconnection of rooftop runoff
- disconnection of non-rooftop impervious area
- sheet flow to buffers
- open channel use
- environmentally sensitive development
- impervious cover reduction

Figure 2.5 Example of Conventional Stormwater Detention Pond



PLAN VIEW



PROFILE

A typical detention facility provides channel protection control (Cp_v) and overbank flood control (Q_p) but not water quality control (WQ_v).

3.0 Performance Criteria for Urban BMP Design

This chapter outlines performance criteria for five groups of structural water quality stormwater BMPs that include ponds, wetlands, infiltration practices, filtering systems and open channels.

Each set of BMP performance criteria, in turn, is based on six factors:

- General Feasibility
- Conveyance
- Pretreatment
- Treatment/Geometry
- Environmental/Landscaping
- Maintenance

One significant caveat applies to all performance criteria. The criteria represent a set of conditions that ensure an effective and durable BMP. In this chapter, *Mandatory* performance criteria are distinguished from suggested design criteria (the former is required at all sites in Maryland, while the latter are only recommended for most sites and conditions). Thus, in the text, mandatory performance criteria are indicated by *italics*, whereas suggested design criteria are shown in normal typeface.

IMPORTANT NOTES:

1) Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local Soil Conservation District (SCD) or appropriate review authority.

2) In USE III watersheds, temperature increases caused by development are a primary impact to the quality of receiving waters. Stormwater BMPs may contribute to this problem. Therefore, to minimize temperature increases caused by new development in USE III watersheds, stormwater BMP designs should:
   a) Minimize permanent pools,
   b) Limit extended detention times for Cp_v to 12 hours (see Appendix D.11),
   c) Provide shading for pools and channels,
   d) Maintain existing forested buffers, and
   e) Bypass available baseflow and/or springflow.

Section 3.1 Stormwater Ponds

Definition: Practices that have a permanent pool, or a combination of extended detention or shallow wetland with a permanent pool equivalent to the entire WQ_v. Design variants include:

- P-1 micropool extended detention pond (Figure 3.1)
- P-2 wet pond (Figure 3.2)
- P-3 wet extended detention pond (Figure 3.3)
- P-4 multiple pond system (Figure 3.4)
- P-5 pocket pond (Figure 3.5)

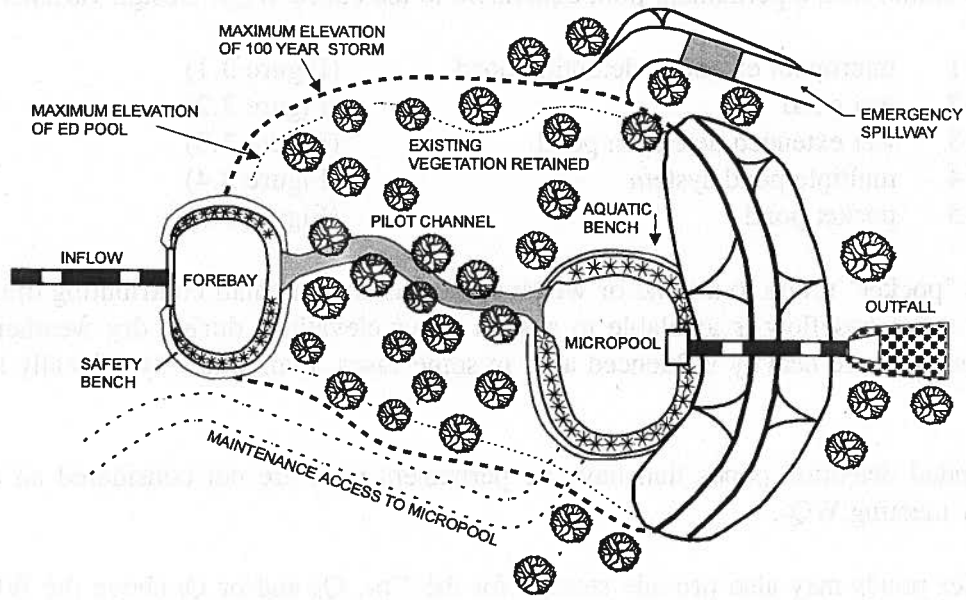
The term "pocket" refers to a pond or wetland that has such a small contributing drainage area that little or no baseflow is available to sustain water elevations during dry weather. Instead, water elevations are heavily influenced and, in some cases, maintained by a locally high water table.

Dry extended detention ponds that have no permanent pool are not considered an acceptable option for meeting WQ_v.

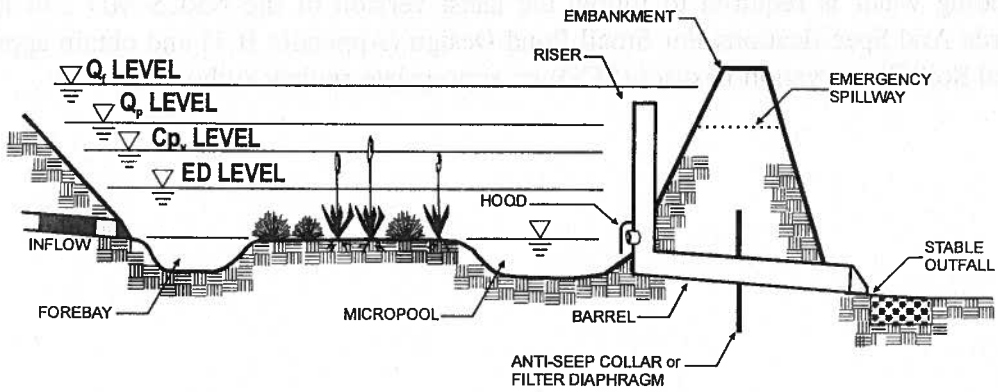
Stormwater ponds may also provide storage for the Cp_v, Q_p and/or Q_f above the WQ_v storage elevation.

IMPORTANT NOTE: Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local Soil Conservation District (SCD) or appropriate review authority.

P-1	**Figure 3.1** Example of "Micropool" Extended Detention Pond	P-1



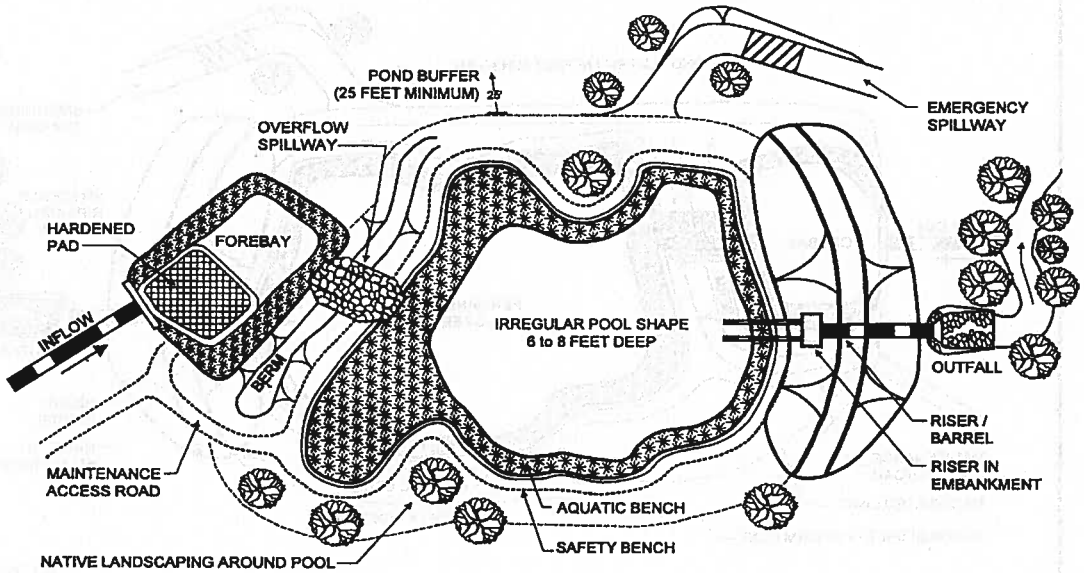
PLAN VIEW



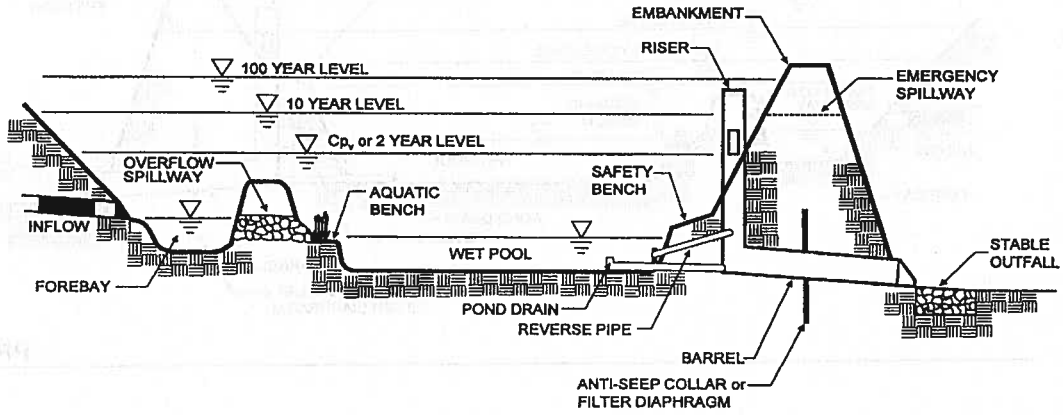
PROFILE

A micropool is provided in an extended detention pond to prevent resuspension of previously settled sediments and prevent clogging of the low flow orifice.

P-2	Figure 3.2 Example of Wet Pond	P-2



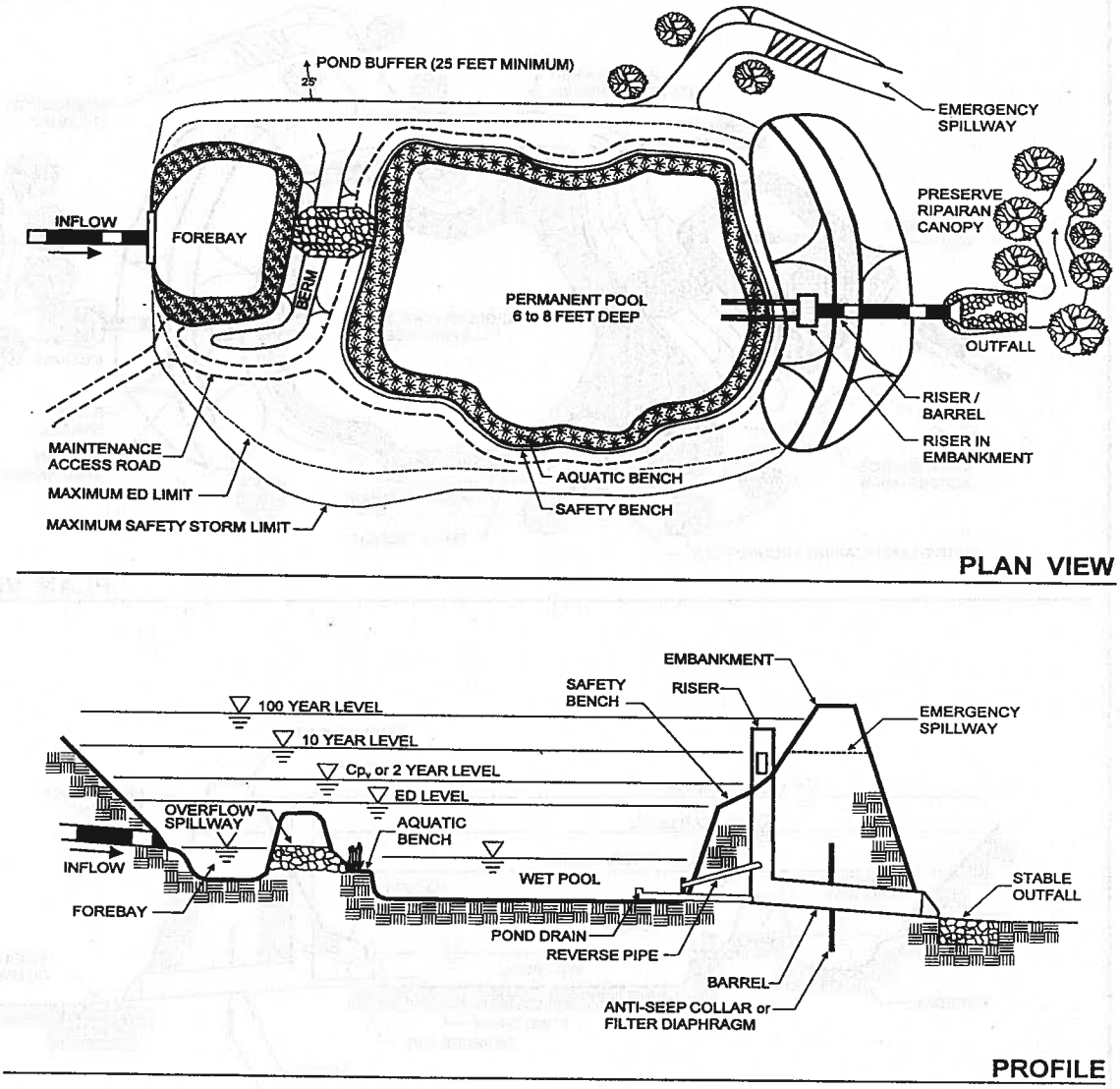
PLAN VIEW



PROFILE

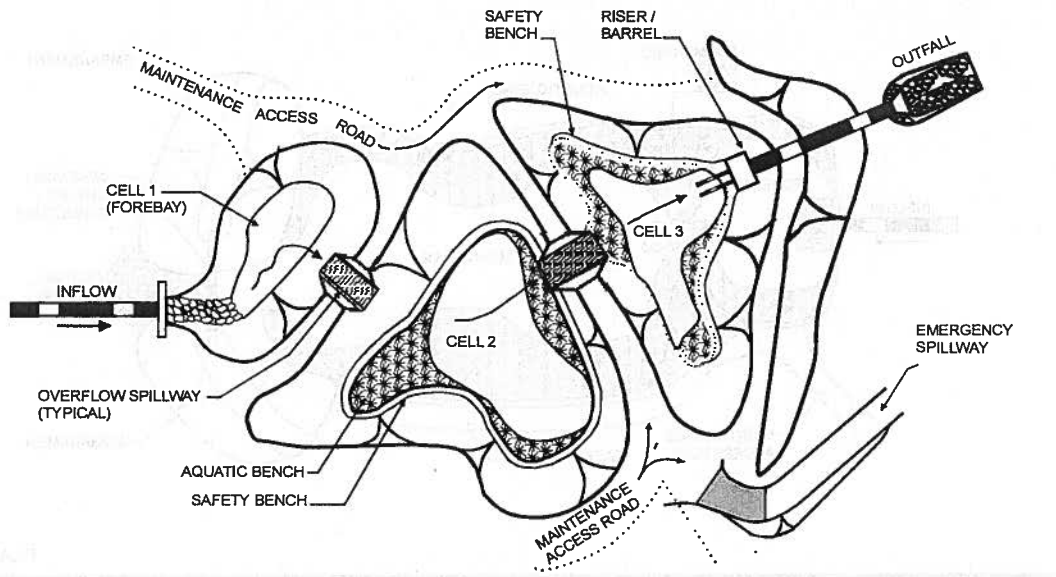
A wet pond provides all of water quality volume storage in a permanent pool.

P-3	**Figure 3.3** Example of Wet Extended Detention Pond	P-3

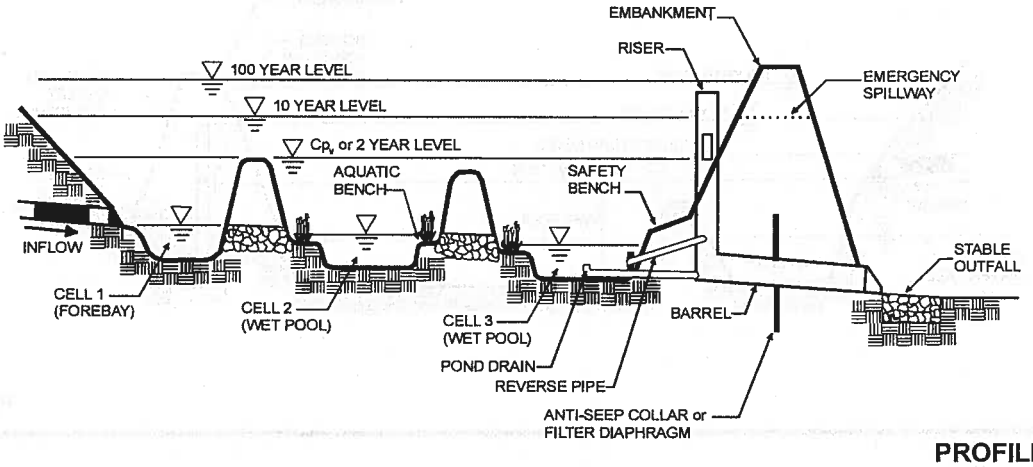


The wet ED pond provides water quality storage through a combination of permanent pool and extended detention storage.

P-4	**Figure 3.4** Example of Multiple Pond System	P-4



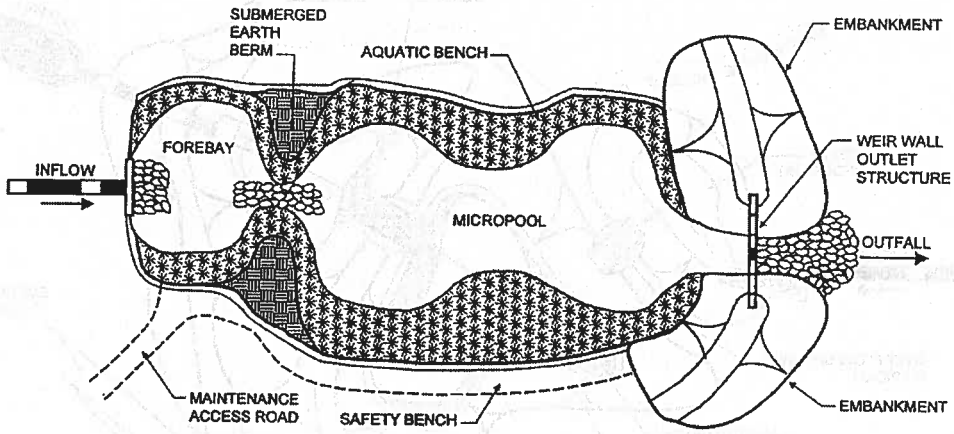
PLAN VIEW



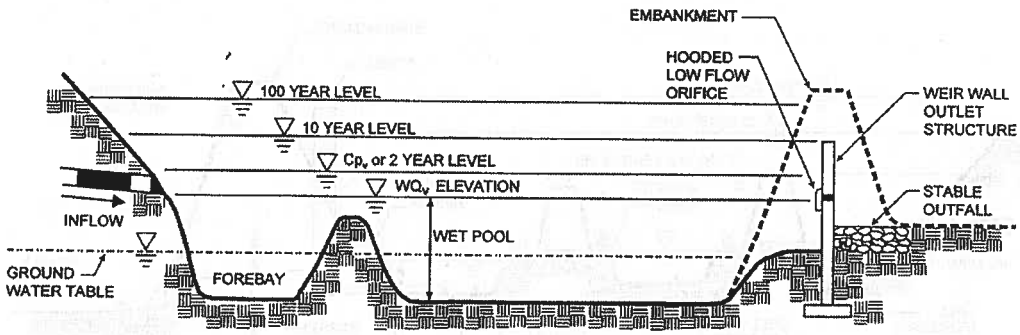
PROFILE

Multiple pond systems provide WQ_v storage in two or more cells that create longer pollutant removal pathways.

P-5	**Figure 3.5** Example of Pocket Pond	P-5



PLAN VIEW



PROFILE

A high water table or groundwater interception maintains permanent pool level in a pocket pond. However, excavation to groundwater interception should be avoided where the land uses draining to the pond may contaminate drinking water supplies.

3.1.6 Pond Maintenance Criteria

Maintenance Measures

Maintenance responsibility for a pond and its buffer shall be vested with a responsible party by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval or local permitting processes.

The principal spillway shall be equipped with a trash rack that provides access for maintenance.

Sediment removal in the forebay shall occur when 50% of the total forebay capacity has been lost.

Sediments excavated from stormwater ponds that do not receive runoff from designated hotspots are not considered toxic or hazardous material and can be safely disposed by either land application or land filling. Sediment testing may be required prior to sediment disposal when a hotspot land use is present.

Sediment removed from stormwater ponds should be disposed of according to current erosion and sediment control regulations.

Maintenance Access

A maintenance right-of-way or easement shall extend to a pond from a public or private road.

Maintenance access should be at least 12 feet wide; have a maximum slope of no more than 15%; and be appropriately stabilized to withstand maintenance equipment and vehicles.

The maintenance access should extend to the forebay, safety bench, riser, and outlet and be designed to allow vehicles to turn around.

Non-clogging Low Flow Orifice

The low flow orifice shall have a minimum diameter of 3 inches and shall be adequately protected from clogging by an acceptable external trash rack. Two examples of approved external trash racks are provided in Detail No. 1 and 2 of Appendix D.8. *The low flow orifice diameter may be reduced to one inch if an internal orifice is used* (e.g., an over-perforated vertical standpipe that is protected by hardware cloth and a stone filtering jacket). A schematic design of an acceptable internal orifice protection design is provided in Detail No. 3 of Appendix D.8.

The preferred method is a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation.

Alternative methods are to employ a broad crested rectangular, V-notch, or proportional weir, protected by a half-round corrugated metal pipe (CMP) or similar device that extends at least 12 inches below the normal pool. (See Detail No. 7 of Appendix D.8.)

The use of horizontal perforated pipe protected by geotextile and gravel is not recommended.

Vertical pipes may be used as an alternative if a permanent pool is present.

Riser

The riser shall be located within the embankment for maintenance access, safety and aesthetics.

Access to the riser is to be provided by lockable manhole covers and manhole steps within easy reach of valves and other controls. Riser openings should be fenced with pipe or rebar to prevent trash accumulation.

Pond Drain

Each pond shall have a drain pipe that can completely or partially drain the pond within 24 hours. This requirement is waived for the Lower Eastern Shore where positive drainage is difficult to achieve due to very low relief.

Care should be exercised during pond drawdowns to prevent downstream discharge of sediments or anoxic water and slope instability caused by rapid drawdown.

The approving jurisdiction shall be notified before draining a pond.

Valves

The pond drain shall be equipped with an adjustable valve (typically a handwheel activated knife or gate valve).

The pond drain should be sized one pipe size greater than the calculated design diameter.

Valve controls shall be located inside of the riser at a point where they (a) will not normally be inundated and (b) can be operated in a safe manner.

To prevent vandalism, the handwheel should be chained to a ringbolt, manhole step or other fixed object.

Section 3.2 Stormwater Wetlands

Definition: Practices that create shallow wetland areas to treat urban stormwater and often incorporate small permanent pools and/or extended detention storage to achieve the full WQ_v. Design variants include:

- W-1 shallow wetland (Figure 3.6)
- W-2 ED shallow wetland (Figure 3.7)
- W-3 pond/wetland system (Figure 3.8)
- W-4 pocket wetland (Figure 3.9)

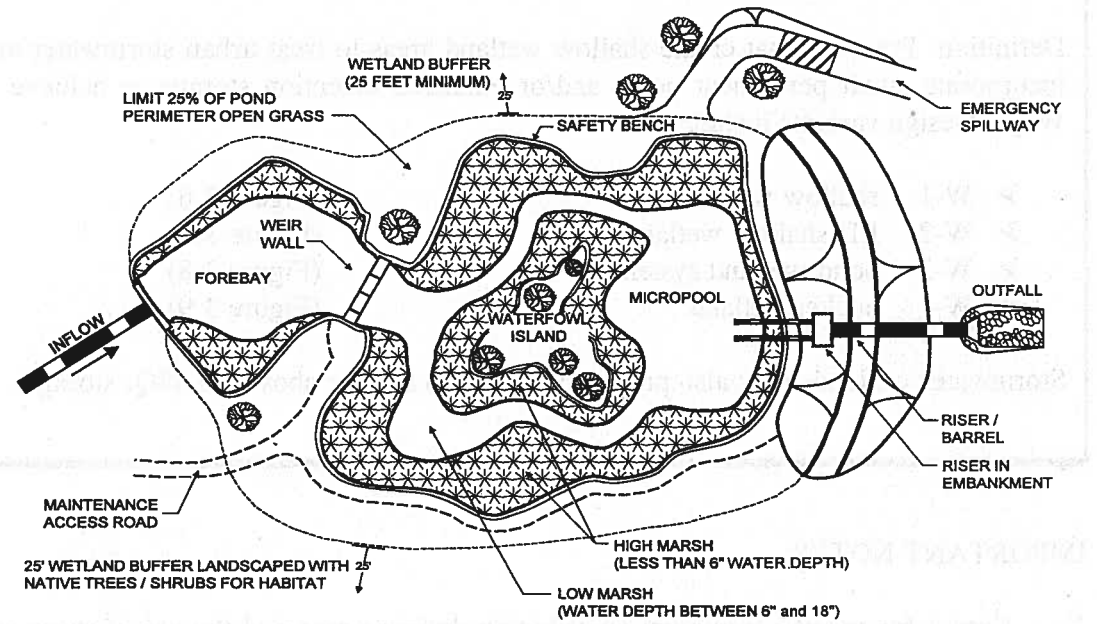
Stormwater wetlands may also provide Cp_v and Q_p storage above the WQ_v storage.

IMPORTANT NOTES:

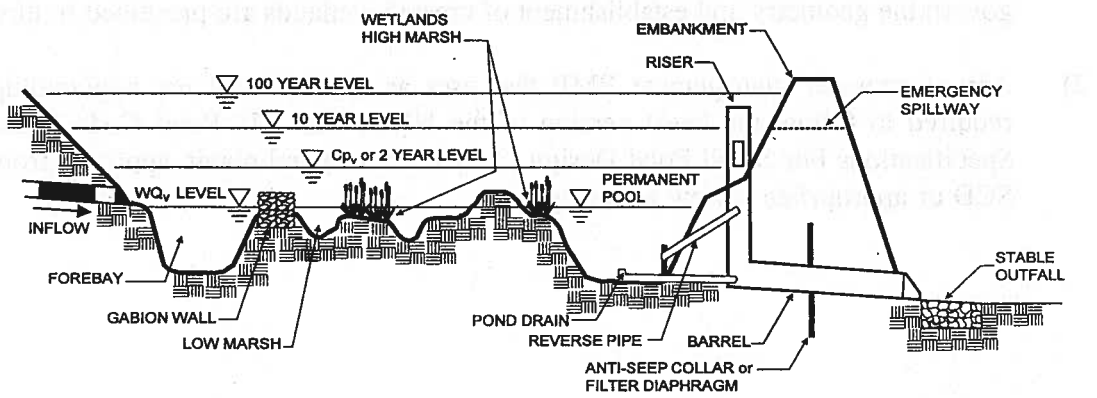
1) Except for specific minimum contributing drainage area and the use of these practices in coldwater streams (USE III AND IV), all of the pond performance criteria presented in section 3.1 also apply to the design of stormwater wetlands. Additional criteria that govern the geometry and establishment of created wetlands are presented in this section.

2) Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local SCD or appropriate review authority.

W-1	**Figure 3.6** Example of Shallow Wetland	W-1



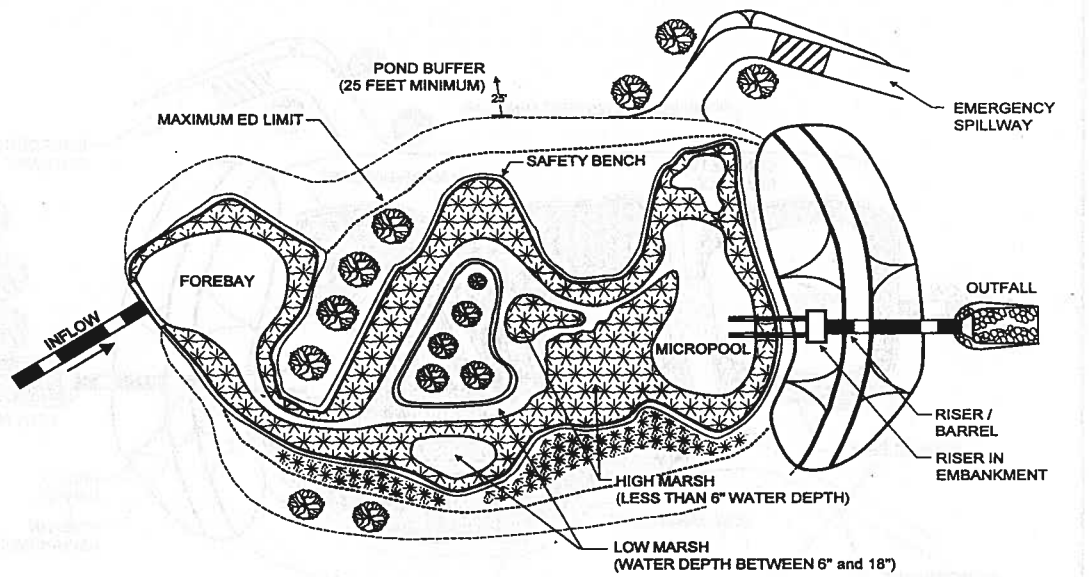
PLAN VIEW



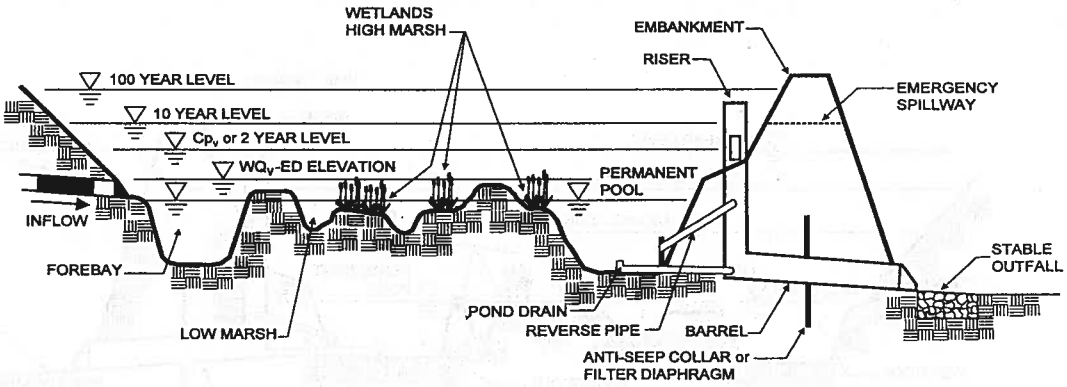
PROFILE

Shallow wetlands provide WQ_v in a shallow pool that has a large surface area.

W-2 **Figure 3.7** Example of Extended Detention Shallow Wetland W-2



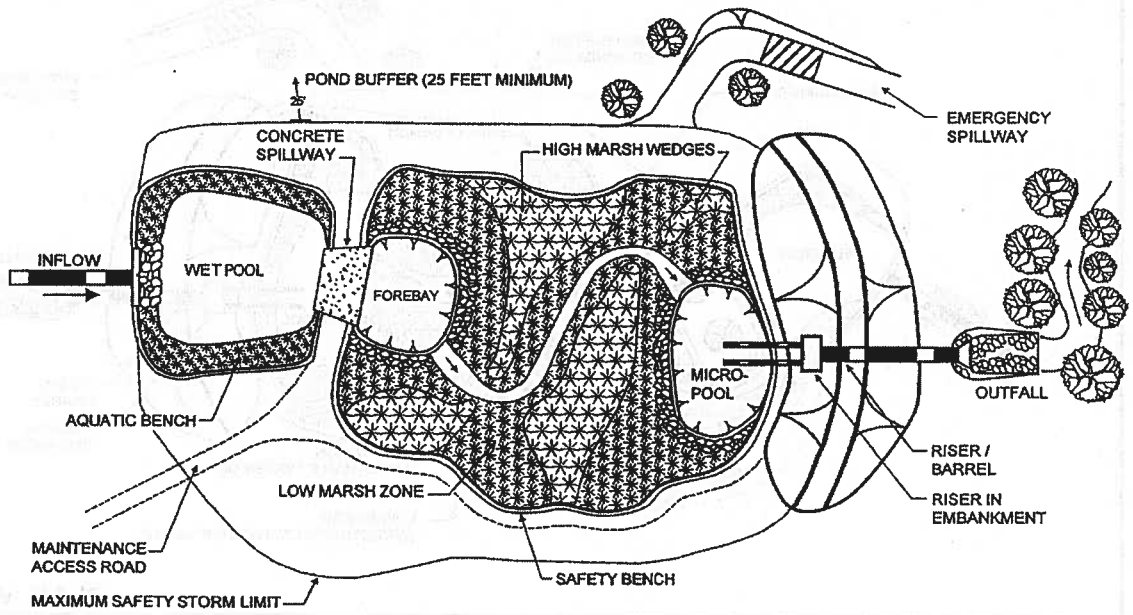
PLAN VIEW



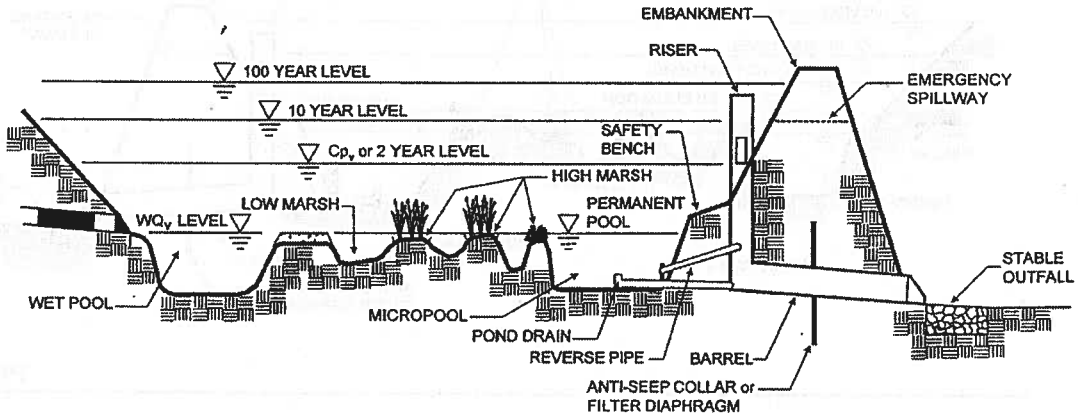
PROFILE

ED shallow wetlands provide water quality storage by a combination of shallow wetland pool and extended detention storage.

W-3 | **Figure 3.8** Example of Pond/Wetland System | W-3



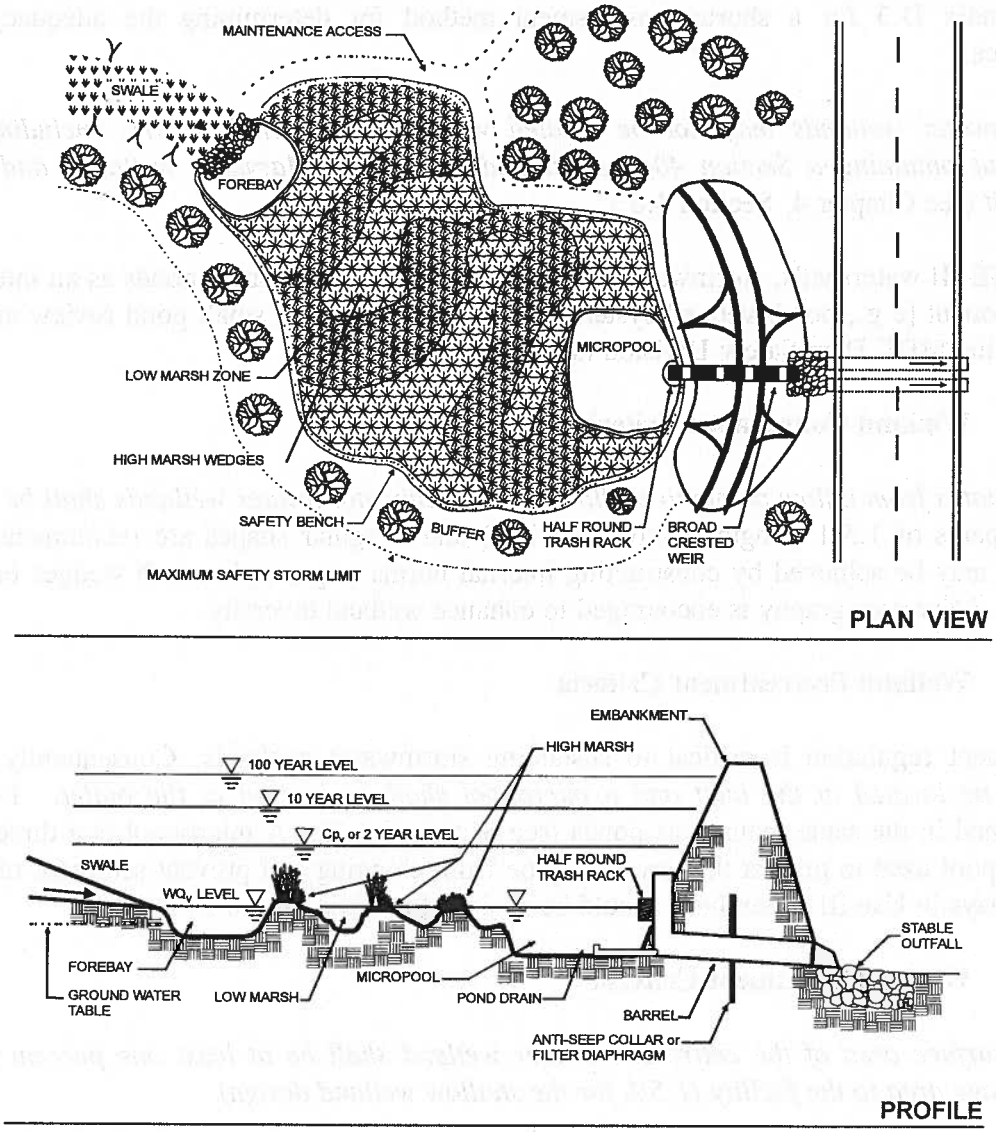
PLAN VIEW



PROFILE

In this BMP, a deep permanent pool is placed before the shallow wetland.

W-4	**Figure 3.9** Example of Pocket Wetland	W-4



A high water table or groundwater interception helps maintain the shallow wetland pool in a pocket wetland.

3.2.1 Wetland Feasibility Criteria

A water balance must be performed to demonstrate that a stormwater wetland can withstand a thirty day drought at summer evaporation rates without completely drawing down. See Appendix D.3 for a shortcut assessment method for determining the adequacy of water balance.

Stormwater wetlands may not be located within jurisdictional waters, including wetlands without obtaining a Section 404 permit and/or State of Maryland wetlands and waterways permit (see Chapter 4, Section 4.6.).

In USE III watersheds, stormwater wetlands that include permanent ponds as an integral design component [e.g., pond/wetland systems (W-3)] may require a small pond review and approval from the MDE Dam Safety Division (see Appendix B.1.2).

3.2.2 Wetland Conveyance Criteria

Flowpaths from inflow points to outflow points within stormwater wetlands shall be maximized. Flowpaths of 1.5:1 (length relative to width) and irregular shapes are recommended. These paths may be achieved by constructing internal berms (e.g., high marsh wedges or rock filter cells). Microtopography is encouraged to enhance wetland diversity.

3.2.3 Wetland Pretreatment Criteria

Sediment regulation is critical to sustaining stormwater wetlands. Consequently, *a forebay shall be located at the inlet and a micropool shall be located at the outlet.* Forebays are designed in the same manner as ponds (see Section 3.1.3). A micropool is a three to six foot deep pool used to protect the low flow pipe from clogging and prevent sediment resuspension. Forebays in Use III watersheds should be designed to drain within 24 hours.

3.2.4 Wetland Treatment Criteria

The surface area of the entire stormwater wetland shall be at least one percent of the total drainage area to the facility (1.5% for the shallow wetland design).

At least 25% of the total WQ_v shall be in deepwater zones with a minimum depth of four feet (the forebay and micropool may meet this criteria). This criteria may be reduced if the wetland is located where thermal impacts are a primary concern (e.g., Use III watersheds).

A minimum of 35% of the total surface area shall have a depth of six inches or less and at least 65% of the total surface area shall be shallower than 18 inches.

The bed of the wetland should be graded to create a maximum internal flowpath and microtopography.

If extended detention is utilized in a stormwater wetland, *the ED volume shall not comprise more than 50% of the total wetland design, and the maximum water surface elevation shall not extend more than three feet above the normal pool.* Q_p and/or Cp_v storage can be provided above the maximum WQ_v elevation within the wetland.

To promote greater nitrogen removal, rock beds may be used as a medium for the growth of wetland plants. The rock should be one to three inches in diameter and placed up to the normal pool elevation. Rock beds should also be open to flow-through from either direction.

3.2.5 Wetland Landscaping Criteria

A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of pondscaping zones, selection of corresponding plant species, planting configuration, and sequence for preparing wetland bed (including soil amendments, if needed).

Landscaping plans for stormwater wetlands located within Use III and IV watersheds should incorporate features and plant species commonly found in wooded wetlands.

Structures such as fascines, coconut rolls, or straw bales can be used to create shallow marsh cells in high energy areas of the stormwater wetland.

The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.

A wetland buffer should extend 25 feet outward from the maximum water surface elevation with an additional 15 foot setback to structures.

Wetland Establishment Guidance

The most common and reliable technique for establishing an emergent wetland community in a stormwater wetland is to transplant nursery stock obtained from local aquatic plant nurseries. The following guidance is suggested when transplants are used to establish a wetland.

The transplanting window extends from early April to mid-June. Planting after these dates is not recommended, as the wetland plants need a full growing season to build the root reserves needed to get through the winter. If at all possible, the plants should be ordered at least three months in advance to ensure the availability of the desired species.

The optimal depth requirements for several common species of emergent wetland plants are often six inches of water or less.

To add diversity to the wetland, 5 to 7 species of emergent wetland plants should be used, drawn from the suggested species listed in Appendix A. Of these, at least three species should be selected from the "aggressive colonizer" group (e.g., bulrush, pickerelweed, arrow arum, three square and rice cutgrass) (MDE, 1986).

The wetland area should be sub-divided into separate planting zones of more or less constant depth. Approximately half the wetland surface area should be planted. One plant species should be planted within each flagged planting zone, based on their approximate depth requirements. Plants should be installed in clumps with individual plants located an average of 18 inches on center within each clump. Individual plants should be spaced 12 inches to 24 inches on center.

Post-nursery care of wetland plants is very important in the interval between delivery of the plants and their subsequent installation, as they are prone to desiccation. Stock should be frequently watered and shaded while on-site.

A wet hydroseed mix should be used to establish permanent vegetative cover in the buffer outside of the permanent pool. For rapid germination, scarify the soil to ½ inch prior to hydroseeding. Alternatively, red fescue or annual rye can be used as a temporary cover for the wet species.

Because most stormwater wetlands are excavated to deep sub-soils, they often lack the nutrients and organic matter needed to support vigorous growth of wetland plants. At these sites, three to six inches of topsoil or wetland mulch should be added to all depth zones in the wetland from one foot below the normal pool to six inches above. Wetland mulch is preferable to topsoil if it is available.

The stormwater wetland should be staked at the onset of the planting season. Depths in the wetland should be measured to the nearest inch to confirm the original planting zones. At this time, it may be necessary to modify the pondscape plan to reflect altered depths or the availability of wetland plant stock. Surveyed planting zones should be marked on an "as-built" or design plan and located in the field using stakes or flags.

The wetland drain should be fully opened at least three days prior to the planting date (which should coincide with the delivery date for the wetland plant stock).

Wetland mulch is another technique to establish a plant community that utilizes the seedbank of wetland soils to provide the propagules for marsh development. The majority of the seedbank

Section 3.3 Stormwater Infiltration

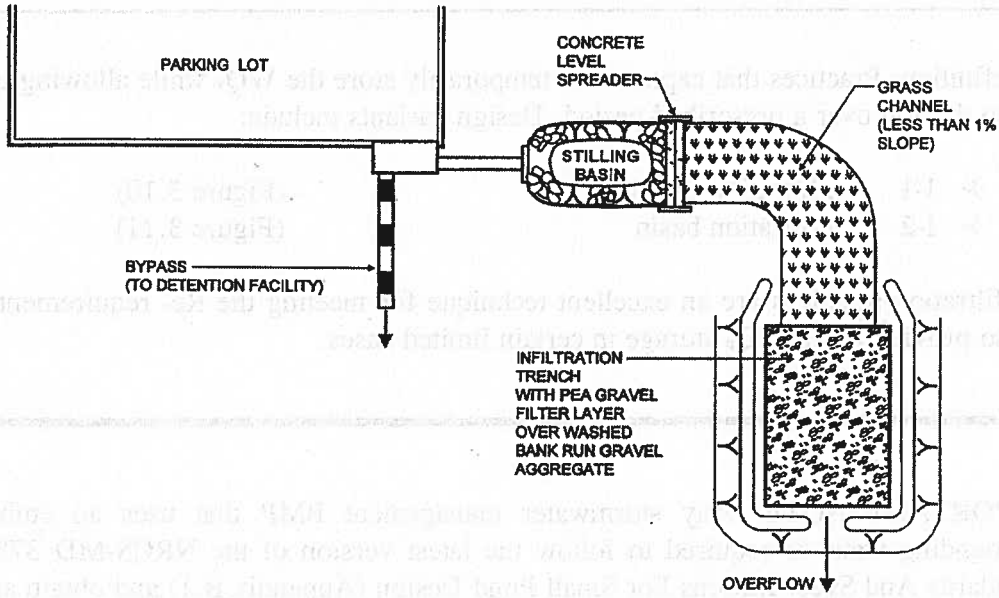
Definition: Practices that capture and temporarily store the WQ_v while allowing infiltration into the soil over a prescribed period. Design variants include:

- I-1 infiltration trench (Figure 3.10)
- I-2 infiltration basin (Figure 3.11)

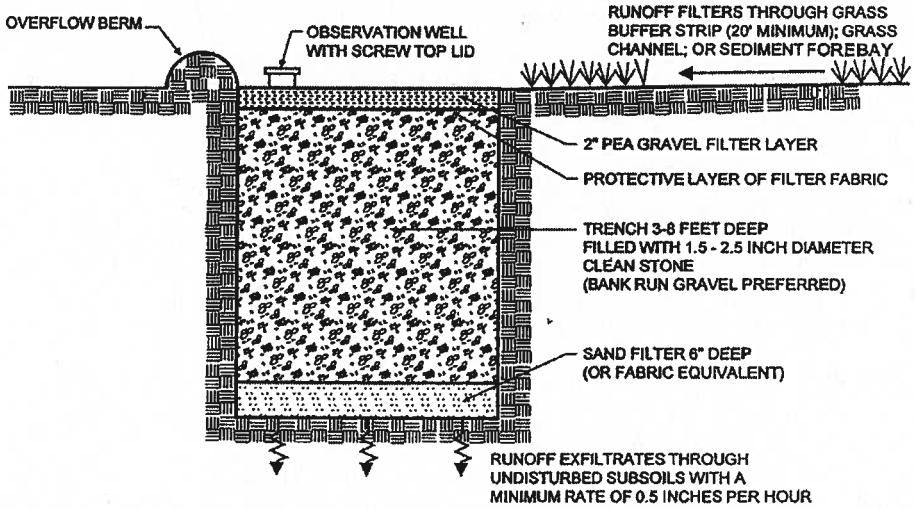
Infiltration practices are an excellent technique for meeting the Re_v requirement and may also provide Cp_v and Q_p storage in certain limited cases.

IMPORTANT NOTE: Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local SCD or appropriate review authority.

I-1 **Figure 3.10** Example of Infiltration Trench I-1



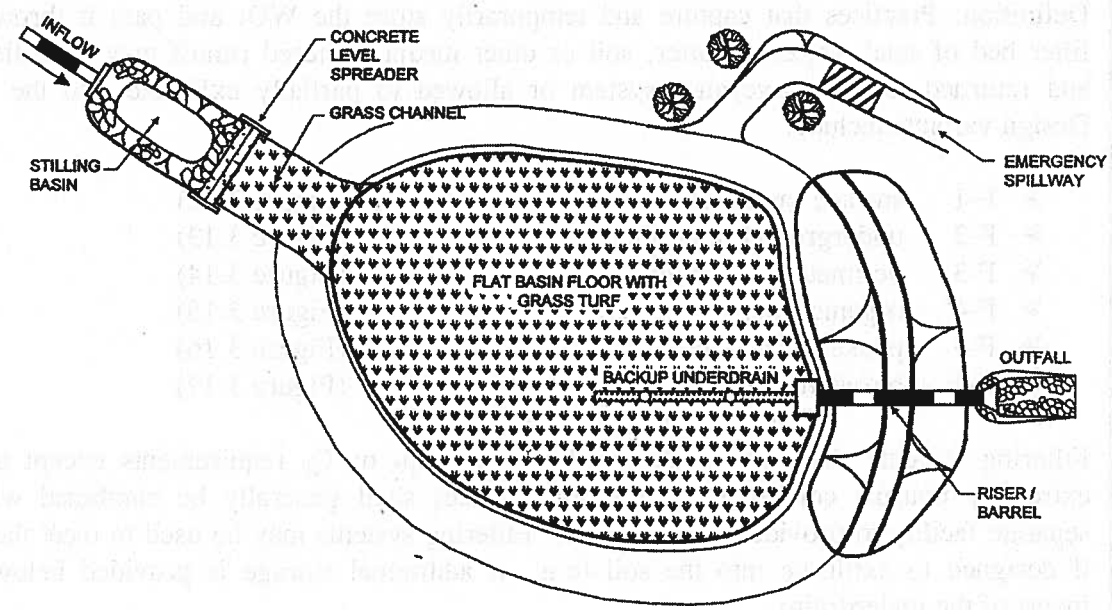
PLAN VIEW



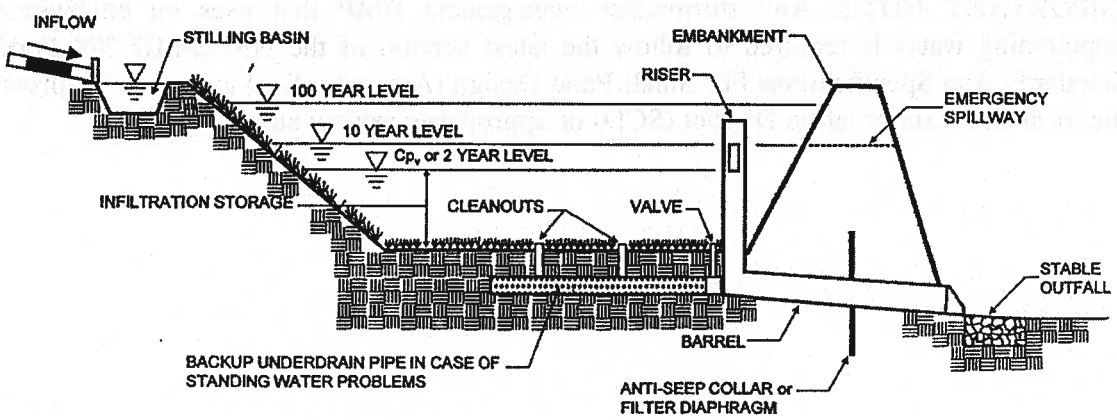
PROFILE

The infiltration trench provides Re_v and WQ_v in one location.

I-2 **Figure 3.11** Example of Infiltration Basin I-2



PLAN VIEW



PROFILE

The WQ_v is retained in an infiltration basin, where it percolates through the floor of the basin in a two day period.

Section 3.4 Stormwater Filtering Systems

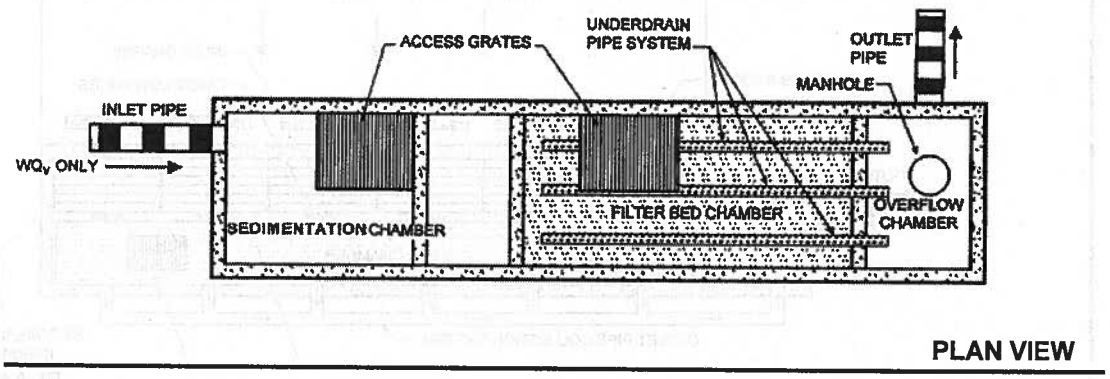
Definition: Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil or other media. Filtered runoff may be collected and returned to the conveyance system or allowed to partially exfiltrate into the soil. Design variants include:

- F-1 surface sand filter (Figure 3.12)
- F-2 underground sand filter (Figure 3.13)
- F-3 perimeter sand filter (Figure 3.14)
- F-4 organic filter (Figure 3.15)
- F-5 pocket sand filter (Figure 3.16)
- F-6 bioretention (Figure 3.17)

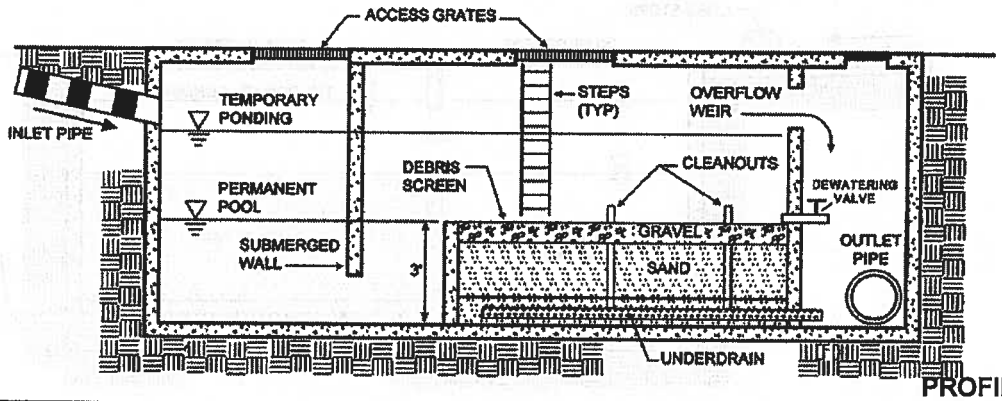
Filtering systems shall not be designed to meet Cp_v or Q_p requirements except under extremely unusual conditions. Filtering practices shall generally be combined with a separate facility to provide those controls. Filtering systems may be used to meet the Re_v if designed to exfiltrate into the soil (e.g., if additional storage is provided below the invert of the underdrain).

IMPORTANT NOTE: Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local Soil Conservation District (SCD) or appropriate review authority.

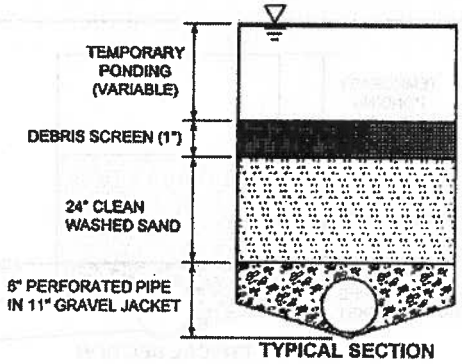
F-2	**Figure 3.13** Example of Underground Sand Filter	F-2



PLAN VIEW



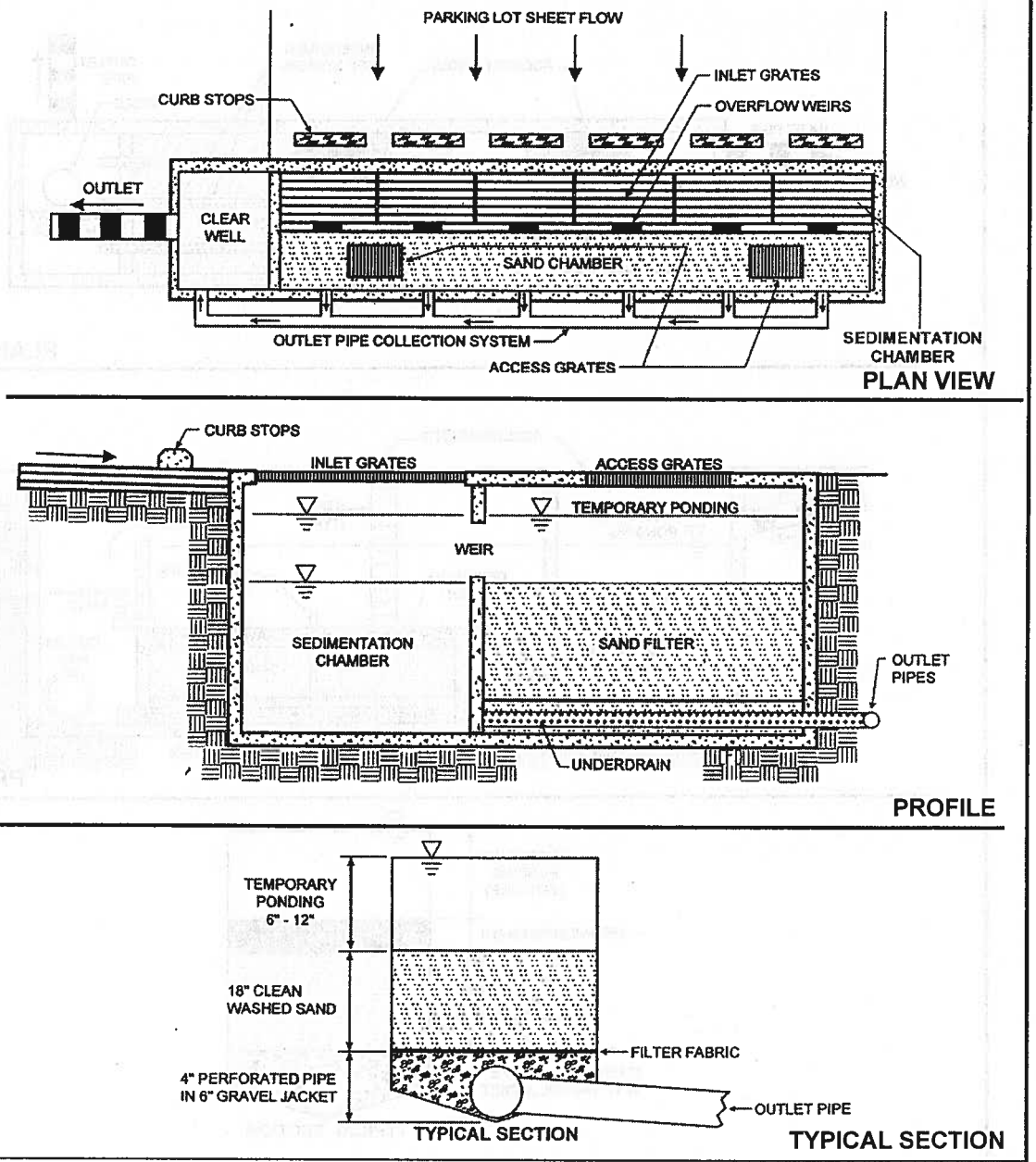
PROFILE



TYPICAL SECTION

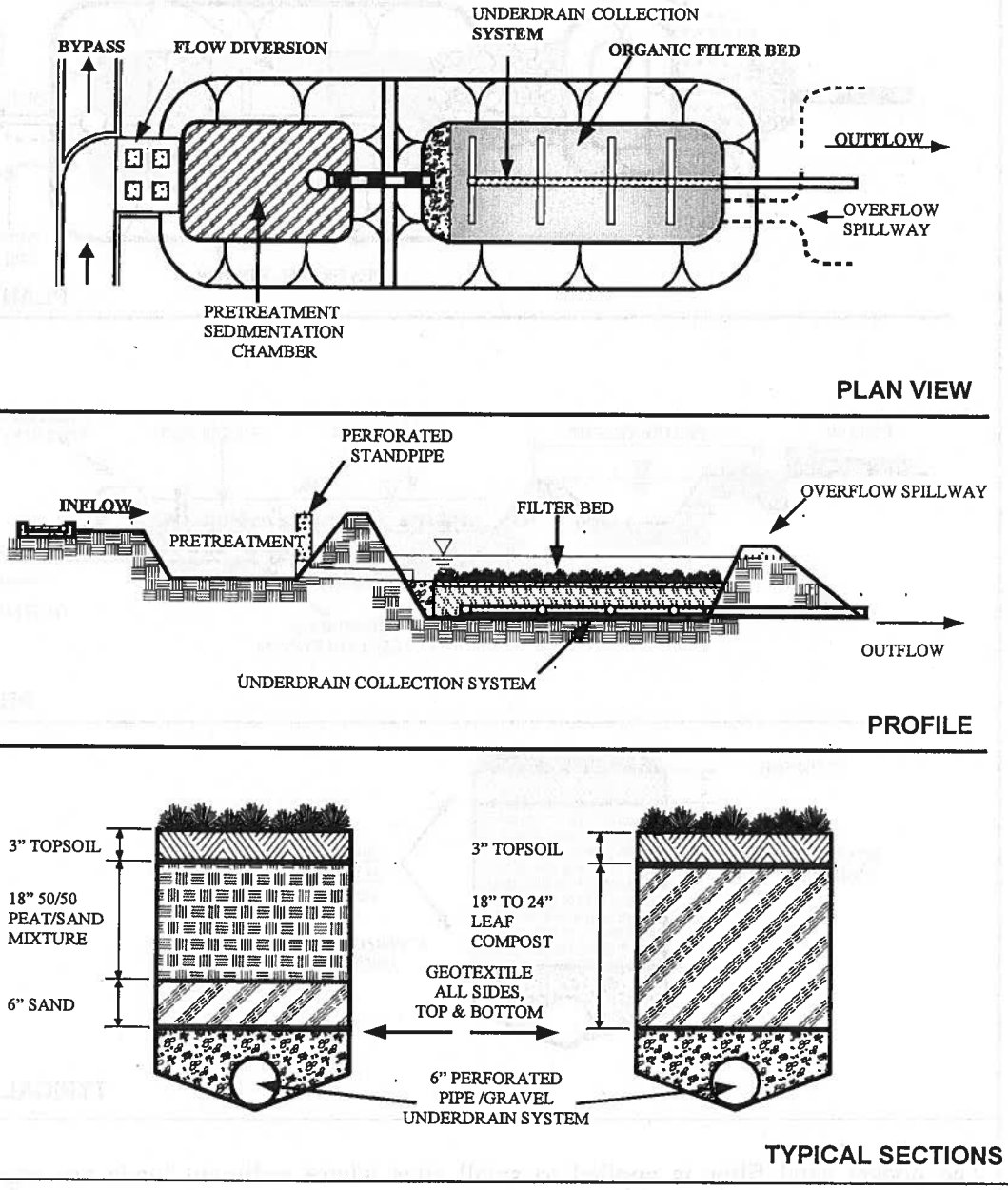
The underground sand filter is an option for providing WQ_v where space is limited.

F-3	**Figure 3.14** Example of Perimeter Sand Filter	F-3



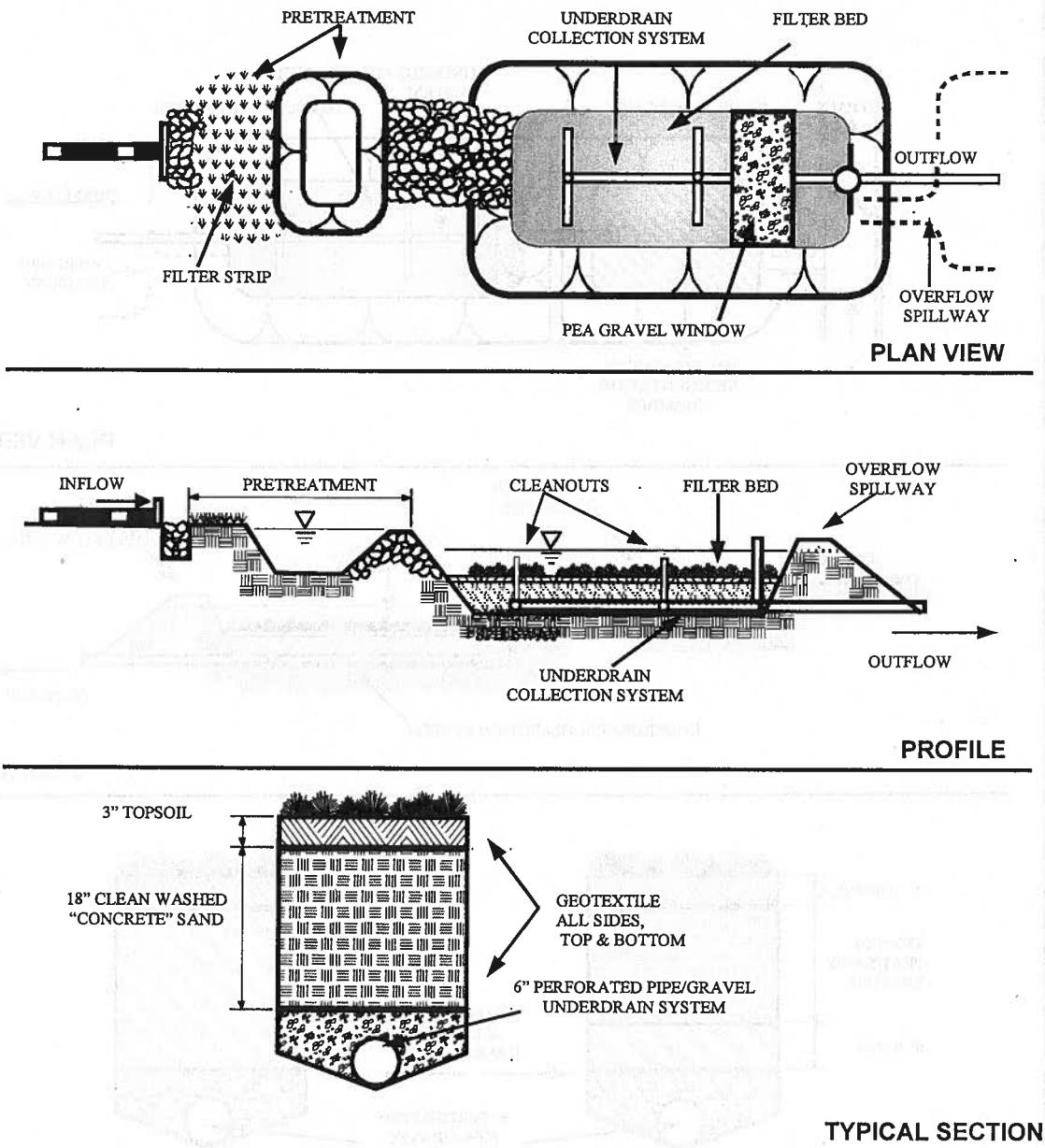
The perimeter sand filter is most practical for small sites with flat terrain or a high water table.

F-4 **Figure 3.15** Example of Organic Filter F-4



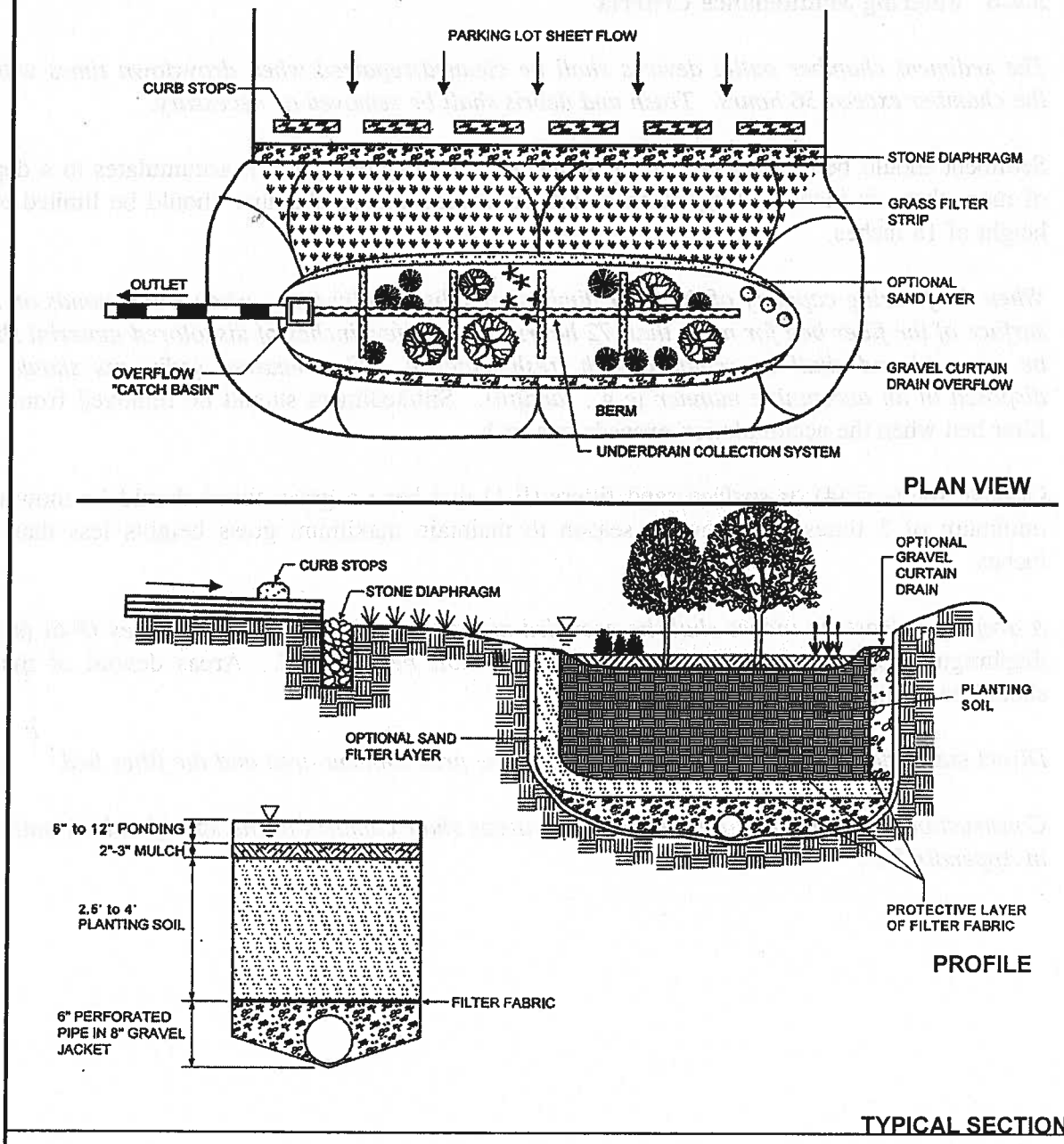
The organic filter is used when maximum nutrient or trace metal removals are desired.

F-5	**Figure 3.16** Example of Pocket Sand Filter	F-5



The pocket sand filter is applied to small sites where sediment loads are expected to be moderate to low. The pea gravel windows allow runoff into the filter if the surface becomes clogged.

F-6	**Figure 3.17** Example of Bioretention	F-6



Bioretention combines open space with stormwater treatment.

- Woody vegetation should not be specified at inflow locations.

3.4.6 Filtering Maintenance Criteria

The sediment chamber outlet devices shall be cleaned/repaired when drawdown times within the chamber exceed 36 hours. Trash and debris shall be removed as necessary.

Sediment should be cleaned out of the sedimentation chamber when it accumulates to a depth of more than six inches. Vegetation within the sedimentation chamber should be limited to a height of 18 inches.

When the filtering capacity of the filter diminishes substantially (e.g., when water ponds on the surface of the filter bed for more than 72 hours), the top few inches of discolored material shall be removed and shall be replaced with fresh material. The removed sediments should be disposed in an acceptable manner (e.g., landfill). Silt/sediment should be removed from the filter bed when the accumulation exceeds one inch.

Organic filters (F-4) or surface sand filters (F-1) that have a grass cover should be mowed a minimum of 3 times per growing season to maintain maximum grass heights less than 12 inches.

A drop of at least six inches shall be provided at the inlet of bioretention facilities (F-6) (stone diaphragm). *Dead or diseased plant material shall be replaced.* Areas devoid of mulch should be re-mulched on an annual basis.

Direct maintenance access shall be provided to the pretreatment area and the filter bed.

Construction of sand filters and bioretention areas shall conform to the specifications outlined in Appendix B.3.

Section 3.5 Open Channel Systems

Definition: Vegetated open channels that are designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means. Design variants include:

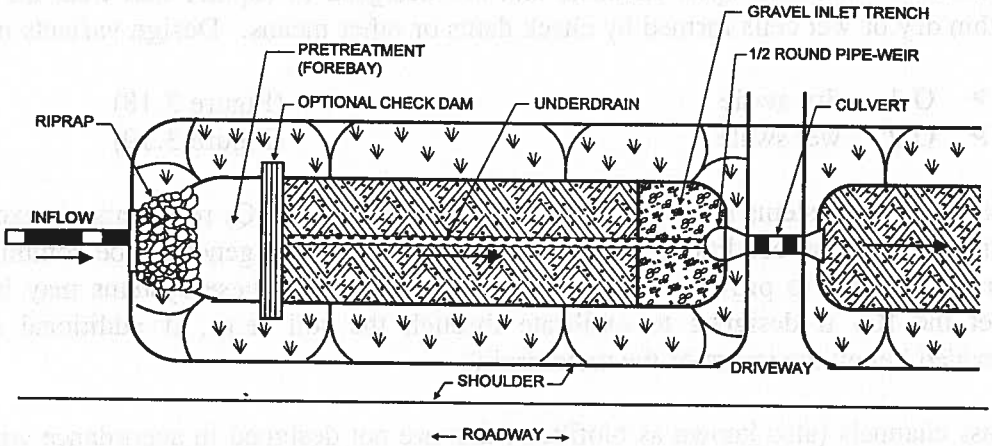
- O-1 dry swale (Figure 3.18)
- O-2 wet swale (Figure 3.19)

Open channel systems shall not be designed to meet Cp_v or Q_p requirements except under extremely unusual conditions. Open channel practices shall generally be combined with a separate facility to provide those controls. Additionally, these systems may be used to meet the Re_v if designed to exfiltrate through the soil (e.g., if additional storage is provided below the invert of the underdrain).

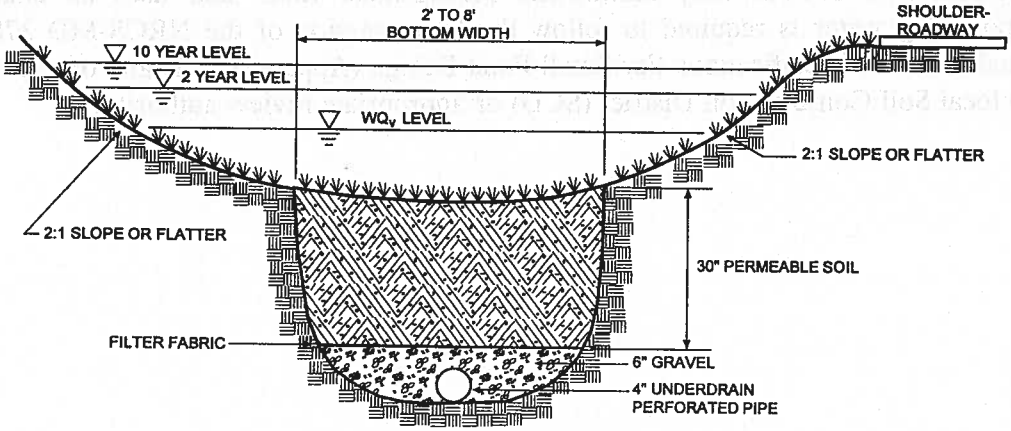
Grass channels (also known as biofilters) that are not designed in accordance with Section 3.5 are not considered an acceptable practice to meet the WQ_v requirements unless designed according to the criteria in Chapter 5.

IMPORTANT NOTE: Any stormwater management BMP that uses an embankment for impounding water is required to follow the latest version of the NRCS-MD 378 Pond Code Standards And Specifications For Small Pond Design (Appendix B.1) and obtain approval from the local Soil Conservation District (SCD) or appropriate review authority.

O-1	**Figure 3.18** Example of Dry Swale	O-1



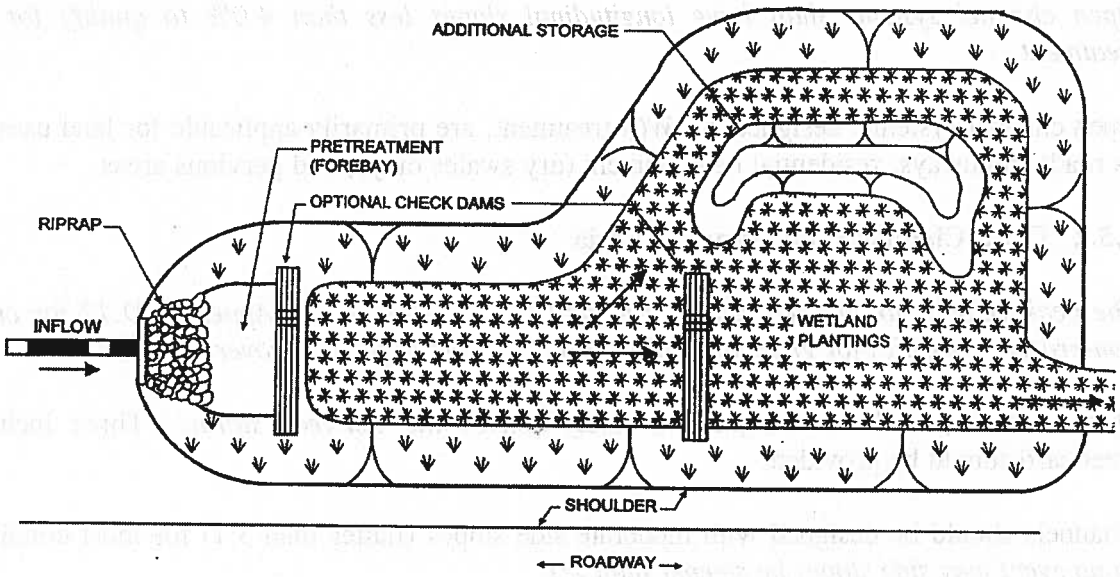
PLAN VIEW



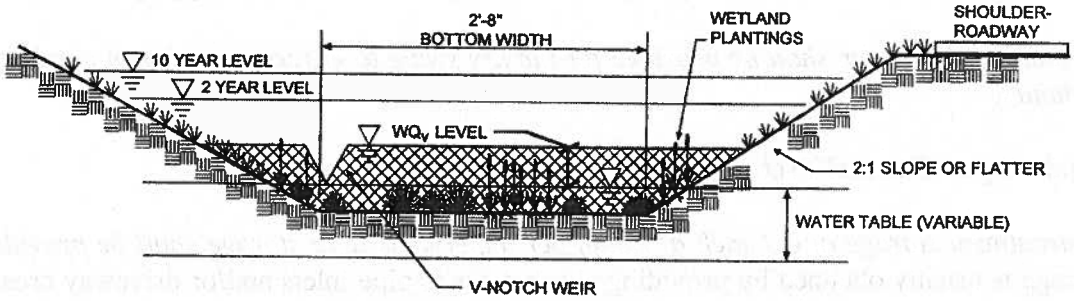
SECTION

Dry swales are used at low density residential projects or for very small impervious areas.

O-2	**Figure 3.19** Example of Wet Swale	O-2



PLAN VIEW



PROFILE

Wet swales are ideal for treating highway runoff in low lying or flat terrain areas.

3.5.1 Open Channel Feasibility Criteria

Open channel systems shall have longitudinal slopes less than 4.0% to qualify for WQ_v treatment.

Open channel systems, designed for WQ_v treatment, are primarily applicable for land uses such as roads, highways, residential development (dry swales only), and pervious areas.

3.5.2 Open Channel Conveyance Criteria

The peak velocity for the ten-year storm shall be non-erosive (see Appendix D.12 for critical non-erosive velocities for grass and soil) for the soil and vegetative cover provided.

Open channels shall be designed to safely convey the ten-year storm. Three inches of freeboard should be provided.

Channels should be designed with moderate side slopes (flatter than 3:1) for most conditions. *In no event may side slopes be steeper than 2:1.*

The maximum allowable ponding time within a channel shall be less than 48 hours. The minimum ponding time of 30 minutes is recommended for meeting WQ_v treatment goals.

Open channel systems which directly receive runoff from impervious surfaces may have a six inch drop onto a protected shelf (pea gravel diaphragm) to minimize clogging of the inlet.

An underdrain system shall be provided for the dry swale to ensure a maximum ponding time of 48 hours.

3.5.3 Open Channel Pretreatment Criteria

Pretreatment storage of 0.1 inch of runoff per impervious acre storage shall be provided. This storage is usually obtained by providing check dams at pipe inlets and/or driveway crossings.

A pea gravel diaphragm and gentle side slopes should be provided along the top of channels to accommodate pretreatment for lateral sheet flows.

Direct discharge of concentrated flow (e.g., by pipe) shall be pretreated.

3.5.4 Open Channel Treatment Criteria

Dry and wet swales shall be designed to temporarily store the WQ_v within the facility for a maximum 48 hour period.

Open channels shall have a bottom width no wider than 8 feet or a meandering drainage pattern shall be established to avoid gullying or channel braiding.

Dry and wet swales should maintain a maximum ponding depth of one foot at the "mid-point" of the channel profile (longitudinal dimension) and a maximum depth of 18" at the downstream end point of the channel (for storage of the WQ_v).

3.5.5 Open Channel Landscaping Criteria

Wet swales are not recommended for residential developments as they can create potential nuisance or mosquito breeding conditions.

Landscape design should specify proper grass species and wetland plants based on specific site, soils and hydric conditions present along the channel (see Appendix A).

3.5.6 Open Channel Maintenance Criteria

Open channel systems and grass filter strips should be mowed as required during the growing season to maintain grass heights in the 4 to 6 inch range. Wet swales, employing wetland vegetation or other low maintenance ground cover do not require frequent mowing of the channel.

Sediment build-up within the bottom of the channel or filter strip shall be removed when 25% of the original WQ_v has been exceeded.

Construction specifications for open channel systems are specified in Appendix B.3.