Constructed Wetlands

Description: Constructed wetland systems that are designed specifically for the purpose of managing stormwater. Runoff volume is stored and pollutants are removed in the wetland facility.

Variations: Pocket wetland, pond/wetland system, shallow wetland, extended detention shallow wetland.

Components:

- Ponding area – for water quality treatment through settling, biological, and chemical processes
- Marsh area – for water quality treatment through plant uptake; provides some filtering as well
- Forebay – settles larger sediments before entering pond; aids maintenance
- Spillway system(s) – provides control of pond discharge

Advantages/Benefits:

- High removal of typical urban stormwater pollutants
- Provides habitat for wildlife
- Can be designed for multi-objective use, including water quantity control
- Can be designed to treat stormwater from multiple developments

Disadvantages/Limitations:

- Requires a large amount of land to construct
- Can cause nuisance problems if not properly designed, installed and maintained
- Needs constant source of water to maintain function
- Wetland area can quickly become filled with sediment, causing the wetland to fail
- Warm water discharged from wetland can cause habitat degradation downstream

Design considerations:

- Minimum drainage area is 25 acres; 5 acres for pocket wetland
- Flow path through the wetland system should be 2:1 (length: width); may need serpentine system to be created internally
- Must design marsh area and ponding area through a water balance to ensure wetland does not fail in droughts

Selection Criteria:

- ✓ **Water Quality 80 % TSS Removal**
- ✓ **Accepts Hotspot Runoff**
- ✓ **Residential Subdivision**
- ✓ **High Density / Ultra Urban Use**

Maintenance:

- Remove accumulated sediments
- Remove invasive vegetation
- Harvest vegetation every 5 years to prevent overgrowth of plants and a reduced water storage

Maintenance Burden

M	Shallow Wetland
M	ED Shallow Wetland
H	Pocket Wetland
M	Pond/Wetland

L = Low M = Moderate H = High

General Description

Constructed wetlands, or stormwater wetlands, are constructed basin marsh systems that are designed to both treat urban stormwater for pollutants and control runoff volumes. The basin has a sediment forebay for coarse sediments. Runoff then flows through shallow marsh (also called, high marsh) and deep marsh (also called, low marsh) areas (see Figure 2.1). As stormwater runoff flows through the wetland facility, pollutant removal is achieved through settling and uptake by marsh vegetation. Wetlands are among the most effective stormwater practices for pollutant removal and they offer aesthetic value and wildlife habitat. Constructed stormwater wetlands differ from natural wetland systems because they are engineered facilities designed specifically for the purpose of treating stormwater runoff and typically have less biodiversity than natural wetlands both in terms of plant and animal life. However, as with natural wetlands, stormwater wetlands require a continuous base flow or a high water table to support aquatic vegetation.

There are several design variations of the stormwater wetland. Each design differs in the relative amounts of shallow and deep water, and dry storage above the wetland. These include the shallow wetland, the extended detention shallow wetland, pond/wetland system and pocket wetland. Below are descriptions of each design variant.

Shallow Wetland – In the shallow wetland design, most of the water quality treatment volume is in high marsh or relatively shallow low marsh depths. The only deep portions of the shallow wetland design are the forebay at the inlet to the wetland, and the micropool at the outlet. One disadvantage of this design is that, since the marsh area is very shallow, a relatively large amount of land is typically needed to store the water quality volume.

Extended Detention (ED) Shallow Wetland – The extended detention (ED) shallow wetland design is the same as the shallow wetland; however, part of the water quality treatment volume is provided as extended detention above the surface of the marsh and released over a period of 24 hours. This design can treat a greater volume of stormwater in a smaller space than the shallow wetland design. In the extended detention wetland option, plants that can tolerate both wet and dry periods need to be specified in the ED zone, since plants this zone is sometimes dry.

Pond/Wetland Systems – The pond/wetland system has two separate cells: a wet pond and a shallow marsh. The wet pond traps sediments and reduces runoff velocities prior to entry into the wetland, where stormwater flows receive additional treatment. Information on designing wet ponds is found in PTP-01. Less land is required for a pond/wetland system than for the shallow wetland or the ED shallow wetland systems.

Pocket Wetland – A pocket wetland is intended for smaller drainage areas of 5 to 10 acres and typically requires excavation down to the water table

Site and Design Considerations

for a reliable water source to support the wetland system.

Location and Siting

1. Stormwater wetlands should normally have a minimum contributing drainage area of 25 acres or more. For a pocket wetland, the minimum drainage area is 5 acres.
2. A continuous base flow or high water table is required to support wetland vegetation. A water balance must be performed to demonstrate that a stormwater wetland can withstand a 30-day drought at summer evaporation rates without completely drawing down. (See Step #2 of Design Procedure for water balance calculation).
3. Wetland siting should also take into account the location and use of other site features such as natural depressions, buffers, and undisturbed natural areas, and should attempt to aesthetically "fit" the facility into the landscape. Bedrock close to the surface may prevent excavation.
4. Stormwater wetlands cannot be located within navigable waters of the U.S., including wetlands, without obtaining a Section 404 permit under the Clean Water Act, and any other applicable State permit. In some isolated cases, a wetlands permit may be granted to convert an existing degraded wetland in the context of local watershed restoration efforts.
5. A wetland facility may be designed as either an on-line or off-line system. It is recommended that higher flows be slowed to prevent erosion and wetland vegetation mortality.
6. For various reasons, it is suggested that wetlands be setback from certain areas. Some suggested minimum setbacks for stormwater wetland facilities are as follows:
   1. From a property line – 10 feet
   2. From a private well – 100 feet; if well is down gradient from a hotspot land use then the minimum setback is 250 feet
   3. From a septic system tank/leach field – 50 feet
7. All utilities should be located outside of the wetland site.

General Design

8. A well-designed stormwater wetland consists of:
   1) Shallow marsh areas, which vary in depth, with wetland vegetation,
   2) Permanent micropool, and
   3) Overlying zone in which runoff control volumes are stored.
9. Pond/wetland systems include a stormwater pond (see PTP-01 for design information).
10. In addition, **all wetland designs must include a sediment forebay at the inflow** to the facility to allow heavier sediments to drop out of suspension before the runoff enters the wetland marsh. (See sediment forebay design information in PTP-01).
11. Additional pond design features include an **emergency spillway, maintenance access, safety bench, wetland buffer, and appropriate wetland vegetation and native landscaping**.

Site and Design Considerations (Continued)

12. Figures 2.2 through 2.5 provide plan view and profile schematics for the designs of shallow, ED shallow, pond/wetland, and pocket wetlands.

Physical Specifications/Geometry

13. In general, wetland designs are unique for each site and application. However, there are number of geometric ratios and limiting depths for the design of a stormwater wetland that must be observed for adequate pollutant removal, ease of maintenance, and improved safety. Table 2.1 provides the recommended physical specifications and geometry for the various stormwater wetland design variants.

Table 2.1 Recommended Design Criteria for Stormwater Wetlands

Modified from Massachusetts DEP, 1997; Schueler, 1992

Design Criteria	Shallow Wetland	ED Shallow Wetland	Pond/ Wetland	Pocket Wetland
Length to Width Ratio (minimum)	2:1	2:1	2:1	2:1
Extended Detention (ED)	No	Yes	Optional	Optional
Allocation of WQ_v Volume (pool/marsh/ED) in %	25/75/0	25/25/50	70/30/0 (includes pond volume)	25/75/0
Allocation of Surface Area (deepwater/low marsh/high marsh/semi-wet) in %	20/35/40/5	10/35/45/10	45/25/25/5 (includes pond surface area)	10/45/40/5
Forebay	Required	Required	Required	Optional
Micropool	Required	Required	Required	Required
Outlet Configuration	Reverse-slope pipe or hooded broad-crested weir	Reverse-slope pipe or hooded broad-crested weir	Reverse-slope pipe or hooded broad-crested weir	Hooded broad-crested weir

Depth:
Deepwater: 1.5 to 6 feet below permanent pool elevation
Low marsh: 6 to 8 inches below permanent pool elevation
High marsh: 6 inches or less below permanent pool elevation
Semi-wet zone: Above permanent pool elevation

Site and Design Considerations (Continued)

14. The stormwater wetland should be designed with the recommended proportion of "depth zones." Each of the four wetland design variants has depth zone allocations which are given as a percentage of the stormwater wetland surface area. Target allocations are found in Table 2.1. The four basic depth zones are:
    - **Semi-wet zone** Those areas above the permanent pool that are inundated during larger storm events. This zone supports a number of species that can survive flooding
    - **High marsh zone** From the permanent pool to 6 inches below the permanent pool. This zone will support a greater density and diversity of wetland species than the low marsh zone. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone.
    - **Low marsh zone** From 6 to 18 inches below the permanent pool or water surface elevation. This zone is suitable for the growth of several emergent wetland plant species.
    - **Deepwater zone** From 1.5 to 6 feet deep to the top of the permanent pool elevation. Includes the outlet micropool and deepwater channels through the wetland facility. This zone supports little emergent wetland vegetation, but may support submerged or floating vegetation.

    .
15. A minimum dry weather flow path of 2:1 (length to width) is required from inflow to outlet across the stormwater wetland and should ideally be greater than 3:1. This path may be achieved by constructing internal dikes or berms, using marsh plantings, and by using multiple cells. Finger dikes are commonly used in surface flow systems to create serpentine configurations and prevent short-circuiting. Microtopography (contours along the bottom of a wetland or marsh that provide a variety of conditions for different species needs and increases the surface area to volume ratio) is encouraged to enhance wetland diversity.
16. A 4 to 6 foot deep micropool must be included in the design at the outlet to prevent the outlet from clogging and resuspension of sediments, and to mitigate thermal effects.
17. Maximum depth of any permanent pool areas should generally not exceed 6 feet.
18. The volume of the extended detention must not comprise more than 50% of the total WQ_v, and its maximum water surface elevation must not extend more than 3 feet above the permanent pool. Storage for larger storms can be provided above the WQ_v elevation.
19. The perimeter of all deep pool areas (4 feet or greater in depth) should be surrounded by safety and aquatic benches similar to those for stormwater ponds (see Stormwater Ponds, PTP-01).
20. The perimeter of the wetland should be irregular to provide a more natural landscaping effect.

Site and Design Considerations (Continued)

Pretreatment/Inlets

21. Sediment regulation is critical to sustain stormwater wetlands. A wetland facility should have a sediment forebay or equivalent upstream pretreatment. A sediment forebay is designed to remove incoming sediment from the stormwater flow prior to dispersal into the wetland. The forebay should consist of a separate cell, formed by an acceptable barrier. A forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the wetland facility.
22. The forebay is sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The pretreatment storage volume is part of the total WQ_v requirement and may be subtracted from WQ_v for wetland storage sizing.
23. A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time. The bottom of the forebay may be hardened (e.g., using concrete, paver blocks, etc.) to make sediment removal easier.
24. Inflow channels are to be stabilized with flared riprap aprons, or the equivalent. Inlet pipes to the pond can be partially submerged. Exit velocities from the forebay must be nonerosive.

Outlet Structures

25. Flow control from a stormwater wetland is typically accomplished with the use of a concrete or corrugated metal riser and barrel. The riser is a vertical pipe or inlet structure that is attached to the base of the micropool with a watertight connection. The outlet barrel is a horizontal pipe attached to the riser that conveys flow under the embankment. The riser should be located within the embankment for maintenance access, safety and aesthetics.
26. A number of outlets at varying depths in the riser provide internal flow control for routing runoff volumes. The number of orifices can vary and is usually a function of the pond design.
27. For shallow and pocket wetlands, the riser configuration is typically comprised of a flood protection outlet (often a slot or weir).

    Since the water quality volume is fully contained in the permanent pool, no orifice sizing is necessary for this volume. An off-line shallow or pocket wetland providing *only* water quality treatment (not ED) can use a simple overflow weir as the outlet structure.

    In the case of an extended detention (ED) shallow wetland, there is generally a need for an additional outlet (usually an orifice) that is sized to pass the extended detention water quality volume that is surcharged on top of the permanent pool. Flow will first pass through this orifice, which is sized to release the water quality ED volume in 24 hours. The

Site and Design Considerations (Continued)

preferred design is a reverse slope pipe attached to the riser, with its inlet submerged 1 foot below the elevation of the permanent pool to prevent floatables from clogging the pipe and to avoid discharging warmer water at the surface of the pond. The outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention water quality volume.

Alternative hydraulic control methods to an orifice can be used and include the use of a broad-crested rectangular, V-notch, or proportional weir, or an outlet pipe protected by a hood that extends at least 12 inches below the normal pool. (Refer to Stormwater Ponds, PTP-01 for orifice equations.)

28. The water quality outlet (if design is for an ED shallow wetland) should be fitted with adjustable gate valves or other mechanism that can be used to adjust detention time.
29. Higher flows pass through openings or slots protected by trash racks further up on the riser.
30. After entering the riser, flow is conveyed through the barrel and is discharged downstream. Anti-seep collars should be installed on the outlet barrel to reduce the potential for pipe failure.
31. Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the outlet of the barrel to prevent scouring and erosion. If a wetland facility daylights to a channel with dry weather flow, care should be taken to minimize tree clearing along the downstream channel, and to reestablish a forested riparian zone in the shortest possible distance.
32. The wetland facility must have a bottom drain pipe located in the micropool with an adjustable valve that can completely or partially dewater the wetland within 24 hours.
33. The wetland drain should be sized one pipe size greater than the calculated design diameter. The drain valve is typically a handwheel activated knife or gate valve. Valve controls shall be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.
34. See the design procedures in Volume 2 – Procedures of the Stormwater Management Manual for additional information and specifications on pond routing and outlet hydraulics. Orifice sizing is also presented in Stormwater Ponds, PTP-01.

Site and Design Considerations (Continued)

Emergency Spillway

35. An emergency spillway is to be included in the stormwater wetland design to safely pass flows that exceed the design storm flows. The spillway prevents the wetland's water levels from overtopping the embankment and causing structural damage. The emergency spillway must be located so that downstream structures will not be impacted by spillway discharges.
36. A minimum of 1 foot of freeboard must be provided, measured from the top of the maximum design storm elevation to the lowest point of the dam embankment, not counting the emergency spillway.

Maintenance Access

37. A maintenance right of way or easement must be provided to the wetland facility from a public or private road. Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 15 percent, and be appropriately stabilized to withstand maintenance equipment and vehicles.
38. The maintenance access must extend to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.
39. Access to the riser is to be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

Safety Features

40. All embankments and spillways must be designed to State of Tennessee guidelines for dam safety.
41. Fencing of wetlands is not generally desirable, but it may be infeasible to leave them unfenced because of community concerns. A preferred method is to manage the contours of deep pool areas through the inclusion of a safety bench (see above) to eliminate drop-offs and reduce the potential for accidental drowning.
42. The principal spillway opening should not permit access by small children, and endwalls above pipe outfalls greater than 48 inches in diameter should be fenced to prevent a hazard.

Landscaping

A landscaping plan should be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed) and sources of plant material. Landscaping zones include low marsh, high marsh, and semi-wet zones. The low marsh zone ranges from 6 to 18 inches below the permanent pool. This zone is suitable for the growth of several emergent plant species. The high marsh zone ranges from 6 inches below the permanent pool up to the permanent pool.

Site and Design Considerations (Continued)

This zone will support greater density and diversity of emergent wetland plant species. The high marsh zone should have a higher surface area to volume ratio than the low marsh zone. The semi-wet zone refers to those areas above the permanent pool that are inundated on an irregular basis and can be expected to support wetland plants.

43. The landscaping plan should provide elements that promote greater wildlife and waterfowl use within the wetland and buffers.
44. Woody vegetation may not be planted on the embankment or allowed to grow within 15 feet of the toe of the embankment and 25 feet from the principal spillway structure.
45. The wetland shall have a 15-foot setback to structures.
46. To discourage resident geese populations, the area surrounding the constructed wetland can be planted with trees, shrubs and native ground covers. The soils of a wetland buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils is so great that it effectively prevents root penetration and therefore may lead to premature mortality or loss of vigor. Consequently, it is advisable to excavate large and deep holes around the proposed planting sites and backfill these with uncompacted topsoil.

Other Constraints

- Karst – Requires poly or clay liner to sustain a permanent pool of water and protect aquifers; limits on ponding depth; geotechnical tests may be required
- Hydrologic group "A" soils and some group "B" soils may require liner (not relevant for pocket wetland)

Design Procedures

Step 1. Compute the Water Quality Volume.

Calculate the Water Quality Volume (WQ_v).

$WQ_v = P \times Rv \times A/12$

Where: WQ_v = water quality treatment volume, ac-ft
P = rainfall for the 85% storm event (1.1 in)
Rv = runoff coefficient (see below)
A = site area, acres

$Rv = 0.05 + 0.0092I$

Where: I = site impervious cover, % (i.e., 50% imperviousness = 50)

Step 2. Determine if the development site and conditions are appropriate for the constructed wetland.

See the *Site and Design Considerations* in the section, above.
Perform Water Balance calculations to ensure that drainage basin has characteristics to support permanent pool. See Volume 2, Section 8.8.1 for an example water balance calculation.

Step 3. Confirm design criteria and applicability to site.

Check with Metro and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply.

Step 4. Determine pretreatment volume.

A sediment forebay is to be provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the pond. The forebay should be sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay storage volume counts toward the total WQ_v requirement and may be subtracted from the WQ_v for subsequent calculations.

$F_v = 0\ .1$ inches x A_I acres x .0833

Where:
F_v = Forebay volume (ac-ft)
A_I = Impervious area of drainage basin, acres
0.0833 = conversion factor of acre inches to acre feet

Design Procedures (Continued)

Often, it is more manageable to work with forebay volumes in cubic feet rather than acre feet, because they are small volumes. To convert F_v in acre feet to cubic feet, multiply F_v by 43560 square feet.

Step 5. Allocate the WQ_v among marsh, micropool, and ED volumes.

Use recommended criteria from Table 2.1

Step 6. Determine wetland location and preliminary geometry, including distribution of wetland depth zones.

This step involves initially laying out the wetland design and determining the distribution of wetland surface area among the various depth zones (high marsh, low marsh, and deepwater). Set WQ_v permanent pool elevation (and WQ_v-ED elevation for ED shallow wetland) based on volumes calculated earlier.

Determine if constructed wetland is on-line or off-line. Off-line wetlands require a diversion structure to divert low flows towards wetland and high flows away from wetlands. See Figure 2.6 for example diversion structure and Figure 2.7 for an example of an off-line system.

See the Physical Specifications/Geometry section (pages 4 to 6) of *Site and Design Considerations* for more details.

Step 7. Compute extended detention orifice release rate(s) and size(s), and establish WQ_v elevation.

Shallow Wetland, *Pocket Wetland and ED Shallow Wetland*: Based on the elevations established in Step 6 for the extended detention portion of the water quality volume, the water quality orifice is sized to release this extended detention volume in 24 hours. The water quality orifice should have a minimum diameter of 3 inches or use a perforated riser, and should be adequately protected from clogging by an acceptable external trash rack. A reverse slope pipe attached to the riser, with its inlet submerged one foot below the elevation of the permanent pool, is a recommended design. Adjustable gate valves can also be used to achieve this equivalent diameter.

*An off-line shallow or pocket wetland providing only water quality treatment can employ a simple overflow weir.

Step 8. Calculate 100-year storm release rate and water surface elevation.

Set up a stage-storage-discharge relationship for the control structure for the extended detention orifice(s) and the 100-year storm.

Design Procedures (Continued)

Step 9. Design embankment(s) and spillway(s).

Size emergency spillway to pass flows larger than the maximum design storm and to pass flows when the inlet bypass (for off-line systems) or outlet structures malfunction. Attenuation may not be required.

Step 10. Design safe design velocity for on-line systems.

For on-line systems, scour and erosion and wetland vegetation mortality may be of concern. Flow velocities must be minims to prevent these conditions. Limit in-flow velocities to less that five feet per second into the wetland area. Energy dissipaters should be used to reduce flow velocities.

Step 11. Investigate potential pond/wetland hazard classification.

The design and construction of ponds in Tennessee must follow the requirements of the Safe Dams Act. Contact the Tennessee Department of Environment and Conservation, Division of Water Supply for more information about building dams in Tennessee.

Step 12. Design inlets, sediment forebay(s), outlet structures, maintenance access, and safety features.

See the *Site and Design Considerations* section for information on design.

Step 13. Prepare Vegetation and Landscaping Plan.

A landscaping plan for the wetland facility should be prepared to indicate how aquatic and terrestrial areas will be stabilized and established with vegetation.

Operations and Maintenance

Each BMP must have an Operations and Maintenance agreement that is submitted to Metro for approval and is maintained and updated by the BMP owner. Refer to Volume 1 Appendix C for the Operation and Maintenance Agreement for wetlands, as well as an inspection checklist. The O&M Agreement must be completed and submitted to Metro with site plans. The O&M Agreement is to be used by the BMP owner in performing routine inspections. The developer/owner is responsible for the cost of maintenance and annual inspections. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Clean and remove debris from inlet and outlet structures.
2. Mow side slopes. Periodic mowing of the wetland buffer is only required along maintenance rights-of-way and the embankment. The remaining buffer can be managed as a meadow (mowing every other year) or forest.
3. Monitor wetland vegetation and perform replacement planting as necessary.
4. Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.

Maintenance (Continued)

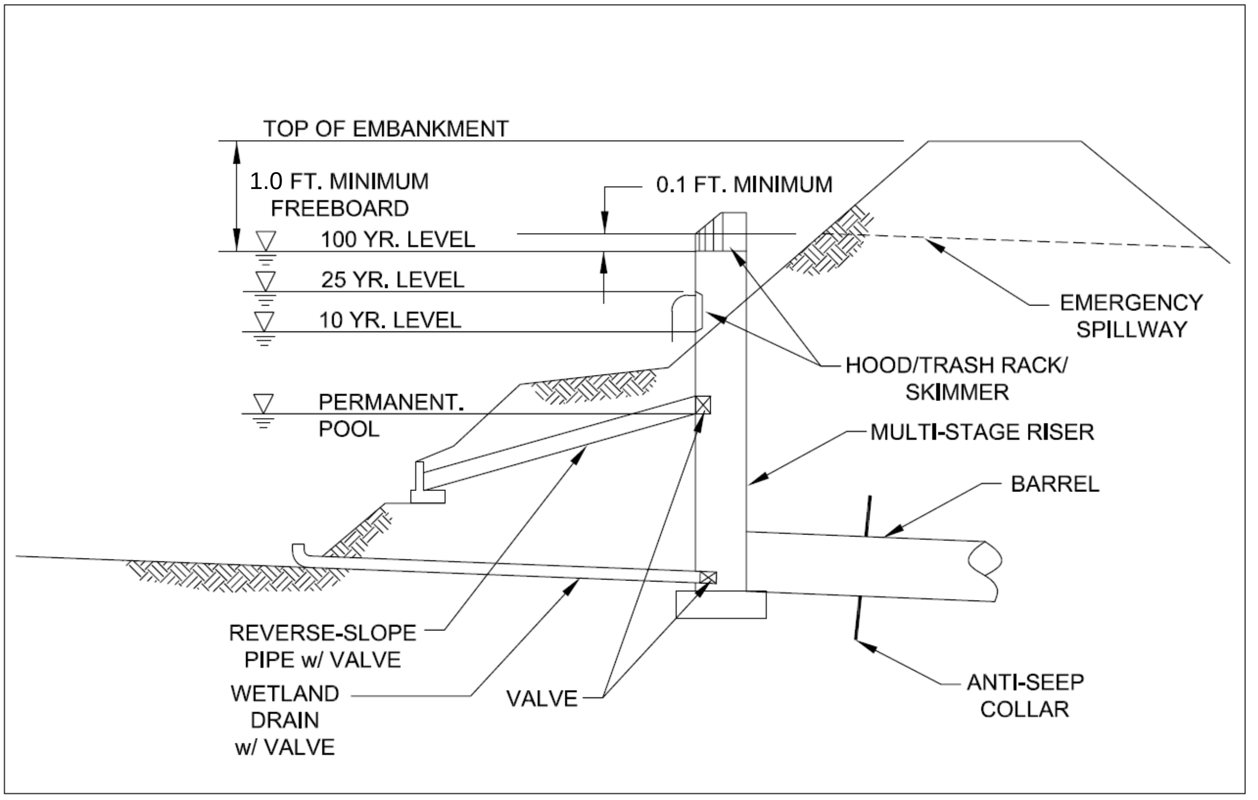
5. Examine stability of the original depth zones and microtopographical features. Inspect for invasive vegetation, and remove where possible.
6. Inspect for damage to the embankment and inlet/outlet structures. Repair as necessary. Note signs of hydrocarbon build-up, and remove appropriately.
7. Monitor for sediment accumulation in the facility and forebay.
8. Examine to ensure that inlet and outlet devices are free of debris and operational.
9. Repair undercut or eroded areas.
10. Harvest wetland plants that have been "choked out" by sediment build-up. A sediment marker should be located in the forebay to determine when sediment removal is required. Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly, plants are "choked" with sediment, or the wetland becomes eutrophic.
11. Maintenance requirements for constructed wetlands are particularly high while vegetation is being established. Monitoring during these first years is crucial to the future success of the wetland as a stormwater structural control. Wetland facilities should be inspected after major storms (greater than 2 inches of rainfall) during the first year of establishment to assess bank stability, erosion damage, flow channelization, and sediment accumulation within the wetland. For the first 3 years, inspections should be conducted at least twice a year.
12. Sediments excavated from stormwater wetlands that do not receive runoff from designated hotspots are not considered toxic or hazardous material and can be safely disposed of by either land application or landfilling. Sediment testing may be required prior to sediment disposal when a hotspot land use is present.

As-Built Certification

An as-built certification of the constructed wetland performed by a registered Professional Engineer must be submitted to Metro prior to the release of the site's bond or issuance of a Use and Occupancy permit. The as-built certification verifies that the BMP was installed as designed and approved. If components of the stormwater wetland constructed in the field differ from the design approved by Metro, the as-built certification must: (1) Note the differences between the measure in the field and the design approved by Metro; (2) Demonstrate that the design meets the requirements of Metro's stormwater program; and/or (3) Propose additional measures to be included on the site to mitigate the differences.

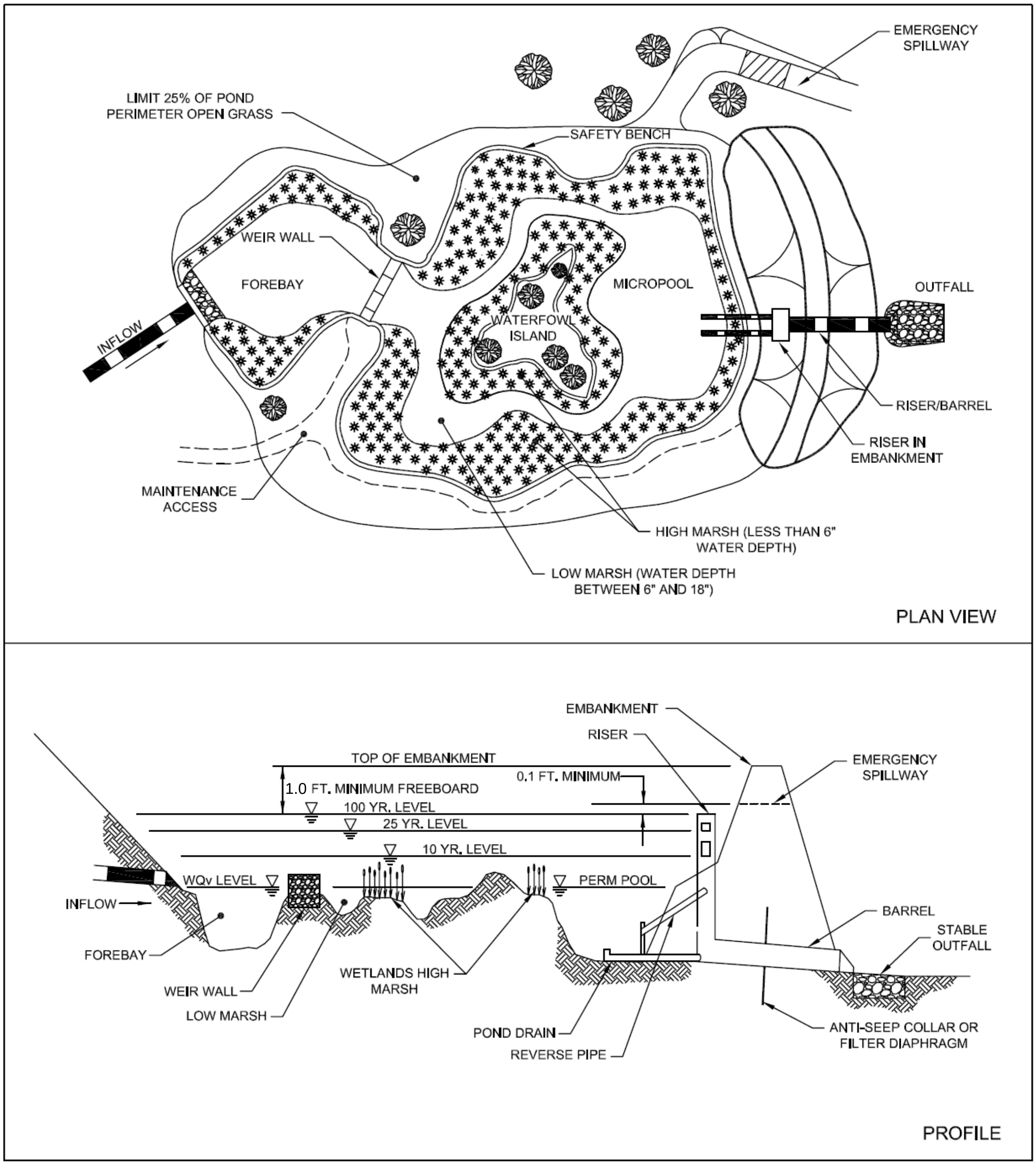
The following components should be addressed in the as-built certification:

- Sediment forebay of sufficient size to pretreat runoff.
- Access to all components of the wetland for maintenance
- Sufficient water depth to prevent the creation of stagnant water.
- Depth of treatment area.
- Side slopes and benches created as noted in the plans.
- Properly functioning spillway systems.



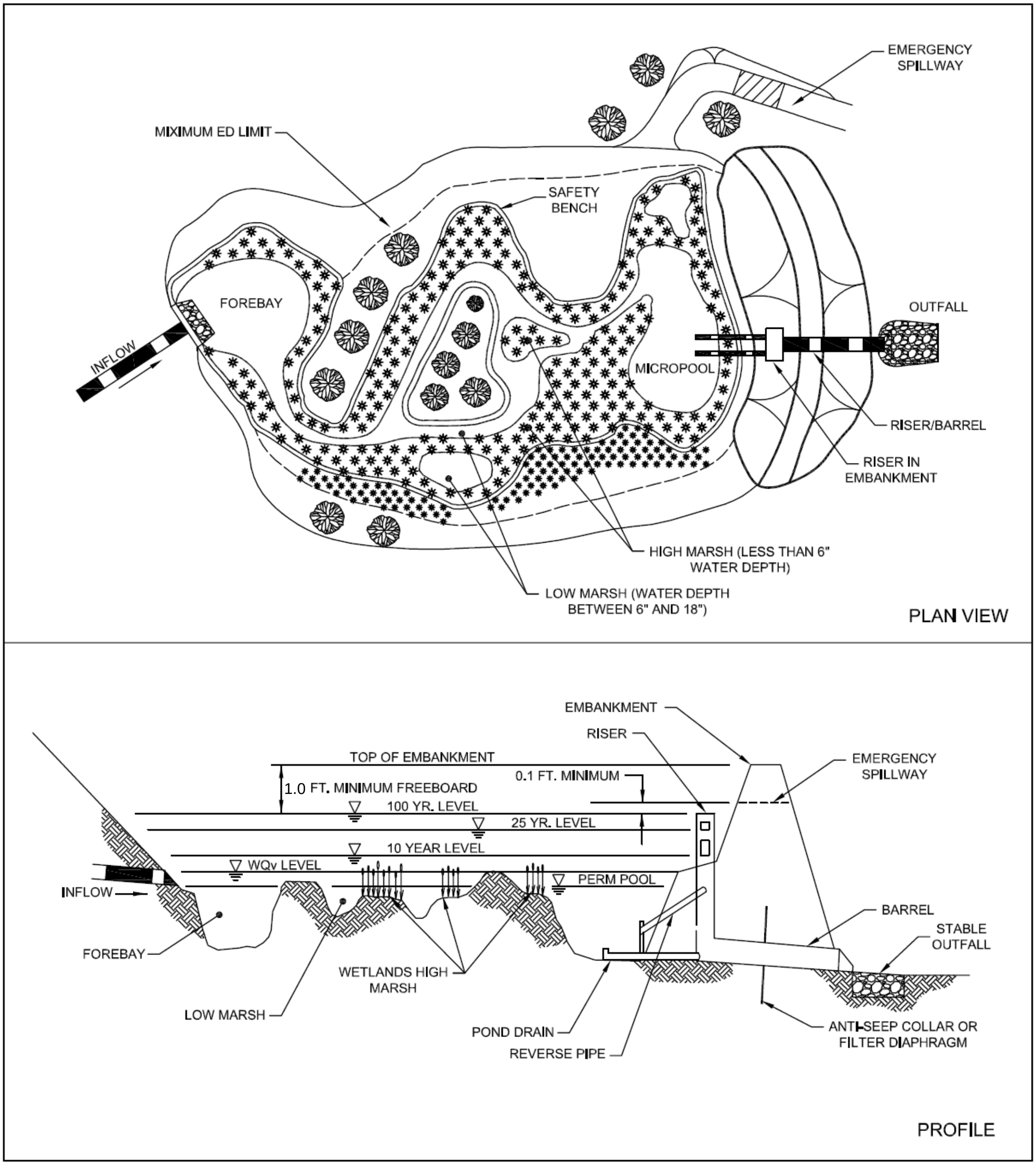
(Adapted from Center for Watershed Protection)

Figure 2.1 Typical Wetland Facility Outlet Structure



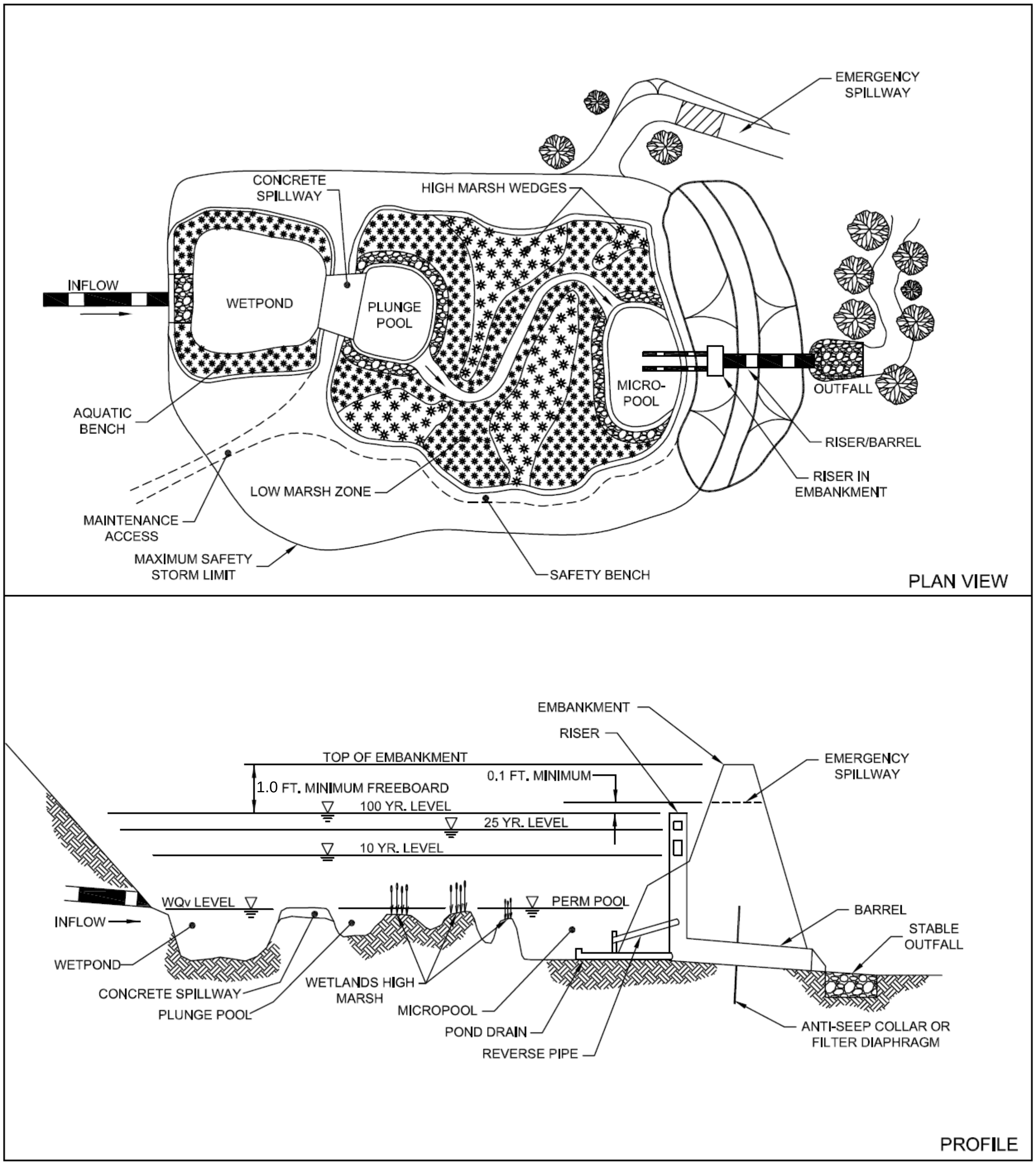
(*Source: Center for Watershed Protection)*

Figure 2.2 Schematic of Shallow Wetland



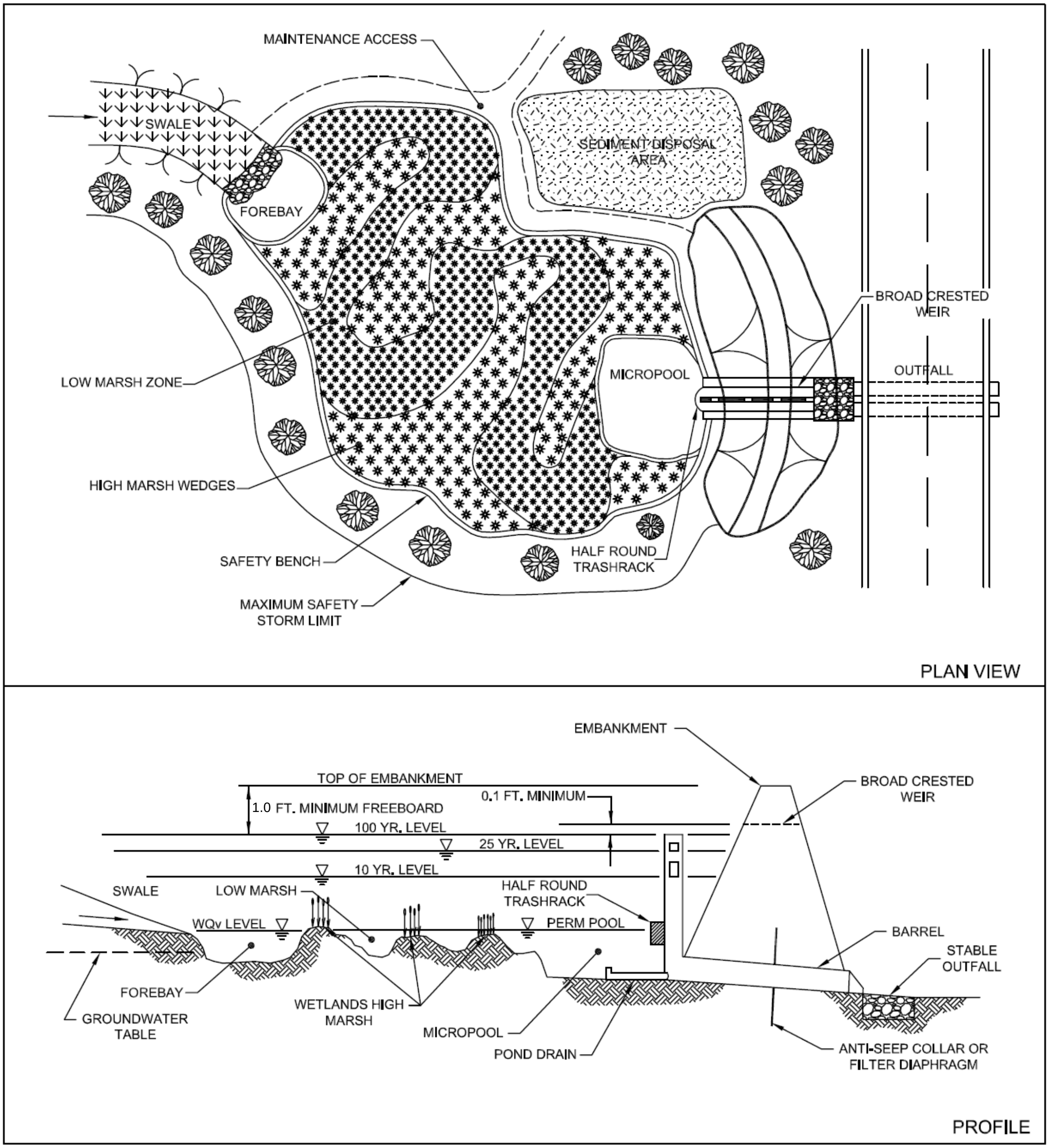
(Adapted from Center for Watershed Protection)

Figure 2.3 Schematic of Extended Detention Shallow Wetland



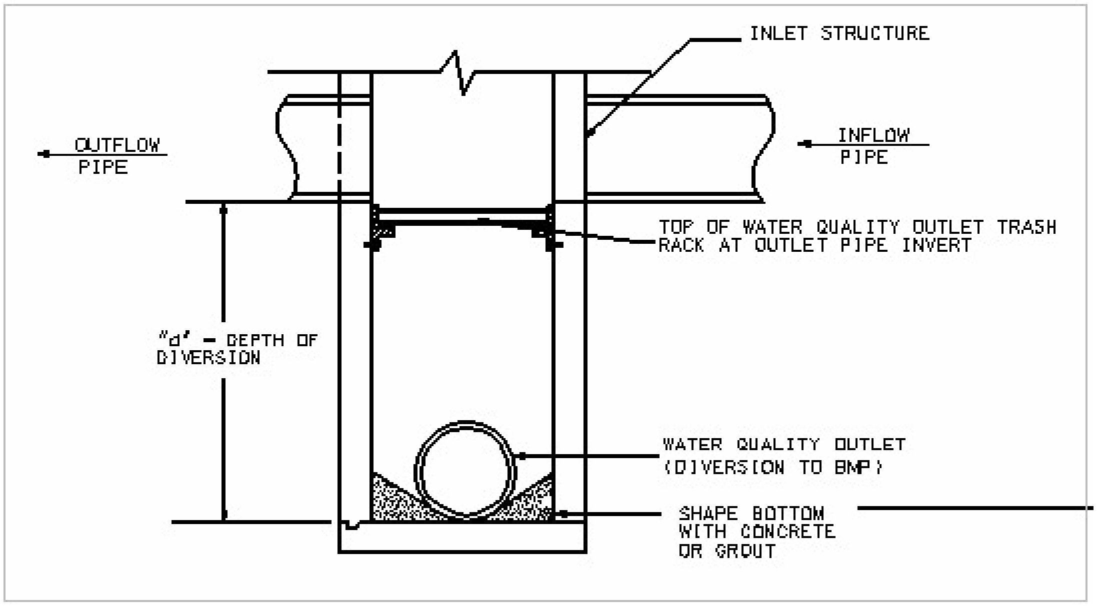
(Adapted from Center for Watershed Protection)

Figure 2.4 Schematic of Pond/Wetland System



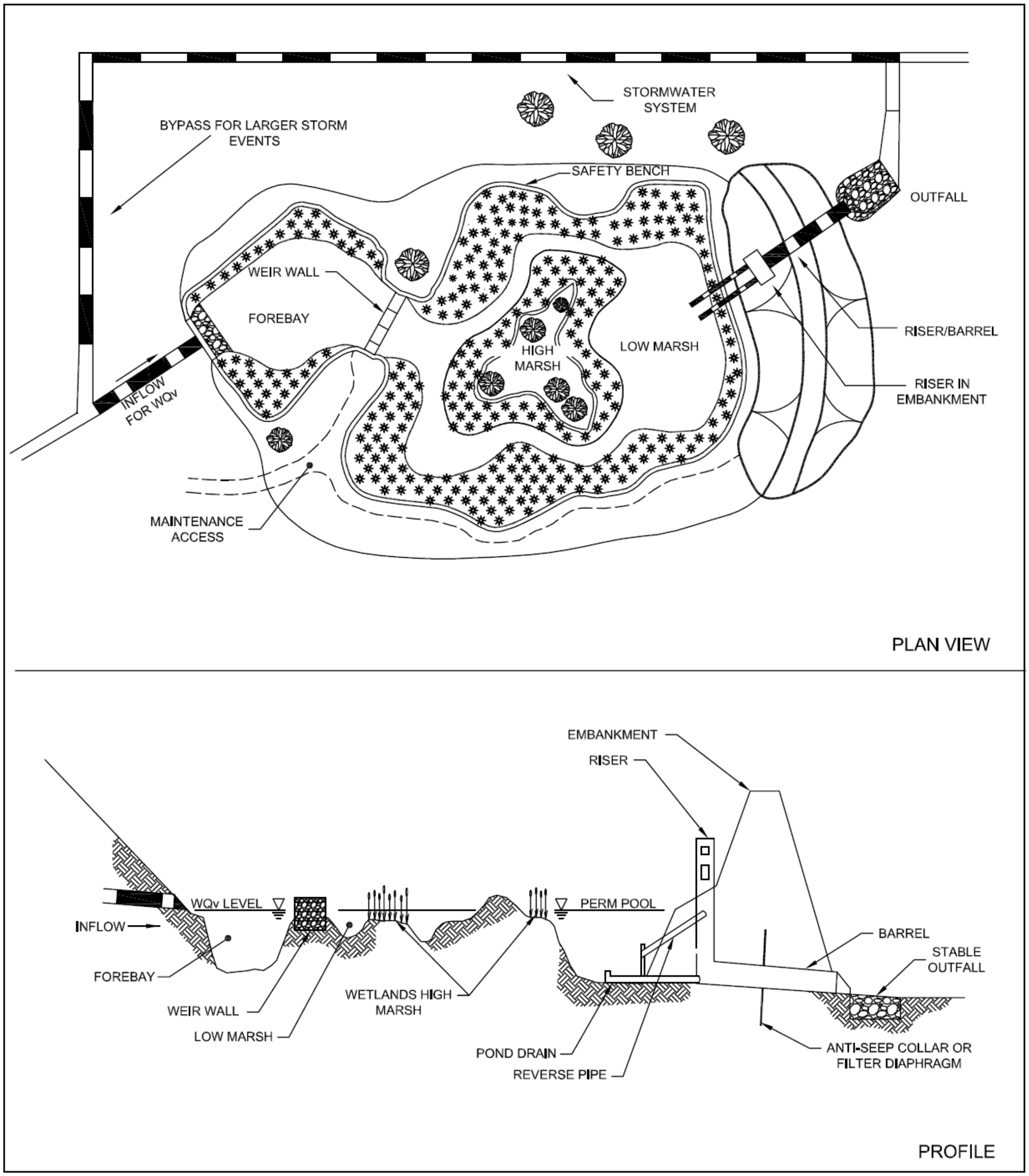
(Source: Center for Watershed Protection)

Figure 2.5 Schematic of Pocket Wetland System



(Source: AMEC)

Figure 2.6 Example Diversion Structure



(Adapted from the Center for Watershed Protection)

Figure 2.7 Example of Off-line Constructed Wetland

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