2H-1 General Information for Stormwater Wetlands

BENEFITS Low = <30% Medium = 30-65% High = 65-100%	Low	Med	High
Suspended Solids			■
Nitrogen		■	
Phosphorous	■	■	
Metals		■	■
Bacteriological		■	■
Hydrocarbons			■

Description: Stormwater wetlands are constructed wetland systems explicitly designed to incorporate the functions of natural wetlands to aid in pollutant removal from stormwater. Constructed wetlands can also provide for quantity control of stormwater by providing a significant volume of temporary water storage above the permanent pool elevation. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake within the practice. Wetlands are among the most effective stormwater practices in terms of pollutant removal, and also offer aesthetic value. A sediment forebay is provided for removal of course sediments that could degrade performance.

Typical uses:

- Larger residential developments and medium-density suburban commercial areas. Not suited for high-density/ultra urban areas due to space constraints.

Advantages/benefits:

- Very good removal of suspended and particulate pollutants.
- Biological uptake of nutrients by wetland plants.
- Reduction of peak flows and flood attenuation.
- Enhancement of vegetation diversity and wildlife habitat in urban areas.
- Relatively low maintenance costs

Disadvantages/limitations:

- Needs continuous baseflow for viable wetland vegetation – a critical design factor for smaller areas (<20 acres).
- Usually some release of nutrients in the fall and winter months.
- May act as a heat sink with discharge of warmer water to downstream reaches.
- May attract year-round population of wild geese if natural buffers not included in the wetland design.
- Relatively higher land requirements and construction costs than most other BMPs.

Maintenance requirements:

- Replacement of wetland vegetation to maintain at least 50% surface area coverage.
- Remove invasive vegetation.
- Monitor sediment accumulation and remove periodically.

A. Description

Stormwater wetlands are constructed wetland systems explicitly designed to incorporate the natural functions of wetlands to aid in pollutant removal from stormwater. Constructed wetlands can also provide for quantity control of stormwater by providing a significant volume of temporary water storage above the permanent pool elevation. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake within the practice. A sediment forebay is provided for removal of course sediments that could degrade performance. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less bio-diversity 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 differing 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:

1. **Shallow wetland.** In the shallow wetland design, most of the water quality treatment volume is in the relatively shallow high marsh or low marsh depths. The only deep portions of the shallow wetland design are the forebay at the inlet to the wetland, and the micro-pool at the outlet. One disadvantage of this design is that since the pool is very shallow, a relatively large amount of land is typically needed to store the water quality volume. (See Figure 2).

2. **Extended detention 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. (See Figure 3).

3. **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. Less land is required for a pond/wetland system than for the shallow wetland or the ED shallow wetland systems. (See Figure 4).

4. **Pocket wetland.** A pocket wetland is intended for smaller drainage areas of 2-10 acres and typically requires excavation down to the water table for a reliable water source to support the wetland system. (See Figure 5).

B. Stormwater management suitability

Similar to stormwater detention systems (wet ponds), stormwater wetlands are designed to control both stormwater quantity and quality. Thus, a stormwater wetland can be used to address all of the unified stormwater sizing criteria for a given drainage area.

1. **Water quality.** Pollutants are removed from stormwater runoff in a wetland through uptake by wetland vegetation and algae, vegetative filtering, and through gravitational settling in the slow-moving marsh flow. Other pollutant removal mechanisms are also at work in a stormwater wetland, including chemical and biological decomposition, and volatilization.

2. **Channel protection.** The storage volume above the permanent pool/water surface level in a stormwater wetland is used to provide control of the channel protection volume (Cpv). This is accomplished by releasing the 1-year, 24-hour storm runoff volume over 24 hours (extended detention). It is best to do this with minimum vertical water level fluctuation, as extreme fluctuation may stress vegetation.

3. **Overbank flood protection:** A stormwater wetland can also provide storage above the permanent pool/water surface level to reduce the post-development peak flow of the 10-year storm (Qp) to pre-development levels (detention). If a wetland facility is not used for overbank flood protection, it should be designed as an off-line system to pass higher flows around rather than through the wetland system.

4. **Extreme flood protection:** In situations where it is required, stormwater wetlands can also be used to provide detention to control the 100-year storm peak flow (Qf). Where Qf peak control is not required, a stormwater wetland must be designed to safely pass extreme storm flows.

Figure 1: Stormwater wetland examples

Shallow Wetland

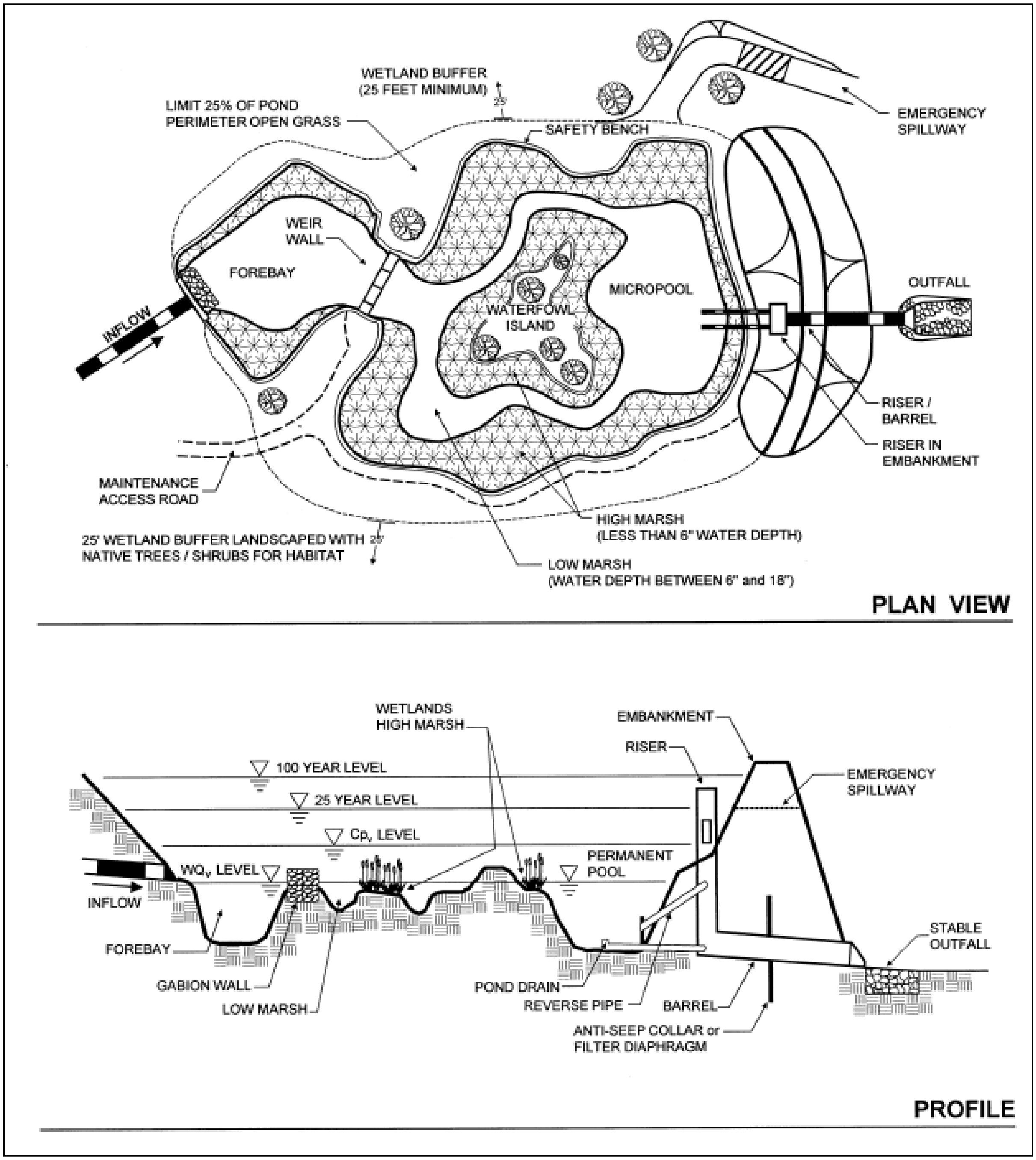
Shallow ED Wetland

Newly Constructed Shallow Wetland

Pocket Wetland

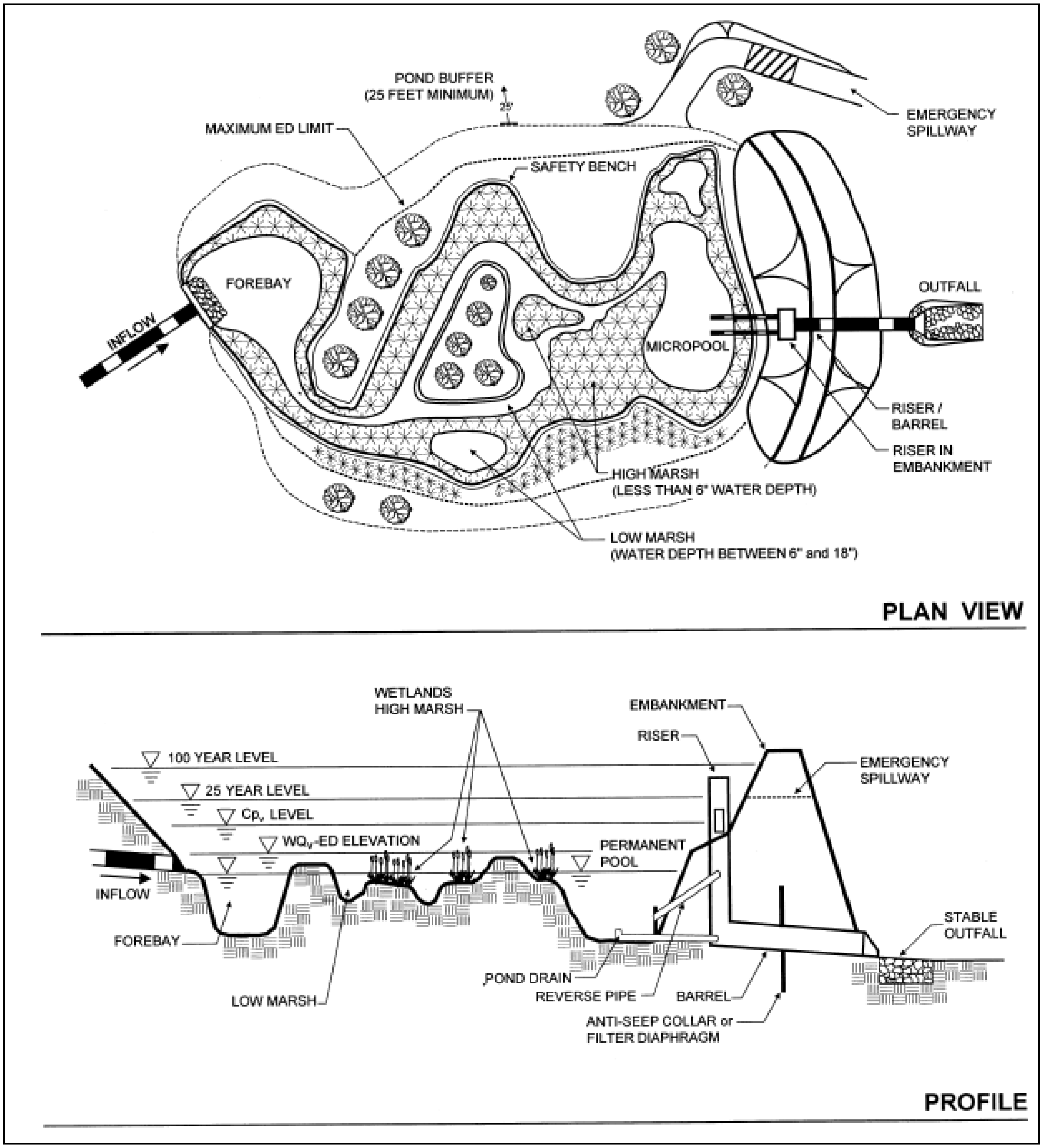
Source: Georgia Stormwater Manual, 2002

Figure 2: Shallow wetland schematic



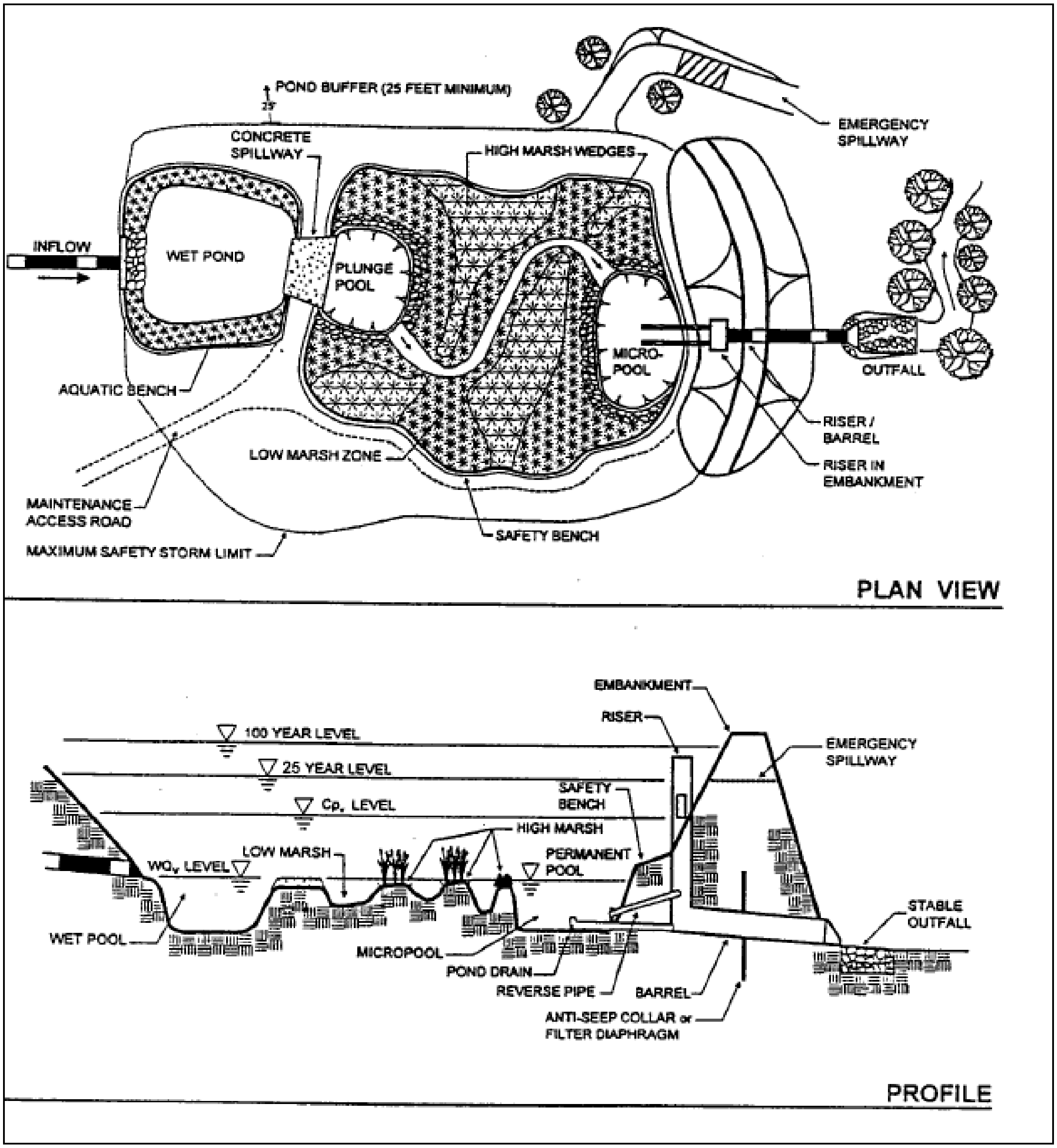
Source: Center for Watershed Protection

Figure 3: Extended detention shallow wetland schematic



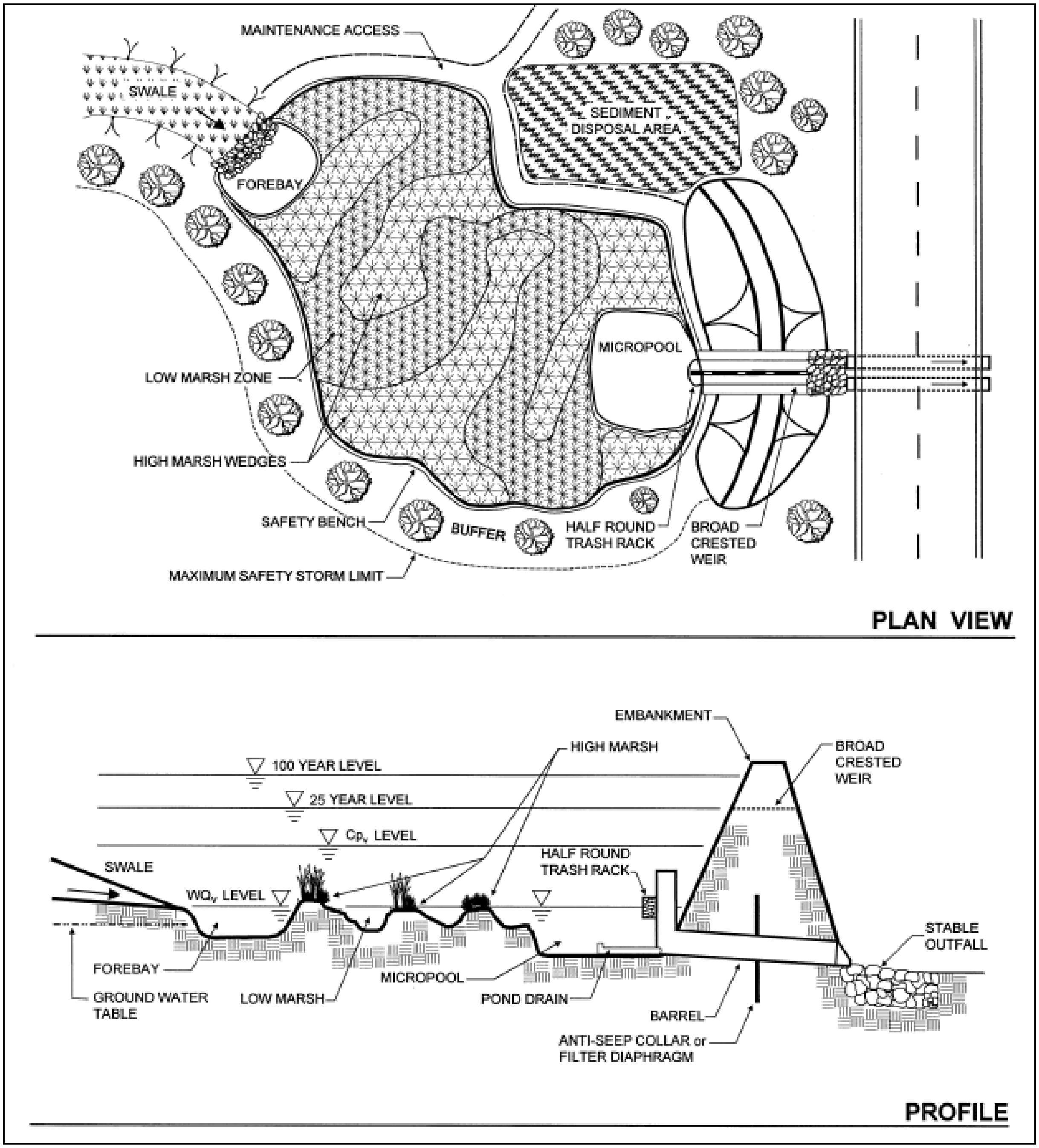
Source: Center for Watershed Protection

Figure 4: Pond/wetland system schematic



Source: Center for Watershed Protection

Figure 5: Pocket wetland system schematic



Source: Center for Watershed Protection

C. Pollutant removal capabilities

Conventional stormwater wetlands have a high pollutant removal capability, generally comparable to wet ponds. All of the stormwater wetland design variants are presumed to be able to remove 80% of the TSS load in typical urban post-development runoff when sized, designed, constructed, and maintained in accordance with the recommended specifications. Phosphorous and nitrogen removal will be more variable. Under-sized or poorly-designed wetland facilities can reduce TSS removal performance. The following design pollutant removal rates are conservative average pollutant reduction percentages for design purposes derived from previous published sampling data, modeling, and professional judgment. In a situation where a removal rate is not deemed sufficient, additional controls may be put in place at the given site in a series or treatment train approach.

- Total suspended solids – 80%
- Total phosphorus – 40%
- Total nitrogen – 30%
- Fecal coliform – 70% (if no resident waterfowl population present)
- Heavy metals – 50%

Overall performance is greatest during the growing season and lowest during the winter months (Strecker, et al, 1990). For additional information and data on pollutant removal capabilities for stormwater wetlands, see the National Pollutant Removal Performance Database (2nd Edition) available at www.cwp.org and the National Stormwater Best Management Practices Database at www.bmpdatabase.org.

D. Application and feasibility

Stormwater wetlands are generally applicable to most types of new development and redevelopment, and can be used in both residential and non-residential areas. However, due to the large land requirements, wetlands may not be practical in higher-density areas. The following criteria should be evaluated to ensure the suitability of a stormwater wetland for meeting stormwater management objectives on a site or development.

1. **General feasibility:**
   - Suitable for residential subdivision usage – yes (some concern for insect control)
   - Suitable for high-density/ultra-urban areas – land requirements may preclude use
   - Regional stormwater control – yes

2. **Physical feasibility – physical constraints at project site:**
   - **Drainage area.** A minimum of 25 acres and a positive water balance is needed to maintain wetland conditions; 5 acres for pocket wetland.
   - **Space required.** Approximately 3-5% of the tributary drainage area.
   - **Site slope.** There should be no more than 8% slope across the wetland site.
   - **Minimum head.** Elevation difference needed at a site from the inflow to the outflow: 3-5 feet; 2-3 feet for pocket wetland.
   - **Minimum depth to water table.** If used on a site with an underlying water supply aquifer or when treating a hotspot, a separation distance of 2 feet is recommended between the bottom of the wetland and the elevation of the seasonally high water table; pocket wetland is typically below water table.
   - **Soils.** Permeable soils are not well-suited for a constructed stormwater wetland without a high water table. Underlying soils of hydrologic group C or D should be adequate to maintain wetland conditions. Most HSG A soils and some B soils will require a liner. Evaluation of soils should be based upon an actual subsurface analysis and permeability tests.

2H-2 Design of Stormwater Wetlands

A. Planning and design criteria

The following are to be considered minimum criteria for the design of a stormwater wetland facility:

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 Section 2C-10).

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. A Section 401 evaluation may also be required.

5. If a wetland facility is not used for overbank flood protection, it should be designed as an off-line system to bypass higher flows rather than passing them through the wetland system.

6. Minimum setback requirements for stormwater wetland facilities (when not specified by local ordinance or criteria):
    - From a property line – 10 feet
    - From a private well – 100 feet; if well is down gradient from a hotspot land use, then the minimum setback is 250 feet
    - From a septic system tank/leach field – 50 feet
    - All utilities should be located outside of the wetland site

B. General design

1. A well-designed stormwater wetland consists of:
    - Shallow marsh areas of varying depths with wetland vegetation
    - Permanent micropool
    - Overlying zone in which runoff control volumes are stored

2. Pond/wetland systems also include a stormwater pond facility; see Part 2G for pond design information.
3. 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. (Design information for sediment forebays can be found in Section 2C-12).

4. Additional pond design features include an emergency spillway, maintenance access, safety bench, wetland buffer, and appropriate wetland vegetation and native landscaping.

C. Physical specifications and geometry

1. 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 1 provides the recommended physical specifications and geometry for the various stormwater wetland design variants.

Table 1: Design criteria for stormwater wetlands

Design Criteria for Stormwater Wetlands				
Design Element	*Shallow Marsh*	*Pond/Wetland*	*ED Wetland*	*Pocket Wetland*
Wetland/watershed ratio	0.2	0.01	0.01	0.01 (target)
Minimum drainage area	25 acres	25 acres	10 acres	1-10 acres
Length to width ratio (minimum)	1:1	1:1	1:1	1:1 (target)
Extended detention	No	No	Yes	No
Allocation of treatment volume (pool/marsh/ED)	40/60/0	70/30/0	20/30/50	20/80/0
Allocation of surface area (deep/low/high)	20/40/40	45/25/30	20/35/45	10/40/50
Cleanout frequency	2-5 years	10 years	2-5 years	10 years
Forebay	Required	No	Required	Optional
Micropool	Required	Required	Required	Optional
Outlet configuration	Reverse slope pipe or hooded broad-crested weir	Same	Same	Hooded broad-crested weir
Propagation technique	Mulch or transplant; seeding and plugs	Mulch or transplant; seeding and plugs	Mulch or transplant; seeding and plugs	Volunteer; seeding and plugs
Buffer (feet)	25-50	25-50	25-50	0-25
Pondscaping plan requirements	Emphasize wildlife habitat, marsh micro-topography buffer	Emphasize wildlife habitat and high-marsh wedges	Emphasize stabilization of the ED zone, project pondscaping zones	Pondscaping plan optional
Depth: Deepwater: 1.5-6 feet below normal pool elevation High marsh: 6 inches or less below normal pool elevation Low marsh: 6-18 inches below normal pool elevation Semi-wet zone: Above normal pool elevation				

Source: Schueler, 1992

2. 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 1. The four basic depth zones are:

    a. **Deepwater zone.** From 1.5-6 feet deep; 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.

    b. **Low marsh zone.** From 6-18 inches below the normal permanent pool or water surface elevation. This zone is suitable for the growth of several emergent wetland plant species.

    c. **High marsh zone.** From 6 inches below the pool to the normal pool elevation. 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.

    d. **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.

3. 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. Micro-topography (contours along the bottom of a wetland or marsh that provide a variety of conditions for different species and increases the surface area to volume ratio) is encouraged to enhance wetland diversity.

4. A 4- to 6-foot deep micropool must be included in the design at the outlet to prevent the outlet from clogging and re-suspension of sediments, and to mitigate thermal effects.

5. Maximum depth of any permanent pool areas should generally not exceed 6 feet.

6. The volume of the extended detention must not comprise more than 50% of the total WQv, and its maximum water surface elevation must not extend more than 3 feet above the normal pool. Qp and/or Cpv storage can be provided above the maximum WQv elevation within the wetland.

7. The perimeter of all deep pool areas (4 feet or greater in depth) is surrounded by safety and aquatic benches similar to those for stormwater ponds (see Section 2G).

8. The contours of the wetland should be irregular to provide a more natural landscaping effect.

D. Pre-treatment inlets

1. Sediment regulation is critical to sustain stormwater wetlands. A wetland facility should have a sediment forebay or equivalent upstream pre-treatment. A sediment forebay is designed to remove incoming sediment from the stormwater flow prior to dispersal into the wetland. The forebay consists of a separate cell, formed with a functional barrier. A forebay is provided at each inlet, unless the inlet provides less than 10% of the total design storm inflow to the wetland facility.

2. The forebay is sized to contain 0.1 inches per impervious acre of contributing drainage and should be 4-6 feet deep. The pre-treatment storage volume is part of the total WQv requirement and may be subtracted from WQv for wetland storage sizing.

3. A fixed vertical sediment depth marker is 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.

4. Inflow channels are 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.

E. Outlet structures

1. 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 (see Figure 7). The riser should be located within the embankment for maintenance access, safety, and aesthetics.

2. A number of outlets at varying depths in the riser provide internal flow control for routing of the water quality, channel protection, and overbank flood protection runoff volumes. The number of orifices can vary and is usually a function of the pond design. For shallow and pocket wetlands, the riser configuration is typically comprised of a channel protection outlet (usually an orifice) and overbank flood protection outlet (often a slot or weir). The channel protection orifice is sized to release the channel protection storage volume over a 24-hour period (12-hour extended detention may be warranted to protect some streams from warm water discharges). Since the water quality volume is fully contained in the permanent pool, no orifice sizing is necessary for this volume. As runoff from the water quality event enters the wet pond, it simply displaces that same volume through the channel protection orifice. Thus, an off-line shallow or pocket wetland providing only water quality treatment can use a simple overflow weir as the outlet structure.

3. 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 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 next outlet is sized for the release of the channel protection storage volume. The outlet (often an orifice) invert is located at the maximum elevation associated with the extended detention water quality volume and is sized to release the channel protection storage volume over a 24-hour period (12-hour extended detention may be warranted to protect some streams from warm water discharges).

4. Alternative hydraulic control methods to an orifice can be used and include the use of a broad-crested rectangular, v-notch, proportional weir, or an outlet pipe protected by a hood that extends at least 12 inches below the normal pool.

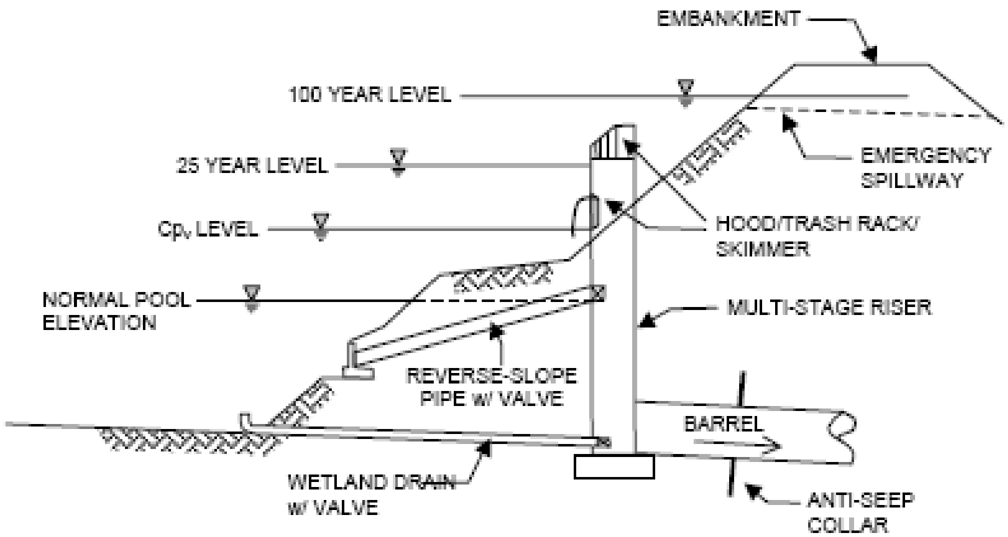
5. The water quality outlet (if design is for an ED shallow wetland) and channel protection outlet should be fitted with adjustable gate valves or other mechanism that can be used to adjust detention time.

6. Higher flows (overbank and extreme flood protection) flows pass through openings or slots protected by trash racks further up on the riser.

7. 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.

8. Riprap, plunge pools or pads, or other energy dissipators 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. See Part 2N for more guidance.

Figure 7: Typical wetland facility outlet structure



9. 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.

10. The wetland drain should be sized one pipe size greater than the calculated design diameter. The drain valve is typically a hand wheel-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.

11. See the design procedures in Part 2C for additional information and specifications on pond routing and outlet works.

F. Auxiliary spillway

1. An auxiliary spillway is 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 auxiliary spillway must be located so that downstream structures will not be impacted by spillway discharges.

2. A minimum of 1 foot of freeboard must be provided, measured from the top of the water surface elevation for the extreme flood to the lowest point of the dam embankment, not counting the emergency spillway.

G. Maintenance access

1. A maintenance right-of-way or easement must be provided to the wetland facility from a public or private road. The maintenance access is least 12 feet wide, has a maximum slope of no more than 10%, and is appropriately stabilized to withstand maintenance equipment and vehicles.

2. 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.
3. Access to the riser is to be provided by lockable manhole covers, and manhole steps within easy reach of valves and other controls.

H. Safety features

1. All embankments and spillways must be designed to State of Iowa guidelines for dam safety (see Part 2G).

2. Fencing of wetlands is not generally desirable, but may be required by the local review authority. 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.

3. The principal spillway opening should not permit access by small children, and end walls above pipe outfalls greater than 48 inches in diameter should be fenced to prevent a hazard.

I. Landscaping

1. 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.

2. Landscaping zones include low marsh, high marsh, and semi-wet zones. The low marsh zone ranges from 6-18 inches below the normal pool. This zone is suitable for the growth of several emergent plant species. The high marsh zone ranges from 6 inches below the pool up to the normal pool. 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.

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

4. 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.

5. A wetland buffer shall extend 25 feet outward from the maximum water surface elevation, with an additional 15-foot setback to structures. The wetland buffer should be contiguous with other buffer areas that are required by existing regulations (e.g., stream buffers) or that are part of the overall stormwater management concept plan. No structures should be located within the buffer, and an additional setback to permanent structures may be provided.

6. Existing trees should be preserved in the buffer area during construction. It is desirable to locate forest conservation areas adjacent to ponds. To discourage resident geese populations, the buffer can be planted with trees, shrubs, and native ground covers.

7. 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.

8. Guidance on establishing wetland vegetation can be found in the SUDAS Specifications Manual Section 9010.

J. Additional site-specific design criteria and issues

1. **Physiographic factors - local terrain design constraints.**
   - Low relief – providing wetland drain can be problematic
   - High relief – embankment heights restricted
   - 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

2. **Soils.** Hydrologic group A soils and some group B soils may require liner (not relevant for pocket wetland).

K. Design procedures

1. **Step 1.** Compute runoff control volumes from the unified stormwater sizing criteria.

   a. Calculate the WQv, Cpv, Qp, and the Qf.

   b. Details on the unified stormwater sizing criteria are found in Part 2B.

   c. Hydrological analysis procedures are covered in Part 2C.

2. **Step 2.** Determine if the development site and conditions are appropriate for the use of a stormwater wetland. Consider the Application and Feasibility criteria in this section.

3. **Step 3.** Confirm any local jurisdiction design criteria and applicability standards.

   a. Consider any special site-specific design conditions/criteria listed in this section.

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

4. **Step 4.** Determine pre-treatment volume. A sediment forebay is 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 4-6 feet deep. The forebay storage volume counts toward the total WQv requirement and may be subtracted from the WQv for subsequent calculations.

5. **Step 5.** Allocate the WQv volume among marsh, micropool, and ED volumes. Use recommended criteria from Table 1.

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

   a. 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 WQv permanent pool elevation (and WQv-ED elevation for ED shallow wetland) based on volumes calculated earlier.

   b. See Physical Specifications/Geometry for more details.

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

   a. **Shallow Wetland and Pocket Wetland.** The Cpv elevation is determined from the stage storage relationship and the orifice is then sized to release the channel protection storage volume over a 24-hour period (12-hour extended detention may be warranted in some coldwater streams). The channel protection orifice should have a minimum diameter of 3 inches 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 1 foot below the elevation of the permanent pool is a recommended design. The orifice diameter may be reduced to 1 inch if internal orifice protection is used (i.e., an over-perforated vertical stand pipe with ½-inch orifices or slots that are protected by wire cloth and a stone filtering jacket). Adjustable gate valves can also be used to achieve this equivalent diameter.

   b. **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, 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. The Cpv elevation is then determined from the stage-storage relationship. The invert of the channel protection orifice is located at the water quality extended detention elevation, and the orifice is sized to release the channel protection storage volume over a 24-hour period (12-hour extended detention may be warranted in some coldwater streams).

8. **Step 8.** Calculate Qp_{25} (25-year storm) release rate and water surface elevation.

   a. Develop a stage-storage-discharge relationship for the control structure for the extended detention orifice(s) and the 25-year storm.

   b. Perform a storage routing for the 25-yr storm event.

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

   a. Size emergency spillway, calculate 100-year water surface elevation, set top of embankment elevation, and analyze safe passage of the Qf.

b. At final design, provide safe passage for the 100-year event. Attenuation may not be required.

10. **Step 10.** Investigate potential pond/wetland hazard classification. The design and construction of stormwater management ponds and wetlands are required to follow the current version of the Iowa Technical Bulletin 16 related to embankment dam safety rules.

11. **Step 11.** Design inlets, sediment forebay(s), outlet structures, maintenance access, and safety features. (See Parts 2C and 2N).

12. **Step 12.** Prepare vegetation and landscaping plan.

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

    b. See SUDAS Specifications for Stormwater BMPs for more details.

L. Inspection and maintenance requirements

Table 2: Inspection and maintenance requirements for stormwater wetlands

Activity	Schedule
Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.	One-time activity
Clean and remove debris from inlet and outlet structure. Mow side slopes.	Frequently (3 to 4 times/year)
Monitor wetland vegetation and perform replacement planting as necessary.	Semi-annual inspection (first 3 years)
Examine stability of the original depth zones and micro-topographical features. Inspect for invasive vegetation and remove where possible. Inspect for damage to the embankment and inlet/outlet structures; repair as necessary. Note any signs of hydrocarbon build-up and remove accordingly. Monitor for sediment accumulation in the facility and forebay. Examine to ensure that inlet and outlet devices are free of debris and operational.	Annual Inspection
Repair undercut or eroded areas.	As needed
Harvest wetland plants that have been “choked out” by sediment accumulation.	Annually
Removal of sediment from the forebay.	5 to 7 years or after 50% of the total forebay capacity has been lost
Monitor sediment accumulations and remove sediment when pool volume has become reduced significantly (~25%), plants are “choked” with sediment, or the wetland becomes eutrophic.	10 to 20 years or after 25% of the wetland volume has been lost

1. **Additional maintenance considerations and requirements.**

    a. 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 three years, inspections should be conducted at least twice a year.

b. A sediment marker should be located in the forebay to determine when sediment removal is required.

c. Accumulated sediments will gradually decrease wetland storage and performance. The effects of sediment deposition can be mitigated by the removal of the sediments.

d. 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 at a permitted landfill. Sediment testing may be required prior to sediment disposal when a hotspot land use is present. Sediment removed from stormwater wetlands should be disposed of according to an approved erosion and sediment control plan.

e. 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.

Table 3: Design forms

Stormwater Wetland Design Form					
Preliminary Hydrologic Calculations					
Watershed Data					
Total upstream drainage area			Total area, A_{total}		acres
% Imperviousness of DA			% Imperviousness		%
Total impervious area			Total Imp. Area, A_{Imp}		acres
Watershed CN			CN =		
Time of Concentration, tc			t_c =		hours
1a	Compute WQv requirements				
	Compute Runoff Coefficient, Rv		Rv =		
	Compute WQv requirements		WQv =		acre-ft
1b	Compute CPv		CPv =		acre-ft
	Compute average release rate		release rate		ft^3/sec
	Compute Qp-25		Qp-25 =		acre-ft
	Add 15% to the required Qp-25 volume		Qp-25 * 0.15 =		acre-ft
	Compute Qf (100-yr)		Qf =		acre-ft
Stormwater Wetland Design					
2	Is the use of a stormwater wetland appropriate?				
3	Confirm local design criteria and applicability				
4	Pre-treatment volume				
	$V_{PRE} = A_{IMP}$ *(0.1-inches) * (1-ft/12 in)		V_{PRE} =		acre-ft
5	Allocation of pool, marsh, and ED volumes				
	Shallow wetland	VOL_{pool} = 0.2*(WQv)	VOL_{pool} =		acre-ft
		VOL_{marsh} = 0.7*(WQv)	VOL_{marsh} =		acre-ft
	Shallow ED wetland	VOL_{pool} = 0.1*(WQv)	VOL_{pool} =		acre-ft
		VOL_{marsh} = 0.3*(WQv)	VOL_{marsh} =		acre-ft
		VOL_{ED} = 0.5*(WQv)	VOL_{ED} =		acre-ft
	Pocket wetland	VOL_{pool} = 0.1*(WQv)	VOL_{pool} =		acre-ft
		VOL_{marsh} = 0.8*(WQv)	VOL_{marsh} =		acre-ft
6	Allocation of surface area				
	Pool/deep water wetland zone (1.5-6 feet deep)		$Area_{WATER}$ =	acres	%=
	Low marsh wetland zone (6-18 inches deep)		$Area_{LOW}$ =	acres	%=
	High marsh wetland zone (0-6 inches deep)		$Area_{HIGH}$ =	acres	%=
	Semi-wet wetland zone (above pool level depth)		$Area_{SEMI}$ =	acres	%=
					100%

Table 3: Design forms (continued)

Stormwater Wetland Design Form								
6	Conduct grading and determine storage volume available for marsh zones (and ED if applicable) and compute orifice size.				Prepare an elevation-storage table and curve using the average area method for computing volumes			
	Elevation	**Area**	**Avg. Area**	**Depth**	**Volume**	**Cumulative Volume**	**Cumulative Volume**	**Volume Above Permanent Pool**
	MSL	**ft^2**	**ft^2**	**ft**	**ft^3**	**ft^3**	**ac-ft**	**ac-ft**

Table 3: Design Forms (continued)

Stormwater Wetland Design Form				
7	WQv orifice calculations			
	Average ED release rate (if applicable)	release rate Qr=		ft^3/sec
	Average head, h=(ED elev-perm. pool elev)/2	H=		ft
	Area of orifice from orifice equation $Q=CA(2gh)^{0.5}$	A=		ft^2
		diameter=		inches
	Discharge equation, $Q=h^{0.5}$	factor=		$h^{0.5}$
	Compute release rate for CPv-ED control and establish CPv elevation	WSEL=		ft-NVGD
	Average head, h =)CPv elev-perm pool elev)/2	h=		ft
	Area of orifice from orifice equation: $Q=CA(2gh)^{0.5}$	A=		ft^2
		diameter=		inches
	Discharge equation, $Q= h^{0.5}$	factor=		$h^{0.5}$

8	Calculate Qp-25 release rate and WSEL								Set up a stage-discharge-discharge relationship							
	Elevation	Storage	Low-Flow		Riser				Barrel				Emergency Spillway		Total Storage	
			WQv-ED		CPv=ED		High Storage		Inlet		Pipe					
							Orifice	Weir								
	MSL	acre-ft	H(ft)	Q(cfs)	H(ft)	Q(cfs)	H Q	H Q	H(ft)	Q(cfs)	H(ft)	Q(cfs)	H(ft)	Q(cfs)	Q(cfs)	
	Qp-25 =(pre-dev peak discharge)-(WQv-ED release rate+CPv-ED release rate)										Qp-25=			ft^3/sec		
	Maximum head										Hmax=			ft		
	Use weir equation for slot length ($Q=CLH^{3/2}$)										L=			ft		
	Check inlet condition										Use Culvert design charts in Part 2F					
	Check outlet condition															

Table 3: Design Forms (continued)

Stormwater Wetland Design Form				
9	Size emergency spillway, calculate 100-year WSEL and set top of embankment elevation			
		$WSEL_{25}$=		ft
		$WSEL_{100}$=		ft
		Q_{ES}=		ft^3/sec
		Q_{PS}=		ft^3/sec