4.3 Storm Water Wetland BMP Summary Fact Sheets

Description: Constructed storm water wetlands temporarily store runoff in relatively shallow pools that support conditions suitable for the growth of wetland plants. Storm water wetlands are wetland systems designed to maximize the removal of pollutants from storm water runoff through settling and both uptake and filtering by vegetation. Wetlands typically consist of four zones: shallow land (temporary storage), shallow water, open water (forebay and micro-pool), and upland areas. The runoff volume is both stored and treated in the storm water wetland permanent pool and temporary storage volume above the surface of the marsh.

IMPORTANT CONSIDERATIONS

DESIGN CRITERIA:

- Contributing drainage area must be a minimum of 10 acres.
- Storm Water Wetland must remain hydrated as shown with a water balance analysis.
- Minimum dry weather flow path of 1.5:1 (length:width) must be provided.
- Depths in BMP should be a minimum 30% shallow land (normal pool to 1 foot), 38% shallow water (0 – 6 inches), and a minimum 15% deep pool (greater than 18 inches).
- Maximum permanent pool depth of 9 feet.
- Sediment forebay must be provided for all concentrated inflows must be provided.
- Wetland vegetation that covers 90% of the wetland area must be assured after one year through an approved vegetation and maintenance plan.
- Inflow energy dispersion is required to distribute flow and prevent short-circuiting.
- Safety ledges must be provided adjacent to permanent pool areas that are deeper than 3 feet.
- Maximum temporary ponding depth above the permanent pool is 1 foot for the WQ_V.
- Maximum temporary ponding depth above permanent pool is 3 feet for design storms greater than the WQ_V.

ADVANTAGES/BENEFITS:

- Good nutrient removal.
- Provides natural wildlife habitat and aesthetic values.
- Can be used to reduce peak runoff rates.

DISADVANTAGES/LIMITATIONS:

- Requires large land area.
- Each month must have a positive water balance.
- Sediment regulation is critical to sustain wetlands.
- Large commitment to establish and maintain vegetation.
- Permanent pool elevation should be no higher than 6" above the seasonally high water table (SHWT).

MAINTENANCE CONSIDERATIONS:

- Wetland vegetation must be maintained to achieve at least 90% of surface area coverage.
- Remove invasive vegetation.
- Monitor sediment accumulation and remove when surviving vegetation coverage is less than 90%.
- Implement measures to deter destructive wildlife.

STORMWATER MANAGEMENT SUITABILITY

L = Low **M** = Moderate **H** = High

H	**1-inch, 6-hr. Water Quality Control**
H	**1-yr, 24-hr Channel Protection Volume**
M	**Peak Attenuation Control for 10-yr, 6-hr Storm**
M	**Peak Attenuation Control for 25-yr, 6-hr storm**

Wetlands facilities are highly effective in controlling pollution removal for the 1-inch, 6-hr storm (WQ_v) and can be designed to control the volume for the 1-yr, 24-hr storm (CP_v) and peak attenuation for the 10- and 25-yr, 6-hr storms.

IMPLEMENTATION CONSIDERATIONS

H	**Land Requirements**
H	**Capital Cost**
M	**Maintenance Cost**
H	**Maintenance Considerations**

PRIMARY POLLUTANT REMOVAL PROCESSES

- Settling
- Biological

POLLUTANT REMOVAL RATES

Effectiveness	Detention Time	WQ_v/PP_v	Pollutant Removal Rates
Optimal Efficiency	**4 days**	**0.6**	**85% TSS 70% TP**
Standard Efficiency	**2 days**	**1.1**	**60% TSS 40 % TP**
TSS-Only Efficiency	**4 days**	**0.8**	**85% TSS**

4.3 Storm Water Wetlands

4.3.1 General Description

Storm water wetlands (also referred to as treatment wetlands or constructed wetlands) are constructed shallow marsh systems that are designed to treat urban storm water and control runoff volumes. As storm water runoff flows through the wetland facility, pollutant removal is achieved through settling, filtering, and uptake by marsh vegetation. Storm water wetlands temporarily store storm water runoff in shallow pools that support emergent and riparian vegetation.

Wetlands are among the most effective storm water practices in terms of pollutant removal and also offer aesthetic value and wildlife habitat. Storm water wetlands differ from natural wetland systems in that they are engineered facilities designed specifically for the purpose of treating storm water runoff and typically have less biodiversity than natural wetlands both in terms of plant and animal life. However, as with natural wetlands, storm water wetlands must remain wet as shown by a water balance analysis in order to support aquatic vegetation. The designer may want to ensure that the permanent pool is replaced weekly to minimize negative issues associated with stagnation, including mosquitoes, odor, etc.

The storm water wetland design has most of the water quality treatment volume in the relatively high marsh or low marsh depths. In addition, part of the water quality treatment volume is provided as extended detention above the surface of the marsh. In the storm water wetland, plants that can tolerate the different conditions of water depth and duration must be specified. For example, both wet and dry periods need to be specified in the extended detention zone. The upper stages of the storm water wetland can be designed to provide extended detention of the channel protection volume, 1-year, 24-hour storm (CP_v), as well as normal detention of larger storm events to meet Q_p requirements.

Figure 4.3.1 shows typical local storm water wetland facilities and Figure 4.3.2 shows schematics of a typical storm water wetland application.

Figure 4.3.1 Storm Water Wetland Example

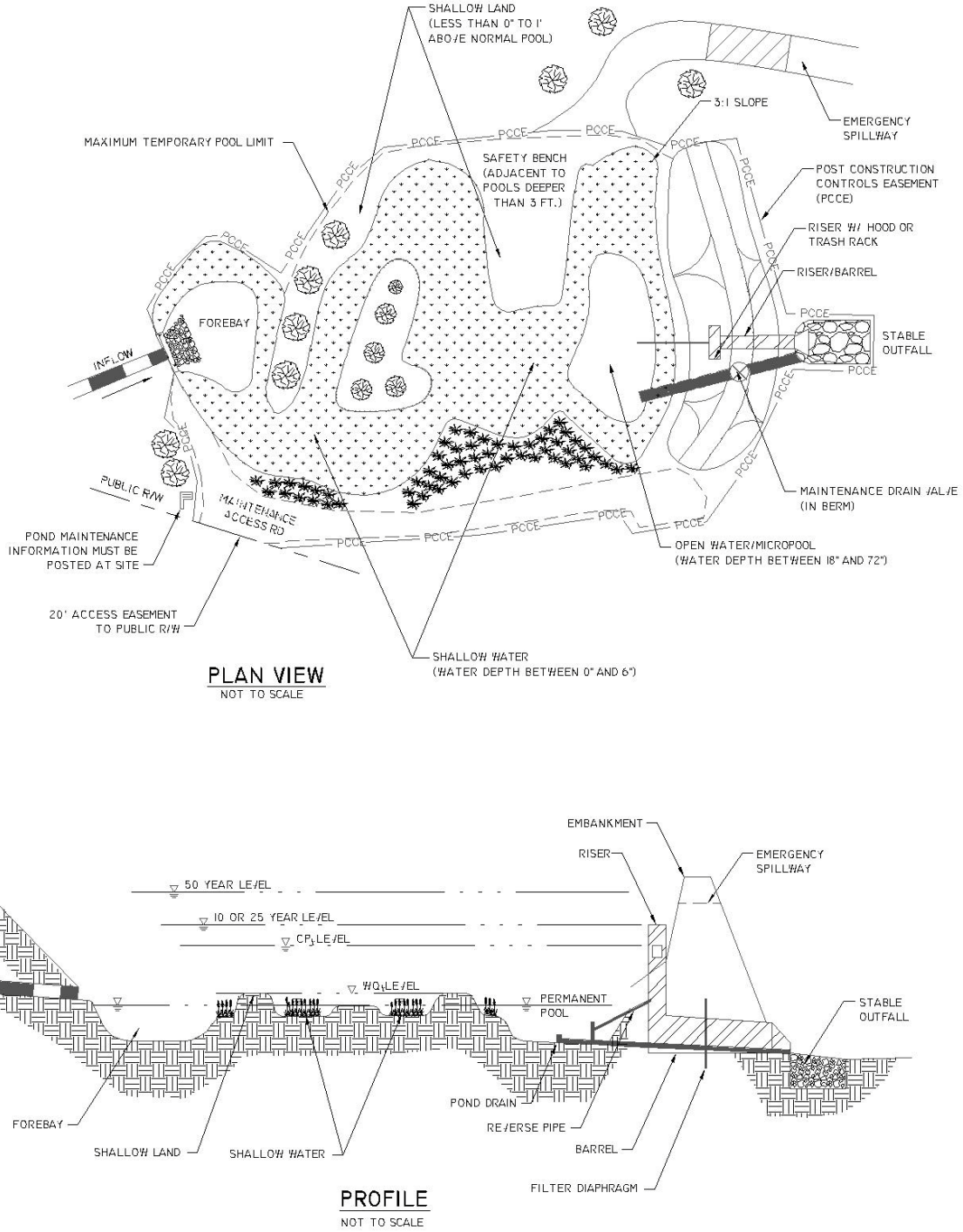

Figure 4.3.2 Schematic of Storm Water Wetland

4.3.2 Storm Water Management Suitability

Similar to ponds, storm water wetlands are designed to control both storm water quantity and quality. Thus, a storm water wetland can be used to address all of the storm water criteria for a given drainage area.

Water Quality

The primary pollutant removal occurs in a storm water wetland through biological uptake by wetland vegetation through gravitational settling in the slow moving marsh flow, and extended detention. Other pollutant removal mechanisms are also at work in a storm water wetland including filtering, and chemical and biological decomposition and volatilization. The maximum ponding depth allowed for the WQ_v temporary storage is 1 feet above the normal pool elevation.

Channel Protection

The storage volume in addition to the WQ_v above the permanent pool in a storm water wetland can be used to provide some of the control of the channel protection volume (CP_v). This is accomplished by releasing the 1-year, 24-hour storm runoff over 24 hours (a minimum of 5 percent of the CP_v must remain within the wetland temporary storage volume 24 hours after the 12th hour, the center of rainfall for projects within Mecklenburg County and the six Towns. Within the City of Charlotte and its ETJ, this release is over 48 hours. It is best to do this with minimum vertical water level fluctuation, as extreme fluctuation may stress vegetation. The plant list in Chapter 6 – Vegetation and Landscaping gives allowable ponding depths and durations for different plants. The maximum ponding depth for allowed for control of the CP_V and larger storm events is 3 feet above the normal pool elevation.

On-site Flood Control

A storm water wetland can attenuate the post-development peak flow of the 10- and 25-year, 6-hour storm (if required) (Q_p) to pre-development levels by using the water quality and channel protection storage volume and/or using additional storage volume above the water quality and channel protection volume. The emergency spillway design is the 50-year storm event with 6 inches of freeboard for embankments less than 15 feet in height. More detailed design standards for embankments taller than 15 feet can be found in the North Carolina Dam Safety Regulations.

4.3.3 Pollutant Removal Capabilities

Three wetland designs have been developed for application in the Mecklenburg County area. The *optimal efficiency design* has the capability to remove 85% of the total suspended solids and 70% of the total phosphorus load. The *standard efficiency design* has the capability to remove 60% of the total suspended solids and 40% of the total phosphorus load. The *TSS-only efficiency design* has the capability to remove 85% of the total suspended solids and negligible total phosphorus load. All of these designs assume urban post-development runoff conditions that have been observed in the Mecklenburg County area and that the facilities are sized, designed, constructed and maintained in accordance with the recommended specifications contained in this manual. The design pollutant removal rates are derived from sampling data and computations completed for the development of this manual. 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. Pollution removal rates are affected by the choice of design variables. See Section 4.3.4 for a discussion of design variables and appropriate pollution removal rates for specific designs.

4.3.4 Planning and Design Criteria

The following criteria are to be considered minimum standards for the design of a storm water wetland. Items listed in Section 4.3.4.A through 4.3.4.H. are requirements and must be addressed in the design. Items listed in Section 4.3.4.I. are recommendations and are optional.

A. Design Requirements

Following is a list of design requirements that must be followed in the design of storm water wetland BMPs.

- Following are the design values that are required for the three wetland facility designs that are available for application in Mecklenburg County. The appropriate minimum design values and associated pollutant removal rates for each of these three designs are given in Table 4.3.1.

Table 4.3.1 Design Values and Pollution Removal Rates

Effectiveness	Min. WQ_v Detention Time	Minimum WQ_v/PP_v	Pollution Removal Rate
Optimal Efficiency	**4 days**	**0.6**	**85% TSS 70% TP**
Standard Efficiency	**2 days**	**1.1**	**60% TSS 40% TP**
TSS-Only Efficiency	**4 days**	**0.8**	**85% TSS**

- Contributing drainage area must be a minimum of 10 acres.

- Storm water wetlands must be shown to remain hydrated through a water balance analysis. See section 3.4 for a discussion of water balance calculations.

- A minimum dry weather flow path of 1.5:1 (length to width) is required from inflow to outlet across the storm water 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.

- The area of the permanent pool should have four zones that have different water depths. The depths should be minimum area of 30 percent as shallow land (normal pool to 1-foot), minimum area of 38 percent as shallow water (0 – 6 inches – low marsh), minimum area of 15 percent as deep pool (18 – 72 inches). A minimum of 10% of the deep pool should consist of the inlet forebay. More detailed discussion of the wetland zones is provided in section 4.3.4.B.

- The maximum depth of the permanent pool of a wetland is 9 feet.

- All storm water wetland designs must include a sediment forebay at every concentrated inflow point to the facility to allow heavier sediments to drop out of suspension before the runoff enters the wetland marsh. The forebay volume is sized to contain 0.2 inches per impervious acre of contributing drainage and should be 4 to 6 feet deep. The forebay can be used in addition to the main wetland area to meet the total WQ_v requirement sizing.

- Inflow energy dissipation required to distribute flow.

- Safety ledges are needed adjacent to any permanent pool areas that are deeper than 3 feet. Figure 4.3.3 illustrates the desired safety bench geometry.

- All utilities must be located outside of the wetland site.

- All embankments shall be designed per the North Carolina Dam Safety Law of 1967, if applicable, and designed according to the requirements in Section 4.0.6. of this manual.

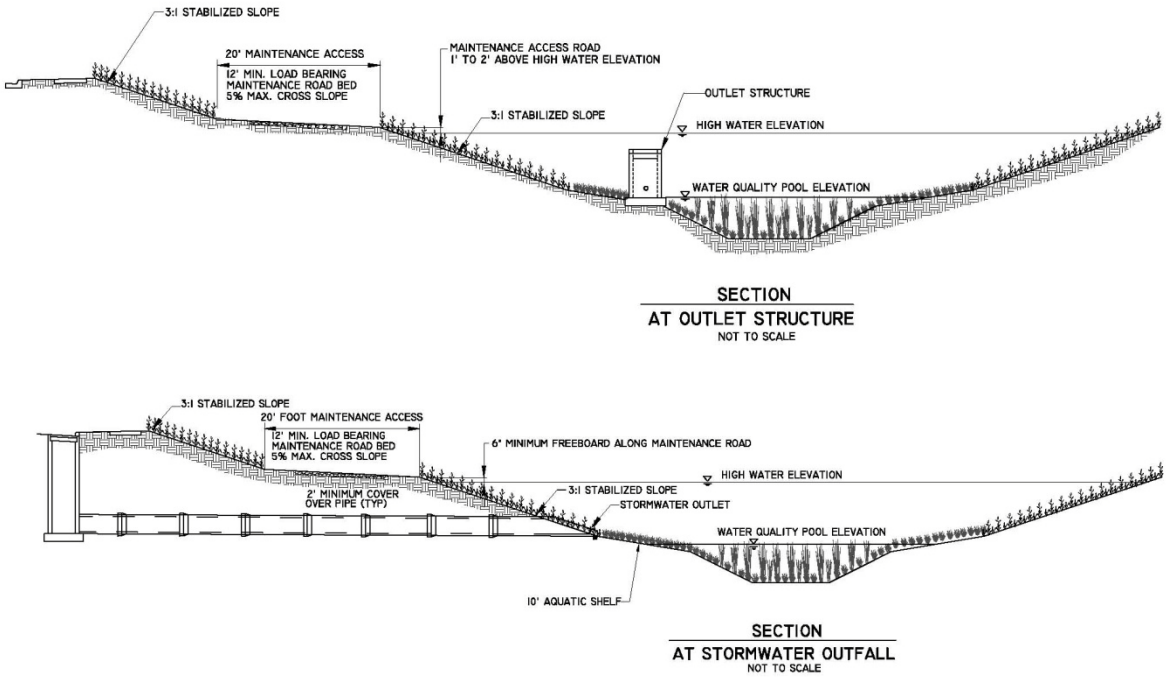

Figure 4.3.3 Typical Wetland Geometry Criteria

- Minimum setback requirements for storm water 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/spray area – 50 feet.

- A water-tight seal (rubber boot or equivalent) must be provided between all riser and pipe joint connections to minimize leakage.

- Outlet structures should have protected access that may be accessed easily from the shore for inspection. Boats and ladders should not be needed to access outlet structures.

Storm water wetlands cannot be located within navigable waters of the U.S., including natural wetlands, without obtaining a Section 404-permit under the Clean Water Act, and any other applicable State permit.

B. Physical Specifications/Geometry

In general, storm water wetland designs are unique for each site and application. However, there are a number of ratios and depths that must be incorporated in to design in order to provide adequate pollutant removal, ease of maintenance, and safety.

- For storm water wetlands the four basic depth zones are:
  Deep Pool
  The deep pool zone extends from 1.5 to 6 feet deep and includes the inlet forebay, outlet micropool, and other deep water areas within the wetland. This zone supports little emergent wetland vegetation, but may support submerged or floating vegetation.
  Shallow Water
  The shallow water zone extends from 0 to 6 inches below the normal permanent pool or water surface elevation. This zone is suitable for the growth of several emergent wetland plant species. Herbaceous plants are recommended for this area because the more efficiently remove pollutants and discourage mosquitos.
  Shallow Land
  The shallow land zone extends from normal pool elevation to 1 foot above the normal pool. This is the zone of the temporary water quality pool. It is wet only after a rain event. This area should be planted with vegetation that withstands irregular inundation and occasional drought.
  Upland Areas
  The upland zone is that area above the shallow land zone that are inundated during larger storm events. This zone supports a number of species that can survive flooding.

- A 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.

- The maximum ponding depth for the WQ_v temporary storage is 1 feet above the normal pool elevation. Storage for CP_v and larger storm events can be provided up to 3 feet above the normal pool elevation.

- The contours of the wetland must be irregular to provide a more natural landscaping effect.

C. Inlets/Forebay

Sediment regulation is critical to sustain storm water wetlands. The wetland facility must have a forebay designed to remove incoming sediment from the storm water 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 concentrated inlet location.

The forebay is sized to contain 0.2 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.

Inflow channels must be stabilized with riprap aprons prior to the entrance to the forebay. Inlet pipes to the forebay must not be submerged. Inflow pipe, channel velocities and exit velocities from the forebay must be non-erosive.

D. Outlet Structures

Flow control from a storm water wetland is typically accomplished with the use of a concrete or aluminized steel 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 4.3.2).

A number of outlets at varying depths in the riser provide internal flow control for routing of the water quality protection volume, channel protection volume, and flood control runoff volumes. The number of orifices can vary and is usually a function of the wetland design.

For the storm water wetlands, there is a need for an orifice that is sized to pass the water quality volume (WQ_v) that is temporarily stored on top of the permanent pool. Flow will first pass through this orifice, which is sized to release the water quality volume (WQ_v) in 2 to 4 days depending on the pollutant removal goals of the BMP design. The preferred design is a reverse slope pipe attached to the riser (refer to figure 5-9), 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 from the surface of the storm water wetland. The next outlet is sized for the release of the channel protection volume (CP_v). The outlet invert is located at or above the peak stage associated with the water quality volume (WQ_v) and is sized to release the channel protection volume over a 24-hour period within Mecklenburg County and the six Towns and a 48-hour period within the City of Charlotte and its ETJ.

Alternative hydraulic control methods, in lieu of an orifice, can be used. These methods include weirs or an outlet pipe protected by a hood that extends at least 12 inches below the normal pool. Other approved non-clogging outlet designs are presented in Chapter 5.

Anti-seep collars or filter diaphragms must be installed on the outlet barrel to reduce the potential for pipe failure.

Riprap or other energy dissipators are to be placed at the outlet to the barrel to prevent scouring and erosion. If a storm water 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 Chapter 8, Energy Dissipation, in the Charlotte-Mecklenburg Storm Water Design Manual for more guidance.

The storm water 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. The bottom drain must be accessible by maintenance personnel during the 50-year storm event by either being located within the embankment or through alternative maintenance access.

The storm water wetland drain (bottom drain pipe) must be sized one pipe size greater than the calculated design diameter. The drain valve is typically a hand wheel activated knife or gate valve.

The outlet system must be designed to be water-tight. A water-tight seal (rubber boot or equivalent) must be provided between all riser and pipe joint connections to minimize leakage. This is particularly crucial in the connection between the riser and barrel of the spillway.

E. Emergency Spillway

An emergency spillway must be included in the storm water wetland design to safely pass the 50-year storm event (or higher storms, if applicable). 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.

A minimum of 0.5 feet of freeboard must be provided, measured from the top of the water surface elevation for the 50-year flood to the lowest point on top of the dam.

F. Maintenance Access

A maintenance right of way or easement must be provided to the storm water wetland facility from a public road or easement. Maintenance access must be at least 12-feet wide, maximum longitudinal slope of 15 percent, and maximum cross-slope of 5 percent, and be stabilized to support maintenance equipment and vehicles. A 20-foot wide maintenance access easement must be provided.

The maintenance access must extend from public right-of-way to the forebay, safety bench, riser, and outlet and, to the extent feasible, be designed to allow vehicles to turn around.

Access to the inside of the riser must be provided and manhole steps should be within easy reach of valves and other controls.

G. Safety Features

Fencing of wetlands is not generally desirable, but may be allowed depending upon the jurisdiction. If a fence is allowed in the design, access must be provided for inspections. A preferred method is to manage the contours of deep pool areas through the inclusion of a safety bench (see Figure 4.2.3) to eliminate dropoffs and reduce the potential for drowning. In addition, the safety bench may be landscaped to deter access to the permanent pool.

The outlet structure openings should not permit access by unauthorized people. Warning signs should be posted near the wetland to prohibit swimming and fishing in the facility.

H. Landscaping

A vegetation and landscaping plan must be provided that indicates the methods used to establish and maintain wetland coverage. The vegetation and landscaping plan must demonstrate that 90 percent vegetation coverage of the storm water wetland will occur with one year. Minimum elements of a plan include: delineation of landscaping zones, selection or corresponding plant species, planting plan, sequence for preparing wetland bed (including soil amendments, if needed), number of plant species, and sources of plant material.

For planting within treatment wetlands, it is necessary to determine what hydrologic zones will be created. Hydrologic planting zones describe the degree to which an area is inundated by water. The hydrologic planting zones are illustrated for a typical wetland in Figure 4.3.4. Plants have differing tolerances to inundation and the six zones described in this section will dictate which plants will survive in each zone (Chapter 6 of this manual provides detailed description of zones):

- In Zone 1 plant material must be able to withstand constant inundation of water of one foot to a maximum of three feet in depth.
- In Zone 2 plant material must be able to withstand constant inundation of water to depths between zero and 6 inches deep.
- In Zone 3 plant material must be able to withstand frequent inundation with water, as well as occasional drought.
- In Zone 3 plant will be partially submerged at certain times.
- In Zone 3 plant should be located to reduce human access where there are potential hazards, but should not block the maintenance access.
- In Zone 3 plant should be resistant to disease and other problems which require chemical applications (since chemical application is not advised in stormwater ponds). Native plants are preferred because they are low maintenance and disease resistant.
- In Zone 3, where shoreline plants will be susceptible to being smothered by floating trash, provisions for routine maintenance, including removal of trash and other wrack, should be a part of the maintenance plan.
- If shading is needed along the shoreline, the more rapidly-growing species such as Sycamore are preferred over the more slowly developing species, such as Swamp White Oak. For this purpose, trees should not be planted in Zone 3, but rather in the adjacent Zone 4.
- In Zone 3 and 4 plants material should have very low maintenance requirements, since they may be difficult to access.
- In Zone 4 plants must be able to withstand periodic inundation of water after storms, as well as occasional drought during the warm summer months.
- In Zone 4 plants should stabilize the ground from erosion caused by run-off.
- In Zone 5 plant material should be able to withstand occasional but brief inundation during storms. In between storms, typical moisture conditions may be moist, slightly wet, or even exhibit drought conditions during the dry weather periods.

- In Zone 5 plants should stabilize the basin slopes from erosion.
- Ground cover in zone 5 and 6 should be very low maintenance, since they may be difficult to access on steep slopes or if frequency of mowing is limited.
- In Zone 6 plant material should be able to withstand occasional but brief inundation during storms. In between storms, typical moisture conditions may be moist to slightly wet, with the potential for drought like conditions during extended dry weather periods.
- In Zone 6 plants should be used to stabilize the basin slopes from erosion.

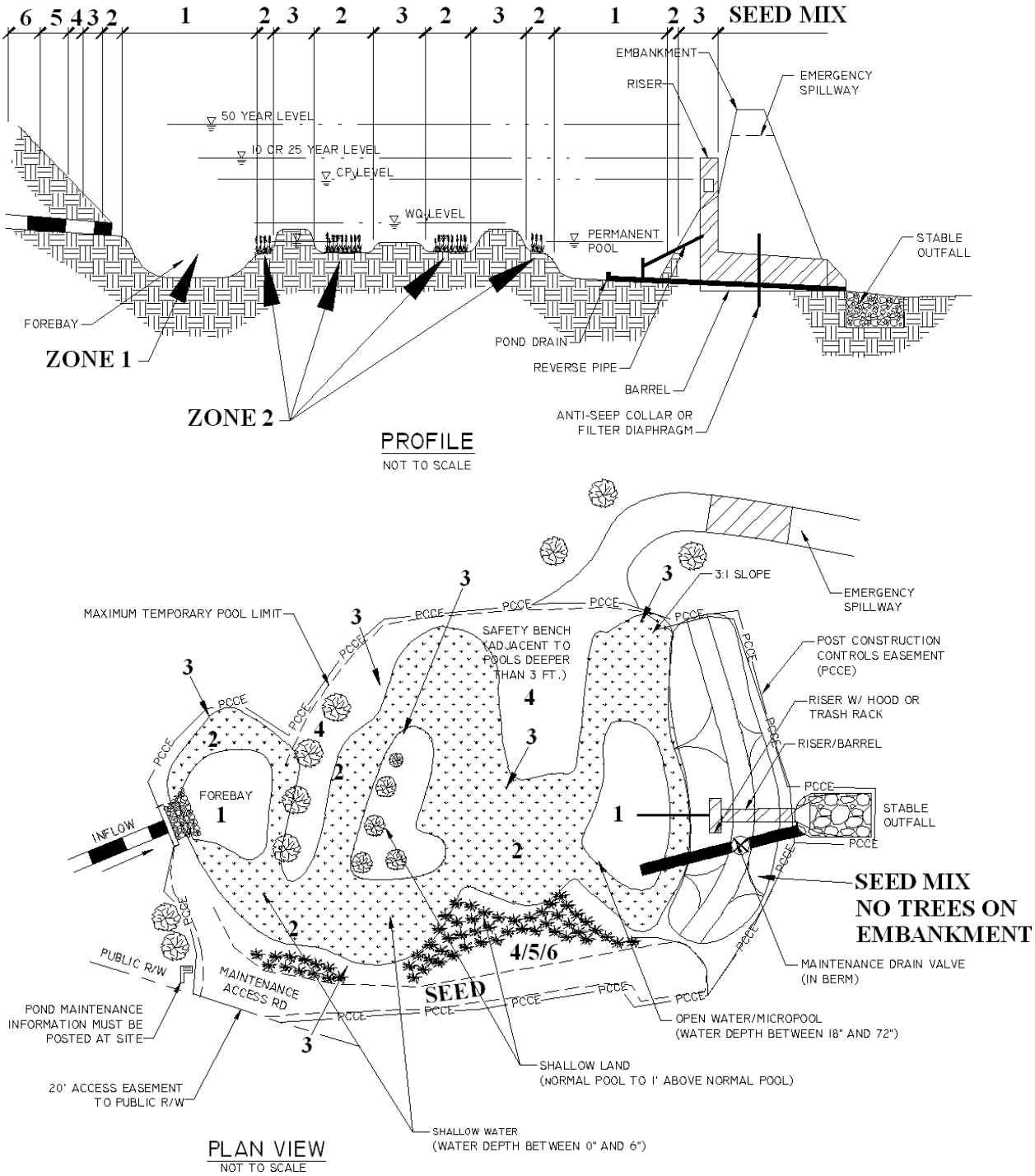

Figure 4.3.4 Wetland Planting Zones

Other landscaping considerations are presented below:

- Landscaping zones include shallow land, shallow water, and deep pool. The shallow water zone ranges from the normal pool to 6 inches. This zone is suitable for the growth of several emergent plant species, with herbaceous plants preferred. The shallow land zone ranges from the permanent pool to the high water elevation of the water quality storm, which is a maximum of 1 foot above the normal pool. The shallow land is a semi-wet zone consisting of the area above the permanent pool that is inundated by runoff during storm events and can be expected to support wetland plants.

- Woody vegetation must not be planted on a dam embankment or allowed to grow within 15 feet of the toe of the dam and 25 feet from the principal spillway structure.

- No buildings should be located within 25 feet of the maximum water surface elevation

- 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 water fowl populations, the buffer can be planted with trees, shrubs and native ground covers.

- The soils of a storm water wetland buffer are often severely compacted during the construction process to ensure stability. The density of these compacted soils can be 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.

- Plants can be used to stabilize the bottom of the pond, as well as the edge of the pond, absorbing wave impacts and reducing erosion, when water level fluctuates.

- Plants can be used to stabilize the shoreline to minimize erosion caused by wave and wind action or water fluctuation.

- Plant material should, whenever possible, shade the water surface, especially the southern exposure. This will help to reduce water temperature.

- Plants can be used to shade the low flow channel to reduce pool warming whenever possible.

General Guidance on establishing wetland vegetation can be found in Chapter 6 – Vegetation and Landscaping.

I. Design Recommendations

In addition to the design requirements and variables, following are some design recommendations that should be considered for storm water wetland design.

- 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.

- If a wetland facility is not used for flood control, an off-line system should be considered to bypass higher flows rather than passing them through the wetland system.

- Generally, there should be no more than 8% slope across the wetland.

- Permanent pool elevation should be no higher than 6” above the seasonally high water table (SHWT). It is expected that a sufficient analysis will have the following minimum elements: (1) multiple soil samples serving to identify the soil type, (2) multiple field K results, (3) multiple soil samples to

establish the SHWT at the proposed pond location, (4) a clear statement of the conservative aspects of the design case subjected to the hydrogeological analysis.

- Permeable soils are not well suited for a storm water wetland without a high water table. Underlying soils of hydrologic group “C” or “D” should be adequate to maintain wetland conditions. Most group “A” soils and some group “B” soils may require a liner. Evaluation of soils should be based upon an actual subsurface analysis and permeability tests.

4.3.5 Design Procedures

Step 1 Using the BMP Selection Matrix at the beginning of Chapter 4 to determine if the development site and conditions are appropriate for the use of a storm water wetland facility.

Step 2 Consider any special site-specific design conditions and any additional restrictions and/or surface water or watershed requirements that may apply.

Step 3 Compute water quality volume (WQ_v) using equations 3.2 and 3.3.

Step 4 Compute site hydrologic parameters using the SCS procedures and/or computer models that use the SCS procedures.

Step 5 Compute water quality peak flow (WQ_p) using equation 3.4 for a modified curve number and the SCS hydrograph procedures with a 1-inch, 6-hr, balanced storm event.

Step 6 Compute channel protection volume (CP_v) using the SCS method and a 1-yr, 24-hr storm event. Estimate approximate storage volume for channel protection using the Static method.

Step 7 Size flow diversion structure, if needed, to divert the water quality volume to the storm water wetland area or to divert larger flood events around the wetland.

Step 8 Compute the preliminary storage volumes and release rates for the water quality control (WQ_v) and channel protection volume (CP_v) control for either of the three design thresholds for TSS and TP control.

Step 9 Compute pretreatment volume

A sediment forebay is provided at each inlet, unless the inlet is not concentrated flow to the wetland. The forebay should be sized to contain 0.2 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.

Step 10 Allocate the WQ_v volume among permanent pool and temporary pool according to the design requirements in Section 4.3.4.A.

Step 11 Determine storm water 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 (open water, high marsh, low marsh, and temporary storage). Set WQ_v permanent pool elevation and extended detention elevation based on volumes calculated earlier.

Step 12 Set design elevations and dimensions of facility.

Step 13 Compute extended detention orifice release rate(s) and size(s), and establish CP_v elevation and flood control releases.

Based on the elevations established in Step 12 for the extended detention portion of the water quality volume, the water quality orifice is sized to release this extended detention volume in 2 to 4 days, depending on the selected design threshold. The water quality orifice must be adequately protected from clogging by an acceptable external trash rack. A reserve slope pipe attached to the riser, with its inlet submerged one foot below the elevation of the permanent pool, is a recommended design. The CP_v 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 the required period (24-hour period for Mecklenburg County and six Towns; 48-hour period within the City of Charlotte and its ETJ). Additional outlets may be needed to limit the outflow from larger flood events and any peak flow attenuation that is included in the design.

Step 14 Route flows using an approved hydrologic/hydraulic model through storm water wetland facility and adjust design of facility to meet all design criteria.

Step 15 Design conveyances to facility (off-line systems).

Step 16 Design embankment(s) and spillways(s). Size emergency spillway, calculate 50-year surface elevation, set top of embankment elevation, and analyze safe passage of the 50-year event without causing flooding damage. An overflow must be provided to bypass and/or convey larger flows to the downstream drainage system or stabilized watercourse. Nonerosive velocities must to be provided at the outlet point.

Step 17 Investigate potential pond/wetland hazard classification.

Step 18 Prepare vegetation and landscaping plan. A landscaping plan for the storm water wetland area must be prepared to indicate how aquatic and terrestrial areas will be stabilized and established with vegetation in the short term (1-year) and long-term (3-year).

4.3.6 Inspection and Maintenance Requirements

Specific maintenance inspections and requirements are contained in Chapter 7 of the Administrative Manual.

4.3.7 Design Forms

Design Procedure Form: Storm Water Wetlands

STORM WATER WETLAND FEASIBILITY	**NOTES:**
1. Is the use of a storm water wetland appropriate?	
2. Confirm local design criteria and applicability.	
PRELIMINARY HYDROLOGIC CALCULATIONS	
3. Compute, WQ_v water quality volume requirements Compute Runoff Coefficient, R_v Compute WQ_v volume requirements	 Rv = _____ WQ_v = _____ acre-ft
4. Compute WQ_p peak flow Compute modified SCS curve number	 WQ_p = _____ cfs CN = _____
5. Compute CP_v Compute S (maximum retention) Compute 1-yr, 24-hr total rainfall depth Compute q_d (runoff volume) Compute CP_v (channel protection volume) Estimate t_c (time of concentration) Estimate q_u Compute approximate CP_v	 S = _____ Rainfall Depth = _____ inches Q_d = _____ inches CP_v =__ acre-ft t_c = _____ hours q_u = _____ cfs/mi^2/inch CP_v = _____ acre-ft
6. Size flow diversion structure	
7. Compute release rates Compute WQ_v release rate Compute CP_v release rate	 Release Rate = _____ cfs Release Rate = _____ cfs
8. Compute site hydrologic input parameters Development Conditions Area CN (SCS curve number) Adjusted CN (curve number adjusted for 1-inch storm) Time of concentration	 Pre-developed Post-developed _____ acres _____ acres _____ _____ _____ _____ _____ hours _____ hours
STORM WATER WETLAND DESIGN	
9. Pretreatment volume Vol_{pre} = Acres of Impervious Area(0.2")(1'/12")	 WQ_{pre} = _____ acre-ft
10. Allocate permanent pool and temporary pool storage volumes based on design requirements.	WQ_v (storage volume) = _____ at elev. CPv (storage volume) = _____ at elev.
11. Allocate the shallow land, shallow water, and deep pool zones. Area $_{shallow\ land}$ $\geq$ 0.30 (BMP area @ WQ_V elevation) Area $_{shallow\ water}$ $\geq$ 0.38 (BMP area @ WQ_V elevation) Area $_{deep\ pool}$ $\geq$ 0.15 (BMP area @ WQ_V elevation)	 Area $_{shallow\ land}$ = _____ acre Area $_{shallow\ water}$ = _____ acre Area $_{deep\ pool}$ = _____ acre

12. Set design elevations and dimensions of facility

Length = _____ ft
Width = _____ ft
Elevation top of facility = _____ ft
Other elevations = _____ ft
= _____ ft
= _____ ft

13. WQ_v Orifice Computations
Average ED release rate
Average head, h = (ED elev.–Permanent pool elev.)/2
Area of orifice from orifice equation: $Q = CA(2gh)^{0.5}$

Compute release rate for CP_v control and
Establish CP_v elevation
Release rate
Average head h = CP_velev.–Permanent pool elev.)/2
Area or orifice from orifice equation: $Q = CA(2gh)^{0.5}$

Release Rate = _____cfs
h = _____ft
A = _____ ft^2
Diameter = _____in

WSEL = _____ ft
Release Rate = _____cfs
h = _____ft
A = _____ ft^2
Diameter = _____in

Set Up Stage-Storage-Discharge Relationship For Routing

14. Route flows through bioretention facility.
Peak stage for the 1-inch, 6-hour storm
Peak stage for the 1-yr, 24-hour storm
Peak Q_{10} – Undeveloped
Peak Q_{10} – Developed
Peak Q_{25} – Undeveloped
Peak Q_{25} – Developed

Peak Stage = _____ ft
Peak State = _____ ft
$Q_{10\text{-undev}}$ = _____ cfs
$Q_{10\text{-dev}}$ = _____ cfs
$Q_{25\text{-undev}}$ = _____ cfs
$Q_{25\text{-dev}}$ = _____ cfs

15. Design conveyances to facility (off-line systems)

= _____ Online or _____ Offline?

16. Size emergency spillway, calculate 50-year WSEL and set top of embankment elevation.

$WSEL_{50}$ = _____ft
Embankment Elevation = _____ft

Length = _____ ft

Length of Weir (if used) = _____ ft

17. Investigate Potential pond/wetland hazard classification.

16. Prepare vegetation and landscaping plan.

Notes:

4.3.8 Design Example

The design example prepared for the wet pond facility and presented in Section 4.2.8 serves as the storm water wetland design example.