C-5. Stormwater Wetland

Design Objective

Stormwater wetlands are constructed systems that mimic the functions of natural wetlands and use physical, chemical, and biological processes to treat stormwater. A stormwater wetland shall be designed to capture the design storm and release it slowly over a period of two to five days via a properly design outlet structure. The wetland shall be designed in a manner that protects the device, the areas around the device and the receiving stream from erosion. Stormwater wetlands temporarily store stormwater runoff in shallow pools that support emergent and riparian vegetation. The storage, complex microtopography, and vegetative community in stormwater wetlands combine to form an ideal matrix for the removal of many pollutants. Stormwater wetlands can also effectively reduce peak runoff rates and stabilize flow to adjacent natural wetlands and streams.

Design Volume

The design volume for a wetland is equivalent to the volume that is retained for a two to five-day period between the temporary pool elevation and the permanent pool elevation.

Important Links

Rule 15A NCAC 2H .1054. MDC for Stormwater Wetlands
SCM Credit Document, C-4. Credit for Stormwater Wetlands
**Figure 1: Stormwater Wetland Example - Plan View**

- **Non-forebay Deep Pools**
  (a) 5% to 15% of the wetland surface area
  (b) Provide throughout wetland and adjacent to outlet structure

- **Outlet Structure**
  Place inlets and outlets to avoid short circuiting and design for erosion protection

- **Emergency Spillway**
  Provided for major storms and designed for erosion protection

- **Forebay**
  (a) 10% to 15% of the wetland surface area
  (b) Provide at inlet into stormwater wetland

- **Shallow Water Zone**
  (a) 35% to 45% of the wetland surface area
  (b) Planting options:
    1) 50 herbaceous plants per 200 sq. ft.

- **Temporary Inundation Zone**
  (a) 30% to 45% of the wetland surface area
  (b) Planting options:
    1) 50 herbaceous plants per 200 sq. ft.
    2) 8 shrubs per 200 sq. ft.
    3) One tree and 40 grass-like herbaceous plants per 100 sq. ft.

- A landscape plan shall be provided and shall include the following:
  (a) Delineation of planting zones;
  (b) Plant layout with species names and locations, and
  (c) Total number and sizes of all plant species.

- Cattails shall not be planted in wetland

---

**Figure 2: Stormwater Wetland Example – Schematic Cross-Section**

Note: Depending on site soils and groundwater elevations, a clay or synthetic liner may be required to maintain PPE at design elevation.
**Figure 3: Stormwater Wetland Example – Cross-Section**

- **Temporary Inundation Zone**
  - (a) Draw down between 2 and 5 days
  - (b) Wetland may temporarily pond peak attenuation volume at a depth exceeding 15”
  - (c) Depth: 0-15” above permanent pool

- **Shallow Water Zone**
  - Depth: 0-7” below permanent pool

- **Embayment and Perimeter Fill Slopes**
  - Plant with non-clumping turf grass; no trees or woody shrubs

- **Forebay**
  - (a) Entrance shall be deeper than exit
  - (b) Depth: 24-40” below permanent pool
  - (c) If depth <15”, clean out forebay

- **Sediment Storage**
  - Adjust the pH, compaction, and other attributes of the first 12” depth of the soil if necessary to promote plant establishment and growth

- **Non-Forebay Deep Pool**
  - (a) Design to retain water between storm events
  - (b) Depth: a minimum of 15” below permanent pool

**Figure 4: Stormwater Wetland Example - Riser**

- **Trash Rack (Required)**
- **Weir (or other method) to establish temporary pool**
- **Riser Crest**
- **Temporary Pool**
- **Normal Pool**
- **Outlet to establish normal pool**
- **Must drain down temporary pool in two to five days**
- **Dewatering Method**
  - Provide a method to draw down standing water to facilitate maintenance and inspection (e.g., skimmer or pump)

- **Anti-Floatation Slab**
- **Anti-seep Measures are recommended**
- **Outlet Pipe**
Guidance on MDC

**WETLAND MDC 1. TEMPORARY PONDING DEPTH.**
The ponding depth for the design volume shall be a maximum of 15 inches above the permanent pool.

The temporary ponding depth for the design volume may not exceed 15 inches in order to protect the health of the plants and the integrity of the soils.

**WETLAND MDC 2. PEAK ATTENUATION DEPTH.**
The wetland may be designed to temporarily pond peak attenuation volume at a depth exceeding 15 inches.

Additional depth may be provided for peak attenuation; a storm size is not specified, that may be determined by the applicant and will likely be based on local peak attenuation requirements.

**WETLAND MDC 3. SURFACE AREA.**
The surface area shall be sufficient to limit the ponding depth to 15 inches or less. The surface area specifications in Wetland MDC (6) through (9) are based on the wetland at its temporary ponding depth.

The minimum wetland surface area at temporary pool shall be determined by dividing the design volume in cubic feet by 1.25 feet (the maximum allowed ponding depth for the temporary pool). The designer is allowed to make the wetland larger (with a shallower ponding depth).

**WETLAND MDC 4. SOIL AMENDMENTS.**
The pH, compaction, and other attributes of the first 12-inch depth of the soil shall be adjusted if necessary to promote plant establishment and growth.

A soil analysis should be conducted within the stormwater wetland to determine the viability of soils for healthy vegetation growth. Imported or in-situ soils may be amended with organic material, depending on soil analysis results, to enhance suitability as a planting media. More guidance on soil amendments can be found in Part A-3 of this manual.

**WETLAND MDC 5. LOCATION OF INLET(S) AND OUTLET.**
The inlet(s) and outlet shall be located in a manner that avoids short circuiting.

Stormwater wetlands shall be designed in manner that maximizes the flow path from the inlet or inlets to the outlet. This allows for sufficient contact time for pollutant removal. Figure 1 at the beginning of this chapter shows how the flow path can be enhanced with thoughtful grading.
WETLAND MDC 6. FOREBAY.
A forebay shall be provided at the inlet to the stormwater wetland. The forebay shall comprise 10 to 15 percent of the wetland surface area. The forebay depth shall be 24 to 40 inches below the permanent pool elevation. The forebay entrance shall be deeper than the forebay exit. If sediment accumulates in the forebay in a manner that reduces its depth to 15 inches, then the forebay shall be cleaned out and returned to its design state.

The forebay is a deep pool that follows the inlet to ease maintenance of the stormwater wetland. Making the forebay entrance deeper than the exit increases its effectiveness at dissipating energy and settling solids.

WETLAND MDC 7. NON-FOREBAY DEEP POOLS.
Deep pools shall be provided throughout the wetland and adjacent to the outlet structure to prevent clogging. The non-forebay deep pools shall comprise 5 to 15 percent of the wetland surface area and shall be designed to retain water between storm events. The deep pools at their deepest points shall be at least 18 inches below the permanent pool elevation.

Stormwater wetlands should be equipped with non-forebay deep pools that are always full of water and where rooted plants do not live. These pools provide additional pollutant removal and habitat for gambusia fish and other predators (Figure 5), which prey upon mosquito larvae. Submerged and floating plants may be used in this area, except around the wetland outlet device. The deep pool at the outlet should be non-vegetated to prevent clogging. Deep pools in A or B soils should be lined to insure that they stay wet between storm events.

Figure 5: Gambusia fish

WETLAND MDC 8. SHALLOW WATER ZONE.
The shallow water zone shall comprise 35 to 45 percent of the wetland surface area. The shallow water zone shall be zero to nine inches below the permanent pool elevation.

Shallow water includes all areas inundated by the permanent pool to a depth of zero to nine inches with occasional drying during periods of drought. The shallow water zone provides a constant hydraulic connection between the inlet and outlet structure of the stormwater wetland. The top of the shallow water zone represents the top of the permanent pool elevation.

WETLAND MDC 9. TEMPORARY INUNDATION ZONE.
The temporary inundation zone shall comprise 30 to 45 percent of the wetland surface area. The temporary inundation zone shall be between 0 and 15 inches above the permanent pool elevation.
The temporary inundation zone is wet only after rain events, and rooted plants live in this zone. The plants and soils in the temporary inundation zone remove pollutants via filtering and biological processes and provide shade for the stormwater wetland. Soil bioengineering techniques, such as the use of fascines, stumps or logs, and coconut fiber rolls, can be used to create and reinforce the temporary inundation zone in areas of the stormwater wetland that may be subject to high flow velocities.

**WETLAND MDC 10. DRAWDOWN TIME.**
The design volume shall draw down to the permanent pool level between two and five days.

Besides drawing the design volume down in two to five days, the outlet in a stormwater wetland should be accessible to operators and resistant to clogging. In addition, the outlet structure shall have a bypass structure for larger storm events, and may, if the applicant so chooses, be designed to attenuate peak flows. The orifice may also include manual drawdown valves or flashboard risers (also called sliding weir plates) so that maintenance personnel can drain the wetland for maintenance purposes. If installed, drawdown valves should be secured so that only intended personnel can access them.

Figure 6 shows the drawdown orifice, the overflow for larger storm events, and a manually operated valve for maintenance. One method to prevent clogging in the drawdown orifice is to turn the orifice downward below the normal pool. This prevents floating debris or vegetation from clogging the orifice.

If the wetland is in trout-sensitive waters, consider extending the orifice to close to the bottom of the drawdown structure among a pile of riprap. This will ensure that cooler water enters the stream to protect trout, which thrive in cold water.

The overflow structure should be located near the edge of the wetland so that it can be accessed easily for maintenance. Overflow structures that are several feet into the wetland are difficult to reach and likely will not be maintained. See Figure 7.

**Figure 6: Outlet Structure**

**Figure 7: How to Plan for Outlet Structure Maintenance**
WETLAND MDC 11. PROTECTION OF THE RECEIVING STREAM.
The wetland shall discharge the runoff from the one-year, 24-hour storm in a manner that minimizes hydrologic impacts to the receiving channel.

Eventually, there will be more technical information available on this MDC. For now, it is being researched at NCSU.

WETLAND MDC 12. LANDSCAPING PLAN.
A landscape plan prepared by a licensed professional shall be provided and shall include the following:
(a) delineation of planting zones;
(b) plant layout with species names and locations; and
(c) total number and sizes of all plant species.

Plants improve water quality by slowing velocity, which settles solids. Plants also supply carbon sources and habitat for microbes that decompose organic compounds and convert significant quantities of nitrate directly to nitrogen gas. Many herbaceous wetland plants die back during the winter. This creates a dense layer of plant litter that also provides a substrate that traps solids supports and microbial growth.

For these reasons, planning and maintaining the health of the stormwater wetland plants is crucial. See Figure 8 for a summary of the how plants, microbes and soil contribute to the function of stormwater wetlands. Having a dense stand of healthy plants is more important to wetland functioning than the specific plant species that are present. The best species are native, non-invasive plants with high colonization and growth rates that can establish large areas that continue through the winter dormant season. In addition, the plant should be robust in periodically flooded environments that may dry out during periods of drought.

The landscaping plan should be prepared by a qualified design professional licensed in North Carolina should include the following:
Elements of a stormwater wetland landscape plan include:
(a) delineation of planting zones (required);
(b) plant layout with species names and locations (required);
(c) total number and sizes of all plant species (required);
(d) source of plant materials;
(e) sequence and timing for preparing wetland bed (including soil amendments, initial fertilization, and watering, as needed); and
(f) specification of supplementary plantings to replenish losses.

Plant recommendations are listed in Tables 1-3 below. The list of plant species is not exhaustive. There are many excellent plant references in publication as well as recommendations from wetland scientists and landscape architects.

**Figure 8: Stormwater Wetland Microbes, Plants, and Soil**

**WETLAND MDC 13. SHALLOW WATER PLANTINGS.**
The shallow water zone shall be planted at a minimum density of 50 herbaceous plants per 200 square feet (equivalent to 2 foot on center spacing).

Herbaceous plants are recommended in the shallow water area because they are more efficient in the pollutant removal process and less likely to encourage mosquito growth.
### Table 1: Herbaceous Plants for Shallow Water

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acorus subcordatum</td>
<td>Sweetflag</td>
</tr>
<tr>
<td>Iris virginica</td>
<td>Blue flag iris</td>
</tr>
<tr>
<td>Juncus effusus var. pylaei or solutus</td>
<td>Soft rush</td>
</tr>
<tr>
<td>Peltandra virginica</td>
<td>Arrow arum</td>
</tr>
<tr>
<td>Pontederia cordata</td>
<td>Pickerelweed</td>
</tr>
<tr>
<td>Sagittaria latifolia</td>
<td>Duck Potato</td>
</tr>
<tr>
<td>Sagittaria lancifolia</td>
<td>Bulltongue</td>
</tr>
<tr>
<td>Saururus cernuus</td>
<td>Lizard’s tail</td>
</tr>
<tr>
<td>Schoenoplectus tabernaemontani</td>
<td>Soft stem bulrush</td>
</tr>
<tr>
<td>Schoenoplectus americanus</td>
<td>Three-square bulrush</td>
</tr>
<tr>
<td>Schoenoplectus pungens var. pungens</td>
<td></td>
</tr>
<tr>
<td>Scirpus cyperinus</td>
<td>Woolgrass</td>
</tr>
</tbody>
</table>

**WETLAND MDC 14. TEMPORARY INUNDATION ZONE PLANTINGS.**

The temporary inundation zone shall be planted according to one of the following options:
(a) 50 herbaceous plants per 200 square feet (equivalent to 2-foot on center spacing);
(b) eight shrubs per 200 square feet (equivalent to 5 foot on center spacing); or
(c) one tree and 40 grass-like herbaceous plants per 100 square feet.

The temporary inundation zone should be planted with vegetation able withstand irregular inundation and occasional drought.
Table 2: Herbaceous Plants for the Temporary Inundation Zone

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asclepias incarnata</td>
<td>Swamp Milkweed</td>
</tr>
<tr>
<td>Eupatoriarhodelphus fistulosus</td>
<td>Joe Pye Weed</td>
</tr>
<tr>
<td>Hibiscus coccineus</td>
<td>Scarlet rose mallow</td>
</tr>
<tr>
<td>Lobelia cardinalis</td>
<td>Cardinal flower</td>
</tr>
</tbody>
</table>

Table 3: Shrubs for the Temporary Inundation Zone

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aronia arbutifolia</td>
<td>Red Chokeberry</td>
</tr>
<tr>
<td>Cephalanthus occidentalis</td>
<td>Common Buttonbush</td>
</tr>
<tr>
<td>Clethra alnifolia</td>
<td>Sweet pepperbush</td>
</tr>
<tr>
<td>Cyrilla racemiflora</td>
<td>TiTi</td>
</tr>
<tr>
<td>Hypericum densiflorum</td>
<td>Bushy St. Johnswort</td>
</tr>
<tr>
<td>Ilex glabra</td>
<td>Inkberry</td>
</tr>
<tr>
<td>Itea virginica</td>
<td>Virginia Sweetspire</td>
</tr>
<tr>
<td>Rosa palustris</td>
<td>Swamp Rose</td>
</tr>
</tbody>
</table>

WETLAND MDC 15. DAM STRUCTURE AND PERIMETER FILL SLOPES.
On the dam structure and perimeter fill slopes, non-clumping turf grass shall be provided, and trees and woody shrubs shall not be allowed.

The turf areas on the dam structure and perimeter fill slopes should be stabilized within 14 days after the end of construction. The stabilization might be the final vegetation or a temporary stabilization measure until the vegetation becomes established.
At first glance, cattails, with their long, thick leaves and their decorative brown seed heads are interesting and attractive in a stormwater wetland. However, cattails are very invasive (250,000 seeds per seed head) and can quickly take over an entire stormwater wetland, outcompeting other plants and eventually reducing the storage capacity of the wetland. Matted cattails detritus also provides excellent mosquito habitat. The plants in Tables 1-3 above are just as impressive and not invasive.

**Figure 9: Cattails**

---

A trash rack or other device to trap debris shall be provided on piped outlet structures.

See Part A-3 for more information on how to select a trash rack.

**Recommendations**

**WETLAND RECOMMENDATION 1: SUFFICIENTLY LARGE DRAINAGE AREA**
It is recommended to have a drainage area of at least two acres to provide year-round hydration for wetland plants to grow and thrive.

Stormwater wetlands often thrive better when they have a sufficiently large drainage area (two acres or more) to provide year-round hydration, particularly when they are installed in A or B soils. Since water depths are shallower than in wet detention ponds, water loss by evaporation is an important concern.

**WETLAND RECOMMENDATION 2: CONSIDER THE IMPACTS OF INFILTRATION**
If the wetland is to be constructed in A or B soils and will be perched above the SHWT, consider the impacts of infiltration on the plant species.

Site soils and groundwater elevation strongly influence the manner in which stormwater wetlands should be constructed and their ultimate success or failure. A soils report with a determination of the seasonal high water table (SHWT) and in-situ soil permeability should be prepared. If the SHWT is not located near ground surface and the wetland will be located in A or B soils, consider installing a clay or geomembrane liner the deep pools and shallow water areas to sustain the permanent pool of water. Figure 10 shows a stormwater wetland in Garner, NC that has been negatively impacted by infiltration.
Figure 10: Stormwater Wetland Impacted by Infiltration

WETLAND RECOMMENDATION 3: DEEP ZONE PLANTINGS.
Deep zone plantings are not required, but the designer may use them if desired for aesthetic purposes. They may not be planted in the deep zone adjacent to the outlet structure to prevent clogging.

Table 4: Floating Aquatic Plants for the Deep Zone

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemna spp.</td>
<td>Duckweed</td>
</tr>
<tr>
<td>Nelumbo lutea</td>
<td>American lotus</td>
</tr>
<tr>
<td>Nuphar lutea ssp. polysepala</td>
<td>Rocky Mtn Pond-lily</td>
</tr>
<tr>
<td>Nuphar lutea ssp. advena</td>
<td>Yellow Pond-lily</td>
</tr>
</tbody>
</table>

Table 5: Submerged Aquatic Plants for the Deep Zone

<table>
<thead>
<tr>
<th>Botanical Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eleocharis acicularis</td>
<td>Needle spikerush</td>
</tr>
</tbody>
</table>
Construction

Consider construction sequencing so that vegetation can be planted and the wetland brought online within 14 days. Plants may need to be watered during this time if the device is not brought online the same day. Stabilization may be in the form of final vegetation plantings or a temporary means until the vegetation becomes established. A good temporary means of stabilization is a wet hydroseed mix. For rapid germination, scarify the soil to a half-inch prior to hydroseeding.

Inlet and outlet channels should be protected from scour that may occur during periods of high flow. Standard erosion control measures should be used. The Land Quality Section of the North Carolina Department of Environment and Natural Resources and the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) can provide information on erosion and sediment control techniques.

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

The wetland drain should be fully opened for no more than 3 days prior to the planting date (which should coincide with the delivery date for the wetland plant stock) to preserve soil moisture and workability.

The most common and reliable technique for establishing an emergent wetland community in a stormwater wetland is to transplant nursery stock obtained from local aquatic plant nurseries. The optimal period for transplanting extends from early April to mid-June so that the wetland plants will have a full growing season to build the root reserves needed to survive the winter. However, some species may be planted successfully in early fall. Contact your nursery well in advance of construction to ensure that they will have the desired species available.

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

Although wetland plants require water for growth and reproduction, they can be killed by drowning in excessively deep water. Usually, initial growth is best with transplanted plants in wet, well-aerated soil. Occasional inundation followed by exposure to air of the majority of the vegetation enables the plants to obtain oxygen and grow optimally. Conversely, frequent soil saturation is important for wetland plant survival.

Dramatic shifts can occur as plant succession proceeds. The plant community reflects management and can indicate problems or the results of improvements. For example, a requirement of submerged aquatic plants, such as pondweed (Potamogeton spp.), is light penetration into the water column. The disappearance of these plants may indicate inadequate water clarity. The appearance of invasive species or development of a monoculture is also a sign of a problem with the aquatic/soil/vegetative requirements. For instance, many invasive species can quickly spread and take over a wetland. If cattails become invasive, they can be removed by a licensed aquatic pesticide applicator by wiping aquatic glyphosate, a systemic herbicide, on the cattails.

Unlike maintenance requirements for wet or dry stormwater ponds, sediment should only be selectively removed from stormwater wetlands, primarily from the forebay. Sediment removal disturbs stable vegetation cover and disrupts flowpaths through the wetland. The top few inches of sediment should be stockpiled so that it can be replaced over the surface of the wetland after the completion of sediment removal to re-establish the vegetative cover using its own seed bank. Accumulated sediment should be removed from around inlet and outlet structures.

Important maintenance procedures include:

1. Immediately following construction of the stormwater wetland, conduct bi-weekly inspections and water wetland plants bi-weekly until vegetation becomes established (commonly six weeks).
2. No portion of the stormwater wetland will be fertilized after the first initial fertilization that is required to establish the wetland plants.
3. Maintain stable groundcover in the drainage area to reduce the sediment load to the wetland.
4. Inspect the embankment by a dam safety expert at least once annually. Any problems that are found shall be repaired immediately.
5. After the stormwater wetland is established, inspect it monthly and within 24 hours after every storm event greater than 1.0 inches (or 1.5 inches if in a Coastal County).
6. Keep a maintenance record in a log in a known set location. Any deficiencies noted in an inspection will be corrected, repaired or replaced immediately. Deficiencies can affect the integrity of structures, safety of the public, and the removal efficiency of the SCM.
### Table 6: Sample Operation and Maintenance Agreement for Stormwater Wetlands

<table>
<thead>
<tr>
<th>SCM element:</th>
<th>Potential problems:</th>
<th>How to remediate the problem:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire SCM</td>
<td>Trash/debris is present.</td>
<td>Remove the trash/debris.</td>
</tr>
<tr>
<td>Perimeter of wetland</td>
<td>Areas of bare soil and/or erosive gullies have formed.</td>
<td>Regrade the soil if necessary to remove the gully, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application.</td>
</tr>
<tr>
<td></td>
<td>Vegetation is too short or too long.</td>
<td>Maintain vegetation at an appropriate height.</td>
</tr>
<tr>
<td>Inlet device: pipe or swale</td>
<td>The pipe is clogged (if applicable).</td>
<td>Unclog the pipe. Dispose of the sediment offsite.</td>
</tr>
<tr>
<td></td>
<td>The pipe is cracked or otherwise damaged (if applicable).</td>
<td>Replace the pipe.</td>
</tr>
<tr>
<td></td>
<td>Erosion is occurring in the swale (if applicable).</td>
<td>Regrade the swale if necessary to smooth it over and provide erosion control devices such as reinforced turf matting or riprap to avoid future problems with erosion.</td>
</tr>
<tr>
<td>Forebay</td>
<td>Sediment has accumulated in the forebay to a depth that inhibits the forebay from functioning well.</td>
<td>Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a location where it will not cause impacts to streams or the BMP.</td>
</tr>
<tr>
<td></td>
<td>Erosion has occurred.</td>
<td>Provide additional erosion protection such as reinforced turf matting or riprap if needed to prevent future erosion problems.</td>
</tr>
<tr>
<td></td>
<td>Weeds are present.</td>
<td>Remove the weeds, preferably by hand. If a pesticide is used, wipe it on the plants rather than spraying.</td>
</tr>
<tr>
<td>Deep pool, shallow water and shallow land areas</td>
<td>Algal growth covers over 50% of the deep pool and shallow water areas.</td>
<td>Consult a professional to remove and control the algal growth.</td>
</tr>
<tr>
<td></td>
<td>Cattails, phragmites or other invasive plants cover 50% of the deep pool and shallow water areas.</td>
<td>Remove invasives by physical removal or by wiping them with pesticide (do not spray) – consult a professional.</td>
</tr>
<tr>
<td></td>
<td>Shallow land remains flooded more than 5 days after a storm event.</td>
<td>Unclog the outlet device immediately.</td>
</tr>
<tr>
<td><strong>Embarkment</strong></td>
<td>Plants are dead, diseased or dying.</td>
<td>Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application to establish the ground cover if necessary.</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Best professional practices show that pruning is needed to maintain optimal plant health.</td>
<td>Prune according to best professional practices.</td>
</tr>
<tr>
<td></td>
<td>Sediment has accumulated and reduced the depth to 75% of the original design depth of the deep pools.</td>
<td>Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a location where it will not cause impacts to streams or the BMP.</td>
</tr>
<tr>
<td><strong>Micropool</strong></td>
<td>A tree has started to grow on the embankment.</td>
<td>Consult a dam safety specialist to remove the tree.</td>
</tr>
<tr>
<td></td>
<td>An annual inspection by appropriate professional shows that the embankment needs repair.</td>
<td>Make all needed repairs.</td>
</tr>
<tr>
<td></td>
<td>Evidence of muskrat or beaver activity is present.</td>
<td>Consult a professional to remove muskrats or beavers.</td>
</tr>
<tr>
<td><strong>Outlet Structure</strong></td>
<td>Sediment has accumulated and reduced the depth to 75% of the original design depth.</td>
<td>Search for the source of the sediment and remedy the problem if possible. Remove the sediment and dispose of it in a location where it will not cause impacts to streams or the BMP.</td>
</tr>
<tr>
<td></td>
<td>Clogging has occurred.</td>
<td>Clean out the outlet device. Dispose of the sediment off-site.</td>
</tr>
<tr>
<td></td>
<td>The outlet device is damaged</td>
<td>Repair or replace the outlet device.</td>
</tr>
<tr>
<td><strong>Receiving water</strong></td>
<td>Erosion or other signs of damage have occurred at the outlet.</td>
<td>Contact the NC Division of Water Resources.</td>
</tr>
</tbody>
</table>
Photo Gallery

Figure 11: View of Wetland With Long Flow Path
(Caldwell Co. Photo by Seth Nagy)
Figure 12: Stormwater Wetlands, Washington, DC & Raleigh, NC