Introduction to Stormwater Treatment Practices

Municipal Inland Wetland Commissioner’s Training Program

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DEP
Inland Water Resources Division
Introduction

Do these first!

Site Planning and Design

Stormwater Quality
- Construction
  - Erosion & Sedimentation Control
- Post-Construction
  - Source Controls and Pollution Prevention

Stormwater Quantity
- Drainage Design and Flood Control

Stormwater Treatment
Outline

- Introduction to Practices (Chapter 6)
  - Stormwater Design Criteria
  - Treatment Practice Selection
  - Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices
Guiding Principles

- Preserve pre-development hydrology
- After construction, reduce annual solids by 80%
- Preserve and protect wetlands, stream buffers, and natural drainage
- Manage runoff velocity & volume to preserve/protect integrity of existing waterways
- Prevent pollutants from entering receiving waters and wetlands beyond their ability to assimilate
- Seek multiple benefits from stormwater practices
Guiding Principles

- Preserve pre-development hydrology

Larger peak flow and volume …

... and sooner.

Source: NEMO
Guiding Principles

- After construction, reduce annual solids loading by 80%

Source: NEMO
Guiding Principles

- Preserve and protect wetlands, stream buffers, and natural drainage
Guiding Principles

- Manage runoff velocity & volume to preserve/protect integrity of existing waterways
Guiding Principles

- Prevent pollutants from entering receiving waters and wetlands beyond their ability to assimilate
Guiding Principles

- Seek multiple benefits from stormwater practices

Source: NEMO
Stormwater Management Objectives

- Remove pollutants from runoff
  - Sediment
  - Floatable debris
  - Oil & petroleum products
- Groundwater recharge
- Peak runoff attenuation
- Stream channel protection
Treatment Train Concept

**REQUIRED:**
- Site Planning
- Source Controls/Pollution Prevention

**OPTIONS:**
- Primary Treatment Practices (one or more)
- Combination of Secondary and Primary Treatment Practices
- Multiple Secondary Practices (at the discretion of the regulatory authority)
  - Retrofits
  - Ultra-urban sites
  - Significant Source Controls/LID
## Primary versus Secondary Treatment Practices

<table>
<thead>
<tr>
<th>Primary Practices</th>
<th>Secondary Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Capable of stand-alone treatment</td>
<td>▪ Not Suitable as Stand-alone systems</td>
</tr>
<tr>
<td>▪ Provide high level of water quality treatment</td>
<td>▪ Not capable of meeting performance criteria</td>
</tr>
<tr>
<td>▪ Meet performance standards</td>
<td>▪ Have not been through evaluation needed to demonstrate capability</td>
</tr>
<tr>
<td></td>
<td>▪ Appropriate in certain applications</td>
</tr>
</tbody>
</table>
Outline

- Introduction to Practices
- **Stormwater Design Criteria (Chapter 7)**
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices
## Sizing and Design Criteria

<table>
<thead>
<tr>
<th>Objective</th>
<th>Criteria</th>
<th>Post-Development Storm Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollutant Reduction</td>
<td>Water Quality Volume (WQV)</td>
<td>First 1” of rainfall</td>
</tr>
<tr>
<td></td>
<td>Water Quality Flow (WQF)</td>
<td></td>
</tr>
<tr>
<td>Groundwater Recharge and Runoff Capture</td>
<td>Groundwater Recharge Volume (GRV)</td>
<td>Not Applicable</td>
</tr>
<tr>
<td></td>
<td>Runoff Capture Volume (RCV)</td>
<td>First 1” of rainfall</td>
</tr>
<tr>
<td>Peak Flow Control</td>
<td>Stream Channel Protection</td>
<td>2-yr, 24-hr</td>
</tr>
<tr>
<td></td>
<td>Conveyance Protection</td>
<td>10-yr, 24-hr</td>
</tr>
<tr>
<td></td>
<td>Peak Runoff Attenuation</td>
<td>10-, 25-, 100-yr, 24-hr</td>
</tr>
<tr>
<td></td>
<td>Emergency Outlet Sizing</td>
<td>100-yr, 24-hr</td>
</tr>
</tbody>
</table>
Pollutant Reduction

- Water Quality Volume
  - Rationale
    - Majority of pollutant loading from small frequent storms
    - “First flush” concept (traditionally first ½ to 1 inch runoff)
    - 90% Rule: Capture 90% of runoff events annually and majority of pollutant load
    - Northeastern US: Approximately 1 inch rainfall
Pollutant Reduction

- **Water Quality Volume**
  - Runoff generated by first inch of rainfall over site
  - Equation

\[
WQV = \frac{(1') (R) (A)}{12}
\]

- WQV = acre-ft
- R = runoff coefficient = 0.05 + 0.009(l)
- l = % impervious cover
- A = site area in acres
Pollutant Reduction

- **Water Quality Volume**
  - Estimating Site Impervious Coverage
    - Directly connected to drainage system
    - From site plan
      - Paved surfaces
      - Roofs
      - Patios, decks
    - Tabulated land use values

\[
R = \text{runoff coefficient} = 0.05 + 0.009(I)
\]

<table>
<thead>
<tr>
<th>Parcel Size (acres)</th>
<th>Average Percent Impervious Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1/8</td>
<td>39</td>
</tr>
<tr>
<td>1/8 to 1/4</td>
<td>28</td>
</tr>
<tr>
<td>1/4 to 1/2</td>
<td>21</td>
</tr>
<tr>
<td>1/2 to 3/4</td>
<td>16</td>
</tr>
<tr>
<td>3/4 to 1</td>
<td>14</td>
</tr>
<tr>
<td>1 to 11/2</td>
<td>10</td>
</tr>
<tr>
<td>11/2 to 2</td>
<td>9</td>
</tr>
<tr>
<td>&gt;2</td>
<td>8</td>
</tr>
</tbody>
</table>
Groundwater Recharge

- **Groundwater Recharge Volume (GRV)**
  - Calculation concept
    - Estimate pre-developed recharge volume
    - Determine annual recharge volume lost due to new impervious coverage
  - Hydrologic soil group approach
    - Based on NRCS hydrologic soil groups
    - Average annual recharge
  - Accomplish recharge
    - Primary and secondary practices
    - Site design techniques
Groundwater Recharge

- **Groundwater Recharge Volume (GRV)**
  - Hydrologic soil group approach (cont.)
  
  \[ GRV = \frac{(D)(A)(I)}{12} \]
  
  - D = depth to be recharged
  - A = site area
  - I = site imperviousness

- Subtract GRV from WQV
- Other approaches

<table>
<thead>
<tr>
<th>NRCS Hydrologic Soil Group</th>
<th>Average Annual Recharge</th>
<th>Groundwater Recharge Depth (D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18 inches/year</td>
<td>0.4 inches</td>
</tr>
<tr>
<td>B</td>
<td>12 inches/year</td>
<td>0.25 inches</td>
</tr>
<tr>
<td>C</td>
<td>6 inches/year</td>
<td>0.10 inches</td>
</tr>
<tr>
<td>D</td>
<td>3 inches/year</td>
<td>0 inches (waived)</td>
</tr>
</tbody>
</table>
Groundwater Recharge

- **Groundwater Recharge Volume (GRV)**
  - Reasons to waive criterion
    - Stormwater “hotspots”
      - Salvage yards
      - High intensity commercial parking
    - Public works storage
    - Industrial facilities
    - Subsurface contamination
    - Groundwater supply
      - Aquifer recharge areas
      - Wellhead protection areas
Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection (Chapter 8)
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices
Treatment Practice Selection

- Stormwater Management Effectiveness
- Land Use
- Physical/site Feasibility
- Downstream Resources
- Maintenance
- Winter Operation
- Nuisance Insects and Vectors
- Natural Wetlands and Vernal Pools
Treatment Practice Selection

- **Land Use**
  - Land Requirements
  - Pollutant Loads
  - Land Use Compatibility

### Table 8-2 Land Use Selection Criteria

<table>
<thead>
<tr>
<th>Category</th>
<th>Practice</th>
<th>Rural</th>
<th>Residential</th>
<th>Roads and Highways</th>
<th>Commercial/Industrial</th>
<th>Ultra Urban¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stormwater Pond</td>
<td>Wet pond</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Micropool extended detention pond</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Wet extended detention pond</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Multiple pond system</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Stormwater Wetlands</td>
<td>Shallow wetland</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Extended detention wetland</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Pond/wetland system</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Infiltration Practices</td>
<td>Infiltration trench</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
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<tr>
<td></td>
<td>Infiltration basin</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
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<tr>
<td>Filtering Practices</td>
<td>Surface sand filter</td>
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<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
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<tr>
<td></td>
<td>Underground sand filter</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
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<tr>
<td></td>
<td>Perimeter sand filter</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Bioretention</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td>Water Quality Swales</td>
<td>Dry swale</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>Wet swale</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>○</td>
</tr>
</tbody>
</table>

Notes:
- ●: Appropriate
- ○: Somewhat appropriate
- ○: Least appropriate

¹If not designed to infiltrate
²May require pond liner
³Secondary treatment practices and stormwater treatment trains are typically more appropriate for Ultra Urban land uses
Residential

- **Potentially Suitable Practices**
  - Alternative site design
  - Permeable pavement
  - LID
  - Bioretention
  - Water quality swales
  - Ponds/wetlands

- **Issues/Concerns**
  - Public safety
  - Nuisance insects

Jordan Cove, Waterford, Source: UConn
Commercial/Industrial

- **Potentially Suitable Practices**
  - Alternative site design
  - Parking Lot
  - Bioretention
  - Swales, ponds, wetlands
  - Below-ground detention or infiltration

- **Issues/Concerns**
  - Litter
  - Hydrocarbons
  - Metals
  - Spills

UTC Fuel Cells, South Windsor, Source: UTC Fuel Cells
Ultra-Urban

- **Potentially Suitable Practices**
  - Below-ground detention/treatment
  - Treatment train
  - Green roofs
  - Permeable pavement
  - Bioretention
  - Retrofits

- **Issues/Concerns**
  - Little available land area
  - Wide range of pollutants
  - Infrastructure constraints
Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan (Ch. 9)
- Retrofits
- Stormwater Management Practices
- Appendices
Plan Content

- Applicant/site information
- Project narrative
- Calculations
- Design drawings and specifications
- Construction erosion and sedimentation controls
- Supporting documents and studies
- Other required permits
- Operation and maintenance
PLAN DEVELOPMENT

- **Criteria to require plan**
  - Disturbance ≥ 1 acre
  - Residential development
    - ≥ 5 units
    - < 5 units, new road (re)construction
    - < 5 units, > 30 % impervious
  - Discharge to wetlands/watercourse
  - Discharge < 500 ft. from tidal wetlands
  - Land uses with potential for higher pollutant loadings
PLAN DEVELOPMENT

- Criteria to require plan (cont.)
  - Industrial & commercial
    - ≥ 10,000 sq. ft. impervious surface
    - May have specific DEP requirements
  - New highway, road, street construction
  - Storm drainage modifications
Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits (Chapter 10)
- Stormwater Management Practices
- Appendices
INTRODUCTION

- **Retrofit?**
  - Modify existing development by…
    - Implementing source controls
    - Installing treatment practices
  - Results: Improved water quality
OBJECTIVES AND BENEFITS

- **Objectives**
  - Old stormwater management systems
    - Remedy problems
    - Improve water quality
  - Re-development
    - Incorporate treatment practices
    - Encourage Low Impact Development

- **Benefits**
  - Combine quality and quantity controls
  - Remedy local nuisances & maintenance problems
  - Landscape to improve appearance
WHEN IS RETROFITTING APPROPRIATE?

- **Table 10-1 site considerations**
  - Retrofit purpose
  - Construction/maintenance access
  - Subsurface conditions
  - Utilities
  - Conflicting land use
  - Wetlands, sensitive water bodies
  - Complementary restoration projects
  - Permits and approvals
  - Public safety
  - Cost
Stormwater Retrofit Options

- Stormwater drainage systems
- Stormwater management facilities
- Storm drain outfalls
- Highway rights-of-way
- Parking lots
- In-stream practices
- Wetland creation and restoration
Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices (Chapter 11)
- Appendices
Primary Treatment Practices

- Capable of stand-alone treatment
- Provide high level of water quality treatment
- Performance standards:
  - Capture & treat WQV or WQF
  - Remove 80% annual total suspended solids
  - Remove floatable debris, including oil/petroleum
  - Acceptable performance and operational longevity
Primary Treatment Practices

Chapter 11

Summary

Description

Stormwater Wetlands

Source: Nonpoint Education for Municipal Officials (NEMO).

Description

Stormwater wetlands are constructed wetlands that incorporate marsh areas and permanent pools to provide enhanced treatment and attenuation of stormwater flows. Stormwater wetlands differ from stormwater ponds as that wetland vegetation is a major element of the overall treatment mechanism as opposed to a supplementary component. This section includes three types of stormwater wetlands:

- Shallow Wetland
- Extended Detention Shallow Wetland
- Pond-Wetland System

While stormwater wetlands can provide some of the ecological benefits associated with natural wetlands, these benefits are secondary to the function of the system to treat stormwater. Stormwater wetlands can be very effective at removing pollutants and reducing peak flows of runoff from developed areas. Removal of particulate pollutants in stormwater wetlands can occur through a number of mechanisms similar to stormwater ponds, including sedimentation and filtration by wetland vegetation. Soluble pollutants can also be removed by adsorption to sediments and vegetation, absorption, precipitation, microbial decomposition, and biological processes of aquatic and fens: wetland vegetation. Stormwater wetlands are particularly advantageous when nitrogen and/or dissolved pollutants are a concern.

The key to maximizing pollutant removal effectiveness in stormwater wetlands is maintaining wet conditions all year round to support wetland vegetation. To achieve this, the constructed wetlands must either intercept the groundwater table or must be lined with an impermeable liner and have a watershed large enough to supply storm flows that will maintain wetness even during dry periods.
Primary Treatment Practices

Chapter 11
Design Variations

Advantages/Limitations

Stormwater wetland systems should be designed to operate on the plug flow principle where incoming water displaces the water retained in the system from the previous storm event. This is accomplished by maximizing length versus width ratios and/or by creating distinct cells along the treatment path. Ideally, the wetland system would be designed to retain the water quality volume (WQV) between storm events. As a result, storms that generate runoff less than the WQV would be entirely retained while only a percentage of the runoff from storms that generate more than the WQV would be retained. The value provided by this process is that a portion of the "new" polluted runoff is retained, and the "old" treated water is discharged from the wetland, thereby allowing extended treatment of the WQV.

Stormwater wetlands should be equipped with a sediment footer or similar form of pretreatment to minimize the discharge of sediments to the primary treatment wetland. High solids loadings to the system will degrade system performance and result in more frequent clearing, which could result in additional disturbance to the wetland vegetation. A multipool or permanent pool is often included just prior to the discharge for additional solids removal.

**Design Variations**

There are several common stormwater wetland design variations. The various designs are characterized by the volume of the wetland in the deep pool, high storm and low flow zones, and whether the design allows for detention of small storms above the permanent pool.

**Shallow Wetland**

Most shallow wetland systems are referred to as "shallow" wetlands, consisting of aquatic vegetation with a permanent pool ranging from 6 to 10 inches during normal conditions. Shallow wetlands are designed such that flow through the wetlands is conveyed uniformly across the treatment area. While pathways, serpents, or other varied systems could influence the aesthetic or ecosystem value of the wetland, they could also cause short-circuiting through the wetland, thereby reducing the overall treatment effectiveness. As a result, to maximize treatment performance, providing a uniformly shaped system is recommended. In order to enhance plug flow conditions across the wetland, individual wetland cells can be connected and separated by swales. Figure 11-P2-1 depicts a typical schematic design of a shallow wetland.

**Extended Detention Shallow Wetland**

Extended detention shallow wetlands provide a greater degree of downstream channel protection as they are designed with more vertical storage capacity. The additional vertical storage volume also provides extra runoff detention above the normal pool elevations. Water levels in the extended detention shallow wetland may increase by as much as three feet after a storm event and return gradually to pre-storm elevations within 24 hours of the storm event. The growing area in extended detention shallow wetlands extends from the normal pool elevation to the maximum water surface elevation. Wetland plants that tolerate intermittent flooding and dry periods should be selected for the extended detention area above the shallow marsh elevations. Figure 11-P2-2 depicts a typical schematic design of an extended detention shallow wetland.

**Pond/Wetland Systems**

Multiple cell systems, such as pond-wetland systems, utilize at least one pond component in combination with a shallow marsh component. The first cell is typically a wet pond, which provides pretreatment of the runoff by removing particulate pollutants. The wet pond is also used to reduce the velocity of the runoff entering the system. The shallow marsh then provides the pollutant, particularly for soluble pollutants, prior to discharge. These systems require less area than the shallow marsh systems since some of the water volume is stored in the deep pond which can be designed to reduce peak flows. Because of this system’s ability to significantly reduce the velocity and volume of incoming peak flows (i.e., flow regulation or dampening), it can often achieve higher pollutant removal rates than other similarly sized stormwater wetland systems. Figure 11-P2-3 depicts a typical schematic design of a pond-wetland system.

**Advantages**
- Efficient in removing both particulate and soluble pollutants.
- Capable of providing aesthetic benefits.
- Capable of providing audiological benefits with appropriate vegetation elements.
- Provides ability to minimize peak runoff flows.

**Limitations**
- More costly than extended detention basins.
- Requires a relatively large land area that is directly proportional to the size of the contributing drainage area.
- Very sensitive to the ability to maintain wet conditions especially during extended dry periods where there may be significant evaporative losses.
Chapter 11

Siting Considerations

Design Criteria

- Siting Considerations:
  - Drainage Area: Stormwater wetlands that utilize a linear system to maintain the desired permanent pool should have a contributing drainage area that is adequate to maintain minimum water levels. Typically, minimum contributing drainage areas are twenty-acre tracts, especially for shallow systems. A water budget for the wetlands should be calculated to ensure that evaporation losses do not exceed infiltrations during warm weather months.
  - Groundwaters: Upgradient basins must intersect the groundwater table in order to maintain the desired permanent pool. In this case, the elevations of the basins should be slightly higher than the groundwater level to ensure the desired permanent pool formation. Special attention should be paid to the desired permanent pool elevation. The elevation of the groundwater should be considered, which can be very problematic in low permeability soils.
  - Land Use: Land uses with direct potential pollutants of streams and potential safety risks. For those land uses where there is significant potential for soluble pollutants, especially those that are highly susceptible to groundwater transport, the use of a liner is recommended. An impermeable liner may not be required, depending on the risk of downstream contamination, but a low permeable liner constructed in fill soils may be acceptable. Additional residential land use poses the greatest public safety risks for mosquito breeding and water hazards must be considered.

- Design Criteria:
  - Wetland design may vary significantly due to site constraints, local requirements, or the designer's preferences. The five common design elements that should be considered for all stormwater wetlands are:
    - Vegetation
    - Treatment
    - Containment
    - Maintenance reduction
    - Landscape

Design considerations for stormwater wetlands are presented below and summarized in Table 11-P-2.
Primary Treatment Practices

Chapter 11

Cold Climate Design Considerations

Construction Considerations

Table 11-P2-2 Stormwater Wetland Liner Specifications

<table>
<thead>
<tr>
<th>Linear Material</th>
<th>Property</th>
<th>Recommended Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>Minimum Thickness</td>
<td>1.5 to 2.5 inches</td>
</tr>
<tr>
<td></td>
<td>Permeability</td>
<td>(0.01 cm/hr)</td>
</tr>
<tr>
<td></td>
<td>Porosity</td>
<td>Maximum 10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geomembrane</td>
<td>Minimum Thickness</td>
<td>10 mils (0.001 inches)</td>
</tr>
<tr>
<td></td>
<td>Material</td>
<td>Ultraviolet resistant polyethylene</td>
</tr>
</tbody>
</table>

Source: NYSDEC, 2001. All other listed specifications from City of Atlanta, 2009 (d Metropolitan Council, 2011)

- Ponds should be manually operated drain to drain down the pond for appropriate maintenance or draining of the main cell of the pond.
- Metal components of outlet structures should be corrosion resistant but not guaranteed due to the contribution of zinc to water (Washington, 2009).
- Outlet structures should be designed to prevent freezing and ice action in the pond.

Cold Climate Design Considerations

The following design elements should be considered to minimize potential performance impacts caused by cold weather:

- Inlet pipes should not be insulated, since this can result in freezing and resultant damage from freezing and settling.
- Outlets should be equipped to prevent freezing and pipe freezing.
- Equipment standing water in the pipe and to reduce the potential for ice formation, because the slope of silt pipes in a minimum of 1 percent, if the conditions allow.
- If perforated pipe is used, the minimum surface diameter should be 5 inches. In addition, the pipe should have a diameter of at least 6 inches.
- Water at standard 0.06 or 0.001, the minimum slope should be 1.5 inches, especially when the site is all.
- Baffle stones can prevent ice formation near the outlet by preventing surface ice from blocking the outlet, ensuring the movement of base flow through the system.

Construction

Any stormwater treatment practices that create an embayment, including stormwater wetlands, are under the jurisdiction of the Dam Safety Section of the Connecticut DEP's Water Resources Division (WRD) and should be constructed, inspected, and maintained in accordance with 6.22.2 through 6.22.3, inclusive, and applicable DEP guidelines.

Avoid soil compaction to promote growth of vegetation.

Temporary erosion and sediment controls should be used during construction, and sediment deposited in the wetlands should be removed after construction, but preferably before wetland vegetation is planted.

Temporary dewatering may be required if construction extends below the water table. Appropriate sedimentation controls will be required for any dewatering discharges.
inspection and maintenance

installation and maintenance

- Plans for maintenance refills should identify:
  - required inspection and maintenance requirements,
  - inspection and maintenance schedules, and
  - responsibilities for maintenance.
- The principal spillway should be equipped with a removable trash rack and be generally accessible from dry land.
- Sediment removal in the forebay and interpool should occur at a minimum of every five years or before the sediment storage capacity has been filled.
- Sediment removal should beographed in accordance with an approved comprehensive operation and maintenance plan.
- Inspect twice per year for the first three years to evaluate plant sustainability, winter kill, slope stability, and the outlet structure.
- Perform maintenance outside of revegetative growing and wildflower seasons.
- Harvesting of reed plant material is not required except in cases where high pollutant removal efficiency, especially for nutrients, is required.

maintenance access

- A maintenance right of way or easement should extend to the weir from a public road.
- Maintenance access should be at least 12 feet wide, have a maximum slope of no more than 1:5:1:1, and be appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access should extend into the forebay, safety beach, river, and outlet and be designed to allow vehicles to turn around.

Non-digging low flow orifice

- A low flow orifice shall be provided, with the size of the orifice sufficient to ensure that no clogging will occur.

Drain

- Except where local slopes prohibit this design, each weir should have a drain pipe that can complete or partially drain the weir. The drain pipe shall have an erosion control and management system that minimizes sediment deposition and is capable of draining the pond within 24 hours.
- Care should be exercised during pond draining to prevent rapid discharges and minimize downstream discharge of sediments or excess water. The appropriate permission must be obtained before draining a pond.
Primary Treatment Practices

Stormwater Ponds
Stormwater Wetlands
Infiltration Practices
Filtering Practices
Water Quality Swales
Primary Practice: Stormwater Ponds

- Permanent pool
- May have extended detention
- Pollutant removal
  - Sedimentation
  - Biological uptake
  - Microbial breakdown
  - Gas exchange
  - Volatilization
  - Decomposition
- Various wet pond designs
  - Wet ponds
  - Micropool extended detention ponds
  - Wet extended detention ponds
  - Multiple pond systems
Primary Practice: Stormwater Wetlands

- Constructed wetlands systems
- May not have the full range of functions of either natural or mitigation wetlands
- Typical components
  - Sediment forebay
  - Shallow & deep pool areas
  - Meandering flow paths
  - Vegetation
- Design Types
  - Shallow Wetland
  - Extended Detention
  - Pond/wetland system

![Figure 11-P2-2 Extended Detention Shallow Wetland](dnr.cornell.edu)
Primary Practice: Infiltration

- **Function**
  - Capture
  - Temporarily store
  - Infiltrate into permeable soils

- **Pollutant removal**
  - Adsorption onto soil particles
  - Biological & chemical conversion

- Must be carefully designed, constructed, and maintained to prevent premature clogging

- Pretreatment is critical!

- **Design Types**
  - Trench
  - Basin
Primary Practice: Filtration

- **Capture, store and filter through:**
  - Sand
  - Soil
  - Organic Material
  - Other Porous Media

- **Pollutant removal**
  - Physical straining
  - Adsorption

- **Pretreatment is critical!**

- **Design Types**
  - Surface filters
  - Bioretention
  - Underground filters

![Figure 11-P4-1 Earthen Surface Sand Filter](image)
Primary Practice: Water Quality Swales

- Reduce Velocity
- Temporarily Store Runoff
- Promote Infiltration
- Differ from conveyance swales
- Design Types
  - Dry swale
  - Wet swale

UTC Fuel Cells, South Windsor
Secondary Practices

- **Not Suitable as Stand-alone**
  - Are not capable of meeting performance criteria
  - Have not been through evaluation needed to demonstrate capability

- **Appropriate Applications**
  - Pretreatment
  - Use in treatment train to meet specific objectives

- **Conventional Practices**

- **Innovative/Emerging**
Secondary Treatment Practices

Chapter 11

Summary

Description

Reasons for Limited Use

Suitable Applications

Dry Detention Ponds

Reasons for Limited Use

Suitable Applications
Design Considerations

The design of detention ponds is dictated by local stormwater quantity control requirements. Local codes typically require that post-development peak flows be controlled to pre-development levels for storms ranging from 2-year through 100-year return periods. Control of more frequent events may also be required. The reader should consult the local authority for specific quantity control requirements, as well as the following references for guidance on the design and implementation of conventional dry detention ponds for stormwater quantity control:

- Connecticut Department of Transportation (ConnDOT), Connecticut Department of Transportation Drainage Manual, October 2000.

Whenever possible, detention ponds should be designed as extended detention ponds or wet ponds, or used in conjunction with other stormwater treatment practices to provide water quality benefits. Extended detention ponds, which are considered primary stormwater treatment practices (see the Stormwater Ponds section of this chapter), are modified dry detention ponds that incorporate a number of enhancements for improved water quality function. Older, existing dry ponds are abandoned candidates for stormwater retrofits by incorporating these recommended enhancements (see Chapter 10), which are summarized below.

**Sediment Forebay** A sediment forebay is an additional storage area near the inlet of the pond that facilitates maintenance and improves pollutant removal by capturing large particles. Sediment forebays can be created by berms or baffles, constructed of stone, brick, or other materials. The forebay should include a deep permanent pool to maintain the potential for sediment re-suspension (Metropolitan Council, 2003).

**Extended Detention Storage** Extended detention requires sufficient storage capacity to hold stormwater from low 24-hour to allow solids to settle out. The additional storage volume is usually provided in the lower stages of the pond for treatment of smaller storms associated with the water quality volume, while the upper stages provide storage capacity for large, infrequent storms. To reduce the potential for mosquito breeding, detention ponds should not be designed to hold water for longer than 5 days.

Any stormwater treatment practices that create an embayment, including stormwater detention ponds, are under the jurisdiction of the Erosion Safety Section of the Connecticut DEP Island Water Resources Section (IDWR) and should be commenced, inspected, and maintained in accordance with Connecticut General Statutes §§29-301 through 29-411, inclusive, and applicable DEP guidance.

**Outlet Wet Ponds** A relatively shallow, permanent pool of water at the pond outlet can provide additional pollutant removal by settling fine sediments and reducing re-suspension. The wet pond at the outlet can also be planted with wetland species to enhance pollutant removal.

**Pond Configuration** The inlet and outlet of the pond should be positioned to minimize short-circuiting. Buffers and internal grading can be used to lengthen the flow path within the pond. A minimum length-to-width ratio of 2:1 is recommended, and irregularly shaped ponds are desirable due to their more natural and less engineered appearance.

**Low Flow Channels** Low flow channels prevent erosion and are treated as runoff that enters a city pond during the initial period of a storm event, and after a storm, route the final portion to the pond outlet.
Secondary Practices

- **Conventional Practices**
  - Dry detention basins
  - Underground detention facilities
  - Deep sump catch basins
  - Oil/particle separators
  - Dry wells
  - Permeable pavement
  - Vegetated filter strips/level spreaders
  - Grass drainage channels

- **Innovative/Emerging Technologies**
  - Catch basin inserts
  - Hydrodynamic separators
  - Media filters
  - Underground infiltration systems
  - Alum injection
Secondary Practice: Dry Detention Basins

- **Reasons for limited use**
  - Limited or no water quality treatment
  - Subject to re-suspension of materials

- **Suitable applications**
  - Peak flow control
  - Channel protection
Secondary Practice: Underground Detention and Infiltration

- Reasons for limited use
  - Not intended for pollutant removal
  - Particulates can be re-suspended
  - Risk of groundwater contamination

- Suitable applications
  - Peak flow control/groundwater recharge
  - Stormwater retrofits
  - Space-limited sites
  - Must have pretreatment
Secondary Practice: Grass Drainage Channels

- **Reasons for limited use**
  - Can’t achieve 80% TSS removal
  - Require moderate maintenance
  - Impractical in areas with steep grades or very flat sites
  - Large area requirements

- **Suitable applications**
  - Part of conveyance system
  - Replace curb & gutter drainage
  - Highway road runoff

These are not the same as Water Quality Swales!
Secondary Practice: Catch Basin Inserts

- **Reasons for limited use**
  - High maintenance
  - Susceptible to clogging

- **Suitable applications**
  - Stormwater retrofits and pretreatment
  - Temporary construction sediment control
  - Oil control for small areas
  - Target specific pollutant
Secondary Practice: Hydrodynamic Separators

- **Reasons for limited use**
  - Limited peer-reviewed data
  - Soluble and fine particles not removed
  - Source of pollutants if not maintained

- **Suitable applications**
  - Sediment removal over range of flow conditions
  - Pretreatment
  - Stormwater retrofits
  - Ultra-urban sites
Secondary Practices: Other Innovative Strategies
Outline

- Introduction to Practices
- Stormwater Design Criteria
- Treatment Practice Selection
- Site Stormwater Management Plan
- Retrofits
- Stormwater Management Practices
- Appendices
Appendices

- A: Plant List
- B: Calculation Guidance
- C: Model Ordinances
- D: Site Plan Checklist
- E: Maintenance Checklist
- F: Glossary