Chapter 4 - BEST MANAGEMENT PRACTICE STANDARDS,

CONSTRUCTED WETLAND

(Permanent Practice)

Definition

A modified natural or constructed shallow basin for treatment of contaminated waters by wetland vegetation.

Purpose

The basin shall receive and temporarily hold contaminated waters to prevent downstream surface water pollution and to provide biological treatment of contaminants to acceptable standards.

Conditions Where Practice Applies

This practice applies where runoff is contaminated by oils, pesticides, nutrients, fertilizers, or animal wastes to levels unacceptable for downstream receiving waters. The greatest concern is where the downstream waters are used for recreation, fishing, shellfish harvesting, swimming, or water supply.

Planning Considerations

Federal, State, and Local regulations must be followed in planning and installing a constructed wetland. Discharge from the constructed wetland entering state waters or crossing property lines must first be approved by the Department of Environmental Quality, Office of Pollution Control. When constructed wetlands encroach upon natural wetlands, the U.S. Army Corps of Engineers should be contacted for a possible Section 404 dredge and fill permit. Additional planning considerations include:

I. Contamination Source. The contributing drainage area to the wetland shall be ex mined for potential contamination sources such as oil from street and parking areas, yard spray (pesticides) and fertilization residue, animal waste discharges, building or driveway washdowns, and runoff from stored materials, trash, debris, or bare soil areas.

2. Soils. The soils at the wetland site must be able to hold the contaminated water for treatment and for protection of the area groundwater. Some wetland areas may require plating or sealing when existing soils are too permeable.

3. Hydrology. The constructed wetland area must have sufficient detention volume to store the design storm runoff volume or the "first flush" of runoff which contains the majority of pollutants. When less than the full runoff is stored, bypass of the excess flow must be provided.

Release of the stored and treated water must also be provided in preparation for receiving the next storm runoff. The storage volume, detention time, and release rate must be compatible with the space available for the constructed wetland and bypass waterway.

4. Sediment Trap. Drainage areas that contribute significant sediment and organic debris to the constructed wetland must provide for its entrapment. Entry of sediment and debris into the wetland will progressively fill it and reduce its area and effectiveness.

5. Maintenance. The constructed wetland area configuration should provide at least two parts (cells) so one part can be shut down for maintenance and still provide some degree of treatment. All perimeter and divider levees should be wide enough for maintenance equipment access, when needed. Burning or seasonal drying are the preferred methods of maintenance of vegetative growth but plant residue build-up may require occasional removal.

Design Criteria

Constructed wetlands included in this practice standard are the 'Free Water Surface' type with a water surface always visible. The 'Subsurface Flow System' where contaminated water flows through a porous (gravel) medium is subject to biological clogging of the porous voids under certain conditions rendering it ineffective and is not recommended for nonpoint source treatment.

1. Soils. Locate constructed wetlands on soils of slow to moderate permeability or on soils that can seal through biological action. Final soil hydraulic conductivity shall approach 10- cm/sec. Soils having more than 20 percent passing the 200 sieve and having a Plasticity Index greater than 10 will be acceptable.

   Areas of the wetland that do not meet the hydraulic conductivity limit shall be sealed with an impermeable membrane or undercut and backfilled with a minimum of 9" of compacted clay material.

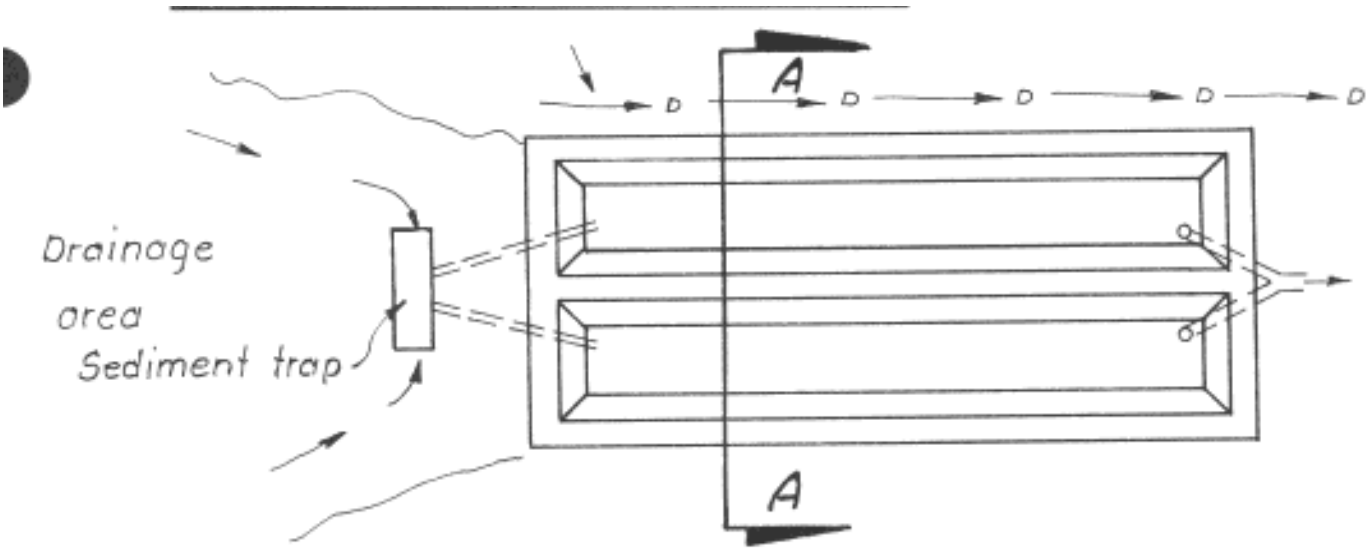
2. Design Storm. The constructed wetland system should be designed to handle the 1-year storm runoff. Limited area sites handling only the "first flush" volume shall have a minimum capacity to store 0.51, of runoff volume from the entire drainage area. Some Florida data estimates that this would handle up to 80 percent of the annual runoff.

3. Wetland Cells. The constructed wetland system design should include a wetland cell(s) that incorporate the following design criteria.

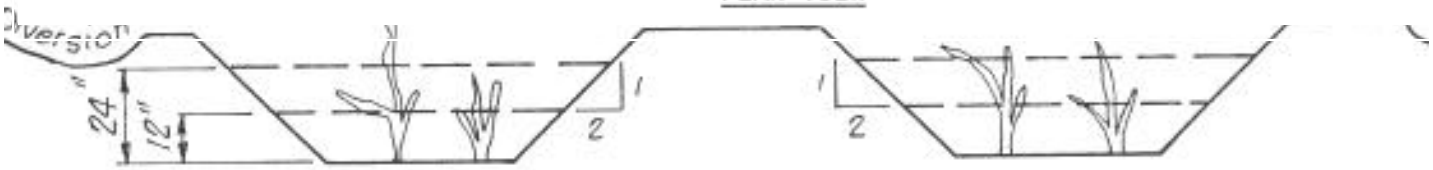
   a. Shape - The shape of the constructed wetland system can be adjusted to fit the site conditions. Cell function improves when flow enters one end of an elongated area having a length-to-width ratio ranging from 4:1 to 10:1. Multiple cells in series may be needed to improve treatment. A small grade should be provided toward the outlet end (see Figure 4-102).

   b. Depth - The water storage depth in the cell can be as much as 24-inches. Detention storage time for release of water must meet the practice objectives of preserving vegetation, providing pollutant settling and treatment, and providing available storage for the next storm. Detention period guidelines to achieve these objectives are:

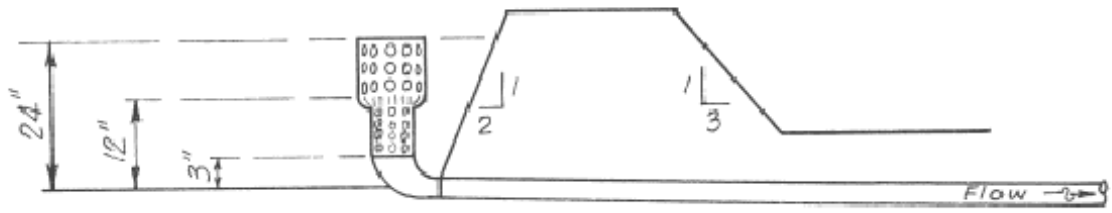
Figure 4-102 Representative constructed wetland layout.



PLAN VIEW



Typical Cross Section A-A



Wetland Cell Pipe Outlet

b. (continued)

24” to 12” depth: Release over a 36-hour period
12” to 3” depth: Release over a 5-day period
3” to 0" depth: Plant consumption and evaporation

c. Outlet - Each wetland cell must have an outlet pipe to automatically regulate storage release in accordance with the design detention time. A perforated pipe riser(s) having different density of perforations for the respective release rates works well (see Figure 4-102).

4. Treatment. The treatment capacity of the constructed wetland system is related to the following factors: pretreatment removal of sediment and organic debris, residence time of contaminated waters, and density of vegetation.

a. Pretreatment - A surface water inlet shall be provided to capture debris and suspended sediment before runoff enters the wetland cells. The sediment trap may be equipped with a grate or screen and will be designed so trapped residue can be removed.

b. Residence Time - Storm generated runoff entering the wetland cells will closely approximate a mixed flow condition and have a high level of oxygen concentration in the water for biological treatment processes. The mixed flow formula is:

$$\frac{C_o \text{ (Outflow } BOD_5 \text{ Concentration, mg/l)}}{C_i \text{ (Inflow } BOD_5 \text{ Concentration, mg/l)}} = \left[\frac{1}{1 + K_c T_n}\right]^n$$

Where Kc Complete mix first order reaction rate in units/day (Summer0.625, Winter = 0.144).

Tn - Hydraulic residence time in the cell in days (1.5 day for top 12" and 5.0 day for lower 9”). Note, Tn = cell length x width x depth * average flow.

n - Number of equal-sized wetland cells in series (normally 1).

Using the mixed flow formula, the following relationships are calculated:

Summer:	For 1.5 day detention, Co = 51.6 percent of Ci
	For 5.0 day detention, Co = 24.2 percent of Ci
Winter:	For 1.5 day detention, Co = 82.2 percent of Ci
	For 5.0 day detention, Co = 58.1 percent of Ci

The remaining need is to measure or estimate the inflow BOD5 concentration. This value will vary widely depending on the contaminant, contributing drainage area, etc. Collection and analysis of samples from various sites at various stages of the runoff hydrograph will provide valuable information.

5. Vegetation. Vegetation selected for the constructed wetland will be emergent hydrophytic plants suitable for local climatic conditions and tolerant of the concentrations of nutrients, pesticides, and other constituents in the stormwater. Principal plants to be used include cattail, maidencane, bulrush, rushes, and reeds.

   Although natural wetlands typically have a wide diversity of plant life, attempts to reproduce the natural diversity in a constructed wetland have proven unnecessary. Cattails alone or in combination with either reeds or bulrushes will often dominate in an established system.

   Free floating plants, such as water hyacinth and duckweed, have proven useful in municipal treatment systems; however, they are not to be used in constructed wetlands associated with these requirements due to the need for harvesting. For aesthetics and beautification, consider blueflag iris, canna lily, ginger lily, and wildflowers on dikes and other disturbed areas which are outside of maintenance activity areas.

   Nutrient uptake is not a major consideration in plant selection. The roots and stems in the water column serve as a medium for bacterial growth and serve as a media for filtration and adsorption of solids and enhanced settling. The s stems and leaves at or above the water surface provide shade and thus reduce growth of algae. Wetland plants provide for the transfer of oxygen to and from the submerged parts of the constructed wetland plants.

   Plants can be planted with a dibble bar, trencher, or a one-row tree planter and should be established on about 3.0 foot centers. The planting depth will vary, depending on species but all roots should be covered with 2-4 inches of soil mixed with available organic matter. Immediately cover plant roots with $_{211}$ of water to set and establish root system.

6. Parameter Limits. For the constructed wetland practice to be effective, continued management of the wetland system will be required. Management responsibilities should be assigned for the operational phase of the practice after the construction contractor has finished.

   The treatment objectives for the constructed wetland system should adhere to the following minimum outflow concentrations unless otherwise required or allowed by the appropriate state regulatory agency:

BOD_5:less than 30 mg/l	
Total Suspended Solids:	less than 30 mg/l
Ammonia and Ammonium:	less than 15 mg/l

7. Maintenance. Maintenance checks on the following items shall be made on the constructed wetland system at least seasonally and after major storms:

   a. Remove limbs, trash, and debris and clean out leave and sediment as needed.

b. Check storm overflow bypass for erosion and repair as needed.

c. Check wetland vegetation for stress from disease, insects, contaminates, etc., and treat as needed.

Plans and Specifications

Plans for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Specifications for construction and installing a constructed wetland shall use or be in conformance with the following. any variation from these specifications shall be approved by an engineer.

1. Scope. Work shall consist of shaping the constructed wetland and placing excavated material and earthfill as specified on the drawings or as staked in the field. The planned location of the constructed wetland shall be as shown on furnished drawings or as staked in the field.

2. Site Preparation. The site shall be free of all trees, brush stumps, and other objectionable material that will interfere with construction or proper functioning of the constructed wetland. Objectionable material shall be removed from the site and disposed of in an environmentally sound manner by burning, burying, or removal from field area.

3. Dimensions of Installation. Constructed wetlands shall be constructed to the line and grade and cross-sectional as specified on furnished drawings or as staked in the field. Finished elevations shall be within $\pm$ 0.1 foot of design grade. A positive slope toward the outlet shall be provided.

4. Material. Excavated material that is free of roots and organic matter will be used to construct the wetland levees or other fills as specified. The levee shall be compacted to provide a firm embankment with a minimum of settlement. Enough topsoil should be left in the wetland area to support vegetation growth. Where shallow soil areas are encountered, topsoil should be added to the area to support a vegetative cover.

5. Seepage Control. All perimeter and divides levees shall be firmly bonded to the foundation soil to contain and hold the contaminated runoff for treatment and discharge. Any sandy or permeable material encountered in the levee foundation or wetland cell bottom shall be removed and replaced with compacted clay.

6. Pipe Outlet. Pipe material shall be corrosion resistant for a wide variety of pollutants. Pipe shall be set to design elevations and riser perforations sized and located to release the treated water within the designated time period.

7. Vegetation. The selected wetland plants shall be planted at the designated spacings and immediately covered with 2 inches of water. Levees and adjacent disturbed areas shall have needed lime and fertilizer applied and incorporated and shall be seeded to grasses or other vegetation compatible with required maintenance activities.

Constructed Wetland Design Form

Project Location: City _____, County _____,

Section _____, Range _____, Township _____

Planned Construction Date: _____, Ending Date _____

Structural Data: Drainage Area _____ Acres Discharge Rate _____ CFS

Wetland Cells: Number in Parallel _____, Number in Series _____,

Width _____ feet, Depth _____ feet, Length _____, _____, _____

Detention Time: 24-12" _____ hours, 12-3" _____ hours

Release Pipe: Diameter _____ inches, Capacity _____CFS

Embankment: Top Width _____ feet, Side Slopes _____:1

Sediment Trap: Width _____ feet, Length _____ feet, Height _____ feet

Plant Selection: _____, _____

Project/Developer Representative: _____, _____
Name Date

Note: Alter section as required to show additions and omissions.