Guidelines for Constructed Wetlands for Municipal Wastewater Facilities

State of Georgia
Department of Natural Resources
Environmental Protection Division
Watershed Protection Branch
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GUIDELINES FOR CONSTRUCTED WETLANDS
MUNICIPAL WASTEWATER TREATMENT FACILITIES

Georgia Environmental Protection Division
Watershed Protection Branch
Engineering & Technical Support Program

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INTRODUCTION

Constructed wetlands consist of a properly designed basin that contains wastewater, a substrate, and wetlands plants. Constructed wetlands are natural wastewater treatment systems that may have lower construction and operation and maintenance costs than conventional mechanical treatment systems. They are primarily used in Southern states due to the warmer climate and greater land availability. Their use is especially suited for smaller communities due to their ease of operation.

There are two basic types of constructed wetlands that are characterized by the flow path of the wastewater through the treatment system: Free Water Surface (FWS) and Vegetated Submerged Bed (VSB). A FWS cell is a basin or channel lined to prevent seepage containing soil or another growth medium to support emergent vegetation. The wastewater flows at a shallow depth over the soil surface. A VSB cell is a trench or bed lined to prevent seepage containing gravel, sand, or another growth medium to support growth of emergent vegetation. The water level is below the top of the growth medium. In general, VSB systems require less land area and have fewer vector problems. The FWS systems generally are cheaper to install (no gravel media), have fewer clogging problems, and may be more suitable for most communities. Preliminary treatment must be provided prior to either system to reduce the influent solids to the system.

EPA generally disfavors the construction of wetland treatment systems within natural wetlands or other waters of the United States. Constructed wetlands that have the primary purpose of wastewater treatment are not considered mitigation wetlands.

These guidelines are intended to provide recommendations for the engineer's consideration during planning and design.

PROCEDURES FOR STATE REVIEW AND APPROVAL

Constructed wetlands generally include a discharge to surface waters. If a community is interested in installing a constructed wetlands system for wastewater treatment, a wasteload allocation request must be submitted to EPD. The request must include a map of the proposed discharge location and the proposed plant capacity. A wasteload allocation will then be determined for the proposed receiving stream. The wasteload allocation assigned to the proposed facility will be based upon the assimilative capacity of the proposed receiving stream. If the effluent limitation includes low nutrient limits, constructed wetlands may not be appropriate.

Once a wasteload allocation has been determined for the proposed facility, an antidegradation analysis must be performed to demonstrate the need for a discharge rather than a no-discharge system. A Design Development Report (DDR) and an Environmental Information Document (EID) must then be prepared. The EID must be submitted prior to the DDR. The EID is to discuss the environmental impact of the proposed project. At least one public meeting, advertised in advance for a minimum of 30 days, must be held in conjunction with the EID development. Proof of advertisement and meeting minutes must be submitted with the EID. Additional information on preparing an EID can be found on EPD's website.

During review of the EID and the DDR, the reviewer at EPD will conduct a site inspection of the proposed location of the treatment facility and constructed wetlands to determine if the site is generally acceptable. Generally, a site well-suited for constructed wetlands is conveniently located to the source of wastewater, provides adequate space, is gently sloping, contains soils that can be sufficiently compacted to minimize seepage, is above the water table, is not in a floodplain, will not impact threatened or endangered species, and does not contain significant archeological or historic resources.

The DDR contents must include, at a minimum, the areas shown in the following table. Following EPD concurrence with the DDR, the City or County must submit an NPDES permit application for the proposed constructed wetlands system. The draft NPDES permit will be issued for public comment prior to a permit being issued. Plans and specifications for the proposed facility must be submitted for EPD review and approval. The plans and specifications will not be approved until the final NPDES permit has been issued. Construction cannot start on the facility until the plans and specifications are approved. An Operations Manual must be prepared for the facility during construction and completed before the system begins operation. A watershed assessment and protection plan must be developed and implemented prior to initiation of operation. Following construction, EPD will inspect the facility to verify that construction is complete. The permittee will then be authorized by EPD to begin operation under their NPDES permit.

<u>DDR Contents - Minimum Requirements</u>

1. Design influent and effluent wastewater characteristics including flow (average and peaks), BOD_5, TSS, pH, NH_3 -N, any industrial flows, and any other plant specific considerations, such as a P limit.
2. Description of any existing facilities including flow schematics, sizes of unit operation / unit process, sizes of major equipment, and proposed operating conditions.
3. Proposed and selected treatment alternatives including flow schematics, mass balance for liquid and sludge, design criteria, sizes of unit operation / unit process, sizes of major equipment and proposed operating conditions.
4. Sludge and Vegetation Removal and Disposal methods.
5. Construction cost estimates.

DESIGN CONSIDERATIONS

The site topography can dictate the total length and/or width available for constructed wetlands cells. Any dimensional constraints should be considered in the design calculations. Multiple constructed wetlands cells allow for greater operational flexibility. Parallel and series operation with various recycle schemes will allow for adjusting the operation to maximize treatment efficiency, especially during low flow conditions. Appropriate flow distribution to each cell and within a cell is important. Piping to allow for recycling of flows and/or for step feeding should be considered for maximum flexibility. A combination of pond(s) and wetlands cells can be beneficial. The operating water level should be adjustable to allow for cell flooding for weed control, for cell draining, and for adjustment of detention times. The ability to control depth is an important control for aerating cells, discouraging pest infestations, easing pipe repair, and general operation of the wetlands. The cells may have to be lined to prevent seepage to the groundwater and to maintain the water level in the cells. The influent to a cell must be free from floatable and large settleable solids and excessive levels of oil and grease.

VSB media should be washed prior to placement to remove fines that can lead to premature clogging. Use of crushed limestone for VSB media is not recommended due to the potential for compaction and a chemical reaction with wastewater constituents to form a gel that can clog the media. Algae production and suspended solids in the effluent from upstream treatment processes must be controlled to reduce media clogging in downstream VSB cells. Use of step feeding of influent wastewater can be beneficial in preventing media clogging. The VSB media around the influent and effluent pipes for the first and last two feet of bed length should be larger in diameter than the remainder of the media. The surface level of the media should be flat with the bottom of the cell sloping from the inlet down to the outlet at a slope not to exceed 1%. VSB systems tend to have difficulty meeting low ammonia effluent limitations (< 5 mg/l). A supplemental ammonia conversion system such as a recirculating gravel filter or intermittent sand filter may be required.

FWS cells length to width ratios are recommended to be in the range of 3:1 to 5:1. Approximately six inches of soil should be placed over the liner to support the vegetation. Deep-water areas within the cell can allow for re-distribution of flow and can provide havens for stocked mosquito fish. A possible layout would be a cell with an open water zone for initial solids settling, then an emergent vegetation zone with two days detention at maximum flow, then an open water zone of two days detention, and then an emergent vegetation zone of two days detention. Facilities with stringent effluent ammonia limitations may want to consider using FWS cells for BOD removal and a supplemental ammonia removal system such as a recirculating gravel filter or an intermittent sand filter, especially if land is limited.

The influent piping to a constructed wetlands cell should either contain multiple inlet ports or a deep-water area at the influent end should be provided to allow for even flow distribution across the width of the cell. The effluent collection piping should include water level control piping to allow for manipulation of the operating water depth. Open areas will generate algae that may result in high nutrient levels in the effluent if the outfall is not separated from an open area by a marsh area.

The top of the dikes should be at least two feet wide to allow for mowing and/or at least six feet wide for vehicle access. A freeboard of at least 2.0 feet above the maximum water elevation should be provided. The construction of wetlands cells must be closely monitored to ensure that the grading follows the specified slope. Due to the shallow depths of the cells, the grading of the bottoms is critical.

Post aeration would be required to meet a Dissolved Oxygen effluent limitation. If fecal coliform and Total Residual Chlorine limits are assigned to the facility, disinfection and dechlorination (if chlorine is used) would be required to meet the limit. The compliance point for fecal coliform may be prior to the wetlands system, if the permit allows it.

VEGETATION

USDA-NRCS has a publication entitled <u>Guidelines for Establishing Aquatic Plants in Constructed Wetlands</u> that makes recommendations for selecting, planting, sources, and operation and maintenance of the wetlands vegetation. Contact with the USDA, Natural Resources Conservation Service in Athens, Georgia is strongly encouraged prior to specification of aquatic plants for constructed wetlands.

The vegetation in constructed wetlands provides oxygen to the bacteria located in its root zone. It also maintains the permeability of the growth media. The stem and leaves in the water column promote sedimentation and provide a substrate for the growth of beneficial microorganisms. The net nutrient uptake by the vegetation is negligible, even with harvesting and removal of the vegetation

The plant species to be used in constructed wetlands depend upon the water depth and frequency of flooding. The selected plant species can be purchased from commercial nurseries, collected in the wild, or grown for the specific project. Species used in constructed wetlands may include giant bulrush, maidencane, cattails, and common reed. Decorative species, which can be planted around the cell perimeters to enhance their aesthetic appeal, may include canna lily, iris, day lily, sweetflag, swamp lily, and marshmallow.

Planting should be done from early April until mid June in a clean water environment. The plants should be well established before any wastewater is added to the system. A minimum of 4 to 6 weeks should be allowed for plant establishment after planting before wastewater is added to the cell. The USDA publication contains specific recommendations for maximum water depths and plant spacings for a variety of species. Emergent vegetation should be planted so that the majority of the stems and leaves are located above the water surface.

A significant portion of the vegetation may die off during the first few years of operation. Plant replacements should be included in the Operation and Maintenance budget for a facility. Maintenance of proper water depth will enhance the chances for vegetative survival. The water level should be maintained to a specified maximum so the plants are not drowned and to a specified minimum so that the roots are not exposed for extended periods.

OPERATION CONTROL CONSIDERATIONS

The detention time in a cell is controlled by the bottom slope, water depth, vegetation, and geometric shape, as well as the degree of clogging in a cell. Treatment performance is a function of detention time. Hydraulic detention times may have to be increased during winter to account for the decreased biological activity during periods of low temperature.

Algae can be a problem in warm weather. Duckweed can be used to provide some nutrient uptake, if it is harvested and removed, as well as to control algae. A volunteer population of duckweed is likely to develop in any open water areas in the cells.

Periodic flooding of a cell may inhibit growth of weeds.

In general, mosquitoes are not of concern in VSB systems due to the water depth being maintained below the top of the media. Periodic flooding and draining of parallel FWS cells can interrupt the life cycle of mosquitoes and inhibit their proliferation. If mosquito fish (Gambusia affinis) are used for mosquito control in FWS systems, deep water zones should be provided for fish refuges. Use of pesticides and insecticides on constructed wetlands is not encouraged.

Attention must be paid to dike maintenance. Some aquatic mammals such as muskrats and beavers may burrow into the dikes, which can cause failure. Installation of welded wire in the dikes during construction can inhibit burrowing.

Harvesting of vegetation may be required to maintain uniform flow through a wetlands cell and promote nutrient removal. Dead vegetation may accumulate in a cell, especially in winter, and may have to be removed to maintain flow. Routine maintenance will include checking weir settings and the inlet and outlet structures, cleaning off surfaces where solids and floatable substances have accumulated, removing nuisance species, maintaining the appearance and general status of the vegetation and wildlife populations, and removing sediment accumulations in forebays.

Flow monitoring of the influent flow to a wetlands system may be useful in addition to the effluent flow monitoring required for permitting purposes for evaluating the loading rates to cells.

APPENDIX - REFERENCES

The references consulted in the development of these Guidelines include the following.

Constructed Wetlands Treatment of Municipal Wastewaters, U.S. Environmental Protection Agency, EPA/625/R-99/010, September 2000.

Guiding Principles for Constructed Treatment Wetlands, U. S. Environmental Protection Agency, EPA 843-B-00-003, October 2000.

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