Technical Overview

NESC

CONSTRUCTED WETLANDS

Item Number SFBLTO08

National Environmental Services Center

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West Virginia University

(304) 293-4191

www.nesc.wvu.edu

Project Staff

Edward Winant – Author

Jennifer Hause – Technical Review

Andrew Lake – Technical Review

Tim Suhrer – Editorial Review

Francine Wolfe – Editorial Assistant

Jeanne Allen – Project Coordinator

John Fekete – Senior Graphic Designer

Jamie Bouquot – Graphic Designer

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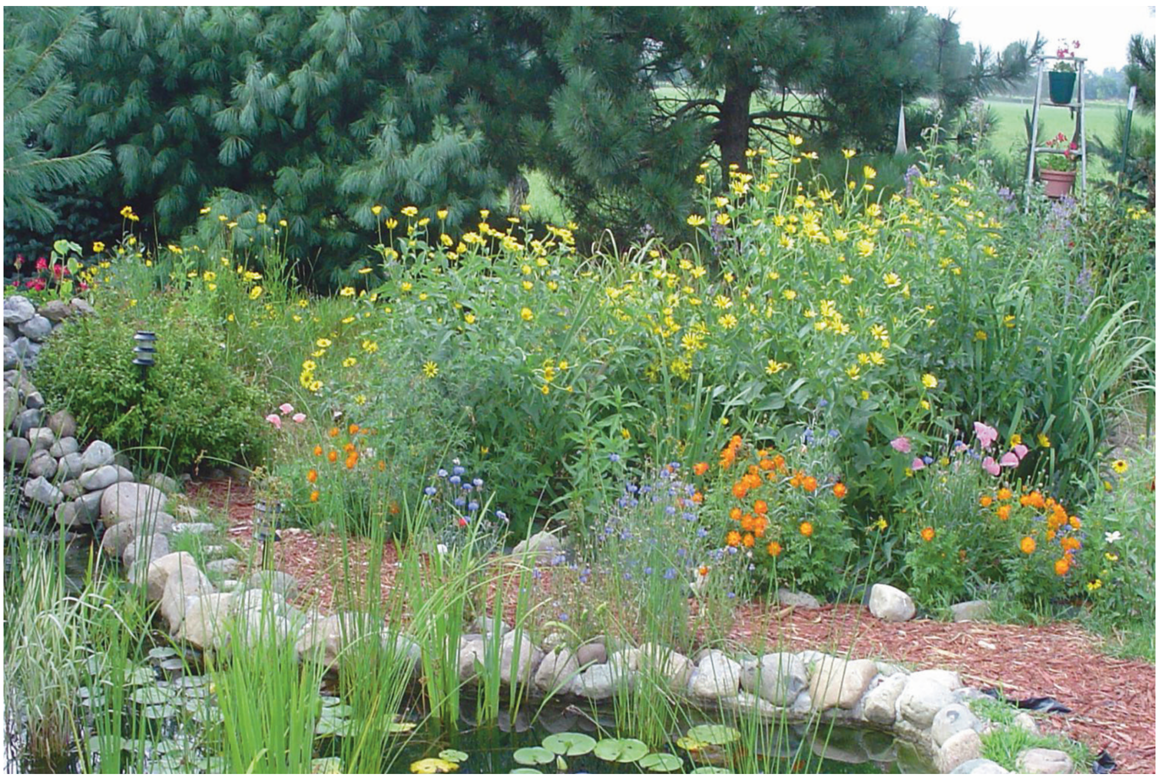
INTRODUCTION

The constructed wetland is an alternative treatment and effluent dispersal system that makes use of filtration and plant uptake processes. It is a natural system design that uses water-loving plants to assist in the treatment of wastewater. Mostly, wetlands are used as an advanced treatment or polishing step before final dispersal, but at times they can be approved as a dispersal step in themselves.

Typically, a wetland system consists of a septic tank or aerobic treatment unit, two or more wetland "cells," and a final subsurface dispersal system. The wetland cells are gravel or sand beds that support the growth of wetland plants. Effluent from the first tank (septic or aerobic) flows laterally through the wetland bed. In these cells, the effluent is filtered in the sand or gravel, biologically treated by natural bacteria living in the cell, and exposed to the plant roots. The roots provide oxygen to the effluent, uptake some of the water for plant use, and remove nutrients like nitrogen and phosphorus.



Example of residential constructed wetland

There are two different types of wetland systems: free surface and submerged. Free surface wetlands have water flowing above the gravel or sand surface, while submerged wetlands contain the effluent within the media bed. With no free water surface, submerged wetlands control odor better, reduce mosquito breeding possibilities, and restrict human access to untreated effluent. For these reasons, this overview will deal only with submerged wetlands and not free surface ones.

DESIGN

There are two controlling factors in wetlands design: hydraulic loading and biological loading. A related issue is detention time, or how long the effluent is retained in the wetland cell. Using loading rates prescribed by regulatory agencies, the wetland designer will calculate the length and width of the cell and the depth of the media needed.

These three factors (length, width, and depth) will give the volume of media needed, as well as the wetland's capacity for holding effluent and thus the detention time. Detention time is figured as wetland capacity divided by daily flow. For example, if a wetland cell is 20 feet wide and 30 feet long, with 2 feet of sand, it would contain 1,200 cubic feet of sand. Supposing this sand to have a void ratio of 0.3, there would be 0.3 x 1,200 c.f. = 360 c.f. of space available to hold effluent. 360 cubic feet is equivalent to 2,700 gallons. If the daily flow for this wetland is 900 gallons, the detention time in the wetland would be 3 days.

One of the uncertain elements of wetlands design is the length to width ratio. The optimal shape for wetlands is rectangular, to avoid short-circuiting in the effluent flow paths. The element of controversy is whether it should be long and skinny like a bowling alley, or wide and short like a volleyball court.

Proponents of the bowling alley concept stress the length as increasing flow paths and increasing the contact time for each element of effluent with the media and plants. On the other hand, volleyball enthusiasts point to the enlarged frontal area of a wide wetland, which reduces the frontal loading and serves to control biomat growth at the interface.

WV Class II installer course

Calculating the dimensions of the wetlands, though, depends on the two loading rates (hydraulic and biological). The biological loading rate is a function of how much treatment is required (the amount of reduction needed in biological oxygen demand [BOD]) and the temperature of the effluent. Because temperature is such a major component of the equation, designers typically run two cases—summer and winter—to determine which case requires the larger system. In a continuously operated facility, such as a primary residence, the winter case, with much lower temperatures, is always controlling. However, many times wetlands are installed on seasonal use facilities, such as camps or resorts, where the winter use is reduced and the summer case may be the controlling one.

Of course for residences, many states will provide design guidelines for suitable dimensions. For example, in West Virginia, for a three-bedroom house with a design flow of 360 gallons per day, you could install one cell 8 feet wide and 41 feet long, or two cells, each 8 feet wide and 20.5 feet long. In either case, the gravel depth would need to be 18 to 20 inches.

The choice of one cell versus two is somewhat arbitrary, but has some relationship to site constraints and subsurface discharge. For site constraints, if a single cell will not fit in the prescribed area, splitting it into two cells may allow better placement. The issue of subsurface discharge addresses the final fate of the effluent. In one-cell wetlands, the bottom and sides should be lined with an impermeable membrane to keep the effluent in the cell. However, in many cases the second cell can be unlined, with the possibility of effluent seeping into the native soil underlying the cell. If this is allowed, there are still the vertical separation distances from the cell to the groundwater or bedrock to be observed. If the second cell is lined, a final subsurface dispersal system must be provided separately.

SITING ADVANTAGES AND DISADVANTAGES

Constructed wetland cells do take up a bit of space. In terms of area, they can be smaller than drainfields, but being above ground, they deny the use of that space for any other purpose. Drainfields, on the other hand, leave the homeowner with a yard available for recreation or other light uses.

However, wetland cells can be beautified with the use of ornamental, flowering plants and thus serve as a garden or landscaping feature. Thus, the area devoted to a cell is perhaps not completely lost.

A leveling device for a subsurface constructed wetland

While the wastewater is kept below the gravel surface, it is somewhat accessible with a little digging. Plant beds make great playgrounds for toddlers and puppies. So, homeowners with young children or pets are advised to fence the wetland cell area to prevent unwanted access. Wetland plants also make good grazing for wildlife, so in rural areas, fencing is also recommended to prevent deer from devouring the leaves.

Constructed wetland cell

OPERATION AND MAINTENANCE

One of the biggest concerns people express about constructed wetlands is the amount of maintenance required. Some amount of trimming the leaves back in the fall or replanting in the spring may be required, but in general, constructed wetlands thrive on their own.

Additionally, there is the maintenance of the septic tank or aerobic treatment unit that precedes the constructed wetlands. Septic tanks should be inspected and pumped out regularly. Aerobic treatment units should be inspected several times per year and pumped when necessary.

COSTS

The main construction costs for constructed wetlands are the gravel or sand and labor. A typical wetland system for a three- or four-bedroom house would take around 40 to 50 tons of gravel or sand and can be constructed in one day with the proper earthmoving machinery. One of the advantages of a constructed wetlands system is that much of the labor can be done by the homeowner and friends, using sweat equity to cover a large share of the costs. Wetland plants, for instance, can be grubbed from nearby locations and transplanted, saving money and providing plants that are already acclimated to the climate.

A typical wetland, sized for a three- to four-bedroom home, costs in the range of $4,000 to $5,000 including the septic tank. With sweat equity and perhaps a donated backhoe, this cost can be halved to about $2,000 in materials. Using an aerobic tank increases the costs of treatment but allows for a smaller wetland cell volume. Where sand and gravel costs are high, this can be significant.

If you would like more information on constructed wetlands, the National Small Flows Clearinghouse maintains a Bibliographic Database with articles about all aspects of subsurface dispersal and a Manufacturers Database with company listings of firms that market equipment used in these systems. Both databases are searchable online at the Web site *http://www.nesc.wvu.edu/nsfc/*. Or you can call the toll-free hotline at (800) 624-8301, option 2, and request a database search from the technical assistance unit.

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