Constructed Wetlands

A constructed wetland system treats wastewater by filtration, settling, and bacterial decomposition in a lined marsh. Constructed wetland systems have been used nationally and internationally with good results, although the speed of water treatment decreases in cold climates during winter.

Our natural wetlands function like the kidneys of Earth, purifying the water.   In the spirit of imitating our Grandmother Earth to provide for our needs, we can also re-create wetlands in order to treat our wastewater.

A properly operating constructed wetland should produce an effluent with less than 30 mg/liter BOD (biochemical oxygen demand, a measure of organic material), less than 25 mg/liter TSS (total suspended solids), and less than 10,000 cfu/100mL fecal coliform bacteria, an indicator of viruses and pathogens.

Wetlands Application

Since wastewater leaves a constructed wetland as high-quality effluent, the soil in the trench or mound soil treatment system may be better able to accept it, and the system should last longer. Soil treatment systems receiving pretreated wastewater could be downsized to reduce the total area required. The cleaner wastewater makes wetlands useful for sites that have been compacted, cut, or filled.

The two most popular CWS design types for individual sewage treatment are the surface flow (SF), (Figures 2 and 3), also called free-water system, and the subsurface flow (SSF) system (Figure 4). Both of these are horizontal flow systems where wastewater enters at one end of a lined excavation and exits from the other end.

Figure 2. Open water SF wetland

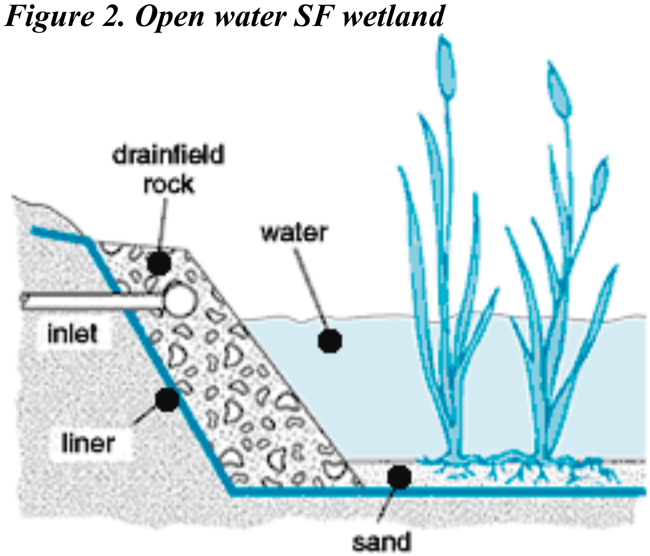


Figure 3. Hydroponic SF wetland

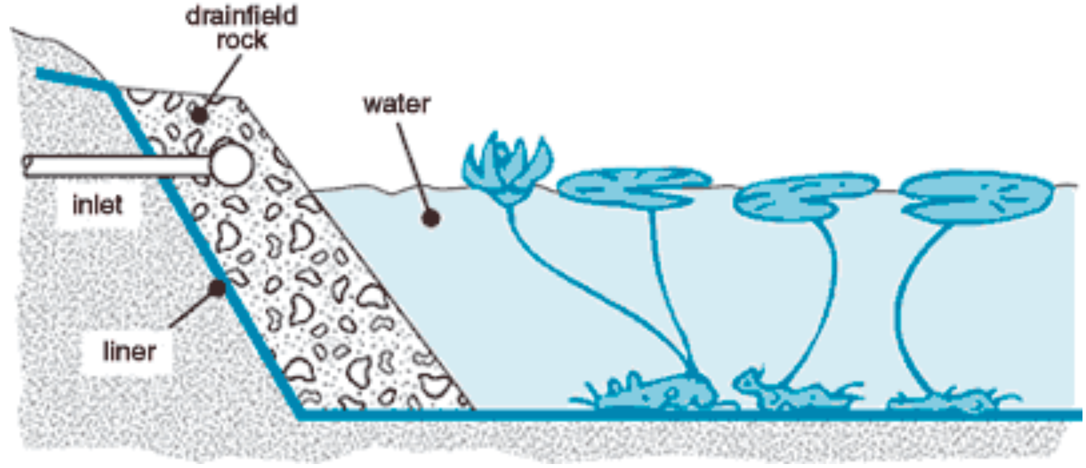
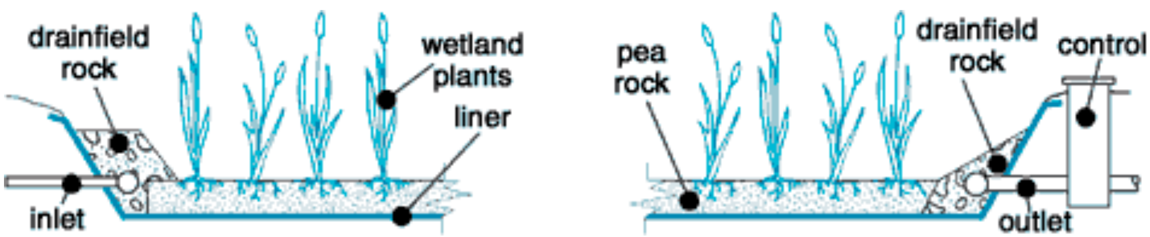


Figure 4. Subsurface flow constructed wetland



The SF system is usually a basin or channel surrounded by a barrier of ponded wastewater and soil to support the growth of rooted emergent vegetation. The two types of SF wetlands are shown in Figures 2 and 3. The open-water wetland in Figure 2 has a small layer of sand to root the plants while the hydroponic wetland in Figure 3 does not. SF wetlands are better suited for large community systems in milder climates for several reasons: the system can be fenced to prevent public contact, mosquito habitat is not a major issue, freezing is unlikely, and the amount of gravel is minimal, therefore lowering cost.

In the SSF system, the water level is maintained below the surface of the gravel substrate by a stand-pipe structure at the discharge end of the cell which minimizes the risk of exposure to people and animals and greatly reduces mosquito breeding. The SSF is the most common constructed wetland system used for small flows, and is often used for individual homes, small clusters of houses, or resorts.

How Do Wetlands Work?

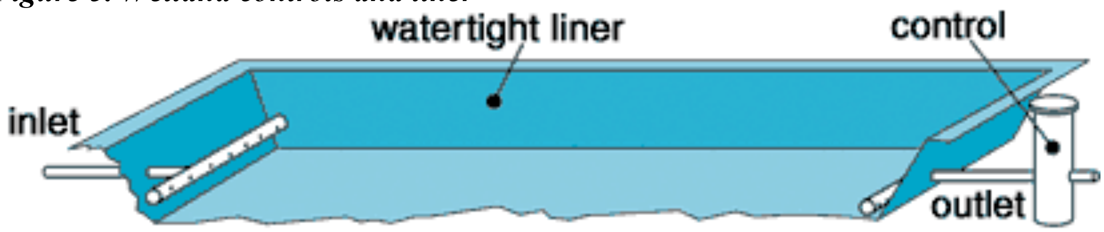
Solids are removed by physical filtration and settling within the gravel/root hair matrix. Organic matter may also be removed by these physical processes, but is ultimately removed through biodegradation. Biological treatment may be anaerobic (as in a septic tank where very little or no oxygen is present in the wastewater); or aerobic, with oxygen supplied by both diffusion from the atmosphere at the surface of the beds (much lower in SSF than SF systems) and by "leaking" of oxygen from the roots of cattails, bulrushes, reeds, and other emergent aquatic plants.

Aerobic treatment processes are faster than anaerobic processes, but oxygen is limited within the wetland. Some designers include an active aeration component to fully break down the BOD and nitrify the ammonium present in the septic tank effluent to nitrate-nitrogen.

Constructed wetlands have four parts: the liner, distribution media, plants, and underdrain system.

The *liner* keeps the wastewater in and groundwater out of the system. Although the liner can be made from a number of materials, 30 mil polyvinyl chloride (PVC) is the most common and the most reliable (Figure 5). Clay liners are not recommended because they can crack if too thin, allowing untreated wastewater to move into the soil and contaminate groundwater.

Figure 5. Wetland controls and liner



The *distribution medium* at the inlet is usually coarse drainfield rock that is 3/4 to 21/2 inches in diameter. This first part of the distribution system spreads the wastewater across the width of the wetland. Both gravity and pressure distribution can be used to spread the wastewater evenly over the system. The media in the filter is pea gravel that is 3/8 to 3/4 inch in diameter. The depth of the pea gravel varies from 18 to 24 inches.

Plants growing in the cell are often cattails, but other species include bulrushes, reeds, and sedges. Flora must grow and flourish in the system for it to operate at maximum efficiency.

The *underdrain system* at the end of the wetland is a slotted 4-inch pipe covered with drainfield rock. The underdrain moves the treated effluent out of the wetland and keeps the effluent level below the surface of the gravel. This prevents the effluent from coming into contact with people and keeps mosquitoes from breeding in the wetland. It also keeps the water level high enough to sustain plant growth.

Designing Wetland Systems

Subsurface flow systems, as the name implies, are constructed so the effluent moves through the medium below the surface. These systems require more space than surface flow systems, but can add treatment area. They also have fewer odor problems and are less prone to freezing (although they need freeze prevention management, particularly during winters with subnormal snowfall). SSF systems are generally more expensive to build than SF systems because of the cost of transporting materials, but are often recommended for Minnesota because of their relative simplicity and established performance record throughout the world.

Freezing may be minimized by deepening the bed, which increases the cost and decreases performance if much of the waste water can then move through the system without contacting the root zone. Difficulties at research sites in northern Minnesota during mild, low-snow winters suggest that the cells should be covered with a layer of insulating material. This may reduce their treatment performance by decreasing oxygen transfer.

The size of the system depends on the level of treatment desired balanced against the wastewater strength. Wetlands should be sized in cold climates for a minimum detention time of 10-13 days to ensure high quality effluent. For SSF wetlands, the rock medium must be included in calculations for the system size. A 30% porosity ratio takes the rock volume into account, increasing the system volume necessary for adequate retention time. The length should be two to three times larger than the width to ensure that the wastewater is not flowing too quickly through the system.

Placement

The system should be located on the contour with drainage directed away from the system. Surface water inflow can cause overloading problems. A barrier to sediment, such as rock landscaping or sod, is needed to minimize erosion and wetland cell problems.

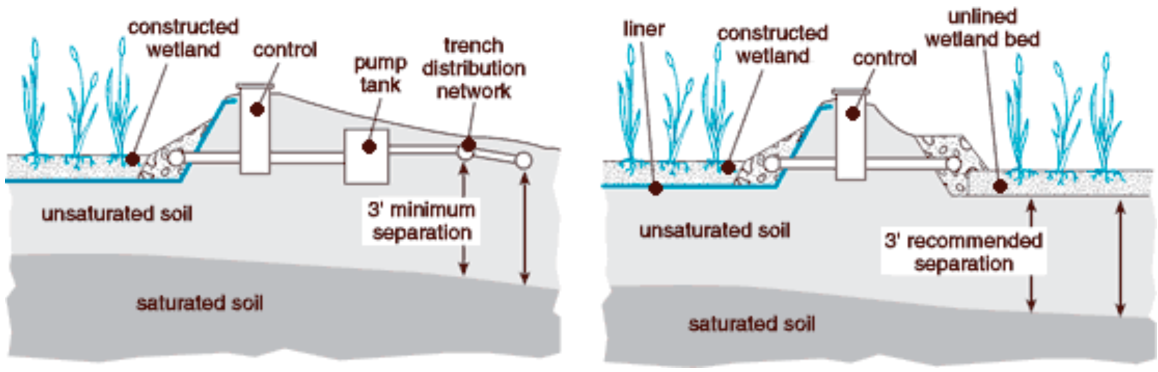
Final Disposal of Wastewater

Wastewater from the CWS must be routed to the subsoil for final treatment. This route may take the form of an additional unlined seepage cell or a standard set of drainfield trenches or a drip distribution system.

System Classification

The size and design of a soil treatment system for wetland effluent has not yet been established, although it could be smaller than conventional soil treatment systems for similar flows using septic tank effluent. Two types of final treatment systems are shown in Figure 6.

Figure 6. A trench system and unlined wetland bed for final treatment



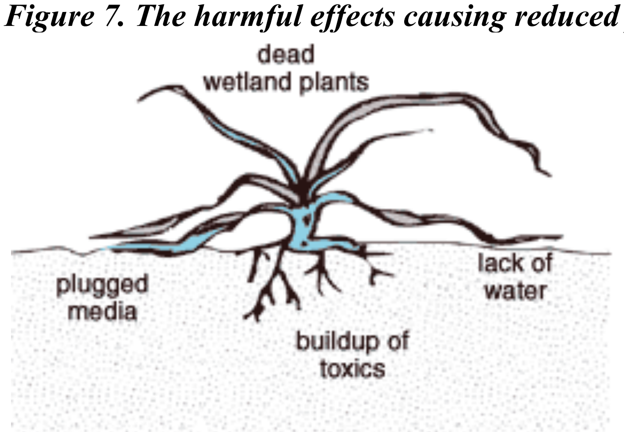
In Minnesota, a CWS is considered a "performance" system unless followed with a soil treatment system with three feet of unsaturated soil. The local unit of government must allow performance systems and issue an operating permit. Operating permits have a monitoring and mitigation plan, requiring the installation of a flow meter.

Operation and Maintenance

All the routine operation and maintenance practices suggested for any onsite treatment system apply to wetlands.

Constructed wetlands require more maintenance than conventional septic-tank-drainfield systems. A maintenance contract is strongly recommended. Depending on the local governmental unit requirements and the recommendations of the manufacturer, the system may require quarterly to yearly maintenance. Maintenance includes inspecting all components and cleaning and repairing the system when needed. Visual inspection of the effluent is required and often a lab analysis is necessary. The pump and electrical dosing unit must be inspected annually. Plants should be inspected and, if a good stand does not exist, replanted. Consider introducing a different species mix.

Figure 7. The harmful effects causing reduced plant growth or death



The flow meter and timer should be checked to ensure the right amount of effluent is being applied to the system. Water must be present at all times or the system will dry out, killing the plants and bacteria that treat the waste. Large flows (caused by excessive wastewater flows or by natural events such as torrential rains) can impair treatment by washing pathogens and nutrients through the media. They can lead to short-or long-term reduction in the ability of the system to provide treatment.

The quality of the wastewater that goes out of the septic tank and into the wetland (influent) affects system operation. Toxic chemicals can harm or kill plants and bacteria in the wetland, with serious consequences. In commercial applications, plugging the media with solids, organic matter, or grease may be a problem. Higher strength influents to the CWS may also decrease its performance and the influent should be carefully monitored before design stage.

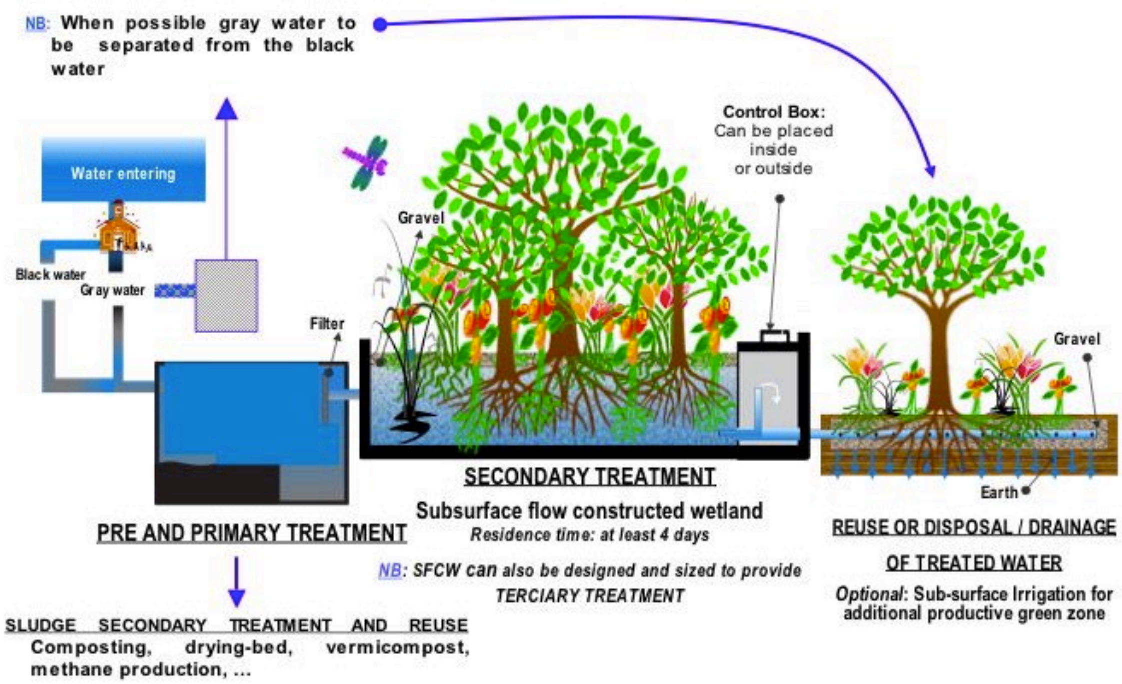
Daily running costs for a wetland are based on the operation of a small submersible pump and average less than a dollar per month for an individual home. Overall operational costs of $200-$500 per year includes pumping, repairs, maintenance, and electricity.

Winter Operation

Years with below-normal snowfall may require extra insulation, such as extra bed depth (adding cost and possibly reducing efficiency) or extra surface insulation. The water level may also be lowered in winter, allowing an ice cap to form an insulating layer of air in the system.

Summary

Constructed wetlands are an effective option for on-site wastewater treatment when properly designed, installed, and maintained. They do require more maintenance (such as insulating, plant replacement, and weeding) than other systems.



For more information:

Arcata Marsh and Wildlife Sanctuary
http://www.humboldt.edu/arcatamarsh/

EPA Information Page
http://water.epa.gov/type/wetlands/restore/cwetlands.cfm

Or Contact Us at Sustainable Nations for large and small scale design details!
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