IANR NebGuide
University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources
Know how. Know now.

G1474
(Revised September 2008)

Residential Onsite Wastewater Treatment: Constructed Wetlands for Effluent Treatment

Jan R. Hygnstrom Extension Project Manager
Sharon O. Skipton, Extension Drinking Water Educator
Wayne Woldt, Extension Environmental Engineering Specialist

Recommended practices for the design and installation of a constructed wetland as part of a residential onsite wastewater treatment system.

This NebGuide explains the basics of a constructed wetland system, including how it works, design considerations and maintenance. In Nebraska, the Nebraska Department of Environmental Quality (NDEQ) requires the landowner to have a permit prior to building of a constructed wetland. The constructed wetland must be designed by a professional engineer. A registered environmental health specialist, professional engineer, certified installer, or someone under their direct supervision must install the system.

Many Nebraskans live in homes that do not have access to a public wastewater treatment system. Instead, they must rely on their own onsite systems for wastewater treatment and recycling.

In southeastern Nebraska where soil has very slow percolation rates, a residential lagoon often provides treatment for wastewater. A septic tank/drainfield system is the most commonly used system throughout Nebraska. Wastewater from the home goes to the septic tank where it receives some treatment. When wastewater leaves the septic tank, it is called effluent. Effluent contains bacteria, viruses, organic particles, chemicals and nutrients, and must receive additional treatment. The traditional drainfield, also known as a lateral, leachfield or soil absorption field, is appropriate for effluent treatment if soils and the site are suitable. Other types of effluent treatment systems include a gravelless drainfield, constructed wetland, and mound. Consider a constructed wetland for effluent treatment if the soil at a site has a slow percolation rate.

How a Constructed Wetland System Works

Constructed wetlands are designed to mimic natural wetlands and use plants and microorganisms to treat effluent. A constructed wetland system consists of a septic tank, the wetland cell(s), and a method for returning the treated wastewater back to the environment, such as a drainfield if the soil is adequate, or a polishing lagoon or wildlife habitat pond (*Figure 1*).

In the septic tank, wastewater receives initial treatment. Anaerobic bacteria begin to break down wastes, and solids settle to form a sludge layer, while greases and oils float to form a scum layer. The clarified middle layer (effluent) travels to the constructed wetland cell.

There are two main types of wetlands — surface-flow and subsurface. Surface-flow wetlands look like natural wetlands because wastewater flows on top of existing soil. They are more economical for treating large volumes of wastewater such as those generated by communities. (Surface-flow constructed wetlands are not discussed in this publication.)

The subsurface constructed wetland is a cell of gravel (*Figure 2)* designed so that wastewater remains about 1 to 3 inches beneath the surface. This controls mosquitoes and offers little chance of human contact with the wastewater. Cattails, bulrushes, reeds, and other aquatic plants are planted in the cell. Microorganisms living on the surface of the gravel stones and plant roots break down organic materials in the wastewater. The plants in turn provide oxygen to the cell and remove some of the nutrients from the wastewater. Some of the wastes settle out and attach to particle surfaces.

From the wetland, effluent goes through a water-level control sump that allows the wetland water level to be adjusted. This is important because the wetland water level must remain below the gravel surface in order to prevent odors, yet be high enough to prevent plant roots in the cell from drying or

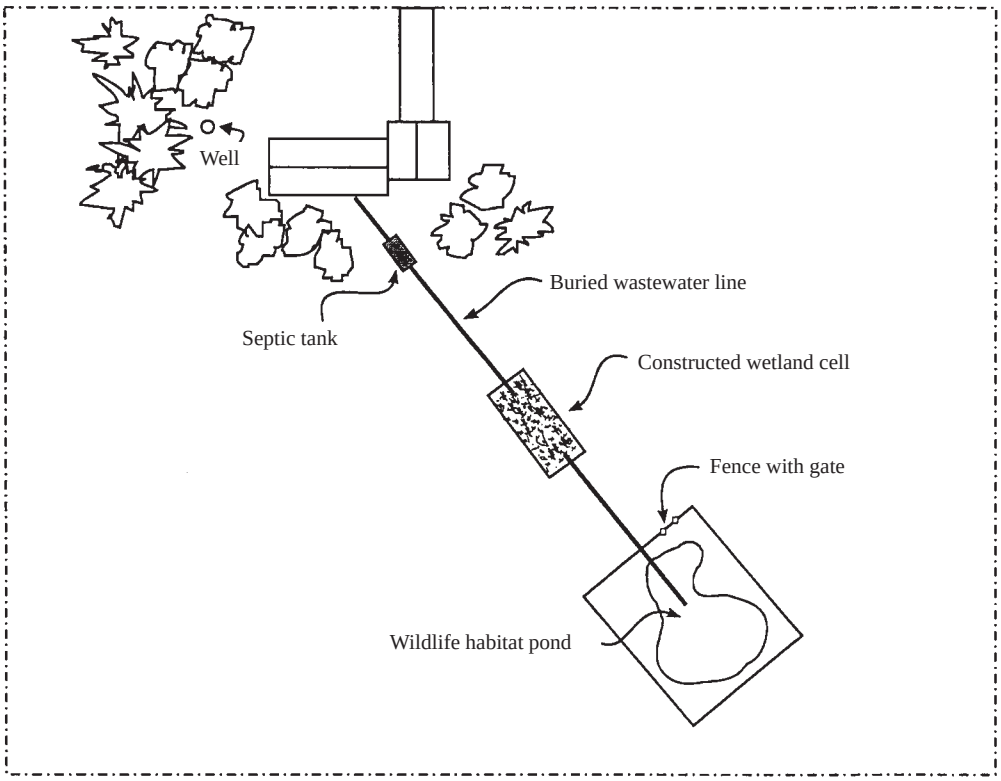

Figure 1. Constructed wetland system on residential site.

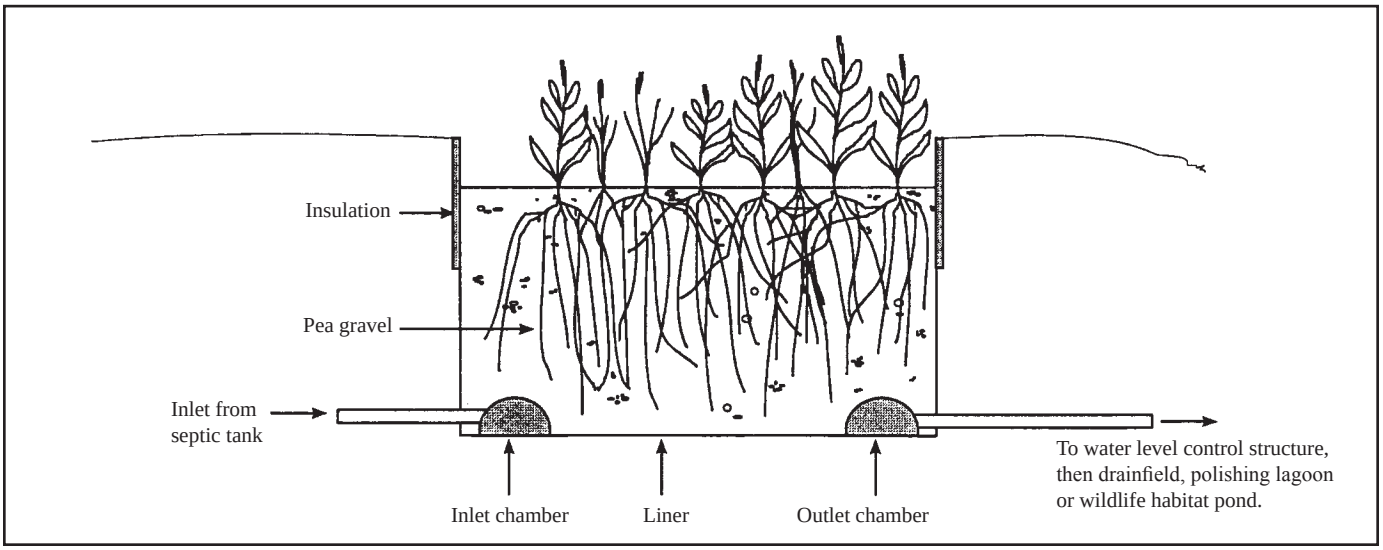

Figure 2. Constructed wetland cell.

freezing. Occasionally, water levels may drop to more than 3 inches below the surface of the wetland cell. This is acceptable periodically because it allows for plant root development.

If the soil and site characteristics are suitable, effluent flows from the constructed wetland to a subsurface drainfield where microorganisms and soil continue treatment as effluent is released back into the environment. If the soil is not suitable for a drainfield, the effluent may go to a polishing lagoon or wildlife habitat pond, where more treatment may occur. Discharge to land or natural bodies of surface water is illegal in Nebraska unless a permit is obtained. From the polishing lagoon or habitat pond, effluent evaporates into the air and some will seep into the soil. Seepage rates must not exceed 1/8 inch per day.

Constructed Wetland Design

Although a septic tank/constructed wetland system is more expensive than either a traditional septic tank/drainfield system or a lagoon, some people prefer it because a wetland

can be very attractive and benefit wildlife. The wetland must be designed by an engineer and permitted by NDEQ.

If the constructed wetland system site will be lower than the homesite, effluent can travel by means of gravity through the system. Otherwise, a pump will be needed to force effluent through the system. Pumps require an energy source and maintenance, which will increase the cost of installing and using the system.

The wetland cell is a bed of graded stone where aquatic plants are grown. The cell is generally an earthen basin lined with compacted native clay, bentonite, concrete or a synthetic liner. The bed itself is usually gravel but can be any porous material that resists corrosion or being dissolved by effluent. Limestone is not satisfactory because it breaks down in the acidic conditions of the cell. The gravel or other material should be free of silt and clay (fines) that could clog the pores. The wetland cell has pipes or chambers (*Figure 2*) to distribute effluent entering it, and again to collect it after it has traveled horizontally through the cell. Slightly sloping the wetland bottom helps gravity move effluent through the cell. Common slopes in residential systems range from 0 to 1 percent, or a 0 to 1 foot drop per 100 feet of length. To reduce the risk of freezing, consider having the top 18 to 24 inches of the cell's perimeter insulated.

The wetland cell should have a length-to-width ratio ranging from 2:1 to 3:1 to ensure proper water flow. For example, a 300-square-foot wetland could be 30 feet long by 10 feet wide (30 feet/10 feet = 3:1). If the wetland cell must be enlarged, keep the length-to-width ratio constant by increasing both the length and width. The engineer will determine the size of the system based on temperature, which affects how fast the wetland can remove nutrients and other pollutants, and the amount of effluent that needs treatment, typically determined by the number of bedrooms in the home. This information is used to determine hydraulic retention time — the amount of time effluent needs to stay in the wetland for proper treatment. The longer the effluent stays in the wetland, the more time microorganisms and plants have to treat the water. Generally, effluent should stay in the wetland system for two to three days. After treatment in the wetland cell, effluent may travel to a drainfield system, as discussed previously, for further treatment and dispersal into the environment.

Wildlife Habitat Pond

In cases where soils are not suitable for a drainfield, a wildlife habitat pond may be used for final effluent recycling. Unlike a residential lagoon, a wildlife habitat pond can be designed to look more natural, such as making it kidney-shaped. If possible, locate the pond so that effluent from the constructed wetland can flow by gravity to the wildlife habitat pond. The constructed wetland cell is connected to the pond using a 4-inch diameter Schedule 40 Thermoplastic PVC pipe or equivalent with a slope of at least 0.5 percent or ½ foot per 100 feet.

Follow the fencing requirements for a residential lagoon found in *Title 124*. However, since the effluent has been partially treated in both the septic tank and the constructed wetland, you could propose a variation in the permit application that is submitted to NDEQ for review. Remember that a fence will prevent children and pets from wandering into the water, and therefore is a good safety measure.

An engineer will design the pond and size it based on wastewater generation rates and evaporation and precipitation rates for the geographic area. Try to maintain at least 2 feet of water in the pond for aesthetics and to encourage wildlife use. Unless a synthetic liner has been installed, the bottom may form cracks if the pond is allowed to dry up. Cracks will increase seepage to more than the allowed maximum of ⅛-inch per day.

Operation and Maintenance

Each part of the constructed wetland system — the septic tank; constructed wetland cell; and drainfield, wildlife habitat pond or polishing pond — requires maintenance. Routinely inspecting and pumping the tank is necessary for proper wastewater treatment. If the tank has an effluent filter (which is a highly recommended feature) to prevent solids from entering the wetland cell, the filter should be inspected and cleaned periodically by a certified professional.

The constructed wetland requires minimal but necessary maintenance to ensure proper wastewater treatment. When performing maintenance tasks, the professional should always minimize exposure to wastewater by always wearing protective and waterproof gloves to avoid any exposure to open skin wounds or sores. After completing tasks, thoroughly wash hands or shower, and disinfect any breaks in the skin.

Water Level

Adjust the water level in the wetland so it usually is within 1 to 3 inches of the gravel surface. In the hot summer or cold winter months, lower water levels could cause plant roots and tubers to dry out or freeze. However, occasional lower water levels during seasons not subject to freezing temperatures may not harm the plants. The wetland will have an odor if the wastewater level is too close to the gravel surface. Moving the pipe in the water level control sump will adjust the water level in the wetland.

During times with low wastewater flow, low rainfall and/or high evapotranspiration (water loss through plants and soil), the constructed wetland may need to have water added. Run water from an indoor faucet, or water the wetland directly with a garden hose until water level is at least a foot below the wetland cell surface. Check water level at least weekly during hot and windy weather and add water as needed. Ask a neighbor to check and add water as needed during prolonged absences.

Vegetation

Inspect vegetation for signs of stress, including yellowing, excessive dead material, insect infestations or disease. At the first signs of stress, make sure water is at the proper level. If the water level is correct, 1 to 3 inches from the

media surface, have a horticulturist or other plant specialist look at the system.

Remove volunteer trees, shrubs and grasses such as fescue and brome from the wetland cell. These will compete with aquatic plants and could crowd them out. Remove manually if possible. Spot treat with an approved herbicide on a calm day to reduce the chance of drift to desirable aquatic vegetation.

Replace dead aquatic vegetation with new plants as soon as possible.

Sunlight is necessary for good plant growth. Control the growth of trees and tall shrubs near the wetland to prevent excessive shading.

Remove dormant (not actively growing) and brown plant material during the winter months. For cattails, rushes and other plants that have a stalk, leave at least 12 inches of plant above the wetland cell surface to support new spring plant growth. Standing plant material collects snow, which will insulate the cells during winter months.

Additional Concerns

Research is still being conducted on the effectiveness of wastewater treatment during cold winter months. A constructed wetland may not be suitable for a vacation home or cabin that is not used during cold winter months. The most appropriate setting seems to be one where there is year-round use. Since the constructed wetland system is an alternative system, a professional engineer must design it and a NDEQ permit is required.

A fence around the wetland cell is usually not necessary as wastewater is below the surface of the media. While establishing vegetation, however, a woven wire fence may prevent deer and rabbits from chewing tender young plants. A 1-foot high fence with 1-inch mesh installed around the perimeter will help exclude rabbits and wild rodents from the constructed wetland. Wildlife such as muskrats may dig into the sides of constructed wetland cells and cause leaks. If you observe holes or "runways," trap or use toxicants, if legal and appropriate in your area, to remove muskrats. Check with the Nebraska Game and Parks Commission for details. Have damage to the wetland cell repaired. For additional information on fencing or preventing damage from wildlife, go online to the Internet Center for Wildlife Damage Management (*www.icwdm.org/*) or, for muskrat control, to *Prevention and Control of Wildlife Damage* (*www.icwdm.org/handbook/rodents/ro_b61.pdf*).

Control surface drainage so surface water does not flow into the cell. Make sure the sides of the cell are 6 inches or more above the surrounding soil surface. Maintaining minimum water levels in summer during periods of nonuse may require planning and effort.

Level any low or high spots on the surface of the wetland with a rake or by filling in with additional gravel or filter material. Low spots can cause wastewater to pond, which could lead to odors.

Summary

A properly designed, installed and maintained septic tank/constructed wetland cell can treat wastewater to reduce risk to groundwater, surface water and human health. The constructed wetland system consists of a septic tank, the wetland cell and a drainfield, wildlife habitat pond or polishing lagoon (depending upon soil characteristics) for reintroducing wastewater into the environment. The system must be designed by an engineer and a construction permit obtained from NDEQ prior to construction. Proper maintenance includes inspecting and pumping the septic tank on a regular basis, cleaning the septic tank effluent filter if present, managing vegetation in and around the wetland cell, managing the water level, and checking and repairing the wildlife habitat pond or polishing lagoon structure if present.

Partial funding for materials development was provided by the U.S. Environmental Protection Agency, Region VII, and the Nebraska Department of Environmental Quality under Section 319 of the Clean Water Act (Nonpoint Source Programs).

This publication has been peer reviewed.

UNL Extension publications are available online at *http://extension.unl.edu/publications.*

Index: Waste Management
Home Waste Systems
2002, Revised September 2008