Grailville Constructed Wetlands

The Choice

In 2001 Grailville's main septic system leach field failed. Several options for replacement were considered; among them, connection to city or county sewage treatment, replacement of the failed system, and various alternative systems. The constructed wastewater treatment wetland was chosen because it offers the following advantages that express the values of sustainability to which Grailville aspires.

- Natural treatment of sanitary wastewater, storm-water and agricultural run-off
- Flexible sizing and layout for new facilities or additional capacity
- Adaptable to seasonal use cycles (peak use/no use)
- Low operation and maintenance costs
- Chemical-free treatment
- High quality of treated water
- Evapo-transpiration reduces wastewater discharge volume
- Aesthetically pleasing treatment area
- Uses local, native plant species such as sedges and rushes
- Showy native plants can be added for color and cutting
- Creation of habitat for wildlife
- Educational opportunities for biology and water quality studies

Timeline

The constructed wastewater treatment wetland was built in response to the failure of septic systems serving several Grailville buildings.

- March 2001 – research and planning by Grail and Grailville WET team begins
- July 2002 – Grailville signs design contract with J.F. New Inc.
- May 27, 2003 – construction begins
- September 17, 2003 – system comes on-line

Relationships

Grailville's 300 acres are drained by Osage Orange, Bares, and O'Bannon creeks, the Little Miami River, the Ohio River, and the Mississippi River.

- Everyone downstream of Grailville benefits from the choice made here to treat wastewater without using chemical additives
- Immediate neighbors, both humans and wildlife, benefit from the inclusion of native plants in the system
- Grailville visitors experience first-hand how human systems can fit beneficially into natural systems
- Students learn the basics of the water cycle
- Professionals in the wastewater field can study how an alternative system works

The System

The system includes the following mechanical and natural components.

- buildings served
- collection tanks
- filter tank
- dosing tank and alarm system
- force main
- wetland structure
- wetland plants
- leach field
- prairie plants

Collection Tanks

Three collection tanks collect water from four buildings, solids settle out, water moves to filter tank.

Filter Tank

Water is filtered through 1/16th inch filter. Filter must be cleaned once each year with garden hose

Dosing Tank and Alarm Box

Water is pumped from the dosing tank through the force main to the wetland.

- Water is pumped at a rate of 200 gallons every four hours
- Floats in the tank shut off pumps if water level becomes too low
- Floats in the tank signal alarm if water level becomes too high
- Manual override can be used if needed
- System is designed to handle Grailville's wide fluctuations of use

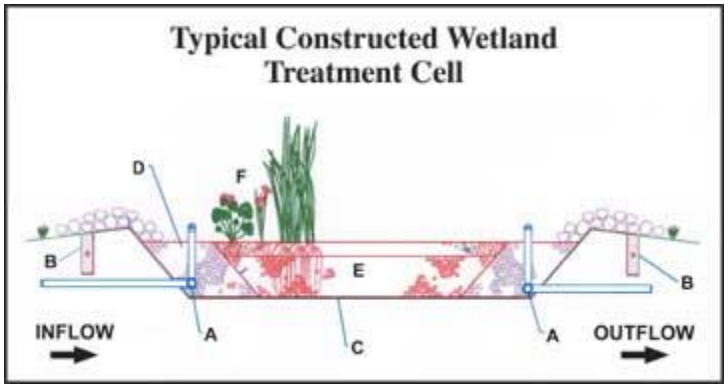
Force Main

Water is pumped under pressure through a line drilled under the parking lot from the dosing tank to the wetland.

Wetland Structure

The constructed wastewater treatment wetland, designed to serve Grailville's guest services buildings, was permitted by the Ohio EPA. Wetlands for residential use can be scaled to size and are permitted by the county in which they are located.

- 4-foot-deep excavation
- A: influent and effluent manifolds with cleanouts
- B: liner toe
- C: 45-millimeter rubber pond liner, 3-inch riprap covers where above ground
- D: liner filled to 24 inches with 1 1/2 inch gravel
- E: gravel capped with 3 inches of pea gravel into which the plants are planted
- F: plants mulched with two inches of peat for insulation



Subsurface Flow Wetland

The majority of polluting nutrients are removed from the water by the wetland treatment. The USEPA research project is designed to collect specific data regarding the efficiency of this removal.

- water takes an average 5 1/2 days to move through the wetland
- beneficial bacteria harbored in the gravel and the roots of the plants break down the organic matter in the water into usable forms of nutrients (i.e., nitrogen, phosphorus, and calcium)
- bacteria and plants take up the nutrients broken down by the bacteria
- plants take up water through the roots and release it to the air through leaves
- unused water collects in the effluent tank and is released by gravity to the leach field

Wetland Plants

The plants used in the wetland are native to the bioregion and provide habitat for insects, birds, and butterflies. Though cattails and purple loosestrife do a good job of taking up nutrients, they are not native and tend to create monocultures, so they are not included here.

Research Project

The plastic channel dividers and other hardware seen here under construction are for the USEPA/University of Cincinnati research study on the efficiency of constructed wetlands for wastewater treatment. They will be removed at the end of the study.

- Bimonthly samples from each channel are analyzed for nutrient removal
- Samples from the leach field effluent, nearby creeks, and Grailville's pond are analyzed for comparison
- Weekly samples (1/05 – 6/05) are analyzed for bacteria
- Bio-mass samples are being harvested (Spring 2005) to study the efficacy of nutrient removal and transpiration

Leachfield

The leachfield provides tertiary treatment of the water before it reaches the groundwater or watershed. The treatment provided by the wetland allows for a smaller sized leachfield and extends the life of the leachfield significantly, perhaps indefinitely. This is especially important in southwest Ohio clay soils.

- Leach lines are 900 feet long and buried 2 feet deep
- Release water into the soil over approximately 1/4 acre

Native Prairie Plants

Deep-rooted native prairie forbs add habitat, color, and interest to the leachfield surface. The area was seeded in November, 2003, and continues to need maintenance to become established. Roots of native prairie plants may go as deep as 15 feet

- Roots take up any remaining nutrients released into the soil
- Prairie plants (not grasses) were seeded in 11/03, additional seeding each year
- May take up to three years to become established

The Wetland Plants

Native plants were chosen for the wetland though others, such as cattails, pickerel weed, and purple loosestrife, might do the same job. The natives that occur naturally within Southwest Ohio's bioregion have adapted to the local soil conditions and the climate, evolving defenses to many diseases and insects. Many are long-lived perennials that survive for many decades.

While the plants have adapted over the centuries, so has wildlife. Butterflies, hummingbirds, songbirds, beneficial insects, and small mammals have adapted to these plants for habitat, protection, and food. In return, the animals spread seed, thus aiding in plant reproduction. Native plants help stabilize and restore soil, absorb excess nutrients from runoff and wastewater, and contribute to greater biodiversity.

The following species were planted in the wetland cell in September 2003. They produced significant bio-mass in one season of growth. The USEPA is conducting biomass measurements as part of their research on the effectiveness of the wetland system for nutrient removal.

The native plants in our Constructed Wetland are:

- Spartina pectinata (Prairie cordgrass)
- Scirpus georgianus (Dark-green bulrush)
- Scirpus pungens Vahl (Three-square bulrush)
- Scirpus cyperinus (Woolgrass)
- Scirpus fluviatilis (River bulrush)
- Carex frankii (Frank's sedge)
- Iris virginicus (Virginia blueflag)
- Helianthus angustifolia (Swamp sunflower)
- Aster puniceus (Swamp aster)
- Lobelia cardinalis (Cardinal flower) (lower right)
- Helenium autumnale (Sneezeweed)
- Eupatoriadelphus fistulosus (Purple Joe Pye weed)
- Mimulus alatus (Monkey flower)

The Prairie

Native prairie forbs, not grasses, were chosen to replace the existing turf grass lawn over the leachfield for aesthetic as well as ecological reasons. Once established the 50- x 70-foot patch near Grailville's entrance will require little maintenance because the plants are hardy and reproduce themselves. Forbs, being flowering plants, can provide cut flowers for Grailville's residents and visitors, as well as food and habitat for resident wildlife, including beneficial insects, and pollinators. Meanwhile, the roots of these plants are hard at work taking up the excess water that reaches the leachfield from the wetland.

One third of these roots die at the end of the growing season and decay into organic matter, adding to the fertility of the soil. Re-introducing these valuable plants aids in restoration of depleted soils. The result is greater infiltration of rainwater into the groundwater aquifer, reduction of storm-water run-off and flooding, and, ultimately, a decrease in pollutants reaching the watershed.

As native species become re-established, they will out-compete short-lived, non-native weeds and grasses. These introduced species, called exotics, come from other regions of the country and the world. They often establish themselves in a disturbed area, such as farm fields, and grow aggressively to the detriment of local native plant populations. The unchecked spread of one of these species causes a drop in the diversity of the invaded area, upsetting the balance with wildlife.

The leachfield was seeded with the following species in November of 2003 and routine mowing was done twice during the following season to control invasive plants. Spot seeding was done in fall 2004, and a second broadcast seeding will be done in spring 2005, after removal of patches of turf grass is accomplished. Seedlings grown in Grailville's greenhouse will be transplanted into the prairie site, as well.

The following species were planted over the leachfield:

- Aster, New England (Aster novae-angliae)
- Goldenrod, Riddell's (Solidago riddellii)
- Sideoats Grama (g) (Bouteloua curtipendula)
- Sneezeweed (Helenicum autumnale)
- Obedient plant (Physotegia virginiana)
- Goldenrod, showy (Solidago speciosa)
- Boneset (Eupatorium perfoliatum)
- Goldenrod, stiff-leaved (Solidago rigida)
- Blazingstar (Liatris spicata)
- Joe Pye weed (Eupatorium maculatum)
- Senna, wild (Cassia hebecarpa)
- Partridge pea (Cassia fasciculata)
- Culver's Root (Veronicastrum virginicum)
- Lobelia, great blue (Lobelia siphilitica)
- Coneflower, grey-headed (Ratibida pinnata)
- Rosinweed (Silphium integrifolium)
- Compass plant (Silphium laciniatum)
- Coneflower, purple (Echinacea purpurea)
- Vervain, blue (Verbena hastata)
- Tickseed tall (Coreopsis tripteris)
- Rose mallow, swamp (Hibiscus palustris(moscheutos)
- Mistflower (wild ageratum) (Eupatorium coelestinum)
- Seed-box (Ludwigia alternifolia)
- Monkey flower (Mimulus ringens)
- Milkweed (Asclepias syriaca)
- Sunflower, stiff leaved (Helianthus rigida)
- Rattlesnake master (Eryngium yuccafolium) (at right)

- Tickseed, lance-leaved (Coreopsis lanceolata)
- Beard-tongue, hairy (Penstemon hirsutus)
- Spiderwort, Ohio (Tradescantia ohiensis)
- Buttonbush (Cephalanthus occidentalis)
- Cinquefoil, shrubby (Potentilla fruticosa)
- Black-eyed Susan (Rudbeckia hirta)
- Bluestem, Little (g) (Schizachyrium scoparium)
- Beard-tongue, foxglove (Penstemon digitalis)
- Golden Alexander (Zizia aurea)
- Coneflower, orange (Rudbeckia fulgida)
- Blazingstar (Liatris aspera, Liatris spicata/pynostacia)
- Bergamot, wild (Monarda fistulosa)
- Meadowsweet (Spirea alba)
- Mountain mint (Pycnanthemus tenuifolium)

The System

Wastewater from toilets, showers, sinks, and laundry flows from four Grailville buildings into holding tanks. From there, it flows by gravity into a larger collection tank, then a filtration tank. The filter removes solids as small as 1/16th of an inch.

The filtered water flows into the dosing tank, from which it is pumped through an underground pipe, called the force main, into the wetland cell. This four-foot-deep excavation is lined with a 45mm rubber pond liner and filled with 1 1/2-inch gravel topped with pea gravel. The plants are planted into the pea gravel and mulched with peat.

Over an average period of five and a half days, the water flows through the wetland cell below the surface of the gravel. This sub-surface flow precludes standing water in which mosquitoes could breed. The plants take up water, and the microorganisms living on plant roots and gravel convert the bulk of the pollutants (phosphates, nitrates, etc.) to usable nutrients and innocuous by-products.

The water then flows into the adjacent leachfield under its blanket of native prairie plants for tertiary treatment and ultimately re-enters the groundwater. The USEPA/UC research project is designed to determine the amount of the nutrients that ultimately leave the system.

Sequence

The system includes mechanical and natural components:

A: buildings served

B: collection tanks

C: filter tank

D: dosing tank and alarm system

E: force main

F: wetland structure and wetland plants

G: leachfield and prairie plants

Constructed wetlands, both the type at Grailville called sub-surface flow and the open-water type, mimic the processes found in nature. These processes, harnessed to treat wastewater, may provide an alternative to chemical treatment in centralized sewage treatment plants. More than 500 constructed wetlands are in use throughout the United States.