Septic tank system

View from influent end of wetland cell

Ben Pressman in wetland cell

Discharge point

Rocky Mountain Shambhala Center Facility Statistics	
Nearest Town:	**Red Feather**
County:	**Larimer**
River Basin:	
Receiving Water Body:	**Non-discharging**
Year Online:	**1996**
Population:	**200 (winter)** **500 (summer)**
Elevation (feet):	**7800**
Design Flow (mgd):	**0.05**
Average Flow (mgd):	**Fluctuates seasonally**
Size (acres):	**0.23**

Facility Description

The Rocky Mountain Shambhala Center wastewater facility is a small evaporative system. Each building in the community has an individual septic system. Overflow from these septic systems are collected and conveyed to a bank of 6 – 2200 gallon septic tanks. Overflow from these tanks is then distributed into two parallel subsurface wetland cells. Effluent from the wetlands is discharged into an abandoned lagoon for evaporation and groundwater seepage. No discharges are made to surface waters.

Background Information

The Rocky Mountain Shambhala Center is a non-profit Buddhist organization that provides space for group retreats. The primary use of this Center is during summer months. Planned expansions at the Center will upgrade from temporary housing structures (tent platforms, trailers, etc.) to permanent housing structures that will be used year round. In anticipation of this growth, the Center began the process of upgrading its wastewater treatment system. Some considerations that were taken into account by the Center when choosing a new system were:

- Must be able to handle fluctuations in waste loadings due to seasonal population
- Operation and maintenance must be simple
- Must be able to operated during sustained low temperatures
- Costs must be minimal
- The system should operate in harmony with the natural environment.

The Center decided to install a pilot scale subsurface wetland system. The U.S. Bureau of Reclamation and the U.S.G.S. are currently assisting the Center with performance testing of the wetland system.

Energy Analysis

Energy consumption in the system is minimal. Flow through the wetlands is by gravity. The septic tanks are pumped annually, at a minimal energy expenditure.

Construction Costs

Construction of the wetland was approximately $200,000.

Wetland Design

Design Methods

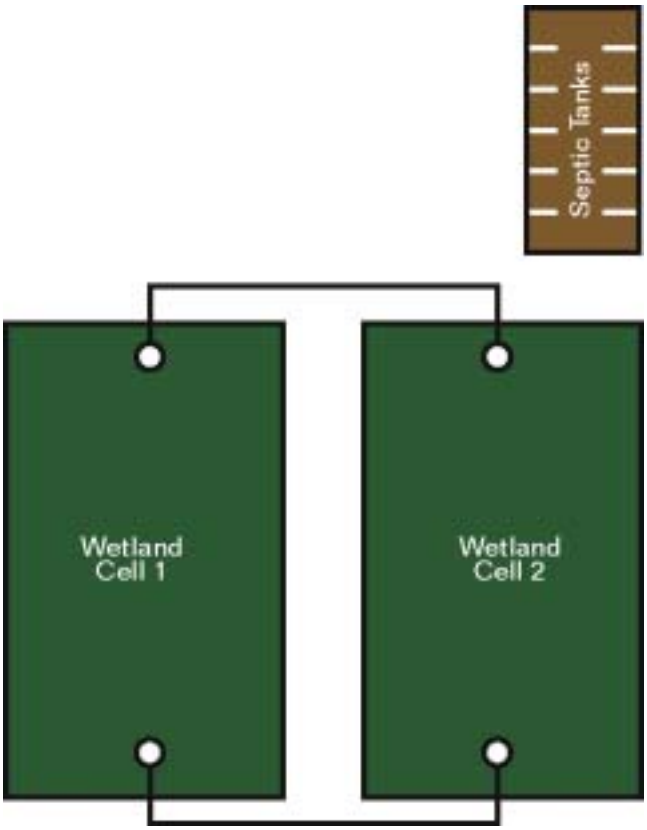
The design method used is based on first order plug flow for BOD and the nitrogen removal model developed by Reed, Middlebrooks, and Crites[1]. The nitrogen model used assumes a that most of the nitrogen will be removed by the nitrification of ammonia and then the denitrification of nitrate. The uptake of nitrogen by the wetland plants is assumed to be negligible. This design procedure is an iterative process.

[1] Reed, Sherwood C., Crites, Ronald W., Middlebrooks, E. Joe, Natural Systems for Waste Management and Treatment, McGraw-Hill Inc., New York, 1995.

The kinetic equations are first used to size the wetland for BOD and nitrogen removal. A heat loss equation is then used to determine the temperature conditions in the wetland cell. This temperature is then used to modify the kinetic equations for BOD and nitrogen removal. This process is repeated until the temperatures calculated by both the kinetic equations and the heat loss equation agree.

Objectives

The primary design objectives for this system were to decrease BOD and TSS in the septic overflow. Nitrogen removal was also addressed by the design methods.



Size

This system has two parallel subsurface flow wetland cells that each have a surface area of 5000 square feet. The dimensions of the surface are 42’ by 120’. The average wetted depth is 1.8 feet. The porosity of the gravel is 0.38.

Shape

As shown by the schematic, the wetland cells are rectangular. Each wetland cell has an aspect ratio of 2.9:1.

Hydraulics

The effluent from the septic tanks flows to a splitter box. Flow is discharge through to the subsurface wetland cells. Each wetland cell is fully lined with a 30-millimeter polypropylene liner to prevent groundwater interaction. Flow in the wetland was designed according to Darcy’s Equation. Sufficient head was provided to ensure that flow would remain subsurface through the system, even in the event of some clogging in the bed. The water level can be maintained with a swiveling Tee attached to the outlet pipe. This system has experienced problems with maintaining a sufficient water level at the inlet portion of the system to promote plant growth. A temporary sprinkler system was installed to allow the plants to develop root structures that will intercept the water level in the wetland.

Treatment Goals

Treatment Goals	
BOD_5:	**10 mg/l**
TSS:	**50 mg/l**
TN (as TKN)	**40 mg/l**

Water Quality Data

This wastewater treatment facility operates under a groundwater permit. Since it is not discharging into a surface water, monthly discharge monitoring reports are not required. The U.S. Bureau of Reclamation and the U.S.G.S. are currently assisting the Center with performance testing of the wetland system. Data presented below are from the samples collected during this effort.

Removal rates in the wetland system varied over the two-year study period. BOD removal in the wetland system fluctuated from a low of 45% to a high of 97%. TSS removal fluctuated between 50% and 70% removal, with some internal loading of TSS experienced in the wetland. Some ammonia removal was noted, however internal loadings were also experienced in the wetland. Removal efficiencies are not operating at design levels.

Parameter	March 1998	July 1998	Sept 1998	Dec 1998	Jan 1999	July 1999	Sept 1999
Temp, °C							
Inflow	4.22	18.41	18.48	7.98	9.41	19.10	16.25
Cell 1 Outflow	0.76	15.78	15.50	3.63	2.53	15.26	11.25
Cell 2 Outflow	0.76	14.79	15.21	3.43	2.42	15.39	10.90
Conductance, μS/cm							
Inflow	969	918	966	684	763	1035	857
Cell 1 Outflow	960	863	865	773	717	844	954
Cell 2 Outflow	989	8449	933	720	748	827	929
DO, mg/l							
Inflow	0.31	0.79	2.36	1.75	1.46	1.72	7.78
Cell 1 Outflow	0.67	0.73	0.50	2.64	2.24	0.84	1.30
Cell 2 Outflow	0.46	0.51	0.61	2.45	1.90	0.87	2.03
pH							
Inflow	7.18	6.69	6.95	6.90	6.96	7.14	8.33
Cell 1 Outflow	7.20	6.89	7.03	7.14	7.11	7.28	7.25
Cell 2 Outflow	7.14	6.95	6.96	7.19	7.10	7.28	7.24
BOD, mg/l							
Inflow	310	210	130	180	255	295	140
Cell 1 Outflow	170	110	25	68	60	32	4
Cell 2 Outflow	190	61	13	<20	80	56	6
N-Ammonia, mg/l							
Inflow	34	61	50	36	54	85	53
Cell 1 Outflow	26	42	49	31	40	62	64
Cell 2 Outflow	32	37	54	30	34	62	62
N-Nitrate/Nitrite, mg/l							
Inflow	<0.5	<0.5	<0.5	<0.5	0.09	0.05	0.12
Cell 1 Outflow	<0.5	<0.5	0.07	0.35	0.11	<0.5	0.6
Cell 2 Outflow	<0.5	<0.5	0.07	0.32	0.09	<0.5	<0.05

Parameter	March 1998	July 1998	Sept 1998	Dec 1998	Jan 1999	July 1999	Sept 1999
N-Nitrite, mg/l							
Inflow	<0.02						
Cell 1	<0.02						
Outflow							
Cell 2	<0.02						
Outflow							
P-Total Phosphate, mg/l							
Inflow	9.6	9.3.	7.8	11.6	10.1	10	7.9
Cell 1	8.3	6.4	5.2	5.3	9.8	7.2	6.6
Outflow							
Cell 2	8.5	6.7	6.0	5.5	10.9	7.3	6.9
Outflow							
Dissolved solids, mg/l							
Inflow	710	390	470	360	400	420	410
Cell 1	630	398	340	370	360	320	350
Outflow							
Cell 2	620	366	350	340	380	310	310
Outflow							
TSS, mg/l		50					
Inflow	44	42	40	44	41	72	76
Cell 1	20	34	36	40	16	<40	<20
Outflow							
Cell 2	26		32	20	22	<40	<20
Outflow							
Fecal Coliforms, MPN/100ml							
Inflow	1,600,000	1,600,000	240,000	1,600,000	>2419.2	>241,920	81,640
Cell 1	40	22,000	430	8	>2419.2	48,840	1100
Outflow							
Cell 2	11	50,000	210	13	>2419.2	98,040	740
Outflow							

General Ecological Setting

The ponderosa pine forests surrounding the constructed wetlands at the Rocky Mountain Shambhala Center are generally open with varying tree density. An abundant herbaceous understory is associated with more open areas. This understory may include common wild geranium and sticky cinquefoil. Bunch grasses and sedges are also common in the open forests.

Cell Vegetation

Vegetation cover in both cells of the constructed wetland was less than 30 percent. Of the species present, cattail (*Typha latifolia*) is dominant. Other species include hardstem bulrush (*Scirpus acutus*), Nebraska sedge (*Carex nebrascensis*), beaked sedge (*Carex rostata*), curly dock (*Rumex crispus*), and wild iris (*Iris missouriensis*). Both willow (*Salix* spp.) and chokecherry (*Prunus virginiana*) were recently planted in less saturated areas of the subsurface wetland.

Planting/Seeding

The constructed wetland was planted in spring 1996 with three-square bulrush (*Scirpus americanus*), Colorado rush (*Juncus confuses*), sunflower (*Helianthus nuttallii*), hardstem bulrush, Nebraska sedge, beaked sedge, and wild iris. The initial planted suffered very high attrition due to the planting of bare root stock.

Weeds

Noxious weeds were not observed in the wetland. Areas without vegetation cover were heavily mulched with straw, which may have inhibited establishment by noxious weeds.

Maintenance Issues

Preventing damage to newly planted willow and cherry should be considered. The three most successful methods for limiting damage from deer, rabbits, and other animals include—

1. Fencing to exclude deer. Conventional deer-proof fence is 8 feet high and constructed of woven wire. Enclosures can also be constructed for individual seedlings and designed to exclude both deer and rabbits.
2. Installing tubes of netting around individual seedlings and small trees. The material (Vexar) degrades in sunlight and breaks down in 3 to 5 years. These tubes can be installed to protect only the growing terminals, or can completely enclose small trees.
3. Installing budcaps. Budcaps are rectangular pieces of material folded and stapled around the terminal branch. They form a protective barrier around the leader and bud.

Wildlife

Vegetation in the constructed wetland provides habitat for songbirds and small and mid-sized mammals. A heavy browse line attributed to mule deer was observed on the willows and cherry. Cottontail rabbits were observed consuming the buds of these plants. In general, the constructed wetland does not add to wildlife habitat available in the surrounding landscape. Wildlife habitat and habitat diversity rated low. Total functional points were 30% of the total possible, and this wetland was rated a category IV wetland.

Wetland Biodiversity Functional Assessment

Wetland biodiversity functional assessment.		
Function and Value Variables	**Functional Points (0.1 to 1)**	**Possible Points**
General Wildlife Habitat	0.1 (low)	1
General Fish / Aquatic Habitat	NA	1
Production Export / Food Chain Support	0.1 (low)	1
Habitat Diversity	0.1 (low)	1
Uniqueness	0.2 (low)	1
Total Points	1.5 (30%)	5
Wetland Category (I, II, III, or IV)	IV	-

Human Use

From a human use perspective, the Rocky Mountain Shambhala Center treatment wetland was designed as an integral part of the landscape. Wastewater treatment is regarded within the context of the Center's land management. This wetland has low aesthetic value because it is dominated by areas of bare gravel and weedy species.

Overall Site Comments

The wetland system has experienced some trouble with establishment of plants. Water quality data show that the system is not operating to the level intended. However, it does perform the function of polishing septic overflow before discharge into an evaporative lagoon. An abandoned sewage lagoon provides open water habitat for waterfowl.