Belle River
Conservation Club

Constructed Wetland

Project Summary
1994-1997

Agriculture & Agri-Food Canada's
Rural Conservation Clubs Program

Project Summary Report
March 1997March 1997

Constructed Wetland Project

Introduction

The Belle River Conservation Club conducted a four year study determining the feasibility of utilizing a constructed wetland to treat barnyard runoff and milkhouse washwater waste Funding was received through Agriculture & Agri-Food Canada's Rural Conservation Clubs Program, part of the Canada-Ontario Green Plan. This report highlights the results of the study conducted by the Belle River Conservation Club.

Project Need

Rural water quality concerns were brought to the forefront of government attention in 1984 Water quality studies identified faulty septic tanks, improper manure storage' livestock entering watercourses and inappropriate milkhouse washwater handling facilities as being the leading contributors of rural bacterial pollution. This resulted in the formation of the Clean Up Rural Beaches Program on Ontario (1992 1996).

Depending on the size of the farm operation, conventional methods of disposing of liquid manure runoff could prove to be costly Combined with changes in management practices (handling liquid manure) and possible problems with contaminating surface water through field tiles, conventional methods were sometimes not feasible. Interested parties started looking at different means of handling livestock wastes. The Association of Conservation Authorities of Ontario took a lead role in establishing partnerships to study constructed wetlands to treat livestock and milkhouse washwater wastes. Project funding came from a variety of sources including private landowners, Agriculture & Agri-Food Canada the Ontario Ministry of Environment & Energy and private interest groups.

Project Highlights

REMOVAL RATES	
BOD5	**95%**
NH3-N	**96%**
T-PO4	**88%**
S.S.	**85%**
E. coli	***99%***

Construction Open House	1993
Quebec Farmers Tour	1995
Project Open House	1995
Drainage Superintendent Association Annual Meeting	1995
Farm Business-NoTill Conference Speaking Engagement	1995
Essex County Secondary School Tours	4,000 Students

Background

The constructed wetland project took place at Malden Valley Farms, a 200 head registered Holstein operation which is owned and operated by the Unholzer Family of Woodlsee. Manure from the operation is handled in a solid form and is stored in a 240 day covered manure storage facility partially funded through the Ontario Ministry of Environment & Energy's (OMOEE) Clean Up Rural Beaches (CURB) Program.
Prior to the construction of the manure storage facility and constructed wetland, all runoff from the cement pad storage area and milkhouse washwater wastes entered Woltz Creek via stone drains.

Direct connections to watercourses are major causes of bacteria pollution - *caption*

A total annual wastewater figure was calculated based on the area of the cement barnyard and daily washwater volumes Using average rainfall data & evapotranspiration rates for the Essex Region, the storage pond and wetland was sized according to the total volume of wastewater produced. Extra precautionary measures were build into the design to handle a 1:100 year storm events. A serpentine wetland was designed for a minimum 14 day retention time.
All barnyard runoff and milkhouse washwater wastes were redirected to a collection station via subsurface drains. Settling of finer solids was encouraged in the yard by restricting the flow of water through drop pipe inlets. The water was then pumped from a central station underground into a storage pond. The liquids are stored from November until April when conditions are less than ideal for wastewater treatment. During the growth season, the wastewater is released into the wetland box through a control box. This was replaced in

1996 by a sewage pump controlled by an electric timer. The water was treated in a serpentine wetland where it eventually ended up in a polishing pond for final treatment. Excess water was applied to an adjacent vegetative pasture strips when needed

Water was stored in a 50 m by 20 m (1,400 m^3) storage pond. The serpentine cell was 120 m by 3 m and operated at a depth ranging from 20 cm to 40 cm. Vegetation was transplanted into the wetland cell in the spring of 1994. The following species were transplanted: cattail *(Typha* latifolia), Water plantain *(silica plantago-aquatica),* Arrowhead *(Sagittaria latifolia).* Flowering rush *(Butomus umbellatus).* Soft Stem Bulrush *(Scirpus validus),* Bur-Reed *(Sparganium angustifolium* and Sedge (Carex spp.).
Operating periods were based on average water temperatures above 6°C and averaged 180 days.
PVC pipes were used to transport the wastewater between system components. Flow was regulated manually from the storage pond to the wetland using an age-drain in line water control structure (1994 - 1995) and a sewage pump in 1996.

Monitoring Program - Surface Water

On site sample collection was conducted for surface water measurements from April through to October. Grab samples were taken at various stages throughout the wetland. Sample intervals were bi-weekly during this period. Samples were analyzed for a number of parameters including BOD5, NH_3-N, total phosphorous. suspended solids and E. *coli.*
Water samples were collected following the OMOEE water -quality sampling guidelines and were shipped via courier to the London Regional OMEE lab for analysis following provincial water analysis protocol.
A meteorological monitoring station was installed at the constructed wetland site by Conservation Authority and OMOEE staff.
The system consists of depth sondes, water temperature probes. air temperature sensor. a tipping bucket rain gauge and a data logger. All instruments were sighted to conform with Atmospheric Environment Service Standards where possible. Maintenance was performed by Conservation Authority staff with technical support was provided by Mr. Jim Eddie. Ontario Ministry of Environment & Energy, Science &: Technology Branch.

The main Objectives of the project were as follows:

i) To demonstrate and research the environmental benefits of using a marsh wetland treatment facility to treat manure storgae runoff and milkhouse washwater wastes.
ii) To provide research data and design criteria for marsh wetland treatment facilities for other potential livestock operators.
iii) To promote environmentally feasible alternatives for farmers who wish to adequately address on farm waste disposal.

Campbell Scientific meteorological monitoring equipment used at Malden Valley Farms. - caption

Monitoring Program - Groundwater

Seven piezometers were installed around the wetland site to monitor groundwater. A groundwater sampling protocol was established in consultation with OMEE & OMAFRA groundwater specialists.

Samples were taken throughout the year to coincide with fluctuating groundwater tables.

Results

The following is a brief summary of weather for the period 1995-1996. A comparison to the 30 year norm is also given. For a complete summary, please see Appendix B.

Weather:

Table 2: Yearly weather summaries compared to 30 year norm for period April 1 - October 31.

	Rain (mm)	Temp (°C)
1995	458.6	14.6
1996	426.2	15.3
Average	570.8	18.3

Rainfall was 80 % of the normal 30 year average for 1995 and 75% of the norm 1996 from April-October.

Snow values were not calculated into the yearly figures and as such yearly comparisons could not be made.

Temperatures values were below normal both years. Spring temperatures in 1996 resulted in growth delays as water temperatures took longer to warm up than expected. This consequently reduced period the for waste water treatment based on minimum water temperatures of 6°C.

Groundwater

Groundwater results upstream & downstream showed no conclusive evidence of impairment. More long term data is needed to track trends, subject to funding availability.

Wetlands *help purify* water acting as the "early *kidneys" (Photo: Windsor Star)*

Table3: System Treatment Efficiencies (Two year average 1994-1995)

Parameter	**Transfer Pump (mg/l)**	**Polishing Pond (mg/l)**	**Removal %**
BOD5	670.2	17.8	97.3
NH_{3}-N	45.2	1.7	96.2
TPO_4	24.6	12.5	83.7
S.S.	573.6	75.0	86.9
E.*coli*	532,254	2,393	99.6

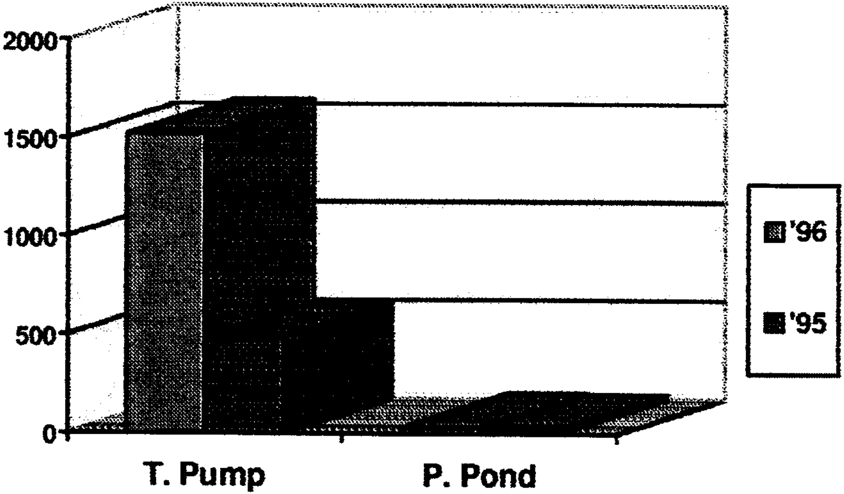

Figure 1: Three year BOD5 concentration levels for Storage Pond and Polishing Pond.

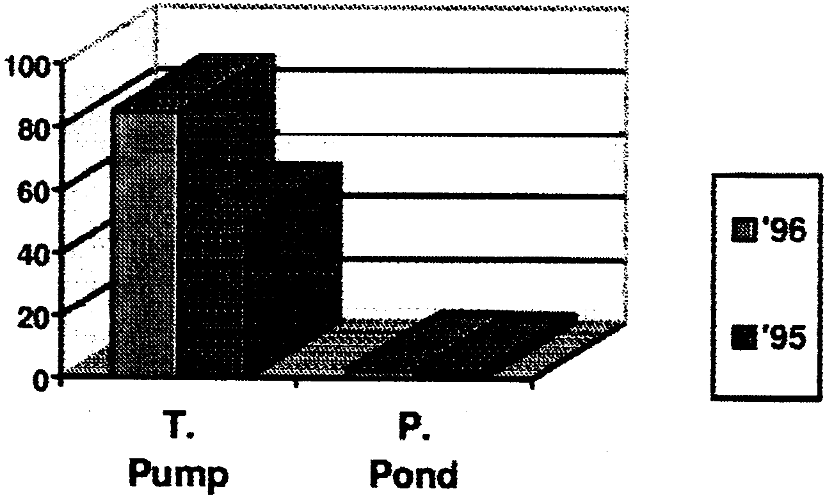

Figure 2 Three year NH3N concentration levels for Transfer Pump and Polishing Pond

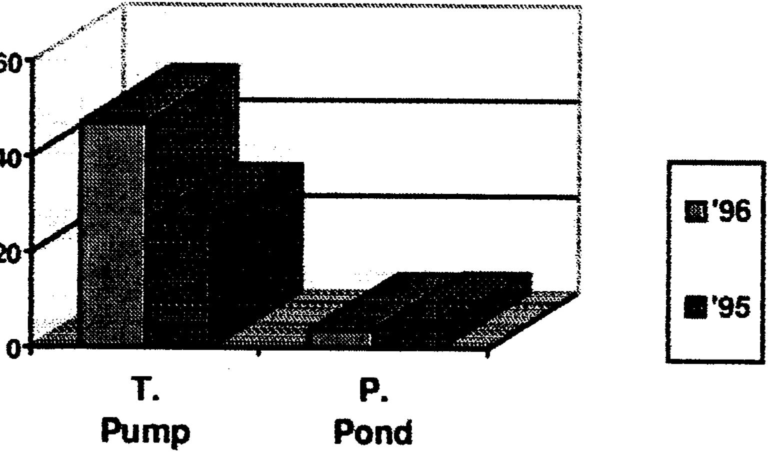

Figure 3 *Two year TPO4 concentration levels for Transfer Pump and Polishing Pond*

Reduction rates for BOD5, NH3N, TPO4, SS and E. coli are summarized in Table 3.

Reduction rates for BOD5, NH_{3}-N, Total Phosphate (TPO_4), suspended solids (S.S). and E. *coli* are summarized in Table 3.

Rates were based on taking the geometric average for a given parameter at the start of the system (influent-transfer pump 1995 & 1996) and comparing it to the geometric mean at the end of the system (effluent-polishing pond).

On a concentration basis, total removal rates for the entire system varied from 88% to 99% depending on the parameter type.

Removal efficiency rates varied depending on the system component. Over ninety percent removal was obtained for BOD5 and E. *coli* in the storage pond. Sixty percent of the TPO_4 removal occurred within the wetland complex while 45% of the suspended solids settled out in the storage pond and 45% settled out in the wetland.

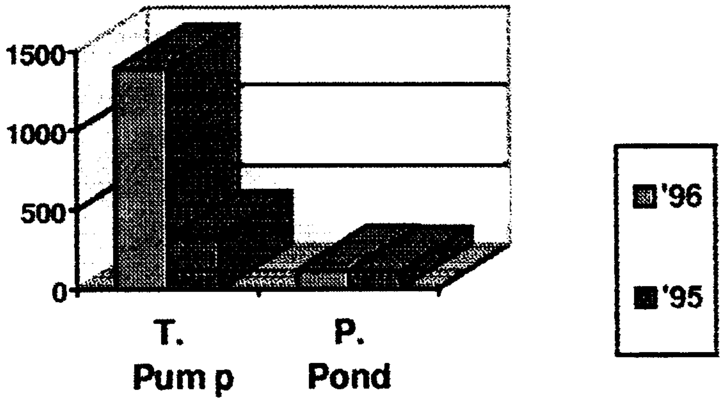

Figure 4 *Two year Suspended Solids concentration levels for Transfer Pump and Polishing Pond*

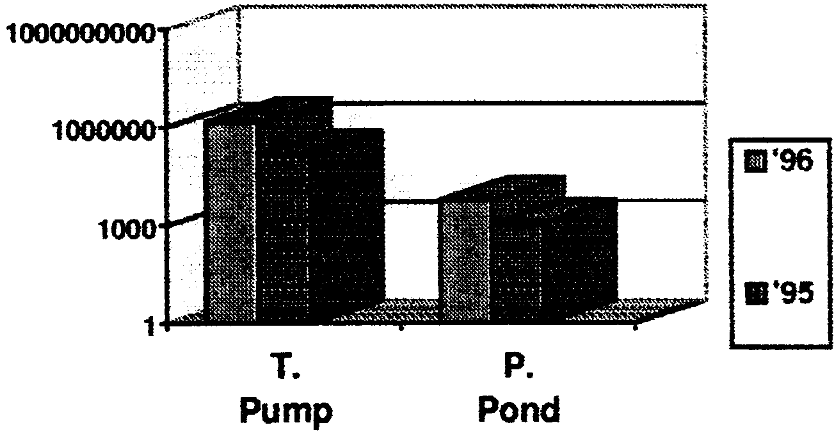

Figure 5 *Two year E. coli concentration levels for Transfer Pump and Polishing Pond*

Communication Activities

Sharing information was a major part of the Belle River Conservation Club's initiative in undertaking this project. Communication activities included: sharing information with farm organizations, report highlights in newsletters, media involvement and one on one personal contact. The following is a list of activities undertaken:

- A project brochure entitled *"A Constructed Wetland: Dairy Farms in Harmony with Nature was* produced and distributed.
- An open house media day was held in 1993 to showcase construction activities. Local and province wide newspapers, including the Ontario Farmer highlighted the constructed wetland.
- A table top display showing the various construction steps was made and taken to various agriculture events in the county.
- Numerous tours were held for venous farm groups including: Hamilton Wentworth Holstein Club and the Quebec Dairy Farmers Association. Tours were held for non-farm groups including: Fenco McClaren Engineering, ERCA Full Authority, the International Joint Commission, Canada Trust Friends of the Environment Foundation and the Windsor Chamber of Commerce.
- School groups were one focal point of information dissemination. Groups included over 4000 school kids from local high schools and elementary schools as well as students from the Ridgetown College of Agricultural Technology.
- The Malden Valley Farms Constructed Wetland was instrumental in developing technologies for other constructed wetlands in the Essex Region. Other wetlands have been constructed in the area including: Essex County Landfill (treat surface runoff) and storm water retention wetlands for the City of Windsor.
- Speaking engagements included the Soil & Crop Improvement Association Annual Meeting, Chatham; Green Plan Workshop, London: Drainage Superintendents Association Annual Meeting; London and the North American Engineers Conference in Guelph.

Overall sharing of information was a huge e success for the Belle River Conservation Club. Information was received positively by farmers and urbanites.

Discussion

This section serves as a quick question and answer section on questions most asked about the Malden Valley Farm Constructed Wetland.

What preliminary investigations did you do?

A preliminary investigation was carried out by Ms. Jennifer McLellan. Ontario Ministry of Agriculture, Food & Rural Affairs. Since the constructed wetland would be build similar to an earthen lagoon, the site had to meet earthen storage requirements as outlined by OMAFRA.

Based on the investigation results, the site met the requirements established by OMAFRA based on soil texture analysis and depth to groundwater.

It is highly advisable that a site inspection be conducted by a qualified agency prior to the design stage to help reduce costs.

How was the wetland designed?

Wetland design was based on rainfall and retention time. Using information available at the time of construction, a minimum retention time of 14 days was build into the construction using a 1:100 year storm event. This would allow for ample freeboard to avoid flooding problems.

Since the completion of the wetland at Malden Valley Farms, new design criteria has been established by experts in the United States. The criteria calls for the following:

- A maximum loading rate of nitrogen to the wetland equaling 3 kg/ha/day for (Hammer & Knight. 1994).
- A marsh-pond-marsh wetland system design (Hammer, 1994).

To help reduce BOD5 and nitrogen overload' a pretreatment anaerobic lagoon followed by an aerobic pond should be constructed prior to the marsh-pond-marsh complex (Mar. 1997. The Malden Valley Farm incorporated an anaerobic storage pond before the wetland. This helped to reduce BOD5 and nitrogen levels before the wastewater entered the wetland. It also allowed for solids to settle out. More importantly in southwestern Ontario climate, the anaerobic lagoon acts as a storage pond from November until April when ambient temperatures are less than ideal for wastewater treatment.

Potential muskrat problems should be taken into account with any wetland. When designing a wetland ensure all berms and pond walls are sufficient in width to avoid burrowing. At the Malden Valley Farms wetland muskrats burrowed up to 40 feet in length.

What are the optimum operating conditions?

Microbial activity is directly affected by temperature. As temperature values drop so to does microbial activity.

This affects the wetland treatment efficiencies especially for nitrogen which needs temperatures above 6°C to perform at optimum rates (Hammer, 1989).

For the Malden Valley farms constructed wetland. the optimum operating period for water temperatures above 6°C was from April l5 - October 31.

Do large solid particles affect wastewater treatment ?

Solids particles in a wetland causes the system to go from aerobic (oxygen rich) to anaerobic. This reduces the overall efficiency of the wetland Measures should be incorporated to reduce the amount of solid wastes that get into a wetland system

Can the water be "dumped"' back into a watercourse?

Any system that is "designed with an outlet that drains towards a watercourse or municipal drain is considered by OMEE under the Water Resources Act as a sewage works and will require a Certificate of Approval from the Regional OMEE office”. (OMEE, Science & Technology Branch, Jan., 1995).

Provincial Water Quality criteria have been established by the OMEE. At this time the treated water from the wetland system does not meet these standards.

Excess water was then land applied to pasture located directly beside polishing pond.

What permits, if any were required for construction'?

No permits were required for the wetland facility. It is our understanding at this time that is the system is enclosed with no outlet a permit from OMEE is not required. Approval was granted from the local municipality and conservation authority for this project. It is advisable that you contact the appropriate agencies prior to construction to avoid delays down the road.

How much would it cost to build a wetland ?

The cost of building the wetland component (storage pond/wetlandl/polishing pond) was $ 21,000. This did not include the cost of transfer pump or collection system.
The transfer collection costs would have been accrued whether the wastewater was pumped into a wetland or storage lagoon.
In comparison to other options (e.g. concrete holding tank $ 40,000) the wetland facility proved to be a viable alternative.
The Unholzer family also did not want to have to handle liquid manure due to the inconvenience factor. Added with this is the yearly operating costs of handling liquid manure which vary depending on various manure handling options.

Did you experience any management problems during the course of the demonstration?

Establishment of aquatic vegetation was the most difficult task. Vegetation growth was extremely successful in 1994 but, the success rate in 1995 & 1996 was less than ideal. A few factors can be attributed to this. They include:

- Muskrats invading the wetland
- High water elevations in the wetland in the spring of 1995

A few management changes were incorporated which helped relieve these problems. Water elevations were lowered over the fall/winter period in 1995. All of the water was pumped out of the polishing pond which allowed for extra overflow storage during the winter. Various wildlife management techniques were utilized to help control the muskrats population. Lower water levels (20 cm) restricted muskrat populations. Once one muskrat was caught and left on site, others seemed to flee the wetland.

Why did you switch from an agri-drain in-line control structure to timed pump?

The agri-drain was good at controlling water flow at the start. However, as time went the mechanism started to plug up as "solids from the wastewater adhered to the walls the agri-drain. The agri-drain also drained water from the bottom of the storage pond.
It was advantageous from to drain water from top of the storage pond as this water in the top column was "cleaner" in terms of water quality.
The sewage pump also allowed for superior regulation in terms of varying flows to the wetland during different time periods. as determined using an electronic timer.

What design criteria would you recommend?

Based on information from the United States and experience from other constructed wetlands in Ontario (including the MVF wetland) the following is suggested:

1. Total Nitrogen loading to a wetland should not exceed 3 kg /ha/day Hammer & Knight. 1994).
2. A anaerobic storage lagoon followed by an aerobic pond should be build prior to a wetland complex to help reduce nitrogen and BOD5 loading (Mar, 1997).
3. A marsh-pond-marsh complex is best suited for agriculture wastewater treatment (Hammer, 1994).

Design will ultimately depend on management practices and landowner preferences. For example, a landowner may want to these designs using a serpentine shaped wetland to increase aesthetics. A 365-day storage pond is also recommended to handle excess precipitation. Some form of grass overflow at the end of the polishing pond is needed to take care of any excess wastewater.

Economics should also be taken into account. Based on design criteria, it may not be economically feasible to try and build a system that will meet OMEE water quality guidelines. It may be more advantageous to build a wetland that meets certain reduction criteria where water can be applied to a grass filter at the least cost to the farmer.

What specific construction equipment would you recommend?

Equipment used at the Malden Valley Farm included a bulldozer. excavator and sheeps foot roller.

The sheeps foot roller was used to help compact the wetland during construction to help mitigate potential problems.

What techniques did you use to reduce the amount of wastewater that has to be treated?

All roof water was directed to Woltz Creek as clean water. If needed? this water could be redirected into the wetland system to help plant growth.

Conclusion

The Malden Valley Farms constructed wetland served as a valuable experience to research and explore alternative methods for handling wastewater wastes from a livestock operation. Although effluent water quality criteria will not meet OMEE's guidelines for direct discharge to a watercourse, the wetland serves as a feasible solution to the conventional methods of handling liquid manure.

More long term research data is needed for Ontario climatic conditions to determine if any long term release of nutrients back into the system will occur.

As design modifications are changed to reflect increased knowledge, newer and better systems will be designed. However, the economic and environmental costs of constructing a wetland has to be reviewed on a farm by farm basis. What is ultimately sound for one farm operation may not be feasible for another.

Thank You

The Belle River Conservation Club would like to thank Agriculture & Agri-Food Canada and the Rural Conservation Clubs Program for their funding assistance.

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- Ontario Ministry of Environment & Energy (Jim Eddie & Peter Mar) -technical support
- Canada Trust Friends of the Environment Foundation (monitoring equipment) - donation
- Ontario Ministry of Agriculture, Food & Rural Affairs (groundwater investigation) - Jennifer McLellan
- Agriculture & Agri-Food Canada - Harrow, Ontario
- Essex Region Conservation Authority

and finally ... Malden Valley Farms - Unholzer Family for their interest and perseverance in undertaking the project.

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