Agriculture Waste Management Program

1992/93 Final Report

Ministry of Environment
Upper Thames River Conservation Authority

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Acknowledgements

Funding for this program is provided by the Ministry of Environment and Energy, Southwest Region. Many thanks to Murray Blackie, MOEE and Stuart Thornley, MOEE for program input and financial support.

Executive Summary

Objectives and Findings

1.0 Initiate a study/demonstration project to set-up and monitor a wetland treatment system for manure runoff from a solid manure storage system.

- a wetland treatment system to treat solid manure runoff will be installed at a dairy farm in Fullarton township
- background research and a design (3 stage treatment) were completed by UTRCA staff
- due to wet weather, construction was postponed from November '92 to the spring of '93
- both surface and groundwater will be monitored

2.0 During winter conditions determine the effect of freezing temperatures on nutrients and bacteria in field spread manure.

- 6 study plots were set up at the Rick Arts farm in Kintore
- plots were spread with liquid pig manure (mixed with tracer bacteria)
- daily temperature and snow depth were monitored
- results suggest greater bacterial survival below the soil surface and with the insulating effect of snow cover
- very cold temperatures with bright sunlight increase bacteria die-off

3.0 Provide assistance on a study in cooperation with Agriculture Canada to monitor the effect of liquid manure application and management on surface and tile water quality from conservation tillage systems.

- the study in cooperation with Agriculture Canada is on-going at the McMurray farm in the Kintore area
- 30 plots were set up in May '92 to monitor surface runoff and infiltration to sub-surface tile
- a manure injector with a pre-cultivation attachment is being tested
- rainfall simulation runs were completed in May and June
- initial data suggests minimum tillage results in less tile contamination than no-till

4.0 Continue to monitor water quality in the Timms Creek sub-watershed to evaluate the effect of restricting cattle from the creek at the three access sites. Investigate and promote the remediation of failing septic systems in the Timms Creek watershed.

- 2 of the 3 cattle access sites in the watershed have been fenced
- bacteria levels remain elevated downstream of the unrestricted site

- preliminary results of benthic samples taken by a University of Waterloo student support the water chemistry findings
- all landowners were notified of the Timms Creek project and septic system grants available

5.0 Continue to monitor background and runoff event conditions of the Kintore Creek east and west sub-basins.

- a total of 28 routine sampling runs (196 samples) were carried out at the 7 sampling stations
- 19 storm event days (329 samples) were sampled at intervals throughout the event using ISCO automatic samplers
- samples were analyzed at the MOE Regional Lab in London

1.0 Constructed Wetland to Treat Barnyard Runoff Background

In the spring of 1992 Bill French, a Fullarton township dairy farmer approached the UTRCA at a Clean Up Rural Beaches (CURB) workshop with the idea of installing a marsh system to treat runoff from his dairy operation. Authority staff responded and initiated research into the project.

Prior to the installation of this type of project a zoning by-law amendment was required by the township of Fullarton. Because of the experimental nature of this project, a temporary use by-law (three year) was granted.

Research

A meeting was held in July 1992 to bring together people from MOE, OMAF, and Conservation Authorities who are particularly interested in the use of constructed wetlands for the treatment of agricultural waste. Since this meeting, much information has been gathered, mainly from sources in the United States. Several natural wetlands in the Fullarton area have been visited to determine vegetation types applicable to this project.

On September 21, as part of a UTRCA professional development tour, a constructed wetland designed to treat runoff from a dairy farm was viewed in Lagrange County, Indiana.

On March 29 to 30, 1993 staff attended an excellent short course on Building and Using Wetlands. This course was given by Michigan State University and the Michigan Department of Natural Resources.

Design and Construction

A design was completed by the Conservation Authority (Figure 1). Construction was scheduled to begin in October of 1992. Wet weather delayed construction attempts until November. In November the contractor was on-site and two test holes were dug. The water table was perched, approximately 3 ft from the ground surface. It was decided that the success of the project would be jeopardized if the construction took place in these less than ideal conditions. Construction was postponed until the spring of 1993. In November, while the contractor was on-site, some preliminary work re-routing field tiles around the future wetland area was completed.

The constructed wetland will be 0.8 acres in size and consist of a three stage treatment system. Runoff from the concrete yard and storage area will be temporarily ponded in a grassed settling area where water will drain slowly through a vertical pipe inlet to the second treatment cell.

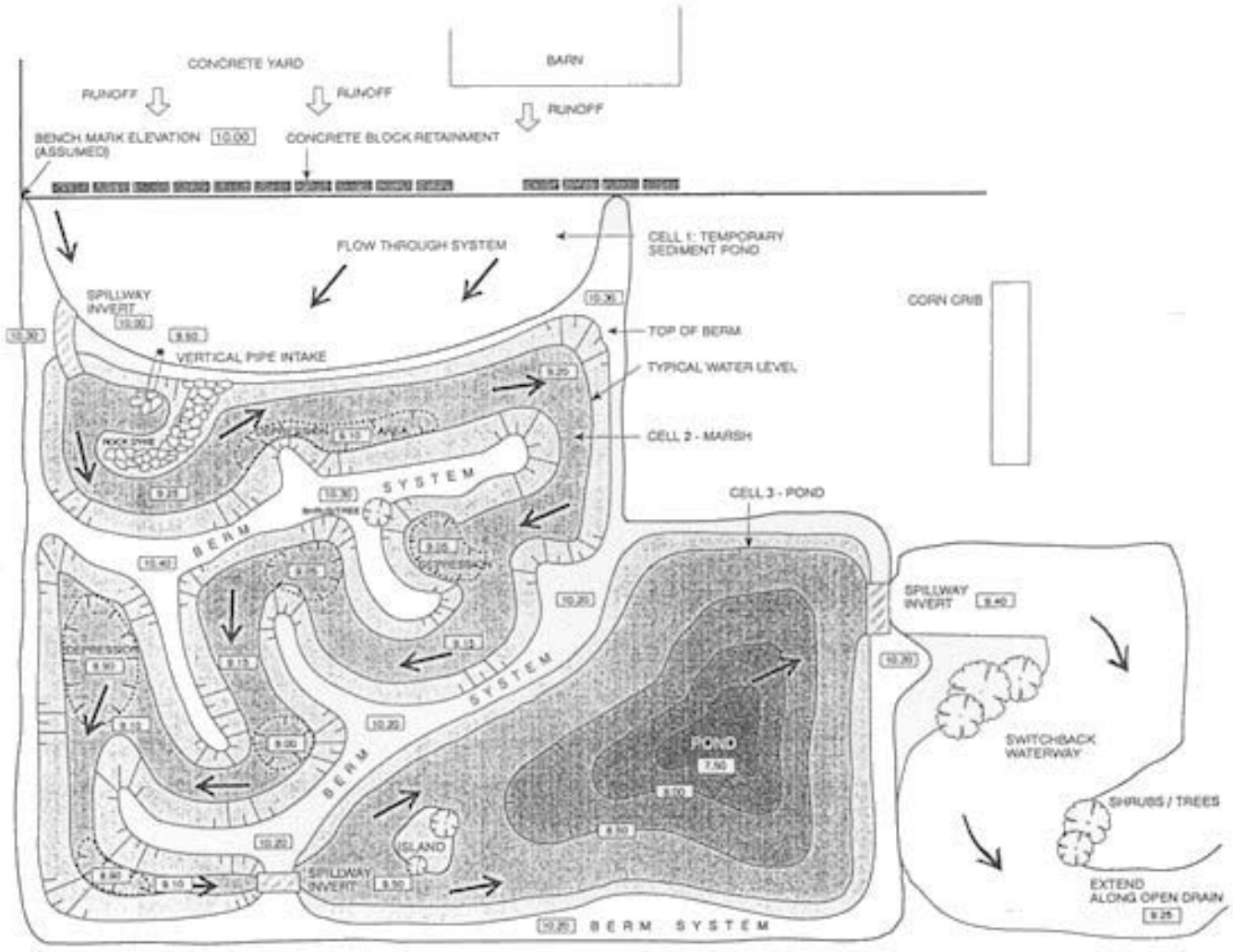


Figure 1: Constructed Wetland Design

The second cell is designed to move the runoff water through a shallow winding channel (20 to 30 cm deep) which will be planted with cattails and other marsh vegetation. Wetland vegetation and associated microorganisms will use up excess nutrients thereby acting to purify the runoff.

Water from the second cell will flow into a third pond-like area which will contain a variety of wetland vegetation suitable for shallow and deeper water. The system is designed to have very little effluent water leaving the system, however there will be a grassed waterway at the outlet of the wetland for additional filtering of any water leaving the system. Trees and shrubs will also be planted around the wetland to aid in nutrient uptake as well as providing habitat for wildlife.

Monitoring

Some monitoring equipment has been purchased for measuring water flow through the wetland as well as rainfall and water temperature. Two data loggers, 2 pressure transducers, one tipping bucket, and one temperature probe have been purchased. This equipment was acquired with funds from Canada Trust's Friends of the Environment Foundation in Stratford. An additional pressure transducer and data logger will be needed to complete the desired flow monitoring. Funds are still required for the purchase of this equipment. Three weirs will be designed and constructed by authority staff for the outlet of the first bermed area, the outlet of the serpentine channel, and the outlet of the ponded area.

Water quality samples should be taken at the outlet of each of the three areas (in conjunction with the flow monitoring). Additional samples should be taken at various stages of the serpentine channel and the pond. The following parameters should be measured: BOD, free ammonia, total kjeldahl, nitrite, nitrate, total phosphorus, dissolved reactive phosphorus, pH, suspended solids, conductivity, total coliforms, fecal coliforms, *E. coli,* and *Pseudomonas aeruginosa.*

Groundwater will be monitored below the wetland. Centralia College researchers will do the groundwater monitoring. Background soil testing has been initiated and piezometers are being installed.

Other specific monitoring to determine microscale relationships within the wetland will be conducted by University of Waterloo researchers.

Partners

This constructed wetland project has generated much interest from organizations and individual farmers. Attempts will be made to establish partners while maintaining control of the overall project (coordinating construction, transplanting, monitoring, reporting and media contacts).

Partners Involvement

Task	Responsible
Coordinating Project (reports, media contacts, long term coordination)	UTRCA
Background Research and Design	UTRCA, landowner
Background hydrology and soils analysis	Centralia College
Construction	UTRCA, landowner
Vegetation Transplanting and propagation	UTRCA, volunteer groups
Groundwater Monitoring	Centralia College
Surface Water Monitoring	UTRCA
Microscale studies	University of Waterloo
Maintenance	landowner (long term maintenance) and UTRCA

Students from Northwestern Secondary School in Stratford will be assisting in transplanting cattails and bulrushes into the wetland.

The Essex Region Conservation Authority is also developing a constructed wetland for manure runoff. Attempts will be made to coordinate the studies to enhance this research.

Funding

Funding for this project has come from several sources. Staffing has been funded through the Ministry of the Environment SW Region Agriculture Waste Management program. The Clean Up Rural Beaches (CURB) program is partially funding the construction of the project. The landowner will cover the other costs of the project installation. The Canada Trust Friends of the Environment Foundation is funding some of the monitoring equipment needed to assess this project.

It is anticipated that the wetland will take several years to establish enough vegetation to reach its treatment potential. Funds are required for staffing and lab support for long-term monitoring, assessment, and revisions to the design.

If the project proves successful it will provide a low-cost alternative for handling barnyard runoff with the added benefit of providing some wildlife habitat.

Media

Country Guide magazine covered the proposed constructed wetland project at the French farm in their March '93 issue (see attachment 1).

Ontario Farmer - Spring '93 Dairy Edition article

Talk of the Thames UTRCA newsletter

UTRCA staff will be putting together a video covering the construction, monitoring, and progress of the wetland treatment system.

2.0 Winter Spreading Study

The land spreading of manure during winter conditions is a common practice among rural landowners. Survival rates of bacteria in manure over winter have not been well documented. The CURB model, developed to identify source impacts to water quality, did not have a strong Ontario literature backing for the determination of the impacts of winter spread manure.

In an effort to gain more insight into the acceptable field conditions for the spreading of manure, a winter spreading study was initiated. The purpose of the study was to determine the effects of various winter conditions on nutrients and bacteria in field spread manure. This will help to indicate key factors that may lead to bacteria die-off or survival, and to provide more information for the CURB model.

Procedure

The study took place on the farm of Rick Arts, lot 17, concession 11, Zorra Township. UTRCA staff selected a site where the field trials would be accessible and liquid manure was accessible. Six open-top plastic containers (38 cm x 28 cm x 16 cm deep) were placed side by side in an open area of a harvested, unplowed corn field. Each container was then filled with the excavated soil block. The containers were placed so that the top of each was flush with the ground surface.

A sample of liquid manure was taken from the pit on site, and analyzed at the Ministry of the Environment Microbiology laboratory to determine the existing concentrations of Fecal Coliform bacteria. Tracer bacteria *E.coli* NAL was produced in a similar concentration to that measured in the manure.

After the soil in each container had frozen, 630 ml of a manure and tracer bacteria mixture was manually applied to evenly cover the surface of each plot. The rate of application was comparable to 6000 gallons/acre. Manure was applied at time zero and a sample of manure plus tracer, and a sample of surface applied soil were taken to the laboratory for analysis of bacteria and chemical parameters (DOC, Ammonia, Nitrate and Soluble Phosphorus).

Following the application of manure, one container (or half container) was removed at regular intervals and taken to the lab for analysis. Sample were taken on day 6, day 8, day 14, day 28, day 41, day 50, day 55 and day 69. Sampling took place from February 4 to April 13, 1993. Each soil block taken to the lab from the site was sampled at two depths, 1-1.5 inches from the surface and 1.5 inches above the bottom of the block. Twenty grams of the sediment was sampled for each depth. Buffered water was added and the sample was homogenized. Several dilutions were inoculated and incubated for various time periods. The Most Probable Number method was used for bacteria enumeration.

The maximum, minimum and current air temperatures and the snow depth were recorded daily on each plot by the landowner.

Results

A significant die-off (log 3) in the surface level of the tracer bacteria occurred between time 0 and day 6. During this period there was little to no snow cover on the plots (Figure 3). Temperatures were continuously cold (Figure 2) and there was a high number of bright sunlight hours (Figure 4). The first depth sample on Day 14 showed that bacteria in the bottom of the plots were one log higher in number than at the surface. This difference remained consistent until the soil was totally thawed in the plots and became mixed. After the significant decrease in numbers between time 0 and day 6, surface levels of bacteria continued to decline at a fairly constant and gradual rate until day 28. The surface sample on day 41 showed slightly higher values and numbers increased again day 50. The depth sample results showed bacteria numbers to continuing to decrease at a slow rate until Day 50 when an increase in numbers occurred. By Day 50 the snow cover was melting as a result of warmer temperatures (Figures 2,3). The soil was still frozen at this date. The soil within the plots was fully thawed by Day 55 and the samples became mixed during transport to the lab. A large decrease in numbers was measured on Day 55. There was no snow cover on the plot on this day. The sample at Day 69 showed an increase in bacteria numbers (Figure 2). The plot was well thawed at this point and very moist. The temperature at the end of the sampling period averaged well above zero degrees.

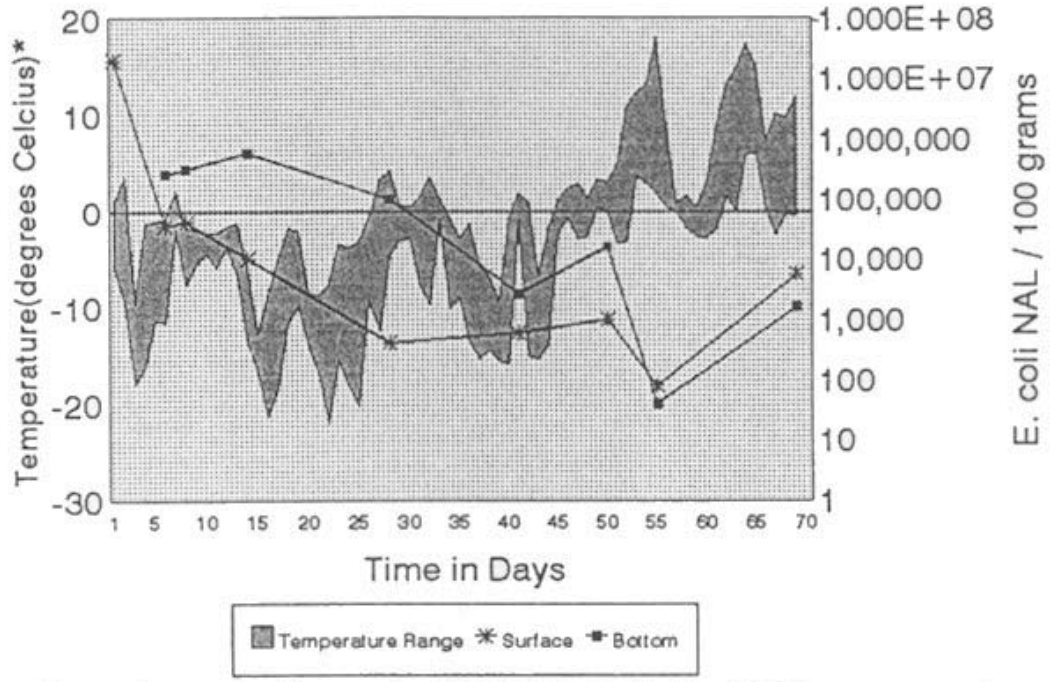


Figure 2: Winter Manure Spreading Study: Bacteria Survival

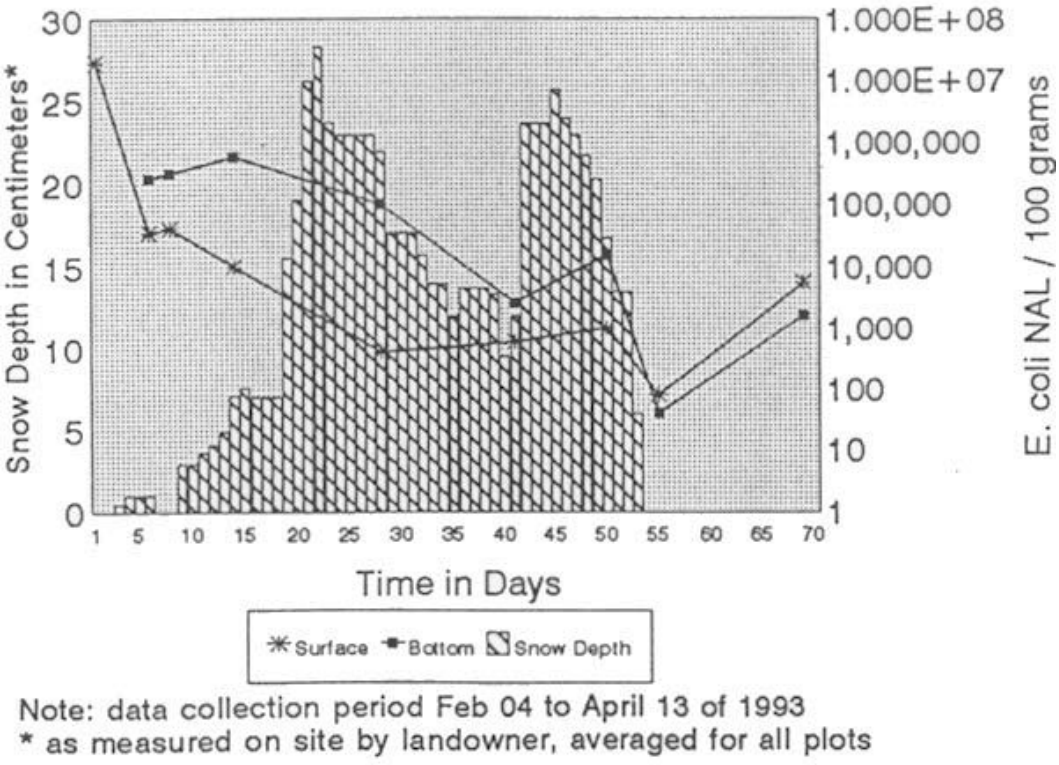


Figure 3: Winter Manure Spreading Study: Bacteria Survival

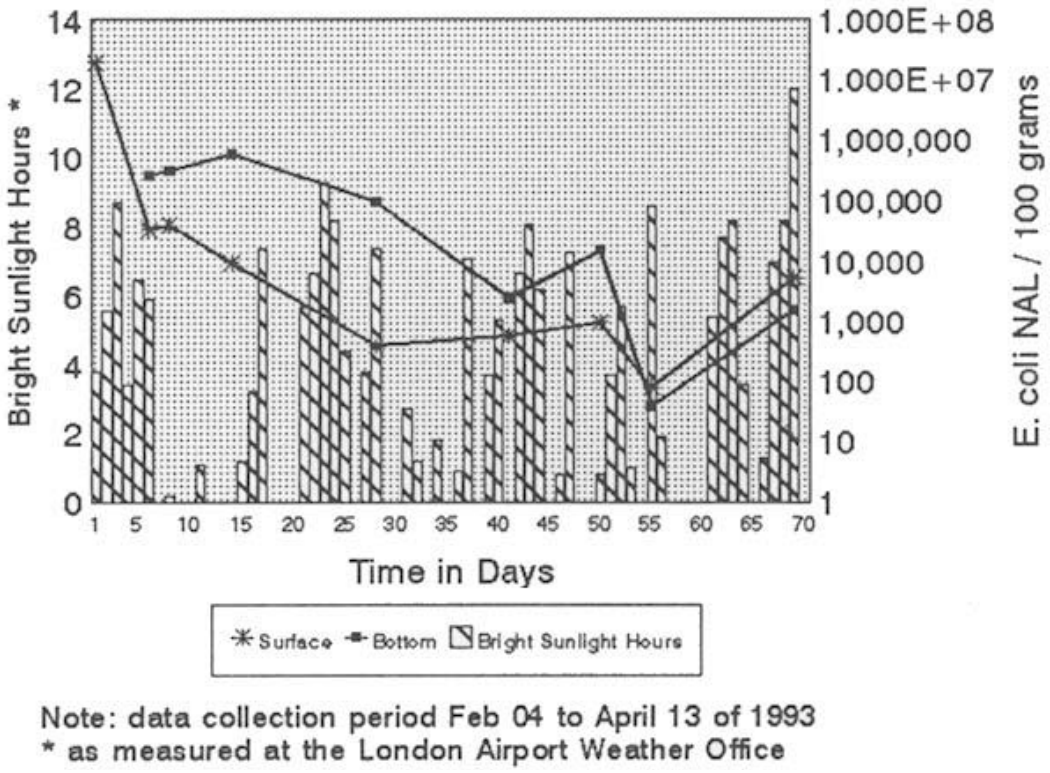


Figure 4: Winter Manure Spreading Study: Bacteria Survival

Discussion

Results show that the bacteria on the surface of the soil had a higher initial rate of die-off than the bacteria at the bottom of the soil blocks. The dramatic decrease in numbers observed over the first 6 days of the project may have been caused by desiccation as a result of dry, cold, and sunny conditions. Following the start of snow cover, the die-off rates decreased suggesting that snow acted as a protective insulator. Any moisture in the soil appeared to be less stressful to the bacteria than dry and cold conditions.

The die-off rate of the bottom bacteria increased following day 28 and became higher than that on the surface, where levels seemed to reach a plateau and then start to increase. At that time temperatures were slightly warmer and the snow cover was beginning to melt. At Day 50 both sample locations showed increased bacteria levels followed by a dramatic decrease on day 55. The thawing of the soil in the plots may have shocked the bacteria enough to cause this high die-off rate. However, once the plot remained thawed, the bacteria appear to have recovered to levels near those before the thaw. The moist soil and warm temperatures appear to have allowed this bacteria growth.

Conclusions and Summary

In summarizing the findings, it appears that dry, frozen, and bright sunny conditions provide the greatest die-off of bacteria in winter field spread manure. However, re-growth can occur if some bacteria have survived and temperatures become warm and soil moisture increases. Bacteria in manure which seeps below the soil surface also shows a greater rate of survival over bacteria on the soil surface. These findings suggest that optimum conditions for minimizing bacterial pollution during winter spreading are during an extended dry, sunny, and freezing period with no snow cover.

More data should be gathered to determine whether some of the apparent surface die-off is due to downward movement of the bacteria within the soil column following manure spreading.

3.0 Manure Application Study

UTRCA staff are working in conjunction with Agriculture Canada on a study to determine manure application methods and tillage practices which minimize surface runoff and manure infiltration to tiles.

Methods and Results

Thirty plots (1m x 1m) were set up in May 1992. Three tiles were installed under each plot to monitor downward movement of contaminants. Surface runoff collection pans were also installed.

Working with a Husky equipment dealership, a manure tanker has been modified by adding a pre-cultivation attachment. The intent of this unit to break up any soil macropores ahead of the manure injectors. Modifications are still being made to the attachment in order to reduce the amount of disturbance to the soil.

Both no-till and minimum-till plots planted with corn were used in the study. Plots received a specific manure application treatment; conventional injection, modified injection, surface applied, surface applied and incorporate, or control.

One rainfall simulation run was completed in May with a second run in June after the corn was up. Results of these trials suggest the minimum-till plots had less contamination of the tiles than no-till. However, not enough data is available to make any conclusions on the effects of the modified injection or the type of tillage. A third rainfall simulation was scheduled for November 1992 but had to be cancelled because wet weather prevented the corn harvest in the study field.

Due to the contract agreement, this two-year study will be going to field scale in 1993. A field in the Kintore area will be used for this phase of the study. Further rainfall simulation trials on the test plots will also be done in 1993.

Demonstration Day

A demonstration day held in Kintore on August 25, 1992, featured the Husky manure tanker with the pre-cultivation injector unit along with a computerized Ag Canada Tractor. The tractor will measure the power requirements of the injector unit. This media day had 7 local and farm newspapers covering both the event and information of the manure application study and the Kintore Creek study.

4.0 Timms Creek Subwatershed Project

Background

A livestock fencing project was initiated in 1991 along the Timms Creek which flows into the north east end of the Pittock Reservoir. The three cattle access sites located along this creek were targeted for remedial work.

The Timms Creek Project is the co-operative effort of several agencies. The Ministry of Environment Agriculture Waste Management Program provided funding for both landowner assistance with projects and water quality monitoring. Through the Ministry of Natural Resources' Community Fisheries Improvement Program, the Oxford Fish and Game Protection Association was involved in the project installations. As well, U.T.R.C.A. staff coordinated the Timms Creek Project, designed and oversaw the installation of a crossing, and monitored the water quality. Several other local interest groups were also involved.

In 1991, two of the livestock access restrictions were completed. Site 1 (figure 5) included the installation of an above grade crossing and 2400 feet of high tensile fencing. On Site 3, 3000 feet of fencing was installed in an area where an above grade crossing was already present. The installation of fencing and alternate watering facilities for Site 2 was scheduled for the spring of 1992. However due to continued reluctance by the landowner to complete this work, Site 2 still has livestock access. The landowner is waiting to find an adequate alternative watering source before proceeding. While this has slowed the overall remediation of this sub-watershed, it does provide an opportunity to compare restricted and non-restricted sites.

Water Monitoring Results

Of the three access sites monitored Site 3 (livestock restricted) shows the best results for the upstream-downstream comparison. Mean monthly *E. coli* concentrations were found to be lower downstream for all eight months in which samples were taken (figure 8). The mean *E. coli* concentration upstream was 274 per 100 ml while downstream was 43 per 100 ml. At Site 1 (livestock restricted) upstream and downstream sample results were similar (figure 6). Mean monthly *E. coli* concentrations for four of the eight months were higher in downstream water. However, two of these downstream samples were still below the MOE guideline level. At Site 2 (unrestricted access) five of the eight mean monthly downstream concentrations were found to be higher than upstream values (figure 7). The mean upstream *E. coli* concentration for Site 2 was 187 per 100 ml compared to 494 per 100 ml downstream.

Total phosphorous concentrations upstream and downstream of these three sites were generally consistent (figures 9, 10, and 11). Site 3 was the only site where any significant downstream improvements were found (figure 11). The mean annual concentration upstream of Site 3 ranged between 0.085 and 0.104 mg/L while the mean concentration downstream of Site 3 was 0.052 mg/L.

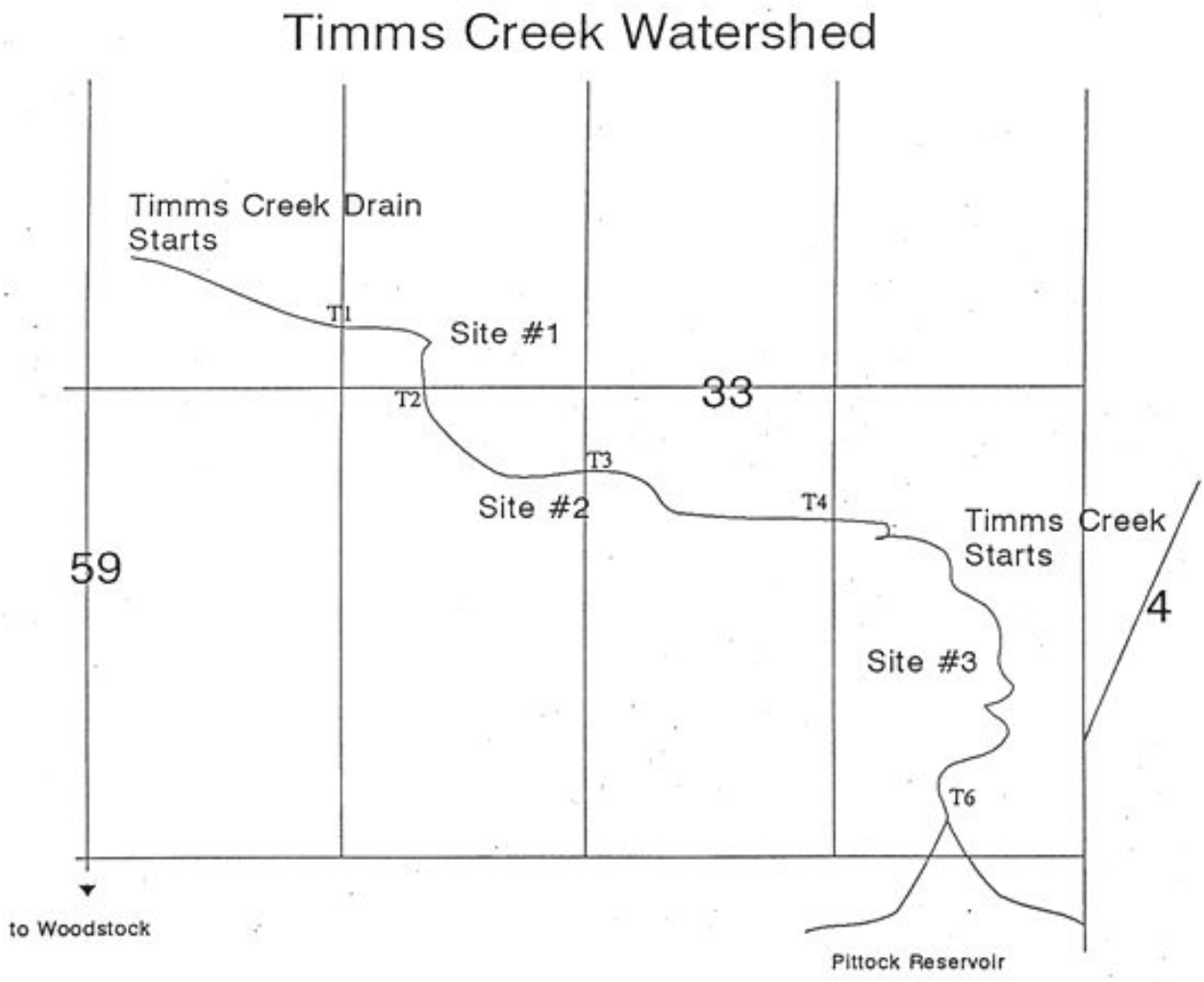


Figure 5: Timms Creek Demonstration Project Sites

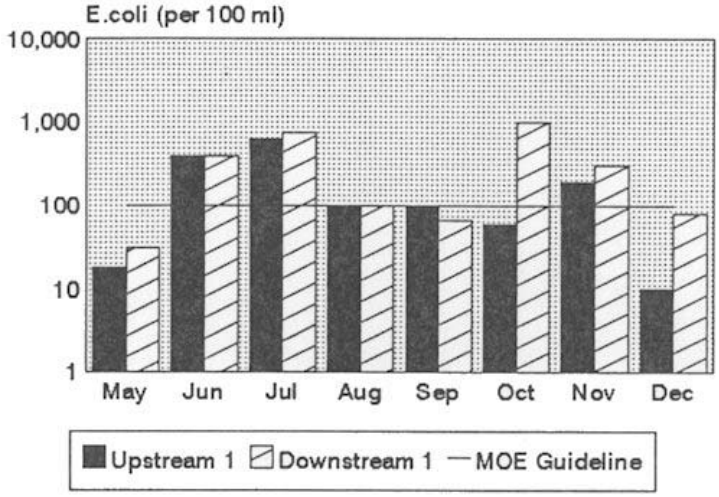


Figure 6: TIMMS CREEK: Mean Monthly *E. coli* Concentrations 1992 Upstream/Downsream Access Site 1

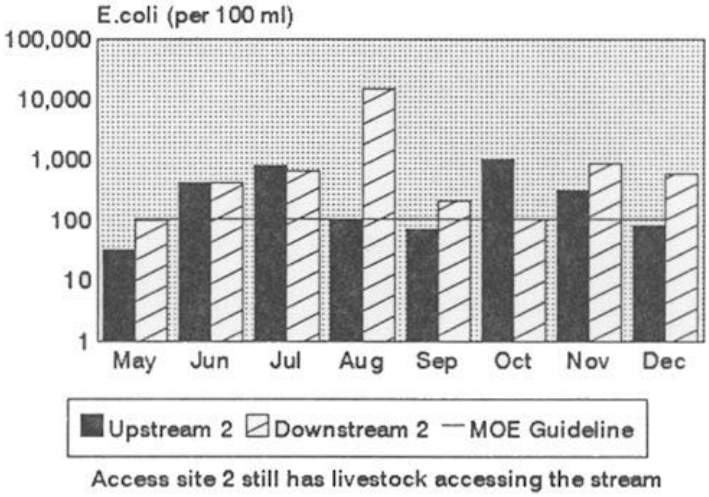


Figure 7: TIMMS CREEK: Mean Monthly *E.coli* Concentrations 1992 Upstream/Downsream Access Site 2

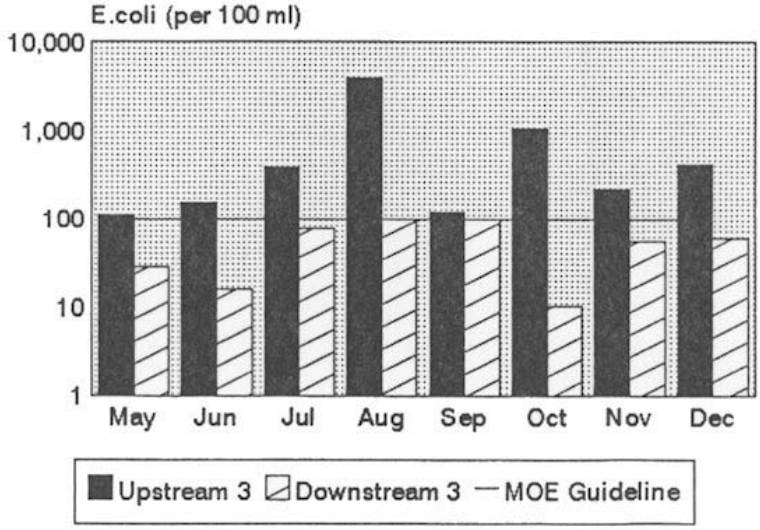


Figure 8: **TIMMS CREEK:** Mean Monthly *E. coli* Concentrations 1992 Upstream/Downsream Access Site 3

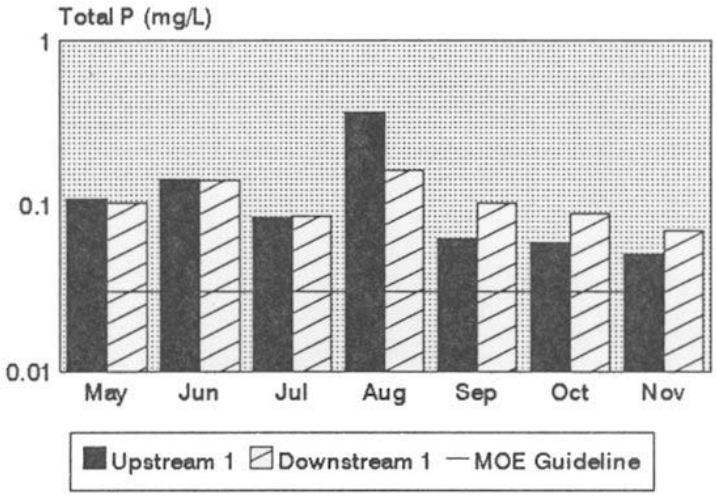


Figure 9: **TIMMS CREEK:** Mean Monthly Total P Concentrations 1992 Upstream/Downsream Access Site 1

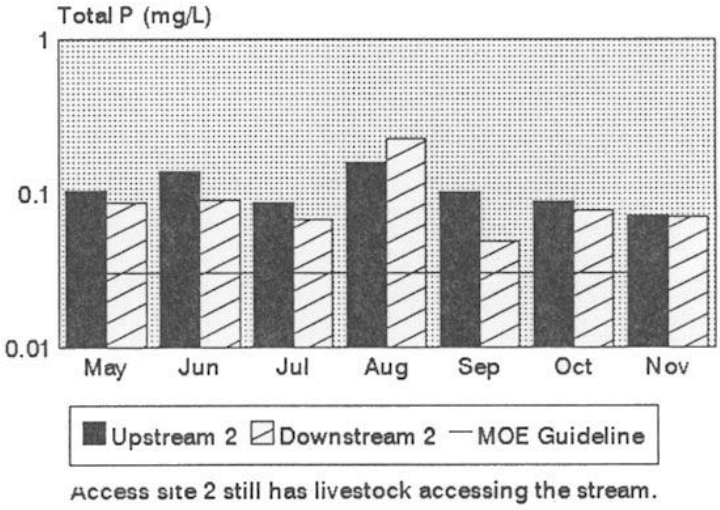


Figure 10: **TIMMS CREEK:** Mean Monthly Total P Concentrations 1992 Upstream/Downsream Access Site 2

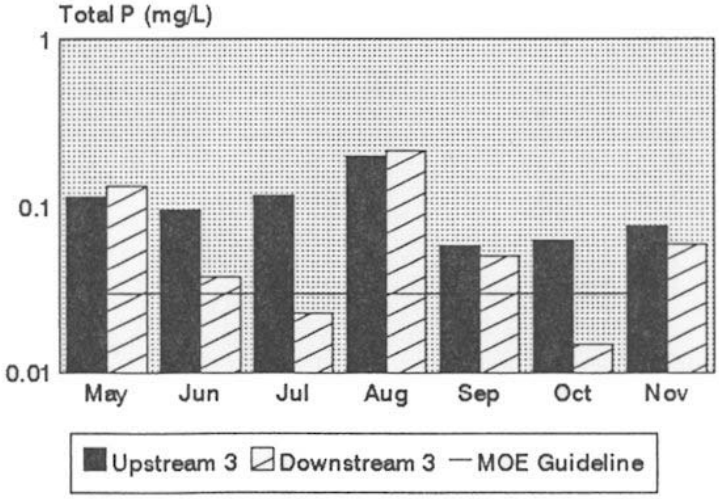


Figure 11: **TIMMS CREEK:** Mean Monthly Total P Concentrations 1992 Upstream/Downsream Access Site 3

Additional Monitoring

In the summer of 1992 a University of Waterloo student began a thesis project which involved benthic sampling of Timms creek. Sampling sites were coordinated with those monitored by the UTRCA for bacteria and chemistry parameters.

Initial results have shown that the benthic organisms present reflect the chemical and bacterial water quality results. Organisms indicative of poorer water quality were present immediately downstream of the unrestricted access Site 2. Further data interpretation is in progress.

Water temperature, stream morphology, and fish populations are also being monitored to identify changes as a result of the remedial work. A fish inventory was completed in the fall of 1990 before any work was initiated. These inventories will continue on an annual basis to note any changes that have taken place.

Other Work

Some elevated levels of contamination at the headwaters of this watershed have indicated the presence of faulty septic systems in the watershed. A letter was sent out to landowners in the watershed explaining the Timms Creek project and providing information on CURB grants available to replace or upgrade faulty systems. To date only one landowner has requested assistance.

The Timms Creek Demonstration Project has been part of several tours through the area including an S.W.C.S. tour and the Rural Routes '92 tour in June. A sign on county road 33 identifies the Timms Creek Project.

5.0 Kintore Creek Monitoring

Routine sampling of the Kintore Creek east and west sub-basins took place from January 15, 1992 through to December 10, 1992 at the 7 sampling stations (Figure 12). 28 background sampling runs were carried out. The total number of water samples collected at the 7 sampling stations was 196. At the MOE laboratory, these samples were analyzed for Total Phosphorus, Suspended Solids, four forms of Nitrogen, pH, Conductivity, and Soluble Reactive Phosphorus. The SRP samples were field filtered before being analyzed at the laboratory. Results of the routine sampling analysis are presented in Tables 1 to 7.

In addition to the background samples collected, 19 storm events (329 storm samples) were monitored using the ISCO automatic samplers located at the two sub-watershed outlets. The samplers were activated by depth level actuators to collect water throughout the storm hydrograph. These samples were analyzed for Total Phosphorus and Suspended Solids. The data is summarized in Tables 8 and 9.

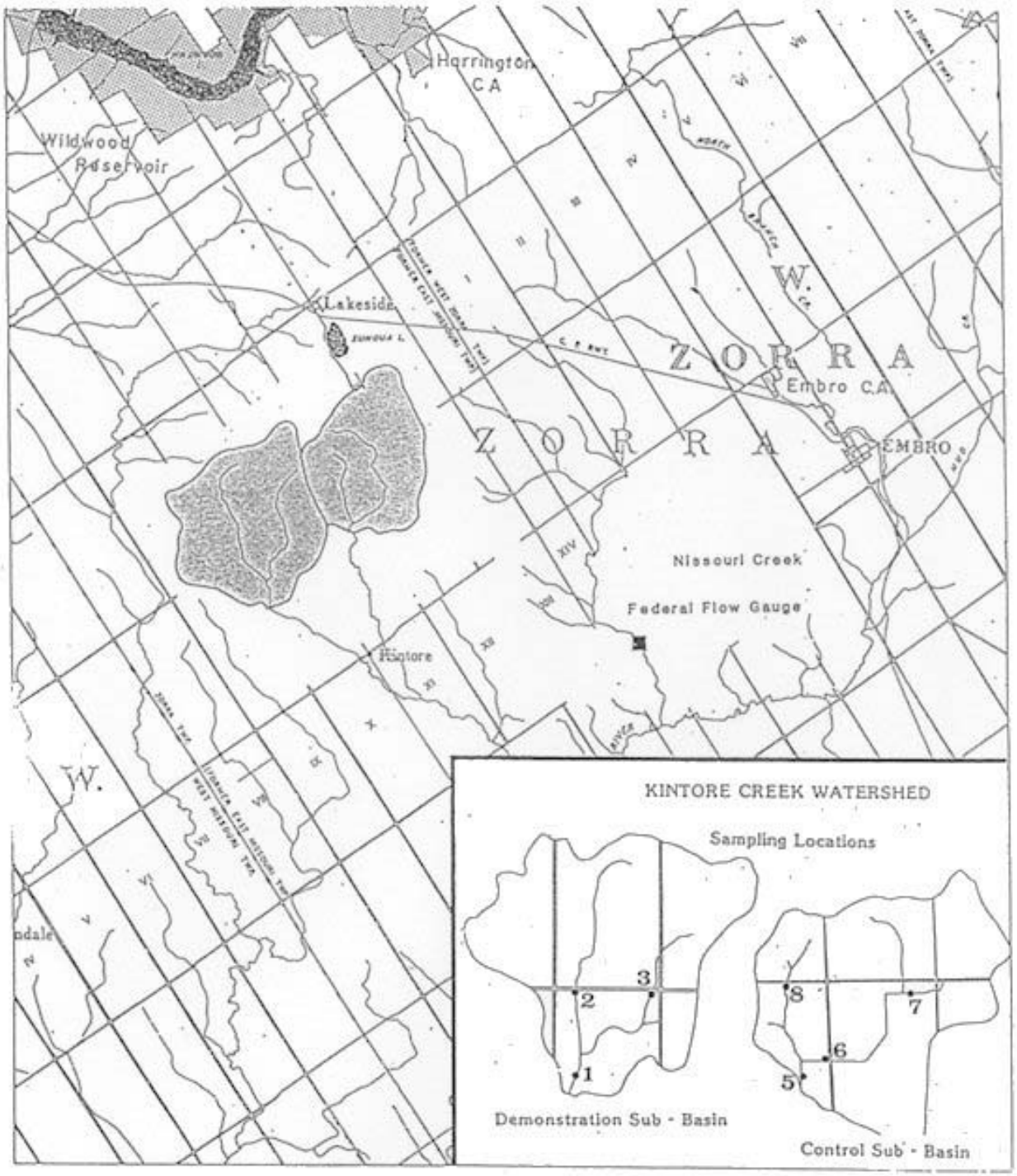


Figure 12: Kintore Creek Water Sampling Locations

Table 1: STATION 1, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
21-Feb-92	1115	0.648		5.0	0.616	1.22	0.030	10.9	0.115		7.95	631
02-Mar-92	1125	0.625		5.0	0.236	0.91	0.020		0.065	0.063	7.98	649
03-Mar-92	1215	0.775	4.0	5.0	0.023	0.86	0.240	9.9	0.081	0.045	7.62	526
02-Apr-92	945	0.558		5.0	0.044	0.42	0.040	6.6	0.019	0.006	8.07	601
13 -Apr-92	1105	0.549		3.3	0.111	0.47	0.040	6.8	0.013	0.006	8.23	624
27-May-92	931	0.500		5.0	0.019	0.45	0.040	6.5	0.009	0.003	8.18	638
01-Jun-92	934	0.520		6.0	0.050	0.50	0.040	5.7	0.014	0.006	8.32	618
08-Jun-92	944	0.510		5.0	0.029	0.52	0.030	5.7	0.018	0.002	8.44	638
15-Jun-92	1030	0.490	14.0	21.4	0.048	0.'75	0.020	5.3	0.051	0.006	8.34	642
22-Jun-92	1307	0.510	18.0	7.4	0.038	0.47	0.010	6.2	0.073	0.003	8.23	619
29-Jun-92	950	0.510	15.5	10.9	0.076	0.46	0.020	5.8	0.033	0.021	8.38	630
07-Jul-92	944	0.510	13.0	5.7	0.040	0.42	0.020	5.1	0.018	0.011	8.19	626
08-Jul-92	1510	0.598		80.1	0.100	1.39	0.020	3.7	0.180	0.080	7.87	444
13-Jul-92	910	0.544	15.5	5.0	0.005	0.53	0.030	6.0	0.027		8.20	667
17-Jul-92	1425	1.171		207.0	0.010	2.75	0.030	8.5	0.505	0.035	7.57	483
27-Jul-92	931	0.564	14.0	3.3	0.012	0.56	0.058	7.7	0.020	0.006	7.97	676
04-Aug-92	917	0.548	13.5	5.0	0.021	0.45	0.120	6.4	0.018	0.007	8.12	661
11-Aug-92	1000	0.560	14.0	5.0	0.013	0.49	0.010	5.7	0.019	0.001	8.09	681
17-Aug-92	1110	0.580	14.0	5.0	0.028	0.56	0.010	5.2	0.016	0.004	8.08	688
31-Aug-92	935	0.620		5.0	0.099	0.79	0.050	7.7	0.046	0.024	7.97	705
08-Sep-92	1200	0.738	16.5	16.5	0.087	0.73	0.070	7.2	0.069	0.035	7.74	691
10-Sep-92	1540	0.965	17.5	26.4	0.014	1.12	0.080	5.1	0.116	0.079	7.78	589
22-Sep-92	838	1.158		102.0	0.207	1.95	0.020	4.0	0.330	0.057	7.49	482
29-Sep-92	1135	0.592	12.0	5.0	0.021	0.44	0.010	6.6	0.016	0.014	8.17	713
06-Oct-92	1120	0.580	10.0		0.001	0.38	0.010	7.2	0.011	0.001	8.16	658
13-Oct-92	1305	0.585	11.0	5.0	0.030	0.41	0.010	5.2	0.012	0.001	8.25	656
15-Oct-92	1055	1.250	10.0	251.0	0.001	2.70	0.020	3.9	0.620		7.46	390
20-Oct-92	1035	0.645	8.0	5.0	0.026	0.53	0.010	5.1	0.026	0.010	7.99	693
27-Oct-92	945	0.602	9.0		0.067	0.68	0.010	6.4	0.077	0.008	8.06	693
09-Nov-92	1125	0.617	7.0	5.0	0.008	0.44	0.020	6.7	0.015	0.001	7.90	680
12-Nov-92	1239	1.230		303.0	0.221	3.25	0.050	3.2	0.665		7.39	399
23-Nov-92	955	0.905	6.0	41.4	0.141	1.60	0.050	5.5	0.228		7.60	548
02-Dec-92	920	0.625	6.5	7.9	0.066	0.51	0.020	6.3	0.031	0.015	7.91	662
14-Dec-92	935	0.620	3.5	5.0	0.073	0.37	0.020	7.5	3.035		8.06	666
21-Dec-92	935	0.640	3.0	12.2	0.010	0.46	0.020	6.3	0.023	0.001	7.78	671

Table 2: KINTORE CREEK WATER SAMPLING DATA, STATION 2, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92				5.0	0.064	0.39	0.030	5.0	0.013		8.12	586
21-Feb-92	940	0.910	2.5	7.1	0.168	0.79	0.020	7.8	0.046		7.98	565
21-Feb-92	1030	0.910		5.0	0.004	0.63	0.010	5.0	0.028		7.92	470
02-Mar-92	1100	0.870		5.0	0.030	0.53	0.010		0.024	0.010	7.86	570
09-Mar-92	1140	1.075	4.5	5.0	0.063	0.62	0.060	7.7	0.075	0.039	7.68	474
02-Apr-92	1000	0.730		5.0	0.008	0.37	0.040	4.1	0.012	0.116	8.10	553
13-Apr-92	1230	0.740		3.3	0.034	0.44	0.030	4.1	0.013	0.002	8.33	555
27-May-92	1110	0.660		5.2	0.030	0.37	0.020	3.5	0.040	0.021	8.27	579
01-Jun-92	1155	0.705		6.1	0.045	0.47	0.030	3.8	0.016	0.002	8.40	570
08-Jun-92	1145	0.690		5.0	0.001	0.42	0.010	3.4	0.016		8.52	585
15-Jun-92	1200	0.630	17.0	6.2	0.078	0.26	0.010	2.8	0.016	0.011	8.50	573
22-Jun-92	1700	0.650	15.0	6.7	0.019	0.46	0.010	4.2	0.020	0.001	8.26	578
29-Jun-92	1120	0.660	12.5	7.1	0.030	0.38	0.020	3.5	0.019	0.002	8.37	578
07-Jul-92	1137	0.640	15.0	7.1	0.023	0.36	0.020	3.0	0.015	0.002	8.31	573
08-Jul-92	1450	2.250		476.0	0.100	3.38	0.020	5.8	0.780	0.010	7.57	321
13-Jul-92	1115	0.700	16.5	5.0	0.003	0.48	0.010	4.0	0.024		8.27	600
17-Jul-92	1326	2.200		376.0	0.038	3.35	0.020	5.8	0.645	0.032	7.55	427
21-Jul-92	1418	0.760	15.5	5.5	0.004	0.61	0.040	6.2	0.028	0.010	7.87	621
27-Jul-92	1200	0.710	16.0	5.0	0.019	0.48	0.040	4.8	0.015	0.001	8.11	610
04-Aug-92	1120	0.674	14.5	5.0	0.019	0.42	0.070	3.8	0.012	0.006	8.10	594
06-Aug-92	1145		16.0	5.0	0.001	0.38	0.010	2.7	0.018	0.002	8.28	571
11-Aug-92	1210	0.698	16.5	5.0	0.022	0.41	0.010	3.5	0.017	0.001	8.20	605
17-Aug-92	1255	0.735	15.0	5.0	0.018	0.47	0.010	3.5	0.014	0.002	8.13	631
31-Aug-92	1423	0.780		5.0	0.011	0.60	0.020	5.8	0.023	0.007	8.10	637
08-Sep-92				39.0	0.030	1.38	0.050	3.5	0.120	0.037	7.80	557
10-Sep-92	1347	0.650	16.5	30.6	0.018	1.03	0.080	6.9	0.106	0.032	7.78	634
22-Sep-92	1021	2.000		33.0	0.005	1.24	0.010	3.3	0.145	0.030	7.61	510
29-Sep-92	1340	1.260	12.0	5.0	0.017	0.41	0.010	3.8	0.012	0.010	8.26	641
06-Oct-92	1105	0.770	10.0	5.0	0.001	0.34	0.010	3.5	0.011	0.002	8.33	603
13-Oct-92	1535	0.800	10.0	5.0	0.001	0.36	0.010	3.3	0.018	0.001	8.32	617
15-Oct-92	1400	2.480	11.0	45.1	0.042	1.34	0.010	2.9	0.212		7.63	381
20-Oct-92	1300	0.945	8.0	5.0	0.023	0.46	0.010	4.2	0.014	0.004	7.99	623
27-Oct-92	1105	0.900	8.5	5.0	0.042	0.43	0.010	3.8	0.015	0.001	8.12	613
09-Nov-92	1415	0.960	7.0	5.0	0.011	0.38	0.010	4.2	0.011	0.001	7.99	625
12-Nov-92	1500	2.800		169.0	0.031	2.00	0.040	2.3	0.455		7.34	316
23-Nov-92	1355	1.490	7.0	21.3	0.108	1.50	0.020	5.4	0.182		7.70	580
02-Dec-92	1110	1.190	6.0	5.2	0.017	0.38	0.010	4.6	0.018	0.004	8.00	613
14-Dec-92	1145	1.170	5.0	5.0	0.008	0.37	0.010	5.6	0.014		8.12	620
21-Dec-92	1050	1.170	4.0	5.0	0.020	0.46	0.010	5.2	0.020	0.001	7.82	634

Table 3: KINTORE CREEK WATER SAMPLING DATA, STATION 3, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92				13.8	0.008	0.74	0.020	5.9	0.040		8.17	633
21-Feb-92	950	1.058	2.5	9.9	0.052	0.73	0.020	4.0	0.038		8.10	601
02-Mar-92	1055	1.020		17.2	0.010	0.72	0.010		0.046	0.001	8.08	643
09-Mar-92	1130	1.145	6.5	17.3		0.71			0.078	0.022	7.91	470
02-Apr-92	1003	0.970		8.3	0.018	0.49	0.040	4.6	0.024	0.004	8.18	583
13-Apr-92	1220	0.995		19.0	0.024	0.75	0.030	4.3	0.043	0.001	8.33	597
27-May-92	1100	0.890		17.5	0.012	0.51	0.020	5.9	0.034	0.001	8.28	609
01-Jun-92	1145	0.920		22.2	0.022	0.67	0.020	5.6	0.050	0.009	8.42	589
08-Jun-92	1130	0.895		36.4	0.001	0.58	0.010	5.7	0.046		8.50	607
15-Jun-92	1150	0.870	16.0	53.3	0.057	1.04	0.010	4.9	0.102	0.007	8.45	609
22-Jun-92	1454	0.885	18.0	27.3	0.032	0.90	0.010	6.4	0.540	0.001	8.24	612
29-Jun-92	1112	0.900	16.5	26.5	0.029	0.63	0.010	6.2	0.049	0.001	8.38	608
07 -Jul-92	1133	0.950	15.0	35.9	0.020	0.56	0.010	5.6	0.040	0.007	8.28	610
08 -Jul-92	1646	1.651		65.3	0.100	1.61	0.040	1.8	0.230	0.030	7.68	398
13 -Jul-92	1110	0.900	15.0	15.1	0.005	0.50	0.010	5.2	0.033		8.31	620
17-Jul-92	1320	1.540		121.0	0.082	2.40	0.030	0.9	0.370	0.068	7.69	536
21-Jul-92	1410	0.950	14.5	9.3	0.003	0.72	0.040	4.6	0.025	0.013	8.00	576
27-Jul-92	1152	9.250	15.0	5.8	0.012	0.52	0.030	5.0	0.019	0.001	8.10	617
04-Aug-92	1112	0.910	14.0	5.0	0.016	0.33	0.060	5.0	0.014	0.003	8.19	616
11-Aug-92	1200	0.925	15.5	5.0	0.007	0.42	0.010	4.5	0.018	0.001	8.22	641
17-Aug-92	1244	0.898	15.0	5.0	0.013	0.51	0.010	4.4	0.021	0.013	8.18	672
31-Aug-92	1422	0.940		5.0	0.013	0.54	0.020	5.0	0.020	0.140	8.20	603
08-Sep-92	1425		18.0	11.4	0.042	0.87	0.050	1.6	0.078	0.045	7.96	686
10-Sep-92	1414	0.910	17.0	18.0	0.039	1.00	0.080	3.5	0.083	0.031	7.98	523
22-Sep-92	1014	1.345		12.3	0.006	0.94	0.010	1.4	0.099	0.035	7.82	586
29-Sep-92	1330	0.930	12.0	5.0	0.015	0.41	0.010	4.9	0.015	0.010	8.26	626
06-Oct-92	1100	0.910	10.0	10.8	0.001	0.31	0.010	4.8	0.010	0.001	8.26	614
13-Oct-92	1440	0.910	10.0	5.0	0.012	0.32	0.010	4.7	0.010	0.001	8.25	633
15-Oct-92	1350	1.360	10.0	20.9	0.029	0.85	0.010	1.5	0.111		7.91	484
20-Oct-92	1255	0.970	7.0	5.3	0.028	0.61	0.010	4.1	0.019	0.001	8.11	604
27-Oct-92	1100	0.930	8.0	25.6	0.036	0.44	0.010	4.4	0.026	0.001	8.20	620
09-Nov-92	141O	0.950	7.0	5.0	0.034	0.62	0.010	4.0	0.028	0.011	8.08	621
12-Nov-92	1450	1.590		89.0	0.028	1.54	0.010	0.9	0.254		7.70	404
23-Nov-92	1350	1.130	7.0	14.1	0.117	1.03	0.010	2.7	0.100		7.86	508
02-Dec-92	1101	0.930	5.5	5.1	0.017	0.51	0.010	4.7	0.020	0.007	8.08	574
14-Dec-92	1140	0.920	5.0	5.0	0.007	0.40	0.010	6.0	0.018		8.19	611
21-Dec-92	1045	0.900	4.0	6.9	0.002	0.52	0.010	4.9	0.021	0.001	7.94	589

Table 4: KINTORE CREEK WATER SAMPLING DATA, STATION 5, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92		0.310		5.0	0.025	0.54	0.060	4.0	0.024		8.10	549
21-Feb-92	1050	0.385		5.0	0.055	0.71	0.010	4.8	0.050		7.98	488
02-Mar-92	1005	0.342		5.0	0.099	0.77	0.180		0.054	0.019	7.79	517
09-Mar-92	1035	0.472	4.0	5.0	0.036	0.69	0.060	4.7	0.059	0.025	7.72	413
02-Apr-92	1020	0.300		5.0	0.042	0.48	0.030	3.0	0.027	0.012	8.10	485
13-Apr-92	1130	0.290		5.0	0.032	0.49	0.030	3.1	0.018	0.005	8.22	502
27-May-92	1010	0.218		5.0	0.012	0.51	0.030	4.4	0.022	0.003	8.30	578
01-Jun-92	1035	0.235		6.4	0.047	0.49	0.040	2.8	0.026	0.004	8.39	541
08-Jun-92	1030	0.205		5.0	0.031	0.51	0.020	3.2	0.068	0.037	8.47	581
15-Jun-92	1105	0.175	17.0	5.9	0.045	0.42	0.020	3.3	0.031	0.014	8.42	591
22-Jun-92	1400	0.190	19.0	7.4	0.083	0.60	0.020	4.5	0.008	0.001	8.28	574
29-Jun-92	1025	0.172	18.0	14.7	0.053	0.55	0.040	3.8	0.066	0.023	8.33	596
07-Jul-92	1020	0.178	14.0	5.7	0.038	0.40	0.020	3.5	0.025	0.012	8.25	585
08-Jul-92	1545	0.700		392.0	0.100	3.88	0.300	69.9	0.720	0.040	7.56	359
13-Jul-92				689.0	0.007	6.00	0.020	6.5	1.180		7.80	551
13-Jul-92	955	0.218	16.0	5.0	0.006	0.53	0.020	3.5	0.025		8.20	600
17-Jul-92	1439	0.042*		306.0	0.003	3.60	0.060	3.9	0.790	0.052	7.53	341
27-Jul-92	1015	0.268	11.5	5.0	0.056	0.67	0.040	4.5	0.026	0.016	8.00	599
04-Aug-92	950	0.241	14.5	26.6	0.014	0.72	0.090	3.9	0.046	0.005	8.00	613
11-Aug-92	1054	0.268	16.5	5.0	0.053	0.81	0.010	2.9	0.034	0.001	8.12	611
17-Aug-92	1130	0.285	17.0	3.1	0.002	0.78	0.010	3.0	0.023	0.010	8.09	620
31-Aug-92	1315	0.008*		5.0	0.030	0.77	0.030	4.7	0.038	0.019	8.09	622
08-Sep-92	1230	0.828	19.0	221.0	0.067	2.55	0.050	1.4	0.835	0.070	7.71	380
10-Sep-92	1513	0.695	17.5	12.5	0.005	1.18	0.070	2.0	0.067	0.017	7.99	599
22-Sep-92	915	0.884		72.7	0.071	1.72	0.020	2.6	0.290	0.065	7.54	437
29-Sep-92	1200	0.292	12.5	49.3	0.024	0.79	0.010	3.7	0.073	0.015	8.27	636
06-Oct-92	1255	0.258	11.5	5.0	0.001	0.44	0.010	3.7	0.019	0.001	8.18	612
13-Oct-92	1240	0.310	10.0	5.0	0.018	0.62	0.010	2.1	0.022	0.004	8.18	610
15-Oct-92	1133	1.190	10.0	287.0	0.047	3.05	0.020	2.1	0.765		7.49	299
20-Oct-92	1110	0.378	7.0	5.0	0.018	0.68	0.010	6.7	0.240	0.009	7.96	600
27-Oct-92	1010	0.330	8.5	9.2	0.122	0.57	0.010	3.2	0.029	0.001	8.06	615
09-Nov-92	1145	0.360	6.0	31.3	0.001	0.56	0.010	3.2	0.020	0.001	8.02	583
12-Nov-92	1220	0.995		437.0	0.226	5.05	0.060	1.8	1.320		7.30	336
23-Nov-92	1110	0.622		15.1	0.033	0.77	0.010	3.5	0.075		7.72	471
02-Dec-92	1000	0.310	5.0	9.8	0.025	0.62	0.010	3.5	0.050	0.016	7.94	569
14-Dec-92	1005	0.305		5.0	0.090	0.45	0.010	4.0	0.040		8.04	578
21-Dec-92	1000	0.308	2.5	7.0	0.007	0.57	0.010	4.9	0.026		7.81	582

Table 5: KINTORE CREEK WATER SAMPLING DATA. STATION 6, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92		0.216		5.0	0.012	0.43	0.020	4.0	0.009		8.12	533
02-Mar-92	1024	0.249		5.0	0.027	0.48	0.010		0.019	0.004	8.04	495
09-Mar-92	1055	0.305	4.0	5.0	0.031	0.65	0.010	6.0	0.046	0.023	7.79	396
02-Apr-92	1015	0.235		5.0	0.033	0.47	0.040	2.8	0.010	0.003	8.10	465
13-Apr-92	1150	0.225		5.0	0.028	0.50	0.030	3.0	0.008	0.002	8.28	478
27-May-92	1025	0.179		5.0	0.013	0.49	0.020	4.9	0.007	0.001	8.30	576
01-Jun-92	1110	0.200		3.1	0.064	0.57	0.020	2.9	0.012	0.001	8.43	531
08-Jun-92	1055	0.180		5.0	0.008	0.55	0.010	3.5	0.011		8.53	568
15-Jun-92	1119	0.150	17.0	4.0	0.040	0.39	0.020	4.3	0.012	0.006	8.51	589
22-Jun-92	1420	0.163	19.5	5.3	0.073	0.58	0.030	5.2	0.014	0.002	8.34	576
29-Jun-92	1037	0.150	18.0	5.8	0.031	0.34	0.020	4.5	0.014	0.010	8.47	581
07-Jul-92	1115	0.170	17.0	21.6	0.058	0.36	0.020	4.1	0.012	0.001	8.23	540
08-Jul-92	1608	0.420		1288.0	0.100	6.10	0.010	3.2	2.150	0.010	7.66	263
13-Jul-92	1040	0.198	17.5	5.0	0.005	0.53	0.010	3.5	0.021		8.34	586
17-Jul-92	1528	0.500		149.0	0.003	1.55	0.020	3.3	0.290	0.029	7.58	352
21-Jul-92	1343	0.23	16.5	4.1	0.004	0.82	0.02	4.6	0.021	0.005	7.9	537
27-Jul-92	1040	0.214	11.0	5.0	0.028	0.72	0.040	3.5	0.016	0.009	8.09	567
04-Aug-92	1031	0.198	16.0	5.0	0.012	0.61	0.070	3.3	0.013	0.001	8.22	577
11-Aug-92	1110	0.212	16.5	5.0	0.013	0.66	0.010	2.4	0.022	0.001	8.18	582
17-Aug-92	1155	0.244	16.0	2.6	0.008	0.67	0.010	2.4	0.016	0.002	8.12	596
31-Aug-92	1340	0.240		5.0	0.014	0.79	0.020	4.0	0.027	0.009	8.11	593
08-Sep-92		0.430		139.0	0.056	1.75	0.050	2.1	0.315	0.074	7.71	380
10-Sep-92	1445	0.420	17.5	83.0	0.010	1.26	0.070	2.5	0.104	0.006	8.04	553
22-Sep-92	947	0.485		62.7	0.007	1.22	0.010	2.6	0.172	0.030	7.65	447
29-Sep-92	1217	0.235	11.0	5.0	0.016	0.66	0.010	3.1	0.020	0.012	8.19	616
06-Oct-92	1020	0.210	9.0	9.3	0.060	0.54	0.010	3.4	0.017	0.006	8.20	599
13-Oct-92	1400	0.310	9.5	5.0	0.010	0.46	0.010	2.0	0.014	0.001	8.13	596
15-Oct-92	1255	0.588	10.0	95.4	0.027	1.52	0.010	2.5	0.348		7.59	345
20-Oct-92	1130	0.310	7.0	5.0	0.025	0.74	0.010	3.0	0.018	0.004	8.00	562
27-Oct-92	1035	0.275	8.0	5.2	0.197	0.61	0.010	2.9	0.019	0.001	8.10	589
09-Nov-92	1245	0.300	5.0	5.0	0.005	0.63	0.010	2.9	0.016	0.001	8.08	553
12-Nov-92	1400	0.597		239.0	0.029	2.15	0.030	2.0	0.515		7.70	314
23-Nov-92	1040	0.433	6.0	23.9	0.030	0.86	0.010	2.7	0.073		7.81	440
02 -Dec-92	1015	0.290	4.5	6.7	0.017	0.62	0.010	3.3	0.023	0.008	8.05	536
14 -Dec-92	1025	0.290	3.0	5.0	0.007	0.50	0.010	3.4	0.020		8.06	537
21 -Dec-92	1020	0.280	3.0	6.0	0.005	0.56	0.010	4.0	0.018	0.001	7.86	556

Table 6: KINTORE CREEK WATER SAMPLING DATA, STATION 7, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92		0.239		17.1	0.013	0.42	0.010	1.1	0.034		8.05	537
21-Feb-92	1012	0.468		14.1	0.012	0.40	0.010	1.2	0.045		8.03	473
02-Mar-92	1040	0.445		12.1	0.010	0.42	0.010		0.039	0.005	7.97	498
09-Mar-92	1110	0.580		22.3	0.021	0.68	0.010	2.0	0.066	0.022	7.80	374
02-Apr-92	1010	0.233		7.5	0.031	0.35	0.030	0.8	0.027	0.008	7.93	483
13-Apr-92	1200	0.335		11.4	0.027	0.36	0.020	0.6	0.031	0.006	8.08	499
27-May-92	1045	0.120		3.4	0.004	0.19	0.010	0.1	0.017	0.001	8.15	575
01-Jun-92	1120	0.158		16.6	0.018	0.44	0.020	0.3	0.046	0.038	8.26	561
08-Jun-92	1109	0.115		5.0	0.018	0.33	0.010	0.3	0.024	0.006	8.42	583
15-Jun-92	1130	0.095	14.0	43.4	0.041	1.08	0.010	0.1	0.146	0.013	8.36	579
22-Jun-92	1430	0.081	14.5	14.0	0.040	0.41	0.010	1.4	0.037	0.003	8.14	567
29-Jun-92	1055	0.085	14.0	5.8	0.030	0.19	0.010	0.2	0.026	0.008	8.31	582
07-Jul-92	1122	0.138	13.0	38.0	0.042	52.00	0.010	0.3	0.080	0.010	8.15	583
08-Jul-92	1631	0.390		491.0	0.100	3.90	0.020	1.8	1.380	0.010	7.40	181
13-Jul-92	1055	0.089	14.5	5.0	0.004	0.33	0.010	0.2	0.040		8.16	590
17-Jul-92	1305	1.150		303.0	0.395	3.30	0.010	0.1	0.610	0.016	7.55	263
21-Jul-92	1355	0.145	15.5	5.5	0.002	0.38	0.010	0.3	0.025	0.001	7.85	551
27-Jul-92	1130	0.133	15.0	6.7	0.011	0.35	0.020	0.4	0.023	0.003	7.97	581
04-Aug-92	1045	0.145	13.5	5.0	0.010	0.34	0.020	0.2	0.027	0.002	8.02	592
11-Aug-92	1137	0.265	15.0	9.6	0.008	0.37	0.010	0.2	0.032	0.001	8.08	600
17-Aug-92	1215	0.155	2.0	8.9	0.016	0.42	0.010	0.2	0.015	0.004	8.07	616
31-Aug-92	1400	0.190		12.3	0.037	0.54	0.010	0.4	0.034	0.011	8.03	596
08-Sep-92				24.1	0.003	0.89	0.020	0.1	0.122	0.046	7.85	400
10-Sep-92	1422	0.540	18.0	17.6	0.011	0.76	0.030	0.1	0.079	0.003	7.99	465
22-Sep-92	955	0.780		23.7	0.006	0.85	0.010	0.4	0.119	0.028	7.88	425
29-Sep-92	1225	0.125	10.0	8.1	0.016	0.26	0.010	0.2	0.019	0.011	8.05	624
06-Oct-92	1030	0.129	9.5	31.7	0.010	0.55	0.010	0.1	0.070	0.006	8.01	598
13-Oct-92	1420	0.190	10.0	6.0	0.010	0.30	0.010	0.1	0.020	0.002	7.98	621
15-Oct-92	1330	1.000		35.3	0.018	1.06	0.010	0.3	0.268		7.66	313
20-Oct-92	1155	0.290	7.0	5.0	0.017	0.32	0.010	0.4	0.020	0.002	7.91	582
27-Oct-92	1045	0.270	8.0	42.2	0.067	0.27	0.010	0.2	0.020	0.001	8.02	599
09-Nov-92	1310	0.315	5.0	13.1	0.006	0.40	0.010	0.3	0.035	0.001	7.84	577
12-Nov-92	1435	1.150		60.9	0.050	1.12	0.020	0.2	0.208		7.66	277
23-Nov-92	1140	0.540	6.0	13.1	0.088	0.68	0.010	0.5	0.082		7.84	433
02-Dec-92	1040	0.315	4.5	8.1	0.020	0.34	0.010	0.6	0.024	0.009	7.87	565
14-Dec-92	1035	0.305	4.0	5.0	0.014	0.24	0.010	0.5	0.020		7.94	575
21-Dec-92	1030	0.280	3.0	9.9	0.001	0.34	0.010	0.7	0.038	0.001	7.80	572

Table 7: KINTORE CREEK WATER SAMPLING DATA, STATION 8, 1992

Date of Sample	Time	Staff Gauge	Temp (C)	Suspended Solids	Nitrogen				Phosphorus		pH	Conductivity
					Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Dissolved Reactive		
04-Feb-92		0.260		79.5	0.003	1.50	0.010	4.4	0.130		8.10	575
21-Feb-92	1000	0.350	3.0	31.6	0.013	0.94	0.010	4.5	0.058		8.11	541
02-Mar-92	1048	0.300		55.5	0.005	1.15	0.010		0.072	0.011	8.05	560
09-Mar-92	1125	0.550	4.0	152.0	0.011	2.10	0.010	4.2	0.270	0.005	7.88	442
02-Apr-92	1005	0.290		37.8	0.025	1.10	0.030	4.0	0.062	0.004	8.02	549
13-Apr-92	1210	0.325		29.2	0.019	0.86	0.020	0.6	0.031	0.006	8.08	499
27-May-92	1050	0.185		8.6	0.007	0.44	0.010	4.0	0.016	0.001	8.06	588
01-Jun-92	1135	0.202		10.9	0.022	0.50	0.020	4.1	0.021	0.003	8.26	571
08-Jun-92	1125	0.180		5.0	0.001	0.39	0.010	3.6	0.016	0.007	8.43	589
15-Jun-92	1145	0.140	12.0	9.3	0.044	0.57	0.010	3.5	0.029	0.020	8.31	598
22-Jun-92	1435	0.162	10.5	18.1	0.022	0.68	0.010	4.7	0.032	0.001	8.12	596
29-Jun-92	1105	0.150	13.0	9.2	0.020	0.40	0.010	3.7	0.021	0.004	8.29	594
07-Jul-92	1128	0.170	13.0	5.8	0.020	0.32	0.010	3.0	0.008	0.001	8.18	599
08-Jul-92	1640	0.845		120.0	0.100	2.22	0.020	6.4	0.220	0.010	7.73	346
13-Jul-92	1102	0.170	14.5	5.0	0.003	0.37	0.010	3.3	0.013		8.13	595
17-Jul-92	1315	1.100		217.0	0.001	2.65	0.020	1.4	0.405	0.003	7.72	226
21-Jul-92	1404	0.180	14.0	8.3	0.002	0.44	0.030	4.3	0.016	0.005	7.98	589
27-Jul-92	1142	0.179	14.5	5.0	0.012	0.40	0.030	3.6	0.014	0.001	8.02	595
04-Aug-92	1106	0.185	13.5	5.0	0.004	0.37	0.080	3.4	0.014	0.005	8.16	587
11-Aug-92	1151	0.185	15.0	5.0	0.007	0.34	0.010	3.3	0.014	0.001	8.08	600
17-Aug-92	1230	0.540	15.0	5.0	0.007	0.37	0.010	3.2	0.012	0.003	8.12	608
31-Aug-92	1406	0.178		5.0	0.014	0.44	0.020	3.9	0.019	0.007	8.15	603
08-Sep-92	1420	0.340	17.5	27.9	0.023	0.98	0.040	1.9	0.056	0.015	7.99	537
10-Sep-92	1429	0.380	17.0	17.1	0.004	1.02	0.080	3.3	0.053	0.021	8.00	497
22-Sep-92	1008	0.590		28.7	0.006	0.95	0.010	1.7	0.079	0.002	7.84	468
29-Sep-92	1230	0.180	10.0	17.4	0.012	0.39	0.010	3.2	0.023	0.006	8.24	594
06-Oct-92	1050	0.205	9.0	6.7	0.001	0.43	0.010	3.0	0.018	0.005	8.11	596
13-Oct-92	1440	0.500	10.0	5.0	0.004	0.39	0.010	3.1	0.014	0.001	8.12	606
15-Oct-92	1340	0.030	11.0	39.5	0.012	1.08	0.010	2.2	0.082		7.86	431
20-Oct-92	1200	0.240	7.0	9.4	0.020	0.42	0.010	3.6	0.018	0.001	8.09	590
27-Oct-92	1055	0.220	8.0	50.2	0.079	0.58	0.010	3.5	0.030	0.001	8.13	604
09-Nov-92	1350	0.280	6.5	27.6	0.010	0.90	0.010	3.1	0.048	0.001	7.96	592
12-Nov-92	1445	0.970		174.0	0.026	1.95	0.030	0.9	0.315		7.68	271
23-Nov-92	1150	0.480	6.0	16.8	0.014	0.61	0.010	3.1	0.043		7.92	527
02-Dec-92	1150	0.280	6.0	34.2	0.013	0.92	0.010	4.1	0.060	0.007	8.03	586
14-Dec-92	1040	0.230	4.0	49.6	0.006	1.16	0.010	4.9	0.090		8.12	587
21-Dec-92	1035	0.220	4.0	40.2	0.001	0.72	0.010	4.3	0.048	0.001	7.98	599

Table 8: KINTORE CREEK WATER SAMPLING DATA STORM EVENT SAMPLINGS, STATION 1, ISCO, 1992

Date	Time	Suspend Solids	Total Phos.	Date	Time	Suspended Solids	Total Phosph.	Date	Time	Suspend. Solids	Total Phosph.	Date	Time	Suspended Solids	Total Phosph.
05-Mar-92	1530	78.0	0.278	16-Apr-92	700	25.8	1.380	14-Jul-92	400	14.4	0.142	15-Oct-92	1116	205.0	0.455
05-Mar-92	1730	106.0	0.290	16-Apr-92	900	113.0	0.145	14-Jul-92	500	67.2	0.158	15-Oct-92	1316	132.0	0.360
05-Mar-92	1930	105.0	0.265	16-Apr-92	1100	116.0	0.225	14-Jul-92	600	60.3	0.152	15-Oct-92	1516	51.7	0.230
05-Mar-92	2030	81.0	0.282	16-Apr-92	1300	93.9	0.245	14-Jul-92	700	147.0	0.300	15-Oct-92	1716	32.8	0.186
05-Mar-92	2130	66.7	0.238	16-Apr-92	1500	216.0	0.415	14-Jul-92	800	60.0	0.198	15-Oct-92	1916	22.2	0.150
05-Mar-92	2330	57.2	0.264	16-Apr-92	1700	178.0	0.360	14-Jul-92	900	33.4	0.117	15-Oct-92	2116	17.0	0.114
06-Mar-92	130	61.2	0.216	16-Apr-92	1900	178.0	0.370	14-Jul-92	1000	23.2	0.110	15-Oct-92	2316	11.8	0.085
06-Mar-92	330	44.9	0.222	16-Apr-92	2100	301.0	0.625	14-Jul-92	1100	17.3	0.091	16-Oct-92	116	12.1	0.079
06-Mar-92	530	30.2	0.171	16-Apr-92	2300	212.0	0.505	14-Jul-92	1935	54.8	0.132	16-Oct-92	316	13.3	0.068
06-Mar-92	730	39.8	0.335	17-Apr-92	100	104.0	0.320	14-Jul-92	2135	37.9	0.113	16-Oct-92	516	44.4	0.120
06-Mar-92	1200	25.6	0.121	17-Apr-92	300	66.3	0.220	14-Jul-92	2335	30.2	0.100	16-Oct-92	716	187.0	0.535
06-Mar-92	1400	32.6	0.126	17-Apr-92	500	42.2	0.148	15-Jul-92	135	21.2	0.088	16-Oct-92	916	70.9	0.330
06-Mar-92	1600	29.1	0.132					15-Jul-92	335	19.5	0.078	16-Oct-92	1200	36.4	0.184
06-Mar-92	1800	46.6	0.216	31-May-92	2400	23.1	0.034	15-Jul-92	535	21.0	0.068	16-Oct-92	1400	41.3	0.222
06-Mar-92	2000	75.5	0.282	31-May-92	200	58.2	0.047					16-Oct-92	1600	28.5	0.160
06-Mar-92	2200	105.0	0.292	31-May-92	400	69.1	0.082	17-Jul-92	1200	8.3	0.060	16-Oct-92	1800	22.2	0.186
07-Mar-92	2400	103.0	0.282	31-May-92	1200	30.8	0.033	17-Jul-92	1300	126.0	0.280	16-Oct-92	2000	19.6	0.138
07-Mar-92	200	96.9	0.278	31-May-92	1400	75.3	0.075	17-Jul-92	1400	258.0	0.550	16-Oct-92	2200	17.5	0.114
07-Mar-92	400	105.0	0.304	31-May-92	1600	72.6	0.094	17-Jul-92	1500	136.0	0.305				
07-Mar-92	600	76.6	0.260					17-Jul-92	1600	105.0	0.290	4-Nov-92	1000	185.0	0.395
07-Mar-92	800	68.0	+	18-Jun-92	2400	27.7	0.086	17-Jul-92	1700	137.0	0.305	4-Nov-92	1100	95.8	0.295
07-Mar-92	1000	47.6	0.220	18-Jun-92	200	12.9	0.053	17-Jul-92	1800	65.6	0.202	4-Nov-92	1200	53.5	0.232
07-Mar-92	1200	38.9	0.194	18-Jun-92	400	7.5	0.046	17-Jul-92	1900	39.4	0.153	4-Nov-92	1300	40.5	0.194
07-Mar-92	1400	39.5	0.196	18-Jun-92	600	9.4	0.063	17-Jul-92	2000	31.9	0.152	4-Nov-92	1400	35.6	0.184
07-Mar-92	1600	40.1	0.176					17-Jul-92	2100	19.9	0.123	4-Nov-92	1500	29.4	0.168
07-Mar-92	1800	33.4	0.169	03-Jul-92	1700	8.8	0.014	17-Jul-92	2200	25.1	0.124	4-Nov-92	1600	27.5	0.138
07-Mar-92	2000	32.3	0.159	03-Jul-92	1800	17.1	0.037	17-Jul-92	2300	18.0	0.098	4-Nov-92	1700	25.2	0.129
				03-Jul-92	1900	407.0	0.670	18-Jul-92	2400	12.2	0.099	4-Nov-92	1800	20.7	0.112
				03-Jul-92	2100	202.0	0.370	18-Jul-92	100	26.9	0.104	4-Nov-92	1900	18.9	0.093
09-Mar-92	1400	26.5	0.104	03-Jul-92	2200	302.0	0.660	18-Jul-92	200	15.0	0.087				
09-Mar-92	1600	47.2	0.168	03-Jul-92	2300	236.0	0.530	18-Jul-92	1800	43.4	0.106	10-Nov-92	2000	29.6	0.056
09-Mar-92	1800	38.4	0.138					18-Jul-92	2000	153.0	0.282	10-Nov-92	2200	75.4	0.182
09-Mar-92	2000	25.3	0.132	08-Jul-92	1500	99.5	0.290	18-Jul-92	2200	72.0	0.292	11-Nov-92	2400	67.3	0.188
09-Mar-92	1215	19.4	0.088	08-Jul-92	1600	1877.0	3.000	19-Jul-92	2400	101.0	0.220	11-Nov-92	200	48.5	0.140
09-Mar-92	1315	13.7	0.088	08-Jul-92	1700	797.0	1.420	19-Jul-92	200	14.8	0.104	11-Nov-92	800	33.3	0.096
09-Mar-92	1415	19.3	0.094	08-Jul-92	1800	349.0	0.700	19-Jul-92	400	12.8	0.106	11-Nov-92	1000	59.3	0.168
09-Mar-92	1515	22.4	0.104	08-Jul-92	1900	198.0	0.460					11-Nov-92	1200	47.2	0.134
09-Mar-92	1615	24.1	0.162	08-Jul-92	2000	142.0	0.360	28-Aug-92	400	14.4	0.084	11-Nov-92	1400	42.3	0.095
09-Mar-92	1715	26.7	0.100	08-Jul-92	2100	111.0	0.320	28-Aug-92	500	13.1	0.070	12-Nov-92	1000	56.8	0.097
09-Mar-92	1815	21.8	0.100	08-Jul-92	2200	109.0	0.290	28-Aug-92	600	14.8	0.080	12-Nov-92	1300	186.0	0.445
09-Mar-92	1915	21.3	0.110	08-Jul-92	2300	140.0	0.340	28-Aug-92	700	187.0	0.365	12-Nov-92	1400	209.0	0.525
10-Mar-92	815	12.5	0.088	08-Jul-92	2400	87.7	0.260	26-Aug-92	800	317.0	0.710	12-Nov-92	1600	221.0	0.450
10-Mar-92	915	19.5	0.172	09-Jul-92	100	84.6	0.260	28-Aug-92	900	107.0	0.535	12-Nov-92	1700	197.0	0.510
10-Mar-92	1015	19.2	0.154	09-Jul-92	200	78.6	0.260	28-Aug-92	1000	50.3	0.525	12-Nov-92	1800	226.0	0.605
10-Mar-92	1115	26.2	0.120	09-Jul-92	300	70.3	0.230	28-Aug-92	1200	33.5	0.252	12-Nov-92	1900	201.0	0.520
				09-Jul-92	400	66.3	0.190	28-Aug-92	1400	12.4	0.244	12-Nov-92	2000	199.0	0.550

09-Jul-92	500	54.5	0.170	28-Aug-92	1600	12.1	0.280	12-Nov-92	2100	212.0	0.570
09-Jul-92	600	51.6	0.150	28-Aug-92	1800	8.4	0.179	12-Nov-92	2200	247.0	0.690
09-Jul-92	700	49.0	0.150	28-Aug-92	2000	11.8	0.118	12-Nov-92	2300	223.0	0.670
09-Jul-92	800	40.8	0.130					13-Nov-92	100	152.0	0.555
09-Jul-92	900	32.9	0.150	22-Sep -92	900	272.0	0.610	13-Nov-92	200	129.0	0.535
				22-Sep-92	1000	56.1	0.190	13-Nov-92	400	123.0	0.550
				22-Sep-92	1100	29.4	0.152	13-Nov-92	500	106.0	0.480
				22-Sep-92	1200	25.2	0.124	13-Nov-92	600	91.5	0.450
				22-Sep-92	1300	24.1	0.118	13-Nov-92	700	72.5	0.420
				22-Sep-92	1400	20.4	0.113	13-Nov-92	800	76.0	0.395
								13-Nov-92	900	61.0	0.332
								13-Nov-92	1000	53.0	0.312
								13-Nov-92	1100	46.3	0.286
								13-Nov-92	1200	52.3	0.294

Table 9: KINTORE CREEK WATER SAMPLING DATA STORM EVENT SAMPLINGS, STATION 5, ISCO, 1992

Date	Time	Suspend Solids	Total Phos.	Date	Time	Suspended Solids	Total Phosph.	Date	Time	Suspend. Solids	Total Phosph.	Date	Time	Suspended Solids	Total Phosph.
05-Mar-92	1607	51.8	0.178	31-May-92	1200	7.3	0.033	14-Jul-92	400	37.1	0.102	15-Oct-92	1140	216.0	0.530
05-Mar-92	1807	78.6	0.194	31-May-92	1400	14.2	0.046	14-Jul-92	500	66.2	0.182	15-Oct-92	1340	76.4	0.292
05-Mar-92	2007	93.4	0.218	31-May-92	1600	10.6	0.043	14-Jul-92	600	63.1	0.178	15-Oct-92	1540	22.1	0.110
05-Mar-92	2207	53.1	0.176	31-May-92	1800	11.2	0.044	14-Jul-92	700	44.6	0.160	15-Oct-92	1740	17.1	0.092
05-Mar-92	2307	54.6	0.176	31-May-92	2000	8.8	0.035	14-Jul-92	800	39.2	0.153	15-Oct-92	1940	14.2	0.079
06-Mar-92	2407	49.5	0.156	31-May-92	2200	11.4	0.046	14-Jul-92	900	22.4	0.112	15-Oct-92	2140	10.9	0.065
06-Mar-92	107	34.2	0.128					14-Jul-92	1000	16.8	0.080	15-Oct-92	2340	10.8	0.055
06-Mar-92	307	37.3	0.120					14-Jul-92	1100	14.7	0.066	16-Oct-92	140	9.7	0.050
06-Mar-92	507	27.5	0.104					14-Jul-92	2000	27.9	0.136	16-Oct-92	340	8.3	0.054
06-Mar-92	707	22.9	0.085					14-Jul-92	2200	29.4	0.120	16-Oct-92	540	115.0	0.275
06-Mar-92	907	22.3	0.082					15-Jul-92	2400	16.0	0.085	16-Oct-92	740	39.5	1.300
06-Mar-92	1200	12.4	0.078					15-Jul-92	200	13.4	0.053	16-Oct-92	940	79.5	0.295
06-Mar-92	1400	24.1	0.086	03-Jul-92	1800	69.0	0.148	15-Jul-92	400	6.0	0.074	16-Oct-92	1300	151.0	0.382
06-Mar-92	1600	85.9	0.150	03-Jul-92	1900	34.8	0.080	15-Jul-92	600	9.9	0.057	16-Oct-92	1500	68.5	0.286
06-Mar-92	1800	58.1	0.142	03-Jul-92	2000	148.0	0.240					16-Oct-92	1700	21.4	0.129
06-Mar-92	2000	129.0	0.230	03-Jul-92	2100	79.8	0.172	17-Jul-92	1200	241.0	0.455	16-Oct-92	1900	19.8	0.093
06-Mar-92	2200	160.0	0.295	03-Jul-92	2200	75.0	0.160	17-Jul-92	1300	9.3	0.050	16-Oct-92	2100	15.0	0.077
06-Mar-92	2400	174.0	0.315	03-Jul-92	2300	33.5	0.083	17-Jul-92	1400	255.0	0.805	16-Oct-92	2300	10.6	0.058
07-Mar-92	200	+	0.216					17-Jul-92	1500	217.0	0.490				
07-Mar-92	400	121.0	0.238	08-Jul-92	1500	565.0	0.950	17-Jul-92	1600	98.1	0.255	4-Nov-92	1015	126.0	0.425
07-Mar-92	600	91.4	0.190	08-Jul-92	1600	1076.0	1.650	17-Jul-92	1700	59.7	0.242	4-Nov-92	1115	76.3	0.332
07-Mar-92	800	57.7	0.142	08-Jul-92	1700	688.0	1.380	17-Jul-92	1800	23.7	0.136	4-Nov-92	1215	39.1	0.192
07-Mar-92	1000	45.8	0.140	08-Jul-92	1800	393.0	0.900	17-Jul-92	1900	24.5	0.103	4-Nov-92	1315	26.2	0.128
07-Mar-92	1200	37.7	0.122	08-Jul-92	1900	221.0	0.660	17-Jul-92	2000	20.9	0.083	4-Nov-92	1415	197	0.092
07-Mar-92	1400	46.8	0.136	08-Jul-92	2000	129.0	0.450	17-Jul-92	2100	18.4	0.080	4-Nov-92	1515	14.0	0.073
07-Mar-92	1600	170.0	0.130	08-Jul-92	2100	72.7	0.270	17-Jul-92	2200	14.2	0.079	4-Nov-92	1815	13.3	0.066
07-Mar-92	1800	37.4	0.124	08-Jul-92	2200	54.1	0.200	17-Jul-92	2300	12.5	0.066	4-Nov-92	1715	12.4	0.061
07-Mar-92	2000	30.0	0.105	08-Jul-92	2300	40.5	0.170	18-Jul-92	2400	10.5	0.061	4-Nov-92	1815	12.2	0.056
				09-Jul-92	2400	29.3	0.130	18-Jul-92	100	12.3	0.067	4-Nov-92	1915	12.7	0.058
09-Mar-92	2200	21.6	0.096	09-Jul-92	100	25.3	0.110	18-Jul-92	200	8.9	0.061				
09-Mar-92	2400	22.0	0.116	09-Jul-92	200	21.2	0.100	18-Jul-92	1800	164.0	0.440	10-Nov-92	2000	30.4	0.080
10-Mar-92	200	17.0	0.082	09-Jul-92	300	19.4	0.080	18-Jul-92	2000	71.5	0.240	10-Nov-92	2200	71.0	0.212
10-Mar-92	400	15.5	0.076	09-Jul-92	400	16.6	0.080	18-Jul-92	2200	27.2	0.121	11-Nov-92	2400	48.2	0.188
10-Mar-92	800	14.4	0.078	09-Jul-92	500	15.7	0.080	19-Jul-92	2400	19.4	0.083	11-Nov-92	200	24.4	0.098
10-Mar-92	900	32.4	0.154	09-Jul-92	600	15.7	0.070	19-Jul-92	200	16.5	0.078	11-Nov-92	800	28.2	0.098
10-Mar-92	100	38.2	0.174	09-Jul-92	700	13.9	0.060	19-Jul-92	400	12.6	0.058	11-Nov-92	1000	47.8	0.240
10-Mar-92	1100	30.6	0.144	09-Jul-92	800	11.9	0.050					11-Nov-92	1200	22.6	0.134
				09-Jul-92	900	3.6	0.040	28-Aug-92	500	23.3	0.062	11-Nov-92	1400	12.9	0.071
16-Apr-92	600	66.0	0.126					28-Aug-92	600	78.2	0.175	12-Nov-92	800	17.8	0.036
16-Apr-92	800	157.0	0.355					28-Aug-92	700	122.0	0.280	12-Nov-92	1000	35.0	0.348
16-Apr-92	1000	186.0	0.410					28-Aug-92	800	176.0	0.435	12-Nov-92	1230	416.0	1.070
16-Apr-92	1200	183.0	0.405					28-Aug-92	900	112.0	0.405	12-Nov-92	1330	334.0	0.850
18-Apr-92	1400	240.0	0.455					28-Aug-92	1000	84.2	0.305	12-Nov-92	1430	198.0	0.590
16-Apr-92	1600	208.0	0.470					28-Aug-92	1200	27.9	0.126	12-Nov-92	1530	255.0	0.650
16-Apr-92	1800	115.0	0.232					28-Aug-92	1400	16.3	0.092	12-Nov-92	1630	260.0	0.635
16-Apr-92	2000	288.0	0.600					28-Aug-92	1600	17.9	0.092	12-Nov-92	1730	471.0	0.950

16-Apr-92	2200	268.0	0.590				28-Aug-92	1800	14.6	0.080	12-Nov-92	1830	415.0	0.920
17-Apr-92	2400	126.0	0.274				28-Aug-92	2000	7.6	0.069	12-Nov-92	1930	332.0	0.740
17-Apr-92	200	75.3	0.162				28-Aug-92	2200	12.7	0.058	12-Nov-92	2030	570.0	1.300
17-Apr-92	400	51.2	0.128								12-Nov-92	2130	500.0	1.030
							10-Sep-92	200	267.0	0.420	12-Nov-92	2230	168.0	0.530
							10-Sep-92	300	166.0	0.600	12-Nov-92	2330	92.0	0.305
							10-Sep-92	400	98.9	0.290	13-Nov-92	2430	54.5	0.206
							10-Sep-92	500	62.5	0.180	13-Nov-92	130	41.1	0.162
											13-Nov-92	230	49.7	0.166
							22-Sep-92	1000	53.0	0.186	13-Nov-92	330	720.0	1.220
							22-Sep-92	1100	28.6	0.129	13-Nov-92	430	388.0	0.785
							22-Sep-92	1200	22.1	0.092	13-Nov-92	530	256.0	0.540
							22-Sep-92	1300	12.8	0.072	13-Nov-92	630	221.0	0.480
							22-Sep-92	1400	12.3	0.066	13-Nov-92	730	182.0	0.445
							22-Sep-92	1500	11.3	0.062	13-Nov-92	830	228.0	0.515
											13-Nov-92	930	180.0	0.445
											13-Nov-92	1030	168.0	0.370
											13-Nov-92	1130	158.0	0.345

Attachment 1

CLEAN WATER from barnyard runoff

Wetlands are natural water purification systems. This dairy farmer is putting the principle to work on runoff from his manure pile

By Trish Scott

Society's growing concern for nature means wetland preservation is now a popular cause. As a landowner, protecting watery wildlife habitat can make you a local hero. And one southwestern Ontario dairy farmer is going a step farther. He's building a wetland.

Bill French, of Mitchell, Ont., readily admits to an ulterior motive. He plans to use the wetland for purifying barnyard runoff. But he also likes the idea of sheltering wildlife.

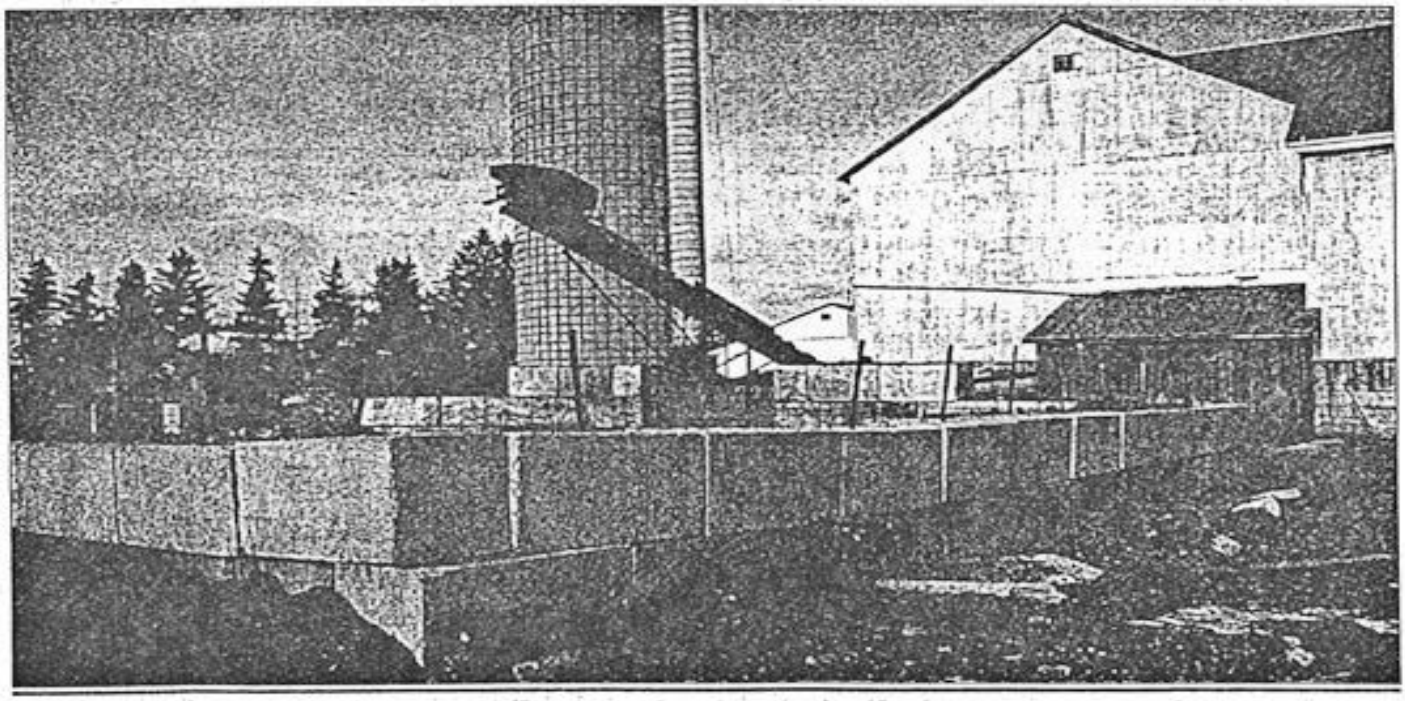
The dairy barn at Jefholm Farms is only 300' from an open municipal ditch. Manure piled in a concreted yard is retained by a cement block wall. No solid manure escapes, but some liquid does seep between the cement blocks. The flow increases sharply when it rains. This runoff, and a natural grade toward the open ditch (which eventually flows into the Thames River), concerns French.

"Building a liquid manure tank would eliminate the runoff problem," he notes, "but my 31-cow operation isn't large enough to justify the $70,000 investment. The wetland system can be built for only $7,000."

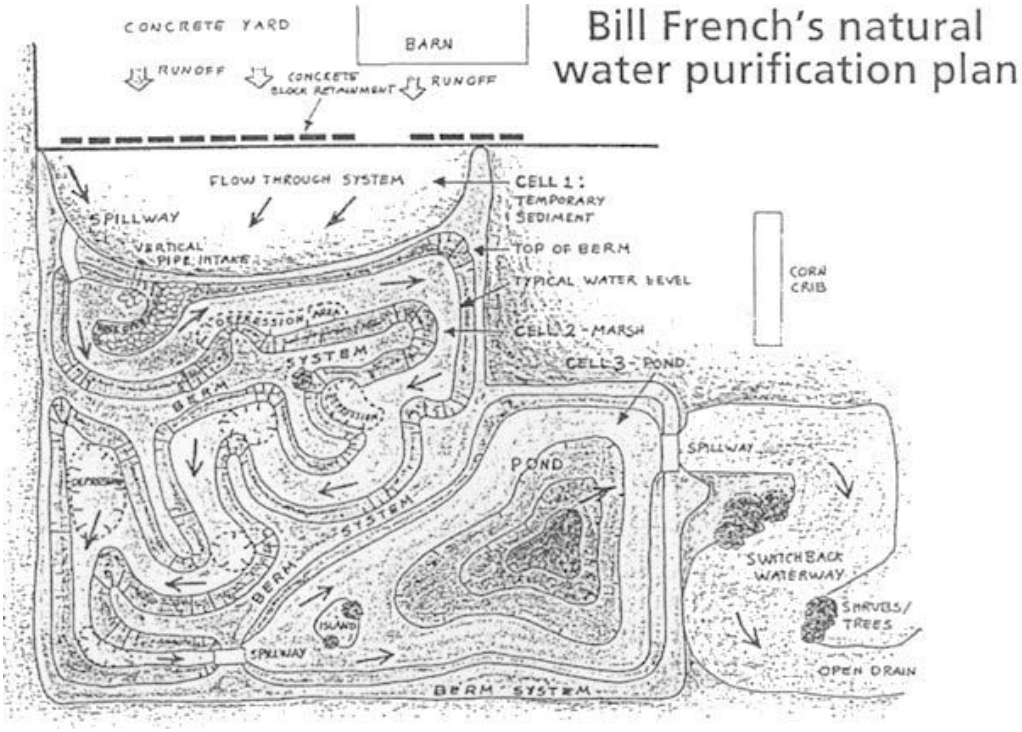
Will it work, though? That's not certain, but French is sharing the gamble with the provincial government. After talking to a neighbor about wetland waste treatment systems in Europe, he became attracted to the concept and approached the Upper Thames Conservation Authority with the idea.

Very interested, the conservation authority agreed to design and partly fund the wetland as a demonstration project on French's farm. The Ontario environment ministry's Clean Up Rural Beaches (CURB) program also helped with financing. French will cover 25% of the $7,000 cost.

Conservation authority officials Brad Glasman and Karen Poel designed the wetland in consultation with French. Glasman is a conservation services engineer and Poel is a water quality technician. Construction of the 3-stage system is scheduled for this spring.



Seepage and runoff from this manure storage will soon pass through a natural purification system en route to the nearest ditch



The one-acre site is just behind the barn. Runoff from the concrete yard and manure storage area will first flow through 2, possibly 3, entry points in the retaining wall into a grassed settling area. There, contaminated water should shed most of its sediment as it moves slowly toward a vertical intake leading into the next stage of the system.

This primary settling area will be seeded with reed canary grass, a heavy user of nitrogen. In dry spells, the cows will graze it, thus recycling some manure nutrients. The runoff will carry remaining dissolved nitrogen and phosphate into the wetland's second stage, a shallow winding channel no more than a foot deep.

The winding pattern has a purpose. "The more surface area the better," explains Glasman. "We want runoff to travel through as long a path as possible to maximize transpiration (through plants) and evaporation of water. A long winding path will also allow maximum nutrient removal."

The channel will be planted with marsh vegetation such as cattails and bullrushes brought from a local pond.

As it grows, this water-loving vegetation will absorb nitrogen and phosphorus from the water. Microorganisms associated with aquatic vegetation also utilize nitrogen and phosphorus through their life cycles, notes Poel.

Conversely, fecal bacteria and other undesirable organisms from manure are not adapted to life in a wetland. Exposed to sunlight, they'll die.

Water from the second stage will flow into a third pond-like area, which will also be stocked with a variety of wetland vegetation and fish such as carp. A floating windmill may be installed to keep the pond aerated.

Although emergency spillways will protect all structures in the event of abnormally intense rainfall, the whole complex is designed to evaporate most of the runoff water, notes Glasman. Under normal conditions, any that does escape over the final spillway into the ditch should have little or no remaining bacterial or chemical contamination.

Trees and shrubs planted at higher spots around the wetland will further aid in nutrient uptake, and provide wildlife habitat.

University of Waterloo scientists will monitor ground water quality in and around the site. "As well, flow measurements and water quality samples will be taken at the outlet of each stage in the constructed wetland to determine the system's effectiveness in improving water quality," says Dave Blowes, a researcher at the university's Centre for Ground Water Research.

Glasman expects the wetland to take 2 years to reach its full treatment potential. If successful, the project will show other livestock producers how to clean up barnyard runoff at reasonable cost, and enhance wildlife habitat at the same time.

French is optimistic. "I can't see why this system won't work," he says. "We'll learn as we go. The monitoring program will tell us what's happening. Even if the wetland doesn't remove all pollutants from the runoff, it will certainly be an improvement over letting it all flow untreated into the watercourse."

If anything, Glasman is afraid water inflow might be too little rather than too much. "Once the wetland is established, we'll have to maintain the required water level for growth of water-loving plants," he notes. "If necessary, water could possible be brought in by redirecting a field tile."

French's project has a 3-year temporary zoning amendment from the township. It can be extended if necessary. "If the wetland works, permanent zoning will be granted," says French. "If township officials. are not comfortable with the results, it will have to be filled in."