PREOPERATIVE POINT SOURCE IMPACT STUDY OF THE EMBARRASS RIVER RELATED TO THE VILLAGE OF EMBARRASS PUBLICLY OWNED TREATMENT WORKS

Performed as part of the 1981
Lake Michigan District Basin Assessment
Survey Program

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GENERAL INFORMATION

Drainage Basin:	Wolf River - 112
Location of Study Reach:	Embarrass River from Hwy "YY" above the Village of Embarrass Publicly Owned Treatment Works, downstream to Behnke Road, T25N, R15E, Sections 5, 8, 17, Matteson Township, Waupaca County, Wisconsin.
Investigation Dates:	August 27, 1981 and November 16, 1981.
Chemical Survey Personnel:	Michael Reif and Laura Herman
Macroinvertebrate Survey Personnel:	Michael Reif
Macroinvertebrate Indentification:	Michael Reif

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY AND CONCLUSIONS

1. A study was conducted in the summer and fall of 1981 to document water quality conditions (biological, chemical, and physical) in the Embarrass River as they relate to the Village of Embarrass Publicly Owned Treatment Works (POTW) prior to implementation of a new POTW.

2. A chemical survey was conducted on August 27, 1981. No measurable impacts were found. POTW concentrations of BOD_5 were very near the yearly average, but the effluent flows were down, near 50%, from yearly average. It is assumed with an effluent flow near the yearly average, parameter increases may be found in the river.

3. A macroinvertebrate survey was conducted on November 16, 1981. All sites above and below the POTW indicated very good water quality. No measurable water quality impact was observed related to the Village of Embarrass POTW.

OBJECTIVE

The objective of this study was to document water quality conditions (biological, chemical, and physical) in the Embarrass River as they relate to the Village of Embarrass Publicly Owned Treatment Works (POTW) prior to facility modifications to increase effluent quality.

INTRODUCTION

The Village of Embarrass has a population of 472 and during this study had a primary POTW. The effluent limits for this plant are in Table 1. A 2-cell lagoon system was completed in the fall of 1981 to meet secondary effluent limits (Table 2).

Table 1. WPDES permit effluent limits for the Old Village of Embarrass POTW.

	Average lbs/day	Average mg/l	Minimum s.u.	Maximum s.u.
BOD_5	93.8	150	--	--
BOD_5	141.0	225	--	--
SS (monthly)	62.6	100	--	--
SS (weekly)	93.8	150	--	--
pH	--	--	6.0	9.0

Table 2. WPDES permit effluent limits for the new Village of Embarrass POTW (to December 31, 1984).

	Average lbs/day	Average mg/l	Minimum s.u.	Maximum s.u.
BOD_5 (monthly)	488	30	--	--
BOD_5 weekly)	732	45	--	--
SS (monthly)	488	30	--	--
SS (weekly)	732	45	--	--
pH (daily)	--	--	6.0	9.0

This study was conducted to document water quality conditions in the Embarrass River related to the primary POTW prior to start-up of the lagoon system. A post-operative study will be conducted in the same study reach after the aquatic biological communities have become established after the start-up of the lagoon system (approximately 2-3 years). This study is part of an ongoing pre-postoperative study program on several POTW's throughout the state.

PHYSICAL SETTING OF STUDY AREA

The study reach extended from 100 feet above Hwy "YY" downstream to 50 feet below Behnke Road (Figure 1). The Embarrass River is a moderately large river in the study reach (approximately 100-300 feet in width) with fairly deep areas. A large part of the study reach has a moderate current and sandy bottom. However, 3 riffle areas with rock bottoms were found as sampling sites. The new lagoon system will discharge just below the mixed point of the old POTW (Figure 1).

The surrounding land use is approximately 75% farmland and 25% woodland. Evidence of cattle crossing was observed at the mixed point.

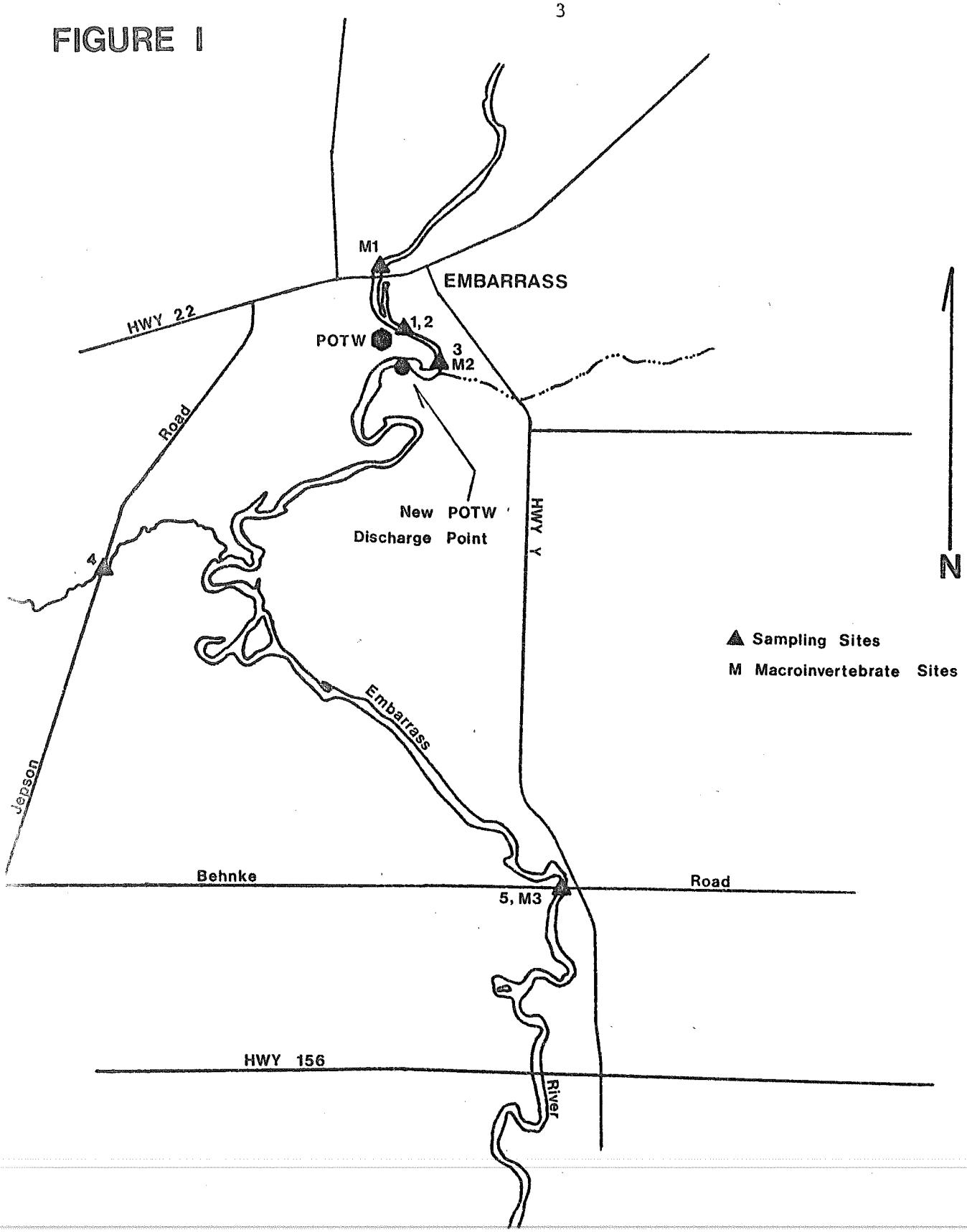
A single tributary discharged to the Embarrass River from the west near the center of the study reach. Farmland makes up most of the land use around this tributary from the sampling point at Jepson Road to the Embarrass River.

The fishery of the Embarrass River in the study reach is warmwater dominated by redhorse and white suckers with northern pike, smallmouth bass and walleye comprising the major game species. Also present are lake sturgeon, panfish, (rock bass, bluegill, crappie, perch and sunfish), catfish and white bass. Other rough fish present are carp, sheepshead, burbot, dogfish and quillback.

METHODS AND MATERIALS

The chemical sampling for this study was conducted on August 27, 1981. Samples were collected from the Embarrass River from the sites illustrated and listed in Figure 1. Samples were iced after collection and sent to the

FIGURE I


M1
EMBARRASS
HWY 22
1,2
POTW
3
M2
Road
New POTW
Discharge Point
HWY Y
4
N
Sampling Sites
M Macroinvertebrate Sites
Embarrass
Jepson
Behnke
Road
5, M3
HWY 156
River

State Laboratory of Hygiene for biochemical oxygen demand, 5-day (BOD_5), suspended solids (SS), dissolved ammonia nitrogen (NH_3-N), dissolved nitrite plus nitrate nitrogen (NO_2+NO_3-N), total Kjeldahl nitrogen (TKN), total phosphorus (T-P), conductivity (cond.), fecal coliform (FC), and fecal streptococcus (FS). Water temperature and dissolved oxygen (D.O.) were conducted on-site.

Macroinvertebrates were collected from 3 sites on the Embarrass River on November 16, 1981. These sites are illustrated and listed in Figure 1. A strong effort was made to choose sites that were similar in physical characteristics so the only variable between sites would be water quality.

A D-frame net was used to collect bottom material (12-inch opening with Lmm^2 mesh openings). Macroinvertebrates were collected by placing the net downstream and disturbing the bottom with ones feet while the current carried the dislodged material into the net. Macroinvertebrates were also collected manually from sticks, rocks and leaves collected from the stream bottom. Material was collected to obtain at least 100 organisms. All material was placed into pint Mason jars half full of 95% ethyl alcohol.

In the laboratory macroinvertebrates were initially separated into easily discernable taxa. They were picked from a white enamel pan and put into vials containing 95 percent alcohol. Picking of each sample continued until at least 100 organisms were picked. Macroinvertebrates were then identified to the lowest possible taxonomic level.

A taxonomic list was prepared for each site with numbers of each taxa. Biotic index values were assigned for each appropriate taxa and a biotic index calculated for each site according to Wisconsin Department of Natural Resources Technical Bulletin 100 by William Hilsenhoff. Biotic index values range from 0-5 with 0 being indicative of undisturbed streams and 5 of severely disturbed streams. Water quality determinations from biotic index values listed by Hilsenhoff are below (Table 3).

Table 3. Water quality determinations from biotic index values.

Biotic Index	Water Quality	State of Stream
<1.75	Excellent	No organic pollution
1.75 - 2.25	Very Good	Possible slight pollution
2.26 - 2.75	Good	Some pollution
2.76 - 3.50	Fair	Significant pollution
3.51 - 4.25	Poor	Very significant pollution
4.26 - 5.00	Very Poor	Severe pollution

RESULTS AND DISCUSSION

1981 POTW Discharge Monitoring Reports

A summary of the 1981 effluent flow, BOD_5 and SS from the Village of Embarrass POTW discharge monitoring reports is in Table 4.

Chemical and Bacteriological Survey

The chemical and bacteriological results for this study are in Table 5. The loads were calculated for these results and are in Table 6.

There were no observable effects in the Embarrass River due to the Village of Embarrass POTW except for a gray color in the water immediately downstream from the outfall due to the outfall.

The distinct rise in FC and Fs numbers at the mixed point were due to the POTW. The operator said he was having problems with the Chlorinator and it was not operating during the survey. The high FC/FS ratios at the outfall and mixed point indicate human origin. There were very high FC and Fs numbers in the tributary at Jepson Road (Site 4). The FC/FS ration indicates a gray area so the origin could be animal or human. Non-point source input (agricultural) was evident above and below the site.

Input of POTS effluent had little to insignificant effect on the concentrations of most parameters from above the POTW to the mixed point. Only TKN showed a significant rise (more than 2 times). Since the dis-NH_3-N fraction of the TKN only increased from 0.04 mg/l to 0.96 mg/l (within the $\pm$ 0.02 test error) most of the TKN increase was due to dissolved and/or particulate organic nitrogen. However, most parameter concentrations were very high in the effluent. Concentrations of most parameters showed little change (a slight drop in some nutrients) between the mixed point and Behnke Road (Site 5).

The concentrations of nutrients, BOD_5 and SS were significantly higher in the tributary at Jepson Road than at any point sampled in the Embarrass River. Nutrient levels in this tributary were high enough to be at significant pollution levels. The SS of 20 mg/l was apparently a result of the previous week's, evening's and morning's rain. Other high parameter levels can be attributed in a large part to these rainfall events. The tributary was significantly turbid and the bottom could not be seen. All these observations indicate non-point source runoff.

Most loading data can be explained in the same manner as the concentration data. The BOD_5 and SS concentrations of the POTW were very near the average yearly concentrations of the discharge monitoring reports so the POTW chemical sampling of this study can be assumed to be representative relative to concentrations. However, the flow was only 53% of the yearly average. Therefore, if the POTW had been discharging at the yearly average, stream parameters may have risen significantly considering the high nutrient, BOD_5, and SS concentrations in the effluent.

Macroinvertebrate Survey

The physical characteristics of the macroinvertebrate sample sites are in Table 7. A taxonomic list including numbers of species is in Table 8. The biotic index values for these sites are in Table 9 and vary very little from above the POTW to Behnke Road. All indicate very good water quality. Substrate and sampling method was primarily responsible for varying species composition. The large number of Pycnopsyche guttifer collected at the mixed point resulted from carefully looking for them on the stream bottom and collecting them by hand. This was necessary to acquire enough organisms because the riffle at the mixed point had a bottom comprised of small (½") pebbles and little other attachment for macroinvertebrates. Sites 1 and 3 had deeper water and a large amount of attachment sites (i.e. sticks and larger rocks) than site 2. As a result, sites 1 and 3 had much more similar communities than 1 and 2 or 2 and 3. However, current was sufficiently similar on all 3 sites to allow adequate biotic index comparison.

Table 4. Summary of the effluent flow, BOD_5, and SS data of the Village of Embarrass POTW 1981 discharge monitoring reports.

		BOD_5				SS			
Month	Monthly Average Flow MGD	Monthly Average mg/l	Minimum Daily Average mg/l	Maximum Daily Average mg/l	Monthly Average lbs/day	Monthly Average mg/l	Minimum Daily Average mg/l	Maximum Daily Average mg/l	Monthly Average lbs/day
January	.068	102	73	131	58	39	13	65	22
February	.086	105	66	144	75	49	31	66	35
March	.086	79	43	115	57	61	38	83	44
April	.105	76	38	114	67	45	20	70	39
May	.077	78	40	116	50	50	35	65	32
June	.054	118	59	177	53	83	50	115	37
July	.039	131	90	171	43	-	-	-	-
August	.074	146	113	180	90	-	-	-	-
September	.042	139	68	210	49	-	-	-	-
October	.048	118	32	215	47	59	33	87	24
November	.043	135	103	201	48	71	40	94	25
Yearly	.066	112	32	215	58	57	13	115	32

Table 5. Chemical results from the August 27, 1981, chemical survey.

Parameter	Site 1	2	3	4	5
Time	09:25	09:30	09:45	10:35	11:00
Water Temp (°C)	18.0	16.0	17.8	16.0	18.0
D.O. (mg/l)	8.9	2.9	8.6	7.2	9.6
Lab pH (s.u.)	8.2	7.5	8.2	8.0	8.3
Cond. (UMHOS/cm)	410	830	410	620	410
BOD_5 (mg/l)	2.9	110	3.3	4.5	3.3
SS (mg/l)	16	60	12	20	15
T-P (mg/l)	0.06	5.9	0.06	0.35	0.06
T-Kjel-N (mg/l)	0.6	40	1.4	2.2	0.9
Dis-NO_2+NO_3-N (mg/l)	0.65	0.1	0.62	0.79	0.63
Dis-NH_3-N (mg/l/	0.04	31	0.06	0.28	0.04
Fec. Coli. M-FCAGAR/100 ml	100	6,300,000	3,600	100,000	1,600
Fec. Strep. MF M-ENT/100 ml	120	810,000	290	40,000	530
FC/FS ratio	0.83	7.78	12,41	2.50	3.02

Table 6. Loading data for the August 27, 1981, chemical survey.

Parameter	Site 1	2	3	4	5
BOD_5 (lbs/day)	1733.5	29	1973.5	14.3	1984
SS (lbs/day)	9564	16	7176	64	9018
T-P (lbs/day)	35.87	1.6	35.88	1.11	36.07
T-Kjel-N (lbs/day)	358.7	11	837.2	7.00	541.1
Dis-NO_2+NO_3-N (lbs/day)	388.54	0.03	370.78	2.51	378.76
Dis-NH_3-N (lbs day)	23.9	8	35.88	0.89	24.05
CFS	110.83*	0.05	110.88	0.59	111.47+

* Calculated by subtracting 2 from 3.

\+ Calculated by adding 3 and 4.

Table 7. Physical characteristics of the macroinvertebrate sample sites.

	Site		
	1	2	3
Substrate Composition			
% Boulders	10	0	10
% Rubble	10	5	20
% Gravel	60	20	60
% Sand	10	50	5
% Silt	0	0	0
% Clay	0	0	0
% Debris	10	25	5
% Muck	0	0	0
% Vegetation	0	0	0
Current	Moderate	Moderate	Moderate
Current Characteristic	riffle	riffle	riffle
Average Width (A)	100	100	100
Average Depth (ft)	1.5	0.5	1.5
Streambank	Wooded	Pasture	Wooded

Table 8. Taxonomic list and number of macroinvertebrates from the macroinvertebrate survey.

Taxa	Site M1 No.	M2 No.	M3 No.
Amphipoda			
Hyallela azteca	-	-	1
Gammarus pseudolimneaus	1	6	2
Coleoptera			
Stenelmis spp	1	-	3
Diptera			
Antocha spp	-	0	3
Atherix variegata	5	-	7
Chironomus spp	-	1	-
Orthodadius spp	-	-	2
Tabanus spp	-	-	1
Thienemannimyia spp	-	-	2
Ephemeroptera			
Baetis intercalaris	-	-	1
Ephemerella spp	1	-	-
Heptagenia flavescens	-	-	1
Leptophiebia spp	1	7	25
Stenacron interpunctatum	-	-	9
Stenonema tripunctatum	5	-	2
Stenonema mediopunctatum	-	-	1
Isopoda			
Asellus intermedius	-	1	-
Megaloptera			
Sialis spp	-	-	1
Odonata			
Argia spp	-	-	3
Plecoptera			
Acroneuria abnormis	11	-	11
Isoperla marlynia	-	1	-
Perlinella spp	-	2	-
Pteronarcys spp	14	1	4
Taeneopteryx spp	-	1	-
Tricoptera			
Brachycentrus numerosus	19	-	4
Cheumatopsyche spp	29	-	13
Chimarra socia	2	-	-
Hydropsyche spp	-	-	1
Neureclipsis spp	-	-	3
Pycnopsyche guttifer	-	69	1
Symphitopsyche morosa	2	-	-
Symphitopsyche spp	1	-	-
Total	92	89	101

Table 9. Resultant biotic index values from the November 16, 1981 macroinvertebrate survey.

	Site 1	2	3
Biotic Index Value	1.78	1.84	2.08

LITERATURE CITED

Hilsenhoff, W. L. 1981. Use of arthropods to evaluate water quality of streams. Tech. Bul. No. 100. Wis. Dept. Nat. Res. 17 p.

APPENDIX

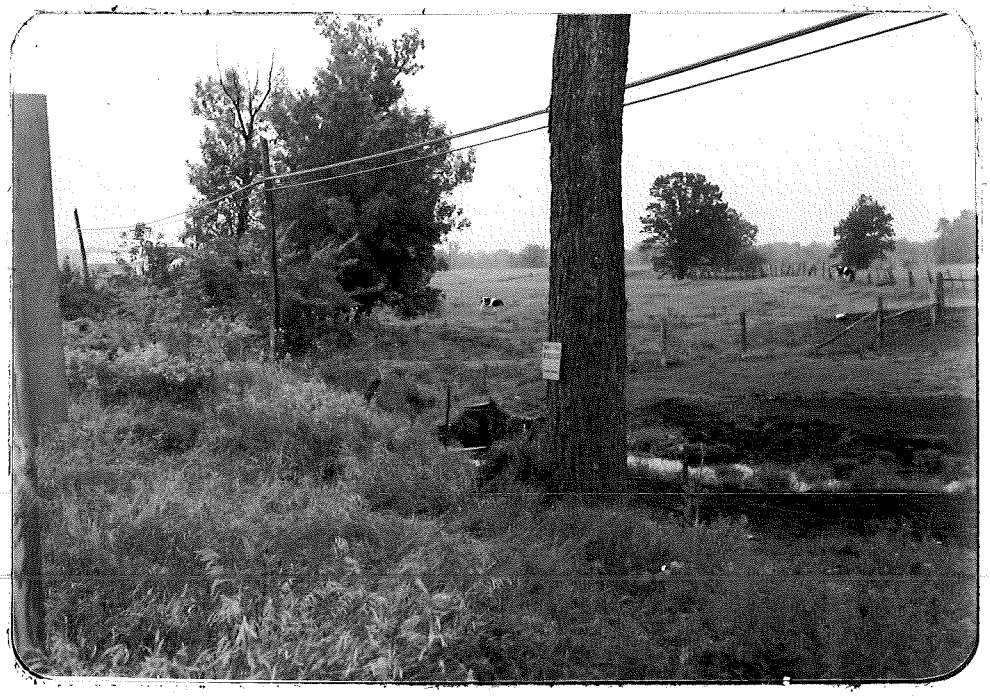
Embarrass River looking downstream from the park boat landing beyond the Village of Embarrass POTW outfall located approximately 1/2 inch from the right edge of the photograph (September 3, 1981).

Macroinvertebrate Site 2 looking upstream. It was assumed the effluent from the POTW was mixed sufficiently at this point for a Macroinvertebrate site. Note the non-point sources. (September 3, 1981).

Embarrass River looking upstream toward macro-invertebrate site 2 which was located just around the corner. The new POTW outfall is just to the right outside the photograph. (September 3, 1981).

This photograph was taken from the old POTW parking lot. The new POTW outfall is located to the left of the white-grey stone pile. (September 3, 1981).

Embarrass River looking downstream past the new POTW outfall. (September 3, 1981).



Tributary looking downstream from Jepson Road. Note the non-point source impact. (September 3, 1981).

Embarrass River looking upstream from Behnke Road (September 3, 1981).

Embarrass River looking downstream from Behnke Road. Macroinvertebrate Site 3 was located at the bottom of the photograph. (September 3, 1981).