PREOPERATIVE AND INDUSTRIAL POINT SOURCE IMPACT STUDY OF BLACK OTTER CREEK RELATED TO THE EFFLUENTS OF THE CITY OF HORTONVILLE PUBLICLY OWNED TREATMENT WORKS AND THE LARSEN COMPANY

Publication Date: June 1983

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GENERAL INFORMATION

Drainage Basin:	Wolf River - 112
Location of Study Reach:	Black Otter Creek from the dam of Black Otter Lake downstream to approximately 3/4 miles above the Wolf River, T22N, R15E; Sections 26, 35, Hortonia Township, Outagamie County.
Chemical Survey Investigation Dates:	4/30/81 and 8/6/82
Macroinvertebrate Survey Investigation Dates:	4/30/81 and 10/22/81
Chemical Survey Personnel:	Michael Reif, Tim Doelger and Laura Herman
Macroinvertebrate Survey Personnel:	Michael Reif and Tim Doelger
Macroinvertebrate Identification:	Laura Herman for 1981 macroinvertebrate identification; Michael Reif for 1982 macroinvertebrate identification.
Fish Survey and Results and Discussion:	Lee Meyers
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SUMMARY AND CONCLUSIONS

1. Black Otter Creek was documented by this study to have been significantly degraded by three sources: Black Otter Lake, The Larsen Company (primarily their contact cooling water) and the Village of Hortonville Publicly Owned Treatment Works (POTW) with the POTW having the largest impact.

2. Anoxic conditions in Black Otter Lake during the summer caused probable nutrient release from sediments and result in low dissolved oxygen levels in Black Otter Creek at the origin of the study reach (the Black Otter Lake Dam).

3. Black Otter Creek does not meet the DO mg/l minimum water quality standard as established by Wisconsin Administrative Code NR 104 due to Black Otter Lake.

4. The Larsen Company's 001 effluent (contact cooling water) significantly degraded Black Otter Creek about 1/4 mile below the dam by causing a heavy slime growth which covered most of the streamm bottom for at least 100 yards. The slime growth significantly reduced the numbers of macroinvertebrates in Spring Creek.

5. The degredation of Black Otter Creek by The Larsen Company's cooling water occurred even though there was only one BOD WPDES permit violation during the two year period of the study. Therefor, it is concluded that The Larsen Company's WPDES permit should be revaluated so no degredation occurs in Black Otter Creek.

6. The Village of Hortonville POTW significantly increased the biotic index resulting in very poor water quality conditions at the mixed point. The POTW also caused dramatic increases in all nutrient levels and caused a dramatic reduction in dissolved oxygen in Black Otter Creek in the summer (down to 0.9 mg/l) though this decrease was also related to the other sources stated agove and the physical nature of the creek below the POTW (slow current and low flow in the summer).

7. The macroinvertebrate communities were found to exhibit biotic index values 1.37 units higher in the fall than spring on the average due to a combined effect of the natural (low flow) stream characteristic and pollution sources.

8. I therefore conclude that the water quality of Black Otter Creek would be significantly improved by:

   a. The dredging of Black Otter Lake. Increasing the depth of the lake should result in more stable dissolved oxygen conditions.

   b. Stabilizing the outflow of the lake if possible which should result in stable stream conditions.

c. The Larsen Company's 001 effluent quality being upgraded so the heavy slime growth in Black Otter Creek is eliminated.

D. The POTW effluent discharge being moved to discharge to he Wolf River which has already occurred.

9. As a result of a fish survey of Black Otter Creek above Hwy 45 in the fall of 1982, it appears the creek possesses a high number of young northern pike indicating natural reproduction of northern pike, many of which probably move down to supplement the Wolf River fishery. Further improvement of the water quality may increase the number of panfish and forage minnow species present in Black Otter Creek.

10, The post-operative portion of this study should be conducted after the degradation of Black Otter Creek by the Larsen Company cooling water has been eleminated.

OBJECTIVES

The objective of this study was to document water quality conditions (biological, chemical, and physical) in Black Otter Creek related to the effluents of the City of Hortonville Publicly Owned Treatment Works (POTW) prior to upgrading of the facility and elimination of its discharge to Black Otter Creek, and the effluents of the Larsen Company.

INTRODUCTION

The Village of Hortonville (1980 population of 2,016) POTW had a trickling filter during this study with secondary effluent limits (Table 1). It had a discharge to Black Otter Creek approximately 1/4 mile downstream from Hwy 45 (Figure 1). The new Village POTW (constructed during this study on the same site) is a rotating biological contactor plant and has a discharge to the Wolf River at Hwy M (Figure 1).

The Larsen Company cans mixed vegetables and has a contact cooling water discharge, a spray irrigation system for washwater which runs off into a lagoon system, and a fill and draw discharge to Black Otter Creek (Figure 1 and Table 3). The effluent limits are in Table 2 for the 2 outfalls to Black Otter Creek (001 and 002).

STUDY AREA

The study reach extended from the Black Otter Lake dam downstream to 3/4 mile above the Wolf River (Figure 1). An elevation vs distance downstream graph is in Figure 2.

Black Otter Lake is a 75-acre impoundment. It is significant in that it is one of only 3 named lakes in Outagamie County and is therefore a highly valued recreational resource for local residents. Recreational use has been restricted due to heavy weed growth and seasonal low dissolved oxygen levels (DNR, 1981).

Black Otter Creek is primarily composed of riffles and moderate flow areas with sand, gravel, and rubble bottom from the dam downstream to the mixed point below the POTW (see photographs in Appendix C). This section has a large amount of attachment for aquatic insects. From the mixed point to the end of the study reach, the stream has a slow to moderate flow with silt and sand bottom. This section has a much reduced amount of attachment for aquatic organisms from the above section.

The flow of Black Otter Creek fluctuates widely seasonally and as a result of fluctuations of flow at the Black Otter Lake Dam. This large fluctuation in flow has a significant impact on the water quality of Black Otter Creek.

Table 1. Village of Hortonville POTW WPDES permit limits (12-12-80 to 12-31-81).

Parameter	Average lbs/day	Average mg/l	Minimum s.u.	Maximum s.u.
BOD_5 (monthly)	156	100	--	--
BOD_5 (weekly)	234	150	--	--
SS (monthly)	140.4	90	--	--
SS (weekly)	210.5	135	--	--
pH	--	--	6.0	9.0

Table 2. Larsen Company WPDES permit effluent limits (January 1, 1978 to December 31, 1981)

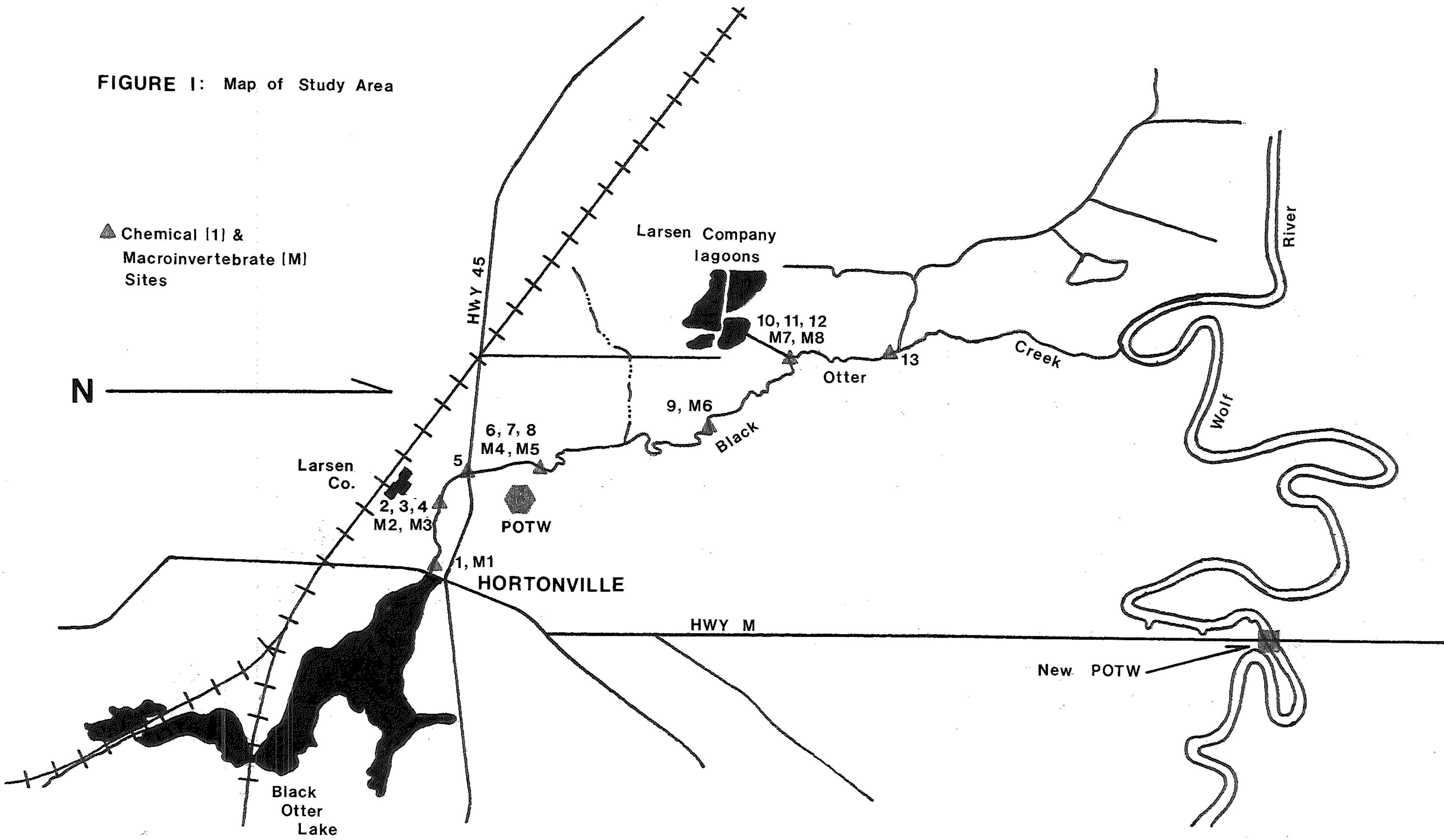
Parameter	Outfall 001	Outfall 002
pH (min.-max.)	6.0-9.0	6.0-9.0
SS (max.)	51,801 lbs/yr	30 mg/l*
BOD_5 (Avg.)	---	10 mg/l*
BOD_5 (max.)	100 mg/l 27,475 lbs/yr	20 mg/l* ---
Temp. (max.)	---	46.2°C

*Calculated from a one-hour composite of 3 grabs.

Table 3: Black Otter Creek study sample site descriptions.

1, M1.	100 feet below dam.
2, M2.	Black Otter Creek - 50 feet above Larsen Co. 001.
3.	Larsen Co. 001.
4, M3.	Black Otter Creek - mixed point below Larsen Co. 001.
5.	Black Otter Creek - 50 feet above HWY 45.
6, M4.	Black Otter Creek - 100 feet above Hortonville POTW outfall.
7.	Hortonville POTW outfall.
8, M5.	Black Otter Creek - mixed point below Hortonville POTW outfall.
9, M6.	Black Otter Creek - sag point below Hortonville POTW outfall.
10.	Black Otter Creek - Larsen Co. property line.
11, M7.	Black Otter Creek - 100 feet above Larsen Co. 002.
12.	Larsen Co. 002.
13, M8.	Black Otter Creek - mixed point below Larsen Co. 002.
14.	Black Otter Creek - 1/4 mile below Larsen Co. 002.

FIGURE I: Map of Study Area



The land use was primarily urban from the dam down to the POTW, but the banks have a large amount of trees and bushes growing on them. The land use was 40% pasture and 60% wooded through the remainder of the study reach.

METHOD AND MATERIALS

The chemical surveys of this study were conducted on April 30, 1981, and August 6, 1981. Sites were sampled on 4/30/81 to measure the effect of the POTW effluent and the Larsen Company's 002 outfall on Black Otter Creek (sites 1, 5, 6, 7, 8, 9, 11, 12, 13, 14). Larsen Company's 001 was not discharging on 4/30/81. Samples were iced and sent to the State Laboratory of Hygiene for biochemical oxygen demand, 5-day (BOD_5), suspended solids (SS), total phosphorus (T-P), ortho phosphorus (O-P), total Kjeldahl nitrogen (TKN), dissolved ammonia nitrogen (NH_3-N), nitrite plus nitrate nitrogen (NO_2+NO_3-N), conductivity, fecal coliform (FC), and fecal streptococcus (FS). Sites were sampled on 8/6/81 to measure the effect of Larsen Company's 001 effluent and the POTW effluent on Black Otter Creek (1, 2, 3, 4, 6, 7, 8, 9 and 10). Larsen Company's 002 was not discharging on 8/6/81. Samples were treated as on 4/30/81 except O-P, FC and FS were not analyzed and chlorides (Cl^-) were. Water temperatures, pH, and dissolved oxygen (D.O.) were measured on-site.

The fishery of Black Otter Creek was sampled on September 29, 1982, at the Village Park located immediately west of Hwy 45 on the south shore of Black Otter Creek. A 150 volt, DC longline shocker was used.

Macroinvertebrates were collected on 4/30/81 from sites M1, and M4 - M8 (Figure 1). M2 and M3 were not sampled because Larsen Company's 001 was not discharging. Macroinvertebrates were collected on 10/22/81 from sites M1 – M8. Macroinvertebrates were collected from sites M2 and M3 on 9/7/82 during a compliance monitoring survey of the Larsen Company.

A D-frame net was used to collect bottom material (12-inch opening with $1mm^2$ 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% alcohol. Picking of each sample continued until at least 100 organisms were picked. Macroinvertebrates were then identified to the lowest possible toxonomic level.

A taxanomic 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 132 by William Hilsenhoff. Bioticindex values range from 05 with 0 being indicative of undisturbed streams and 5 of severely disturbed streams. Water quality determinationsfrom biotic index values listed by Hilsenhoff are below (Table 2).

Table 4. Water quality determinations from biotic index values.

Biotic Index	Water Quality	State of Stream
0.00 - 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

Summary of the 1981 Discharge Monitoring Reports for the Village of Hortonville POTW.

A summary of the 1981 Village of Hortonville discharge monitoring reports is in Table 5. All values are monthly averages. The POTW discharge values for the surveys discussed in the next section are from grab samples.

Summarh of the 1981 and 1982 Discharge Monitoring Reports for The Larsen Company.

Summaries of the 1981 and 1982 discharge monitoring reports for the Larsen Company are in Tables 6 and 7.

Several WPDES permit violations occurred at the Larsen Company cooling water discharge (002). These are listed as follows:

1 SS violation in August 1981
1 SS violation in September 1981
1 SS violation in July 1982
1 SS violation in August 1982
1 BOD violation in September 1982
1 SS violation in September 1982
2 SS violations in October 1982

Chemical and Bacteriological Survey Results and Discussion.

Data from this study indicate Black Otter Creek to be highly degraded from three sources: (1) Village of Hortonville POTW: (2) The Larsen Company outfall 001; and (3) Black Otter Lake.

The major impact on Black Otter Creek indicated from the data collected during this study, was from the Village POTW, though the impact of the other sources was also significant. This can be dramatically seen in Figures 3 - 8 which are graphs of D.O. and nutrients for the two chemical surveys. Also see Tables A, A2 and A4 in Appendix A for the concentration data collected during the April 30, 1981, and August 6, 1981, chemical surveys and Tables A3 and A5 in Appendix A for the loading data calculated from these surveys. A number of impacts occur in Black Otter Creek throughout the study reach so it is useful to describe the chemical surveys from Black Otter Lake downstream.

Table 5. Summary of Village of Hortonville WPDES effluent DMR data for 1981.

Month	Flow MGD	BOD_5 Avg mg/l	SS Avg mg/l	pH Min.	pH Max
J	0.182	74	58	7.6	8.0
F	0.191	64	69	7.4	7.9
M	0.200	52	54	7.6	8.0
A	0.247	26	33	7.4	8.0
M	0.225	49	73	7.4	7.9
J	0.209	34	58	7.5	7.9
J	0.172	32	44	7.1	8.1
A	0.172	29	35	7.6	8.2
S	0.166	37	46	7.6	8.2
O	0.169	26	43	7.6	8.1
N	0.146	34	50	7.8	8.1
D	0.155	38	51	7.8	8.1
Avg.	0.186	41	51		

Table 6. Summary of The Larsen Company 1981 DMRs.

Outfall	Parameter	J	F	M	A	M	J	J	A	S	O	N	D
		Month											
001	Flow Avg. (MGD)	-	-	-	0.350	0.251	0.122	-	-	-	0.314	0.022	-
	pH Min. (s.u.)	-	-	-	7.0	7.7	8.2	-	-	-	7.8	7.9	
	pH Max. (s.u.)	-	-	-	8.9	8.2	8.6	-	-	-	8.1	7.9	-
	SS Avg. (mg/l)	-	-	-	46	29	49	-	-	-	37	18	-
	SS Min. (mg/l)	-	-	-	28	0	22	-	-	-	6	18	-
	SS Max. (mg/l)	-	-	-	57	48	86	-	-	-	68	18	-
	BOD_5 Avg. (mg/l)	-	-	-	10	17	23	-	-	-	13	8	-
	BOD_5 Min. (mg/l)	-	-	-	6	11	16	-	-	-	4	8	-
	BOD_5 Max. (mg/l)	-	-	-	16	32	39	-	-	-	24	8	-
002	Flow Avg. (MGD)	-	-	-	-	-	0.029	0.066	0.099	0.151	0.067	0.039	
	pH Min. (s.u.)	-	-	-	-	-	7.8	8.1	7.6	7.0	7.5	7.4	
	pH Max. (s.u.)	-	-	-	-	-	7.8	8.5	7.8	8.3	8.0	7.7	
	SS Avg. (mg/l)	-	-	-	-	-	8	12	17	25	17	11	-
	SS Min. (mg/l)	-	-	-	-	-	0	0	0	0	0	0	-
	SS Max. (mg/l)	-	-	-	-	-	15	22	32	57	26	27	-
	Water Temp. Avg. (°F)	-	-	-	-	-	88	100	91	97	87	75	
	Water Temp. Min. (°F)	-	-	-	-	-	80	83	75	86	64	68	
	Water Temp. Max. (°F)	-	-	-	-	-	105	112	100	106	99	80	-
	BOD_5 Avg. (mg/l)	-	-	-	-	-	1	6	7	8	2	7	-
	BOD_5 Min. (mg/l)	-	-	-	-	-	0	4	0	3	0	4	-
	BOD_5 Max. (mg/l)	-	-	-	-	-	1	9	11	15	6	10	-

Table 7. Summary of The Larsen Company 1982 DMRs.

Outfall	Parameter	J	F	M	A	M	J	J	A	S	O	N	D
		Month											
001	Flow Avg. (MGD)	-	-	-	-	-	0.015	0.457	0.038	0.494	-	-	-
	pH Min. (s.u.)	-	-	-	-	-	7.7	7.6	7.1	7.5	-	-	-
	pH Max. (s.u.)	-	-	-	-	-	8.4	8.6	7.9	8.1	-	-	-
	SS Avg. (mg/l)	-	-	-	-	-	117	27	77	8	-	-	-
	SS Min. (mg/l)	-	-	-	-	-	19	3	53	0	-	-	-
	SS Max. (mg/l)	-	-	-	-	-	258	49	100	21	-	-	-
	BOD_5 Avg. (mg/l)	-	-	-	-	-	19	18	24	31	-	-	-
	BOD_5 Min. (mg/l)	-	-	-	-	-	10	8	22	8	-	-	-
	BOD_5 Max. (mg/l)	-	-	-	-	-	40	32	25	65	-	-	-
002	Flow Avg. (MGD)	-	-	-	-	-	0.025	0.113	0.105	0.155	0.078	0.023	-
	pH Min. (s.u.)	-	-	-	-	-	7.6	7.3	6.6	7.4	7.7	7.6	-
	pH Max. (mg/l)	-	-	-	-	-	7.7	8.2	8.4	8.1	8.0	7.6	-
	SS Avg. (mg/l)	-	-	-	-	-	25	23	16	11	37	11	-
	SS Min. (mg/l)	-	-	-	-	-	21	8	7	1	0	6	-
	SS Max. (mg/l)	-	-	-	-	-	30	61	41	36	88	16	-
	Water Temp. Avg. (^{o}F)	-	-	-	-	-	85	94	105	103	102	84	
	Water Temp. Min. (^{o}F)	-	-	-	-	-	84	82	98	98	92	80	-
	Water Temp. Max. (^{o}F)	-	-	-	-	-	85	102	112	110	108	88	-
	BOD_5 Avg. (mg/l)	-	-	-	-	-	2	10	6	11	8	8	-
	BOD_5 Min. (mg/l)	-	-	-	-	-	1	5	0	2	1	3	-
	BOD_5 Max. (mg/l)	-	-	-	-	-	3	17	13	18	13	12	-

Dissolved oxygen levels fluctuate widely in Black Otter Lake (DNR, 1981). Black Otter Lake is very shallow with a muck bottom and therefore produces a large population of aquatic vascular plants and filamentous algae. Summer and winter kills are frequent. The somewhat low dissolved oxygen in Black Otter Creek at sites 1 and 2, measured during the August 6 chemical survey (Table A4 in Appendix A), are assumed to have been largely due to poor D.O. levels in the lake. The large difference in T-P levels between the spring and fall (0.04 mg/l and 0.25 respectively) indicate probable P release from the sediment during anoxic conditions. The assumption of the existence of anoxic conditions in Black Otter Lake during the summer chemical survey is substantiated by an extensive summer kill I observed while supervising the herbicide treatment of Black Otter Lake on July 14, 1981.

Approximately one-quarter mile below the dam Black Otter Creek is degraded by the contact cooling water and yard runoff of the Larsen Company. During the August 6, 1981, chemical survey, as well as my compliance monitoring surveys of September 23, 1981 and August 19, 1982 (see DNR industrial wastewater file for correspondence), a large growth of *Sphaerotilus natans* covered the bottom of the cooling water ditch and Black Otter Creek in the mixing and mixed zone below the cooling water ditch. There was a drop in D.O. from above to below the cooling water ditch down to site 6 above the POTW on August 6, 1981. At least part of this D.O. drop can be assumed to be due to the cooling water. Bottom samples were collected on August 19, 1982, from 5 feet above the cooling water discharge and in the mixing zone 5-10 feet below the cooling water ditch for algae, filamentous bacteria and fungi identification. No filamentous bacteria was found above, but it was found below, the cooling water ditch. T-P concentrations were raised in Black Otter Creek by nearly 100% (0.24 to 0.46 mg/l) resulting from the cooling water discharge (Table A4). Nitrogen concentrations had no significant change.

The Village of Hortonville POTW had a dramatic effect on nearly all parameters measured during the April 30 and August 6 chemical surveys (Tables 5, 6, 7, 8 and 9 and Figures 3-8). Early morning and afternoon dissolved oxygen levels dropped nearly 2 mg/l by site 13 on April 30. The drop in D.O. was even more dramatic on August 6 when D.O. levels dropped to 0.9 mg/l by site 9 (the sag point). These drops in D.O. levels are assumed to be a combined effect of the lake, cooling water and POTW though the POTW may have had the largest effect.

Larsen Company lagoon 4 was discharging on April 30. It had a large effect on phosphorus, SS, BOD_5 and conductivity levels (Table A2 and Figure 4). The high SS solids concentration in the effluent was due to algae. The effluent was a bright green color as a result of the algae. The low NH_3-N and NO_2+NO_3-N levels and high TKN levels in the effluent indicate nitrogen to be tied up in the algae.

Fish Survey Results and Discussion

Seven northern pike ranging from 8.5 to 10.9 inches (probably age 0+) were captured along with three pumpkinseed sunfish ranging 1.5 to 4.9

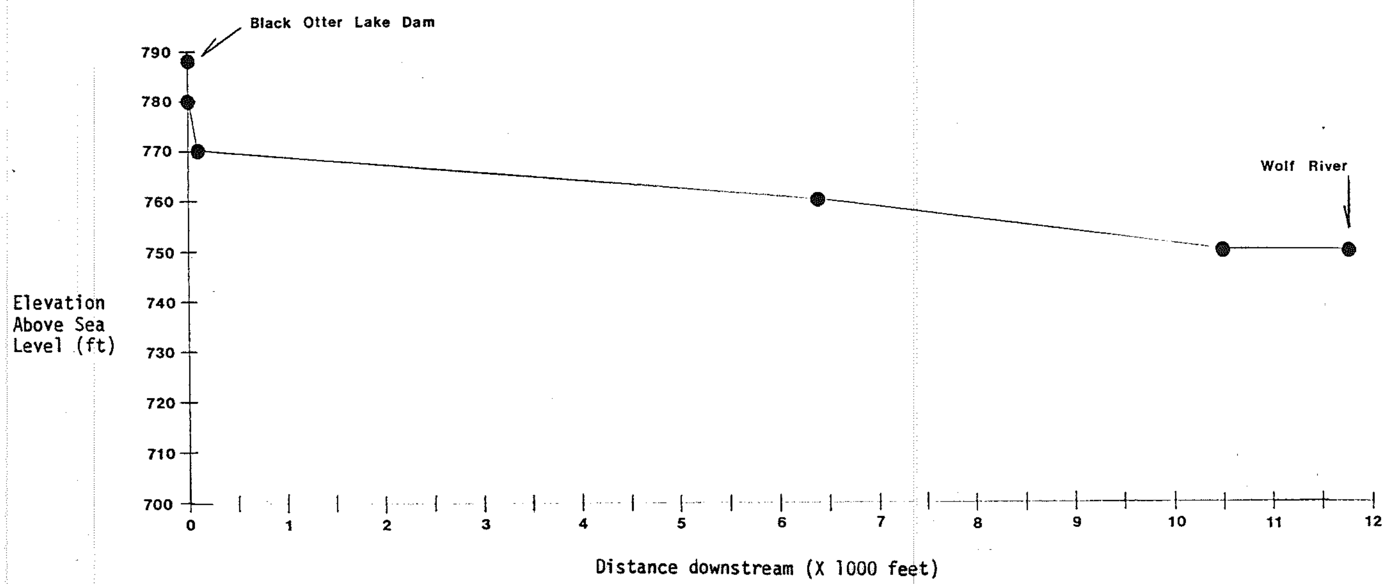


Figure 2. Stream elevation profile of the study reach.

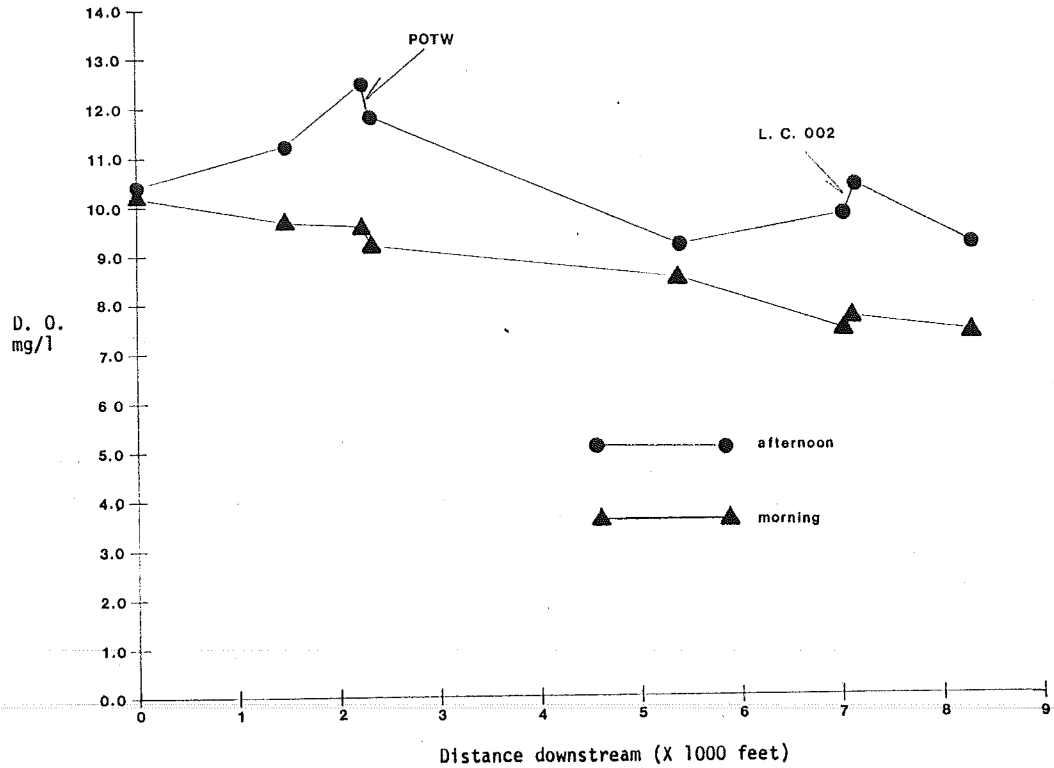


Figure 3. Early morning and afternoon stream dissolved oxygen profiles from the 4-30-81 chemical survey.

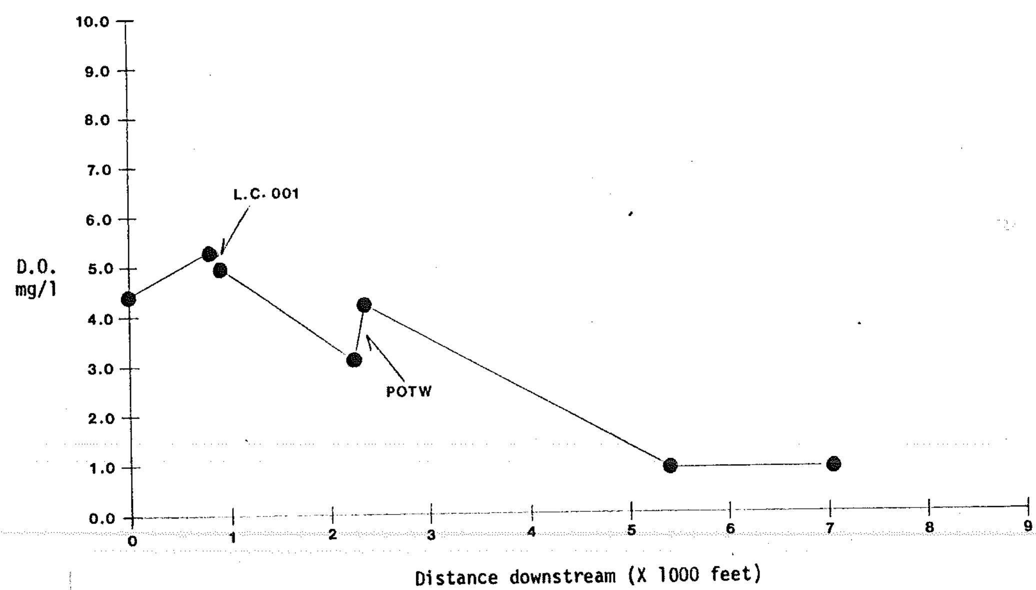


Figure 4. Dissolved oxygen profile from the 8-6-81 chemical survey.

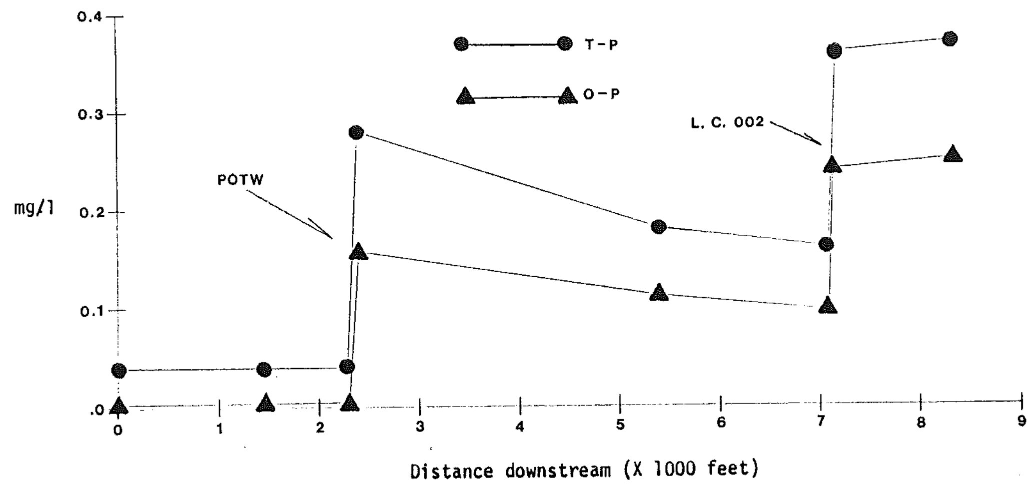


Figure 5. Ortho and total phosphorus profile from the 4-30-81 chemical survey.

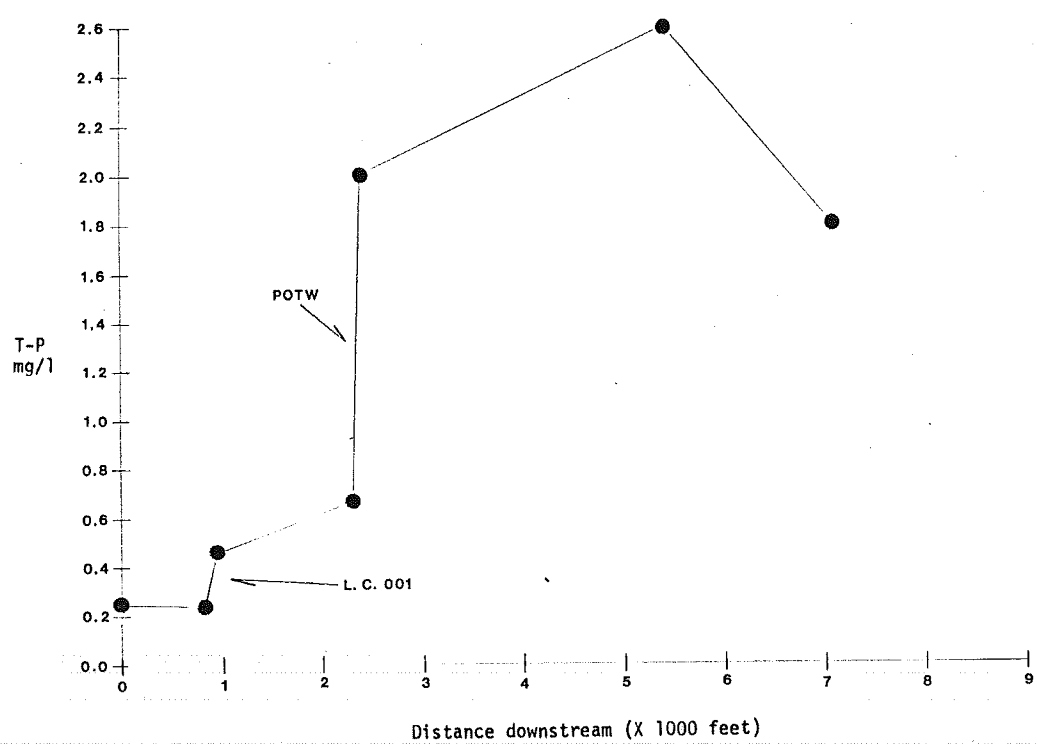


Figure 6. Total phosphorus profile from the 8-6-81 chemical survey.

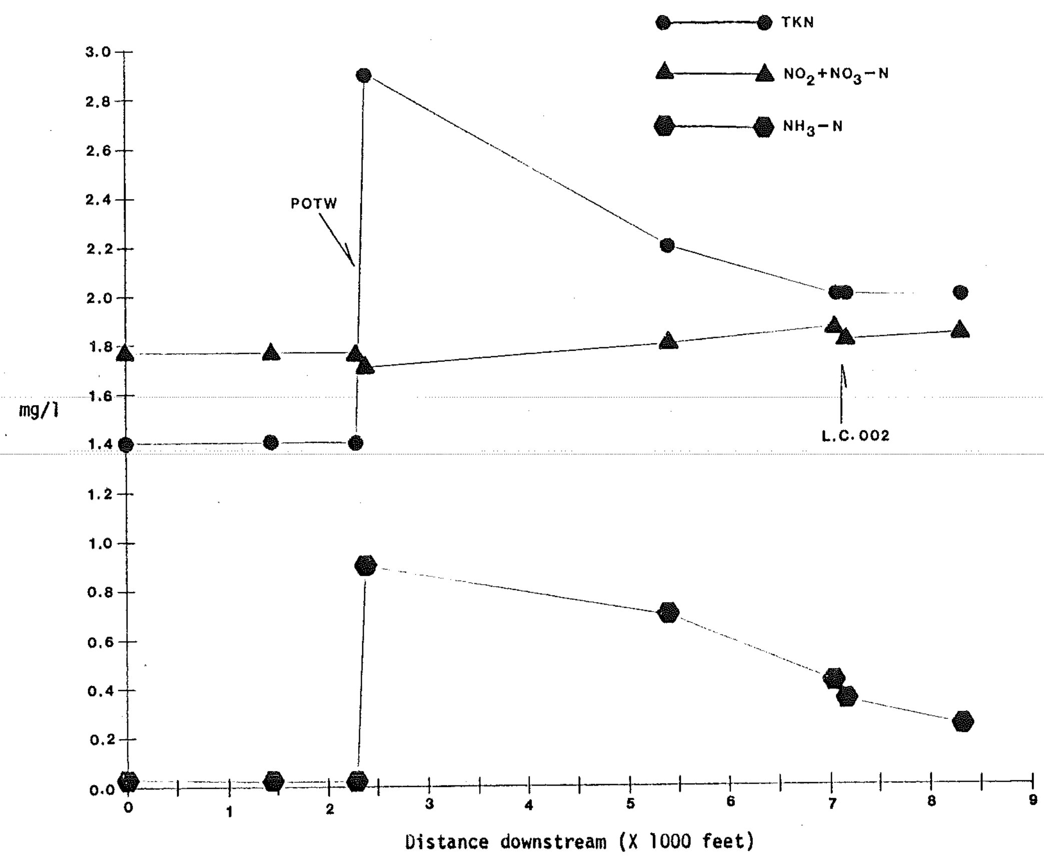


Figure 7. Nitrogen series profile from the 4-30-81 chemical survey.

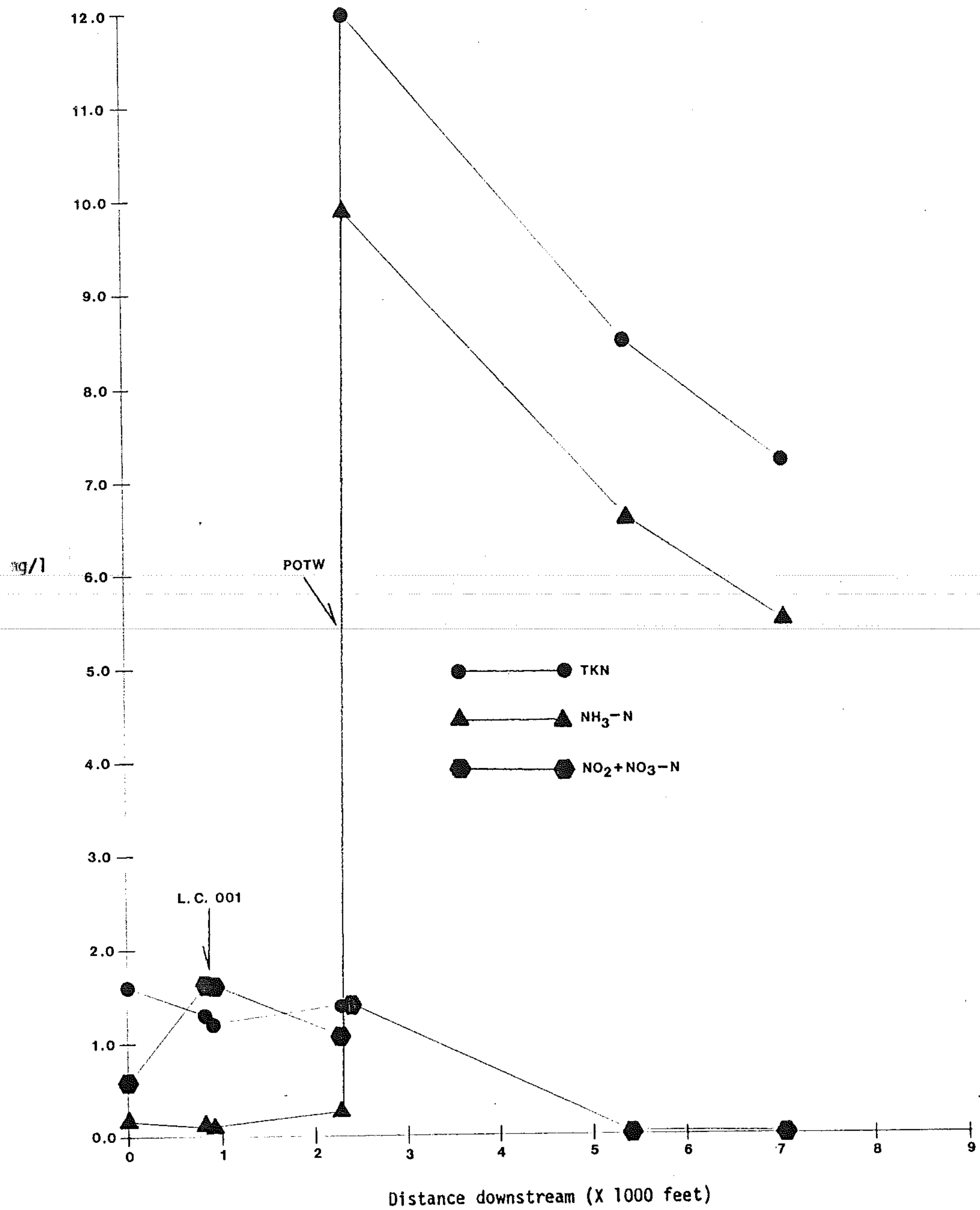


Figure 8. Nitrogen series profile from the 8-6-81 chemical survey.

inches in length. Other fish species captured were the black bullhead, central mudminnow, white sucker and burbott.

The bottom substrate in this stream section was covered by filamentous algae and the only aquatic invertebrates noted were a few caddisflies.

However, at the present time the lower reaches of Black Otter Creek appear to possess a high number of young northern pike indicating natural reproduction of northern pike, many of which probably move down to supplement the Wolf River fishery. Further improvement of the water quality may increase the number of panfish and forage minnow species present in Black Otter Creek.

Macroinvertebrate Survey Results and Discussion

The biotic indices varied significantly between the spring and fall 1981 samplings (Table 6 and Figure 9) with the average difference being 1.37 units. Several factors are probably involved interrelated with the physical characterisitics of Black Otter Creek. The flow was significantly greater during the April 30, 1981, chemical survey than during the August 6, 1981, chemical survey (95% greater) and the flow was still relatively low during the fall macroinvertebrate survey. The decrease in flow resulted in a considerable decrease in point velocity in Black Otter Creek especially in the lower reaches causing stagnant conditions and less attachment for aquatic insects. It appears this fluctuation in flow is characteristic of Black Otter Creek and apparently the macroinvertebrate populations have adjusted themselves accordingly with the communities comprised of mostly bivoltine and multivoltine species which are tolerant of degraded stream conditions (Tables B1-B7 in Appendix B). This difference in flow and the more degradation in water quality in the summer discussed in the chemical survey section result in considerable decreased diversities of macroinvertebrates in the fall compared to the spring with *Chironomus spp* and *Asellus intermedius* comprising large portions of the fall communities. This can be expanded in a more detailed discussion of each sampled community and the stream physical characteristics of each site (see Table 7 for these physical characteristics).

Macroinvertebrate site 1 was located from the dam downstream about 100 feet. The drop in elevation was greater here than at any point in the study reach. This site was also much wider than any other site in the study reach causing sampling problems when the stream flow was low since water trickled over the dam and then split into small channels around the large rocks. This along with the facts that dam elevation levels fluctuate (or are fluctuated) heavily, and the lake water quality is poorer in the summer and fall than spring results in a large amount of stress on the macroinvertebrate community at this site. An increase in lake water quality and a more level fluctuation in lake effluent flow (if possible) would be an aid to the macroinvertebrate community at this site as well as downstream which will become apparent in further discussion.

Much of the above is also true at macroinvertebrate site 2 though stress on the macroinvertebrate community is not as great here as M1, since the creek has less width and less area is left dry under low flow conditions. As a result, the B.I. here was 0.76 units lower than M1 in the fall (3.54 at M2 compared to 4.30 at M1; see Table 6 and Figure 8). Given good stream flow (near 5 cfs), the physical characteristics of the site, as well as M1, M3, M4, and M5, present very good to excellent habitat for macroinvertebrate community development. M2 as well as M3 were not sampled in the spring (4/30/81) since Larsen Company's 001 was not discharging at that time.

Macroinvertebrate site 3 was located at the mixed point below the Larsen Company's 001 ditch (Figure 1). The physical characteristics of this site were very similar to M2 (Table 7). In the fall of 1981 the macroinvertebrate community at this site was very similar to M2 (Tables B2 and B3) and the biotic indices very similar (Table 6). However, collection time had to be more than double that of M2 to collect 100 macroinvertebrates because of the heavy growth of S. natans which took up more of the attachment space for macroinvertebrates. This heavy bacterial growth was the result of Larsen Company's 001 and along with the decrease in macroinvertebrate numbers is definite evidence for water quality degredation caused by the Larsen Company's 001 effluent.

During my September 7, 1982, compliance monitoring survey of the Larsen Company, I re-sampled M2 and M3 and found a very similar situation to the 1981 fall sampling though the growth of S.natans was noticably heavier. The macroinvertebrate community was found (as in 1981) to be much lower in numbers at M3 than M2 and though similar in composition to M2 was definitely more dominated by Asellus intermedius which directly caused the B.I. to be 0.71 units higher at M3 than M2 (Table 6). This is further evidence to the significant degredation of Black Otter Creek by Larsen Company's 001.

Macroinvertebrate site M4 was located about 50 feet above, and MT was located at the mixed point below, the Village of Hortonville POTW (Figure 1). Both sites were very similar in physical characteristics (Table 7) so the decreases in B.I. in the spring and fall of 1981 from M4 to M5 can be assumed to be due directly to the POTW effluent. The macroinvertebrate community also varied significantly between these sites on both dates, being more diverse at M4 and composed almost entirely of Chironomidae at M5 in the spring and Chironomus at M5 in the fall. These are definite evidence to the significant degredation of the water quality of Black Otter Creek by the Village of Hortonville POTW.

The B.I.'s were noticably higher in the spring and fall at M4 than the above sites due at least partially to a decrease in stream physical characteristics (Table 7). As was discussed earlier, a more level stream flow during low flow times may decrease this problem. Also, the Larsen Company 001 effluent was probably still exhibiting a degrading effect at M4 in the fall though the S. natans growth had disappeared by this point.

Macroinvertebrate site 6 was located at the sag point (Figure 1) and was somewhat more degraded physically than M4 or M5 (Table 7) exhibited by somewhat slower current and a muddier bottom. However, lower B.I.'s at M6 in the spring and fall than at M5 indicates the stream recovers somewhat from the degrading effect of the Village POTW effluent. The current, and as a result point volocity, was noticably slower in the fall than spring at this site. From this site down to the end of the study reach, the stream noticably flattens out nearly becoming stagnant during low flow periods as discussed in the chemical survey results and discussion.

Macroinvertebrate site 7 was located 50 feet above Larsen Company's 002 outfall and M8 at the mixed point. Stream physical characteristics at these sites were very similar to M6 (Table 7). M7 exhibited a higher B.I. than M8 in the spring (Table 6 and Figure 9) due to poorer sampled attachment sites which resulted in more Asellus intermedius and less black flies and chironomids being sampled at M7 and the reverse being true at M8. This problem was eliminated in the fall sampling because low flow conditions evened the characteristics of both sites out. No significant effect of the Larsen Company's 002 effluent on Black Otter Creek was found according to these macroinvertebrate data.

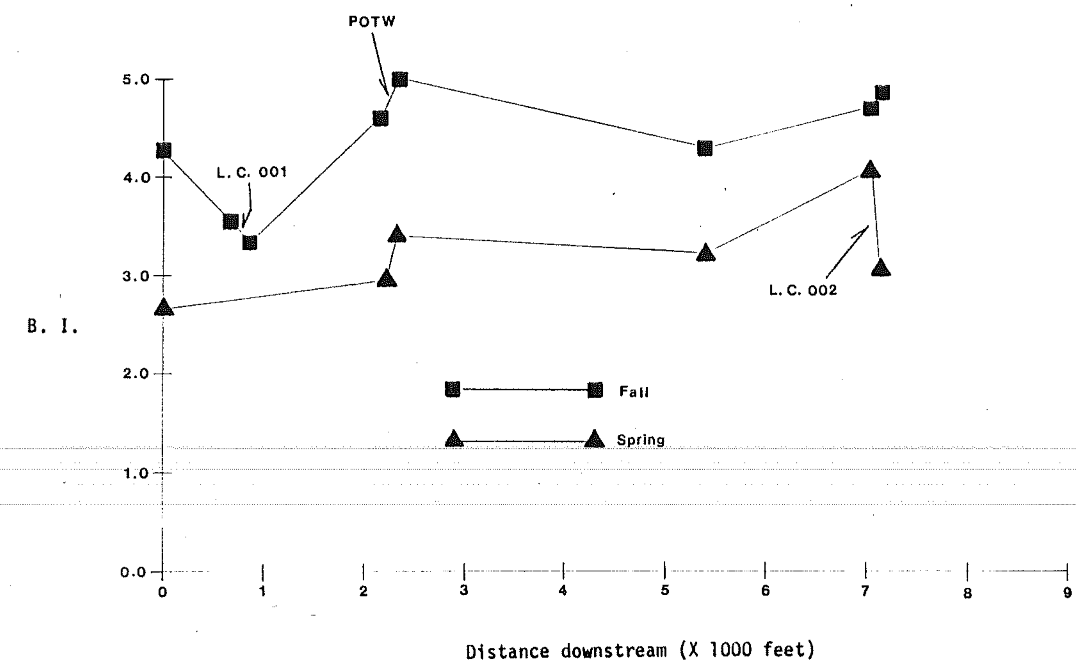


Figure 9. Biotic index profiles from the spring and fall 1981 macroinvertebrate surveys.

Table 8. Biotic index values from the macroinvertebrate sites (4-30-81, 10-22-81 and 9-7-82).

Site	B.I. 4-30-81	B.I. 10-22-81	B.I. 9-7-82
MS1	2.66	4.30	--
MS2	--	3.54	3.30
MS3	--	3.35	4.01
MS4	2.99	4.63	--
MS5	3.44	5.00	--
MS6	3.21	4.33	--
MS7	4.19	4.73	--
MS8	3.14	4.87	--

Table 9. Physical characteristics of the macroinvertebrate sites.

	Site							
	M1	M2	M3	M4	M5	M6	M7	M8
Substrate Composition								
% Boulders	25	15	5	0	0	0	0	0
% Rubble	50	25	25	0	10	0	0	0
% Gravel	15	50	50	10	25	5	5	5
% Sand	0	5	10	65	55	50	50	50
% Silt	0	0	5	10	5	25	25	25
% Clay	0	0	0	10	0	5	5	5
% Debris	5	5	5	5	5	10	10	10
% Muck	0	0	0	0	0	0	0	0
% Vegetation	5	0	0	0	0	5	5	5
Current	Fast	Fast	Fast	Mod.	Mod.	Slow	Slow	Slow
Current Characteristics	Riffle	Riffle	Riffle	Run	Riffle	Run	Run	Run
Average Width (ft)	20	5	5	5	5	10	10	10
Average Depth (ft)	0.5	0.5	0.5	1.0	1.0	1.0	2.5	2.5
Streambank	Wooded	Wooded	Grass	Wooded	Wooded	Pasture	Wooded	Wooded

LITERATURE CITED

Department of Natural Resources. 1980. Black Otter Lake Outagamie County Feasibility Study Results; Management Alternatives. Office of Inland Lake Renewal. 20p.

APPENDIX A

Table A1. Data from the 4-30-82 early morning D.O. profile.

Site	Time	Temp. °C	D.O. mg/l
1	06:04	11.3	10.2
5	06:04	11.0	9.7
6	06:18	10.8	9.6
8	06:22	10.7	9.2
9	06:40	9.9	8.5
10	06:54	9.8	7.4
12	07:02	9.8	7.7
13	07:10	9.7	7.4

Air temp was 5°C at 06:00
0% cloud cover at 06:00

Table A2. Chemical data from the April 30, 1981 survey.

Parameter	Site 1	5	6	7	8	9	10	11	12	13
Time (D.S.T.)	12:49	12:58	13:08	13:12	13:14	13:37	13:57	14:00	14:04	14:20
Water Temp. (°C)	14.0	14.0	13.9	-	13.7	14.2	12.0	-	13.1	13.1
D.O. (mg/l)	10.4	11.2	12.5	-	11.8	9.2	9.8	-	10.4	9.2
pH (s.u.)	8.01	8.41	8.31	7.30	8.31	8.40	8.08	8.42	8.11	8.03
BOD_5 (mg/l)	2	1.8	2	100	10	4.5	2.9	28	3.7	4.7
SS (mg/l)	2	2	4	64	8	4	4	62	8	10
T-P (mg/l)	0.04	0.04	0.04	3.2	0.28	0.18	0.16	5.3	0.36	0.37
O-P (mg/l)	< 0.004	< 0.004	0.004	1.9	0.158	0.112	0.096	3.9	0.24	0.25
TKN (mg/l)	1.4	1.4	1.4	21	2.9	2.2	2.0	5.4	2.0	2.0
NH_3-N (mg/l)	0.03	0.02	0.02	13	0.9	0.7	0.42	0.03	0.35	0.25
NO_2+NO_3-N (mg/l)	1.77	1.77	1.76	1.4	1.7	1.8	1.86	0.03	1.81	1.82
Cond (umho/cm)	585	585	585	1220	647	630	647	2020	723	723
FC (M-FCAGAR/100 ml)	< 10	10	30	970	7300	7600	1400	10	950	410
FS (MF M-ENT/100 ml)	20	30	20	-	8900	5300	680	< 10	780	470
FC/FS	0.50	0.33	1.50	-	0.82	1.43	2.06	1.00	1.22	0.87

Air temperature was 16°C at 14:20

Table A3. Loading data for the April 30, 1981, chemical survey.

Parameter	Site 1	6	7	8	10	11	12
BOD_5 (lbs/day)	68	87	198	453	166	107	226
SS (lbs/day)	68	173	127	362	229	237	489
T-P (lbs/day)	1.36	1.73	6.3	12.68	9.18	20.2	22.02
O-P (lbs/day	0.136	0.173	3.8	7.154	5.505	14.9	14.68
TKN (lbs/day)	47.8	60.6	42	131.3	114.7	20.6	122.3
NH_3-N (lbs/day	1.02	0.87	26	40.7	24.09	0.11	21.41
NO_2+NO_3-N (lbs/day)	60.4	76.18	2.8	77.0	106.67	0.11	110.71
Flow ($F+^3$/Sec)	6.33	8.03	0.37*	8.40**	10.64	0.71***	11.35****
Flow (MGD)	4.0909	5.1896	0.2376	5.4287	6.8763	0.458	7.3343

* Flow obtained from the operator for 13:21.
** Flow obtained by adding sites 6 and 7.
*** Flow obtained from Larsen Co. DMR for 4-30-81.
**** Flow obtained by adding sites 10 and 11.

Table A4. Chemical data from the August 6, 1981 survey.

Parameter	Site 1	2	3	4	6	7	8	9	10
Time	09:20	09:32	09:50	09:37	10:12	10:21	10:32	11:05	11:16
Water Temp. (°C)	23	17.9	25.0	18.3	20.0	17.9	18.9	18.9	21.5
D.O. (mg/l)	4.4	5.3	4.0	5.0	3.1	6.2	4.2	0.9	0.9
pH (s.u.)	7.50	7.42	8.28	7.52	7.52	7.48	7.58	7.64	7.45
BOD_5 (mg/l)	2.4	2.0	3.3	2.9	2.9	23	1.8	8.6	4.5
SS (mg/l)	4	9	12	12	8	41	20	11	33
T-P (mg/l)	0.25	0.24	1.05	0.46	0.67	4.6	2.0	2.6	1.80
TKN (mg/l)	1.6	1.3	0.3	1.2	1.41	32	12	8.5	7.2
NH_3-N (mg/l)	0.17	0.10	0.3	0.10	0.25	27	9.9	6.6	5.5
NO_2+NO_3-N (mg/l)	0.56	1.62	4.5	1.62	11.05	2.2	1.41	<0.02	<0.02
Cl^- (mg/l)	26	28	28	32	54	350	180	70	90
Cond. (umhos/cm)	570	640	900	660	740	2000	1300	900	920
Cloud cover	100%								

Table A5. Loading data for the August 6, 1981, chemical survey.

Parameter	Site 2	3	4	6	7	8
BOD_5 (lbs/day)	2.0	0.2	3.1	6.6	40	7.0
SS (lbs/day)	9	1	13	18	71	78
T-P (lbs/day	0.25	0.06	0.50	1.52	8.0	8
TKN (lbs/day	1.3	0.02	1.3	3.2	56	47
NH_3-N (lbs/day)	0.10	0.02	0.11	0.57	47	38.4
NO_2+NO_3-N (lbs/day)	1.66	0.2	1.75	2.38	3.8	5.47
Cl^- (lbs/day)	29	2	35	122	609	699
Flow (F^{+3}/Sec)	0.19	0.01	0.20*	0.42	0.32	0.72
Flow (MGD)	0.1228	0.0065	0.1293	0.2714	0.2088	0.4653

* Flow obtained by adding site 2 and 3.
** Flow obtained from the operator for 10:21.

APPENDIX B

Table B1. Taxonomic list of macroinvertebrate from MS1 (4-30-81 and 10-22-81).

Taxa	# Spring	# Fall
Amphipoda		
Hyallela azteca	--	78
Diptera		
Ablabesmyia spp	4	--
Cnephia dacotensis	8	--
Polypedilum spp	9	2
Simulium jenningsi	24	--
Simulium venustum	10	--
Simulium vittatum	8	--
Simuliidae	4	--
Ephemeroptera		
Baetis macdunnoughi	7	--
Baetis phoebus	--	1
Isopoda		
Asellus intermedius	3	50
Odonata		
Enallagma spp	1	--
Tricoptera		
Cheumatopsyche spp	14	5
Hydropsyche betteni	8	--
Total	100	136

Table B2. Taxanomic list of macroinvertebrates from MS2 (10-22-81 and 9-7-82).

Taxa	# 1981	# 1982
Amphipoda		
Gammarus pseudolimneaus	20	-
Hyallela azteca	32	1
Coleoptera		
Stenelmis spp (larvae)	2	3
Diptera		
Crictopus spp	-	1
Polypedilium spp	-	12
Ephemeroptera		
Baetis phoebus	1	2
Isopoda		
Asellus intermedius	28	19
Tricoptera		
Cheumatopsyche spp	41	58
Hydropsyche betteni	-	11
Total	124	107

Table B3. Taxonomic list of macroinvertebrates from MS3 (10-22-81 and 9-7-82).

Taxa	# 1981	# 1982
Amphipoda		
<u>Gammarus pseudolimneaus</u>	43	2
<u>Hyallela azteca</u>	33	2
Coleoptera		
<u>Stenelmis spp</u> (larvae)	2	10
Diptera		
<u>Cricotopus spp</u>	--	2
<u>Polypedilum spp</u>	--	13
<u>Smittia spp</u>	--	1
<u>Simulium jenningsi</u>	--	5
<u>Thienimannimyia spp</u>	--	2
Ephemeroptera		
<u>Baetis phoebus</u>	3	--
Isopoda		
<u>Asellus intermedius</u>	28	53
Tricoptera		
<u>Cheumatopsyche spp</u>	13	12
<u>Hydropsyche betteni</u>	--	2
Total	122	103

Table B4. Taxanomic list of macroinvertebrate from MS4 (4-30-81 and 10-22-81).

Taxa	# Spring	# Fall
Amphipoda		
Hyallela Azteca	1	16
Coleoptera		
Stenelmis spp (larvae)	1	--
Diptera		
Ablabesmyia spp	27	--
Chironomidae	--	2
Chironomus spp	--	8
Eusimulium aurium	4	--
Orthocladius spp	3	--
Polypedilum spp	4	--
Rheotanytarsus spp	2	--
Simulium verecundum	--	--
Simulium vittatum	10	--
Tabanus spp	--	1
Ephemeroptera		
Baetis brunneicolor	--	2
Baetis frondalis	18	--
Isopoda		
Asellus intermedius	5	50
Odonata		
Enallagma spp	--	2
Tricoptera		
Cheumatopsyche spp	2	--
Hydropsyche betteni	___	1
Total	103	82

Table B5. Taxonomic list of macroinvertebrates from MS5 (4-30-81 and 10-22-82).

Taxa	# Spring	# Fall
Diptera		
Ablabesmyia spp	39	--
Chironomidae	5	8
Chironomus spp	25	116
Eukiefferiella spp	12	--
Orthocladius spp	4	--
Polypedilum spp	8	--
Simulium venustum	4	--
Stictochironomus spp	1	--
Isopoda		
Asellus intermedius	2	1
Total	100	125

Table B6. Taxonomic list of macroinvertebrates from MS6 (4-30-81 and 10-22-82).

Taxa	# Spring	# Fall
Diptera		
Ablabesmyia spp	21	-
Chironomidae	1	-
Chironomus spp	-	30
Cricotopus spp	10	-
Eusimulium johannseni	6	-
Orthocladius spp	-	3
Psectrotanypus spp	-	19
Simulium venustum	3	-
Simulium verecundum	6	-
Isopoda		
Asellus intermedius	-	28
Adonata		
Enallagma spp	-	7
Ischnura verticalis	15	-
Tricoptera		
Cheumatopsyche spp	1	-
Total	63	87

Table B7. Taxonomic list of macroninvertebrates from MS7 (4-30-81 and 10-22-81).

Taxa	# Spring	# Fall
Amphipoda		
Hyallela azteca	--	8
Diptera		
Ablabesmyia spp	14	--
Chironomidae	1	1
Chironomus spp	2	8
Einfeldia spp	--	2
Microspectra spp	--	3
Orthocladius spp	19	1
Polypedilum spp	--	1
Procladius spp	--	1
Simulium venustum	4	--
Simulium vittatum	5	--
Isopoda		
Asellus intermedius	54	85
Odonata		
Enallagma spp	--	1
Ischnura spp	2	--
Total	101	111

Table B8. Taxanomic list of macroinvertebrate from MS8 (4-30-81 and 10-22-81).

Taxa	# Spring	# Fall
Amphipoda		
Hyallela azteca	--	6
Diptera		
Ablabesmyia spp	11	--
Chironomidae	1	--
Chironomus spp	2	2
Cnephia spp	5	--
Orthocladius spp	26	--
Procladius spp	--	1
Simulium jenningsi	10	--
Simulium venustum	13	--
Simulium vittatum	20	--
Isopoda		
Asellus intermedius	15	99
Total	104	111

APPENDIX C

Black Otter Creek
looking upstream
toward the dam
(4-30-81).

Black Otter Creek
looking upstream
from the sag point,
site 9.
(4-30-81)

Black Otter Creek looking upstream from site 4 past Larsen Company 001 ditch which enters the creek from the right in the lower center of this photograph (September 7, 1982).

Larsen Company plant looking NW across the parking lot past the 001 sampling manhole which is located in the lower left center. Note the puddle of corn serum in the center and lower center. It appeared that some of this high BOD substance had gotten into the storm sewer through the manhole and into Black Otter Creek. (September 7, 1982)

Black Otter Creek looking upstream from
site 2 (September 7, 1982).

Larsen Company spray irrigation field. Note the heavy erosion and dead vegetation resulting from overloading of wastewater. (September 7, 1982)

Larsen Company spray irrigation field looking SE past the lagoons. The wastewater is sprayed onto this field and then allowed to drain into the lagoon in the center of the photograph. Note the large amount of dead vegetation resulting from wastewater overloading of the field. (September 7, 1982).

Larsen Company Lagoon 4. in early morning looking NNE (4-30-81).