BLACK OTTER LAKE
OUTAGAMIE COUNTY
FEASIBILITY STUDY RESULTS;
MANAGEMENT ALTERNATIVES

By

Wisconsin Department of Natural Resources

OFFICE OF INLAND LAKE RENEWAL

1980

BLACK OTTER LAKE

Background

Black Otter Lake is a 75-acre impoundment of Black Otter Creek in southwestern Outagamie County (Figure 1). The dam for this impoundment is located in the Village of Hortonville. Since Black Otter Lake is one of only three named lakes in the county, and the only one over five acres with public access, it is highly valued as a recreational resource by local residents. However, recreational use has been restricted in recent years due to heavy weed growth and seasonally low dissolved oxygen levels.

Black Otter Creek drains more than 15 square miles as it loops southeast, east, northeast and finally north before it empties into Black Otter Lake at Hortonville (Figure 2). Since the creek drains a relatively small basin and has very low flows, only the first mile and a half above Black Otter Lake is classified as a perennial stream. The rest of the creek is an intermittant stream fed by occasional springs, marshland and swamp. In combination, the perennial and seasonal portions of Black Otter Creek form a turbid, hardwater stream with several hundred acres of adjacent wetlands. Excluding these wetlands and some isolated woodlots, most of this watershed is used for agriculture.

Three major soil associations, Hortonville-Symco, Carbondale-Keowns-Cathro and Menomonie-Grays-Rouseau are found in the Black Otter Lake watershed. Soils in the Hortonville-Symco association cover most of the drainage basin except for the northeast corner and low areas along Black Otter Creek. Most of the nearly level to rolling soils in this association are used for cultivated crops. The steep or undrained wet soils are used for pasture or left for wildlife habitat. Soils in the Carbondale-Keowns-Cathro association are generally limited to wetlands adjacent to Black Otter Creek. Most of the soils in this association are found in drainage-

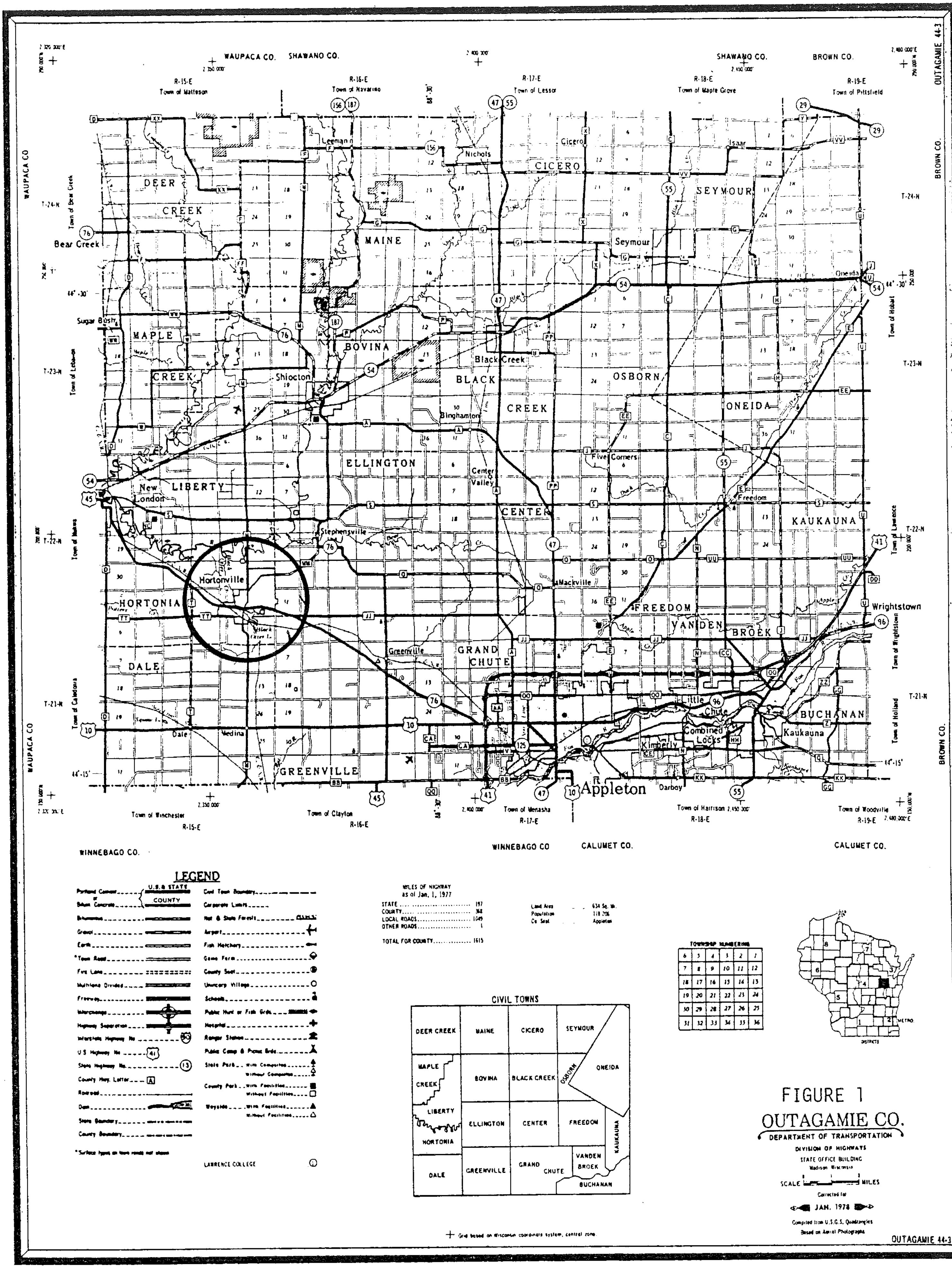

FIGURE 1
OUTAGAMIE CO.
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
STATE OFFICE BUILDING
Madison Wisconsin
Corrected to JAN. 1978
Compiled from U.S.G.S. Quadrangles
Based on Aerial Photographs

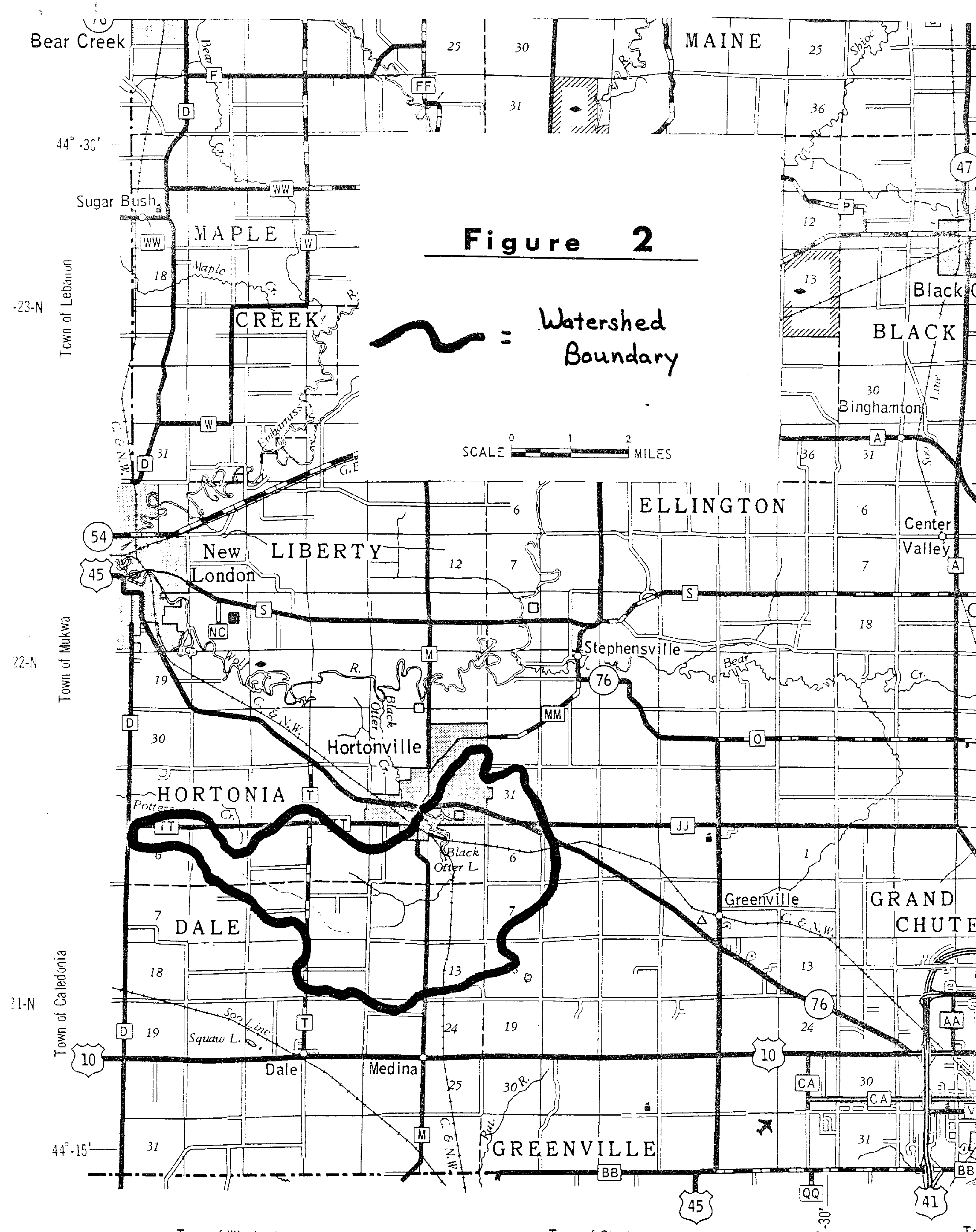
Watershed Boundary
SCALE 0 1 2 MILES
Bear Creek
MAINE
Sugar Bush
MAPLE
CREEK
BLACK
Black C
Binghamton
ELLINGTON
Center Valley
New London
LIBERTY
Stephensville
Hortonville
HORTONIA
Black Otter L.
DALE
Greenville
GRAND CHUTE
Dale
Medina
GREENVILLE
Squaw L.
Town of Lebanon
Town of Mukwa
Town of Caledonia
44° -30′
44°-15′
23-N
22-N
21-N

Figure 2

ways, depressional areas and old glacial lake basins. Due to their poorly drained nature, these soils are generally unsuitable for agriculture and have remained as swamp or marshland.

The dam on Black Otter Lake was first constructed around 1847 to run a sawmill. As arable land in the county was cleared in the late 1800's, logging activities declined. By the turn of the century, water from the dam was used to run a grist-mill. In 1943 the mill was razed and ownership of the dam transferred to the Village of Hortonville. Since then the primary purpose of the dam has been to maintain Black Otter Lake as a recreational pool.

Although early records are sketchy, it appears that Black Otter Lake has a long history of use by recreational enthusiasts. As early as the 1950's, however, local residents expressed concern over nuisance weeds, siltation and a declining fishery. In 1956, the lake was drawn down in an attempt to consolidate soft sediment and control nuisance weeds. While the bed of the lake was drying, local residents started a drive to further improve recreational opportunities on the lake. These activities included access development off U.S. Highway 45 and dredging of some spring holes to improve flow and wintertime D.O. (dissolved oxygen) levels. Before the lake was refilled in 1957, three spring holes were deepened and over 15,000 cubic yards of sediment removed. After the lake was reflooded, northern pike, largemouth bass and panfish were stocked in order to re-establish a sport fishery.

Despite high hopes and optimistic predictions, the revitalized fishery was short lived. Low flows in Black Otter Creek and low D.O. levels in the lake during winter continued. In 1959 for example, Black Otter Creek froze solid to the bottom at the point where it enters the lake. As a result, a major fishkill occurred late in winter. To maintain the sport fishery, northern pike, largemouth bass and pan-fish were restocked during the following summer. Again during the winter of 1961-62, D.O. levels in Black Otter Creek at the head of the lake dropped below two ppm (parts per million). The area fish manager pointed out that D.O. levels were above 10 ppm at the County Highway M crossing--less than a mile above Black Otter Lake. Thus it was apparent that decaying vegetation in the marsh between County Trunk M and the lake (Figure 3) was using up most of the oxygen. Since flow through this marsh area was diffuse, the fish manager suggested that in early winter the village draw Black Otter Lake down a couple of feet. This reduced water level inlake would also lower water levels in the marsh above the lake and thus help confine water in the creek to a single channel.

This partial drawdown approach was attempted during the winter of 1962-63. This winter drawdown was a reversal of the normal practice of lowering the lake level somewhat in summer and raising it in winter. Late winter sampling indicated 3.4 ppm D.O. in the center of the lake and 7.6 ppm D.O. in the south end near the main inlet. While these values are not remarkably high, they are sufficient to sustain fish and therefore represent a considerable improvement over the previous winter. For unknown reasons, the village did not continue this winter drawdown. Instead, water levels were maintained at a nearly constant level throughout the year.

In the mid-1960's, Black Otter Creek between County Highway M and a small railroad bridge downstream (in the southern part of section 1) was straightened and deepened. The purpose of this channelization was to prevent the stream from spreading out in the marsh where decaying vegetation would deplete the oxygen during periods of low flow, i.e. winter. Although the stream straightening effectively confined flow to a single channel, the rate of flow remained unchanged. Consequently, the lake continues to be plaqued with low D.O. in winter and is an annual candidate for fish-kills. Because of this winterkill potential, the Department of Natural Resources now stocks only northern pike, perch and bluegills.

Since the straightening operation, that part of Black Otter Creek between County Highway M and the lake resembles a drainage ditch in both appearance and function.

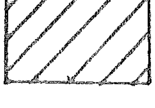 = Marshland along Black Otter Creek above the lake

FIGURE 3

Raising or lowering the lake level rapidly results in similar water level changes in Black Otter Creek because very little difference in elevation exists between the sill of the dam and the stream below the Highway M crossing. This close relationship between lake level and stream level was brought to the public's attention in 1968 when local farmers requested the village to return to its former practice of lowering the lake level in spring. In the years since this practice was abandoned, standing high water in Black Otter Creek had hindered and occasionally prevented tillage and harvesting operations on cropland adjacent to that portion of the stream below Highway M. In response to these concerns, the village agreed to lower the lake approximately six inches in May and then raise it again in September. Since 1968, this seasonal adjustment of lake level has continued.

In September 1976, the Outagamie County Board passed a resolution forming the Black Otter Lake District in accordance with Chapter 33 of the Wisconsin Statutes. Shortly thereafter the lake district submitted an application to the Department of Natural Resources for technical assistance. In order to quantify existing problems, identify possible causes and determine potential lake improvement schemes, the Office of Inland Lake Renewal recommended a data collection program (feasibility study) in January 1977. The lake district contracted with the consulting firm Aqua-Tech, Inc. to conduct the work starting in November 1977. The study was completed by November 1978, and by January 1979, the final report was received.

STUDY RESULTS

The Black Otter Lake Feasibility Study included surveys in the following areas:

1. Streamflow in Black Otter Creek above the lake and below the dam.
2. Nutrient and sediment concentrations at the lake's inlet and outlet.
3. Inlake water quality.
4. Inlake aquatic plant species, relative abundance and depth of growth.
5. Inlake sediment volume and accumulation rates.

Flow Volumes at the Inlet and Outlet

Precipitation records for the Hortonville area indicate that 1978 as a whole was a near-normal water year (Table 1). Only two minor deviations from the norm occurred during the course of the study. The first occurred in November and December 1977 when a total of 38 inches of snow fell. This is 24 inches above the average for that two-month period. The daily temperature highs for December 1977 revealed the second deviation from the norm. On December 11, a thaw cycle started and in eight days the snow depth on the level dropped from 14 inches to barely a trace.

Two sites on Black Otter Creek were monitored during the study year--the County Highway M crossing and roughly 100 yards below the dam. Flow at the County Highway M site was measured instantaneously at periodic intervals while the site below the Black Otter dam was monitored continuously. Although the feasibility study called for a full 12 months of flow data, the field data for the last month and a half (September 9-October 31) was not reported. Fortunately this mid-fall period is usually characterized by low flow.

Flow in Black Otter Creek at the County Highway M crossing ranged from zero to approximately 15 cfs (cubic feet per second). As expected, peak flows occurred during spring runoff and following summer rainfall events. Two extended periods of zero (measurable) flow also occurred. One was in late summer (July 19-August 22) and the second was in mid-winter (January to mid-March) when the stream froze.

Flow in Black Otter Creek below the Hortonville dam ranged from zero to roughly 40 cfs. Two peaks, one major and one minor, occurred during the study year. As expected, a major peak of +40 cfs occurred during spring runoff. A small peak of nearly seven cfs occurred in the second half of December 1977. This minor peak came on the tail end of the previously mentioned eight-day thaw which reduced snowcover from 14 inches to virtually zero. Of greater significance to Black Otter

TABLE 1: PRECIPITATION RECORDS FOR HORTONVILLE AND APPLETON IN INCHES

Date	Actual Precipitation at Hortonville	29-year Average for Appleton	Difference Between Average and Actual
Nov. 77	2.96	1.98	+0.98
Dec. 77	1.80	1.46	+0.34
Jan. 78	1.26	1.19	+0.07
Feb. 78	0.19	1.15	-0.96
Mar. 78	0.79	1.96	-1.17
Apr. 78	3.91	3.02	+0.89
May 78	5.21	3.33	+1.89
June 78	2.21	4.20	-1.99
July 78	5.10	3.53	+1.57
Aug. 78	2.06	2.98	-0.92
Sept. 78	6.29	3.39	+2.90
Oct. 78	2.28	2.05	+0.23
	34.06	30.23	+3.83

Lake, however, were the extended periods of low flow that occurred during the study year. For nearly nine months of the year, flow at the lake's outlet was less than 1.0 cfs. Compounding this situation was a ten-day period of no measurable flow in mid-November 1977. Only during spring runoff and early summer was flow at the lake's outlet consistantly greater than 1.0 cfs.

At the maximum flow of 40 cfs, the flushing rate or exchange time for water in the lake is nearly four days. At five cfs, the average flow during the study year, the flushing rate is 30 days. At 0.1 cfs, the seven-day, ten-year low flow, the flushing rate is over four years. These slow flushing rates are unusual for a shallow impoundment like Black Otter Lake and point directly to the lake's most serious problem--zero or very low flow throughout much of the winter.

One advantage of such low flow is that only a limited amount of sediment can be transported to the lake. This will be mostly fines--silt, clay or organic material--which won't precipitate rapidly. Unfortunately, this advantage is more than offset by the two disadvantages that are brought about by low flow. The first, as previously discussed, is chronic low D.O. levels. Any shallow weed-filled impoundment that becomes virtually stagnant during the winter months is a prime candidate for annual winterkill. Maintaining a sport fishery under these conditions is nearly impossible. The second disadvantage of low flow is evident in mid-to-late summer when infrequent flushing and high nutrient water results in heavy algae blooms and thick mats of floating duckweed. Although not detrimental to the fish population, duckweed and algae can become a serious aesthetic problem as they reduce water clarity and pile up on windward shorelines to rot.

Nutrient and Sediment Concentrations

Unless environmental conditions such as light or temperature are limiting, aquatic plants or algae respond to the quantity of nutrients made available to them. The major nutrients essential to plant growth are nitrogen and phosphorus. Nutrient control schemes have thus far been directed primarily at the one element most easily controlled--phosphorus. Thus for purposes of this discussion, phosphorus is considered the key element in calculating a nutrient budget.

Phosphorus concentrations in Black Otter Creek above the lake ranged from 0.010 to 0.202 mg/l (milligrams per liter). It is interesting to note that the lower concentration in this range is from the first water sample collected during the study (November 18, 1977), and the upper concentration is from the last water sample collected during the study (September 6, 1978). Concentration in the other 20 samples collected through out the year ranged from 0.030 to 0.123 mg/l. Consistent grouping of concentrations within this range suggests that it is probably a more representative indicator of nutrient levels. Phosphorus concentrations appear highest during spring runoff and then drop off gradually, except for some rainstorms, through the summer. Unfortunately, Black Otter Creek at the County Highway M crossing froze nearly to the bottom during the winter of 1977-78. Thus winter sampling was impossible. Water quality data from other sources suggest that even in winter, concentrations do not drop much below 0.030 mg/l. These nutrient concentrations are in excess of those needed to stimulate either weed or algae growth.

Phosphorus concentrations in Black Otter Creek below the lake ranged from 0.057 to 1.150 mg/l. Although phosphorus concentrations at the outlet were high throughout the study year, two distinctive peaks occurred. The first started in January and remained high until after spring runoff. Presumably this mid-winter peak is due to release of phosphorus from sediments when the bed of the lake goes anoxic. Phosphorus remained high through ice breakup in late March and didn't drop until the lake was completely flushed by runoff from spring rains in early April. The second rise in phosphorus occurred in late summer and early fall and was characterized by frequent oscillations between high and medium concentrations. The exact cause of these fluctuations is unknown, but it is probably related to the decay of aquatic plants as the lake cools.

Total suspended solids concentration in Black Otter Creek above the lake ranged from <1.0 to 91 mg/l. These values remained relatively low throughout winter and spring and then increased slightly in late summer. This suggests that much of the sediment carried by Black Otter Creek is not runoff related fine sand or silt, but rather it is clay or organic material. Whether this material is from the bed and bank of the stream or from decaying vegetation in the marsh above the lake is unknown. However, the latter seems more likely when one views land uses and vegetation types adjacent to the perennial portion of the stream.

Total suspended solids concentration below the Black Otter Lake dam ranged from <1.0 to 103 mg/l. In reviewing this data, no obvious patterns emerge other than that these values are consistently low.

Inlake Water Quality

Dissolved oxygen measurements were taken on a monthly basis at a site in the center of Black Otter Lake (Figure 4). Sample results shown in Table 2 indicate that D.O. levels are starting to drop by late December, 1977. By early Februaury 1978, D.O. in this part of the lake was below levels normally tolerated by gamefish. Apparently most fish concentrated in spring holes or near the inlet where D.O. levels were somewhat higher since there was no report of a fish kill.

Phosphorus concentrations in lake water roughly paralled concentrations at the lake's outlet. The study results show two extended periods of elevated phosphorus levels. The first started in early January when portions of the lake bed became anoxic and continued until spring breakup in early April. Inlake phosphorus levels dropped sharply in April as the lake was flushed by spring rains. Phosphorus levels remained low until mid-summer when D.O. levels in the bottom water started dropping due to infrequent flushing. As bottom D.O. levels declined, phosphorus concentrations rose and remained elevated until water temperature dropped in late fall. Overall, phosphorus concentrations were quite high throughout the study year and could easily stimulate heavy algae blooms.

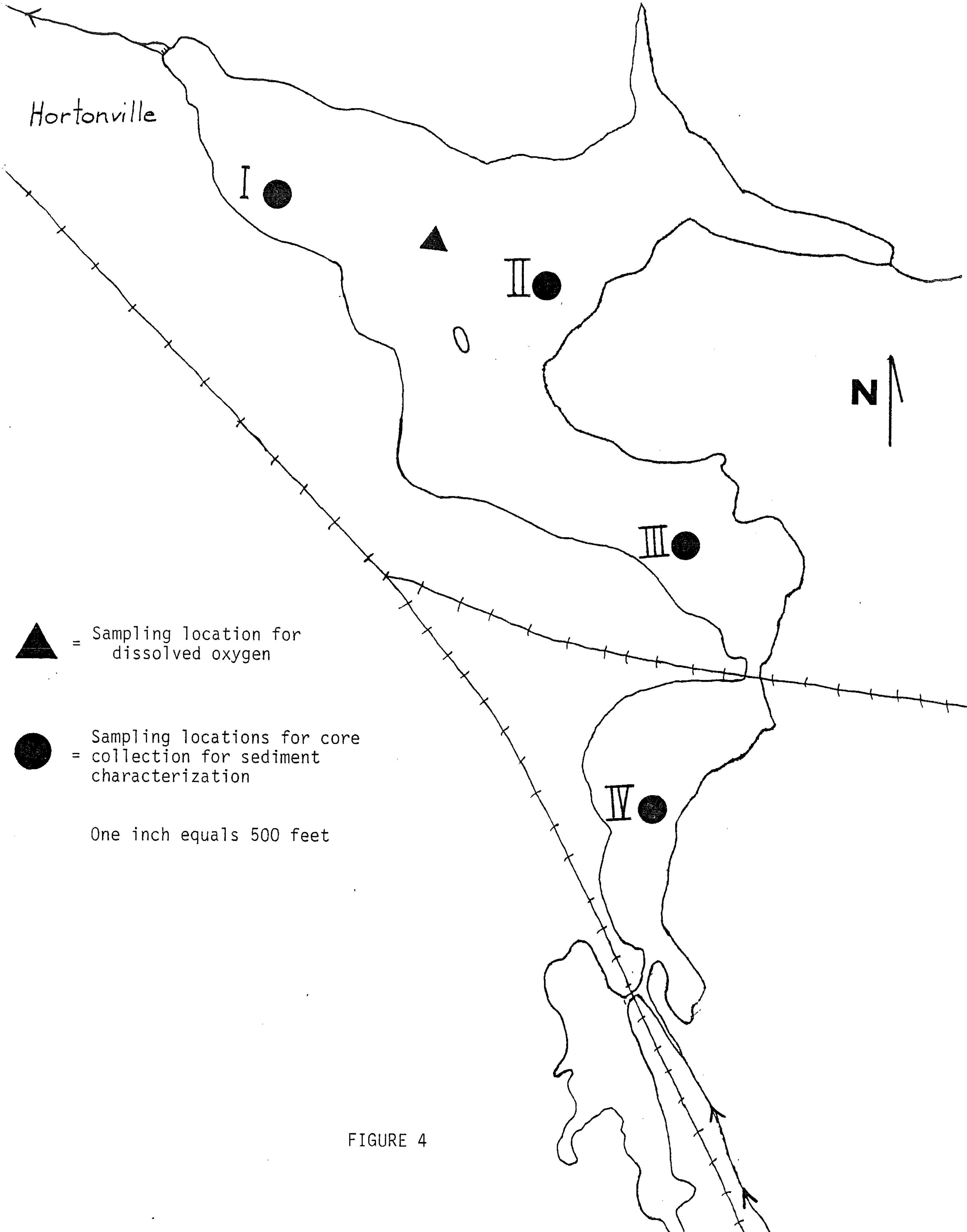
Hortonville
I
II
III
IV
N
= Sampling location for dissolved oxygen
= Sampling locations for core collection for sediment characterization
One inch equals 500 feet

FIGURE 4

TABLE 2: DISSOLVED OXYGEN LEVELS IN BLACK OTTER LAKE (in mg/l)

Date	Surface	3 Feet	6 Feet
Nov. 21, 1977	11.6	12.4	9.3
Dec. 29, 1977	5.5	3.2	2.9
Feb. 2, 1978	1.3	0.8	-
Mar. 3, 1978	0.9	0.6	-
Mar. 21, 1978	5.1	0.0	-
Apr. 21, 1978	12.4	12.4	13.0
May 9, 1978	8.9	8.2	8.2
June 7, 1978	11.5	11.3	9.7
July 25, 1978	8.6	8.7	6.8
Aug. 6, 1978	9.4	9.4	6.3
Oct. 3, 1978	9.3	9.1	9.0
Oct. 18, 1978	10.2	10.3	10.9

Chlorophyll a concentration, a measure of algal biomass, was measured monthly during the growing season. The values obtained indicate that moderate blooms occurred in June and early October. Since inlake nutrient levels were well above those needed to support nuisance algae growth, one would expect frequent and heavy blooms throughout the summer. Apparently competition from aquatic plants prevented algae from building up to heavy bloom levels.

Water transparency as measured by a Secchi disc was three to four feet during the growing season. For an impoundment with heavy weed growth these are relatively low transparency values and are probably due to a combination of dark stained water and moderate algae blooms.

Aquatic Plants

An aquatic plant survey was conducted on Black Otter Lake in mid-June and again in late August, 1978. Vegetation was found in all but five of the 80 sampling sites in June, but reached the surface at only 54 of these sites. Results obtained during the August survey were similar except for some changes in species density. Maximum depth of growth during the summer was nearly eight feet.

The dominant open water species in June were coontail (*Ceratophyllum demersum*), milfoil (*Myriophyllum spp.*), flatstem pondweed (*Potamogeten zosteriformes*) and common pondweed (*Potamogeten pusillus*). By August, the percent occurrence and relative density of milfoil and the pondweeds had declined while coontail had increased. Several minor species were present during the June survey and most of these showed an increase in both occurrence and density by August. Shoreline and extreme shallow water areas were dominated by arrowhead (*Sagittaria latifolia*), cattail (*Typha latifolia*) and canary grass (*Phalaris arundinacea*). These emergent species were relatively stable throughout the summer.

The aquatic plant problem in Black Otter Lake seems to be one of balance. A certain amount of vegetation is highly desirable. For example, the aquatic vegetation in the upper end provides both food and cover for waterfowl, furbearers, shorebirds and songbirds. In a similar manner, some vegetation in the rest of the lake is valuable as cover for fish. However, the nuisance levels of vegetation found in the lake indicates that this desired balance is long gone. Thus, vegetation becomes so dense that fishing, boating or swimming are severely restricted during the summer.

Inlake Sediment

The bed of Black Otter Lake was probed at 70 sites to determine the depth of water and thickness of soft sediment. Average water depth was nearly four feet. Average depth of soft sediment was two and a half feet. Maximum depth of soft sediment was seven feet. Total volume of sediment in Black Otter Lake is approximately 225,000 cubic yards.

Sediment cores were collected at four sites in the lake (Figure 4). Analytical results of those cores is shown in Table 3. As expected, the percent water and percent organic were generally quite high in the surface layers and declined in the deeper sediments. Similarly the deeper sediments tend to have less clay or silt than sand. However, some layering is evident, particularly at the inlet site.

To supplement the feasibility study data, the Inland Lake Renewal staff collected sediment cores from Black Otter Lake in the fall of 1978. These cores were used for radiometric dating to determine recent sedimentation rates. The analysis, completed in July 1979, was conducted by the U.S. Department of Agriculture, Agricultural Research Service (ARS) in Oxford, Mississippi.

The sediment cores were collected at four sites (Figure 5). The probable rates of sediment accumulation and total depth of accumulation as calculated by J. R. McHenry (of ARS, USDA) are shown in Table 4.

TABLE 3: SEDIMENT CORE ANALYSIS RESULTS

Depth cm	Percent H_2O I	II	III	IV	Percent Organic I	II	III	IV	Percent Clay Percent Silt Percent Sand I	II	III	IV
0-10	98.6	92.1	99.7	95.1	11.4	12.9	10.4	16.9	- - 1.3	- - .4	- - 0.0	- - .4
10-20	74.8	53.4	99.3	81.0	9.2	9.2	10.7	12.5	20.0 35.1 45.1	10.3 68.9 20.9	28.9 55.6 16.0	8.4 21.7 71.4
20-30	67.8	64.4	89.2	74.5	8.2	6.0	6.8	11.7	30.7 37.3 31.9	8.3 39.9 51.9	5.9 42.8 51.2	19.1 55.2 27.6
30-40	55.0	70.1	78.9	61.1	7.0	5.4	5.9	0.5	24.3 58.5 17.8	5.7 15.9 82.0	5.0 30.0 65.2	7.8 41.8 51.9
40-50	77.7	66.9	86.0	56.0	10.2	11.4	6.0	4.6	21.2 22.2 57.0	3.4 9.9 89.2	5.4 22.8 72.0	3.8 42.8 53.8
50-60	57.8	59.3	63.9	44.6	2.8	12.7	3.0	1.7	1.6 16.0 82.7	4.4 22.9 76.9	4.9 29.5 65.9	8.8 38.8 52.5
60-70	37.8		48.4	42.7	1.7		4.6	2.4	3.0 17.7 79.4		10.6 36.2 54.1	13.7 37.5 48.7
70-80				53.3				0.1[illegible]				1.8 37.7 60.9

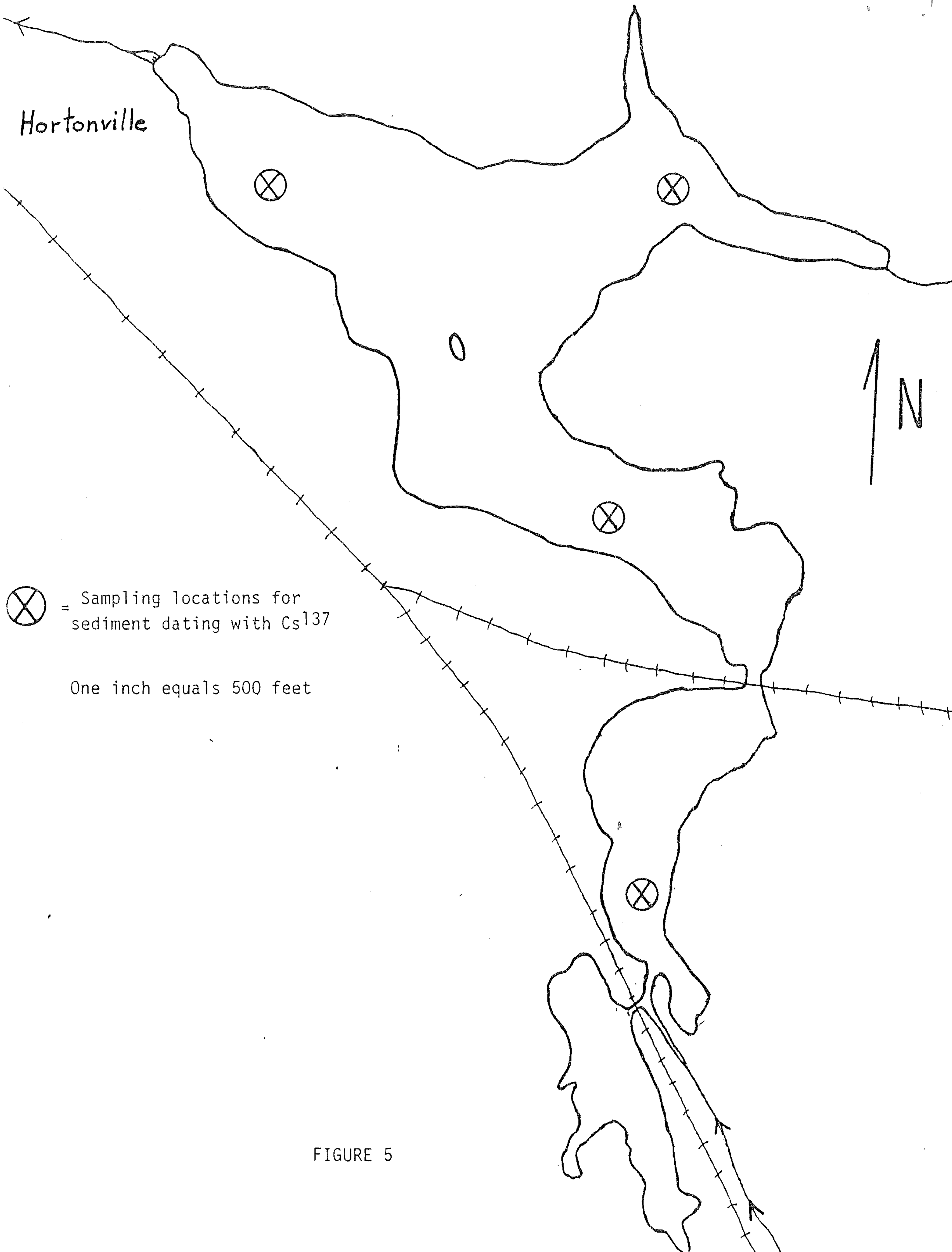
Hortonville
N
= Sampling locations for sediment dating with Cs137
One inch equals 500 feet

FIGURE 5

TABLE 4: ESTIMATED RATES OF SEDIMENT ACCUMULATION AND TOTAL DEPTH OF ACCUMULATION SINCE 1954

Site	Sediment Accumulation		Total Accumulation
	1954-1964 Inches/year	1964-1978 Inches/year	1954-1978 Inches
Near Dam	0.49	0.19	7.75
NE arm	0.98	0.52	17.60
Mid-lake	0.49	0.19	7.75
Upper Inlet	0.79	0.26	11.80

The data indicates that sedimentation rates have decreased in recent years at all four sites. Surprisingly the northeast had the highest accumulation rate for the 25-year period even though this area drains a relatively small area compared to Black Otter Creek. This suggests some unusual activities in this area, and indeed past records show some major rechanneling of runoff from State Highway 45 into this arm in 1957. Other sediment producing activities in this area include development of a public access, sand blankdting and channel dredging. With all these operations occurring in the lake's shoreline it is difficult to tell whether the elevated sedimentation rate for this part of the lake is indicative of land use practices above (north of) State Highway 45 or merely the unfortunate result of local shoreline and drainage channel manipulation. It is likely that the latter category is having the most influence on sedimentation rates in this part of the lake.

As expected, the upper inlet site has a higher accumulation rate than the mid-lake or near dam sites. Apparently most settling takes place above the railroad bridge since accumulation rates are not only low but identical for the mid-lake and near dam sites.

Overall, these accumulation rates are quite low for an impoundment. Absolute concentrations of the material used for dating, Cesium -137, were relatively high. This suggests that sediment deposited in the lake is from erosion of cultivated uplands in the watershed. The dramatic decline in sediment accumulation from the 1954-64 period to the 1964-78 period is probably a result of improved upland conservation practices in the watershed. Excluding the northeast arm, the rest of Black Otter Lake is accumulating sediment at an annual rate of approximately 0.21 inches/year. This translates into roughly 1,800 cubic yards per year.

MANAGEMENT ALTERNATIVES

Based on the preceding background information and study results, the following are management alternatives for Black Otter Lake. Inlcuded with each alternative is a brief discussion regarding advantages, disadvantages and cost. These alternatives are not inclusive and the lake district should consider its needs and priorities in formulating a management plan.

1. Sediment Removal

The objective of this alternative is to deepen all or portions of the lake. This in turn would increase water volume and decrease aquatic plant abundance, thereby improving the usability of the flowage for recreational activities.

The extent of the area opened up by dredging is variable depending on the preferences of the lake district. For purposes of calculation, two situations will be discussed. The first is dredging to firm bottom that portion of the lake north of the railroad tracks (roughly 60 acres). The second is dredging the same area of the lake to below the photic zone (depth below which light does not penetrate).

Dredging that portion of Black Otter Lake north of the railroad tracks to firm bottom would require the removal of approximately 180,000 cubic yards of sediment.

Following removal of this material, water depth would average nearly six feet and the water volume of this part of the lake would be increased by 50 percent. After dredging, aquatic plants would be severely limited due to the marginal substrate (hard bottom). Recalling that the lake has a sedimentation rate of approximately 0.20 inches/year, it would take over 100 years for the lake to fill with sediment to its present depth. Although it would take a long time to refill, it would not take that long for aquatic plants to become reestablished. A relatively thin layer of six inches of soft sediment on top of the hard bottom would be enough material to provide an easy rooting, nutrient rich substrate for nuisance levels of aquatic plants. Thus at the rate of 0.20 inches/year, it would take roughly 25 to 30 years for aquatic plants to return to their present levels.

Dredging that portion of Black Otter Lake north of the railroad tracks to below the photic zone would require the removal of approximately 400,000 cubic yards. Dredging to below the light penetration zone would virtually eliminate all rooted aquatic plants until such time as the lake fills with sediment to the point where light again reaches the bottom. After dredging, the average water depth would be eight feet and the lake's water volume would be nearly doubled. At the rate of 0.20 inches/year, it would take more than 50 years for rooted aquatic plants to reestablish, and it would take much longer before they reached nuisance levels.

The upper end of Black Otter Lake, south of the railroad tracks, was excluded from consideration for dredging because of its value to fish and wildlife as a shallow lake. This area could be deepened to improve its efficiency as a sediment trap, but recent sedimentation rates suggest that the area is functioning effectively in that capacity already. If the lake is dredged and its water volume significantly increased, it is likely that algal biomass will increase. As discussed earlier, algae blooms during the study year were considerably less than expected. Apparently the rooted aquatic vegetation has an inhibiting effect on the algae. If most of the rooted aquatic vegetation is removed, an increase in alage biomass is almost a certainty. Also, a shift in species from relatively innocuous diatoms and small green algae to noxious blue-green algae is possible. Such a shift would be undesirable because blue-green can rapidly increase in biomass in warm nutrient rich water and cause intense blooms.

Removal of the soft sediment from most of Black Otter Lake would indirectly benefit the sport fishery. The wintertime sediment oxygen demand would be reduced because very little decaying organic material would be left. With less oxygen demand, dissolved oxygen levels should remain higher during periods of ice cover; thereby reducing the likelihood of winterkill. However, dredging is not a cure-all. In years when Black Otter Creek freezes solid to the bottom, or when streamflow is reduced to zero for several consecutive days, winterkill is likely.

Either mechanical excavation or hydraulic dredging could be used to remove sediment. If drawdown and sufficient drying out of the sediments is possible, removal of sediment from the lake bed could be done by earthmoving equipment. This type of mechanical excavation is less complicated but not necessarily less costly than hydraulic dredging. If mechanical excavation is feasible, the sediment removed can be stockpiled on nearby uplands or used as fill. Consequently, adequate disposal sites are usually available.

Considering the village's experience with mechanical excavation in 1956-57, it is likely that this approach could be successfully repeated on a larger scale.

Hydraulic dredging involves a cutterhead and pump to remove sediments. This type of dredging generally requires one or more large holding ponds, out of the floodway, to settle out the dredged material. Usually dikes have to be constructed to create holding ponds. Thus a common problem with hydraulic dredging is finding adequate disposal sites. Dredging would require a permit under Chapter 30, Wisconsin Statutes, and approval by the U.S. Army Corps of Engineers. Spoil disposal sites would require approval under the new State Solid Waste Act. A dredging permit would generally require that any water returned to the stream or impoundment from the disposal areas meet water quality standards. This means that if the dredging alternative is selected, further investigation on settling rates of solids in a sediment-water mixture will be necessary.

Various factors influence dredging costs, including project size, method of removal, type of material to be dredged, distance to disposal sites and availability of contractors. Unit costs on current dredging projects range from 1.25 to 1.75 dollars per cubic yard of material removed. Thus removal of approximately 180,000 cubic yards of sediment from the bed of Black Otter Lake would cost between $225,000 and $315,000.

2. Aeration

The objective of this alternative is to improve the lake's sport fishery potential by increasing dissolved oxygen during winter.

Various types of aeration devices have been used in other Wisconsin lakes in an attempt to prevent dissolved oxygen depletion and fish winterkill during periods of ice cover. The most common method of aeration and the one most suitable to Black Otter Lake is called total aeration.

Total aeration involves mixing the entire water column and is accomplished by pumping compressed air to the deepest part of the lake. The air is then released and the rising bubbles carry the slightly warmer bottom water to the surface. If total aeration starts before the lake freezes over, the slightly warmer water in combination with surface turbulence from rising air bubbles will maintain an ice-free area. Dissolved oxygen conditions are improved by atmospheric oxygen transfer at the open water surface and oxygen production by aquatic plants during photosynthesis. Thus, the area of open water maintained during periods of ice cover is important.

In order to be successful, aeration must be tailored to the specific problems and needs of Black Otter Lake. In its present condition, most of the lake is too shallow for aeration. Eight to ten feet of water depth over a sizable area (5-10 acres) would be necessary before a reasonable chance of improvement by aeration could be expected. Thus aeration is necessarily linked with dredging.

Black Otter Lake has several potential sites suitable for a combination dredging-aeration project. One such site is shown in Figure 6. Dredging this ten acre site to an average depth of 10 feet would require the removal of approximately 100,000 cubic yards of sediment. If the entire lake below the railroad tracks were first dredged to hard bottom (180,00 yds^3), dredging the site shown in Figure 6 to ten feet would require the removal of an additional 65,000 cubic yards for a total of 245,000 cubic yards of sediment.

Aeration should start in late fall before ice forms on the lake and continue until ice-out in early spring. Since a small area of the lake will be ice-free during the winter, safety precautions (i.e. snowfence) will be necessary to prevent unauthorized access to the open water.

The initial purchase price of one aeration unit--blower, air supply hose and diffuser--ranges from $2,500 to $7,500. Annual power requirements and maintenance will probably average 10 percent of the initial purchase price. Placing an aeration unit on the bed of Black Otter Lake would require a permit under Chapter 30, Wisconsin Statutes.

3. <u>Drawdown</u>

The objective of this alternative is to reduce the probability of winterkill by consolidating the bottom sediments and freezing out the submergent aquatic plants.

In the mid-1920's, a controversy developed between the owner of the milldam and landowners in the watershed over water levels. The landowners maintained that the

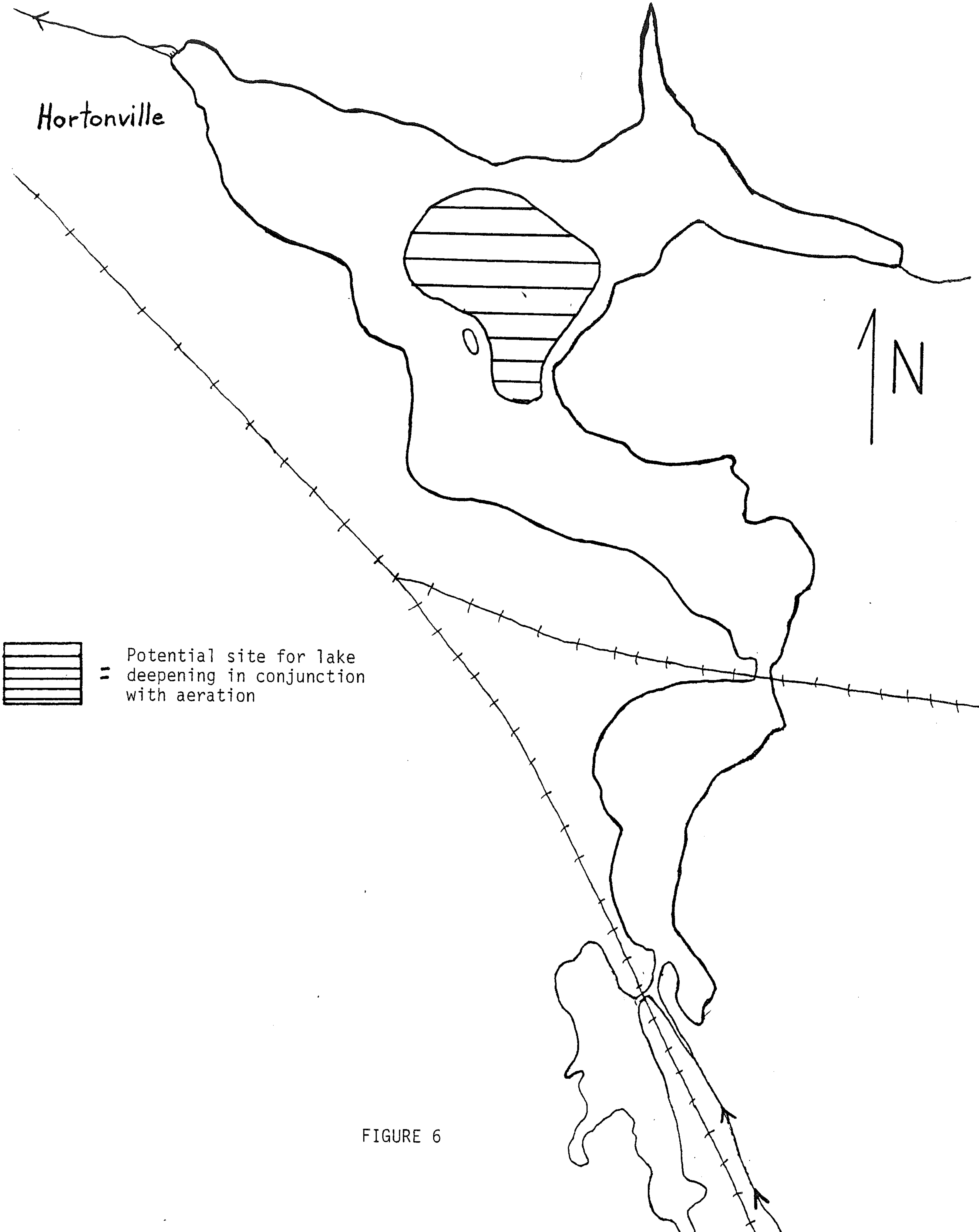
Hortonville
N
= Potential site for lake deepening in conjunction with aeration

FIGURE 6

water level of the lake and consequently in Black Otter Creek was held above a previously agreed upon maximum. As a result of these high water levels, cropland and timberland adjacent to the pond and Black Otter Creek were flooded or waterlogged. In 1926, the parties involved reached an agreement that the flashboards on the dam would be maintained at an elevation of 94.57 from May 1st to September 15th and at an elevation of 95.40 between September 15th and May 1st. Thus the agreement called for nearly a ten-inch drawdown during the growing season.

This summer drawdown arrangement had obvious benefits for landowners in the watershed and, as long as the water in the pond was used to run a gristmill, the rationale for maintaining high water levels during the rest of the year was clear. However, when the operation of the mill ended in the early 1940's, and the Village assumed ownership of the dam, this practice of raising the water level in fall was continued even though it was no longer necessary. The continuation of this practice to the present time may in fact be contributing to the lake's problems.

In many impoundments in Wisconsin, it is common practice to draw the lake down a foot or more in the fall and keep it down until spring thaw to help freeze out and reduce aquatic plants. A reversal of this common practice--raising the water level during winter--will have the opposite effect and, therefore, may be partly responsible for Black Otter Lake's weed and winterkill problems.

Since no minimum water level has ever been established, it appears that the lake district has a number of drawdown options available. The first practical option would be to maintain the flashboards in the dam at the summer elevation of 94.57 throughout the year. At this level, water in Black Otter Creek would move more rapidly through the marsh and drainage ditches above the lake. In addition, the volume of the lake would be reduced somewhat and the flowthrough time would be decreased. Although this increased flow would probably not eliminate the winterkill problem, it would help and, in some marginal years, may be enough to sustain the fishery. Along with some improvement in dissolved oxygen levels, a lower water level will, in some years, reduce the weed problem. Under the present practice, weeds in the shallow water areas are protected over winter by the icecover. With a lower lake level, shallow water areas would occasionally freeze solid to the bottom and would frequently be scoured by shifting ice.

Another option would be to maintain the lake at 94.57 from May 1st through September 15th, and then draw the lake down approximately 12 inches for the rest of the year. The effects of this option on flow, dissolved oxygen and weeds would be similar to those discussed previously, only more accentuated. Under this option, winterkill might be reduced from a frequent to an infrequent occurrence. Since the lake level would not be raised until early May, the upper end of the lake (south of the railroad tracks) would not trap sediment during spring runoff as effectively as it does under the present arrangement. Thus some increase in sedimentation farther downlake could be expected.

A final option worth considering is a complete drawdown (down to the stream channel) for 12 months. This approach would maximize sediment consolidation and weed control. However, recreational activities on the lake would be temporarily eliminated. A major drawdown of this type would be beneficial on an occasional basis (every 4-5 years) but should not be repeated annually. Any planned water level deviation from the agreement reached in 1926 would require approval from the Department of Natural Resources pursuant to Chapter 31, Wisconsin Statutes.

4. Aquatic Plant Control by Herbicides or Harvesting

The objective of this alternative is to reduce the submergent aquatic plant population in selected areas, thereby improving recreational opportunities.

Recalling that Black Otter Creek drains over 10,000 acres before reaching the lake, it is unlikely that the nutrient load to the lake could be reduced to the point where weed growth is inhibited. Recognizing that a certain level of nutrient loading is unavoidable, the resulting aquatic plants could be controlled by means other than dredging. These other methods include herbicide applications and harvesting, both of which have been moderately successful in achieving at least temporary weed control.

Herbicide treatment is a commonly used, effective approach for control of aquatic weeds. All weed species in the lake could be controlled chemically, although effective control will probably require using more than one herbicide. Some of the disadvantages of herbicide treatment include: 1) treatment has to be repeated annually, and probably more than once per summer, 2) the treated and dying weeds settle to the bottom resulting in an increased oxygen demand during decomposition, organic sediment accumulation and ultimately providing an increased nutrient base for future growth, and 3) only near shore (shallow) and small areas can be treated effectively.

Anyone conducting chemical control of aquatic nuisance in Black Otter Lake must obtain a permit from the Department of Natural Resources in accordance with Wisconsin Administrative Code Section NR 107.

Weed harvesting is another common method used to reduce plant abundance and maintain open water areas. There are two variations to this method. One method involves a cutter and a push bar which simply cuts the weeds and does not collect them. Wisconsin Statutes require, however, that cut weeds be removed. A cutter and push bar machine can be obtained commercially for approximately $3,500. A collection system and transport to disposal area would add substantially to the cost.

The other variation is to use a weed harvesting system consisting of a harvester, transport barge and shore conveyor. This system has an advantage over the cutter and push bar system in that it cuts, collects and delivers the weeds to a shore station. A small weed harvesting system can be obtained commercially for $10,000 to $15,000. Large harvesting systems cost upwards of $50,000.

Harvesting has several advantages over herbicides, including: 1) discrete areas can be treated anywhere in the lake, 2) plant biomass and nutrients are removed from the lake, and 3) all species present will be controlled. Retreatment will still be required annually, and adequate control may necessitate cutting an area 2-3 times each summer. The primary disadvantages compared with herbicides include initially higher equipment costs, and the need to remove and dispose of the harvested material. In addition, a small harvester can only clear a couple of acres per day. Thus, a small harvester would have to be in operation all summer long just to keep 30-50 acres open. In recent years, commerical harvesting services have become available. Rates for the 1979 season ranged from $120 to $200 per acre. A review of macrophyte biology, mechanical harvesting options and costs, effects of harvesting on the associated fishery and development of economic uses for harvested biomass is available in the proceedings of a recent conference on Aquatic Plants, Lake Management and Ecosystem Consequences of Lake Harvesting by Breck, Prentki and Loucks, 1979.

Because they are considered cosmetic approaches which treat the symptoms rather than the cause of the problem, state and federal cost-sharing is generally not available for chemical or mechanical weed control practices.

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Any management alternative selected by the lake district that requires Department of Natural Resources permits and/or more than $25,000 of state funds will be evaluated by completion of an Environmental Impact Assessment (EIA). The EIA will provide an opportunity for public review and comment on its findings and will determine the need for an Environmental Impact Statement (EIS). If the EIA demonstrates that the selected management alternative will significantly affect the quality of the human environment, the Department will prepare an EIS prior to project approval.

D.

4/28/80
djc