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DEPARTMENT OF ECOLOGY
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MEMORANDUM
April 5, 1983

To: Frank Monahan

From: Lynn Singleton

Subject: Results of Harts Lake Reconnaissance: February 24, 1983

Harts Lake has been the subject of several past water quality complaints and concerns. These complaints usually pertain to the manure-handling practices at Wilcox Farms, a very large dairy and egg operation. The complaintants generally report manure entering the lake and cite this input as being responsible for the worsening water quality conditions in Harts Lake. In the past few years, fishkills have occurred in late summer or early fall. Concerned over the lake's condition and the fishery impact, the Washington State Deaprtment of Game (WDG) and the Southwest Regional Office (SWRO), Washington Department of Ecology (WDOE) requested technical assistance. A reconnaissance of the Harts Lake drainage was conducted on February 24, 1983. Darrel Anderson (SWRO) and myself represented the WDOE and Tom Cropp and an assistant furnished the boat and represented WDG. The results of the reconnaissance survey are discussed below.

Reconnaissance Data

The six stations sampled are depicted in Figure 1. Surface grab samples were collected at all sites. A vertical profile sample was also collected at station 1. This profile indicates the lake was fairly well mixed. Temperatures were not taken, so it is not possible to determine whether thermal stratification had begun. Thermal stratification may be a factor in the lower dissolved oxygen concentrations observed in the bottom water. Lower oxygen levels are an indication of sediment oxygen demand. Historic data indicated Harts Lake exhibits extreme anoxia during the summer months (Collings, 1973; Bortleson, et al., 1974, 1976; and Sumioka and Dion, draft). The most severe case of anoxia on record occurred in August, 1971, when the concentration of dissolved oxygen below a depth of eight feet was less than 1 mg/L.

The nutrient concentrations in the lake are very high and indicate the lake is eutrophic. This is verified by historic data collected during the growing seasons. The lake has been classified as a meso- to eutrophic system having high nutrient and chlorophyll a concentrations and hypolimnetic anoxia (Collings, 1973).

The lake's uncontrolled outflow (station 3) is located at the southern end of the lake. As would be expected, the water quality conditions vary little from the mid-lake station.

Surface water inflow to the lake is primarily confined to three intermittent streams; stations 2, 4, and 5. A relative quantitative ranking of influent flows indicates the streams represented by stations 4, 2, and 5 are in order of descending importance. In addition to being the predominant hydraulic source, the data indicate that station 4, Little Lake outflow, is the significant source of nutrient and bacterial loading to Harts Lake. The source to Little Lake was traced to a ditch at the southern end of the lake (station 6). The ditch originates from an undisturbed swampy area and flows past two large Wilcox Farms egg-production sheds. The chicken manure-handling practices at the sheds are totally inadequate. Manure is washed from a concrete pad at the end of one building, down a bank, and into the ditch where a large sludge bed has developed. At the manure entry point, the normal algal growth was replaced by grey strands of Sphaerotilus sp. The ditch flows under the shed and past fallow fields which receive spray-irrigated manure slurry from the dairy operation. Runoff from these rain-soaked fields also enters the ditch. Erosion around the field drains was obvious the day of the reconnaissance. The ditch then flows into Little Lake. Solids washed into Little Lake are incorporated into the sediments and become a long-term nutrient source and sediment oxygen demand. Little Lake supports a heavy aquatic plant population. These plants also act as a nutrient source. These nutrient- and bacteria-laden waters then flow into Harts Lake. A cursory inspection of aerial photographs and maps indicates this ditch has been present for some time. A long-term nutrient source such as this ditch has certainly not helped water quality in Little Lake or Harts Lake.

The use of the hillside located at the south shore of Harts Lake is a persistent source of complaints. It has been used as a site for both manure slurry and solids application. Mr. Wilcox (Wilcox Farms) had agreed to stop applying animal wastes in the vicinity of Harts Lake (Anderson, 1981). Mr. Wilcox appears to have changed his position on this in light of recent complaints (Anderson, 1983). In the most recent incident, the hill was regraded in January and manure solids applied to prevent erosion and enhance the growth of grasses. The outcome of regrading a slope in western Washington during the winter rain season ought to be obvious. Erosion will quite probably be a problem and the manure solids are not noted for their adhesive characteristics. The

manure is either washed downhill and into the system outright, or the nutrients leach from the manure and enter the lake via the groundwater. In either case, the system is enriched. During the reconnaissance, erosion cuts six to 12 inches deep were present on this hillside. It was also obvious that some solids had washed into the lake. The presence of both erosion and sediment entering the lake illustrates that the above concerns are well founded. A slope stabilization fabric might be more appropriate and cost-effective for future efforts. At any rate, the practice of spreading manure in any form on this hillside should be discontinued permanently and the slope should be stabilized to prevent eroded solids from further entering the lake.

Historical Conditions

Historical water quality data (Collings, 1973; Bortleson, et al., 1974, 1976; and Sumioka and Dion, draft) indicate Harts Lake has experienced water quality problems associated with eutrophication for at least 13 years. These problems have included hypolimnetic anoxia, high nutrient concentrations, low water clarity, and algal blooms. Ammonia concentrations are high enough to potentially cause un-ionized ammonia toxicity problems.

In recent times, a relative measure of a lake's water quality has been a desirable management tool. Several such measures, or trophic indices, are available and some have been applied to Washington lakes (Bortleson, 1978; Sumioka and Dion, draft). Trophic indices are relative to the lakes they are applied to and may use a few key parameters or several. The Bortleson Index is one of these and uses 14 key water quality variables. The resulting value when applied to Harts Lake was 534 (Sumioka and Dion, draft). Bortleson (1978) ranked 617 lakes in Washington using this index. Harts Lake ranked 19th worst when compared to the other lakes. If only compared to western Washington lakes, it maintains the 4th worst position out of 326.

Fishkills

The fishkills Harts Lake has experienced in the past will quite likely continue. The sequence of events which lead to a fishkill is usually repeated each year in a eutrophic lake. The hypolimnion becomes totally devoid of oxygen and contains very high ammonia levels. The metalimnion is either anoxic or has low oxygen and high nutrients concentrations. The lake waters begin to cool with the onset of fall. When the lake's temperature is uniform from top to bottom, wind action causes circulation and mixing. The oxygen-poor, ammonia-rich stratum comes to the surface where the fish have taken refuge from the toxic conditions. Mortality occurs from suffocation and/or un-ionized ammonia toxicity.

Treatment of Harts Lake Problems

The first action to be taken in Harts Lake is to stop nutrient and bacterial input to Little Lake. This may be possible by preventing the entry of chicken wastes to the ditch directly; however, real success is questionable because of current land uses. As long as manure is applied to the fields adjacent to the ditch, nutrient and bacteria concentrations will be high. Another option would be to divert the ditch, causing it to flow to the Harts Lake outlet ditch. I have two concerns regarding this option. The first is that the water quality in this ditch appears to be in poor condition. Additional input might cause problems in its receiving water, the Nisqually River. Water collected from underdrains which enter the lake outlet ditch had ammonia concentrations of 110 mg/L and a chemical oxygen demand (COD) of 900 mg/L (Oberlander, 1979). More data are needed to fully address this concern and the current waste management practices on Wilcox Farms as they relate to the lake outlet ditch. The second concern is that if the ditch were cleaned up, Harts Lake and Little Lake may hydraulically benefit from the flow. Diversion of this flow may alter current lake levels and flushing rates.

The impact of another nutrient source present in Harts Lake was not evaluated. Caroll Clubb currently rears trout in lake holding pens. The food and wastes associated with this practice should be considered in any future nutrient budget.

Regardless of the remedy for the on-going nutrient input, Little Lake will still be a major nutrient source to Harts Lake. Conditions in Harts Lake would probably remain the same even if the Little Lake input was removed. Harts Lake's internal nutrient cycle is established and quite probably would maintain similar in-lake conditions. The Harts Lake drainage basin is relatively small and therefore so is its hydraulic flushing. Adequate flow data are not available at present to determine its flushing rate.

Harts Lake has been treated with copper sulfate once in the past. Such treatment will provide temporary aesthetic relief from algal blooms; however, will do little to alleviate long-term problems.

Tom Cropp (WDG) has suggested using an aerator. This could possibly help diminish the anoxia and ammonia concentrations; however it may not. Adequate data do not exist to determine if the lake is nutrient-limited; however, if it is, an aerator will move nutrients from the hypolimnion to the euphotic zone where they will stimulate more algal production. Greater production ultimately means higher dieoff/decomposition, which results in higher oxygen demand and ammonia remineralization. This cycle may prevent the desirable solution. More data are needed if such remedies are desired. Acquisition of data and a determination of the cost effectiveness will be the responsibility of the involved parties.

Table 1. Water quality data collected from Harts Lake and associated drainage (2/23/83).

Depth (meters)	D.O. (mg/L)	pH (S.U.)	Spec. Cond. (μmhos/cm)	Secchi Disk (feet)	F. Coliform (col/100 ml)	NO_3-N (mg/L)	NO_2-N (mg/L)	NH_3-N (mg/L)	O-PO_4-P (mg/L)	T-PO_4-P (mg/L)
Station 1 - Mid-lake Sample										
S	9.1	7.4	134	8	<1	0.26	<0.01	0.9	0.30	0.36
1	8.9	7.4	137			0.27	<0.01	0.96	0.33	0.38
3	8.0	7.3	137			0.27	<0.01	0.99	0.34	0.42
6	8.0	7.3	137			0.26	<0.01	1.0	0.35	0.38
9	7.8	7.3	137			0.26	<0.01	1.0	0.34	0.39
12	7.0	7.2	139			0.26	<0.01	1.0	0.35	0.38
Station 2 - Influent Stream										
S	9.3	7.0	89		150	0.11	<0.01	0.4	0.03	0.08
Station 3 - Outflow Channel										
S	7.8	7.3	140		<1	0.29	<0.01	0.95	0.34	0.37
Station 4 - Outflow of Little Lake; influent to Harts Lake										
S	7.4	7.5	232		130	0.50	<0.01	2.9	0.90	0.94
Station 5 - Influent Stream										
S	7.5	6.7	67		18	0.21	<0.01	0.05	0.05	0.09
Station 6 - Influent Ditch to Little Lake										
S	0.7	7.4	366		3200 est.	0.04	<0.01	5.7	3.4	3.7

S = Surface
Est. = Estimated

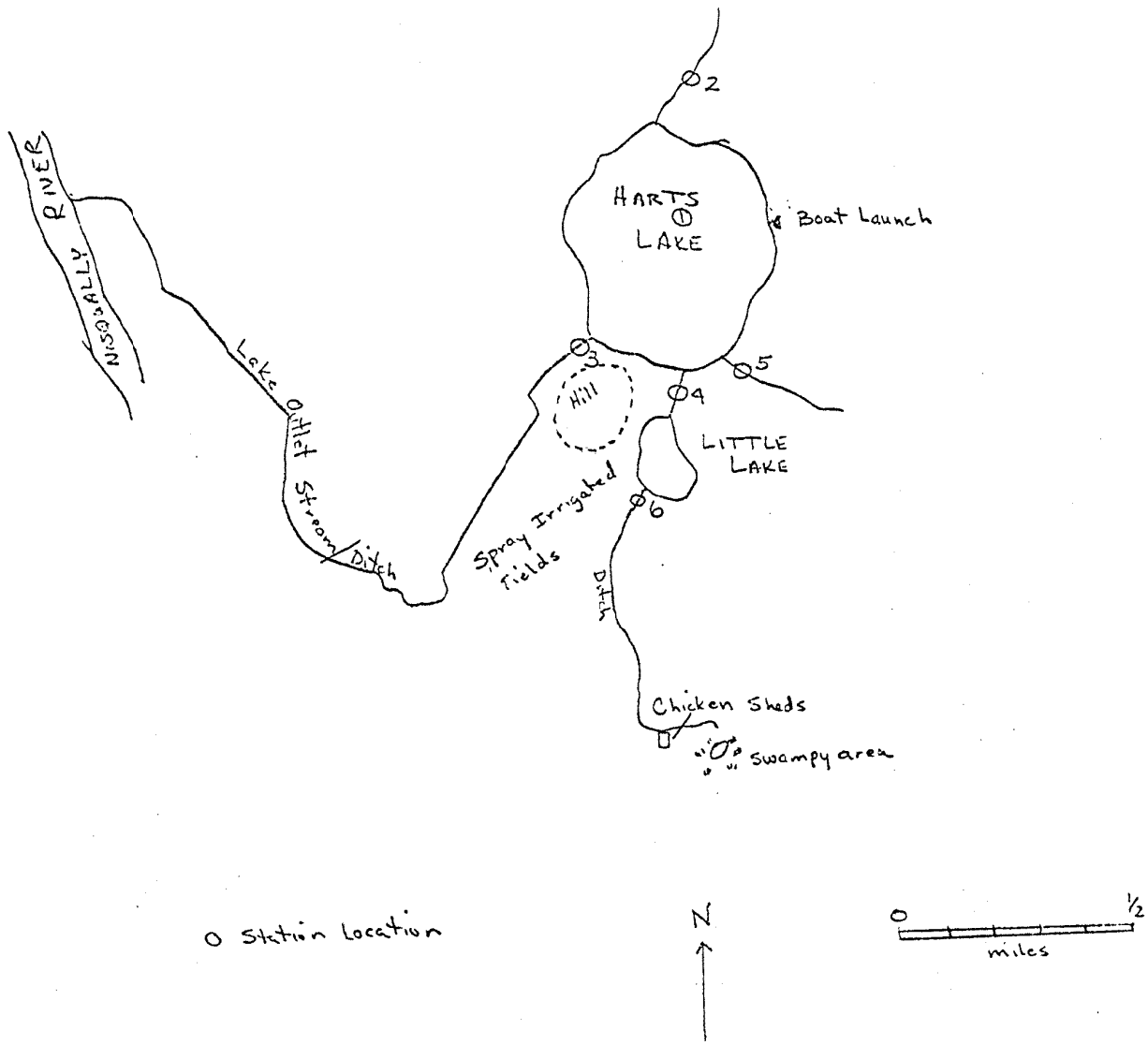

Figure 1. Map of reconnaissance area. Harts Lake, February 24, 1983.

Eutrophication in Harts Lake has undoubtedly been accelerated by Wilcox Farms. A lake sediment survey combined with aerial photographs and maps may provide the information needed to determine when and how nutrient enrichment began. This type of study is beyond this scope of work.

Conclusions/Recommendations

1. Harts Lake and Little Lake are eutrophic.

2. Fishkills will probably continue to occur under present conditions.

3. Little Lake is the major source of nutrient and bacterial loading to Harts Lake.

4. The major source of nutrients and bacterial loading to Little Lake is the ditch which is degraded as it flows through the Wilcox Farms property.

5. Abatement of nutrient addition alone will probably not prevent future water quality problems in Harts Lake. Internal nutrient cycling will be a continual problem.

6. Rerouting of the ditch from its present location to the Harts Lake outlet ditch may impact its receiving water, the Nisqually River.

7. Manure application to the hillside on the south shore of Harts Lake should be stopped premanently and other methods used to stabilize bank erosion.

8. Solutions to the fishkill problem such as an aerator may have limited benefit and should be evaluated further by the involved parties.

LRS:cp

Attachments

cc: Files
Darrel Anderson

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