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DEPARTMENT: POLLUTION CONTROL AGENCY

STATE OF MINNESOTA

Office Memorandum

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SUBJECT: Little Rock Lake (05-0013) Investigation and Recommendation for Inclusion on 2008 303(d) Draft List for Nutrient Impairment

Little Rock Lake experienced very severe algal blooms over the past few weeks in July and these blooms raised extensive concerns with lakeshore property owners and lake users. These concerns were forwarded to the Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Natural Resources (MDNR). Multiple staff from the MPCA surveyed conditions on the lake during the week of July 23, 2007. This memorandum will focus primarily on sampling conducted by Harold Wiegner, David Tollefson (intern) and myself on July 25 but will also note an initial investigation by Matt Lindon and Kelly O'Hara on July 12, 2007.

Background

Little Rock is a relatively large (~1,270 acre) but shallow lake (mean depth = 8 feet and maximum depth = 19 feet) in Benton County that drains to the Mississippi River. It has a very large (~68,000 acre) agriculturally dominated watershed. It has been studied on at least two occasions by MPCA as reflected in a 1971 investigational report and a detailed Lake Assessment (LAP) study conducted in 1990. The LAP report may be found at http://www.pca.state.mn.us/publications/reports/lar-05-0013.pdf . Data from this and more recent efforts may be found at Environmental Data Access (EDA) at http://www.pca.state.mn.us/data/eda/STresults.cfm?stID=05-0013&stOR=MNPCA1&year=2007 . These data suggest hypereutrophic conditions for the lake. Findings from the LAP report and more recent data in EDA will be used to place 2007 in perspective.

July 25th sampling effort

Water samples and field measurements were collected at four sites on the lake: 1) beach/access at Benton County Park on the north side; 2) Little Rock Creek inflow bay; 3) west side of lake near 105th Avenue; and lake outlet at public access at US Highway 10 as noted in Figure 1 and the pictures of each site. At each site algal toxin samples were collected for microcystin and saxitoxin analysis. Field measures of dissolved oxygen, temperature, pH and conductivity were taken at all sites and total phosphorus and chlorophyll-a samples were collected at sites 1 and 4. Sites 1 and 4 represent actual "water" samples while sites 3 and 4 were collected amidst the algal blooms that had accumulated along the shoreline. Field and laboratory data are summarized in the following tables and data from July 30, 1990 are offered for perspective.

Table 1. Field data from July 25, 2007 and data from 1990 LAP study

Site	Dissolved oxygen (mg/L)	Temperature (C)	pH (SU)	Conductivity (µmhos/cm)
1. Beach	13.4	27.5	9.7	237
2. L. Rock Creek	0.2	29.2	8.1	368
3. West side	--	--	--	--
4. L. Rock outlet	13.3	28.9	9.9	239
July 30, 1990 (mid-lake sample)	10.1	21.0		250

Table 2. Lab data from July 25, 2007 and data from 1990 LAP study

Site	Total phosphorus (ppb)	Chlorophyll-a (ppb)	Pheophytin-a (ppb)
1. Beach	271	120	4.0
2. L. Rock Creek	---	----	
3. West side	---	---	
4. L. Rock outlet	431	127	5.5
July 30, 1990 (mid-lake sample)	210	126	2.4

Table 3. Algal toxin data from July 25, 2007 and July 12

Site	Microcystin (µg/L)	Saxitoxin (ng/L)
1. Beach	22	<0.02
2. L. Rock Creek	38,000	0.03
3. West side	>80,000	0.04
4. L. Rock outlet	17	<0.02
July 12 – south side	120	

Water temperatures were exceedingly warm on July 25, 2007 as compared to July 30, 1990. Dissolved oxygen was supersatured at sites 1 and 4 and is a direct reflection of algal productivity. pH values were elevated at these sites as well for the same reason. Conductivity (an indirect measure of dissolved minerals in the water) was rather similar in July 2007 as compared to July 1990.

Total phosphorus (TP) was high on July 25, 2007 (indicative of hypereutrophic conditions) and both samples were higher than the corresponding sample in 1990. TP at the outlet (site 4) was higher than site 1 and this may be an indication of internal recycling within the lake; however this is difficult to ascertain with a single sample. The 1990 LAP study indicated that TP increased from May through September, which often is an indication of internal phosphorus recycling.

Chlorophyll-a concentrations were exceedingly high on July 25, 2007 and indicative of severe nuisance blooms. These values though were quite comparable to the sample from July 30, 1990 (Table 2). The dominant alga on July 25, 2007 was the blue-green Microcystis -- a form noted for its ability to produce the toxin microcystin. Microcystis and another blue-green – Aphanizomenon (also a toxin-producer) were dominant in the July 30, 1990 sample.

Algal toxin samples were collected on July 25 and during an initial investigation by Matt Lindon and Kelly O'Hara on July 12, 2007 (Table 3). The World Health Organization (WHO) provides a basis for placing the microcystin concentrations in perspective in terms of human health risk as follows:
< 10 ppb – low risk; 10-20 ppb – moderate risk, 20-2,000 ppb – high risk and >2,000 – very high risk. Further details on blue-green algal toxins and levels of microcystin in Minnesota lakes may be found at:
http://www.pca.state.mn.us/water/clmp-toxicalgae.html and
http://www.pca.state.mn.us/publications/reports/wq-lar3-11.pdf respectively.

Based on the WHO categories the sample taken on July 12, 2007 is considered high risk. The two open water samples (site 1 and 4) on July 25th are considered moderate to high risk and the two samples taken amidst the blooms (sites 2 and 3) would be very high risk. The saxitoxin levels are below or just above detection, which is consistent with other work that suggests saxitoxin concentrations are typically quite low in freshwater algal blooms. The microcystin results support the recommendations to avoid contact with the water.

Impaired waters (303(d)) listing

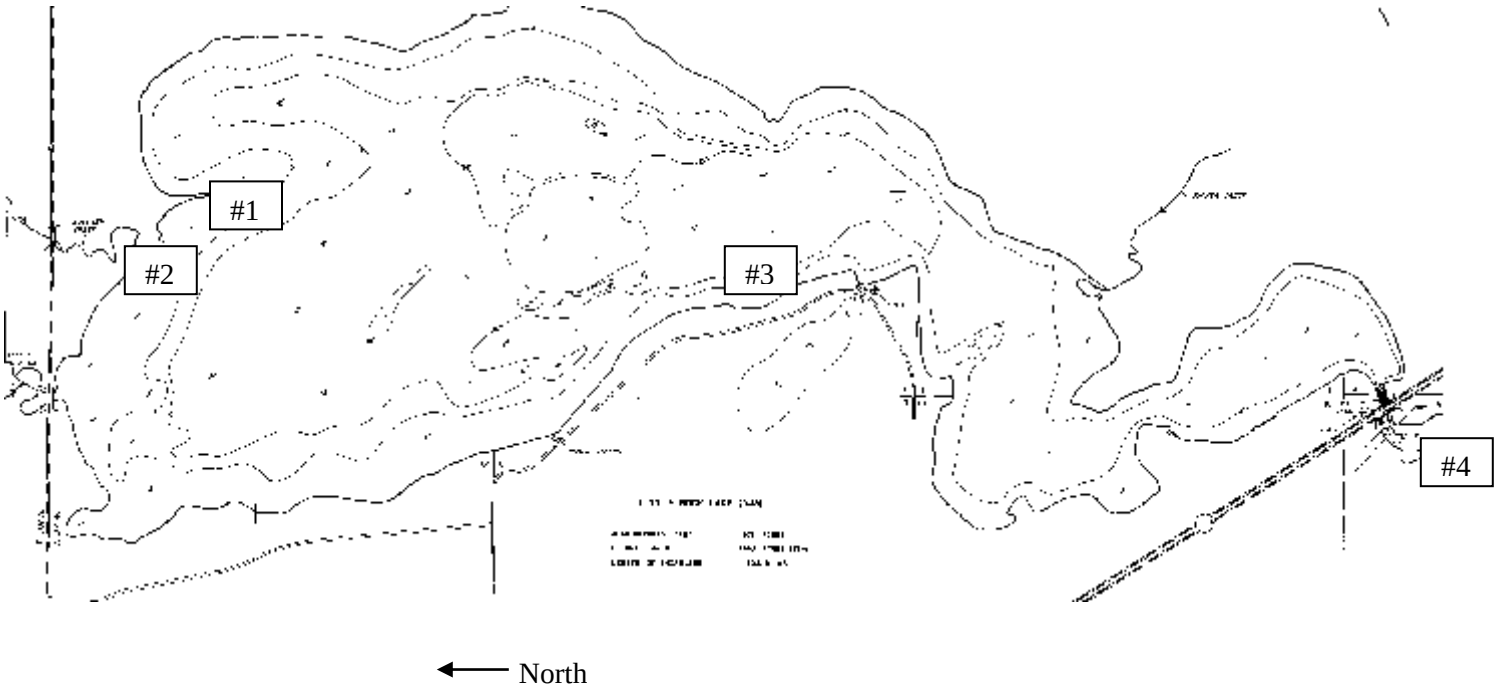
Because eutrophication criteria have not yet been adopted into standards the existing trophic status thresholds are the primary basis for the 2008 303(d) assessment; however for purposes of discussion the draft criteria have been included as well (Tables 5 and 6). When data was compiled for the current 2008 303(d) assessment (considers data collected from 1997 – 2006), in spring 2007, Little Rock Lake was not included because it had insufficient data. In fact no TP or chlorophyll-a data had been collected since the 1990 LAP study. Since that time data have been added to EDA for 2003 and 2006 and when combined with the 1990 LAP data this provides a good basis for assessing Little Rock Lake (Table 4).

Table 4. Little Rock trophic status. Summer (June to September) means. Number of sample dates noted.

	TP		**Chl-a**		**Secchi**	
	mean	N	**mean**	N	**mean**	N
1990	179	4	91	4	0.5	62
2003&2006	132	7	77	7	0.7	16
	ppb		**ppb**		**m**	

These values (Table 4) suggest that Little Rock is well above the TP, chlorophyll-a, and Secchi thresholds for North Central Hardwoods Forests Lakes (Table 5) and is also above recommended criteria for shallow lakes in that region as well (Table 6). In addition, algal toxin testing indicates elevated levels of microcystin relative to WHO thresholds, which is an additional factor to consider for 303(d) listing based on the most recent assessment guidance document (http://www.pca.state.mn.us/publications/wq-iw1-06.pdf page 66). Given this weight of evidence I am recommending that Little Rock Lake be included on the 2008 draft 303(d) list.

Figure 1. Little Rock map and sample sites.



Site 1. Boat Access north side

Site 2. Little Rock Creek

Site 3. West side of lake

Site 4. Outlet of lake

Table 5. Trophic Status Thresholds for Determination of Use Support for Lakes. (Carlson's TSI Noted for Each Threshold.)

Ecoregion (TSI)	TP ppb	Chl ppb	Secchi m	TP Range ppb	TP ppb	Chl ppb	Secchi m
305(b):	**Full Support**			**Partial Support to Potential Non-Support**			
303(d):	**Not Listed**			**Review**	**Listed**		
NLF	< 30	<10	≥ 1.6	30 – 35	> 35	> 12	< 1.4
(TSI)	(< 53)	(< 53)	(< 53)	(53-56)	(> 56)	(> 55)	(> 55)
CHF	< 40	< 15	≥ 1.2	40 - 45	> 45	> 18	< 1.1
(TSI)	(< 57)	(< 57)	(< 57)	(57 – 59)	(> 59)	(> 59)	(> 59)
WCP & NGP	< 70	< 24	> 1.0	70 - 90	> 90	> 32	< 0.7
(TSI)	(< 66)	(< 61)	(< 61)	(66 – 69)	(> 69)	(> 65)	(> 65)

TSI = Carlson trophic state index; Chl = Chlorophyll-a; ppb = parts per billion or µg/L; m = meters

Table 6. Proposed eutrophication criteria by ecoregion and lake type.

Ecoregion	TP	Chl-a	Secchi
	ppb	ppb	meters
NLF – Lake trout (Class 2A)	**< 12**	**< 3**	**> 4.8**
NLF – Stream trout (Class 2A)	**< 20**	**< 6**	**> 2.5**
NLF – Aquatic Rec. Use (Class 2B)	**< 30**	**< 9**	**> 2.0**
CHF – Stream trout (Class 2a)	**< 20**	**< 6**	**> 2.5**
CHF – Aquatic Rec. Use (Class 2b)	**< 40**	**< 14**	**> 1.4**
CHF – Aquatic Rec. Use (Class 2b) Shallow lakes	**< 60**	**< 20**	**> 1.0**
WCP & NGP – Aquatic Rec. Use (Class 2B)	**< 65**	**< 22**	**> 0.9**
WCP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	**< 90**	**< 30**	**> 0.7**