CARLETON COLLEGE

LYMAN LAKES

1984

INTERIM REPORT

on

LAKE SAMPLING

Schilling Environmental Consultants

St. Paul, Minnesota

January, 1985

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Background

In early 1984, discussions were initiated between Carleton College staff and Schilling Environmental Consultants regarding the improvement of Lyman lakes. The discussions culminated in the submission of a proposal for consulting services (June, 1984) which outlined recommended work tasks needed in the overall project. A portion of the proposal, that dealing with lake water quality sampling, was begun as authorized and directed by Mr. Dennis Easley, Superintendent of Grounds.

The Lyman lakes system consists of two small artificial impoundments constructed on the lower end of Spring Creek in northeastern Rice County and wholly contained on the campus of Carleton College, Northfield, Minnesota. The two impoundments, constructed in the 1930's, are known as Upper and Lower Lyman Lakes. Upper Lyman Lake, the smaller of the two reservoirs, has the following characteristics:

Area: 2.3 acres (0.93 ha)
Mean Depth: 1.9 ft. (0.57 m)
Volume: 4.33 ac-ft. (5306 m^3)

Lower Lyman Lake with the following characteristics is located immediately downstream of the control structure separating it from the upstream reservoir:

Water Area: 5.0 acres (2.02 ha)
Islands' Area: 0.8 acres (0.32 ha)
Mean Depth: 4.1 ft. (1.25 m^3)

Volume: 20.5 ac-ft. (25,293 m^3)

Lower Lyman is only slightly more than twice the surface area of Upper Lyman, however, it contains nearly five times the volume. The physical characteristics were determined planimetrically from bathymetric maps developed by Professor C. E. Buchwald (see Figures I and II). The upstream impoundment was deepened by dredging in 1960, but neither prior or post-construction bottom contour maps were available. Therefore, it is not possible, except by more expensive methods, to easily determine the extent of sediment deposition which has occurred over the last 20+ years.

The direction of the project was to initially gather as much information on the physical, chemical and biological characteristics as fiscal resources would permit. Analysis of the information gathered would dictate the direction and scope of future efforts.

Methodology

Three water quality sample stations were located in the lakes with two being in Lower Lyman. The shallow nature of both lakes precluded either depth-integrated or stratigraphic sampling modes. Grab samples at a depth of 1.5 feet (0.46 m) were taken at each of the stations (see Figures I and II). Table I depicts the analytical parameters gathered at each station. Water samples were collected for parameters #3, #5 thru #17 with quantity and preservation methods according to USEPA (1976). Deviation from accepted field methods was made for parameter #4, chlorophyll a. With the alternate method,

water samples were shipped for lab filtration and analysis rather than the accepted procedure of field sample filtration and lab filter analysis. Laboratory analyses were conducted by Environmental Research Group, Inc., St. Paul, Minnesota, according to USEPA (1973). Field measurements for dissolved oxygen and temperature were made with a Yellow Springs Instrument Co., Model 54 meter with lake transparency using a standard 8 inch black and white Secchi disc.

Water sample collection and field measurements were conducted by Carleton College staff and students. Due to late season field program initiation, sample collection consisted of once in June and September with bimonthly during July and August.

Results

It should be stressed that one partial growing season of lake sampling does not present the entire picture of the chemical, physical or biological characteristics of any lake. As is often the case in pure or applied research efforts, answers are provided to questions while still new ones are posed. Lyman lakes are most unusual because their shallow depth and small surface area may cause their characteristics to fall between both riverine and lake environments.

Total Alkalinity

The measurement of total alkalinity as $CaCO_3$ serves as an indicator of the

lake's ability to buffer or neutralize acids. The calcareous (containing calcium carbonate) condition of the soils and bedrock in this region of Minnesota provide a large buffering capacity for the lakes and rivers. The small range in total alkalinity values for both the upper (excluding July 10th) and lower lakes along with their consistently high levels is a probable reflection of contact with calcareous material. The mean values of 282 mg/L for Upper Lyman and 256 mg/L for Lower Lyman would be within the 99th percentile of 391 lakes examined statewide by Minnesota Pollution Control Agency (1982). Moyle (1954) found in a major study involving 1546 water analyses that the highest total alkalinities (>200 mg/L) were from shallow waterfowl lakes of western and southwestern Minnesota.

Of particular interest is the relatively low value of 140 mg/L found at ULL-01 on July 10th. The sampling occurred following a rainfall of 2.32 inches (Goodsell Observatory, 1984) which was an approximately 2 year frequency event (Metropolitan Council, 1984). It appears likely that moderate rainfall runoff of low alkalinity water contributed to the reduction in lake concentration. With respect to Lower Lyman on July 10th, the alkalinity was apparently only slightly affected by the rainfall event. If it is assumed that the lower lake pre-rainfall concentration was about 270 mg/L, then dilution from rainfall alone at a level of 10 mg/L would have reduced the alkalinity to 258 mg/L in contrast to the mean value observed between LLL-01 and LLL-02 of 255 mg/L.

Phosphorus/Nitrogen

Total phosphorus concentrations within both Upper and Lower Lyman lakes reflected ranges of nearly 1000 percent from a low of 0.030 to a high of 0.330

mg/L. The high values on both July 10th and 26th coincide with rainfall events recorded at Goodsell Observatory. While the storm event which occurred on July 10th, discussed previously, was clearly of a magnitude to cause surface runoff, the effects of the July 26th event of 0.31 inches are not as obvious. In a major study involving watershed runoff and storm event sampling, Oberts (1984) found that as little as 0.1 inches of rainfall resulted in runoff for predominantly urban drainage areas. Therefore, depending on the extent of immediate urban drainage runoff to the lakes, it is possible that the phosphorus concentrations are storm event related for both dates.

The mean total phosphorus levels for Upper Lyman (0.107 mg/L) and Lower Lyman (0.108 mg/L) are nearly identical! A t-test was used to analyze the two groups of data. At the 95% confidence level, it is probable that the mean total phosphorus values differ significantly. With respect to the ortho phosphorus levels in both lakes, the values generally are very low or below the detection limit of 0.010 mg/L. Thus, during the sampling periods very little phosphorus is available for algae growth was present.

The nitrogen situation for the two lakes was quite different. The mean levels of 9.09 and 6.99 mg/L for the Upper and Lower lakes are extremely high. As is evident, total nitrogen is comprized of four individual parameters: Ammonia Nitrogen and Organic Nitrogen which are analyzed in combination as Kjeldahl Nitrogen and Nitrate-Nitrite Nitrogen, also analyzed in combination. In general for lakes, the latter parameter (nitrate-nitrite) is a small portion (< 20%) of total nitrogen. The Metropolitan Council (1981) found that 58 of the 60 lakes examined had nitrate-nitrite concentrations less than or equal to 0.10 mg/L. In Lyman Lakes, the nitrate-nitrite proportion ranges from 75-95% of

total nitrogen with concentrations from 3.70 to 9.90 mg/L. Of 379 lakes examined by MPCA (1982), the maximum total nitrogen level was 8.70 mg/L with a mean of 1.50 mg/L.

In addition, it's important to note the processes of the nitrogen cycle which may be occurring through the lakes. Table VI depicts the positive or negative changes (increase or decrease) between the two lakes for each of individual nitrogen components. There appears to be two primary processes taking place. First is nitrification which results in the conversion of ammonia to nitrite and nitrite to nitrate nitrogen in the presence of adequate oxygen. Second is biological uptake of either ammonia or nitrate-nitrite nitrogen. Therefore, as a decrease is observed in ammonia and nitrate-nitrite nitrogen due to plant uptake and nitrification, a subsequent increase is then seen in the biological component or organic nitrogen.

Nitrogen: Phosphorus Ratios

The importance of nitrogen and phosphorus in the growth of algae has been well documented by numerous authors Vollenwider (1968), Sawyer (1947), and Schindler (1975). Improvement of lake quality is often directed at strategies to reduce the loading of one of these key nutrients. With nitrogen to phosphorus in algal cells corresponding to a ratio in weight from 4.5:1 to 9:1 according to Chiaudani and Vighi (1974), then it follows in natural waters an N:P ratio deviating from these values could suggest one of the two nutrients acting as a limiting factor. It should be noted that algal biomass is often expressed as the amount of chlorophyll a in lakes. Sakamoto (1966) noted that chlorophyll yield was a logarithmic function of both total phosphorus and total nitrogen.

He concluded that chlorophyll was dependent on total nitrogen when N:P $\leq$10, on total phosphorus when N:P $>$17 and very nearly in balance over the range $\leq$10 N:P $\leq$17. The same conclusions were drawn by Forsberg et al (1978) from algal growth experiments on Swedish lakes.

In Lyman Lakes the high levels of nitrate-nitrite nitrogen have generally resulted in N:P (TOT) ratios which would suggest phosphorus limitation. Of more importance are the consistently high ratios for total inorganic nitrogen to orthophosphate phosphorus ranging N:P (SOL) from 200:1 to 2000:1. Chaudani and Vighi (1974) found in laboratory algal experiments that there was no increase in growth by phosphorus addition (emphasis added) when ratios were less than 10; an increase in all cases when ratios were less than 5 and following nitrogen addition; and an increase in growth following phosphorus addition when ratios were greater than 10.

Therefore, in Lyman Lakes phosphorus clearly appears to be the nutrient which limited algal growth during the sampling period.

Chlorophyll/Secchi/Suspended Solids/Color/Turbidity

As discussed previously, chlorophyll a is the green pigment in photosynthetic plant life and is a good measurement of the standing crop of biomass of algae in lakes. Various studies: Dillon and Rigler (1974), Jones and Bachman (1976), and Metropolitan Council (1981) produced the following logarithmic equations which predict chlorophyll a concentrations from total phosphorus.

Dillon & Rigler (1974) Log CHL a = 1.449 Log TPHOS -1.136

Jones & Bachmann (1976) Log CHL *a* = 1.460 Log TPHOS -1.090

Met. Council (1981) Log CHL *a* = 1.186 Log TPHOS -0.525

Upper Lyman with a mean chlorophyll *a* level of 5.2 mg/m^3 was far below the range of 64 to 76 mg/m^3 that the previous studies would have predicted. It is likely that the shallow nature and short water residence play a major role in the reduced algae populations of Upper Lyman Lake. Similarly, the mean chlorophyll *a* level of 27 mg/m^3 for Lower Lyman Lake is only about 38 percent of the predicted range of 65-77 mg/m^3 . Again hydraulic water residence may be affecting algal growth. However, a more likely possibility is the unavailability of ortho phosphorus. As is evident in Table V, ortho phosphorus concentrations remain below detection limits (10 µg/L) on all occasions. According to Stumm and Morgan (1970) the high calcium levels which are likely in Lyman Lakes along with elevated pH would result in the prevalence of hydroxyapatite $Ca_{10}(PO_4)_3(OH)_2$ (s) and limit available phosphorus. It is interesting to note, however, that there is a consistent positive increase in chlorophyll *a* levels from Upper to Lower Lyman Lakes during the sampling period (see Table VI).

The secchi disc transparency measurements were of no value on Upper Lyman Lake due to its shallow condition. The picture is not quite as evident for Lower Lyman Lake. The mean transparency of 0.96 m is significantly less than the predictive linear regression equation estimate by Metropolitan Council (1981) of 1.42 m, but within 15 percent of a similar equation by MPCA (1982).

Met Council (1981) Log Secchi = $^{-}$0.564 Log CHL *a* + 0.961

MPCA (1982) Log Secchi = $^{-}$0.577 Log CHL *a* + 0.876

Transparency can be affected by materials other than algae such as dissolved organic compounds, often resulting from vegetation decay (i.e. leaves, grass clippings, wetland grasses). Brezonik (1978) found in a study examining 55 Florida lakes that the relative significance of organic color on transparency readings depends on turbidity. He developed a corrective regression equation which accounts for the effects due to color and turbidity.

Brezonik (1978) 1/Secchi = 0.106 + 0.128 TURB + 0.0025 COLOR

In applying the mean color of 26 Pt.-Co. units and the median turbidity of 4.2 NTU to the equation for Lower Lyman Lake results in a corrected secchi disc transparency of 1.4 m. It is well to note that the corrected secchi disc would probably be the maximum value expected in the absence of algal, color or turbidity effects due to the shallow depth of Lower Lyman Lake.

The ratio of suspended solids to turbidity in Lower Lyman ranged from 0.5 to 0.8 which is in agreement with a study of three TVA reserviors for turbidities less than 100 NTU by Brown (1984).

Temperature/Dissolved Oxygen

The shallow nature of both lakes precluded the formation of thermal stratification. The dissolved oxygen levels in both lakes during the period were adequate to support aquatic life and within Minnesota Code of Agency Rules (4.8014) requirement of not less than 5 mg/L at all times.

Fecal Coliform/Fecal Streptococcus

Both lakes met the State standard for Fecal coliform organisms (6 MCAR 4.8014) which requires that not more than 10% of all samples taken in a calendar month not exceed 2000 organisms/ml.

In an effort to further identify the extent and possible origin of fecal pollution to Upper Lyman Lake, the relationship of fecal coliform to fecal streptococcus (FC:FS) densities was undertaken. The FC:FS relation is based on the consistent differences found in their proportions in the feces of a variety of warm-blooded animals, including humans. According to Geldrich (1968) a ratio greater than 4.0 is typical of human fecal material while a ratio less than 1.0 is typical of other warm-blooded animals. Ratios over 1.0 but less than 4.0 have no clear interpretation, but may warrant further investigation. Due to potential change in the ratios as the result of differential die-off rates or possible aftergrowth of these groups, Quigley (1984) suggested that the test was most reliable when water samples are taken near pollution sources or within 24 hours flow downstream. In consideration of this caution, only data for Upper Lyman Lake was examined. As is evident within Table II, two of the four dates show values less than 1.0 while the remaining two dates indicate inconclusive values.

With this limited number of samples and in consideration of compliance with State standards discussed previously, it is concluded that coliform impacts are not of a serious nature for the Upper or Lower Lakes.

Upstream Influences

The drainage area upstream of Lyman Lakes is largely of agricultural landuse. The more immediate landuse consists of an urban setting including portions of the City of Northfield and the Carleton College campus. It was beyond the scope of this effort to examine in detail the influence of these landuses. However, the initial lake data received in July indicating the unusually high nitrogen values raised a question as to the source of possible loadings. Personal communication by Mr. Easley, Superintendent of Grounds with Northfield Golf Course staff elicited information on their fertilizing practices.

Spring Creek meanders through the 18 hole golf course and to insure suitable playing conditions, large amounts of fertilizer are applied by maintenance staff. The Fairways (~35 acres) receive granular urea (45% Nitrogen) three times per year at an application rate of 1 pound of nitrogen per 1000 square feet (ft^2). This calculates into about 130 lbs. of Nitrogen per acre per year. The Greens (~2.5 acres) receive granular fertilizer applications at a frequency of every 3-4 weeks at a rate of 8 lbs. of Nitrogen per 1000 ft^2. Based upon a conservative application frequency of 5 times per year, the total Greens application rate would equal about 1740 lbs./acre/year. As a perspective, a high application rate for corn would typically be 300-400 lbs./acre according to Logan, et al (1980). Loss rates of nitrogen for agricultural applications ranging from 100 to 400 lbs./acre average about 20-25 percent (ibid). While it is not appropriate to apply those loss rates to the Golf Course fertilizer applications, it does provide cause for further investigation.

The final influence which must be addressed for Lyman Lakes relates to water

residence time. Because the individual lakes are small in surface area and very shallow, any efforts to evaluate the effects from nutrient or sediment loadings must consider hydraulics. For example, consider a Spring Creek inflow rate of only 0.5 cubic feet per second (cfs) and the water residence in Upper Lyman Lake would be 4.5 days which is inadequate for growth requirements of algae (~7-10 days). In addition, at high flows of 5-10 cfs, residence time is reduced to hours, and appears to be inadequate for settlement of suspended sediment other than coarse grain materials. Similar projections can be presented for Lower Lyman Lake water residence. The importance of flow measurements cannot be stressed enough. Until comprehensive flow data is gathered, it is not possible to evaluate the extent of "washout" which may occur during Spring runoff or rainfall events. Measures to improve water quality in Lower Lyman and increase the sedimentation characteristics of Upper Lyman will require good estimates of inflow/concentration and loadings.

Summary

A limited 1984 Summer growing season water quality sampling program was conducted on Upper and Lower Lyman Lakes. Observed high total alkalinity values appear to reflect the calcareous nature of the watershed soils and bedrock, while additionally complexing soluble ortho phosphorus as hydroxyapatite and thus unavailable for algal growth. While very high nitrogen concentrations were significantly affected by the nitrate-nitrite component, those total phosphorus levels that were elevated appear to be the result of rainfall storm events. The ratios of nitrogen to phosphorus appear to indicate phosphorus limitation. However, algal biomass as chlorophyll a may be

controlled by other factors (e.g. water residence, chemical complexing). Secchi disc transparency revealed the attenuation of surface light due to the combined effects of algae, color, suspended solids and turbidity. Dissolved oxygen in the lakes is adequate to support aquatic life. The relationships of fecal coliform to fecal streptococcus densities do not appear to reflect impacts from human sources.

The high application rates of nitrogen fertilizer to the Northfield Golf Course and its possible loss may be the source of elevated nitrate-nitrite nitrogen in the downstream lakes. Finally, the small size and shallow nature of the lakes emphasizes the need to address flow, nutrient concentration and loadings in the investigation of improvement techniques.

TABLE I

Parameter - Units

ROW	Parameter	Description	Units
#1	STATION	Lake Sample	---
#2	DATE	Date of Sample	Year-Month-Day
#3	TALKA	Total Alkalinity	mg/L*
#4	CHL-a	Chlorophyll a	mg/L**
#5	COLOR	Color (apparent)	Platinum-Cobalt Units
#6	NH_3-N	Ammonia Nitrogen	mg/L
#7	NO_3+NO_2-N	Nitrate + Nitrite Nitrogen	mg/L
#8	TKN	Total Kjeldahl Nitrogen	mg/L
#9	ORG-N	Organic Nitrogen	mg/L
#10	pH	pH	Standard Unit
#11	TPHOS	Total Phosphorus	mg/L
#12	OPHOS	Ortho Phosphorus	mg/L
#13	SUS-SOLIDS	Suspended Solids	mg/L
#14	SPEC-COND	Specific Conductivity	µmhos
#15	TURB	Turbidity	Nephelometric Turbidity Unit
#16	FCOL	Fecal Coliform	No./100 ml
#17	FSTREP	Fecal Streptococcus	No./100 ml
#18	N:P (SOL)	Inorganic Nitrogen to Ortho Phosphorus ratio	--
#19	N:P (TOT)	Total Nitrogen to Total Phosphorus ratio	--
#20	SECCHI	Secchi disc transparency	meters
#21	TEMP C	Temperature degrees Centigrade	°C
#22	DO	Dissolved Oxygen	mg/L
#23	FC:FS	Fecal Coliform to Fecal Streptococcus ratio	--

* milligrams per liter or parts per million
** micrograms per liter or parts per billion

TABLE II

	1	2	3	4	5	6	7
1	Station ULL-01						
2	DATE	840625	840710	840726	840807	840829	840919
3	TALKA	280.00	140.00	272.00	290.00	290.00	280.00
4	CHL-a	N/A	11.00	7.10	2.10	5.30	<1.0
5	COLOR	20.00	50.00	15.00	20.00	10.00	15.00
6	NH3-N	0.17	0.31	0.22	0.34	0.09	0.09
7	NO3+NO2-N	9.80	3.90	8.80	9.90	8.90	8.70
8	TKN	0.59	1.40	0.64	0.59	1.00	0.37
9	ORG-N	0.42	1.09	0.42	0.25	0.91	0.28
10	pH	7.85	7.68	7.92	7.47	7.67	7.80
11	TPHOS	0.04	0.19	0.32	0.03	0.03	0.03
12	OPHOS	0.01	0.02	<0.01	<0.01	<0.01	<0.01
13	SUS-SOLIDS	12.00	57.00	16.00	7.00	4.00	8.00
14	SPEC-COND	680.00	290.00	570.00	500.00	540.00	580.00
15	TURB	4.00	34.00	4.70	2.40	1.50	18.00
16	FCOL	N/A	N/A	54.00	160.00	54.00	92.00
17	FSTREP	N/A	N/A	100	540	50.00	73.00
18	N:P(SOL)	997:1	210:1	1804:1	2048:1	1798:1	1758:1
19	N:P(TOT)	260:1	28:1	29:1	350:1	330:1	302:1
20	SECCHI	0.8*	0.4	0.75*	0.75*	0.75*	0.70*
21	TEMP C	19.00	22.5	20.00	18.00	18.50	14.50
22	D O	11.20	6.4 **	13.60	12.80	5.80	5.20
23	FC:FS	N/A	N/A	0.50	0.30	1.10	1.30
24							
25							
26	*Secchi disc resting on bottom.						
27	**Suspect value.						
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TABLE III

	1	2	3	4	5	6	7
1	Station LLL-01						
2	DATE	840625	840710	840726	840807	840829	840919
3	TALKA	270	250.00	237.00	240.00	270.00	260.00
4	CHL-a	60	13.00	29.00	15.00	28.00	26.00
5	COLOR	35.00	30.00	25.00	35.00	20.00	20.00
6	NH3-N	0.09	0.21	0.06	0.50	0.04	0.29
7	NO3+NO2-N	6.50	4.90	4.40	7.60	6.60	6.20
8	TKN	1.10	1.10	0.90	0.86	1.10	1.00
9	ORG-N	1.01	0.89	0.84	0.36	1.06	0.71
10	pH	8.04	7.93	7.99	7.88	8.22	8.13
11	TPHOS	0.12	0.05	0.36	0.03	0.04	0.07
12	OPHOS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13	SUS-SOLIDS	28.00	11.00	15.00	3.00	7.00	13.00
14	SPEC-COND	650.00	470.00	830.00	380.00	490.00	520.00
15	TURB	9.50	6.00	5.40	3.40	3.80	38.00
16	FCOL	N/A	N/A	13.00	92.00	92.00	24.00
17	FSTREP	N/A	N/A	0.00	30.00	70.00	3.00
18	N:P(SOL)	1318:1	1022:1	892:1	1620:1	1328:1	1298:1
19	N:P(TOT)	63:1	120:1	15:1	282:1	192:1	103:1
20	SECCHI	0.60	0.85	0.80	1.10	1.15	0.95
21	TEMP C	21.00	20.50	23.50	24.00	23.00	16.50
22	D O	13.60	7.50	17.10	11.90	10.90	12.60
23	FC:FS	N/A	N/A	13.00	3.10	1.30	8.00
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TABLE IV

	1	2	3	4	5	6	7
1	Station LLL-02						
2	DATE	840625	840710	840726	840807	840829	840919
3	TALKA	270.00	260.00	241.00	240.00	270.00	260.00
4	CHL-a	56.00	14.00	<1**	17.00	27.00	9.60
5	COLOR	25.00	30.00	20.00	35.00	15.00	20.00
6	NH3-N	0.08	0.11	0.11	0.07	0.04	0.03
7	NO3+NO2-N	6.90	7.20	3.00	7.00	6.50	6.20
8	TKN	0.94	1.30	0.71	0.86	1.30	0.73
9	ORG-N	0.86	1.19	0.60	0.79	1.26	0.70
10	pH	8.05	8.09	8.02	7.87	8.20	8.04
11	TPHOS	0.10	0.09	0.31	0.04	0.04	0.05
12	OPHOS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13	SUS-SOLIDS	17.00	8.00	16.00	10.00	7.00	12.00
14	SPEC-COND	590.00	500.00	530.00	390.00	460.00	530.00
15	TURB	6.00	5.80	3.70	4.40	3.40	26.00
16	FCOL	N/A	N/A	N/A	35.00	92.00	24.00
17	FSTREP	N/A	N/A	N/A	20.00	20.00	29.00
18	N:P(SOL)	1396:1	1462:1	622:1	1414:1	1308:1	1246:1
19	N:P(TOT)	78:1	94:1	12:1	196:1	195:1	139:1
20	SECCHI	0.90	0.85	1.05	1.20	1.10	1.30
21	TEMP C	22.00	20.50	23.50	24.00	22.50	15.50
22	D O	10.60	7.50	14.50	12.30	12.10	11.70
23	FC:FS	N/A	N/A	N/A	1.75	4.60	0.80
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25	**Suspect value.						
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TABLE V

	1	2	3	4	5	6	7
1	Mean: (LLL-01 + LLL - 02)						
2	DATE	840625	840710	840729	840807	840829	840919
3	TALKA	270.00	255.00	239.00	240.00	270.00	260.00
4	CHL-a	58.00	13.00	14**	16.00	27.00	18.00
5	COLOR	30.00	30.00	22.00	35.00	17.00	20.00
6	NH3-N	0.08	0.16	0.08	0.28	0.04	0.16
7	NO3+NO2-N	6.70	6.05	3.70	7.30	6.55	6.20
8	TKN	1.02	1.20	0.80	0.86	1.20	0.86
9	ORG-N	0.93	1.04	0.72	0.57	1.16	0.70
10	pH	8.04	8.01	8.00	7.87	8.21	8.08
11	TPHOS	0.11	0.07	0.33	0.03	0.04	0.06
12	OPHOS	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
13	SUS-SOLIDS	22.00	9.00	15.00	6.00	7.00	12.00
14	SPEC-COND	620.00	485.00	680.00	385.00	475.00	525.00
15	TURB	7.70	5.90	4.50	3.90	3.60	32.00
16	FCOL *	N/A	N/A	13.00	57.00	92.00	24.00
17	FSTREP *	N/A	N/A	0.00	24.00	37.00	9.00
18	N:P(SOL)	1357:1	1242:1	757:1	1517:1	1318:1	1272:1
19	N:P(TOT)	70:1	107:1	13:1	239:1	193:1	118:1
20	SECCHI	0.70	0.85	0.90	1.10	1.10	1.10
21	TEMP C	16.70	20.50	23.50	24.00	22.70	16.00
22	D O	12.10	7.50	15.80	12.10	11.50	12.10
23	FC:FS	N/A	N/A	13.00	2.40	2.50	2.70
24							
25	*Logarithmic mean.						
26	** Suspect value.						
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TABLE VI

	1	2	3	4	5	6	7
1	Percent Change: ULL - 01 vs Mean (LLL - 01 + LLL - 02)						
2	DATE	840625	840726	840726	840807	840829	840919
3	TALKA	NEG	POS	NEG	NEG	NEG	NEG
4	CHL-a	0	POS	POS	POS	POS	POS
5	COLOR	POS	NEG	POS	POS	POS	POS
6	NH3-N	NEG	NEG	NEG	NEG	NEG	POS
7	NO3+NO2-N	NEG	POS	NEG	NEG	NEG	NEG
8	TKN	POS	NEG	POS	POS	POS	POS
9	ORG-N	POS	NEG	POS	POS	POS	POS
10	pH	POS	POS	POS	POS	POS	POS
11	TPHOS	POS	NEG	POS	0	POS	POS
12	OPHOS	NEG	NEG	0	0	0	0
13	SUS-SOLIDS	POS	NEG	NEG	NEG	POS	POS
14	SPEC-COND	NEG	POS	POS	NEG	NEG	NEG
15	TURB	POS	NEG	NEG	POS	POS	POS
16	FCOL	0	0	NEG	NEG	POS	NEG
17	FSTREP	0	0	NEG	NEG	NEG	NEG
18	N:P(SOL)	POS	POS	NEG	NEG	NEG	NEG
19	N:P(TOT)	NEG	POS	NEG	NEG	NEG	NEG
20	SECCHI	0	POS	0	0	0	0
21	TEMP C	POS	NEG	POS	POS	POS	POS
22	D O	POS	0	POS	NEG	POS	POS
23							
24							
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