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Cayuga Lake Water Quality Monitoring, Related to the LSC Facility: 2000

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1. Objective/Study Area

The primary objective is to conduct an ambient water quality monitoring program focusing on the southern portion of Cayuga Lake to support long-term records of trophic state indicators, including concentrations of phosphorus and chlorophyll, and Secchi disc transparency, and other measures of water quality.

Cayuga Lake is the second largest of the Finger Lakes. A comprehensive limnological description of the lake has been presented by Oglesby (1979). The lake is monomictic (stratifies in summer), mesotrophic (intermediate level of biological productivity), and is a hardwater alkaline system. Much of the tributary inflow received by the lake enters at the southern end; e.g., ~ 40% is contributed by the combination of Fall Creek and Cayuga Inlet (Figure 1). Effluent from two domestic wastewater treatment (WWT) facilities also enters this portion of the lake (Figure 1). The discharge from Cornell's LSC facility enters the southern portion (e.g., south of McKinney's Point) of the lake along the east shore (Figure 1). The LSC facility started operating in early July of 2000.

2. Design

2.1. Description of Parameters Selected for Monitoring

2.1.1. Phosphorus (P)

Phosphorus (P) plays a critical role in supporting plant growth. Phosphorus has long been recognized as the most critical nutrient controlling phytoplankton (microscopic plants of the open waters) growth in most lakes in the north temperate zone. Degradation in water quality has been widely documented for lakes that have received excessively high inputs of P from man's activities. Increases in P inputs often cause increased growth of phytoplankton in lakes. Occurrences of particularly high concentrations of phytoplankton are described as "blooms". The accelerated "aging" of lakes associated with inputs of P from man's activities has been described as cultural eutrophication.

The three forms of P measured in this monitoring program, total P (TP), total dissolved P (TDP), and soluble reactive P (SRP), are routinely measured in many limnological and water quality programs. TP is widely used as an indicator of trophic state (level of plant production). TDP and SRP are measured on filtered (0.45 µm) samples. Most TDP is assumed to be ultimately available to support phytoplankton growth. SRP is a component of TDP that is usually assumed to be immediately available to support phytoplankton growth. Particulate P (PP; incorporated in, or attached to, particles) is calculated as the difference between paired measurements of TP and TDP. The composition of PP can vary greatly in time for a particular lake, and between different lakes. Contributing components include phytoplankton and other P-bearing particles that may be resuspended from the bottom or received from stream/river inputs.

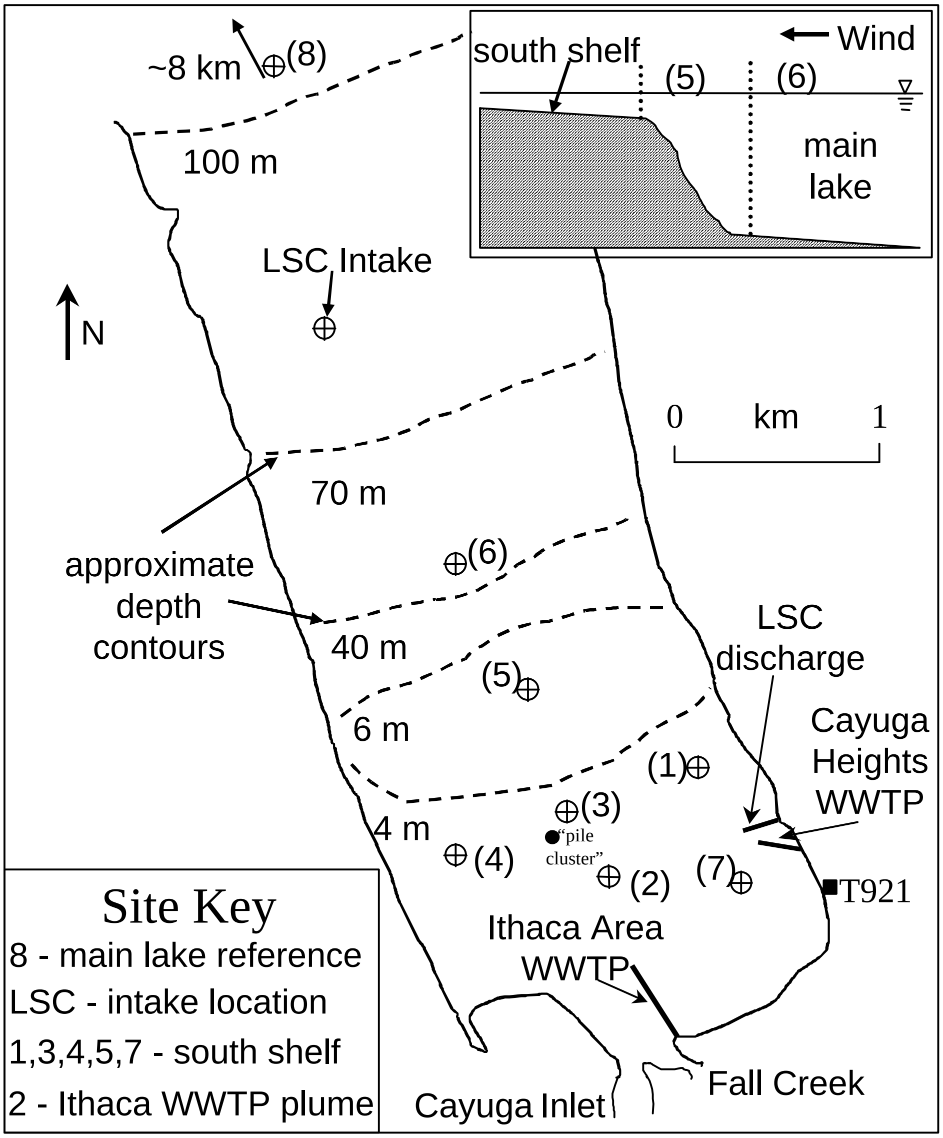

Figure 1a. Sampling sites, setting, approximate bathymetry, for LSC monitoring program, southern end of Cayuga Lake.

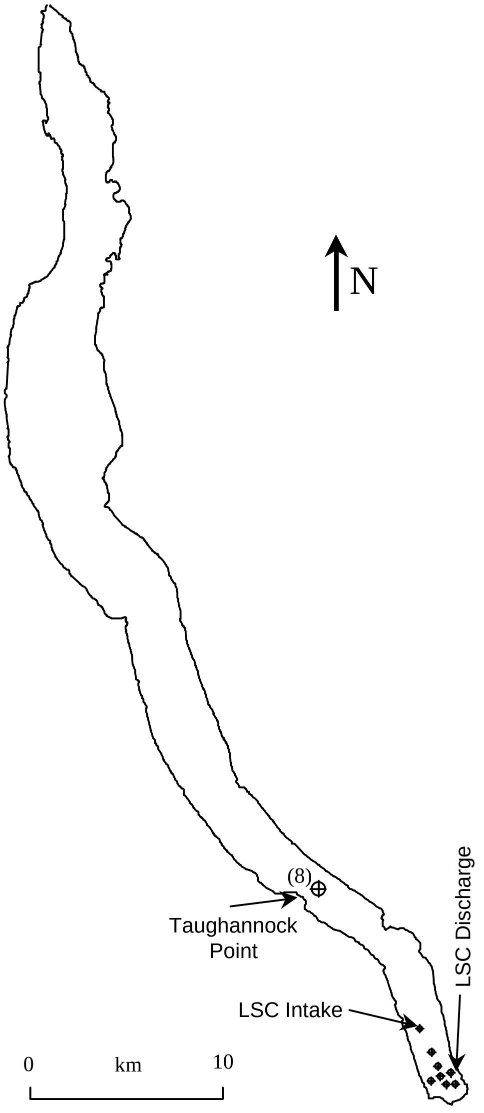

Figure 1b. Sampling sites for LSC monitoring program, within the context of the entire Cayuga Lake basin.

2.1.2. Nitrogen (N)

Nitrogen exists in a number of different forms in lakes. Two forms of N are important to plant nutrition, ammonium ion (NH_4^+) and nitrate (NO_3^-). Ammonium is preferred over nitrate because it is more easily assimilated. For that reason ammonium is frequently depleted to levels below detection limits of common analytical procedures. Nitrogen is probably the second most critical nutrient controlling phytoplankton growth. Nitrogen becomes the limiting nutrient seasonally in a number of lakes. The development of N-limiting conditions is usually considered undesirable, as it can promote proliferation of a group of phytoplankton that is capable of obtaining ("fixing") N from the atmosphere to augment or meet their N requirements. This group of phytoplankton (N-fixing filamentous blue-green algae/cyanobacteria) is generally considered undesirable because they may cause nuisance conditions, such as floating scums.

The three forms of N measured in this program, total dissolved N (TDN), total ammonia (T-NH_3), and total oxidized N (NO_x), are routinely measured in many limnological and water quality programs. These forms are monitored here to stay apprised of the availability of N to phytoplankton, and the major components of dissolved N in the system. Total ammonia includes ammonium (NH_4^+) and free (or un-ionized; NH_3) ammonia. Ammonium is the dominant component at the pH values common to Cayuga Lake. Two components contribute to NO_x, NO_3^-, and nitrite (NO_2^-). The dominant component, by a wide margin, is NO_3^-, as NO_2^- is almost always present in low concentrations due to its highly reactive character. The difference between TDN and the sum of T-NH_3 and NO_x is an estimate of the concentration of dissolved organic N (DON). Biochemical processes can cause the conversion of DON to T-NH_3, and T-NH_3 to NO_x.

2.1.3. Chloride (Cl^-)/Specific Conductance

Chloride (Cl^-) behaves in a conservative manner in freshwaters. In other words, it is not taken up or produced as part of chemical and biochemical processes that occur in lakes. For that reason, it is commonly incorporated in monitoring programs as a **tracer**. In lakes, where there are distinct differences in Cl^- concentrations in inflows or discharges, routine measurements may serve to identify the contribution(s) of various inputs, and even the movement of these inputs within the lake. Measurements of Cl^- are included in this program for these reasons.

Specific conductance is an aggregate measure of the summed ionic content of water. This parameter is also used as a tracer, though it does not meet the conservative assumption as well as Cl^-. This parameter is measured in the field.

2.1.4. Clarity/Optical Properties

The extent of the penetration of light in water (e.g., ability to see submerged objects), described as clarity, is closely coupled to the public's perception of water quality. Light penetration is particularly sensitive to the concentration, composition and size of particles. In lakes where phytoplankton are the dominant component of the particle population, measures of clarity may be closely correlated to concentrations of TP and phytoplankton biomass (e.g., as measured by chlorophyll). Clarity is relatively insensitive to phytoplankton biomass when and where concentrations of other types of particles are high. In general, light penetration is low when concentrations of phytoplankton, or other particles, are high.

Two measures of light penetration are made routinely in this program, Secchi disc transparency (in the field) and turbidity (laboratory). The Secchi disc measurement has a particularly long history in limnological studies, and has proven to be a rather powerful piece of information, even within the context of modern optical measurements. It remains the most broadly used measure of light penetration. The higher the Secchi disc measurement the greater the extent of light penetration. Turbidity, as measured with a nephelometric turbidimeter, measures the light captured from a standardized source after passage through a water sample. Turbidity and Secchi disc depth are regulated by a heterogeneous population of suspended particles that include not only phytoplankton, but also clay, silt, and other finely divided organic and inorganic matter. The higher the turbidity value the higher the concentration of particles that limit light penetration.

Two other optical measurements are made as part of this program, irradiance and beam attenuation. These parameters are included to augment the information concerning light penetration. Depth profiles of irradiance are collected to determine the attenuation (or extinction) coefficient, another measure of light penetration.

2.1.5. Chlorophyll/Fluorescence

Chlorophyll **a** is the principal photosynthetic pigment that is common to all phytoplankton. Chlorophyll (usually as chlorophyll **a**) is the most widely used surrogate measure of phytoplankton biomass, and is generally considered to be the most direct and reliable measure of trophic state. Increases in chlorophyll concentrations indicate increased phytoplankton production. The major advantages of chlorophyll as a measure of phytoplankton biomass are: (1) the measurement is relatively simple and direct, (2) it integrates different types and ages of phytoplankton, (3) it accounts to some extent for viability of the phytoplankton, and (4) it is quantitatively coupled to optical properties that may influence clarity. However, the chlorophyll measurement does not resolve phytoplankton type, and the chlorophyll content per unit biomass can vary according to species and ambient environmental conditions. Therefore, it is an imperfect measure of phytoplankton biomass. Fluorescence has been widely used as a surrogate measure of chlorophyll. Fluorescence measurements are made in the field in this program.

Rather wide variations in chlorophyll concentrations can occur seasonally, particularly in productive lakes. The details of the timing of these variations, including the occurrence of blooms, often differ year-to-year. Seasonal changes in phytoplankton biomass reflect imbalance between growth and loss processes. Factors influencing growth include nutrient availability (concentrations), temperature and light. Phytoplankton are removed from the lake either by settling, consumption by small animals (e.g., zooplankton), natural death, or exiting the basin. During intervals of increases in phytoplankton, the rate of growth exceeds the summed rates of the various loss processes.

2.1.6. Temperature

Temperature is a primary regulator of important physical, chemical, and biochemical processes in lakes. It is perhaps the most fundamental parameter in lake monitoring programs. Lakes in the northeast go through major temperature transformations linked primarily to changes in air temperature and incident light. Important cycles in aquatic life and biochemical processes are linked to the annual temperature cycle. Deep lakes stratify in summer in this region, with the warmer less dense water in the upper layers (epilimnion) and the colder more dense water in the lower layers (hypolimnion). A rather strong temperature/density gradient in intermediate depths between the epilimnion and hypolimnion (metalimnion) limits cycling of materials from the hypolimnion to the epilimnion during summer. Gradients in temperature are largely absent over the late fall to spring interval, allowing active mixing throughout the watercolumn (e.g., turnover).

2.2. Timing

Lake sampling and field measurements were conducted by boat during the spring to fall interval of 2000, beginning in April and extending through early November. The full suite of laboratory and field measurements was made for 16 bi-weekly monitoring trips. The bi-weekly monitoring program was augmented with an additional 8 sampling trips conducted during the May – August interval, a period bracketing start-up of the LSC facility. Measurements made for the additional monitoring trips included total phosphorus (TP), Chlorophyll **a** (Chl), Secchi disc transparency (SD) and turbidity (T_n). The additional samplings resulted in weekly sampling for a 17-week interval bounding start-up of the LSC facility. Additionally, recording thermistors were deployed continuously at one location; temperature measurements were made hourly over the April – October interval. The thermistors were exchanged biweekly with fresh units for data downloading and maintenance. Deployments made in November (2000) will be retrieved in April (2001). Measurements will be recorded on a daily basis over this later interval. Laboratory measurements of phosphorus concentration, T_n, dissolved oxygen concentration (DO), and pH were made on samples from the LSC influent and effluent collected weekly during operation of the LSC facility.

2.3. Locations

An array of sampling sites (e.g., grid) has been adopted that provides a robust representation of the southern portion of the lake (Figure 1). This sampling grid may reasonably be expected to resolve persistent water quality gradients that may be imparted by the various inputs/inflows that enter this portion of the lake. Further, inclusion of these sites is expected to contribute to fair representation of average conditions for this portion of the lake.

Seven sites were monitored for the full suite of parameters in the southern end of the lake (sites 1 through 7). An eighth (site 8) point was located further north as a reference for the main lake conditions. Positions (latitude, longitude) for the eight sites are specified in Table 1. The configuration of sites includes two transect lines; one with 3 sites along an east-west line extending from an area near the discharge location, the other with 4 sites running approximately along the main axis of the lake (Figure 1). Additionally, two sites (1 and 7) bound the location of sampling/monitoring sites. A reference position located at the southern end of the lake (Figure 1) was used to assess the accuracy of the GPS for each monitoring trip.

Table 1: Specification of site locations for ambient water quality monitoring (refer to Figure 1).

Site No.	Latitude	Longitude
1 (discharge boundary)	42°28.3’	76°30.5’
2	28.0’	30.8’
3	28.2’	30.9’
4	28.2’	31.4’
5	28.5’	31.1’
6	28.8’	31.3’
7 (discharge boundary)	28.0’	30.3’
8 (off Taughannock Pt.)	33.0’	35.0’
thermistor “pile cluster”	28.1’	31.0’
LSC Intake	29.4’	31.8’

2.4. Field Measurements/Seabird Profiling

Instrumentation profiles were collected in the field at 9 locations (sites 1 through 8 and the Intake; Figure 1) with a SeaBird profiler. Profiles extended from the surface to within 2m of the lake bottom, or to 20m at deeper sites, for sites, 1 through 8. Deeper profiles were obtained for the intake site. Parameters measured in the profiles and the potential utility of the information are summarized in Table 2. Additionally, dissolved oxygen was measured at site 3 each monitoring trip with a HydroLab Surveyor 3, calibrated and operated according to the manufacturer’s specifications. Secchi disc transparency was measured with a 20 cm diameter black and white quadrant disc (Wetzel and Likens 1991).

Table 2: SeaBird profiler: parameters and utility.

Parameter	Utility
Temperature	heat budget, density stratification
Conductivity	tracer, mixing patterns
Fluorescence	measure of chlorophyll
Beam attenuation	identification of particle rich layers, including benthic nepheloid layers
Irradiance Scalar Downwelling	determination of attenuation coefficients

2.5. Field Methods

Water samples were collected with a well-rinsed Van Dorn sampler or submersible pump, with depths marked on the line/hose. Care was taken that the sampling device was deployed vertically within the water column at the time of sampling. Samples for laboratory analysis (except for coliforms) for sites 1 - 8 were composite-type, formed from equal volumes of sub-samples collected at depths of 0, 2 and 4 meters. The composite-type samples avoid over-representation of the effects of temporary secondary stratification in monitored parameters. Samples (3) for coliform analysis were grab-type; collected from the surface at sites 1 and 7, and as the near-bottom sample at the intake (Figure 1). Sample bottles were stored in ice and transported to the laboratory on the same day of sampling. Chain of custody procedures were observed for all samples collected for laboratory analysis.

2.6. Laboratory Analyses, Protocols

Laboratory analyses for the selected parameters were conducted according to methods specified in Table 3. Detection limits for these analyses are also included. Most of these laboratory analyses are “Standard Methods”. The chlorophyll method is one of the most commonly used in lake studies. The acidified turbidity method has been applied by this study team for a number of hard water systems such as Cayuga Lake. Specifications adhered to for processing and preservation of samples, containers for samples, and maximum holding times before analyses, are summarized in Table 4.

2.7. Quality Assurance/Control Program

A quality assurance/control (QA/QC) program was conducted to assure that ambient lake data collected met data quality objectives for precision, accuracy, representativeness, comparability, and completeness.

Table 3: Specification of laboratory methods for ambient water quality monitoring

Analyte	Method No.	Reference	Limit of Detection
total phosphorus	4500-P	APHA (1992)	$0.6\ \mu g\cdot\ L^{-1}$
soluble reactive phosphorus	4500-P	APHA (1992)	$0.3\ \mu g\cdot\ L^{-1}$
total dissolved phosphorus	4500-P	APHA (1992)	$0.6\ \mu g\cdot\ L^{-1}$
turbidity	2130-B	APHA (1992)	-
acidified turbidity		Effler and Johnson (1987)	-
total dissolved nitrogen		Ebina et al. 1983	$0.01\ mg\cdot\ L^{-1}$
ammonia nitrogen	350.1	USEPA (1983)	$0.01\ mg\cdot\ L^{-1}$
nitrate and nitrite nitrogen	353.2	USEPA (1983)	$0.01\ mg\cdot\ L^{-1}$
chlorophyll **a**		Parsons et al. (1984)	$0.4\ \mu g\cdot\ L^{-1}$
chloride	$4500\text{-}CL^{-}$	APHA (1992)	$0.05\ mg\cdot\ L^{-1}$
fecal coliform	9222-D	APHA (1992)	-

2.7.1. Field Program

Precision of sampling and sample handling was assessed by a program of field replicates. Samples for laboratory analyses were collected in triplicate at site 1 on each sampling day. Triplicate samples were collected at one of the other eight stations each monitoring trip. This station was rotated each sampling trip through the field season. Secchi disc measurements were made in triplicate at site 1 and another site that rotated (with the triplicate sampling described above) through the field season.

Precision was high for the triplicate sampling/measurement program, as represented by the average values of the coefficient of variation for the 2000 program (Table 5). The greatest variability was associated with the chlorophyll measurement (Table 5).

2.7.2. Laboratory Program

The laboratory quality assurance/control program conducted was as specified by the Environmental Laboratory Approval Program (ELAP 1999) of the New York State Health Department. ELAP methods were used to assure precision and accuracy, completeness and comparability (ELAP 1999). The program included analyses of reference samples, matrix spikes, blind proficiency samples, and duplicate analyses. Calibration and performance evaluation of analytical methods was as specified in the ELAP program; this includes control charts of reference samples, matrix spikes, and duplicate analyses.

Table 4: Summary of processing, preservation, storage containers and holding times for laboratory measurements; see codes below.

Parameter	Processing	Preservation	Container	Holding Time
total phosphorus	a	a	1	1
soluble reactive phosphorus	a	b	1	2
total dissolved phosphorus	a	a	1	1
chlorophyll **a**	b	c	2	3
turbidity	c	b	2	2
acidified turbidity	d	b	2	2
chloride	c	d	2	1
total dissolved nitrogen	a	b	2	4
ammonia nitrogen	a	b or a	2	4
nitrate and nitrite nitrogen	a	b or a	2	4
fecal coliform	c	d	3	5

codes:

processing: a - filter with 0.45 µm cellulose acetate filter
b - filter with 0.45 µm cellulose nitrate filter
c - whole water sample
d - acidified to pH = 4.3 for 1 min.

preservation: a - H_2SO_4 to pH < 2
b - none
c - store filter frozen until analysis
d - none sample kept at < 4° C, and in the dark

container: 1 - 250 ml acid washed borosilicate boston round
2 - 4L polypropylene container
3 - sterilized, glass or plastic

holding time: 1 - 28 days
2 - 24 hours
3. - 200 days
4 - unpreserved 48 hours, preserved 28 days
5 - 30 hours

Table 5: Precision for triplicate sampling/measurement program for key parameters for 2000, represented by the average coefficient of variation.

Parameter	Site 1	Rotating Site*
total phosphorus	0.06	0.08
chlorophyll **a**	0.12	0.08
nitrate plus nitrite	0.04	0.02
Secchi disc	< 0.01	< 0.01

* average of Sites 2, 3, 4, 5, 6, 7, 8, LSC

3. Results, 2000

The measurements made in the 2000 monitoring program are presented in two formats here: (1) in tabular form (Table 6) as selected summary statistics for each site, and (2) as time plots (Figure 2) for selected sites and site groupings. Detailed listings of data are presented in Appendix I. LSC Discharge Monitoring Report Data are presented in Appendix 2. The adopted summary statistics include the mean, the range of observations, and the coefficient of variation (CV = standard deviation/mean; Table 6). Additionally, the individual observations for coliforms are presented (Table 6). The plots present three time series; these include (except for Secchi disc) one for site 2, another for site 8, and the third is an “average” of sites intended to represent overall conditions in the southern portion of the lake. This southern portion is designated as the “shelf”, as depths are less than 6 m. The “average” for the shelf is the mean of observations for sites 3, 4, 5, and the average of sites 1 and 7 (together to represent conditions in the eastern portion of the study area; see Figure 1). Observations for site 6 are not included in this averaging because this location, while proximate, is in deeper water (> 40 m; i.e., off the shelf). Measurements at site 8 are presented separately in these plots to reflect lake-wide (or the main lake) conditions. Observations for site 2 are separated from the other sites of the southern end because the results indicate this location is at times within the discharge plume of the Ithaca WWTP. On several occasions concentrations of forms of phosphorus (TP, TDP, and SRP) and nitrogen (TDN and T-NH_3) were much higher at site 2 than at any other location (Table 6, Figure 2), consistent with the proximity to the discharge (Figure 1) enriched in these components. This site is omitted in the formation of the average for the shelf because the effect is localized, temporally irregular, and is representative of only a relatively small volume of water. Time series for site 2 appear as insets in the time plots (Figure 2) to accommodate the much greater magnitudes of some of the observations for this site, and still allow resolution of temporal structure observed for other locations. The Secchi disc plot (Figure 2h) presents observations for the deeper sites (where observations were always < bottom depth); sites 6, LSC, and 8. Time series for the LSC influent, the LSC effluent, and the shelf are presented separately (Figure 2m-r). Paired profiles of temperature, the beam attenuation coefficient (BAC), and chlorophyll fluorescence obtained at LSC on each of 12 monitoring dates in 2000 are also presented (Figure 3).

Table 6: Summary of results of monitoring program according to site, 2000.

TP (µgP· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	18.7	0.53	7.9 – 55.6
2	39.8	1.03	9.9 – 200.9
3	21.2	0.47	6.4 – 44.5
4	14.8	0.64	7.2 – 44.5
5	15.6	0.43	8.2 – 42.4
6	12.3	0.23	6.9 – 17.9
7	24.7	0.44	10.4 – 56.9
8	11.2	0.28	5.3 – 20.0
LSC	11.1	0.22	7.0 – 15.6

TDP (µgP· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	4.1	0.70	0.4 – 10.2
2	23.9	1.96	1.4 – 180.9
3	5.0	0.67	0.7 – 13.4
4	3.4	0.46	0.3 – 6.7
5	2.7	0.58	0.7 – 6.1
6	2.4	0.49	0.3 – 4.3
7	6.7	0.65	1.8 – 18.4
8	2.4	0.68	0.3 – 6.4
LSC	3.0	0.67	0.3 – 7.8

TDN (mgN· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	1.42	0.10	1.24 – 1.78
2	1.80	0.50	1.20 – 4.39
3	1.56	0.27	1.12 – 2.59
4	1.33	0.10	1.00 – 1.52
5	1.40	0.07	1.23 – 1.59
6	1.42	0.09	1.23 – 1.82
7	1.49	0.09	1.24 – 1.73
8	1.43	0.07	1.27 – 1.63
LSC	1.43	0.08	1.23 – 1.58

SRP (µgP· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	2.0	1.18	0.2 – 7.7
2	19.1	2.39	0.2 – 179.6
3	2.9	1.14	0.2 – 11.2
4	1.6	1.09	0.2 – 6.0
5	1.3	1.30	0.2 – 4.8
6	0.9	1.40	0.2 – 3.5
7	3.2	1.08	0.2 – 13.6
8	0.4	1.46	0.2 – 2.4
LSC	0.8	1.41	0.2 – 3.3

NO_X (mgN· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	1.02	0.13	0.76 – 1.21
2	1.27	0.58	0.56 – 3.72
3	1.08	0.25	0.77 – 1.08
4	0.94	0.21	0.47 – 1.27
5	1.00	0.12	0.76 – 1.17
6	1.00	0.14	0.78 – 1.21
7	1.03	0.16	0.76 – 1.43
8	1.06	0.15	0.80 – 1.40
LSC	1.08	0.16	0.80 – 1.43

T-NH$_3$ (mgN· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	0.046	1.09	0.005 – 0.173
2	0.196	1.32	0.005 – 0.808
3	0.089	1.83	0.005 – 0.671
4	0.027	0.92	0.005 – 0.102
5	0.030	0.88	0.005 – 0.091
6	0.019	0.99	0.005 – 0.077
7	0.071	0.78	0.005 – 0.204
8	0.009	0.59	0.005 – 0.018
LSC	0.014	0.72	0.005 – 0.043

Table 6 (cont.): Summary of results of monitoring program according to site.

CHL A (µg· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	5.6	0.71	1.9 – 17.1
2	4.6	0.67	0.7 – 10.8
3	4.4	0.63	1.4 – 10.3
4	3.5	0.60	1.1 – 7.5
5	4.3	0.61	1.4 – 11.7
6	4.4	0.47	1.2 – 9.7
7	5.6	0.87	1.4 – 24.1
8	4.2	0.47	1.3 – 9.4
LSC	4.5	0.60	0.7 – 11.5

T$_n$ (NTU)			
SITE	MEAN	**CV**	**RANGE**
1	3.5	1.12	0.9 – 16.1
2	6.2	1.40	0.8 – 31.6
3	4.0	1.36	0.5 – 21.2
4	3.7	2.17	0.5 – 40.5
5	4.2	2.22	0.6 – 46.8
6	1.9	0.60	0.6 – 4.6
7	4.1	1.27	0.6 – 23.9
8	1.5	0.58	0.7 – 3.7
LSC	1.5	0.47	0.6 – 3.3

Cl (mg· L^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	40.6	0.05	37.3 – 44.8
2	40.6	0.13	34.6 – 52.9
3	40.1	0.06	34.6 – 43.0
4	40.2	0.05	35.1 – 42.0
5	40.3	0.03	37.7 – 42.6
6	41.1	0.03	39.2 – 43.0
7	40.4	0.07	33.5 – 43.7
8	41.4	0.02	39.5 – 43.3
LSC	41.3	0.02	39.2 – 43.3

Temperature (°C)			
SITE	MEAN	**CV**	**RANGE**
1	15.8	0.34	5.4 – 23.4
2	15.5	0.34	6.9 – 23.3
3	15.7	0.34	5.9 – 23.2
4	15.3	0.38	5.7 – 23.3
5	15.6	0.37	5.5 – 23.4
6	15.6	0.37	4.6 – 23.5
7	15.7	0.34	6.3 – 23.4
8	15.5	0.39	4.0 – 23.2
LSC	15.4	0.40	4.5 – 23.3

Beam Attenuation Coeff. (m^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	2.06	0.68	0.90 – 6.06
2	2.42	0.87	0.97 – 8.90
3	2.37	0.97	0.55 – 9.45
4	1.21	0.54	0.40 – 2.47
5	2.24	1.45	1.00 – 15.56
6	1.40	0.39	0.95 – 2.16
7	1.69	0.63	0.61 – 4.50
8	1.21	0.37	0.64 – 1.89
LSC	1.40	0.48	0.87 – 3.26

K_s Attenuation Coeff. (m^{-1})			
SITE	MEAN	**CV**	**RANGE**
1	0.66	0.64	0.37 – 2.24
2	1.03	1.04	0.40 – 4.46
3	0.93	1.10	0.37 – 4.27
4	0.57	0.29	0.34 – 0.85
5	0.88	1.77	0.34 – 7.09
6	0.44	0.24	0.31 – 0.66
7	0.85	0.38	0.38 – 1.43
8	0.42	0.33	0.25 – 0.78
LSC	0.38	0.26	0.30 – 0.65

Table 6 (cont.): Coliform results, 2000.

Date	**Fecal Coliform Concentrations (cfu· 100 ml^{-1})***			
2000	**Site 1**	**Site 2**	**Site 7**	**LSC, bottom**
April 6	80	200	100	2
April 20	20	-	28	4
May 11	< 2	-	2	< 2
May 18	40	-	18	8
June 1	2	-	< 2	2
June 15	6	-	2	136
June 29	20	-	10	18
July 13	< 2	-	<2	2
July 27	< 2	4	-	6
August 10	20	-	< 10	< 10
August 24	< 2	-	< 2	2
September 7	< 2	-	12	< 2
September 21	< 2	-	< 2	< 2
October 5	8	-	24	2
October 24	40	-	8	2
November 2	< 2	-	2	32

* cfu· 100 ml^{-1} – colony forming units per 100 ml

Fecal coliform standard for bathing beaches (Chapter I. State Sanitary Code, Part 6, Subpart 6-2, bathing beaches (1988):

> "The fecal coliform density from the five successive sets of samples collected daily on five different days shall not exceed a logarithmic mean of 200 per ml. When fecal coliform density of any sample exceeds 1,000 per 100 ml, consideration shall be given to closing the beach and daily samples shall immediately be collected and analyzed for fecal coliform for at least two consecutive days"

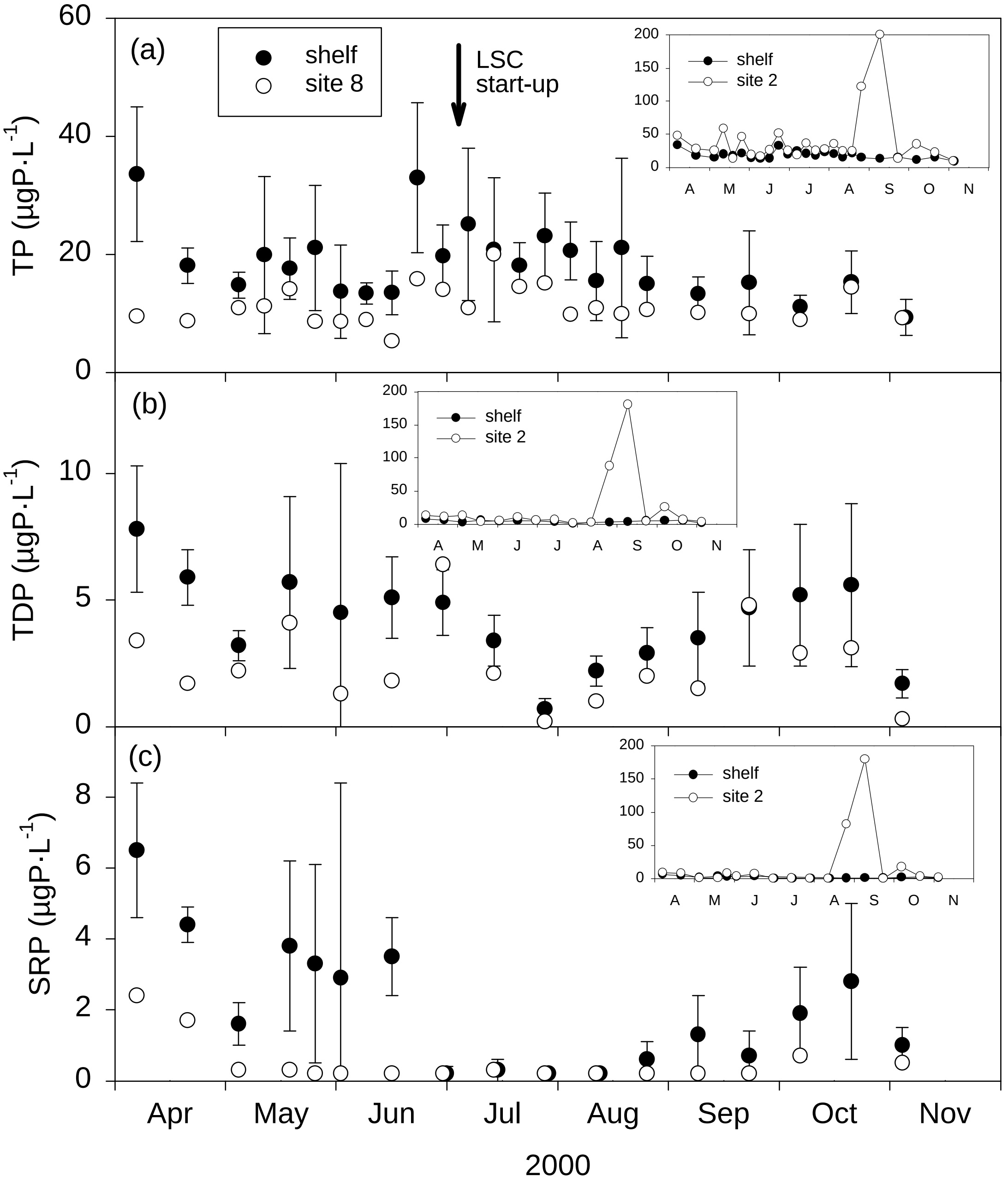

Figure 2a-c. Time-series of parameter values for Cayuga Lake for 2000: (a) TP, (b) TDP, and (c) SRP. Insets present results for site 2. Results for the "shelf" are averages; the dimensions of the bars are ± 1 standard deviation.

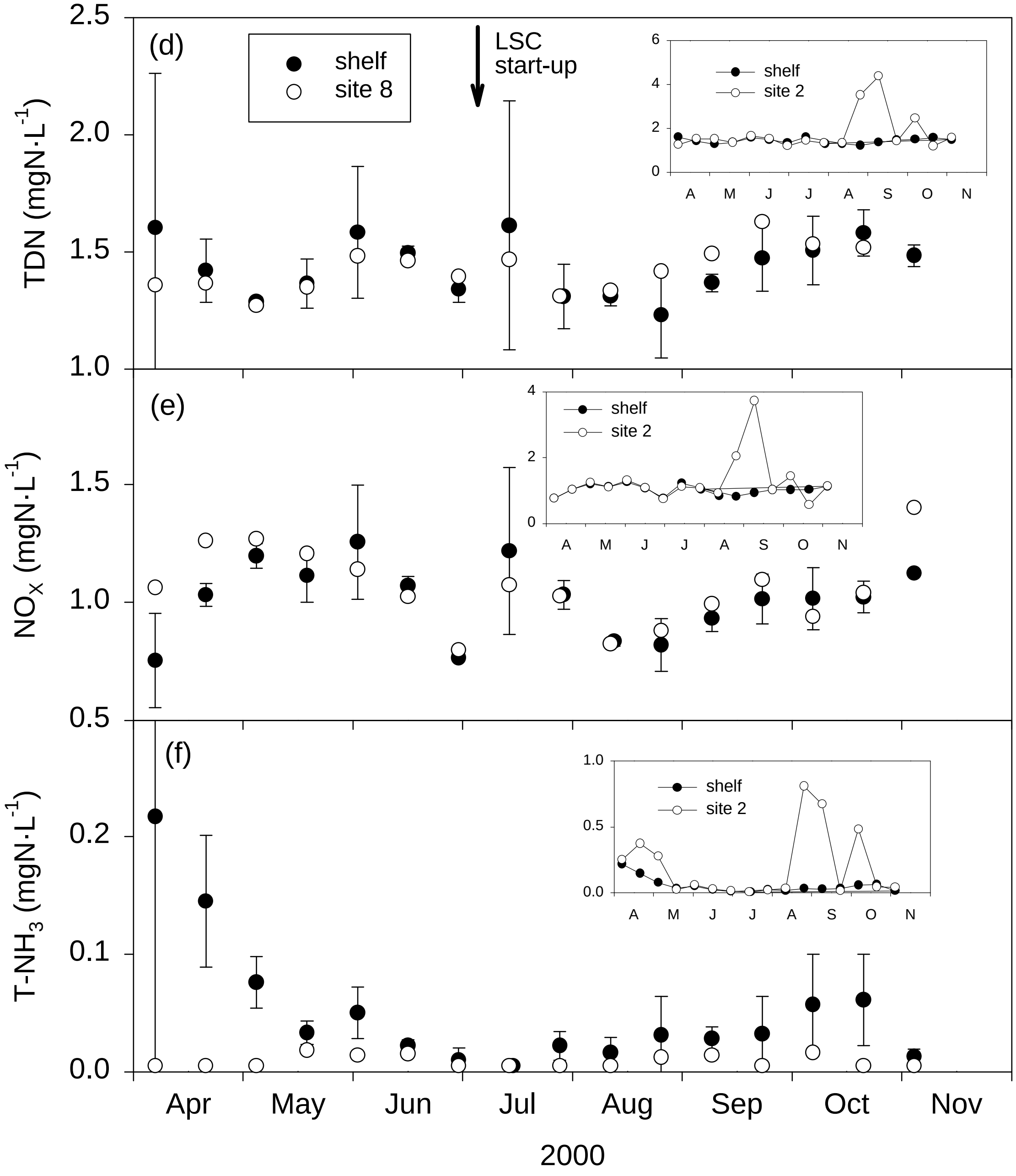

Figure 2d-f. Time-series of parameter values for Cayuga Lake for 2000: (d) TDN, (e) NO_X, and (f) $T\text{-}NH_3$. Insets present results for site 2. Results for the "shelf" are averages; the dimensions of the bars are ± 1 standard deviation.

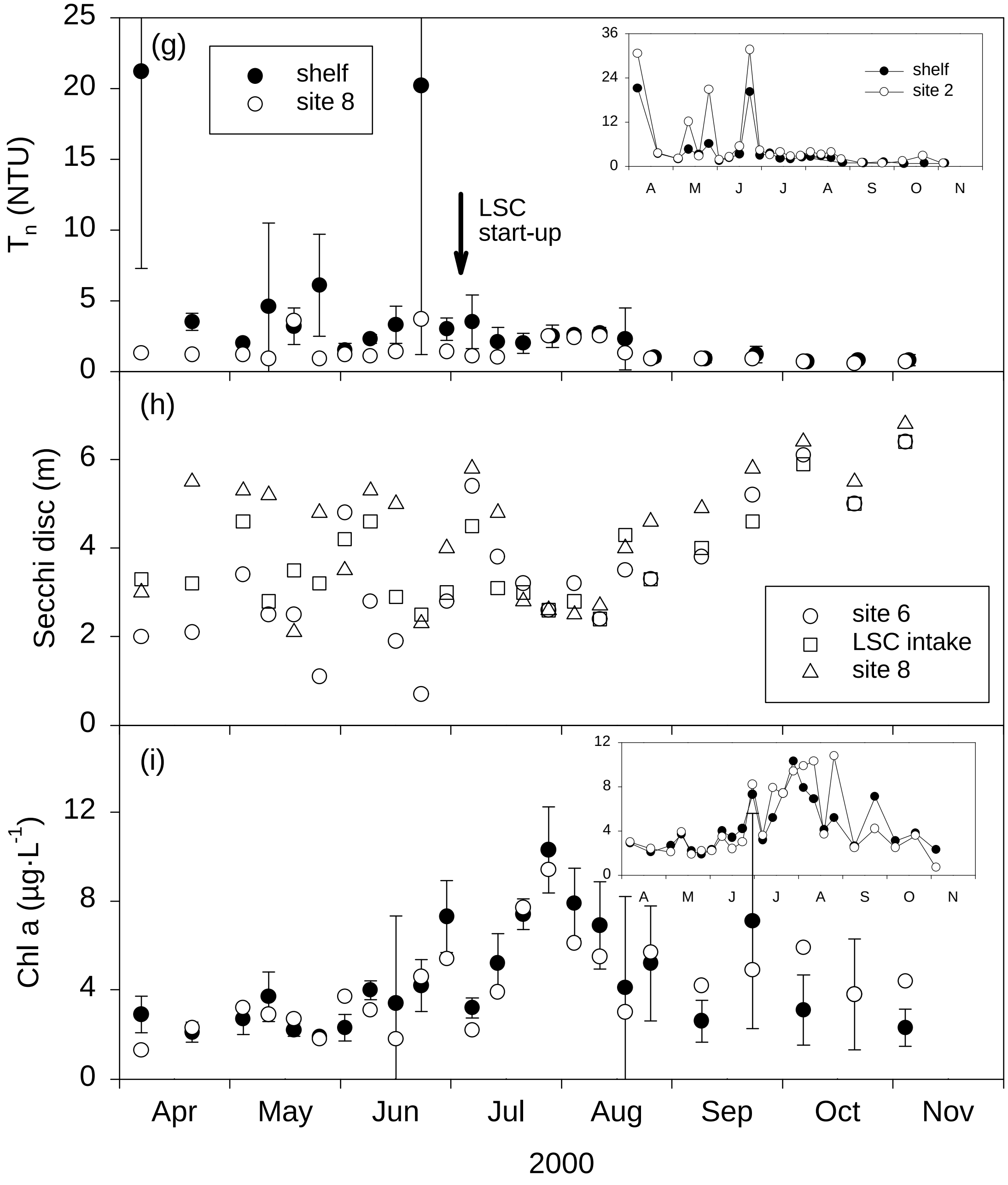

Figure 2g-i. Time-series of parameter values for Cayuga Lake for 2000: (g) T_n, (h) Secchi disc, and (i) Chl a. Insets present results for site 2. Results for the "shelf" are averages; the dimensions of the error bars are ± 1 standard deviation.

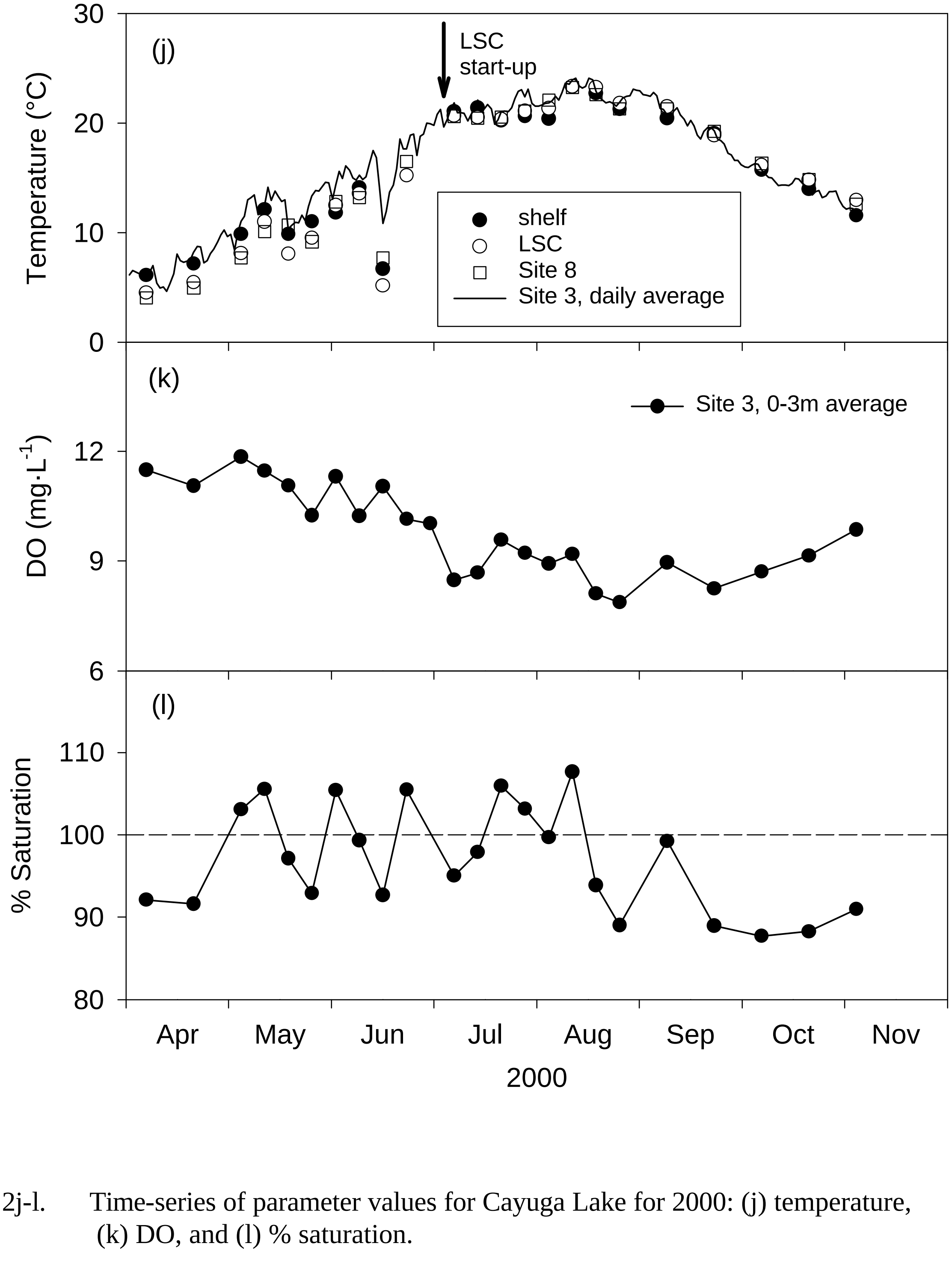

Figure 2j-l. Time-series of parameter values for Cayuga Lake for 2000: (j) temperature, (k) DO, and (l) % saturation.

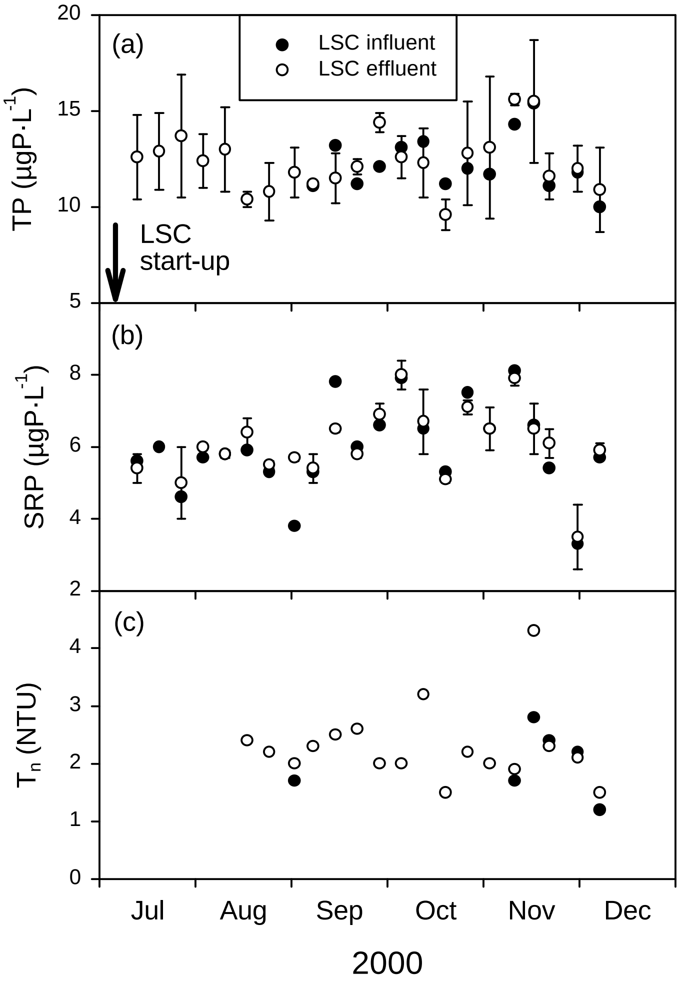

Figure 2m-o. Time series of parameter values for the LSC influent and effluent for 2000: (m) TP, (n) SRP, and (o) T_n. Error bars represent 95 % confidence intervals determined from analyses of field triplicates.

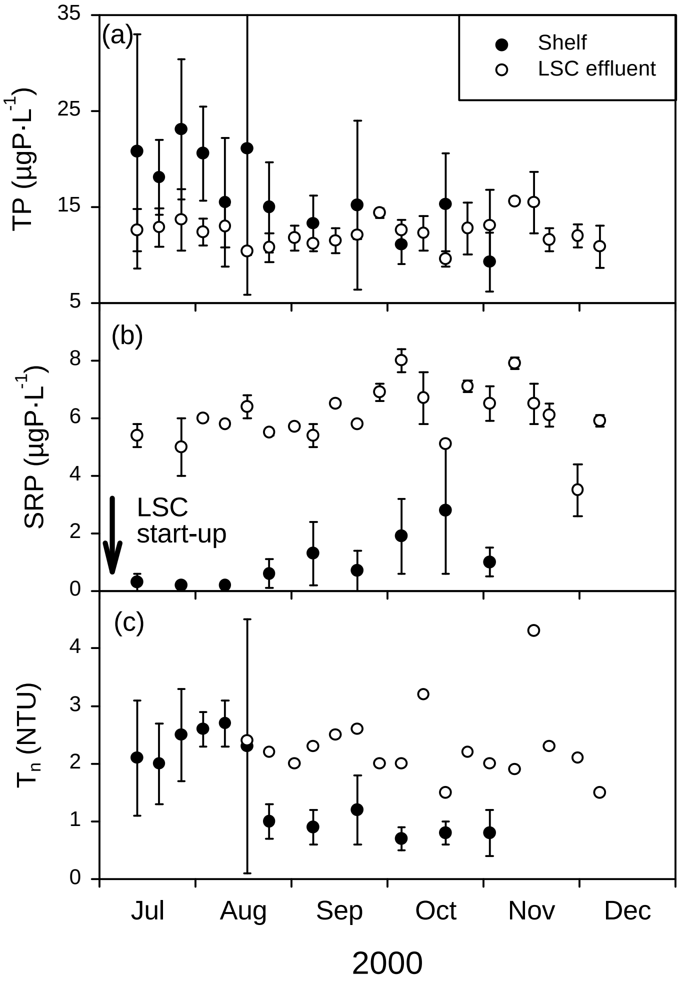

Figure 2p-r. Time series of parameter values for the south shelf and the LSC effluent for 2000: (p) TP, (q) SRP, and (r) T$_n$. Results for the "shelf" are averages; the dimensions of the error bars are ± 1 standard deviation. Error bars for the LSC effluent represent 95 % confidence intervals determined from analyses of field triplicates.

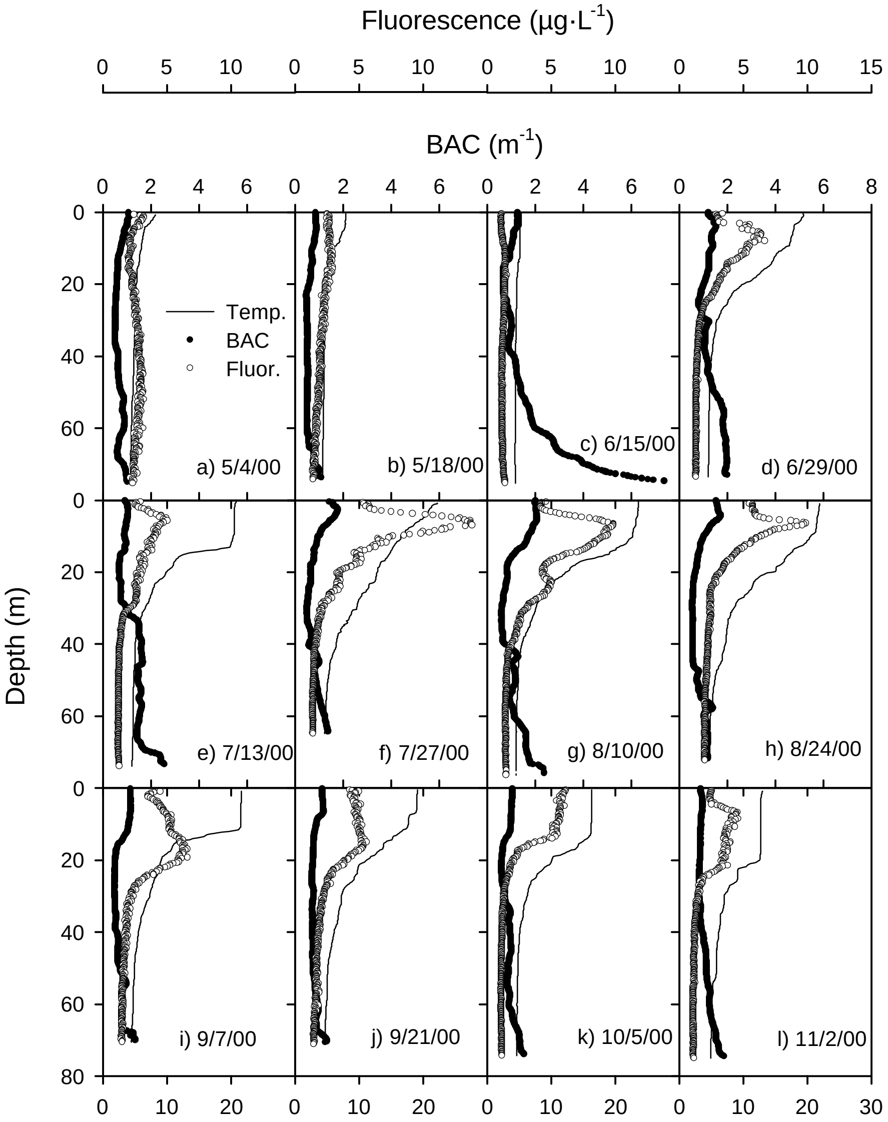

Figure 3. Vertical profiles of temperature, chlorophyll fluorescence, and beam attenuation coefficient for LSC site in 2000: (a) May 4, (b) May 18, (c) June 15, (d) June 29, (e) July 13, (f) July 27, (g) August 10, (h) August 24, (i) September 7, (j) September 21, (k) October 5, (l) November 2.

Table 7: Average values for TP, SRP, and T_n in the LSC effluent and on the shelf. Averages determined form paired measurements only.

Location	TP (µg· L^{-1}) n=12	SRP (µg· L^{-1}) n=9	T_n (NTU) n=7
LSC effluent	12.0	5.8	2.2
Shelf	16.4	1.0	1.1

4. Selected Topics

4.1. Measures of Clarity

Secchi disc is a systematically flawed measure of clarity for much of the southern portion of Cayuga Lake monitored in this program because of its shallowness. Secchi disc transparency (SD) was observed to extend beyond the lake depth at sites 1, 2, 3, 4, 5 and 7 on several occasions during the 2000 study interval. Use of the population of SD measurements available (i.e., observations of SD < lake depth) results in systematic under-representation of clarity for each of these sites by eliminating the inclusion of deeper measurements. It may be prudent to consider an alternate representation of clarity that does not have these limitations. Turbidity (T_n) represents a reasonable alternative, in systems where particles regulate clarity (Effler 1988).

The relationship between SD and T_n is evaluated in the inverse format (e.g., Effler 1988) in Figure 4. A linear relationship is expected (Effler 1988), and has been observed for the observations of 1998, 1999 and 2000 (Figure 4). Based on these results (Figure 4), T_n should be considered as an alternate, and apparently more robust, measure of light penetration in shallow portions of the monitored area. The relationship between SD and T_n will continue to be evaluated in future years of this monitoring program.

4.2. Inputs of Phosphorus to Southern End of Cayuga Lake

Phosphorus loading is an important driver of primary production in phosphorus limited lakes. It is therefore valuable to consider the relative magnitudes of the various sources of phosphorus that enter the southern end of Cayuga Lake. Monthly average loading estimates are presented for the Ithaca and Cayuga Heights wastewater treatment plants (WWTPs) for 1998, 1999 and 2000 (Table 8), based on flow and concentration data made available by these facilities. Discharge flows are measured continuously at these facilities. Concentrations of total phosphorus (TP) in the effluents are measured twice per week at the Ithaca WWTP and once per week at the Cayuga Heights WWTP. The estimates of the monthly loads (Table 8) are the product of the monthly average flows and concentrations. Other estimation techniques may result in modest differences in these loads. Rather wide monthly and interannual differences in loading rates has been observed for both WWTPs (Table 8) over the 1998 – 2000 interval (all TP observations were at or below the permit requirement of 1 mg· L^{-1}).

Estimates of monthly tributary phosphorus loading presented in the **Draft Environmental Impact Statement** for the LSC facility, for the combined inputs of Fall Creek and Cayuga Inlet, for the May – October interval are included for reference in Table 8. These were developed for what was described in that document as an “average hydrologic year on historic data for these two tributaries. Tributary loads can vary substantially year-to-year, based on natural variations in runoff. Further, the tributary phosphorus loads of Table 8 were not for TP, but rather total soluble phosphorus (see Bouldin (1975) for analytical protocols), to better represent the potential for these inputs to support plant growth.

Estimates of monthly TP loading to the shelf from the LSC facility and the percent contribution of this source during 2000 are presented in Table 8. Concentrations of TP are measured weekly at the LSC discharge. The estimates of the monthly loads (Table 8) are the product of the monthly average flows and concentrations that are reported monthly as part of the Discharge Monitoring Report (DMR; Appendix 2). The peak TP load from LSC occurred during July when it accounted for ~ 5 % of the total TP load to the shelf. Over the July – October interval, LSC contributed ~ 3 % to the total TP load, a smaller contribution than projected in the **Draft Environmental Impact Statement** for the LSC facility (Stearns and Wheler 1997).

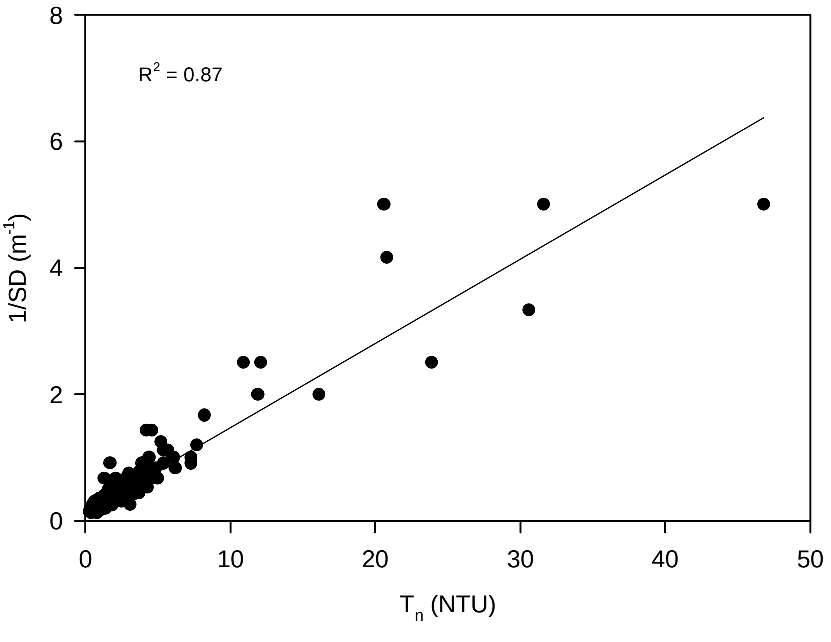

Figure 4. Relationship between Secchi disc transparency (SD) and turbidity in the southern end of Cayuga Lake based on paired observations in 1998, 1999 and 2000.

Table 8: Estimates of monthly external loads of phosphorus to the southern portion of Cayuga Lake.

Month	**Ithaca WWTP*** **(kg· d^{-1})**			**Cayuga Heights WWTP✚** **(kg· d^{-1})**			**Tributary †** **(kg· d^{-1})**	**LSC*** **(kg· d^{-1})**	**Total** **(kg· d^{-1})**	**% LSC**
	1998	**1999**	**2000**	**1998**	**1999**	**2000**		**2000**	**2000**	**2000**
May	14.1	19.7	24.1	8.7	3.7	3.5	29.0	-	56.6	-
June	5.8	9.1	16.6	7.5	4.3	5.1	15.8	-	37.5	-
July	16.4	11.4	13.7	4.4	2.6	3.4	8.8	1.4	27.3	5.1
August	17.0	12.5	19.1	4.7	1.5	4.6	6.0	1.0	30.7	3.3
September	32.8	20.0	18.5	7.7	1.8	4.0	7.5	0.9	30.9	2.9
October	16.2	9.4	15.4	9.1	1.7	4.1	13.1	0.6	33.2	1.8
Mean	*17.1*	*13.7*	*16.5*	*7.0*	*2.6*	*4.1*	*13.3*	*1.0*	*34.9*	*2.9*

* total phosphorus, from facility permit reporting

✚ total phosphorus; personal communication with Brent Cross, Village Engineer

† total soluble phosphorus, for average hydrologic year; summation of Fall Creek and Cayuga Inlet; from Draft Environmental Impact Statement, LSC Cornell University, 1997

4.3. Variations in Runoff and Wind Speed

Meteorological conditions and coupled features of runoff have important effects on lake ecosystems. These conditions are not subject to management, but in fact demonstrate wide variations in many climates that can strongly modify measures of water quality (e.g., Auer and Effler 1989, Lam et al. 1987). Thus the effects of natural variations in these conditions can be mistaken for impacts of man's activities (e.g., pollution). The setting of the southern end of the lake, including the localized entry of tributary flows and its shallowness, may promote interpretive interferences with the measurements of total phosphorus (TP), Secchi disc transparency (SD), and turbidity (T_n). These interferences are associated with potential influxes of non-phytoplankton particles that would diminish SD and increase T_n and TP concentrations, features that could be misinterpreted as reflecting increases in phytoplankton concentrations. These influxes may be associated with external loads carried by the tributaries, particularly during runoff events, and internal loads associated with sediment resuspension, driven by wind events (e.g., Bloesch 1995). Thus, it is prudent to consider natural variations in tributary flow and wind speed in evaluating seasonal and interannual differences in these parameters for the southern end of Cayuga Lake.

Runoff and wind conditions for the study period of 2000 are represented here by daily average flows measured in Fall Creek by USGS, and daily average wind speed, out of the north to northwest, measured by Cornell University (Figure 5). These conditions are placed in a historic perspective by comparison to available records. The record for Fall Creek is quite long, about 75 years; the wind database reflects 17 years of measurements. Daily measurements of Fall Creek flow and wind speed for 2000 are compared to time-series of daily median values for the available records (Figure 5a and c). Additionally, monthly average flows for the study period are compared to quartiles for the period of record (Figure 5b). Due to the orientation of the southern end of Cayuga Lake, winds out of the north to northwest (315° - 360°) are expected to drive the greatest turbulence, and thus resuspension, in this part of the lake.

Fall Creek flows were high compared to long-term median values for much of the April – July 2000 interval (Figure 5a). Significant runoff events were common during this period, and coincided with sampling days during April, May and June (Figure 5a). Monthly average flows remained above the 75-percentile level from May through July (Figure 5b). Monthly average flows were near the long-term average for August and September, and slightly elevated in October (Figure 5b). The unusually high flows observed during the April – July interval of 2000 approach an extreme in climatic forcing conditions.

Major wind events (e.g., protracted intervals of high winds) did not occur over the study interval of 2000 (Figure 5c). However, winds were above average for extended periods during May, early June, early July, mid-August, and October (Figure 5c). Wind velocities were distinctly above average on, or before, the monitoring days of June 1, July 20, and August 17 (Figure 5c).

4.4 Limitations in Measures of Trophic State on the Shelf

Circumstantial scientific evidence, provided by the findings for 2000 (Figure 2), indicates that T_n and TP are systematically flawed indicators of the trophic state on the shelf. In particular, substantial variations and increases in both parameters on the south shelf appear to be uncoupled at times from patterns and magnitudes of phytoplankton biomass. These features appear to be associated with greater contributions of non-phytoplankton particles (e.g. clay and silt) to the measures of TP and T_n on the south shelf. There are at least four lines of circumstantial evidence supporting this position, based on the 2000 observations.

1. the highest T_n (Figure 2g) values reported over the study interval on the shelf were observed after major runoff events of early April, late May, and late June (Figure 5a). This suggests greater contributions of non-phytoplankton particles received in runoff to the measurements of T_n.

2. high T_n (Figure 2g) values were reported at the deep water sites during the "whiting" event of late July and early August. These increases in T_n were driven largely by increases in T_c (calcium carbonate turbidity; Figure 6). This "whiting" event was similar in both magnitude and timing to a "whiting" observed during late July of 1999.

3. the ratio of particulate P (PP) to chlorophyll **a** was often substantially higher on the south shelf than at the deep stations (Figure 7) suggesting greater contributions of non-phytoplankton particles to the PP pool at the southern end of the lake. Further, unlike the deep sites, the ratio was often above the range of values commonly associated with phytoplankton biomass (e.g., Bowie et al. 1985).

4. application of reasonable literature values of light scattering (e.g., T_n) per unit chlorophyll (e.g., Weidemann and Bannister 1986) to the chlorophyll **a** observations indicate that non-phytoplankton particles made greater contributions to T_n on the shelf than in deep waters (Figure 8).

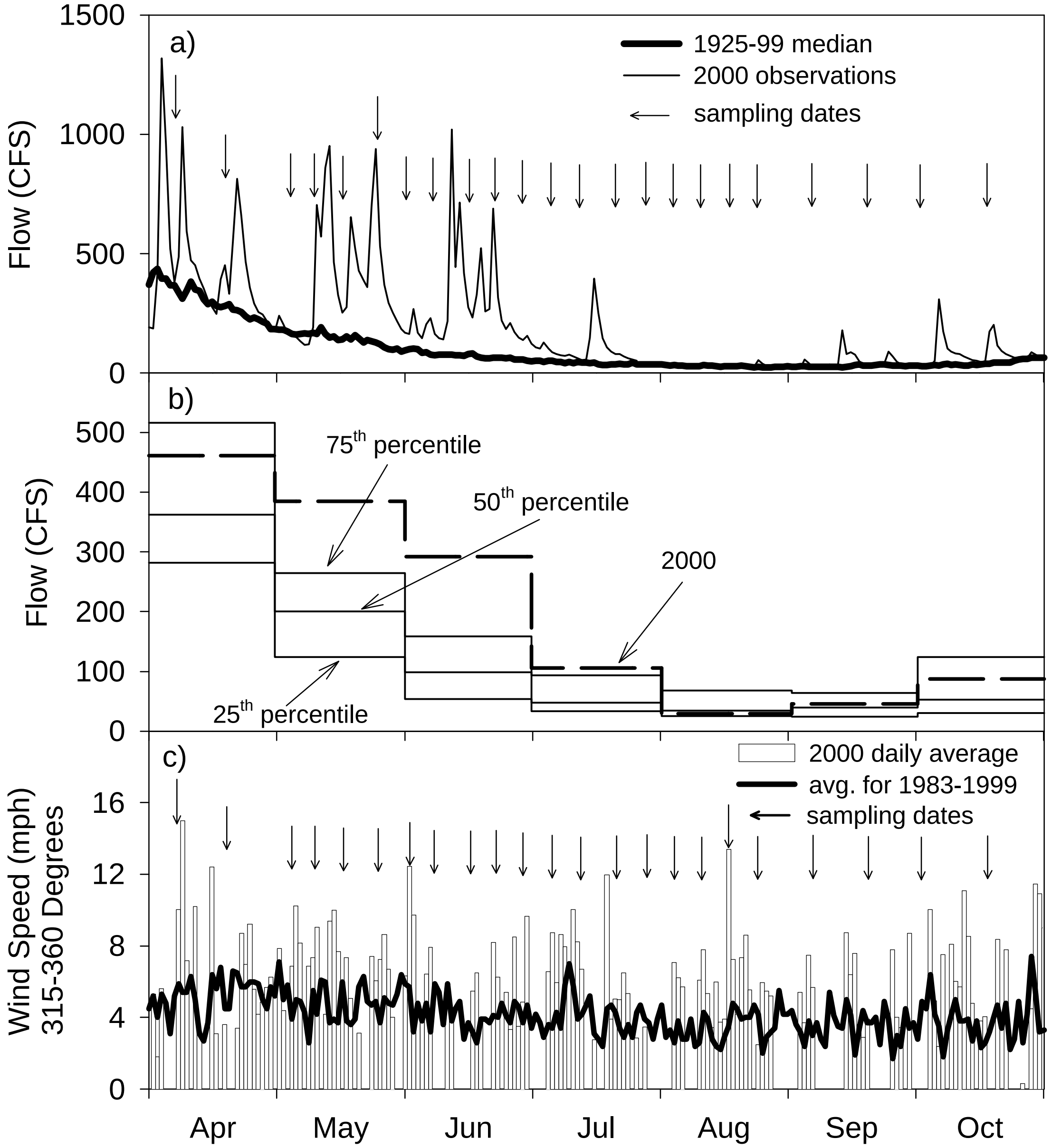

Figure 5. Runoff and wind conditions for the April – October interval of 2000: (a) daily average flows in Fall Creek compared to median daily values for the 1925 – 1999 record, (b) monthly flows in 2000 compared to quartile levels of flow for the 1925 – 1999 record, and (c) daily average wind speed.

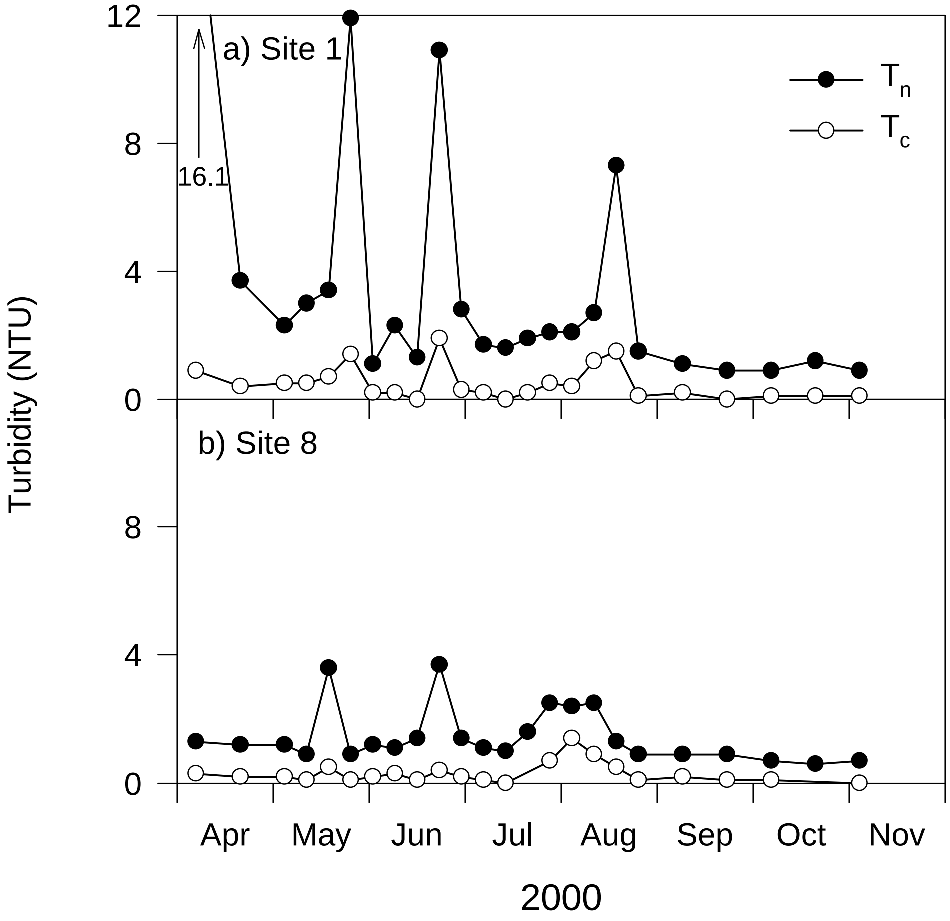

Figure 6. Distributions of total turbidity (T_n) and calcium carbonate turbidity (T_c) in the upper waters of Cayuga Lake in 2000: (a) site 1, (b) site 8.

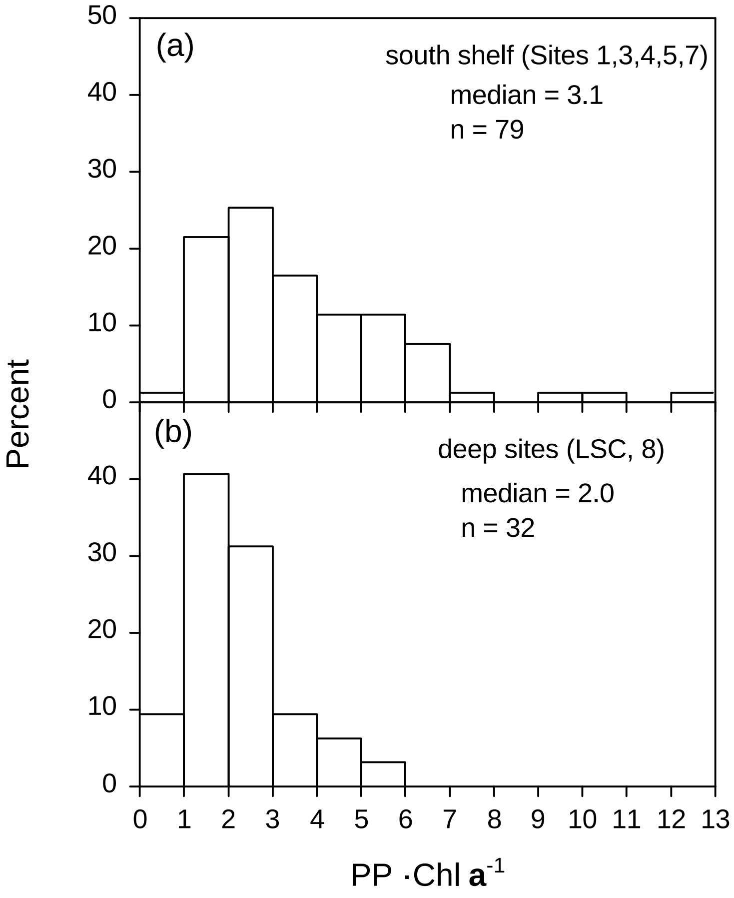

Figure 7. Distributions of the particulate P (PP) to chlorophyll **a** (Chl **a**) ratio values in Cayuga Lake in 2000: (a) south shelf sites, and (b) deep water sites.

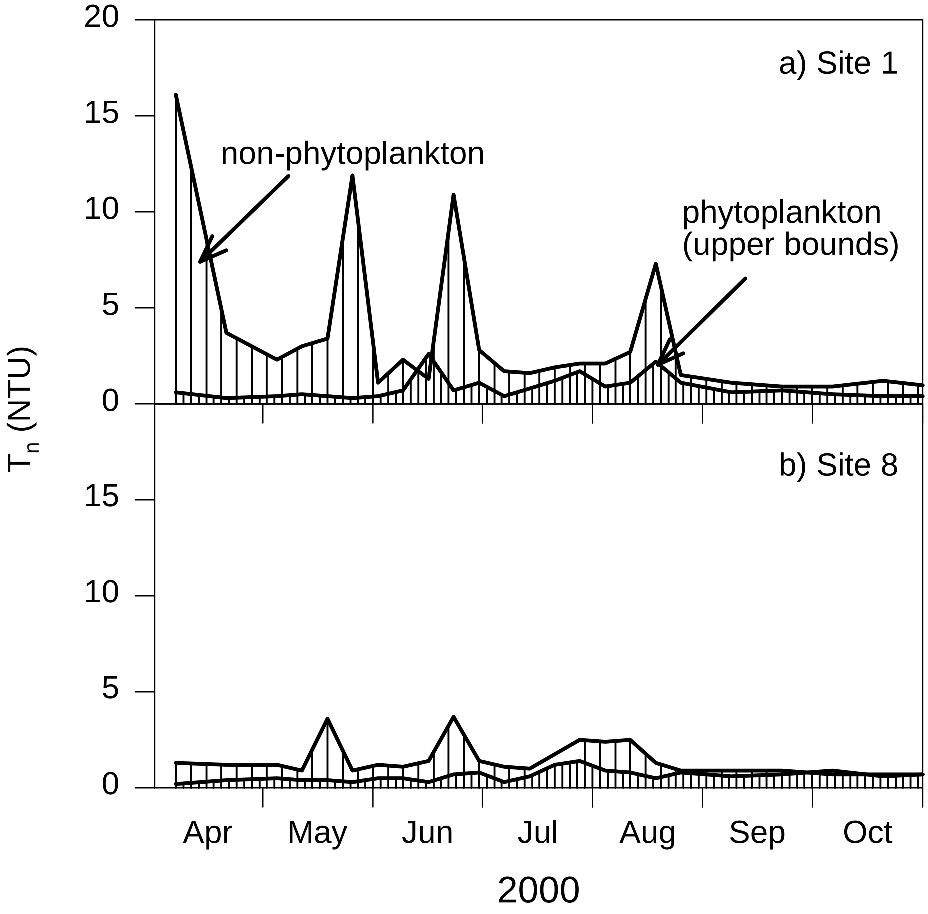

Figure 8. Time-series for the April – October interval of 2000, T_n versus the upper bound contribution of phytoplankton: (a) site 1, and (b) site 8.

The 2000 results suggest substantial seasonal differences occur for TP and T_n on the shelf that are uncoupled from the trophic state issue. Additional measurements were made in 1999, beyond the scope of the LSC monitoring program, to more comprehensively resolve the constituents/processes regulating the SD and TP measurements. The protocols adopted for these additional analyses have been described in the scientific literature (Effler et al. 1998, Auer et al. 1998). The results of this additional program of measurements will be presented in a separate report.

4.5 Continuation of the Long-Term Record of Water Quality/Eutrophication Indicators

Degradation can only be quantitatively documented if reliable measurements are available for historic conditions. Concentrations of TP and chlorophyll **a** have been measured irregularly in the open waters of Cayuga Lake over the last three decades. Measurements made over the late 1960s to mid 1970s were made mostly as part of research conducted by Cornell University staff (Tables 9 and 10). These data were collected mostly at deep water locations. No comprehensive data sets were found to represent conditions in the 1980s. Measurements were continued in the 1994 – 1996 interval as part of studies conducted to support preparation of the **Draft Environmental Impact Statement** for the LSC facility (Stearns and Wheler 1997). These included observations for both the shelf and deeper locations (Tables 9 and 10). The record will continue to be updated annually, for both a deep water location and the shelf, over the 1998 – 2002 period based on monitoring sponsored by Cornell University related to operation of the LSC facility.

Summer (June – August) average concentrations are presented for the lake's upper waters; sources of data are included (Tables 9 and 10). Higher TP concentrations were observed on the shelf compared to deeper portions of the lake in 1994, 1995, 1996, 1998, 1999 and 2000 (Table 9). Distinctly higher chlorophyll **a** concentrations were observed on the shelf in the summers of 1994 – 1996 compared to deeper water sites, however, the averages were similar over the 1998 – 2000 interval (Table 10). The 1998 average does not include June observations. Summer average concentrations of TP and chlorophyll **a** for deep water sites are consistent with a mesotrophic trophic state classification (i.e., intermediate level of primary productivity; e.g., Chapra and Dobson 1981, Dobson et al. 1974, Vollenweider 1975).

Table 9: Summer (June - August) average total phosphorus (TP) concentrations for the upper waters of Cayuga Lake.

Year	**Total Phosphorus (µg· L^{-1})**		**Source**
	Deep-Water Location(s)	**Southern Shelf**	
1968[Δ]	20.2 (n = 19)	-	Peterson 1971
1969[Δ]	15.3 (n = 22)	-	Peterson 1971
1970[Δ]	14.0 (n = 32)	-	Peterson 1971
1972[x]	18.8 (n = 22)	-	USEPA 1974
1973[Δ]	14.5 (n = 88)	-	Godfrey 1973
1994[*,⊕]	21.7	30.8	Stearns and Wheler 1997
1995[*,⊗]	16.5	23.7	Stearns and Wheler 1997
1996[*,⊗]	12.4	21.7	Stearns and Wheler 1997
1998[+]	14.7	26.5	UFI 1999
1999[++]	10.6	15.9	UFI 2000
2000[++]	11.9	19.4	this report

[Δ] Myers Point

[x] one sample, multiple sites and depths

[*] averages of 0 m observations

[+] July – August, 0 – 4 m composite samples

[++] 0 – 4 m composite samples

[⊕] site in 62 m of water, south of Myers Point, surface samples

[⊗] site in 70 m of water, south of Myers Point, surface samples

Table 10: Summer (June – August) average chlorophyll **a** (Chl **a**) concentrations for the upper waters of Cayuga Lake.

Year	Chlorophyll a (µg· L^{-1}) Deep-Water Location(s)	Chlorophyll a (µg· L^{-1}) Southern Shelf	Source
1966*	2.8	-	Hamilton 1969
1968**	4.3	-	Wright 1969
1968 – 1970	4.8	-	Oglesby 1978
1970	3.7	-	Trautmann et al. 1982
1972	10.3	-	Olgelsby 1978
1973	8.2	-	Trautmann et al. 1982
1974	8.1	-	Trautmann et al. 1982
1977	8.6	-	Trautmann et al. 1982
1978	6.5	-	Trautmann et al. 1982
1994	5.5	8.9	Stearns and Wheler 1997
1995	4.8	6.8	Stearns and Wheler 1997
1996	3.4	7.6	Stearns and Wheler 1997
1998+	4.8	5.7	UFI 1999
1999	4.7	4.4	UFI 2000
2000	4.8	5.5	this report

* Hamilton 1969, 15 dates
** Wright 1969, 4 dates – 7 to 9 longitudinal sites
\+ July – August

4.6 Comparison to Other Finger Lakes: Chlorophyll a

Synoptic surveys of all eleven Finger Lakes have been conducted in recent years (NYSDEC, with collaboration of the Upstate Freshwater Institute) that support comparison of selected conditions among these lakes. Chlorophyll **a** data (Callinan et al., 2000) collected from those surveys are reviewed here, as this may be the most representative indicator of trophic state of the measurements made. Samples (n=15 to 16) were collected in these surveys over the spring to early fall interval of 1996 through 1999. The sample site for Cayuga Lake for this program coincides approximately with site 8 of the LSC monitoring program (Figure 1b).

There is not universal agreement on the concentrations of chlorophyll **a** that demarcate trophic states. A summer average value of 2.0 µg L^{-1} has been used as the demarcation between oligotrophy and mesotrophy (Dobson et al. 1974, National Academy of Science 1972). There is less agreement for the demarcation between mesotrophy and eutrophy; the boundary summer average value reported from different sources (e.g., Dobson et al. 1974, National Academy of Science 1972, Great Lakes Group 1976) ranges from 8 to 12 µg L^{-1}.

The average chlorophyll **a** concentration for Cayuga Lake for this synoptic program (3.5 µg L^{-1}) is compared to the values measured in the other ten Finger Lakes in Figure 9. These data support Cayuga Lake's classification as mesotrophic. Six of the lakes had average concentrations lower than observed for Cayuga Lake (Figure 9). Two of the lakes, Canandaigua and Skaneateles, had concentrations consistent with oligotrophy, while two (Conesus and Honeoye) bordered on eutrophy (Figure 9).

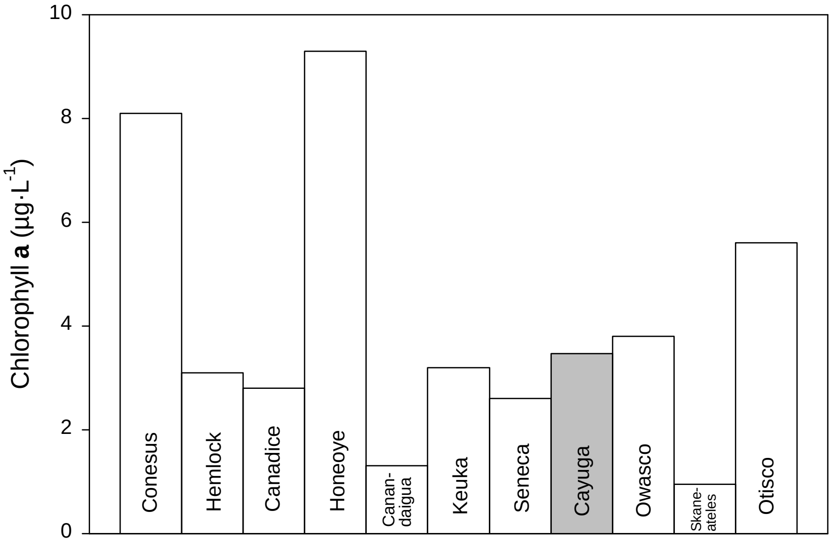

Figure 9. Comparison of average chlorophyll **a** concentrations for the spring-early fall interval for the eleven Finger Lakes, based on samples (n=15 to 16) collected over the 1996 through 1999 interval (data from Callinan et al. 2000).

4.7 Interannual Comparisons

Interannual differences in water quality can occur as a result of both human interventions and natural variations in climate. Because of its location and shallowness, water quality on the south shelf can vary substantially from year to year as a result of changes in forcing conditions. Conditions for runoff, wind speed and TP loading from the Ithaca WWTP are compared here for 1998, 1999 and 2000 (Figure 10). Daily average flows measured in Fall Creek (Figure 10a) were distinctly higher over the April – July intervals of 1998 and 2000. Major runoff events occurred throughout the April – July interval of 2000 and flows were elevated for much of this period. Flows remained low during the May – August interval of 1999; no significant runoff events occurred from late April through mid-September. Flow conditions during 1998 were similar to

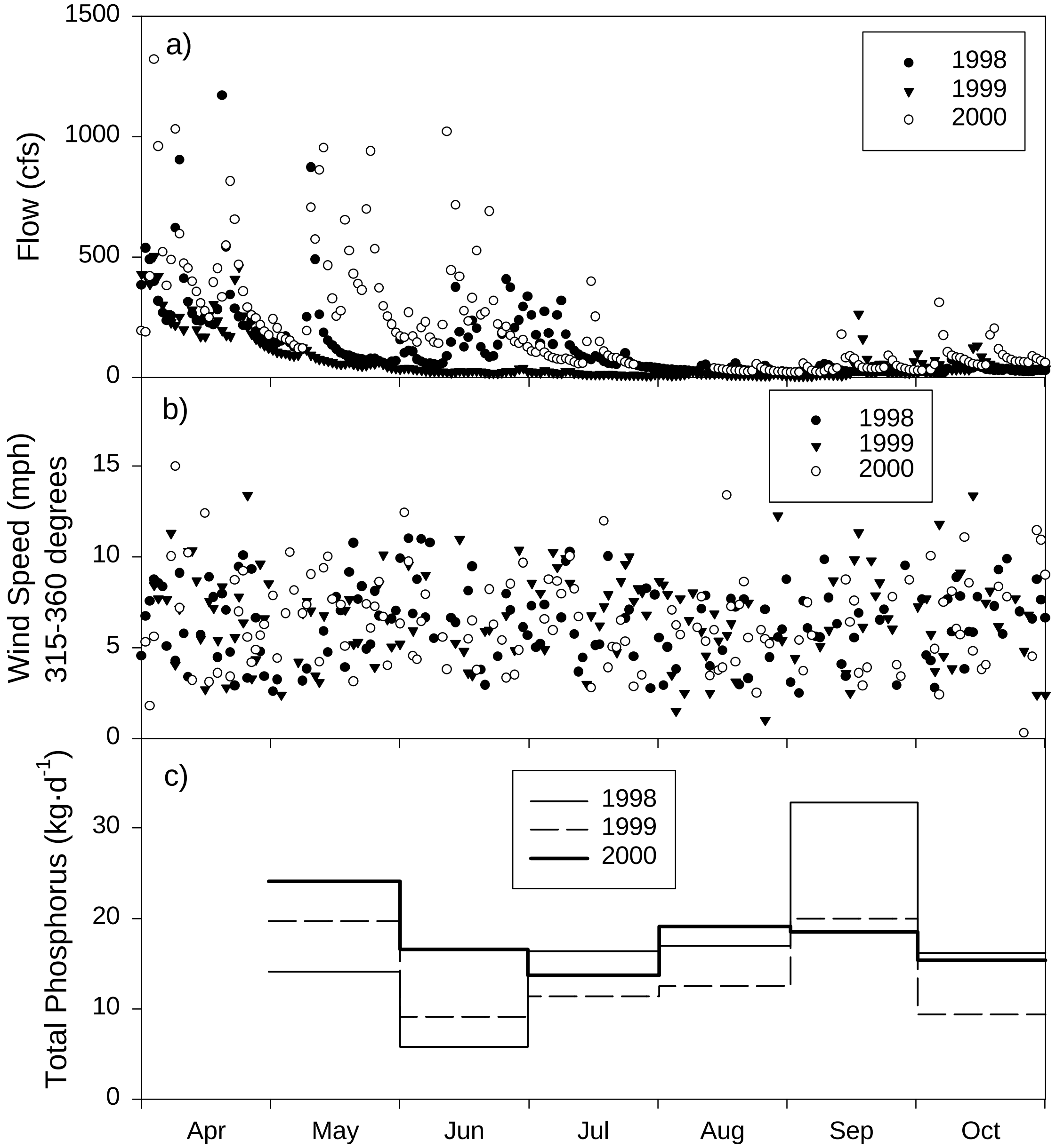

Figure 10. Comparison of 1998, 1999 and 2000 conditions for runoff, wind and total phosphorus loading for the April – October interval: a) daily average flows in Fall Creek, b) daily average wind speed, and c) monthly loads of total phosphorus from the Ithaca WWTP.

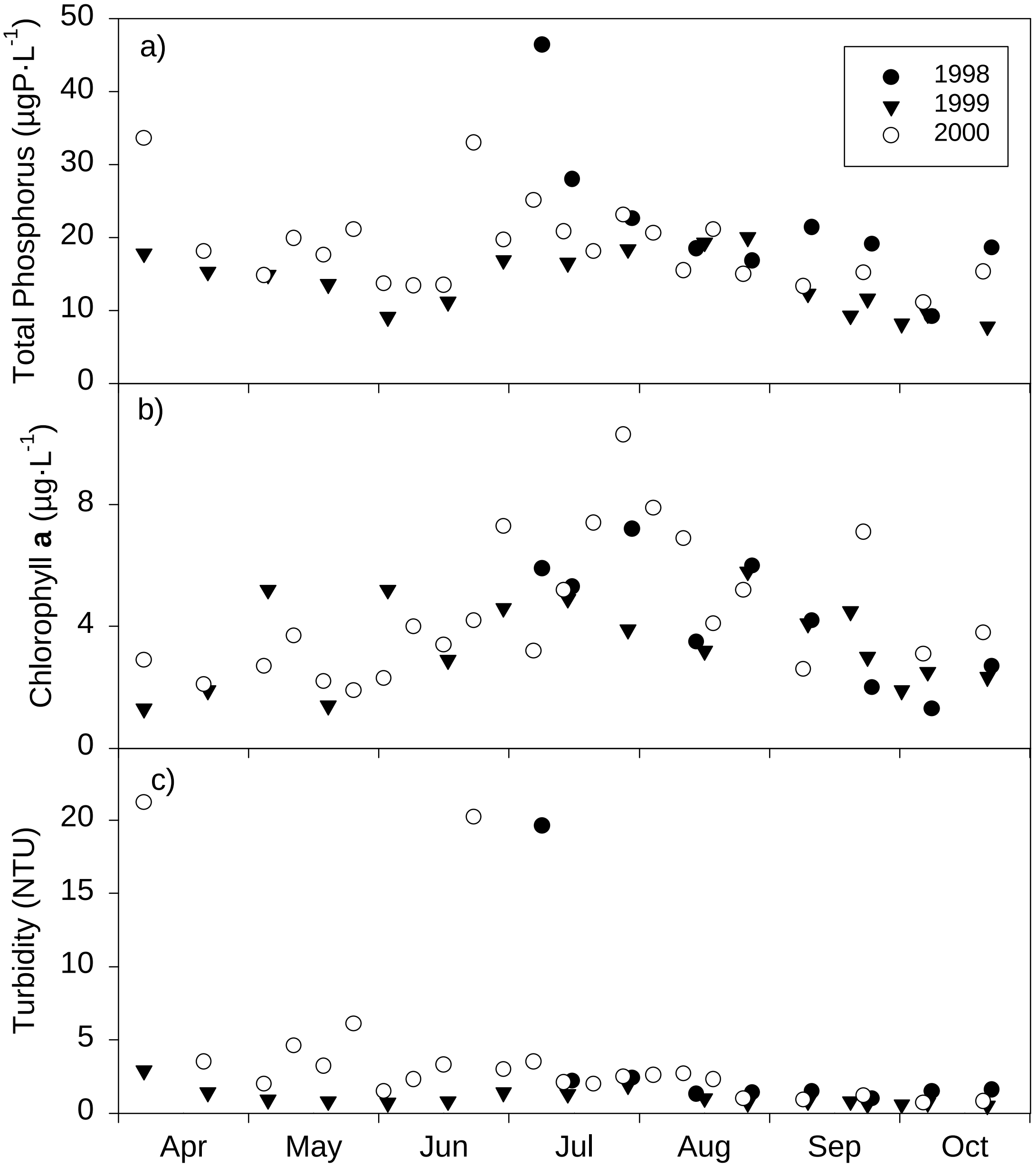

Figure 11. Comparison of 1998, 1999 and 2000 conditions for total phosphorus, chlorophyll **a**, and turbidity on the south shelf of Cayuga Lake for the April – October interval: a) total phosphorus, b) chlorophyll **a**, and c) turbidity.

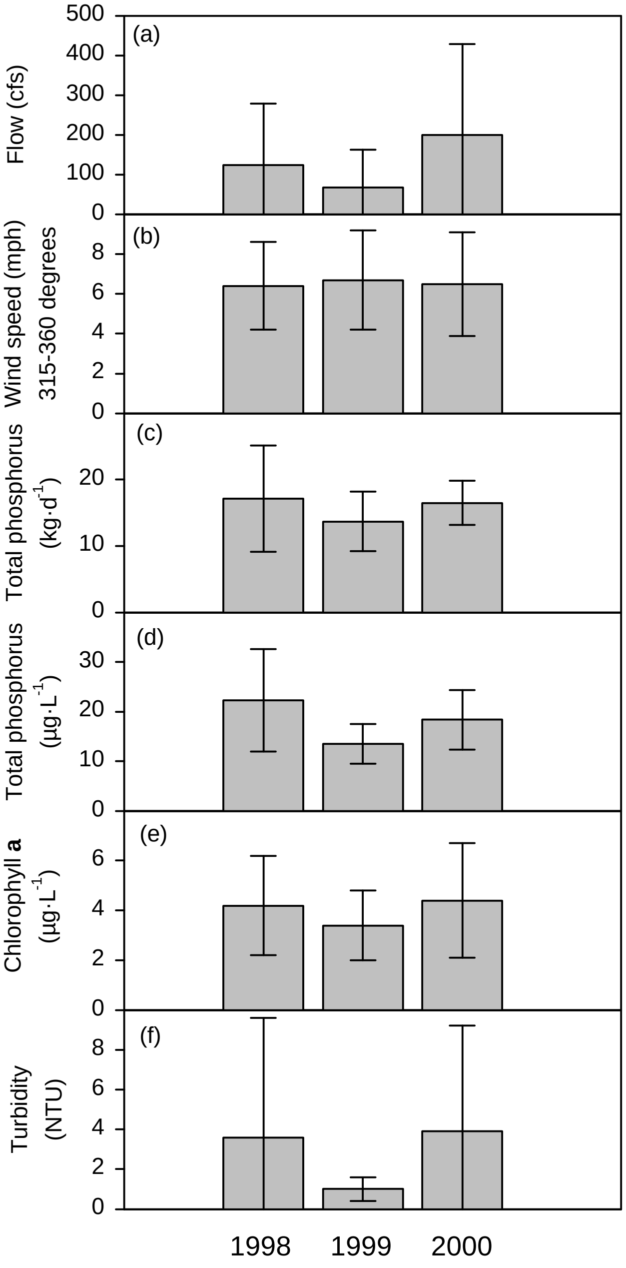

Figure 12. Comparison of 1998, 1999 and 2000 averages for runoff, wind, total phosphorus loading, total phosphorus concentration, chlorophyll **a** concentration and turbidity: a) Fall Creek flow, b) wind speed, c) loads of total phosphorus from the Ithaca WWTP, d) total phosphorus concentration on the south shelf, e) chlorophyll **a** concentration on the south shelf, and f) turbidity on the south shelf. 1998 averages for total phosphorus concentration, chlorophyll **a** concentration and turbidity are for the July – October interval; all other averages are for the April – October interval. The dimensions of the error bars are ± 1 standard deviation.

those of 2000; major runoff events occurred during April and May, and flows were elevated during much of June and July.

Daily average wind speeds, out of the north to northwest, for 1998, 1999 and 2000 are presented in Figure 10b. Wind speeds greater than 10 mph were more common in 1999 and 2000 than in 1998. Estimates of monthly average total phosphorus (TP) loads for the Ithaca WWTP are compared here for 1998, 1999 and 2000 (Figure 10c). Compared to the 1999 TP loads, the 2000 loads were greater during May, June, July, August and October and lower during September. Compared to the 1998 TP loads, the 2000 loads were greater during May, June, and August and lower during July, September and October.

Time series for TP, chlorophyll **a**, and T_n are presented for the July – October interval of 1998, and the April – October interval of 1999 and 2000 (Figure 11). Data were not collected during the April – June interval of 1998. Plotted values, the mean of observations for sites 3, 4, 5, and the average of sites 1 and 7, are intended to represent conditions on the shelf. Concentrations of TP were generally higher in 1998 and 2000 (Figure 11a). High TP concentrations (e.g., > 30 $\mu g \cdot L^{-1}$) were not observed during the1999 study interval. Chlorophyll **a** concentrations were similar during the three study years with the exception of the higher values observed during the late July – early August interval of 2000 (Figure 11b). High turbidity values were observed on sampling dates that coincided with major runoff events in early July 1998, early April 2000 and mid-June 2000 (Figure 11c). High turbidity values (e.g., > 5 NTU) were not observed during the1999 study interval.

The temporally detailed data presented in Figures 10 and 11 are summarized in Figure 12 as averages for the three study years. Fall Creek flows were highest in 2000 and lowest in 1999 (Figure 12a). Average wind speeds were essentially equal for the three study years (Figure 12b). Total phosphorus loading from the Ithaca WWTP was lowest in 1999 and essentially equal in 1998 and 2000 (Figure 12c). Greater month-to-month variability in TP loading was observed in 1998 than in 2000 (Figures 10c and 12c). Study period averages for TP, Chl **a**, and T_n on the shelf were very similar for 1998 and 2000, but lower in 1999 (Figure 12d-f).

Noteworthy observations from the 2000 data include:

1. site 2 was enriched in all three forms of phosphorus (TP, TDP, and SRP), all three forms of nitrogen (TDN, NO_X, and T-NH_3), and had higher turbidity (T_n) compared to the other monitored sites (Figure 2, Table 6).

2. the deep water sites (6, 8 and LSC) had the lowest concentrations of total phosphorus (TP) and turbidity (T_n), on average, of the monitored sites (Figure 2, Table 6).

3. substantial spatial variations were observed within the southern end of the lake (“shelf”; exclusive of site 2) for most parameters included in the monitoring program Figure 2, Table 6).

4. variances of measures of trophic state (chlorophyll **a**, TP, and T_n) were greater for the south shelf sites than for deep water sites (sites 6, 8 and LSC; Figure 2, Table 6).

5. clarity, as measured by Secchi disc transparency (SD) and turbidity (T_n), was low on the south shelf on the first monitoring day (April 6) and on June 22 (Figure 2g-h).

6. chloride concentrations were spatially and temporally uniform compared to other parameters measured in the monitoring program (Table 6).

7. more than two-thirds of the phosphorus was in a particulate form [e.g., (TP-TDP)/TP] over the monitored period (exclusive of site 2).

8. average concentrations of TP, TDP, SRP, and T-NH_3 were higher in the eastern portion (sites 1 and 7), compared to other sites (4 and 5) on the shelf (Table 6).

9. chlorophyll concentrations, on a monitoring period average basis, were relatively similar across the spatial bounds of sampling, though substantial spatial variability was observed on individual days (Figure 2i, Table 6).

10. temperatures were relatively uniform over the monitored bounds of the upper waters of the lake during the period of measurements (Figure 2j).

11. a major decrease in temperature was observed at all monitoring sites in mid-June (Figure 2j).

12. turbidity (T_n) values and concentrations of total phosphorus (TP) and soluble reactive phosphorus (SRP) were essentially equal in the LSC influent and effluent (Figure 2m-o).

13. the concentration of total phosphorus (TP) in the LSC effluent was less than the concentration on the south shelf on most sampling days (Figure 2p); on average, the concentration was 4.4 $\mu g \cdot L^{-1}$ lower (Table 7).

14. the concentration of soluble reactive phosphorus (SRP) was higher in the LSC effluent than on the shelf on all sampling days (Figure 2q), consistent with projections made in the **Draft Environmental Impact Statement** (Stearns and Wheler, 1997); on average, the concentration was 4.8 $\mu g \cdot L^{-1}$ higher (Table 7).

15. turbidity (T_n) values were higher in the LSC effluent than on the shelf on all sampling days (Figure 2r); on average, the turbidity was greater by 1.1 NTU (Table 7).

16. dissolved oxygen concentrations at site 3 were within 10 % of saturation (equilibrium with the atmosphere) over most of the study interval (Figure 2k).

17. concentrations of fecal coliforms were below public health limits for contact recreation at monitored sites (LSC, and sites 1 and 7) on all monitored dates (Table 6). The unusually high concentration (136 cfu· 100 ml^{-1}) reported for the LSC intake on June 15 coincided with a major decrease in temperature on the shelf (Figure 2j) and a major increase in beam attenuation coefficient observed near the bottom of the LSC site (Figure 3c).

18. modest increases in beam attenuation coefficient (BAC) were observed near the bottom of the LSC site on several monitored dates, indicating the occurrence of small increases in turbidity with the approach to the bottom at this site (Figure 3). A major increase in BAC was observed near the bottom of the LSC site on June 15 (Figure 3c) that coincided with a major decrease in temperature on the shelf (Figure 2j).

19. chlorophyll fluorescence profiles indicate subsurface peaks in phytoplankton concentrations occurred at the LSC intake site during the stratification period of 2000 (Figure 3). These peaks occurred above, or at, the maximum temperature (i.e., density) gradient, at depths 20 meters.

20. Secchi disc transparency (SD) was observed to extend beyond the lake depth at multiple sites on several occasions during the 2000 study interval (Appendix 1).

21. the 2000 results continue to support turbidity (T_n) as an alternate measure of light penetration in shallow portions of the shelf (Figure 4).

22. phosphorus loading from the Ithaca and Cayuga Heights WWTPs was higher in 2000 than in 1999, but not as high as in 1998 (Table 8).

23. LSC contributed ~ 3 % of the TP load to the shelf over the July – October interval of 2000, a smaller contribution than projected in the **Draft Environmental Impact Statement** (Stearns and Wheler 1997; Table 8).

24. Fall Creek flows during the April – July 2000 interval were high compared to long-term median values (Figure 5a-b), and were distinctly higher than 1999 flows (Figure 10a).

25. major wind events did not occur over the study interval of 2000 (Figure 5c) and average wind speeds were essentially equal in 1998, 1999, and 2000 (Figure 12b).

26. the 2000 results continue to support the position that TP and T_n are systematically flawed indicators of trophic state on the shelf.

27. summer average concentrations of TP and Chl **a** for deep water sites continue to be consistent with mesotrophy, an intermediate level of primary productivity (Tables 9 and 10).

28. study period average values for TP, Chl **a**, and T_n on the shelf were similar for 1998 and 2000, and distinctly lower for 1999 (Figure 12d-f).

29. no conspicuous changes in water quality were observed on the shelf following start-up of the LSC facility (Figure 2).

5. Summary

This report presents the design and salient findings of a water quality monitoring study conducted for Cayuga Lake in 2000, sponsored by Cornell University. This is the third annual report for a monitoring program that will be conducted annually through 2002. A number of noteworthy findings are reported here for 2000 that have value for lake management. Water quality on the south shelf apparently varies substantially from year to year. Potential sources of variation include interannual differences in runoff, loading from WWTPs, and wind. For example, Fall Creek flows were high in 2000 compared to long-term median values and were distinctly higher than 1999 flows. Major runoff events occurred throughout the April – July interval of 2000. No significant runoff events occurred from late April through mid-September 1999. Phosphorus loading from the Ithaca and Cayuga Heights WWTPs was higher in 2000 than in 1999, but not as high as in 1998. Although north to northwest wind speeds greater than 10 mph were more common in 1999 and 2000 than in 1998, study average wind speeds were essentially equal for the three study years. Study period average values for TP, Chl **a**, and T_n on the shelf were similar for 1998 and 2000, but lower in 1999. Summer average concentrations of TP and Chl **a** for deep water sites continue to be consistent with mesotrophy, a classification shared by seven of the eleven Finger Lakes. Total phosphorus (TP) concentrations were generally lower, and turbidity (T_n) values and SRP (soluble reactive phosphorus) concentrations were generally higher, in the LSC effluent than on the shelf. LSC contributed ~ 3 % of the TP load to the shelf over the July – October interval of 2000, a smaller contribution than projected in the **Draft Environmental Impact Statement**. No conspicuous changes in water quality were observed on the shelf following start-up of the LSC facility.

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Appendix I

Data Listing

Total Phosphorus (μgP· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	28.9	17.5	13.3	22.6	17.4	31.6	7.9	14.2	9.7	29.6	19.7	14.9	18.4	17.8	15.5	16.2	12.6
2	48.0	27.9	25.2	58.6	13.6	46.1	18.9	16.4	26.2	51.9	25.4	18.9	36.7	25.2	27.1	35.5	24.7
3	41.4	21.3	17.8	12.4	14.0	30.2	25.5	13.4	16.1	44.5	26.1	18.1	37.8	18.6	32.9	26.9	19.8
4	42.3	15.1	12.5	14.3	16.2	8.9	11.0	11.1	10.0	17.9	15.1	44.5	8.9	13.8	16.0	21.6	9.7
5	17.7	15.9	14.6	13.1	15.0	15.6	9.0	13.5	17.2	42.4	15.6	19.4	16.7	16.9	24.1	15.5	9.8
6	12.4	13.8	12.6	15.5	12.3	15.8	8.2	10.6	13.5	15.9	12.5	11.0	16.1	12.2	13.0	10.7	10.3
7	37.3	22.5	15.3	56.9	33.1	27.6	10.4	16.8	11.3	24.6	24.5	21.9	21.0	28.3	23.6	20.6	32.4
8	9.5	8.7	10.9	11.2	14.1	8.6	8.6	8.9	5.3	15.8	14.0	10.9	20.0	14.5	15.1	9.8	10.9
LSCT	9.5	10.4	11.3	15.3	9.1	10.6	8.9	8.8	9.0	10.2	14.2	12.6	12.7	15.5	15.2	10.8	9.0
LSCB	9.3	8.1	9.3	10.9	12.0	13.5	24.9	15.8	29.7	13.0	14.1	14.0	16.6	14.0	13.9	10.3	12.6
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	16.3	13.3	12.4	9.4	11.5
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	12.6	12.9	13.7	12.4	13.0
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	55.6	18.6	-	13.6	-	10.8	-	12.1	-	19.9	-	10.5	-	-	-	-	-
2	24.5	122.2	-	200.9	-	13.6	-	35.0	-	22.7	-	9.9	-	-	-	-	-
3	13.8	16.3	-	15.2	-	9.2	-	11.8	-	20.2	-	6.4	-	-	-	-	-
4	10.1	9.0	-	9.7	-	12.1	-	8.6	-	9.8	-	7.2	-	-	-	-	-
5	16.9	14.2	-	12.2	-	11.3	-	10.5	-	9.5	-	8.2	-	-	-	-	-
6	13.7	17.9	-	14.4	-	8.8	-	8.1	-	9.4	-	6.9	-	-	-	-	-
7	31.4	22.2	-	18.8	-	45.7	-	14.7	-	17.1	-	14.0	-	-	-	-	-
8	9.9	10.6	-	10.1	-	9.9	-	8.9	-	14.4	-	9.2	-	-	-	-	-
LSC	11.7	15.6	-	11.2	-	8.7	-	9.3	-	10.5	-	7.0	-	-	-	-	-
LSCB	12.3	9.8	-	10.4	-	12.2	-	12.4	-	11.0	-	15.0	-	-	-	-	-
LSC3B	8.5	11.4	-	10.9	-	9.9	-	13.8	-	11.0	-	13.8	-	-	-	-	-
LSCEFF	10.4	10.8	11.8	11.2	11.5	12.1	14.4	12.6	12.3	9.6	12.8	13.1	15.6	15.5	11.6	12.0	10.9
LSCINF	-	-	-	11.1	13.2	11.2	12.1	13.1	13.4	11.2	12.0	11.7	14.3	15.4	11.1	11.8	10.0

Total Dissolved Phosphorus (µgP· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	7.8	5.8	3.8	-	3.0	-	1.3	-	2.8	-	9.1	-	2.8	-	0.3	-	2.4
2	13.3	11.1	12.6	-	4.0	-	5.2	-	10.6	-	5.7	-	6.5	-	1.4	-	2.2
3	10.2	6.8	3.9	-	3.7	-	13.4	-	6.5	-	4.5	-	3.6	-	0.7	-	2.4
4	6.7	5.0	2.8	-	4.4	-	1.8	-	3.0	-	4.5	-	4.4	-	0.3	-	1.5
5	4.8	4.9	2.5	-	3.9	-	1.1	-	6.1	-	3.9	-	2.1	-	0.7	-	1.9
6	-	4.3	1.6	-	3.1	-	2.7	-	4.1	-	2.8	-	1.6	-	0.3	-	1.1
7	11.0	7.9	3.0	-	18.4	-	2.1	-	6.4	-	4.6	-	4.5	-	1.8	-	3.5
8	3.4	1.7	2.2	-	4.1	-	1.3	-	1.8	-	6.4	-	2.1	-	0.3	-	1.0
LSCT	3.9	3.6	1.0	-	2.5	-	7.8	-	3.4	-	6.2	-	3.2	-	0.3	-	1.2
LSCB	4.8	3.2	5.3	-	5.4	-	9.3	-	6.7	-	11.0	-	6.8	-	5.3	-	5.8
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	6.9	-	5.2	-	6.8
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	5.4	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	2.9	-	2.1	-	3.9	-	6.3	-	10.2	-	1.5	-	-	-	-	-
2	-	87.8	-	180.9	-	4.4	-	25.9	-	6.5	-	3.6	-	-	-	-	-
3	-	2.4	-	3.0	-	4.7	-	7.7	-	5.0	-	1.3	-	-	-	-	-
4	-	3.6	-	3.6	-	4.2	-	2.7	-	3.9	-	1.8	-	-	-	-	-
5	-	1.8	-	1.6	-	2.2	-	2.7	-	1.8	-	1.2	-	-	-	-	-
6	-	2.9	-	1.5	-	3.1	-	3.0	-	2.8	-	0.9	-	-	-	-	-
7	-	4.9	-	9.6	-	11.4	-	8.8	-	7.2	-	2.6	-	-	-	-	-
8	-	2.0	-	1.5	-	4.8	-	2.9	-	3.1	-	0.3	-	-	-	-	-
LSC	-	3.5	-	0.8	-	3.8	-	3.1	-	2.4	-	1.0	-	-	-	-	-
LSCB	-	8.6	-	5.7	-	12.2	-	8.9	-	6.5	-	7.6	-	-	-	-	-
LSC3B	-	5.7	-	6.0	-	9.9	-	9.1	-	7.0	-	6.0	-	-	-	-	-
LSCEFF	7.7	6.9	6.5	6.4	9.3	12.1	8.2	8.9	10.0	5.8	6.7	5.4	9.7	7.3	8.6	6.1	7.3
LSCINF	-	-	-	6.4	-	-	-	-	-	-	-	-	-	-	-	-	-

Soluble Reactive Phosphorus (μgP· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	5.1	4.0	1.9	-	0.6	5.9	0.2	-	2.2	-	0.9	-	0.4	-	0.2	-	0.2
2	9.1	8.2	1.0	-	1.0	8.4	3.6	-	7.3	-	0.3	-	0.8	-	0.2	-	0.2
3	9.3	4.9	2.4	-	1.4	6.4	11.2	-	4.5	-	0.2	-	0.7	-	0.3	-	0.2
4	6.0	4.3	1.3	-	3.7	0.8	0.2	-	2.3	-	0.2	-	0.2	-	0.2	-	0.2
5	4.8	3.8	1.0	-	3.0	1.2	0.2	-	4.3	-	0.2	-	0.2	-	0.2	-	0.2
6	3.4	3.5	0.2	-	1.2	0.9	0.2	-	3.4	-	0.2	-	0.3	-	0.2	-	0.2
7	6.9	5.1	1.4	-	13.6	4.0	0.2	-	3.7	-	0.2	-	0.4	-	0.2	-	0.2
8	2.4	1.7	0.3	-	0.3	0.2	0.2	-	0.2	-	0.2	-	0.3	-	0.2	-	0.2
LSCT	3.3	3.1	0.2	-	0.9	0.3	0.2	-	2.3	-	0.2	-	0.2	-	0.2	-	0.2
LSCB	3.7	3.0	4.2	-	4.1	5.3	6.1	-	6.3	-	4.6	-	5.5	-	5.3	-	5.2
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	5.3	-	5.2	-	5.8
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	5.4	-	5.0	6.0	5.8
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	5.6	6.0	4.6	5.7	5.8

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	0.3	-	0.2	-	0.5	-	2.4	-	7.7	-	1.1	-	-	-	-	-
2	-	82.4	-	179.6	-	0.2	-	17.8	-	3.3	-	1.9	-	-	-	-	-
3	-	0.3	-	0.8	-	0.5	-	3.0	-	2.4	-	1.3	-	-	-	-	-
4	-	1.4	-	1.5	-	0.6	-	0.8	-	2.1	-	0.8	-	-	-	-	-
5	-	0.3	-	0.2	-	0.2	-	0.7	-	0.7	-	0.4	-	-	-	-	-
6	-	0.2	-	0.2	-	0.2	-	0.6	-	0.2	-	0.5	-	-	-	-	-
7	-	0.5	-	5.5	-	2.9	-	3.8	-	4.0	-	1.8	-	-	-	-	-
8	-	0.2	-	0.2	-	0.2	-	0.7	-	0.2	-	0.2	-	-	-	-	-
LSC	-	0.8	-	0.2	-	0.2	-	0.5	-	0.2	-	0.3	-	-	-	-	-
LSCB	-	6.7	-	5.6	-	5.6	-	7.5	-	5.0	-	7.1	-	-	-	-	-
LSC3B	-	5.1	-	5.5	-	5.1	-	7.5	-	5.2	-	6.6	-	-	-	-	-
LSCEFF	6.4	5.5	5.7	5.4	6.5	5.8	6.9	8.0	6.7	5.1	7.1	6.5	7.9	6.5	6.1	3.5	5.9
LSCINF	5.9	5.3	3.8	5.3	7.8	6.0	6.6	7.9	6.5	5.3	7.5	6.5	8.1	6.6	5.4	3.3	5.7

Total Dissolved Nitrogen (mgN· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	1.24	1.64	1.30	-	1.32	-	1.48	-	1.55	-	1.30	-	1.38	-	1.36	-	1.33
2	1.26	1.53	1.52	-	1.36	-	1.66	-	1.54	-	1.20	-	1.45	-	1.35	-	1.34
3	2.59	1.30	1.28	-	1.33	-	2.00	-	1.49	-	1.35	-	2.41	-	1.12	-	1.31
4	1.18	1.39	1.32	-	1.24	-	1.41	-	1.45	-	1.27	-	1.35	-	1.36	-	1.25
5	1.36	1.38	1.28	-	1.40	-	1.40	-	1.52	-	1.34	-	1.29	-	1.44	-	1.34
6	1.43	1.49	1.23	-	1.34	-	1.34	-	1.40	-	1.45	-	1.34	-	1.36	-	1.39
7	1.33	1.58	1.24	-	1.65	-	1.58	-	1.49	-	1.50	-	1.44	-	1.26	-	1.34
8	1.36	1.37	1.27	-	1.35	-	1.48	-	1.46	-	1.39	-	1.47	-	1.31	-	1.33
LSCT	1.35	1.56	1.34	-	1.40	-	1.53	-	1.43	-	1.23	-	1.40	-	1.31	-	1.30
LSCB	1.32	1.55	1.30	-	1.34	-	1.60	-	1.53	-	1.43	-	1.59	-	1.50	-	1.55
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.57
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	1.33	-	1.33	-	1.40	-	1.44	-	1.78	-	1.54	-	-	-	-	-
2	-	3.52	-	4.39	-	1.43	-	2.47	-	1.20	-	1.58	-	-	-	-	-
3	-	1.24	-	1.33	-	1.47	-	1.71	-	1.52	-	1.49	-	-	-	-	-
4	-	1.00	-	1.41	-	1.27	-	1.37	-	1.50	-	1.52	-	-	-	-	-
5	-	1.23	-	1.35	-	1.58	-	1.45	-	1.59	-	1.42	-	-	-	-	-
6	-	1.44	-	1.36	-	1.37	-	1.50	-	1.53	-	1.82	-	-	-	-	-
7	-	1.56	-	1.45	-	1.73	-	1.54	-	1.66	-	1.48	-	-	-	-	-
8	-	1.42	-	1.49	-	1.63	-	1.53	-	1.52	-	-	-	-	-	-	-
LSC	-	1.42	-	1.43	-	1.54	-	1.56	-	1.58	-	1.53	-	-	-	-	-
LSCB	-	1.66	-	1.63	-	1.85	-	1.64	-	1.73	-	1.65	-	-	-	-	-
LSC3B	-	1.70	-	1.60	-	1.86	-	1.68	-	1.77	-	1.78	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Nitrate + Nitrite Nitrogen (mgN· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	1.01	1.03	1.21	-	1.10	-	1.17	-	1.16	-	0.76	-	1.05	-	1.08	-	0.83
2	0.76	1.03	1.24	-	1.10	-	1.30	-	1.09	-	0.74	-	1.12	-	1.07	-	0.92
3	0.77	0.97	1.18	-	1.08	-	1.61	-	1.09	-	0.77	-	1.74	-	1.08	-	0.86
4	0.47	1.08	1.27	-	1.00	-	1.07	-	1.02	-	0.77	-	1.13	-	0.95	-	0.84
5	0.88	1.04	1.15	-	1.11	-	1.17	-	1.06	-	0.76	-	0.96	-	1.02	-	0.83
6	1.03	1.14	1.21	-	1.13	-	1.11	-	0.96	-	0.76	-	0.95	-	1.00	-	0.73
7	0.79	1.05	1.16	-	1.43	-	1.16	-	1.05	-	0.76	-	1.04	-	1.07	-	0.80
8	1.06	1.26	1.27	-	1.21	-	1.14	-	1.02	-	0.80	-	1.07	-	1.03	-	0.82
LSCT	1.11	1.25	1.33	-	1.18	-	1.17	-	1.04	-	0.80	-	1.07	-	1.02	-	0.83
LSCB	1.17	1.29	1.29	-	1.22	-	1.30	-	1.06	-	0.87	-	1.25	-	1.28	-	1.18
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.14
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	0.95	-	0.91	-	1.00	-	0.87	-	1.13	-	1.13	-	-	-	-	-
2	-	2.05	-	3.72	-	1.01	-	1.44	-	0.56	-	1.13	-	-	-	-	-
3	-	0.88	-	0.94	-	1.04	-	1.21	-	0.98	-	1.13	-	-	-	-	-
4	-	0.66	-	0.85	-	0.87	-	0.96	-	0.97	-	1.12	-	-	-	-	-
5	-	0.82	-	0.96	-	1.12	-	1.00	-	1.02	-	1.11	-	-	-	-	-
6	-	0.86	-	0.97	-	1.05	-	0.88	-	1.00	-	1.15	-	-	-	-	-
7	-	0.88	-	1.04	-	1.07	-	0.93	-	1.11	-	1.14	-	-	-	-	-
8	-	0.88	-	0.99	-	1.10	-	0.94	-	1.04	-	1.40	-	-	-	-	-
LSC	-	0.94	-	0.99	-	1.10	-	0.96	-	1.05	-	1.43	-	-	-	-	-
LSCB	-	1.30	-	1.38	-	1.42	-	1.25	-	1.30	-	1.45	-	-	-	-	-
LSC3B	-	1.27	-	1.37	-	1.43	-	1.23	-	1.30	-	1.44	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Ammonia Nitrogen (mgN· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	0.068	0.173	0.088	-	0.020	-	0.033	-	0.014	-	0.030	-	0.005	-	0.005	-	0.005
2	0.249	0.373	0.276	-	0.023	-	0.058	-	0.028	-	0.013	-	0.005	-	0.019	-	0.031
3	0.671	0.198	0.097	-	0.036	-	0.083	-	0.028	-	0.005	-	0.005	-	0.037	-	0.023
4	0.046	0.102	0.046	-	0.025	-	0.041	-	0.023	-	0.005	-	0.005	-	0.021	-	0.005
5	0.069	0.091	0.074	-	0.024	-	0.035	-	0.023	-	0.005	-	0.005	-	0.020	-	0.005
6	0.030	0.077	0.021	-	0.023	-	0.033	-	0.015	-	0.005	-	0.005	-	0.019	-	0.005
7	0.096	0.204	0.082	-	0.071	-	0.052	-	0.016	-	0.019	-	0.005	-	0.012	-	0.056
8	0.005	0.005	0.005	-	0.018	-	0.014	-	0.015	-	0.005	-	0.005	-	0.005	-	0.005
LSCT	0.019	0.043	0.005	-	0.017	-	0.020	-	0.018	-	0.005	-	0.005	-	0.005	-	0.005
LSCB	0.013	0.023	0.005	-	0.013	-	0.014	-	0.020	-	0.049	-	0.005	-	0.005	-	0.005
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.005
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	0.020	-	0.025	-	0.014	-	0.068	-	0.143	-	0.025	-	-	-	-	-
2	-	0.808	-	0.673	-	0.015	-	0.482	-	0.043	-	0.039	-	-	-	-	-
3	-	0.020	-	0.021	-	0.014	-	0.109	-	0.068	-	0.013	-	-	-	-	-
4	-	0.015	-	0.020	-	0.014	-	0.019	-	0.042	-	0.005	-	-	-	-	-
5	-	0.010	-	0.032	-	0.021	-	0.026	-	0.021	-	0.014	-	-	-	-	-
6	-	0.005	-	0.009	-	0.005	-	0.022	-	0.016	-	0.005	-	-	-	-	-
7	-	0.140	-	0.057	-	0.145	-	0.083	-	0.081	-	0.015	-	-	-	-	-
8	-	0.012	-	0.014	-	0.005	-	0.016	-	0.005	-	0.005	-	-	-	-	-
LSC	-	0.012	-	0.012	-	0.017	-	0.021	-	0.012	-	0.005	-	-	-	-	-
LSCB	-	0.005	-	0.005	-	0.005	-	0.016	-	0.005	-	0.005	-	-	-	-	-
LSC3B	-	0.005	-	0.005	-	0.005	-	0.016	-	0.005	-	0.005	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Chlorophyll a (μg· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	3.7	2.2	2.7	3.5	2.7	1.9	2.9	4.7	17.1	4.5	7.1	2.8	5.6	8.1	11.5	6.3	7.6
2	3.0	2.4	2.1	3.9	1.9	2.2	2.2	3.5	2.4	3.0	8.2	3.6	7.9	7.4	9.4	9.9	10.3
3	2.9	2.3	2.9	2.8	2.4	1.8	2.7	3.6	1.5	5.2	7.3	3.1	6.8	7.0	10.3	9.7	8.6
4	2.9	1.7	1.8	3.3	2.2	-	1.8	4.5	1.3	4.2	6.6	3.8	3.7	6.8	7.5	7.5	4.9
5	1.9	1.8	3.5	3.5	1.8	2.0	1.8	3.8	1.4	2.5	5.8	2.7	4.8	8.4	11.7	8.3	5.4
6	1.7	2.8	3.9	3.3	1.6	2.4	2.5	5.1	1.2	3.9	4.1	3.1	3.9	6.8	9.7	5.8	7.3
7	4.2	3.1	2.6	7.2	1.6	2.0	2.9	4.0	1.4	5.0	12.0	3.5	5.7	6.8	11.5	5.7	9.4
8	1.3	2.3	3.2	2.9	2.7	1.8	3.7	3.1	1.8	4.6	5.4	2.2	3.9	7.7	9.4	6.1	5.5
LSCT	2.2	2.2	4.0	3.7	2.0	2.9	2.2	3.8	1.1	3.4	0.7	2.5	3.7	8.6	11.5	6.8	5.8
LSCB	0.9	1.7	1.1	0.6	0.2	0.8	1.3	1.5	-	0.2	7.0	0.6	1.1	0.2	1.5	1.3	1.6
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	1.1	1.1	0.9
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	14.6	7.3	-	4.1	-	4.5	-	3.4	-	2.5	-	2.8	-	-	-	-	-
2	3.7	10.8	-	2.5	-	4.2	-	2.5	-	3.6	-	0.7	-	-	-	-	-
3	1.8	5.3	-	3.0	-	4.1	-	1.4	-	7.2	-	1.5	-	-	-	-	-
4	1.1	1.5	-	1.5	-	5.6	-	2.6	-	1.6	-	1.8	-	-	-	-	-
5	3.3	7.2	-	-	-	4.4	-	5.1	-	3.8	-	3.2	-	-	-	-	-
6	4.1	7.2	-	5.0	-	4.5	-	6.3	-	4.7	-	4.5	-	-	-	-	-
7	5.6	6.1	-	2.4	-	24.1	-	2.9	-	2.2	-	2.9	-	-	-	-	-
8	3.0	5.7	-	4.2	-	4.9	-	5.9	-	3.8	-	4.4	-	-	-	-	-
LSC	4.4	9.8	-	4.8	-	5.2	-	6.4	-	5.4	-	4.1	-	-	-	-	-
LSCB	2.1	0.6	-	0.4	-	1.4	-	0.2	-	1.1	-	0.2	-	-	-	-	-
LSC3B	0.7	1.5	-	0.2	-	1.7	-	1.0	-	0.2	-	1.0	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Chloride (mg· L^{-1})

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	37.7	37.6	39.6	-	39.4	-	40.4	-	41.1	-	37.3	-	40.5	-	41.0	-	41.0
2	35.3	36.3	41.6	-	39.4	-	39.4	-	35.8	-	35.6	-	39.6	-	39.7	-	39.9
3	34.6	36.5	38.6	-	40.9	-	42.3	-	38.4	-	38.5	-	42.0	-	39.0	-	40.4
4	35.1	41.1	40.9	-	38.0	-	38.4	-	39.2	-	39.4	-	42.0	-	41.5	-	41.5
5	39.4	38.2	39.6	-	39.4	-	39.4	-	37.7	-	39.3	-	40.5	-	40.0	-	41.3
6	42.8	39.2	40.6	-	39.4	-	39.9	-	39.7	-	39.4	-	40.5	-	41.0	-	41.3
7	34.6	33.5	38.6	-	43.3	-	40.4	-	38.8	-	37.5	-	41.3	-	42.5	-	41.3
8	43.3	42.1	40.6	-	40.4	-	39.5	-	40.6	-	40.4	-	40.5	-	42.5	-	41.3
LSCT	43.3	39.2	41.1	-	40.4	-	40.4	-	41.6	-	40.4	-	41.5	-	41.0	-	40.9
LSCB	42.8	42.1	41.6	-	41.3	-	42.3	-	42.1	-	42.3	-	42.5	-	43.5	-	43.3
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.0	-	42.3
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	-	41.3	-	41.4	-	41.7	-	42.6	-	42.0	-	44.8	-	-	-	-	-
2	-	52.0	-	52.9	-	41.0	-	44.3	-	34.6	-	42.2	-	-	-	-	-
3	-	41.2	-	42.2	-	41.5	-	43.0	-	41.0	-	41.7	-	-	-	-	-
4	-	41.2	-	40.8	-	40.5	-	42.0	-	40.4	-	41.8	-	-	-	-	-
5	-	42.2	-	41.3	-	40.5	-	41.5	-	41.8	-	42.6	-	-	-	-	-
6	-	42.2	-	41.7	-	42.0	-	43.0	-	42.8	-	42.2	-	-	-	-	-
7	-	42.2	-	43.7	-	42.0	-	42.0	-	42.3	-	41.7	-	-	-	-	-
8	-	41.2	-	40.8	-	42.0	-	42.0	-	42.8	-	41.7	-	-	-	-	-
LSC	-	41.7	-	40.8	-	42.0	-	41.5	-	42.3	-	42.2	-	-	-	-	-
LSCB	-	42.2	-	43.7	-	43.0	-	42.5	-	42.8	-	44.1	-	-	-	-	-
LSC3B	-	43.6	-	42.7	-	43.0	-	42.5	-	43.3	-	43.1	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	42.2	-	-	-	-	-	-	-	-	-	-

Turbidity (NTU)

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	16.1	3.7	2.3	3.0	3.4	11.9	1.1	2.3	1.3	10.9	2.8	1.7	1.6	1.9	2.1	2.1	2.7
2	30.6	3.6	2.1	12.1	2.7	20.8	1.8	2.5	5.4	31.6	4.4	3.1	3.9	2.7	2.8	3.9	3.2
3	21.2	4.1	2.0	1.5	2.9	8.2	1.4	2.3	3.9	20.6	4.2	3.2	3.5	2.2	3.1	3.0	2.9
4	40.5	2.7	1.8	1.6	5.0	2.0	2.2	2.0	3.2	5.2	2.3	6.3	1.6	1.4	1.5	2.6	2.1
5	7.9	3.5	2.0	1.8	2.1	4.2	1.3	2.1	4.6	46.8	2.5	2.0	1.5	1.6	3.0	2.6	2.8
6	2.5	2.4	1.6	2.3	2.1	3.9	1.2	1.6	4.3	4.6	2.0	1.1	1.3	1.3	2.7	2.1	2.8
7	14.8	3.4	2.1	23.9	2.2	7.7	1.2	2.9	2.0	5.4	3.2	3.1	1.8	3.8	2.4	2.2	3.5
8	1.3	1.2	1.2	0.9	3.6	0.9	1.2	1.1	1.4	3.7	1.4	1.1	1.0	-	2.5	2.4	2.5
LSCT	1.2	1.8	1.1	2.4	1.6	1.7	1.3	0.9	2.3	2.1	1.8	1.1	1.2	1.6	2.7	2.3	3.3
LSCB	1.2	1.3	1.8	1.3	2.2	2.9	6.4	5.5	11.8	3.2	3.6	4.6	3.3	3.4	3.0	2.6	4.1
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2	2.7	2.4	4.1
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	7.3	1.5	-	1.1	-	0.9	-	0.9	-	1.2	-	0.9	-	-	-	-	-
2	3.9	2.0	-	1.0	-	0.8	-	1.4	-	2.8	-	0.8	-	-	-	-	-
3	1.0	1.4	-	0.9	-	0.8	-	0.5	-	0.9	-	0.5	-	-	-	-	-
4	0.5	0.7	-	0.5	-	0.9	-	0.5	-	0.5	-	0.6	-	-	-	-	-
5	2.3	0.8	-	1.2	-	1.0	-	0.8	-	0.8	-	0.6	-	-	-	-	-
6	1.2	1.0	-	1.2	-	0.7	-	0.7	-	0.6	-	0.6	-	-	-	-	-
7	3.5	1.1	-	0.6	-	3.2	-	0.9	-	0.8	-	1.8	-	-	-	-	-
8	1.3	0.9	-	0.9	-	0.9	-	0.7	-	-	-	0.7	-	-	-	-	-
LSC	1.1	1.1	-	1.0	-	0.7	-	0.7	-	0.6	-	0.6	-	-	-	-	-
LSCB	4.2	2.3	-	2.1	-	2.5	-	2.4	-	1.7	-	2.9	-	-	-	-	-
LSC3B	1.7	2.3	-	2.1	-	1.8	-	2.1	-	2.0	-	2.8	-	-	-	-	-
LSCEFF	2.4	2.2	2.0	2.3	2.5	2.6	2.0	2.0	3.2	1.5	2.2	2.0	-	-	-	-	-
LSCINF	-	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CaCO$_3$ Turbidity (NTU)

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	0.9	0.4	0.5	0.5	0.7	1.4	0.2	0.2	0.0	1.9	0.3	0.2	0.0	0.2	0.5	0.4	1.2
2	1.6	0.3	0.5	1.3	0.4	0.0	0.2	0.4	0.4	4.0	0.4	0.5	0.4	0.6	0.4	0.8	0.6
3	1.1	0.1	0.3	0.2	0.6	0.5	0.3	0.4	0.4	3.7	0.3	0.5	0.1	0.5	0.5	0.6	0.9
4	2.3	0.4	0.4	0.3	0.5	0.2	0.3	0.5	0.4	0.2	0.1	2.5	0.3	0.2	0.1	0.6	1.0
5	0.6	0.1	0.4	0.3	0.2	0.5	0.3	0.4	0.5	5.8	0.3	0.4	0.1	0.0	0.3	1.1	1.3
6	0.2	0.0	0.3	0.5	0.2	0.4	0.2	0.4	1.0	0.0	0.0	0.1	0.1	0.0	1.0	1.0	1.1
7	1.6	0.0	0.1	5.3	0.1	1.0	0.2	0.4	0.7	0.0	0.2	0.5	0.0	1.4	0.3	0.3	0.9
8	0.3	0.2	0.2	0.1	0.5	0.1	0.2	0.3	0.1	0.4	0.2	0.1	0.0	-	0.7	1.4	0.9
LSCT	0.1	0.1	0.0	0.1	0.2	0.1	0.2	0.1	0.2	0.4	0.1	0.0	0.0	0.4	1.0	1.1	1.4
LSCB	0.2	0.3	0.0	0.3	0.3	0.5	0.6	0.1	1.2	0.5	0.7	0.4	0.1	0.1	0.2	0.5	0.0
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	1.1	0.3	0.2	0.2
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	1.5	0.1	-	0.2	-	0.0	-	0.1	-	0.1	-	0.1	-	-	-	-	-
2	0.8	0.0	-	0.1	-	0.0	-	0.0	-	0.2	-	0.1	-	-	-	-	-
3	0.3	0.2	-	0.1	-	0.0	-	0.0	-	0.1	-	0.1	-	-	-	-	-
4	0.0	0.1	-	0.1	-	0.1	-	0.0	-	0.1	-	0.1	-	-	-	-	-
5	0.5	0.0	-	0.1	-	0.2	-	0.0	-	0.0	-	0.0	-	-	-	-	-
6	0.3	0.0	-	0.2	-	0.0	-	0.0	-	0.0	-	0.0	-	-	-	-	-
7	0.0	0.0	-	0.0	-	0.4	-	0.1	-	0.1	-	0.4	-	-	-	-	-
8	0.5	0.1	-	0.2	-	0.1	-	0.1	-	-	-	0.0	-	-	-	-	-
LSC	0.5	0.1	-	0.2	-	0.0	-	0.0	-	0.0	-	0.1	-	-	-	-	-
LSCB	0.6	0.0	-	0.2	-	0.0	-	0.4	-	0.3	-	0.5	-	-	-	-	-
LSC3B	0.1	0.2	-	0.2	-	0.1	-	0.3	-	0.8	-	1.0	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Alkalinity (mg $CaCO_3 \cdot L^{-1}$)

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	95.4	103.6	107.8	109.7	105.2	105.9	106.7	112.3	108.4	109.3	112.0	109.1	108.8	106.5	107.3	106.0	99.5
2	90.3	101.8	109.6	113.9	106.2	100.9	110.1	114.1	109.1	106.2	115.8	112.0	120.7	107.6	113.3	109.2	112.1
3	84.1	102.2	110.1	108.1	105.2	105.2	109.6	112.5	108.4	106.2	112.0	111.0	117.8	106.2	123.9	108.6	105.3
4	87.4	105.2	107.8	106.2	107.6	107.2	110.1	109.1	110.1	107.2	108.1	110.1	106.7	104.3	107.3	104.3	98.5
5	100.3	102.3	106.2	106.5	106.2	107.2	107.2	111.0	108.1	106.2	108.0	109.1	108.1	106.2	113.1	103.4	99.5
6	104.2	102.3	107.6	106.2	107.2	108.1	109.1	110.1	110.1	108.1	108.1	107.8	105.7	105.2	109.2	106.3	99.5
7	88.4	103.3	109.1	115.8	106.2	108.9	108.1	117.3	110.1	110.1	113.9	113.0	108.0	108.1	106.3	108.7	104.3
8	105.1	106.2	107.2	107.2	107.2	107.2	107.8	107.2	107.2	108.6	107.2	107.2	105.7	104.7	107.8	103.4	97.5
LSCT	101.8	105.2	106.2	107.2	107.2	108.1	108.1	105.7	108.1	107.2	110.1	109.1	105.2	105.7	109.2	103.4	98.5
LSCB	103.7	106.7	107.2	106.2	106.7	107.2	107.2	106.7	109.1	108.1	106.2	106.7	104.3	104.3	107.3	104.3	106.3
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	105.7	108.2	106.3	106.3
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	119.8	97.5	-	98.0	-	100.3	-	102.2	-	106.3	-	105.2	-	-	-	-	-
2	102.9	107.8	-	105.3	-	103.9	-	115.6	-	135.6	-	106.3	-	-	-	-	-
3	98.5	102.4	-	98.5	-	102.9	-	102.4	-	109.5	-	103.9	-	-	-	-	-
4	98.0	91.7	-	95.1	-	99.0	-	100.4	-	101.9	-	104.2	-	-	-	-	-
5	99.3	97.5	-	99.0	-	100.0	-	101.4	-	101.9	-	104.3	-	-	-	-	-
6	97.5	99.0	-	98.5	-	100.4	-	101.4	-	102.4	-	104.8	-	-	-	-	-
7	108.2	100.4	-	100.9	-	106.3	-	101.4	-	104.3	-	108.2	-	-	-	-	-
8	98.5	98.5	-	97.0	-	99.0	-	100.9	-	101.9	-	104.3	-	-	-	-	-
LSC	97.5	98.0	-	97.5	-	99.5	-	100.9	-	101.4	-	104.3	-	-	-	-	-
LSCB	110.2	108.2	-	107.3	-	108.2	-	107.3	-	108.2	-	110.2	-	-	-	-	-
LSC3B	107.3	106.8	-	106.3	-	106.3	-	108.7	-	108.7	-	110.2	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	110.7	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Secchi Disc (m)

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	0.5	1.3	2.0	1.3	1.8	0.5	4.7	1.8	3.4	0.4	1.6	3.2	3.0	2.7	2.6	2.9	2.2
2	0.3	1.5	2.8	0.4	2.9	0.2	3.5	2.1	1.1	0.2	1.0	2.0	1.3	1.8	1.7	1.7	1.7
3	0.3	1.2	2.5	3.4	2.3	0.6	bottom	2.0	1.2	0.2	1.2	2.2	1.5	3.0	1.9	2.0	2.1
4	0.3	1.9	3.5	3.0	1.5	3.1	bottom	2.8	2.0	0.8	2.5	bottom	3.2	3.0	bottom	2.2	3.0
5	0.7	1.3	2.4	3.2	2.5	0.7	4.0	1.7	1.5	0.2	2.5	3.5	3.3	2.7	2.3	2.9	2.6
6	2.0	2.1	3.4	2.5	2.5	1.1	4.8	2.8	1.9	0.7	2.8	5.4	3.8	3.2	2.6	3.2	2.4
7	0.4	1.4	2.2	0.4	2.6	0.8	bottom	1.7	bottom	0.9	1.6	2.1	2.5	1.9	2.5	2.6	2.2
8	3.0	5.5	5.3	5.2	2.1	4.8	3.5	5.3	5.0	2.3	4.0	5.8	4.8	2.8	2.6	2.5	2.7
LSCT	3.3	3.2	4.6	2.8	3.5	3.2	4.2	4.6	2.9	2.5	3.0	4.5	3.1	3.0	2.6	2.8	2.4
LSCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	1.1	2.8	-	3.8	-	4.2	-	bottom	-	4.0	-	bottom	-	-	-	-	-
2	bottom	2.5	-	bottom	-	bottom	-	bottom	-	1.8	-	bottom	-	-	-	-	-
3	bottom	2.8	-	bottom	-	bottom	-	bottom	-	3.5	-	bottom	-	-	-	-	-
4	bottom	bottom	-	bottom	-	bottom	-	bottom	-	bottom	-	bottom	-	-	-	-	-
5	2.2	3.7	-	3.7	-	4.6	-	bottom	-	5.0	-	bottom	-	-	-	-	-
6	3.5	3.3	-	3.8	-	5.2	-	6.1	-	5.0	-	6.4	-	-	-	-	-
7	1.7	bottom	-	bottom	-	bottom	-	bottom	-	bottom	-	bottom	-	-	-	-	-
8	4.0	4.6	-	4.9	-	5.8	-	6.4	-	5.5	-	6.8	-	-	-	-	-
LSC	4.3	3.3	-	4.0	-	4.6	-	5.9	-	5.0	-	6.4	-	-	-	-	-
LSCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Temperature (°C) @ 2m

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Site:																	
1	5.40	7.80	10.31	12.07	10.23	12.71	13.14	14.71	6.87	15.36	18.51	21.27	21.07	20.27	21.00	20.05	23.39
2	6.91	7.83	9.33	11.97	9.50	13.37	12.68	13.36	6.98	13.98	17.96	21.00	21.39	20.09	20.24	20.31	23.32
3	5.92	7.38	11.28	11.64	10.03	11.98	11.76	13.48	6.74	16.71	17.79	21.11	21.30	20.27	21.07	20.30	23.19
4	6.43	5.72	9.09	11.72	10.36	8.58	10.53	14.07	5.81	14.69	17.99	20.95	21.10	20.16	20.09	20.72	23.26
5	5.49	6.78	9.34	11.77	9.57	8.25	11.96	14.71	6.65	15.39	18.62	20.90	21.94	20.33	20.99	20.47	23.41
6	4.57	6.06	9.05	11.53	8.85	10.72	12.16	14.25	7.48	14.96	18.61	20.59	20.75	20.30	21.40	21.14	23.53
7	6.25	8.29	10.17	14.97	9.43	13.16	11.18	15.14	7.46	14.41	18.22	21.43	21.35	20.18	20.65	20.10	23.44
8	4.04	4.95	7.68	10.08	10.71	9.16	12.82	13.19	7.71	16.50	19.79	20.62	20.44	20.54	21.07	22.08	23.24
LSCT	4.49	5.45	8.09	10.98	8.06	9.50	12.47	13.56	5.15	15.22	18.94	20.67	20.52	20.33	21.09	21.33	23.34
LSCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Site:																	
1	22.76	21.12	-	21.23	-	18.95	-	15.42	-	14.12	-	11.79	-	-	-	-	-
2	22.52	21.14	-	19.67	-	19.13	-	15.94	-	12.66	-	10.67	-	-	-	-	-
3	22.63	21.44	-	20.33	-	19.12	-	15.68	-	14.01	-	11.76	-	-	-	-	-
4	22.74	21.21	-	20.36	-	19.11	-	15.68	-	14.43	-	11.92	-	-	-	-	-
5	23.03	21.31	-	21.37	-	18.81	-	15.84	-	14.62	-	12.71	-	-	-	-	-
6	23.30	21.54	-	21.40	-	18.62	-	16.18	-	14.75	-	12.76	-	-	-	-	-
7	22.51	21.23	-	19.71	-	19.24	-	15.62	-	14.07	-	9.62	-	-	-	-	-
8	22.58	21.28	-	21.28	-	19.26	-	16.31	-	14.82	-	12.60	-	-	-	-	-
LSC	23.26	21.77	-	21.47	-	18.90	-	16.14	-	14.82	-	12.96	-	-	-	-	-
LSCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSC3B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LSCEFF	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-
LSCINF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dissolved Oxygen (mg· L^{-1}) Site 3

Date:	4/6/00	4/20/00	5/4/00	5/11/00	5/18/00	5/25/00	6/1/00	6/8/00	6/15/00	6/22/00	6/29/00	7/6/00	7/13/00	7/20/00	7/27/00	8/3/00	8/10/00
Depth:																	
0	11.47	10.93	11.75	11.42	11.09	10.63	11.16	10.17	10.79	10.03	-	8.69	8.41	9.57	9.39	8.49	8.57
1	11.47	10.92	11.78	11.39	11.08	10.16	11.34	9.97	10.73	10.22	-	8.70	8.46	9.46	9.67	8.86	8.84
2	11.52	11.13	11.67	11.47	11.04	10.06	11.33	10.45	11.24	10.22	10.03	8.56	8.79	9.56	9.70	9.29	9.72
3	11.50	11.25	12.19	11.62	11.05	10.16	11.41	10.34	11.39	-	-	7.97	9.05	9.73	8.11	9.07	9.65
4	11.48	11.29	12.57	11.71	11.38	11.18	11.17	10.24	11.25	-	-	7.97	8.19	8.10	6.00	5.68	7.91

Date:	8/17/00	8/24/00	9/1/00	9/7/00	9/14/00	9/21/00	9/28/00	10/5/00	10/12/00	10/19/00	10/26/00	11/2/00	11/10/00	11/16/00	11/21/00	11/30/00	12/7/00
Depth:																	
0	8.07	7.96	-	9.13	-	8.34	-	8.71	-	9.32	-	9.71	-	-	-	-	-
1	8.10	7.90	-	9.09	-	8.33	-	8.71	-	9.24	-	9.79	-	-	-	-	-
2	8.08	7.92	-	9.08	-	8.33	-	8.72	-	9.25	-	9.87	-	-	-	-	-
3	8.19	7.69	-	8.53	-	8.00	-	8.70	-	8.80	-	10.06	-	-	-	-	-
4	8.18	7.04	-	8.22	-	7.86	-	8.67	-	8.56	-	10.15	-	-	-	-	-

Appendix 2

Lake Source Cooling
Discharge Monitoring Report Data

DMR Date	Temperature (Centigrade)		Flow Rate (m^3/second)		Dissolved Oxygen (mg/L)		pH (SU)		Total Phosphorus (mg/L)		Reactive Phosphorus (mg/L)	
	Daily Ave	**Daily Max**	**Daily Ave**	**Daily Max**	**Daily Ave**	**Daily Max**	**Min**	**Max**	**Daily Ave**	**Daily Max**	**Daily Ave**	**Daily Max**
Jul-00[a]	10.33	10.89	1.189	1.306	11.0	11.1	7.96	8.09	0.0133	0.0136	0.005[b]	0.005[b]
Aug-00	10.2	11.6	1.02	1.3	11.0	11.5	8.0	8.1	0.0116	0.013	0.0059	0.0064
Sep-00	9.8	11.8	0.81	1.38	10.6	10.9	7.9	8.12	0.0122	0.0144	0.0061	0.0069
Oct-00	9.1	9.8	0.57	0.93	10.4	10.7	7.8	8.1	0.012	0.014	0.0067	0.0081
Nov-00	8.98	9.75	0.49	0.97	10.9[c]	12.2[c]	7.7	8.14	0.014	0.016	0.006	0.008
Dec-00d	8.2	9.5	0.48	0.67	12.49	12.49	7.85	7.85	0.0109	0.0109	0.0059	0.0059
Jan-01e	7.3	7.6	0.39	0.52								

Notes:

[a] During the month of July 2000, the Lake Source Cooling Heat Exchange Facility was commercially operational (following a brief commissioning period) from July 17 through July 31, therefore the data reported in the DMR is reflective of the 15 days of operation out of the 31 total days in the month.

[b] The data reported for soluble reactive phosphorus in July 2000 is from one sampling date, 7/27/2000, during the last calendar week of July. The SPDES permit requires soluble reactive phosphorus samples to be analyzed weekly. Although a sample was collected by Cornell University during the third calendar week of July, the sample was not analyzed due to laboratory error. This error has been corrected.

[c] One of the five samples analyzed for dissolved oxygen had a false high result and was eliminated from reporting on this DMR on the recommendation of our consultant/analytical laboratory, Upstate Freshwater Institute Inc.

[d] The LSC discharge was shut down for emergency repairs on December 8, 2000 and remained off line for the rest of the month of December. The data reported on the DMR is reflective of monitoring conducted between December 1 and December 8 (samples collected weekly, so the data is from one sampling event).

[e] Please note that there are no data presented in the DMR for effluent parameters DO, pH, total phosphorus, and reactive phosphorus. The LSC discharge was shut down for emergency repairs on December 8, 2000 and remained off line until January 29, 2001. Effluent sampling was conducted the week of January 29 as required by the permit; the effluent sample was collected on Thursday February 1. The effluent data for the sample collected during the last week of January will be included with the data presented in the February DMR.