2003 Big Bowman Pond Water Quality Monitoring Project
Big Bowman Pond (Rensselaer County), New York
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prepared by

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I. Introduction:

Big Bowman Pond is located in the Town of Sand Lake in the south-central portion of Rensselaer County in New York State. It possesses a shoreline length of about 3.1 miles, a surface area of roughly 30.6 acres, and has a mean and maximum depth of 2.8 meters (9 feet) and 10.1 meters (33 feet), respectively. The outlet is located along the northwestern margin of the pond and the pond itself has a flushing rate of about 1.4 times per year.

The pond is utilized primarily for recreational purposes such as boating, swimming, fishing, and ice-skating. Big Bowman Pond possesses a surface water classification of *B*. The *B* classification qualifies water from this body of water to be used as a source of water for primary and secondary contact recreation and fishing.

Adirondack Ecologist's (**AE**) involvement in the management of Big Bowman Pond began during the summer of 2002 when the firm performed a limited reconnaissance inspection of the pond at the request of Tom Simons, Co-President of the Bowman Lake Association (**BLA**). One of the primary concerns of several of the **BLA** members was a perceived change in the density and distribution of the aquatic plant community of the pond. There seemed to be a subjective consensus that aquatic vegetation was becoming more prolific in the pond and some shore owners were concerned that the lake was becoming more eutrophic (productive).

The inspection was performed on August 1, 2002 by boat. The results of the cursory inspection did not yield any definitive information to explain the perceived increase in aquatic vegetation observed by some members of the **BLA**. Other than the presence of *Nymphoides cordatum* (floating heart), a relatively diverse native aquatic plant community was found to exist in Big Bowman Pond. Other than an extensive coverage of water lilies near the northern end of the lake, **AE** felt that the distribution and density of aquatic macrophytes in the pond were normal and healthy for a body of water possessing the same morphological characteristics as Big Bowman.

After a discussion of the findings of the inspection, it was decided by the **BLA** that the collection of current water quality data might help foster a better understanding of the trophic condition of the pond, and thus possibly identify any potential problems or trends if they exist. Based on this decision, a limnological investigation of the pond was initiated in July of 2003 by **AE**.

The primary objective of the investigation was to determine the current quality of the pond's water and to also assess the quality of incoming water from the tributary situated on the southwestern margin of the pond. To accomplish this objective in as cost-effective a manner as possible, **AE** recommended that the pond basin, outlet, and the southwestern tributary be tested twice per year during the summer. A July trip was planned to collect water samples a few weeks prior to that time of the year deemed by the **BLA** to be the "busiest" time of the year, i.e., most intensive use of camps and the pond itself. A follow-up trip in August was also planned to collect water samples a week or so after the period of peak use of the pond. It was hoped that these "snapshots" in time of the water quality condition of the pond before and after peak use would yield a better understanding of the cultural influences on the pond.

A secondary objective of the study was to assist in the creation of an up-to-date scientific database that could be used as a "benchmark" to compare the results of historical and future water quality monitoring efforts with. It was hoped that this database, once established, would serve as an educational and informational resource for shore property owners

The research regimen consisted of tributary, outlet, and basin water testing once during July and once in August. Water quality parameters analyzed were ortho and total phosphorus, total nitrogen, nitrate, chloride, sulfate, pH, alkalinity, conductivity, total dissolved solids, calcium, iron, and turbidity. Surface water chlorophyll a levels were also measured during each sampling trip. A dissolved oxygen and temperature profile was performed at the lake basin testing station during each sampling trip, and secchi disk transparency readings were also obtained.

In addition to the chemistry samples, bacteriological water samples were collected at various locations around the lake. These samples were analyzed for fecal coliform, total coliform, and fecal streptococcus bacteria. The goal of this testing was to help ascertain whether non-point source pollution from septic systems was a major contributing factor to the qualitative "character" of Big Bowman Pond. The decision was made to collect water samples for bacteriological analysis around the majority of the pond's shoreline with a concentration on areas where numerous residences were situated.

The principal investigator for the 2003 study was Steven A. LaMere, a Certified Lake Manager and Certified Fisheries Professional, and the president of **AE**.

II. Methods

Water samples and limnological data were obtained from the lake by **AE** on July 9 and August 12, 2003. In order to ensure the collection of accurate "baseflow" data, no water samples were taken within 48 hours of a major storm event. During each sampling run, a total of four water chemistry samples and eight bacteriological samples were collected. The epilimnetic (i.e., "surface" pondwater) and hypolimnetic (i.e., "bottom" pondwater) samples were collected by boat using a Van Dohrn Sampler. These samples were obtained at a location representative of the pond's basin (Note: A depth finder was utilized to locate this area). The Van Dohrn was utilized to collect an epilimnetic sample of water 1.5 meters below the pond surface and a hypolimnetic sample 1.5 meters above the pond bottom. The tributary and outlet samples were taken via "grab" sampling. The tributary was sampled just before it entered Big Bowman Pond and the outlet sample was taken roughly 10 yards before it drained the pond.

Any chemistry bottles used for the collection of chemistry water samples were first acid-washed in the laboratory and then triple rinsed with distilled water prior to departure for the field. Water samples obtained were stored on ice and transported to the laboratory at the Darrin Fresh Water Institute (**DFWI**) in Bolton Landing, New York within six hours of collection. For information detailing the laboratory procedures followed by the **DFWI** in analyzing the water samples, please refer to *Appendix A*.

A YSI model 50 B dissolved oxygen (DO) meter was utilized to perform a dissolved oxygen and temperature profile of the pond's vertical water column during each trip, and a secchi disk was employed to obtain secchi disk transparency (SDT) measurements.

III. Miscellaneous Information:

The Basics of Lake Ecology

Lakes can be classified according to various chemical, biological, and physical criteria and characteristics. Generally, however, lakes and ponds are classified according to the level of biological productivity or trophic status of the waterbody. Clear, unproductive bodies of water are classified as oligotrophic. These lakes and ponds are normally relatively young (from a geologic perspective) and are nutrient-poor. Mesotrophic ("middle-aged") lakes possess more nutrients and are more biologically productive than oligotrophic lakes. A majority of New York's lakes would probably fall into this category. Eutrophic bodies of water are nutrient-rich and very productive, while hypereutrophic bodies of water possess such high concentrations of soluble nutrients that recreational use impairment can occur.

Eutrophication is a scientific term that refers to the natural "aging" process that all lakes and ponds undergo. Each body of water will, through nutrient enrichment (i.e., phosphorus and nitrogen additions) and basin filling, become shallower with time and progress towards a wetland status. This natural process may take thousands of years. Humans and animals can, however, dramatically speed up this process by their actions or habits. The artificial acceleration of the lake aging process via the introduction of significant amounts of nutrients (e.g., domestic, municipal, and industrial wastewater, fertilizers, animal waste, etc.), sediments (e.g., particulate matter created by watershed disruptions), and detritus is termed cultural eutrophication.

Phosphorus is generally the most limiting nutrient in New York lakes. Since it acts as a fertilizer, the amount or concentration of phosphorus present in lakewater directly influences the extent to which aquatic plants and algae thrive. The more phosphorus that is available the more productive a lake will be. Phosphorus can be introduced into a lake via external sources or it can be recycled internally. Natural weathering and watershed processes, stormwater runoff events, improperly designed or malfunctioning septic systems, industrial or municipal wastewater discharges, near-shore lawn fertilization activities, and watershed and shoreline disruptions are all examples of external input. Internal recycling occurs when phosphorus that is "locked up" in lake bottom sediments becomes redistributed into the water column. This phenomenon is directly related to low dissolved oxygen (DO) conditions in the hypolimnion and is indirectly related to the process of eutrophication.

As a lake progresses towards the eutrophic and hypereutrophic stages of it's "life", it may become more difficult for some forms of aquatic life to survive. Generally, the more productive a body of water the more bacterial decomposition (respiration) present in the bottom sediments. Many of these types of bacteria consume DO during the process of breaking down and consuming bottom detritus. Serious, long-term DO depletions can result in stress to fish and other aquafauna. Most species of fish require a minimum of 4 to 5 ppm (parts per million) of DO for growth and survival. In addition, low dissolved oxygen levels can stimulate or increase internal (in-lake) recycling or "loading" of phosphorus by solubilizing phosphorus that is bound to metals like iron or calcium. Thus, phosphorus that would normally remain unavailable to aquatic life becomes redistributed into the water column via this process.

With an increase in the availability of soluble nutrients, aquatic plants and algae become more abundant. More plant and algal growth leads to a larger accumulation of biomass (living tissue). As these plants senesce and die, they settle to the lake bottom and eventually are decomposed, releasing those nutrients that are locked up in their tissues.

In order to understand the complexity and importance of the aquatic plant community, one first needs to understand a little about the function and life history of aquatic plants. Different aquatic plant species often reproduce by various means. Some species reproduce via flowers or seeds. Some plants spread by utilizing shoots or tubers along the lake bottom in order to extend their "sphere of influence". Other species like Eurasian water milfoil (*Myriophyllum spicatum*), for instance, are capable of reproducing asexually via fragmentation. This exotic plant produces stem fragments which float for a couple of weeks before sinking and eventually taking root in a new locale within the lake, thus, establishing a new watermilfoil bed.

Rooted aquatic macrophytes are generally grouped into three classes. Emergents (e.g., cattails and pipewort) are plants that, to a large extent, grow out of the water. They are normally found growing in shallow water near the shoreline. Floating-leaved plants (e.g., water lillies and watershield), as the name implies, are macrophytes which possess leaves that float on top of the water's surface. Submergents (e.g., elodea, pondweeds, water mil-foils, etc.) are plants that grow entirely beneath the surface of the water. Due to their photosynthetic requirements, these submergents will grow profusely only where underwater illumination (sunlight penetration) is sufficient.

In addition to a variety of rooted aquatic plants, there are also many different species of algae that reside in a lake. Phytoplankton or algae are microscopic plants that live in the open waters of lakes and ponds and serve as a food source for zooplankton. Many of these small plants do not root to the lake bottom, but rather float freely throughout the water column of the lake (e.g., green and yellow-brown algae). They, like rooted macrophytes, produce dissolved oxygen and are nutrient-limited in their growth. In some cases, epiphytic forms of algae (e.g., filamentous green algae) can be seen growing attached to surfaces, such as stones, dock pilings, and macrophytes. Cyanobacteria (or blue-green algae, as they are sometimes referred to) are also organisms that float freely throughout the water column and possess photosynthetic capabilities. Unlike green and yellow-brown algae, however, blue-green algae are not "true" algae, but instead are a type of bacteria. Charophytes (e.g., *Chara spp.* and *Nitella spp.*) are tiny "understory" (low-growing) plants that resemble rooted macrophytes, but in truth are macroalgae.

The relative abundance of phytoplankton is heavily dependent upon the predatory effectiveness of zooplankton. The zooplankton community is comprised of tiny microscopic crustaceans that inhabit lakes, ponds, and rivers. They are an extremely important component of the aquatic food web. The degree to which zooplankton prey upon algae is a function of the species of zooplankton present in a lake at any given time and their average body size. Most species of zooplankton range in size from 0.5 to 1.0 mm (millimeters) in length. Generally, the larger the size of each individual zooplankter the more algae it can consume. The size and species of zooplankton present in a particular lake are in turn dependent upon the extent of predation by zooplanktivorous ("zooplankton-eating") fish, like the yellow or white perch.

There are two major types of crustacean zooplankton: cladocerans (e.g., *Daphnia spp.*, *Bosmina spp.*, etc.) and copepods (e.g., *Cyclops spp.*, *Diaptomus spp.*, *Mesocyclops spp.*, etc.). The relative abundance of various zooplankton species varies greatly, in terms of density, from lake to lake. The density can be as low as <1 individual per liter in oligotrophic waters and as high as 500 individuals per liter in eutrophic lake systems. Cladocerans tend to be more abundant in summer, probably due to the greater availability of food, while copepods, which are generally perennial, exhibit active overwintering populations.

Typically, the zooplankton community of most lakes is composed of five to eight dominant species and several rare forms. The number of species found to be present is normally influenced by factors such as the availability of light, oxygen, food, and nutrients. Temperature and water movements within the lake are also important factors in determining which species will be able to survive and which will eventually become dominant.

During years in which a lake system is dominated by an overabundance of adult zooplanktivorous fish or a "bumper crop" of young-of-the-year (YOY) fish during the summer, it is possible to note observable population shifts within the zooplankton community as a result of increased predation by these fish. Research has indicated that size-selective predation by zooplanktivores can influence the composition and size of zooplankton communities. In general, fish select the more visible, larger zooplankton species such as *Daphnia*, thus allowing for an increase in the relative abundance of smaller zooplankton species. Zooplankton measuring more than 1 millimeter in total length normally suffer the greatest losses due to predation by fish.

A well-established, balanced fish community that contains piscivorous ("fish-eating") species like largemouth bass, smallmouth bass, walleye, etc., is beneficial in controlling zooplanktivorous fish populations. As a result, size-selective predation on zooplankton is diminished and phytoplankton are more efficiently controlled. When explosive phytoplankton growth cycles are prevented from occurring, an overall improvement in lake water clarity is normally observed.

IV. Results:

The following narrative consists of a "summarized interpretation" of the data collected in 2003 on Big Bowman Pond. In addition, references are made to historical data collected by the Rensselaer Polytechnic Institute (**RPI**) in 1985 and 1990 and the Adirondack Lake Survey Corporation (**ALSC**) in 1987. *Appendix E* consists of a map that outlines all of the water testing sites.

A. Water Quality

The results of the water quality monitoring program are presented in this section. Raw data in the form of laboratory printouts and tabulated limnological analyses can be found in *Appendices B* and *C (Tables 1-4)*. *Figures 1* through *3* in *Appendix D* provide pictorial illustrations of historical and current chloride, total phosphorus, and water transparency data collected by various authorities. Caution needs to be exercised when evaluating this data for any perceivable short- or long-term trends since inherent differences in field and laboratory techniques exist from one research authority to another. In addition, there does not yet exist enough historical or current data to accurately determine the extent to which a perceived trend is present.

Dissolved Oxygen

The results of dissolved oxygen and temperature profiles performed in July and August are contained in *Tables 1* through *2* in *Appendix B*. These profiles were performed at a location representative of the basin of the pond. During the performance of these profiles water temperature and dissolved oxygen data was recorded every two feet from the top of the water column to the bottom.

The profiles indicated that in July and August Big Bowman Pond was thermally stratified and that during periods of thermal stratification, the pond possessed an anaerobic hypolimnion. In addition, it was discovered that a large percentage of the water column was so devoid of dissolved oxygen as to not be able to support some forms of aquatic life. During July and August, respectively, roughly 52% and 74% of the total depth of the pond's basin possessed too little dissolved oxygen to adequately support fish life.

Secchi Disk Transparency& Turbidity

July and August secchi disk transparency (SDT) levels were 11.9 and 8.6 feet, respectively. These readings are comparable to those observed in 1989, but are less than those observed in 1985. *Figure 2* plots epilimnetic SDT and total phosphorus data from 1985, 1987, 1989 and 2003.

There appears to be a trend towards decreasing water clarity in Big Bowman Pond since 1985. Seasonal fluctuations in secchi disk transparency are expected, and annual weather patterns can significantly affect water clarity from one year to the next. Additional data needs to be collected to define any long-term changes in the clarity of this pond's surface waters.

Turbidity readings obtained at all sampling locations were within expected ranges.

Phosphorus

Total phosphorus (TP) measurements, which include organically bound phosphates, condensed phosphates, and orthophosphates, were obtained from each water sample collected. The term phosphate is sometimes used interchangeably (and erroneously) with the term phosphorus. Phosphates are chemical compounds that contain the element phosphorus.

All samples collected in 2003 exhibited TP concentrations that were within expected limits, with surface water TP levels for the basin exhibiting readings of 11.7 and 8.9 ppb in July and August, respectively. There has been relatively little change in surface water TP levels since the 1985 study by RPI.

July 2003 hypolimnetic TP levels were higher than August levels and these "deepwater" July levels were roughly three times more "rich" in phosphorus than those observed in the epilimnion. In addition, it was discovered that in August all of the total phosphorus present in the hypolimnetic waters of Big Bowman Pond was in the form of ortho phosphorus. This means that the phosphorus was, for all practical purposes, in a form already immediately available for use by plants and algae once thermal and chemical destratification occurred.

Figure 2 includes a pictorial illustration of six points of TP data assembled over an eighteen-year period (from 1985 to 2003). These data and the graphed trendline seem to suggest that the surface waters of Big Bowman Pond are gradually becoming more enriched. In addition, a review of *Figure 3*, which depicts the hypolimnetic TP levels observed on the same dates, also suggests that the deepwater environment of the pond is becoming more productive over time.

Tributary water sampling and analysis did not yield any data that suggested that excessively high levels of phosphorus were being introduced into the pond from this particular inlet.

Nitrate & Total Nitrogen

Total nitrogen levels were, for the most part, within normal limits for all of the water samples analyzed. The August 12 sample of Big Bowman Pond's hypolimnion was elevated, as would be expected under extensive anaerobic conditions.

Nitrate levels for all water samples collected were also found to be within normal limits. The southwestern inlet exhibited the highest nitrate readings of all collected samples, ranging between 0.12 and 0.20 mg/L.

pH & Alkalinity

Water samples collected from the pond basin, outlet, and the southwestern inlet all exhibited a circumneutral pH. Hypolimnetic pH readings were lower than at other sampling locations. This is a normal phenomenon since phytoplankton are active in the epilimnion and metalimnion of most bodies of water and their activity (photosynthesis) reduces the amount of carbon dioxide in water and thus increases the pH. In addition, the presence of an anaerobic hypolimnion results in the formation of hydrogen sulfide gas which acts to increase the acidity of the bottom water environment.

The alkalinities of water samples taken from the tributary and the pond testing stations were relatively low, as is the case with many of the waters in this area and further north. This means that the buffering capacity of Big Bowman Pond to resist sudden shifts in pH is relatively poor. Fortunately, the pond has not succumbed to this problem despite the existence of poor buffering capability.

Conductivity, Total Dissolved Solids, & Chloride

Electrolytic conductivity or specific conductance is the ability of a solution to pass an electric current. Current is carried by inorganic solids, such as nitrate, sulphate, chloride, and phosphate ions, in water, as well as cations such as sodium, magnesium, calcium, iron, and aluminum. High specific conductance levels can sometimes be indicative of pollution from sources like septic or salt leachate. This is because chlorides, which are present in road de-icing agents (e.g., calcium chloride, sodium chloride, and magnesium chloride) and human waste (Note: On average, one liter of waste contains 5 grams of Cl^-), are electrolytic in nature.

Epilimnetic conductivity levels in July and August of 2003 were comparable to those observed in both 1985 and 1989 with readings ranging between 139.0 and 165.0 uS/cm. Hypolimnetic readings were much higher with the July sample measuring 283.0 and the

August sample measuring 275.0 uS/cm. The southwestern inlet possessed the highest overall reading of 426.0 uS/cm, this reading being observed in July.

Chloride levels during the summer sampling ranged between 26.7 and 32.0 mg/L for the epilimnion and between 56.8 and 57.2 mg/L for the hypolimnion. The outlet exhibited a range between 26.3 and 32.4 mg/L and the southwestern inlet ranged between 35.2 mg/L on August 12 and 80.2 mg/L on July 9. These chloride readings are higher than what **AE** would expect to observe on Big Bowman Pond and confirm the results of earlier studies that have identified elevated chloride levels in this body of water.

Elevated chloride levels are normally indicative of contamination from road salt runoff or septic leachate. The highest chloride levels were registered at the southwestern inlet sampling station in August, but the hypolimnion also possessed consistently high levels. It is theorized that either a long-term (chronic) build up or a relatively dramatic (acute) short-term introduction of chlorides has occurred on Big Bowman Pond. It may be that the bottom sediments of the pond are "saturated" with chlorides, and that this is the reason why hypolimnetic chloride levels were double those in the epilimnion during the summer of 2003.

Figure 1 in the appendix illustrates the chloride levels observed during the various studies performed on the pond since 1985. A review of this figure suggests that the chloride concentration of Big Bowman Pond's surface waters has been steadily increasing over the past eighteen years.

Calcium

Epilimnetic basin calcium levels on July 9 and August 12, 2003 ranged from between 5.0 and 5.5 mg/L. These relatively low concentrations of calcium are consistent with data obtained by RPI in 1989. Hypolimnetic levels were found to be 10.8 mg/L on July 9 and 13.1 mg/L on August 12, and the southwestern inlet possessed calcium concentrations of 9.5 and 16.9 mg/L in July and August, respectively.

While not considered high, these levels are high enough to cause concern for potential zebra mussel (*Dreissena polymorpha*) colonization. Zebra mussels normally require at least 10 to 12 mg/L of calcium in order to form their calcareous shells. Zebra mussels, however, in the relatively short period of time that they have been in North America, have exhibited the ability to adapt much quicker than originally expected to the environmental conditions of our region. It is now widely believed by scientists that the environmental tolerances of zebra mussels are much broader than originally thought, and that this exotic species possesses the ability to take advantage of the presence of "microrefugia". In other words, eventhough a host waterbody may possess calcium concentrations considered too low for large-scale colonization, zebra mussels may still be able to locate and utilize certain unique areas (microrefugia or microhabitats) within that waterbody – areas near inlets with higher calcium concentrations, for instance – which can support them. Thus, the assumption cannot necessarily be made, based on the relatively low calcium concentrations observed, that Big Bowman Pond is protected from such an introduction.

Chlorophyll a

Surface water samples collected from the basin of the pond were analyzed for chlorophyll a, a plant pigment that limnologists often measure to indirectly assess algal biomass.

Epilimnetic chlorophyll a levels for Big Bowman Pond on July 9 and August 12, 2002 were 6.8 and 9.0 mg/L, respectively. These readings are indicative of those normally associated with a late mesotrophic body of water. Relatively little historical chlorophyll a data exists on Big Bowman Pond, and because of this it is difficult to ascertain to what extent the amount of algal biomass present in the pond has changed through the years.

Sulfate

Sulfate levels observed in bodies of water not significantly impacted by atmospheric deposition normally range between 1 and 3 mg/l. All of the sulfate analyses performed on samples obtained from Big Bowman Pond indicated levels less than 3 mg/l.

Bacteriological Analysis

Fecal coliform bacteria grow in the intestinal tracts of warm-blooded animals and are present in fecal wastes. Large numbers of fecal coliform bacteria present in water serve as excellent biological indicators for pathogenic bacteria. Total coliform, on the other hand, are naturally occurring bacteria and are ubiquitous in a lake environment. They can originate from decaying matter in the lake as well as fecal matter. High total coliform bacteria counts do not necessarily mean that the water has been contaminated with sewage.

Fecal streptococcus bacteria are also present in humans, but humans have relatively low levels of this bacteria compared to other warm-blooded mammals. In solid human waste, the ratio of fecal coliform to fecal streptococcus bacteria is about 4 to 1. Ratios from other warm-blooded animals are much lower, normally less than 1 to 1.

The New York State Department of Health (**NYSDOH**) drinking water standards are predicated on total coliform. The drinking water standards in New York allow for 0 colonies coliform per 100 millileters (ml) of sample water. The number of coliform bacteria present in human fecal matter is estimated to be between 10^{11} and 10^{13} (100,000,000,000 to 10, 000,000,000,000) colonies per person per day.

The **NYSDOH** standards for contact recreation for total and fecal coliform require that a logarithmic mean for a series of five or more samples in any 30-day period not exceed 2,400 colonies/100 ml and 200 colonies/100 ml, respectively for each of these types of bacteria. In addition, 20% of the total samples collected during the period may not exceed 5,000 colonies/100 ml for total coliform. Furthermore, when fecal coliform density exceeds 1,000 colonies/100ml for any particular sample, consideration shall be given to closing the beach.

A total of nine bacteriological samples were collected from Big Bowman Pond on July 9 and eight samples were collected on August 12 (see *Appendix E* for a lake study map that outlines the various sampling locations). One of the samples collected in July, a sample from Site #9, was misplaced by the **DFWI** laboratory and never analyzed. Thus, there are eight samples from July and eight samples from August that appear on the data sheets. A sample from Site #8, a site representative of the pond basin, was collected in July but not in August. This sample was collected in July in order to provide some form of "baseline" data with which to compare the results of testing at other locations around the lake with.

A few trends were noticeable in the results of the bacteriological testing program on Big Bowman Pond. First, fecal coliform and fecal streptococcus bacteria were higher in all samples collected on July 9 than those collected on August 12. Second, total coliform samples collected near the western and southern shoreline of the pond possessed higher coliform bacteria counts during the July 2003 sampling than did samples collected in August. Conversely, Site #1 (situated near the northern tip of the pond) and Site #3 (located along the eastern margin of the pond) exhibited much higher total coliform bacteria in August than in July.

While many of the coliform and streptococcus bacterial counts were elevated, none of the readings exceeded **NYSDOH** standards for contact recreation. In addition, there did not appear to be a clear correlation between elevated bacterial readings and intensive use of the lake or it's immediate watershed.

V. Conclusions:

A review of the graphs in *Appendix D* help visualize, to a certain extent, the degree to which any water quality or water clarity changes have occurred in Big Bowman Pond. With the existence of a relatively limited dataset, however, it is not clear yet whether the limnological symptoms and "trends" being observed are primarily a result of cultural or natural causes. In addition, it is not clear as to whether these "trends" are of a short-term or long-term nature. Some of the conclusions from this study are as follows:

1. Data suggest that the pond is a circumneutral, mesotrophic body of water. Big Bowman Pond occasionally possesses chlorophyll a levels inconsistent with the mesotrophic classification, and could be classified as an early eutrophic pond during these times.

2. The performance of dissolved oxygen profiles at the basin of the pond during the summer indicate that periods of hypolimnetic oxygen depletion are present in July and August.

3. Internal regeneration of phosphorus in the hypolimnion of the pond has been observed and documented. It also appears that hypolimnetic TP levels have gradually increased from 1985 to 2003, and that a significant portion of the phosphorus available in the hypolimnion is in the form of ortho phosphorus.

4. Surface water conductivity and total phosphorus levels appear to have gradually increased since 1985, and water clarity, as evidenced by historical and current secchi disk transparency data, appears to be on the decline during the same time period.

5. No correlation between intensive use of Big Bowman Pond by shore owners and increasing coliform and or streptococcus bacterial levels was observed.

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APPENDIX

APPENDIX A

Laboratory Protocol & Exhibit 1

Analyte	*Method*	*Instrument*
pH	Electrometric	Orion, Model 231
Specific Conductance	Wheatstone Bridge type meter (EPA Method 120.1)	Fisher Digital Conductivity Meter
Alkalinity	Titrimetric – pH 4.5 (EPA Method 310.1)	Orion, Model 231
Chloride	Ion Chromatograph (EPA Method 300)	Dionex QIC
Chlorophyll & Pheophytin	Fluorometric (Standard Methods 10200)	Turner, Model 10-AU
Nitrate	Ion Chromatograph (EPA Method 300)	Dionex QIC
Ammonia	Phenate Method (Standard Methods 4500-NH_3 F.)	Spectronics Genesys 5
Soluble Reactive Silica	Molybdate Reactive (Standard Methods 4500E)	Technicon Autoanalyzer II
Sulfate	Ion Chromatograph (EPA Method 300)	Dionex QIC
Total & Total Soluble Phosphorus	Colorimetric – Persulfate Oxidation (EPA Method 365.2)	Spectronics Genesys 5
Molybdate Reactive Phosphorus (OP)	Colorimetric (EPA Method 365.2)	Spectronics Genesys 5
Total Nitrogen	Colorimetric – Persulfate Oxidation	Spectronics Genesys 5
Metals	Atomic Absorption Spectroscopy – Flame Standard Methods 3111	Perkin Elmer PE 5000

EPA Methods listed in this table are derived from: US EPA, Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Cincinnati, OH.
Standard Methods for the Examination of Water and Wastewater, 20th ed. (1998). APHA, AWWA, & WEF. Washington, DC.

Exhibit 1: Index of Water Quality Parameters Analyzed

Conductivity - *also known as specific conductance, it is a measure of how resistant a particular solution is to the flow of electricity. The theory behind conductivity is that the resistivity of a solution is inversely proportional to its ion content. Thus, specific conductance serves as an indirect measurement of the number of dissolved ions (electrolytes) in water. Soft water lakes have few dissolved ions, resulting in a specific conductance of < 100 umho/cm or uS/cm; hard water lakes often have a specific conductance > 300 umho/cm. In the field, conductivity values provide a general measure of the amount of Total Dissolved Solids (TDS) present in the solution.*

Turbidity - *suspended materials such as clay, silt, algae, and other constituents can cause light to be scattered and absorbed, not transmitted in straight lines through water. Turbidity has a major influence on secchi disk transparency and therefore the clarity of a body of water.*

pH - *A measure of the number of hydrogen ions in solution. pH is measured on a scale ranging from 1 to 14, with "1" being extremely acidic in nature and "14" being extremely alkaline in nature. Most lakes are circumneutral (a pH range of 6 to 9); an acceptable range for most aquatic organisms. Pure rainwater has a pH of around "5.6", while acidic precipitation can have a pH as low as "4".*

Alkalinity - *measures the capacity of a lake to "buffer" or neutralize acidic inputs. Alkalinity usually refers to the quantity and kinds of compounds present which tend to shift the pH towards basic. These compounds usually consist of carbonates, bicarbonates, and hydroxides. Usually hardwater lakes exhibit higher alkalinities than do softwater lakes.*

Total Phosphorus - *is normally the most limiting nutrient in New York State lakes, and thus serves as the focus of most nutrient abatement strategies. Total phosphorus levels > 20 ug/l or ppb (parts per billion) are often found in bodies of water with significant algae growth. Oligotrophic lakes normally have total phosphorus levels < 10 ug/l.*

Ortho Phosphorus - *the most readily available form of phosphorus to aquatic plants and algae.*

Total Nitrogen - *is an essential plant nutrient required by all living plants and animals for building protein, and as such, it influences the productivity of aquatic systems. Nitrogen concentrations are usually < 1 mg/l in most of our relatively pristine Adirondack lakes, with concentrations in the neighborhood of 0.1 to 0.6 mg/l being commonly found.*

Nitrate - *occurs naturally, but is also found in agricultural fertilizers, livestock manure, and in sewage and industrial wastes. Nitrates in large amounts in water can cause "blue baby syndrome" or Methemoglobinemia in infants less than six months of age, and they can contribute significantly to lake eutrophication. Most natural lakes exhibit nitrate concentrations < 1 mg/l, but in the Adirondacks, nitrate concentrations are usually < 0.3 mg/l.*

Chloride - *is one of the major anions to be found in water and sewage.*

Calcium - *is a metal found naturally in lake systems. Note: Zebra mussels normally require 9 to 12 mg/l of calcium to form their calcareous shells.*

Hardness - *is the total alkaline earth content that can produce insoluble soaps. In areas where soils are sandy and porous, total hardness is low, whereas in areas rich in limestone and/or dolomite or where clay soils abound, total hardness is high. Hardness is expressed as mg/Liter or ppm of* $CaCO_3$*. Soft, medium, and hard water normally possess hardness ranges of 0-50 ppm, 51-100 pmm, and 101-300 ppm, respectively.*

APPENDIX B

Dissolved Oxygen & Temperature Profiles
(Tables 1 & 2)

Table 1. Big Bowman Pond Limnological Analysis – July 2003

Lake: Big Bowman Pond
County: Rensselaer **State:** New York
Date: 7/09/03 **Secchi Disk Transparency:** 11.9 feet **Cloud Cover:** 100%
Time: 10:00 a.m. **Weather:** Rain (showers)

Depth (feet)	Temperature (C)	Dissolved Oxygen (mg/l)
Surface	25.4	7.7
1	25.5	7.7
2	25.5	7.7
3	25.5	7.7
4	25.5	7.7
5	25.5	7.8
6	25.5	7.8
7	25.0	8.0
8	24.9	8.4
9	22.4	10.0
10	20.7	8.6
11	19.1	7.8
12	16.9	6.9
13	14.9	6.9
14	13.3	6.9
15	12.5	6.0
16	11.1	4.1
17	10.1	2.1
18	9.5	0.7
19	8.5	0.7
20	8.0	0.6
21	7.6	0.6
22	7.2	0.6
23	6.7	0.5
24	6.5	0.5
25	6.4	0.5
26	6.3	0.5
27	6.3	0.5
28	6.2	0.5
29	6.1	0.5
30	6.1	0.5
31	6.1	0.5

Table 2. Big Bowman Pond Limnological Analysis – August 2003

Lake: Big Bowman Pond
County: Rensselaer **State:** New York
Date: 8/12/03 **Secchi Disk Transparency:** 8.6 feet **Cloud Cover:** 100%
Time: 11:15 a.m. **Weather:** Warm & cloudy (showers earlier in morning)

Depth (feet)	Temperature (C)	Dissolved Oxygen (mg/l)
Surface	25.0 (77.0 °F)	8.9
1	25.1	8.9
2	24.8	9.1
3	24.6	9.0
4	24.5	8.8
5	24.4	8.6
6	24.3	8.6
7	23.9	7.8
8	23.3	5.8
9	22.4	2.2
10	21.6	0.6
11	20.7	0.2
12	19.8	0.2
13	18.1	0.4
14	15.9	0.4
15	14.5	0.3
16	13.1	0.3
17	11.8	0.3
18	10.7	0.3
19	9.5	0.3
20	8.9	0.3
21	8.3	0.3
22	7.6	0.3
23	7.4	0.2
24	7.3	0.2
25	7.1	0.2
26	7.0	0.2
27	6.9	0.2
28	6.6	0.2
29	6.5	0.2
30	6.4	0.2
31	6.4 (43.5 °F)	0.2

APPENDIX C

Water Quality Monitoring Data
(Tables 3 & 4)

Table 3. July 2003 WQ Data
Big Bowman Pond

Site	Number	Date	pH	air-eq pH	Alkalinity mg/l $CaCO_3$	OP ug P/l	TP ug P/l	TN mg N/l	Cl mg/l	NO_3 mg N/l	Sulfate mg S/l
Main Lake, epilimnion	LM3-19	9-Jul-03	7.72	6.98	13.0	3.2	11.7	0.28	32.0	lt 0.01	1.53
Main Lake, hypolimnion	LM3-20	9-Jul-03	6.67	6.46	44.0	11.7	32.3	0.73	56.8	lt 0.01	1.13
Southwestern Inlet	LM3-21	9-Jul-03	7.37	7.20	50.0	20.1	30.0	0.52	80.2	0.21	2.54
Outlet	LM3-22	9-Jul-03	7.36	6.75	62.0	4.3	16.5	0.33	32.4	lt 0.01	1.58

Site	Number	Date	Calcium mg/l	Iron mg/l	Chlorophyll ug/l	Conductivity uS/cm	TDS mg/L	Turb. NTU
Main Lake, epilimnion	LM3-19	9-Jul-03	5.7	lt 0.05	6.8	165.0	82.0	0.2
Main Lake, hypolimnion	LM3-20	9-Jul-03	10.8	0.17		283.0	141.0	2.2
Southwestern Inlet	LM3-21	9-Jul-03	16.9	lt 0.05		426.0	213.0	0.3
Outlet	LM3-22	9-Jul-03	5.5	lt 0.05		166.0	83.0	0.2

lt = less than

Site	Number	Total coliform colonies/100ml	Fecal coliform colonies/100ml	Fecal strepticocci colonies/100ml
Site #2	03-125	60	69	21
Site #1	03-126	180	130	45
Site #5	03-127	330	320	184
Site #6	03-128	350	68	239
Site #3	03-129	130	65	57
Site #7	03-130	340	75	260
Site #4	03-131	370	191	120
Site #8	03-132	150	23	500

Table 4. August 2003 WQ Data
Big Bowman Pond

Site	Number	Date	pH	air-eq pH	Alkalinity mg/l $CaCO_3$	OP ug P/l	TP ug P/l	TN mg N/l	Cl mg/l	NO_3 mg N/l	Sulfate mg S/l
Main Lake, epilimnion	LM3-31	12-Aug-03	7.35	7.12	15.0	2.9	8.9	0.37	26.7	lt 0.01	1.32
Main Lake, hypolimnion	LM3-32	12-Aug-03	6.76	6.68	55.0	12.7	10.6	3.19	57.2	lt 0.01	0.13
Southwestern Inlet	LM3-33	12-Aug-03	7.21	7.21	95.0	13.5	13.7	0.50	35.2	0.12	2.03
Outlet	LM3-34	12-Aug-03	7.18	6.98	13.0	2.2	8.2	0.32	26.3	lt 0.01	1.30

			Calcium mg/l	Iron mg/l	Chlorophyll ug/l	Cond. uS/cm	TDS mg/L	Turb. NTU
Main Lake, epilimnion	LM3-31	12-Aug-03	5.4	lt 0.05	9.0	139.0	69.0	0.2
Main Lake, hypolimnion	LM3-32	12-Aug-03	13.1	9.2		275.0	137.0	2.0
Southwestern Inlet	LM3-33	12-Aug-03	9.5	lt 0.05		223.0	111.0	0.4
Outlet	LM3-34	12-Aug-03	5.0	lt 0.05	3.7	144.0	72.0	0.1

lt = less than

		Total coliform colonies/100ml	Fecal coliform colonies/100ml	Fecal strepticocci colonies/100ml
Site #1	03-193	600	14	22
Site #3	03-194	130	14	7
Site #6	03-195	30	3	46
Site #9	03-196	30	4	77
Site #2	03-197	22	4	12
Site #7	03-198	50	25	13
Site #4	03-199	30	1	108
Site #5	03-200	60	4	30

APPENDIX D

Graph (Figures 1 through 3)

Figure 1. 1985-2003 Big Bowman Pond Epilimnetic Basin Chloride Levels

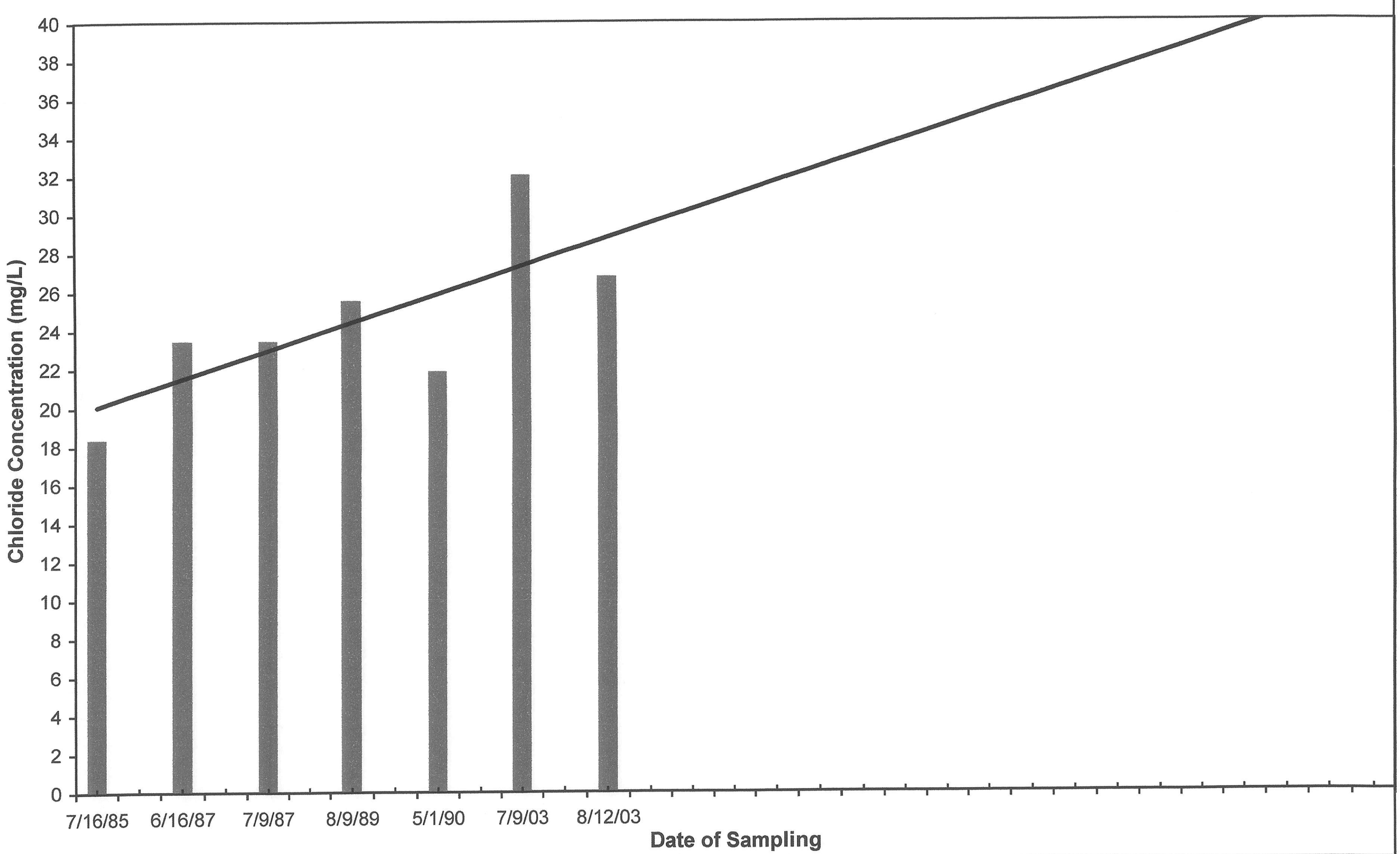


Figure 2. 1985-2003 Big Bowman Pond Epilimnetic Basin Total Phosphorus vs. Secchi Disk Transparency Levels

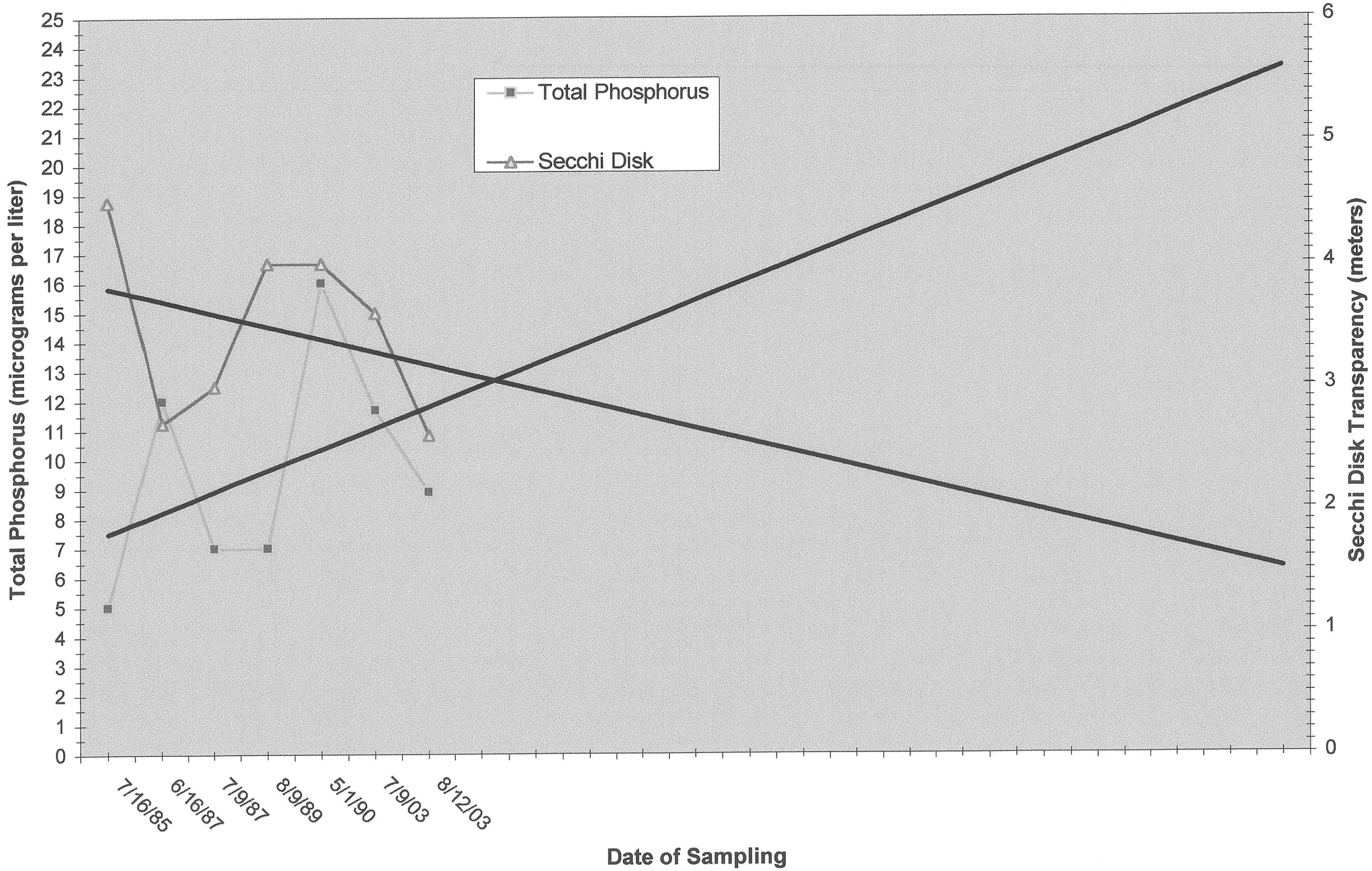
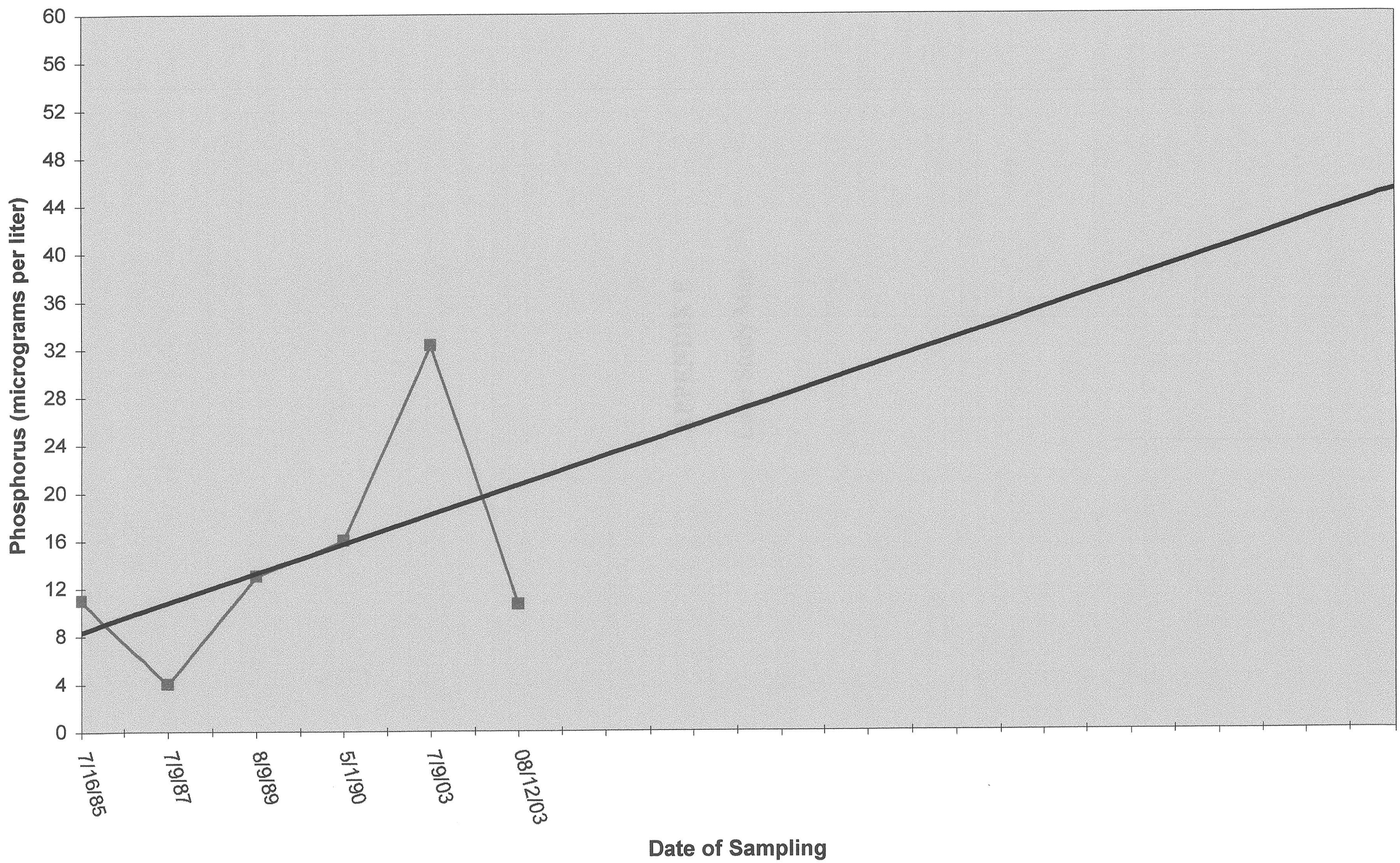
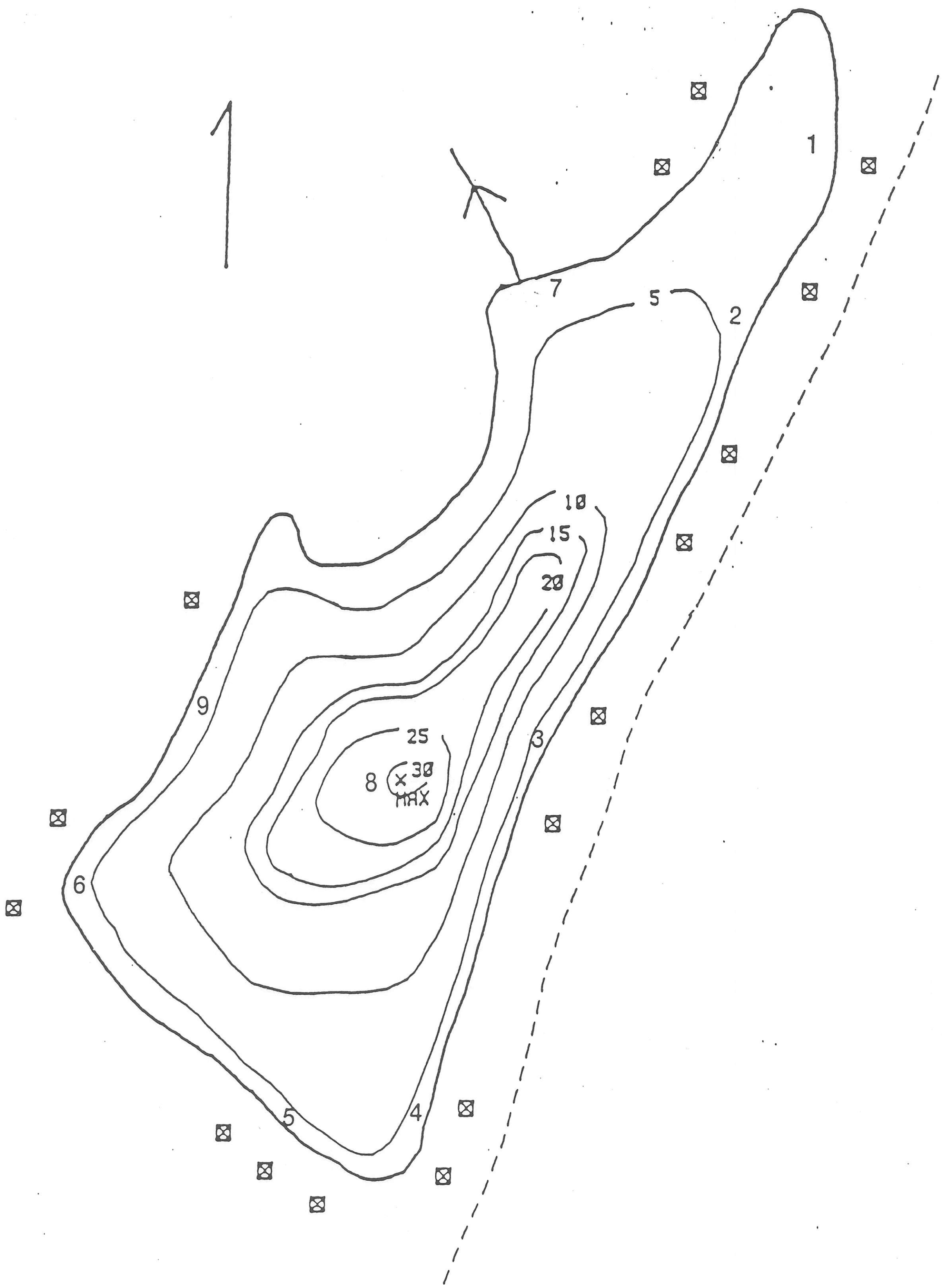


Figure 3. 1985-2003 Big Bowman Pond Hypolimnetic Basin Phosphorus Concentrations





BIG BOWMAN POND
13-Ø444
ALSC 6/15/87
CONTOUR INTERVAL: 5 FT
SURFACE AREA: 3Ø ACRES
MAXIMUM DEPTH: 33 FT

325'
⊠ DWELLING
-- ROAD/TRAIL