# BANANA LAKE SEDIMENT INACTIVATION PROJECT
# Polk County Contract #06-267

# PRE- & POST-TREATMENT MONITORING RESULTS

**February 2008**

**Prepared For:**

**Polk County**
**Natural Resources Division**

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# 1. Introduction

## 1.1 Site History

Banana Lake is a 242-acre waterbody located in unincorporated Polk County, south of the City of Lakeland and west of Lake Hancock. A location map for Banana Lake is given on Figure 1. Banana Lake outfalls to Banana Creek which discharges into Lake Hancock, Saddle Creek, and ultimately into the Peace River. The drainage basin for Banana Lake is largely urbanized and includes much of the City of Lakeland. Also included in this evaluation is Stahl Lake, a 30.6-acre waterbody located northwest of Banana Lake and connected to Banana Lake by a navigable channel. Inflows from the Banana Lake drainage basin enter at the northwest corner of Stahl Lake, passing through Stahl Lake before entering Banana Lake. An aerial overview of Banana Lake and Stahl Lake is given in Figure 2.

## 1.2 Summary of Historical Data

Over the past several decades, Banana Lake has been characterized by elevated levels of total phosphorus, chlorophyll-a, and total nitrogen, combined with poor water column clarity. According to the Polk County Water Atlas, the historic average Trophic State Index (TSI) for Banana Lake from 1984-2005 is 83.7, indicating hypereutrophic conditions. Phosphorus release and recycling from nutrient-rich sediments is thought to be a contributing factor to the ongoing poor water quality characteristics within the lake.

## 1.3 Purpose of This Project

The objective of this project is to reduce internal phosphorus loading to Banana Lake from existing sediments, improving water quality and reducing downstream loadings to Lake Hancock, Saddle Creek, and the Peace River. This reduction of internal phosphorus loading is being considered at this time because many other sources of phosphorus to the lake, including historical point source inputs, have been eliminated or treated in some way.

## 1.4 Evaluation of Sediment Inactivation Requirements

During January 2006, a report was issued by Environmental Research & Design, Inc. (ERD) titled “Banana Lake Sediment Characterization and Inactivation Study” which summarized the results of field monitoring and laboratory analyses to evaluate sediment characteristics in Banana Lake and Stahl Lake. Sediment samples were collected at a total of 47 sites in Banana Lake and Stahl Lake, and the 0-10 cm layer was carefully sectioned off for further analyses. The physical and chemical characteristics of the collected sediment samples were quantified, and a speciation process was conducted to evaluate the potential for internal recycling of phosphorus from sediments into the overlying water column. This analysis indicated that approximately 39% of the existing total phosphorus within the sediments of Banana Lake and Stahl Lake is potentially available for release into the overlying water column.

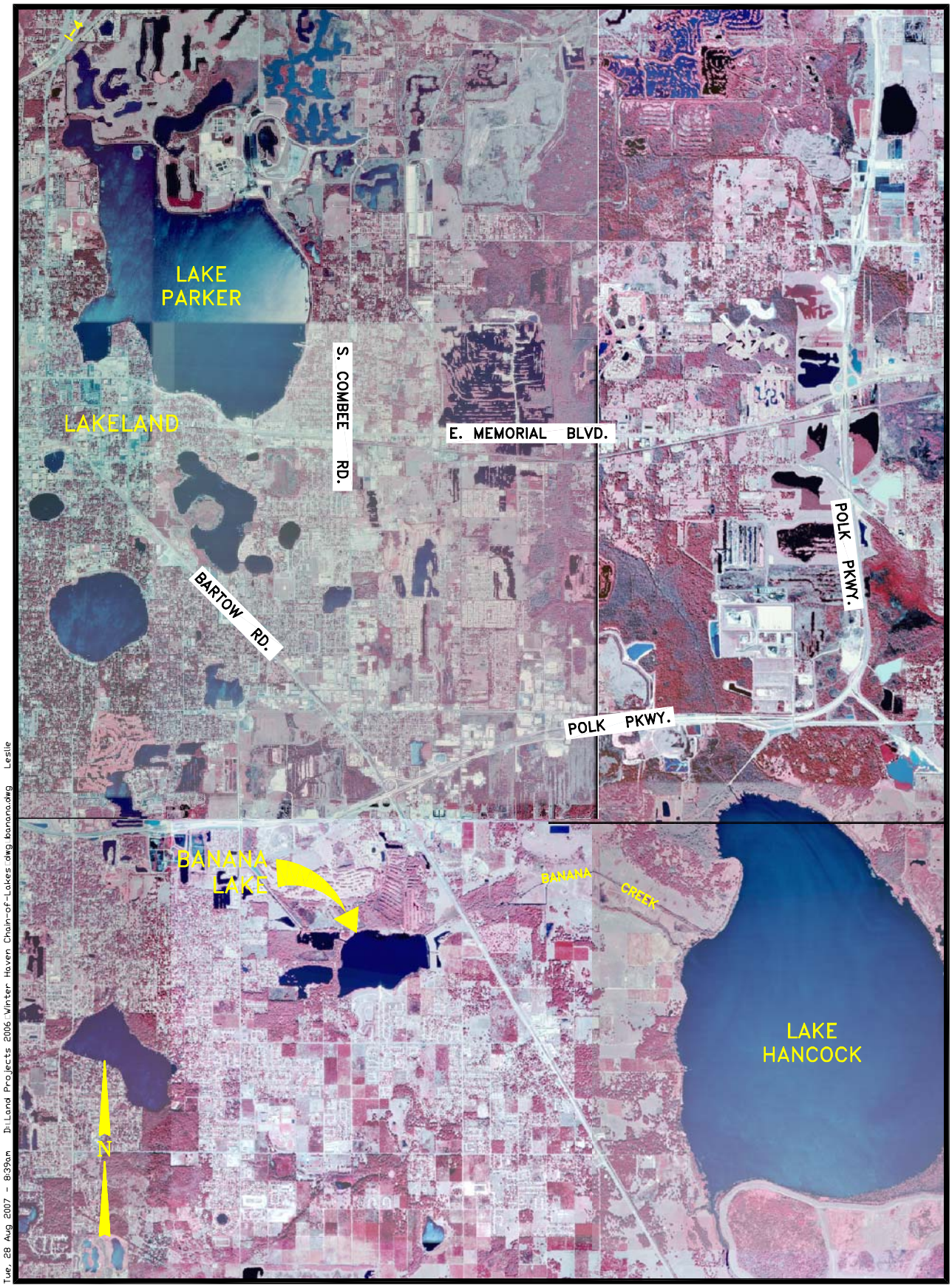


Figure 1. Location Map for Banana Lake.

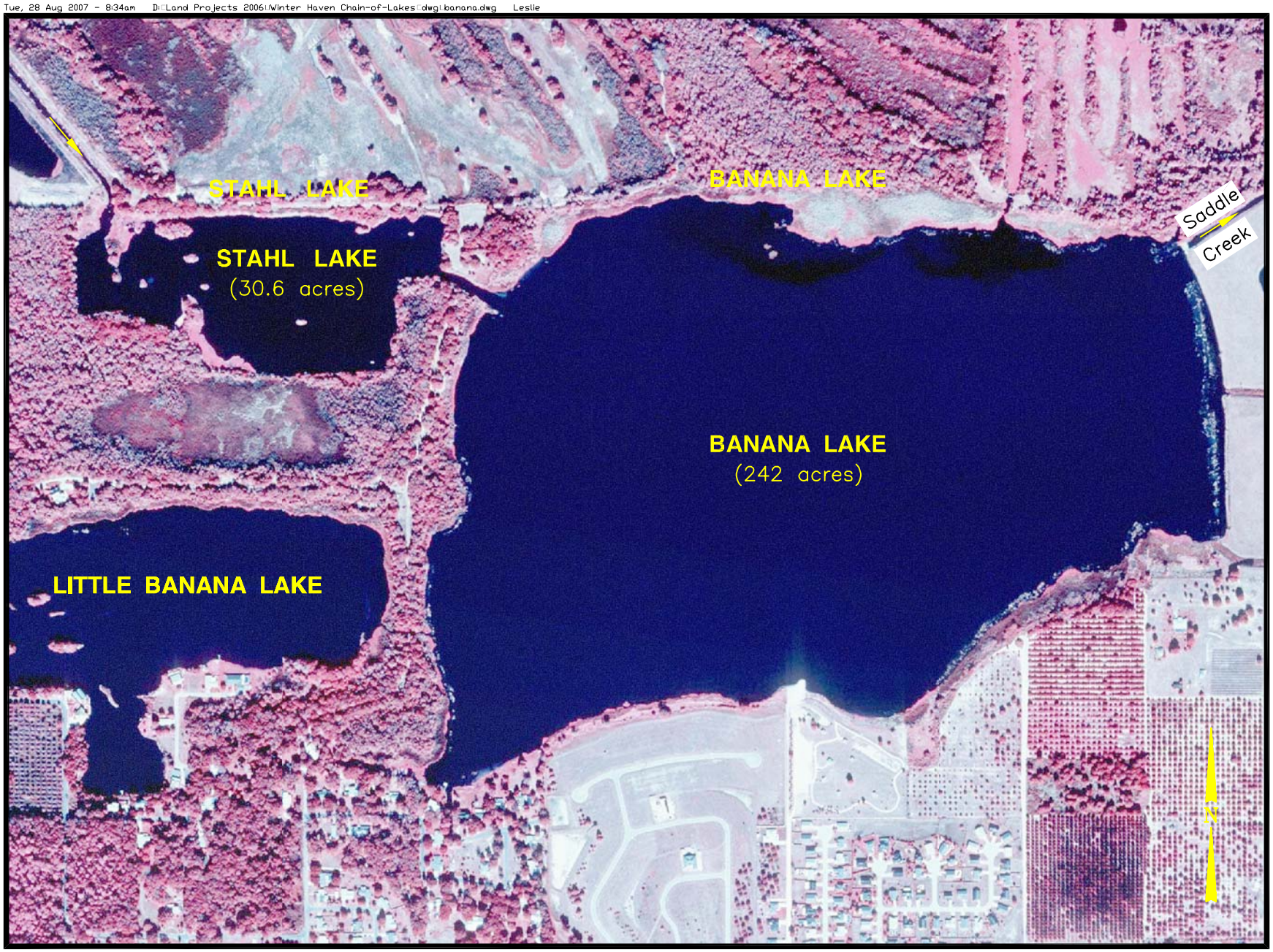


Figure 2. Overview of Banana Lake and Stahl Lake.

Based upon the analysis conducted by ERD, the 0-10 cm layer of sediments in Banana Lake contain approximately 1,580,938 moles of available phosphorus, with an additional 302,571 moles of available phosphorus in the sediments of Stahl Lake, for a total of 1,883,509 moles of available phosphorus to be inactivated in the two lakes. Using an aluminum: phosphorus (Al:P) ratio of 2:1, a total of 3,767,018 moles of aluminum is required for sediment inactivation in Banana Lake and Stahl Lake. This equates to an alum volume of approximately 458,701 gallons.

## 1.5 Alum Application

The recommended alum addition of 458,701 gallons to Banana Lake and Stahl Lake would easily exceed the available buffering capacity within the two lakes, resulting in a rapid decrease in water column pH, even if the alum application was divided into 2-3 separate treatments. Therefore, sodium aluminate (an alkaline form of alum) was used as a buffering agent during the application process. Sodium aluminate provides a high level of buffering, as well as supplemental aluminum ions, which reduces the total amount of alum required.

Pre-application composite surface water samples were collected from Banana Lake and Stahl Lake and evaluated in the ERD laboratory to determine the appropriate ratio of alum: sodium aluminate to maintain neutral pH conditions during the application process. Based upon the laboratory testing, a ratio of approximately 4.5 gallons of alum:1 gallon sodium aluminate was determined to be necessary to maintain neutral pH conditions. This ratio was used to establish the relative quantities of alum and sodium aluminate applied to each lake.

The recommended alum:sodium aluminate application to Banana Lake and Stahl Lake was divided into two separate applications. The first application was conducted from January 11-February 15, 2007. A summary of alum and sodium aluminate applications during this period is given in Table 1. Overall, 150,033 gallons of liquid alum and 30,517 gallons of sodium aluminate were added during this application.

A second alum:sodium aluminate application was conducted from July 30-August 23, 2007. A summary of alum and sodium aluminate applications during this period is given in Table 2. During this application, approximately 137,934 gallons of liquid alum and 34,204 gallons of sodium aluminate were applied. The two combined applications resulted in a total of 3,767,018 moles of aluminum applied to the two lakes.

# TABLE 1

## BANANA LAKE AND STAHL LAKE
## ALUM APPLICATION SUMMARY
## (First Application)

| DATE | ALUM APPLIED | | | SODIUM ALUMINATE APPLIED | | |
|---|---|---|---|---|---|---|
| | (lbs) | (gal) | (moles Al) | (lbs) | (gal) | (moles Al) |
| 1/11/07 | 50,102 | 4,502 | 36,958 | 45,880 | 3,767 | 80,836 |
| 1/15/07 | 50,091 | 4,501 | 36,949 | | 0 | 0 |
| | 50,101 | 4,501 | 36,957 | | 0 | 0 |
| 1/16/07 | 50,108 | 4,502 | 36,962 | 48,200 | 3,957 | 84,924 |
| | 50,108 | 4,502 | 36,962 | | 0 | 0 |
| 1/18/07 | 50,090 | 4,500 | 36,949 | 47,280 | 3,882 | 83,303 |
| | 50,103 | 4,502 | 36,958 | | 0 | 0 |
| 1/19/07 | 50,086 | 4,500 | 36,946 | | 0 | 0 |
| | 50,085 | 4,500 | 36,945 | | 0 | 0 |
| 1/22/07 | 50,091 | 4,501 | 36,949 | 46,280 | 3,800 | 81,541 |
| | 50,098 | 4,501 | 36,955 | | 0 | 0 |
| 1/23/07 | 50,089 | 4,500 | 36,948 | 44,680 | 3,668 | 78,722 |
| | 50,089 | 4,500 | 36,948 | | 0 | 0 |
| 1/31/07 | 50,106 | 4,502 | 36,960 | | 0 | 0 |
| | 50,101 | 4,501 | 36,957 | | 0 | 0 |
| | 50,101 | 4,501 | 36,957 | | 0 | 0 |
| 2/1/07 | 50,094 | 4,501 | 36,952 | | 0 | 0 |
| | 50,069 | 4,499 | 36,933 | | 0 | 0 |
| 2/2/07 | 50,104 | 4,502 | 36,959 | | 0 | 0 |
| | 50,109 | 4,502 | 36,963 | | 0 | 0 |
| 2/5/07 | 50,095 | 4,501 | 36,952 | 46,200 | 3,793 | 81,400 |
| | 50,076 | 4,499 | 36,938 | | 0 | 0 |
| 2/6/07 | 50,033 | 4,495 | 36,907 | | 0 | 0 |
| | 50,082 | 4,500 | 36,943 | | 0 | 0 |
| 2/9/07 | 50,104 | 4,502 | 36,959 | | 0 | 0 |
| | 50,088 | 4,500 | 36,947 | | 0 | 0 |
| 2/12/07 | 50,097 | 4,501 | 36,954 | 47,080 | 3,865 | 82,950 |
| | 50,097 | 4,501 | 36,954 | | 0 | 0 |
| 2/13/07 | 50,092 | 4,501 | 36,950 | | 0 | 0 |
| | 50,094 | 4,501 | 36,952 | 46,100 | 3,785 | 81,224 |
| 2/14/07 | 50,097 | 4,501 | 36,954 | | 0 | 0 |
| 2/15/07 | 50,098 | 4,501 | 36,955 | | 0 | 0 |
| | 50,095 | 4,501 | 36,952 | | 0 | 0 |
| | 16,791 | 1,509 | 12,386 | | 0 | 0 |
| **Totals:** | | **150,033** | **1,231,769** | | **30,517** | **654,900** |

**Total Moles Applied: 1,886,669**

## TABLE 2

## BANANA LAKE AND STAHL LAKE
## ALUM APPLICATION SUMMARY
## (Second Application)

| DATE | ALUM APPLIED | | | SODIUM ALUMINATE APPLIED | | | |
|---|---|---|---|---|---|---|---|
| | (lbs) | (gal) | (moles Al) | (lbs) | (gal) | (% $Al_2O_3$) | (moles Al) |
| 7/30/07 | 50,101 | 4,501 | 36,957 | 41,440 | 3,376 | 19.79 | 73,005 |
| | 50,121 | 4,503 | 36,972 | | | | |
| 7/31/07 | 50,118 | 4,503 | 36,969 | 41,820 | 3,407 | 19.92 | 74,158 |
| | 50,100 | 4,501 | 36,956 | | | | |
| 8/2/07 | 50,115 | 4,503 | 36,967 | | | | |
| | 50,120 | 4,503 | 36,971 | | | | |
| 8/3/07 | 50,117 | 4,503 | 36,969 | 41,940 | 3,416 | 20.16 | 75,267 |
| | 50,120 | 4,503 | 36,971 | | | | |
| 8/6/07 | 50,113 | 4,503 | 36,966 | 41,860 | 3,410 | 20.02 | 74,602 |
| | 50,106 | 4,502 | 36,960 | | | | |
| 8/7/07 | 50,115 | 4,503 | 36,967 | | | | |
| | 50,120 | 4,503 | 36,971 | | | | |
| 8/9/07 | 50,118 | 4,503 | 36,969 | 42,120 | 3,431 | 20.31 | 76,152 |
| | 50,107 | 4,502 | 36,961 | | | | |
| 8/10/07 | 50,095 | 4,501 | 36,952 | 41,880 | 3,411 | 19.95 | 74,376 |
| | 50,095 | 4,501 | 36,952 | | | | |
| 8/13/07 | 50,092 | 4,501 | 36,950 | | | | |
| | 50,013 | 4,494 | 36,892 | | | | |
| 8/14/07 | 50,105 | 4,502 | 36,960 | 42,440 | 3,457 | 20.28 | 76,618 |
| | 50,120 | 4,503 | 36,971 | | | | |
| 8/16/07 | 50,111 | 4,502 | 36,964 | 42,120 | 3,431 | 19.68 | 73,790 |
| | 50,114 | 4,503 | 36,966 | | | | |
| 8/17/07 | 50,108 | 4,502 | 36,962 | | | | |
| | 50,094 | 4,501 | 36,952 | | | | |
| 8/20/07 | 50,122 | 4,503 | 36,972 | 42,560 | 3,467 | 20.16 | 76,380 |
| | 50,122 | 4,503 | 36,972 | | | | |
| 8/21/07 | 50,103 | 4,502 | 36,958 | 41,720 | 3,398 | 19.95 | 74,092 |
| | 50,049 | 4,497 | 36,918 | | | | |
| 8/23/07 | 50,108 | 4,502 | 36,962 | | | | |
| | 50,057 | 4,497 | 36,924 | | | | |
| | 32,110 | 2,885 | 23,686 | | | | |
| **Totals:** | | **137,934** | **1,132,441** | | **34,204** | | **748,440** |

**Total Moles Applied: 1,880,349**

## 2. Pre- and Post-Monitoring Activities

Pre- and post-treatment surface water samples were collected near the geographic center of Banana Lake and Stahl Lake. Collection of surface water samples was conducted by ERD using a 12-volt portable peristaltic pump following procedures outlined in DEP-SOP, Section 4.2.3.3 – Sample Acquisition. One surface water sample was collected at a water depth equal to one-half of the Secchi disk depth, and another (if applicable) at approximately 0.5 m from the lake bottom at each site. All samples were placed in low-density polyethylene (LDPE) sample containers as appropriate for the parameters to be analyzed. Collected samples were preserved in the field, placed on ice, and returned to the ERD laboratory where each of the samples was analyzed for general parameters, nutrients, chlorophyll-a, and dissolved aluminum.

Measurements of pH, dissolved oxygen, water temperature, specific conductivity, and oxidation/reduction potential (ORP) were performed at each site using a Hydrolab Data Sonde 4a water quality monitor with measurements beginning 0.25 m and 0.5 m below the water surface and extending at 0.5 m intervals through the water column to the bottom. Measurements of Secchi disk depth (water column transparency) were also conducted at each monitoring location. Pre- and post-calibration was performed and documented on the Hydrolab unit for each day of use based on the manufacturer's instructions.

All operating procedures for field activities adhered to standard operating procedures outlined in *DEP-SOP-001/01, Standard Operating Procedures for Field Activities*, dated February 1, 2004. Additional details concerning equipment cleaning, decontamination, collection methods and references, laboratory analytical methods, and detection limits are contained in the document titled *"Banana Lake Sediment Inactivation Project – Pre- and Post-Treatment Monitoring Plan"*, dated June 2007, prepared by ERD.

## 3. Pre- and Post-Treatment Monitoring Results

### 3.1 Vertical Profiles

A complete listing of vertical field profiles of pH, dissolved oxygen, temperature, specific conductivity, and turbidity collected in Banana Lake and Stahl Lake prior to and following each of the two surface applications is given in Appendix A. A compilation of vertical depth profiles collected in Banana Lake is given on Figure 3. No significant thermal stratification was observed in Banana Lake during any of the monitoring events. Pre-treatment pH values in Banana Lake were extremely elevated, with values approaching 10 units. Gradual decreases in pH in Banana Lake were observed with each subsequent alum addition. At the completion of the first alum application, measured pH values ranged from approximately 6-7. A trend of increasing pH was observed between the two applications, with a subsequent decrease following the second application.

Relatively isograde conductivity profiles were observed in upper portions of the water column of Banana Lake during most events. However, significant increases in conductivity were observed near the water-sediment interface, providing evidence of internal recycling within the lake. Similarly, relatively good concentrations of dissolved oxygen were observed in upper portions of the water column during most monitoring events. However, rapid reductions in dissolved oxygen were observed at water depths of approximately 1 m or greater during 6 of the 9 monitoring events. This rapid oxygen depletion corresponds closely to the elevated levels of conductivity.

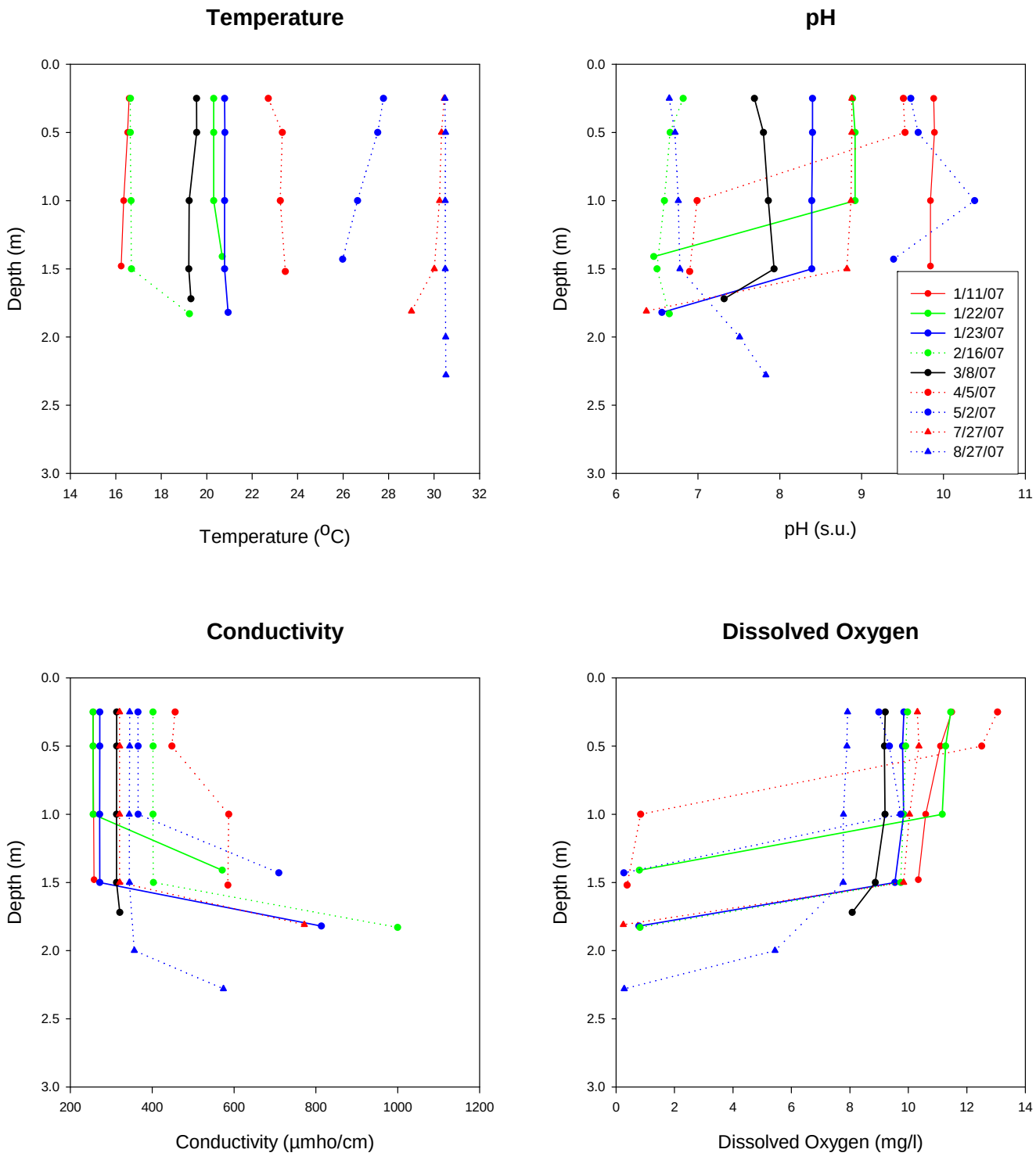


Figure 3. Compilation of Vertical Depth Profiles Collected in Banana Lake.

A compilation of vertical profiles collected in Stahl Lake is given in Figure 4. No significant thermal stratification was observed in Stahl Lake, although a general trend of decreasing temperature with increasing water depth was observed during most events. A similar pattern was observed for vertical pH measurements in Stahl Lake which also exhibited a decrease with increasing water depth during most events. A relatively unusual pH profile was observed during the May 2007 monitoring event, with localized pH maxima observed at water depths of 2 m and 5 m. Relatively uniform conductivity measurements were observed in upper portions of the water column, with substantial increases observed near the water-sediment interface during approximately half of the monitoring events. Adequate levels of dissolved oxygen were observed in Stahl Lake to a water depth of approximately 2-3 m during most monitoring events. Below this depth, anoxic conditions were observed during 7 of the 9 events, extending to the lake bottom.

## 3.2 Laboratory Measurements

A complete listing of the results of laboratory chemical analyses conducted on surface water samples collected in Banana Lake and Stahl Lake before and following each of the two surface treatment applications is given in Appendix B. A summary of water quality characteristics measured in Banana Lake before, during, and after the initial alum treatment is given in Table 3. Data presented in this table reflect laboratory analyses on samples collected at a depth of 0.5 m.

**TABLE 3**

**WATER QUALITY CHARACTERISTICS IN BANANA LAKE BEFORE, DURING, AND AFTER THE INITIAL ALUM TREATMENT**

| PARAMETER | UNITS | PRIOR TO TREATMENT (1/11/07) | DURING TREATMENT (1/19/07) | END OF TREATMENT (2/16/07) | FOLLOWING TREATMENT | | |
|---|---|---|---|---|---|---|---|
| | | | | | 3/8/07 | 4/5/07 | 5/2/07 |
| Alkalinity | mg/l | 85.8 | 79.2 | 7.8 | 18.8 | 28.4 | 28.6 |
| $NH_3$ | µg/l | 68 | 105 | 157 | 71 | 51 | 55 |
| $NO_x$ | µg/l | < 5 | 6 | < 5 | < 5 | 6 | < 5 |
| Diss. Org. N | µg/l | 618 | 439 | 131 | 306 | 436 | 512 |
| Particulate N | µg/l | 1478 | 462 | 15 | 103 | 582 | 592 |
| Total N | µg/l | 2166 | 1012 | 305 | 482 | 1075 | 1161 |
| SRP | µg/l | 106 | 100 | < 1 | 1 | < 1 | < 1 |
| Diss. Org. P | µg/l | 11 | 4 | 3 | 3 | 6 | < 1 |
| Particulate P | µg/l | 235 | 225 | 2 | 31 | 68 | 92 |
| Total P | µg/l | 352 | 329 | 6 | 35 | 75 | 93 |
| Chlorophyll-a | $mg/m^3$ | 105 | 53.2 | 0.8 | 7.0 | 31.0 | 18.9 |
| Turbidity | NTU | 15.8 | 4.7 | 0.8 | 2.8 | 4.3 | 6.2 |
| TSS | mg/l | 38 | 9.4 | 1.8 | 6.5 | 7.9 | 13.8 |
| Diss. Al | µg/l | 83 | 31 | 11 | 82 | 185 | 218 |

NOTE: Alum treatment conducted from 1/11/07-2/15/07

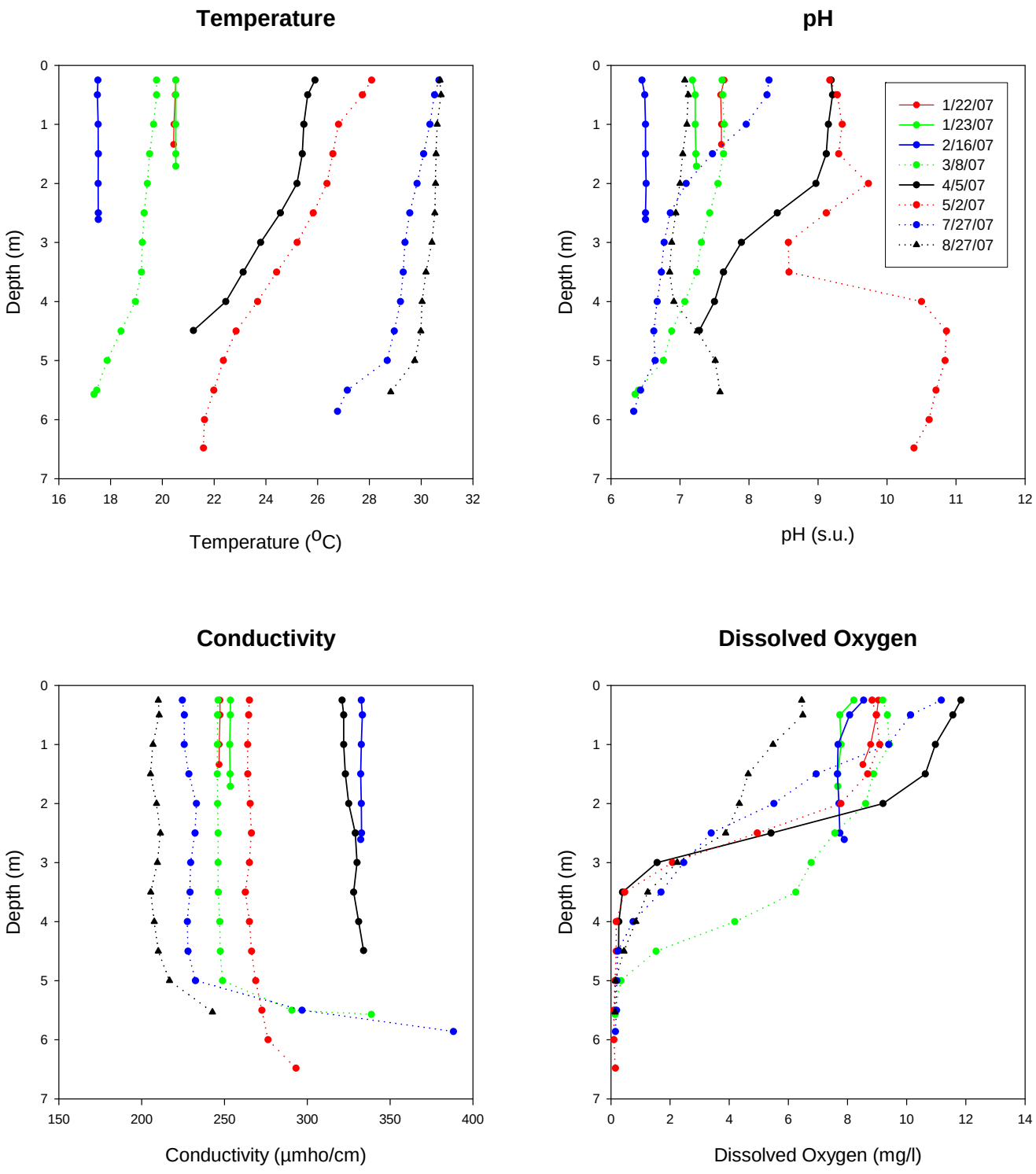


Figure 4. Compilation of Vertical Depth Profiles Collected in Stahl Lake.

The alum/sodium aluminate treatment to Banana Lake resulted in a decrease in alkalinity within the water column. Measured alkalinity values decreased from an initial concentration of 85.8 mg/l prior to the treatment to a value of 7.8 mg/l at the end of the treatment. However, alkalinity within Banana Lake appeared to recover quickly, reaching approximately 28 mg/l during April and May. A slight increase in measured concentrations of ammonia was observed during the treatment process, with concentrations returning to below initial values during April and May. The alum treatment appeared to have no significant impact on measured concentrations of $NO_x$. Substantial reductions in measured concentrations for dissolved organic nitrogen and particulate nitrogen were observed as a result of the alum treatment, although subsequent increases in concentrations for both parameters were observed in the months following the treatment. A similar reduction was observed in measured concentrations of total nitrogen, with a concentration of 2166 μg/l prior to the treatment and 305 μg/l at the end of the treatment. A steady increase in total nitrogen was observed following the treatment, although total nitrogen concentrations measured during April and May were still less than half of the initial total nitrogen concentration prior to the treatment.

The alum application resulted in substantial reductions in measured concentrations for all phosphorus species. Measured concentrations of SRP (soluble reactive phosphorus) decreased from 106 μg/l prior to the treatment to less than 1 μg/l following the treatment. This concentration was maintained within Banana Lake through May 2007. Measured concentrations of particulate phosphorus decreased from 235 μg/l prior to the treatment to only 2 μg/l following the treatment. However, a steady increase in particulate phosphorus concentrations was observed during the months following the treatment, although concentrations were still 60% lower than the initial value. A similar reduction was observed for concentrations of total phosphorus, with a steady increase in total phosphorus during the 3-month period following the treatment. However, the measured concentration during May 2007 still reflects a decrease of approximately 74% in water column phosphorus concentrations in Banana Lake.

A similar pattern was observed for measured concentrations of chlorophyll-a which decreased from 105 $mg/m^3$ prior to the treatment to 0.8 $mg/m^3$ following the treatment. An increase in chlorophyll-a was observed during the months following the treatment, although post-treatment concentrations were still substantially lower than the initial chlorophyll-a value. A similar pattern was observed for both turbidity and TSS, with substantial reductions observed for each parameter at the end of the treatment process, followed by steady increases over the next few months. However, even after a period of three months, post-treatment concentrations for these parameters were still substantially lower than observed prior to the treatment.

Dissolved aluminum concentrations in Banana Lake were substantially lower at the end of the treatment than observed prior to the treatment. An increase in dissolved aluminum was observed during the 3-month period following the treatment, presumably due to increases in pH within the water column of the lake. However, dissolved aluminum concentrations did not exceed 230 μg/l at any time during the monitoring program.

A summary of water quality characteristics measured in Stahl Lake prior to and at the end of the alum treatment process is given in Table 4. Addition of alum to the Stahl Lake area did not begin until January 22, 2007, and the pre-treatment characteristics summarized in Table 4 reflect the water sample collected prior to alum addition. However, Stahl Lake is a relatively small waterbody which receives a significant inflow from the watershed areas upstream from Banana Lake. The water detention time in Stahl Lake is relatively short, and as a result, water quality improvements created by the alum addition were rapidly diluted by the continuous incoming flow. As a result, the water quality improvements observed in Stahl Lake were substantially lower than observed in Banana Lake.

## TABLE 4

## WATER QUALITY CHARACTERISTICS IN STAHL LAKE BEFORE, DURING, AND AFTER THE INITIAL ALUM TREATMENT

| PARAMETER | UNITS | PRIOR TO TREATMENT (1/22/07) | END OF TREATMENT (2/16/07) | FOLLOWING TREATMENT | | |
|---|---|---|---|---|---|---|
| | | | | 3/8/07 | 4/5/07 | 5/2/07 |
| Alkalinity | mg/l | 79.2 | 43.0 | 53.0 | 65.0 | 61.2 |
| $NH_3$ | µg/l | 105 | 98 | 77 | 50 | 43 |
| $NO_x$ | µg/l | 6 | < 5 | < 5 | < 5 | < 5 |
| Diss. Org. N | µg/l | 439 | 206 | 304 | 419 | 422 |
| Particulate N | µg/l | 462 | 249 | 277 | 382 | 430 |
| Total N | µg/l | 1012 | 555 | 660 | 853 | 897 |
| SRP | µg/l | 100 | < 1 | 1 | < 1 | < 1 |
| Diss. Org. P | µg/l | 4 | 3 | 2 | 8 | 6 |
| Particulate P | µg/l | 225 | 39 | 66 | 53 | 75 |
| Total P | µg/l | 329 | 43 | 69 | 62 | 82 |
| Chlorophyll-a | $mg/m^3$ | 53.2 | 14.8 | 26.3 | 55.7 | 21.7 |
| Turbidity | NTU | 7.4 | 8.5 | 7.4 | 6.3 | 5.6 |
| Diss. Al | µg/l | 31 | 21 | 66 | 96 | 148 |

NOTE: Alum treatment conducted from 1/11/07-2/15/07

The alum/sodium aluminate addition to Stahl Lake reduced the initial alkalinity value of 79.2 mg/l to 43.0 mg/l at the end of the treatment process. This value gradually increased over the following months, returning to approximately 61.2 mg/l during May. Addition of alum to Stahl Lake resulted in a small decrease in measured ammonia concentrations, with a gradual continued decrease over subsequent months. No significant change was observed in concentrations of $NO_x$. The alum treatment process reduced concentrations of dissolved organic nitrogen and particulate nitrogen in Stahl Lake by approximately 50% at the end of the treatment, although values for these parameters increased to near pre-treatment levels by May 2007. A similar pattern was observed for total nitrogen, although the total nitrogen concentration in Stahl Lake measured during May was still somewhat lower than the initial value of 1012 µg/l.

A more substantial and longer-lasting improvement was observed for phosphorus species in Stahl Lake. The alum addition reduced the concentration of SRP in Stahl Lake from an initial value of 100 µg/l to non-detectable levels which remained through May 2007. No significant change was observed for dissolved organic phosphorus. However, substantial reductions were observed for both particulate phosphorus and total phosphorus at the end of the treatment process. Although a gradual increase was observed over time for each of these parameters, the concentrations measured during May 2007 were still substantially less than the initial values measured within the lake.

The alum addition reduced chlorophyll-a concentrations in Stahl Lake from 53.2 mg/$m^3$ to 14.8 mg/$m^3$ at the end of the treatment, with a continued increase in chlorophyll-a over time. A similar pattern was observed for turbidity levels in Stahl Lake. Dissolved aluminum concentrations decreased from 31 µg/l prior to treatment to 21 µg/l at the end of the treatment. However, an increase in dissolved aluminum was observed over the next three months, reaching a maximum concentration of 148 µg/l during May 2007.

A summary of water quality characteristics in Banana Lake before and after the second alum application is given in Table 5. Similar to the pattern observed during the initial treatment, the second alum application resulted in a reduction in measured alkalinity from 56.7 mg/l to 12.6 mg/l. Measured concentrations of ammonia were reduced by approximately 50%, with no significant change in $NO_x$. Substantial reductions were also observed for measured concentrations of dissolved organic nitrogen, particulate nitrogen, and total nitrogen, with a total nitrogen concentration of 447 µg/l following the second treatment compared with 1894 µg/l prior to the second treatment.

**TABLE 5**

**WATER QUALITY CHARACTERISTICS IN BANANA LAKE BEFORE, DURING, AND AFTER THE SECOND ALUM TREATMENT**

| PARAMETER | UNITS | PRIOR TO TREATMENT (7/27/07) | END OF TREATMENT (8/27/07) |
|---|---|---|---|
| Alkalinity | mg/l | 56.7 | 12.6 |
| $NH_3$ | µg/l | 108 | 55 |
| $NO_x$ | µg/l | < 5 | < 5 |
| Diss. Org. N | µg/l | 570 | 257 |
| Particulate N | µg/l | 1214 | 133 |
| Total N | µg/l | 1894 | 447 |
| SRP | µg/l | 1 | < 1 |
| Diss. Org. P | µg/l | 15 | 4 |
| Particulate P | µg/l | 94 | 15 |
| Total P | µg/l | 110 | 20 |
| Chlorophyll-a | mg/$m^3$ | 24.7 | 3.7 |
| Turbidity | NTU | 18.0 | 5.4 |
| Diss. Al | µg/l | 230 | 16 |

NOTE: Alum treatment conducted from 7/30/07-8/23/07

The second alum application to Banana Lake resulted in substantial decreases in phosphorus concentrations within the lake. At the beginning of the second treatment, the SRP concentration within the lake was 1 μg/l, compared with 106 μg/l prior to the initial treatment. The initial particulate phosphorus concentration at the start of the second treatment was 94 μg/l compared with 235 μg/l prior to the initial application. Similarly, the total phosphorus concentration prior to the second treatment was 110 μg/l compared with 352 μg/l prior to the initial treatment. The final total phosphorus concentration at the end of the second treatment was approximately 20 μg/l.

Measured concentrations of both chlorophyll-a and turbidity prior to the second treatment were still substantially less than measured in the lake before the initial treatment. The final chlorophyll-a and turbidity measurements of 3.7 $mg/m^3$ and 5.4 NTU reflect extremely low values for each of these parameters.

A comparison of water quality characteristics in Stahl Lake before and after the second alum application is given in Table 6. The second alum application appears to have had little impact on water quality in Stahl Lake due to the rapid flushing of the lake which was occurring during the final alum treatment as a result of wet season flow conditions. The water quality characteristics measured in Stahl Lake at the end of the treatment process reflects primarily the characteristics of the inflow from the large watershed area.

**TABLE 6**

**WATER QUALITY CHARACTERISTICS IN STAHL LAKE BEFORE, DURING, AND AFTER THE SECOND ALUM TREATMENT**

| PARAMETER | UNITS | PRIOR TO TREATMENT (7/27/07) | END OF TREATMENT (8/27/07) |
|---|---|---|---|
| Alkalinity | mg/l | 78.6 | 46.4 |
| $NH_3$ | μg/l | 109 | 241 |
| $NO_x$ | μg/l | < 5 | 5 |
| Diss. Org. N | μg/l | 624 | 133 |
| Particulate N | μg/l | 92 | 506 |
| Total N | μg/l | 827 | 886 |
| SRP | μg/l | 37 | 85 |
| Diss. Org. P | μg/l | 24 | 50 |
| Particulate P | μg/l | 129 | 137 |
| Total P | μg/l | 190 | 272 |
| Chlorophyll-a | $mg/m^3$ | 32.0 | 43.9 |
| Turbidity | NTU | 14.6 | 12.6 |
| Diss. Al | μg/l | 46 | 38 |

NOTE: Alum treatment conducted from 7/30/07-8/23/07

Variations in pH and dissolved oxygen in Banana Lake and Stahl Lake from January-August 2007 are illustrated on Figure 5. A decrease in pH was observed in each of the two lakes during the application process, with pH values in Banana Lake decreasing from an initial value of approximately 10 to a pH of 6.5 at the end of the treatment process. Measured pH levels within the two lakes increased over time following the alum application, decreasing again during the second application. Dissolved oxygen concentrations in the two lakes were found to be highly variable, with supersaturated conditions observed during most monitoring events. Dissolved oxygen concentrations did not fall below a value of 6 mg/l during any of the monitoring events from January-August 2007.

Variations in turbidity and conductivity in Banana Lake and Stahl Lake from January-August 2007 are illustrated on Figure 6. A rapid decrease in turbidity was observed in Banana Lake during the initial alum application, following by increases during the subsequent 3-month period. Another substantial decrease in turbidity was observed as a result of the second alum treatment. Changes in turbidity in Stahl Lake were less noticeable due to the significant inflow into the lake. Measured conductivity values in both Banana Lake and Stahl Lake increased slightly at the end of the initial alum application, followed by relatively steady concentrations over the next three months. No significant change in specific conductivity was observed as a result of the final alum application.

Variations in concentrations of total phosphorus and total nitrogen in Banana Lake and Stahl Lake from January-August 2007 are illustrated on Figure 7. The initial alum application resulted in substantial reductions in phosphorus concentrations in each of the two lakes. A subsequent increase in phosphorus concentration was observed in both lakes, although Banana Lake appeared to reach an equilibrium concentration of approximately 100 μg/l. A subsequent reduction in phosphorus concentrations was observed in Banana Lake during the second treatment, although phosphorus concentrations in Stahl Lake actually increased due to impacts from inflows into the lake. The initial alum treatment also reduced concentrations of total nitrogen in both lakes, presumably as a result of precipitation and settling of algal biomass. Increases in total nitrogen were observed in both lakes over the next three months, followed by an additional decrease in Banana Lake during the second alum application. The second application appears to have had no impact on Stahl Lake due to the significant inflow into the lake.

Variations in measured concentrations of chlorophyll-a and dissolved aluminum in Banana Lake and Stahl Lake from January-August 2007 are illustrated on Figure 8. The initial alum treatment resulted in substantial reductions in chlorophyll-a in both lakes, with Banana Lake reaching an equilibrium concentration of approximately 20 $mg/m^3$ compared with an initial value in excess of 100 $mg/m^3$. A second reduction in chlorophyll-a was observed during the second treatment in Banana Lake, with no significant impact on Stahl Lake. Measured dissolved aluminum concentrations in the two lakes actually decreased at the completion of the alum treatment due to readjustment of the lake pH into the range of minimum solubility for aluminum. An increase in dissolved aluminum was observed in both lakes as the pH in the lake increased following the alum treatment, with subsequent reductions in dissolved aluminum at the completion of the second alum application.

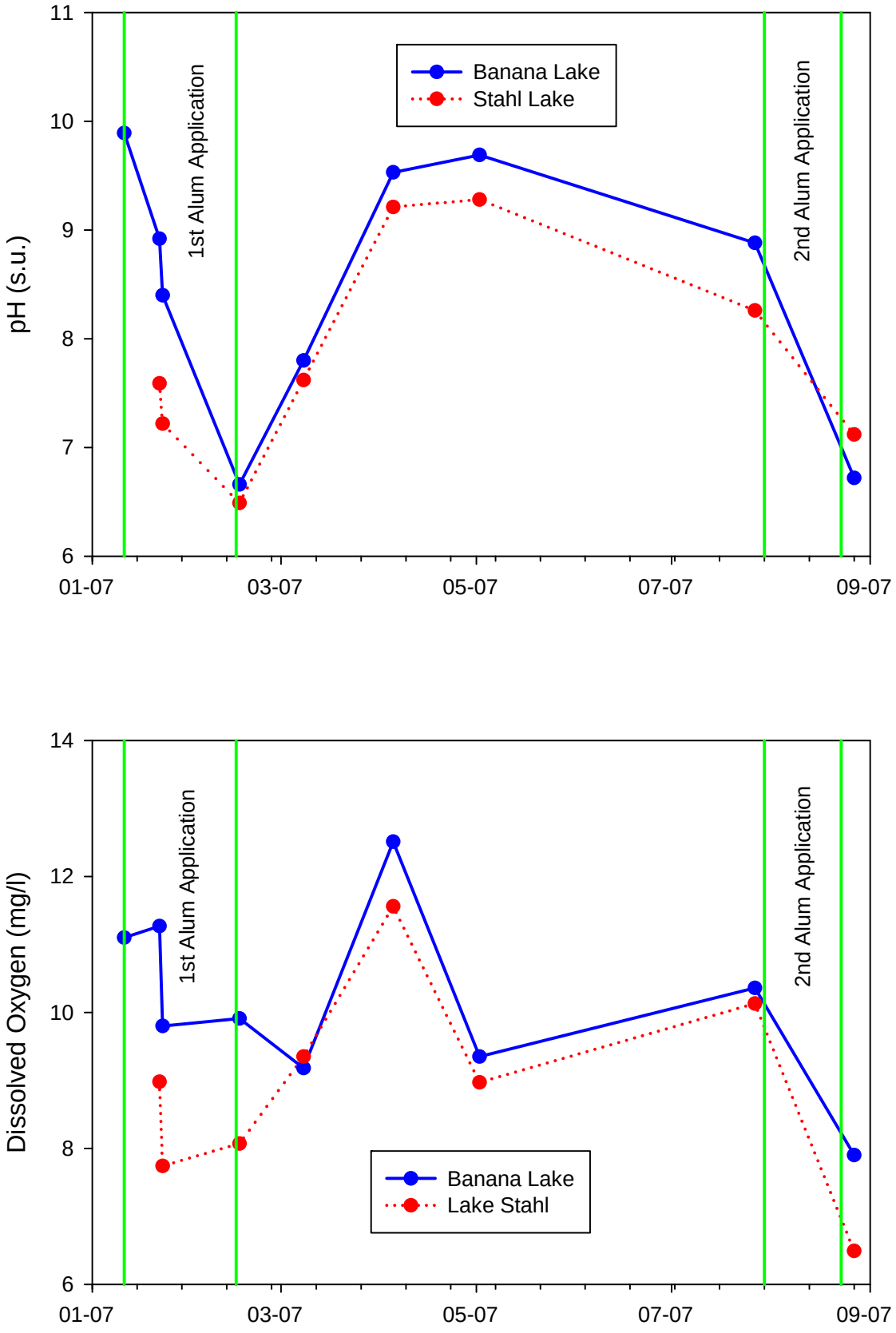


Figure 5. Variations in pH and Dissolved Oxygen in Banana Lake and Stahl Lake from January-August 2007.

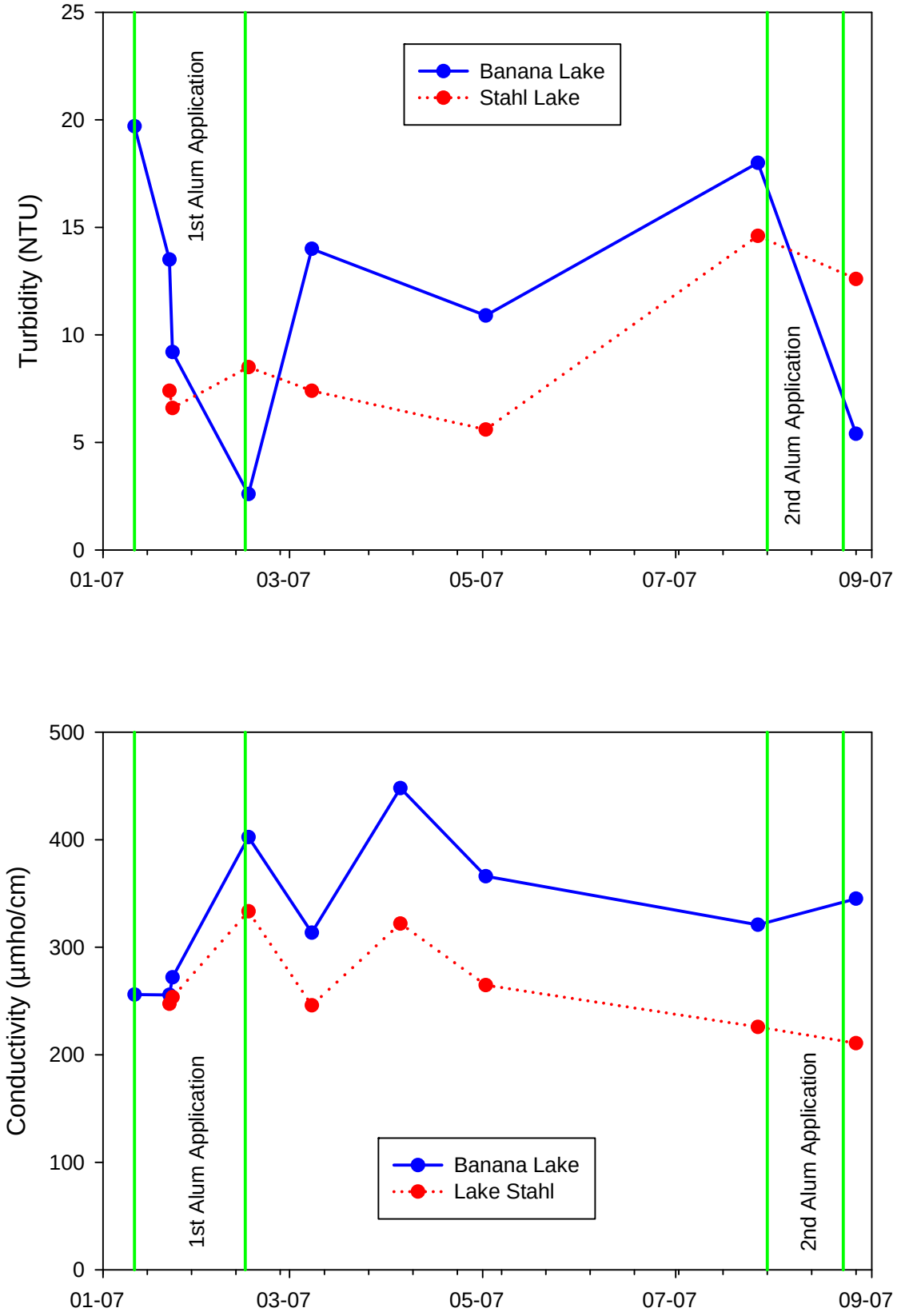


Figure 6. Variations in Turbidity and Conductivity in Banana Lake and Stahl Lake from January-August 2007.

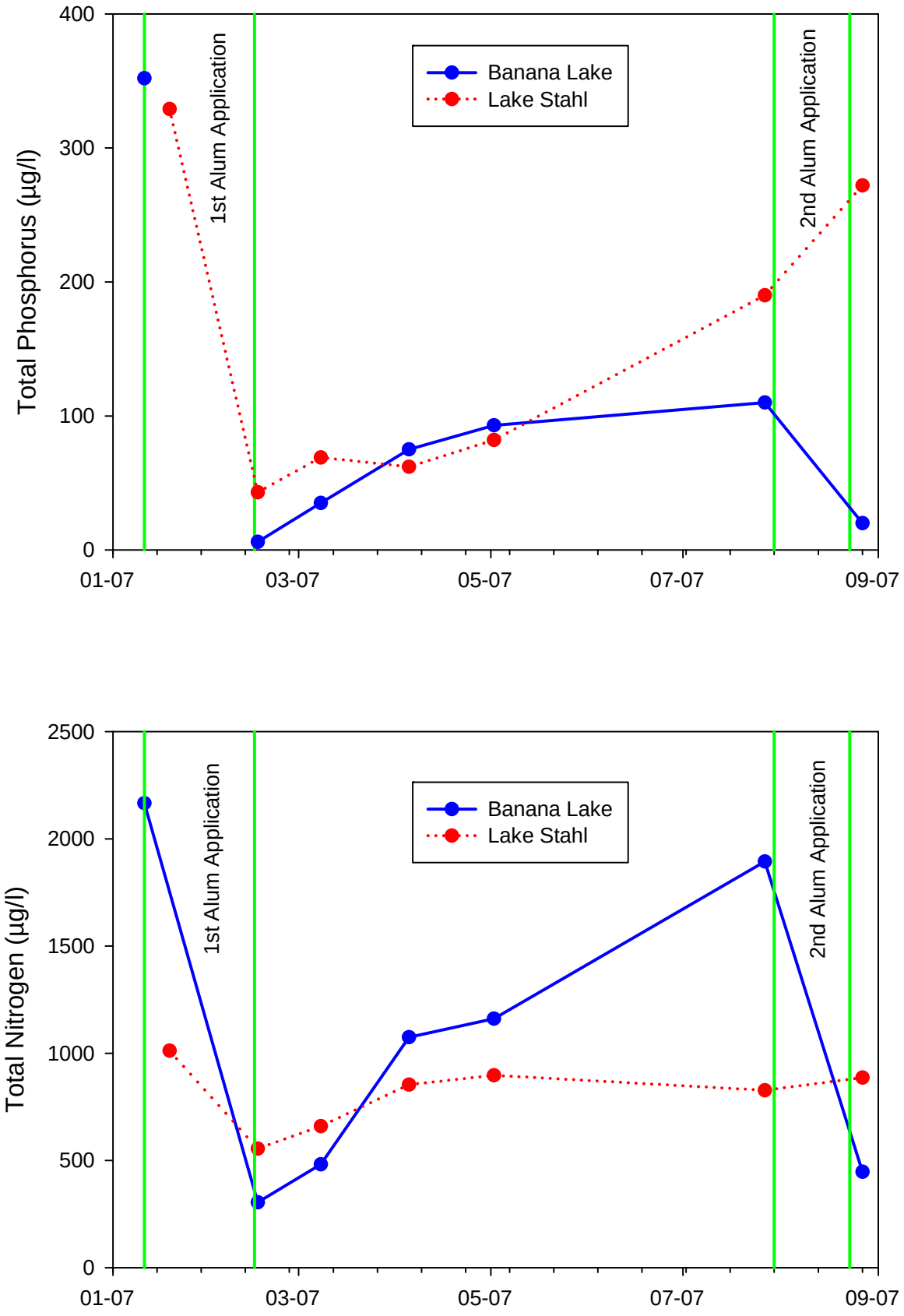


Figure 7. Variations in Total Phosphorus and Total Nitrogen in Banana Lake and Stahl Lake from January-August 2007.

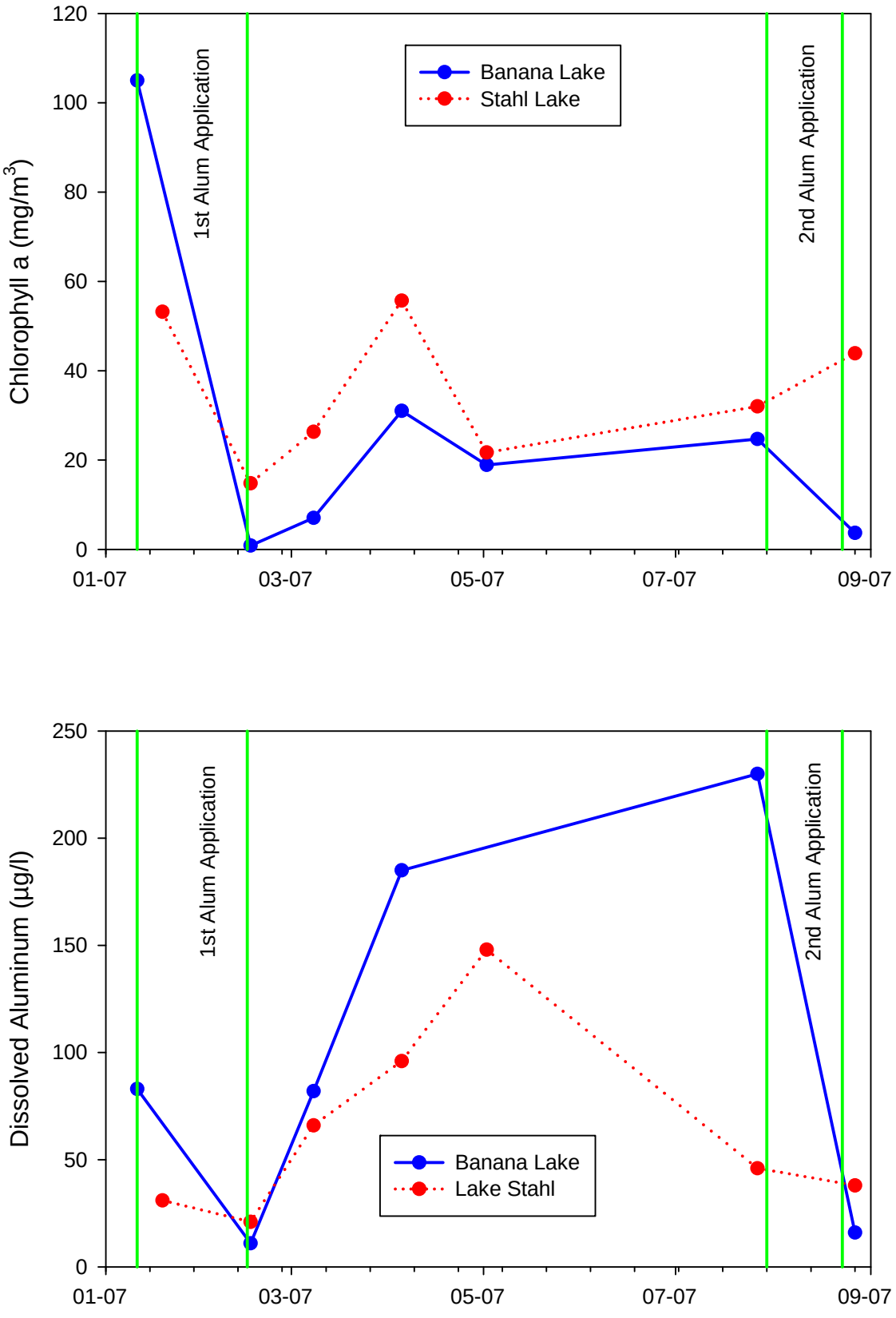


Figure 8. Variations in Chlorophyll-a and Dissolved Aluminum in Banana Lake and Stahl Lake from January-August 2007.

As seen in Appendix B, separate water samples were collected near the bottom of Banana Lake and Stahl Lake during selected monitoring events. These samples were collected to evaluate variability in water quality characteristics within the water column of each lake. Banana Lake is a relatively shallow waterbody with a maximum water depth of approximately 6 ft in central portions of the lake. However, the bottom contours of Stahl Lake are highly irregular, with isolated pockets extending to depths in excess of 25 ft.

Top and bottom samples were collected in Banana Lake during the pre- and post-treatment monitoring events for the second alum application. The chemical characteristics at the top and bottom monitoring sites in Banana Lake were relatively similar for both the pre- and post-monitoring events. This finding is not surprising due to the shallow nature of Banana Lake. Water quality monitoring was conducted at top and bottom stations in Stahl Lake during the majority of the monitoring events. During the February, March, and April monitoring events when well mixed conditions would be expected, water column characteristics were relatively similar between the top and bottom monitoring sites. However, during the May monitoring event, elevated levels of total nitrogen and total phosphorus were observed in the bottom samples collected in Stahl Lake. However, this trend was not observed during the July 27, 2007 monitoring event immediately prior to the second alum application. At the completion of the second alum application, substantially elevated levels of ammonia and total nitrogen were observed in the bottom sample collected in Stahl Lake, although phosphorus concentrations in the bottom sample were actually lower than values observed in the top sample.

## 4. Summary

The alum applications to Banana Lake and Stahl Lake resulted in immediate significant reductions in both total nitrogen and total phosphorus in each of the two lakes. Although total nitrogen concentrations in the two lakes appeared to rebound following the alum application, the phosphorus concentrations in Banana Lake appear to have reached equilibrium values which are approximately one-third of the initial phosphorus concentrations. This suggests that the alum application may have been successful in reducing the availability of phosphorus in Banana Lake. This trend is also apparent in chlorophyll-a concentrations in Banana Lake which also appear to reach an equilibrium substantially lower than pre-treatment concentrations. Water quality improvements in Stahl Lake are less than those observed in Banana Lake due to the rapid flushing of water through this lake from the upstream drainage basin.

The alum application had no significant impact on dissolved oxygen concentrations within either lake, with no measured concentrations less than 6 mg/l during the treatment process. The mixture of alum and sodium aluminate was sufficient to maintain a pH level within each of the two lakes in excess of 6.5 throughout each of the two treatment processes. Reductions in dissolved aluminum concentrations were observed in each of the two lakes at the completion of the alum treatment process, although increases in dissolved aluminum were observed in Banana Lake after the initial treatment. These increases are due to solubilization of some of the fresh floc precipitate by the increasing pH levels in Banana Lake following completion of the alum application. However, the maximum aluminum concentration of 230 µg/l measured in Banana Lake is still substantially lower than potential toxicity levels to aquatic organisms within the State of Florida.

In summary, it appears that the alum application has been successful in reducing internal recycling in Banana Lake and reducing the recycling of phosphorus into the water column. Long-term monitoring should be conducted to evaluate the long-term impacts and longevity of the alum application.

# APPENDICES

# APPENDIX A

# PRE- AND POST-TREATMENT VERTICAL FIELD PROFILES COLLECTED IN BANANA LAKE AND STAHL LAKE

## Prior to Initial Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Banana | 1/11/07 | 9:57 | 0.25 | 16.59 | 9.88 | 256 | 164 | 11.5 | 118 | 15.6 |
| Banana | 1/11/07 | 9:58 | 0.50 | 16.52 | 9.89 | 256 | 164 | 11.1 | 114 | 19.7 |
| Banana | 1/11/07 | 9:58 | 1.00 | 16.35 | 9.84 | 257 | 164 | 10.6 | 108 | 22.5 |
| Banana | 1/11/07 | 9:59 | 1.48 | 16.24 | 9.84 | 258 | 165 | 10.3 | 105 | 25.6 |

## During Initial Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Banana | 1/22/07 | 9:53 | 0.25 | 20.31 | 8.89 | 256 | 164 | 11.5 | 127 | 12.8 |
| Banana | 1/22/07 | 9:53 | 0.50 | 20.31 | 8.92 | 256 | 164 | 11.3 | 125 | 13.5 |
| Banana | 1/22/07 | 9:54 | 1.00 | 20.31 | 8.92 | 256 | 164 | 11.2 | 124 | 13.7 |
| Banana | 1/22/07 | 9:57 | 1.41 | 20.68 | 6.46 | 571 | 366 | 0.8 | 8 | >1000 |
| Stahl | 1/22/07 | 11:56 | 0.25 | 20.52 | 7.64 | 247 | 158 | 9.0 | 101 | 7.5 |
| Stahl | 1/22/07 | 11:57 | 0.50 | 20.50 | 7.59 | 247 | 158 | 9.0 | 100 | 7.4 |
| Stahl | 1/22/07 | 11:58 | 1.00 | 20.45 | 7.60 | 247 | 158 | 8.8 | 98 | 7.4 |
| Stahl | 1/22/07 | 11:59 | 1.34 | 20.44 | 7.60 | 247 | 158 | 8.5 | 95 | 8.1 |
| Banana | 1/23/07 | 9:33 | 0.25 | 20.79 | 8.40 | 272 | 174 | 9.9 | 110 | 9.2 |
| Banana | 1/23/07 | 9:34 | 0.50 | 20.80 | 8.40 | 272 | 174 | 9.8 | 110 | 9.2 |
| Banana | 1/23/07 | 9:34 | 1.00 | 20.79 | 8.39 | 272 | 174 | 9.8 | 110 | 9.1 |
| Banana | 1/23/07 | 9:35 | 1.50 | 20.79 | 8.39 | 272 | 174 | 9.5 | 107 | 9.2 |
| Banana | 1/23/07 | 9:37 | 1.82 | 20.94 | 6.56 | 814 | 521 | 0.8 | 9 | >1000 |
| Stahl | 1/23/07 | 9:47 | 0.25 | 20.52 | 7.18 | 254 | 162 | 8.2 | 91 | 6.7 |
| Stahl | 1/23/07 | 9:48 | 0.50 | 20.52 | 7.22 | 254 | 162 | 7.7 | 86 | 6.6 |
| Stahl | 1/23/07 | 9:49 | 1.00 | 20.52 | 7.22 | 253 | 162 | 7.8 | 87 | 6.7 |
| Stahl | 1/23/07 | 9:49 | 1.50 | 20.52 | 7.23 | 253 | 162 | 7.7 | 85 | 6.7 |
| Stahl | 1/23/07 | 9:50 | 1.71 | 20.52 | 7.24 | 254 | 162 | 7.7 | 85 | 6.8 |

## At End of Initial Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Banana | 2/16/07 | 10:40 | 0.25 | 16.65 | 6.82 | 402 | 257 | 10.0 | 103 | 2.6 |
| Banana | 2/16/07 | 10:41 | 0.50 | 16.64 | 6.66 | 402 | 258 | 9.9 | 102 | 2.6 |
| Banana | 2/16/07 | 10:41 | 1.00 | 16.67 | 6.59 | 402 | 257 | 9.8 | 101 | 2.9 |
| Banana | 2/16/07 | 10:42 | 1.50 | 16.69 | 6.50 | 403 | 258 | 9.7 | 100 | 12.7 |
| Banana | 2/16/07 | 10:46 | 1.83 | 19.24 | 6.65 | 1000 | 640 | 0.8 | 9 | >1000 |
| Stahl | 2/16/07 | 11:00 | 0.25 | 17.51 | 6.45 | 333 | 213 | 8.5 | 89 | 8.6 |
| Stahl | 2/16/07 | 11:00 | 0.50 | 17.49 | 6.49 | 333 | 213 | 8.1 | 85 | 8.5 |
| Stahl | 2/16/07 | 11:01 | 1.00 | 17.52 | 6.50 | 333 | 213 | 7.7 | 81 | 7.9 |
| Stahl | 2/16/07 | 11:02 | 1.50 | 17.53 | 6.50 | 332 | 213 | 7.7 | 80 | 7.1 |
| Stahl | 2/16/07 | 11:02 | 2.00 | 17.52 | 6.51 | 333 | 213 | 7.7 | 81 | 6.5 |
| Stahl | 2/16/07 | 11:03 | 2.50 | 17.53 | 6.50 | 333 | 213 | 7.7 | 81 | 6.2 |
| Stahl | 2/16/07 | 11:04 | 2.61 | 17.53 | 6.50 | 332 | 213 | 7.9 | 83 | 6.0 |

## Following Initial Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Banana | 3/8/2007 | 12:39 | 0.25 | 19.55 | 7.69 | 314 | 201 | 9.2 | 101 | 5.4 |
| Banana | 3/8/2007 | 12:42 | 0.50 | 19.56 | 7.80 | 314 | 201 | 9.2 | 100 | 14.0 |
| Banana | 3/8/2007 | 12:43 | 1.00 | 19.23 | 7.86 | 313 | 200 | 9.2 | 100 | 10.2 |
| Banana | 3/8/2007 | 12:44 | 1.50 | 19.21 | 7.93 | 313 | 201 | 8.9 | 96 | 7.4 |
| Banana | 3/8/2007 | 12:46 | 1.72 | 19.31 | 7.32 | 321 | 206 | 8.1 | 88 | >1000 |
| | | | | | | | | | | |
| Stahl | 3/8/2007 | 12:55 | 0.25 | 19.78 | 7.61 | 246 | 158 | 9.2 | 101 | 7.5 |
| Stahl | 3/8/2007 | 12:56 | 0.50 | 19.78 | 7.62 | 246 | 157 | 9.4 | 103 | 7.4 |
| Stahl | 3/8/2007 | 12:57 | 1.00 | 19.66 | 7.64 | 246 | 157 | 9.4 | 103 | 7.4 |
| Stahl | 3/8/2007 | 12:57 | 1.50 | 19.51 | 7.63 | 246 | 157 | 8.9 | 97 | 7.4 |
| Stahl | 3/8/2007 | 12:58 | 2.00 | 19.42 | 7.55 | 246 | 157 | 8.6 | 94 | 7.8 |
| Stahl | 3/8/2007 | 12:59 | 2.50 | 19.30 | 7.43 | 246 | 158 | 7.6 | 82 | 7.8 |
| Stahl | 3/8/2007 | 13:00 | 3.00 | 19.23 | 7.31 | 246 | 158 | 6.8 | 73 | 7.6 |
| Stahl | 3/8/2007 | 13:01 | 3.50 | 19.19 | 7.24 | 246 | 158 | 6.3 | 68 | 7.9 |
| Stahl | 3/8/2007 | 13:02 | 4.00 | 18.96 | 7.07 | 247 | 158 | 4.2 | 45 | 7.7 |
| Stahl | 3/8/2007 | 13:03 | 4.50 | 18.41 | 6.88 | 248 | 158 | 1.5 | 16 | 8.2 |
| Stahl | 3/8/2007 | 13:04 | 5.00 | 17.87 | 6.76 | 249 | 159 | 0.3 | 4 | 10.8 |
| Stahl | 3/8/2007 | 13:05 | 5.50 | 17.47 | 6.40 | 291 | 186 | 0.1 | 1 | >1000 |
| Stahl | 3/8/2007 | 13:06 | 5.57 | 17.36 | 6.35 | 339 | 217 | 0.1 | 1 | >1000 |
| | | | | | | | | | | |
| Banana | 4/5/2007 | 12:01 | 0.25 | 22.71 | 9.51 | 456 | 292 | 13.1 | 152 | x |
| Banana | 4/5/2007 | 12:02 | 0.50 | 23.33 | 9.53 | 448 | 287 | 12.5 | 147 | x |
| Banana | 4/5/2007 | 12:04 | 1.00 | 23.24 | 6.99 | 587 | 376 | 0.8 | 10 | x |
| Banana | 4/5/2007 | 12:08 | 1.52 | 23.46 | 6.90 | 585 | 374 | 0.4 | 5 | x |
| | | | | | | | | | | |
| Stahl | 4/5/2007 | 12:18 | 0.26 | 25.90 | 9.19 | 321 | 205 | 11.8 | 146 | x |
| Stahl | 4/5/2007 | 12:18 | 0.52 | 25.62 | 9.21 | 322 | 206 | 11.6 | 142 | x |
| Stahl | 4/5/2007 | 12:19 | 0.99 | 25.47 | 9.15 | 322 | 206 | 11.0 | 134 | x |
| Stahl | 4/5/2007 | 12:19 | 1.52 | 25.41 | 9.12 | 323 | 207 | 10.6 | 130 | x |
| Stahl | 4/5/2007 | 12:20 | 2.02 | 25.20 | 8.97 | 325 | 208 | 9.2 | 112 | x |
| Stahl | 4/5/2007 | 12:21 | 2.52 | 24.56 | 8.41 | 329 | 211 | 5.4 | 65 | x |
| Stahl | 4/5/2007 | 12:22 | 3.00 | 23.80 | 7.89 | 330 | 211 | 1.6 | 19 | x |
| Stahl | 4/5/2007 | 12:22 | 3.50 | 23.12 | 7.63 | 328 | 210 | 0.4 | 5 | x |
| Stahl | 4/5/2007 | 12:23 | 4.04 | 22.45 | 7.50 | 331 | 212 | 0.3 | 3 | x |
| Stahl | 4/5/2007 | 12:24 | 4.49 | 21.20 | 7.28 | 334 | 214 | 0.3 | 3 | x |
| | | | | | | | | | | |
| Banana | 5/2/2007 | 12:19 | 0.25 | 27.77 | 9.60 | 366 | 234 | 9.0 | 115 | 10.6 |
| Banana | 5/2/2007 | 12:20 | 0.50 | 27.52 | 9.69 | 366 | 234 | 9.4 | 119 | 10.9 |
| Banana | 5/2/2007 | 12:21 | 1.00 | 26.63 | 10.38 | 366 | 234 | 9.7 | 122 | 14.8 |
| Banana | 5/2/2007 | 12:24 | 1.43 | 25.98 | 9.39 | 710 | 454 | 0.3 | 3 | >1000 |
| | | | | | | | | | | |
| Stahl | 5/2/2007 | 12:45 | 0.25 | 28.09 | 9.17 | 265 | 170 | 8.8 | 113 | 5.1 |
| Stahl | 5/2/2007 | 12:46 | 0.50 | 27.73 | 9.28 | 265 | 169 | 9.0 | 114 | 5.6 |
| Stahl | 5/2/2007 | 12:46 | 1.00 | 26.81 | 9.35 | 264 | 169 | 9.1 | 114 | 6.4 |
| Stahl | 5/2/2007 | 12:47 | 1.50 | 26.59 | 9.30 | 264 | 169 | 8.7 | 108 | 7.1 |
| Stahl | 5/2/2007 | 12:48 | 2.00 | 26.36 | 9.73 | 266 | 170 | 7.8 | 97 | 7.5 |
| Stahl | 5/2/2007 | 12:49 | 2.50 | 25.83 | 9.12 | 266 | 170 | 5.0 | 61 | 7.1 |
| Stahl | 5/2/2007 | 12:49 | 3.00 | 25.21 | 8.57 | 265 | 170 | 2.1 | 25 | 6.3 |
| Stahl | 5/2/2007 | 12:51 | 3.50 | 24.42 | 8.58 | 263 | 168 | 0.5 | 6 | 7.2 |
| Stahl | 5/2/2007 | 12:52 | 4.00 | 23.68 | 10.50 | 265 | 170 | 0.2 | 2 | 8.7 |
| Stahl | 5/2/2007 | 12:52 | 4.50 | 22.85 | 10.86 | 266 | 170 | 0.2 | 2 | 10.4 |
| Stahl | 5/2/2007 | 12:53 | 5.00 | 22.36 | 10.84 | 269 | 172 | 0.1 | 2 | 12.8 |
| Stahl | 5/2/2007 | 12:54 | 5.50 | 21.99 | 10.71 | 273 | 174 | 0.1 | 1 | 17.1 |
| Stahl | 5/2/2007 | 12:55 | 6.00 | 21.63 | 10.61 | 276 | 177 | 0.1 | 1 | 20.7 |
| Stahl | 5/2/2007 | 12:56 | 6.48 | 21.59 | 10.39 | 293 | 188 | 0.2 | 2 | >1000 |

## Prior to Second Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Stahl | 7/27/07 | 11:32 | 0.25 | 30.69 | 8.29 | 225 | 144 | 11.2 | 150 | 13.8 |
| Stahl | 7/27/07 | 11:33 | 0.50 | 30.52 | 8.26 | 226 | 145 | 10.1 | 135 | 14.6 |
| Stahl | 7/27/07 | 11:34 | 1.00 | 30.34 | 7.96 | 226 | 144 | 9.4 | 125 | 14.3 |
| Stahl | 7/27/07 | 11:35 | 1.50 | 30.10 | 7.47 | 229 | 146 | 6.9 | 93 | 11.6 |
| Stahl | 7/27/07 | 11:36 | 2.00 | 29.84 | 7.09 | 233 | 149 | 5.5 | 73 | 10.2 |
| Stahl | 7/27/07 | 11:37 | 2.50 | 29.56 | 6.86 | 232 | 149 | 3.4 | 45 | 10.0 |
| Stahl | 7/27/07 | 11:38 | 3.00 | 29.38 | 6.77 | 230 | 147 | 2.5 | 32 | 10.2 |
| Stahl | 7/27/07 | 11:39 | 3.50 | 29.31 | 6.73 | 229 | 147 | 1.7 | 22 | 10.4 |
| Stahl | 7/27/07 | 11:40 | 4.00 | 29.20 | 6.67 | 228 | 146 | 0.8 | 10 | 10.5 |
| Stahl | 7/27/07 | 11:40 | 4.50 | 28.96 | 6.62 | 228 | 146 | 0.2 | 3 | 11.5 |
| Stahl | 7/27/07 | 11:41 | 5.00 | 28.69 | 6.64 | 233 | 149 | 0.2 | 3 | 16.0 |
| Stahl | 7/27/07 | 11:42 | 5.50 | 27.15 | 6.43 | 297 | 190 | 0.2 | 2 | 22.5 |
| Stahl | 7/27/07 | 11:43 | 5.86 | 26.77 | 6.33 | 388 | 249 | 0.2 | 2 | >1000 |
| Banana | 7/27/07 | 11:59 | 0.25 | 30.45 | 8.88 | 321 | 205 | 10.3 | 138 | 18.0 |
| Banana | 7/27/07 | 12:00 | 0.50 | 30.33 | 8.88 | 321 | 205 | 10.4 | 138 | 18.0 |
| Banana | 7/27/07 | 12:01 | 1.00 | 30.24 | 8.87 | 321 | 205 | 10.0 | 134 | 18.3 |
| Banana | 7/27/07 | 12:02 | 1.50 | 30.01 | 8.82 | 321 | 205 | 9.8 | 130 | 40.0 |
| Banana | 7/27/07 | 12:04 | 1.81 | 29.01 | 6.37 | 772 | 494 | 0.3 | 3 | >1000 |

## Following Second Treatment

| Lake | Date | Time | Depth (m) | Temp (°C) | pH (s.u.) | Sp.Cond (µmho/cm) | TDS (mg/l) | DO (mg/l) | DO (% sat.) | Turb (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|
| Stahl | 8/27/07 | 10:12 | 0.25 | 30.73 | 7.07 | 210 | 134 | 6.5 | 86 | 12.3 |
| Stahl | 8/27/07 | 10:13 | 0.50 | 30.77 | 7.12 | 211 | 135 | 6.5 | 87 | 12.6 |
| Stahl | 8/27/07 | 10:14 | 1.00 | 30.62 | 7.10 | 207 | 132 | 5.5 | 73 | 12.4 |
| Stahl | 8/27/07 | 10:15 | 1.50 | 30.58 | 7.04 | 205 | 131 | 4.6 | 62 | 12.3 |
| Stahl | 8/27/07 | 10:16 | 2.00 | 30.56 | 7.00 | 209 | 134 | 4.3 | 58 | 11.7 |
| Stahl | 8/27/07 | 10:17 | 2.50 | 30.53 | 6.94 | 211 | 135 | 3.9 | 52 | 10.8 |
| Stahl | 8/27/07 | 10:18 | 3.00 | 30.42 | 6.88 | 210 | 134 | 2.2 | 30 | 10.4 |
| Stahl | 8/27/07 | 10:19 | 3.50 | 30.19 | 6.85 | 206 | 132 | 1.3 | 17 | 10.2 |
| Stahl | 8/27/07 | 10:20 | 4.00 | 30.04 | 6.91 | 208 | 133 | 0.8 | 11 | 11.0 |
| Stahl | 8/27/07 | 10:21 | 4.50 | 29.99 | 7.25 | 210 | 134 | 0.4 | 6 | 11.5 |
| Stahl | 8/27/07 | 10:22 | 5.00 | 29.75 | 7.51 | 217 | 139 | 0.2 | 2 | 12.7 |
| Stahl | 8/27/07 | 10:22 | 5.53 | 28.83 | 7.58 | 243 | 155 | 0.1 | 2 | 15.3 |
| Banana | 8/27/07 | 9:56 | 0.25 | 30.48 | 6.65 | 345 | 221 | 7.9 | 106 | 5.9 |
| Banana | 8/27/07 | 9:57 | 0.50 | 30.50 | 6.72 | 345 | 221 | 7.9 | 106 | 5.4 |
| Banana | 8/27/07 | 9:57 | 1.00 | 30.49 | 6.76 | 344 | 220 | 7.8 | 104 | 5.3 |
| Banana | 8/27/07 | 9:58 | 1.50 | 30.49 | 6.78 | 344 | 220 | 7.8 | 104 | 5.7 |
| Banana | 8/27/07 | 9:59 | 2.00 | 30.51 | 7.51 | 357 | 228 | 5.4 | 73 | >1000 |
| Banana | 8/27/07 | 10:01 | 2.28 | 30.52 | 7.83 | 574 | 368 | 0.3 | 4 | >1000 |

# APPENDIX B

# RESULTS OF LABORATORY ANALYSES CONDUCTED ON SURFACE WATER SAMPLES COLLECTED IN BANANA LAKE AND STAHL LAKE

## Characteristics of Pre and Post Treatment Samples Collected in Banana Lake and Stahl Lake

| Location | Date Collected | Alk (mg/l) | NH3 (µg/l) | NOx (µg/l) | Dis Org N (µg/l) | Part. N (µg/l) | Total N (µg/l) | SRP (µg/l) | Dis Org P (µg/l) | Part. P (µg/l) | Total P (µg/l) | Chl-a (mg/m3) | Turb. (NTU) | TSS (mg/l) | Diss. Al (µg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Banana | 1/11/07 | 85.8 | 68 | <5 | 618 | 1478 | 2166 | 106 | 11 | 235 | 352 | 105 | 15.8 | 38 | 83 |
| Stahl | 1/22/07 | 79.2 | 105 | 6 | 439 | 462 | 1012 | 100 | 4 | 225 | 329 | 53.2 | 4.7 | x | 31 |
| Banana | 2/16/07 | 7.8 | 157 | <5 | 131 | 15 | 305 | <1 | 3 | 2 | 6 | 0.8 | 0.8 | 1.8 | 11 |
| Stahl - Top | 2/16/07 | 43.0 | 98 | <5 | 206 | 249 | 555 | <1 | 3 | 39 | 43 | 14.8 | 2.8 | 5.4 | 21 |
| Stahl - Bottom | 2/16/07 | 40.2 | 109 | <5 | 255 | 177 | 543 | <1 | <1 | 46 | 47 | 14.4 | 2.9 | 6.3 | 15 |
| Banana - Top | 3/8/07 | 18.8 | 71 | <5 | 306 | 103 | 482 | 1 | 3 | 31 | 35 | 7.0 | 2.8 | 6.5 | 82 |
| Stahl - Top | 3/8/07 | 53.0 | 77 | <5 | 304 | 277 | 660 | 1 | 2 | 66 | 69 | 26.3 | 4.0 | 6.6 | 66 |
| Stahl - Bottom | 3/8/07 | 54.0 | 82 | <5 | 276 | 318 | 678 | 1 | <1 | 75 | 76 | 21.5 | 4.7 | 7.9 | 27 |
| Banana - Top | 4/5/07 | 28.4 | 51 | 6 | 436 | 582 | 1075 | <1 | 6 | 68 | 75 | 31.0 | 4.3 | 7.9 | 185 |
| Stahl - Top | 4/5/07 | 65.0 | 50 | <5 | 419 | 382 | 853 | <1 | 8 | 53 | 62 | 55.7 | 4.4 | 7.4 | 96 |
| Stahl - Bottom | 4/5/07 | 63.4 | 48 | <5 | 370 | 365 | 785 | <1 | 7 | 71 | 79 | 15.8 | 3.8 | 4.5 | 26 |
| Banana - Top | 5/2/07 | 28.6 | 55 | <5 | 512 | 592 | 1161 | <1 | <1 | 92 | 93 | 18.9 | 6.2 | 13.8 | 218 |
| Stahl - Top | 5/2/07 | 61.2 | 43 | <5 | 422 | 430 | 897 | <1 | 6 | 75 | 82 | 21.7 | 4.7 | 6.9 | 148 |
| Stahl - Bottom | 5/2/07 | 68.2 | 893 | <5 | 392 | 854 | 2141 | <1 | 14 | 173 | 188 | 25.1 | 19.3 | 14.8 | 22 |
| Banana - Top | 7/27/07 | 56.7 | 108 | <5 | 570 | 1214 | 1894 | 1 | 15 | 94 | 110 | 24.7 | 18.0 | x | 230 |
| Banana - Bottom | 7/27/07 | 63.8 | 203 | <5 | 80 | 1000 | 1285 | <1 | 17 | 94 | 112 | 28.0 | 25.3 | x | 76 |
| Stahl - Top | 7/27/07 | 78.6 | 109 | <5 | 624 | 92 | 827 | 37 | 24 | 129 | 190 | 32.0 | 14.6 | x | 46 |
| Stahl - Bottom | 7/27/07 | 82.4 | 166 | <5 | 316 | 161 | 645 | 72 | 19 | 89 | 180 | 16.5 | 22.5 | x | 30 |
| Banana - Top | 8/27/07 | 12.6 | 55 | <5 | 257 | 133 | 447 | <1 | 4 | 15 | 20 | 3.7 | 5.4 | x | 16 |
| Banana - Bottom | 8/27/07 | 14.7 | 66 | 5 | 246 | 97 | 414 | <1 | 3 | 9 | 13 | 4.7 | 5.7 | x | 32 |
| Stahl - Top | 8/27/07 | 46.4 | 241 | 6 | 133 | 506 | 886 | 85 | 50 | 137 | 272 | 43.9 | 12.6 | x | 38 |
| Stahl - Bottom | 8/27/07 | 43.6 | 3967 | <5 | 683 | 222 | 4875 | 3 | 17 | 105 | 125 | 132 | 12.7 | x | 28 |