November 30, 2010

Kirk Mackey
Twin and Walker Creek Watershed Association
65 Lenape Lane
Twin Lakes, PA 18458

RE: Twin and Walker Creek Watershed Monitoring Program
2010 Water Quality Monitoring Final Report
FXB File No. PA1551-08

Dear Kirk:

The purpose of this letter is to present results of the 2010 Twin and Walker Creek Watershed Monitoring Program. The primary purpose of the monitoring program is to characterize the trophic state within Big Twin Lake, Little Twin Lake, and Walker Lake based on measurements of Secchi depth, total phosphorus, and chlorophyll a. The monitoring program consisted of volunteers from the Twin and Walker Creek Watershed Association collecting lake samples from the photic zone of Big Twin Lake, Little Twin Lake, and Walker Lake and measuring the Secchi depth on four occasions during the 2010 growing season. F. X. Browne, Inc. performed the total phosphorus and chlorophyll a laboratory analysis and analyzed all the 2010 lake monitoring data.

**Results**

Table 1 presents raw and averaged data for the study period. The significance of these results is described in the following sections. In all cases, confidence interval (±) is expressed as twice the standard deviation, equivalent to approximately a 95% confidence interval.

***Phosphorus***

Phosphorus is one of the three main nutrients of life, along with nitrogen and carbon. In the northeast, phosphorus is the nutrient that most often controls productivity of lake systems. Total phosphorus is a measure of all forms of phosphorus, both organic and inorganic. Total phosphorus concentrations are directly related to the trophic condition (water quality status) of a lake. Excessive amounts of phosphorus lead to algae blooms and loss of oxygen in lakes. Epilimnetic (surface water) total phosphorus concentrations less than 10 micrograms per liter (µg/L)/0.010 milligrams per liter (mg/L) are associated with oligotrophic (clean, clear water) conditions and concentrations greater than 25 µg/L (0.025 mg/L) are associated with eutrophic (nutrient-rich) conditions.

The average surface water total phosphorus concentration was highest in Walker Lake (0.022 mg/L ± 0.153) and lowest in Little Twin Lake (0.012 mg/L ± 0.015).

### *Chlorophyll a*

Chlorophyll *a* is the green pigment in plants used for photosynthesis, and measuring it provides information on the amount of algae (microscopic plants) in lakes. Chlorophyll *a* concentrations can also be used to classify lake trophic state. Chlorophyll *a* concentrations less than 2 micrograms per liter (µg/L) are associated with oligotrophic conditions, while concentrations greater than 8 µg/L are associated with eutrophic conditions.

The average chlorophyll a concentration was highest in Walker Lake (8.1 mg/L ± 13.6) and lowest in Big Twin Lake (4.2 mg/L ± 3.5).

### *Transparency*

Transparency is a measure of water clarity in lakes and ponds. It is determined by lowering a 20 cm black and white disk (Secchi disk) into a lake to the depth where it is no longer visible from the surface. Since algae are the main determinant of water clarity in non-stained lakes that lack excessive amounts of inorganic turbidity (suspended silt), transparency is used as an indicator of lake trophic state. Transparencies greater than 4.6 meters (15.1 feet) are associated with oligotrophic conditions, while transparencies less than 2 meters (6.6 feet) are associated with eutrophic conditions (DEC & FOLA 1990).

The Secchi disk transparency was highest (most favorable) in Little Twin Lake (3.71 m ± 2.00), and lowest at Walker Lake (2.38 m ± 2.20).

### *Trophic State*

*Trophic state* is a key term used in limnology to describe the amount of algae and macrophytes (aquatic plants) found in a lake. *Oligotrophic* lakes have few algae and macrophytes and appear clean and clear, while *eutrophic* lakes show an overabundance of growth and often have a pronounced green color due to algae. *Eutrophication* is a natural process whereby lakes increase in trophic state over long periods of time. However, the process of eutrophication can be greatly accelerated by human activities (such as watershed development and sewage disposal) which introduce additional nutrients, organic matter and silt into the lake system. This cultural eutrophication can be reversed by controlling human inputs, but in many cases additional in-lake treatments are required in order to accelerate this rehabilitation process.

The Carlson (1977) Trophic State Index (TSI) is an extremely valuable tool for the evaluation of lakes. This index is calculated using summer averages for total phosphorus, chlorophyll *a*, and/or transparency (Secchi depth) data. In order to calculate this index, each seasonal average is logarithmically converted to a scale of relative trophic state ranging from 1 to 100. This index was constructed such that an increase in ten units represents a doubling in algal biomass. For example, a lake with a chlorophyll TSI of 40 has twice as much algae as a lake with a TSI value of 30. Generally, TSI values less than 37 are considered oligotrophic, while TSI values greater than 51 are considered eutrophic (DEC & FOLA 1990).

Average values for Secchi depth, total phosphorus, and chlorophyll a were used to compute trophic state indices following Carlson, 1977. The TSI values for each lake are shown in Table 1. Figures 1, 2, and 3 compare trophic state indices for 2010 with those calculated for previous years.

**Table 1. 2010 Twin and Walker Creek Watershed Monitoring Program Lake Monitoring Results**

| *Waterbody Name* | *Date Collected* | | *Total Phosphorus (mg/l)* | *Chlorophyll a (mg/l)* | *Secchi Depth (m)* |
|---|---|---|---|---|---|
| Big Twin Lake | 6/20/2010 | | 0.023 | 2.9 | 2.50 |
| | 7/18/2010 | | 0.011 | 2.7 | 3.10 |
| | 8/28/2010 | | 0.020 | 4.5 | 4.00 |
| | 9/18/2010 | | 0.009 | 6.5 | 1.60 |
| | | | | | |
| | ***Average*** | | ***0.016*** | ***4.2*** | ***2.80*** |
| | ***Standard deviation*** | | ***0.007*** | ***1.8*** | ***1.01*** |
| | ***Trophic State Index*** | | ***44*** | ***45*** | ***45*** |
| Little Twin Lake | 6/20/2010 | | 0.022 | 4.1 | 4.80 |
| | 7/18/2010 | < | 0.006 | 3.0 | 4.00 |
| | 8/28/2010 | | 0.012 | 6.8 | 3.65 |
| | 9/18/2010 | | 0.006 | 3.5 | 2.40 |
| | | | | | |
| | ***Average*** | | ***0.012*** | ***4.4*** | ***3.71*** |
| | ***Standard deviation*** | | ***0.008*** | ***1.7*** | ***1.00*** |
| | ***Trophic State Index*** | | ***39*** | ***45*** | ***41*** |
| Walker Lake | 6/20/2010 | | 0.030 | 7.1 | 4.00 |
| | 7/18/2010 | | 0.014 | 17.5 | 1.60 |
| | 8/28/2010 | | 0.018 | 1.3 | 2.10 |
| | 9/18/2010 | | 0.024 | 6.6 | 1.80 |
| | | | | | |
| | ***Average*** | | ***0.022*** | ***8.1*** | ***2.38*** |
| | ***Standard deviation*** | | ***0.007*** | ***6.8*** | ***1.10*** |
| | ***Trophic State Index*** | | ***48*** | ***51*** | ***48*** |

**Figure 1. Comparison of Phosphorus-Based Trophic State Index 2002-2010 for Big Twin Lake, Little Twin Lake, and Walker Lake**

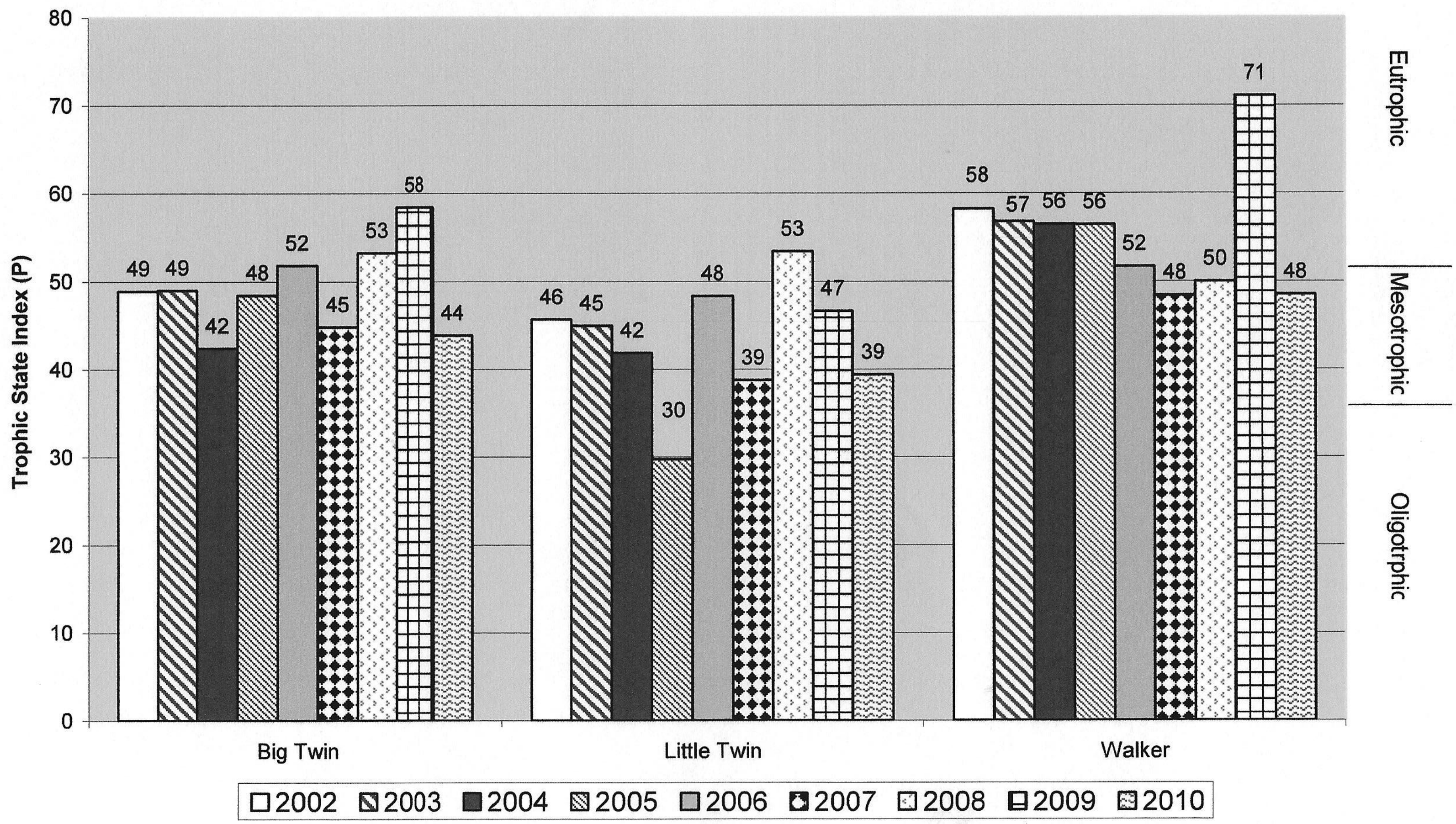


**Figure 2. Comparison of Chlorophyll a - Based Trophic State Index 2002-2010 for Big Twin Lake, Little Twin Lake and Walker Lake**

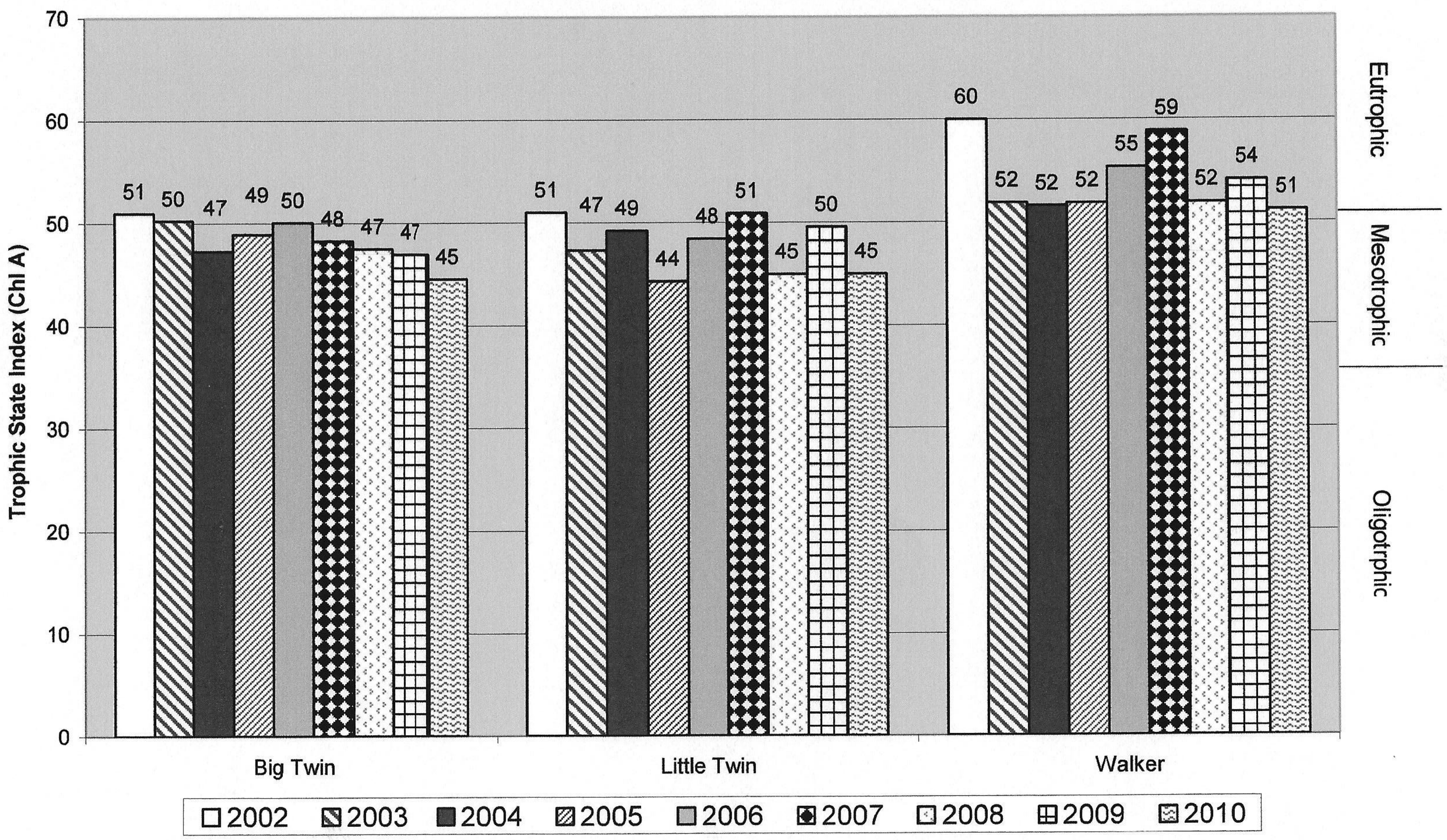
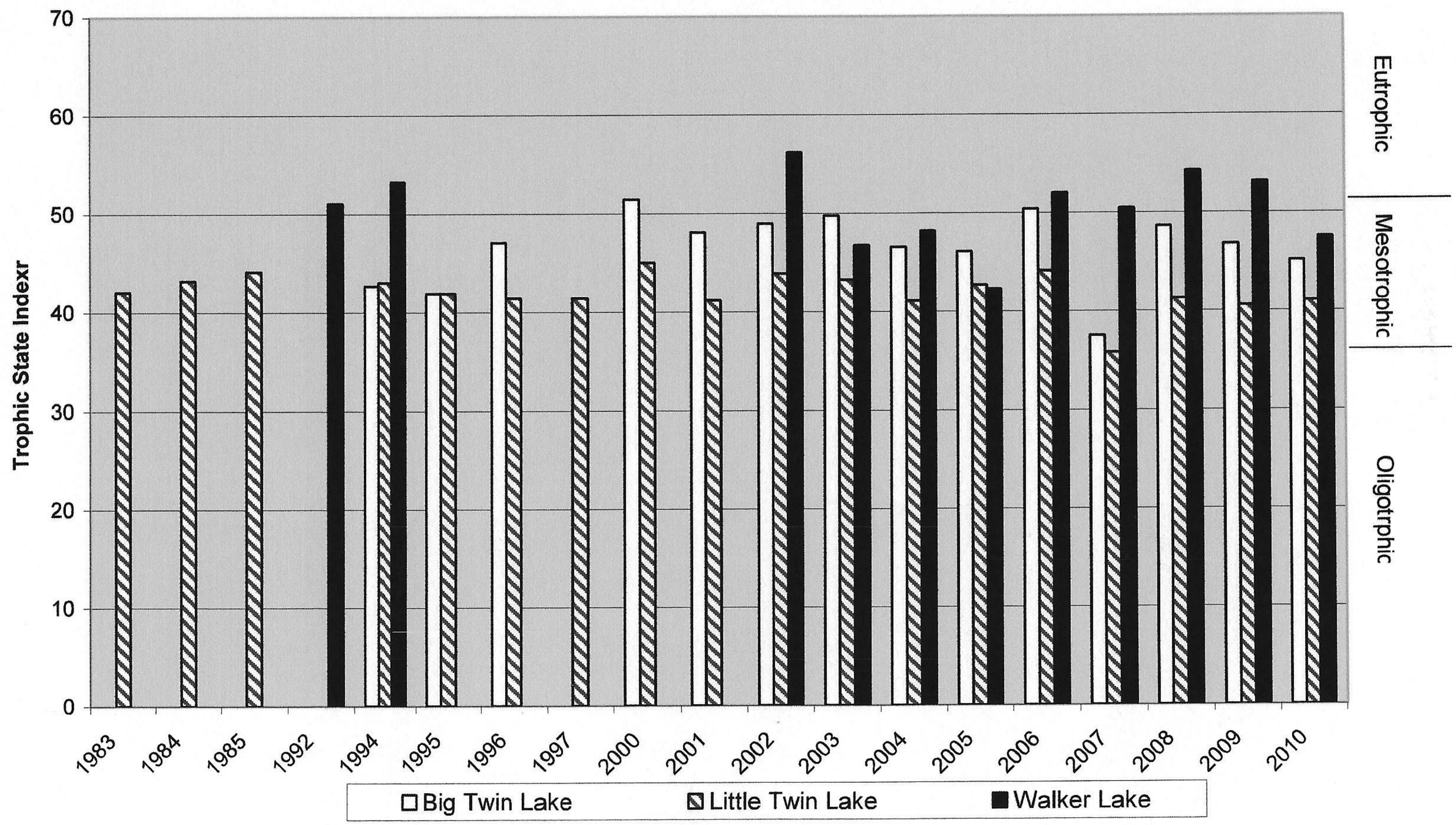


**Figure 3. Comparison of Secchi Depth-Based Trophic State Index for Big Twin Lake, Little Twin Lake, and Walker Lake 1983-2010**



Big Twin Lake

Big Twin Lake can be classified as mesotrophic with respect to total phosphorus, chlorophyll a and transparency during 2010. The chlorophyll a TSI value at Big Twin Lake continued to exhibit a general decrease (less algae, improved water quality) over the study period and was the lowest on record for that lake in 2010. The phosphorus TSI value was lower than in recent years and close to the record low value of 42 in 2004.

Little Twin Lake

Little Twin Lake was mesotrophic with respect to total phosphorus, chlorophyll a and transparency during 2010. Little Twin continued to have the best water quality of the three lakes. The Secchi depth TSI value in Little Twin Lake was similar to prior years, while chlorophyll *a* and total phosphorus were lower in 2010 compared to recent years.

Walker Lake

Walker Lake was mesotrophic during 2010, with a total phosphorus TSI value on the mesotrophic/eutrophic boundary. All three TSI parameters were lower in 2010 in Walker Lake than in the prior several years.

***Conclusions and Recommendations***

In general, Walker Lake had the worst water quality in 2010 while Little Twin Lake had the best water quality in 2010. The water quality in the three lakes showed some improvement in water quality over the past several years with respect to total phosphorus, chlorophyll a and transparency values. However, year to year variability indicates the lakes are sensitive to any increase in nutrient inputs. Nutrient reduction strategies that reduce the introduction of nutrients into the lakes should therefore be implemented to maintain or reestablish mesotrophic conditions. Such strategies include septic system upgrades, diversion and/or treatment of storm water, and the control of Canada geese populations. An educational program for lakefront property owners should be put in place in order to instruct those homeowners on proper lakefront best management practices for protecting and restoring good water quality. This program can include lectures and educational materials on lakefront landscaping, proper use of fertilizer, pet waste management, runoff control, and the identification and management of invasive species, aquatic plants, and algae.

Thank you again for choosing F. X. Browne, Inc. for your lake consulting needs. We look forward to continuing our work together in the future. If you should have any questions concerning the 2010 report, please contact me at mmartin@fxbrowne.com at any time.

NALMS

Certified Lake Manager

#93-02M Date 11/30/2010

Sincerely,

**F. X. Browne, Inc.**

Michael R. Martin, CLM
Senior Project Scientist