



F. X. Browne, Inc.

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March 5, 2019

Kirk Mackey
Twin and Walker Creek Watershed Association
875 Twin Lakes Road
Shohola, PA 18458

RE: Twin and Walker Creek Watershed Monitoring Program
2018 Water Quality Monitoring Final Report
FXB File No. PA1551-17

Dear Kirk:

The purpose of this letter is to present results of the 2018 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 three occasions during the 2018 growing season. QC Laboratories performed the total phosphorus and chlorophyll *a* laboratory analysis, and F. X. Browne, Inc. analyzed all the 2018 lake monitoring data and prepared this report.

Results

Table 1 presents the 2018 raw data, the seasonal average concentrations for each parameter for each lake, the standard deviation, and the seasonal Carlson Trophic State Indices for each parameter for each lake. The significance of these results is described in the following sections.

Phosphorus

Phosphorus is one of the three main nutrients of life, along with nitrogen and carbon. In the northeast United States, 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 ($\mu\text{g/L}$)/0.010 milligrams per liter (mg/L) are associated with oligotrophic (clean, clear water) conditions and concentrations greater than 25 $\mu\text{g/L}$ (0.025 mg/L) are associated with eutrophic (nutrient-rich) conditions.

Table 1						
2018 Twin and Walker Creek Watershed Monitoring Program						
Lake Monitoring Results						
Waterbody Name	Date Collected		Total Phosphorus (mg/l)		Chlorophyll a (ug/L)	Secchi Depth (m)
Big Twin Lake	6/16/2018		0.004		3.17	2.5
	7/22/2018		0.010		8.79	3.0
	8/19/2018		0.007	<	2	2.3
Average			0.007		4.7	2.60
Standard deviation			0.003		3.6	0.36
Trophic State Index			32		46	46
Little Twin Lake	6/16/2018	<	0.003		5.58	4.5
	7/22/2018		0.009		3.34	3.7
	8/19/2018		0.006	<	2	3.0
Average			0.006		3.6	3.73
Standard deviation			0.003		1.8	0.75
Trophic State Index			30		43	41
Walker Lake	6/17/2018		0.012		13.2	1.0
	7/28/2018		0.022		19.6	1.1
	8/19/2018		0.017	<	2	1.0
Average			0.017		11.6	1.03
Standard deviation			0.005		8.9	0.06
Trophic State Index			45		55	60

The average surface water total phosphorus concentrations during 2018 were similar in Big Twin and Little Twin Lakes. The average total phosphorus concentration during 2018 in Walker Lake was twice as high as Big Twin and Little Twin Lake, but the average was still relatively low and in the mesotrophic range. The average total phosphorus concentration in Big Twin Lake was 0.006 mg/L and the average total phosphorus concentration in Little Twin Lake was 0.007 mg/L. Both Big Twin and Little Twin Lake were classified as oligotrophic in 2018 with respect to total phosphorus concentrations. The average total phosphorus concentration in 2018 in Walker Lake was 0.017 mg/L, and the lake was classified as mesotrophic. Overall, total phosphorus concentrations were low in all lakes during 2018 which may be due to flushing from the unusually high rainfall during 2018 compared to the past 20-year average rainfall. The average

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rainfall over the past 20 years in northeast Pennsylvania is 52.11 inches. In 2018, the total rainfall was 78.53 inches.

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. Concentrations less than 2 micrograms per liter ($\mu\text{g/L}$) are associated with oligotrophic conditions, while concentrations greater than 7-10 $\mu\text{g/L}$ are associated with eutrophic conditions.

In 2018, the average chlorophyll a concentration was highest in Walker Lake ($11.6 \mu\text{g/L} \pm 8.9$) and lowest in Little Twin Lake ($3.6 \mu\text{g/L} \pm 1.8$). The average chlorophyll a concentration in Big Twin Lake was $4.7 \mu\text{g/L} \pm 3.6$. Therefore, based on chlorophyll a concentrations, Walker Lake was classified as eutrophic in 2018, and Big Twin and Little Twin Lakes were classified as mesotrophic in 2018. The average chlorophyll a concentration in Walker Lake was higher in 2018 than in 2017 and lower in Big Twin and Little Twin Lakes in 2018 compared to 2017.

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 at which 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.

The average Secchi disk transparency was highest (most favorable) in Little Twin Lake ($3.73 \text{ m} \pm 0.75$), and lowest at Walker Lake ($1.03 \text{ m} \pm 0.06$). The average Secchi disk transparency was $2.60 \text{ m} \pm 0.36 \text{ m}$ in Big Twin Lake. Therefore, based on Secchi disk transparency, Little Twin Lake and Big Twin Lake were classified as mesotrophic in 2018, and Walker Lake was classified as eutrophic during 2018. However, since the main water source feeding Walker Lake is tannin in nature, the brown coloration may impact the Secchi disk transparency readings. For Walker Lake, therefore, it is best to rely on the phosphorus and chlorophyll concentrations for evaluating the trophic state of the lake. In 2018, the transparency in Big Twin and Little Twin Lakes was similar the transparencies in 2017. The transparency decreased in Walker Lake from 1.5 meters to 1.03 meters in 2018 compared to 2017.

Trophic State

Trophic state is a term that describes the biomass 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 plant life and often have a pronounced green

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color due to algae. A more holistic approach to defining trophic state looks at the nutrient concentrations, water transparency, types of algae and macrophytes present, thermal dynamics, and dissolved oxygen dynamics.

The Carlson (1977) Trophic State Index (TSI) is the main index used in evaluating the trophic state of a lake. This index is calculated on a scale from 1 to 100 using summer or warm weather average values for total phosphorus, chlorophyll a, and Secchi Disk transparency. The 2018 TSI values for each lake are shown in Table 1. Figures 1, 2, and 3 compare trophic state indices for 2018 with those calculated for previous years. The trend over the years is as follows:

1. The total phosphorus TSI was in the mesotrophic range for Big Twin and Little Twin Lakes for most of the years 2002 through 2018; it was in the eutrophic range in past years for Walker Lake, but it has been in the mesotrophic-eutrophic range for the past 9 years for Walker Lake.
2. The chlorophyll a TSI was in the mesotrophic range for Big Twin and Little Twin Lakes from 2002 through 2018 with the exception that the chlorophyll TSI for Big Twin was in the eutrophic range in 2017. The chlorophyll TSI was in the eutrophic range in past years for Walker Lake but was in the mesotrophic-eutrophic range from 2013 through 2016. The Chlorophyll a TSI for Walker Lake has been increasing for the past 3 years.
3. The Secchi Dish transparency TSI was in the mesotrophic range from 1983 through 2018 for Big Twin and Little Twin Lakes; it was mostly in the eutrophic ranged for Walker Lake from 1983 through 2018. However, since the main water source feeding Walker Lake is tannin in nature, the brown coloration may impact the Secchi disk transparency readings. For Walker Lake, therefore, it is best to rely on the phosphorus and chlorophyll concentrations for evaluating the trophic state of the lake.