West Twin Lake

2022 Water Quality Monitoring Report

Twin Lakes Association,
Salisbury, CT

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I. Executive Summary

Aquatic Ecosystem Research (AER) was contracted by Twin Lakes Association (TLA) to assess the water quality in West Twin Lake in Salisbury, CT using data and water samples collected in 2022 by member volunteers. Data and water sample collections occurred on April 20th, May 24th, June 22nd, July 20th, August 11th, September 11th and October 11th, 2022. The maximum depth at the sampling site was approximately 6.7 meters. The lake was stratified in August with the upper metalimnetic boundary situated between 4-5 meters of depth and the thermocline situated between 5-6 meters of depth.

On August 11th, anoxic conditions were observed in the water column in the strata between the upper metalimnetic boundary and the lake bottom. On that date, between 4 - 5 meters of depth, oxygen levels decreased from >6 mg/L to <1 mg/L and were 0 mg/L at 6 meters of depth. By September 11th, after the water column had mixed, oxygen was able to diffuse to lower depths. By October 11th the entire water column had an oxygen concentration of >8 mg/L.

Based on the field and laboratory data and trophic classification criteria, WTL is early-mesotrophic to mesotrophic. Average Secchi disk transparency was characteristic of a mesotrophic lake. Season and summer month chlorophyll-*a* averages were indicative of early-mesotrophic algal productivity. The season epilimnetic total phosphorus average was 5.7 µg/L which is characteristic of an oligotrophic lake system. The hypolimnetic total phosphorus season average of 23.7 µg/L, which is indicative of phosphorus loading from the bottom.

Ammonia loading at the bottom was also observed in the latter part of the season. Also, increasing specific conductance and alkalinity levels at the bottom suggest loading from sediments during periods of anoxia. This is additionally supported by the low oxidation-reduction potential at the bottom in August.

When the 2021 and 2022 datasets were compared, we found no statistically significant differences between trophic variables and algae counts. Additionally, no significant differences were observed between 2021 and 2022 for epilimnetic and hypolimnetic alkalinity, specific conductance, or pH. However, there were significant differences between epilimnetic and hypolimnetic pH in both years, which is not uncommon in deeper lakes. Like East Twin Lake, coprecipitation of phosphorus likely influences trophic variables at West Twin Lake.

TROPIC LEVEL: **Early-mesotrophic to mesotrophic**

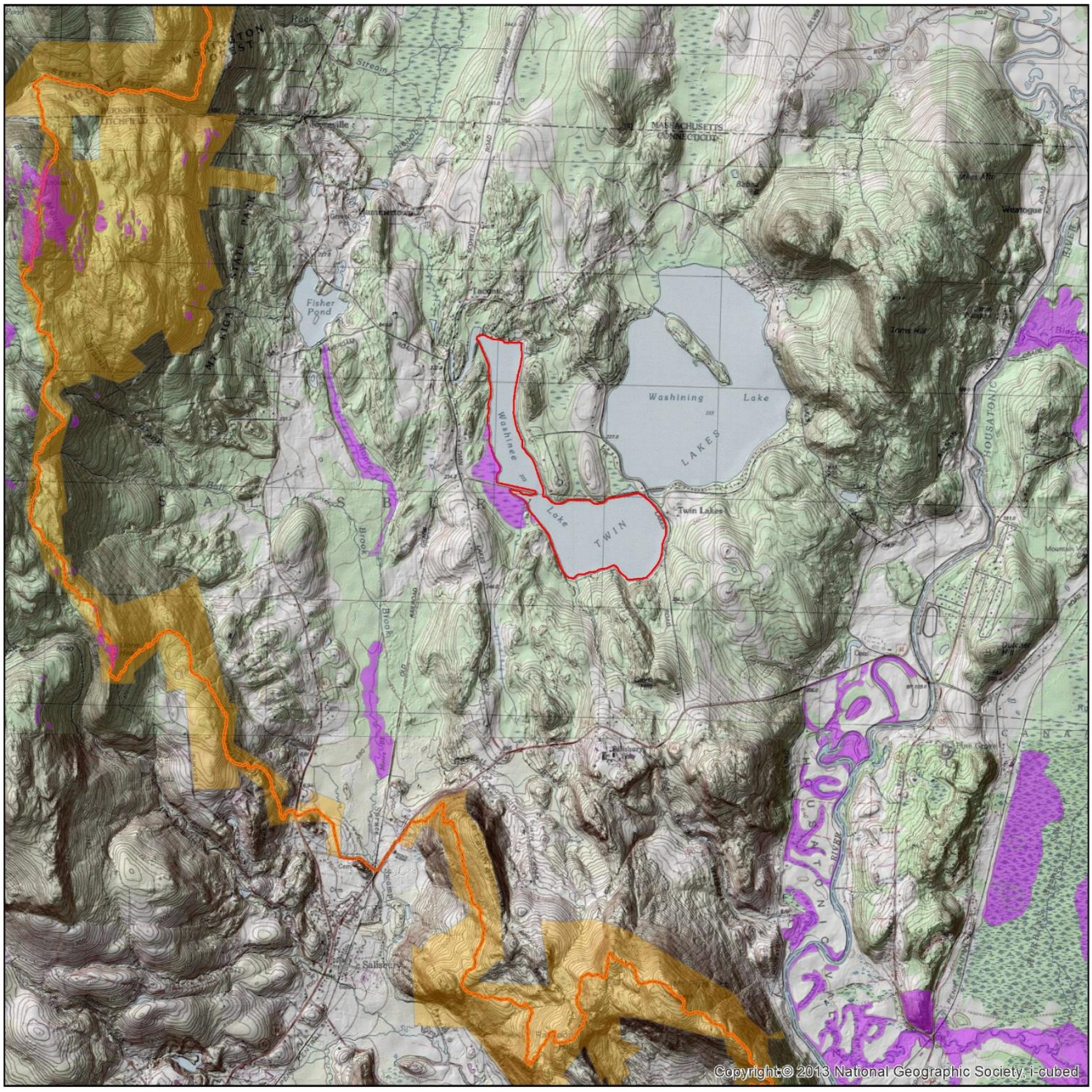

FIG. 1 - LOCATION MAP

West Twin (Washinee) Lake
Salisbury, CT

Legend

- West Twin Lake
- Protected Trail Corridor
- Appalachian Trail
- CT Critical Habitats

SCALE

N

0 0.25 0.5 1 Miles

NOTES
(1) This map contains no authoritative data and is intended for planning purposes only; (2) The location and extent of features illustrated are based on GPS-collected field data as well as direct observations and are approximate only; (3) Basemap data sources include USGS topographic (USA TOPO) maps, 2016 orthophotography and road maps from ESRI and CT ECO map services.

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Figure 1. Location map for West Twin Lake.

II. Introduction

West Twin Lake (aka Washinee Lake and hereafter WTL) is a 290-acre natural lake located in Salisbury, CT. Bordering the Twin Lakes to the west is the steep Taconic Ridge that includes Bear Mountain, Mount Riga State Park and the Appalachian Trail Corridor (see Fig.1). WTL is in the Schenob Brook subregional watershed of the Housatonic mainstem basin which extends northward to Sheffield, Mass. According to the Connecticut Department of Energy & Environmental Protection (CTDEEP) CT Fishing Guide, the local watershed basin is 4,575 acres, therefore the watershed area to lake surface area ratio is 16. WTL is the headwaters of Schenob Brook, a *Class A* stream that flows out of WTL and to the north into the flat valley to the east of the Taconic Ridge. According to the Connecticut Water Quality Standards, designated uses for *Class A* streams includes potential public water supplies. The large wetland on the western shore of WTL contains a Rich Fen, which is designated as one of Connecticut's "critical habitats."

Land use within the watershed is rural residential and forest mixed with extensive agricultural fields and wetlands associated with Schenob Brook. Much of the lake's watershed falls within Connecticut's Marble Valley and – as the name suggests – most of the bedrock geology is comprised of marble; a metamorphized limestone that is rich in calcium carbonate rock which was deposited in the early Paleozoic age. Jacobs and O'Donnell (2002) reported the maximum depth of the lake was 22 feet (6.7 meters) and average depth was 8.7 feet (2.7 meters). The deepest area where water samples are collected is in the larger oval basin at the southern end of the lake (see Fig. 2). The Connecticut Western Railroad tracks once bisected WTL for its train service from Millerton, NY to Hartford. The long narrow panhandle to the north of the former railroad bridge is shallow and largely colonized by aquatic plants. WTL is connected to East Twin Lake via a large culvert and a small waterway.

Unlike East Twin Lake and many of the other larger lakes in Connecticut, West Twin Lake was not included in the major surveys of lakes in Connecticut conducted throughout the 1900s (e.g., Deevey 1940; Frink and Norvell 1984; Canavan and Siver 1994, 1995). Therefore, West Twin Lakes lacks important historical water quality data. The Twin Lakes Association (TWA) engaged Aquatic Ecosystem Research (AER) in 2016 to develop a management program for the Twin Lakes system. Since that time volunteers from the TWA have collected field data and water samples from East Twin Lake. This is the second year that the volunteer monitoring program was expanded to West Twin Lake. In 2022, due to problems with the sampling meter, full water column profile data (temperature, dissolved oxygen, etc.) was only collected on the last three months of the season (See Appendix A).

III. Methods

A volunteer monitoring program was developed by the Twin Lake Association (TLA) with guidance from AER in 2016. Since that time, volunteers from the TLA have conducted annual monitoring at East Twin Lake. In 2021 & 2022, water quality monitoring was also performed at West Twin Lake by TLA volunteer Russ Conklin who sampled one site on April 20, May 24, June 22, July 20, August 11, September 11, and October 11, 2022.

Water samples were collected for nutrient analyses at a depth of one meter below the surface, and at 0.5m to 1m above the sediment-water interface using a Van Dorn horizontal sampler. Samples were stored in a cooler at approximately 3°C and delivered to York Environmental, a Connecticut State certified laboratory located in Newtown, CT. Additional water sample, which were an integration of the top 3m of the water column, were collected with a 3m tube sampler. One was collected for chlorophyll-a analyses by York Environmental and the other for phytoplankton (algae) analyses. The sample for algae analyses were treated with Lugol's solution before delivery to York Environmental, where AER picked them up for analysis.

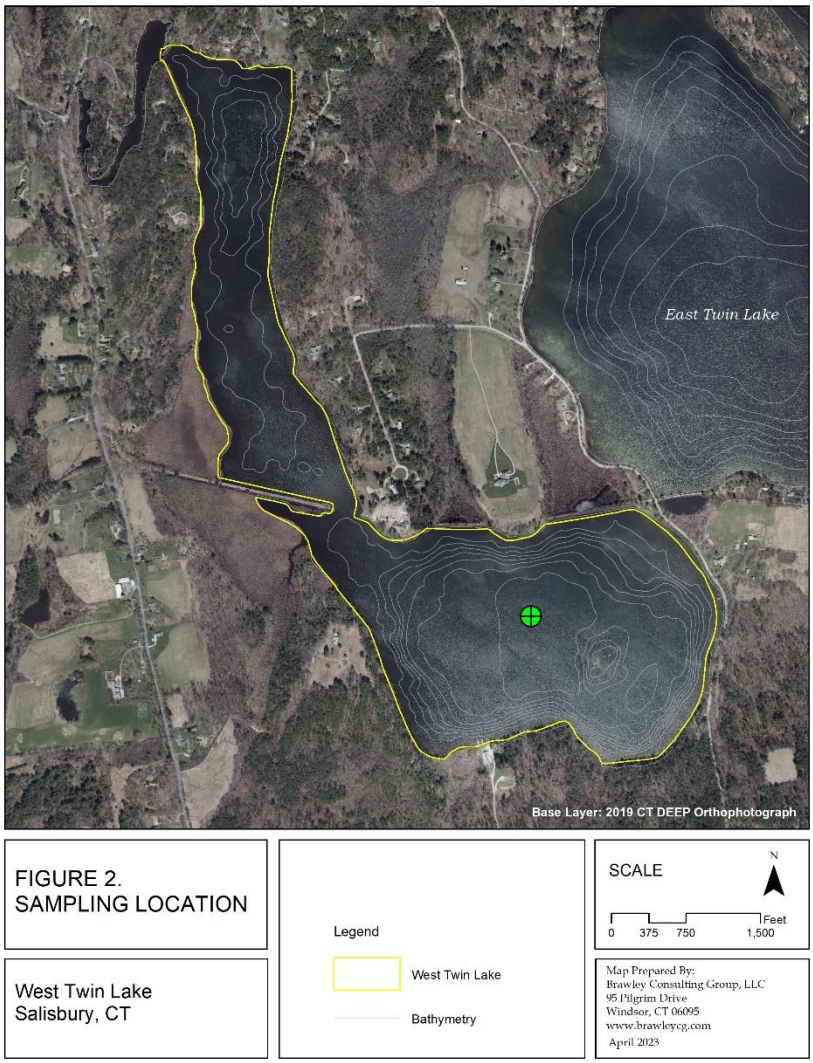

Figure 2. West Twin Lake sampling site location.

Hydrostatic pressure was applied to algae samples to collapse gas vesicles that might be contained within cyanobacteria cells (Lawton et. al. 1999). Known volumes of the samples were concentrated into smaller volumes with centrifugation and a vacuum pump / filtration flask system and measured. A portion of the concentrates were pipetted into a counting chamber then genus-level algal cell enumerations were performed by counting individual cells in a subset of fields within the counting chamber using an inverted Nikon Diaphot research microscope. Those counts were then corrected to be reflective of the entire sample.

IV. Temperature and Dissolved Oxygen

The water temperature profile data provide a view into the thermal characteristics of the lake and seasonal *stratification* resulting from temperature/density differences between depths. In shallow New England lakes, or shallow sites in a deep lake, *stratification* can occur. When a lake is thermally stratified, a middle transitional layer (known as the metalimnion) separates the upper warmer layer (epilimnion) from lower colder waters below (hypolimnion). Within the boundaries of the metalimnion is the thermocline, which is the stratum where the temperature/density change and resistance to mixing are the greatest. This stratification may be short in duration

because wind energy can mix the water column. In deeper lakes or sites, stratification is not easily broken by wind energy.

An oxygen concentration of 5mg/L is generally considered the threshold that delineates favorable conditions for most aerobic organisms in freshwater systems. As concentrations decrease below that threshold, conditions become stressful for aquatic organisms. Minimum oxygen requirements for fisheries in Connecticut's lakes and ponds range from 4 to 5mg/L for cold-water fish (e.g., trout), 2mg/L for cool-water fish (e.g., walleye), and 1 to 2mg/L for warm-water fish (e.g., bass and panfish; Jacobs and O'Donnell 2002).

The loss or absence of oxygen at the bottom of the water column modifies the chemical environment compared to conditions where oxygen is present. These anoxic conditions result in the dissolution of compounds (e.g., iron phosphate) in the sediments that can then dissolve in the interstitial waters and eventually into the waters above the sediments.

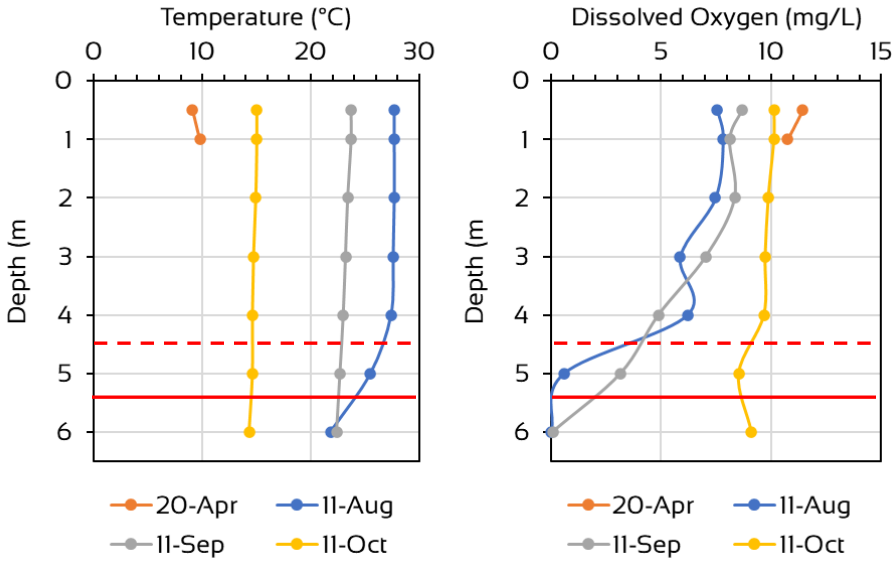

Figure 3. Full temperature and dissolved oxygen profiles from data collcted on August 11th, September 11th, and October 11th of 2022 at West Twin Lake. Partial profile data colleced on Aprl 20th is also displayed. The dashed red line and solid red line represent the location of the August 11th upper metalimnetic boundary and thermocline, respectively.

As noted earlier, WTL water column data (e.g., temperature & dissolved oxygen) could not be collected in the first half of the season due to problems with TLA's multiprobe. However, full data sets were collected on August 11th, September 11th, and October 11th. On those dates, highest temperatures of nearly 28°C were observed on August 11th in the top four meters of the water column. Below that depth temperatures decreased to approximately 22°C (Fig. 3). It was only on August 11th when the water column was stratified with the upper metalimnetic boundary situated between 4 and 5 meters of depth and the thermocline situated between 5 and 6 meters of depth. On September 11th and October 11th, the water temperatures were lower, and the water column was thermally mixed (i.e. no longer stratified).

On August 11th, anoxic conditions were observed in the water column in the strata below the upper metalimnetic boundary and the lake bottom (Fig. 3). On that date, between 4 - 5 meters of depth, oxygen levels decreased from >6 mg/L to <1 mg/L and were 0 mg/L at 6 meters of depth. By September 11th, after the water column had mixed, oxygen was able to diffuse to lower depths. By October 11th the entire water column had an oxygen concentration of >8 mg/L (Fig. 3).

V. Trophic Characteristics

Several of the water quality variables measured in 2022 were used to estimate the current trophic status of WTL. A lake's trophic state is a based on the level of productivity it can support and is determined based on variables that limit or are related to algal productivity, including phosphorus concentration, Secchi transparency, and chlorophyll-*a* concentrations (see Table 1). Lakes supporting very little productivity are typically clear and are referred to as oligotrophic lakes; lakes supporting high levels of productivity are more turbid and are termed eutrophic or highly eutrophic. It is generally those eutrophic or highly eutrophic lakes that experience algal blooms. Based on the sampling data and classification criteria in Table 1, the trophic status of WTL is early-mesotrophic to mesotrophic.

Table 1 . Trophic classification criteria used by the Connecticut Experimental Agricultural Station (Frink and Norvell, 1984) and the CT DEP (1991) to assess the trophic status of Connecticut lakes. The categories range from oligotrophic or least productive to highly eutrophic or most productive.

Trophic Category	Total Phosphorus (µg / L)	Total Nitrogen (µg / L)	Summer Chlorophyll-*a* (µg / L)	Summer Secchi Disk Transparency (m)
Oligotrophic	0 - 10	0 - 200	0 - 2	>6
Early Mesotrophic	10 - 15	200 - 300	2 - 5	4 - 6
Mesotrophic	15 - 25	300 - 500	5 - 10	3 - 4
Late Mesotrophic	25 - 30	500 - 600	10 - 15	2 - 3
Eutrophic	30 - 50	600 - 1000	15 - 30	1 - 2
Highly Eutrophic	> 50	> 1000	> 30	0 - 1

A. Secchi Disk Transparency

Secchi disk transparency is a measure of how much light is transmitted through the water column. Light transmission is influenced by several variables including the quantity of inorganic and organic particulate material in the water column that absorbs or reflects light. In the open water environment, Secchi disk transparency is inversely related to algal productivity.

Light in lakes is important for several reasons, particularly for its role in open water photosynthesis and algal productivity. As light diminishes with depth, so does photosynthetic potential. Photosynthesis decreases with depth and there is a depth where oxygen produced from algal photosynthesis is equal to the oxygen consumed via

algal cellular respiration. That is referred to as the compensation point and is estimated by multiplying the Secchi disk transparency by 2.

Secchi disk transparencies for the season ranged from lows of approximately 2.5 meters on April 20th, September 11th, and October 11th, to a high of 4 m on July 20th (Fig. 4). The season average was 2.98 and the summer average (June – September) was 3.24 m. Those averages are generally characteristic of mesotrophic lakes. Secchi disk transparencies indicated that algal productivity and/or particulate matter in the water column increased from April 20th through July 20th, then decreased through September 11 and remained constant through October 11th.

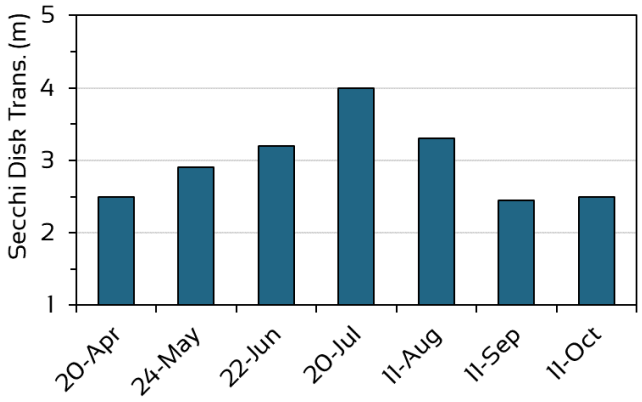

Figure 4. Secchi disk transparencies measured in West Twin Lake during the 2022 season.

B. Chlorophyll-a

Chlorophyll-*a* is the photosynthetic pigment common to all freshwater algae, including cyanobacteria, and is used as a surrogate measurement for algal biovolume in the water. Samples analyzed were integrations of the top three meters of the water column where photosynthetic potential is greatest. Most chlorophyll-*a* concentrations were with a range of 2.5 to 3.5 µg/L (Fig. 5). Those concentrations which did not fall within that range occurred on September 11th when a season low of 1.5 µg/L was measured, and October 11th when a season high of 4.0 µg/L was measured. The season average was 3.1 µg/L, while the summer month average was 2.8 µg/L. Both were indicative of early-mesotrophic algal productivity (See Table 1). Unlike Secchi disk transparency, chlorophyll-*a* concentrations varied little with the exception of the season low September 11th measurement. That was concurrent with low Secchi disk transparency suggesting that something other than algal productivity was reducing the transmission of light on that date.

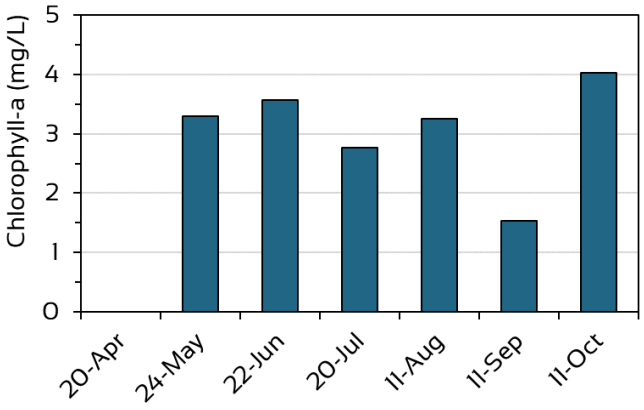

Figure 5. Chlorophyll-a concentrations from samples collected at West Twin Lake during the 2022 season.

C. Total Phosphorus

Algae and cyanobacteria require a variety of micro- and macronutrients to survive. In freshwater systems, phosphorus is what limits algae growth (the *limiting nutrient).* Therefore, total phosphorus (the sum of particulate and dissolved forms of phosphorus) serves as a measure of productivity in most lake studies.

Epilimnetic total phosphorus levels in 2022 were generally low, gradually increasing from 3 to 10 µg/L between May 24th and October 11th (Fig. 6). The season epilimnetic average was 5.7 µg/L which is characteristic of oligotrophic lake systems.

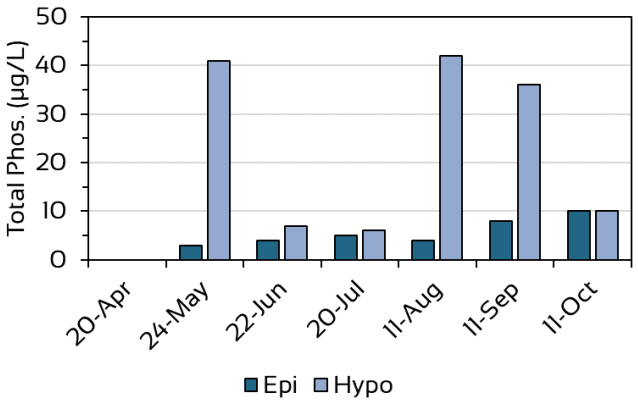

Figure 6. Epilimnetic and hypolimnetic total phosphorus concentrations in West Twin Lake in 2022.

Hypolimnetic total phosphorus levels were more variable during the sampling season. Concentrations on June 22nd, July 20th and October 11th were between 7 and 10 µg/L and were similar to corresponding epilimnetic levels. Hypolimnetic levels on May 24th, August 11th, and September 11th were between 36 and 42 µg/L and significantly higher than epilimnetic levels ($p<0.005$). Two of the three elevated levels (August 11th and September 11th occurred when hypolimnetic oxygen concentrations were <1 mg/L, and likely the result of the protracted period of anoxia at the bottom. The hypolimnetic season average of 23.7 µg/L, when compared to the epilimnetic average, was indicative of some phosphorus loading from the bottom.

D. Nitrogen

Nitrogen is typically the second most limiting nutrient for algae growth in freshwater systems. It can be present in several forms in lake water. Ammonia – a reduced form of nitrogen – is important because it can affect the productivity, diversity, and dynamics of the algal and plant communities. Ammonia can be indicative of internal nutrient loading since bacteria will utilize other forms of nitrogen (e.g., nitrite and nitrate) in lieu of oxygen for cellular respiration under anoxic conditions, resulting in ammonia enrichment of the hypolimnion.

Total Kjeldahl nitrogen (TKN) is a measure of the reduced forms of nitrogen (including ammonia) and total organic proteins in the water column. Since TKN accounts for biologically derived nitrogen-rich proteins in the water column, it is useful in assessing the productivity of the lentic system. Nitrate and nitrite are often below detectable levels in natural systems because they are quickly cycled by bacteria and aquatic plants. Total nitrogen is the sum of TKN, nitrate, and nitrite; since the latter two are often below detectable limits, TKN levels are often similar or equal to total nitrogen levels.

Unfortunately, much of the nitrogen data reported by the commercial laboratories that did the analyses were nominally useful in understanding the trophic status of WTL. Last year, the TLA received high quality data from the State-certified laboratory HydroTechnologies, LLC located in New Milford, CT. HydroTechnologies applied

minimum detection limits (MDLs) and reporting limits (RLs) for lake monitoring projects that were consistent and appropriate for Limnological assessments. For other clients, HydroTechnologies appropriately applied MDLs that were not as low, e.g., and instead used for wastewater treatment facility clients, because levels are much higher in those types of samples. In late 2021, HydroTechnologies was purchased by Pace Analytical Laboratory, a New York-based company. By May of 2022, Pace Analytical stopped receiving walk-in samples at the New Milford facility. Additionally, Pace Analytical utilized MDLs and RLs that were not consistent with lake-related studies.

Prior to May sampling events on the Twin Lakes, AER advised the TLA to switch its commercial laboratory to Aqua Environmental Laboratory in Newtown, CT, a subsidiary of York Analytical Laboratory. This occurred following discussions between AER and Aqua Environmental on MDLs and RLs. Despite those discussions, consistent and appropriate MDLs and RLs were not always used. We communicated with Aqua Environmental throughout the season the need to retest or recalculate nutrient levels when possible, using appropriate MDLs and RLs.

Aqua Environmental was able to lower its MDL and RL for total phosphorus for this study to 10 µg/L, which is the level delineating oligotrophic phosphorus levels from early-mesotrophic phosphorus levels (Table 1). For total Kjeldahl nitrogen, which is an important constituent of total nitrogen, the MDL was 600 µg/L which is the lower limit of eutrophic levels. MDLs of 50 and 100 µg/L have been used for ammonia, and 50 µg/L was used for nitrate and nitrite.

Nitrate was detected in the epilimnetic and hypolimnetic samples collected on May 20th, at 0.07 mg/L and 0.08 mg/L, respectively. Nitrate was not reported in any samples collected afterwards. Epilimnetic total Kjeldahl nitrogen (TKN) exceeded the minimum detection limit (0.6 mg/L) only on July 20th and was 1.06 mg/L. Hypolimnetic TKN exceeded minimum detection limits on September 11th and October 11th and were 0.73 mg/L and 0.63 mg/L, respectively.

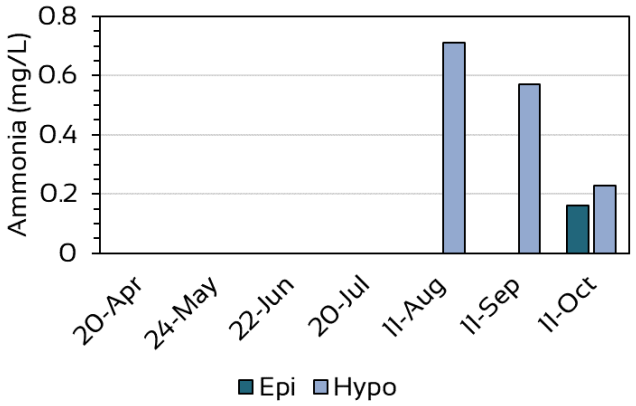

Figure 7. Epilimnetic and hypolimnetic ammonia concentrations in West Twin Lake in 2022.

Ammonia loading was observed in the latter part of the season with hypolimnetic concentrations of 0.71 mg/L and 0.57 mg/L measured in August and September, respectively. In October, the hypolimnetic concentration was 0.23 mg/L, while the epilimnetic concentration was detectable for the first time measured and reported at 0.16 mg/L. This suggests that the bottom waters with the higher concentrations of ammonia were mixed throughout the water column, thereby decreasing hypolimnetic concentration and increasing epilimnetic concentrations.

E. Algae Community Dynamics

Algae have been used in the assessments of inland water resources for many years. The composition and concentrations of algae living in the water column (i.e., phytoplankton) are responsive to environmental conditions. For example, lakes that are high in nutrients are often dominated by Cyanophyta (aka cyanobacteria or blue-green algae) and cell concentrations will likely be high. High concentrations of cyanobacteria can form harmful algal blooms, which can also be toxic (CT DPH & CT DEEP 2021). Algae communities that are more diverse and include species from the Bacillariophyta (aka diatoms), Chrysophyta (aka golden algae), and Chlorophyta (aka green algae) typically have lower cell concentrations, can reflect lower nutrient conditions, and are not considered toxigenic.

Algae cell concentrations, including cyanobacteria (aka blue-green algae) in the samples collected in surface waters of West Twin Lake were low except for June 22nd sample (Fig. 8). The cell concentration of the June 22nd sample was 3,583 cells/mL and dominated by green algae. Cell concentrations of ≤1,500 cells/mL were measured in samples collected on all other dates.

Although they increased with time, cyanobacteria cell concentrations were low (<1,000 cells/mL) throughout the season (see Fig. 8). For comparative purposes, the CT DPH and CT DEEP (2021) associate cyanobacteria cell concentration of <20,000 cyanobacteria cells/mL with Visual Rank Category 1 conditions, which presents the least amount of risk from cyanobacteria to recreational users of freshwaters. Cyanobacteria cell concentrations of >100,000 cells/mL are characteristic of Visual Rank Category 3 conditions, which present the greatest risk to those in contact with the water, and when the State advises municipalities to post beach closure signage.

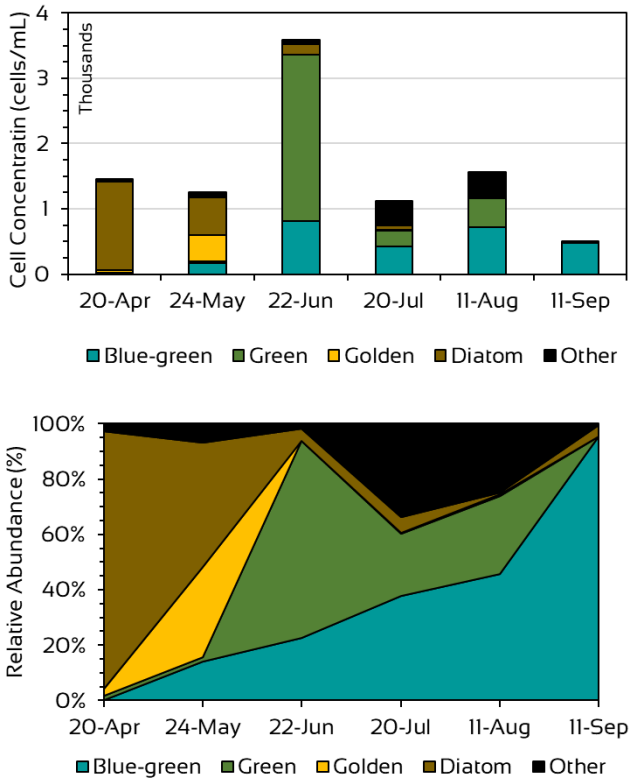

Figure 8. Algae cell concentrations (top) and relative abundance of taxonomic groups (bottom) of samples collected as an integration of the top three meters of the water column. Blue-green algae = Cyanophyta, green algae = Chlorophyta, golden algae = Chrysophyta, diatoms = Bacillariophyta. The Other taxon included dinoflagellates (Dinophyceae), Cryptophyceae, Euglenophyceae, and Ochrophyta.

Diatoms and golden algae were the dominant taxa in the early part of the season (Fig. 8). Most abundant diatoms included *Cyclotella spp*., *Fragilaria spp*., and *Synedra spp*., while the dominant golden algae genus was *Dinobryon spp*. By June, Chlorophyta, followed by cyanobacteria, were the dominant algae in the water column. The colonial *Gloeocystis spp*. was the most abundant green algae, while the cyanobacteria *Dolichospermum spp*.

and *Aphanocapsa spp*. increased in importance over the mid-summer months. By September, cyanobacteria reached its greatest relative abundance (% of all algae cells), although cell concentrations remained low. *Microcystis spp*. was the most abundant cyanobacteria. Others observed in the late season sample included *Dolichospermum spp*. and *Aphanocapsa spp*.

The Chrysophyta *Dinobryon spp*. is considered a clear water species in temperate lakes (Guiry & Guiry 2021) as are golden algae in general. The cyanobacteria *Aphanocapsa spp*. is a picoplankton (cell diameters of ≤2µm) which have been shown to be more efficient at absorbing nutrients than algae of larger cell sizes, providing it the ability to grow and outcompete other algae when nutrients are limiting (Wehr 1989). These constituents of the planktonic algae community, along with the low algae cell concentrations, are consistent with other trophic variables (e.g., low epilimnetic total phosphorus concentrations).

VI. Specific Conductance

Conductivity is a surrogate measurement for the sum of the ionized minerals, metals and salts in the water, and are a measure of water's ability to transmit an electrical current. Data collections included measures of both conductivity and specific conductance and were measured in microsiemens per cm (µS/cm). Specific conductance is conductivity standardized to a set water temperature of 25°C. Temperature influences conductivity and – in the field – temperature varies with depth and date. Specific conductance is an important metric in limnological studies due to its ability to detect pollutants and/or nutrient loadings. Specific conductance can also have an influence on organisms that inhabit a lake or pond; particularly, algae. The composition of algal communities has been shown to be related, in part, to conductivity levels in lakes (e.g., Siver 1993, McMaster & Schindler 2005).

Specific conductance was measured at surface depths on April 20th and throughout the water column on August 11th, September 11th, and October 11th (Fig. 9). Specific conductance from the surface to a depth of 4 meters were consistently between 255 and 260 µS/cm on September 11th and October 11th. Specific conductance increased slightly with depth on September 11th. The August 11th specific conductance profile differed in two ways. Levels from the surface to 4 meters of depth were slightly higher (between 268 and 270 µS/cm) than levels in the following months. Secondly specific conductance below the upper limnetic boundary (approximately 4.5 meters) increased to 359 µS/cm by 6 meters of depth.

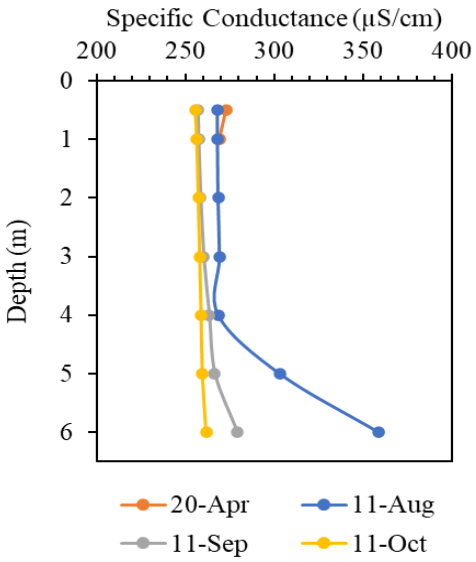

Figure 9. Specific conductance profiles from data collcted on August 11th, September 11th, and October 11th of 2022 at West Twin Lake. Partial profile data colleced on Aprl 20th is also displayed.

VII. Alkalinity and pH

Alkalinity is a measure of calcium carbonate and is an indication of a lake's ability to neutralize acid (i.e., buffering capacity). Alkalinity of surface waters is largely influenced by local geology and other watershed characteristics. West Twin Lake lies in the Marble Valley of Connecticut where lakes inherently have high alkalinity due to the calcium carbonate in marble bedrock. Alkalinity at the bottom of the water column can also be generated internally from the biologically mediated reduction of iron, manganese, and sulfate via cellular respiration in the anoxic lake sediments, and denitrification of nitrate to elemental nitrogen (Wetzel 2001).

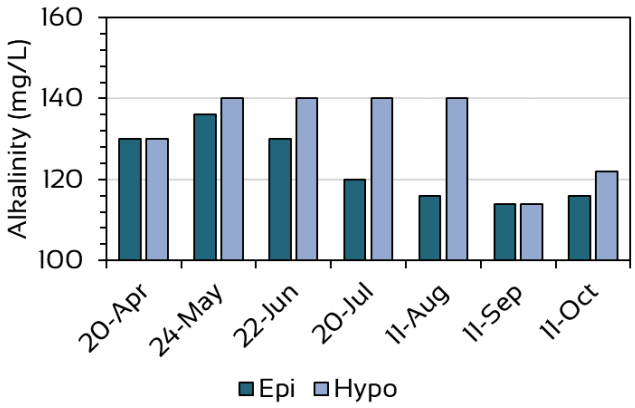

Figure 10. Epilimnetic and hypolimnetic alkalinity concentrations in West Twin Lake in 2022.

Alkalinity levels were generally high for CT lakes, but consistent with levels in Marble Valley Lakes (Canavan and Siver 1994, 1995). Epilimnetic levels were between 130 and 136 mg/L in April, May, and June (Fig. 10). Levels decreased to 116 mg/L between June and August and varied very little afterwards (Fig. 10). Hypolimnetic alkalinity increased from 130 to 140 mg/L between April and May, and remained at that level through August 11th. Hypolimnetic levels were substantially lower in September and October, after the lake had mixed.

The normal pH of surface waters of lakes in the Northeast can range from approximately 6 to 9 SU (standard units). Very low or very high pH levels will not support diverse fauna and flora in freshwater ecosystems. Algal community composition is influenced by pH. For example, the pH of the water will determine the type of dissolved carbon in the water column which will algae community characteristics. At pH levels greater than 8.3 SU, bicarbonate is the dominant form of carbon available to the pelagic algal community. Blue-green algae have adaptive advantages over other algal groups in those conditions because they can efficiently utilize that form of carbon. Other algal groups are dependent upon carbon dioxide which is more readily available in water below a pH of 8.3.

Since pH was measured with the multiprobe, the only pH data available were from April, August, September, and October (Fig. 11). Epilimnetic pH measurements ranged from a low of 8.3 in April to highs of 8.6 to 8.8 during the final three sampling events. The season average based on those data was

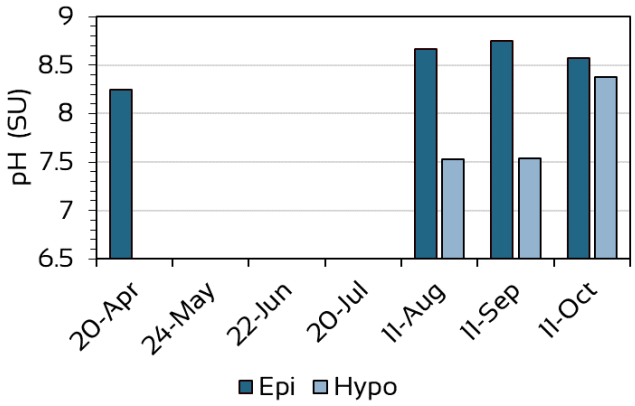

Figure 11. Epilimnetic and hypolimnetic pH at West Twin Lake in 2022.

8.6. Hypolimnetic pH was on average lower (average of 7.8), and likely a result of higher carbon dioxide concentrations at lower depths. The hypolimnetic pH levels were 7.5 on August 11th and September 11th. On October 11th the hypolimnetic pH of 8.4 was more similar to the corresponding epilimnetic pH (Fig. 11).

VIII. Oxidation Reduction Potential

Field data collected at West Twin Lake also included oxidation-reduction potential (aka ORP or Redox). The ORP in lakes refers to the oxidative or reductive state in a particular stratum of the water column. It can provide some insight as to whether phosphorus is changing from an insoluble particulate state in lake sediments to a soluble state that readily diffuses to water between sediment particles and by diffusion to overlying waters. If mixed into the photic zone (i.e., where algae can harvest it for growth) the phosphorus can become available to lentic algae. When OPR is ≥200 millivolts (mV) phosphate remains bound to available iron; at ORP values of <200mV, iron is reduced and the phosphate chemically bound to the iron becomes soluble (Søndergaard 2009).

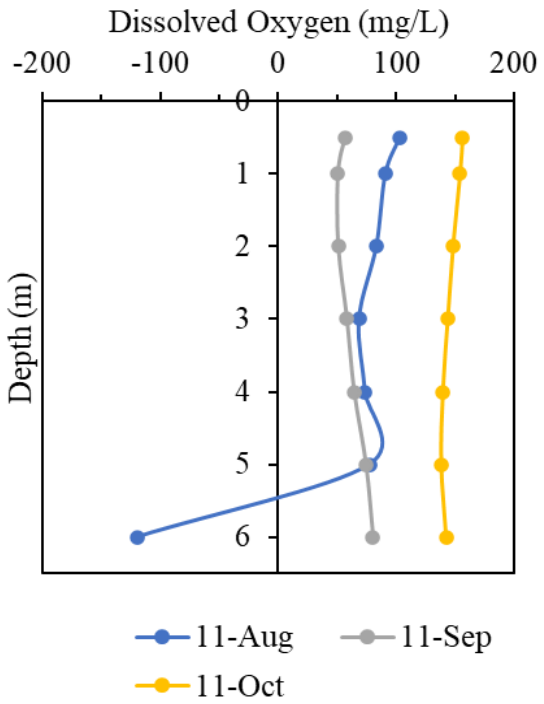

Figure 12. Oxidation-reduction potentials measured at West Twin Lake in 2022.

Water column ORP is presented in Figure 12. All measurements were <200 mV. We suspect the ORP probe may require calibration. We checked to see if it was consistent with data collected last year. However, ORP was not reported last year. The ORP profile from August 11th was notable in that a dramatic decrease occurred between 5 and 6 meters of depth. We suspect that the ORP at 6 meters was reflective of conditions where iron was reduced and the phosphorus loaded at the bottom.

IX. Historical Trends and Discussion

The 2022 season was the second consecutive season water quality data was collected by the TLA. For this report, the 2022 data was compared to the 2021 data and analyses were performed to determine whether there were significant differences in the season averages for 2021 and 2022. In 2021, WTL was stratified from May through August but the relative thermal resistance to mixing was never strong (RTRM >80). Although water temperature data was unavailable from April through July of 2022, the August data indicated that the water column was stratified and resistance to mixing on that date was strong (RTRM >80). In both years the water column was mixed by September and October. Strength of resistance to mixing in the water column is largely a consequence of seasonal weather, e.g., temperature and wind.

Overall, there was no significant difference between trophic variables measured in 2021 and 2022. The 2021 and 2022 season average Secchi disk transparencies were 3.79 meters and 2.98 meters respectively which is not significantly different ($p>0.05$). Average epilimnetic total phosphorus in 2021 and 2022 was 18.3 µg/L and 5.7 µg/L, respectively, which although notably different, were not significantly different ($p>0.05$). Average hypolimnetic total phosphorus in 2021 and 2022 were 25.3 µg/L and 23.7 µg/L, respectively, which was not significantly different ($p>0.05$).

Lastly, to assess the trophic state and algal productivity, we compared the 2021 and 2022 average total algae cell concentrations and the average cyanobacteria cell concentrations. In both cases, averages were not significantly different ($p>0.05$). The 2021 and 2022 average total algae cell concentrations were 3,862 and 1,597 cells/mL and average cyanobacteria concentrations were 1,446 and 434 cells/mL.

For chemical variables, the 2021 and 2022 epilimnetic and hypolimnetic averages for specific conductance, alkalinity, and pH were compared. Average epilimnetic specific conductance was 236 µS/cm in 2021 and 263 µS/cm in 2022, which is not significantly different ($p>0.05$). Hypolimnetic season averages were also not significantly different ($p>0.05$) with 2021 and 2022 averages of 264 µS/cm and 300 µS/cm, respectively. It is important to note that the number of samples for the 2022 epilimnetic and hypolimnetic datasets were 4 and 3, respectively, while the samples size for both depths in 2021 was 6.

Average epilimnetic alkalinities in 2021 and 2022 were 117 mg/L and 123 mg/L, respectively, andhypolimnetic averages were 127 mg/L and 132 mg/L. Averages for each depth were not significantly different ($p>0.05$).

Lastly, the average epilimnetic pH values in 2021 and 2022 were both 8.6 while the respective hypolimnetic averages were 7.7 and 7.8. Seasonal averages for each depth were not significantly different ($p>0.05$). Season epilimnetic and hypolimnetic averages for each season were significantly different ($p<0.05$). As with specific conductance, the 2022 epilimnetic and hypolimnetic sample sizes were 4 and 3, respectively, while in 2021 each average was based on 6 measurements.

Given the small sample size of the data (2 years), it is not surprising that differences between years were not detected. The data does provide good baselines from which potential change in the future can be measured. Average trophic variables in 2022 spanned oligotrophic to mesotrophic characteristics: average total phosphorus was characteristic of oligotrophic conditions; average chlorophyll-*a* concentration was characteristic of early-mesotrophic productivity; and average Secchi transparency was characteristic of mesotrophic productivity. Average algae cell concentrations were low and consistent with lower average chlorophyll-*a* concentration. Collectively, an assessment of early-mesotrophic is fitting.

Like East Twin Lake, coprecipitation likely influences trophic variables at West Twin Lake. Coprecipitation refers to the process of phosphorus in the water column binding with calcite minerals. This occurs in lakes with high pH and high calcium concentrations. The pH in the epilimnion has consistently been high. As a

lake situated in the Marble Valley of Connecticut, the calcium levels are also likely to be high. Alkalinity, which is reported as milligrams of calcium carbonate, is also high. It is notable that epilimnetic alkalinity decreased as the season progresses, signifying a loss of calcium due to it precipitating out of the water column. The precipitate can also result in a loss of transparency since the calcite-phosphorus minerals can also absorb and reflect light.

West Twin Lake exhibits some signs of aging, e.g., loading of phosphorus, ammonia, and alkalinity in the hypolimnion in the latter part of the summer season, after the bottom waters have been anoxic. Those levels tended to decrease after mixing in the fall.

X. Recommendations

Since the TLA actively manages aquatic plants at West Twin Lake, we strongly recommend continued water quality monitoring and building a database for the lake. This database will serve to provide a foundation from which shifts in water quality can be assessed in the future.

We also recommend annual or biannual calibration of the YSI multiprobe by US Environmental in East Hartford, CT. The oxidation-reduction potential data did appear suspect and that sensor may require calibration or replacement. We advise checking with US Environmental on the warranty that may have come with the initial instrument purchase.

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Appendix A – Laboratory and Field Data

20-Apr	Depth (m)	ChL-a (µg/L)	Alk (mg/L)	NH4 (mg/L)	NO3 (mg/L)	TP (µg/L)	TKN (mg/L)
	Epi		130	0	0.07	0	0
	Hypo		130	0	0.08	0	0
24-May	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	3.29	136	0	0	3	0
	Hypo		140	0	0	41	0
22-Jun	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	3.257	130	0	0	4	0
	Hypo		140	0	0	7	0
20-Jul	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	2.76	120	0	0	0	1.06
	Hypo		140	0	0	0	0
11-Aug	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	3.25	116	0	0	4	
	Hypo		140	0.71	0	42	0
11-Sep	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	1.53	114	0	0	8	
	Hypo		114	0.57	0	36	0.73
11-Oct	**Depth (m)**	**ChL-a (µg/L)**	**Alk (mg/L)**	**NH4 (mg/L)**	**NO3 (mg/L)**	**TP (µg/L)**	**TKN (mg/L)**
	Epi	4.03	116	0.16	0	10	0
	Hypo		122	0.23	0	10	0.65

April 22, 2022 **Total Depth: 6.6m** **Secchi Disk: 2.5 m**

Depth (M)	Temp(C)	mmHg	DO(%L)	DO(mg/L)	Cond(uS/cm)	SPC(uS/cm)	pH
0.5	9.1	747.8	100.7	11.43	189.8	272.9	8.38
1	9.8	747.8	96.3	10.75	191.0	269.3	8.25
2							
3							
4							
5							
6							
6.1							

August 11, 2022 **Total Depth: 6.35 m** **Secchi Disk: 3.3 m**

Depth (M)	Temp(C)	mmHg	DO(%L)	DO(mg/L)	Cond(uS/cm)	SPC(uS/cm)	pH	ORP(mv)
0.5	27.7	740.0	98.7	7.56	282.0	268.2	8.68	103.0
1	27.7	739.9	102.0	7.81	282.0	268.3	8.67	90.9
2	27.7	739.9	97.5	7.47	282.2	268.6	8.68	83.2
3	27.6	739.9	76.6	5.87	282.9	269.4	8.66	68.5
4	27.4	739.9	80.6	6.20	281.2	268.8	8.63	73.6
5	25.5	739.9	7.4	0.59	306.2	303.4	7.53	77.3
6	21.8	739.9	0.0	0.00	337.0	358.9	7.53	-119.5

September 11, 2022 **Total Depth: 6.55 M** **Secchi Disk: 2.45 m**

Depth (M)	Temp(C)	mmHg	DO(%L)	DO(mg/L)	Cond(uS/cm)	SPC(uS/cm)	pH	ORP(mv)
0.5	23.7	743.6	104.7	8.66	250.9	257.1	8.75	56.4
1	23.7	743.6	98.1	8.12	250.8	257.3	8.75	50.6
2	23.4	743.6	100.3	8.34	250.6	258.5	8.72	50.9
3	23.2	743.6	84.1	7.03	251.3	260.2	8.52	58.2
4	23.0	743.5	58.20	4.88	253.1	263.3	8.05	64.3
5	22.7	743.6	37.50	3.16	254.9	266.5	7.81	74.3
6	22.4	743.5	0.90	0.08	265.6	279.2	7.54	80.3

October 11, 2022 **Total Depth: 6.5 m** **Secchi Disk: 2.5 m**

Depth (M)	Temp(C)	mmHg	DO(%L)	DO(mg/L)	Cond(uS/cm)	SPC(uS/cm)	pH	ORP(mv)
0.5	15.0	744.9	102.8	10.15	206.9	255.6	8.63	155.8
1	15.0	745.1	102.6	10.14	207.3	256.5	8.57	153.6
2	14.9	745.0	99.8	9.88	207.8	257.4	8.59	147.9
3	14.7	745.0	98.0	9.74	207.3	258.2	8.58	143.5
4	14.6	745.0	97.2	9.68	207.5	259.0	8.55	139.5
5	14.6	745.0	85.5	8.53	207.9	259.7	8.52	138.2
6	14.3	745.1	90.9	9.11	208.5	261.8	8.38	142.1

Appendix B – Algae Data

April 20, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	2	0.2
	Aphanocapsa sp.	2	0.2		
	Coelosphaerium sp.	0	0.0		
	Woronichinia sp.	0	0.0		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	22	1.5
	Coelastrum sp.	0	0.0		
	Cruceginia sp.	0	0.0		
	Scenedesmus sp.	20	1.4		
	Staurastrum sp.	0	0.0		
	Tetraedron sp.	2	0.2		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	38	2.6
	Dinobryon sp.	0	0.0		
	Kephyrion sp.	18	1.2		
	Mallomonas sp.	2	0.2		
	Synura sp.	2	0.2		
	Uroglenopsis sp.	16	1.1		
Bacillariophyta	*Asterionella sp.*	7	0.5	1351	92.9
	Aulocoseria sp.	38	2.6		
	Cyclotella sp.	1157	79.6		
	Fragilaria sp.	18	1.2		
	Synedra sp.	123	8.4		
	Tabellaria sp.	9	0.6		
	Pennate Diatom	0	0.0		
Dinophyceae	*Ceratium sp.*	0	0.0	7	0.5
	Glenodinium sp.	2	0.2		
	Gymnodinium sp.	4	0.3		
	Peridinium sp.	0	0.0		
Cryptophyceae	*Cryptomonas sp.*	9	0.6	9	0.6
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	0	0.0
	Trachelomonas sp.	0	0.0		
	Unknown	25	1.7	25	1.7
Taxa identified					
16	Totals	1454	100	1454	100

May 24, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	175	13.9
	Dolichospermum sp.	175	13.9		
	Gomphosphaeria	0	0.0		
	Woronichinia sp.	0	0.0		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	20	1.6
	Coelastrum sp.	0	0.0		
	Cosmarium sp.	3	0.3		
	Oocystis sp.	3	0.3		
	Pediastrum sp.	0	0.0		
	Scenedesmus sp.	13	1.1		
	Tetraedron sp.	0	0.0		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	411	32.6
	Dinobryon sp.	404	32.1		
	Kephyrion sp.	0	0.0		
	Mallomonas sp.	7	0.5		
Bacillariophyta	*Asterionella sp.*	119	9.5	566	45.0
	Aulocoseria sp.	17	1.3		
	Cyclotella sp.	33	2.6		
	Fragilaria sp.	361	28.7		
	Synedra sp.	36	2.9		
	Tabellaria sp.	0	0.0		
	Pennate Diatom	0	0.0		
Dinophyceae	*Ceratium sp.*	7	0.5	33	2.6
	Glenodinium sp.	3	0.3		
	Gymnodinium sp.	3	0.3		
	Peridinium sp.	20	1.6		
Cryptophyceae	*Cryptomonas sp.*	26	2.1	26	2.1
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	0	0.0
	Trachelomonas sp.	0	0.0		
	Unknown	26	2.1	26	2.1
Taxa identified					
16	*Totals*	1258	100	1258	100

June 22, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	815	22.7
	Aphanocapsa sp.	638	17.8		
	Dolichospermum sp.	115	3.2		
	Microcystis sp.	62	1.7		
	Snowella sp.	0	0.0		
	Woronichinia sp.	0	0.0		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	2547	71.1
	Cruceginia sp.	244	6.8		
	Dictyosphaerium sp.	0	0.0		
	Elakatothrix sp.	18	0.5		
	Eudorina elegans	0	0.0		
	Gloeocystis sp.	1936	54.0		
	Mougiotia sp.	0	0.0		
	Nephrocytium sp.	53	1.5		
	Oocystis sp.	226	6.3		
	Quadrigula sp.	71	2.0		
	Tetraedron sp.	0	0.0		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	0	0.0
	Dinobryon sp.	0	0.0		
	Synura sp.	0	0.0		
	Uroglenopsis sp.	0	0.0		
Bacillariophyta	*Asterionella sp.*	0	0.0	159	4.4
	Aulocoseria sp.	0	0.0		
	Cyclotella sp.	159	4.4		
Dinophyceae	*Ceratium sp.*	18	0.5	18	0.5
	Glenodinium sp.	0	0.0		
	Peridinium sp.	0	0.0		
Cryptophyceae	*Cryptomonas sp.*	31	0.9	31	0.9
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	0	0.0
	Phacus sp.	0	0.0		
	Trachelomonas sp.	0	0.0		
	Unknown	13	0.4	13	0.4
Taxa identified					
12	*Totals*	3583	100	3583	100

July 20, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	421	37.7
	Aphanocapsa sp.	43	3.9		
	Chroococcus sp..	72	6.4		
	Dolichospermum sp.	304	27.2		
	Microcystis sp.	2	0.2		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	252	22.6
	Coelastrum sp.	0	0.0		
	Gloeocystis sp.	195	17.5		
	Oocystis sp.	50	4.5		
	Quadrigula sp.	0	0.0		
	Scenedesmus sp.	2	0.2		
	Schroederia sp.	0	0.0		
	Selenastrum sp.	2	0.2		
	Tetraedron sp.	2	0.2		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	4	0.4
	Dinobryon sp.	2	0.2		
	Mallomonas sp.	2	0.2		
	Synura sp.	0	0.0		
	Uroglenopsis sp.	0	0.0		
Bacillariophyta	*Asterionella sp.*	0	0.0	63	5.6
	Aulocoseria sp.	26	2.3		
	Cyclotella sp.	37	3.3		
	Fragilaria sp.	0	0.0		
Dinophyceae	*Ceratium sp.*	2	0.2	9	0.8
	Glenodinium sp.	4	0.4		
	Gymnodinium sp.	0	0.0		
	Peridinium sp.	2	0.2		
Cryptophyceae	*Cryptomonas sp.*	2	0.2	2	0.2
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	22	1.9
	Trachelomonas sp.	22	1.9		
Ochrohyta	*Stichogloea sp.*	317	28.4	317	28.4
	Unknown	26	2.3	26	2.3
Taxa identified					
19	*Totals*	1116	100	1116	100

August 11, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	716	45.8
	Aphanocapsa sp.	81	5.2		
	Chroococcus sp..	5	0.3		
	Cylindrospermopsis sp.	73	4.7		
	Dolichospermum sp.	553	35.4		
	Lyngbya sp.	3	0.2		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	442	28.2
	Coelastrum sp.	0	0.0		
	Cosmarium sp.	0	0.0		
	Cruceginia sp.	3	0.2		
	Gloeocystis sp.	355	22.7		
	Nephrocytium sp.	62	4.0		
	Oocystis sp.	14	0.9		
	Selenastrum sp.	3	0.2		
	Tetraedron sp.	5	0.3		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	5	0.3
	Synura sp.	3	0.2		
	Uroglenopsis sp.	3	0.2		
Bacillariophyta	*Asterionella sp.*	0	0.0	14	0.9
	Aulocoseria sp.	3	0.2		
	Cyclotella sp.	8	0.5		
	Fragilaria sp.	3	0.2		
Dinophyceae	*Ceratium sp.*	8	0.5	16	1.0
	Glenodinium sp.	5	0.3		
	Gymnodinium sp.	0	0.0		
	Peridinium sp.	3	0.2		
Cryptophyceae	*Cryptomonas sp.*	5	0.3	5	0.3
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	43	2.8
	Phacus sp.	0	0.0		
	Trachelomonas sp.	43	2.8		
Ochrophyta	*Stichogloea sp.*	260	16.6	260	16.6
	Unknown	62	4.0	62	4.0
Taxa identified					
22	*Totals*	1565	100	1565	100

September 11, 2022

Taxa	Genus / species	Cells / mL	%	Taxa cells / mL	Taxa %
Cyanophyta	*Aphanizomenon sp.*	0	0.0	477	95.4
	Aphanocapsa sp.	23	4.6		
	Chroococcus sp..	7	1.3		
	Dolichospermum sp.	31	6.1		
	Microcystis sp.	417	83.3		
Chlorophyta	*Anikistrodesmus sp.*	0	0.0	0	0.0
	Coelastrum sp.	0	0.0		
	Nephrocytium sp.	0	0.0		
	Oocystis sp.	0	0.0		
	Tetraedron sp.	0	0.0		
Chrysophyta	*Chrysosphaerella sp.*	0	0.0	0	0.0
	Mallomonas sp.	0	0.0		
	Synura sp.	0	0.0		
	Uroglenopsis sp.	0	0.0		
Bacillariophyta	*Asterionella sp.*	0	0.0	21	4.2
	Aulocoseria sp.	21	4.2		
Dinophyceae	*Ceratium sp.*	0	0.0	0	0.0
	Glenodinium sp.	0	0.0		
	Gymnodinium sp.	0	0.0		
	Peridinium sp.	0	0.0		
Cryptophyceae	*Cryptomonas sp.*	0	0.0	0	0.0
	Rhodomonas sp.	0	0.0		
Euglenophyceae	*Euglena sp.*	0	0.0	2	0.4
	Phacus sp.	0	0.0		
	Trachelomonas sp.	2	0.4		
	Unknown	0	0.0	0	0.0
Taxa identified					
6	*Totals*	500	100	500	100

Laurence J. Marsicano

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RELEVANT EXPERIENCE

- Over 30 years as a lake ecologist, manager, advocate, educator, and leader in Connecticut. Successful in the academic, public, and private sectors.
- Advanced the mission of the Candlewood Lake Authority from 1998 through 2017 with the last 14 of those as Executive Director. The board and staff of that agency served the five municipalities surrounding Candlewood Lake, the largest lake in the State and one of Connecticut's most important inland water resources.
- Developed meaningful relationships and worked with the general CT lake community, local and state environmental agency staff, academic researchers, elected leaders at all levels of government, and educators from middle school through college/university levels.
- Co-directed an interdistrict grant program that utilized Candlewood Lake as a living, learning laboratory. The program ran for 10+ years and engaged ~150 high school students and teachers each year.
- Have trained and supervised employees and/or students in Limnological and Paleolimnological field and laboratory methods.
- I was a founding member of the Connecticut Federation of Lakes, have, and continue to serve as a volunteer and an officer of Connecticut's lake advocacy, nonprofit organization.

PROFESSIONAL EXPERIENCE

- **Principal Partner – Aquatic Ecosystem Research, LLC.** July 2017 to present
- **Adjunct Faculty** – Western Connecticut State University, Biological and Environmental Science Department. August 2011 to present
- **Executive Director –** Candlewood Lake Authority, Sherman, CT 06784. April 2003 to July 2017
- **Lake Preservation Director –** Candlewood Lake Authority, Sherman, CT 06784. April 1998 to Oct. 2002
- **Academic Research Associate –** Connecticut College, New London, CT 06320. Sept. 1989 to Jan. 1998
- **Visiting Lecturer –** Connecticut College, New London, CT 06320. August 1997 to January 1998
- **Research Assistant** – Western Connecticut State University, Danbury, CT 06810. 1987 to 1989

CERTIFICATION, EDUCATION, AND TRAINING

- **Certified Lake Manager**, North American Lake Management Society, 2017
- **Professional Certification** in GIS, Pace University, 2014
- **Certification** by National Project WET as a Teacher Training Facilitator, CT DEP 2002
- **Graduate Certification** in GIS Technology, University of New Haven 2001
- **M.A. in Botany**, Connecticut College 1993
- **B.A. in Biology**, Western Connecticut State University 1988

AWARDS

- **Excellence in Environmental Stewardship** from the **Connecticut Outdoor and Environmental Education Association** in 2018
- **Recognition of Service** in the **Congressional Record** by **US Rep. Elizabeth Esty** on June 14, 2017
- **Watershed Conservationist Award** from the **Housatonic Valley Association** in 2011
- **Conservation Professional of the Year** from the **Litchfield County Conservation District** in 2002
- **Honor Award**, **Southern New England Chapter of the Soil and Water Conservation Society** in 2000.
- **Green Circle Award** from the **Connecticut Department of Environmental Protection** in 1999.
- **Conservation Award** from **Housatonic Valley Association** for educational publication entitled *Candlewood Lake: Watershed Awareness and Lake Preservation* in 1998.

ORGANIZATIONS

- **Connecticut Federation of Lakes** – Founding member 1995 - present; Treasurer from 1995 – 2001; Vice President from 2009 – 2011, 2018 - present; President from 2011 - 2015
- **Northwest Conservation District** – Board member from 2003 – 2010
- **Connecticut Forest and Park Association** – Board member from 1994 – 2002
- **North American Lakes Management Society** – Member since 1990

SELECTED PUBLICATIONS

PEER-REVIEWED SCIENTIFIC PAPERS

Siver, P.A., Sibley, J., Lott, AM., **Marsicano**, L.J. Temporal changes in diatom valve diameter indicate shifts in lake trophic status. J Paleolimnology 66, 127–140 (2021). https://doi.org/10.1007/s10933-021-00192-y

Siver, P., L. **Marsicano**, A. Lott, S. Wagener, N. Morris. 2018. Wind Induced Impacts on Hypolimnetic Temperature and Thermal Structure of Candlewood Lake (Connecticut, U.S.A.) from 1985-2015. Geo: Geography and the Environment. 5(2). https://doi.org/10.1002/geo2.56

Kohli, P., Siver, P.A., **Marsicano**, L.J., Hamer, J.S., and Coffin, A.M. 2017. Statistical Assessment of Long-term Trends for Management of Candlewood Lake, Connecticut, USA. Journal of Lake and Reservoir Management. 33:280-300

Lonergan, T., L. **Marsicano**, and M. Wagener. 2014. A laboratory examination of the effectiveness of winter seasonal drawdown to control invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Journal of Lake and Reservoir Management. 30:381-392

Moore H.H., Niering W.A., **Marsicano** L.J, and Dowdell M. 1999. Vegetation change in created emergent wetlands (1988–1996) in Connecticut (USA). Wetland Ecology and Management. 7:177-191.

Siver, P.A. A. M. Lott, E. Cash, J. Moss, and L.J. **Marsicano**. 1999. Century changes in Connecticut, USA, lakes as inferred from siliceous algal remains and their relationship to land use changes. Limnology and Oceanography 44:1928-1935.

Marsicano, L.J. and A.H. **Brawley**. 1997. Land use, watersheds and aquatic resources. Connecticut Woodlands 62(3): 21-23

Siver, P.A. and L.J. **Marsicano**. 1996. Inferring trophic conditions using scaled chrysophytes. Beiheft zur Nova Hedwigia 114:233-246.

Siver, P.A., Canavan, R.W. IV, Field, C., **Marsicano**, L.J. and A.M. Lott. 1996. Historical changes in Connecticut lakes over a 55-year period. Journal of Environmental Quality 25: 334-345

Marsicano, L.J., J.L. Hartranft, P.A. Siver, and J.S. Hamer. 1995. An historical account of water quality changes in Candlewood Lake, Connecticut, over a sixty-year period using paleolimnology and ten years of water quality data. Journal of Lake and Reservoir Management 11:15-28.

Lott, A.M., Siver, P.A., **Marsicano**, L.J., Kodama, K.P. and R.E. Moeller. 1994. The paleolimnology of a small waterbody in the Pocono Mountains of Pennsylvania, USA: reconstructing 19th-20th century specific conductivity trends in relation to changing land use. Journal of Paleolimnology 12: 75-86.

Marsicano, L.J. and P.A. Siver. 1993. A paleolimnological assessment of lake acidification in five Connecticut lakes. Journal of Paleolimnology 9:202-221.

Siver, P.A. and L.J. **Marsicano**. 1993. *Mallomonas connensis* sp. nov., a new species of Synurophyceae from a small New England lake. Nordic Journal Botany. 13: 337-342

Siver, P.A. and L.J. **Marsicano**. 1991. Assessing acidification trends in Connecticut lakes using a paleolimnological approach. CT. Department of Environmental Protection Bulletin, 44 pp. + appendices

POLICY PAPERS AND SUBMITTALS

Marsicano, LJ. 2009. An Examination of Recreational Pressures on Candlewood Lake, CT. Candlewood Lake Authority. Sherman, CT. 68 pp.

Marsicano, L.J., et al. 2000 – 2017. Submittals of the Candlewood Lake Authority to the Federal Energy Regulatory Commission during license renewal and management plan processes for Housatonic Hydro, FERC Docket No. P-2576.

A. Hunter Brawley
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hbrawley@gmail.com

PROFESSIONAL EXPERIENCE

Owner/Manager, Brawley Consulting Group LLC, Windsor, CT
(January 2008 to present).
Provides land conservation and management services to local land trusts and conservation organizations, including designing and implementing habitat restoration projects, grant writing, trail design and construction, crafting and monitoring conservation easement, boundary posting, Baseline Documentation Reports and developing property management plans. www.brawleycg.com

Land Manager, Naromi Land Trust, Sherman, CT
(March 2004 to present).
Manage all land trust properties and help acquire, monitor and enforce conservation easements. Responsibilities also include designing and building trails, securing funding for habitat restoration projects, and assisting with organizational and administrative tasks. Work cooperatively with the town and other conservation organizations to identify and prioritize lands for future acquisition. www.naromi.org

Land Manager, Kent Land Trust, Kent, CT
(September 2008 to August 2014).
Manage all land trust properties and help acquire, monitor and enforce conservation easements. Responsibilities also include securing funding for habitat restoration projects and preparing Baseline Documentation Reports (BDRs) and property management plans. Addressed backlog of stewardship items required for Kent Land Trust to become the second land trust in Connecticut accredited by the Land Trust Alliance.

Project Manager, Northeast Instream Habitat Program, Amherst MA.
(January 2004 to March 2005).
Coordinated all facets of two fisheries habitat assessment projects working with researcher at the University of Massachusetts, including project planning, data collection, hiring and overseeing seasonal staff, data analysis and report preparation. http://www.neihp.org/index.htm

Executive Director, Pomperaug River Watershed Coalition, Southbury, CT
(July 2001 to May 2003).
Managed all activities of non-profit watershed management organization dedicated to conserving regional water resources, including research, outreach, budgets, grant writing, website development, fundraising, and volunteer relations. www.pomperaug.org

Senior Project Manager, LabLite, LLC, New Milford, CT
(January 2000 to June 2001).
Product development, testing, sales, and customer service for a software company that provides Laboratory Information Management Software (LIMS) to environmental and other laboratories. www.lablite.com

Research Coordinator, The National Audubon Society, Southbury, CT
(March 1998 to January 2000).
Designed and implemented all research on birds and other wildlife at the 625-acre wildlife sanctuary. Conducted natural resources inventory, created checklists of wildlife and plants, established environmental education programs, and coordinated cooperative research projects with state agencies and regional conservation organizations.
http://ct.audubon.org/IBA_BOR.html

Environmental Analyst, Land-Tech Consultants, Inc., Southbury, CT
(November 1996 to February1998).

As Project Manager conducted environmental impact statements, wetland assessments, and wildlife surveys; prepared federal, state and local permit applications; designed pond and tidal wetland restoration projects; and conducted lake diagnostic studies. Worked with state agencies and local land use agencies to mitigate impacts of residential and commercial development projects. www.landtechconsult.com

Wetland Ecologist, The Deep River Land Trust, Deep River, CT.
(July to October 1995).
Worked in association with The Nature Conservancy Connecticut Chapter on a conservation project at two freshwater tidal marshes in the lower Connecticut River. Position entailed mapping dominant vegetation communities, identifying potential environmental impacts, researching information on appropriate buffer zones and recommending methods for long-term monitoring of the system.

Research Assistant, The Nature Conservancy CT Chapter, Weston, CT.
(May to July 1995).
Assisted with research on the productivity and survivorship of Worm-eating Warblers at the 1700-acre Devil's Den Preserve in Weston, CT. Responsibilities included mist-netting, bird banding, and locating and monitoring approximately 25 nest sites throughout the breeding season.
http://www.nature.org/wherewework/northamerica/states/connecticut/

Master's Thesis Research, Connecticut College, New London, CT.
(September 1993 to May 1995).
Conducted two-year study investigating relationships between bird populations and environmental conditions in tidal wetlands of Connecticut. Quantified bird use, vegetation, and selected environmental parameters in eight tidal marsh systems on the Long Island Sound to assess the use of birds as indicators of environmental quality.
http://www.conncoll.edu/departments/botany/index.htm

Research Associate, Connecticut College Arboretum, New London, CT.
(Sept. 1992 to January 1994).
Conducted a natural resources inventory of The Harriet C. Moore Foundation property in Westerly, RI, including producing lists of all plants and animals (flora and fauna), conducting a breeding bird census, and identifying and tagging over 100 ornamental trees. Developed a five-year plan for the management and use of this 35-acre public land preserve.
http://arboretum.conncoll.edu/

Principal Investigator, The Nature Conservancy CT Chapter, Middletown, CT
(Summer 1994).
Studied five marshes in the tidelands of the lower Connecticut River to assess the impacts of the spread of common reed (*Phragmites australis*) on bird populations. Designed project that included the systematic collection of data on bird use, vegetation sampling and an analysis of physical site characteristics.
http://www.nature.org/wherewework/northamerica/states/connecticut/

EDUCATION

Connecticut College, New London, CT. Master of Arts in Botany, 1995.

Connecticut College, New London, CT. Bachelor of Arts in American History, 1982.

The Loomis Chaffee School, Windsor, CT. Graduated 1978.

PUBLICATIONS

Brawley, A. H., Zitter, R. and L. Marsicano, Editors. 2005. Candlewood Lake Buffer Guidelines. Candlewood Lake News *Special Edition*, Vol 1:21.

Warren, R.S., P. E. Fell, R. Rozsa, A. H. Brawley, A. C. Orsted, E. T. Olson, V. Swamy and W. A. Niering. 2002. Salt Marsh Restoration in Connecticut: 20 years of Science and Management. *Restoration Ecology* 10 (3) 497-513.

Markow, J. and H. Brawley. 2001. Herpetofaunal and Avifaunal Surveys of Vaughn's Neck Peninsula, Candlewood Lake, Connecticut. Report to the Town of New Fairfield, CT. 32 p.

Brawley, A. H. 1998. A Vegetation Survey and Conservation Analysis of Vaughn's Neck Peninsula. Report to The Candlewood Lake Authority. The National Audubon Society. 11 p.

Brawley, A. H., R. S. Warren and R. A. Askins. 1998. Bird Use of Restoration and Reference Marshes Within the Barn Island Wildlife Management Area, Stonington, Connecticut, USA. *Environmental Management* 22(4): 625-633.

Marsicano, L. J. and A. H. Brawley. 1997. Land Use, Watersheds, and Aquatic Resources. *Connecticut Woodlands* 62(3): p. 21.

Niering, W. A., and A. H. Brawley. 1996. Functions and Values Assessment of Area A Downstream Wetlands and Watercourses. Naval Submarine Base New London, Groton, CT. Report to Brown & Root Environmental, The Environmental Protection Agency, and The United States Navy. 36 p.

Brawley, A.H. 1995. Pratt and Post Coves: A Vegetation Survey and Conservation Analysis. Report to the Deep River Land Trust, Deep River, CT. 62 p.

Brawley, A.H. 1995. Birds of Connecticut's Tidal Wetlands: Relating Patterns of Use to Environmental Conditions. Master's Thesis, Connecticut College, New London, CT. 87 p.

Brawley, A.H. 1994. Birds of the Connecticut River Estuary: Relating Patterns of Use to Environmental Conditions. Report to the Nature Conservancy Connecticut Chapter Conservation Biology Research Program, Middletown, CT. 23 p.

Brawley, A.H., G.D. Dreyer. 1994. Master Plan for the Future Management and Use of Moore Woods. Connecticut College Arboretum Publication. New London, CT. 65 p.

Brawley, A.H., G.D. Dreyer and W.A. Niering. 1993. Connecticut College Arboretum Phase One Report to the Harriet Chappell Moore Foundation. Connecticut College Arboretum Publication. New London, CT. 100 p.

ACTIVITIES

Forest and Trails Conservation Committee, Connecticut Forest & Park Association (CFPA)

Coverts Project Cooperator, UConn Cooperative Extension System