2013 Monitoring Report For

West Hill Pond

Prepared For:

West Hill Pond Association

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Summary

Two visits to West Hill Pond were made in 2013, April 24, and July 16, 2013 to measure key indicator parameters: Water Clarity, Dissolved Oxygen, Phosphorus and Nitrogen, and to assess the status of Aquatic Plants in the lake. Results show that West Hill Pond continues to exhibit excellent water quality. However, at this time only two measurements are made each year. Conditions in the lake during other periods are not tested or measured.

Water Clarity at West Hill Pond in July 2013 was 24 feet (7.3 meters). Connecticut Lakes with clarity readings exceeding 20 feet are considered exceptional.

Phosphorus in West Hill Pond in July 2013 was 9 parts per billion (ppb) in the photic zone. Connecticut lakes with phosphorus levels below 10 are considered exceptional.

Aquatic Plants - no exotic or invasive species were found during the survey conducted on July 16, 2013. However, aquatic plants appear to be spreading and becoming more pronounced in West Hill Pond. Although still scarce overall, survey results show that at least three native species, large-leaf pondweed, red-leaf pondweed, and tape-grass have proliferated in West Hill Pond. A preliminary relationship appears to exist between dense plant stands and storm-water outfall points. Storm water sampling should be conducted to determine if runoff water is contributing nutrients and sediments to the lake.

Background

West Hill Pond is a 261 acre lake located in the towns of Barkhamsted, and New Hartford, CT. The lake has a maximum depth of 63 feet (19.3 meters) with relatively steep sides along most of the basin. The littoral zone, the shallow shoreline where rooted aquatic plants can grow is mostly narrow around the lake such that only about 75 acres of the total lake surface area can support rooted aquatic plants.

The lake has a small watershed of 790 acres, or about 3.0 times the area of the lake. The flushing rate of lake water is estimated to be very slow, about 20% per year. The long retention 4.8 years, suggests that material residence time will also be long.

2013 Monitoring

Northeast Aquatic Research conducted one water quality sampling visit to West Hill Pond every other year between 2002 and 2010 (years 2002, 2004, 2006, 2008 and 2010). Beginning in 2011, two visits have been made to the lake, first in April and a second in August. Two field visits were made to the lake in 2012, the first on April 24, 2012, and the second on August 14, 2012. Two visits to the lake were made in 2013, the first on April 24, 2013 the second visit on July 16, 2013. During each trip, water clarity was measured, dissolved oxygen and water temperature readings were made at each meter depth, and three water samples were collected (1, 8-10, and 16 meters). Samples were analyzed for total phosphorus, ammonia nitrogen, nitrate nitrogen (surface only), and organic nitrogen.

During the July 2013 visit, the aquatic plants were surveyed around the perimeter of the lake. The survey recorded species presence, relative abundance, and approximate density.

Total Phosphorus

Background

Phosphorus is the principal nutrient feeding planktonic phytoplankton in freshwater lakes. Planktonic phytoplankton–algae are free floating single cells or colonies of photosynthesizers that live in the water column of a lake. Because these plants are always suspended in the water they are dependent on the quantity of phosphorus dissolved in the lake water. Due to this dependent relationship, as the phosphorus concentration in the water increases planktonic algae population numbers increase. As the number of cells in the water increases the water clarity declines. This process, declining clarity with increasing phosphorus, continues until phosphorus reaches about 30 parts per billion (ppb) when phytoplankton has become so abundant that it self-shades its own growth. Secchi disk depth at this point is less than 1 meter.

The primary goal of lake water-quality monitoring is to track changes in this clarity/phosphorus relationship over time. A comprehensive lake monitoring plan includes collecting nutrient and water clarity data monthly beginning in April and ending in October. This whole season approach is necessary because a lake progresses through a series of stages during the year. Each stage effects distribution of nutrients and types of algae in the water column in different ways.

At West Hill Pond, one sample collected in mid-August attempts to represent possible seasonal worst case conditions within the lake. Worst case conditions are defined here in two ways for purposes of choosing one single date during the season to perform a visit. The first has to do with loss of dissolved oxygen in deepest water and bottom phosphorus occurring at its highest concentration of the summer. The second involves possible seasonal maximum growth of aquatic plants. If only one visit a year was going to be made, August provides observations of both these factors.

Difficulties with this supposition are worth keeping in mind. First, the timing of highest bottom phosphorus and most severe loss of dissolved oxygen may not occur in August but might, due to the variability in climate, occur in either July or September. Second, aquatic plants may not reach maximum growth until September. Third, some species of aquatic plants have completed their seasonal growth cycle by August so are no long visible at that time. Fourth, one measurement in August means lake condition occurring at other times of the season goes unobserved. Without information from these other months decisions cannot be made about the importance of those unobserved conditions.

Beginning in 2011, the water quality monitoring program was expanded to include a visit to the lake in April to collect measurements and nutrient chemistry at the beginning of the season. Some eutrophication lake models use the spring phosphorus concentration as a way of predicting annual load of phosphorus to the lake. The nutrient allocation plan developed by Columbia Lake Association uses primarily the April phosphorus value to estimate the annual lake loading levels and to determine allowable export concentrations from the drainage basin.

August Phosphorus Results

Epilimnion

The results of summer total phosphorus testing in West Hill Pond are presented in **Table 1** below. Sampling events have occurred mostly in August – the first event was conducted in late July, and the summer sampling event in 2013 was conducted in July. Three samples collected from top, middle, and bottom depths are taken at a location of the lake where water depth is deepest in order to get representation from all depths. Phytoplankton grows in waters receiving sunlight, which for West Hill Pond is approximately the top 10 meters, determined by summer Secchi disk depth. This layer of a lake is referred to as the epilimnion, defined as the equally warm, upper water layer that receives sunlight. Phosphorus concentrations from 1 and 10 meters represent the epilimnion of West Hill Pond and the planktonic algae growth potential. Phosphorus from the bottom sample represents the combined increases due to re-cycling and internal release.

Table 1 – Summer total phosphorus concentrations (ppb) for West Hill Pond

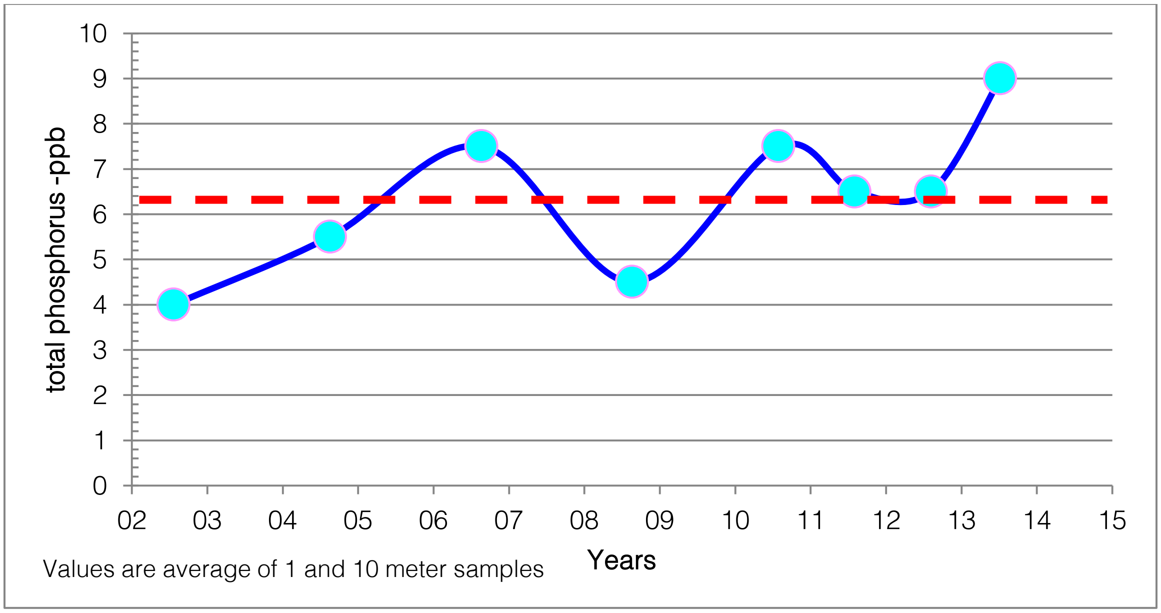
Depth (m)	August 14, 2012	July 16, 2013
1	4	7
10	9	11
18	99	57
Average	*37*	*25*

Depth (m)	August 9, 2011	August 5, 2010	August 24 2008	August 24, 2006	August 19, 2004	July 23, 2002
1	5	4	3	6	4	5
10	8	11	6	9	7	3
18	156	53	19	121	154	20
Average	*56*	*23*	*9*	*55*	*55*	*9*

The mean concentration of phosphorus in 1 and 10 meters samples from July 2013 was 9 ppb, the highest average on record. One goal of the management of West Hill Pond is to ensure that the average of these two values remains below 10 ppb. Testing results show that the long-term average concentration of top and middle samples is 6.4 ppb, well below the threshold of 10 ppb (**Figure 1**). The chart in **Figure 1** shows that the value has fluctuated between a low of 4 ppb and a high of 9 ppb.

The difficultly with tracking phosphorus concentration changes in lakes with very low levels, as in West Hill Pond, is detecting permanent increases. Small increases in the load of phosphorus can go undetected due to natural background fluctuation. At this point we don't know if the variation shown in **Figure 1** represents a normal long-term fluctuation or an upward trend. However, this year's reading and the last three years readings have been at or above the mean level suggesting an upward trend. The most recent value, 9 ppb, raised the mean by 0.36 ppb further indication that phosphorus in the lake is increasing.

Figure 1 – Average phosphorus concentration from 1 and 10 meter samples, red dashed line shows long-term average of 6.4 ppb



Hypolimnion

The bottom phosphorus concentration was within an established range, the eight data points so far collected are; 2013 = 57 ppb, 2012 = 99 ppb, 2011 = 156 ppb, 2010 = 53 ppb, 2008 = 19 ppb, 2006 = 121 ppb, 2004 = 154 ppb, and 2002 = 20 ppb. This range in concentration is acceptable, but more dates with lower values as opposed to higher values are needed. The value from 2013 was below the long-term average of 77 ppb, but was collected a full month before most of the higher values. It is unlikely that July 2013 data is comparable to August data. Currently there is no evidence that increases in phosphorus at the bottom of the lake affect concentrations at 10 meters, or the surface, but this fluctuation requires further inquiry.

April Phosphorus Results

Allowable phosphorus load to a lake during a year is the watershed nutrient allocation. Determining allowable load involves knowing both the lake state and the annual input of phosphorus from the landscape around the lake. The phosphorus in the lake during spring is a surrogate for having phosphorus load measurements from all the inflows during the year. The spring lake concentration makes use of assumptions about flushing rate and retention times to predict the annual load. The spring is defined as "after ice-out," but prior to significant water warming and thermal gradients. Acceptable concentration of spring phosphorus is less than 10 ppb.

The spring phosphorus concentration is an average of all three depth-discrete water samples collected from the lake in April **(Table 2)**. The April 2013 value was 15 ppb. Prior results are; April 2012 = 10.3 ppb, and April 2011 = 8.7 ppb. Phosphorus in the middle layer of the lake was considerably higher in 2013 than in prior years. The difference between the two years was due to changes in bottom water concentrations, with 2012 having a higher level of phosphorus at the bottom. The top and bottom depths--1 and 18 meters--showed no significant change between the two years. Annual phosphorus load to West Hill Pond is estimated using the 2012 and 2011 averages (10.3 and 8.7 ppb) as well as 11.3 ppb--the average of samples from the three years **(Table 2)**.

Table 2 – Spring phosphorus concentrations and predicted annual phosphorus loads to West Hill Pond

Depth (m)	April 24, 2013	April 24, 2012	April 21, 2011
1	6	5	7
10	22	9	9
18	17	17	10
Average	*15.0*	*10.3*	*8.7*

Spring ppb=>	15.0	10.3	8.7	11.3
Model		Kg P/year		
Kirchner and Dillon	219	151	127	168
Vollenweider	173	119	100	133
Jones and Bachmann	129	89	75	99
Chapra	260	178	151	199
Average	*195*	*134*	*115*	*150*

The models predict that the annual load of phosphorus to West Hill Pond potentially ranges between 75 kg P/yr. and 290 kg P/yr. or 165 pounds/yr. to 573 pounds/yr. A nutrient allocation plan divides the estimated load by the acres of the drainage basin, 550 acres, to give an estimate allowable export of phosphorus of 0.3 lb./acre/yr. to 1.04 lb./acre/yr. This states that if the annual load to the lake is 150 lb./yr., then each acre of the watershed can export no more than 0.27 pounds/year in order to maintain the current load. The new information potentially increases the estimated range in values even more than what we already had. If the allocation was set at 1.04 pounds/acre and this proved to be too high, it would be very damaging to the lake. At this preliminary stage, the lower value of 0.21 pounds/year (from the lowest spring phosphorus value collected in 2011) should be considered the most prudent value until more information is collected.

Nitrogen

Water was collected for analysis of the three nitrogen forms most common in lakes, ammonium, nitrate, and organic nitrogen **(Table 3)**. Nitrogen is the second most important plant nutrient in lakes, but has a primary role in growth of rooted aquatic plants.

Nitrate was below the detection limit of 10 ppb at all depths.

Ammonium can be used directly by phytoplankton but is also toxic at high levels. Ammonium was below the detection limit of 10 ppb at the surface, with only a trace amount detected at 10 meters. Ammonium is released from the sediments during periods when bottom water is without dissolved oxygen. Released ammonia accumulates in bottom water. The quantity of ammonium at the bottom in July 2013 was 370 ppb, a relatively low value, however this data was collected almost a full month prior to August data from prior years. The longer anoxia persists in the hypolimnion, the higher the ammonia level will be. This indicates that data from September, and possibly October, would be even higher than data collected in August. Prior data is 2012 = 660 ppb, 2011 = 730 ppb, 2010 = 450 ppb, 2008 = 273 ppb, 2006 = 810, 2004 = 870, and in 2002 = 306 ppb. The range in ammonia concentration - 273 ppb to 870 ppb - is probably due to the depth of well oxygenated water and the duration of time that bottom water had been without dissolved oxygen prior to sample collection.

The organic nitrogen component in lake water is a result of decaying microscopic plant material and organic nitrogen from watershed sources. Epilimnetic average organic nitrogen in West High Pond has ranged between a low of 142 ppb to a high of 338 ppb.

Results from 2013 show epilimnetic organic nitrogen was 344 ppb, well within the established range.

Table 3 - Nitrogen series results from August water sampling of West Hill Pond

2013

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Total (ppb)
1	<10	< 10	145
10	<10	6	159
18	6	370	344

2012

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	<10	< 10	290
10	<10	20	330
18	<10	660	1,580

2011

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	<10	< 10	250
10	<10	< 12	265
18	<10	720	2,140

2010

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	<20	< 10	118
10		< 10	165
18		450	455

2008

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	33	< 10	300
10	< 20	< 10	375
18	< 20	273	1,650

2006

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	< 20	< 10	193
10		< 10	251
18		810	1,760

2004

Depth (m)	Nitrate (ppb)	Ammonia (ppb)	Organic (ppb)
1	< 20	< 10	292
7		< 10	384
15		870	1,350

Secchi Disk Depth

Secchi disk depth should not decrease below a threshold of 6 meters at West Hill Pond. One goal of lake management is to ensure that summer clarity continues to exceed this value.

The July 2013 clarity reading was 7.3 meters, an excellent value but slightly less than the long-term average **(Figure 2)**. Summer Secchi disk depths measured by NEAR are given in **(Table 4)**. Secchi disk depth record for West Hill Pond is given in **Table 5**.

Table 4 – August (July in 2013) Secchi disk depths for West Hill Pond

Date	Meters	Feet
7/16/2013	**7.3**	**24.0**
8/14/2012	7.7	25.3
8/9/2011	8.9	29.2
8/5/2010	8.2	26.9
8/15/2008	6.7	22.0
8/24/2006	6.0	19.7
8/19/2004	9.7	31.8
7/23/2002	6.5	21.3

Figure 2 – August (July in 2013) water clarity in West Hill Pond, red dashed line is long-term average of 7.6 meters

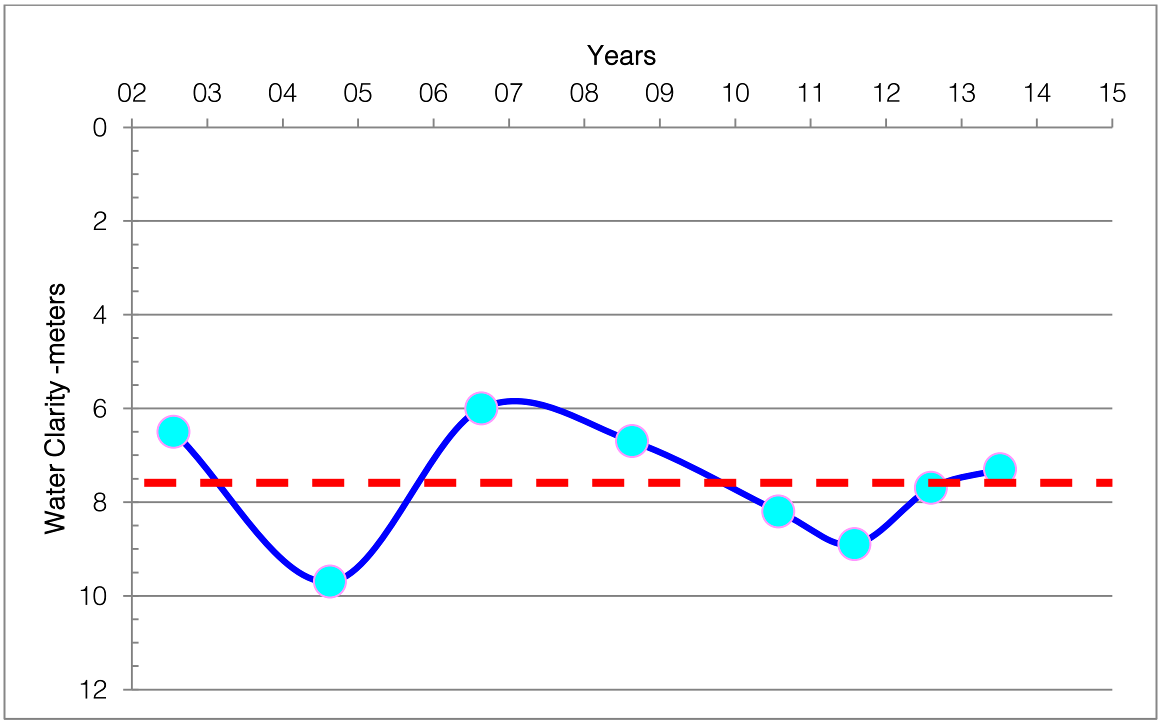


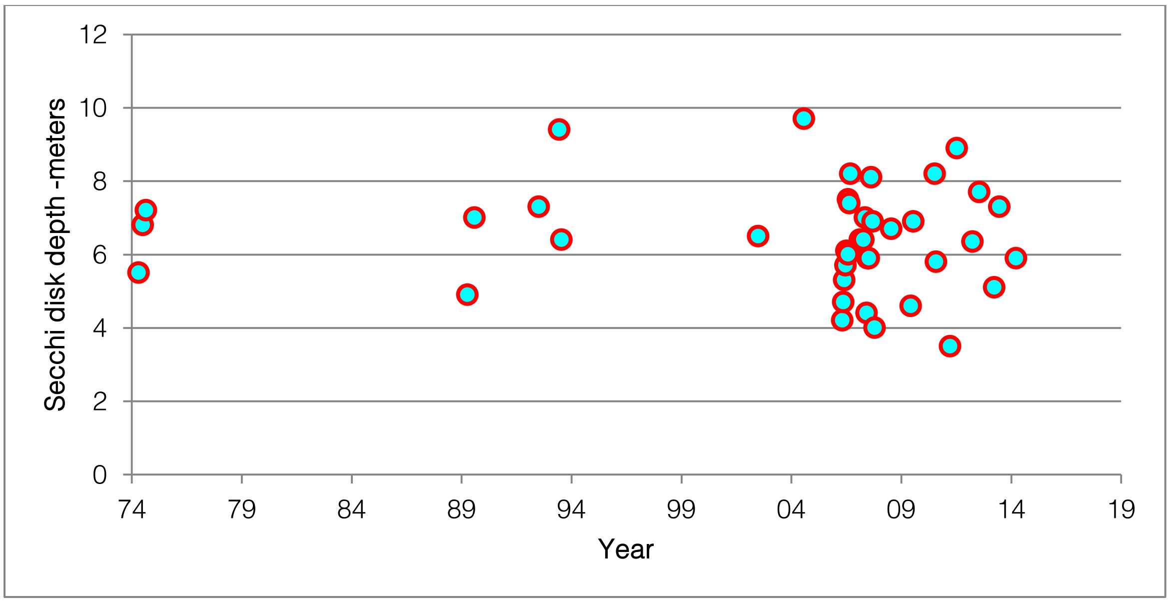
Table 5 - Record of Secchi disk depth readings at West Hill Pond

Date	meters	Date	meters	Date	meters	Date	meters
4/23/1974	5.5	5/21/2006	4.2	3/10/2007	6.4	8/15/2008	6.7
7/2/1974	6.8	6/8/2006	4.7	5/6/2007	6.4	7/2/2009	4.6
8/22/1974	7.2	6/21/2006	5.3	6/6/2007	7.0	8/14/2009	6.9
4/21/1989	4.9	7/12/2006	5.7	7/1/2007	4.4	8/31/2010	5.8
8/17/1989	7.0	7/30/2006	6.1	7/17/2007	5.9	8/5/2010	8.2
7/20/1992	7.3	8/26/2006	6.0	8/5/2007	5.9	4/21/11	3.5
6/23/1993	9.4	8/26/2006	7.5	9/13/2007	8.1	8/9/11	8.9
8/2/1993	6.4	9/13/2006	7.4	10/9/2007	6.9	4/24/12	6.35
7/23/2002	6.5	10/1/2006	8.2	11/11/2007	4.0	8-14-12	7.7

8/19/2004	9.7			4-24-13	5.1
				7-16-13	7.3
				4-21-14	5.9

The range in Secchi disk depth values for West Hill Pond is large, from a low of 3.5 meters to a high of 9.7 meters **(Figure 3)**. The large range in seasonal and year-to-year variation in clarity should be better understood because poor clarity indicates periodic increases in either sediments or phosphorus with each needing to be controlled.

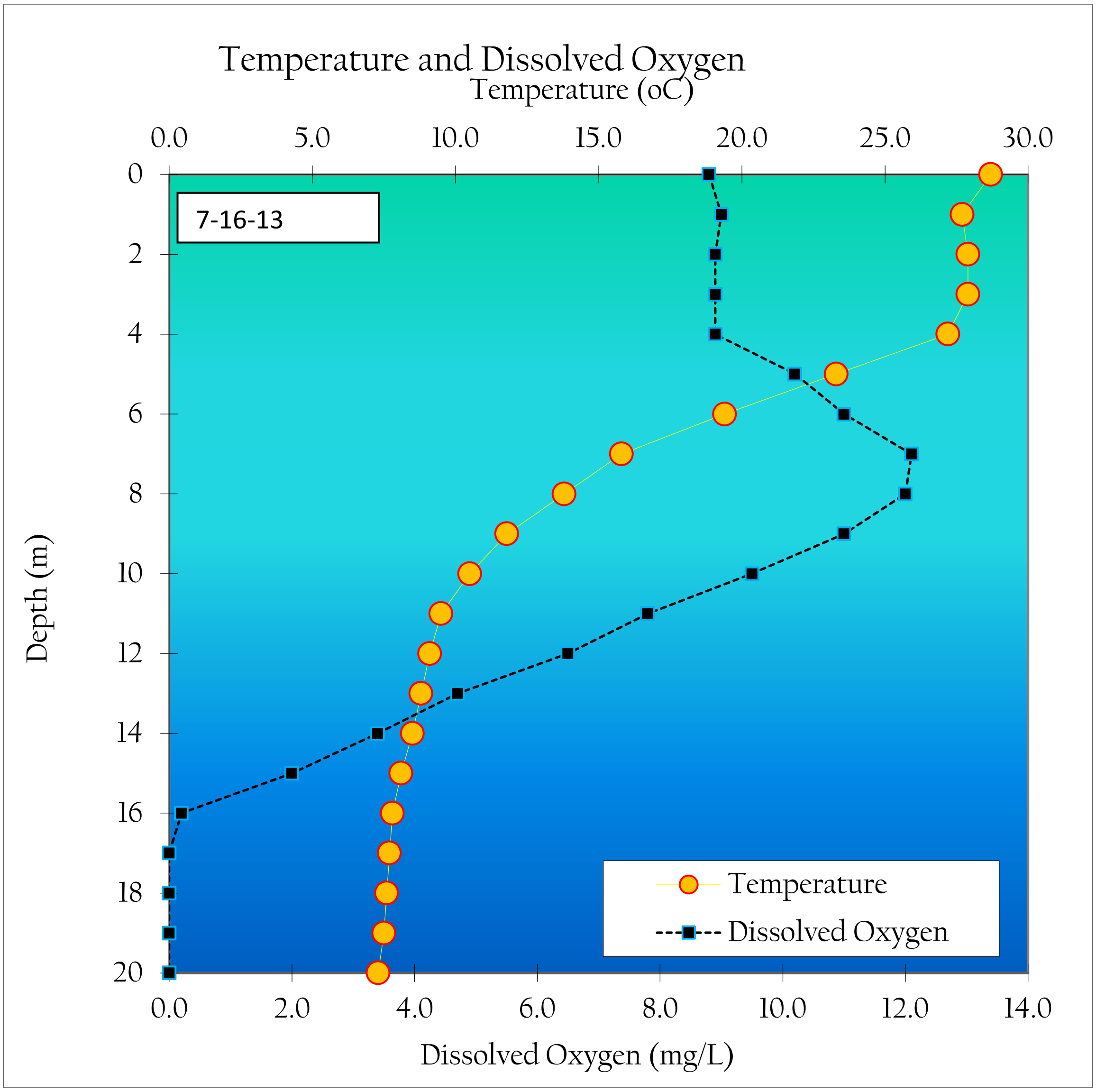
Figure 3 – Record of water clarity readings at West Hill Pond



Temperature / Oxygen Profiles

Two profiles of the temperature and dissolved oxygen of the water column were taken in 2013. The July profile **(Figure 4)** showed that the lake had a well-defined thermocline, or temperature gradient, between 4 and 8 meters. There was excellent dissolved oxygen levels between the surface and a depth of 12 meters (40 feet).

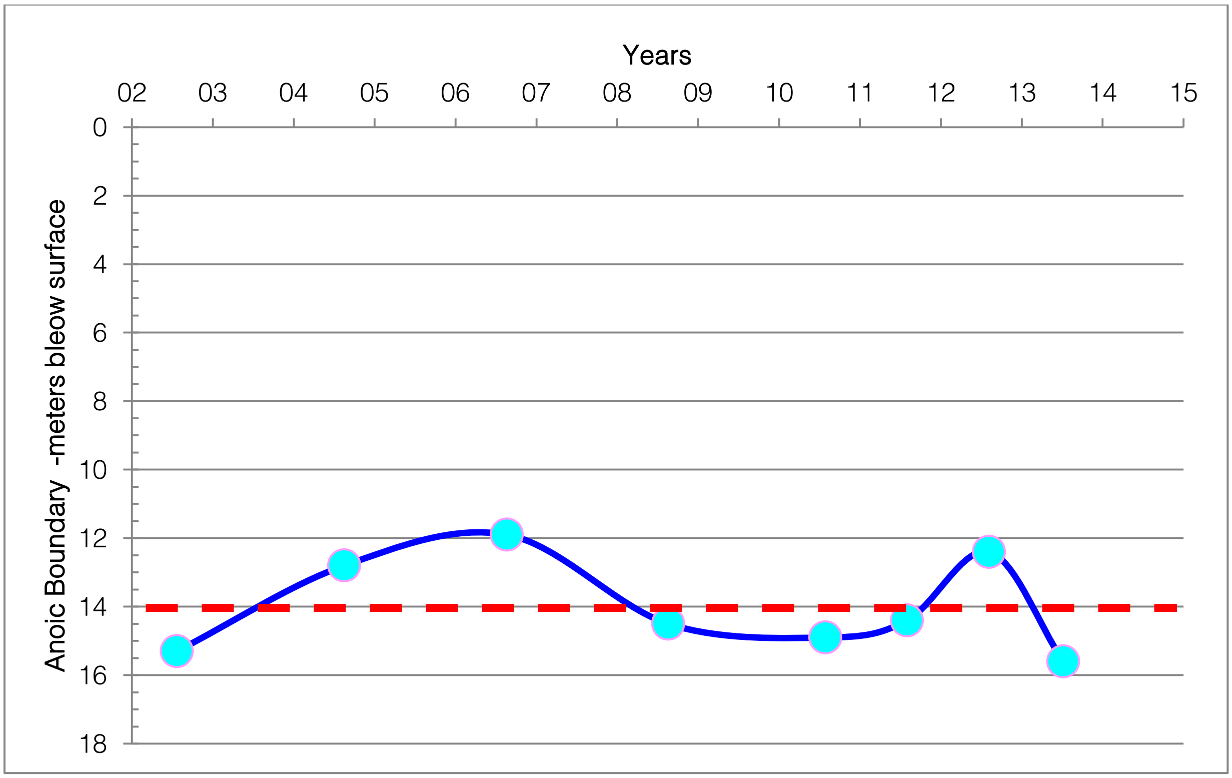
Figure 4 – Water column profile of West Hill Pond showing changes in water temperature and dissolved oxygen content with depth



In 2013, the lake had anoxic conditions below 12 meters (40 feet). Water deeper than this depth was devoid of dissolved oxygen. The boundary between water with and without dissolved oxygen is called the anoxic boundary. The anoxic boundary is recorded as the water depth measured from the surface down to the depth where dissolved oxygen is 1 mg/L.

Dissolved oxygen, black squares in **Figure 4**, showed that below 13 meters water was devoid of dissolved oxygen. The anoxic boundary on this date was 15.6 meters-the depth where dissolved oxygen was at 1 mg/L. The record of depth-to-anoxia in August is shown in **Figure 5**. Measurement in 2013 showed below the average summer depth measured on prior visits, however July anoxic boundary depth is expected to be deeper than August.

Figure 5 – Record of depth-to-anoxic in West Hill Pond with long-term average, 14 meters, shown by red dashed line



Aquatic Plants

A survey of the aquatic plants in West Hill Pond was conducted on July 16, 2013. No invasive aquatic plant species were found during the survey. The aquatic plant species observed are listed in **Table 6,** together with species noted in 2012, 2011 and 2010. Each species is listed with percent frequency of occurrence.

Table 6 - Aquatic plant species list for West Hill Pond from 2010, 2011, 2012 and 2013 surveys.

Common Name	Scientific Name	2010	2011	2012	2013
Red-leaf Pondweed	*Potamogeton epihydrus*	17	8	10	13
Waterwort ##	*Elatine minima*	16	19	5	ND
Water Lobelia ##	*Lobelia dortmanna*	12	19	14	14
Water Naiad	*Najas flexilis*	11	14	3	7
Submersed Arrowhead ##	*Sagittaria graminea*	10	14	8	10
Large-leaf Pondweed	*Potamogeton amplifolius*	9	16	20	18
Cattail	*Typha* sp	6	5	6	8
Submersed Spikerush ##	*Eleocharis acicularis*	5	3	ND	2
Filamentous Algae	*Spirogira* sp	5	2	ND	20
Tape Grass	*Vallisneria americana*	5	13	8	1
Yellow Waterlily	*Nuphar variegata*	5	5	5	5
Spiral-fruited Pondweed	*Potamogeton spirillus*	4	ND	1	ND
Emergent Burreed	*Sparganium* sp	4	3	1	7
Aquatic Moss ##	*Fontinalis* sp.	3	ND	1	ND
Water Weed	*Elodea nuttallii*	3	5	2	3
Leafless Milfoil ##	*Myriophyllum tenellum*	2	1	ND	2
Quillwort ##	*Isoetes* sp.	2	ND	ND	3
Chara	*Chara* sp.	2	ND	ND	ND
Emergent Bulrush	*Scripus* spp.	2	1	3	2
Bladderwort	*Utricularia radiata*	2	1	ND	ND
Creeping Buttercup	*Ranunculus repens*	1	ND	ND	ND
Capillary Pondweed ***	*Potamogeton berchtoldii var. gemmiparus*	1	ND	ND	ND
Oakes Pondweed	*Potamogeton oakesianus*	1	ND	ND	ND
Berchtold's Pondweed	*Potamogeton berchtoldii*	1	4	ND	ND
White Waterlily	*Nymphaea odorata*	1	ND	ND	ND
Water Starwort	*Callitriche heterophylla*	1	1	ND	ND
Water Purslane ##	*Ludwigia palustris*	1	ND	1	ND
Submersed Bulrush ##	*Scripus subterminalis*	1	ND	ND	ND

***Endangered Species in CT

ND = Not Detected; means that species was not observed during the survey

Spread of large-leaf and red-leaf pondweeds in West Hill Pond is of concern. Red-leaf pondweed showed a slight increase in abundance, but that value does not reflect control of a dense bed in the eastern cove using bottom-barriers. There was no red-leaf pondweed in that one location in 2012. Large-leaf pondweed appears to be limited to beds surrounding the center island. Locations of both pondweeds: red-leaf and large-leaf found in 2013 are shown in **Figure 6**.

Figure 6 – Locations of pondweeds in West Hill Pond during survey in 2013, yellow circles = large-leaf pondweed, blue squares = red-leaf pondweed

Changes in the plant community have occurred since NEAR conducted its first survey of West Hill Pond on July 23, 2002.

- Large-leaf pondweed (*Potamogeton amplifolius*) was found for the first time in 2008 along the shoreline of West Hill Pond, although this plant was probably growing among rocks in the center shallows prior to that time. Large-leaf pondweed had spread to 15 locations around the shoreline in 2012. Suction harvesting has effectively removed several beds of large-leaf pondweed from along the southern and westerns shores. In 2013 only 4 sites where large-leaf pondweed was growing along the shoreline were found —other than around the island where dense beds still persist.
- Water weed (Elodea *canadensis/nuttallii*) was first found in 2008. This plant has not increased in abundance lake-wide since that initial finding but has the potential for robust growth.
- In 2010, 8 new species of rooted aquatic plants were found in the lake, 6 of which have the potential for robust growth (see **Table 7**). Since that time, no new species have been found in the lake.
- Red-leaf pondweed (*Potamogeton epihydrus*) initially was found at only one site along the southeastern shore, now occurs at 15 locations around the lake-not including the very dense bed in the eastern cove that was covered with aquaScreen. This eastern cove bed, first noticed in 2008, became dense by 2010.
- Tape-grass (*Vallisneria americana*) was first listed on the 2002 survey due to the presence of 2 isolated plants, now forms a continuous band along the southwest shore.
- In 2002, aquatic plants were found at only 20 locations around the lake, with often only one species being found at each of these sites. In 2013, aquatic plants were noted at over 92 locations in the lake.
- Sand from the beach at the south end of the lake has been eroding off the beach and into the lake for several years. This sand is migrating southward along the shore covering the shallow waters of the littoral zone. Species in **Table 6** marked with ## are tiny shallow water plants

that are in jeopardy of being smothered by accumulating sand. The same impacts occur when permanent structures are built in the lake such as concrete piers and docks and patios—however permanent structures eliminate these lake habitats permanently, while beach sand impacts will dissipate once new sand stops entering the lake. In fact, significantly less water lobelia has been noted in that area of the southern beach over the last several years possibly due to smothering of littoral habitat by beach sand in a wider area than is currently suspected.

Summary

Water quality data collected in 2013 show that that West Hill Pond continues to exhibit oligotrophic conditions with respect to total phosphorus, total nitrogen and water clarity as measured by the Secchi disk. However, the lake remains understudied. Only two visits to the lake are made each year. Complete seasonal information on the lake has yet to be collected. Phosphorus concentrations from spring 2013 were higher than all prior spring data, with average water column phosphorus concentration exceeding 10 ppb. Summer photic zone phosphorus was also higher than all prior measurements. We strongly encourage that full seasonal sampling of the lake (monthly between April and November) is conducted annually to better understand the current condition of the lake and whether possible changes are occurring in the nutrient content over time.

The aquatic plant survey records show aquatic plant growth in the lake appears to be increasing. There appears to be increases in the distribution, proliferation, and density of plants in West Hill Pond, as well in the number of species inhabiting the lake Large-leaf pondweed and red-leaf pondweed have become common and tape-grass is becoming common. Suction harvesting has appeared to now limit most large-leaf pondweed to around the island in the center of the lake. Other species of pondweed have been noted recently as has common water weed. More growths of filamentous algae were noted in the lake in 2013 than were seen in 2012. Specific investigation should be made in the vicinity of the beach at the south end of the lake to determine if aquatic habitats have been lost due to smothering by migrating beach sand.

Storm-water and background stream runoff may be high in nutrients and sediments. Dense aquatic plants grow at the outfalls of the three highest rated inlets, with beds of lower density plants occurring at a number of the other inlets. Water sampling of each of these inflows should be made during both dry and wet weather conditions to determine the nutrient and sediment contributions from these drains. A long-term storm-water/runoff remediation plan needs to be developed.