2015 Annual Monitoring Report For Crystal Pond,

Eastford & Woodstock, CT

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INTRODUCTION

Crystal Pond is a 150 acre lake in the towns of Eastford, and Woodstock, CT. In July 1990, the Crystal Pond Association initiated a water quality monitoring program consisting of collecting water temperatures, dissolved oxygen readings and three water samples for nutrient concentration analysis from a station located over deepest water of the lake—about 32 feet (water samples were first collected in 1992). Beginning in 2004, Northeast Aquatic Research (NEAR) took over the monitoring of Crystal Pond conducting the same sampling at the end of July –that year we also conducted the first aquatic plant survey of the lake. Lake water quality monitoring at the same location at about the same time every year has been consistently collected for 26 years (with the exception of 2007). We started looking at the aquatic plants annually in 2011 and now have 5 years of surveys --2011, 2012, 2013, 2014 and 2015.

In 2012, NEAR began visiting the lake three times a season. The first visit is in spring to investigate the inlets to the lake. The second visit, at the end of July, is to collect the annual mid-summer data that maintains consistency of the long-term record. The third visit is in later summer for assessment of distribution and abundance of aquatic plants, and to scan for presence of invasive species.

This report presents the data record for parameters that have been tracked since 1990 and includes the 2015 information as the newest part of that record. During each lake visit, three water samples have been collected from the lake; one from near surface (1 m), one from about middle depth (5 m), and one from near the bottom (9 m). Monitoring has also included both a water clarity measurement and a profile of the water temperature and dissolved oxygen readings made at each 1 meter depth from top to bottom. When NEAR began visiting the lake three times a year, the same testing was done during the additional visits. Water samples are taken to the Center for Environmental Science and Engineering, University of Connecticut, for analysis of total phosphorus, and total nitrogen (ammonia, nitrate, and organic nitrogen).

SYNOPSIS OF RESULTS

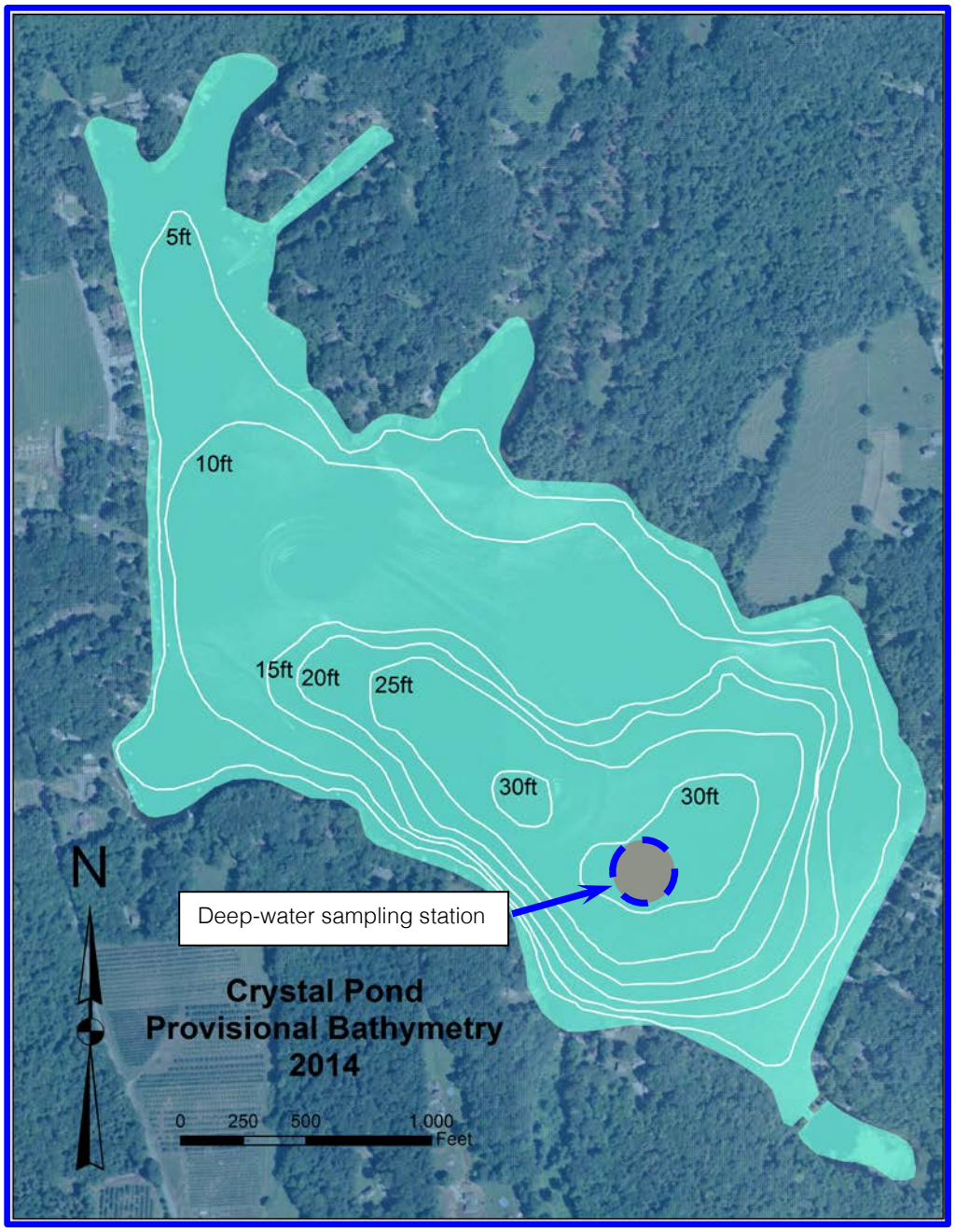
Water quality remained excellent in 2015, continuing exceptional water clarity and good phosphorus levels found in the last few years, although phosphorus was slightly high in 2015. Inlet chemistry in 2015 showed streams #1 continues to have high nitrate, no sample was obtained from Stream 7. Aquatic plants show generally the same pattern but might be increasing in distribution on the eastern side of the lake. The state listed plant Water Marigold was present throughout most of shallower depths along the western shore where it covered the bottom as a blanket with Robbins pondweed, another beneficial native plant. No invasive species were found in the lake specifically fanwort, despite intensive surveys seeking evidence of this noxious weed.

DETAILED MONITORING RESULTS

In 2015, Northeast Aquatic Research made 3 visits to Crystal Pond. The first, May 18th, was to collect spring water quality data and investigate the inlets. The second visit, July 8th, was to survey distribution and abundance of aquatic plants, and the third, July 31st collect the annual mid-summer water quality data consistent with the long-term data set.

Water sampling has traditionally been conducted at the location of maximum depth about 31 ft. (Figure 1). Lake water quality monitoring consists of collection of three water samples from the water column at the deep water station. Samples from the same three depths, analyzed for the same four parameters have been collected at the end of July since 1990. Principal analysis of water quality trends at Crystal Pond uses results of the long-term data set from end of July sampling. Analysis of conditions at Crystal Pond uses the nutrient testing results—specifically phosphorus, although nitrogen is also considered--and the water clarity/dissolved oxygen measurements made at the time of the visits.

Figure 1 – Crystal Pond water depth contours as mapped by NEAR during 2014, showing deep-water sampling station



General Water Quality and Lake Trophic State Concept

Total phosphorus is usually the nutrient limiting growth of phytoplankton in freshwater. The growth of microscopic algae is related to the quantity of phosphorus available in the water; excess phosphorus is the primary cause of nuisance algae blooms in lakes. Lake health is usually associated with clarity of the water--clearer water meaning healthier lakes. The clarity of lake water is based on the amount of total phosphorus available for microscopic algae growth. Higher amounts of phosphorus correlate with higher growth rates of these microscopic algae leading to reduced water clarity.

The CT DEEP has grouped lakes into different categories based on the amount of total phosphorus they contain (Table 1). A trophic category is a way of categorizing the degree of plant growth that occurs in a lake, ranging from very clear water with no weeds or algae (oligotrophic), to lakes with excessive amounts of weeds and very green water (eutrophic). Plants grow in lakes due to nutrient loading from the drainage basin. The CT DEEP criteria uses Secchi disk depth and chlorophyll-*a* as indicators of algae growth. Total nitrogen concentrations tend to follow the enrichment rates and plant growth response The table shows lake Trophic Status, or growth categories ranked by increasing total phosphorus—first column. An increase of 20 ppb phosphorus—going from 10 ppb to 30 ppb—will cause water clarity to decline from 6 meters to less than 2 meters and increase the amount of algae pigment in the water from 2 ppb to 15 ppb, which means the amount of phytoplankton in the lake doubled 3 times.

Table 1 - Lake trophic categories and ranges of indicator parameters

Category	T.P. (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)	Chlorophyll *a* (ppb)
Oligotrophic	0 – 10	0 – 200	6+	0 – 2
Oligo-mesotrophic	10 – 15	200- 300	4 – 6	2 – 5
Mesotrophic	15 – 25	300 - 500	3 – 4	5 – 10
Meso-eutrophic	25 – 30	500 - 600	2 – 3	10 – 15
Eutrophic	30 – 50	600 - 1000	1 – 2	15 – 30
Highly Eutrophic	50 +	1000 +	0 – 1	30 +

Source = CT DEP 1982

Total Phosphorus

Total phosphorus concentrations found in Crystal Pond during the 2015 season are presented in Table 2 together with data from the prior 9 years. The table reports the values--in ppb--from each of three depths. The 1-meter sample represents the top 12 feet or so of the lake. The 5-meter sample represents the middle layer, between 12 and 24 feet down, and the 9-meter sample represents deepest water, below 24 feet. Together, the 1-meter and 5-meter samples represent 94% of the lake volume.

Table 2 - Total phosphorus [P] testing results for Crystal Pond

Depth (m) (ppb)	5/18/15	7/8/15	7/31/15	2015 average
1	17	11	12	13
5	12	24	21	19
9	21	18	28	22
Average	*16.7*	*17.7*	*20.3*	***18.0***

Depth (m) (ppb)	5-19-14	7-18-14	2014 average
1	23	11	17
5	13	10	12
8	13	11	12
Average	*16.3*	*11*	***13.7***

Depth (m) (ppb)	5-20-13	7-31-13	9-23-13	2013 average
1	12	7	11	10
5	13	7	11	10
9	10	17	12	13
Average	*10.7*	*10*	*11.3*	***11***

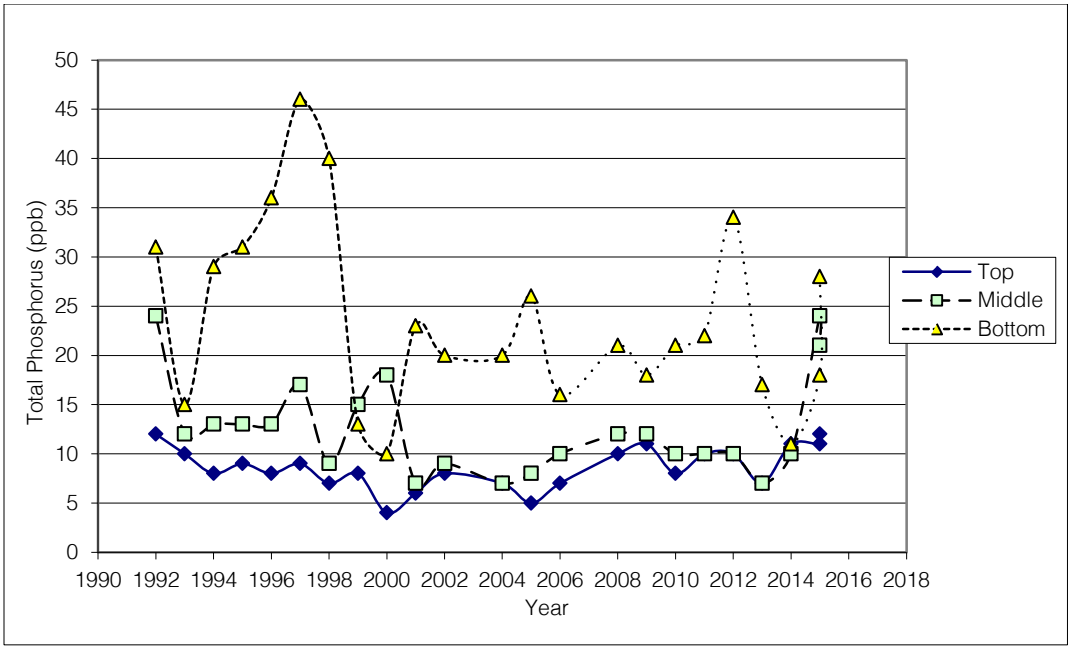
Depth (m) (ppb)	6/16/12	7/24/12	9/13/12	2012 average
1	11	10	9	10
5	19	10	9	13
9	13	34	32	26
Average	*14*	*18*	*17*	***16.3***

Depth (m) (ppb)	8/4/05	7/24/06	8/1/08	7/20/09	8/6/10	7/14/11	Average
1	5	7	10	11	8	10	9
5	8	10	12	12	10	10	10
9	26	16	21	18	21	22	23
Average	*13*	*11*	*14*	*14*	*13*	*14*	***14***

Over the long-term—1992 to 2015--Crystal Pond has consistently had oligotrophic phosphorus concentrations Table 1, averaging 10 ppb at the 1-meter depth, 2015 results showed values slightly higher than 10ppb. Middle depth phosphorus generally

follows 1 meter but is equal or greater, never less. 2015 results from mid-depth had higher phosphorus than all prior results-except the first year. Bottom phosphorus has always been higher than 1 meter and typically higher than mid-depth but not always. 2015 data showed bottom phosphorus concentrations were in-line with range of prior variation.

Figure 2 – Trends in July phosphorus values from the top, middle, and bottom, depths at Crystal Pond 1992-2015



Data Table 2 shows 2015 phosphorus in May was 17 ppb in the surface waters, higher than 2014 (12ppb) but lower than 2013 (23ppb). This value is higher than the threshold of 10ppb indicating drainage basin loading however, we have only three spring phosphorus readings to compare against.

Phosphorus in the deepest water--as represented by the 9 meter water sample--has averaged slightly higher than the 1 and 5 meter samples at 22 ppb long-term. Although concentrations are higher at 9 meters, the sample represents only about 3% of the lake volume.

Total Nitrogen

The results for total nitrogen sampling over the last eleven years are given in Table 3. Total nitrogen includes fractions of nitrate, ammonia, and organic components. In 2015,

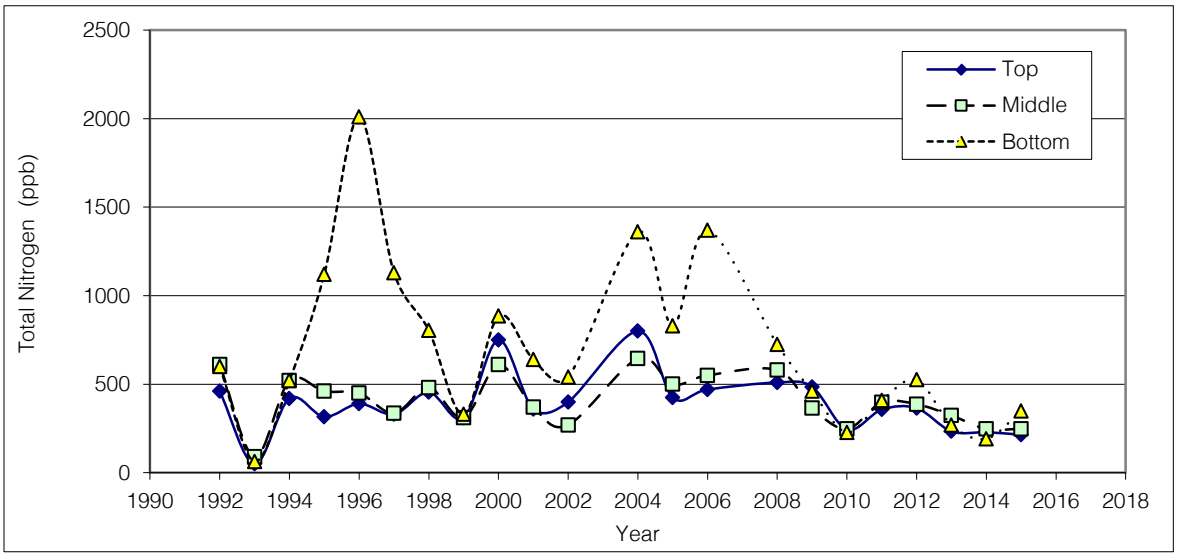
total nitrogen varied between 207 ppb and 348 ppb; lower than most results from the past several years except for lowest values yet recorded from May 2014.

Table 3 – Eleven years of total nitrogen (ppb) results for Crystal Pond

Depth (m) (ppb)	9/13/12	5/30/13	7/31/13	9/23/13	5/19/14	7/18/14	5/18/15	7/8/15 7/31/15
1	310	401	234	233	174	261	245	215/244
5	420	256	324	311	176	229	207	248/247
9	550	276	269	234	186	247	307	348/298
Average	*427*	*311*	*275*	*259*	*179*	*246*	*253*	*270/263*
Depth (m) (ppb)	8/4/05	7/24/06	8/1/08	7/20/09	8/6/10	7/14/11	6/11/12	7/24/12
1	425	470	510	485	244	357	420	Samples
5	500	550	580	365	248	398	355	lost
9	830	1,370	725	460	228	409	500	
Average	*585*	*797*	*605*	*437*	*240*	*388*	*425*	

The total nitrogen in the lake has been decreasing over the past 7 years (see Figure 3). Average TN for 2005-2008 was around 600 ppb, the 2009-2012 average is around 400 ppb. Beginning in 2013 the average has been <300 ppb. This is a good sign for lake condition and could indicate the alleviation of watershed nitrogen loading. The deep-water samples show a large range over the years with highest values near 2,000 ppb. Recently, bottom water concentrations have been low, close to or less than upper water values, indicating that total nitrogen was overall low in the whole water column.

Figure 3 – Trends in July total nitrogen values from top, middle, and bottom depths in Crystal Pond 1992-2015



Secchi Disk Depth

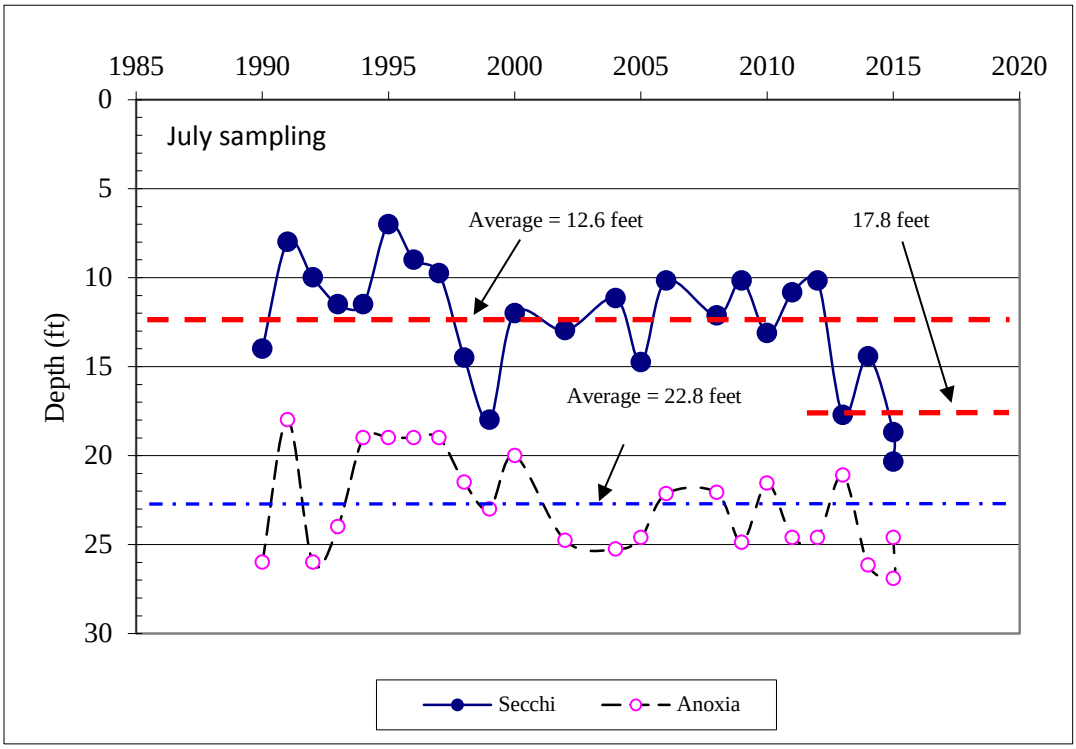
The Secchi disk depth was excellent in 2015, varying between 5.7 meters and 6.4 meters—18.7 and 21 feet (Table 4). The lake has shown better readings beginning in 2012 than all previous years. The readings measured to-date occurred in 2013 and early 2014 when clarity was 7+ meters nearly to the bottom of the lake.

Table 4 – Secchi disk depth measurements at Crystal Pond, 2005-2015

	9-1-12	5-30-13	7-31-13	9-23-13	5-19-14	7-18-14	5-8-158	7-8-15	7-31-15
Depth m (ft)	5.5 (18)	7.5 (24.6)	5.4 (17.7)	7.6 (24.9)	7.2 (23.6)	4.4 (14.4)	6.4 (21)	5.7 (18.7)	6.2 (20.3)
	8-4-05	7-24-06	8-1-08	7-20-09	8-6-10	7-14-11	6-12-12	7-24-12	
Depth m (ft)	4.5 (14.8)	3.1 (10.2)	3.7 (12.1)	3.1 (10.2)	4.0 (13.1)	3.3 (10.8)	4.4 (14.5)	3.1 (10.2)	

The long-term average July Secchi disk depth (1990-2015) is 12.6 feet, although the average of 2013-2015 July readings is 17.8 feet considerable better than prior years (Figure 4).

Figure 4 - Secchi Depths and Anoxic Boundaries at Crystal Pond, 1990-2015



Dissolved Oxygen

The location of the anoxic boundary during the month of July has fluctuated between 19 and 27 feet with an average of 22.8 over the period on record (see Figure 4 for the trend in anoxic boundary). In 2015, the anoxic boundary was located at 26.9/24.6 feet below the surface, better than average. During conditions of very deep anoxic boundary of 25 feet or more only a very small portion of the lake bottom exposed to anoxic conditions, less than 15% of the surface area and less than 4% of the lake volume.

Aquatic Plants

The aquatic plants in Crystal Pond were surveyed in-detail during the July 31st, 2015 visit (see Figure 5 for distribution map of dominant plants during that survey) – no invasive species were found (specifically fanwort). Generally plant beds were similar to those mapped in 2014 (Figure 6). Dominant plants noted in Table 5 appear to be increasing in distribution and abundance, although we have also noted some shifting of bed location. In July 2015, NEAR found 29 species of aquatic plants, more species than any prior single survey (Table 5).

NOTE: the extremely aggressive invasive non-native aquatic plan Hydrilla was found in Coventry Lake (Coventry CT) last fall. Plant fragments were located first at the boat ramp suggesting that fragments have been transported via boat out of the lake. It is extremely important to continue to monitor all boats entering the lake for invasive plants.

All six surveys (2004, 2011 – 2015) show the same few species to be dominant in the lake. The first five and most prevalent species are listed in Table 5: Robbins pondweed, large-leaf pondweed, stonewort/muskgrass, water marigold, and grassy pondweed. Although the percent occurrence numbers vary year-to-year for each of these five species, each has been generally high. Robbins pondweed, stonewort, muskgrass and water marigold, are all low-growing plants that remain close to bottom. Large-leaf

pondweed and grassy pondweed form beds of tall plants that reach the water surface in 4-8 feet of water depth and develop floating leaves.

Table 5 - Aquatic plant species list for Crystal Pond

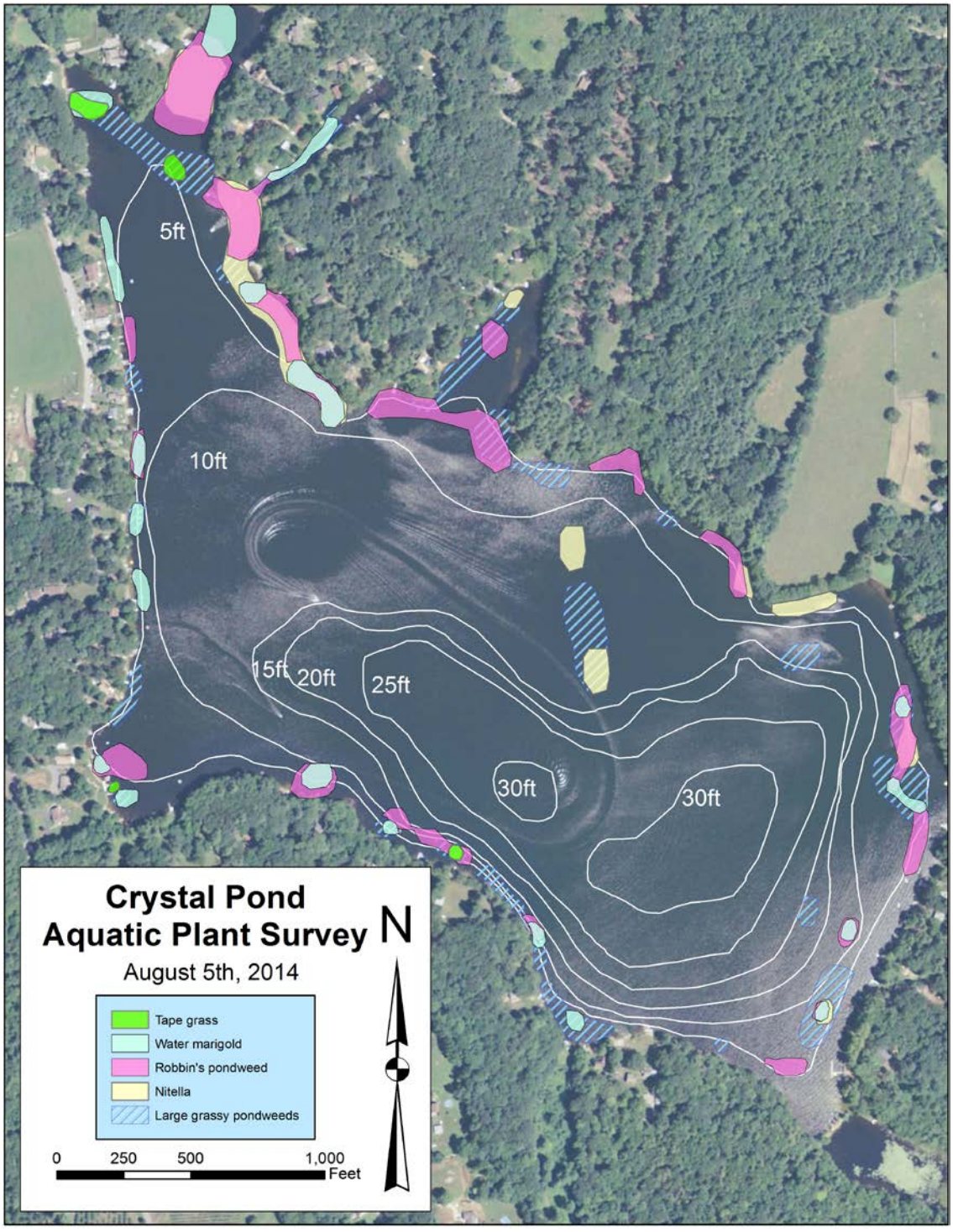
Scientific Name	Common Name	Percent Occurrence					
		2015	2014	2013	2012	2011	2004
Potamogeton robbinsii	Robbins Pondweed	52	31	27	42	57	26
Potamogeton amplifolius	Lg-leaved Pondweed	52	43	16	19	28	24
Nitella sp.	Stonewort / Muskgrass	10	15	0	6	24	48
Bidens beckii***	Water Marigold***	23	30	26	19	40	10
Potamogeton gramineus	Grassy Pondweed	15	20	21	44	23	4
Utricularia purpurea	Purple Bladderwort	12	2	3	6	9	~
Valisneria americana	Tape-grass	10	6	5	7	6	1
Stuckenia pectinata	Thread-lf Pondweed	~	~	~	~	6	~
Utricularia macrorhiza	Large Bladderwort	1	~	~	~	3	1
Utricularia geminiscapa	Hiddenfruit Badderwort	~	1	~	~	3	~
Eleocharis acicularis	Aquatic Rush	4	8	2	4	1	1
Potamogeton epihydrus	Red-leaf Pondweed	6	1	1	~	~	2
Elodea nuttallii	Water-Weed.	~	1	1	~	~	1
Najas guadalupensis	Southern naiad	~	~	~	~	~	1
Fontinalis sp.	Aquatic Moss	3	1	~	~	~	2
Ceratophyllum	Coontail	1	2	~	~	1	~
Sagittaria graminea	Grassy Arrowhead	11	5	1	6	3	6
Potamogeton	Snailseed Pondweed	1	1	~	~	1	4
Isoetes sp.	Quillwort	2	~	~	~	1	1
Myriophyllum humile	Low milfoil	~	2	1	~	~	~
Typha sp.	Cattails	2	~	1	~	~	~
*Phragmites sp.^^*	Phragmites ^^	3	2	1	~	~	~
Potamogeton sp.	Pondweed sp.	1	6	1	~	~	~
Najas flexilis	Naiad	4	~	~	~	~	~
Chara		5	~	~	~	~	~
Nuphar variegata	Yellow Water Lily	3	~	~	~	~	~
Eleocharis robbinsii	Spike-rush	2	~	~	~	~	~
Sparganium fluctuans	Burreed	3	~	~	~	~	~
Utricularia sp.	Bladderwort sp.	1	~	~	~	~	~
Filamentous Algae		3	~	~	~	~	~
Utricularia radiata	Bladderwort	1	~	~	~	~	~
Brasenia schreberi	Water Shield	1	~	~	~	~	~
Lemna	Duckweed	1	~	~	~	~	~
Gratiola aurea	Golden Hedge-Hyssop	1	~	~	~	~	~

*** State listed plant of special concern

^^ invasive wetland plant

Figure 5 – Aquatic Plants in Crystal Pond 2015

Figure 6 – Aquatic Plants in Crystal Pond 2014



Watershed Characteristics

Crystal Pond has a watershed area of 545 acres and a drainage area of only 400 acres (watershed minus the lake area). The lake has no large inlets; instead, water flows into

the lake via several small creeks and drains. The map below (**Figure 7),** showing the drainage basin of Crystal Pond, identifies nine natural sites where surface water could flow into Crystal Pond based on topography. The map doesn't show possible drainage conveyance in the northwestern shoreline area. Investigation of each verified that only sites 1, 4, 7, 8, 9 were actual tributary locations **Figure 8**. Site 10 has subsequently been identified as a culvert that enters the lake subsurface so cannot be sampled. **Table 6,** lists approximate drainage area of each inlet.

Figure 7 - Drainage basin of Crystal Pond showing nine principal sub-basins

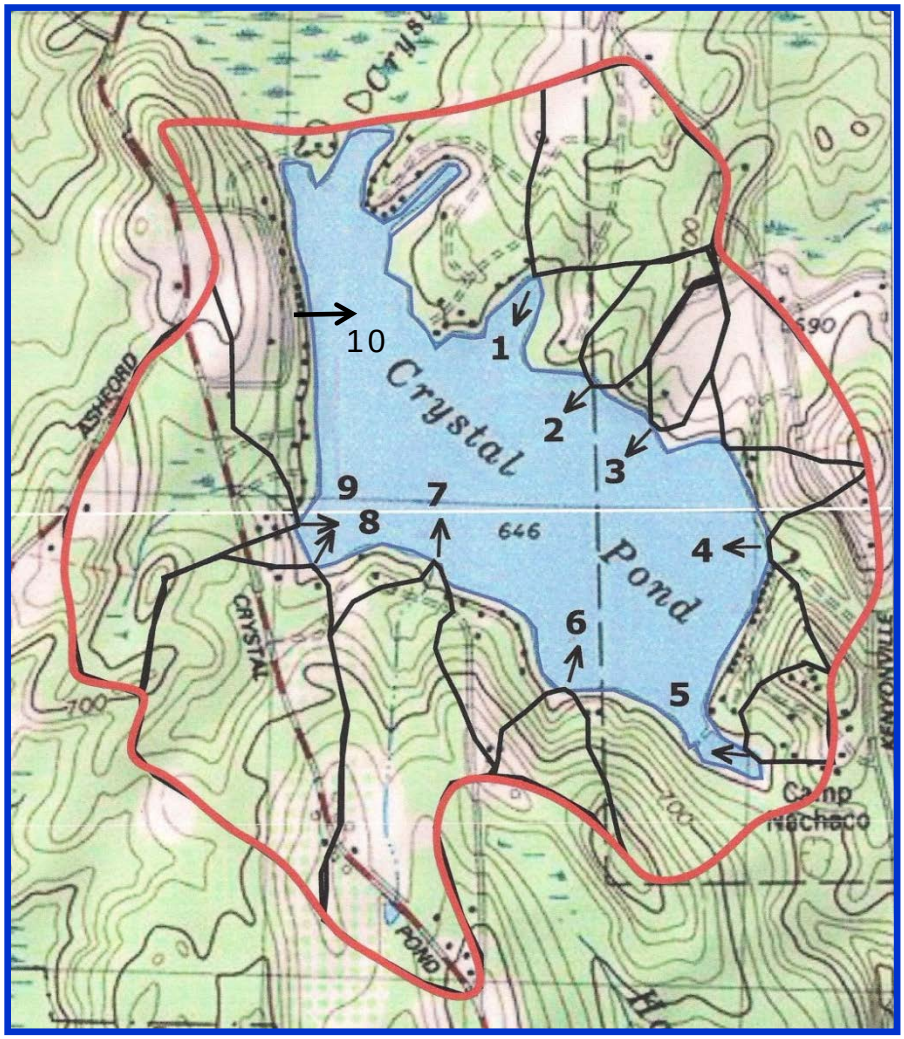
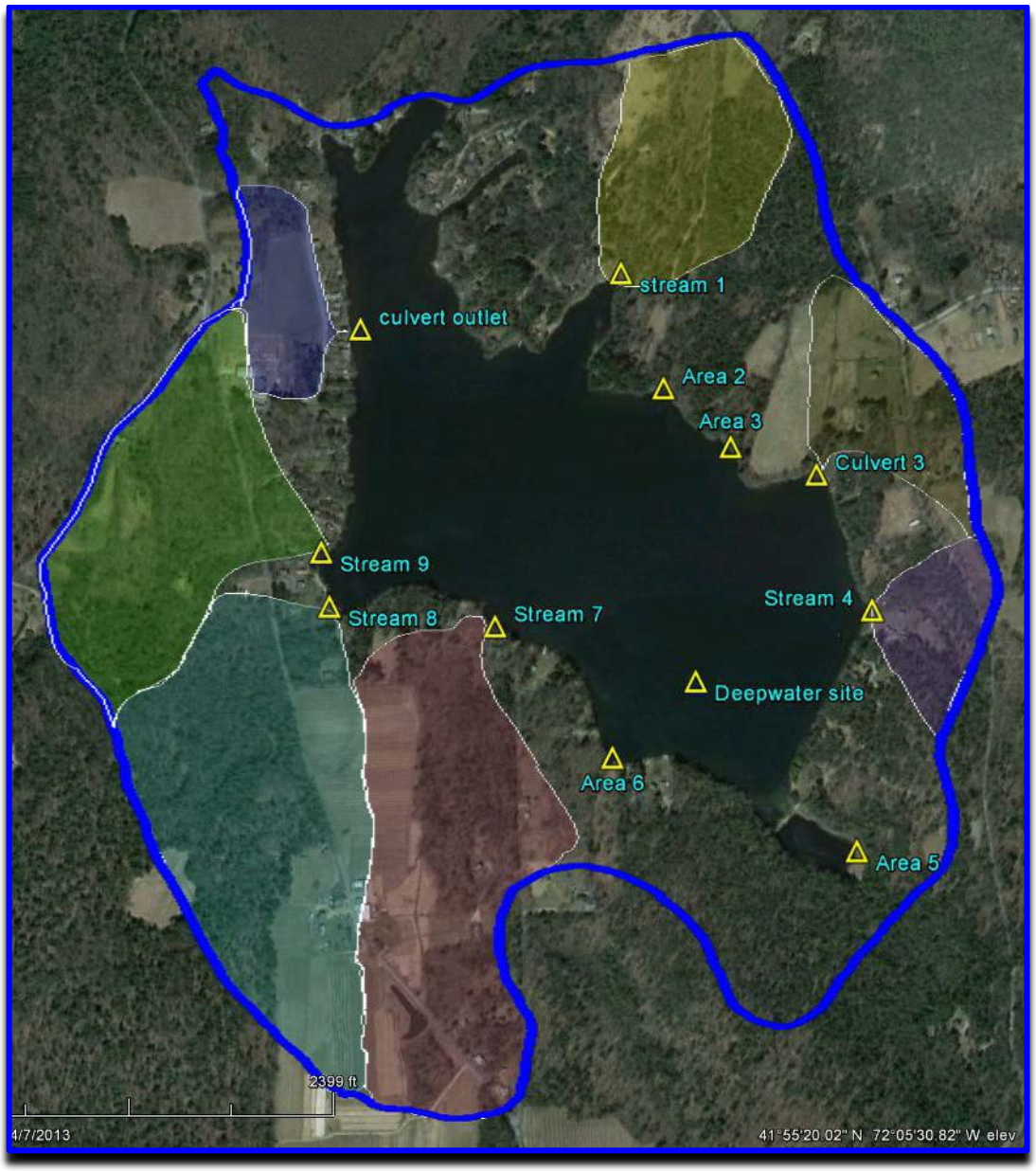


Figure 8 - Drainage basin of Crystal Pond showing seven inlets and sub-basins



The locations where water was found be flowing into the lake are labeled as Streams 1, 4, 7, 8 and 9 in Figure 8. Other sites, Culvert 3, and Areas 2, 3, 5, and 6, have not had flowing water on any of the sampling visit. At the location marked as Culvert Outlet, the end of a culvert was found in approximately 5 feet of water. The culvert pipe was buried with only the very top edge of the pipe visible. It appeared to be the outlet pipe for runoff from a field and roads on the western shore of the lake.

Table 6 – Inlet sites to Crystal Pond

Sub-basin Number Referenced on Fig 10	Acres	Notes
1	34.0	Stream inlet
2	9.0	No inlet to the lake found in this area
3	7.7	Culvert in wall with no flow
4	18.8	Stream inlet
5	7.8	Possible inlet into contiguous swamp at southern end of cove but couldn't be accessed
6	9.7	No inlet to the lake found in this area
7	49.6	Stream inlet
8	54.8	Stream inlet
9	49.5	Stream inlet
Culvert outlet	12.1	Culvert discharges at lake bottom in 5 feet of water

Water sampling results for phosphorus and nitrate are shown in Table 7 below. Cells with no values indicate no samples was collected at that site on that date because no water was found to be flowing into the lake.

Table 7 – Testing results from water entering Crystal Pond

Stream number	Total Phosphorus (ppb)				Nitrate Nitrogen (ppb)			
	6/11/12	5/30/13	5/19/14	5/18/15	6/11/12	5/30/13	5/19/14	5/18/15
1	-	2	7	8	-	**182**	**514**	**178**
4	-	6	14	-	-	0	0	-
7	**39**	16	23	-	**330**	**174**	**370**	**-**
8	11	5	9	16	57	42	92	105
9	-	8	16	26	-	0	14	19

Phosphorus has been generally very low except at Stream 7 where slightly elevated value of 39ppb was reported in 2012. Other steams have low phosphorus levels.

Nitrate has been found at elevated levels in Stream 1 and Stream 7 during 2012-2015 testing. The reported values (between 174ppb 514ppb) are cause for concern if further testing shows higher or sustained values. We will be closely watching the level of nitrate in these streams into the future. Stream 4 appears to have nitrate at levels below detection. Stream 9 shows very low but measurable levels of nitrate, and Stream 8 has constantly had measureable nitrate bordering on being elevated but still acceptable so far.

SUMMARY and RECOMMENDATIONS

Water quality monitoring conducted in 2015 showed the lake to have excellent water clarity

Phosphorus concentration in 2015 was higher than past averages with higher levels at 1 meter and 5 meter depths. At this time it uncertain why phosphorus has increased but water clarity remains exceptional.

Nitrogen levels in the lake were low compared to prior years.

Aquatic plant community remained consistent with prior years with the same dominant plant species, no new species have become prolific. Pondweeds and tape grass show some expansion of distribution but we are not sure that the changes between 2014 and 2015 are significant. Water marigold and Robbins pondweed still cover most bottom areas identified in prior years indicating stability of those species. NO NON-NATIVE SPECIES HAVE BEEN FOUND IN THE LAKE.

Suggested 2016 Actions

CONTINUE WITH THREE LAKE VISITS IN 2016

- May for inlet sampling
- End of July for long term data continuity
- End of August for aquatic plant survey

LATE SEASON MEETING (EARLY AUGUST AS IN PRIOR YEARS)

EXTREME VIGILANCE FOR HYDRILLA – NOW KNOW TO INFEST COVENTRY LAKE COVENTRY CT!