2014 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. The Crystal Pond Association has been collecting water quality data from the lake since 1990. Beginning in 2004, Northeast Aquatic Research (NEAR) has conducted one annual visit to Crystal Pond, typically at the end of July or early August, to collect water quality information.

This report gives the data record of several important lake parameters that have been tracked since 1990 and includes the 2014 information as the newest part of that record. Water quality remained excellent in 2014, continuing very good water clarity and phosphorus levels found in 2013. Inlet chemistry was of minor concern at streams #1 and #7 that had slightly elevated levels of nitrate. Aquatic plants continue to appear to becoming more prolific and perhaps growing to deeper depths. The state listed plant Water Marigold was present throughout most of the lake where it covered the bottom as a blanket with Robbins pondweed, another beneficial native plant. No invasive species were found include fanwort, despite intensive surveys seeking evidence of this weed. At this time there does not appear reason for concern with the aquatic plants in Crystal Pond.

In 2014, Northeast Aquatic Research made four visits to Crystal Pond. The first, May 19th, was to investigate tributary inflow points around the lake. The second visit, July 18th, was to collect the annual mid-summer water quality data, and the third, August 5th, visit was to survey distribution and abundance of aquatic plants and to take depth measurements for the creation of a bathymetric map. The final visit, October 9th, was an in-depth end-of-season scan for any invasive aquatic plant species, specifically focusing on finding fanwort. A specimen of fanwort was presented to NEAR for identification on September 24th 2013. The fragment had been removed from the trailer of a boat launched into Crystal Pond during the summer. No evidence of fanwort was found in the lake during any of the surveys conducted in 2013 or 2014.

On two visits in 2014, three water samples were collected from the lake; one from each the top (3 ft.), middle (13 ft.), and bottom (27 ft.), water depths at a station located over the deepest section of the lake (See Figure 1 below).

Water samples were taken to Center for Environmental Science and Engineering, University of Connecticut, for analysis of total phosphorus, and total nitrogen (ammonia, nitrate, and organic nitrogen). Water temperature and dissolved oxygen content of the water was measured at each meter depth, from top to bottom. Water clarity was measured using a Secchi disk.

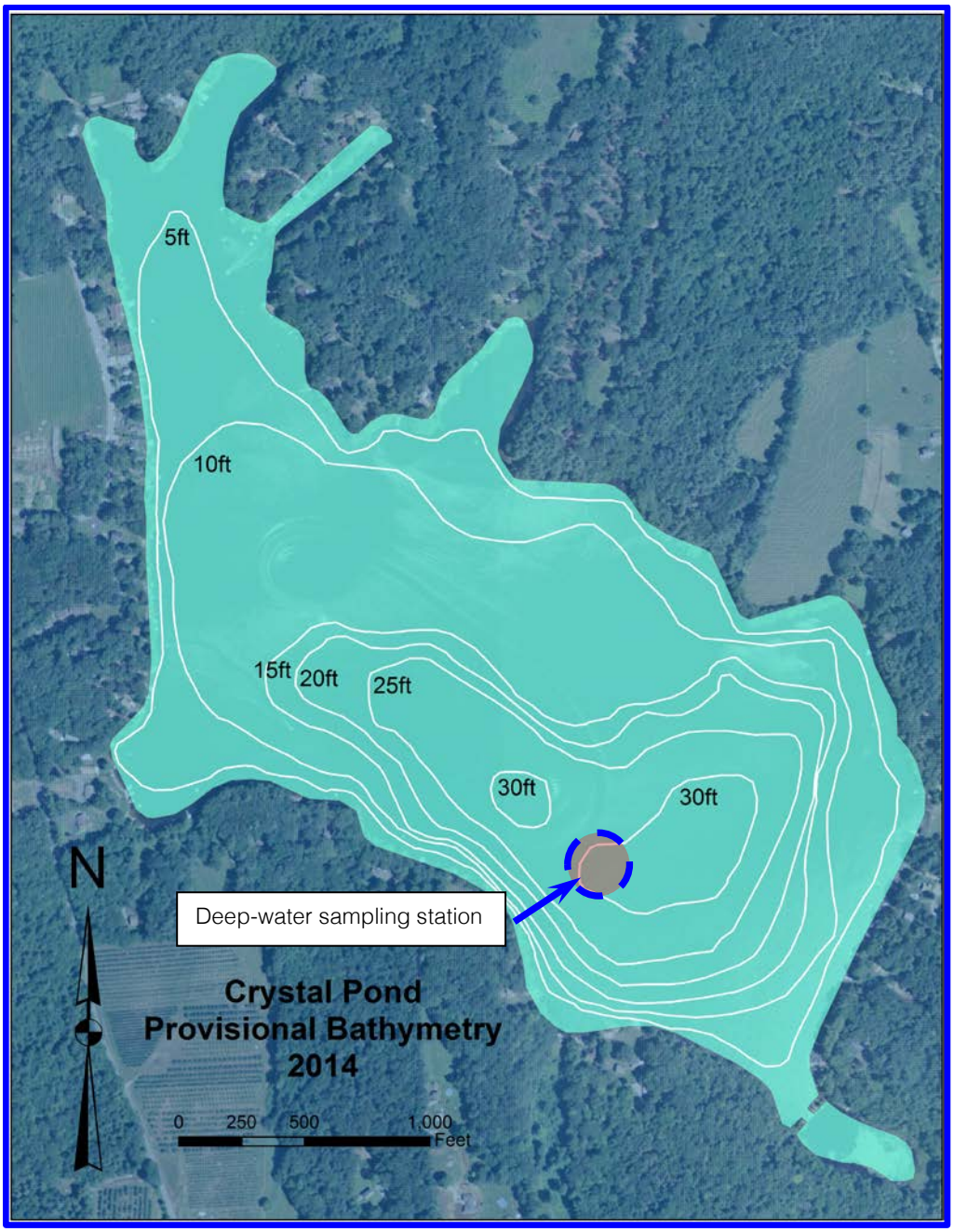
MONITORING RESULTS

Bathymetric Mapping

As lakes age, they accumulate sediment from the watershed and become shallower over time. The Connecticut DEEP published a bathymetric map of Crystal Pond in 1959 that showed the maximum depth of the deep hole at 42 feet (Figure 1). After years of not being able to find water of that depth in the lake, NEAR suggested that it was time to undertake a more thorough bathymetric survey of Crystal Pond and update the maps and volume estimates. In 2014, NEAR collected depth data at over 200 points around the lake and created an updated bathymetric map for Crystal Pond (Figure 2). This map indicates that considerable sedimentation has decreased the maximum depth of the lake from 42 ft. in 1959 (Figure 2) to a current maximum depth of 31 ft. The mean water depth of the lake was, using old bathymetry, 14.7 feet, but decreased to 13.4 ft. with the new water depths. The old volume of Crystal Pond was estimated to be 2,201 acre-feet, decreasing to 1,881 acre-feet with the new contours (an acre-foot of water refers to a volume that is one acre in area by one foot in depth). We will continue to refine the bathymetric contours in 2015 with new soundings in areas missed during the 2014 survey.

Figure 1 – Historical Crystal Pond water depth contours from *A Fishery Survey of the Lakes and Ponds of Connecticut* (1959).

Figure 2 – Crystal Pond water depth contours as mapped by NEAR during 2014, showing deep-water sampling station



Water Quality Analysis

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). 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 in numbers 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

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). The CT DEEP also ranks total nitrogen, Secchi disk depth and chlorophyll a.

Total Phosphorus

Total phosphorus concentrations found in Crystal Pond during the 2014 season are presented in Table 2 together with data from the prior 8 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.

Over the long-term—1992 to 2014--phosphorus concentration in the 1-meter and 5-meter samples has averaged 10 ppb, the upper threshold for Oligotrophic Lakes as shown in Table 1. This indicates that Crystal Pond has consistently had oligotrophic phosphorus since monitoring began in 1992. Data from 2014 shows phosphorus in May increased to 23 ppb in the surface waters, which is quite high for Crystal Pond. In July when data is used for long-term comparison, phosphorus in the 1-meter and 5-meter samples was 11 and 10 ppb, hovering right around the long-term mean.

Phosphorus in the deepest water--as represented by the bottom water sample--has averaged slightly higher than the 1 and 5 meter samples at 25 ppb long-term. Although concentrations are higher at 9 meters, the sample represents only about 3% of the lake volume.

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

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

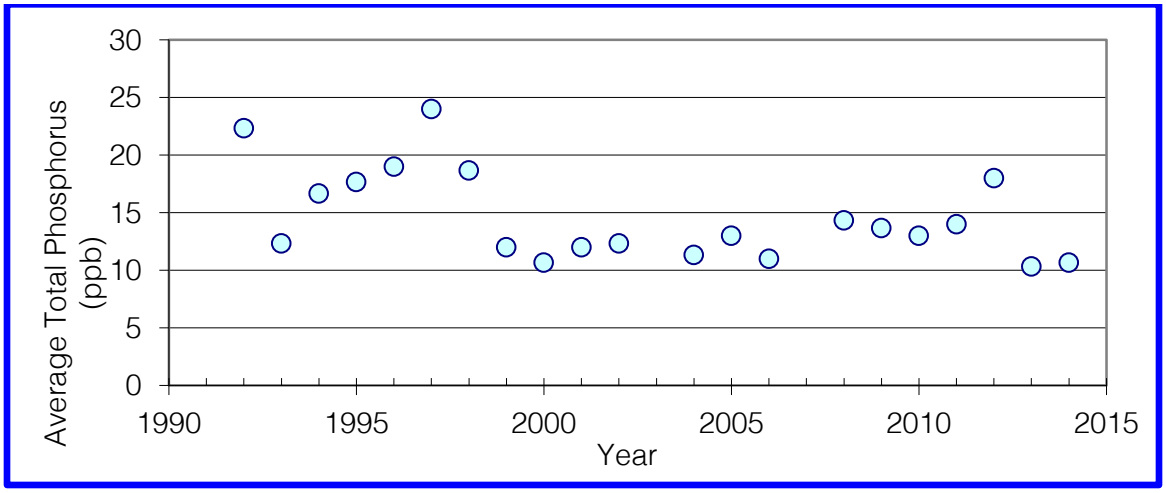
Depth (m) (ppb)	5-20-13	7-31-13	9-23-13	average
1	12	7	11	10
5	13	7	11	10
9	10	17	12	13
Average	*10.7*	*10*	*11.3*	***11***

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

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*	

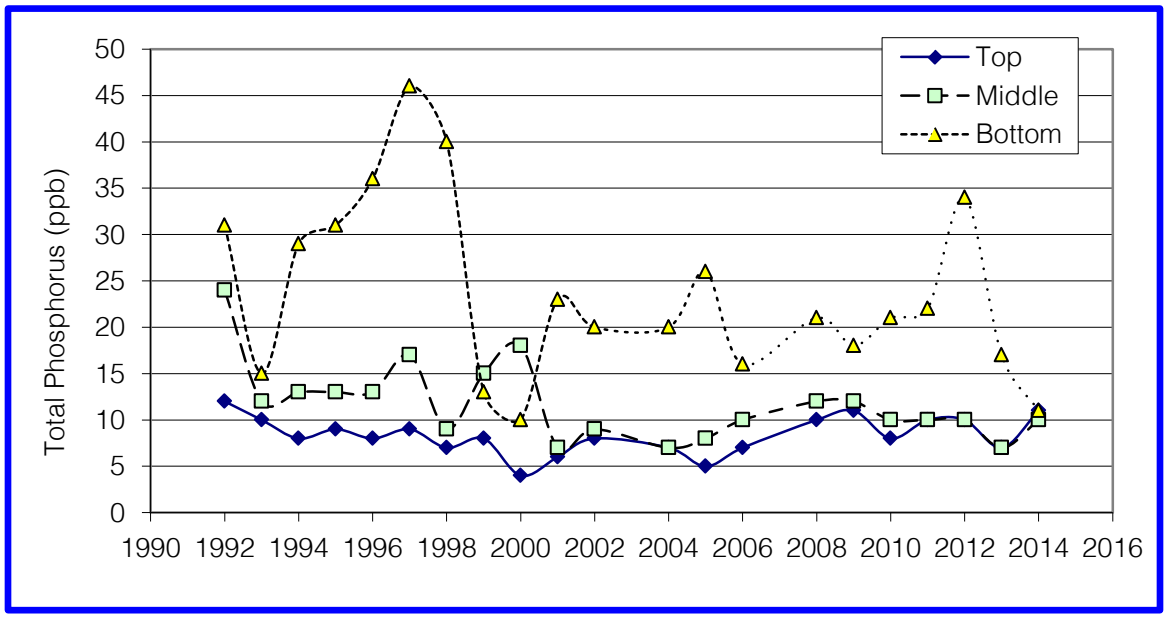
The whole lake average P content—using all three values—has varied between 10 ppb and 15 ppb since 1999 (**Figure 3**). There was higher phosphorus in the lake between 1991 and 1997, but since 1999, the concentration has been constantly within the 10-15 ppb range—except in 2012, when the lake had 18 ppb phosphorus.

Figure 3 - Average total phosphorus concentration in Crystal Pond 1992–2014



Results from each of the three sampling depths--**Figure 4**—shows how 1-meter and 5-meter concentrations have remained consistently between 5 and 15 ppb since 2001, but that bottom water phosphorus has fluctuated widely.

Figure 4 - Phosphorus values from the top, middle, and bottom, depths in June at Crystal Pond 1992-2014



Total Nitrogen

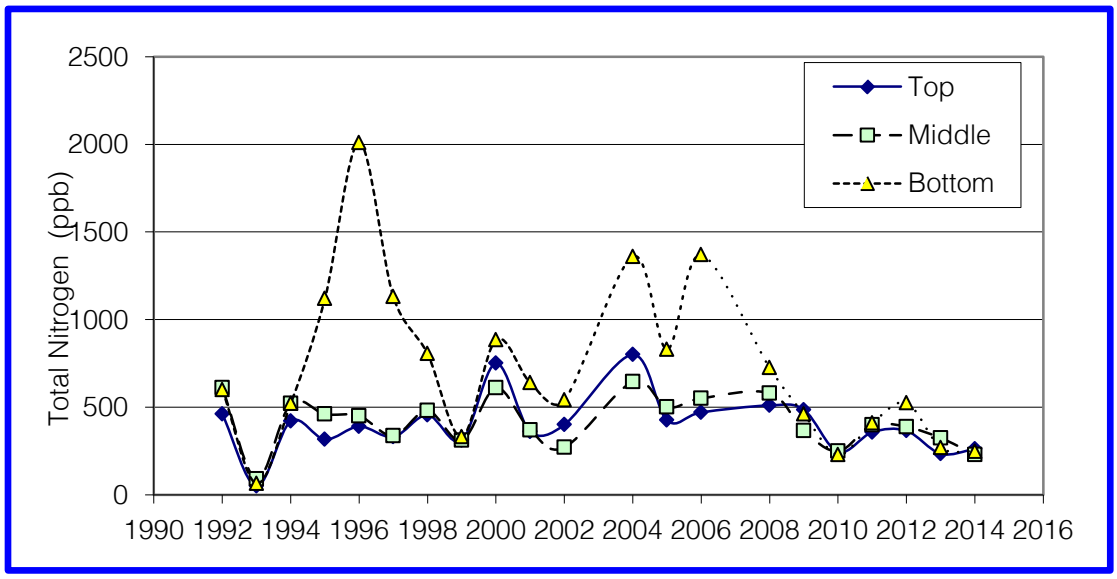
The results for total nitrogen sampling over the last nine years are given in Table 3. Total nitrogen includes fractions of nitrate, ammonia, and organic components. In 2014, Total nitrogen varied between 174 ppb and 261 ppb, lower than most results from the past several years. The results from May show the lowest total nitrogen numbers ever recorded in Crystal Pond.

Table 3 – Nine years of total nitrogen results for Crystal Pond

Depth (m) (ppb)	7-24-12	9-13-12	5-30-13	7-31-13	9-23-13	5/19/14	7/18/14
1	Samples	310	401	234	233	174	261
5	lost	420	256	324	311	176	229
9		550	276	269	234	186	247
Average		***427***	***311***	***275***	***259***	***179***	***246***
Depth (m) (ppb)	8-4-05	7-24-06	8-1-08	7-20-09	8-6-10	7-14-11	6-16-12
1	425	470	510	485	244	357	420
5	500	550	580	365	248	398	355
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 9 years (see Figure 5). Average TN for 2005-2008 was around 600 ppb, the 2009-2012 average is around 400 ppb and the average over the last two years in around 200 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 well mixed in the whole water column.

Figure 5 - Total nitrogen values from top, middle, and bottom depths in Crystal Pond 1992-2014



Secchi Disk Depth

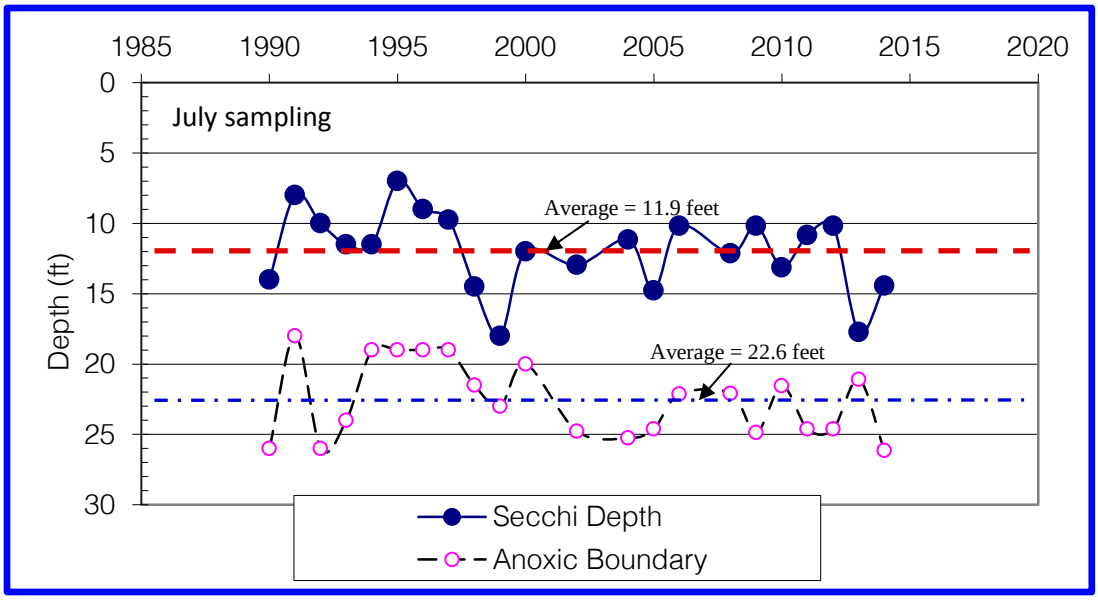
The Secchi disk depth was very good in 2014, varying between 14.4 feet and 23.6 feet—4.4 and 7.2 meters (**Table 4**). The poorest clarity recorded in 2014 occurred in July but was better than most previous July readings, while the best clarity occurred in May. Good clarity measurements like these at Crystal Pond mean that there is not a lot of phytoplankton (cell counts showed total phytoplankton to be less than 1000 cells /mL, an excellent value) in the water column and that light can penetrate deeper into the water column and warm deeper waters. This enhances mixing and oxygenation of deeper waters which in turn prevents the release of nutrients from the sediment and limits phytoplankton growth in the water column. Measurements from the 2014 season together with values from the last nine years are given in **Table 4**.

Table 4 – Nine years of Secchi disk depth measurements at Crystal Pond

	7-24-12	9-1-12	5-30-13	7-31-13	9-23-13	5-19-14	7-18-14
Depth m (ft)	3.1 (10.2)	5.5 (18)	7.5 (24.6)	5.4 (17.7)	7.6 (24.9)	**7.2 (23.6)**	**4.4 (14.4)**
	8-4-05	**7-24-06**	**8-1-08**	**7-20-09**	**8-6-10**	**7-14-11**	**6-12-12**
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)

The long-term average, 1990-2014 of the July Secchi disk depth is 11.9 feet (Figure 6). The July measurement has varied over the years, with a low of 7 feet and a high of 17.7 feet (recorded July 2013).

Figure 6 - Secchi Depths and Anoxic Boundaries at Crystal Pond, 1990-2014



Dissolved Oxygen

The location of the anoxic boundary during the month of July has fluctuated between 6 and 8 meters over the period on record (see Figure 6 for the trend in anoxic boundary). The long-term average location of the anoxic boundary in the water column in July is 22.4 feet below the surface. In 2014, the anoxic boundary was located at 26.1 feet below the surface, better than average, leaving 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 August 5, 2014 visit (see Figure 7 for distribution map of dominant plants during that survey) and observed during the October 19th visit—no invasive species were found. In August, NEAR found 18 species of aquatic plants, more species than have ever been found in a single survey (Table 5).

All five surveys (2004, 2011 – 2014) 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 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. Thus, these species are rarely seen near the surface. Large-leaf pondweed and grassy pondweed form beds of columnar plants that reach the water surface in 4-8 feet of water depth and develop floating leaves. These last two plant species are prized for bass habitat and quality fish structure but can cause serious impairment to other lake recreational uses if they grow too densely.

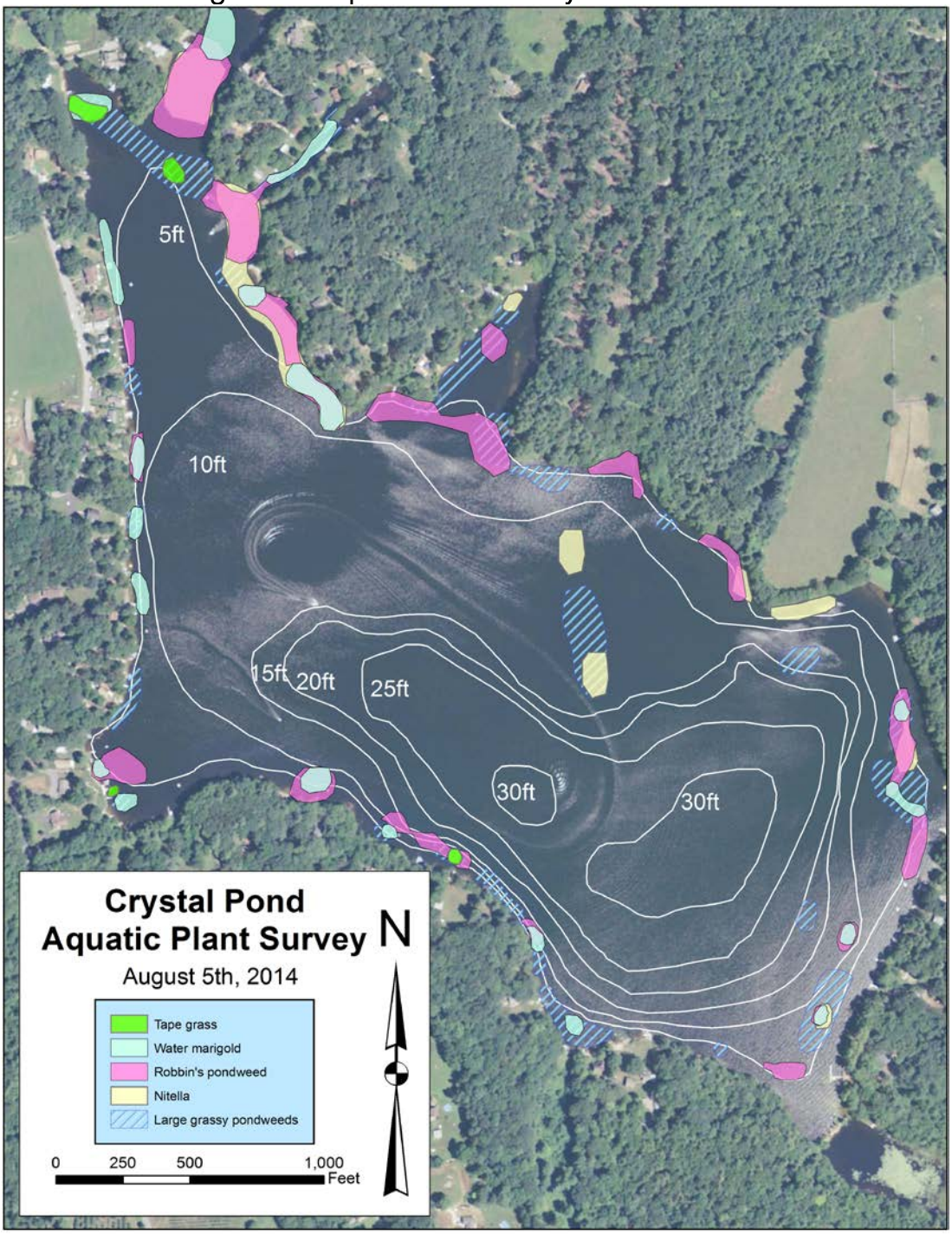
Table 5 - Aquatic plant species list for Crystal Pond

Scientific Name	Common Name	Percent occurrence				
		2014	2013	2012	2011	2004
Potamogeton robbinsii	Robbins Pondweed	31	27	42	57	26
Potamogeton amplifolius	Large-leaved Pondweed	43	16	19	28	24
Nitella sp.	Stonewort / Muskgrass	15	0	6	24	48
*Bidens beckii****	Water Marigold***	30	26	19	40	10
Potamogeton gramineus	Grassy Pondweed	20	21	44	23	4
Utricularia purpurea	Purple Bladderwort	2	3	6	9	~
Valisneria americana	Tape-grass	6	5	7	6	1
Stuckenia pectinata	Thread-leaved Pondweed	~	~	~	6	~
Utricularia macrorhiza	Large Bladderwort	~	~	~	3	1
Utricularia geminiscapa	Hiddenfruit Badderwort	1	~	~	3	
Eleocharis acicularis	Aquatic Rush	8	2	4	1	1
Potamogeton epihydrus	Red-leaf Pondweed	1	1	~	~	2
Elodea nuttallii	Water-Weed.	1	1	~	~	1
Najas guadalupensis	Southern naiad	~	~	~	~	1
Fontinalis sp.	Aquatic Moss	1	~	~	~	2
Ceratophyllum demersum	Coontail	2	~	~	1	~
Sagittaria graminea	Grassy Arrowhead	5	1	6	3	6
Potamogeton bicupulatus	Snailseed Pondweed	1	~	~	1	4
Isoetes sp.	Quillwort	~	~	~	1	1
Myriophyllum humile	Low milfoil	2	1			
Typha sp.	Cattails	~	1			
*Phragmites sp.^^*	Phragmites ^^	2	1			
Potamogeton sp.	Pondweed sp.	6	1			

*** State listed plant of special concern

^^ invasive wetland plant

Figure 7 – Aquatic Plants in Crystal Pond 2014



Tape grass was found in several new locations outside the cove in the northern end of the lake where it has dominated for years. Despite fears in 2013 that Fanwort may have found its way into Crystal Pond via a fragment on a boat trailer, NEAR did not find the

plant anywhere in the lake in 2014 despite an intensive survey in October looking specifically for the invasive plant. This is a very good sign, but we should continue to monitor the lake for invasives every year to allow for a rapid response removal should any be found.

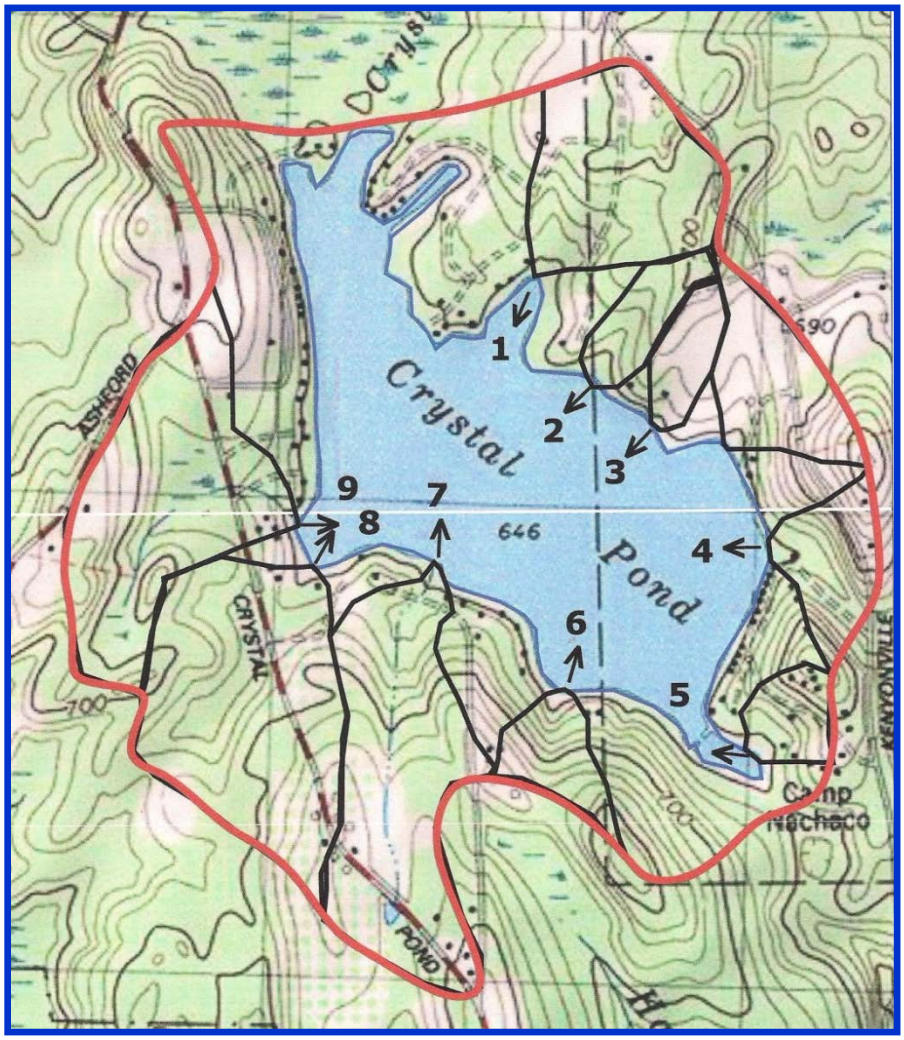
We found plants growing deeper than we ever have before in Crystal Pond this year. Pondweed was found in 18 feet of water depth with a large bed in 13-14 feet of water (See Figure 7). The expansion of this plant into deeper waters could be a reflection of the excellent water clarity and light penetration we have seen in the lake in recent years. Nitella was found growing quite densely in 14 feet of water during the 2014 survey (See Figure 8). This summer, due to the updated contour line map and the discovery of deep growing plants in the lake, NEAR will pay more attention areas of greater depth in the pond during the annual weed survey to identify other locations of deep growing plants.

Figure 8 – *Nitella* in Crystal Pond August 2014

Watershed Characteristics

The drainage basin of Crystal Pond is small at only about 400 acres. The lake has no large inlets; instead, water flows into the lake via several small creeks and drains. The map below, Figure 9, shows nine natural inlet sites where surface water is likely to flow into Crystal Pond based on topography. We investigated each of these areas during our May 2014 visit. Of the 9 sites identified as possible locations of tributaries to Crystal Pond, only sites 1, 4, 7, 8, 9 had flowing water see Table 6, which also lists approximate drainage area of each inlet.

Figure 9 - Drainage basin of Crystal Pond showing nine principal 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 10. In addition, a culvert was found at the site labeled Culvert 3, but no water was flowing at the time of the visit but is likely to carry storm water during

rain events. Other sites, labeled as Areas 2, 3, 5, and 6, indicate where the shoreline was searched because topographic contours suggested inflows are present. Upon inspection, however, no flowing water or drainage conveyance could be identified in these areas, ruling them out as sites of surface drainage into the lake. 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.

Figure 10 - Drainage basin of Crystal Pond showing seven inlets and sub-basins

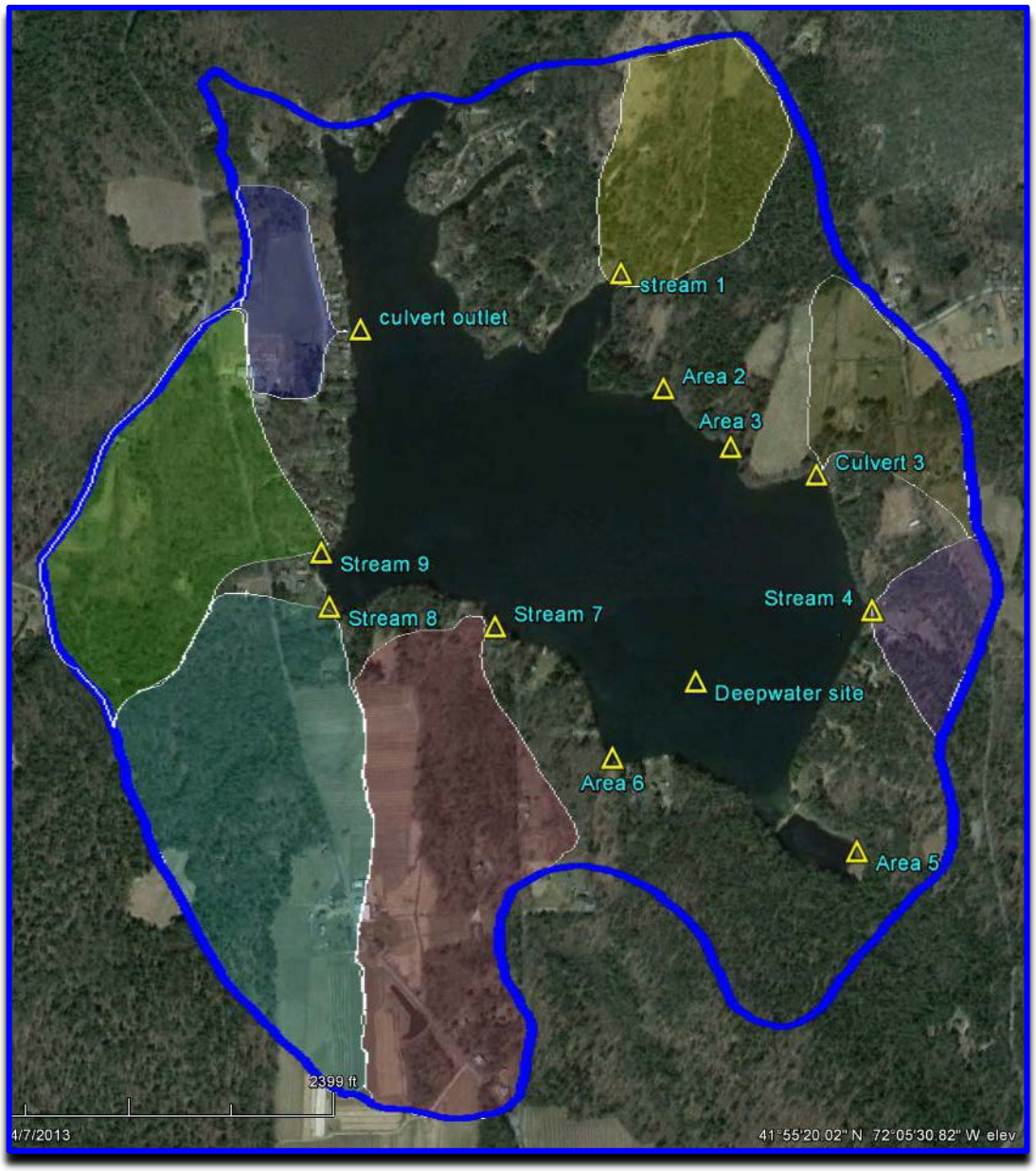


Table 6 – Inlet sites to Crystal Pond

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 at bottom in 5 feet of water

Water sampling results for phosphorus and nitrate are shown in Table 7 below. Nitrate was found in Stream 1 in 2014 at an elevated level that could be cause for concern if further testing shows either higher or sustained values. We will be closely watching the level of nitrate in this stream into the future to see if it was a one-time spike, or it indicates a source of nutrients upstream that should be identified and mitigated. Stream 4 appears to have very low levels of nitrate and very mildly elevated phosphorus. Stream 7 had elevated levels of phosphorus and nitrate present. So far, Stream 7 has had the highest inlet phosphorus levels we have for Crystal Pond. Stream 8 had low phosphorus but slightly elevated nitrate. Stream 9 showed low, to very low, levels of nitrate and mildly elevated phosphorus levels.

Inlet testing shows that Streams 1, 7 have elevated nitrate. The level of nitrate in stream suggests that an investigation of the sub-watershed of this inlet during the May monitoring visit in 2015 may be warranted to see if any obvious sources of nutrients can be identified. The inlets should be watched into the future in ensure then values don't increase.

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	6-11-12	5-30-13	5/19/14
1		2	7		**182**	**514**
4		6	14		0	0
7	**39**	16	**23**	**330**	**174**	**370**
8	11	5	9	57	42	92
9		8	16		0	14

SUMMARY and RECOMMENDATIONS

Water quality monitoring conducted in 2014 showed the lake to have excellent water clarity, slightly lower than last year, but better than average.

Surface phosphorus concentrations were the highest ever recorded in May at 23 ppb but by July that number had dropped back to 11 ppb continuing the trend of oligotrophic phosphorus concentrations in Crystal Pond. Despite some high nitrate levels in the inlets, nitrogen levels in the lake were the lowest on record this year despite some high numbers of nitrate found in several of the inlets sampled in May.

CONTINUE WITH THREE LAKE VISITS IN 2015

Aquatic plants seem to be spreading to deeper areas of the lake, likely due to the increased water clarity and light penetration over the past several years. Now a significant portion of the lake bottom between shoreline and 12 feet of water depth is covered with dense growths of bottom loving plants that are beneficial to the lake.

CONDUCT ONE AQUATIC PLANTS SURVEY IN 2015.

Watershed-monitoring has shown elevated nitrate levels at Stream 1 and moderately elevated phosphorus and nitrate levels at Stream 7. These levels are not alarming but could be cause for concern if they remain elevated. We would like to conduct a brief exploration of the sub-watershed of stream 1 to determine if there are any obvious sources of nutrients to explain the elevated levels.

CONTINUE WITH ONE INLET MONITORING VISIT IN 2015

Others aspects:

WE WOULD LIKE TO ATTEND ONE END OF SEASON MEETING (OR EARLY AUGUST AS IN PRIOR YEARS)