PHOSPHORUS INACTIVATION PROJECT FOR HAMBLIN POND, BARNSTABLE, MASSACHUSETTS




FINAL REPORT

BY WATER RESOURCE SERVICES, INC.

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Contents

Project Background and Need 1
Phosphorus Inactivation Project 10
Monitoring Results 15
Summary and Recommendations 35
References 37
APPENDIX: Water Quality and Biological Data 38

Tables

Table 1. Nutrient loads to Hamblin Pond over time 6
Table 2. Sediment features and aluminum dose calculation for Hamblin Pond in 2015 11

Figures

Figure 1. Location of Hamblin Pond 2
Figure 2. Hamblin Pond bathymetry 3
Figure 3. Hamblin Pond and surrounding area 4
Figure 4. Duck farm at Hamblin Pond circa 1950 5
Figure 5. Groundwater drainage area to Hamblin Pond (from Eichner et al. 2006) 5
Figure 6. Aerial view of Hambln Pond in September 2013 8
Figure 7. Hamblin Pond treatment areas 12
Figure 8. Treatment of Hamblin Pond with aluminum in June 2015 13
Figure 9. Hamblin Pond Secchi disk transparency in June through September over 25 years 16
Figure 10. Hamblin Pond north total phosphorus for all years 17
Figure 11. Hamblin Pond north total phosphorus for all years with TP scale limit 18
Figure 12. Hamblin Pond north total phosphorus 2012-2016 20
Figure 13. Hamblin Pond south total phosphorus 2015-2016 20
Figure 14. Hamblin Pond north total nitrogen for all years 21
Figure 15. Hamblin Pond north total nitrogen 2012-2016 21
Figure 16. Hamblin Pond south total nitrogen 2015-2016 22
Figure 17. Hamblin Pond north nitrates for all years 22
Figure 18. Hamblin Pond south nitrates 2015-2016 23
Figure 19. Hamblin Pond north bottom ammonium for all years 23
Figure 20. Hamblin Pond south bottom ammonium 2015-2016 24
Figure 21. Hamblin Pond total aluminum 2015-2016 25
Figure 22. Hamblin Pond dissolved aluminum 2015-2016 25
Figure 23. T/DO profiles before and after 1995 treatment in Hamblin Pond 27
Figure 24. T/DO profiles before and after 2015 treatment in Hamblin Pond 28
Figure 25. Hamblin Pond chlorophyll a over time 29
Figure 26. Hamblin Pond algal biomass 2015-2016 30
Figure 27. Hamblin Pond zooplankton biomass 2015-2016 31
Figure 28. Hamblin Pond mean zooplankton body length per sample 2015-2016 32

Project Background and Need

Hamblin Pond covers approximately 115 acres (46.4 ha) in the Town of Barnstable, in the Village of Marstons Mills (Figure 1). It is a classic kettlehole pond, with no surface water inlet or outlet, although there have been suggestions that it did have an overflow many decades ago on its eastern side that was filled in by human activity. It does not appear to have ever had a surface connection to adjacent Middle Pond, but groundwater flow from Middle to Hamblin Pond is substantial as the surface elevation of Hamblin Pond is about 3 ft (0.9 m) lower than that of Middle Pond.

Maximum depth in Hamblin Pond is about 63 ft (19.1 m), while average depth is about 28 ft (8.5 m). Recently updated bathymetry (Figure 2) indicates that the deepest point is on the northeast side of the pond, giving the pond an irregular bowl shape. The distance around the pond along the shoreline is roughly 1.9 miles (3040 m). The bottom is very sandy to a depth of at least 20 ft, and in some places to about 40 ft of water depth. Organic muck covers the bottom in deeper water, in some places to depths of more than 5 ft (1.5 m). The volume is approximately 3200 acre-feet (3.9 million m^3).

Hamblin Pond has public access off Rt 149 on the east side of the pond, with a public boat launch and a large park (Burgess Park) with disc golf, walking areas, a historic building, and multiple lake access points (Figure 3). Also off Rt 149 is the town beach complex, at the south end of the pond, which was at one time part of a duck farm that historically impacted the pond until the 1950s. Hamblin Pond has been stocked with trout since the 1960s after a protracted period of debate over whether or not stocked fish would survive; the pond experienced severe algae blooms and low oxygen in water cold enough to support trout during summer until the first phosphorus inactivation project in 1995. Hamblin Pond has also been popular as a warmwater fishery, mainly for smallmouth bass and yellow perch.

There have been few submergent plants, a consequence of coarse substrate and, until the first phosphorus inactivation project, low light caused by algae blooms. The pond was also devoid of freshwater mussels in the early 1990s; mussels were very common in adjacent Middle Pond and upgradient Mystic Lake at the time, leading to speculation that severe algae blooms and low oxygen may have eliminated mussels from Hamblin Pond many years ago.

Water from a cranberry farming operations just north of Hamblin Pond has been discharged to Hamblin Pond for many years. Research on cranberry bog discharges has demonstrated high concentrations of phosphorus in post-harvest outflows, after pond water has been used to flood bogs for picking. Usually the volume of water discharged from the bogs is small relative to the volume of the receiving pond, and immediate impacts are not large, but the accumulation of phosphorus in pond sediments represents a major threat of internal recycling when low oxygen develops in deep water. However, the bog north of Hamblin Pond is small and has not always been flooded for picking. Outflow to Hamblin Pond has not been substantial and this bog is considered a minor influence overall.

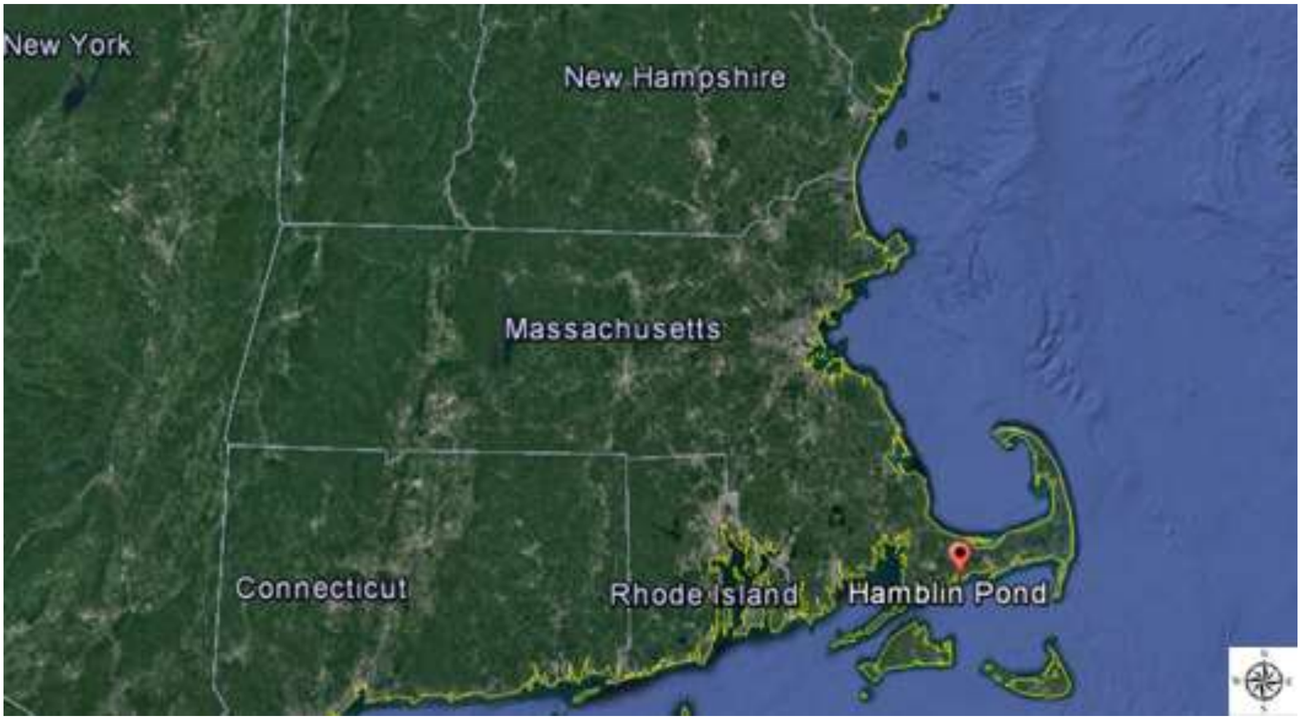


Figure 1. Location of Hamblin Pond

Far more influential was the duck farm at the south end of Hamblin Pond, in production for 35 years from 1920 (Figure 4). About 10,000 ducks at a time were raised there for feathers and meat, with pens extending into the pond. The long-term deposition of fecal material overfertilized Hamblin Pond and set up a cycle of internal loading that persisted long after the farm closed in 1955. When the town beach was created a great amount of sand was dumped in the area and covered the bottom of the swimming area, but much of the pond bottom had been impacted.

Eichner et al. (2006) assessed system hydrology, which is largely based on groundwater flow in this very sandy watershed, with direct precipitation as a lesser input. The surface watershed of Hamblin Pond is only about 162 acres (65.3 ha) in area, but groundwater flows from about 2 miles away to the northwest, from beyond Spectacle, Triangle and Lawrence Ponds in Sandwich (Figure 5). The groundwater table drops from about 60 ft above mean sea level to 41 ft over that distance, a slope of about 0.002. The resultant calculated groundwater flow into Hamblin Pond is about 3.7 million m^3/yr. This is much higher than estimated by BEC (1993), but appears to be a valid assessment.

Reworking the hydrologic, phosphorus and nitrogen budgets from the original BEC (1993) study for consistency with the more detailed hydrologic assessment (Table 1), it is projected that the total flow through Hamblin Pond is just over 4.3 million m^3, suggesting a detention time of 0.9 years for water in the pond. Groundwater is the dominant flow input at about 3.7 million m^3, followed by precipitation at about 550,000 m^3. The cranberry bog north of Hamblin Pond contribute only about 53,500 m3, and these three flow sources are assumed to have remained fairly constant since the early 1990s.

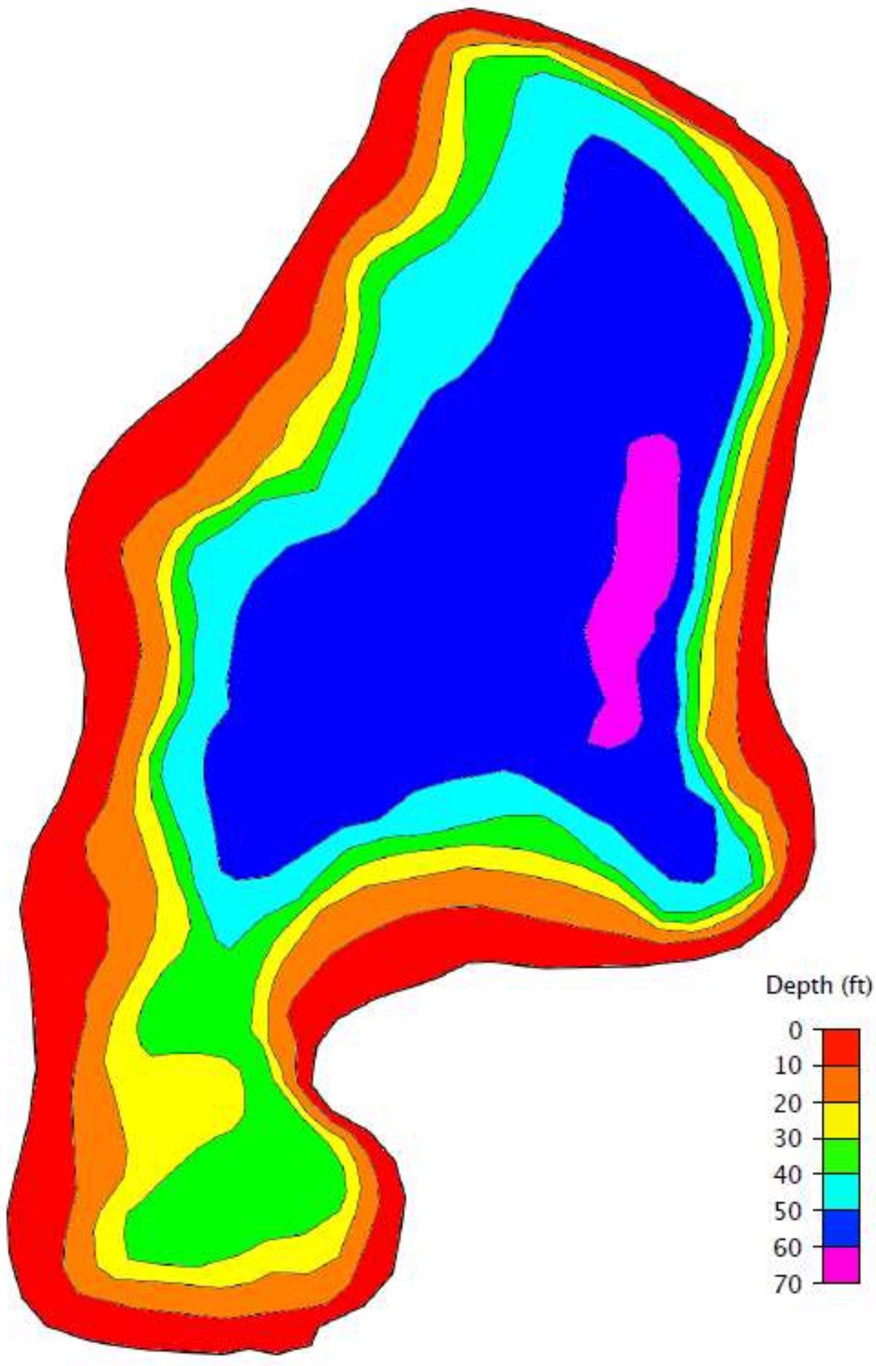


Figure 2. Hamblin Pond bathymetry

Figure 3. Hamblin Pond and surrounding area

Figure 4. Duck farm at Hamblin Pond circa 1950

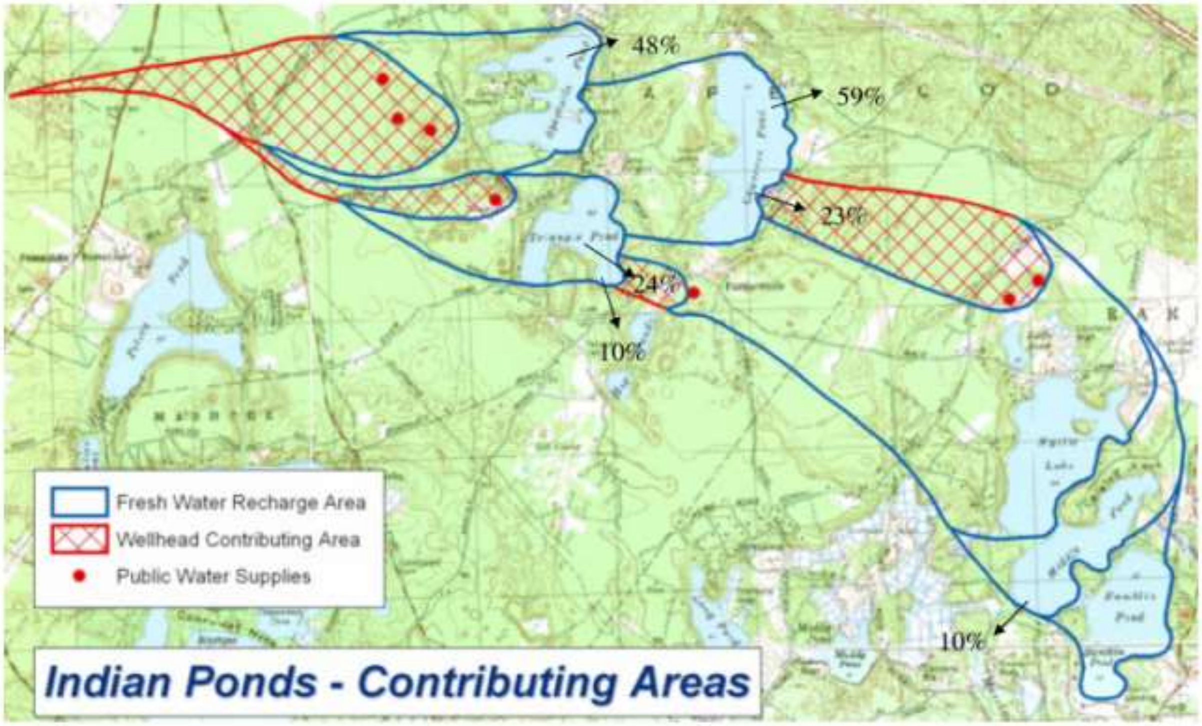


Figure 5. Groundwater drainage area to Hamblin Pond (from Eichner et al. 2006)

Table 1. Nutrient loads to Hamblin Pond over time

Pre-1995	In-lake P = 69 ug/L					
Source	**Water Flow (m3/yr)**	**Water Flow as % of Total**	**P Load (kg/yr)**	**P as % of Total Load**	**N Load (kg/yr)**	**N as % of Total Load**
Precipitation	550,000	12.8%	9.4	1.8%	165.0	9.3%
Ground water	3,700,000	86.0%	37.0	7.3%	1369.0	77.0%
Cranberry Bog Discharge	53,500	1.2%	8.8	1.7%	24.6	1.4%
Internal load	0	0.0%	450.0	88.2%	195.0	11.0%
Waterfowl	0	0.0%	5.0	1.0%	25.0	1.4%
Total	**4,303,500**	**100%**	**510.2**	**100%**	**1778.6**	**100%**

1995-2000	In-lake P = 8 ug/L					
Source	**Water Flow (m3/yr)**	**Water Flow as % of Total**	**P Load (kg/yr)**	**P as % of Total Load**	**N Load (kg/yr)**	**N as % of Total Load**
Precipitation	550,000	12.8%	9.4	13.6%	165.0	9.3%
Ground water	3,700,000	86.0%	37.0	53.5%	1369.0	77.0%
Cranberry Bog Discharge	53,500	1.2%	8.8	12.7%	24.6	1.4%
Internal load	0	0.0%	9.0	13.0%	195.0	11.0%
Waterfowl	0	0.0%	5.0	7.2%	25.0	1.4%
Total	**4,303,500**	**100%**	**69.2**	**100.0%**	**1778.6**	**100%**

2006-2012	In-lake P = 10 ug/L					
Source	**Water Flow (m3/yr)**	**Water Flow as % of Total**	**P Load (kg/yr)**	**P as % of Total Load**	**N Load (kg/yr)**	**N as % of Total Load**
Precipitation	550,000	12.8%	9.4	11.1%	165.0	9.3%
Ground water	3,700,000	86.0%	37.0	43.7%	1369.0	77.0%
Cranberry Bog Discharge	53,500	1.2%	8.8	10.4%	24.6	1.4%
Internal load	0	0.0%	24.4	28.8%	195.0	11.0%
Waterfowl	0	0.0%	5.0	5.9%	25.0	1.4%
Total	**4,303,500**	**100%**	**84.6**	**100.0%**	**1778.6**	**100%**

2014	In-lake P = 35 ug/L					
Source	**Water Flow (m3/yr)**	**Water Flow as % of Total**	**P Load (kg/yr)**	**P as % of Total Load**	**N Load (kg/yr)**	**N as % of Total Load**
Precipitation	550,000	12.8%	9.4	3.6%	165.0	9.3%
Ground water	3,700,000	86.0%	37.0	14.2%	1369.0	77.0%
Cranberry Bog Discharge	53,500	1.2%	8.8	3.4%	24.6	1.4%
Internal load	0	0.0%	200.0	76.9%	195.0	11.0%
Waterfowl	0	0.0%	5.0	1.9%	25.0	1.4%
Total	**4,303,500**	**100%**	**260.2**	**100.0%**	**1778.6**	**100%**

Recalculation of phosphorus and nitrogen loads based on the water quality data collected in 1992 and 1993 indicates that the phosphorus load was just over 510 kg/yr with 88% of it attributable to internal loading, which was release of iron-bound phosphorus from the sediment in deep water with minimal oxygen present. This phosphorus accumulated in the bottom waters and was variably moved to surface waters over time, creating fluctuating phosphorus concentrations in the upper waters of the pond but an overall average of 69 ug/L. This is a close match for the predicted in-lake concentration based on the Lake Loading Response Model as applied to Hamblin Pond for pre-1995 conditions. Nitrogen comes mainly from groundwater (77%), and while the nitrogen load is higher than phosphorus inputs by a factor of 3.5, that is a low N:P ratio that will favor cyanobacteria (blue-green algae).

Excessive phosphorus loading at a low N:P ratio supported severe blooms of cyanobacteria in Hamblin Pond, with *Dolichospermum* (formerly *Anabaena*) dominating the plankton. Water clarity was low, often <4 ft (1.2 m), a level at which it is recommended that swimming areas be closed for safety. Lack of visibility was the primary thrust of that recommendation, but the potential for cyanobacteria to produce toxins represents a significant threat to public health at cell counts high enough to cause such low water clarity.

Given the low water clarity caused by cyanobacteria blooms, it was recommended that the Town of Barnstable contract for a phosphorus inactivation project to lower internal phosphorus loading sufficiently to make phosphorus limiting, eliminate cyanobacterial dominance, and reduce algae biomass overall (BEC 1993). The town did contract for such services, and a treatment with aluminum chemicals was conducted in May 1995. Dose determination was not as sophisticated as it is today, and the ratio of acid-producing aluminum sulfate to base-producing sodium aluminate was too low, causing the pH of the lake to rise during treatment. A substantial fishkill ensued, but the intended chemical reactions did occur, and phosphorus was both stripped from the water column and sealed in the surficial sediments. Cyanobacteria were minimized and water quality increased markedly and remained high for almost 18 years.

The treatment at 45 g/m^2 over about 80 acres (32 ha) strongly curtailed internal phosphorus loading, with a projected decrease of 98% resulting in a new total phosphorus load of just over 69 kg/yr (Table 1). The in-lake phosphorus concentration after the 1995 treatment was about 8 ug/L, a close match for that predicted by the Lake Loading Response Model for the new loading scenario. Based on the work of Eichner et al. in 2006, the load at that time had risen to just under 85 kg/yr and the average in-lake concentration was about 10 ug/L. A gradual decline in water clarity was recognized, but conditions remained acceptable for all uses over a decade after the initial treatment.

In September of 2013 a *Dolichospermum* bloom occurred in Hamblin Pond (Figure 6). It was much like the blooms experienced previous to the 1995 treatment in terms of composition and density. That blooms subsided within a couple of weeks, possibly suggesting that it was based on nutrients available in deeper water and could not be sustained by phosphorus concentrations in the upper waters. Summer of 2014 brought similar blooms with longer duration from early July through September, and phosphorus concentrations in the upper waters were higher than in previous years.

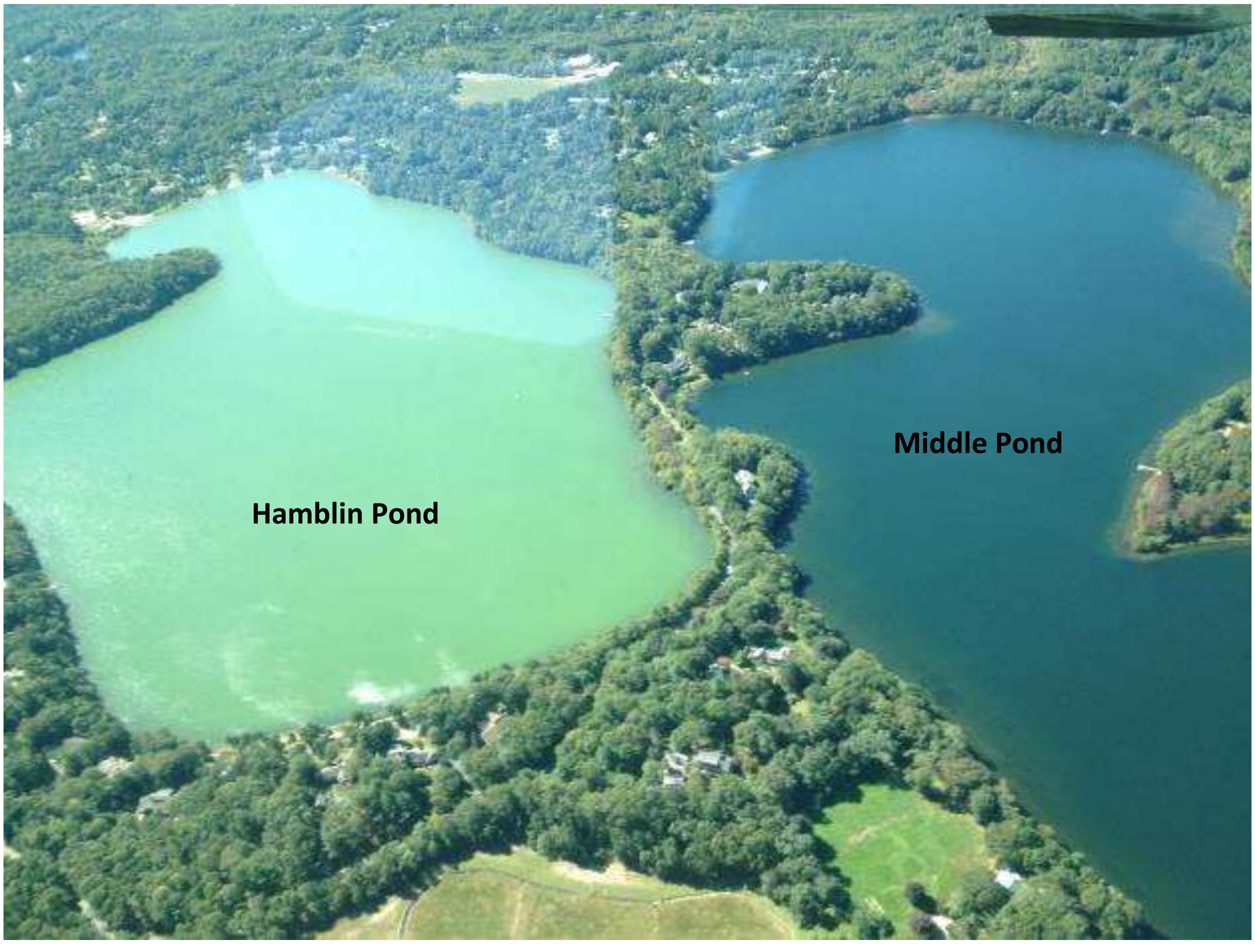


Figure 6. Aerial view of Hambln Pond in September 2013

Much has been learned about how the benefits of aluminum treatments diminish over time since the 1995 treatment. There are three main mechanisms:

- Gradual replacement of the internal load by watershed inputs, which should lead to a gradual diminution of water clarity.
- Decay of organic matter, possibly accelerated by greater oxygen in deeper water after treatment, which releases phosphorus into the water column.
- Upward migration of phosphorus from deeper, untreated sediment that passes through the treated zone and eventually reaches the sediment surface, reinstating the internal load from iron-bound phosphorus exposed to anoxia.

The pattern of water clarity over time indicates some loss of clarity over 17 years but the decline in 2013 that continued in 2014 was much faster than can be accounted for by watershed sources. Oxygen remained low in the deepest water where organic matter accumulates, indicating that aerobic decay is not a major source of phosphorus in this waterbody. That leaves upward migration of phosphorus that was not inactivated by the 1995 treatment, which has proven to be the most common mechanism in deep lakes that have been treated. The duration of benefits was just over 18 years for Hamblin Pond, while a summary of 114 treatments by Huser et al. (2016) suggests a range of 15 to 21 years for similar treatments.

With the resumption of excessive internal load, the overall phosphorus load increased from an estimated 85 kg/yr in 2012 to about 260 kg/yr in 2014 (Table 1), and the average in-lake phosphorus concentration increased from about 10 ug/L to about 35 ug/L. While monitoring was not intensive, there is no indication of any significant increase in loading from any other source (e.g., precipitation, watershed, groundwater, waterfowl). The total load estimated for 2014 was only a little more than half the load measured in the early 1990s, prior to the first aluminum treatment, but the increase in phosphorus was more than enough to support major blooms. A shift in N:P ratios to lower values due to the increase in phosphorus with minimal increase in nitrogen (typical of internal loading) would be expected to favor cyanobacteria. It is interesting that the dominant cyanobacterium appears to be the same one as prior to 1995; resting stages in the bottom sediments are viable for many years and apparently allowed restoration of that population once conditions were favorable.

Given the interpretation of available data and the success of the original treatment in controlling phosphorus concentrations and algae, the Town of Barnstable opted to plan for and conduct a repeat treatment. With advances in sediment assessment and dose determination, a short investigation phase supported planning, and the treatment was conducted in mid-June of 2015.

Phosphorus Inactivation Project

The substrate, or pond bottom material, matters greatly to habitat and water quality. Rocky to sandy substrates have limited impact on overlying water quality, while organic sediments, also called muck sediments, tend to have more interaction with water and can substantially alter water quality. Where there is concern over possible release of phosphorus from sediment exposed to anoxia, both the distribution of anoxia and the types of sediment are of interest.

Organic deposits in Hamblin Pond were noted at depths beyond about 25 feet (7.6 m). Thicker and more extensive muck deposits were not typically encountered until water depths of about 40 ft (12.1 m), but the presence of organic sediment in shallower water represents a threat from cyanobacteria, as localized anoxia is possible (at the sediment-water interface) and phosphorus release may be significant. The 1995 treatment addressed sediment at depths as shallow as 20 ft, but it was determined that treatment at 25 ft and deeper was adequate and reduced the treated area from about 80 acres (1995) to 61 acres (2015). Anoxia is common in summer in the water column at depths >40 ft (12.1 m), so the treatment goes beyond that area to create a "buffer zone" of treated area.

Sediment testing (Table 2) indicated different levels of iron-bound phosphorus in the surficial sediments, and the treatment area was subdivided into three sectors, each with different target doses (Figure 7). The aluminum doses were calculated as ten times the mass of phosphorus in the upper 10 cm. As aluminum is just slightly lighter than phosphorus, this yields a stoichiometric ratio slightly higher than 10:1, the minimum typically applied. As the target doses were all higher than the 1995 treatment that provided excellent results for 18 years, no lab assays to assess the actual reduction in iron-bound phosphorus were conducted for Hamblin Pond sediments prior to the 2015 treatment.

The dose of aluminum to each of the three target zones were 71 g/m^2 to the 21.4 ac (8.6 ha) northern sector, 58 g/m^2 to the 27.6 ac (11.1 ha) central sector, and 45 g/m^2 to the 11.9 ac (4.8 ha) southern sector. A total of 31,260 gallons of aluminum sulfate and 15,685 gallons of sodium aluminate were applied, very close to the 2:1 ratio of alum to aluminate by volume that is expected to produce minimal pH change. A gallon of aluminum sulfate contains just under half a pound (0.22 kg) of aluminum, while a gallon of sodium aluminate contains just over one and quarter pounds (0.57 kg) of aluminum, so the total mass of aluminum applied was 34,940 pounds (15,882 kg).

The treatment dates were June 11th, 15th, 16th, 18th, 19th and 22nd, 2015. SOLitude Lake Management (formerly Aquatic Control Technologies) of Shrewsbury, Massachusetts conducted the treatment, as it has nearly all other treatments of Cape Cod lakes. The skill and professionalism of SOLitude in the conduct of aluminum treatments is acknowledged and appreciated. Photographs of the treatment are provided in Figure 8.

Treatment was staged from the boat launch area on the east side of Hamblin Pond, with tanker trucks delivering aluminum chemicals daily to load the barge that delivered the planned dose in stages to each sector. The first day of treatment was Thursday, June 11th, on which only Area 1 at

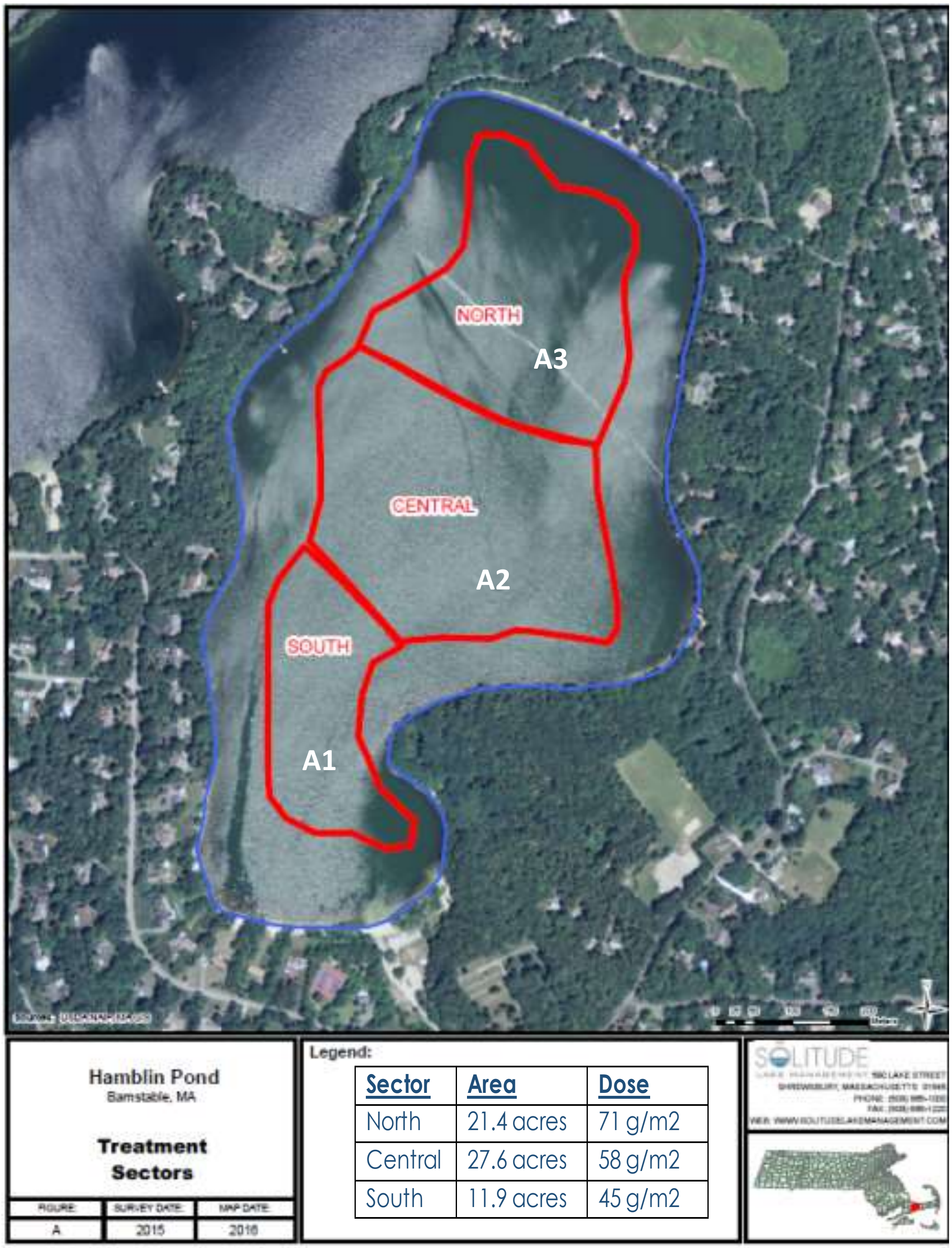
Table 2. Sediment features and aluminum dose calculation for Hamblin Pond in 2015

	LAKE SECTOR		
Lake or Area	**North**	**Central**	**South**
Mean Available Sediment P (mg/kg DW)	1144	823	392
Target Depth of Sediment to be Treated (cm)	10	10	10
Volume of Sediment to be Treated per m2 (m3)	0.100	0.100	0.100
Specific Gravity of Sediment	1.20	1.20	1.20
Percent Solids (as a fraction)	0.052	0.059	0.096
Mass of Sediment to be Treated (kg/m2)	6.2	7.1	11.5
Mass of P to be Treated (g/m2)	7.14	5.83	4.52
Target Area (ac)	21.4	27.6	11.9
Target Area (m2)	86290	111290	47984
Aluminum sulfate (alum) @ 11.1 lb/gal and 4.4% aluminum (lb/gal)	0.4884	0.4884	0.4884
Sodium aluminate (aluminate) @ 12.1 lb/gal and 10.38% aluminum (lb/gal)	1.256	1.256	1.256
Stoich. Ratio (ratio of Al to P in treatment)	10	10	10
Resulting areal dose (g Al/m2)	71	58	45
Ratio of alum to aluminate during treatment (volumetric)	2.00	2.00	2.00
Aluminum Load			
Dose (kg/area)	6160	6485	2167
Dose (lb/area)	13552	14266	4767
Dose (gal alum) @ specified ratio of Alum to Aluminate	12139	12779	4270
Dose (gal aluminate) @ specified ratio of Alum to Aluminate	6069	6389	2135

the south end of the pond was treated with a half dose of 22.5 g/m^2. No further treatment was conducted until Monday, allowing continuous monitoring for any adverse effects for three days after the initial treatment. With no impacts observed, treatment then proceeded on Monday, June 15th.

There are always some mechanical issues with treatments, usually related to clogged valves or pump failures, and field repairs are made whenever possible with limited downtime. In other cases, equipment may require some additional work that delays treatment for a day or so. Additionally, work halts when sustained winds prevent accurate delivery of aluminum to the target area. The 2015 treatment of Hamblin Pond had only one down day (June 16th) that resulted from a problem not encountered previously. The production of the aluminum chemicals was so close in time to the delivery that the liquid was still quite hot when delivered, creating issues for transfer in flexible hoses. Allowing production to get a day ahead, giving time for the solution to cool, solved that problem.

Monitoring was conducted just prior to, every day during, and monthly after the treatment from June through September in 2015 and 2016. During treatment the pH was between 6.4 and 7.5 and usually close to 7.0 standard units, a range at which reactions are optimal and only a very small percentage of the applied aluminum is in a potentially toxic form. Application in stages, maintaining



Sector	Area	Dose
North	21.4 acres	71 g/m2
Central	27.6 acres	58 g/m2
South	11.9 acres	45 g/m2

Figure 7. Hamblin Pond treatment areas

Figure 8. Treatment of Hamblin Pond with aluminum in June 2015

total aluminum concentrations <5 mg/L, also minimizes potential toxicity, as does treatment of segments with a day in between follow up application until the entire dose has been delivered.

Alkalinity was stable throughout treatment at close to 8 mg/L at the top and 13 mg/L near the bottom.mg/L at the bottom. Surface temperatures were between 20 and 23^{o}C and declined with depth to values in the 6 to 9^{o}C range in the deepest water. The pond was stratified at about 30 to 33 ft (9-10 m) at the time of treatment. Oxygen was >4 mg/L everywhere at the start of treatment, but oxygen was depleted in the deepest water during the course of the treatment, a normal phenomenon at this time of year in most deep Cape Cod ponds. Oxygen approached 0 mg/L by the end of the treatment in water >43 ft (13 m) deep, a very small portion of the pond area and volume. Note that the southern monitoring station was only 33 ft (10 m) deep and did not stratify or have any anoxic water during treatment.

No widespread mortality was observed in daily surveys that included visual observation along the shoreline and inspection with underwater video equipment in deeper areas. We found no dead fish at all for several days, then encountered one dead 18 inch trout that was likely a victim of angling mortality. Late in the treatment period three dead yellow perch were encountered at the south end of the lake. Observed fish mortality was lower than expected even in the absence of treatment. Banded killifish and small yellow perch were observed swimming around the periphery of the pond and some yellow perch were observed in the floc with the underwater video system. Hamblin Pond does not have a mussel population that could be impacted, but other Cape Cod treatments have had no documented impacts on mussels, and specific study of mussel response in nearby Mystic Lake found no impacts. Birds were commonly observed on or over the pond, including ducks, gulls, cormorants and osprey. There was no indication of any stress on the bird community.

Monitoring Results

Monitoring prior to the treatment was conducted to extend the baseline for conditions in Hamblin Pond and to provide an immediate comparison point for monitoring during the treatment and shortly thereafter. All field data are included in the Appendix. Results during treatment were briefly discussed in the last section; there were no issues with regard to water quality or stress on aquatic or water-dependent organisms that were detected during treatment.

There was significant fish mortality during the first treatment of Hamblin Pond in 1995 as a consequence of a low ratio of alum to aluminate in the application, leading to a pH higher than 9 standard units. Both pH stress and aluminum toxicity may have caused the fishkill, which involved as many as 16,500 trout, smallmouth bass and yellow perch based on MA DFW assessment. A similar fishkill occurred during treatment of Lake Pocotopaug in Connecticut in 2000, after which lab assays were employed to determine safe levels of aluminum and ratios of aluminum chemicals. There have been no documented fishkills in New England since that time, and the 2015 treatment of Hamblin Pond was conducted with no apparent impact to nontarget organisms.

Even with the fishkill in 1995, the results of the treatment in terms of improved water quality were immediate and marked, and lasted for over 18 years. Comparison from 1992 through 2016 is provided here to put the management of Hamblin Pond over two decades into perspective. The primary purpose of the treatment is to lower phosphorus availability and algae biomass, increasing water clarity. Although measurement of multiple aspects of water quality are conducted and are relevant, the primary comparison made for such treatments over time is water clarity, assessed as Secchi disk transparency.

The record for Hamblin Pond (Figure 9) documents the low clarity prior to the 1995 treatment, the dramatic increase after that treatment, a gradual decline over the next 18 years, and the sudden return of very low clarity at the end of summer 2013 and in summer 2014. The 2015 treatment returned clarity to its high level of 1995-2012, actually even higher, with a new record Secchi value of 10.5 m in September 2016.

The underlying mechanism of the increase in clarity is reduced phosphorus concentrations, illustrated best by monitoring at the northern station (Figures 10 and 11). The data are the same in Figures 10 and 11 but the scale is different to allow overall data appraisal. It only takes about 20 ug/L of phosphorus in upper waters to support blooms. Much larger concentrations often occur in deeper water, but only a portion of that deep water phosphorus reaches the upper waters during summer. With the very high deep water phosphorus concentrations much reduced by both 1995 and 2015 treatments, concentrations in upper waters also declined. The amount and quality of data between 1995 and 2015 is limited, so one should not depend on any one value as an indication of conditions in Hamblin Pond, but the pattern is clear. Internal loading was greatly reduced by treatment, especially the 2015 treatment, leading to much lower phosphorus concentrations

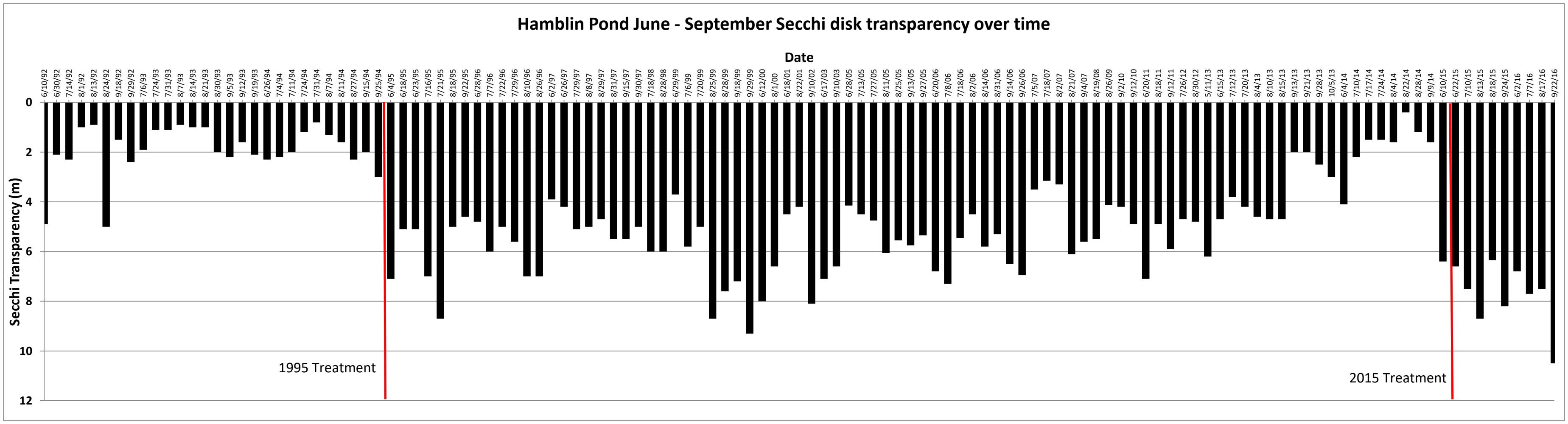


Figure 9. Hamblin Pond Secchi disk transparency in June through September over 25 years

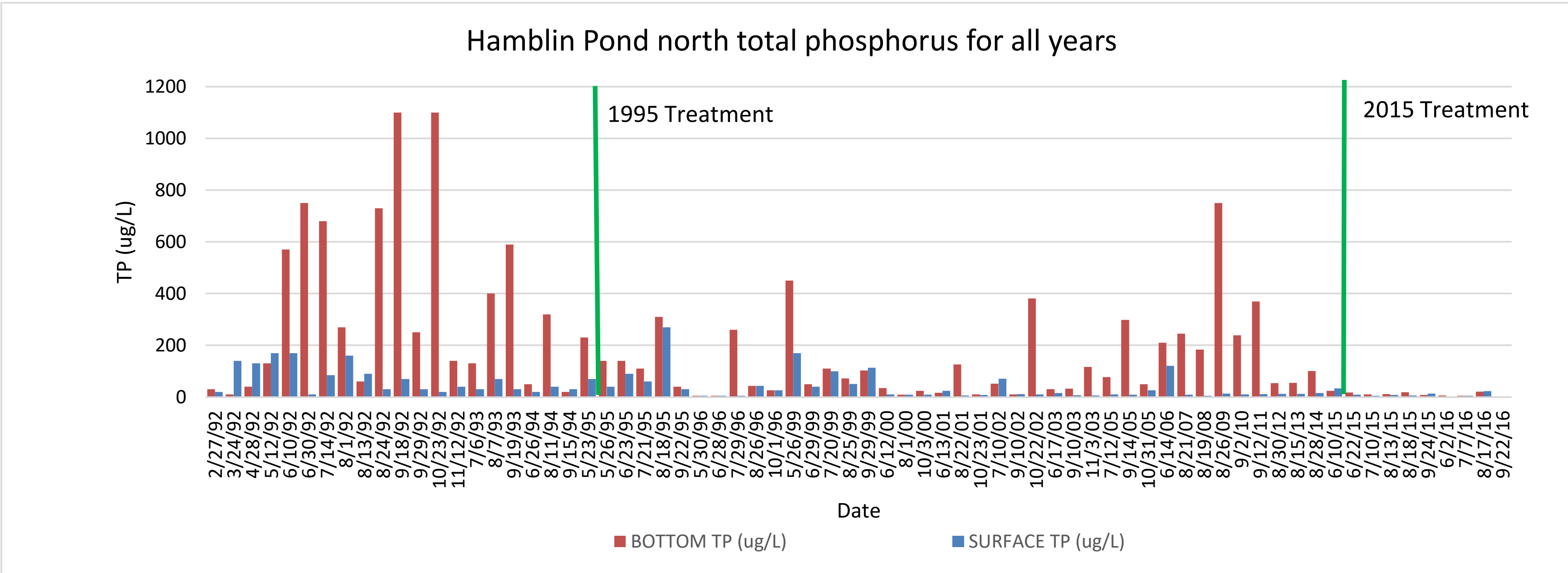


Figure 10. Hamblin Pond north total phosphorus for all years

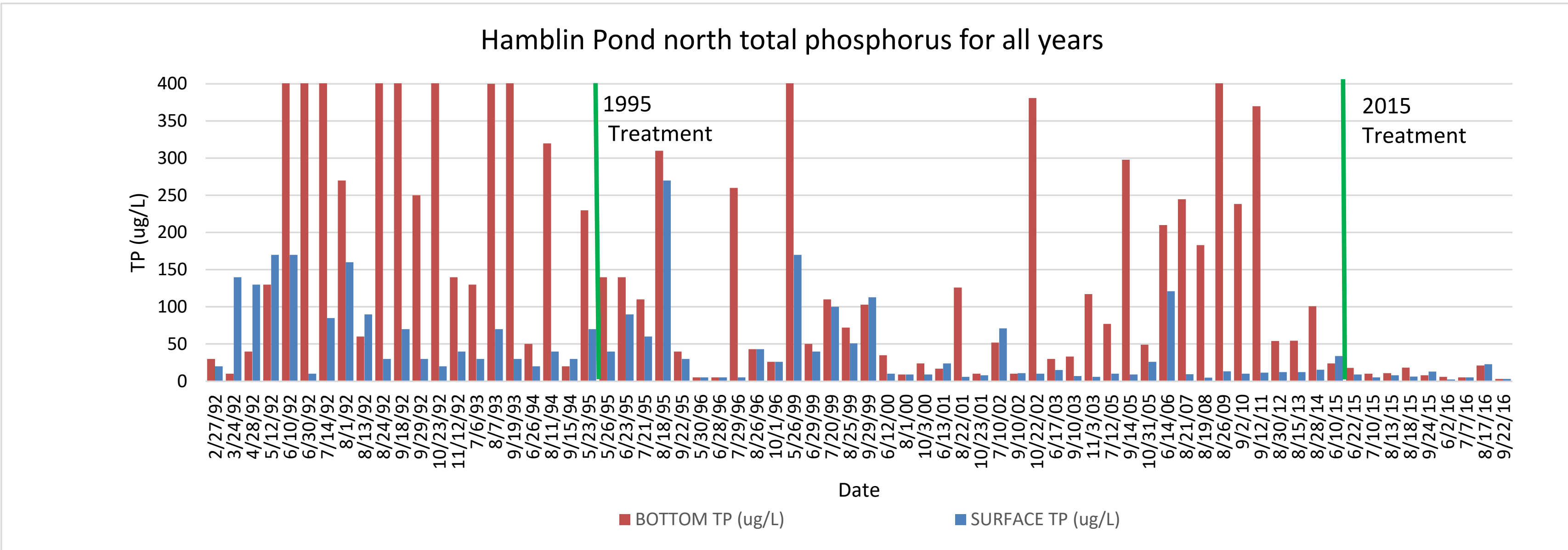


Figure 11. Hamblin Pond north total phosphorus for all years with TP scale limit

overall. The only elevated values since the 2015 treatment occurred in May of 2016, and are believed to represent lab error; similar values were obtained from samples from other clean ponds on that date that indicate a systemic analysis problem, probably equipment contamination.

Considering just the 2015 treatment, the decline in phosphorus at both north and south monitoring stations was not as striking (Figures 12 and 13) as for the overall period of record (Figures 10 and 11), but there are few pre-treatment data and the post-treatment phosphorus concentrations are very low. Some of the problem cyanobacteria can grow at the sediment-water interface at substantial but not maximum depths, then rise into the water column to form blooms even when the phosphorus concentrations it the overlying water are not excessive. The 2015 treatment covered all pond area >25 ft (7.6 m) deep, with the intent of limiting that phenomenon. That approach appears to have been very successful.

Phosphorus is the key to controlling algal growth in the vast majority of lakes, as it is usually in shortest supply relative to the needs of algae, and even if it is not, it can most easily be made to limit productivity. Nitrogen is the other nutrient most often in short supply, and while nitrogen is a powerful determinant of what types of algae will grow, it is available to many cyanobacteria in its dissolved gaseous form and therefore not strongly limiting to cyanobacteria. Low N:P ratios tend to favor cyanobacteria, and when phosphorus is readily available, those algae will proliferate.

Nevertheless, nitrogen is important to the functioning of freshwater lakes and is usually the limiting factor for saltwater systems, so it is routinely monitored with phosphorus and should be whenever possible. Forms of nitrogen that are typically measured include nitrate (which in WRS monitoring programs includes nitrite in the testing), ammonium, and total Kjeldahl nitrogen (which includes ammonium and organic nitrogen forms). Total nitrogen is approximated as the sum of nitrate and total Kjeldahl nitrogen. Total nitrogen concentrations in Hamblin Pond (Figures 14-16) suggest limited impact of aluminum treatment on nitrogen, which comes mostly from groundwater and not the internal loading responsible for elevated phosphorus concentrations. Elevated deep water concentrations are sometimes reduced, but this is largely a function of elevated oxygen in deeper water that prevents accumulation of ammonium. The amount of nitrogen in the upper water layer, best viewed in Figures 15 and 16 for the north and south monitoring stations, is not appreciably altered.

Nitrate nitrogen (Figures 17 and 18) tends to occur at low concentrations in Hamblin Pond, rarely more than 100 ug/L since the 1995 treatment. Nitrate enters with groundwater, but is used up rapidly in the pond. It may in fact be the limiting nutrient in summer for algae incapable of using dissolved nitrogen gas. Aluminum treatments were not expected to alter nitrate concentrations in Hamblin Pond. Higher values back in early 1992 may still occur over winter with continued groundwater inputs but low algae production, but monitoring has not been conducted at that time of year in over two decades.

Ammonium nitrogen (Figures 19 and 20) is typically negligible in surface waters but is highly variable in deeper water, mainly as a result of accumulation when oxygen is depleted. Much of the

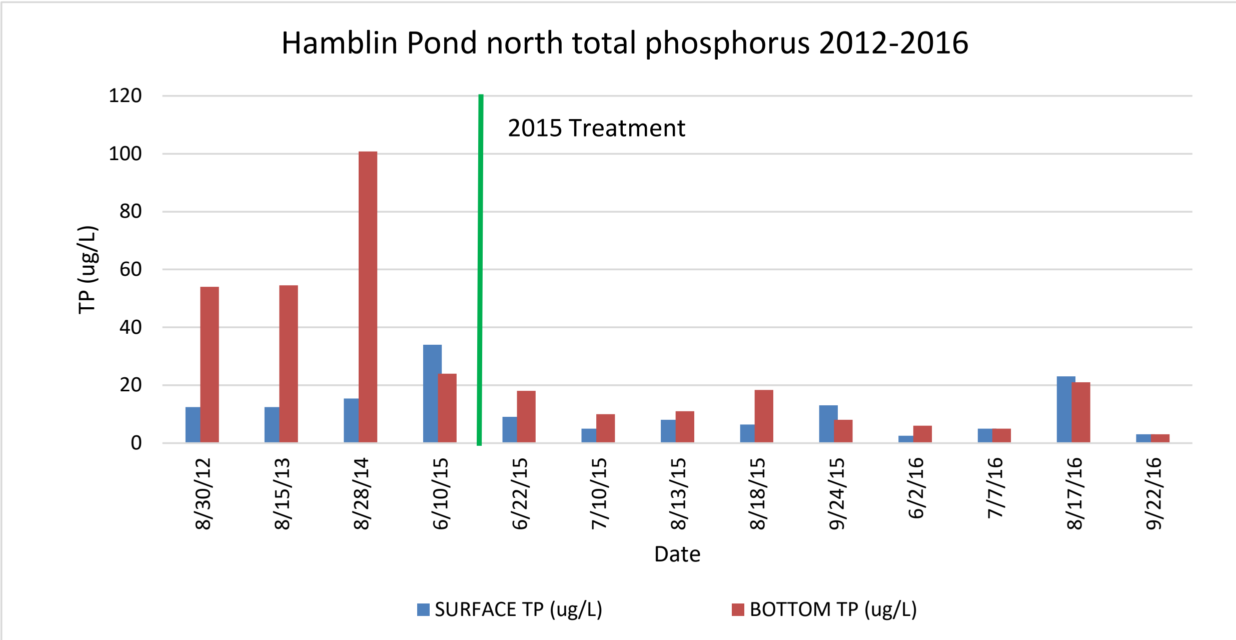


Figure 12. Hamblin Pond north total phosphorus 2012-2016

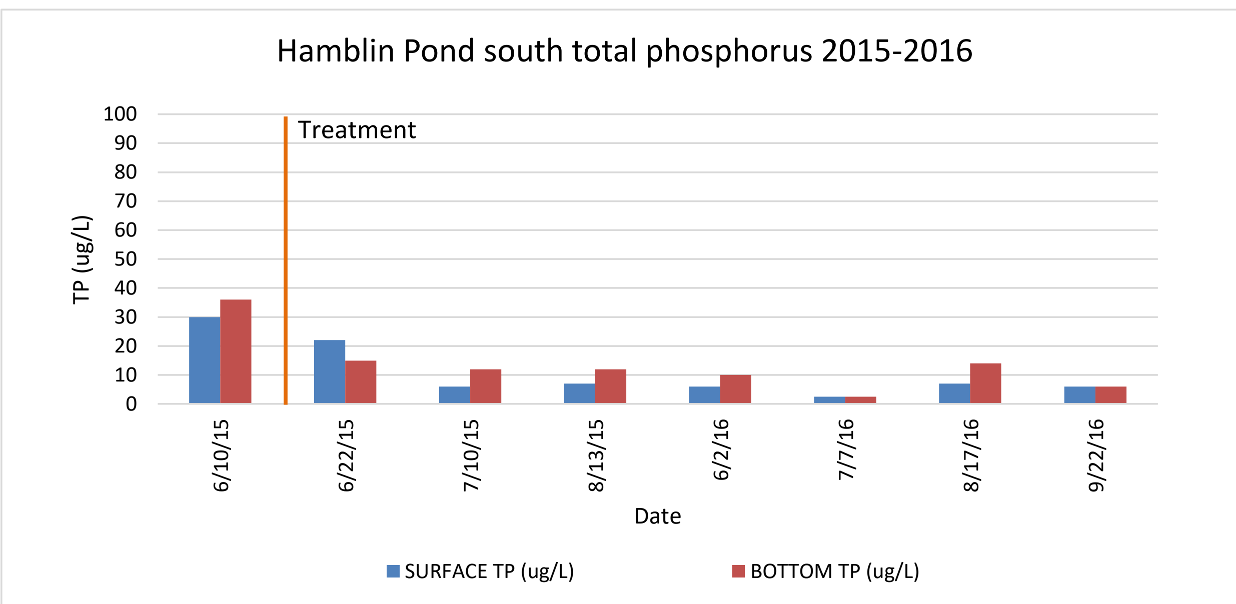


Figure 13. Hamblin Pond south total phosphorus 2015-2016

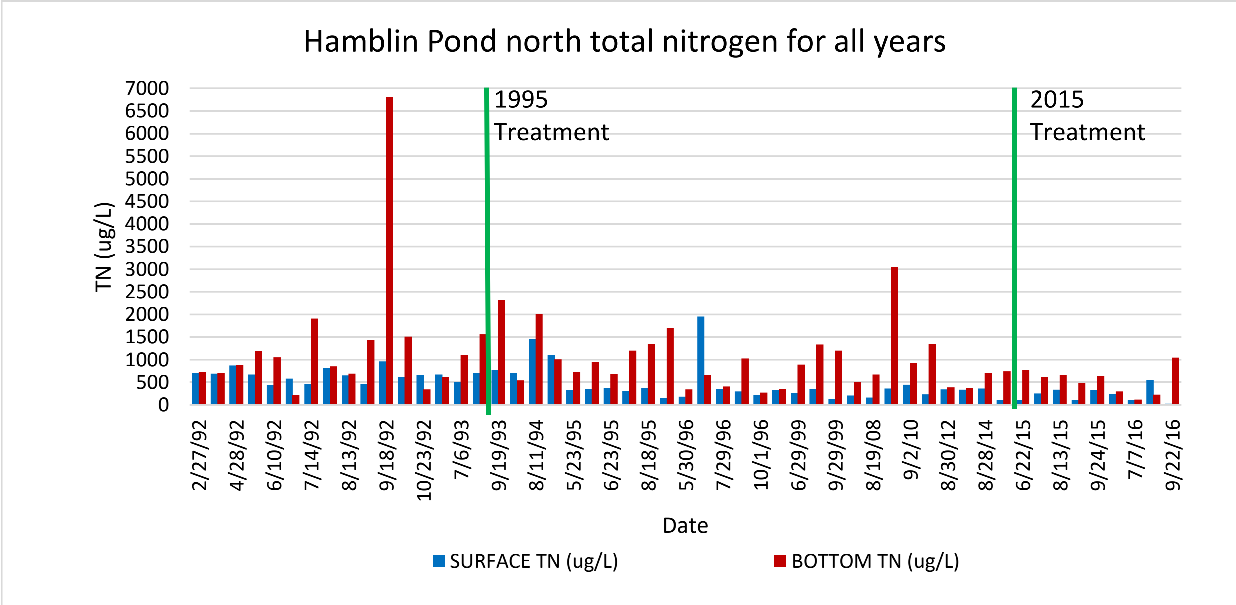


Figure 14. Hamblin Pond north total nitrogen for all years

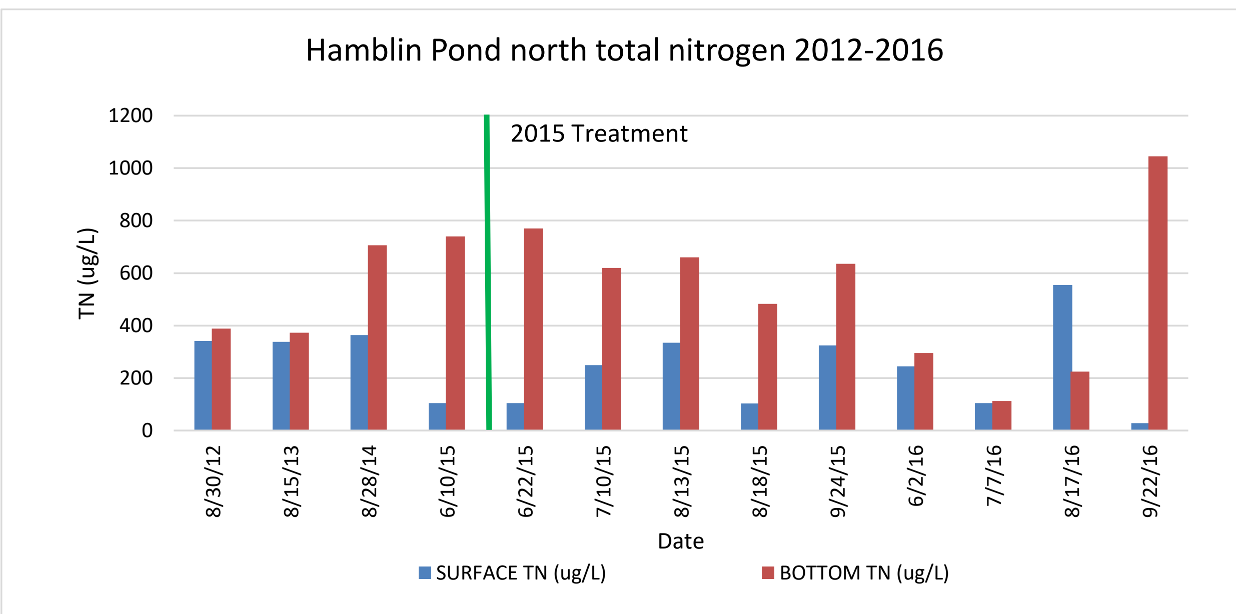


Figure 15. Hamblin Pond north total nitrogen 2012-2016

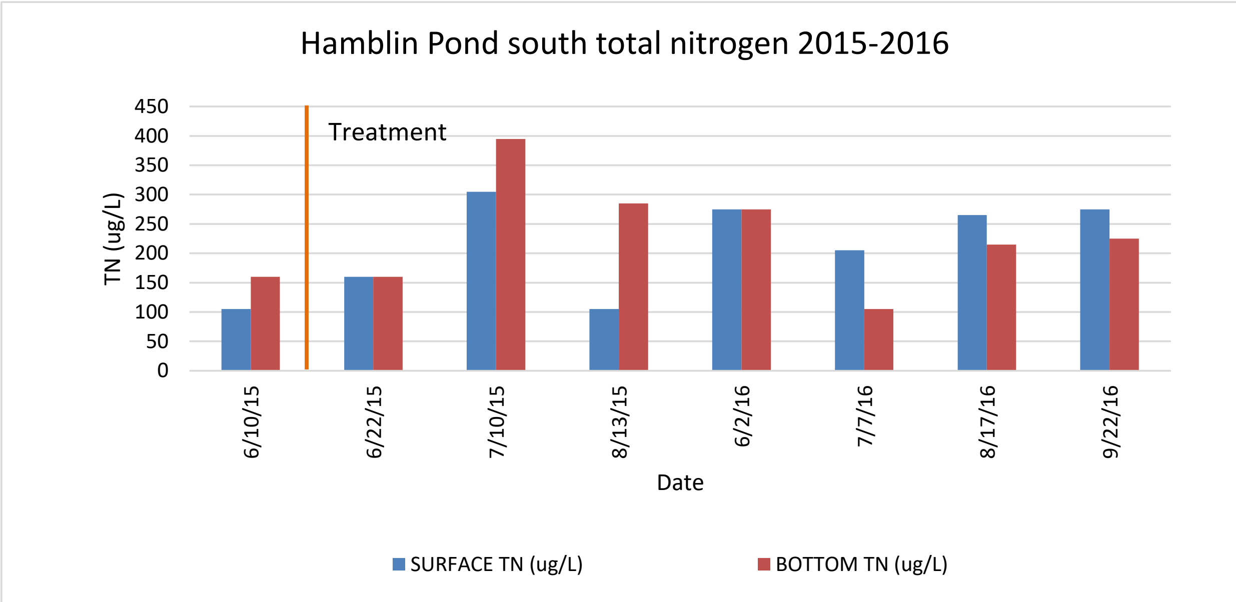


Figure 16. Hamblin Pond south total nitrogen 2015-2016

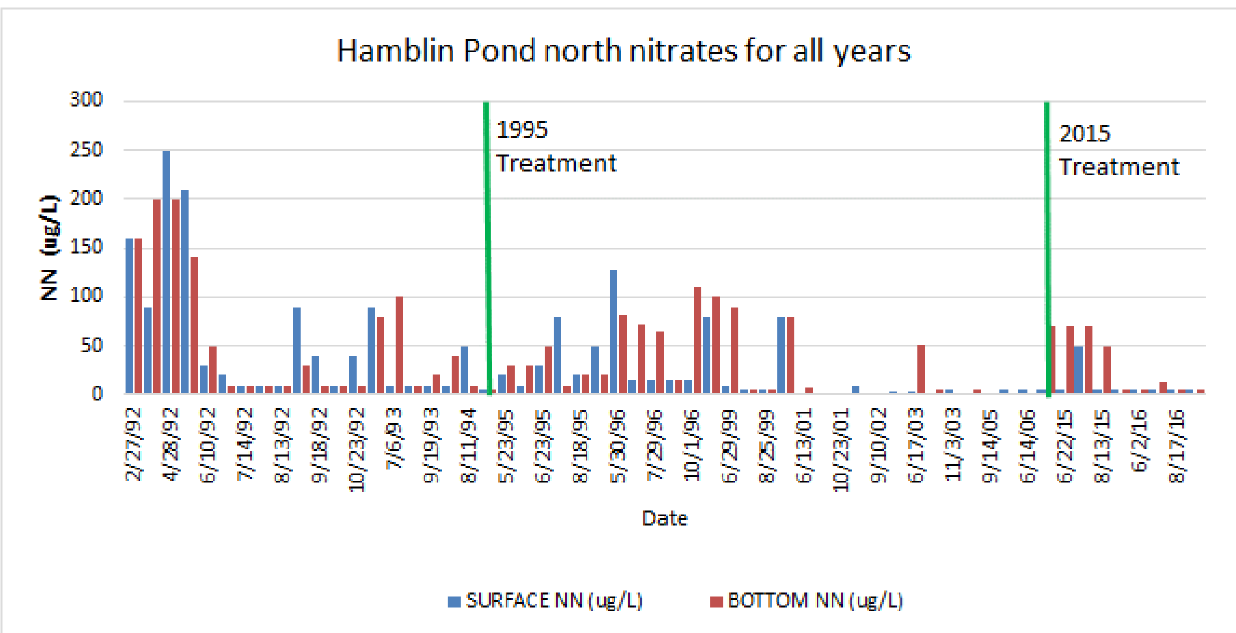


Figure 17. Hamblin Pond north nitrates for all years

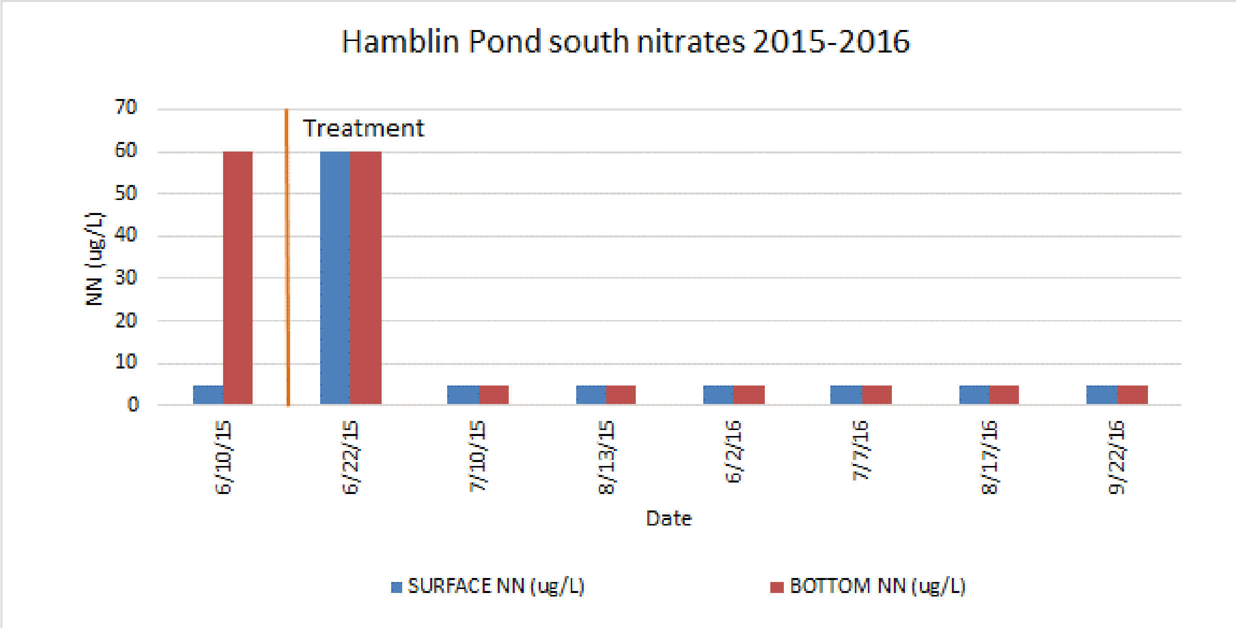


Figure 18. Hamblin Pond south nitrates 2015-2016

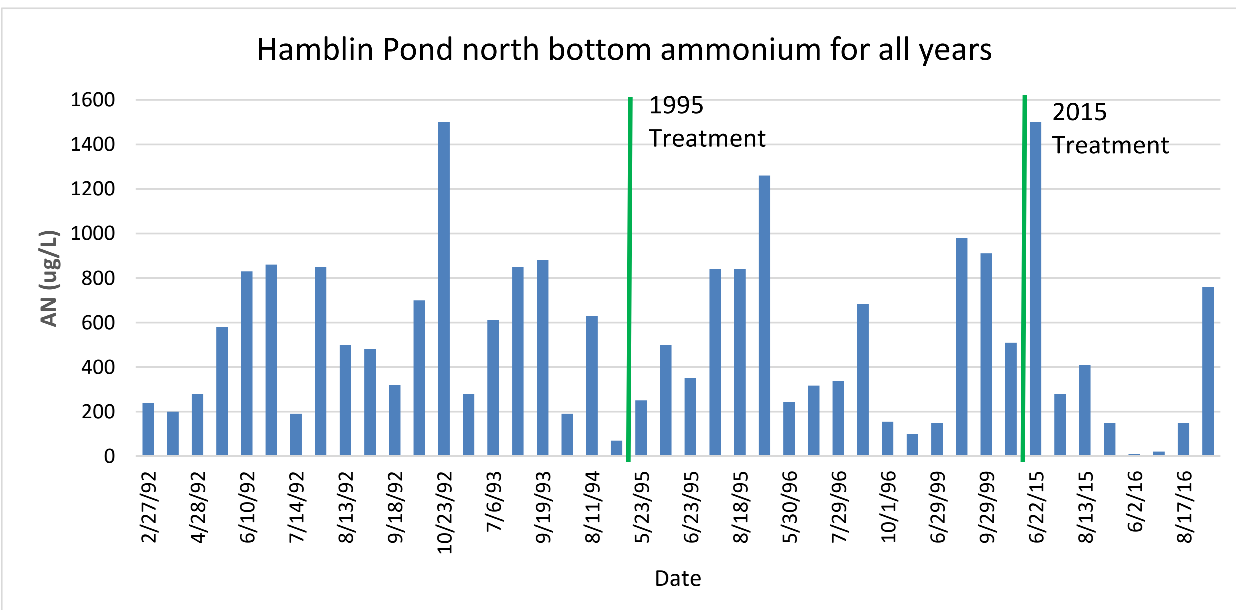


Figure 19. Hamblin Pond north bottom ammonium for all years

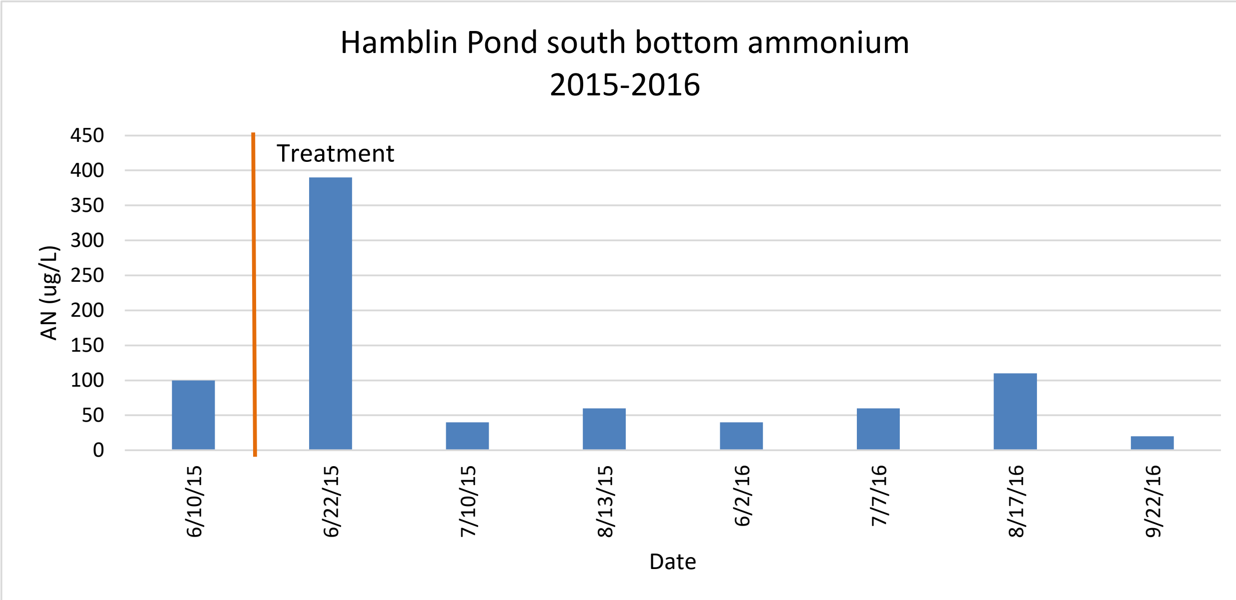


Figure 20. Hamblin Pond south bottom ammonium 2015-2016

bottom water total Kjeldahl nitogen value is ammonium, which tends to increase over summer as oxygen is lost and organic matter can only decay to the ammonium stage as oxygen is needed to form nitrite and nitrate. Treatment with aluminum can affect ammonium concentrations by reducing the rain of algae particles into the deeper water, reducing oxygen demand and increasing oxygen availability for conversion of ammonium to nitrite and nitrate. However, as much of the oxygen demand comes from the accumulated organic sediment, anoxia and ammonium accumulation are still expected, just to a lesser degree. Ammonium concentrations were lower but still elevated in deep water by the end of summer after the 2015 treatment, while no major reduction was observed after the 1995 treatment (Figure 19). At the shallower south station, which does not strongly stratify and does not become anoxic, ammonium tends not to build up and was lower than at the north station.

Aluminum is the second most abundant metal in the crust of the earth, after iron, so it is not uncommon in aquatic habitats. However, aluminum reacts and precipitates out in particulate form, and does not resolubilize under typical lake conditions, so concentrations in the water column are expected to be low unless it is being added during a treatment. Aluminum occurs in multiple forms, some of which can be toxic above a threshold concentration around 100 ug/L. WRS assessed total aluminum just before and just after treatment in 2015, then again twice in 2016 (Figure 21), but focused more on dissolved aluminum (Figure 22), which better represents the forms that might be toxic. Aluminum levels spiked during treatment, represented by sampling on June 22, 2015, just after treatment, then declined over time to levels close to the pre-treatment values. No toxicity was observed during treatment, and values were below literature concentrations for possible toxicity by the time of the July 2015 sampling, declining further after that. No problems with aluminum are indicated.

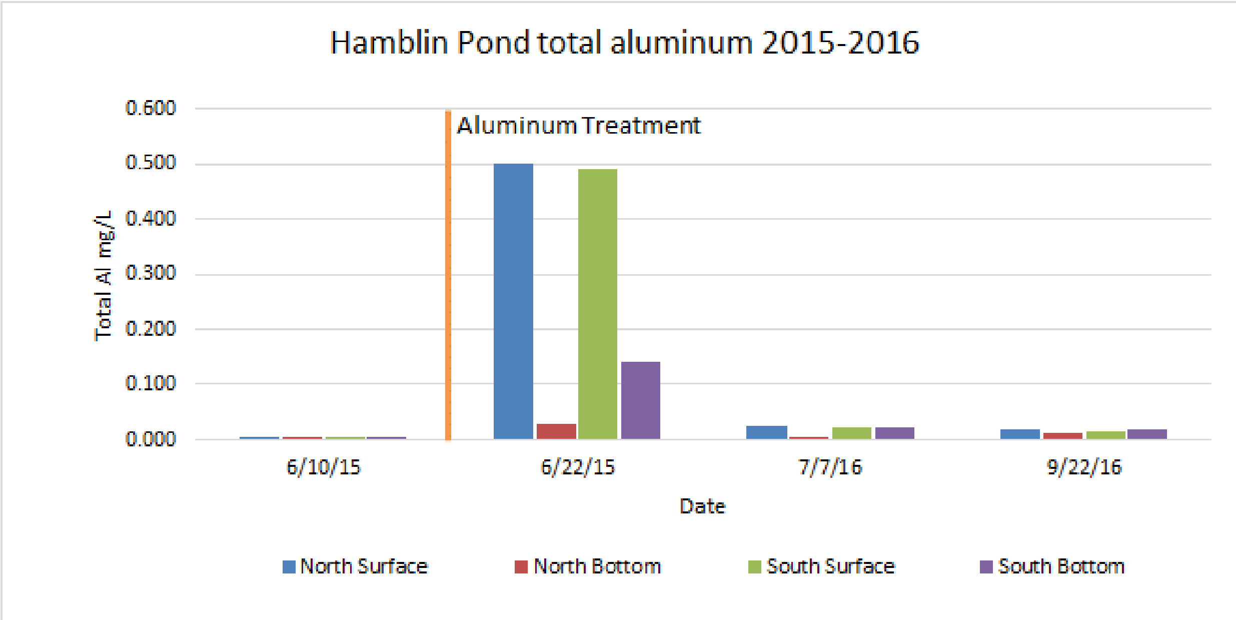


Figure 21. Hamblin Pond total aluminum 2015-2016

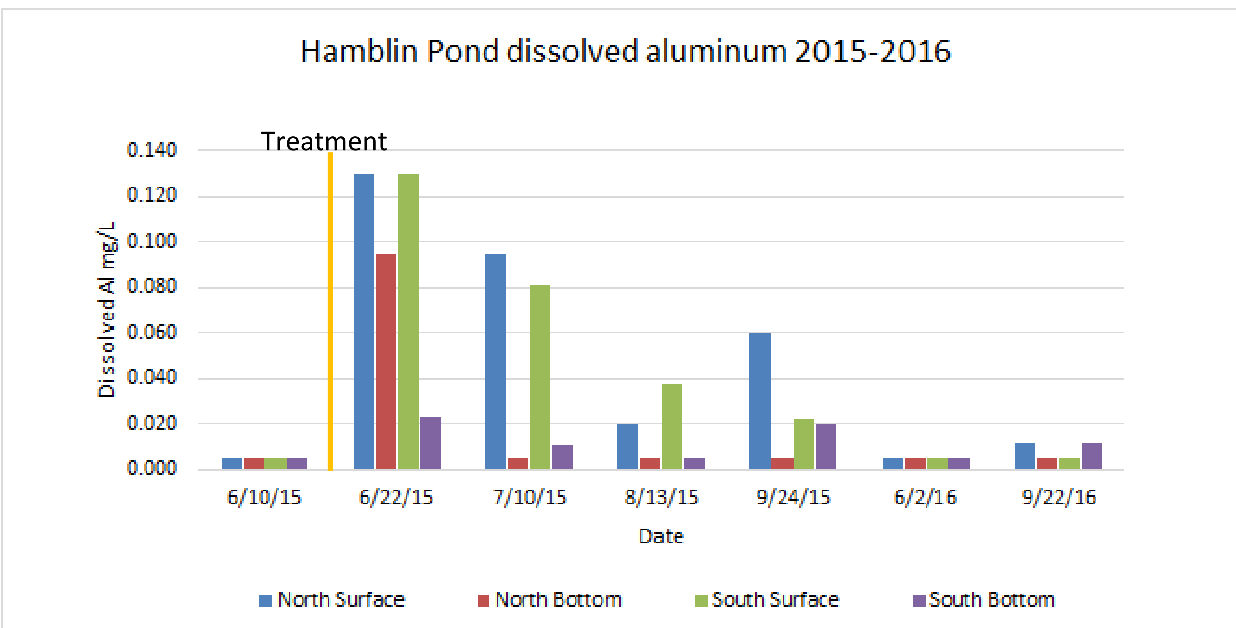


Figure 22. Hamblin Pond dissolved aluminum 2015-2016

Temperature and oxygen profiles prior to the 1995 treatment indicted very little "trout water" during summer in Hamblin Pond; water cold enough to support trout (<21oC) had very little oxygen by July in most summers, certainly less than the 5 mg/L desired for trout support. Temperature is not controllable by any normal management approach, but the reduction of algae production is expected to reduce oxygen demand and should increase oxygen concentrations in deeper water. That effect was observed after the 1995 treatment (Figure 23, compare solid and dashed lines), with the depth of unfavorable oxygen levels declining from about 20 ft (6 m) to between 30 and 43 ft (9-13 m). That favorable oxygen level gradually rose in the water column over time, but was between 33 and 36 ft (10-11 m) in 2013-2014. The 2015 treatment resulted in favorable oxygen levels (Figure 24) down to 36 to 43 ft (11-13 m), functionally resetting the benefits of the 1995 treatment.

The mechanism of oxygen demand reduction depends on less algae biomass settling into the deep water where its decay, either in the water column or at the sediment surface, consumes oxygen that is not replaced during stratification and separation of the deep water layer from the upper water layer and the atmosphere. Oxygen demand in excess of about 0.55 g/m^2 is likely to cause anoxia, and demand >1 g/m^2 will certainly cause anoxia. Oxygen demand prior to the 1995 treatment was measured at 1.7 g/m^2 and decreased to just over 0.2 g/m^2 the year after treatment. Oxygen demand shortly before the 2015 treatment was measured at just under 1 g/m^2 and decreased to just over 0.5 g/m^2 in 2016.

Chlorophyll-a is a photosynthetic pigment that is found in algae and is used to represent algae biomass, although the ratio of biomass to chlorophyll-a varies among algal divisions, so the correlation is not extremely close. In particular, cyanobacteria have more biomass per unit of chlorophyll-a than other algae, so blooms can occur at lower chlorophyll-a concentrations than for those other algae. Chlorophyll-a was measured mostly by lab extraction and spectrophotometry, but more recently fluorometric measurements have been made in the field as well and calibrated by the lab extractions. Values prior to the 1995 treatment were only somewhat elevated (Figure 25), but cyanobacteria were dominant. Values after the 1995 treatment were only sporadically obtained, but were low until 2014; no data were collected during the September 2013 bloom (Figure 8), but chlorophyll-a was obviously elevated then too. Values have been low since the 2015 treatment and correlate well with actual algae data (Figure 26, with detailed data in the Appendix).

Actual data for algae are not commonly collected in on a regular basis from lakes, as it requires considerable training and effort to identify and quantify algae. WRS routinely performs such analyses, but most programs do not. The USEPA has been working to rectify this through a program in the northeastern USA that involves photographic submissions and characterization from those photos, and while not as detailed as a full algal analysis, this sort of documentation is very useful for identifying blooms of common problem species. The primary program applied on Cape Cod, Pond and Lake Stewards (PALS), does not have an algal identification component, so the only recent data are from the WRS monitoring program in 2015-2016.

Data from the 1992 BEC diagnostic/feasibility study indicate a late spring mixed algae assemblage with chlorophytes (green algae) and pyrrhophytes (dinoflagellates) most abundant but cyanobacteria (blue-green algae) already present and a biomass between 1000 and 3000 ug/L. We

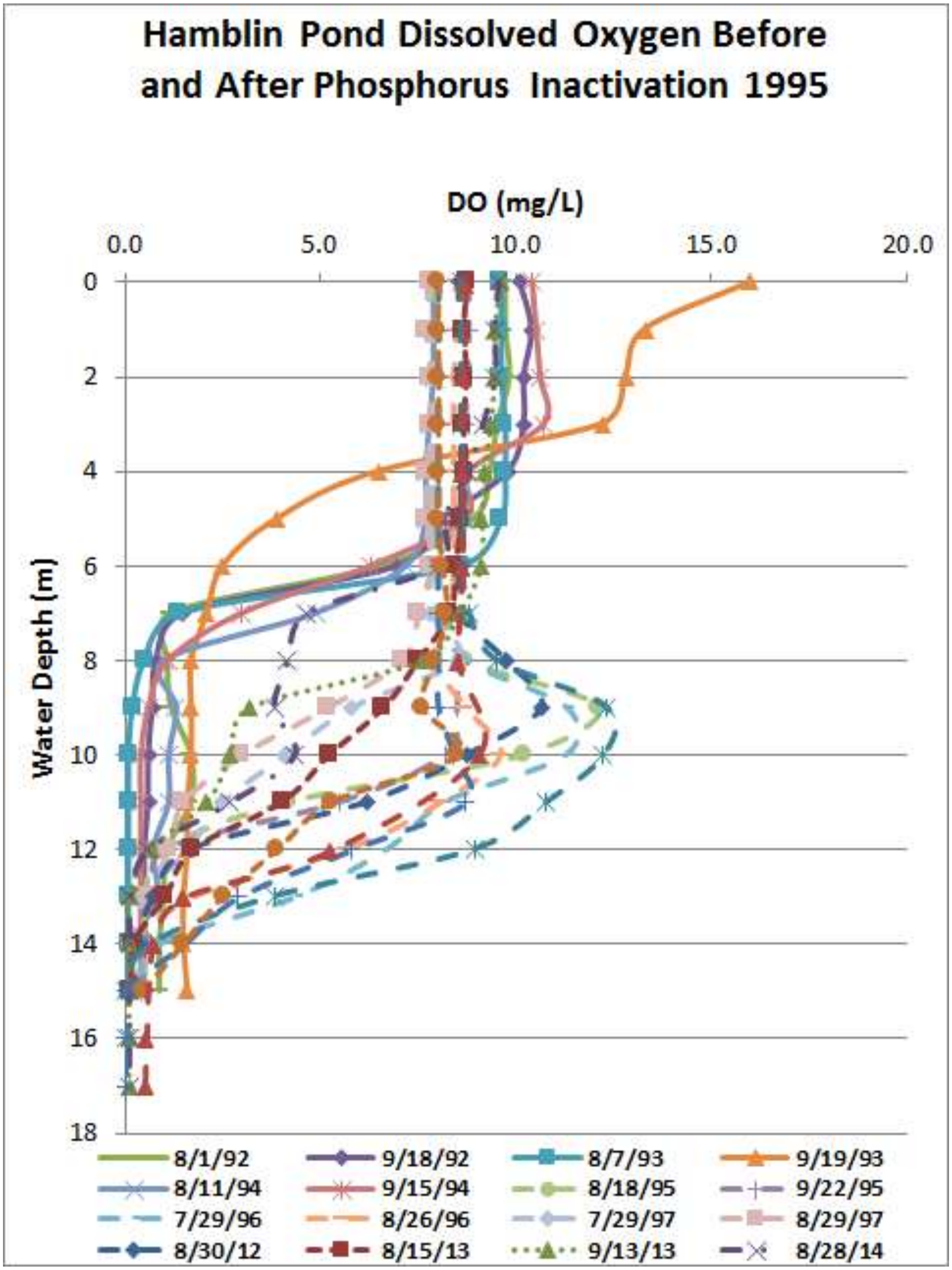


Figure 23. T/DO profiles before and after 1995 treatment in Hamblin Pond

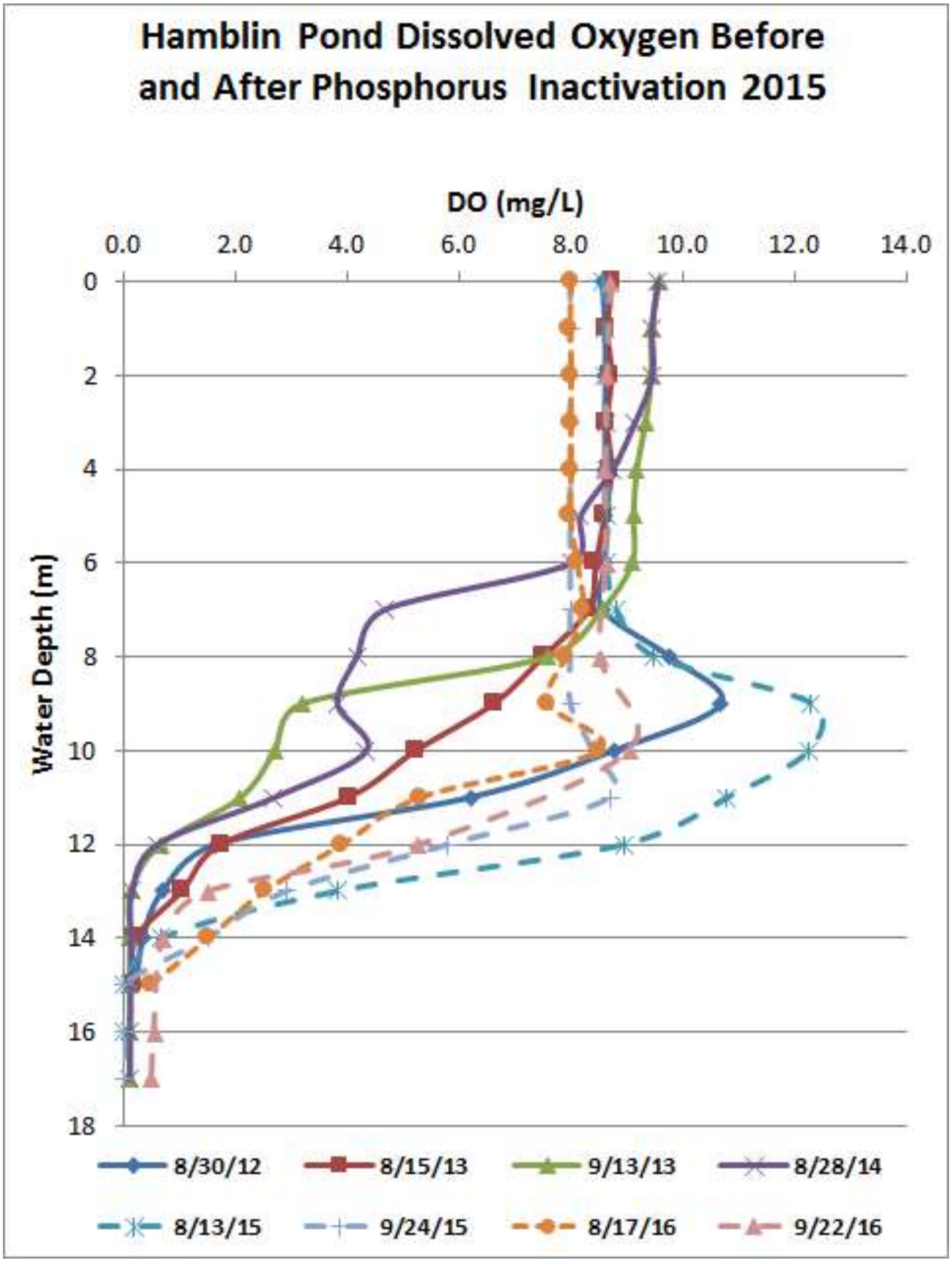


Figure 24. T/DO profiles before and after 2015 treatment in Hamblin Pond

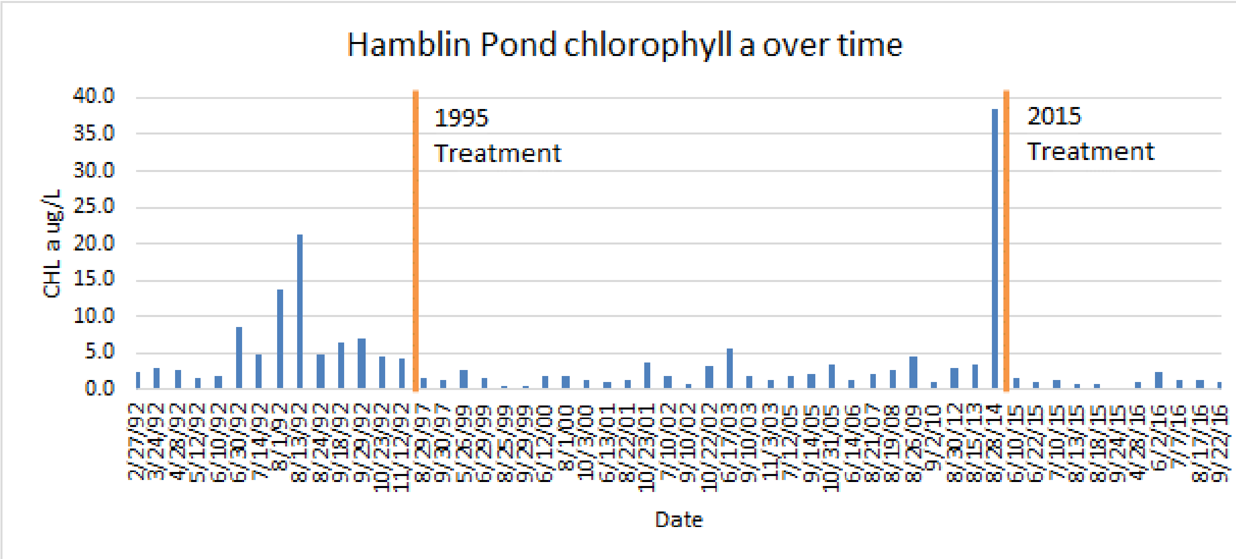


Figure 25. Hamblin Pond chlorophyll a over time

generally consider values of <1000 ug/L to represent no use impairment but expect impairments when biomass exceeds 3000 ug/L. By the end of June biomass had risen to >4600 ug/L, and fluctuated between 4000 and 9400 ug/L through September, declining to <2000 ug/L after mid-October. Chlorophytes were dominant through June, but cyanobacteria were dominant in July through September, with *Anabaena* (now called *Dolichospermum*), *Aphanizomenon*, and *Microcystis* most abundant in various samples. All the dominant cyanobacteria were possible toxin producers.

The blooms in 2013 and 2014 were only qualitatively assessed, but were dominated by *Dolichospermum* (formerly *Anabaena*, and seemingly the same species as back in 1992). Immediately prior to treatment in 2015 the algae community was a mixed assemblage of chlorophytes, pyrrhophytes and chyrsophytes (golden algae) at a biomass just under 1000 ug/L (Figure 26). Treatment removed most algae and prevented cyanobacteria from becoming abundant during summer. Biomass averaged <1000 ug/L and was dominated by golden algae and pyrrhophytes through summer 2016.

Note that biomass was not severely depressed; Hamblin Pond will still have adequate productivity to support a desirable sportfish community, but should not be subject to cyanobacteria blooms for another two decades. It is important to understand that productivity and blooms do not have to be tightly correlated. A productive lake with edible algae and a biological structure capable of using algal resources does not have to experience algae blooms. Other Cape Cod treatments have invariably led to shifts toward more edible algae and lower algal biomass (Wagner et al. 2017), but no fishery problems have been documented.

The zooplankton community is an important link in the food chain, converting algae into biomass that can be consumed by small fish. Zooplankton analysis for Hamblin Pond is restricted to samples

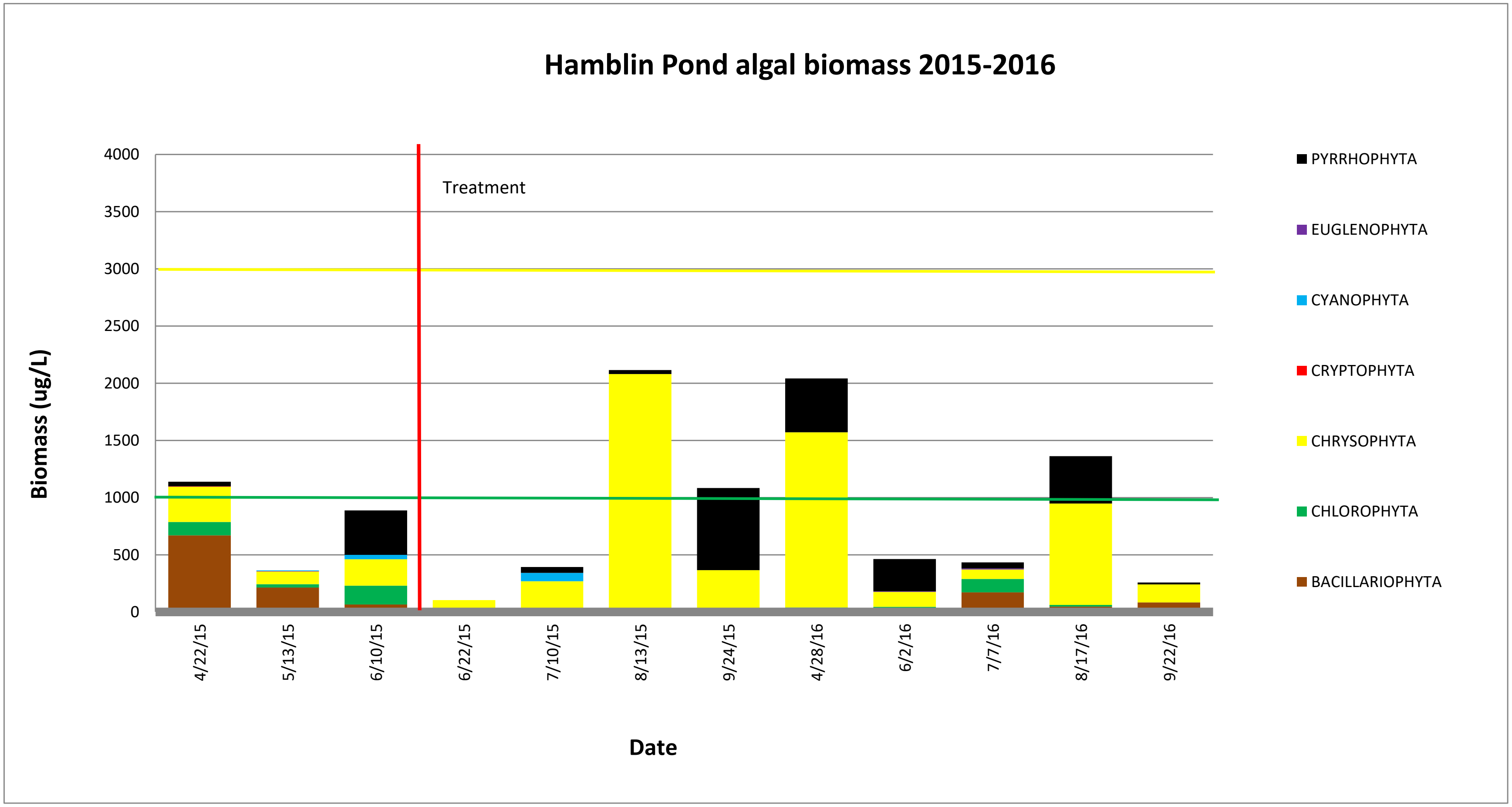


Figure 26. Hamblin Pond algal biomass 2015-2016

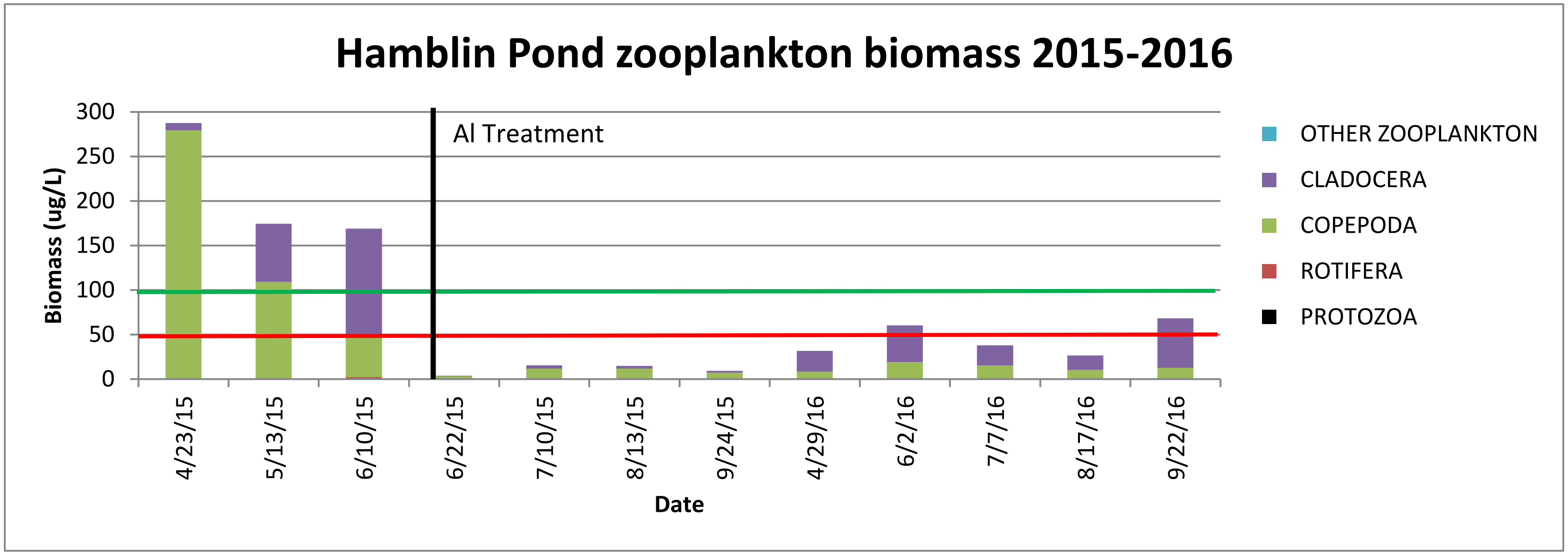


Figure 27. Hamblin Pond zooplankton biomass 2015-2016

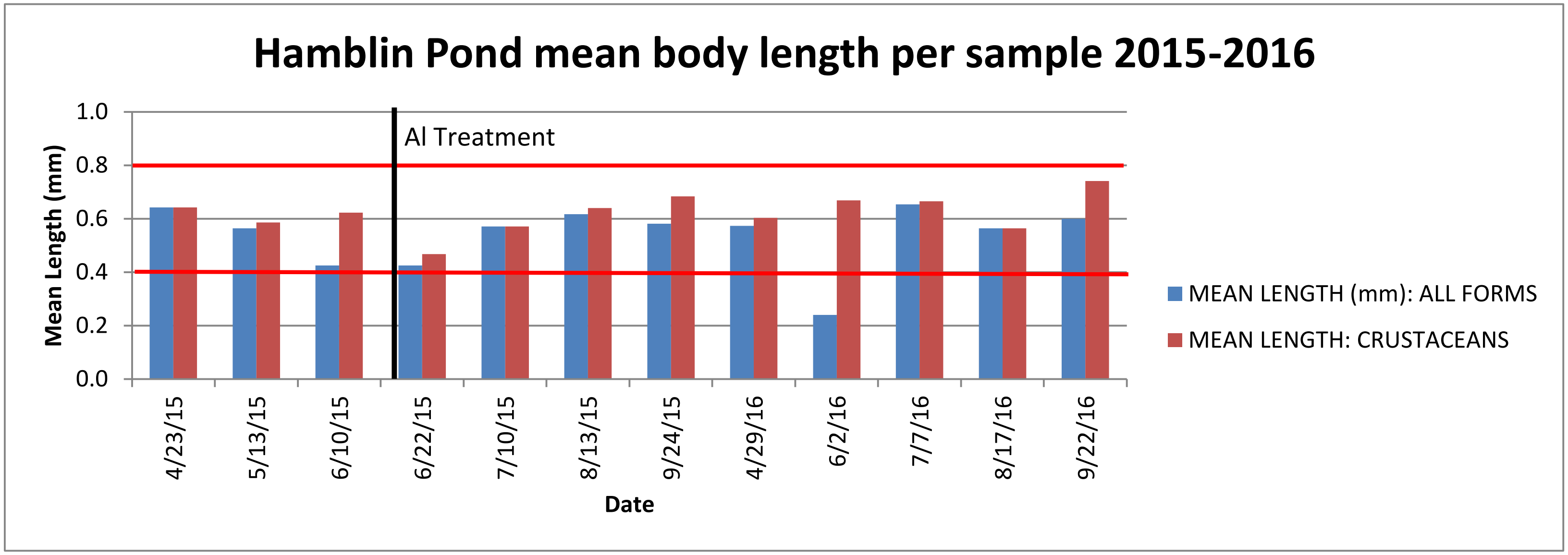


Figure 28. Hamblin Pond mean zooplankton body length per sample 2015-2016

from the 1992 BEC study and the monitoring conducted by WRS surrounding the 2015 treatment (Figures 27 and 28, with detailed data in the Appendix). Data from 1992 are limited, but suggest a desirable biomass of 148 ug/L from an early June sample with a valued cladoceran (*Daphnia*) and a cyclopoid copepod dominant. *Daphnia* are efficient filterers that convert algae into edible biomass for small fish. By early August the biomass had been reduced to 38 ug/L, a low value, with smaller cladocerans and copepods present. This is a typical progression in lakes as a result of predation by small fish, especially the new year class that starts preying on zooplankton in June.

The 2015-2016 data indicate a zooplankton community just before treatment in 2015 that was very similar to that from early June 1992. Treatment appeared to remove many zooplankters, especially the Daphnia, a phenomenon encountered in many other treated lakes but not always observed. Biomass was well under 50 ug/L for the rest of 2015. Some recovery was observed in 2016, with Daphnia reappearing, most likely from resting stages (ephippia) from the sediment (much like algae regeneration each year). However, biomass remained relatively low through 2016. This may be a result of less algae available as a food resource, but the algae data do not suggest this. It is more likely that predation on larger zooplankton has intensified with clearer water that makes them more visible. It is also possible that the aluminum floc is preventing complete recovery from resting stages, much as it is expected to limit cyanobacteria growth at the sediment-water interface in treated areas. Further monitoring is warranted.

The size distribution of zooplankton is important. Larger zooplankton filter water and remove algae more efficiently, and represent better food for small fish (easier to see, more energy per zooplankter ingested). An average crustacean zooplankton length of <0.4 mm suggests intense predation and limited zooplankton capacity to remove algae or support small fish, even at elevated biomass. Average length >0.8 mm may suggest a sparse small fish population, as the largest zooplankton should be removed by normal predation. The 2015-2016 data for Hamblin Pond (Figure 28) suggest a well-balanced size distribution, even with the lower biomass, as all values for crustacean average length were between 0.4 and 0.8 mm. Including other zooplankton, which are predominantly small rotifers, tends to reduce average length, but only one value for average length of all forms was <0.4. This suggests that the more desirable crustacean zooplankters are the dominant forms present.

No monitoring of invertebrates was conducted, but given the zooplankton results, there is some concern that there may be impacts to chironomid and related benthic forms tolerant of low oxygen as a consequence of a smothering effect of the aluminum floc. This effect is not expected in water <25 ft (7.6 m) deep, where benthic invertebrate diversity and biomass tend to be highest, and there are no mussels in Hamblin Pond that could be impacted. While the deep invertebrate community living in sediment is limited by low oxygen, hatches of some forms do constitute food for fish, and fishermen noted fewer hatches in 2015 and 2016. This effect has been observed in other treatments and found to be temporary, usually no more than 3 years (Smeltzer et al. 1999, Mattson et al. 2004).

While not specifically related to the aluminum treatment, there was a report of non-native Asian clams (*Corbicula fluminea*) having invaded Hamblin Pond, and WRS investigated this while on site for other monitoring activities. Asian clams were reported from the town swimming area, and were indeed located there. None were found anywhere else in Hamblin Pond, and follow up control activities are recommended. The use of benthic barriers has been effective in other lakes.

Rooted plants were not specifically monitored in this project, as they are not known to have ever been abundant in Hamblin Pond. In the course of other monitoring WRS noted the presence of plants in several areas, mainly pondweeds and the macroalga *Nitella*, but densities were low and overall coverage was sparse. Rooted plants did not become a prominent feature of Hamblin Pond after the 1995 treatment, and are not expected to proliferate now, mainly due to substrate features.

Fish were not monitored as part of this project, but Hamblin Pond is stocked with brown, rainbow and brook trout and is known to have populations of smallmouth bass, yellow perch and banded killifish. American eel and golden shiner are also reported from the pond historically, but were not captured in the last fish survey. Some large rainbow trout caught in 2016 appeared to be holdover fish in excellent condition. As the last fish survey was conducted in 2002, it would be appropriate for the Massachusetts Division of Fisheries to conduct a survey soon to assess the current fish community.

Summary and Recommendations

Hamblin Pond is a valued resource in the Town of Barnstable and statutory Great Pond in the Commonwealth of Massachusetts. Covering 115 acres, it has a town beach and a public boat launch, offering considerable recreational opportunity as well as aquatic habitat for a range of species, including stocked trout. A duck farm operated on and adjacent to the pond for about 30 years until the mid-1950s, overfertilizing it and promoting algae blooms. Cranberry farming and peripheral development have also added nutrients, but assessment in the early 1990s documented the dominance of internal loading of phosphorus as the main factor in cyanobacterial blooms.

An aluminum treatment was conducted in late May of 1995 to inactivate phosphorus in the surficial sediment over the deepest 80 acres of Hamblin Pond. This was the first aluminum treatment on Cape Cod and only a handful of treatments had been performed in New England at that time. Dose determination and maintenance of a desirable pH range were not as advanced as they later became, and a fish kill was caused by elevated pH and aluminum concentration. Nevertheless, the desired phosphorus inactivation occurred and Hamblin Pond experienced 18 years without algae blooms. Cyanobacteria were rate, oxygen increased in deeper water, and clarity was much increased.

Over the ensuing 20 years since the 1995 treatment, much has been learned about the duration of benefits from aluminum application. Continued watershed inputs will gradually replace inactivated phosphorus, and decomposition of organic matter with increased oxygen availability will release additional phosphorus from bottom sediments, but these are expected to be of limited influence in Hamblin Pond. The primary mechanism of resumed elevated phosphorus availability in deeper treated lakes is upward migration of phosphorus that was not inactivated from under the zone of treatment influence. Treatments are not expected to penetrate more than the upper 4 inches of sediment, but multiple feet of phosphorus rich sediment exist in some deeper areas. The rate of upward migration is not known, but is postulated to be on the order of 0.2 inches per year, suggesting that the duration of benefits should be about 20 years; Hamblin Pond experienced desirable conditions until late in the 18th year after treatment.

Retesting of surficial sediments revealed elevated concentrations of iron-bound phosphorus that could be expected to release enough of that phosphorus under low oxygen conditions to support algae blooms. With differential release of phosphorus, the ratio of nitrogen to phosphorus fell into the range where cyanobacteria were expected to dominate, and indeed such blooms returned to Hamblin Pond in September 2013 and throughout summer 2014. The suddenness of the loss of clarity further suggests upward migration of phosphorus through the inactivated zone as the primary source; both watershed and organic decomposition would be expected to produce a more gradual change.

A second aluminum treatment was planned, with three treatment zones established, each with a different dose based on sediment testing and advances in dose determination from the last 20 years. The lowest dose, applied to 11.9 acres in the south end of Hamblin Pond, was 45 g/m^2, the same as the dose applied everywhere in 1995. The 27.6 acre central area received a dose of 58

g/m^2, while 21.4 acres in the north end received a dose of 71 g/m^2. The total area treated was therefore 61 acres, less than the 80 acres treated in 1995 but with more aluminum applied overall.

The treatment was performed over six days between June 11 and 22, 2015. Aluminum sulfate and sodium aluminate were applied at a ratio of close to 2:1 by volume, causing minimal alteration of pH. These are the same chemicals applied in 1995, but at a higher alum to aluminate ratio. No indication of toxicity or other stress for fish and wildlife was observed during or after treatment in 2015. The treatment did strip algae and zooplankton from the water column, the former by intent and the latter as a sometimes observed but usually temporary consequence of treatment.

Monitoring continued through September 2016. Phosphorus concentrations were reduced to <10 ug/L in nearly all surface samples and <20 ug/L in bottom samples. Water clarity increased markedly, averaging about 26 feet after treatment for two summers. Algae biomass was low to moderate and included very few cyanobacteria; edible forms of algae dominated, potentially fueling a more efficient food web. Zooplankton biomass remained depressed through summer 2016, but the composition and size distribution remained favorable; gradual recovery is expected but should be monitored. Oxygen profiles indicate that more oxygen is present in deeper water than before treatment, very much the way oxygen profiles changed after the 1995 treatment. Habitat for trout will be improved, and a holdover population with growth is expected. The Division of Fisheries and Wildlife should be encouraged to conduct a fishery survey in the near future to update fish data.

Rooted plants have never been abundant in Hamblin Pond from available data. The 1995 treatment greatly enhanced water clarity and rooted plant did not proliferate, mainly due to coarse, sandy substrate that supports only limited rooted growths. No proliferation of rooted plants was observed after the 2015 treatment and is not expected in the future. However, the presence of hydrilla in adjacent Middle and Mystic Ponds is a concern and should be addressed to protect Hamblin Pond and other town aquatic resources.

The only negative aspects of the treatment appear to be a reduction in zooplankton biomass and possibly a reduction in deep water benthic invertebrates. The deposition of an aluminum floc layer in areas deeper than 25 ft may be responsible, and such effects have been observed in other treated lakes on a temporary basis (<3 years of impact). There were no mussels in Hamblin Pond that could have been impacted, and there have not been any since prior to the 1995 treatment. A program to introduce mussels is recommended, and should involve the Natural Heritage and Endangered Species Program, since there are threatened species in adjacent Middle and Mystic Ponds that might benefit from some transplanting.

Independent of the aluminum treatment, Asian clams have been found in Hamblin Pond, just in the town swimming area. This invasive species should be eliminated if possible, and has been addressed in some other lakes with benthic barriers, mats that can be laid down and will smother the clams.

The treatment of Hamblin Pond in 2015 is considered to be a major success, with reduced phosphorus, increased water clarity, elimination of cyanobacteria blooms and increased oxygen in deeper water. Desirable conditions can be expected for the next two decades.

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APPENDIX: Water Quality and Biological Data

Water Chemistry – Near Surface (-S) and Near Bottom (-B)

Station	Date	pH	Alkalinity	NH4-N	NOX-N	TKN	Total N	Diss. P	Total P	TN:TP RATIO
	(MMDDYY)	(SU)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
HPN-S	2/27/92	6.9	6.1	250	160	550	710	30	20	36
HPN-S	3/24/92	6.5	5.3	200	90	600	690	10	140	5
HPN-S	4/28/92	7.0	4.3	100	250	620	870	20	130	7
HPN-S	5/12/92	6.7	4.1	30	210	460	670	8	170	4
HPN-S	6/10/92	7.2	5.9	10	30	410	440	100	170	3
HPN-S	6/30/92	9.4	6.2	10	20	560	580	70	10	58
HPN-S	7/14/92	6.9	5.8	10	10	450	460	110	85	5
HPN-S	8/1/92	8.1	32.2	30	10	800	810	10	160	5
HPN-S	8/13/92	7.8	23.1	30	10	640	650	10	90	7
HPN-S	8/24/92	6.9	3.3	140	90	370	460	10	30	15
HPN-S	9/18/92	8.8	6.0	10	40	920	960	140	70	14
HPN-S	9/29/92	7.2	8.0	10	10	600	610	40	30	20
HPN-S	10/23/92	6.3	5.6	20	40	620	660	20	20	33
HPN-S	11/12/92	6.3	5.8	200	90	580	670	50	40	17
HPN-S	7/6/93			10	10	500	510	10	30	17
HPN-S	8/7/93			10	10	700	710	20	70	10
HPN-S	9/19/93			10	10	760	770	10	30	26
HPN-S	6/26/94			20	10	700	710	10	20	36
HPN-S	8/11/94			10	50	1400	1450	40	40	36
HPN-S	9/15/94			5	5	1100	1105	10	30	37
HPN-S	5/23/95		10.2	50	20	310	330	5	70	5
HPN-S	5/26/95		8.0	50	10	340	350	5	40	9
HPN-S	6/23/95		8.4	50	30	340	370	20	90	4
HPN-S	7/21/95		7.2	50	80	220	300	20	60	5
HPN-S	8/18/95		12.0	50	20	350	370	130	270	1
HPN-S	9/22/95		7.6	50	50	100	150	5	30	5
HPN-S	5/30/96		8.0	20	128	53	181	5	5	36
HPN-S	6/28/96		8.0	5	15	1940	1955	5	5	391
HPN-S	7/29/96		8.0	5	15	338	353	5	5	71
HPN-S	8/26/96		7.0	20	15	279	294	43	43	7
HPN-S	10/1/96		6.0	118	15	203	218	26	26	8
HPN-S	5/26/99		3.0	100	80	250	330	120	170	2
HPN-S	6/29/99		7.0	100	10	250	260	5	40	7
HPN-S	7/20/99		5.0		5			10	100	
HPN-S	8/25/99		5.2	5	5	350	355	10	51	7
HPN-S	9/29/99		6.0	50	80	50	130	82	113	1
HPN-S	6/12/00		5.6					9	10	
HPN-S	8/1/00		5.8					5	9	
HPN-S	10/3/00		1.8					13	9	
HPN-S	6/13/01		5.7		1			27	24	
HPN-S	8/22/01		6.9		1			9	6	
HPN-S	10/23/01		6.2		1			6	8	
HPN-S	7/10/02		4.6		9			7	71	

Station	Date	pH	Alkalinity	NH4-N	NOX-N	TKN	Total N	Diss. P	Total P	TN:TP RATIO
	(MMDDYY)	(SU)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
HPN-S	9/10/02		5.4		1			5	11	
HPN-S	10/22/02		5.9		4			13	10	
HPN-S	6/17/03		5.5		3			13	15	
HPN-S	9/10/03		5.1		1			7	7	
HPN-S	11/3/03		6.1		6			8	6	
HPN-S	7/12/05		4.9		1			7	10	
HPN-S	9/14/05		5.0		1			5	9	
HPN-S	10/31/05		6.0		6			27	26	
HPN-S	6/14/06		4.6		6			49	121	
HPN-S	8/21/07	6.4	5.5				206		9	22
HPN-S	8/19/08	6.5	6.2				163		5	33
HPN-S	8/26/09	6.9	6.7				359		13	27
HPN-S	9/2/10	7.2	7.4				444		10	44
HPN-S	9/12/11						233		12	20
HPN-S	8/30/12						342		12	28
HPN-S	8/15/13						338		12	27
HPN-S	8/28/14	8.7	8.5				364		15	24
HPN-S	4/23/15	6.8								
HPN-S	5/13/15	7.1								
HPN-S	6/10/15	6.7	8.0	30	5	100	105	21	34	3
HPN-S	6/22/15	7.0	8.7	100	5	100	105	5	9	12
HPN-S	7/10/15	6.5	8.1	90	50	200	250	5	5	50
HPN-S	8/13/15	6.8	7.9	70	5	330	335	5	8	42
HPN-S	8/18/15	7.1					104		6	16
HPN-S	9/24/15	6.9	8.2	170	5	320	325	8	13	25
HPN-S	4/28/16	7.1								
HPN-S	6/2/16	7.5	8.5	10	5	240	245	3	3	98
HPN-S	7/7/16	7.0	8.2	10	5	100	105	3	5	21
HPN-S	8/17/16	6.8	8.7	30	5	550	555	3	23	24
HPN-S	9/22/16	7.1	10.1	30	5	270	275	3	6	46
HPN-B	2/27/92	6.9	5.5	240	160	560	720	20	30	24
HPN-B	3/24/92	6.5	5.0	200	200	500	700	10	10	70
HPN-B	4/28/92	6.7	5.7	280	200	680	880	20	40	22
HPN-B	5/12/92	6.6	6.6	580	140	1050	1190	5	130	9
HPN-B	6/10/92	6.6	10.4	830	50	1000	1050	380	570	2
HPN-B	6/30/92	6.6	10.5	860	10	200	210	670	750	0
HPN-B	7/14/92	6.2	15.2	190	10	1900	1910	650	680	3
HPN-B	8/1/92	6.4	10.0	850	10	840	850	190	270	3
HPN-B	8/13/92	6.1	9.8	500	10	680	690	50	60	12
HPN-B	8/24/92	6.7	15.5	480	30	1400	1430	540	730	2
HPN-B	9/18/92	6.7	33.0	320	10	6800	6810	890	1100	6
HPN-B	9/29/92	6.7	13.0	700	10	1500	1510	230	250	6
HPN-B	10/23/92	6.3	24.2	1500	10	330	340	1100	1100	0
HPN-B	11/12/92	6.4	6.3	280	80	530	610	50	140	4
HPN-B	7/6/93			610	100	1000	1100	30	130	8

Station	Date	pH	Alkalinity	NH4-N	NOX-N	TKN	Total N	Diss. P	Total P	TN:TP RATIO
	(MMDDYY)	(SU)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
HPN-B	8/7/93			850	10	1550	1560	380	400	4
HPN-B	9/19/93			880	20	2300	2320	570	590	4
HPN-B	6/26/94			190	40	500	540	30	50	11
HPN-B	8/11/94			630	10	2000	2010	320	320	6
HPN-B	9/15/94			70	5	1000	1005	20	20	50
HPN-B	5/23/95		5.0	250	30	690	720	40	230	3
HPN-B	5/26/95		10.6	500	30	920	950	40	140	7
HPN-B	6/23/95		10.8	350	50	630	680	40	140	5
HPN-B	7/21/95		8.8	840	10	1190	1200	40	110	11
HPN-B	8/18/95		10.8	840	20	1330	1350	100	310	4
HPN-B	9/22/95		14.4	1260	20	1680	1700	40	40	43
HPN-B	5/30/96		10.0	243	81	261	342	5	5	68
HPN-B	6/28/96		10.0	317	73	590	663	5	5	133
HPN-B	7/29/96		8.0	338	65	338	403	53	260	2
HPN-B	8/26/96		12.0	682	15	1010	1025	43	43	24
HPN-B	10/1/96		12.0	155	111	159	270	26	26	10
HPN-B	5/26/99		5.0	100	100	250	350	230	450	1
HPN-B	6/29/99		9.0	150	90	800	890	5	50	18
HPN-B	7/20/99		11.0		5			5	110	
HPN-B	8/25/99		16.6	980	5	1330	1335	10	72	19
HPN-B	9/29/99		14.8	910	80	1120	1200	82	103	12
HPN-B	6/12/00		7.4					27	35	
HPN-B	8/1/00		10.3					14	9	
HPN-B	10/3/00		12.5					29	24	
HPN-B	6/13/01		6.8		7			17	17	
HPN-B	8/22/01		6.0		2			63	126	
HPN-B	10/23/01		6.9		1			7	10	
HPN-B	7/10/02		17.5		1			9	52	
HPN-B	9/10/02		18.8		1			5	10	
HPN-B	10/22/02		32.5		1			113	381	
HPN-B	6/17/03		7.2		52			15	30	
HPN-B	9/10/03		10.7		6			15	33	
HPN-B	11/3/03		27.1		2			46	117	
HPN-B	7/12/05		8.8		6			16	77	
HPN-B	9/14/05		16.4		1			269	298	
HPN-B	10/31/05		6.3		2			27	49	
HPN-B	6/14/06		11.0		2			80	210	
HPN-B	8/21/07	6.1	25.0				504		245	2
HPN-B	8/19/08	6.5	24.9				668		183	4
HPN-B	8/26/09	6.3	2.9				3048		750	4
HPN-B	9/2/10	6.7	19.2				926		238	4
HPN-B	9/12/11						1340		370	4
HPN-B	8/30/12						388		54	7
HPN-B	8/15/13						373		55	7
HPN-B	8/28/14	6.4	9.3				706		101	7
HPN-B	4/23/15	6.8								

Station	Date	pH	Alkalinity	NH4-N	NOX-N	TKN	Total N	Diss. P	Total P	TN:TP RATIO
	(MMDDYY)	(SU)	(mg/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
HPN-B	5/13/15	7.1								
HPN-B	6/10/15	5.8	13.7	510	70	670	740	15	24	31
HPN-B	6/22/15	6.6	12.5	1500	70	700	770	13	18	43
HPN-B	7/10/15	6.2	9.7	280	70	550	620	6	10	62
HPN-B	8/13/15	6.2	9.7	410	50	610	660	8	11	60
HPN-B	8/18/15	6.5					483		18	26
HPN-B	9/24/15	5.9	8.9	150	5	630	635	6	8	79
HPN-B	4/28/16	7.0								
HPN-B	6/2/16	6.7	9.5	10	5	290	295	5	6	49
HPN-B	7/7/16	5.8	7.8	20	13	100	113	3	5	23
HPN-B	8/17/16	5.8		150	5	220	225	16	21	11
HPN-B	9/22/16	5.5		20	5	220	225	3	6	38
HPS-S	6/10/15	6.8	7.6	30	5	100	105	15	30	4
HPS-S	6/22/15	7.2	8.7	310	60	100	160	5	22	7
HPS-S	7/10/15	6.8	7.9	50	5	300	305	3	6	51
HPS-S	8/13/15	7.3	7.5	40	5	100	105	5	7	15
HPS-S	9/24/15	7.0	8.1							
HPS-S	6/2/16	7.8		40	5	270	275	3	6	46
HPS-S	7/7/16	6.8		60	5	200	205	3	3	82
HPS-S	8/17/16	7.1		30	5	260	265	3	7	38
HPS-S	9/22/16	6.8		30	5	230	235	3	3	94
HPS-B	6/10/2015	6.7	7.8	100	60	100	160	14	36	4
HPS-B	6/22/2015	7.1	8.9	390	60	100	160	8	15	11
HPS-B	7/10/2015	6.6	8.0	40	5	390	395	7	12	33
HPS-B	8/13/2015	7.0	7.7	60	5	280	285	9	12	24
HPS-B	9/24/2015	6.8	8.7							
HPS-B	6/2/2016	7.5		40	5	270	275	3	10	28
HPS-B	7/7/2016	6.8		60	5	100	105	3	3	42
HPS-B	8/17/2016	6.9		110	5	210	215	3	14	15
HPS-B	9/22/2016	6.7		760	5	1040	1045	3	3	418

Hamblin Pond Total and Dissolved Aluminum 2015-2016

Station	Date	Diss. Aluminum	Total Aluminum
	(MMDDYY)	(mg/L)	(mg/L)
HPN-S	6/10/15		0.005
HPN-S	6/22/15	0.130	0.500
HPN-S	7/10/15	0.095	
HPN-S	8/13/15	0.020	
HPN-S	9/24/15	0.060	
HPN-S	6/2/16	0.005	
HPN-S	7/7/16		0.027

Station	Date	Diss. Aluminum	Total Aluminum
	(MMDDYY)	(mg/L)	(mg/L)
HPN-S	9/22/16	0.012	0.017
HPN-B	6/10/15		0.005
HPN-B	6/22/15	0.005	0.028
HPN-B	7/10/15	0.005	
HPN-B	8/13/15	0.005	
HPN-B	9/24/15	0.005	
HPN-B	6/2/16	0.005	
HPN-B	7/7/16		0.005
HPN-B	9/22/16	0.005	0.011
HPS-S	6/10/15		0.005
HPS-S	6/22/15	0.130	0.490
HPS-S	7/10/15	0.081	
HPS-S	8/13/15	0.038	
HPS-S	9/24/15	0.022	
HPS-S	6/2/16	0.005	
HPS-S	7/7/16		0.021
HPS-S	9/22/16	0.005	0.017
HPS-B	6/10/15		0.005
HPS-B	6/22/15	0.023	0.140
HPS-B	7/10/15	0.011	
HPS-B	8/13/15	0.005	
HPS-B	9/24/15	0.020	
HPS-B	6/2/16	0.005	
HPS-B	7/7/16		0.023
HPS-B	9/22/16	0.012	0.019

Hamblin Pond Secchi Disk Transparency Over Time

Station	Date	Secchi Depth
	(MMDDYY)	(M)
HPN	2/27/92	2.6
HPN	3/24/92	3.5
HPN	4/28/92	3.2
HPN	5/12/92	4.2
HPN	6/10/92	4.9
HPN	6/30/92	2.1
HPN	7/14/92	2.3
HPN	8/1/92	1.0
HPN	8/13/92	0.9
HPN	8/24/92	5.0
HPN	9/18/92	1.5

Station	Date	Secchi Depth
	(MMDDYY)	(M)
HPN	9/29/92	2.4
HPN	10/23/92	3.2
HPN	11/12/92	2.0
HPN	7/6/93	1.9
HPN	7/24/93	1.1
HPN	7/31/93	1.1
HPN	8/7/93	0.9
HPN	8/14/93	1.0
HPN	8/21/93	1.0
HPN	8/30/93	2.0
HPN	9/5/93	2.2
HPN	9/12/93	1.6
HPN	9/19/93	2.1
HPN	6/26/94	2.3
HPN	7/4/94	2.2
HPN	7/11/94	2.0
HPN	7/24/94	1.2
HPN	7/31/94	0.8
HPN	8/7/94	1.3
HPN	8/11/94	1.6
HPN	8/27/94	2.3
HPN	9/15/94	2.0
HPN	9/25/94	3.0
HPN	5/23/95	4.7
HPN	5/26/95	6.7
HPN	6/4/95	7.1
HPN	6/18/95	5.1
HPN	6/23/95	5.1
HPN	7/16/95	7.0
HPN	7/21/95	8.7
HPN	8/18/95	5.0
HPN	9/22/95	4.6
HPN	5/30/96	5.8
HPN	6/28/96	4.8
HPN	7/7/96	6.0
HPN	7/22/96	5.0
HPN	7/29/96	5.6
HPN	8/10/96	7.0
HPN	8/26/96	7.0
HPN	10/1/96	8.8
HPN	6/2/97	3.9
HPN	6/26/97	4.2
HPN	7/29/97	5.1
HPN	8/8/97	5.0
HPN	8/29/97	4.7
HPN	8/31/97	5.5

Station	Date	Secchi Depth
	(MMDDYY)	(M)
HPN	9/15/97	5.5
HPN	9/30/97	5.0
HPN	7/18/98	6.0
HPN	8/28/98	6.0
HPN	11/1/98	6.2
HPN	5/26/99	6.1
HPN	6/29/99	3.7
HPN	7/6/99	5.8
HPN	7/20/99	5.0
HPN	8/25/99	8.7
HPN	8/28/99	7.6
HPN	9/18/99	7.2
HPN	9/29/99	9.3
HPN	6/12/00	8.0
HPN	8/1/00	6.6
HPN	10/5/00	5.9
HPN	6/18/01	4.5
HPN	8/22/01	4.2
HPN	9/10/02	8.1
HPN	6/17/03	7.1
HPN	9/10/03	6.6
HPN	6/28/05	4.15
HPN	7/13/05	4.50
HPN	7/27/05	4.75
HPN	8/11/05	6.05
HPN	8/25/05	5.55
HPN	9/13/05	5.75
HPN	9/27/05	5.35
HPN	6/20/06	6.80
HPN	7/8/06	7.30
HPN	7/18/06	5.45
HPN	8/2/06	4.50
HPN	8/14/06	5.80
HPN	8/31/06	5.30
HPN	9/14/06	6.50
HPN	9/26/06	6.95
HPN	7/5/07	3.51
HPN	7/18/07	3.15
HPN	8/2/07	3.30
HPN	8/21/07	6.10
HPN	9/4/07	5.60
HPN	8/19/08	5.5
HPN	8/26/09	4.1
HPN	9/2/10	4.2
HPN	9/12/10	4.9
HPN	6/20/11	7.1

Station	Date	Secchi Depth
	(MMDDYY)	(M)
HPN	8/18/11	4.9
HPN	9/12/11	5.9
HPN	7/26/12	4.7
HPN	8/30/12	4.8
HPN	5/11/13	6.2
HPN	6/15/13	4.7
HPN	7/12/13	3.8
HPN	7/20/13	4.2
HPN	8/4/13	4.6
HPN	8/10/13	4.7
HPN	8/15/13	4.7
HPN	9/13/13	2
HPN	9/21/13	2
HPN	9/28/13	2.5
HPN	10/5/13	3
HPN	10/13/13	3.5
HPN	5/9/14	4.3
HPN	6/4/14	4.1
HPN	7/10/14	2.2
HPN	7/17/14	1.5
HPN	7/24/14	1.5
HPN	8/4/14	1.6
HPN	8/22/14	0.4
HPN	8/28/14	1.2
HPN	9/9/14	1.6
HPN	4/23/15	3.1
HPN	5/13/15	5.8
HPN	6/10/15	6.4
HPN	6/22/15	6.6
HPN	7/10/15	7.5
HPN	8/13/15	8.7
HPN	8/18/15	6.4
HPN	9/24/15	8.2
HPN	4/28/16	5.8
HPN	6/2/16	6.8
HPN	7/7/16	7.7
HPN	8/17/16	7.5
HPN	9/22/16	10.5
HPS	6/10/15	6.1
HPS	6/22/15	6.4
HPS	7/10/15	7.3
HPS	8/13/15	8.8
HPS	9/24/15	7.9
HPS	6/2/16	6.8
HPS	7/7/16	7.7

Station	Date	Secchi Depth
	(MMDDYY)	(M)
HPS	8/17/16	7.3
HPS	9/22/16	9.3

Hamblin Pond Chlorophyll a Data Over Time

Station	Date	Chl a
	(MMDDYY)	(ug/L)
HPN	2/27/92	2.3
HPN	3/24/92	3.0
HPN	4/28/92	2.6
HPN	5/12/92	1.5
HPN	6/10/92	1.8
HPN	6/30/92	8.6
HPN	7/14/92	4.8
HPN	8/1/92	13.8
HPN	8/13/92	21.3
HPN	8/24/92	4.7
HPN	9/18/92	6.5
HPN	9/29/92	7.0
HPN	10/23/92	4.4
HPN	11/12/92	4.3
HPN	8/29/97	1.6
HPN	9/30/97	1.2
HPN	5/26/99	2.7
HPN	6/29/99	1.5
HPN	8/25/99	0.6
HPN	9/29/99	0.6
HPN	6/12/00	1.7
HPN	8/1/00	1.7
HPN	10/3/00	1.2
HPN	6/13/01	0.9
HPN	8/22/01	1.4
HPN	10/23/01	3.7
HPN	7/10/02	1.8
HPN	9/10/02	0.8
HPN	10/22/02	3.1
HPN	6/17/03	5.7
HPN	9/10/03	1.8
HPN	11/3/03	1.3
HPN	7/12/05	1.8
HPN	9/14/05	2.2
HPN	10/31/05	3.3
HPN	6/14/06	1.4
HPN	8/21/07	2.0

Station	Date	Chl a
	(MMDDYY)	(ug/L)
HPN	8/19/08	2.5
HPN	8/26/09	4.6
HPN	9/2/10	1.0
HPN	8/30/12	2.8
HPN	8/15/13	3.5
HPN	8/28/14	38.5
HPN	6/10/15	1.6
HPN	6/22/15	1.1
HPN	7/10/15	1.4
HPN	8/13/15	0.7
HPN	8/18/15	0.9
HPN	9/24/15	0.3
HPN	4/28/16	0.9
HPN	6/2/16	2.4
HPN	7/7/16	1.2
HPN	8/17/16	1.2
HPN	9/22/16	1.1
HPS	6/22/15	0.4
HPS	7/10/15	0.1
HPS	8/13/15	0.9
HPS	9/24/15	0.7
HPS	6/2/16	2.2
HPS	7/7/16	0.9
HPS	8/17/16	1.2
HPS	9/22/16	0.9

2015 Hamblin Pond Field Data Profiles

Hamblin 2015 Field Data										
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	Secchi	Alkalinity
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	meters	mg/L
North	4/23/15	0.3	10.7	12.4	113.6	53	6.8	2.0	3.1	
	4/23/15	1.0	10.7	12.5	114.3	53	6.8	1.6		
	4/23/15	2.1	10.7	12.5	114.2	53	6.9	1.5		
	4/23/15	3.0	10.7	12.6	114.8	53	6.9	1.4		
	4/23/15	4.0	10.7	12.6	115.1	53	6.9	1.4		
	4/23/15	5.0	10.6	12.6	114.5	53	6.9	1.4		
	4/23/15	6.0	9.5	12.7	112.9	53	7.0	1.6		
	4/23/15	8.0	8.9	12.7	110.6	53	7.0	1.9		
	4/23/15	8.6	8.0	12.5	106.7	53	6.9	1.6		
	4/23/15	9.1	8.0	12.4	106.3	53	6.9	1.6		
	4/23/15	10.1	7.6	12.4	104.7	53	6.9	1.5		
	4/23/15	11.0	7.0	12.2	102.0	53	6.9	1.4		
	4/23/15	11.9	6.8	12.1	100.6	53	6.9	1.2		
	4/23/15	13.1	6.5	12.0	99.0	53	6.9	1.3		
	4/23/15	13.7	6.3	11.9	97.4	53	6.9	1.3		

Hamblin 2015 Field Data										
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	Secchi	Alkalinity
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	meters	mg/L
	4/23/15	14.1	6.1	11.3	91.9	53	6.9	1.3		
	4/23/15	14.9	6.0	11.2	90.7	53	6.9	1.3		
	4/23/15	15.0	6.0	11.1	90.0	53	6.9	1.2		
	4/23/15	16.0	5.9	10.8	87.3	53	6.9	1.3		
	4/23/15	16.3	5.9	10.1	82.2	53	6.8	2.2		
North	5/13/15	0.1	18.7	9.6	104.5	55	7.1	0.3	5.8	
	5/13/15	1.0	18.7	9.6	104.6	55	7.0	0.3		
	5/13/15	2.0	18.7	9.7	105.0	55	7.1	0.3		
	5/13/15	3.0	18.7	9.7	105.3	55	7.1	0.3		
	5/13/15	4.0	18.6	9.7	105.3	55	7.1	0.3		
	5/13/15	5.0	15.5	10.7	108.3	54	7.1	0.3		
	5/13/15	6.0	13.3	12.0	116.1	54	7.3	0.3		
	5/13/15	7.0	11.9	12.7	119.3	54	7.5	0.3		
	5/13/15	8.0	10.7	12.7	115.9	53	7.5	0.3		
	5/13/15	9.0	9.1	12.2	106.8	53	7.5	0.8		
	5/13/15	10.0	8.6	11.0	95.6	53	7.4	0.5		
	5/13/15	11.1	7.8	10.0	85.5	53	7.3	0.3		
	5/13/15	12.0	7.2	9.6	80.0	53	7.3	0.3		
	5/13/15	13.0	6.8	9.4	78.1	53	7.3	0.3		
	5/13/15	14.0	6.4	8.3	68.5	53	7.2	0.3		
	5/13/15	15.0	6.2	7.4	60.7	53	7.1	0.3		
	5/13/15	16.0	6.1	6.0	49.0	54	7.1	0.3		
	5/13/15	16.3	6.1	5.3	42.9	54	7.1	0.3		
North	6/10/15	0.2	19.4	10.4	114.2	52	6.7	1.1	6.4	8.0
	6/10/15	2.0	19.2	10.5	115.3	53	6.8	1.3		
North	6/10/15	4.0	18.9	10.6	115.0	53	6.7	1.4		
	6/10/15	6.0	17.6	10.7	113.2	52	6.8	1.4		
	6/10/15	8.0	13.0	11.5	110.2	51	6.8	1.4		
	6/10/15	10.0	9.0	12.1	105.9	50	6.8	1.7		
	6/10/15	12.0	6.9	7.9	65.9	50	6.7	1.4		
	6/10/15	14.0	5.9	5.0	40.9	50	6.6	1.4		
	6/10/15	16.0	5.5	0.9	7.5	52	6.5	1.8		
	6/10/15	18.0	5.5	0.0	0.0	71	5.8	5.3		13.7
South	6/10/15	0.1	17.5	10.7	113.5	53	6.8	1.9	6.1	7.6
	6/10/15	1.0	17.6	10.7	113.3	53	6.8	2.0		
	6/10/15	2.0	17.6	10.7	113.9	53	6.8	2.7		
	6/10/15	3.0	17.5	10.7	113.5	53	6.8	2.5		
	6/10/15	4.0	17.4	10.8	113.7	53	6.8	1.9		
	6/10/15	5.0	17.3	10.7	112.9	53	6.8	2.1		
	6/10/15	6.0	17.1	10.7	112.9	53	6.8	2.1		
	6/10/15	7.0	16.7	10.7	111.2	52	6.8	2.0		
	6/10/15	8.0	15.4	10.7	109.0	52	6.8	1.9		
	6/10/15	9.0	9.9	11.0	99.0	51	6.8	2.0		
	6/10/15	9.6	9.3	8.1	71.7	51	6.7	2.2		7.8

Hamblin 2015 Field Data										
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	Secchi	Alkalinity
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	meters	mg/L
North	6/22/15	1.0	22.1	9.3	108.4	65	7.0	1.1	6.6	8.7
	6/22/15	3.0	21.8	9.4	108.3	64	6.9	0.9		
	6/22/15	5.0	21.7	9.5	109.3	64	6.8	1.2		
	6/22/15	7.0	20.3	9.6	107.2	58	6.7	1.1		
	6/22/15	9.0	12.2	9.6	90.6	50	6.7	1.2		
	6/22/15	11.1	9.2	7.9	69.5	49	6.6	1.2		
	6/22/15	13.0	7.3	3.3	28.0	49	6.6	1.0		
	6/22/15	15.0	6.7	0.2	1.7	52	6.6	1.8		
	6/22/15	17.0	6.4	0.2	1.7	62	6.6	2.5		12.5
South	6/22/15	0.2	24.3	9.0	108.4	65	7.2	0.5	6.4	8.7
	6/22/15	2.0	22.2	9.3	108.2	66	7.2	0.7		
	6/22/15	4.0	22.0	9.3	107.2	68	7.1	0.8		
	6/22/15	6.0	21.8	9.2	106.5	65	7.0	0.6		
	6/22/15	8.0	14.6	9.5	94.2	50	7.1	0.9		
	6/22/15	10.0	10.7	9.7	88.5	50	7.1	1.3		8.9
North	7/10/15	1.0	24.4	8.7	105.6	66	6.5	1.0	7.5	8.1
	7/10/15	3.0	24.3	8.7	105.7	66	6.4	1.0		
	7/10/15	5.0	23.8	8.8	105.3	65	6.4	0.9		
	7/10/15	7.0	22.3	8.8	102.6	64	6.2	0.8		
	7/10/15	9.0	14.6	8.9	88.7	50	6.2	0.7		
	7/10/15	11.0	10.7	7.3	66.7	50	6.2	0.9		
	7/10/15	13.0	8.2	4.5	38.7	49	6.2	0.8		
	7/10/15	15.0	7.2	0.7	5.6	52	6.2	1.5		
	7/10/15	16.9	6.9	1.0	8.1	52	6.2	1.7		9.7
South	7/10/15	0.2	23.8	8.9	106.5	66	6.8	0.9	7.3	7.9
	7/10/15	2.0	24.4	8.7	105.3	65	6.8	0.8		
	7/10/15	4.0	24.3	8.7	105.6	66	6.7	0.7		
	7/10/15	6.0	24.2	8.8	106.8	66	6.6	1.0		
	7/10/15	8.0	18.4	10.2	110.0	53	6.5	0.9		
	7/10/15	10.1	13.0	10.0	95.8	50	6.6	1.2		8.0
North	8/13/15	0.1	25.2	8.6	105.7	65	6.8	1.3	8.7	7.9
	8/13/15	1.0	24.9	8.6	105.3	65	6.8	1.3		
	8/13/15	2.1	24.7	8.6	105.1	65	6.8	1.4		
	8/13/15	3.0	24.7	8.6	105.2	65	6.7	1.3		
	8/13/15	4.0	24.6	8.6	105.3	65	6.7	1.5		
	8/13/15	5.0	24.6	8.7	105.3	65	6.6	1.6		
	8/13/15	6.1	24.6	8.6	105.0	65	6.6	1.6		
	8/13/15	7.0	24.5	8.8	107.0	65	6.5	1.5		
	8/13/15	8.1	23.7	9.5	113.5	63	6.4	1.6		
	8/13/15	9.1	17.5	12.3	130.5	51	6.3	1.4		
	8/13/15	10.1	14.8	12.2	122.5	50	6.3	1.5		
	8/13/15	11.0	12.3	10.8	102.1	50	6.2	1.7		
	8/13/15	12.1	10.9	8.9	82.0	50	6.1	1.6		
	8/13/15	13.0	9.4	3.8	33.7	50	6.1	1.9		

Hamblin 2015 Field Data										
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	Secchi	Alkalinity
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	meters	mg/L
	8/13/15	14.1	8.6	0.7	5.8	52	6.2	2.5		
	8/13/15	15.0	8.2	0.0	0.0	53	6.1	3.5		
	8/13/15	15.9	7.9	0.0	0.0	58	6.2	2.0		9.7
South	8/13/15	0.1	24.9	8.6	105.3	65	7.3	0.6	8.8	7.5
	8/13/15	1.0	24.8	8.6	105.7	65	7.3	0.6		
	8/13/15	2.0	24.7	8.6	104.7	65	7.3	0.7		
	8/13/15	3.0	24.7	8.6	104.7	65	7.3	0.7		
	8/13/15	4.1	24.6	8.6	105.1	65	7.3	1.0		
	8/13/15	5.0	24.6	8.6	104.1	65	7.3	0.9		
	8/13/15	6.0	24.6	8.6	104.3	65	7.3	0.9		
	8/13/15	7.1	24.5	8.6	104.3	65	7.3	0.9		
	8/13/15	8.0	24.3	8.6	103.7	64	7.3	0.9		
	8/13/15	8.0	24.2	8.6	104.4	64	7.2	1.1		
	8/13/15	9.0	18.1	10.4	111.5	52	7.2	1.4		
	8/13/15	9.6	17.0	8.5	88.6	52	7.0	2.1		
	8/13/15	9.8	16.9	8.6	90.2	52	7.0	2.1		7.7
North	9/25/15	1.1	22.2	8.0	93.0	63	6.9	2.4	8.2	8.2
	9/25/15	3.0	22.1	8.0	92.4	63	6.8	2.2		
	9/25/15	5.0	22.1	8.0	92.5	63	6.7	2.5		
	9/25/15	5.0	22.1	7.9	92.3	63	6.8	2.6		
	9/25/15	7.0	22.1	8.0	92.5	63	6.6	2.6		
	9/25/15	9.0	21.9	8.0	92.7	63	6.6	2.4		
	9/25/15	11.0	14.7	8.7	87.0	51	6.3	2.5		
	9/25/15	13.0	11.1	2.9	26.6	51	6.2	2.3		
	9/25/15	15.0	9.6	0.0	0.0	55	6.1	5.0		
North	9/25/15	17.1	8.8	0.0	0.0	66	5.9	3.5		8.9
South	9/25/15	0.2	21.2	8.3	94.6	64	7.0	1.9	7.9	8.1
	9/25/15	2.0	21.2	8.3	94.4	64	7.0	2.0		
	9/25/15	4.0	21.2	8.3	94.5	64	6.9	2.2		
	9/25/15	6.0	21.3	8.2	93.4	64	6.9	2.4		
	9/25/15	8.0	21.4	8.1	92.1	64	6.8	2.7		
	9/25/15	10.1	21.5	7.8	89.8	64	6.8	4.1		8.7

2016 Hamblin Pond Field Data Profiles

Hamblin 2016 Field Data											
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Alkalinity	Secchi
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	mg/l	meters
North	4/28/16	1.0	11.7	10.7	100.1	84	7.1	2.4	0.0		5.8
	4/28/16	3.0	11.6	10.7	99.6	85	7.1	2.4	1.0		
	4/28/16	4.9	11.5	10.6	98.8	85	7.1	2.4	1.6		
	4/28/16	7.0	10.9	10.7	97.9	84	7.0	2.4	2.9		

Hamblin 2016 Field Data											
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Alkalinity	Secchi
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	mg/l	meters
	4/28/16	8.9	10.7	10.7	97.4	84	7.0	2.4	4.4		
	4/28/16	11.0	10.4	10.5	95.4	84	7.0	2.3	5.9		
	4/28/16	13.1	9.4	9.4	83.4	84	7.0	2.3	6.9		
	4/28/16	15.0	9.2	8.6	75.6	84	7.0	2.3	3.7		
	4/28/16	17.0	9.1	8.3	72.7	84	7.0	2.3	2.5		
North	6/2/16	1.0	20.7	9.5	106.9	86	7.5	4.5	1.8	8.5	6.8
	6/2/16	3.0	20.6	9.6	107.8	86	7.5	4.6	2.3		
	6/2/16	5.0	18.2	10.3	110.9	86	7.5	4.8	3.2		
	6/2/16	7.0	15.0	10.7	107.1	85	7.4	4.9	3.3		
	6/2/16	9.0	13.0	10.6	101.7	85	7.1	5.1	2.6		
	6/2/16	11.0	12.2	10.2	96.0	85	6.8	5.4	3.5		
	6/2/16	13.0	10.9	7.3	66.9	84	6.6	5.7	22.8		
	6/2/16	14.9	10.0	2.2	19.8	84	6.5	5.8	26.0		
	6/2/16	17.1	9.6	0.5	4.8	85	6.7	5.5	1.6	9.5	
South	6/2/16	1.0	20.8	9.4	106.7	86	7.8	2.4	1.9		6.8
	6/2/16	3.0	20.7	9.4	106.5	86	7.7	2.3	2.6		
	6/2/16	5.0	18.1	10.3	110.4	86	7.8	2.3	2.3		
	6/2/16	7.0	15.1	10.6	107.0	85	7.7	2.3	3.0		
	6/2/16	9.0	12.9	10.5	100.3	84	7.5	2.8	9.8		
North	7/7/16	0.0	26.4	8.6	108.1	89	7.0	2.5	1.2	8.2	7.7
	7/7/16	1.0	25.7	8.6	107.0	89	7.0	3.0	1.0		
	7/7/16	2.0	25.6	8.6	106.8	89	7.0	2.7	0.9		
	7/7/16	3.0	25.5	8.6	107.0	89	7.0	2.8	1.6		
	7/7/16	4.1	25.3	8.7	107.2	89	6.9	2.9	2.2		
	7/7/16	5.0	25.0	8.7	107.0	89	7.0	2.7	2.4		
	7/7/16	6.0	24.4	8.5	103.6	89	7.0	2.7	2.1		
	7/7/16	7.0	19.8	10.5	116.3	87	7.0	2.8	2.4		
	7/7/16	8.0	16.4	10.6	110.0	86	7.1	2.8	1.3		
	7/7/16	9.0	14.9	10.4	104.2	85	7.1	2.8	1.7		
	7/7/16	10.0	13.9	10.5	103.2	85	7.1	2.8	2.0		
	7/7/16	11.0	13.0	10.2	97.7	85	7.1	2.9	2.2		
	7/7/16	12.0	12.3	9.0	84.8	85	6.9	3.1	3.6		
	7/7/16	13.0	11.6	6.3	58.6	85	6.8	3.1	5.2		
	7/7/16	14.0	10.9	1.6	14.4	85	6.5	3.4	7.0		
	7/7/16	15.0	10.3	0.5	4.8	91	5.8	3.7	1.5	7.8	
South	7/7/16	0.1	26.7	8.6	109.4	89	6.8	2.6	0.9		7.7
	7/7/16	1.1	26.4	8.6	108.4	89	6.8	2.7	0.8		
	7/7/16	2.0	25.9	8.6	106.8	89	6.8	2.9	1.1		
	7/7/16	3.0	25.8	8.6	106.5	89	6.8	2.9	1.0		
	7/7/16	4.0	25.3	8.6	106.2	89	6.7	3.1	2.2		
	7/7/16	5.1	24.7	8.6	104.5	89	6.7	3.1	2.1		
	7/7/16	6.1	22.9	9.2	108.3	88	6.7	3.2	2.9		

Hamblin 2016 Field Data											
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Alkalinity	Secchi
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	mg/l	meters
	7/7/16	7.1	18.8	10.3	112.4	86	6.8	3.2	2.6		
	7/7/16	7.4	18.5	10.5	113.3	86	6.8	3.2	3.2		
	7/7/16	7.8	17.5	10.4	110.5	86	6.8	3.2	3.0		
	7/7/16	8.1	17.4	10.3	109.0	86	6.8	3.2	2.6		
	7/7/16	8.5	15.6	10.4	105.5	85	6.8	3.2	2.2		
	7/7/16	9.1	14.8	9.9	99.4	86	6.8	3.2	3.3		
North	8/17/16	1.1	27.5	8.0	102.4	91	6.8	4.2	1.0	8.7	7.5
	8/17/16	3.2	27.4	8.0	102.4	91	6.7	4.3	1.1		
	8/17/16	5.1	27.4	8.0	102.4	91	6.5	4.4	1.4		
	8/17/16	7.3	25.7	8.2	102.1	90	6.4	4.5	1.8		
	8/17/16	9.1	16.9	7.6	79.4	86	6.3	4.6	2.9		
	8/17/16	11.0	14.2	5.3	52.4	85	6.2	4.7	2.0		
	8/17/16	12.9	12.3	2.5	23.8	85	6.1	4.9	1.6		
	8/17/16	15.1	10.8	0.5	4.3	96	5.8	5.1	2.5		
	8/17/16	17.2	10.0	0.4	4.0	103	5.8	5.0	1.7		
South	8/17/16	0.2	27.6	8.1	103.5	91	7.1	3.6	0.8		7.3
	8/17/16	1.0	27.6	8.1	103.4	91	7.1	3.7	1.1		
	8/17/16	2.1	27.5	8.1	103.5	91	7.1	3.8	1.3		
	8/17/16	3.1	27.5	8.1	103.3	91	7.0	3.9	1.4		
	8/17/16	4.0	27.4	8.0	102.9	91	7.0	4.1	1.6		
	8/17/16	5.0	27.1	8.0	102.5	91	6.9	4.2	1.7		
	8/17/16	5.8	27.1	8.1	103.5	91	6.8	4.3	2.0		
	8/17/16	7.0	26.7	8.3	105.1	91	6.8	4.2	2.0		
	8/17/16	8.1	20.8	8.5	96.4	86	6.8	4.7	4.5		
	8/17/16	9.0	17.3	7.5	79.0	86	6.9	6.0	4.4		
	8/17/16	9.9	16.2	7.4	76.2	85	6.9	5.6	4.4		
South	9/22/16	0.1	23.5	8.8	104.7	90	6.8	1.6	0.6		9.3
	9/22/16	1.0	23.2	8.7	103.1	91	6.8	1.8	0.9		
	9/22/16	2.0	23.1	8.7	102.6	91	6.8	1.6	0.8		
	9/22/16	3.0	23.1	8.7	102.4	90	6.8	1.7	1.0		
	9/22/16	4.0	23.0	8.7	102.5	91	6.8	1.7	1.0		
	9/22/16	5.0	23.0	8.6	101.9	91	6.8	1.8	1.1		
	9/22/16	6.0	23.0	8.7	102.1	90	6.8	1.8	1.4		
	9/22/16	7.0	22.9	8.7	102.3	90	6.8	1.7	1.3		
	9/22/16	8.0	22.9	8.6	101.9	91	6.7	1.8	1.4		
	9/22/16	9.0	22.8	8.4	99.2	91	6.7	1.9	1.7		
	9/22/16	9.4	22.1	7.7	88.9	91	6.7	3.6	2.9		
North	9/22/16	0.1	23.4	8.7	103.6	91	7.1	1.7	0.5	10.1	10.5
	9/22/16	2.0	23.0	8.7	102.3	91	7.1	1.8	1.1		
	9/22/16	4.0	23.0	8.6	101.7	91	7.0	2.1	1.0		
	9/22/16	6.0	22.9	8.6	101.7	90	6.9	1.9	1.2		
	9/22/16	8.0	22.7	8.5	100.2	91	6.9	2.1	1.6		
	9/22/16	10.0	19.7	9.0	100.1	88	6.8	2.2	2.9		
	9/22/16	12.0	14.1	5.3	51.8	86	6.7	2.3	3.3		

Hamblin 2016 Field Data										
Station	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Alkalinity	Secchi
		meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	mg/l	meters
	9/22/16	13.0	13.1	1.5	14.5	85	6.4	2.7	2.9		
	9/22/16	14.0	12.6	0.7	6.8	86	6.3	2.8	8.9		
	9/22/16	16.0	10.8	0.5	4.9	109	5.6	3.5	1.9		
	9/22/16	17.0	10.6	0.5	4.5	111	5.5	3.8	2.1		

2015 Hamblin Pond Pre and Post Treatment Field Data Profiles

A1 = south area, A2 = central area, A3 = north area

Pre and Post Treatment Field Data										
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
A1	Pre-treat	6/11/15	0.4	19.3	9.8	108.1	52	7.0	1.7
		6/11/15	1.3	19.3	9.9	108.7	52	6.9	1.9
		6/11/15	2.9	19.3	9.9	109.3	61	6.9	2.5
		6/11/15	3.3	19.3	9.9	108.6	59	6.9	2.9
		6/11/15	5.2	18.4	10.0	108.5	51	6.9	1.9
		6/11/15	6.7	18.3	9.9	107.0	51	6.9	2.1
A1	Pre-treat	6/11/15	0.2	19.3	9.9	108.7	51	7.0	1.1
		6/11/15	1.8	19.2	9.9	109.0	51	7.1	1.5
		6/11/15	3.9	18.9	10.0	109.0	52	7.0	4.1
		6/11/15	5.9	18.4	10.0	107.5	51	7.0	2.9
		6/11/15	8.0	16.5	10.0	103.7	50	7.0	1.6
A1	Treat	6/11/15	0.3	19.8	9.9	109.4	56	7.2	1.6
		6/11/15	2.0	19.6	9.9	109.7	58	7.1	1.6
		6/11/15	4.1	19.2	9.9	108.9	54	7.0	1.4
		6/11/15	6.0	18.7	9.9	107.4	51	7.0	1.7
		6/11/15	8.1	16.8	10.0	104.5	50	7.0	1.7
A1	Treat	6/11/15	0.2	19.9	9.8	109.6	59	7.2	1.9
		6/11/15	2.1	19.6	9.9	109.9	66	7.1	1.9
		6/11/15	4.1	19.4	9.9	109.5	65	7.0	2.4
		6/11/15	6.1	18.9	10.0	108.7	51	7.0	2.1
		6/11/15	8.0	14.0	10.5	103.5	50	7.0	1.9
		6/11/15	9.1	12.0	10.3	96.3	49	7.0	1.6
		6/11/15	10.1	10.2	9.6	86.1	49	6.9	2.5
A1	Treat	6/11/15	0.2	20.2	9.5	106.2	51	7.0	1.3
		6/11/15	2.0	19.7	9.9	109.3	51	7.0	1.2
		6/11/15	4.1	19.6	9.9	109.5	51	7.0	1.2
		6/11/15	6.0	18.9	9.9	108.0	51	7.0	1.4
		6/11/15	8.1	15.7	10.6	108.1	50	7.0	1.6

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
		6/11/15	10.0	10.3	10.5	95.0	49	7.0	1.3
A1	Post-treat	6/11/15	0.1	20.3	9.9	111.4	52	7.3	0.8
		6/11/15	2.0	20.0	10.1	112.2	56	7.2	1.0
		6/11/15	4.0	19.5	10.1	111.9	55	7.2	0.5
		6/11/15	6.0	19.3	10.1	111.5	55	7.2	1.3
		6/11/15	8.0	16.1	10.3	105.5	50	7.1	1.5
		6/11/15	9.9	10.0	7.7	69.3	50	7.1	1.1
A3	Pre-treat/Ref	6/11/15	0.2	20.8	9.6	109.2	51	7.0	1.0
		6/11/15	2.0	20.7	9.9	111.7	52	6.9	1.0
		6/11/15	4.0	20.4	10.0	111.7	53	7.0	0.9
		6/11/15	6.1	18.8	10.1	110.1	51	6.9	1.1
		6/11/15	8.1	15.1	10.8	109.2	50	6.9	1.5
		6/11/15	9.8	9.9	11.5	102.7	49	6.9	1.0
		6/11/15	11.8	8.2	8.5	72.6	49	6.8	0.9
		6/11/15	14.2	6.7	5.7	47.6	49	6.6	0.7
		6/11/15	14.9	6.6	4.6	38.3	49	6.6	0.6
A1	Post-treat	6/12/15	0.3	20.7	9.7	110.0	52	7.0	0.7
		6/12/15	2.0	20.5	9.7	109.6	52	6.9	1.3
		6/12/15	4.0	20.1	9.9	111.0	53	7.0	1.0
		6/12/15	6.0	18.9	10.0	108.6	51	6.9	1.0
		6/12/15	8.0	16.9	9.9	104.0	50	7.0	1.3
		6/12/15	9.6	10.4	7.6	68.5	50	6.7	1.1
A3	Pre-treat/Ref	6/12/15	0.2	20.8	9.8	110.4	52	7.0	1.0
		6/12/15	2.0	20.4	9.8	110.3	53	6.9	1.1
		6/12/15	4.0	20.1	9.9	110.6	53	6.9	1.0
		6/12/15	6.0	19.3	10.0	109.4	52	6.9	1.1
		6/12/15	8.0	15.8	10.6	108.2	50	7.0	1.3
		6/12/15	10.0	10.0	11.6	104.2	49	7.0	1.5
		6/12/15	12.0	8.0	7.8	66.8	49	6.8	0.9
		6/12/15	14.0	6.8	6.3	52.5	49	6.8	0.8
		6/12/15	15.0	6.5	4.9	40.1	49	6.7	0.8
A1	Post-treat	6/12/15	0.2	21.1	9.9	112.6	52	7.0	0.8
		6/12/15	2.0	20.8	10.1	113.8	52	6.9	0.9
		6/12/15	4.0	20.2	10.2	113.9	54	6.9	0.8
		6/12/15	6.0	19.5	10.1	112.1	52	6.9	0.9
		6/12/15	8.0	14.3	10.8	107.4	50	7.0	1.5
		6/12/15	9.4	10.6	7.4	67.1	50	6.7	2.2
A3	Pre-treat/Ref	6/12/15	0.1	21.9	9.6	111.2	52	7.0	3.3
		6/12/15	2.0	21.9	9.7	112.6	52	6.9	2.3
		6/12/15	4.0	20.2	10.0	112.2	53	6.9	1.8
		6/12/15	6.0	19.2	10.2	111.3	51	6.9	1.6

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth meters	Temp °C	DO mg/l	DO % Sat	Sp. Cond µS/cm	pH Units	Turbidity NTU
		6/12/15	8.0	16.5	10.8	111.5	50	6.9	1.7
		6/12/15	10.0	9.9	11.7	104.7	50	6.9	1.9
A3		6/12/15	12.0	7.9	7.7	65.5	49	6.8	1.5
		6/12/15	14.1	6.8	6.5	53.7	49	6.7	1.2
		6/12/15	15.2	6.5	3.7	30.8	49	6.6	0.9
A1	Post-treat	6/13/15	0.3	22.8	9.7	114.4	52	7.1	0.8
		6/13/15	2.0	22.2	9.8	113.8	52	7.1	1.4
		6/13/15	4.0	20.6	10.1	113.3	53	7.1	1.1
		6/13/15	6.0	19.5	10.3	113.8	53	7.1	1.1
		6/13/15	8.0	16.8	10.2	106.6	50	7.1	1.6
		6/13/15	9.5	10.3	8.0	72.5	50	6.9	1.6
A3	Pre-treat/Ref	6/13/15	0.2	21.9	9.7	112.7	53	7.0	1.5
		6/13/15	2.0	21.8	9.8	113.0	53	6.9	1.5
		6/13/15	4.0	21.1	9.9	112.8	53	6.8	1.3
		6/13/15	6.0	19.4	10.3	113.5	53	6.7	1.6
		6/13/15	8.1	15.1	10.9	109.3	50	6.6	1.5
		6/13/15	10.1	9.7	9.2	82.3	50	6.6	1.4
		6/13/15	12.0	7.6	5.8	49.3	49	6.6	0.8
		6/13/15	14.0	6.7	4.4	36.6	49	6.6	0.7
		6/13/15	15.0	6.5	4.2	34.7	50	6.7	0.6
A1	Post-treat	6/14/15	0.3	21.5	9.7	111.3	53	7.2	0.9
		6/14/15	2.0	21.5	9.7	111.0	53	7.0	0.9
		6/14/15	4.0	21.5	9.7	111.6	53	7.0	0.9
		6/14/15	6.0	19.6	10.1	112.0	53	7.1	1.0
		6/14/15	8.0	16.2	10.4	107.3	50	7.1	1.0
		6/14/15	9.9	9.9	8.1	72.9	50	7.0	0.7
A3	Pre-treat/Ref	6/14/15	0.2	21.8	9.6	111.1	53	7.0	1.3
		6/14/15	2.0	21.7	9.6	110.9	53	6.9	1.6
		6/14/15	4.1	20.8	10.0	112.8	53	6.9	1.5
		6/14/15	6.1	19.5	10.1	111.1	52	6.8	1.5
		6/14/15	8.0	16.3	10.6	109.3	50	6.7	1.6
		6/14/15	10.0	10.0	10.5	93.9	49	6.6	1.3
		6/14/15	12.0	8.0	6.4	55.1	49	6.6	0.8
		6/14/15	14.0	7.0	5.8	48.7	49	6.8	0.6
		6/14/15	15.0	6.7	5.7	47.1	49	6.8	0.6
A1	Post-treat	6/14/15	0.3	22.6	9.6	113.1	53	7.2	1.3
		6/14/15	2.0	22.3	9.7	113.5	52	7.1	1.3
		6/14/15	4.0	20.8	10.1	113.9	53	7.0	1.3
		6/14/15	6.0	19.9	10.1	112.6	53	6.9	1.7
		6/14/15	8.0	16.6	10.2	105.8	50	6.9	1.6
		6/14/15	9.5	10.5	8.7	79.4	50	6.9	1.2
A3	Pre-treat/Ref	6/14/15	0.2	22.3	9.6	111.9	53	7.1	1.7

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth meters	Temp °C	DO mg/l	DO % Sat	Sp. Cond µS/cm	pH Units	Turbidity NTU
		6/14/15	2.1	22.4	9.6	112.4	53	7.0	1.6
		6/14/15	4.1	21.7	9.8	113.2	53	6.9	1.3
A3		6/14/15	6.0	19.7	10.1	111.4	53	6.8	1.4
		6/14/15	8.1	16.4	10.2	106.0	50	6.7	1.5
		6/14/15	10.0	10.3	8.6	77.5	49	6.7	1.2
		6/14/15	12.0	8.1	5.5	47.6	49	6.7	0.9
		6/14/15	14.0	7.1	4.7	39.5	49	6.7	0.6
		6/14/15	15.1	6.7	4.3	35.8	49	6.8	0.7
A1	Post-treat/Ref	6/15/15	0.2	21.7	9.3	106.8	53	7.0	2.0
		6/15/15	0.3	21.7	9.5	109.4	53	7.0	1.3
		6/15/15	2.1	21.7	9.5	109.3	53	6.9	1.2
		6/15/15	4.1	21.2	9.8	111.7	53	6.9	1.0
		6/15/15	6.0	19.6	9.9	109.9	52	6.9	1.4
		6/15/15	8.0	15.9	9.9	101.5	50	6.8	1.3
		6/15/15	9.8	10.3	8.2	74.3	50	6.8	0.8
A3	Pre-treat/Ref	6/15/15	0.3	21.7	9.5	109.5	53	7.0	1.5
		6/15/15	2.0	21.7	9.5	109.1	53	6.9	1.5
		6/15/15	4.0	21.6	9.7	111.2	53	6.9	1.8
		6/15/15	6.0	19.8	10.0	111.1	53	6.8	1.9
		6/15/15	8.1	15.5	10.6	107.2	50	6.7	1.9
		6/15/15	10.1	10.1	8.9	80.2	49	6.7	1.6
		6/15/15	12.1	7.6	5.6	47.6	49	6.7	1.0
		6/15/15	14.1	6.6	3.4	28.3	49	6.7	1.2
		6/15/15	15.2	6.5	0.6	5.1	51	6.7	1.5
A2	Treat	6/15/15	0.3	21.7	9.4	108.4	56	7.5	1.9
		6/15/15	2.1	21.7	9.4	108.3	63	7.3	3.1
		6/15/15	4.0	21.6	9.5	109.0	67	7.2	3.3
		6/15/15	6.0	19.8	10.1	112.0	53	7.2	3.2
		6/15/15	8.1	16.2	10.7	109.9	50	7.1	2.3
		6/15/15	10.1	9.5	9.3	83.0	49	7.1	1.8
		6/15/15	12.0	8.1	6.8	57.9	49	7.0	1.5
		6/15/15	13.0	7.7	5.2	43.9	49	6.9	1.7
A2	Treat	6/15/15	0.3	21.6	9.4	108.1	53	7.3	1.6
		6/15/15	2.1	21.6	9.4	108.3	58	7.2	1.9
		6/15/15	4.0	21.5	9.4	107.9	63	7.1	2.0
		6/15/15	6.0	19.6	10.1	111.7	52	7.1	1.6
		6/15/15	8.0	15.7	11.0	111.8	50	7.1	2.1
		6/15/15	10.1	9.9	11.2	100.1	49	7.0	1.8
		6/15/15	12.0	8.1	7.0	60.3	49	6.9	1.6
		6/15/15	14.5	6.8	3.7	30.4	50	6.8	1.4
A2	Treat	6/15/15	0.4	21.5	9.5	109.0	60	7.3	1.7
		6/15/15	2.1	21.5	9.5	108.8	60	7.1	1.7
		6/15/15	4.0	21.5	9.5	109.0	58	7.1	1.6

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
		6/15/15	6.1	19.6	10.0	111.2	53	7.1	1.5
		6/15/15	8.0	16.3	10.5	108.6	50	7.1	1.7
A2		6/15/15	10.0	9.8	10.2	91.4	50	7.1	1.6
		6/15/15	12.1	8.3	6.4	55.6	50	6.9	1.5
		6/15/15	13.2	7.5	3.0	25.1	50	6.8	2.1
A1	Post-treat/Ref	6/15/15	0.3	21.4	9.6	110.0	52	7.1	1.7
		6/15/15	2.0	21.4	9.6	109.6	52	7.1	1.5
		6/15/15	4.1	21.4	9.7	110.7	53	7.0	1.4
		6/15/15	6.0	20.0	10.0	111.1	53	6.9	1.4
		6/15/15	8.1	14.3	10.5	103.4	50	6.9	1.1
A3	Pre-treat/Ref	6/15/15	0.2	21.4	9.6	109.4	55	7.0	1.7
		6/15/15	2.0	21.4	9.6	109.6	55	6.9	1.7
		6/15/15	4.0	21.4	9.7	110.8	56	6.8	1.5
		6/15/15	6.0	19.7	10.1	111.7	53	6.8	1.9
		6/15/15	8.0	15.6	10.6	108.1	50	6.7	2.1
		6/15/15	10.1	10.0	10.0	89.7	49	6.6	1.8
		6/15/15	12.1	7.8	5.4	45.7	49	6.7	1.0
		6/15/15	14.2	6.7	4.4	36.5	49	6.7	1.0
A2	Post-treat	6/15/15	0.3	21.4	9.5	109.3	62	7.0	2.0
		6/15/15	2.1	21.4	9.5	109.0	65	6.9	2.5
		6/15/15	4.1	21.4	9.5	109.1	67	6.9	2.3
		6/15/15	6.1	19.6	10.2	112.2	53	6.8	2.2
		6/15/15	8.1	16.1	10.7	110.2	50	6.8	2.7
		6/15/15	10.1	10.1	11.3	101.5	50	6.6	1.7
		6/15/15	12.0	8.2	6.2	53.4	49	6.6	1.9
		6/15/15	14.0	6.8	2.8	23.5	50	6.6	3.2
		6/15/15	15.4	6.5	1.4	11.9	52	6.7	4.4
A1	Post-treat/Ref	6/16/15	0.2	21.0	9.1	103.3	55	7.1	1.1
		6/16/15	2.0	21.0	9.1	103.0	55	7.0	0.9
		6/16/15	4.0	20.9	9.2	104.4	54	7.0	1.0
		6/16/15	6.0	19.9	9.5	105.7	53	6.9	1.6
		6/16/15	8.0	15.1	9.8	98.2	50	6.9	1.7
		6/16/15	10.0	10.3	7.7	69.9	50	7.0	1.5
A2	Post-treat/Ref	6/16/15	0.2	20.9	9.1	103.4	60	6.9	1.1
		6/16/15	1.0	20.9	9.1	103.7	60	6.9	1.2
		6/16/15	3.0	20.9	9.1	103.5	60	6.8	1.4
		6/16/15	5.0	20.9	9.1	103.1	59	6.7	1.3
		6/16/15	7.0	18.4	9.4	101.8	51	6.6	1.1
		6/16/15	9.0	11.6	9.0	83.5	50	6.5	0.8
		6/16/15	11.1	8.8	6.7	58.7	49	6.5	0.5
		6/16/15	13.1	7.1	3.1	25.9	50	6.5	0.8
		6/16/15	15.0	6.5	0.5	4.2	52	6.5	0.7

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
A3	Pre-treat	6/16/15	0.2	20.9	9.1	103.4	56	7.0	1.3
		6/16/15	1.0	20.9	9.1	102.9	56	6.9	1.5
A3		6/16/15	3.0	20.9	9.1	103.4	58	6.9	1.4
		6/16/15	5.0	20.5	9.3	104.8	55	6.8	1.4
		6/16/15	7.0	18.5	9.7	105.3	51	6.7	1.5
		6/16/15	9.0	12.3	9.8	92.9	49	6.6	1.2
		6/16/15	11.0	8.9	7.4	65.0	50	6.6	1.3
		6/16/15	12.9	7.4	4.5	37.9	49	6.7	1.1
		6/16/15	15.0	6.7	1.1	8.9	50	6.7	1.4
		6/16/15	17.0	6.3	0.1	0.8	52	6.7	1.5
A1	Post-treat/Ref	6/16/15	0.2	22.0	9.1	105.7	55	7.1	1.1
		6/16/15	1.1	21.5	9.2	105.3	55	7.1	1.2
		6/16/15	3.1	21.1	9.3	105.8	54	7.1	1.2
		6/16/15	4.2	21.0	9.4	106.8	53	7.0	1.0
		6/16/15	5.0	20.6	9.6	107.8	53	7.0	1.2
		6/16/15	7.1	18.1	9.8	104.8	51	7.0	1.4
		6/16/15	8.4	13.7	9.5	93.2	50	7.0	1.1
A3	Treat	6/16/15	0.1	22.2	9.0	104.4	56	7.0	1.3
		6/16/15	1.0	21.3	9.1	104.3	60	7.0	1.5
		6/16/15	3.0	21.1	9.1	103.3	64	6.9	1.4
		6/16/15	5.0	20.8	9.3	105.7	60	6.9	1.4
		6/16/15	7.0	18.7	9.8	106.5	51	6.8	1.4
		6/16/15	9.0	11.9	10.3	96.4	50	6.8	1.4
		6/16/15	11.0	9.0	7.7	67.6	49	6.7	1.2
		6/16/15	13.0	7.5	4.4	36.8	50	6.8	1.6
		6/16/15	15.0	6.7	1.8	14.7	50	6.8	1.3
A1	Post-treat/Ref	6/16/15	0.2	22.3	8.4	98.1	55	7.1	1.8
		6/16/15	1.0	21.4	8.5	97.9	55	7.1	1.9
		6/16/15	3.0	21.1	8.7	99.2	54	7.1	1.6
		6/16/15	5.0	20.2	8.8	98.7	53	7.1	1.8
		6/16/15	7.0	18.3	8.6	92.8	51	7.0	1.6
		6/16/15	9.1	10.8	6.8	62.0	50	7.0	1.4
A2	Post-treat/Ref	6/16/15	1.0	21.9	8.4	97.6	57	7.0	1.8
		6/16/15	3.0	21.1	8.6	98.1	58	6.9	1.8
		6/16/15	5.1	20.6	8.8	98.7	60	6.9	1.7
		6/16/15	7.1	18.5	8.8	94.9	51	6.8	1.8
		6/16/15	8.8	12.5	8.7	82.6	50	6.7	1.9
		6/16/15	11.1	9.2	7.0	61.5	50	6.7	1.3
		6/16/15	12.9	7.3	3.6	30.5	49	6.8	1.4
		6/16/15	15.2	6.6	2.0	16.8	51	6.9	1.9
A3	Post-treat	6/16/15	1.0	21.8	8.4	97.3	61	6.9	2.1
		6/16/15	3.0	21.2	8.5	96.6	67	6.8	2.0
		6/16/15	5.0	21.0	8.6	97.8	81	6.7	2.1

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth meters	Temp °C	DO mg/l	DO % Sat	Sp. Cond µS/cm	pH Units	Turbidity NTU
		6/16/15	7.0	18.6	9.0	97.2	51	6.7	2.2
		6/16/15	9.1	11.1	9.5	87.0	49	6.6	2.1
A3		6/16/15	11.1	8.5	6.3	54.3	50	6.5	1.3
		6/16/15	13.0	7.3	4.4	36.7	49	6.6	1.1
		6/16/15	15.0	6.6	2.0	16.6	50	6.7	3.0
		6/16/15	17.0	6.4	1.2	9.8	53	6.7	3.5
A1	Post-treat/Ref	6/17/15	0.3	21.0	9.1	103.0	58	7.1	1.9
		6/17/15	2.0	21.0	9.1	103.0	58	7.1	1.9
		6/17/15	3.9	21.0	9.0	102.6	58	7.0	2.0
		6/17/15	6.0	20.9	9.3	105.4	58	7.0	2.0
		6/17/15	8.0	15.8	9.9	101.6	50	6.9	2.1
		6/17/15	10.1	10.0	7.9	70.5	50	7.1	2.5
A2	Post-treat/Ref	6/17/15	0.9	21.1	9.1	104.0	59	7.0	1.6
		6/17/15	3.0	21.1	9.1	103.8	59	7.0	1.7
		6/17/15	5.0	21.1	9.2	104.5	59	6.9	2.4
		6/17/15	6.9	18.8	9.4	102.3	51	6.8	1.6
		6/17/15	9.6	11.1	9.4	86.3	49	6.7	1.8
		6/17/15	10.5	9.9	7.7	69.4	50	6.7	1.5
		6/17/15	13.6	7.2	4.6	38.3	49	6.8	1.7
		6/17/15	14.4	6.7	1.8	14.7	50	6.8	2.0
A3	Post-treat/Ref	6/17/15	1.1	21.1	9.1	103.9	60	7.1	1.6
		6/17/15	3.0	21.1	9.1	103.8	60	7.0	1.4
		6/17/15	5.2	20.9	9.2	104.2	59	6.9	1.5
		6/17/15	7.1	18.8	9.3	101.1	51	6.8	1.6
		6/17/15	9.7	10.3	9.9	89.2	50	6.7	1.5
		6/17/15	11.3	8.6	7.1	61.3	50	6.7	1.1
		6/17/15	13.0	7.3	4.0	33.6	49	6.7	1.1
		6/17/15	15.3	6.6	1.9	15.7	50	6.7	1.3
A1	Post-treat/Ref	6/18/15	0.2	21.0	9.1	103.3	59	6.9	1.8
		6/18/15	2.0	20.9	9.1	102.7	59	6.8	1.6
		6/18/15	4.0	20.9	9.1	103.5	59	6.8	1.6
		6/18/15	6.0	20.4	9.4	105.6	55	6.7	1.9
		6/18/15	8.0	16.5	9.8	101.2	51	6.6	1.8
		6/18/15	10.1	10.2	8.1	72.7	50	6.5	2.0
A2	Pre-treat	6/18/15	1.0	20.9	9.1	103.3	59	6.7	1.4
		6/18/15	3.0	20.9	9.1	103.3	60	6.6	1.3
		6/18/15	5.0	20.9	9.2	104.2	59	6.6	1.6
		6/18/15	7.0	19.2	9.5	104.2	52	6.5	1.4
		6/18/15	9.1	12.2	9.8	92.2	49	6.4	1.6
		6/18/15	11.0	9.0	8.1	71.2	50	6.3	1.4
		6/18/15	12.9	7.4	4.6	38.8	49	6.3	1.5
		6/18/15	14.7	6.7	3.2	26.3	51	6.2	1.3

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
A3	Post-treat/Ref	6/18/15	1.0	20.9	9.2	103.9	59	6.8	1.8
		6/18/15	3.0	20.9	9.1	103.5	59	6.7	1.7
A3		6/18/15	5.0	20.8	9.2	103.7	59	6.6	1.4
		6/18/15	7.0	19.3	9.4	103.8	52	6.5	1.5
		6/18/15	9.0	11.4	9.7	89.5	49	6.4	1.9
		6/18/15	11.0	9.2	7.9	69.4	49	6.3	1.8
		6/18/15	13.0	7.3	3.7	31.2	49	6.3	1.4
		6/18/15	15.0	6.5	0.0	0.2	51	6.2	2.7
		6/18/15	17.0	6.4	0.1	0.6	58	6.1	2.7
A1	Post-treat/Ref	6/18/15	0.2	21.2	9.1	104.2	58	7.2	1.5
		6/18/15	2.0	21.0	9.2	104.3	58	7.2	1.6
		6/18/15	4.0	20.9	9.3	105.4	59	7.1	1.5
		6/18/15	6.0	20.4	9.5	106.5	56	7.1	1.7
		6/18/15	7.8	16.3	10.0	103.8	50	7.0	1.9
		6/18/15	10.0	10.2	7.3	66.3	50	7.0	1.9
A2	Treat	6/18/15	1.0	20.9	9.2	104.4	59	7.1	1.6
		6/18/15	3.0	20.9	9.1	103.7	63	7.0	1.9
		6/18/15	5.0	20.9	9.2	104.3	75	6.9	2.4
		6/18/15	7.0	19.1	9.4	102.6	52	6.9	2.2
		6/18/15	9.0	11.8	9.3	87.1	50	6.8	1.9
		6/18/15	11.0	9.1	7.3	64.1	49	6.8	1.3
		6/18/15	13.0	7.2	4.1	34.1	49	6.8	1.5
		6/18/15	15.1	6.6	2.4	19.6	52	6.9	2.3
A3	Post-treat/Ref	6/18/15	0.9	21.0	9.2	104.7	59	7.0	1.3
		6/18/15	3.0	20.9	9.3	105.0	59	6.9	1.4
		6/18/15	5.0	20.8	9.3	105.1	59	6.8	1.8
		6/18/15	7.0	18.7	9.5	102.7	51	6.7	1.9
		6/18/15	9.0	12.0	9.6	90.2	49	6.7	1.8
		6/18/15	11.0	8.8	6.4	55.7	50	6.6	1.5
		6/18/15	13.0	7.3	3.8	31.7	49	6.6	1.2
		6/18/15	15.1	6.6	1.4	11.6	50	6.6	2.5
		6/18/15	16.7	6.4	0.4	2.9	51	6.5	4.0
A1	Post-treat/Ref	6/18/15	0.2	21.3	9.3	106.0	59	7.2	1.8
		6/18/15	2.0	21.2	9.3	106.3	60	7.1	2.0
		6/18/15	4.1	21.0	9.4	107.2	62	7.1	1.7
		6/18/15	6.0	20.0	9.8	109.0	54	7.0	2.0
		6/18/15	7.8	16.5	10.2	106.1	50	6.9	2.6
		6/18/15	9.9	10.4	8.1	73.8	50	7.0	2.5
A2	Treat	6/18/15	0.9	21.5	9.2	105.7	70	7.0	2.2
		6/18/15	3.0	21.3	9.3	106.2	68	7.0	2.3
		6/18/15	5.0	21.1	9.3	106.3	66	6.9	2.3
		6/18/15	7.1	18.2	9.7	104.0	51	6.8	2.2
		6/18/15	9.1	12.0	9.2	86.1	50	6.7	2.0

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
		6/18/15	11.0	8.8	5.4	47.5	50	6.7	1.8
		6/18/15	13.1	7.2	3.8	31.9	49	6.7	2.3
A2		6/18/15	15.0	6.7	2.5	20.4	51	6.7	3.9
A3	Post-treat/Ref	6/18/15	1.0	21.4	9.3	106.1	62	7.0	1.6
		6/18/15	3.0	21.4	9.3	107.1	61	7.0	1.7
		6/18/15	5.0	21.4	9.4	107.6	62	6.9	1.7
		6/18/15	7.0	18.6	9.9	107.8	51	6.8	1.9
		6/18/15	9.0	11.9	10.8	101.1	50	6.8	1.8
		6/18/15	11.3	8.5	6.0	52.2	49	6.8	1.7
		6/18/15	12.9	7.4	3.5	29.7	49	6.8	1.5
		6/18/15	15.1	6.5	1.4	11.7	50	6.9	2.1
		6/18/15	16.6	6.4	1.2	9.6	54	7.0	3.3
A1	Post-treat/Ref	6/19/15	0.1	20.8	9.1	102.8	63	7.2	1.4
		6/19/15	2.0	20.9	9.1	103.1	63	7.2	1.6
		6/19/15	4.1	20.9	9.1	103.6	62	7.2	1.6
		6/19/15	6.1	20.2	9.3	103.7	57	7.1	1.6
		6/19/15	8.1	15.4	9.5	96.5	50	7.2	1.8
		6/19/15	10.2	10.3	8.0	72.5	50	7.3	2.0
A2	Post-treat/Ref	6/19/15	1.0	21.0	9.1	103.4	62	7.0	1.7
		6/19/15	3.0	21.0	9.1	103.5	62	7.0	1.8
		6/19/15	5.0	20.9	9.1	103.6	61	6.9	1.6
		6/19/15	7.0	18.8	9.4	102.6	51	6.8	1.6
		6/19/15	9.0	11.7	8.9	82.9	50	6.8	1.7
		6/19/15	11.0	9.2	6.9	60.9	50	6.7	1.6
		6/19/15	13.1	7.2	4.1	34.2	49	6.7	1.7
		6/19/15	14.9	6.6	1.6	12.9	51	6.7	2.2
A3	Pre-treat	6/19/15	1.0	21.0	9.0	102.8	62	7.0	1.7
		6/19/15	3.0	21.0	9.0	102.4	62	6.9	1.8
		6/19/15	5.0	21.0	9.1	102.8	62	6.8	1.8
		6/19/15	7.0	18.6	9.1	98.9	51	6.7	1.9
		6/19/15	9.0	11.8	9.1	84.9	49	6.6	2.0
		6/19/15	11.0	8.8	5.7	49.5	49	6.5	1.8
		6/19/15	13.0	7.4	3.0	25.0	49	6.5	2.0
		6/19/15	15.1	6.7	0.7	5.8	51	6.5	2.0
		6/19/15	16.4	6.5	0.4	3.6	52	6.4	3.8
A3a	Treat	6/19/15	1.0	21.4	9.1	104.6	67	7.1	2.3
		6/19/15	3.0	21.1	9.1	104.1	71	7.0	2.5
		6/19/15	4.9	21.1	9.1	103.9	74	6.9	2.4
		6/19/15	6.6	19.9	9.4	104.3	55	6.8	1.5
		6/19/15	9.4	11.2	10.2	94.1	50	6.7	2.0
		6/19/15	11.2	8.8	6.8	59.0	49	6.7	1.8
		6/19/15	12.7	7.6	4.6	38.5	49	6.7	2.0

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
A3	Pre-treat	6/19/15	1.0	21.6	9.1	104.7	63	7.0	1.4
		6/19/15	3.0	21.4	9.1	104.1	63	6.9	1.4
A3		6/19/15	5.1	21.2	9.0	103.2	63	6.8	1.6
		6/19/15	6.9	18.7	9.4	101.8	51	6.6	1.7
		6/19/15	8.9	11.8	9.3	86.9	49	6.6	1.7
		6/19/15	11.0	8.9	6.8	59.7	49	6.5	1.6
		6/19/15	13.0	7.3	2.8	23.3	49	6.5	1.8
		6/19/15	15.0	6.6	0.5	4.1	51	6.5	2.6
		6/19/15	16.8	6.4	0.6	5.0	53	6.4	2.4
A1	Post-treat/Ref	6/19/15	0.3	22.1	9.1	106.1	63	7.3	1.1
		6/19/15	2.1	21.8	9.2	106.0	63	7.3	0.9
		6/19/15	4.1	21.6	9.2	106.0	62	7.2	1.4
		6/19/15	6.0	21.0	9.4	107.3	63	7.2	1.5
		6/19/15	8.4	13.3	10.7	104.0	50	7.1	1.3
		6/19/15	10.0	10.3	8.7	79.1	50	7.1	1.5
A2	Post-treat/Ref	6/19/15	1.1	21.8	9.1	104.9	63	7.1	1.4
		6/19/15	3.0	21.7	9.2	106.0	63	7.1	1.3
		6/19/15	5.1	21.4	9.4	107.4	62	7.0	1.4
		6/19/15	7.0	18.0	9.7	103.7	52	6.8	1.5
		6/19/15	9.0	12.1	9.9	93.5	50	6.8	1.4
		6/19/15	11.5	8.2	6.0	51.8	49	6.7	1.5
		6/19/15	13.2	7.1	2.7	22.5	49	6.9	1.4
		6/19/15	15.1	6.6	2.5	21.0	51	6.9	1.5
A3	Treat	6/19/15	1.0	21.6	9.2	105.2	64	7.6	2.1
		6/19/15	3.1	21.2	9.2	104.9	68	7.6	2.3
		6/19/15	5.1	20.9	9.3	105.5	65	7.4	2.7
		6/19/15	6.6	20.4	9.3	104.8	60	7.0	4.7
		6/19/15	9.1	12.0	10.8	101.4	49	6.7	1.8
		6/19/15	11.3	8.5	6.9	59.7	50	6.6	1.9
		6/19/15	12.9	7.6	3.3	28.2	49	6.6	1.5
		6/19/15	15.0	6.6	1.2	9.5	50	6.6	2.7
		6/19/15	16.9	6.4	0.3	2.4	56	6.6	3.5
A1	Pre-treat	6/22/15	0.2	21.7	9.3	107.6	65	6.9	1.0
		6/22/15	2.0	21.7	9.3	107.6	64	6.8	1.0
		6/22/15	4.0	21.6	9.4	108.1	65	6.8	0.9
		6/22/15	6.0	20.8	9.6	108.6	61	6.8	0.9
		6/22/15	8.0	15.8	10.0	102.0	50	6.8	1.0
		6/22/15	10.0	10.7	7.6	69.6	50	6.8	1.3
A2	Post-treat/Ref	6/22/15	1.0	21.7	9.3	107.4	64	6.9	1.3
		6/22/15	3.0	21.7	9.3	106.6	64	6.8	1.4
		6/22/15	5.0	21.5	9.3	106.5	64	6.7	1.1
		6/22/15	7.0	20.0	9.3	103.6	56	6.5	1.3
		6/22/15	9.0	12.4	8.7	82.2	50	6.4	1.4

Pre and Post Treatment Field Data									
Treatment Station	Treatment Status	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity
			meters	°C	mg/l	% Sat	µS/cm	Units	NTU
		6/22/15	11.0	9.1	6.7	58.9	49	6.4	1.5
		6/22/15	13.0	7.4	3.9	32.6	49	6.4	1.9
A2		6/22/15	14.7	6.7	0.7	5.4	51	6.3	2.2
A3	Post-treat/Ref	6/22/15	1.0	21.7	9.2	105.9	64	6.8	1.4
		6/22/15	3.0	21.6	9.2	105.8	64	6.8	1.2
		6/22/15	5.0	21.6	9.2	106.1	64	6.6	1.0
		6/22/15	7.0	18.9	9.4	102.9	53	6.6	1.0
		6/22/15	9.0	12.5	9.4	89.8	50	6.5	1.1
		6/22/15	11.0	8.8	6.1	52.9	49	6.5	1.2
		6/22/15	13.0	7.2	3.7	31.2	49	6.4	1.1
		6/22/15	15.0	6.6	0.0	0.0	51	6.4	2.5
		6/22/15	17.1	6.5	0.1	0.5	56	6.4	3.4
A1	Treat	6/22/15	0.2	24.3	9.0	108.4	65	7.2	0.5
		6/22/15	2.0	22.2	9.3	108.2	66	7.2	0.7
		6/22/15	4.0	22.0	9.3	107.2	68	7.1	0.8
		6/22/15	6.0	21.8	9.2	106.5	65	7.0	0.6
		6/22/15	8.0	14.6	9.5	94.2	50	7.1	0.9
		6/22/15	10.0	10.7	9.7	88.5	50	7.1	1.3
A3	Post-treat/Ref	6/22/15	1.0	22.1	9.3	108.4	65	7.0	1.1
		6/22/15	3.0	21.8	9.4	108.3	64	6.9	0.9
		6/22/15	5.0	21.7	9.5	109.3	64	6.8	1.2
		6/22/15	7.0	20.3	9.6	107.2	58	6.7	1.1
		6/22/15	9.0	12.2	9.6	90.6	50	6.7	1.2
		6/22/15	11.1	9.2	7.9	69.5	49	6.6	1.2
		6/22/15	13.0	7.3	3.3	28.0	49	6.6	1.0
		6/22/15	15.0	6.7	0.2	1.7	52	6.6	1.8
		6/22/15	17.0	6.4	0.2	1.7	62	6.6	2.5

Phytoplankton Data

	2015 PHYTOPLANKTON BIOMASS (UG/L)											
	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin
	N	N	N	S	N	S	N	S	N	S	N	S
TAXON	04/22/15	05/13/15	06/10/15	06/10/15	06/22/15	06/22/15	07/10/15	07/10/15	08/13/15	08/13/15	09/24/15	09/24/15
BACILLARIOPHYTA												
Centric Diatoms												
Cyclotella	48.0	73.0	86.5	43.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Araphid Pennate Diatoms												
Asterionella	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Synedra	414.7	70.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.4
Tabellaria	199.7	70.1	0.0	0.0	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0
Monoraphid Pennate Diatoms												
Biraphid Pennate Diatoms												
CHLOROPHYTA												
Flagellated Chlorophytes												
Coccoid/Colonial Chlorophytes												
Elakatothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.9
Oocystis	30.7	0.0	27.7	55.7	0.0	0.0	0.0	0.0	21.3	0.0	13.8	0.0
Schroederia	48.0	0.0	0.0	0.0	36.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Chlorophytes												
Desmids												
Staurastrum	0.0	0.0	13.8	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Teilingia/related taxa	38.4	29.2	69.2	139.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xanthidium	0.0	0.0	5.2	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CHRYSOPHYTA												
Flagellated Classic Chrysophytes												
Chromulina	76.8	20.4	12.1	20.0	16.1	11.9	10.4	16.8	4.0	3.7	2.6	1.5
Dinobryon	230.4	87.6	207.6	208.8	87.6	54.9	155.7	350.4	1755.6	2343.6	311.4	350.4
Mallomonas	0.0	0.0	8.7	0.0	0.0	0.0	0.0	0.0	13.3	9.3	8.7	14.6
Non-Motile Classic Chrysophytes												
Haptophytes												
Tribophytes/Eustigmatophytes												
Centritractus	0.0	2.2	2.6	0.0	0.0	0.0	2.6	2.2	0.0	0.0	0.0	0.0
Raphidophytes												
CRYPTOPHYTA												
Cryptomonas	3.8	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CYANOPHYTA												
Unicellular and Colonial Forms												
Aphanocapsa	0.0	0.0	10.4	12.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Nitrogen Fixers												
Anabaena	0.0	0.0	27.7	27.8	0.0	0.0	0.0	146.0	0.0	0.0	0.0	0.0
Filamentous Non-Nitrogen Fixers												
Planktothrix	0.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA												
PYRRHOPHYTA												
Peridinium	40.3	0.0	778.5	0.0	0.0	0.0	72.7	30.7	27.9	39.1	778.5	657.0

Phytoplankton Data

	2016 PHYTOPLANKTON BIOMASS (UG/L)				
	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin
	N	N	N	N	N
TAXON	04/28/16	06/02/16	07/07/16	08/17/16	09/22/16
BACILLARIOPHYTA					
Centric Diatoms					
Cyclotella	0.0	15.0	0.0	0.0	0.0
Araphid Pennate Diatoms					
Asterionella	34.0	9.6	0.0	0.0	0.0
Tabellaria	0.0	0.0	172.0	47.4	84.0
Monoraphid Pennate Diatoms					
Biraphid Pennate Diatoms					
CHLOROPHYTA					
Flagellated Chlorophytes					
Coccoid/Colonial Chlorophytes					
Filamentous Chlorophytes					
Desmids					
Cosmarium	0.0	0.0	13.8	0.0	0.0
Staurastrum	0.0	0.0	0.0	5.9	0.0
Staurodesmus	6.0	3.6	0.0	4.4	0.0
Teilingia/related taxa	0.0	12.0	103.2	0.0	0.0
CHRYSOPHYTA					
Flagellated Classic Chrysophytes					
Dinobryon	1530.0	126.0	77.4	888.0	157.5
Mallomonas	0.0	3.0	4.3	0.0	0.0
Non-Motile Classic Chrysophytes					
Haptophytes					
Tribophytes/Eustigmatophytes					
Raphidophytes					
CRYPTOPHYTA					
CYANOPHYTA					
Unicellular and Colonial Forms					
Filamentous Nitrogen Fixers					
Filamentous Non-Nitrogen Fixers					
EUGLENOPHYTA					
Trachelomonas	0.0	6.0	8.6	0.0	0.0
PYRRHOPHYTA					
Ceratium	0.0	0.0	0.0	64.4	0.0
Peridinium	471.0	282.6	54.2	348.5	15.8

Zooplankton Data

TAXON	2015 ZOOPLANKTON BIOMASS (UG/L)											
	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin
	N	N	N	S	N	S	N	S	N	S	N	S
	4/23/15	5/13/15	6/10/15	6/10/15	6/22/15	6/22/15	7/10/15	7/10/15	8/13/15	8/13/15	9/24/15	9/24/15
PROTOZOA												
Ciliophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA												
Conochilus	0.0	0.2	4.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
Kellicottia	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COPEPODA												
Copepoda-Cyclopoida												
Cyclops	231.3	55.9	12.8	23.1	0.6	0.6	3.2	0.6	1.0	0.5	0.5	0.4
Mesocyclops	0.0	0.0	11.8	6.6	0.3	0.0	2.3	0.6	12.6	0.3	0.0	0.0
Copepoda-Calanoida												
Diaptomus	3.8	4.9	3.5	3.5	0.1	0.2	3.5	0.6	4.1	1.1	5.9	4.1
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	44.0	48.2	16.7	13.9	1.4	2.8	11.0	1.3	2.1	1.7	1.7	1.7
CLADOCERA												
Bosmina	4.7	4.7	9.4	6.3	0.3	0.3	1.3	0.5	2.0	0.4	0.2	0.2
Ceriodaphnia	0.0	0.0	5.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia ambigua	3.8	46.1	72.9	96.3	0.4	0.0	2.3	0.0	0.0	0.0	0.0	0.0
Daphnia pulex	0.0	13.7	12.2	28.9	0.0	0.0	1.5	1.4	0.0	0.0	1.2	0.9
Diaphanosoma	0.0	0.8	1.0	1.0	0.0	0.0	0.5	0.0	3.2	0.2	0.6	0.8
MEAN LENGTH (mm): ALL FORMS	0.64	0.56	0.30	0.55	0.40	0.45	0.57	0.57	0.69	0.54	0.55	0.61
MEAN LENGTH: CRUSTACEANS	0.64	0.59	0.60	0.64	0.49	0.45	0.57	0.57	0.69	0.59	0.69	0.68

TAXON	2016 ZOOPLANKTON BIOMASS (UG/L)				
	Hamblin	Hamblin	Hamblin	Hamblin	Hamblin
	N&S	N&S	N&S	N&S	N&S
	4/29/16	6/2/16	7/7/16	8/17/16	9/22/16
PROTOZOA					
Ciliophora	0.0	0.9	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0
ROTIFERA					
Conochilus	0.0	0.0	0.0	0.0	0.2
Keratella	0.0	0.1	0.0	0.0	0.0
COPEPODA					
Copepoda-Cyclopoida					
Cyclops	0.0	1.0	0.9	0.0	0.0
Mesocyclops	3.4	1.5	2.8	2.0	1.1
Copepoda-Calanoida					
Diaptomus	1.7	4.8	3.4	1.1	0.2
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	3.1	10.6	7.8	7.2	11.1
CLADOCERA					
Bosmina	2.7	1.2	0.4	1.1	0.4
Daphnia ambigua	0.0	0.0	0.0	0.6	0.7
Daphnia pulex	17.5	33.0	16.6	10.7	49.3
Diaphanosoma	0.0	0.4	2.9	0.4	1.6
Holopedium	3.3	6.7	3.1	3.3	3.5
MEAN LENGTH (mm): ALL FORMS	0.57	0.24	0.65	0.56	0.60
MEAN LENGTH: CRUSTACEANS	0.60	0.67	0.67	0.56	0.74