
Great Pond Alum Treatment Final Report

Town of Eastham,
Massachusetts

EcoLogic LLC

November 21, 2014

Great Pond Alum Treatment

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Great Pond Alum Treatment Program Final Report

Introduction

The Eastham Ponds Action Plan, submitted to the Town of Eastham Massachusetts in December, 2011, recommended an alum treatment program to help mitigate the internal (sediment) phosphorus loading of Herring Pond (top priority) and Great Pond. Both ponds exhibit deteriorating water quality conditions, with increased algal growth during the summer months. The water quality and aesthetic condition of Herring Pond were impaired to a significant degree, while Great Pond was in an earlier stage of decline.

Funding for the alum treatment program of Herring Pond was approved in the Town budget for the fiscal year beginning July, 2012. GHD and EcoLogic, in collaboration with Town officials and advisory boards, obtained the required permits and approvals for the treatment. EcoLogic collected sediment samples from Herring Pond and worked with Spectrum Analytical of Agawam MA to assay the sediments and calculate the application rate that would immobilize the pool of iron-bound phosphorus present in the pond's sediments. The Town Conservation Commission drew up an Order of Conditions to ensure that the alum treatment program would minimize the risk of harm to the environment.

GHD contracted with Aquatic Control Technology (ACT), a licensed applicator, to apply a calibrated mixture of aluminum sulfate (alum) and sodium aluminate to Herring Pond, based on the site-specific dose calculation. The alum treatment program and the associated water quality monitoring of Herring Pond were completed over a several week period, beginning on October 24, 2012 and ending on November 13, 2012. The results of the treatment of Herring Pond were extremely positive: phosphorus concentrations declined significantly following the treatment, as documented by quarterly monitoring during 2013 and confirmed by 2014 PALS monitoring. Summer water quality conditions were highly improved. Water clarity (as measured by Secchi disk transparency) increased from less than 1 m (2010 – 2012 conditions) to 4.5 m in 2013 and 5 m in 2014. The measured improvement is confirmed by positive reaction from residents and visitors.

Funding for an alum treatment program of Great Pond was approved in the Town budget for the fiscal year beginning in July, 2013. The same team that completed the successful Herring Pond project on behalf of the Town worked together on the Great Pond alum treatment program, and followed similar procedures to obtain permits and approvals, test the sediments, calculate dosage, apply the chemicals, and monitor the pond's water quality and biota before, during, and after the alum application.

The chemical treatment program was completed October 4 - 8, 2013. As documented in this report, the treatment program was successful in reducing the mass of phosphorus present in the pond water column. No adverse impacts on the biological community were observed during or after the alum application. The details of the Great Pond treatment and the monitoring results post-treatment are included in this final report.

Chronology

Date	Activity Log
10/03/13	EcoLogic on site, collected samples to profile pond water quality at deepest point. EcoLogic collected water sample from Wiley Park, with Jane Crowley (Town) ACT on site, assembled treatment barge, calibrated spray equipment
10/04/13	ACT treated 10 acres of the total treatment area (28 acres) with one-half the planned dose (applied 1,000 gallons of alum and 500 gallons of sodium aluminate (SA)) Jane Crowley and Jessica Janney (GHD) were on site during application. EcoLogic completed three rounds of water quality monitoring and visual inspections of pond conditions, before, during, and after the chemical application. The pH and alkalinity remained stable, no evidence of stress to aquatic biota. No visual evidence of floc outside of the treatment zone. One dead fish (bass) found. Recreational users on pond.
10/05/13	EcoLogic completed three rounds of visual inspection and water quality monitoring- inside and outside of the treatment area. The pH and alkalinity remained stable, no evidence of stress to aquatic biota. No visual indication of floc, water very clear.
10/06/13	EcoLogic completed one round of visual inspection and water quality monitoring- inside and outside of the treatment area. The pH and alkalinity remained stable, no evidence of stress to aquatic biota. No visual evidence of floc. Observed some foaming on shore by Wiley Park- appeared natural and not related to application.
10/07/13	ACT continued treatment: -Treated entire 28-acre treatment area with half dose (applied 2,850 gallons of alum and 1,425 gallons of SA) EcoLogic completed three rounds of visual inspection and water quality monitoring- inside and outside of the treatment area. The pH and alkalinity remained stable, no evidence of stress to aquatic biota. No visual indication of floc, water very clear.
10/08/13	ACT completed the alum application. Treated remaining 18-acres with half dose (applied 1,800 gallons of alum and 900 gallons of SA) EcoLogic completed three rounds of visual inspection and water quality monitoring- inside and outside of the treatment area. The pH and alkalinity remained stable, no evidence of stress to aquatic biota. No visual indication of floc, water very clear.
10/09/13	ACT demobilized, and restored the site per Order of Conditions. EcoLogic completed post-treatment profile monitoring at the deepest location.
04/02/14	Post-treatment monitoring by GHD
07/02/14	Post-treatment monitoring by GHD
08/27/14	Post-treatment monitoring by GHD
11/04/14	Post-treatment monitoring by GHD

Appended to this report are the maps of daily treatment areas, as submitted by ACT.

Water Quality Monitoring Results

Pre-treatment pond profile results: October 3, 2013

Secchi Disk transparency 2.5 m

Sampling time 10:00 am

Depth (m)	Temp. (°C)	pH (S.U.)	Sp. Cond. (uS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (mg/L)	Total P (mg/L)	SRP (mg/L)
0	19	7.61	141	13	ND (1)	ND (1)	ND (2)
2	19	7.54	141	14	ND (1)	ND (1)	ND (2)
4	18.8	7.42	134	12	ND (1)	ND (1)	ND (2)
6	18.2	7.38	133	10	ND (1)	ND (1)	ND (2)
8	17.1	6.88	166	19	ND (1)	0.013	ND (2)
10	16	6.45	----missing	63	ND (1)	0.029	ND (2)

ND= not detectable

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Post-treatment pond profile (Round 1) results: October 9, 2013

Secchi disk transparency 2.3 m

Sampling time 7:30 am

Depth (m)	Temp. (°C)	pH (S.U.)	Sp. Cond (µS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (µg/L)	Total P (mg/L)	SRP (mg/L)
0	18.1	7.21	136	8	46.6	ND (1)	ND (2)
2	17.6	7.24	135	15	39.8	ND (1)	ND (2)
4	17.5	7.25	136	16	53.2	ND (1)	ND (2)
6	17.2	7.22	138	16	42.6	ND (1)	ND (2)
8	17	7.07	138	19	50.7	ND (1)	ND (2)
10	15.9	6.93	170	43	ND (1)	ND (1)	ND (2)

ND= not detectable

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Post-treatment pond profile (Round 2) results: April 2, 2014

Secchi disk transparency 2.5 m

Sampling time 2:00 pm

Depth (m)	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Sp. Cond (µS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (µg/L)	Total P (mg/L)	SRP (mg/L)
0	6.2	Rejected	19.4	160	14.7	ND (1)	ND (1)	ND (2)
2	5.9	Rejected	19.8	161	14.0	ND (1)	0.010	ND (2)
4	5.8	Rejected	19.9	162	14.4	ND (1)	0.011	ND (2)
6	5.5	Rejected	20.1	162	14.3	ND (1)	0.011	ND (2)
8	5.4	Rejected	20.3	162	14.0	ND (1)	0.011	ND (2)
10	5.3	Rejected	20.4	163	14.2	ND (1)	ND (1)	ND (2)

ND= not detectable

pH data rejected for quality control reasons

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Post-treatment pond profile (Round 3) results: July 2, 2014

Secchi disk transparency 2.5 m

Sampling time 2:00 pm

Depth (m)	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Sp. Cond (µS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (µg/L)	Total P (mg/L)	SRP (mg/L)
0	25.4	8.5	8.2	171	13.4	ND (1)	ND (1)	ND (2)
2	25.4	8.2	8.2	174	13.4	ND (1)	ND (1)	ND (2)
4	25.2	8.1	8.3	172	13.4	ND (1)	ND (1)	ND (2)
6	19.9	8.1	9.3	149	13.8	ND (1)	0.012	ND (2)
8	14.1	7.9	5.5	135	18.5	ND (1)	0.018	ND (2)
10	11.6	7.4	2.3	158	21.8	ND (1)	0.023	ND (2)

ND= not detectable

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Post-treatment pond profile (Round 4) results: August 27, 2014

Secchi disk transparency 2.5 m

Sampling time 10:15 am

Depth (m)	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Sp. Cond (µS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (µg/L)	Total P (mg/L)	SRP (mg/L)
0	24.2	8.4	8.0	163	16.5	ND (1)	ND (1)	ND (2)
2	24.1	8.3	7.9	157	16.8	ND (1)	ND (1)	ND (2)
4	24.1	8.3	8.2	154	16.8	ND (1)	ND (1)	ND (2)
6	23.1	8.0	6.0	149	16.6	ND (1)	ND (1)	ND (2)
8	12.3	7.4	3.0	166	24.9	ND (1)	0.013	ND (2)
10	11.2	7.3	1.0	179	16.6	ND (1)	ND (1)	ND (2)

ND= not detectable

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Post-treatment pond profile (Round 5) results: Nov 4, 2014

Secchi disk transparency 2.5 m

Sampling time 10:15 am

Depth (m)	Temp. (°C)	pH (S.U.)	Diss. Oxygen (mg/L)	Sp. Cond (µS/cm)	Alkalinity (mg/L as CaCO ₃)	Diss. Al (µg/L)	Total P (mg/L)	SRP (mg/L)
0	10.8	7.6	10.5	121	15.6	ND (1)	ND (1)	ND (2)
2	10.6	7.5	10.6	121	15.5	ND (1)	ND (1)	ND (2)
4	10.5	7.4	10.6	121	15.6	ND (1)	ND (1)	ND (2)
6	10.4	7.4	10.7	120	15.5	ND (1)	ND (1)	ND (2)
8	10.4	7.5	10.6	120	15.3	ND (1)	ND (1)	ND (2)
10	10.4	7.5	10.6	120	15.5	ND (1)	ND (1)	ND (2)

ND= not detectable

(1) Reporting limit 0.010 mg/L

(2) Reporting limit 0.015 mg/L

Groundwater monitoring results: pre and post treatment

Location: Wiley Park public tap

Parameter	Pre-treatment (10/3/13)	Post-treatment (7/2/14)	MA drinking water standard*
Aluminum (Dissolved)	0.025 mg/L	0.04 mg/L	0.05 – 2.0 mg/L
Sulfate	10 mg/L	Less than 10 mg/L	250 mg/L

*The drinking water standards for Al and sulfate are secondary standards, related to aesthetic impacts such as discoloration or taste and odor.

Measurements of pH and alkalinity inside and outside the treatment area

The project team monitored pH using a field instrument, and collected water samples for a field titration of total alkalinity, reported as mg/L of CaCO₃ equivalents. This monitoring plan was in place to verify that the application of the alum and sodium aluminate mixture did not consume alkalinity and allow a rapid decline in the pond's pH. The environmental concern is that aluminum in water is amphoteric; defined as more soluble in acidic solutions and in basic solutions than in circumneutral solutions. Ionic aluminum can be harmful to aquatic life. Consequently, the project team calculated the ratio of alum and sodium aluminate to ensure that the pH would not fall below 6.5, nor rise above 8.5 during treatment. ACT and the chemical supplier completed laboratory jar testing using Great Pond water prior to the application.

Results of frequent monitoring before, during and after the application confirmed that the pH remained in a safe range. Similarly, the alkalinity measurements were stable, and quite low. Gradients in pH and alkalinity were measured, notably in the deepest water. Thermal stratification of the pond appeared to be breaking down as the water layers lost heat to the atmosphere, which is characteristic of October conditions on Cape Cod.

Summary of measured pH data during chemical application

Inside Treatment Area			
Depth (m)	Max	Min	Count
0	7.37	7.12	16
2	7.4	7.15	
4	7.41	7.13	
6	7.36	6.9	
8	7.07	6.6	
Outside Treatment Area			
Depth (m)	Max	Min	Count
0	7.34	7.06	15
2	7.41	7.09	
4	7.44	7.07	

Discussion

The alum treatment program of Great Pond was completed successfully. The Orders of Conditions were met and the required samples were collected and analyzed.

The effectiveness of the alum treatment program in reducing phosphorus flux from the pond sediments into the overlying waters, and thereby reducing algal productivity, was evident in the summer of 2014. Continued monitoring and assessment will help determine the effectiveness of this remedial measure.

The concentration of dissolved Al in the pond water was higher after the treatment was completed, but remained well below the federal criterion for chronic exposure developed to protect aquatic life (set at 87 µg/L as a four-day average concentration). Subsequent monitoring demonstrated that the water column concentrations of Al declined to pre-treatment concentrations. The toxicity criteria for Al in fresh water are cited below (EPA 1988).

“The procedures described in the "Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses" indicate that, except possibly where a locally important species is very sensitive, freshwater aquatic organisms and their uses should not be affected unacceptably, when the pH is between 6.5 and 9.0, if the four-day average concentration of aluminum does not exceed 87 µg/L more than once *every* three years on the average and if the one-hour average concentration does not exceed 750 µg/L more than once every three years on the average.”¹

The conclusion that there was no potential for aluminum toxicity during the treatment program was borne out by the field observations as well as by the comparison to the federal criteria. The field team did not observe any adverse impacts on the aquatic biota during their visual assessments of Great Pond, which were conducted at least three times each day.

Massachusetts has adopted secondary standards to regulate the concentrations of aluminum and sulfate in drinking water. A secondary standard is used for contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. The secondary standard for aluminum is 0.05 – 2.0 mg/L; for sulfate the secondary standard is 250 mg/L. There is no indication that the groundwater supply at Wiley Park has been adversely affected by the pond restoration program. Any future groundwater sampling is at the discretion of the Town of Eastham Health Department, in accordance with the Order of Conditions.

Recommendation for Continued Monitoring

The Town of Eastham participates in the Cape Cod PALS program, which provides important information regarding trophic state condition and use attainment. This volunteer monitoring program also serves as a benchmark to compare trends in water quality over time, and among ponds. To track the continued

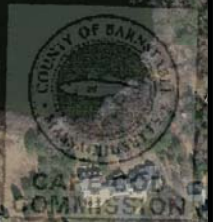
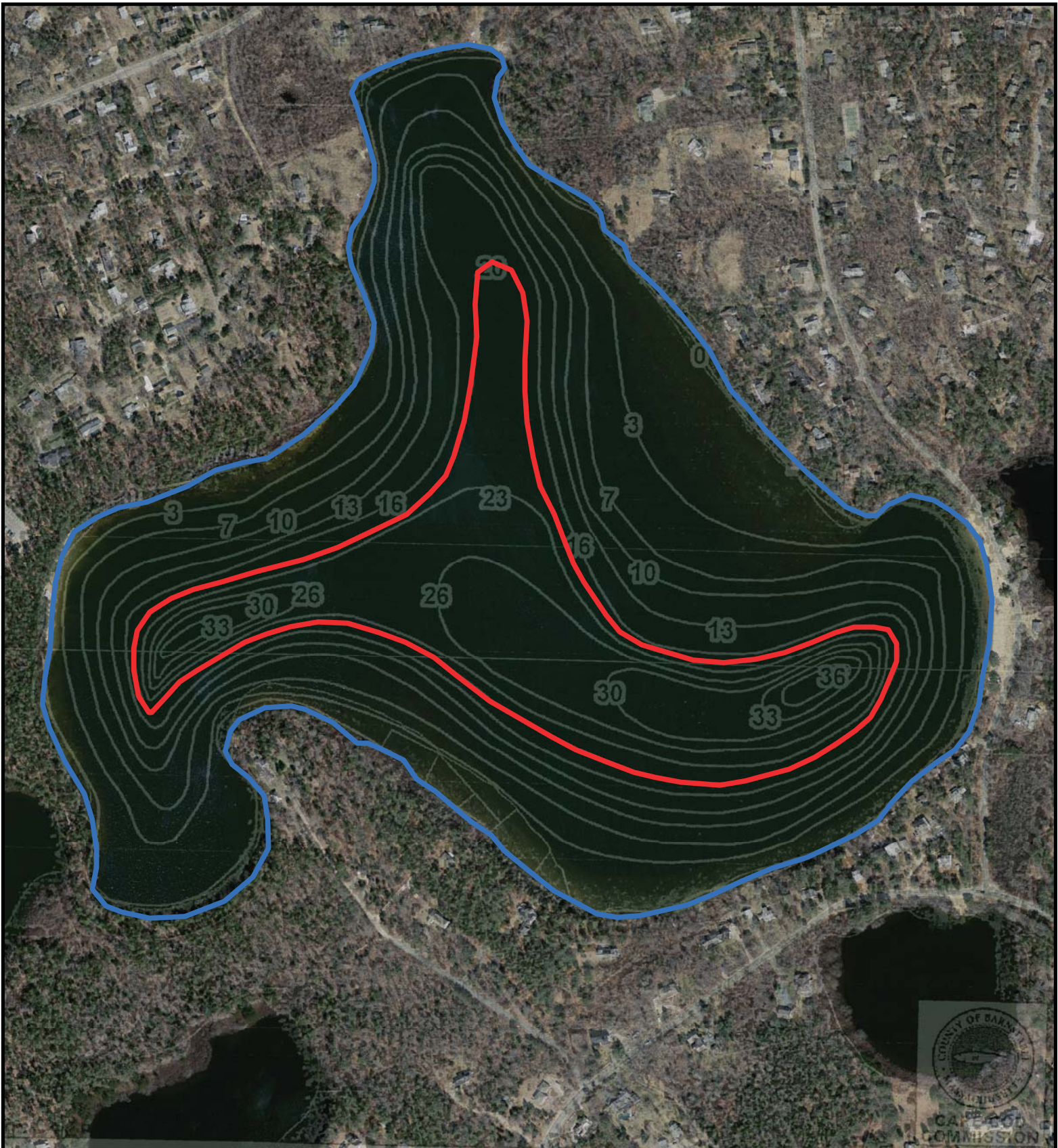
¹ EPA. 1988. Ambient water quality criteria for aluminum. EPA 440/5-86-008

performance of the alum-treated ponds in the Town (Herring Pond and Great Pond), we recommend that an annual monitoring event be conducted each fall, once the ponds have undergone complete destratification (i.e., complete mixing of the water column). This recommended annual monitoring event would supplement, not replace, the PALS monitoring program in Eastham.

The post-stratification pond sampling should include field parameters and collection of discrete samples at 2 m depth intervals to test for total phosphorus (TP) and soluble reactive phosphorus (SRP) levels. The analytical laboratory must employ low-level methods to achieve the lowest possible reporting limit for the phosphorus fractions. Tracking the mass of phosphorus present in the ponds’ water column will provide an indication of the continued effectiveness of the alum application. The application rate was calculated for a minimum longevity of ten years. As the alum loses its effectiveness (binding sites become saturated and new sediment will deposit on top), the fall TP and SRP concentrations will begin to rise. This small investment in additional monitoring will provide the Town with ample early warning of the need for additional measures to restore the ponds.

Analyte(s)	Rationale for inclusion	Sampling depths	Type of samples
pH, water temperature, dissolved oxygen, specific conductance	Confirm destratification	Profile, 2 m depth intervals	In-situ (field monitoring-calibrated meters)
Total and Soluble Reactive Phosphorus	Trophic state	Profile, 2 m depth intervals	Laboratory
Secchi disk transparency	Trophic state	From surface	In-situ (standard 20 cm-Secchi disk on calibrated line)

Appendix: Maps of Treatment Areas



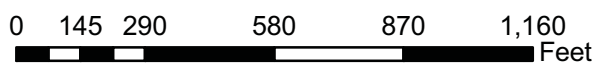
Great Pond

Eastham, MA

Treatment Area

Legend:

- Treatment Area
- Shoreline



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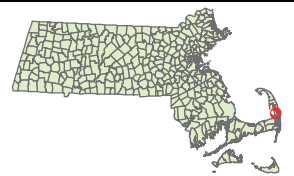


FIGURE:	SURVEY DATE:	MAP DATE:
1		10/2013



Treatment Area - 10 acres
 Dose - 12.5 g/m²
 Alum Quantity - 1,000 gallons
 SA Quantity - 500 gallons

Great Pond
 Eastham, MA

Treatment - 10/4/13

FIGURE:	SURVEY DATE:	MAP DATE:
2		10/2013

Legend:

- Treatment Area
- Shoreline
- Track Log (10/4/13)
- Treatment (10/4/13)

0 150 300 600 900 1,200 Feet

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Treatment Area - 28 acres
 Dose - 12.5 g/m²
 Alum Quantity - 2,850 gallons
 SA Quantity - 1,425 gallons

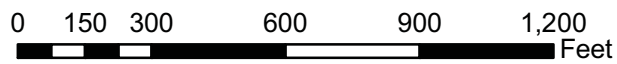
Great Pond

Eastham, MA

Treatment - 10/7/13

Legend:

- Treatment Area
- Shoreline
- Track Log (10/7/13)
- Treatment (10/7/13)



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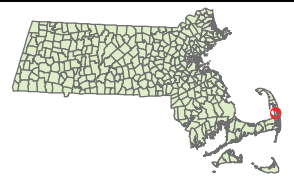


FIGURE:	SURVEY DATE:	MAP DATE:
3		10/2013



Treatment Area - 18 acres
 Dose - 12.5 g/m²
 Alum Quantity - 1,800 gallons
 SA Quantity - 900 gallons

Great Pond
 Eastham, MA

Treatment - 10/8/13

FIGURE:	SURVEY DATE:	MAP DATE:
4		10/2013

Legend:

- Treatment Area
- Shoreline
- Track Log (10/8/13)
- Treatment (10/8/13)

0 145 290 580 870 1,160 Feet

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Treatment Area - 28 acres
 Dose - 25 g/m²
 Alum Quantity - 5,650 gallons
 SA Quantity - 2,825 gallons

Great Pond
 Eastham, MA

Treatment
10/4/13 - 10/8/13

FIGURE:	SURVEY DATE:	MAP DATE:
5		10/2013

Legend:

- Treatment Area
- Shoreline
- Track Log

0 150 300 600 900 1,200 Feet

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