CH2M HILL
1748 West Truck Road
Otis ANGB, MA 02542

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17 December 2010

Mr. Jonathan S. Davis
Remediation Program Manager
HQ AFCEE/MMR
322 East Inner Road
Otis ANG Base, MA 02542-5028

SUBJECT: AFCEE FA8903-08-D-8769; Task Order 0234
MMR SPEIM/LTM/O&M Program
CDRL #A001d
Final Report Ashumet Pond Phosphorus Inactivation Project - 2010

Dear Mr. Davis:

CH2M HILL is pleased to submit to the Air Force Center for Engineering and the Environment, the ***Final Report Ashumet Pond Phosphorus Inactivation Project – 2010, December 2010.*** This has been an exciting project for our team and we appreciate the opportunity to conduct this important work. Enclosed are eight bound copies, one unbound copy and nine compact disc (CD) copies.

If you have any questions or comments, please contact Spence Smith at (617) 626-7054.

Sincerely,

CH2M HILL

Patricia de Groot
Program Manager
(508) 308-1453

Enclosures: (8 bound, 1 unbound & 9 CDs)

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Massachusetts Military Reservation

Final Report

Ashumet Pond Phosphorus Inactivation Project – 2010

December 2010

Prepared for:
AFCEE/MMR
Installation Restoration Program
322 E. Inner Road
Otis ANGB, MA 02542

Prepared by:
CH2M HILL
1748 West Truck Road
Otis ANGB, MA 02542

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ACRONYMS AND ABBREVIATIONS

ACT	Aquatic Control Technology
AFCEE	Air Force Center for Engineering and the Environment
AS	aluminum sulfate
DO	dissolved oxygen
ft	feet
kg	kilogram
LM	Lake Manager
m	meter
mg/L	milligrams per liter
MCC	Mashpee Conservation Commission
MMR	Massachusetts Military Reservation
msl	mean sea level
SA	sodium aluminate
SMAST	University of Massachusetts at Dartmouth School of Marine Science and Technology
TDP	total dissolved phosphorus
TP	total phosphorus
TSI	trophic state index
USGS	U.S. Geological Survey
WWTP	wastewater treatment plant
ZVI	zero valent iron
μg/L	micrograms per liter

1.0 INTRODUCTION

In September 2010, the Air Force Center for Engineering and the Environment (AFCEE) conducted a phosphorus inactivation project in Ashumet Pond using a buffered mixture of aluminum sulfate (AS) and sodium aluminate (SA). The goal of the treatment was to improve the trophic health of Ashumet Pond by reducing internal phosphorus recycling or regeneration from the sediments and thereby reduce the amount of phosphorus available to support algal growth and improve habitat quality by reducing the extent and duration of anoxia in deeper waters during the summer season. This report has been prepared under the Air Force Center for Engineering and the Environment (AFCEE) Installation Restoration Program, Contract Number FA8903-08-D-8769; Task Order 0234, at the Massachusetts Military Reservation (MMR).

The phosphorus inactivation project was conducted according to the *Final Work Plan, Ashumet Pond Phosphorus Inactivation Project* (AFCEE, 2010). Draft and final work plans were submitted by AFCEE to the Mashpee Conservation Commission (MCC) in association with wetlands permit review under the Wetland Protection Act (Chapter 131, §40) and regulations (310 CMR 10.00) and Town of Mashpee Wetlands Bylaw (Chapter 172). The Mashpee Conservation Commission issued an Order of Conditions (DEP file #043-2617) for the project on August 6, 2010 and AFCEE recorded the Order with the Barnstable County Registry of Deeds, August 13, 2010. Work was conducted in conformance with the Order of Conditions and the *Final Workplan* following Labor Day (September 6, 2010). In accordance with the Order of Conditions, direct communications were maintained between the MCC Conservation Agent, AFCEE, and contractors overseeing and conducting the inactivation treatment during the pilot and full scale treatment applications and associated monitoring. The Order of Conditions and other associated permits are attached as appendices to the work plan (AFCEE, 2010).

Seasonal monitoring of trophic health indicators suggested that the trophic health of Ashumet Pond had stabilized and improved for a number of years following a limited phosphorus inactivation treatment of 28 acres conducted in 2001 to reduce internal phosphorus recycling within the pond and the installation of a zero-valent iron (ZVI) geochemical barrier in 2004 to reduce external phosphorus loading to the pond from a plume emanating from the former rapid infiltration beds at the Massachusetts Military Reservation (MMR) sewage treatment plant. However, in recent years, particularly since 2008, monitoring data suggested that the trophic health was likely declining (AFCEE. 2009). Therefore, an expanded phosphorus inactivation treatment of waters generally deeper than 35 ft (10.6 m) and involving 56.5 acres of the pond was planned for 2010 to further reduce internal phosphorus recycling. The phosphorus inactivation treatment was conducted over the course of eight (8) days from September 9-16, 2010, with a pilot application on September 9th and the full-scale treatment from September 13-16. This treatment is expected to stabilize and further improve the trophic health of Ashumet Pond for many years to come, as external groundwater loading of phosphorus to the pond continues to decline.

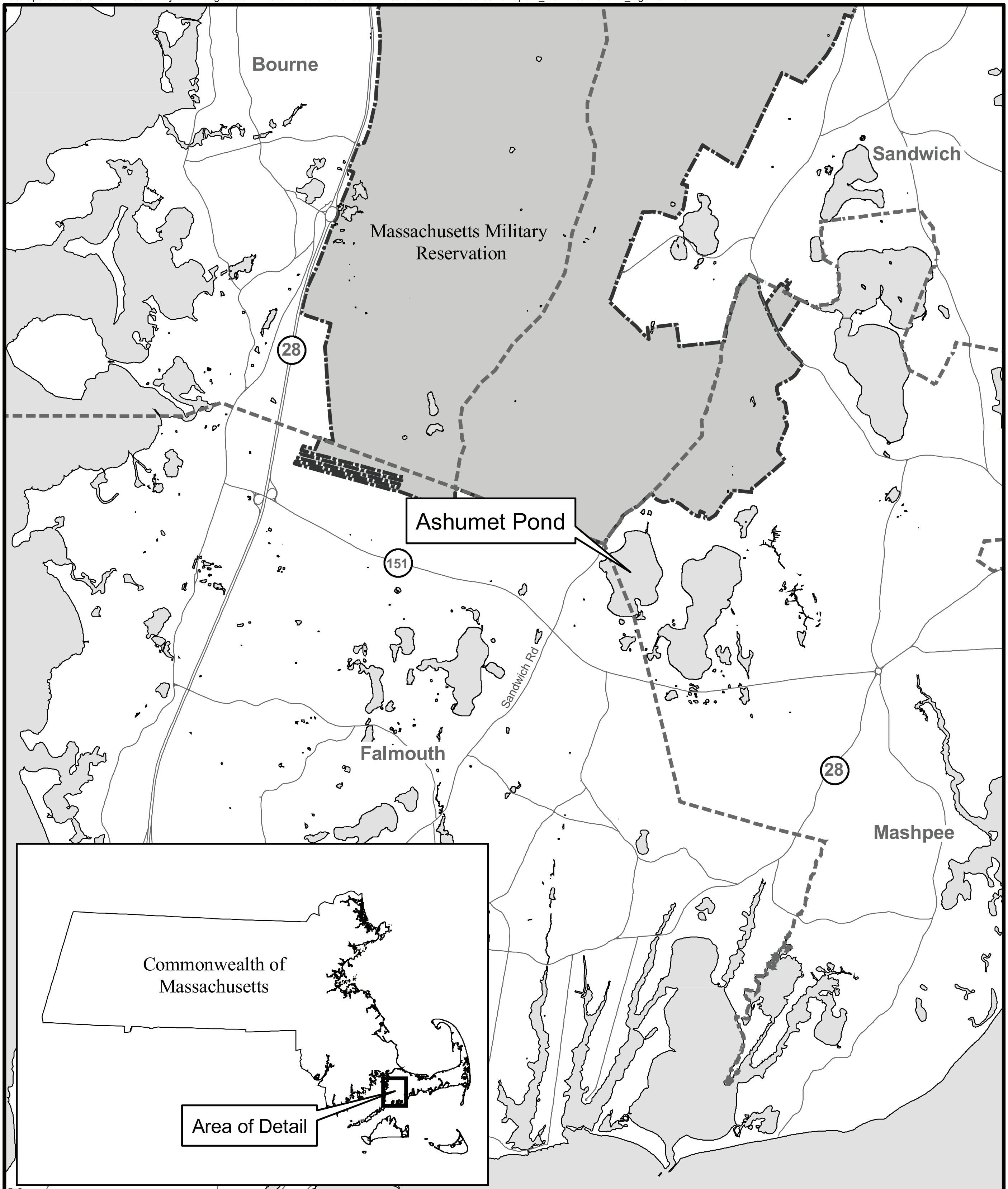
1.1 ASHUMET POND

Ashumet Pond is located south of the Massachusetts Military Reservation (MMR), within the towns of Mashpee and Falmouth in Barnstable County, Massachusetts (Figure 1-1). Ashumet Pond was formed by glacial processes and, based on May 2010 water levels, has a surface area of 226 acres and a maximum recorded depth of approximately 20 meters. Ashumet Pond is a groundwater flow-through pond, with groundwater input in the upgradient (north) end of the pond and subsequent recharge to the aquifer at the downgradient (south) end. The pond has no surface water outlet and during rainy periods it receives some surface water flow from an abandoned cranberry bog located north of the pond. The pond stage reached a historic record (1972-present) high on April 10, 2010 (Figure 1-2). Therefore, the area of the inactivation treatment was delineated based on bathymetric data collected on May 13 and 14, 2010. On these two days the water stage was 47.53 and 47.52 ft above mean sea level based on data from the USGS siphon gage (USGS 413758070320501).

1.2 GROUNDWATER PHOSPHORUS

Phosphate enriched groundwater, affected by secondarily-treated wastewater infiltration into the aquifer over many years, discharges to the pond on the northwest side (Figure 1-3). This plume originates from the rapid infiltration beds of the former MMR wastewater treatment plant, located approximately 2,000 ft northwest of the pond. The plume has affected water quality of Ashumet Pond by increasing the amount of phosphorus available to support algal growth.

The discharge of secondarily-treated wastewater to rapid infiltrations beds, an acceptable practice for many years, began at MMR in 1936 and ceased in 1995 when the plant was closed and the infiltration beds were subsequently excavated. Although these actions addressed a significant watershed source of phosphorus, a large mass of residual phosphorus remains sorbed to the aquifer matrix between the former wastewater treatment plant rapid infiltration beds and the pond. This residual phosphorus continues to feed a groundwater phosphorus plume that is discharging to the pond. This plume is expected to continue to contribute to the external phosphorus load of the pond for many years to come; however, phosphorus concentrations in the groundwater are declining over time (Parkhurst et al., 2003, AFCEE, 2009). To address the continued discharge of phosphorus enriched groundwater, AFCEE installed a geochemical barrier along the shore of Ashumet Pond in 2004 (AFCEE 2004 and 2005).



Data Source: AFCEE, MMR-AFCEE Data Warehouse

Legend

- Town Boundary
- Massachusetts Military Reservation Boundary

N

0 0.7 1.4 Miles

FIGURE 1-1

LOCATION OF ASHUMET POND

AFCEE - Massachusetts Military Reservation

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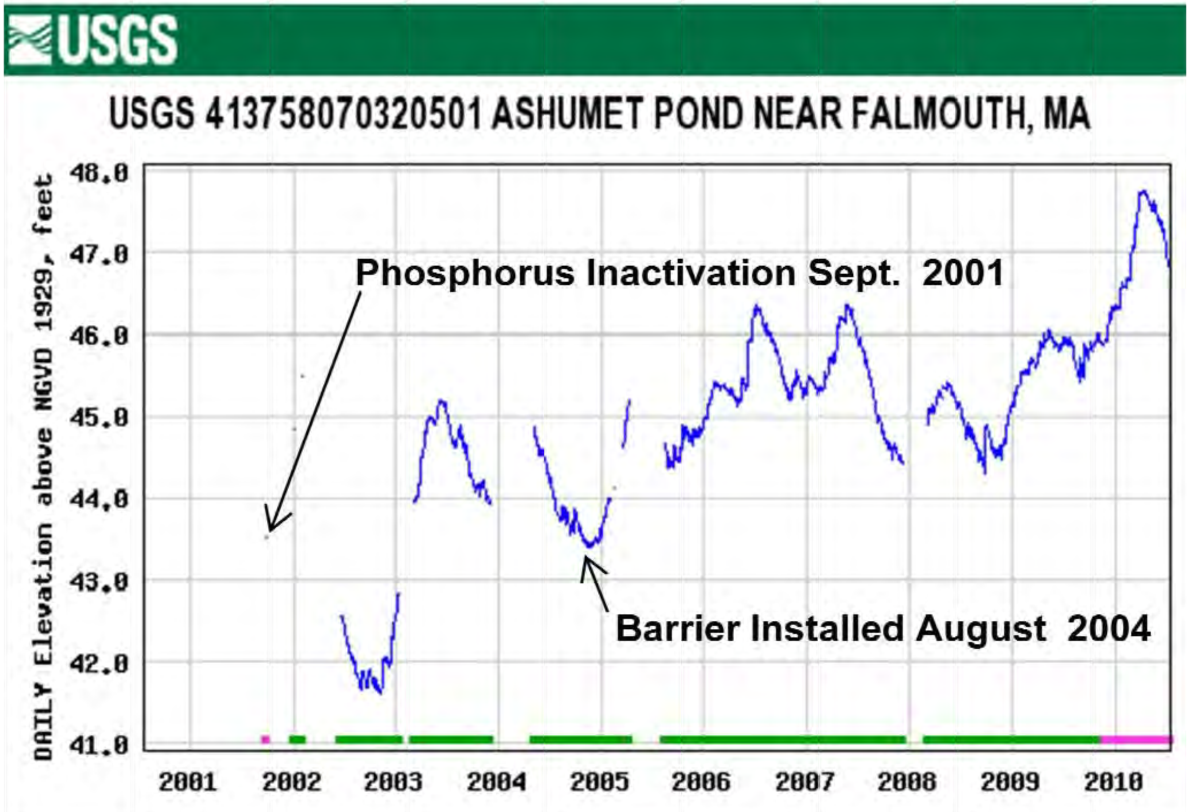
10 Years - 07/18/2000 - 07/18/2010



Period of Record - 12/1972 -7/18/2010

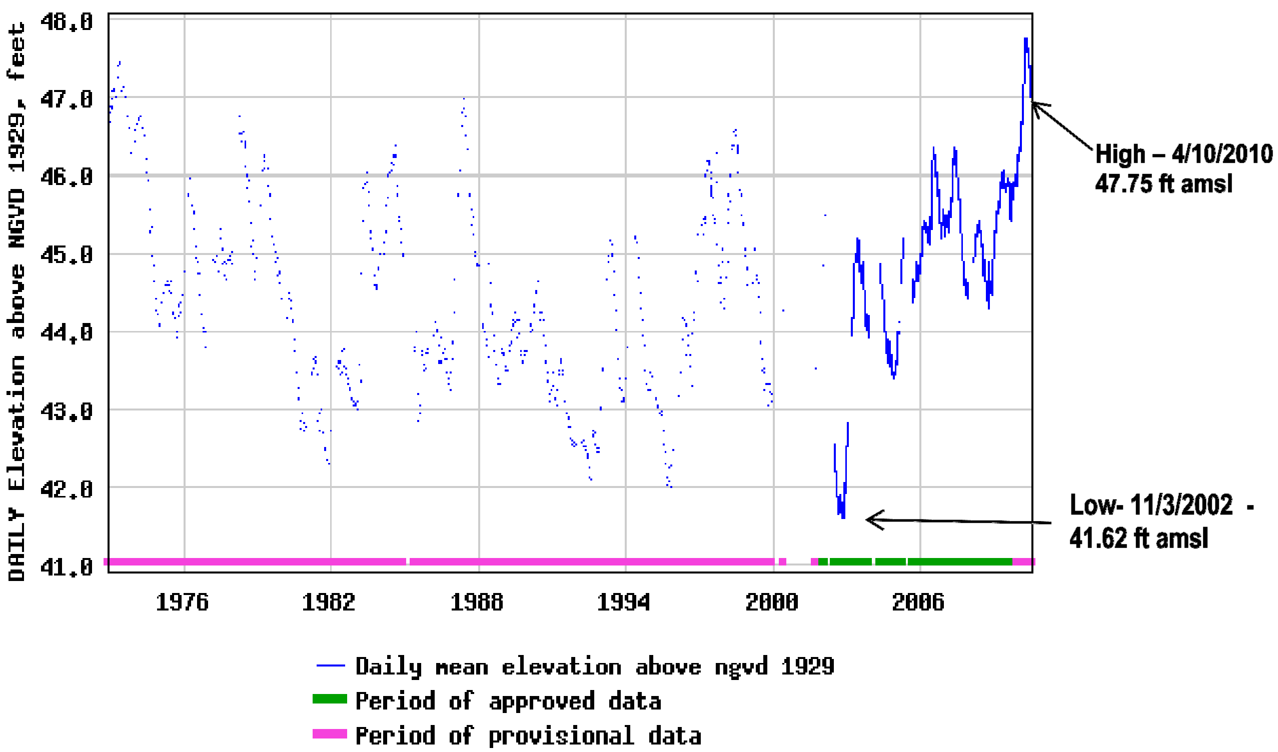


FIGURE 1-2

ASHUMET POND GAGE (USGS - 413758070320501)

AFCEE - Massachusetts Military Reservation

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FIGURE 1-3

PHOSPHORUS PLUME AND DISCHARGE AREA IN ASHUMET POND (2007)

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1.3 SPECIES OF SPECIAL CONCERN

There is one known state-listed species of special concern identified in the waters of Ashumet Pond, the tidewater mucket (*Leptodea ochracea*). Ashumet Pond is listed as priority habitat for the tidewater mucket under the Massachusetts Endangered Species Act (MESA; MGL c. 131 A) and implementing regulations (321 CMR 10.00). AFCEE met with the Division of Fisheries and Wildlife, Natural Heritage Endangered Species Program (NHESP) to discuss the history of activities undertaken to address watershed nutrient sources and to directly improve the trophic health of Ashumet Pond, activities intended to benefit all species, including tidewater mucket. Actions were intended to: improve trophic health and reduce long-term eutrophication; reduce nuisance, seasonal algae blooms; increase the amount of aquatic habitat with adequate dissolved oxygen levels; and favor phosphorus-limited conditions throughout the growing season. AFCEE demonstrated that past actions involving phosphorus sequestration both 1) in deep pond sediments by aluminum hydroxide inactivation and 2) in key shallow groundwater seepage areas with ZVI additions to sediments were designed to improve the trophic health of Ashumet Pond. In addition, they were designed to avoid direct impact to existing mussel habitat during construction or implementation.

Anoxic conditions that develop during the summer when the pond is thermally stratified are potentially limiting the distribution of mussels in the pond to depths less than 25 feet (Appendix A). Phosphorus inactivation should enhance habitat for the tidewater mucket by decreasing the extent and duration of anoxic conditions in Ashumet Pond. NHESP agreed that the proposed 2010 phosphorus inactivation to be conducted in waters generally over 35 feet, in principal meets the requirements of review exemption #11 "for the purpose of maintaining or enhancing the habitat for the benefit of rare species (321 CMR 10.14)", provided that the management is carried out in accordance with a habitat management plan. A habitat management plan, specifying monitoring intended to further document improvements in trophic health, available mussel habitat, and mussel populations in the future following phosphorus inactivation was included as Appendix A in the Final Work Plan for the project (AFCEE, 2010). Monitoring activities conducted in support of the habitat management plan for tidewater mucket are summarized in Section 6 and described in detail in Appendix A of this report.

1.4 REGULATORY FRAMEWORK

An Order of Conditions was necessary from the Town of Mashpee, in accordance with the requirement of the Wetlands Protection Act (Chapter 131, Sect. 40) and regulations (310 CMR 10.00) and the Mashpee Wetlands Bylaw (Chapter 172), in order to conduct the inactivation treatment. An Order of Conditions from Mashpee was the primary permit for the project since the planned treatment was to occur in the Mashpee portion of the pond.

At the conclusion of the inactivation treatment, a *Request for Certificate of Compliance* for the project was submitted to the Town of Mashpee in accordance with the terms of the Order of Conditions, MA DEP # SE 043-2617 (Appendix B). A *Certificate of Compliance* was issued by the Mashpee Conservation Commission on October 8, 2010 (Appendix B).

A License to Apply chemicals was obtained by the subcontractor, Aquatic Control Technology (ACT), from the Department of Environmental Protection, Bureau of Resource Protection – Watershed Management. A Boat Ramp Use Permit was issued by the Massachusetts Department of Fish & Game's Public Access Board relating to the use of the Fisherman's Cove Boat Ramp for staging of equipment.

In accordance with state guidance (MA EOEA 2004 a, b), a Chapter 91 permit is not required for phosphorus inactivation treatments and a Section 404 permit is also not required because the Army Corps of Engineers does not consider nutrient inactivation to be filling of wetland resources. The project did not involve discharge of dredge or fill material and did not meet the inclusionary criteria of 314 CMR 9.04; therefore, a 401 Water Quality Certification was not required.

Massachusetts Environmental Policy Act (MEPA) review was also not necessary. The Massachusetts Secretary of Environmental Affairs issued a certificate for the *Final Generic Environmental Impact Report (GEIR), Eutrophication and Aquatic Plant Management in*

Massachusetts and the *Practical Guide to Lake and Pond Management in Massachusetts (MA EOEA, 2004 a, b) on March 19, 2004.* These two documents provide lakes management guidance to lake and pond managers, conservations commissions and citizens and are intended to provide "a basis for more consistent and effective lake management in the Commonwealth." The phosphorus inactivation approach is included in the guidance and was implemented in accordance with specified performance guidelines. The Secretary's Certificate states that projects implemented in accordance with the performance guideline of Final GEIR *do not require individual MEPA review, except for:*

a. dredging projects that exceed any of the thresholds found in 301 CMR 11.00;

b. proposals to implement new physical or biological techniques for lake management; or

c. proposals to use any new pesticide active ingredient with an aquatic pattern and/or a substantially different formulation from a currently registered active ingredient.

2.0 PHOSPHORUS INACTIVANT TARGET DOSE

Phosphorus inactivation in ponds or lakes is typically achieved by the addition of either aluminum- or iron- rich solutions that rapidly form amorphous iron or aluminum compounds that scavenge phosphorus from the water column, sequester phosphorus in the sediments, and reduce regeneration of sediment-bound phosphorus back into the water column. Aluminum treatments are preferred for ponds or lakes, such as Ashumet Pond, where anoxic conditions develop in the hypolimnion during the summer and oxidized iron compounds are not stable.

2.1 ALUMINUM COMPOUNDS UTILIZED

Aluminum treatment of the water column of a pond or lake often involves the simultaneous introduction of a low pH solution of aluminum sulfate ($Al_2\ (SO_4)_3\ 14H_2O$) and neutralizing, high pH solution of sodium aluminate ($Na_2Al_2O_4 \cdot nH_2O$). Immediately following injection of these compounds, insoluble aluminum hydroxide ($Al(OH)_3$) flocculent (floc) begins to form resulting in co-precipitation and sorption of inorganic and particulate phosphorus in the water column. The treatment process continues as this insoluble aluminum hydroxide floc (and the sorbed and co-precipitated phosphorus) settles to the pond bottom where it forms a surface coating on bottom sediment beneath the area of application. The blanket of aluminum hydroxide floc continues to sorb phosphorus from the sediments, forming a barrier that prevents phosphorus regenerated from the underlying sediments from reaching the overlying water column. Over time sorbed phosphorus reacts with aluminum hydroxide to form a relatively stable aluminum phosphate compound, $AlPO_4$.

The primary risk associated with using aluminum-based compounds for inactivation treatments is the potential toxicity of free aluminum (Al^{3+}), which increases in concentration in water outside the pH range of approximately 6 to 8 pH units. Generally, outside this range the solubility of aluminum hydroxide increases and dissolved aluminum concentrations may exceed the acute water quality criterion of 750 µg/L. The most toxic aluminum species is free aluminum (Al^{3+}) which is the dominant species under acidic conditions. Consequently, two key factors for a successful inactivation treatment include: (1) the determination of the dose of aluminum necessary to achieve appropriate reduction in internal recycling of phosphorus;

and (2) the selection of the appropriate ratio of aluminum sulfate and sodium aluminate to achieve that dose while maintaining pH within a safe range during treatment.

2.2 DOSAGE TESTING

Aluminum sulfate (AS), the most commonly used aluminum salt for sequestering phosphorus in aquatic settings, is an acid-generating compound and is typically best suited for treatment of high alkalinity lakes. The use of aluminum sulfate alone in low alkalinity waters, such as those on Cape Cod, can lead to a decrease in pH and potentially associated toxicity during treatment. Therefore, a mixture of AS and sodium aluminate (SA), to provide pH buffering, was necessary for Ashumet Pond. To maintain pH within a safe range of 6 to 8 pH units, the optimal mix ratio for these two compounds was determined through on-site "jar testing" with pond water three weeks prior to treatment.

The results of the jar testing, discussed in detail in the final work plan (AFCEE, 2010), indicated that treatment with AS alone and with AS:SA ratios of 1:1, 2.2:1, and 2.4:1 produced unacceptable pH levels that could potentially lead to aluminum toxicity. Once the AS:SA ratio exceeded 2:1, pH dropped considerably, suggesting alkalinity was consumed by the reaction. An AS:SA ratio of 1.8:1 was selected for inactivation treatment to provide a margin of safety due to the observed rapid drop in pH observed at ratios greater than 2:1, the small deflection from ambient pH values observed for the ratios of 1.7:1 and 2:1, and the good formation of floc at these ratios.

AFCEE, working with University of Massachusetts School of Marine Science and Technology (SMAST), conducted sediment core incubation studies to assess phosphorus regeneration. Sediment cores were collected and incubated from eleven (11) locations distributed throughout the 30 ft (9.1 m) to 40 ft (12.1 m) contours of Ashumet Pond in May 2010. Single cores were collected to provide greater sample distribution and improved representation of spatial patterns of phosphorus release. The 2010 sediment core data were integrated with sediment phosphorus flux data collected over the last twelve (12) years to gauge the importance of internal phosphorus recycling from pond sediments to the overlying water column. The results of the sediment core studies are described in detail in the

Appendix A and summarized here. The studies indicated that significant regeneration was occurring within the sediments in the proposed treatment area [i.e., water depths greater than 35 ft (10.6 m)]. The areas of the pond deeper than 30 ft (9.1 m) are overlain by anoxic water during most of the warmest summer months, which shifts the system from oxic to anoxic and increases the amount of phosphorus released into the water column (Table 2-1).

Table 2-1. Annual Flux of Phosphorus from Sediments and Aluminum Dosages (SMAST-UMass Dartmouth sediment phosphorus regeneration studies)

	0-30 ft Depth ($mg/m^2/yr$)	30-45 ft Depth ($mg/m^2/yr$)	45-60 ft Depth ($mg/m^2/yr$)
Oxic Release	85.5	39.6	113.7
Chemical Release	NA	120.0	129.5
Anoxic Release	NA	192.7	165.4
Total Phosphorus Release	85.5	352.3	408.6
Al:P Binding Ratio	NA	100:1	100:1
AS/SA Dosage ($g\ Al/m^2$)	NA	35	41

NA – not applicable

The dosage of aluminum required to control the redox-sensitive phosphorus in the sediments was estimated from the annual phosphorus flux values. An aluminum to redox-sensitive phosphorus binding ratio of 100:1 has been demonstrated to be effective in binding the redox-sensitive phosphorus fraction in sediments (James, 2005; Rydin and Welch, 1999). Therefore, the dosage was calculated based on the phosphorus flux data and aluminum to redox-sensitive phosphorus binding ratio of 100:1 (Table 2-1). For ease of implementation and to allow for some additional control of external phosphorus inputs to the 30 ft (9.1 m) to 45 ft (13.6 m) depth area after the treatment, an overall dosage of 40 $g\ Al/m^2$ for the entire treatment area was selected.

3.0 TREATMENT METHODOLOGY

The phosphorus inactivation project was conducted with a pilot area application conducted over five (5) acres prior to the full-scale treatment (Figure 3-1). The pilot area application was conducted to minimize the potential for adverse effects on aquatic biota. Water quality was monitored intensively during and after the pilot application to evaluate potential adverse effects (e.g., changes in pH). Following the pilot area application, there was a planned monitoring period to allow time for evaluation of water chemistry and surveys to identify dead and/or stressed biota. The pilot application was conducted on Thursday, September 9, 2010 and a survey for dead and/or stressed biota was conducted the following day. After the pilot application there were no observed fish kills or stressed biota, pH and alkalinity remained stable, and no dissolved aluminum concentrations exceeded the acute water quality criterion; therefore, the full-scale application commenced the following Monday, September 13, 2010. The areas treated each day are depicted in Figures 1 through 5 in the Treatment Summary Report (Appendix C) and the combined GPS navigation track lines for the application vessel for the entire day are shown on Figure 6 (Appendix C). The daily treatment records documenting volume of inactivant applied are also included in Appendix C.

The AS and SA mixture was applied using a volumetric ratio of 1.8:1, respectively, over a 56.5 acre portion of the pond, in areas generally greater than 35 ft (10.6 m) deep (Figure 3-1). The two compounds were applied simultaneously from an aquatic weed harvester barge through opposed nozzles on a boom lowered 10 ft (3 m) below the water surface, with mixing off the two compounds occurring with the injection. Centrifugal, gasoline powered pumps were used to pump and apply the chemicals through the spray. Aquatic Control Technology of Sutton, MA performed the treatment.

The treatment area within Ashumet Pond was divided into smaller treatment areas each day of the treatment, and the vessel traversed a GPS-guided path to deliver a uniform dose. The treatment vessel was reloaded multiple times to treat each target area, as it carried only 500 gallons of aluminum sulfate and 275 gallons of sodium aluminate with each load. The target dose was “split” with half applied over the entire area followed by application of the second half in a perpendicular direction. This process required more time, but provided a further safeguard against adverse effects to aquatic organisms.

During the full-scale treatment, 4,500 gallons of AS and 2,500 gallons of SA were applied to the pond each day. The chemicals were delivered to the loading area in split tankers (two separate compartments) and two deliveries were made each day of full treatment. Based on the treatment records, a total of 17,559 gallons of AS and 9,805 gallons of SA were applied over the course of the treatment. Based on the delivery records from the chemical supplier, a total of 17,365 gallons of AS and 9,543 gallons of SA were delivered to the pond. These records deviate by 1.1 percent for AS and 2.7 percent for SA. These deviations are within the expected error of the flow meters used to measure the application rate of the chemical delivery and within acceptable thresholds outlined in the work plan. Theoretical calculations using the treatment area of 56.5 acres and a proposed areal dose of 40 g/m^2, yield total volumes needed would be 17,187 gallons of AS and 9,548 gallons of SA. Therefore, the planned dose was exceeded by 2.2 percent for AS and 2.7 percent for SA, based on application flow meters. Using comparisons of chemical delivery records with theoretical dosage volumes, the planned volume for AS was exceeded by 1.0 percent and SA was delivered as planned (only 5 gallons or .05 percent less).

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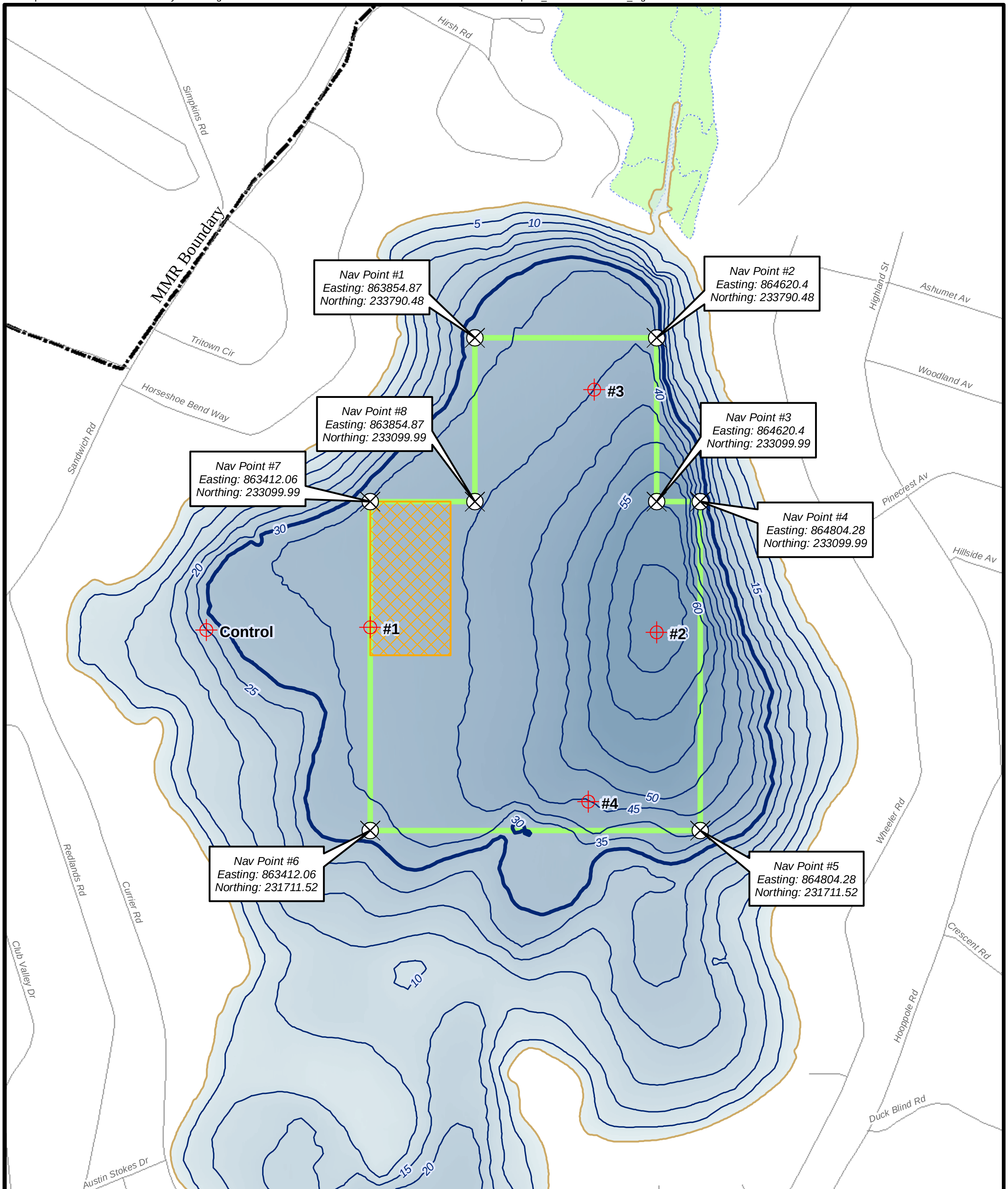

Legend

Monitoring Location

Navigation Point

Depth Contour (5 Foot Interval)

30 Foot Depth Contour

Massachusetts Military Reservation Boundary

Treatment Area

Pilot Test Area

Bog/Wetland

Data Source: AFCEE, MMR-AFCEE Data Warehouse.
UMass Dartmouth, School for Marine Science and Technology Hydrographic Survey, May 2010

N

0 300 600 Feet

FIGURE 3-1

ASHUMET POND AREA OF PHOSPHORUS INACTIVATION WITH NAVIGATION POINTS

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4.0 TREATMENT MONITORING

A monitoring program was developed and implemented to ensure that the inactivation treatment was conducted in an ecologically protective manner and that the conditions of the Mashpee Conservation Commission's Order of Conditions for the project were met. A pilot treatment was conducted prior to the full-scale application in order to identify any unexpected water quality impacts of the treatment. Water quality was monitored intensively during and after the pilot treatment to evaluate the potential for adverse effects to occur during the full-scale application. In addition, pre-treatment and post-treatment monitoring of the water column was conducted to evaluate short-term changes in water chemistry as a result of the treatment. AFCEE is also continuing a long-term monitoring program of the trophic health of Ashumet Pond, involving monthly monitoring. These data will be reported in future monitoring annual reports.

The main objectives of the monitoring program were to:

- Measure and document levels of pH and alkalinity on a regular basis at several depths at five (5) monitoring stations in Ashumet Pond including three located along the periphery of the treatment area, one located at the deep basin, and one control station located at distance from treatment area (refer to Figure 3-1);

- Ensure that pH was maintained within the range of 6-8 to prevent potential negative impacts to aquatic life during the treatment process;

- Monitor Ashumet Pond for observable impacts to the ecosystem during and following the course of treatment (e.g., fish kills); and

- Measure and document water chemistry prior to, during, and after the inactivation treatment.

As part of the monitoring program, in-situ monitoring of selected water chemistry field parameters, including pH, DO, conductivity, and temperature, was conducted periodically in the treatment area and water samples were collected for on-shore alkalinity analysis. To provide real-time data, alkalinity titrations were conducted immediately after sample collection at an on-site laboratory. During the application process, the Lake Manager monitored water chemistry and weather conditions to ensure that treatment thresholds were not exceeded. The Lake Manager also conducted periodic surveys for fish kills and stressed biota and monitored floc distribution using an underwater camera.

4.1 PILOT AREA APPLICATION

The pilot area application of the AS and SA mixture was conducted on September 9, 2010. The results of the pilot application revealed no exceedences of pre-established water quality parameters, including pH, alkalinity, and dissolved aluminum, and no observed fish kills or stressed biota were observed. Therefore, the full-scale application was undertaken as planned from September 13-16, 2010. Intensive short-term monitoring of water quality was continued throughout the course of the full-scale treatment.

The wind was generally light and intermittent during the pilot application, varying from approximately 6 to 12 mph (measured with an anemometer within the pilot area). Some low pH readings of 6.3 to 6.4 were measured in the pond prior to the pilot application, possibly related to changing water chemistry associated with an algal bloom observed in mid-August. The pilot application was initiated based on the in-situ data collected in the morning, which showed no pH readings less than 6.0. The pH at the depth of the AS/SA injection (i.e., 10 ft or 3.1 m) ranged from approximately 7.1 to 7.2, and the lowest pH readings of 6.3 to 6.4 were measured in the upper depth limit of the metalimnion (i.e., 7 to 8 m). There was a slight difference between in-situ readings collected with the YSI meter and the pH readings measured on shore at the on-site laboratory, with some reading less than 6.0. This could have been associated with changing water chemistry in the small aliquots transported for analysis on shore. However, because none of the in-situ pH readings were less the 6.0, the pilot area application was initiated.

The pH minima observed in the upper metalimnion (7 to 8 m) was consistent with similar observations made during the 2001 inactivation treatment and other trophic health monitoring. This was attributed to the density barrier created by the thermocline resulting in the accumulation of settling organic material in this zone, with associated bacterial decomposition involving respiration and the generation of carbon dioxide (leading to decreased pH).

The pH data indicate that the pH was adequately buffered during the pilot application, as the pH readings in this zone (i.e., 7 meter depth) at the boundary of the pilot test (Station #1) remained consistent during the treatment and post-treatment. Alkalinity remained stable as well, indicating that the AS:SA ratio was appropriate with maintenance of ambient pH or alkalinity. No alkalinity measurements were less than the pre-established threshold of 5 mg/L $CaCO_3$ at any point during the pilot area application (Appendix D). Alkalinity in the epilimnion samples from Station #1 located on the perimeter of the pilot area, ranged from 8.3 mg/L pre-treatment to 9.1 mg/L post-treatment, which was very similar to alkalinity concentrations measured at the control station (Table 4-1). Alkalinity varied less than 0.8 mg/L with depth at either station.

Table 4-1
Alkalinity and pH During the Pilot Area Application

	Control				Treatment Area (Station #1)			
	Pre-Treatment		Post-Treatment		Pre-Treatment		Post-Treatment	
	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	pH (SU)	Alkalinity (mg/L as $CaCO_3$)	pH (SU)	Alkalinity (mg/L as $CaCO_3$)
Epilimnion	6.4	8.6	7.1	8.7	6.9	8.3	7.2	9.1
Metalimnion	6.2	9.0	6.6	8.7	6.0	8.4	6.2	9.2

Dissolved aluminum concentrations in samples from the station on the perimeter of the pilot area (Station #1) did not exceed the acute water quality criteria of 750 µg/L (EPA, 2002) following the pilot application (Table 4-2). The aluminum data indicate that pH was maintained during the pilot application in the proper range to keep dissolved aluminum at a minimum and avoid potential toxicity. Minimal solubility of aluminum (as Al^{3+}) occurs above a pH of approximately 5.5.

Table 4-2
Aluminum Concentrations Before and After the Pilot Area Application

	Control				Treatment Area (Station #1)			
	Pre-Treatment		Post-Treatment		Pre-Treatment		Post-Treatment	
	Total Al (µg/L)	Diss. Al (µg/L)	Total Al (µg/L)	Diss. Al (µg/L)	Total Al (µg/L)	Diss. Al (µg/L)	Total Al (µg/L)	Diss. Al (µg/L)
Epilimnion	<50	<50	778	85	NS	NS	145	57
Metalimnion	<50	<50	85	<50	NS	NS	126	<50

Notes:

NS – not sampled

<50 µg/L – not detected

Floc was observed near the surface outside the pilot area boundary near the northwest corner. The floc appeared to be drifting from surface currents created by the paddle wheels of the treatment vessel as it executed turns at the boundary of the treatment area. The extent of the floc drift was limited to the water depths of 27 ft (8.2 m). Floc was not apparent outside the rest of the pilot area. The floc settled rapidly and was not apparent near the surface of the water approximately one-half hour after the last chemical load was applied.

A pond-wide survey for dead and/or stressed fish and other biota was conducted the following morning after the pilot application. No dead or stressed fish or other aquatic biota were observed. Based on the findings that pH and alkalinity were maintained near ambient conditions, no dissolved aluminum concentrations exceeding the acute water quality criteria, and no fish mortality observed through 16 hours after the treatment, the full-scale treatment commenced the following week.

4.2 FULL-SCALE APPLICATION

The greatest overall concern associated with the phosphorus inactivation treatment is safeguarding against the potential for adverse effects associated with sudden shifts in pond pH (and subsequent increase in bioavailable aluminum); therefore, the monitoring focused on measurement and assessment of pH and alkalinity of the pond immediately before, during and after the inactivation treatment.

4.2.1 Weather Evaluation

On the day of the pilot area application and each day of the full-scale application, the Lake Manager periodically evaluated weather conditions and measured wind speed with an anemometer from within the treatment area of the pond according to the work plan and Order of Conditions. The identified wind speed threshold was 15 mph. If the wind speed was lower than 15 mph then the application could proceed. Wind speeds greater than 15 mph and less than 20 mph triggered a review and evaluation by the Lake Manager. If wind speeds exceeded 20 mph, then the application would have been halted.

Wind speed exceeded 15 mph on only one day (September 15) and only during periodic gusts. Excessive wave heights were not observed on any day of treatment. On September 15, some floc drift was observed at the water surface along the eastern boundary of the treatment area. In response to this, ACT pulled back the treatment from the boundary. The treatment track lines for this day are depicted on Figure 4 of Appendix C. Subsequent observation with an underwater camera revealed some floc material on the sediment surface outside the treatment zone. However, the amount of floc deposited outside the treatment boundary did not appear to be significant and was not expected to result in adverse effects to aquatic organisms.

4.2.2 General Observations/Fish Surveys

Observations of pond conditions by the Lake Manager were made each day from a boat during and following treatment, as well as the day following completion of the treatment (September 17). General observations included the location of the application vessel, weather, the presence of visual floc from the treatment, and the presence of any dead fish or other organisms.

No fish kills or other dead organisms attributed to the treatment were observed during or after the treatment. One dead fish was observed at the public boat launch on the morning of September 13, before treatment commenced on that day. The fish mortality was attributed to fishing activity, given its location and the lack of any other observed dead fish.

Floc was observed slightly outside the treatment area on September 15, which was attributed to windy conditions, as described above. As discussed previously, floc was also observed slightly outside the treatment boundary during the pilot application, but neither of these occurrences was considered to pose a significant risk of harm to aquatic biota. In both cases, adjustments were made in the application, at the direction of the Lake Manager, such as shutting off pumps earlier on approach of the established application boundary, to minimize drift outside the treatment area.

4.2.3 Temperature, Dissolved Oxygen, Conductivity, and pH

Depth profiles of temperature, dissolved oxygen (DO), conductivity, and pH were collected at 2 m (6.6 ft) intervals from the pond surface to 1 m (3.3 ft) above the bottom during the inactivation treatment (Appendix E). Thermal structure or stratification was stable throughout the pilot and full-scale application (Figure 4-1) and consistent between the monitoring locations. Similarly, the oxycline, the depth at which DO concentrations abruptly change and anoxic conditions are present below this depth, remained stable throughout the treatment (Figure 4-2). The frequency of the DO, temperature, pH, and conductivity profiles was reduced in the field from the frequency specified in the work plan because of time constraints to complete the other components of the monitoring and the values were stable between readings and stations.

Conductivity in the epilimnion increased slightly over the course of the treatment from approximately 114 to 115 µS/cm to 120 to 124 µS/cm, but remained close to ambient conditions below the thermocline in water deeper than approximately 8 m (26.4 ft) (Figure 4-3).

The pH remained relatively stable throughout the treatment (Figure 4-4). There was a slightly increase in pH in the upper hypolimnion (i.e., 10 m (33 ft) depth) from approximately 6.4 to about 6.7 during the third and fourth day of treatment. However, this change was well within the pH range deemed safe for keeping dissolved aluminum at a minimum. There was little change in pH in the epilimnion over the course of the treatment,

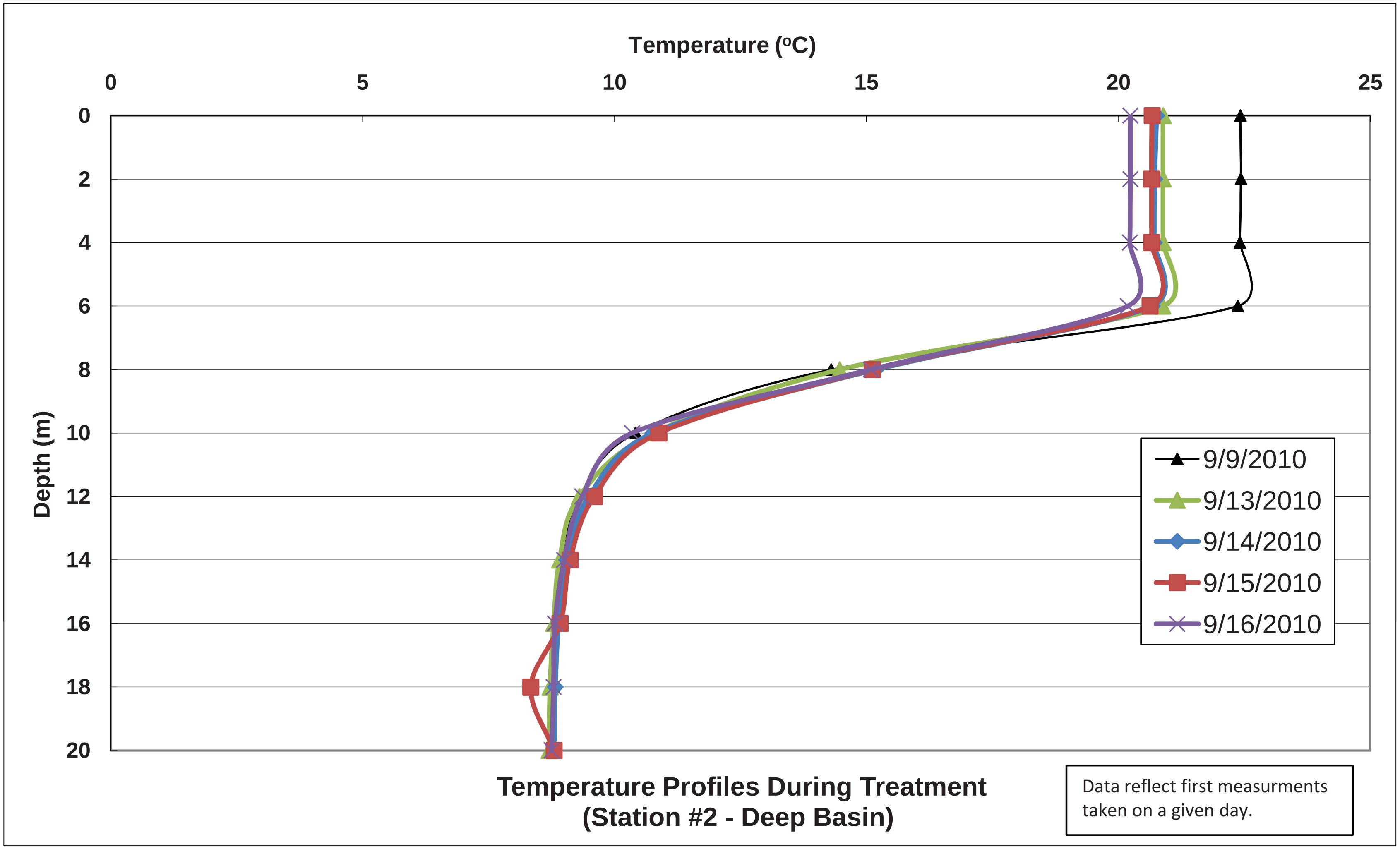

FIGURE 4-1

TEMPERATURE PROFILES DURING TREATMENT

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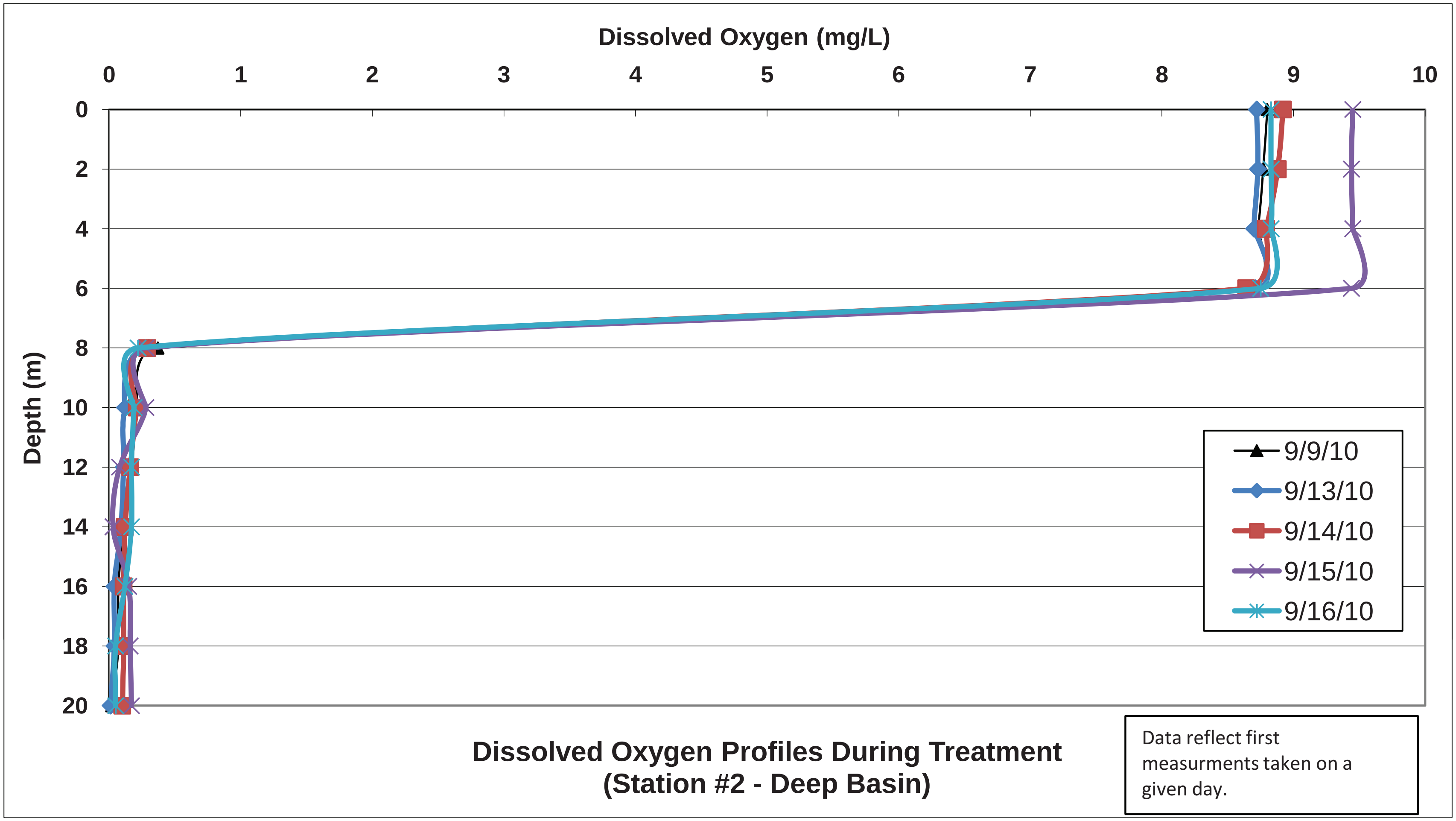

FIGURE 4-2

DISSOLVED OXYGEN PROFILES DURING TREATMENT

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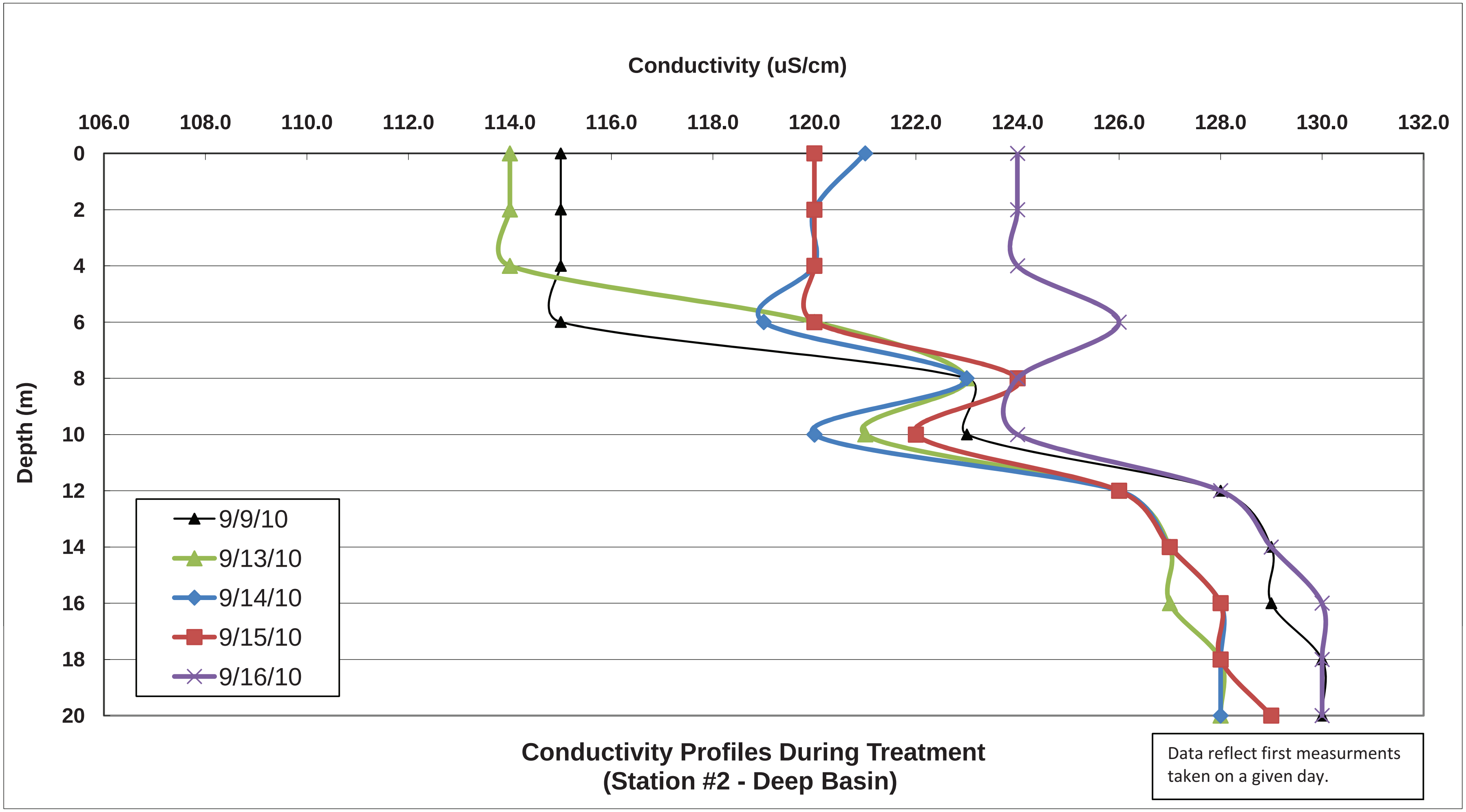

FIGURE 4-3

CONDUCTIVITY PROFILES DURING TREATMENT

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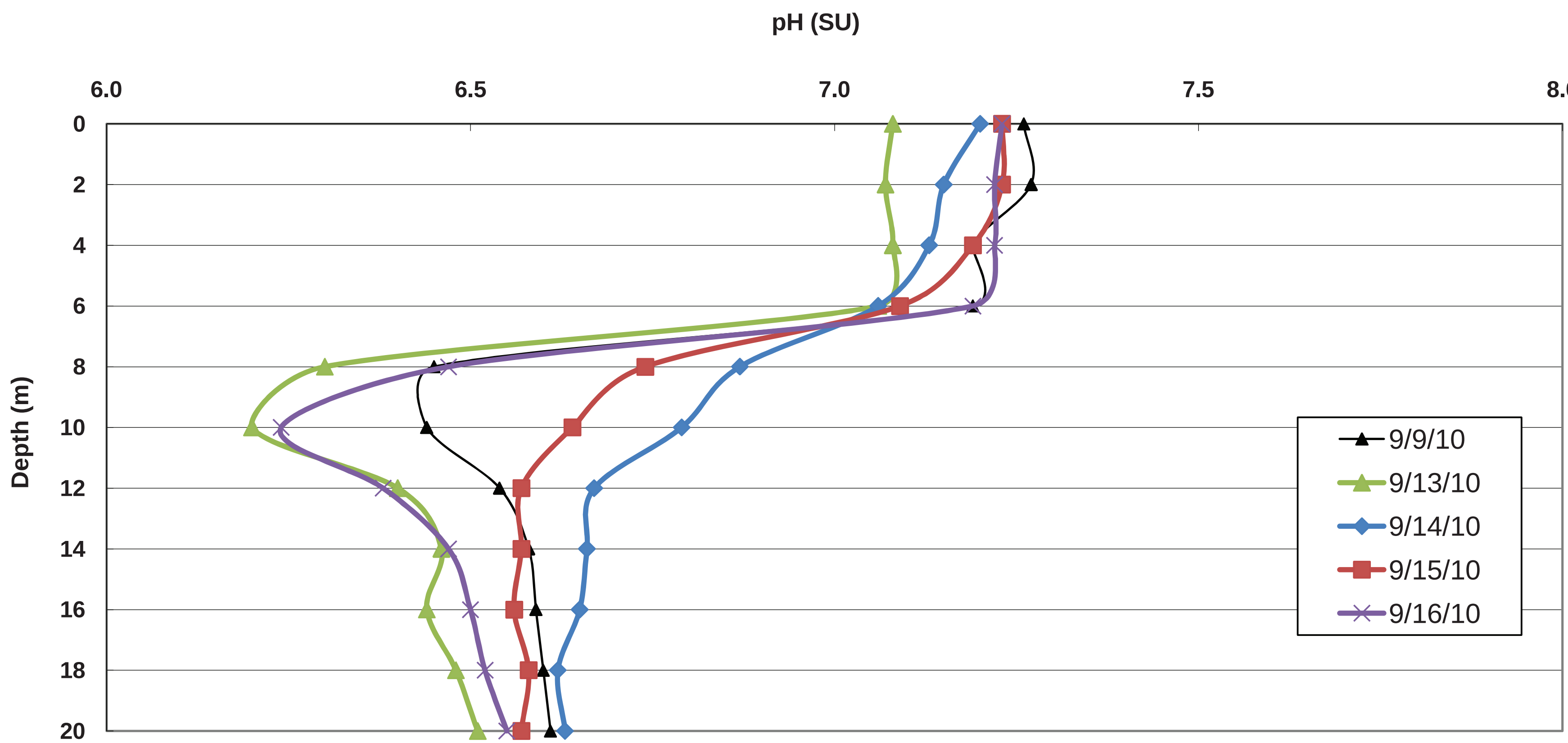

pH Profiles During Treatment
(Station #2 - Deep Basin)

Data reflect first measurments taken on a given day.

FIGURE 4-4

pH PROFILES DURING TREATMENT
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with pH remaining near approximately 7.1 to 7.2. Similarly, little change in pH in the deepest water was noted, with pH readings of approximately 6.5 to 6.6.

Monitoring of pH directly behind the treatment vessel showed little variation in pH from ambient conditions, indicating that the SA was adequately buffering the amount of AS applied. Readings measured from the surface of the pond down to 4 m(13.2 ft) depth indicated neutral pH (7.0), directly in the visual floc stream, approximately 300 feet behind the vessel. Readings measured closer to the treatment vessel at approximately 150 feet behind, were still close to neutral, with pH ranging from 7.1 to 7.2.

4.2.4 Alkalinity and Aluminum

Water samples were collected for alkalinity (Hach digital titration kit, Model #AL-DT) and total and dissolved aluminum analysis (Method 6020A, detection limit of 50 µg/L) from 4 m (13.2 ft), 7 m (23.1 ft), and 15 m (49.5 ft) at the Deep Basin (Station #2) and at 4 m (13.2 ft) and 7 m (23.1 ft) (at the top of the thermocline) at the other monitoring stations. Alkalinity samples were collected from each monitoring station in the morning before the initial application on each treatment day (pre-treatment), during the treatment at approximately mid-day, and near or after the conclusion of the treatment on each day (post-treatment). Pond water samples were collected for total and dissolved aluminum analysis in the morning prior to treatment from the control station and from the Deep Basin (Station #2), and from each monitoring station near or after the conclusion of the treatment each day.

Aluminum and alkalinity samples were collected with a peristaltic pump and weighted tubing lowered to the specified sampling depth. Samples collected for alkalinity were stored in the dark, on ice, in 250 mL plastic bottles until analyzed at the on-site laboratory. Aluminum samples were stored in the dark, on ice, until analyzed at the analytical laboratory. Specific details relating to the collection of the analytical samples and quality assurance are provided in the Sampling and Analysis Plan in the final work plan (AFCEE, 2010).

Alkalinity measurement during treatment revealed low buffering capacity throughout the pond as expected. Alkalinity ranged from 6.5 to 27.3 mg/L at all stations, over the pre-treatment and treatment period, with little variability measured (Appendix D). The highest alkalinities were measured in the deep samples from the hypolimnion. The inactivation treatment did not decrease alkalinity in the pond (Tables 4-3 and 4-4).

Table 4-3
Alkalinity and pH in the Epilimnion Pre- and Post-Treatment

	Control				Treatment Area			
	Pre-Treatment		Post-Treatment		Pre-Treatment		Post-Treatment	
	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)
Minimum	5.8	7.5	7.0	8.5	5.7	6.8	6.7	6.9
Mean	6.3	7.9	7.0	8.6	6.7	8.3	7.2	8.7
Maximum	6.6	8.6	7.1	8.8	7.8	12.1	7.6	9.8

Note: pH measured onshore during alkalinity titrations

Table 4-4
Alkalinity and pH in the Metalimnion Pre- and Post-Treatment

	Control				Treatment Area			
	Pre-Treatment		Post-Treatment		Pre-Treatment		Post-Treatment	
	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)	pH (SU)	Alkalinity (mg/L)
Minimum	5.9	7.2	6.4	7.3	5.5	6.5	6.0	6.9
Mean	6.2	8.0	6.7	8.4	6.1	7.9	6.5	8.4
Maximum	6.5	9.0	7.1	8.9	7.1	9.0	7.2	9.2

Note: pH measured onshore during alkalinity titrations

Total and dissolved aluminum concentrations were not detected in any of the pond water samples collected the morning of the pilot area application, prior to initiation of treatment (Table 4-5). At the conclusion of the pilot application, aluminum was not detected in the samples from Stations #2 and #4, but was detected at low levels, not of ecological concern, in the samples from Station #1 (on the perimeter of the pilot area) and Station #3 to the northeast of the pilot area. Aluminum was also detected in the control station samples post-treatment. The presence of aluminum in the control station samples was likely related to residual treatment chemicals that were flushed from the treatment apparatus with pond water at the conclusion of the pilot application. This was confirmed with ACT and subsequent to this event, ACT flushed the apparatus within the treatment area at the conclusion of each treatment day.

Aluminum was detected at low levels in the samples collected prior to the start of the full-scale application on September 13, including at the control station (Table 4-5). Following the first day of full treatment, aluminum levels remained low at the control station and increased slightly in samples collected from within the treatment area that day, but were well below the acute water quality criteria of 750 µg/L (dissolved). Continued monitoring of aluminum throughout treatment activities suggested that some particulate and dissolved aluminum remained in pond waters because low levels were detected at the control station on each day of treatment. Dissolved aluminum concentrations never exceeded the acute water quality criteria throughout the treatment. The maximum dissolved aluminum concentration measured was 255 µg/L at Station #1 on September 14 at the conclusion of the treatment that day.

Table 4-5
Maximum Aluminum Concentrations Measured During the Treatment

	September 9 (Pilot Application)		September 13 (Day-2)		September 14 (Day-3)		September 15 (Day-4)		September 16 (Day-5)	
	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment	Pre-Treatment	Post-Treatment
Control Station										
Total Al (µg/L)	<50	778	38.7	37.2	95	531	210	534	310	246
Dissolved Al (µg/L)	<50	85	<50	39.5	29.1	100	52	45	79	88
Station #1										
Total Al (µg/L)	-	145	-	153	-	1500	-	338	-	318
Dissolved Al (µg/L)	-	57	-	33.5	-	255	-	83	-	123
Station #2 (Deep Basin)										
Total Al (µg/L)	<50	<50	44.7	435	267	856	257	239	325	619
Dissolved Al (µg/L)	<50	<50	23.4	111	63	218	61	76	75	179
Station #3										
Total Al (µg/L)	-	<50	-	457	-	161	-	1080	-	317
Dissolved Al (µg/L)	-	<50	-	103	-	57	-	102	-	111
Station #4										
Total Al (µg/L)	-	<50	-	189	-	647	-	329	-	244
Dissolved Al (µg/L)	-	<50	-	59	-	80	-	77	-	58

Notes:
- not sampled
<50 - not detected at reporting limit of 50 µg/L

5.0 PRE- AND POST-TREATMENT CHEMISTRY

Pre-treatment and post-treatment monitoring of the water column in Ashumet Pond consisted of both field measurements and laboratory chemical analyses of water quality parameters. Water samples were analyzed for dissolved aluminum, alkalinity, dissolved phosphorus, orthophosphate, total phosphorus, iron, and manganese (iron and manganese data were collected only at the Deep Basin station). The monitoring was conducted seven (7) days prior to treatment (September 2), one (1) day after treatment (September 17), and eight (8) days after treatment (September 24).

Water samples were collected every 2 meters (6.6 ft) at the deep basin monitoring station, Station #2 (Sample ID: CHASP0002). At each of the other monitoring stations, three samples were collected; one from the epilimnion, one from the metalimnion, and one from the hypolimnion. Surface water samples were collected using a peristaltic pump and weighted tubing lowered to the specified sampling depth, which was a deviation from the work plan that was implemented for more efficient sampling. The samples collected seven (7) days prior to treatment were collected with a Niskin bottle, but all remaining samples were collected with a peristaltic pump and tubing.

Depth profiles of temperature, dissolved oxygen, pH, and conductivity were also collected at each station (Appendix E). Secchi disk depth measurements of water clarity were also recorded at each station.

5.1 ALUMINUM

Dissolved aluminum was not detected (detection limit of 100 µg/L) prior to treatment and returned to low levels shortly after treatment (Table 5-1). Dissolved aluminum was detected in only 3 of the 15 samples collected eight days after the treatment (September 24) and at concentrations of 35 µg/L or less, levels not of ecological or human health concern.

Table 5-1
Water Chemistry Monitoring Data

	September 2 (7 Days Prior)			September 17 (1 Day Post)			September 24 (7 Days Post)		
	Epilimnion	Metalimnion	Hypolimnion	Epilimnion	Metalimnion	Hypolimnion	Epilimnion	Metalimnion	Hypolimnion
Control Station									
Alkalinity mg/L)	(10	9	12	10	12	13	10	10	10
Total Phosphorus (ug/L)	22	187	19	10	13	19	9	8 (J)	6 (J)
Orthophosphate (ug/L)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
Dissolved Phosphorus (ug/L)	ND (10)	18	ND (10)	ND (10)	7 (J)	ND (10)	ND (10)	5 (J)	ND (10)
Dissolved Aluminum (ug/L)	ND (100)	ND (100)	ND (100)	61 (J)	43 (J)	40 (J)	35 (J)	ND (100)	ND (100)
Station #1									
Alkalinity mg/L)	(10	9	10	10	10	15	10	11	11
Total Phosphorus (ug/L)	15	319	42	11	11	43	7 (J)	8 (J)	9 (J)
Orthophosphate (ug/L)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	2 (J)	ND (5)
Dissolved Phosphorus (ug/L)	5 (J)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Dissolved Aluminum (ug/L)	ND (100)	ND (100)	ND (100)	55 (J)	51 (J)	ND (100)	ND (100)	ND (100)	ND (100)
Station #2 (Deep Basin)									
Alkalinity mg/L)	(9	10	16	11	15	25	10	10	23
Total Phosphorus (ug/L)	32	19	156	27	15	389	10	9 (J)	211
Orthophosphate (ug/L)	ND (5)	ND (5)	152	ND (5)	ND (5)	138	ND (5)	ND (5)	59
Dissolved Phosphorus (ug/L)	ND (10)	4 (J)	152	ND (10)	ND (10)	263	10	10	202
Dissolved Aluminum (ug/L)	ND (100)	ND (100)	ND (100)	69	ND (100)	ND (100)	34	ND (100)	ND (100)
Dissolved Iron (ug/L)	ND (50)	ND (50)	1157	ND (50)	ND (50)	2520	ND (50)	ND (50)	2196
Dissolved Manganese (ug/L)	ND (10)	2.8 (J)	1826	20	1810	2524	79	128	2584
Station #3									
Alkalinity (mg/L)	9	9	12	10	10	11	10	10	18
Total Phosphorus (ug/L)	24	30	43	15	11	23	17	18	12
Orthophosphate (ug/L)	ND (5)	ND (5)	ND (5)	ND (5)	2 (J)	ND (5)	ND (5)	ND (5)	2 (J)
Dissolved Phosphorus (ug/L)	4 (J)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Dissolved Aluminum (ug/L)	ND (100)	ND (100)	ND (100)	57 (J)	35 (J)	ND (100)	ND (100)	30 (J)	ND (100)
Station #4									
Alkalinity (mg/L)	9	9	10	10	10	10	15	14	22
Total Phosphorus (ug/L)	14	49	28	10	20	20	6 (J)	7 (J)	157
Orthophosphate (ug/L)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)	41
Dissolved Phosphorus (ug/L)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	6 (J)	8 (J)	154
Dissolved Aluminum (ug/L)	ND (100)	ND (100)	ND (100)	61 (J)	ND (100)	70 (J)	ND (100)	ND (100)	ND (100)

Notes: Station #2 samples are average of samples collected in the epilimnion and hypolimnion.

5.2 ALKALINITY

Alkalinities ranged from 9 to 10 mg/L in the epilimnion prior to treatment and from 10 to 15 mg/L in the epilimnion eight days after the treatment (Table 5-1). Alkalinity levels in the metalimnion and hypolimnion samples showed a similar pattern, with a slight increase in alkalinity in the 8-day post-treatment samples.

5.3 PHOSPHORUS

Total phosphorus concentrations of 10 µg/L or greater can support algal blooms (MA EOEA, 2004). Seven days prior to treatment, on September 2, 2010, total phosphorus concentrations ranged from 11 to 71 µg/L in the epilimnion (0-6 m depth), 19 to 319 µg/L in the metalimnion (6-8 m depth), and 19 to 363 µg/L in the deeper waters of the hypolimnion (Appendix E). Total phosphorus concentrations in the epilimnion declined markedly following the treatment to levels less than 20 µg/L (Figure 5-1). The decrease is likely a result of the inactivation treatment removing dissolved inorganic phosphorus, primarily as orthophosphate, and organic matter (organic phosphorus) from the water column as the floc settled through the water. Total phosphorus concentrations in the metalimnion also showed a sharp decrease following the treatment (Figure 5-2); however, a similar trend was not readily apparent in the hypolimnion where there was a slight decrease in total phosphorus at three of the stations (Figure 5-3). These results may be explained by the much higher absolute concentrations of total phosphorus in the hypolimnion and the higher ratio of dissolved phosphorus to particulate phosphorus compared with the epilimnion samples (Table 5-1). Aluminum hydroxide floc is not as efficient at removing dissolved organic phosphorus from the water column as it is at removing phosphorus-rich particulate materials such as algae or detritus. Therefore, the sharp decline in total phosphorus in the epilimnion relative to that observed in the hypolimnion was likely related to the greater proportion of phosphorus in the epilimnion present as more easily removed particulate organic phosphorus.

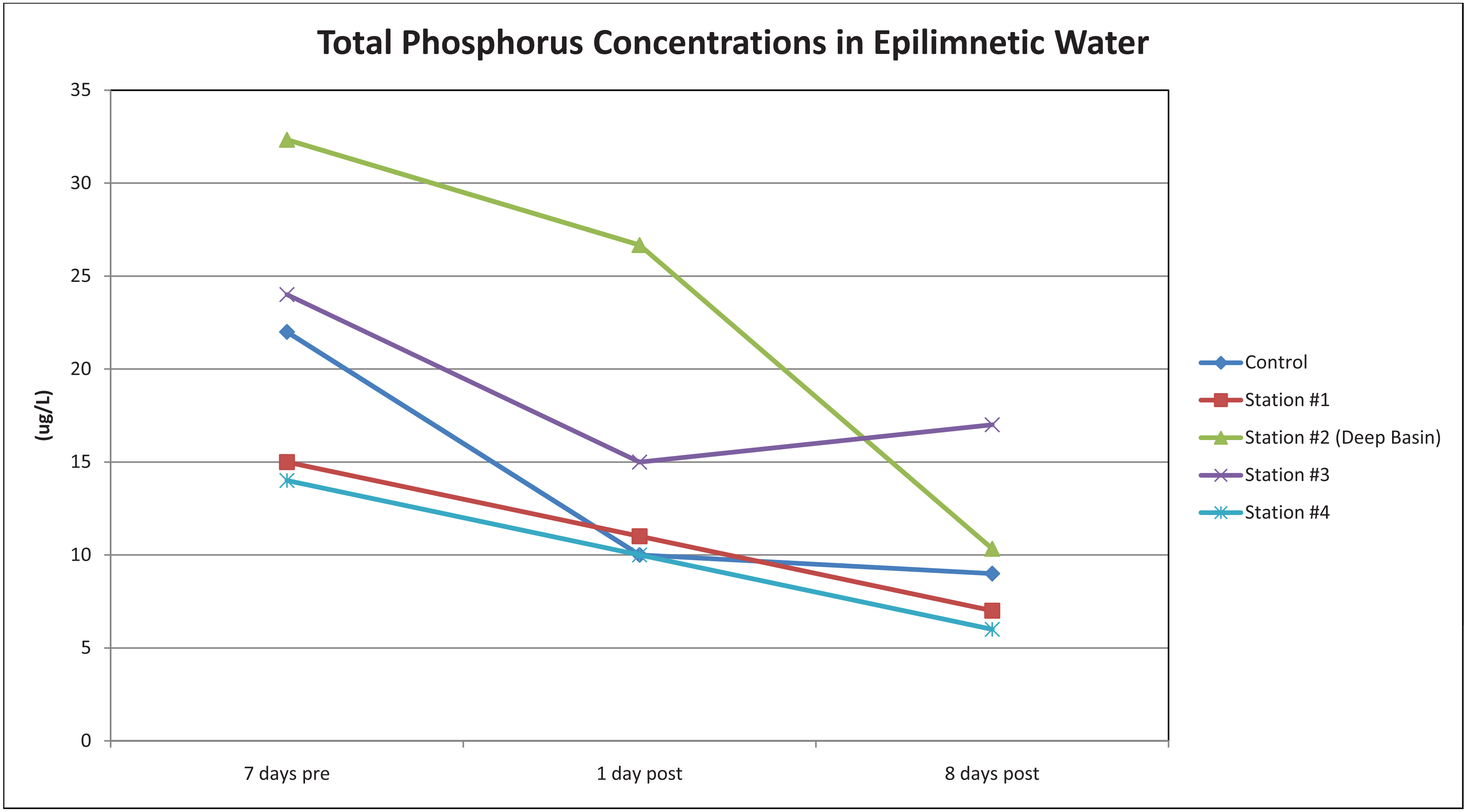

FIGURE 5-1

TOTAL PHOSPHORUS CONCENTRATIONS IN EPILIMNETIC WATER

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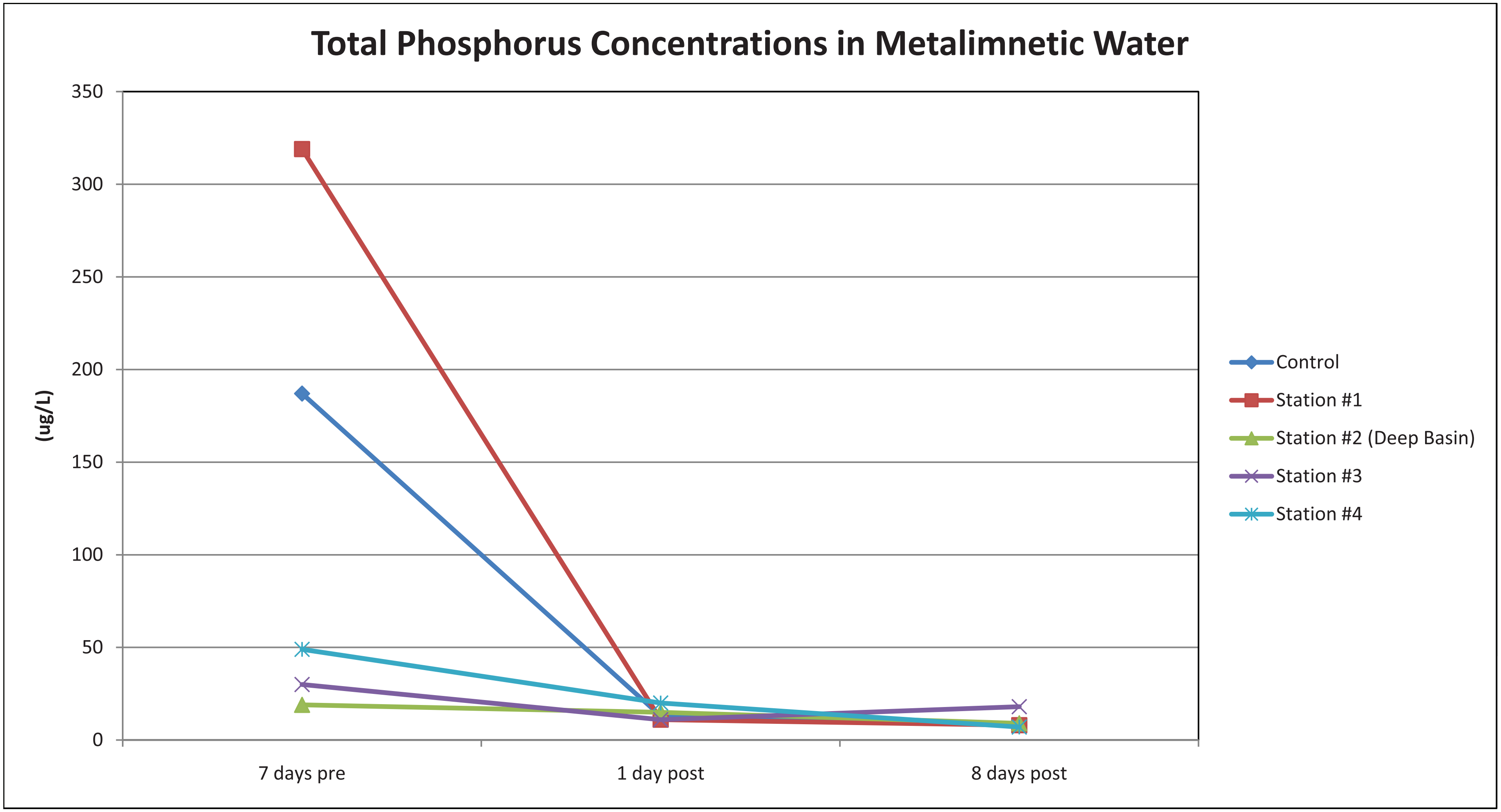

FIGURE 5-2

TOTAL PHOSPHORUS CONCENTRATIONS IN METALIMNETIC WATER

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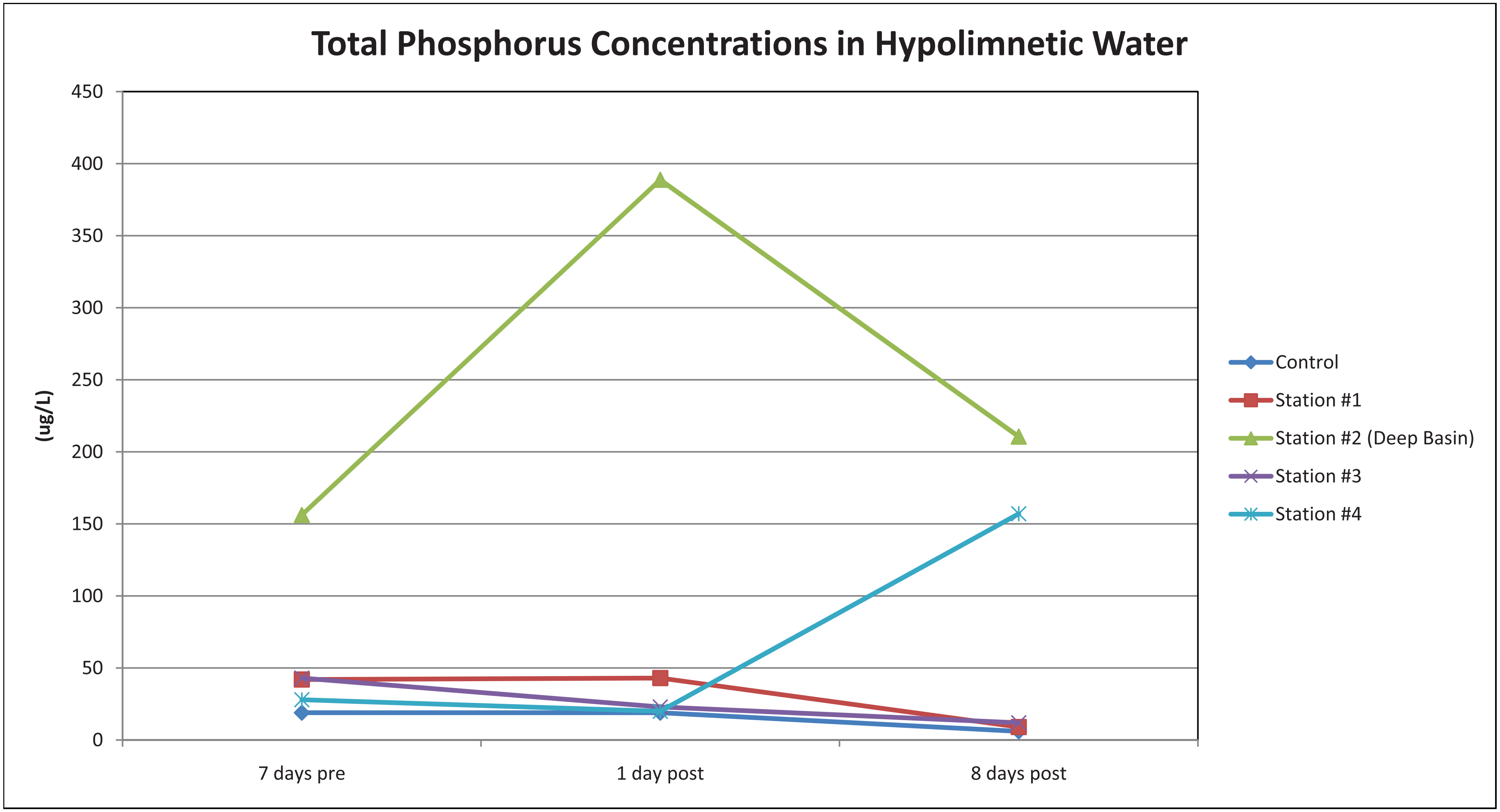

FIGURE 5-3

TOTAL PHOSPHORUS CONCENTRATIONS IN HYPOLIMNETIC WATER

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Dissolved phosphorus concentrations did not show a similar trend; there were no detections in most samples both before and after treatment. Although, the exception was the Deep Basin (Station #2) samples, where dissolved phosphorus was detected in the deeper samples and showed a slight increase following treatment (Table 5-1).

Orthophosphate was detected in only the deeper water samples both before and after treatment and primarily only in the Deep Basin samples (Table 5-1). The average concentration of orthophosphate in the hypolimnion at the Deep Basin decreased from 152 µg/L prior to the treatment, to 58.7 µg/L eight days after the treatment (Table 5-1).

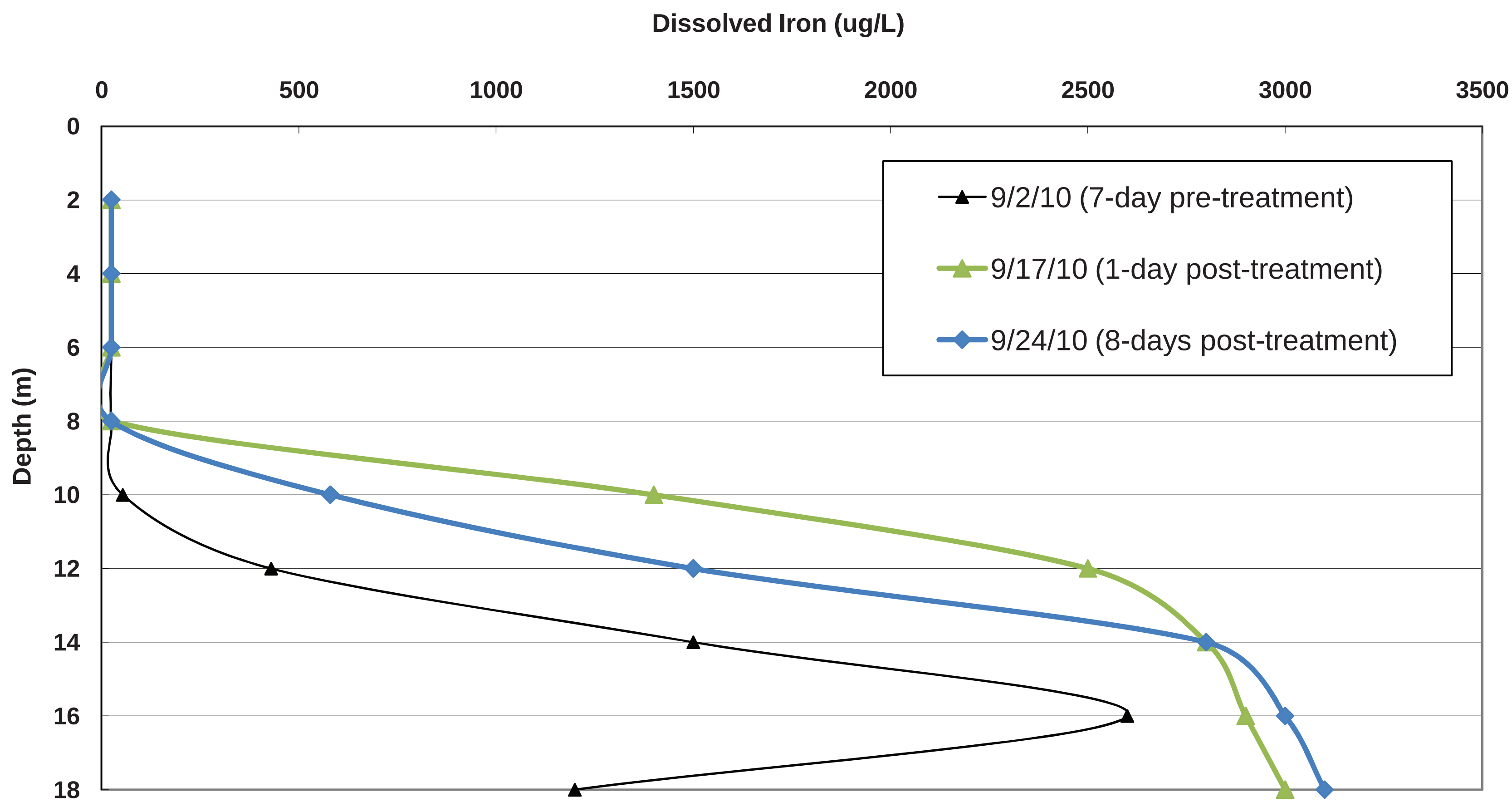
The decrease of total phosphorus concentrations in the epilimnion following treatment is encouraging and suggests substantial removal of phosphorus from the water column. This removal combined with the sequestration of phosphorus in the sediments by the aluminum hydroxide blanket should significantly reduce phosphorus regeneration and consequently reduce the amount of phosphorus available to support future algal blooms in the coming years.

5.4 IRON AND MANGANESE

Dissolved iron concentrations were below the detection limit in the epilimnion sample both prior to the treatment and following the treatment (Table 5-1). Dissolved iron concentrations increased in the hypolimnion following treatment (Figure 5-4).

Dissolved manganese concentrations were below the detection limit in the epilimnion sample prior to the treatment and increased slightly following the treatment (Table 5-1). Dissolved manganese concentrations showed a similar pattern as iron and increased following treatment (Figure 5-5).

Inorganic phases rich in iron or manganese that reach the sediments of the deep basin are subject to redox-mediated biogeochemical processes. Depending on the oxygen content of the overlying water column and the depth of burial in the sediments, iron and manganese in the sediments are continuously cycled between the dissolved state and a mixture of poorly



Dissolved Iron Pre- and Post-Treatment
(Station #2 - Deep Basin)

FIGURE 5-4

DISSOLVED IRON PRE- AND POST TREATMENT

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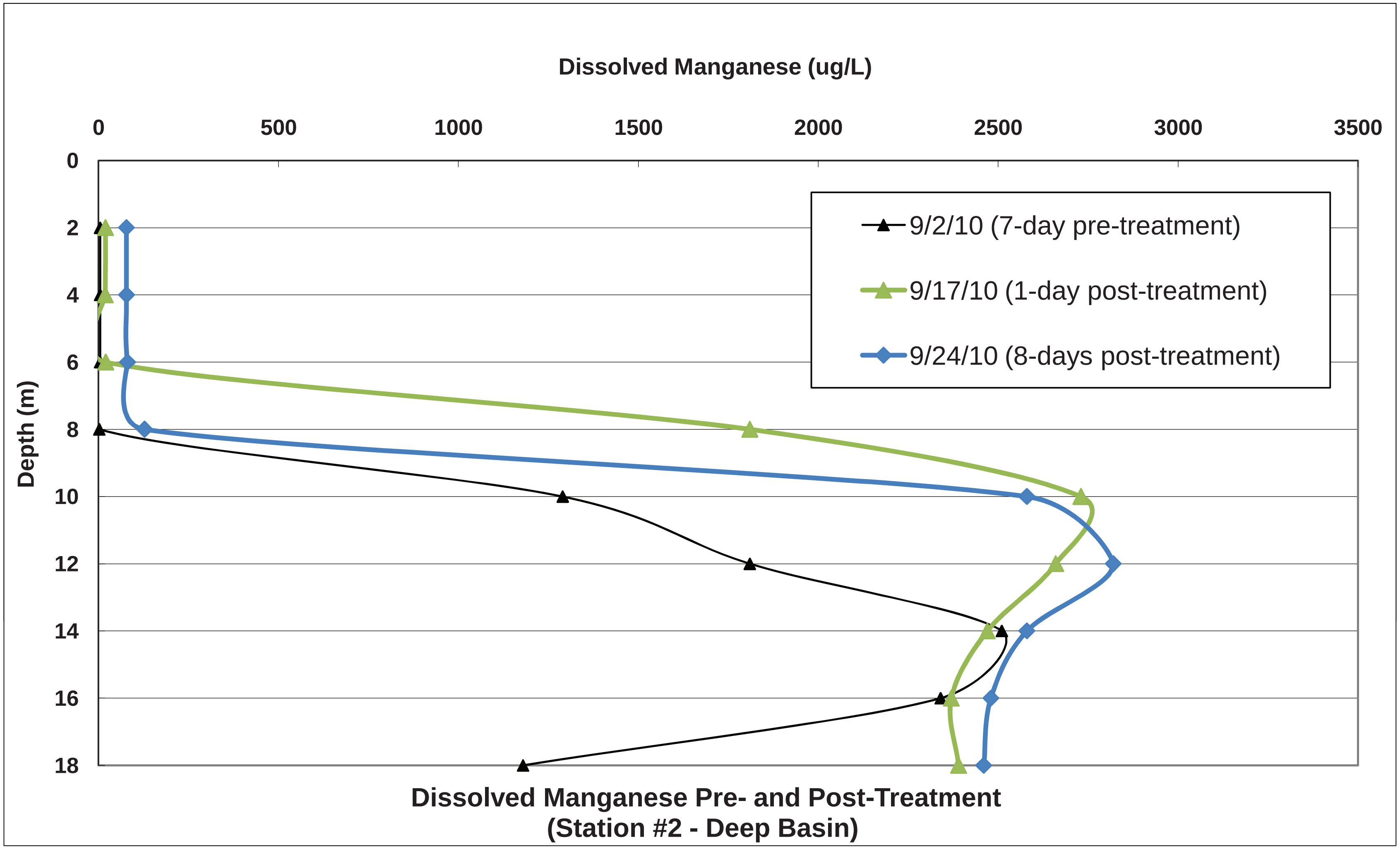

FIGURE 5-5

DISSOLVED MANGANESE PRE- AND POST TREATMENT

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crystalline to amorphous iron- and manganese-rich hydroxides, sulfides and possibly phosphates.

Under anoxic conditions in the hypolimnion, the oxidized iron and manganese phases at the interface undergo microbial mediated reductive dissolution. As dissolution proceeds, the solubilized metals are released into, and accumulate in, the hypolimnion (AFCEE, 2002b). As the summer progresses, elevated concentrations of iron, manganese, silica, ammonium, and phosphorus generally develop in the hypolimnion and progressively extend to shallower depths within it. The observed increase in iron and manganese concentrations in the hypolimnion after the treatment is likely related to the natural seasonal increase in these metals and not related to the treatment itself.

5.5 TRANSPARENCY

Reduction of biologically available phosphorus results in improvements in water clarity by reducing phytoplankton production. Water clarity, as measured by Secchi disk transparency readings, prior to and after the treatment are shown in Figure 5-6. Secchi disk transparency was very low, <4 ft (1.2 m), on August 17, 2010, suggesting the occurrence of an algae bloom. At the beginning of treatment, Secchi disk transparency was about 8 ft (2.4 m). An immediate improvement in water clarity was apparent by the last day of the treatment when Secchi disk depth increased by about 2 ft (0.6 m). This was the result of sweeping of organic matter from the water column. Continual improvement in water clarity was observed at one (1) day post-treatment and at eight (8) days post-treatment. Water clarity eight (8) days post-treatment on September 24 had increased significantly when Secchi disk transparency was 14.5 ft (4.4 m). On September 29, when a long-term monitoring (monthly) event was conducted, the water clarity was slightly less at 11.8 ft (3.6 m). This may relate to recovery of phytoplankton biomass following sweeping of organic matter (ie. phytoplankton) from the water column during treatment.

Data collected roughly a month later on November 3rd, during routine monitoring, indicate that secchi disk transparency had increased to 19.0 feet. This result is very significant since it represents the greatest transparency measured at this time over ten (10) years of record

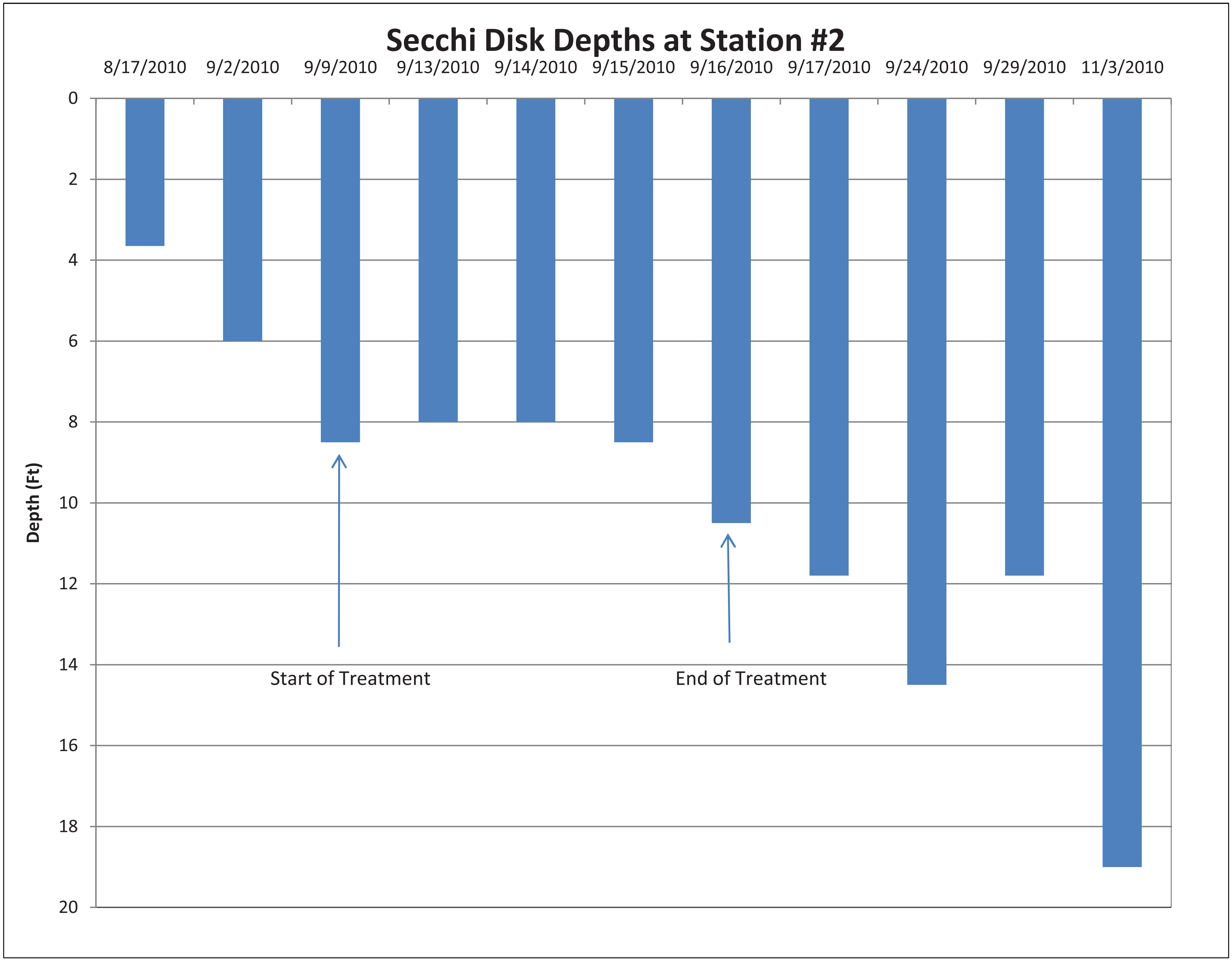

FIGURE 5-6

SECCHI DISK DEPTHS AT STATION #2
AFCEE - Massachusetts Military Reservation

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collected by AFCEE for Ashumet Pond. Typically by November, stratification of the pond has broken down (ie. pond turn-over) with cooler weather and higher winds. Water enriched in phosphorus from the hypolimnion moves into the shallow euphotic zones of the pond supporting a fall bloom and lowering transparency. Dissolved oxygen and temperature data collected on November 3rd, discussed in subsequent sections, indicate that stratification had broken down and the pond had become mixed and of generally uniform temperature and having high dissolved oxygen from top to bottom. Long-term monitoring data collected over the course of the next year and reported in annual monitoring reports is expected to provide further evidence of positive trends in water clarity improvement from the inactivation treatment.

5.6 TEMPERATURE, DISSOLVED OXYGEN, CONDUCTIVITY, AND PH

Depth profiles of temperature, dissolved oxygen (DO), conductivity, and pH were collected at one (1) m (3.3 ft) intervals from the pond surface to one (1) m (3.3 ft) above the bottom during pre- and post-treatment monitoring and during the long-term monitoring events on August 17, 2010, September 29, 2010, and November 3, 2010. Thermal structure or stratification (thermocline) of the pond was stable throughout the pre- and post- treatment monitoring period, although a decline in epilimnion water temperature from approximately 25ºC to 20ºC was observed from September 2nd to September 24th. This decline relates to the seasonal cooling of the epilimnion and perhaps greater wind-driven mixing in the late summer/early fall, as the pond moves toward fall/winter isothermal conditions. Data collected during routine monitoring approximately a month later, on November 3rd, indicate that the thermocline was largely gone with near isothermal conditions, the water column had a small range in temperature varying from approximately 11 to 12.5ºC (Figure 5-7).

The shape of the dissolved oxygen (DO) profile for the pond (Figure 5-8) for events between August 17, 2010 (pre-treatment) and September 29, 2010 (post-treatment) was similar to the thermocline for the period, having greatest DO in the epilimnion and very low DO or anoxic conditions developing between 6 m (19.8 ft) and 8 m (26.3 ft). The general character of the profile remains from pre-treatment to post-treatment, however, the depth at which anoxia develops had increased from approximately 6 m to about 9 m (29.7 ft) over the period

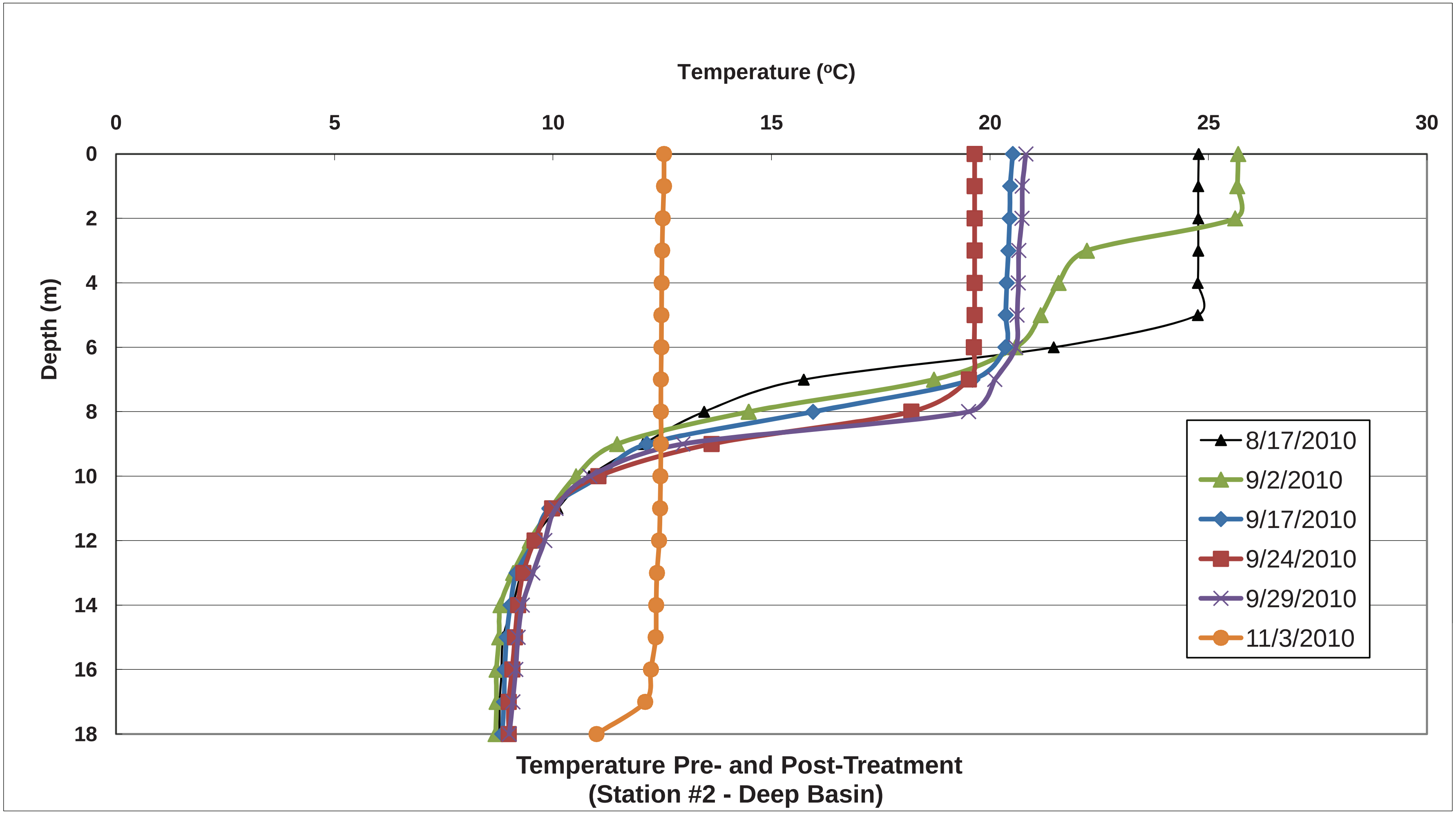

FIGURE 5-7

TEMPERATURE PRE- AND POST-TREATMENT (STATION #2)

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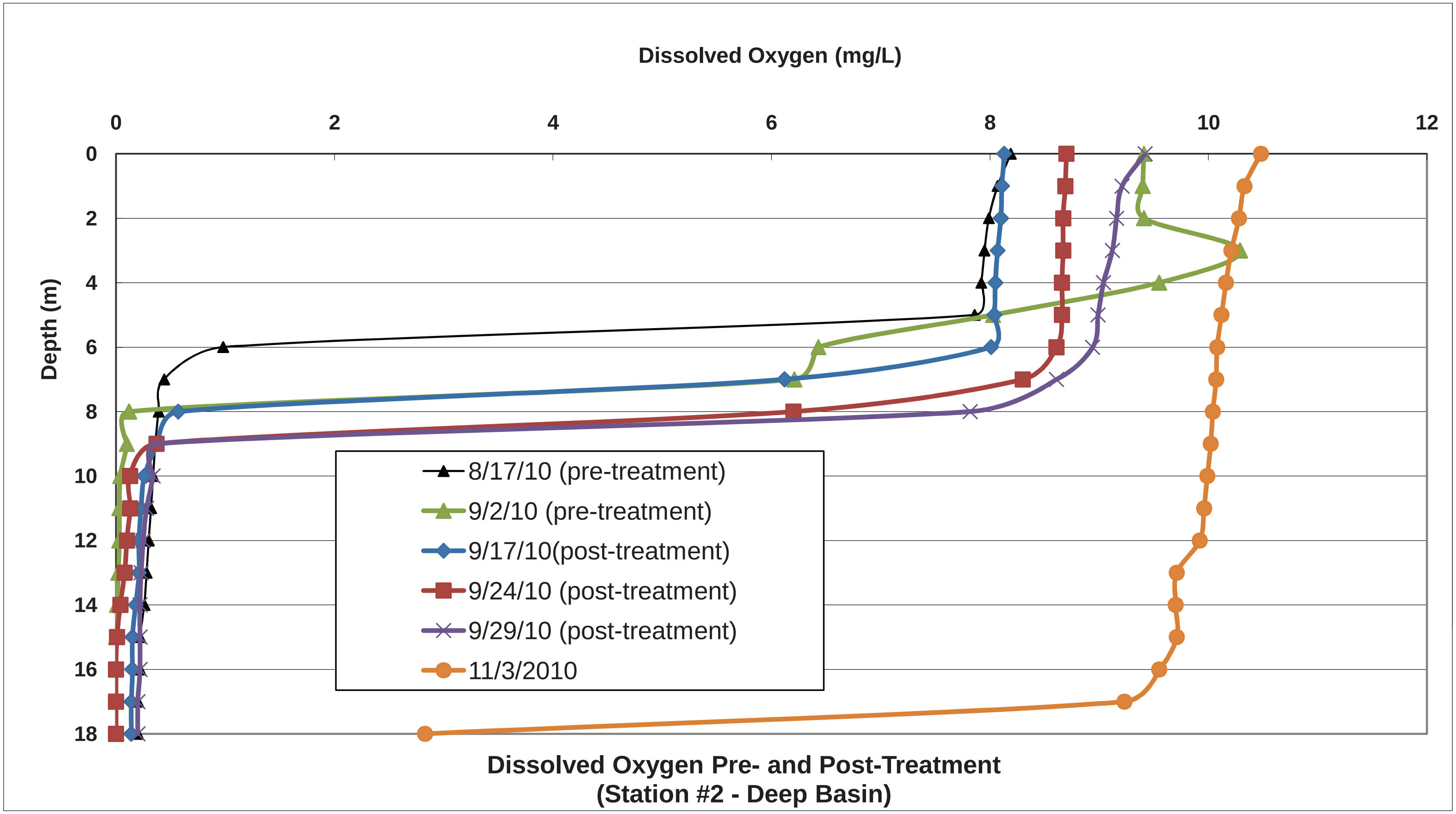

FIGURE 5-8

DISSOLVED OXYGEN PRE- AND POST-TREATMENT (STATION #2)

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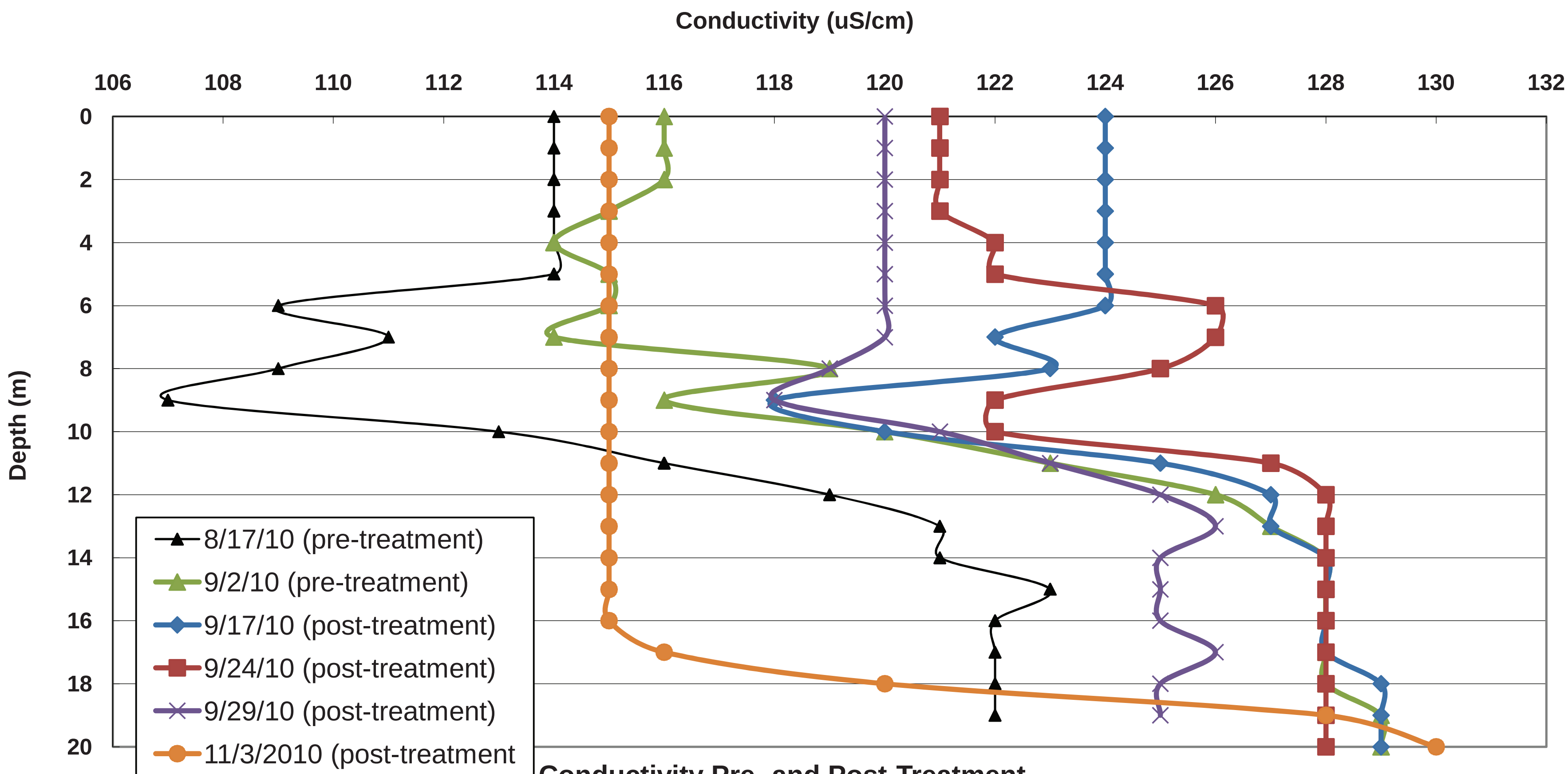
(Figure 5-8). Some of this change is related to seasonal or weather related increases in DO between mid August and early September; however, the treatment was likely an additional factor in depressing the oxic line further between early and late September by reducing overall phytoplankton productivity and associated water-column, biological oxygen demand (BOD) in the hypolimnion. Approximately a month later, on November 3rd, high dissolved oxygen is present through-out most of the water column, due to seasonal mixing and reduced biological productivity, in part due to the treatment and also less solar insolation.

Electrical conductivity of Cape Cod glacial kettle ponds, including Ashumet Pond, are very low due to the low ionic strength of these natural waters developed in a glacial sand aquifer setting. The variation in electrical conductivities vertically within the water column is associated with slight changes in redox chemistry related to photosynthesis during daylight hours. However, this variation is slight, generally less than 15 µS/cm. The monitoring data suggest that the treatment may have slightly increased the overall conductivities in the epilimnion measured on September 17th; however, the variation vertically is similar to pretreatment conditions and the change is not considered significant. This agrees with other water chemistry data. Electrical conductivity below the thermocline in water deeper than approximately eight (8) m (26.4 ft) remained fairly constant through the treatment (Figure 5-9). By November 3rd, however, the electrical conductivity profile is fairly uniform over most of the water column at approximately 115 µS/cm. This is similar to the epilimnion prior to treatment. This likely due to downward mixing of epilimnetic waters and overall lowered biological productivity in the pond.

Profiles of pH before and after the treatment are depicted in Figure 5-10. There was a large increase in pH measured in the top three (3) m (9.9 ft) of the water column one (1) week prior to the treatment on September 2, which was likely related to algal photosynthetic activity. The treatment appeared to increase pH slightly in the epilimnion and deeper water column; however, this effect appears to have been temporary as pH readings shifted back to pretreatment conditions in the days following the treatment. The pH range measured one day after the treatment of 6.7 to 7.7 was well within the range deemed safe for keeping dissolved aluminum (Al^{3+}) at a minimum (pH of 6 to 8). As with other parameters discussed above, the pH of the pond is more uniform vertically by November 3rd, with the breakdown of the thermocline, less productivity, and general downward mixing of pond waters.



Conductivity Pre- and Post-Treatment
(Station #2 - Deep Basin)

FIGURE 5-9

CONDUCTIVITY PRE- AND POST-TREATMENT
(STATION #2)
AFCEE - Massachusetts Military Reservation

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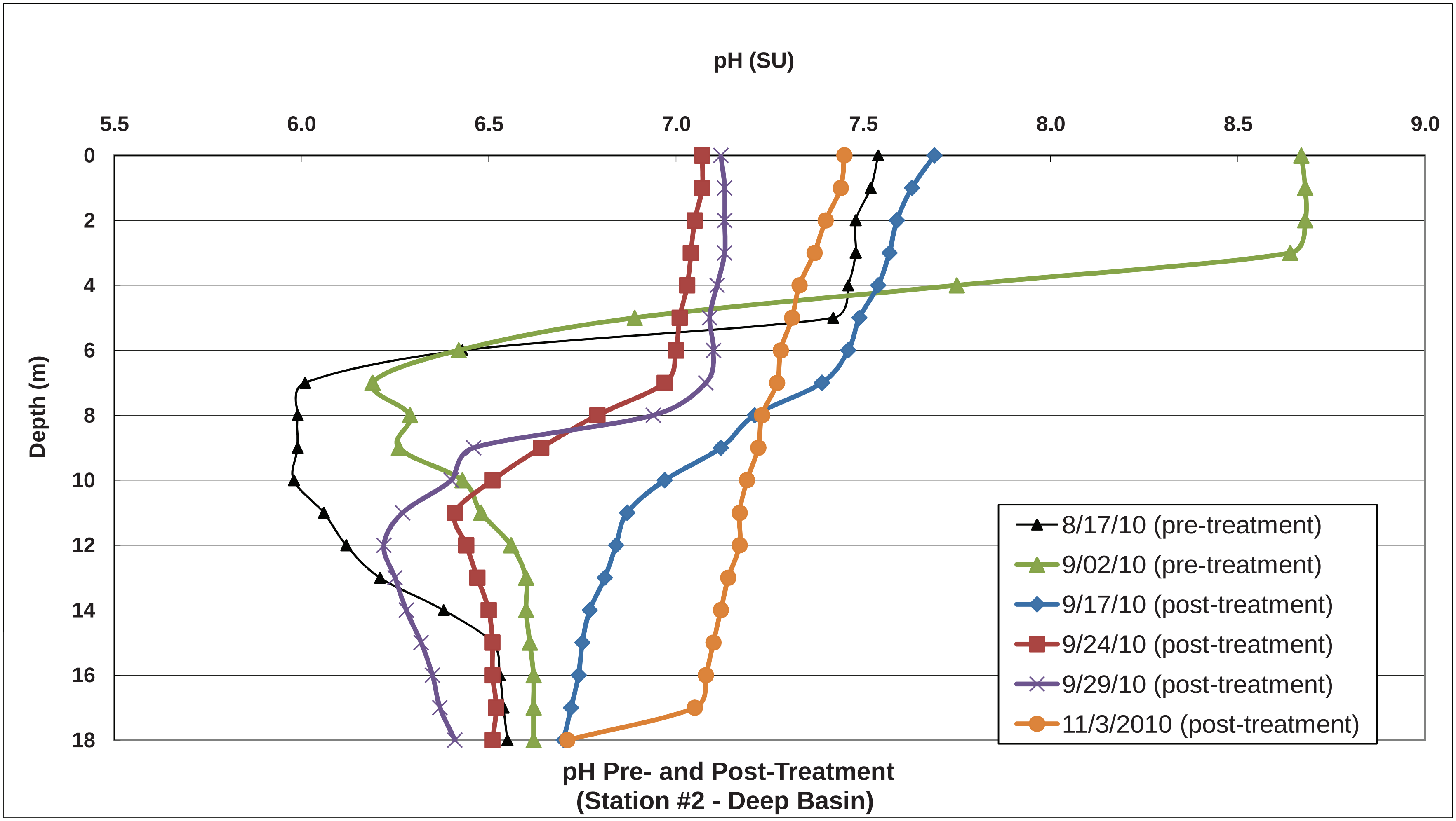

FIGURE 5-10

pH PRE- AND POST-TREATMENT (STATION #2)

AFCEE - Massachusetts Military Reservation

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6.0 PRE- AND POST-TREATMENT MUSSEL BIOLOGY

As part of the planning for the inactivation treatment, a pond-wide survey of mussel distribution was conducted prior to treatment. An investigation of aluminum deposition and potential impacts to mussels from the treatment was also undertaken to address concerns about potential adverse effects to tidewater mucket from the treatment. The results of these studies are summarized here and presented in full in Appendix A.

As part of determining the sediment area within Ashumet Pond to receive the inactivation treatment, a detailed survey of the spatial extent of freshwater mussels was conducted using an autonomous underwater vehicle (AUV) equipped with still cameras and video linked to GPS, with verification by traditional diver survey. The purpose of the survey was (a) to determine the lower depth of existing mussel beds to guide the application and (b) to locate sites for assessing changes in mussels potentially associated with treatment.

The AUV was flown two (2) feet (0.6 m) above the pond bottom using on-board bottom tracking. Transects were established and traversed by the AUV using on-board navigation and GPS. Photos were collected at approximately one (1) meter (3.3 ft) intervals along each transect (See Figure 1, Appendix A). The resulting thousands of individual digital photographs were analyzed to evaluate mussel presence/absence and approximate population density. Findings indicated that all species of mussels generally did not colonize below the 25 ft (7.6 m) depth contour (see Figure 2, Appendix A). It is almost certain that the depth of mussel beds is restricted by summertime hypoxia/anoxia in Ashumet Pond, where historical monitoring has documented development of anoxia below this depth in the midsummer in most years. The survey did not include the deeper areas [>40 feet (12.1 m)] where previous surveys did not find mussel habitat nor very shallow areas where viable benthic habitat has been assumed to exist and treatment was not possible.

Although the application was designed to avoid mussel habitat by targeting depths >35 feet (10.7 m), NHESP as the agency charged with protection of this resource was concerned that tidewater muckets, a species of special concern in Massachusetts, previously identified in Ashumet Pond, might be adversely affected by aluminum hydroxide floc. In order to assess the possible impact of the application on tidewater mucket, a two (2) tiered approach to evaluation was undertaken. Sediment traps were positioned around the perimeter of the AS/SA application area to monitor for deposition of aluminum hydroxide floc that might drift outside the prescribed application area. Sediment traps were positioned above a mussel sampling quadrate fixed to the bottom to allow repeated enumeration of the mussels potentially receiving aluminum hydroxide floc deposition (as measured in the associated trap) and any changes in behavior or potential mortality. Observations were conducted two (2) days prior to the initial application, one (1) day following the end of the 2010 application, and again, ten (10) days later. In this way, the population and behavior of mussels could be assessed through the time to capture any short and medium-term changes. More importantly, if any changes in population or behavior were observed, these changes could be related directly to measured aluminum deposition rates.

Material collected within the sediment traps recovered the day following the AS/SA application contained a visible amount of organic matter either the result of wind-derived sediment resuspension or the flocculating effects of the treatment. Visual inspection of the filters showed no evidence of aluminum hydroxide floc based upon comparison with floc generated in the laboratory using AS and SA provided by ACT. Subsequent quantitative chemical analysis of the digested filters using a colorimeteric assay for aluminum revealed only very low amounts of aluminum deposition in all of the sediment traps. The rates were two (2) orders of magnitude less than the application rate of 40 g Al/m^2 in the deeper waters outside of the mussel areas.

The measured aluminum deposition may in large part be accounted for by the natural deposition to pond sediments that has been historically observed in Ashumet Pond. Sedimentation rates within Ashumet Pond were found to be relatively high as quantified using Pb_{210} techniques in 1999 (5.1 mm/yr for the Deep Basin, and 2.5-2.7 mm/yr for the 10-11 meter depth contour). These rates of total sediment deposition can be used to determine the natural background aluminum deposition, generally associated with allocthonous clay particles (alumino-silicates). The most conservative estimate of ambient aluminum deposition rates was 19.8 mg Al/m^2 (Table 1, Appendix A). After correcting for "background" deposition, the trap results indicate that aluminum was higher in the sediment traps than could be explained by natural aluminum deposition alone, hence the “Net Aluminum” deposition may indicate some deposition of aluminum from aluminum hydroxide floc or other surficial drift. To the extent that this does represent aluminum deposition, it may have resulted from surficial drift due to wind or to micro-floc formed in the application area that could drift outside of the target area. In any case, the level of deposition compared to the treatment area application rate of 40 g Al/m^2, was very low and below levels of concern for acute effects on pond biota.

Twelve (12) fixed quadrates were deployed to measure mussel response to the treatment (see Appendix A for detailed discussion). Quadrates were surveyed the day before the initial treatment, the day after the treatment was completed, and again 10 days later. The surveys included pertinent measurements of the population and the viability of the individual mussels. These measurements included:

(1) sediment type

(2) percent cover by submerged aquatic vegetation

(3) slope of bottom

(4) total water depth

(5) latitude/longitude

(6) number of live mussels

(7) number of dead mussels

(8) number of empty mussel shells (note any recently dead mussels (e.g. tissue attached, shiny, bright nacre) vs. remnant, spent valves)

(9) number of gaping mussels (as an indicator of stressed and/or dying mussels).

(10) observe whether apertures are open, closed, or both – when mussels are filtering the incurrent and excurrent apertures (small opening at posterior end) are open; as possible it will be noted whether mussels are filtering or are remaining closed

(11) level of embeddedness defined as 95% (apertures visible at sediment surface), 50%, 0% (on surface)

(12) visual evaluation of distribution of mussels within the quadrate at each of the 12 locations, by dividing the quadrate into 4 sub-areas and identifying within each the number of mussels and also within each if the mussels are (a) clumped, (b) randomly distributed or a combination or (c) if mussels appear to be moving in certain direction. The concept is to determine if the distribution within a quadrate changes between surveys.

(13) mussel behavioral changes will be assessed within each quadrate on each survey by gently touching 10 individuals that are open and filtering and recording if the mussels (a) close their valves, (b) partially close, or (c) are unresponsive after 5 minutes.

(14) notable habitat observations (algal mat, sand ripples, bacterial mat, evidence of anoxia, etc).

(15) attempt to identify the mussels to species, if possible.

The results of the survey did not provide conclusive evidence of mussel stress in response to the treatment. Indeed, the data suggests that there was little effect whatsoever, which might be anticipated given the very-low level of aluminum deposition. Evidence of stress that was observed was likely due to poor water quality (e.g. low dissolved oxygen at depth) in Ashumet Pond at the end of the summer season at the time of the treatment.

7.0 SUMMARY AND CONCLUSIONS

The phosphorus inactivation treatment of Ashumet Pond was successfully conducted from September 9–16, 2010. Approximately 56.5 acres were treated with aluminum sulfate (AS) (17,559 gallons) and sodium aluminate (SA) (9,805 gallons), with an areal dose of approximately 40 g Al/m^2. The ratio of AS to SA applied was 1.79:1, very close to the targeted ration of 1.8:1. Alkalinity was low as expected, but remained stable and unaffected by the treatment. The pH was maintained between 6.0 and 8.0 in all the in-situ monitoring readings, although some of the pH readings associated with the real-time alkalinity measurements were at times slightly less than 6.0.

No fish or mollusk mortality was observed during or after the treatment that could be attributed to the activity. Post-treatment assessment of water quality at multiple depths at five (5) stations revealed a distinct decline in total phosphorus and only a few aluminum measurements above pre-treatment values eight (8) days after the treatment. However, no dissolved aluminum concentrations exceeded the acute water quality criteria (750 µg/L) at any time during treatment activities or the monitoring period that followed.

The treatment has had no measurable negative impact on mollusk communities. The results of the mussel survey did not indicate mussel stress in response to the treatment. The data suggested that there was little effect and very low levels of aluminum deposition were measured in the mussel habitat areas. Evidence of stress that was observed was likely due to poor water quality (e.g. low dissolved oxygen) in Ashumet Pond at depth toward the end of the summer season, prior to the treatment.

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APPENDIX A – UMASS DARTMOUTH, SMAST TECHNICAL REPORTS

Technical Report

Ashumet Pond Phosphorus Management Program: Aerobic and Anaerobic Phosphorus Release from Sediments within the 30 ft - 40 ft Depth Contour

By:
Dr. David R. Schlezinger
Dr. Brian L. Howes
Coastal Systems Program
School for Marine Science and Technology
University of Massachusetts - Dartmouth
706 S. Rodney French Blvd
New Bedford, MA 02744
508-910-6314

October 28, 2010

Sediment Phosphorus Regeneration

Overview: The release of phosphorus from sediments within the deep basin of Ashumet Pond (45 ft-60 ft) is significant to the annual phosphorus balance of Pond waters. These sediments are overlain by oxic waters during the late fall through spring, with anoxic waters predominating in summer. The 2001 Alum treatment of Ashumet Pond targeted these sediments to reduce this phosphorus source to a level that would significantly improve the trophic status of this pond. While this initial treatment was successful in meeting its goals of improving pond health, the external phosphorus load and the load from untreated sediments previously enriched with phosphorus was sufficiently large that a second treatment was set for 2010. As part of the planning of the second Alum treatment, the potential of increasing the effectiveness and longevity of the treatment by expanding the area of pond sediments receiving Alum was evaluated through laboratory incubations of sediment cores from Ashumet Pond. In order to gauge the increase in treatment effectiveness of treating both deep and shallow sediments the rates of phosphorus release from pond sediments to the overlying water column were measured under oxic and anoxic conditions. These data were then used to gauge the potential reduction in total phosphorus release to the water column under a range of areas for Alum application.

The rates and patterns of release of phosphorus from sediments to overlying water was determined using sediment cores collected and incubated from a variety of locations within the previously untreated, 30 ft-40 ft depth zone of Ashumet Pond. Although these sediments are not overlain by anoxic bottom waters every year, it is clear from the watercolumn monitoring data that anoxic waters do periodically cover these sediments. More importantly, although most phosphorus release occurs when sediments initially go anoxic, release under aerobic conditions may be significant and ecologically important depending on the level of nutrient enrichment of the pond and the contribution of the surface area being examined.

It appears from the results of the sediment phosphorus release analysis that the magnitude of phosphorus reduction will be significantly enhanced by expanding the bottom area receiving alum to include the sediments at shallower depths (30 ft-40 ft) in addition to repeating the treatment of the deep basin. The Alum application should lower the amount of both oxic and anoxic phosphorus release from these sediments, which will likely extend the longevity of the treatment as well.

Approach: The goal of the sediment analysis was to determine the effect of increasing the historic alum treatment area (2001) to encompass the transitional area of the seasonal oxycline. Cores were collected in May 2010 before stratification to gauge the phosphorus load from sediment that supports Spring/Summer phytoplankton growth and to allow estimation of the amount of reduction in phosphorus release from sediments to pond waters under different Alum application coverages (Figure1).

Sediment cores were collected and incubated from eleven (11) locations distributed throughout the 30 ft-40 ft contours of Ashumet Pond in May 2010; single cores were collected to provide greater sample distribution and better representation of spatial patterns of phosphorus release. In addition, duplicate cores were collected at one location for quality assurance purposes.

Results: Summary of the flux results are presented in Table 1. Phosphorus flux was measured for a total of 65 days and encompassed each of three distinct phases of phosphorus release 1.) Oxic release; 2.) Chemical release following anoxia; and 3.) Anoxic release following desorption of iron bound phosphorus. Because the chemical release phase occurs only under anaerobic conditions the rate represents a composite of both chemical release of iron bound phosphorus and anaerobic remineralization. The last column "Net Chemical Release" in Table 1 represents the difference of the total release rate measured during the chemical release phase and the anaerobic release rate, the result is chemical release. The flux rates were similar and do not appear to reflect significant areal differences related to proximity to the ground water plume, iron barrier, or to the fresh water stream input located in the northeastern portion of the pond.

SMAST University of Massachusetts Dartmouth The School for Marine Science and Technology

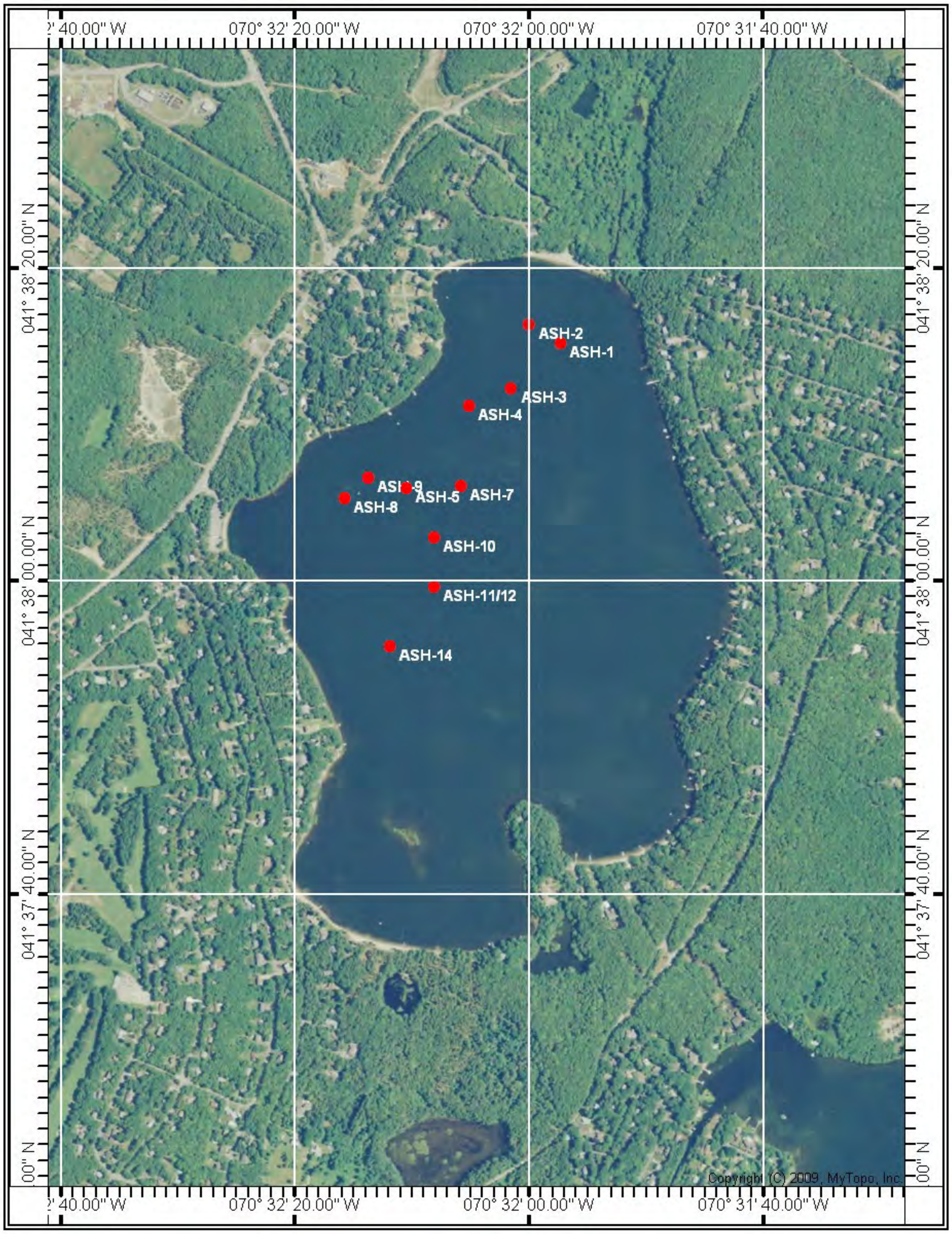

Figure 1. Map of Ashumet Pond showing the locations of cores collected within the 30 ft-40 ft depth contour in May 2010. ASH-11/12 was the location where duplicate cores were taken.

Table 1. Results of sediment phosphorus flux incubation. ASH-11 and ASH-12 are the duplicate cores. Net chemical release represents the difference between the calculated chemical release and the concurrent process of anaerobic phosphorus regeneration. The number of days over which chemical release occurred can be seen in the last column of the table. The "Days of Release" were used to calculate the annual mass chemical release.

	Aerobic Phosphorus Flux				Chemical Release Phase				Anaerobic Phosphorus Flux				Net Chemical Release	
	Rate	Std. Error			Rate	Std. Error			Rate	Std. Error			Rate	
Site	(μMoles/m²/d)		n=	R^2	(μMoles/m²/d)		n=	R^2	(μMoles/m²/d)		n=	R^2	(μMoles/m²/d)	Days of Release
ASH1	10.5	0.7	6	0.984	571.1	30.9	5	0.991	97.5	21.8	4	0.909	473.6	10.0
ASH2	7.6	0.8	6	0.954	543.5	122.1	5	0.868	30.9	11.0	4	0.796	512.6	12.0
ASH3	6.6	1.0	6	0.911	508.6	54.6	5	0.967	66.8	11.4	4	0.945	441.8	11.0
ASH4	4.3	0.7	6	0.901	427.7	28.3	5	0.987	58.6	5.3	5	0.976	369.0	9.0
ASH5	9.2	0.7	6	0.977	581.8	44.4	5	0.983	67.2	11.6	5	0.918	514.6	12.0
ASH7	19.4	2.2	6	0.952	457.9	25.7	5	0.991	86.1	6.9	4	0.987	371.8	9.0
ASH8	4.7	0.8	6	0.890	253.0	12.7	4	0.988	56.6	12.6	3	0.953	196.4	14.0
ASH9	-1.1	1.1	5	0.234	336.8	18.8	5	0.986	64.0	4.6	4	0.990	272.8	7.0
ASH10	7.2	1.8	6	0.795	631.2	45.6	5	0.985	60.4	14.3	4	0.899	570.8	10.0
ASH11	7.7	2.0	6	0.786	588.7	35.5	5	0.989	52.8	7.1	5	0.949	535.9	9.0
ASH12 FD	4.2	1.8	5	0.645	502.1	41.6	5	0.980	64.8	4.4	5	0.987	437.3	9.0
ASH13	0.1	1.7	5	0.002	324.9	21.5	5	0.987	63.7	13.1	5	0.888	261.2	7.0
ASH14	6.8	1.8	7	0.742	480.8	30.2	5	0.988	45.5	15.7	3	0.894	435.4	8.0

The data presented in Table 1 were integrated with sediment phosphorus flux data collected over the last twelve (12) years to gauge the importance of internal phosphorus recycling from pond sediments to the overlying water column. From the integrated dataset it is possible to construct an annual sediment phosphorus budget for Ashumet Pond. Sediment phosphorus release rates from cores collected and incubated from a variety of stations were grouped by depth range 0ft -30 ft, 30 ft-45 ft and 45ft-60 ft. These depth zones within Ashumet Pond represent the shallow oxic zone, the intermediate zone which shows only periodic anoxia, and the deep zone which consistently has anoxic waters each summer. Sediment release rates were available from 1999, 2008, 2009, and 2010. Data was not used from areas treated with Alum (2001), except the most recent years from the 45 ft-60 ft zone where the rates of phosphorus release have returned to near pre-treatment levels. In general, the pattern of sediment phosphorus release is controlled by the oxygen status of the overlying water (oxic/anoxic) and temperature (only in the 0 ft-45 ft regions). These features were accounted for from field measurements in order to construct annual rates of phosphorus release under oxic and anoxic conditions and the amount of chemical desorption of phosphorus upon the onset of anoxia.

All sediment release rates were determined in the same manner and following the same collection, incubation and analytical protocols. Sediment cores were collected and incubated from nine (9) locations distributed throughout Ashumet Pond in May and September of 1999, prior to the original Alum treatment. Cores were collected in triplicate along a transect starting in Fisherman's Cove and extending to the 60 ft depth contour in May. Cores from September were also collected in triplicate, but sampling locations were distributed throughout the pond between the 5 and 40 ft depth contours to provide areal representation. Additional cores were collected in quadruplicate in 2008 and 2009 in the deepest portion of the pond. These data were combined with the rates from the May 2010 cores which were distributed throughout the 30-40 ft depth contours. A weighted average of these incubation results was created for each of the three depth zones shown. These averages accounted for both differences in replication and *in situ* temperature between incubations. Mean rates of phosphorus release for each of the three types of conditions (oxic, chemical and anoxic) were scaled by the average number of days each depth zone experienced those conditions. The onset and duration of oxic/anoxic conditions was developed from high-frequency profiling of oxygen and temperature in the pond during the critical periods of water column stratification and destratification. These surveys indicated that the average duration of anoxia between 45-60 ft is 115 days, 30-40 ft is 76 days and the 0-30 ft is rarely anoxic above 25 ft. The process was simplified by the fact that anoxic conditions occur only in the summer and chemical release is rapid occurring shortly after the onset of anoxia.

Annual oxic release in the shallow, warmer, waters of less than 30 ft in depth was similar to sediments from the 45-60 ft contour which represents a more intense depositional area due to its greater depth and position below the pycnocline (Figure 2). This similarity is striking as the shallow zone has an annual temperature range generally between 3^{o}C and 25^{o}C, while temperatures in the deepest portions of the pond (60 ft) are comparatively constant throughout the year, generally 9-12^{o}C. Below 30 ft the sediments experience anoxic water during the summer months thus shifting the system from oxic to anoxic P release.

The rapid release (chemical desorption) of phosphorus bound to iron in the sediment requires a shift from oxygenated to anoxic bottom water overlying the sediments. As the phosphorus is bound in the sediments during oxic conditions both the intermediate and deep zones rebuild their desorbable phosphorus pools in fall and winter and release this P at the onset of summer anoxia. The rates of both chemical and anoxic release were similar for both of the lower depth zones, suggesting similar amounts of organic P deposition.

The previous alum treatment focused on the deepest zone within the pond. This zone has slightly lower rates of total anoxic release on an annual basis, although the intermediate zone releases its P in less time (76 d vs. 115 d). These data suggest that treating both zones would significantly increase the efficacy and prolong the period of mesotrophic conditions within the pond. In contrast, it appears that treating the shallow zone sediments (<30 ft) would not yield a comparable benefit to the overall phosphorus balance of the pond for a similar acreage of application when compared to either the intermediate of deep zones.

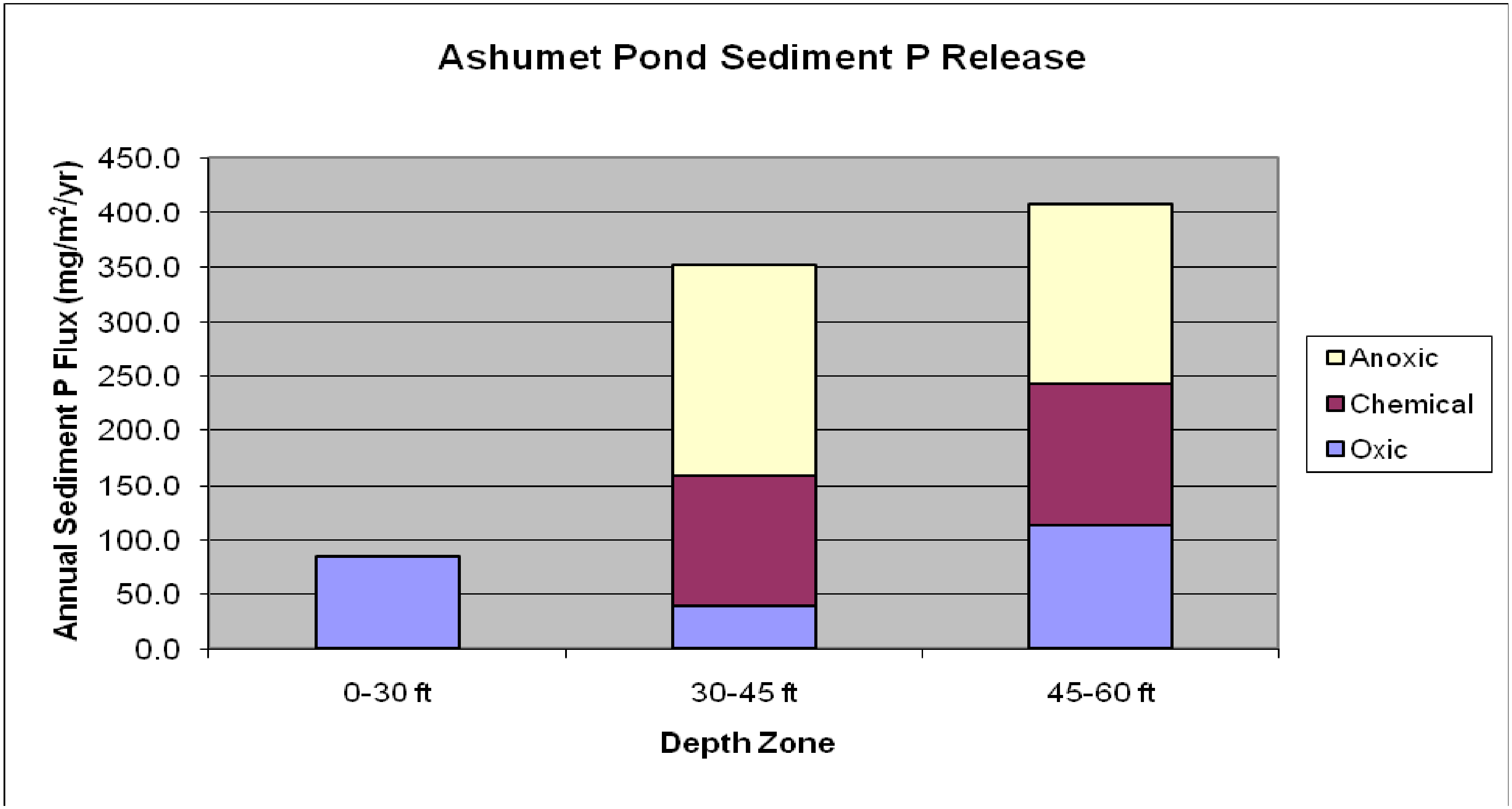

Figure 2. Annual phosphorus regeneration budget for Ashumet Pond separated into three depth zones.

Final Technical Report

Ashumet Pond Phosphorus Management Sediment Traps and Mussel Surveys

By:
Dr. David R. Schlezinger
Dr. Brian L. Howes
Coastal Systems Program
School for Marine Science and Technology
University of Massachusetts - Dartmouth
706 S. Rodney French Blvd
New Bedford, MA 02744
508-910-6314

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Mussel Surveys and Sediment Trap Deployments Relative to the 2010 Ashumet Pond Alum Treatment

Overview: Watershed phosphorus inputs from a variety of sources including residential development and surface water discharges coupled with the entry of a phosphate-rich groundwater plume resulted in accelerated eutrophication of Ashumet Pond. This plume originated from rapid infiltration beds at the former Massachusetts Military Reservation (MMR) wastewater treatment plant, located approximately 2,000 ft northwest of the pond, which operated between 1936 and 1995. Although the discharge of secondarily treated wastewater to the aquifer ceased in 1995, a large mass of residual phosphorus remains sorbed to the aquifer matrix between the wastewater treatment plant and the pond. This residual phosphorus has been slowly desorbing from aquifer sediments, feeding the phosphorus plume that is discharging to the pond. AFCEE has conducted numerous detailed studies related to the phosphorus entry to the pond via the groundwater plume and to the nutrient related health of Ashumet Pond over the past 2 decades. In an effort to remedy the phosphorus enrichment of Ashumet Pond, resulting in part from the phosphorus plume, AFCEE developed a remedial strategy that is outlined in the Final Ashumet Pond Phosphorus Management Plan (AFCEE, 2001). The strategy consisted of three components: (1) reduce internal phosphorus loading by implementing a targeted phosphorus inactivation of the sediments in the deepest section of the pond; (2) install a geochemical barrier within the plume footprint to reduce external phosphorus loading to the pond; and (3) continue the regular water quality monitoring program for Ashumet Pond that began in May 1999.

Consistent with this strategy, a targeted phosphorus inactivation of the pond's hypolimnion was conducted in September 2001 using aluminum sulfate (AS) and sodium aluminate (SA) solutions (AFCEE, 2002a). AFCEE phosphorus regeneration studies conducted by University of Massachusetts School of Marine Science and Technology, documented in the original Trophic Health Technical Memo (AFCEE, 2002b) and the associated Phosphorus Management Plan (AFCEE 2002a) recognized that the targeted inactivation may require further application over a larger area, if successful, to sufficiently reduce internal phosphorus recycling. Details of the phosphorus inactivation treatment implementation in 2001 are provided in the Ashumet Pond Phosphorus Inactivation Report (AFCEE 2002a).

Given the temporal phasing of the remediation program and the amount of phosphorus that had previously entered Ashumet Pond, the effectiveness for the 2001 phosphorus inactivation treatment recently declined. As a result, phosphorus levels in pond waters began to increase, necessitating additional measures. A second Alum treatment was decided upon as the most efficient and effective approach. It should be noted that the need for this treatment was foreseen in the original planning given the initial scale of application and timing of parallel phosphorus remediation steps. However, AFCEE, by following an adaptive management approach, allowed the design of the second treatment to build upon the experience of initial treatment and its effects on the pond ecosystem. The second application was successfully implemented in September 2010.

Both Alum treatments for the inactivation of phosphorus to restore overall pond trophic health, were also specifically designed to minimize any impact on NHESP identified Species of Special Concern, as well as other benthic animals and fish. Given the sentinel nature of freshwater mussels and the presence of the tidewater mucket (*Leptodea ochracea*), a Species of Special Concern, detailed surveys and assessment of mussels relative to the Alum treatment were undertaken.

Survey of Freshwater Mussels in Relation to the 2010 Alum Application: As part of determining the sediment area within Ashumet Pond to receive Alum application for phosphorus inactivation, a detailed survey of the spatial extent of freshwater mussels was determined using an autonomous underwater vehicle (AUV) equipped with still cameras and video linked to GPS, with verification by traditional diver survey. The purpose of the survey was (a) to determine the lower depth of existing mussel beds to guide the application and (b) to locate sites for assessing changes in mussels potentially associated with treatment (see next section). New bathymetry was collected in conjunction with these surveys. Previous Mucket survey results collected in 2008 by the NHESP were used a guide, however, the previous study was s spatially limited.

The AUV was flown 2 feet above the pond bottom using on board bottom tracking. Transects were established and traversed by the AUV using on board navigation and GPS. Photos were collected at approximately 1 meter intervals along each transect (Figure 1). The resulting thousands of individual digital photographs were analyzed to evaluate mussel presence/absence and approximate population density. Findings indicated that all species of mussels generally did not colonize below the 25 foot depth contour (Figure 2). It is almost certain that the depth of mussel beds is restricted by summertime hypoxia/anoxia in Ashumet Pond, where historical monitoring has documented development of anoxia below this depth in the midsummer in most years. The survey did not include the deeper areas (>40 feet) where previous surveys did not find mussel habitat nor very shallow areas where viable benthic habitat has been assumed to exist and Alum treatment was not possible.

Coupled with the AUV survey, sites were selected for confirmation of mussel presence/absence by SCUBA diver. Sites were selected where mussels were dense, sparse and not present and when possible there were definitive features that could be used to confirm location (e.g. rocks, tires, etc.). The goal was to directly validate using confirmed locations the observations collected by the AUV. The results from each validation point were in general agreement with the observation from the AUV survey (Table 1). This is not surprising given the visual nature of both observation techniques and the spatial density of the photos in the AUV survey. Based upon these results, the AUV survey results were deemed to be a reasonable approach for determining the overall distribution of mussels within the survey area and suitable for planning the Alum application in a manner to avoid active beds. Based upon the mapping data, the area designated for Alum application was limited to depths generally greater than 35 feet, deeper than the observed mussel habitat.

Figure 1. Photographs of freshwater mussels collected as part of the mussel survey by the AUV.

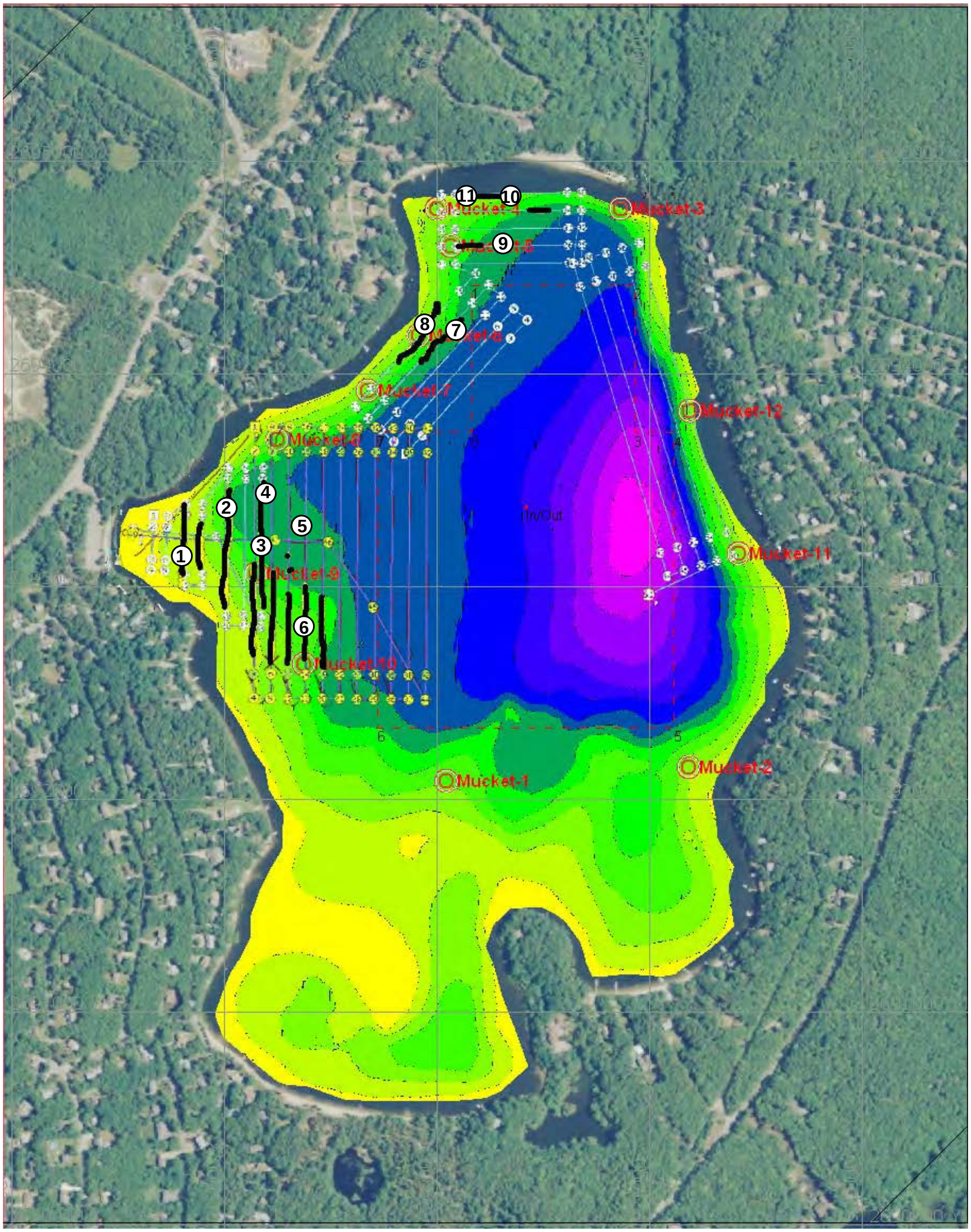

Figure 2. Mussel Survey transects assessed by AUV camera survey. The yellow dots represent way points with the connecting lines indicating the survey lines. The black lines indicate frames where freshwater mussels were observed. The 12 sites (Mucket 1-12) show the locations of sediment traps and associated mussel assay quadrates. The colors represent 5 foot depth contours with pink indicating the deep basin (60 feet) and yellow showing 0-5 feet.

Table 1. Validation of AUV photographic survey. Locations were chosen to represent the various depth ranges and image types. Where possible the location of the AUV was validated by reference to identifiable objects in the photographs.

Location	Latitude	Longitude	Depth	AUV Photograph Description	Location Feature	Diver Validation Observations
1	41.63401	70.5393	10	Very High Density		Very High Density
2	41.63474	70.5382	28	Sparse	Dive Ladder	Sparse, mostly spent shells
3	41.63425	70.53789	33	Very Sparse		1 Mussel in 20 m Search radius, fluid mud
4	41.63526	70.53789	26	High Density		High Density ~30/m^2, sandy bottom, few empty shells
5	41.63459	70.53729	30	No Mussels		No Mussels, soft mud <10 cm thick
6	41.63353	70.53669	26	High Density		High Density ~30/m^2, sandy bottom, few empty shells
7	41.63664	70.53396	34	No Mussels, few features		No Mussels, soft mud, no features
8	41.63705	70.53468	25	Medium Density		10-15 mussels/m^2, patches
9	41.63778	70.53364	33	Maybe has Mussels		No Mussels. Soft mud, deep side of search radius had Begatoia and several dead bait fish
10	41.63824	70.5336	25	No Mussels	Hubcap	Very sparse mussels, sand and gravel, many worm tubes
11	41.63824	70.53425	33	Very High Density	Steel Pipe	Some live mussels, many spent shells, SAV's

Assessment of Alum Deposition and Effects on Freshwater Mussels: Although the application of Alum was designed to avoid mussel habitat by targeting depths >35 feet, NHESP as the agency charged with protection of this resource was concerned that tidewater muckets, previously identified as inhabiting Ashumet Pond, might still be adversely affected by aluminum hydroxide floc. In order to assess the possible impact of the Alum application on Tidewater Muckets, a 2 tiered approach was undertaken. Sediment traps were positioned around the perimeter of the alum application area to monitor for deposition of aluminum hydroxide floc that might drift outside the prescribed application area. Sediment traps were positioned above a mussel sampling quadrate fixed to the bottom to allow repeated enumeration of the mussels potentially receiving aluminum deposition (as measured in the associated trap) and any changes in behavior or potential mortality. Observations were conducted in the 1-2 days prior to the initial Alum application, 1 day following the end of the 2010 application, and again, 10 days later. In this way, the population and behavior of mussels could be assessed through time to capture any short and medium-term changes. More importantly, if any changes in population or behavior were observed, these changes could be related directly to measured Alum deposition rates.

Aluminum Deposition-Sediment Traps: Sediment traps were placed in the center of the 12 quadrates at a height of ~6 inches above the sediment surface. The sites for the paired sediment traps and mussel quadrates were selected to be in areas determined by the AUV survey to support active mussel beds and to be as close to the perimeter of the treatment area as beds occurred (Figures 2 & 3). Due to the fact that in different peripheral areas the mussel beds did not extend to the depth of application, the sites were selected to generally reach the deepest beds possible and also create a distribution surrounding the application area.

During installation and monitoring of sites, special care was taken not to disturb the surficial sediments and create "artificial deposition". Initial specific site selection was refined by the divers in the field. Upon arriving at the pre-determined sediment trap location, divers swam transects normal to the shoreline into deeper water (35’) or to the depth that it was clear that mussels were no longer present. Divers then swam towards shore until the occurrence of mussels was no longer infrequent. In this way, the locations could reflect both the optimal depth relative to the alum application and contain a sufficient quantity of mussels to assess changes in the population.

Sediment traps were 4 inches in diameter and had a length to diameter ratio of 5:1 which is recommended for efficient particle trapping in lacustrine waters with little current. Sediment traps were filled with 0.2 micron filtered Ashumet Pond water and capped for deployment. Sediment traps were held vertical on a metal rod driven in to the sediment at each location. The afternoon before the initial alum treatment, the caps were removed by diver to minimize any contamination coincident with the installation of the traps and quadrates. The day after the last day of Alum application the traps were capped and returned to SMAST for analysis. Assay of trap contents began with vigorous shaking to evenly distribute the particles within the water held in the trap. Aliquots of the mixed trap water were immediately collected and filtered onto 0.2 micron nucleopore filters. These filters were immediately inspected under 100x magnification to determine the presence of any aluminum hydroxide floc. Following microscopic inspection, filters were digested and analyzed for total aluminum, as an estimate of Alum deposition.

Material collected within the sediment traps recovered the day following the alum application contained a visible amount of organic matter either the result of wind derived sediment resuspension or the flocculating effects of the alum treatment. Visual inspection of the filters showed no aluminum hydroxides based upon comparison with Alum floc generated in the laboratory using chemicals provided by the Applicator conducting the work on Ashumet Pond. Subsequent quantitative chemical analysis of the digested filters using a colorimeteric assay for aluminum revealed only very low amounts of aluminum deposition in all of the sediment traps (Table 2). The rates were less than 2 orders of magnitude lower than the Alum application rate of 40 g Al m^{-2} in the deeper waters outside of the mussel areas.

The measured aluminum deposition rate needs to take into account the natural deposition to pond sediments that has been observed in Ashumet Pond. Sedimentation rates within Ashumet Pond were found to be relatively high as quantified using Pb_{210} techniques in 1999 (5.1 mm yr^{-1} for the Deep Basin, and 2.5-2.7 mm yr^{-1} for the 10-11 meter depth contour). These rates of total sediment deposition can be used to determine the natural background aluminum deposition, generally associated with allocthonous clay particles (alumino-silicates). Given that the total sedimentation rates for Ashumet Pond are known, we were able to convert to aluminum deposition rates by assay of total aluminum concentration in the resulting surficial sediments. Sub-sections of sediment cores collected from similar depths to the traps (June 2010) were analyzed to quantify the aluminum concentration. Sediment from the deep basin was found to contain an average aluminum concentration of 3.01 mg Al dry g^{-1} (Std. Dev.= 0.10, N=6) sediment from the 30-40 ft contour cores contained similar amounts of aluminum, 2.68 mg Al dry g^{-1} (Std. Dev. = 0.49, N=15). On a volumetric basis the aluminum levels were 0.22 mg Al cc^{-1} (Std. Dev. = 0.01) and 0.27 (Std. Dev.= 0.04) in sediments from the deep basin and 30-40 ft contours, respectively. The most conservative estimate of ambient aluminum deposition rates was 19.8 mg Al m^{-2} (Table 1). After correcting for this "background" deposition, the trap results indicate that aluminum was higher in the sediment traps than could be explained by natural aluminum deposition, hence the "Net Aluminum" deposition may indicate deposition of Alum. To the extent that this does represent Alum deposition, it may have resulted from surficial drift due to wind or to micro-floc formed in the application area that was able to move slightly outside of the target area. In any case, the level of deposition compared to the treatment area application rate of 40 gr/m^2, was very low and below levels of concern for acute effects on pond biota. It should be noted that inspection of the sediment surface in the area of each trap did not indicate any visible Alum floc, while within the treatment area floc was clearly visible on the sediment surface (J. Burgess, personal communication).

Observed Mussel Response - Quadrates: Twelve fixed quadrates were deployed with a sediment trap (discussed above) located at the center of each. The quadrates were 4 m^2 and anchored to the bottom with corner stakes. This assured that the traps would not move, could be easily recovered, and would hug the sediment creating a restriction to mussel movement. In addition each quadrate was divided with survey tape into 4 equal parts, each 1m x 1m, to simplify diver observations. Quadrates were surveyed the day before the initial Alum application, the day after the Alum treatment was completed, and again 10 days later. The surveys included pertinent measurements of the population and the viability of the individual mussels. These measurements included:

(1) sediment type
(2) percent cover by submerged aquatic vegetation
(3) slope of bottom
(4) total water depth
(5) latitude/longitude
(6) number of live mussels
(7) number of dead mussels
(8) number of empty mussel shells (note any recently dead mussels (e.g. tissue attached, shiny, bright nacre) vs. remnant, spent valves)
(9) number of gaping mussels (as an indicator of stressed and/or dying mussels).
(10) observe whether apertures are open, closed, or both – when mussels are filtering the incurrent and excurrent apertures (small opening at posterior end) are open; as possible it will noted whether mussels are filtering or are remaining closed
(11) level of embeddedness defined as 95% (apertures visible at sediment surface), 50%, 0% (on surface)
(12) visual evaluation of distribution of mussels within the quadrate at each of the 12 locations, by dividing the quadrate into 4 sub-areas and identifying within each the number of mussels and also within each if the mussels are (a) clumped, (b) randomly distributed or a combination or (c) if mussels appear to be moving in certain direction. The concept is to determine if the distribution within a quadrate changes between surveys.

(13) mussel behavioral changes will be assessed within each quadrate on each survey by gently touching 10 individuals that are open and filtering and recording if the mussels (a) close their valves, (b) partially close, or (c) are unresponsive after 5 minutes.
(14) notable habitat observations (algal mat, sand ripples, bacterial mat, evidence of anoxia, etc).
(15) attempt to identify the mussels to species, if possible.

In addition, the positions of live mussels were further described as horizontal or vertical relative to the sediment surface; vertically oriented mussels were further described by how deep they were burrowed into the sediment.

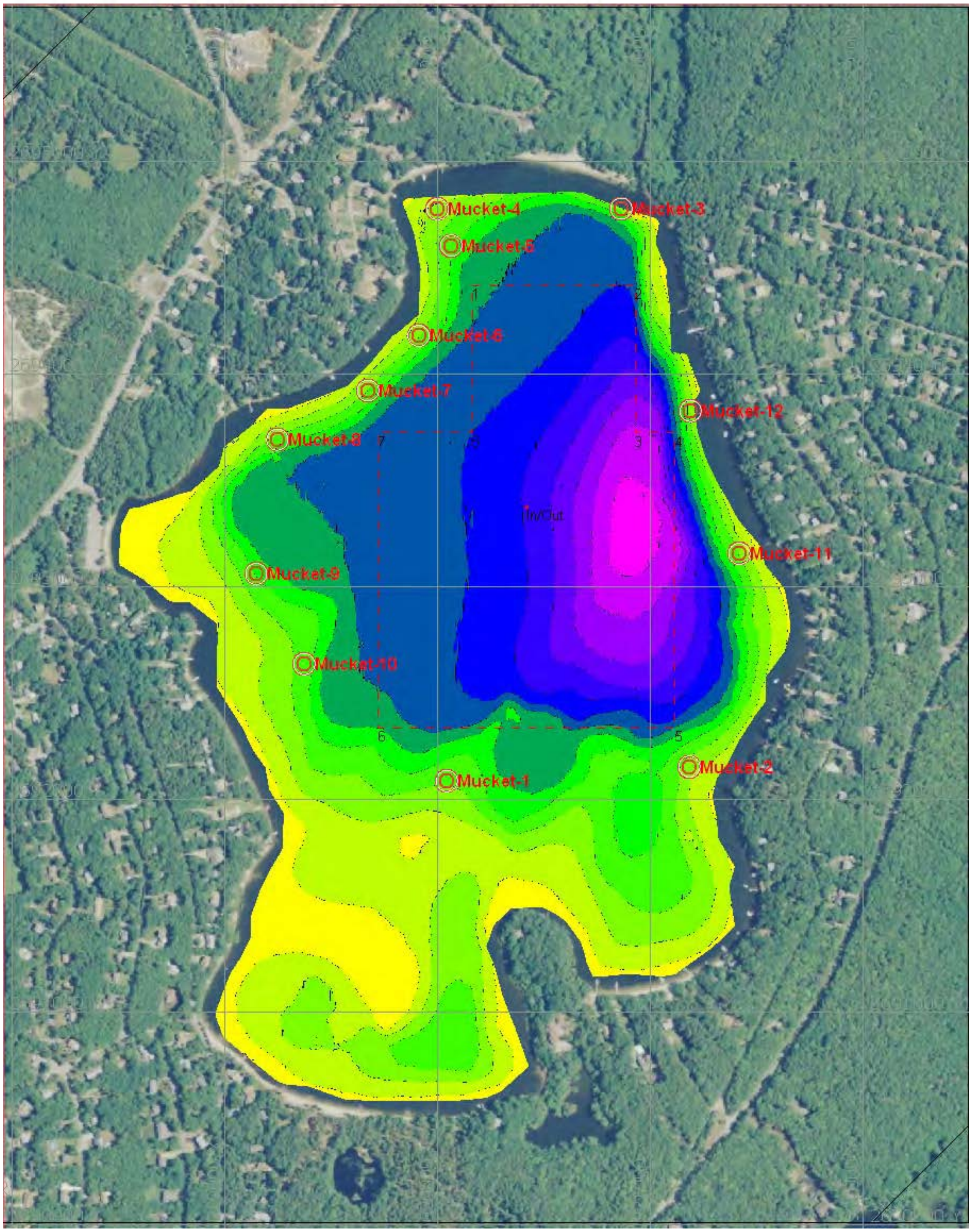

Figure 3. Map of Ashumet Pond showing the locations of sediment traps and mussel quadrates established prior to the alum application on September 7, 2010.

Table 2. Results of sediment trap deployments. The mass of aluminum deposition was scaled to m^2 units and represents deposition for the entire 10 day deployment. Net aluminum has had the conservative estimate of 19.8 mg/m^2 ambient aluminum deposition, determined from Pb_{210} studies, removed. Percent of Application refers to the ratio of aluminum found in the sediment trap and the application rate of 40 g/m^2. The detection limit was 0.2 mg/m^2.

Trap ID	Al (mg/m^2)	Net Al (mg/m^2)	Std Dev (mg/m^2)	Coeff. Of Variation	Percent of Application
1	45.3	25.5	0.7	2%	0.06%
2	53.3	33.5	4.7	9%	0.08%
3	117.5	97.7	12.9	11%	0.24%
4	104.0	84.2	3.2	3%	0.21%
5	194.2	174.4	2.1	1%	0.44%
6	195.0	175.2	10.2	5%	0.44%
7	36.0	16.2	8.4	23%	0.04%
8	137.9	118.1	10.9	8%	0.30%
9	154.8	135.0	3.9	3%	0.34%
10	143.5	123.7	5.7	4%	0.31%
11	151.4	131.6	12.3	8%	0.33%
12	155.3	135.5	7.2	5%	0.34%

The three mussel quadrate surveys were conducted on September 7, 17 and 27. Results from the three surveys showed no obvious signs associated with acute stress (Table 3). There were 1761 live mussels observed with 361 in a horizontal orientation and 4 recently dead. However, the four dead mussels were observed during the first survey, prior to the Alum treatment. No mussels were found to be gaping on any of the 3 surveys. Equally important, the behavioral tests where mussels that were open were "touched" gently by divers and the response (shell closure) recorded did not indicate a sub-lethal effect (using this metric). Of the 1073 tests for aperture closure only 17 individuals showed partial closure or no response, while the remaining 1056 showed "normal" response.

The difference between the number of live mussels observed and the number of actively filtering mussels tested for aperture closure among the 3 sampling dates stems from the lower number of mussels observed during the pre-treatment survey (9/7/10) when water clarity was poor, reducing the population tested. However, scaling the observed result of 17 unresponsive individuals out of 1073 observations to the total number of live mussels observed (1761individuals) suggests that if all live mussels had been tested less than 30 individuals would not have been actively filtering over the three surveys. The lower number of observed mussels appears to have resulted from the lower water clarity on the pre-treatment date and possibly some loss of the fine surface sediment layer through time due to disturbance by divers resuspending sediment while eliciting a closure response from the mussels.

As a determinant of stress in mussels, the degree of embeddedness provided less conclusive results. Mussels under stress may attempt to move to new locations or alternatively, attempt to rise higher in the sediment to keep their siphons above sediment layers of floc which may either irritate or congest their filter apparatus. Poor water clarity during the pre-treatment survey often made observation difficult. In addition, nearly every location was blanketed by a layer of fine fluffy organic matter and silt up to a centimeter thick. Tapping mussels to elicit a response often resulted in decreased visibility (i.e. resuspension), furthermore, by the last survey the silt layer was substantially thinner or absent having been disturbed and displaced by repeated activity. These changes in the ability to see the embedded mussels resulted in the number of live mussels observed in the final survey being higher than in the initial survey (Figure 4, Table 3). The total of all live mussels from the 12 quadrates increased from 480 individuals (September 7, pre-treatment) to 529 individuals and 758 individuals on September 17 and September 27, respectively. Similarly, the empty shells which appeared to be "old", also increased from 612 (September 7, pre-treatment) to 713 and 709 on the 2 post-treatment surveys, respectively. These empty shells support the contention that changes in the ability to see the mussels was the major factor in the changes in total counts. However, since there were no changes in the proportion of responsive organisms from pre to post treatment and also since the number of "non-responsive" organisms was negligible, it can be concluded that there was no clear effect of the Alum on the mussels based upon these metrics. None-the-less, whether these changes were a result of surface sediment movement or specific behavioral changes in mussels was investigated further below. It is important to note that the sediment traps would not be affected by this potential disturbance as they were opened 24 hours after the initial observations and recovered prior to the first post-treatment observations.

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Table 3. Results of quadrate observations.
Ashumet Mussel Survey (Pre-Treatment September 7, 2010)

Location	Latitude	Longitude	Sediment Type	% SAV Cover	Bottom Slope (°)	Depth (ft)	# Live Mussels	# Dead Mussels	# Empty Shells	# Gaping Mussels	Aperture Closing Test				Live Mussel Orientation			Level of Embeddedness				Quadrat Distribution	Habitat
											# Observed	Complete	Partial	None	Horizontal	Horizontal (b)	Vertical	25%	50%	75%	95%		
1	41.6311	-70.5348	Small cobble w/ silt	0	0	20	97	0	39	0	25	25	0	0	42	0	39	5	9	18	7	Clustered	
2	41.6312	-70.5306	Cobble with silt	0	20	15	27	0	65	0	17	16	1	0	10	0	16	2	3	7	4	Even	
3	41.6385	-70.5317	Sand, pebbles	7.5	30	21	10	0	162	0	2	1	1	0	3	1	0	0	0	0	0	Clustered	
4	41.6385	-70.5348	sand silt w/ brown floc	0	0	17	37	0	62	0	27	27	0	0	6	4	27	3	0	12	12	Even	
5	41.6381	-70.5346	soft dark mud over sand	5	0	21	50	0	32	0	10	10	0	0	3	0	47	0	0	8	39	Even	1
6	41.6368	-70.5352	Small cobble w/ silt	0	0	21	47	0	79	0	34	30	0	0	15	0	32	0	10	8	14	Clustered	
7	41.6361	-70.5360	Pebbles and silt	0	0	21	51	0	41	0	30	28	2	0	16	0	35	0	3	32	0	Even	2
8	41.6355	-70.5376	Pebbles and black silt	0	0	25	10	0	6	0	6	6	0	0	4	0	6	0	6	0	0	Sparse	3
9	41.6338	-70.5380	Pebbles w/ black silty floc	0	0	24	37	0	13	0	22	22	0	0	8	0	29	0	0	18	11	Even	
10	41.6326	-70.5372	Pebbles w/ light tan floc	0	0	22	39	0	30	0	6	6	0	0	12	0	27	0	0	27	0	Even	
11	41.6340	-70.5297	Pebbles w/ light tan floc	0	0	20	53	0	38	0	30	29	1	0	27	0	21	2	4	15	0	Even	
12	41.6358	-70.5305	Pebbles	0	0	19	22	0	45	0	7	7	0	0	2	0	13	0	0	7	6	Even	

(b): Partially buried

[1] Fish and crayfish present

[2] Crayfish present

[3] Red floc and dead bait fish

Ashumet Mussel Survey (Post-Treatment September 17, 2010)

Location	Latitude	Longitude	Sediment Type	% SAV Cover	Bottom Slope (°)	Depth (ft)	# Live Mussels	# Dead Mussels	# Empty Shells	# Gaping Mussels	Aperture Closing Test				Live Mussel Orientation			Level of Embeddedness				Quadrat Distribution	Habitat
											# Observed	Complete	Partial	None	Horizontal	Horizontal (b)	Vertical	25%	50%	75%	95%		
1	41.6311	-70.5348	Small cobble w/ silt	0	0	20	56	0	70	0	23	22	1	0	19	0	37	1	7	23	6	Even	
2	41.6312	-70.5306	Cobble w/ silt	0	20	15	59	0	66	0	26	26	0	0	7	0	52	0	14	29	9	Even	
3	41.6385	-70.5317	Sand, pebbles	5%	30	21	8	2	196	0	1	1	0	0	7	0	1	0	0	1	0	Even	
4	41.6385	-70.5348	sand silt w/ brown floc	0	0	17	98	0	46	0	56	56	0	0	4	0	94	0	0	61	33	Even	
5	41.6381	-70.5346	soft dark mud over sand	5%	0	21	69	0	38	0	43	43	0	0	2	0	67	0	5	55	7	Even	
6	41.6368	-70.5352	Small cobble w/ silt	0	0	21	44	0	91	0	34	33	1	0	8	0	40	0	26	14	0	Clustered	
7	41.6361	-70.5360	Pebbles and silt	0	0	21	27	0	45	0	21	20	1	0	6	0	24	3	13	8	0	Even	
8	41.6355	-70.5376	Pebbles and black silt	0	0	25	9	0	9	0	1	1	0	0	7	0	2	0	2	0	0	Sparse	1
9	41.6338	-70.5380	Pebbles w/ black silty floc	0	0	24	24	0	14	0	10	8	2	0	5	0	19	0	4	15	0	Even	
10	41.6326	-70.5372	Pebbles w/ light tan floc	0	0	22	52	0	33	0	13	13	0	0	12	2	39	0	13	30	1	Even	
11	41.6340	-70.5297	Pebbles w/ light tan floc	0	0	20	63	0	47	0	24	24	0	0	17	16	30	0	10	33	3	Even	
12	41.6358	-70.5305	Pebbles	0	0	19	20	0	58	0	7	7	0	0	3	1	17	3	6	7	1	Even	

(b): Partially buried

[1] Needed to clear ~3cm black floc in order to count

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Ashumet Mussel Survey (Post-Treatment September 27, 2010)

Location	Latitude	Longitude	Sediment Type	% SAV Cover	Bottom Slope (°)	Depth (ft)	# Live Mussels	# Dead Mussels	# Empty Shells	# Gaping Mussels	Aperture Closing Test				Live Mussel Orientation			Level of Embeddedness				Quadrat Distribution	Habitat
											# Observed	Complete	Partial	None	Horizontal	Horizontal (b)	Vertical	25%	50%	75%	95%		
1	41.6311	-70.5348	Small cobble w/ silt	0	0	20	142	0	91	0	72	72	0	0	18	0	124	0	101	34	1	Even	
2	41.6312	-70.5306	Cobble with silt	0	20	15	54	0	65	0	38	34	4	0	3	0	51	0	37	14	0	Even	
3	41.6385	-70.5317	Sand, pebbles	25%	30	21	12	0	188	0	3	3	0	0	9	0	3	0	0	2	1	Sparse	
4	41.6385	-70.5348	sand silt w/ brown floc	0	0	17	124	0	44	0	121	121	0	0	5	0	119	0	0	112	7	Even	
5	41.6381	-70.5346	soft dark mud over sand	5%	0	21	84	0	36	0	84	84	0	0	0	0	84	6	52	23	3	Even	
6	41.6368	-70.5352	Small cobble w/ silt	0	0	21	58	0	67	0	67	42	0	0	2	0	65	0	25	40	0	Clustered	1
7	41.6361	-70.5360	Pebbles and silt	0	0	21	28	0	40	0	13	13	0	0	7	0	21	0	12	9	0	Even	
8	41.6355	-70.5376	Pebbles and black silt	0	0	25	17	0	4	0	7	5	0	2	1	0	14	0	0	14	0	Sparse	
9	41.6338	-70.5380	Pebbles w/ black silty floc	0	0	24	59	0	22	0	59	59	0	0	3	0	56	0	24	26	6	Even	
10	41.6326	-70.5372	Pebbles w/ light tan floc	0	0	22	51	0	33	0	18	18	0	0	5	0	46	5	18	23	0	Even	
11	41.6340	-70.5297	Pebbles w/ light tan floc	0	0	20	75	0	57	0	75	72	3	0	17	0	58	1	33	23	1	Even	
12	41.6358	-70.5305	Pebbles	0	0	19	54	4	62	0	41	41	0	0	3	0	51	15	25	11	0	Even	

(b): Partially buried

[1] 2 Crayfish present

To determine if the appearance of new individuals at specific quadrates was a result of exposure to Alum, an analysis of the relationship between measured aluminum deposition and the number of individuals observed was undertaken. If the Alum was in some way causative of the change, a positive relationship between Alum deposition and observed individuals would be expected. However, comparisons of Alum collected in the sediment traps and the number of live individuals did not show a relationship (Figure 4).

Further examination of the results to find potential sub-lethal effects associated with treatment were undertaken. Since the total number of observed mussels increased with each survey we compared the degree to which the mussels were embedded in the sediment as a percent of the total number of individuals through time (Figures 5-17 right panels). Similar plots using only the observed number of individuals were also produced (Figure 5-17 left panels). The general theory is that the principle effect of Alum exposure for mussels would be for the mussels to move higher in the sediment to keep siphons and soft parts away from the Alum floc. The degree to which the mussels were buried or embedded would decrease through time or, at a minimum, peak immediately after treatment. None of the plots show a consistent trend toward movement out of the sediment. Only at Quadrate 8 (Figure 13) did the 0% Embedded quartile increase. The quadrates staked to the bottom would not allow mussels to enter or leave the survey area, thus for all but one location mussels were unlikely to be trying to escape to shallower water.

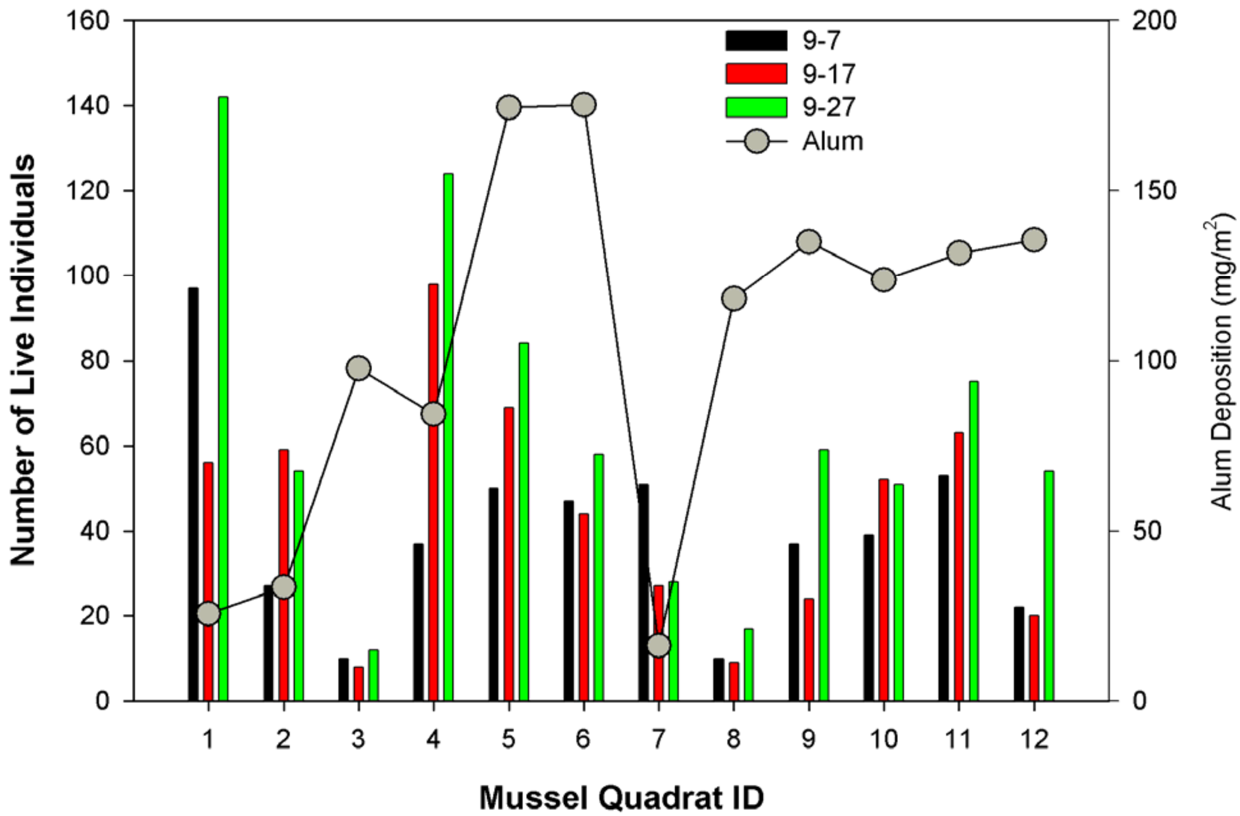


Figure 4. The numbers of live mussels found at each of the twelve quadrats during the three surveys are shown with the mass of Alum (as Aluminum) deposited. Quadrate ID's refers to the location on the maps in Figures 2 & 3.

The percent of buried (95% embedded) mussels decreased at Quadrates 5, 9, and 12. This indicates that there may have been a net movement out of the sediment, however, with the exception of Quadrate 12, which showed the weakest trend, these were the softest, least consolidated sediments, hence the most fluid and subject to movement.

The middle quartiles displayed the most change, but unfortunately are the most subject to observational discrepancies. Without removing each mussel from the sediment to determine the actual length of individuals, the degree to which a particular mussel is embedded in the sediment is quite subjective, especially when classed as a quartile of total body length. Plotting the weighted average of the degree to which the mussels were embedded through time yielded no pattern and no relationship was seen when this measure was compared to the Alum deposition at each quadrate (Figure 18).

The results of the survey did not provide any conclusive evidence of mussel stress in response to the Alum treatment. Indeed, the data suggests that there was little effect whatsoever, which might be anticipated given the very low level of aluminum deposition, hence potential Alum deposition. Since even the maximum potential estimate of Alum deposition in these non-target areas was more than 2 orders of magnitude less than in the application area and the application rate of 40 g Al m^{-2} has not been demonstrated to have a significant effect on pond biota, the lack of an observable response in mussels outside of the target area should not be surprising. Note that this potential Alum deposition could also have resulted wholly or in part from the settling of resuspended sediment material into the sediment trap and not be related to the Alum application. Evidence of stress that was observed was likely due to poor water quality in Ashumet Pond at the end of the summer season as it was found prior to the Alum application. Replication of the more invasive survey techniques used in the original surveys conducted during the original pond inventory of tidewater muckets in 2008 would seem to be warranted in the next few years after the pond has reached a new nutrient equilibrium. AFCEE has planned to conduct these surveys in 2014 and 2018.

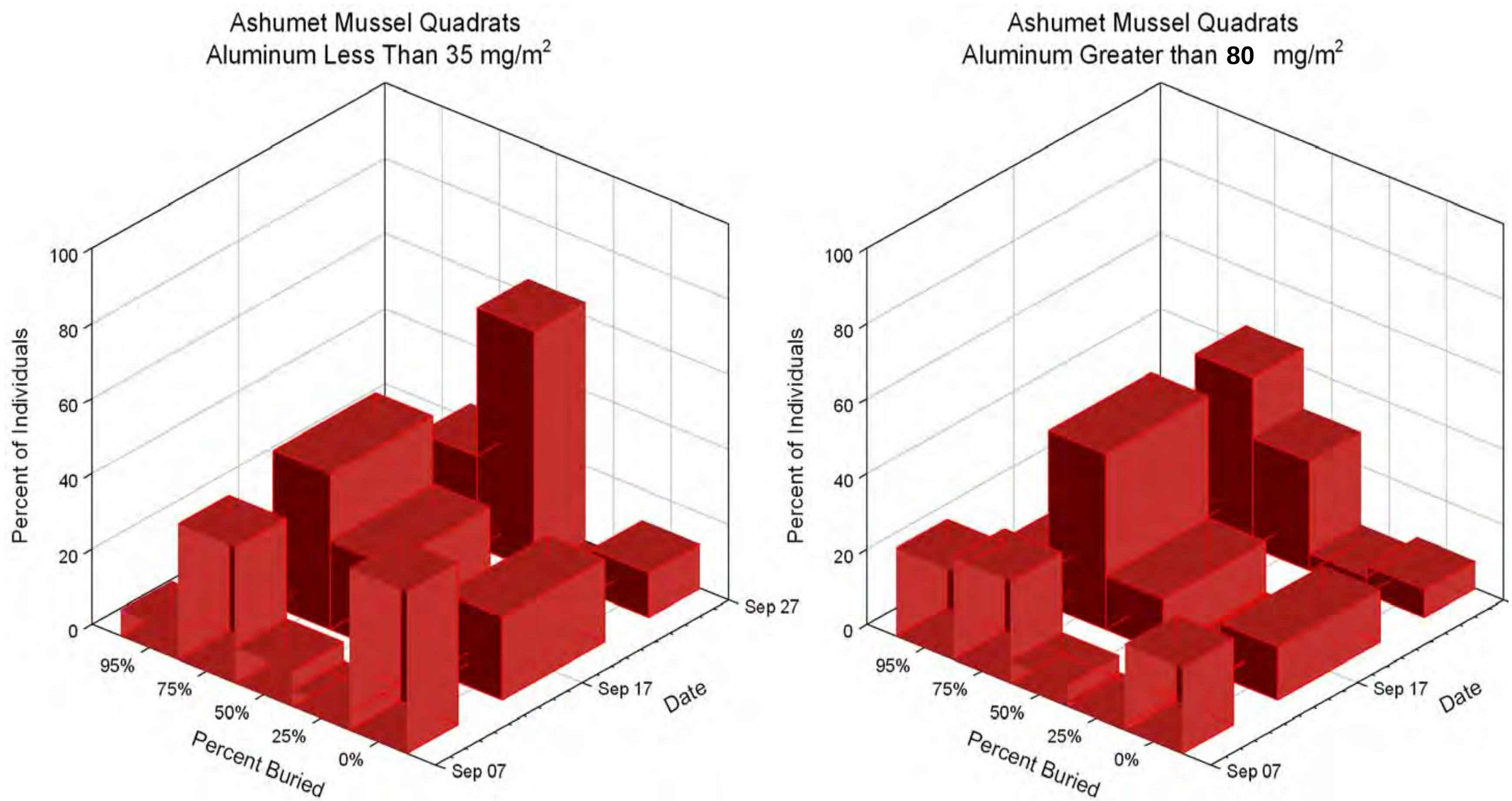


Figure 5. Panel A shows the number of mussels in Quadrats (1,2,7) where the deposition of aluminum was <35 mg m^{-2}, as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B shows the number of mussels in Quadrats (3,4,5,6,8,9,10,11,12) where the deposition of aluminum was >80 mg m^{-2}, as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27).

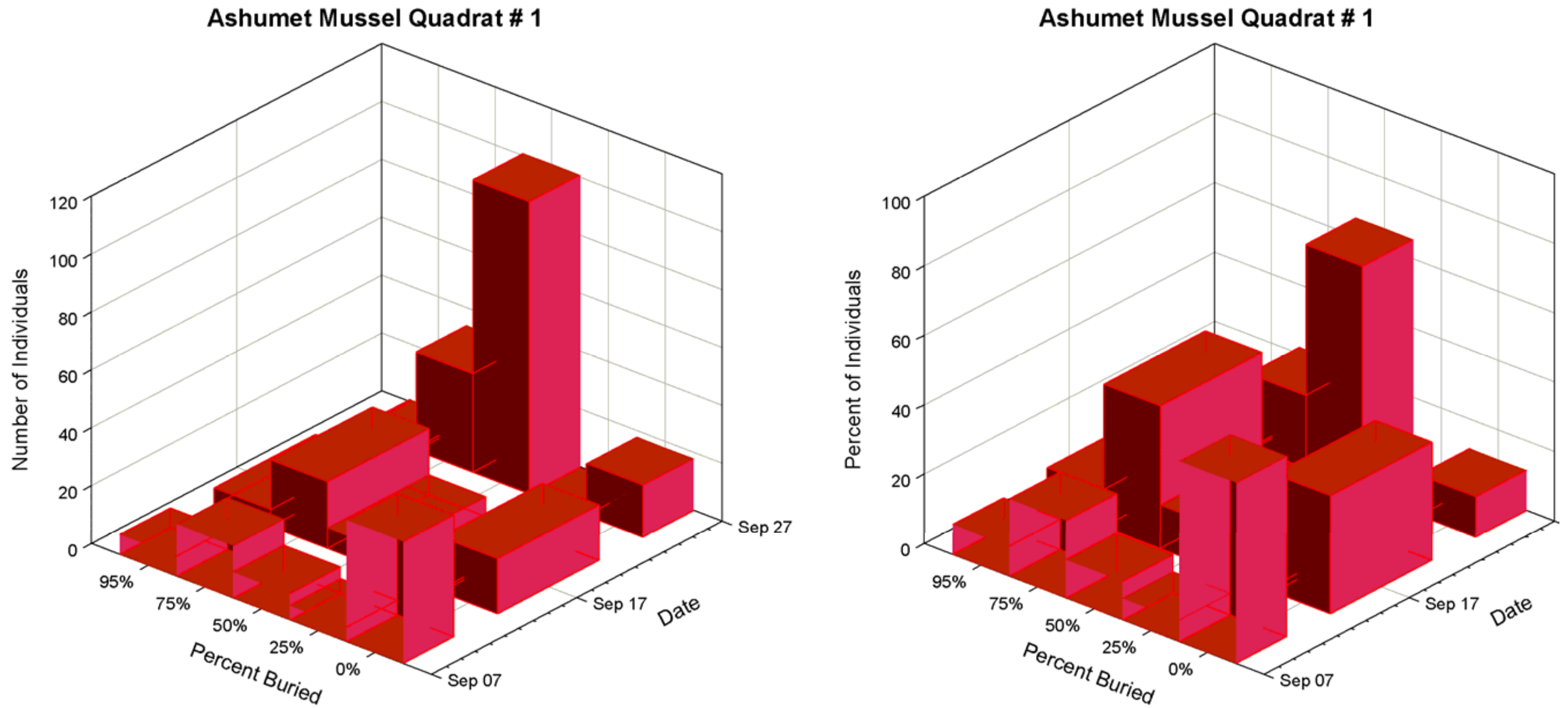


Figure 6. Panel A shows the number of mussels in Quadrate 1 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

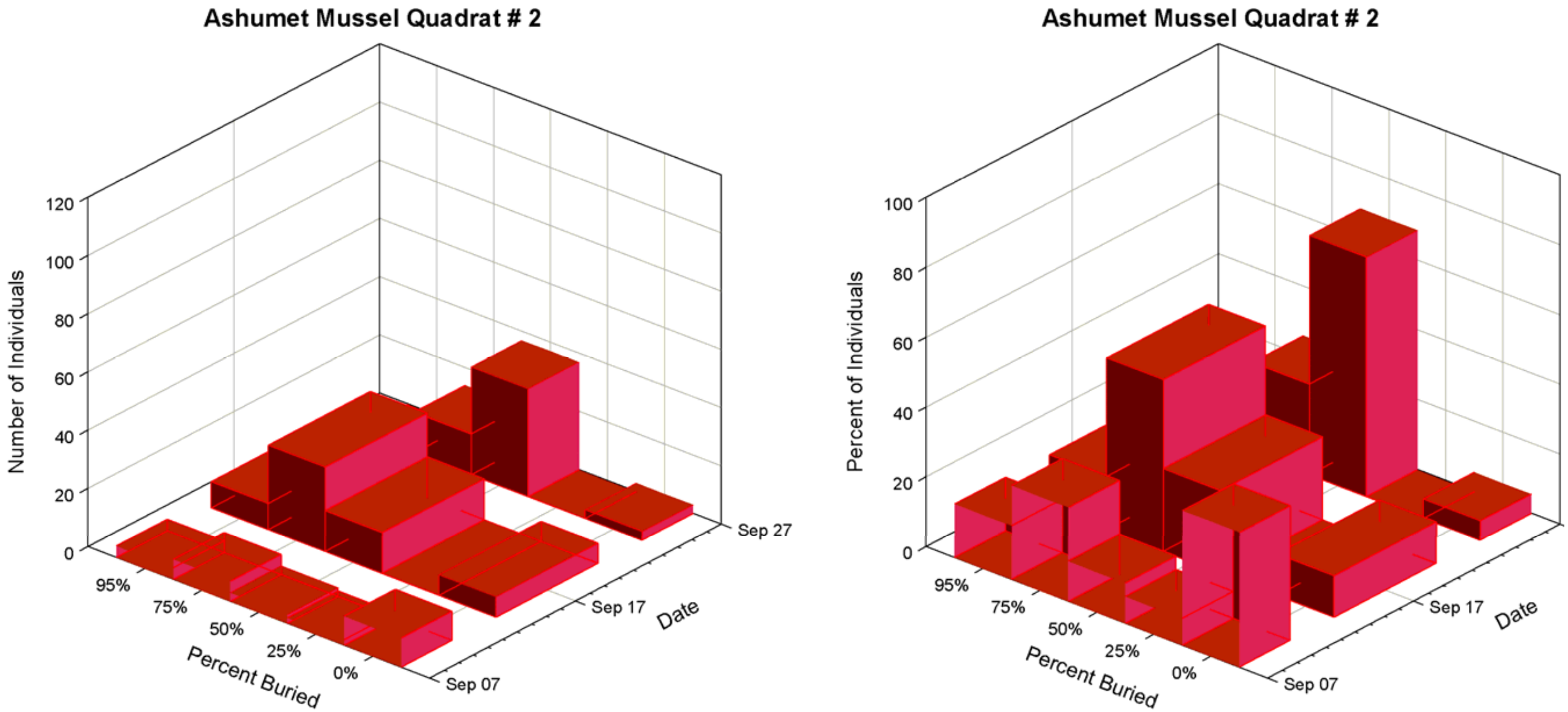


Figure 7. Panel A shows the number of mussels in Quadrate 2 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

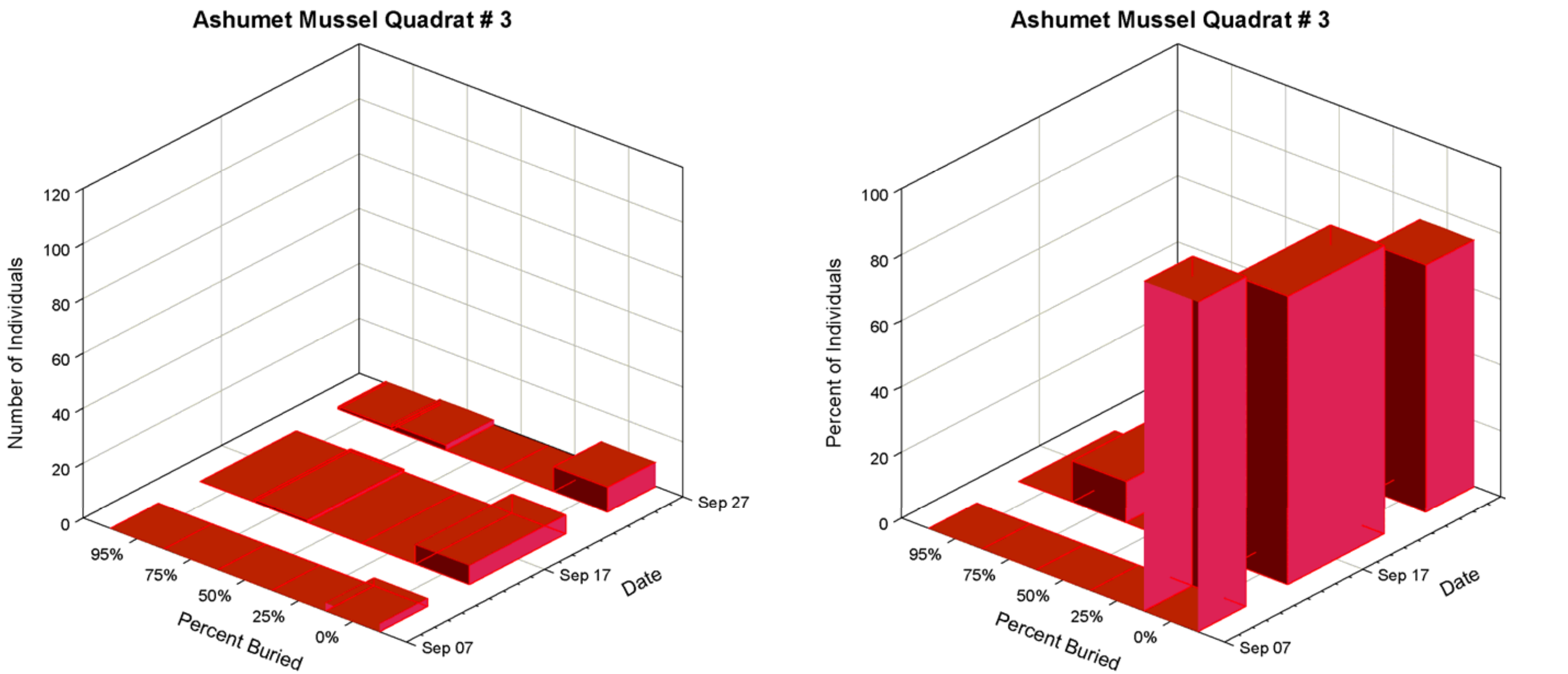


Figure 8. Panel A shows the number of mussels in Quadrate 3 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

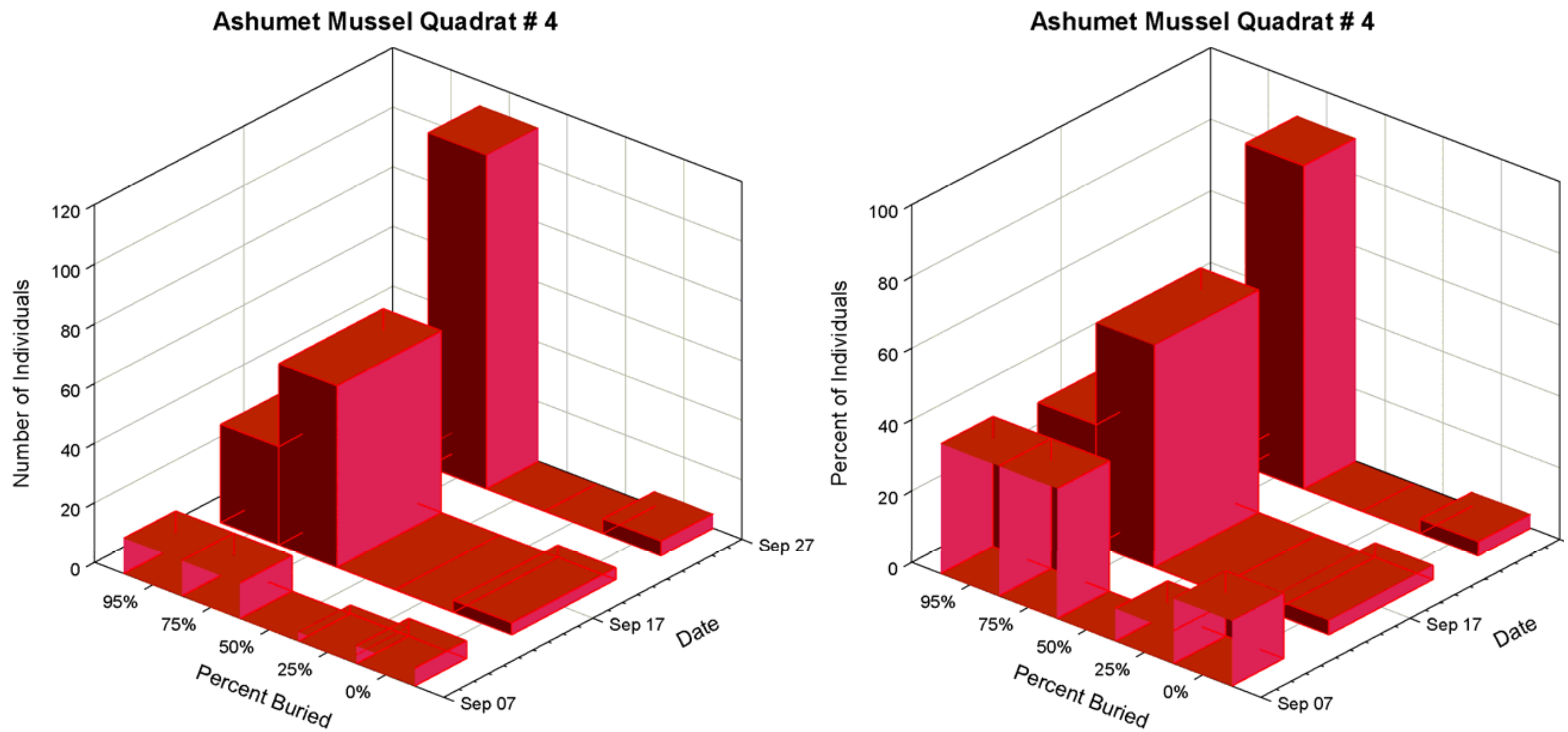


Figure 9. Panel A shows the number of mussels in Quadrate 4 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

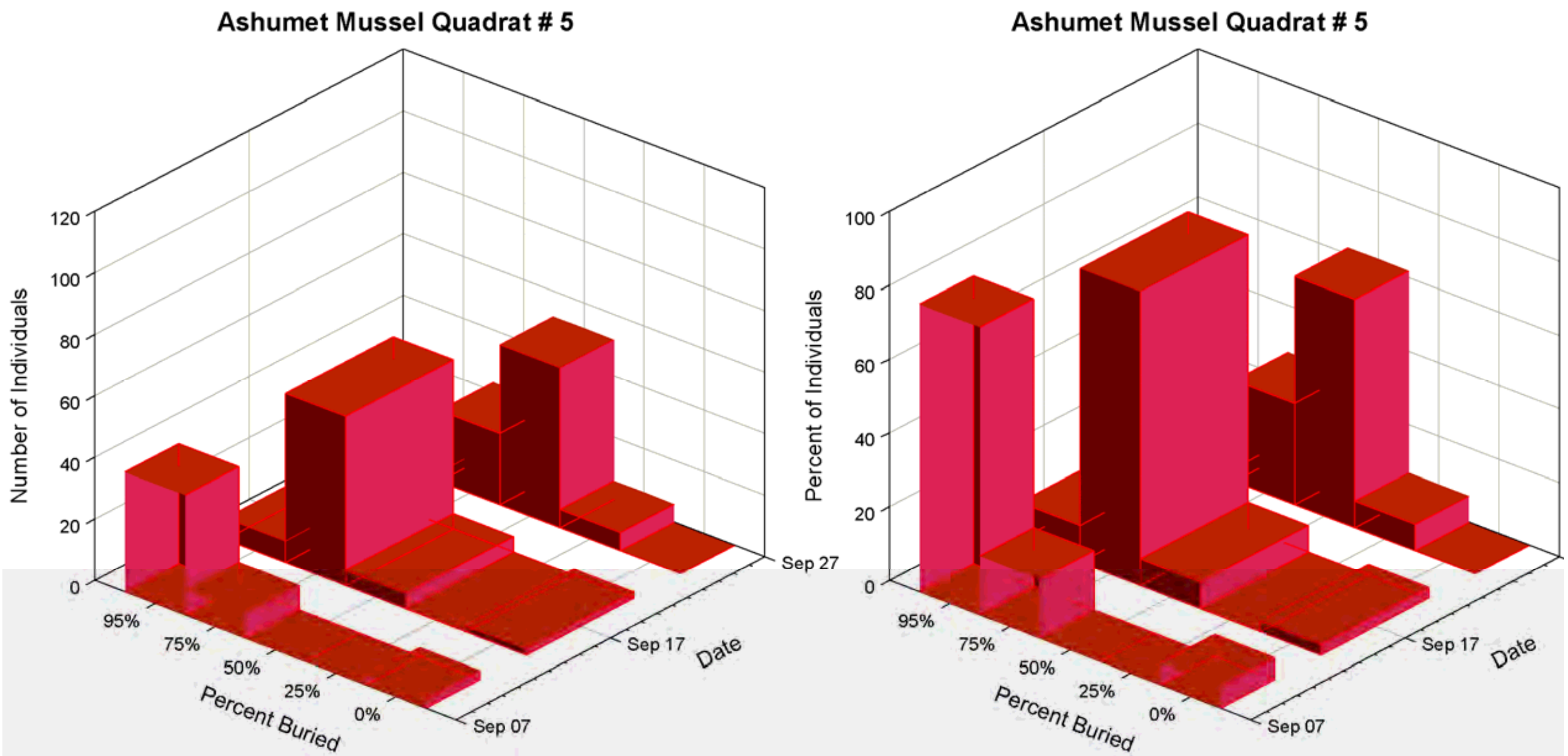


Figure 10. Panel A shows the number of mussels in Quadrate 5 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

The School for Marine Science and Technology
University of Massachusetts Dartmouth

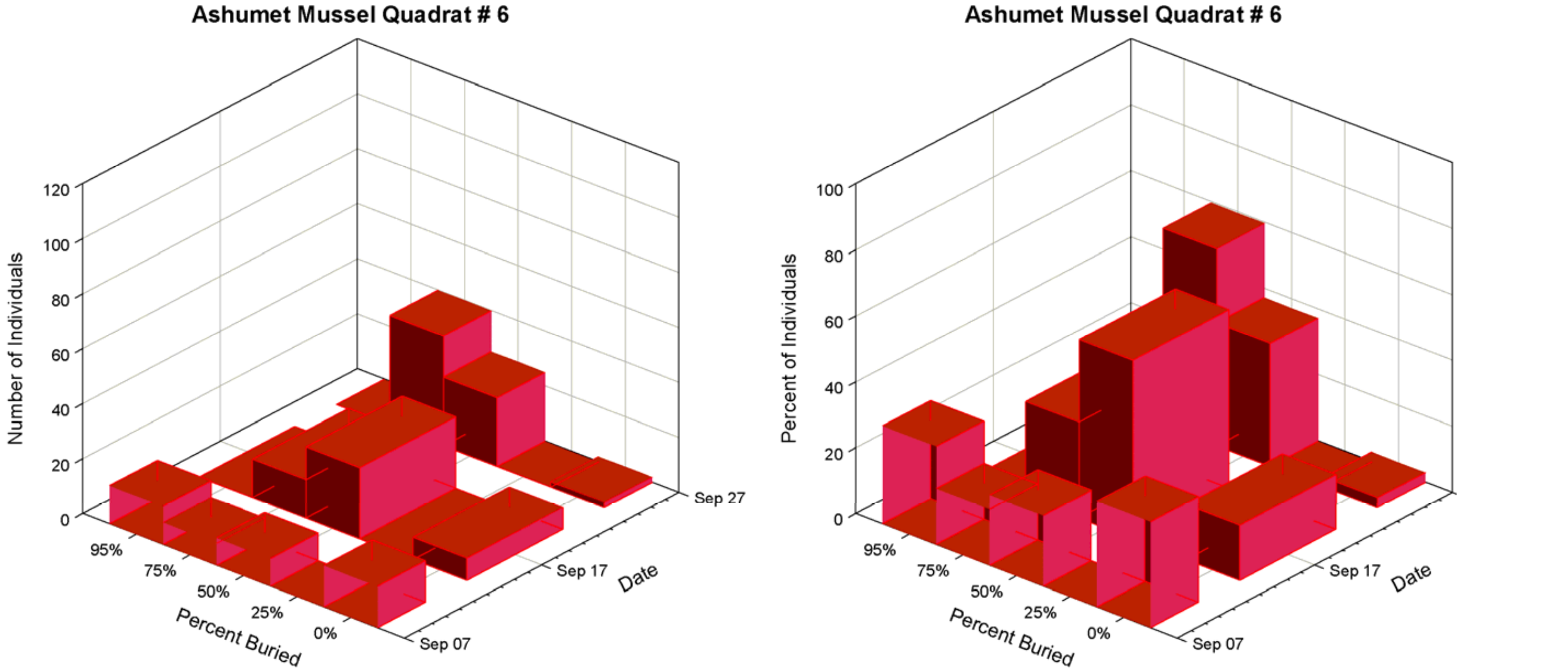


Figure 11. Panel A shows the number of mussels in Quadrate 6 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

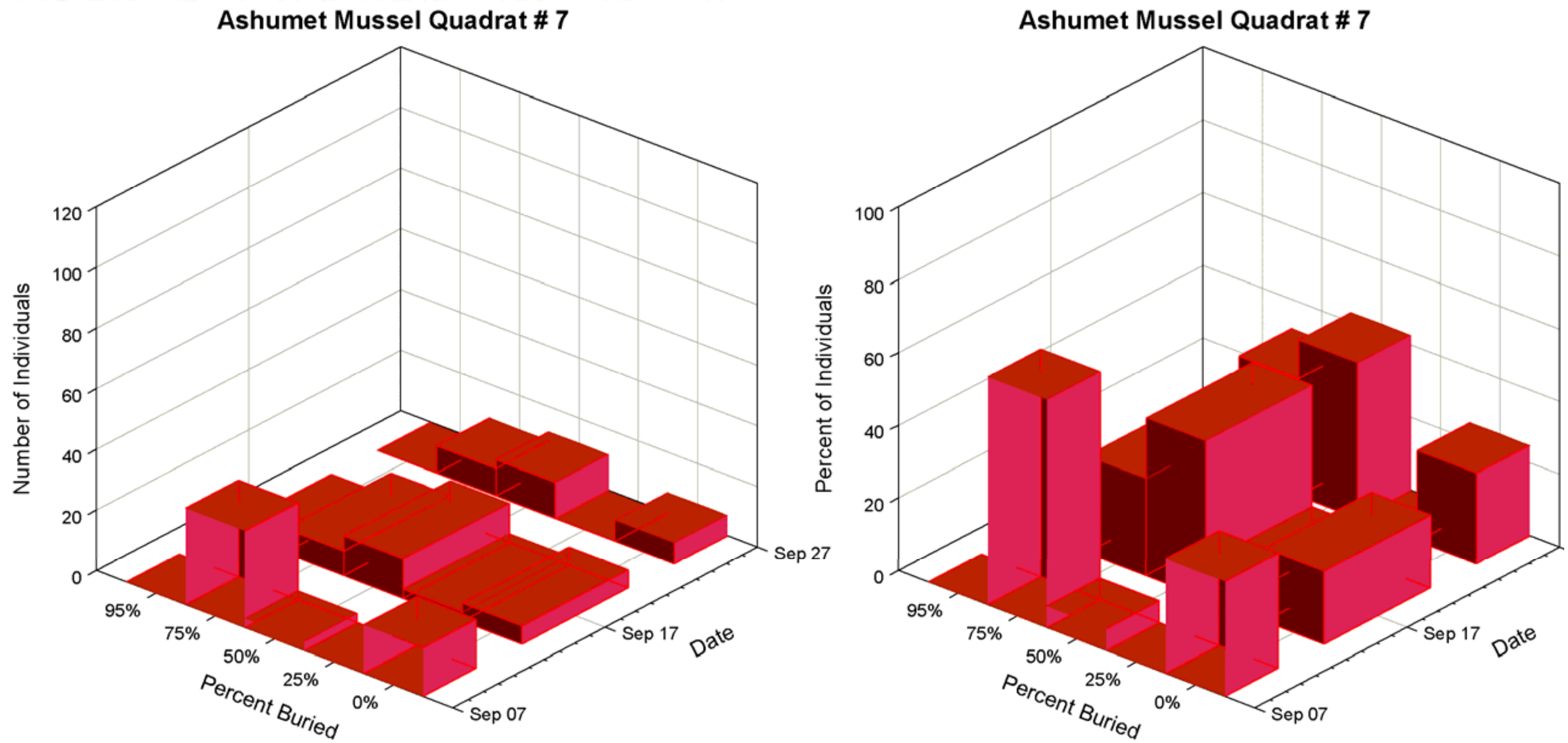


Figure 12. Panel A shows the number of mussels in Quadrate 7 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

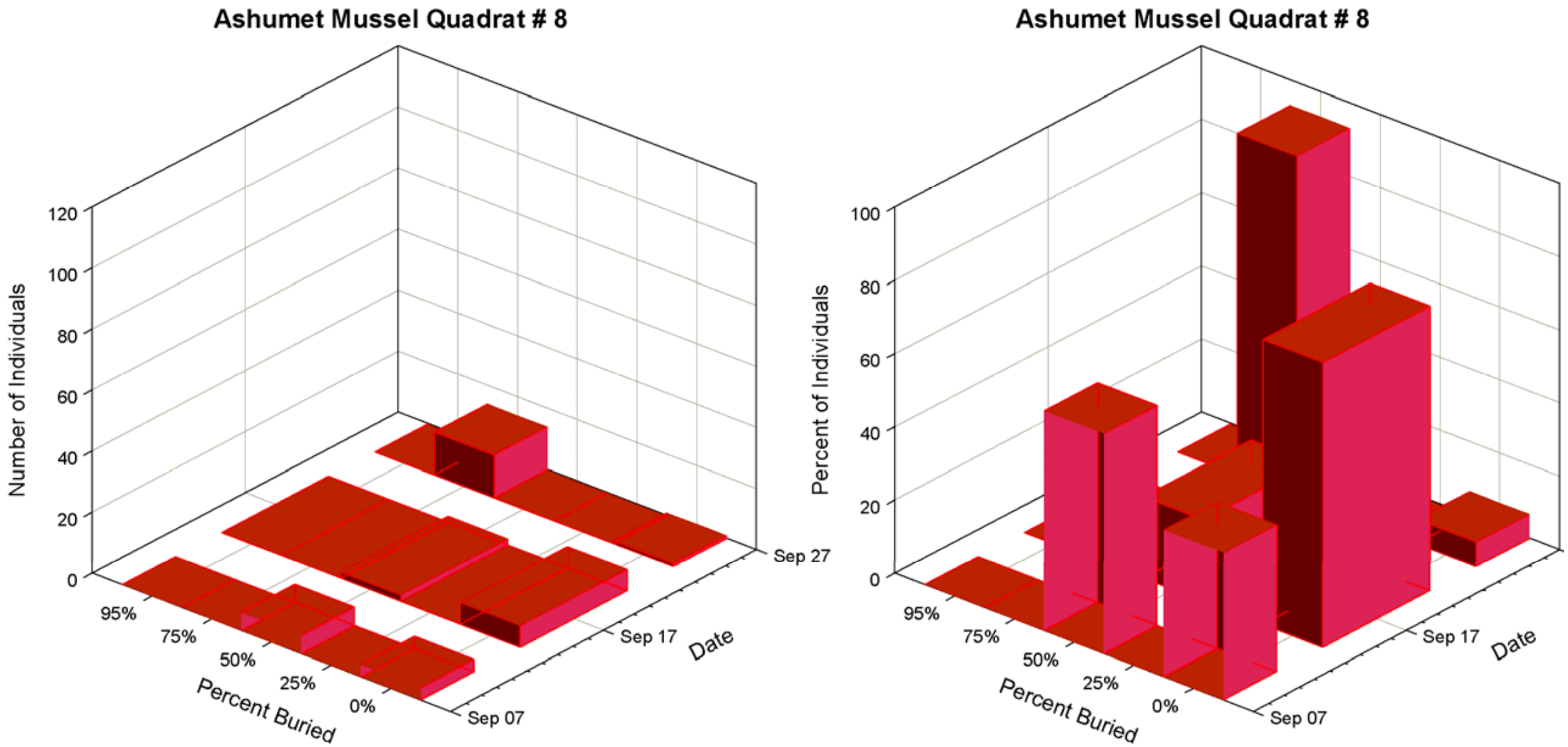


Figure 13. Panel A shows the number of mussels in Quadrate 8 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

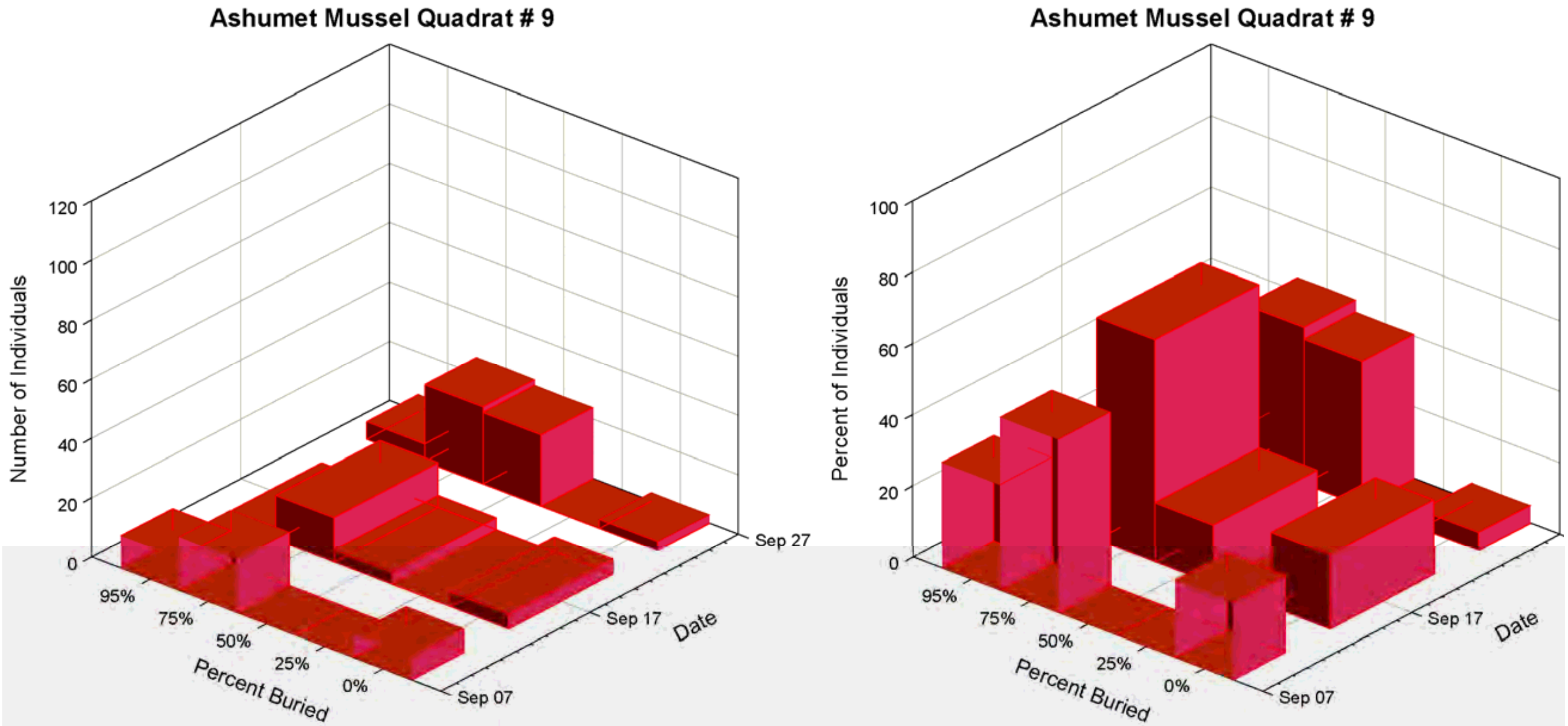


Figure 14. Panel A shows the number of mussels in Quadrate 9 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

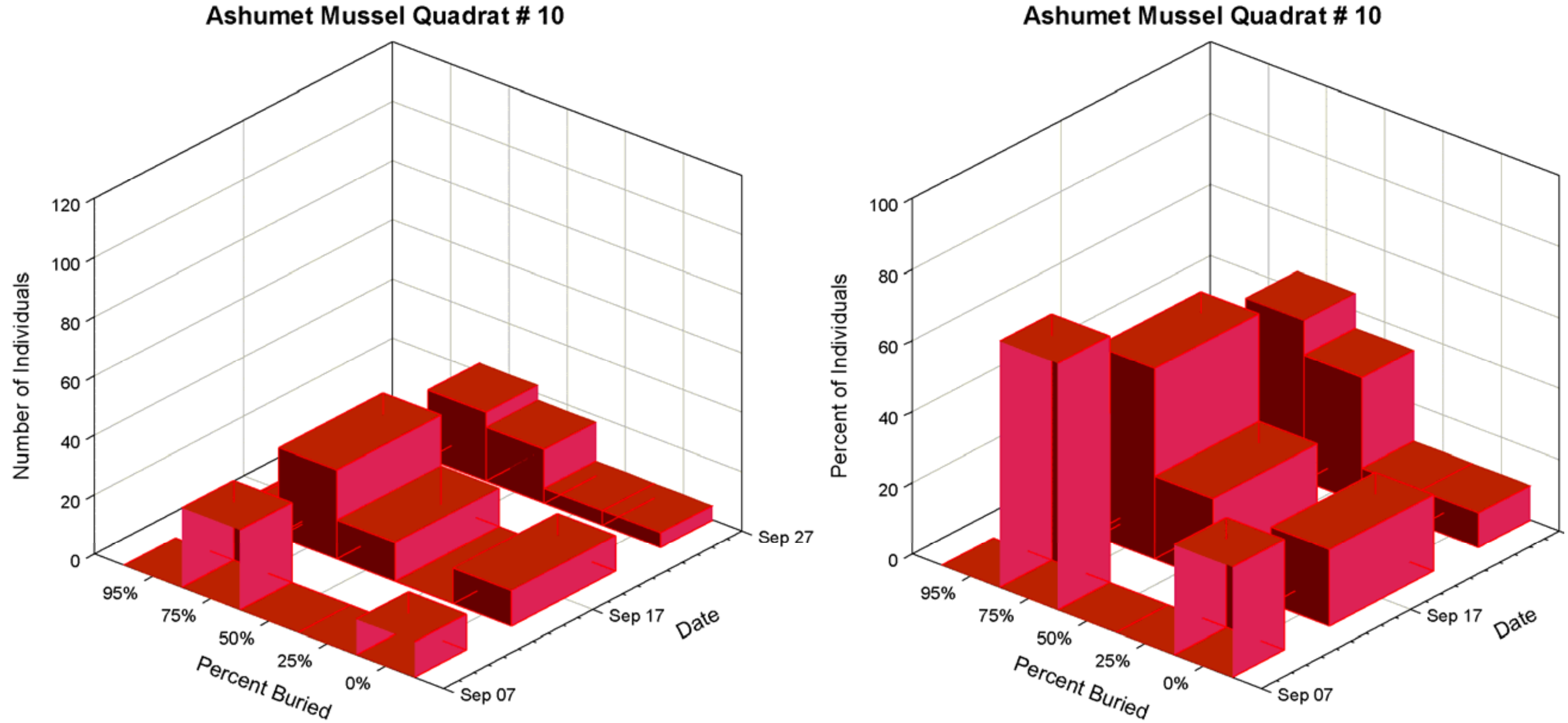


Figure 15. Panel A shows the number of mussels in Quadrate 10 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

University of Massachusetts Dartmouth
The School for Marine Science and Technology

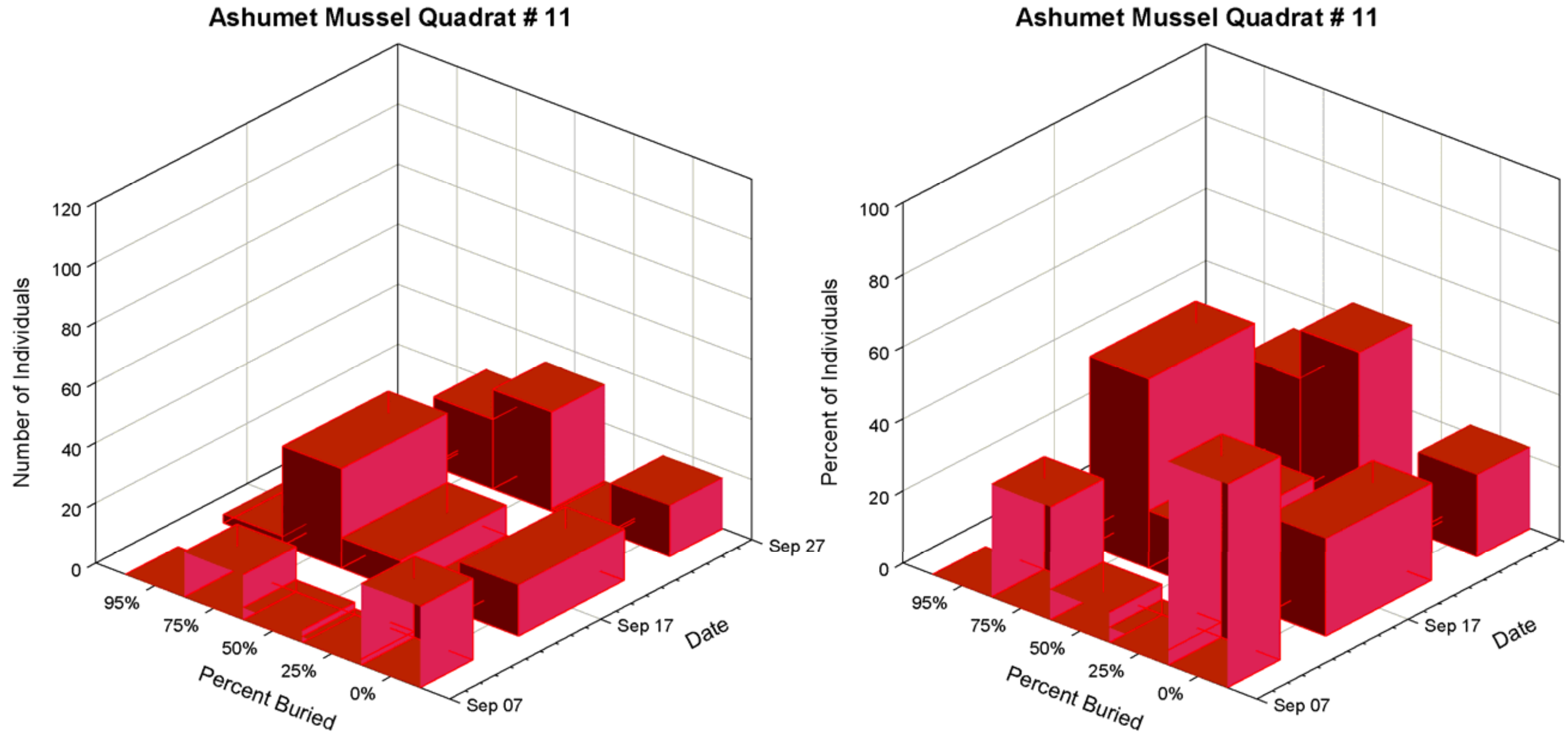


Figure 16. Panel A shows the number of mussels in Quadrate 11 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

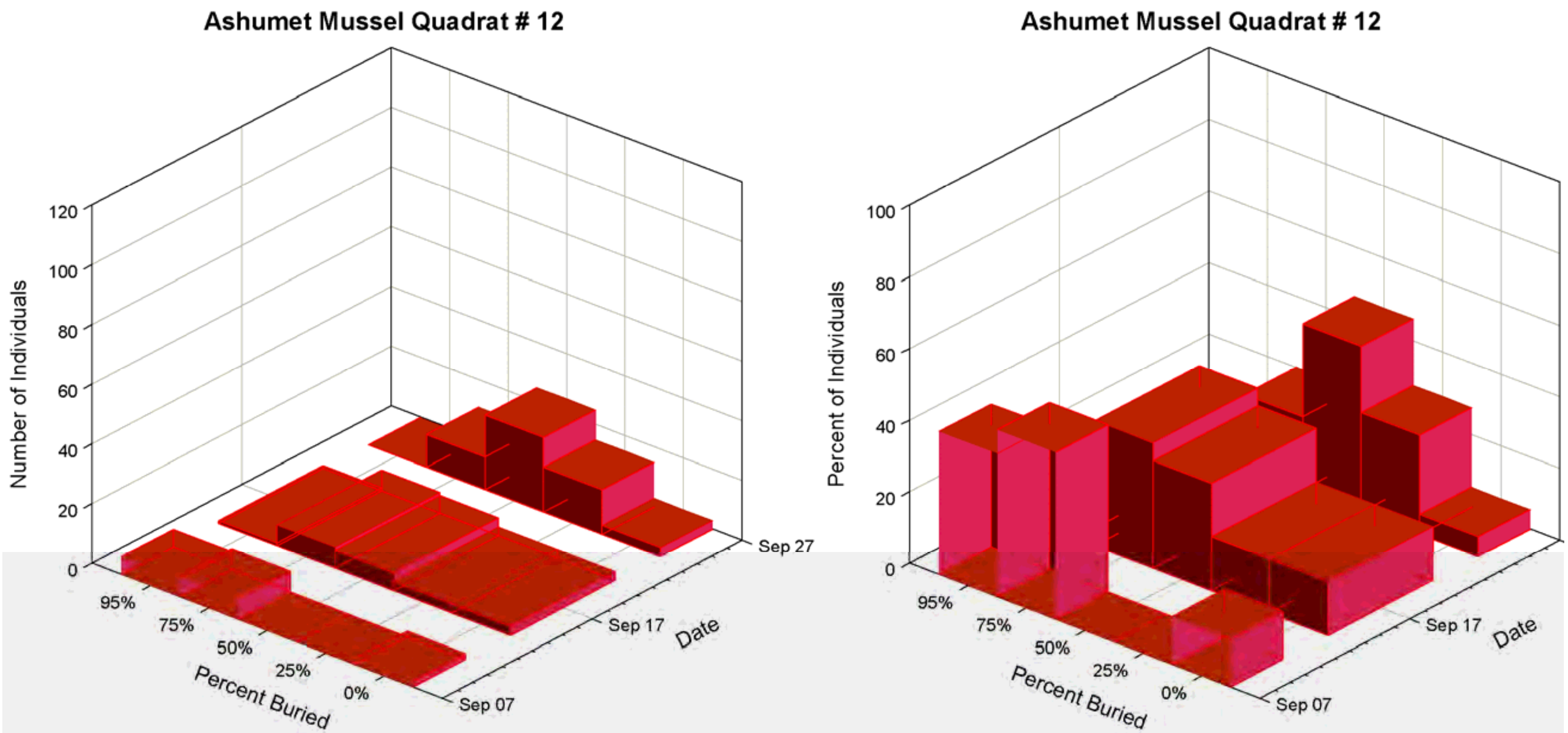


Figure 17. Panel A shows the number of mussels in Quadrate 12 as a function of depth of burial in sediment (embedded) on each of the 3 assay dates (Pre-Treatment, September 7 and Post-Treatment, September 17 & 27). Panel B presents the same data but displayed as percent of total mussels observed on each date in order to normalize for changing number of individuals observed on the different dates. Quadrate ID refers to the location on the maps in Figures 2 & 3.

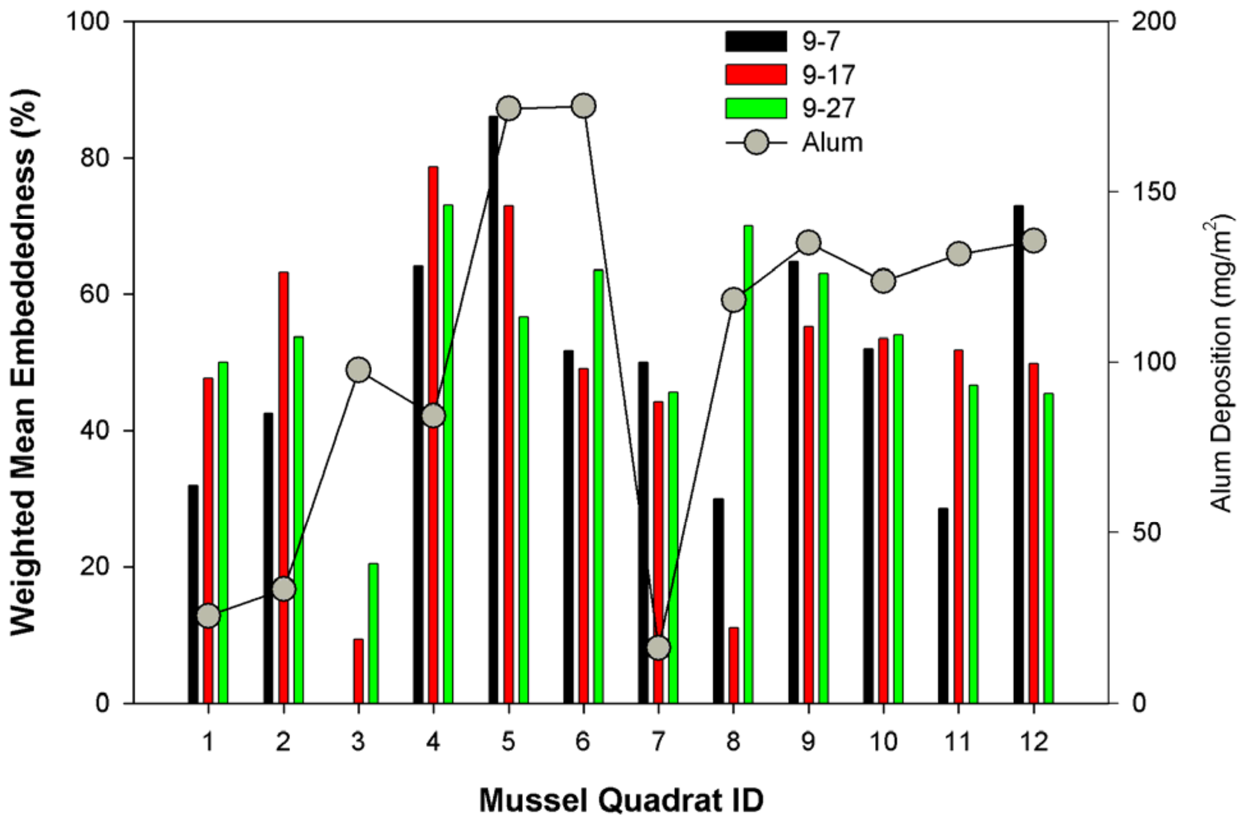


Figure 18. The mean degree to which mussels in the survey quadrates were embedded in the sediment (bars) is show through time for each quadrate. For purposes of comparison, the quantity of Alum captured in the sediment traps at each location is shown (dots). Quadrate ID's refer to the locations on the map in Figures 2 & 3.

APPENDIX B – CERTIFICATE OF COMPLIANCE

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENGINEERING AND THE ENVIRONMENT
INSTALLATION RESTORATION PROGRAM
OTIS AIR NATIONAL GUARD BASE, MA 02542-5028

6 Oct 10

HQ AFCEE/MMR
322 East Inner Road
Otis ANG Base MA 02542

Andrew McManus
Conservation Agent
Mashpee Conservation Commission
Mashpee, MA

Re: Request for Certificate of Compliance, *Ashumet Pond Phosphorus Inactivation Project – 2010; SE 043-2617*

Dear Mr. McManus:

The Air Force Center for Engineering and the Environment (AFCEE) is pleased to submit this *Request for Certificate of Compliance* for the referenced project. This request is made in accordance with the Wetlands Protection Act and regulations (310 CMR 10.00), Town of Mashpee Chapter 172, and the terms of the *Order of Conditions, MA DEP # SE 043-2617*, specifically Special Conditions 9 and 28.

The phosphorus inactivation project was completed on Ashumet Pond successfully following Labor Day with equipment mobilization and treatment of the five (5) acre pilot area on September 9th, data review, and then full implementation, involving the remaining acreage (51.5 acres), during the week of September 13th. We believe careful pre-planning, particularly aluminum compound ratio/dosage studies providing for balanced pH during implementation, and regular water chemistry and observational monitoring ensured success. No fish kills or stressed biota were observed during the treatment process. We are confident the treatment will provide on-going benefits to the trophic health of Ashumet Pond.

A letter from John Burgess, our Lakes Manager for the project, certifying that the work was conducted in accordance with the Order of Conditions and the Final Work Plan, is attached. In addition, a Wetlands Protection Act (M.G.L. c. 131, §40) Form 8A, *Request for Certificate of Compliance* is also attached.

We are confident the phosphorus inactivation treatment will provide on-going benefits to the trophic health of Ashumet Pond for many years to come. We are currently working with post treatment trophic data and will be completing a report, anticipated to be available in December. A courtesy copy of this report will be provided to the Conservation Commission for your records. Please accept our thanks to both you and the Commission for your assistance with this project. If you have any questions, please do not hesitate to give me a call at 508.968.4670 ext 4952 or Spence Smith, CH2M Hill at 617.523.2002.

Sincerely

JONATHAN S. DAVIS, P.E.
Remediation Program Manager

Attachment: (Lakes Manager Certification and WPA Form 8A)
c. Kristin Black and Marea Gabriel, Natural Heritage Endangered Species Program
Christine Odiaga, MassDEP Southeast Region Office,BRP, Wetlands Program

CH2M HILL
25 New Chardon Street
Suite 300
Boston, MA
02114-4770
Tel 617.523.2260
Fax 617.723.9036

October 4, 2010

Mr. Jonathon Davis
Program Manager
Air Force Center for Engineering and Environment
322 East Inner Road
Otis ANG Base, MA 02452

Subject: *Certificate of Compliance, Ashumet Pond Phosphorus Inactivation Project; SE 043-2617*

Dear Mr. Davis,

This letter briefly summarizes results of monitoring conducted during the Ashumet Pond Phosphorus Inactivation Project and certifies, in accordance with Special Condition 9 of the Mashpee Conservation Commission Order of Conditions (File #043-2617), dated August 6, 2010, that the work was conducted both as conditioned by the Commission and consistent with the the final workplan attached by reference to the OOC's. These monitoring data indicate that the phosphorus inactivation treatment was conducted successfully and in an ecologically safe manner.

The treatment was conducted at Ashumet Pond following Labor Day, during the period from September 9 – 16, 2010. A pilot treatment, involving application of aluminum sulfate and sodium aluminate to a 5-acre test plot, was completed on September 9, 2010. Alkalinity, pH, and aluminum concentrations were monitored in pond water prior to, during, and after the pilot treatment at five monitoring stations. Although a few pH readings less than 6.0 were measured at the on-site field laboratory, prior to initiation of the pilot test, none of the in-situ pH measurements recorded in the pond were less than 6.0. Therefore, the treatment subcontractor, Aquatic Control Technology, Inc. (ACT), was approved to proceed with the pilot test, which was completed on September 9th. Alkalinity, pH, and aluminum measurements collected during and after the pilot test showed that pH and alkalinity remained stable and that dissolved aluminum concentrations remained below the Clean Water Act Section 304(a), National Recommended Acute Water Quality criterion of 0.75 mg/L. A pond-wide survey for dead and/or stressed fish conducted the following morning on September 10th did not identify any dead or stressed fish. Therefore, the full-scale treatment was initiated, as planned for the remaining acreage for a total of 56.5 acres, the following Monday, September 13th.

The phosphorus inactivation treatment was completed on September 16th, with a total of 17,559 gallons of aluminum sulfate (AS) and 9,805 gallons of sodium aluminate (SA) applied over the course of the entire treatment, resulting in an overall application ratio of 1.79 to 1 (alum to sodium aluminate), very close to the target ratio of 1.8 to 1. All dissolved aluminum concentrations measured during the treatment remained low, below the acute water quality criterion and pH was maintained in the target range of 6 to 8. Real-time monitoring of alkalinity and pH on a regular basis at three depths at four monitoring stations and a control station showed that these parameters remained stable, indicating that the 1.8 to 1 ratio of the treatment chemicals resulted in expected buffering of pH.

The only weather-related issue encountered during the treatment involved windy conditions on September 15th. The wind did not exceed the 20 mph threshold to stop work and ACT made adjustments in application orientation to ensure the application vessel remained on track. Some minor aluminum hydroxide floc drift, however, was observed outside the treatment zone in the northeast portion of the treatment area. The wind was blowing strongly from the west-northwest. After observing floc drift, I requested the subcontractor pull back the application from the treatment boundary to provide additional buffer from the deep-water treatment area and shallow waters on the east shore of the pond. Observations of the pond bottom in this area using an underwater camera revealed some small amounts of floc on the sediments outside the treatment area. However, the floc drift was mitigated by the action and the amount of floc deposited outside the treatment boundary did not appear to be significant and is not expected to result in adverse effects to aquatic organisms.

Monitoring data collected during the phosphorus inactivation, including pre-treatment and post-treatment water chemistry, will be included in a Phosphorus Inactivation Report, which is currently under preparation. In summary, the phosphorus inactivation treatment did not adversely impact water quality or aquatic life in the pond. An immediate improvement in water clarity was observed during the treatment, with Secchi disk depth measurements increasing approximately 4 feet in depth. I anticipate improvements in the trophic health of the pond will be observed in the coming years resulting from reduced internal regeneration of phosphorus expected from this treatment.

Should you have any questions, please give me a call at (207) 793-4506

Sincerely,

John R. Burgess

John R. Burgess, CLP
Lake Manager

WPA Form 8A – Request for Certificate of Compliance

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number:
SE 043-2617
Provided by DEP

A. Project Information

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

1. This request is being made by:

Jon Davis, AIR FORCE CENTER FOR ENGINEERING & ENVIRONMENT
Name

322 EAST INNER ROAD, BOX 41
Mailing Address

BOURNE	MA	02452
City/Town	State	Zip Code

508.968.4670 ext 4952
Phone Number

2. This request is in reference to work regulated by a final Order of Conditions issued to:

AIR FORCE CENTER FOR ENGINEERING & ENVIRONMENT
Applicant

August 6, 2010	SE 043-2617
Dated	DEP File Number

Upon completion of the work authorized in an Order of Conditions, the property owner must request a Certificate of Compliance from the issuing authority stating that the work or portion of the work has been satisfactorily completed.

3. The project site is located at:

Ashumet Pond (Great Pond)	Mashpee
Street Address	City/Town
	N/A (Great Pond)
Assessors Map/Plat Number	Parcel/Lot Number

4. The final Order of Conditions was recorded at the Registry of Deeds for:

Commonwealth of Massachusetts (Great Pond)
Property Owner (if different)

Barnstable County	24752	223
County	Book	Page

Certificate (if registered land)

5. This request is for certification that (check one):

☒ the work regulated by the above-referenced Order of Conditions has been satisfactorily completed.

☐ the following portions of the work regulated by the above-referenced Order of Conditions have been satisfactorily completed (use additional paper if necessary).

☐ the above-referenced Order of Conditions has lapsed and is therefore no longer valid, and the work regulated by it was never started.

A. Project Information (cont.)

6. Did the Order of Conditions for this project, or the portion of the project subject to this request, contain an approval of any plans stamped by a registered professional engineer, architect, landscape architect, or land surveyor?

☒ Yes — If yes, attach a written statement by such a professional certifying substantial compliance with the plans and describing what deviation, if any, exists from the plans approved in the Order.

☐ No

B. Submittal Requirements

Requests for Certificates of Compliance should be directed to the issuing authority that issued the final Order of Conditions (OOC). If the project received an OOC from the Conservation Commission, submit this request to that Commission. If the project was issued a Superseding Order of Conditions or was the subject of an Adjudicatory Hearing Final Decision, submit this request to the appropriate DEP Regional Office (see http://www.mass.gov/dep/about/region/findyour.htm).

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands

WPA Form 8B – Certificate of Compliance

Massachusetts Wetlands Protection Act M.G.L. c. 131, §40

DEP File Number:
SE043-2617
Provided by DEP

A. Project Information

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

1. This Certificate of Compliance is issued to:

   Jon Davis, Air Force Center for Engineering & Environment
   Name
   322 East Inner Road, Box 41
   Mailing Address
   Bourne | MA | 02452
   City/Town | State | Zip Code

2. This Certificate of Compliance is issued for work regulated by a final Order of Conditions issued to:

   Air Force Center for Engineering & Environment
   Name
   8/6/2010 | SE 043-2617
   Dated | DEP File Number

3. The project site is located at:

   Ashumet Pond (Great Pond) | Mashpee
   Street Address | City/Town
   N/A (Great Pond) |
   Assessors Map/Plat Number | Parcel/Lot Number

   the final Order of Condition was recorded at the Registry of Deeds for:

   Commonwealth of Massachusetts (Great Pond)
   Property Owner (if different)
   Barnstable | 24752 | 223
   County | Book | Page

   Certificate

4. A site inspection was made in the presence of the applicant, or the applicant's agent, on:

   October 6, 2010
   Date

B. Certification

Check all that apply:

☒ **Complete Certification**: It is hereby certified that the work regulated by the above-referenced Order of Conditions has been satisfactorily completed.

☐ **Partial Certification:** It is hereby certified that only the following portions of work regulated by the above-referenced Order of Conditions have been satisfactorily completed. The project areas or work subject to this partial certification that have been completed and are released from this Order are:

☐ Invalid Order of Conditions: It is hereby certified that the work regulated by the above-referenced Order of Conditions never commenced. The Order of Conditions has lapsed and is therefore no longer valid. No future work subject to regulation under the Wetlands Protection Act may commence without filing a new Notice of Intent and receiving a new Order of Conditions.

☒ **Ongoing Conditions**: The following conditions of the Order shall continue: (Include any conditions contained in the Final Order, such as maintenance or monitoring, that should continue for a longer period).

Condition Numbers:

22, 24 & 25 shall extend beyond the Certificate of Compliance (in perpetuity) and shall be referenced in all future deeds to this property.

C. Authorization

Issued by:

Mashpee Conservation — Conservation Commission

10/08/10 — Date of Issuance

This Certificate must be signed by a majority of the Conservation Commission and a copy sent to the applicant and appropriate DEP Regional Office (See http://www.mass.gov/dep/about/region/findyour.htm).

Signatures:

[signatures] 10/7/2010; 10/7/10

D. Recording Confirmation

The applicant is responsible for ensuring that this Certificate of Compliance is recorded in the Registry of Deeds or the Land Court for the district in which the land is located.

Detach on dotted line and submit to the Conservation Commission.

To:

Mashpee Conservation
Conservation Commission

Please be advised that the Certificate of Compliance for the project at:

Ashument Pond (Great Pond) — Project Location
SE 043-2617 — DEP File Number

Has been recorded at the Registry of Deeds of:

Barnstable
County

for:

Property Owner

and has been noted in the chain of title of the affected property on:

Date | Book | Page

If recorded land, the instrument number which identifies this transaction is:

Bk 24910 Pg240 #52668
10-15-2010 @ 10:34a

If registered land, the document number which identifies this transaction is:

Document Number

Signature of Applicant

22. The Plan of Record for this Order of Conditions does not constitute specific acceptance of the boundaries of resource areas under M.G.L. Chapter 131, sec. 40 and Chapter 172 of the Mashpee Code for any work not described in Special Condition 1(A). A new filing/application may be necessary if deemed so by the Commission and may require new plans and/or new delineations of resource areas, as the Commission deems appropriate. The Commission may also require that said plans be prepared by a Professional Engineer and/or Registered Land Surveyor and may further require that resource areas shall be delineated by a professional, as per the provisions as cited in "Requirements for Professional Services" on P.1 (instructions) of the Notice of Intent form.

24. This Order of Conditions or any continuing conditions in perpetuity shall apply to any successor in interest or successor in control.

25. Violation of any conditions of this Order or any continuing conditions in perpetuity may result in the issuance of an Enforcement Order. Such Enforcement Order, if issued, will require the immediate cessation of all work until the mandates in the Enforcement Order are followed. In some instances, the violation may necessitate a hearing, in this case such hearing will be held not more than 15 days from the issuance of the Enforcement Order.

APPENDIX C – ASHUMET POND PHOSPHOROUS INACTIVATION TREATMENT SUMMARY

11 John Road
Sutton, MA 01590

Phone: (508) 865-1000
FAX: (508) 865-1220
e-mail: info@aquaticcontroltech.com
Internet: www.aquaticcontroltech.com

AQUATIC CONTROL TECHNOLOGY INC.
Lake Restoration

Date: November 3, 2010

To: John Burgess; CH2MHill

From: Dominic Meringolo, Senior Environmental Engineer

Re: Ashumet Pond Alum Treatment Summary

Aquatic Control Technology successfully conducted the Alum Treatment of Ashumet Pond during the period of September 7th to September 16th, 2010.

The barge was delivered and launched into the pond on September 7th. On September 8th, we completed assembling the system and ran several test runs using water from the lake. A full calibration test run using water was also conducted on September 8th and again during the morning of September 9th.

Dose calculations and jar-testing conducted prior to treatment were used to determine that a combination of aluminum sulfate (alum) and sodium aluminate (SA) would be applied in a 1.8 to 1 ratio to supply 40g/m^2 of aluminum to the bottom sediments. This equated to volumetric application rate of 304 gallons of alum and 169 gallons of SA per acre. The designated treatment area was provided by CH2MHill and was pre-loaded into our GIS/GPS system. The total treatment area was 56.5-acres.

Table 1 shows the calibration table for the application system based on the designated dose, boom width and speed of the treatment barge. This table was used to set the pumping system flow rates for the two products. The treatment speed of the barge was generally 3 MPH. The spray boom was lowered to a depth of ~ 10 feet for the application.

Per the work plan, the full dose was applied in two halves, with half the dose applied to the entire treatment area followed by the second half. In general, there was a least 48-hours period before the 2nd half of the dose was applied to any area and the two half doses were applied in perpendicular directions. During the pilot treatment, the test plot received the two half doses on the same day.

On September 9th, a pilot treatment was conducted on a 5-acre "test plot" in the northwestern corner of the treatment area. The application record (Table 2) and a map of the treatment tracks (Figure 1) is attached. Our on-board GPS/GIS system logs a point every second while applying the chemicals. The treatment "tracks" displayed on the map are actually these points.

For the remainder of the application period, the treatment area was subdivided based on the amount of product that was ordered for the day. During a full day of treatment, 4500 gallons of alum and 2500 gallons of SA were delivered to the lake. The products were delivered in split tankers (two separate compartments in the trailer). Two deliveries were made each full day of treatment. The treatment records (Table 3-6) and treatment maps (Figures 2-5) for the remainder of the work are attached. Figure 6 shows all of the treatment tracks for the entire application.

Based on the treatment records, we applied a total of 17,559 gallons of alum and 9,805 gallons of SA. This works out to a ratio of 1.79 to 1. Based on the reported volumes delivered by the Holland Company (see attached memo), we applied a total of 17,365 gallons of alum and 9,543 gallons of SA. This deviates from the treatment records by about 1.1% for alum and 2.6% for the SA and is within the expected error of the flow meters and within acceptable thresholds per the work plan. Based on theoretical calculations using 56.5 acres and a dose of 40g/m^2, we should have applied 17,187 gallons of alum and 9,548 gallons of SA. We therefore exceeded the planned dose by 2.1% for alum and 2.7% for SA.

Ashumet Pond Treatment Record Sheet

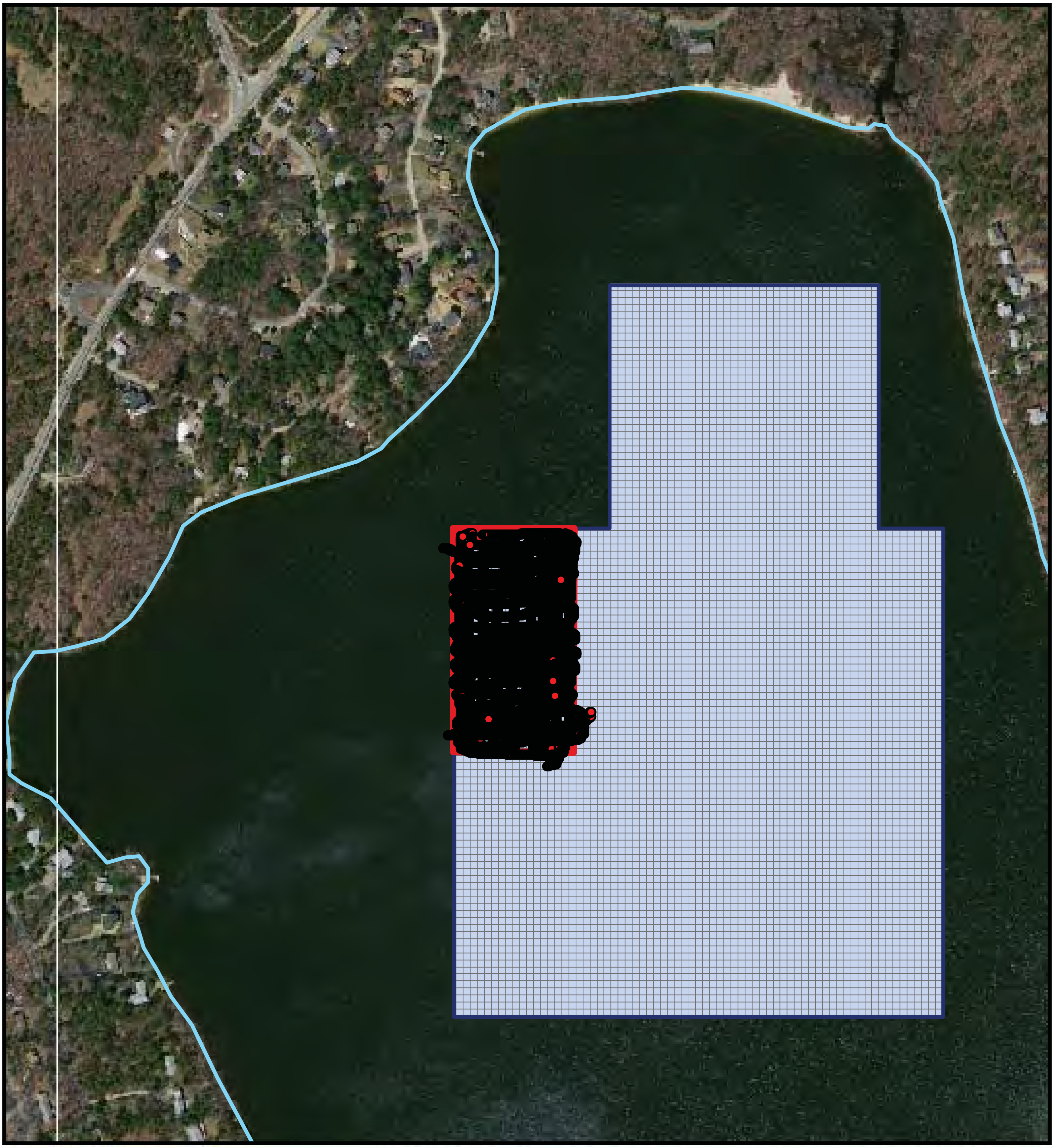
Table 2

Date: 9/9/2010

Target Area: 5-acres (pilot) full dose

Load #	Gal Alum	Gal SA	Time Start	Time Finish	Notes:
1	500	275	10:10 AM	10:46 AM	
2	300	166	10:57 AM	1:15 PM	Broken Paddle Wheel Motor
3	500	275	1:31 PM	2:08 PM	
4	375	225	3:02 PM	3:32 PM	

Treatment Speed: 3 MPH
Alum Flowrate: 18.2 GPM
SA Flowrate 10.1 GPM



Ashumet Pond

Mashpee/Falmouth

Alum Treatment Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
1	9/9/2010	9/10/2010

Legend:

- Treatment Track -9/9/2010
- Treatment Area - 9/9/2010
- Entire Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

Ashumet Pond Treatment Record Sheet

Table 3

Date: 9/13/2010

Target Area: 29.6 acres @ half dose (see map)

Load #	Gal Alum	Gal SA	Time Start	Time Finish	Notes:
1	500	275	9:07 AM	9:45 AM	
2	500	275	10:00 AM	10:38 AM	
3	500	275	10:53 AM	11:27 AM	
4	500	275	11:45 AM	12:23 PM	
5	500	275	12:45 PM	1:17 PM	
6	500	275	1:56 AM	2:35 PM	
7	500	275	2:53 PM	3:28 PM	
8	500	275	3:45 PM	4:19 PM	
9	500	275	4:36 PM	5:12 PM	

Treatment Speed: 3 MPH
Alum Flowrate: 18.2 GPM
SA Flowrate 10.1 GPM

Ashumet Pond

Mashpee/Falmouth

Alum Treatment
Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
2	9/13/2010	9/13/2010

Legend:

- Treatment Track - 9/13/2010
- Treatment Area - 9/13/2010
- Entire Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

Ashumet Pond Treatment Record Sheet

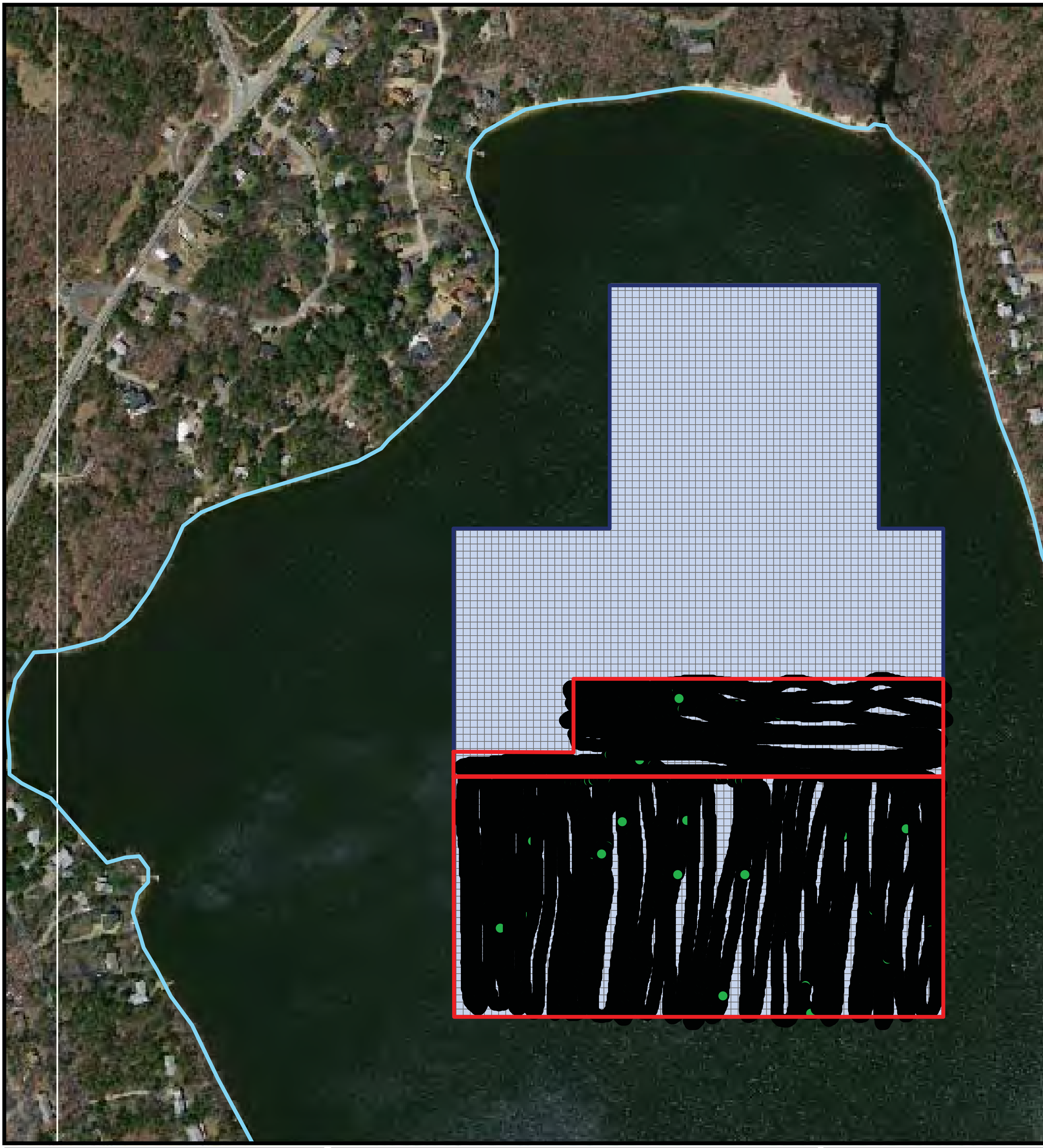
Table 4

Date: 9/14/2010

Target Area: 29.6 acres @ half dose (see map)

Load #	Gal Alum	Gal SA	Time Start	Time Finish	Notes:
1	500	275	9:00 AM	9:41 AM	
2	500	275	9:55 AM	10:30 PM	
3	500	275	10:47 AM	11:21 PM	
4	500	275	11:38 AM	12:15 PM	
5	500	275	12:30 PM	1:07 PM	
6	500	275	1:50 PM	2:27 PM	
7	500	275	2:43 PM	3:22 PM	
8	500	275	3:37 PM	4:13 PM	
9	500	275	4:28 PM	5:05 PM	

Treatment Speed: 3 MPH
Alum Flowrate: 18.2 GPM
SA Flowrate 10.1 GPM



Ashumet Pond

Mashpee/Falmouth

Alum Treatment

Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
3	9/14/2010	9/14/2010

Legend:

- Treatment Area - 9/14/2010
- Treatment Track - 9/14/2010
- Entire Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.

11 JOHN ROAD

SUTTON, MASSACHUSETTS 01590

PHONE: (508) 865-1000

FAX: (508) 865-1220

WEB: WWW.AQUATICCONTROLTECH.COM

Ashumet Pond Treatment Record Sheet

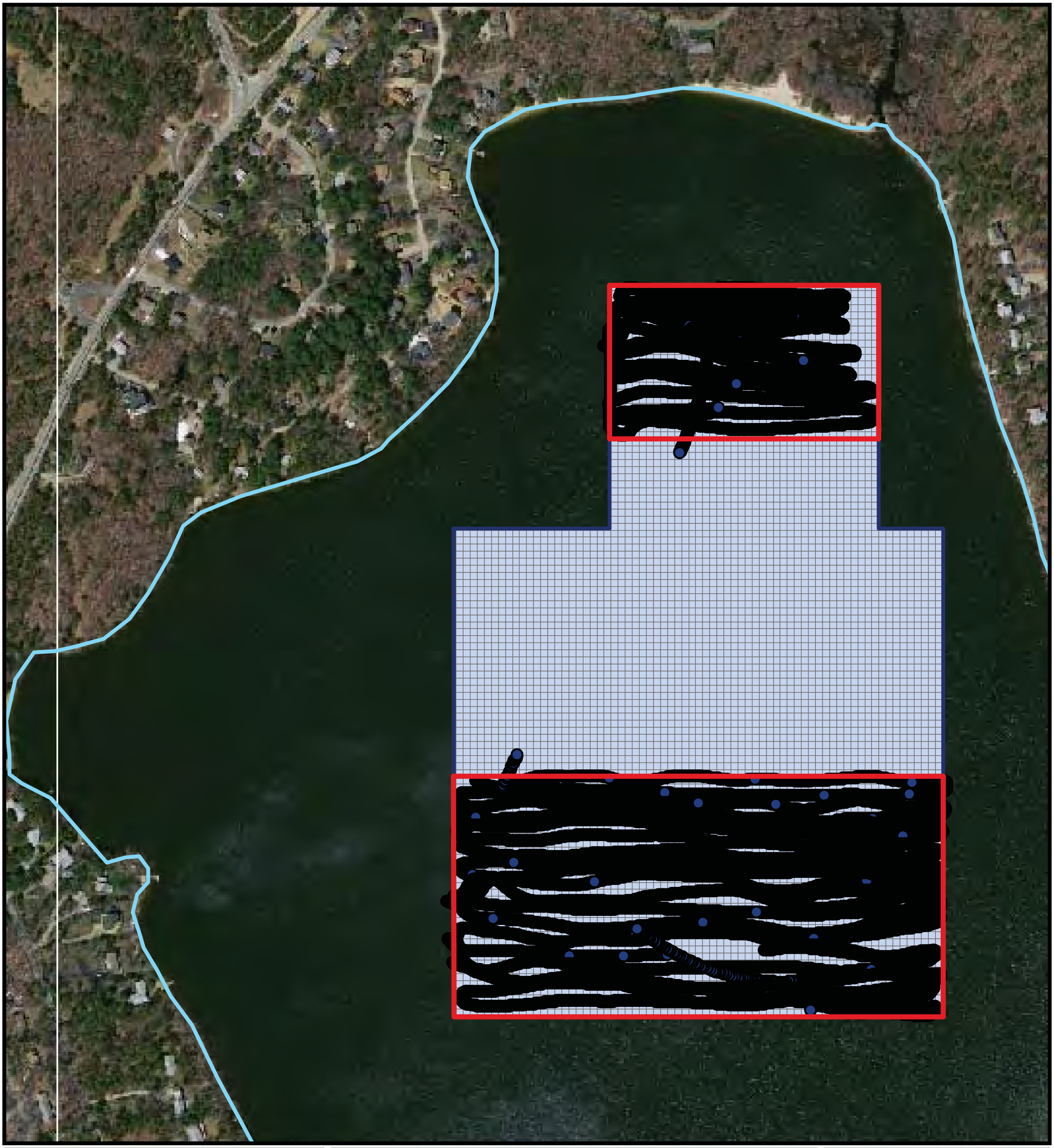
Table 5

Date: 9/15/2010

Target Area: 29.6 acres @ half dose (see map)

Load #	Gal Alum	Gal SA	Time Start	Time Finish	Notes:
1	500	275	8:24 AM	9:00 AM	
2	500	275	9:15 AM	9:47 AM	
3	500	275	10:05 AM	10:39 AM	
4	500	275	10:55 AM	11:29 AM	
5	500	275	11:50 AM	12:26 PM	
6	500	275	1:21 PM	1:55 PM	
7	500	275	2:13 PM	2:52 PM	
8	500	275	3:13 PM	3:48 PM	
9	500	275	4:05 PM	4:47 PM	

Treatment Speed: 3 MPH
Alum Flowrate: 18.2 GPM
SA Flowrate 10.1 GPM



Ashumet Pond

Mashpee/Falmouth

Alum Treatment
Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
4	9/15/2010	9/15/2010

Legend:

- Treatment Area - 9/15/2010
- Treatment Track - 9/15/2010
- Entire Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

Ashumet Pond Treatment Record Sheet

Table 6

Date: 9/16/2010

Target Area: 14.8 acres @ half dose (see map)

Load #	Gal Alum	Gal SA	Time Start	Time Finish	Notes:
1	500	275	8:07 AM	8:45 AM	
2	500	275	9:01 AM	9:36 AM	
3	500	275	9:51 AM	10:26 AM	
4	500	275	10:42 AM	11:16 AM	
5	384	264	11:40 AM	12:16 PM	Leftover SA was diluted and slowly applied in passes starting in the southern end of the treatment area

Treatment Speed: 3 MPH
Alum Flowrate: 18.2 GPM
SA Flowrate 10.1 GPM

Ashumet Pond

Mashpee/Falmouth

Alum Treatment
Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
5	9/16/2010	9/16/2010

Legend:

- Treatment Area - 9/16/2010
- Treatment Track 9/16/2010
- Entire Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

Ashumet Pond

Mashpee/Falmouth

Alum Treatment

Treatment Tracks

FIGURE:	SURVEY DATE:	MAP DATE:
6	9/16/2010	9/16/2010

Legend:

- Treatment Track 9/16/2010
- Treatment Track - 9/15/2010
- Treatment Track - 9/14/2010
- Treatment Track - 9/13/2010
- Treatment Track -9/9/2010
- Treatment Area

0 120 240 480 720 960 Feet

AQUATIC CONTROL TECHNOLOGY, INC.
11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

APPENDIX D – ALKALINITY MONITORING DATA

Ashumet Pond Alum Treatment Alkalinity and pH data

Loon Environmental LLC
Marie Esten
401-433-2684

			PRE-TREATMENT				DURING TREATMENT				POST TREATMENT		
Date	**Site**	**Depth (m)**	**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**
9/9/2010	1	4	6.92	8.3			7.06	8.3			7.24	9.1	
9/9/2010	1	7	6.02	8.4			5.95	8.4			6.24	9.2	
9/9/2010	2	4	6.35	6.8			6.78	8.4			7.11	8.2	
9/9/2010	2	7					5.93	8.1			6.15	9.2	
9/9/2010	2	9	5.74	14.33	1,2, 4								
9/9/2010	2	15	5.30	10.9			5.76	24.5			6.32	24.8	
9/9/2010	3	4	6.53	7.5			6.85	8.1			7.22	9.0	
9/9/2010	3	7	5.54	6.5			6.06	8.5			6.22	9.0	
9/9/2010	4	4	6.59	7.6			6.89	8.4			6.70	6.9	
9/9/2010	4	7	5.51	7.1			5.98	8.5			5.99	8.3	
9/9/2010	Control	4	6.40	8.6			6.66	8.2			7.13	8.7	
9/9/2010	Control	6.2	6.20	9.0			6.14	7.5			6.62	8.7	

			PRE-TREATMENT				DURING TREATMENT				POST TREATMENT		
Date	**Site**	**Depth (m)**	**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**
9/13/2010	1	4	6.90	8.2			6.98	8.2			7.10	8.7	
9/13/2010	1	7	6.54	7.9			6.17	7.8			6.39	8.1	
9/13/2010	2	4	5.68	8.7	3		6.93	8.5			7.08	8.5	
9/13/2010	2	7	5.83	7.4	4		6.00	7.8			5.98	6.9	
9/13/2010	2	15	5.64	23.5			6.03	23.7			6.21	23.6	
9/13/2010	3	4	6.42	7.7			6.95	8.1			7.09	8.7	
9/13/2010	3	7	5.99	7.5			6.03	7.7			6.15	7.7	
9/13/2010	4	4	6.93	8.3			6.90	8.3			6.98	8.7	
9/13/2010	4	7	6.09	7.9			6.20	7.5			6.33	7.7	3
9/13/2010	Control	4	6.51	7.6			6.63	7.8			6.96	8.5	
9/13/2010	Control	6.2	6.49	7.9			6.53	7.6			6.80	8.3	

Loon Environmental LLC
Marie Esten
401-433-2684

			PRE-TREATMENT				DURING TREATMENT				POST TREATMENT		
Date	Site	Depth (m)	pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes		pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes		pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes
9/14/2010	1	4	6.35	8.9			6.95	8.6			7.14	8.7	
9/14/2010	1	7	5.98	8.6			5.80	7.9			6.49	7.8	
9/14/2010	2	4	7.66	9.7	3		6.66	7.8			7.30	9.0	
9/14/2010	2	7	5.81	8.6			6.12	8.0			6.79	8.4	3
9/14/2010	2	15	5.98	27.1			6.14	25.3			6.61	25.6	
9/14/2010	3	4	5.96	8.5			7.07	8.5			7.37	8.8	
9/14/2010	3	7	5.71	8.6			6.85	8.5			6.29	8.5	
9/14/2010	4	4	7.80	12.1	3		6.23	9.2			7.03	8.7	4
9/14/2010	4	7	6.23	8.3			6.25	8.6			6.62	8.4	
9/14/2010	Control	4	5.84	8.5			5.87	8.7			7.09	8.8	
9/14/2010	Control	6.2	5.92	8.6			5.78	8.8			7.05	8.9	

			PRE-TREATMENT				DURING TREATMENT				POST TREATMENT		
Date	Site	Depth (m)	pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes		pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes		pH (S.U.)	Alkalinity (mg/L CaCO3)	Notes
9/15/2010	1	4	6.77	8.0			7.18	8.5			7.45	9.0	
9/15/2010	1	7	6.22	7.6			6.43	7.9	4		6.73	8.8	
9/15/2010	2	4	6.47	7.0			7.34	8.4	3		7.33	8.7	
9/15/2010	2	7	5.92	6.7			6.42	8.4			6.83	8.4	
9/15/2010	2	15	5.67	21.6			6.17	25.0			6.37	26.1	
9/15/2010	3	4	6.83	8.0	3		6.92	8.0			7.54	8.9	
9/15/2010	3	7	6.01	9.0			6.55	8.0	3		7.05	9.0	
9/15/2010	4	4	7.10	8.2			7.13	8.5			7.57	8.8	
9/15/2010	4	7	6.28	7.4			7.03	8.5			7.23	8.7	
9/15/2010	Control	4	6.64	7.5			7.01	8.6			6.99	8.6	
9/15/2010	Control	6.2	6.15	7.2			6.75	8.4			6.77	8.6	

Ashumet Pond Alum Treatment Alkalinity and pH data

Loon Environmental LLC
Marie Esten
401-433-2684

			PRE-TREATMENT				DURING TREATMENT				POST TREATMENT		
Date	**Site**	**Depth (m)**	**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**		**pH (S.U.)**	**Alkalinity (mg/L CaCO3)**	**Notes**
9/16/2010	1	4	6.75	8.3							7.26	9.1	
9/16/2010	1	7	6.70	8.3							6.65	8.5	
9/16/2010	2	4	6.45	7.2							7.62	9.8	
9/16/2010	2	7	5.92	7.0			Last day of treatment				6.83	9.2	
9/16/2010	2	15	5.77	22.5	4		Only 1/2 day spent applying				6.60	27.3	
9/16/2010	3	4	7.10	8.6							6.96	8.8	
9/16/2010	3	7	7.07	8.9							6.88	8.4	
9/16/2010	4	4	7.27	9.2							7.20	8.8	
9/16/2010	4	7	6.72	8.4							6.69	8.5	
9/16/2010	Control	4	6.25	7.5							6.95	8.5	
9/16/2010	Control	6.2	6.28	7.5							6.39	7.3	3

Notes:

1 - Sample was collected below thermocline (9m) and during the next sampling round was collected above thermocline (7m).

2 - pH meter was suspected of giving faulty pH readings as laboratory pH readings were substantially lower than YSI field readings. Therefore, the pH and alkalinity readings on these sampels are somewhat suspect. Backup pH meter was utlized for samples moving forward, initially the backup unit was calibrated using 1 point, later when time allowed, it was re-calibrated with 2 points.When the probe was checked with standards after 1 point calibration, values were within 5%RPD of buffer values.

3- Alkalinity end point overshot slightly, alklainity reported is estimated to be slightly high.

4 - Sample duplicate, values reported are average of duplicates.

pH meter calibration log sheet: Ashumet Pond

Date: 9/9/10

original unit – problems with it – wouldn't hold cal. returned.

Meter Serial Number/Model/Make: HANNA 991301 unit 88903

Calibration Solution Lot #	4003078	2001172	/
Calibration Solution Exp. Date	3-2012	12-2011	/
Std. Value	7	4	/

Calibration Time	08:30		
PreCal Value	~~3.89~~ 6.90	3.89	/
Cal Value	7.01	4.01	/
Temp	21.7	21.7	/
Final Slope	- NA (Not Available w/ this meter)		
Initials	Me		

PostCal Time			
PostCal Value			
Temp			
Initials			

pH meter calibration log sheet: Ashumet Pond

Date: 9/9/10

(MMR standard)

2nd meter

Meter Serial Number/Model/Make: HI 991301 # 4212

Calibration Solution Lot #	095309	094895	-
Calibration Solution Exp. Date	9/2011	9/2011	
Std. Value	7.01	4.01	

Calibration Time	12 23		
PreCal Value	7.2	4.3	
Cal Value	7.01	4.01	
Temp	25.2 °C		
Final Slope	NA		
Initials	Me.		

PostCal Time	18:11		
PostCal Value	7.11	4.08	
Temp	22.1 °C		
Initials	ME		

1 800 579

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 1 of 12

All on 9/9/10 } Lot A Ø131 11/11 HACH 0.1600 N Sulfuric acid

Date 9	9/9/10
Time	10:00
Sample ID	02
Depth	B - 29.5 ft (9m)
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
multiplier	0.05
Final Alkalinity	13.3 mg/L

Temp 21.3°C

pH	Digital Titration Turns
5.61	0
4.96	259
~~4.92~~	~~263~~
4.90	265

} 14% RPD

Date	9/9/10
Time	10:22
Sample ID	02
Depth	B - 29.5 ft (9m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
multiplier	0.05
Final Alkalinity	15.35 mg/L

Temp 21.9°C

pH	Digital Titration Turns
5.86	0
5.16	266
5.12	274
5.08	280
5.04	287
4.97	297
4.95	299
4.93	303
4.91	307

– changed meters single pt calibration 7.0

Date	
Time	1102
Sample ID	02
Depth	13.1 ft (4m)
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	
Final Alkalinity	6.8 mg/L

pH	Digital Titration Turns
6.35	0
5.71	68
~~4.96~~	~~132~~
4.93	135

Alkalinity Log Sheet: Ashumet Pond
Date:
Page: 2 of 12

Date	9/9/10
Time	11:12
Sample ID	02
Depth	49.2 ft (15m)
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	10.9 mg/L

pH	Digital Titration Turns
5.36	~~8~~ 0
4.90	217

Date	9/9/10
Time	11:23
Sample ID	Control
Depth	13 ft (4m)
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
6.4	0
4.97	168
4.94	171

added Bromcresol Green–methyl Red powder pillow color change correspond w/ pH meter

Date	9/9/10
Time	11:36
Sample ID	Control
Depth	20.5 ft (6.2m)
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.95 mg/L

pH	Digital Titration Turns
6.2	0
5.13	160
4.98	172
4.92	179

7.00 = 6.71 checked cal w/ Lot 095309 9/2011 from MME
10.00 = 9.41 lot 095143 9/2011
4.00 = 4.21 lot 094895 9/2011

and re-calibrated (2 point cal) again - record in cal logs for 9/9/10

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 3 of 12

Date	9/9/10
Time	1335
Sample ID	01A
Depth	4m
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.92	0
4.93	163
4.89	165

Date	9/9/10
Time	1344
Sample ID	01B
Depth	7m
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.02	0
4.95	165
4.93	167

Date	9/9/10
Time	1353
Sample ID	03A
Depth	4m
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.53	0
5.03	146
4.99	149
4.93	150

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 4 of 12

Date	9/9/10
Time	14:00
Sample ID	03B
Depth	7m
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	6.5 mg/L

pH	Digital Titration Turns
5.54	0
5.13	88
4.99	118
4.92	129

Date	9/9/10
Time	14:07
Sample ID	04A
Depth	4m
Sample Volume	200
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	7.6 mg/L

pH	Digital Titration Turns
6.59	0
4.95	150
4.90	152

Date	9/9/10
Time	14:17
Sample ID	4B
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	7.1 mg/L

pH	Digital Titration Turns
5.51	0
4.98	121
4.97	125
4.93	134
4.93	137
4.90	147

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 5 of 12

During Treatment

Date	9/9/10
Time	15:15
Sample ID	~~01~~ 01A
Depth	4m
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
7.06	0
4.85	166

Date	9/9/10
Time	1524
Sample ID	01B
Depth	23ft (7m)
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
5.95	0
4.95	165
4.92	167

Date	9/9/10
Time	1531
Sample ID	02A
Depth	13.1ft (4m)
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.78	0
4.94	165
4.89	167

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 6 of 12

Date	9/9/10
Time	15:38
Sample ID	2
Depth	23ft (7m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.1 mg/L

pH	Digital Titration Turns
5.93	0
4.98	158
4.95	160
4.92	162
4.88	164

Date	9/9/10
Time	15:45
Sample ID	2
Depth	49.2ft (15)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	24.5 mg/L

pH	Digital Titration Turns
5.76	0
5.33	290
5.22	350
5.17	380
5.08	410
5.01	450
4.96	462
4.94	470
4.94	473
4.99	485
4.93	~~492~~ 495

4.89/499

Date	9/9/10
Time	16:03
Sample ID	03
Depth	13ft (4m)
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.1 mg/L

pH	Digital Titration Turns
6.85	0
4.94	162
4.86	166

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 7 of 12

Date	9/9/10
Time	16:09
Sample ID	03 B
Depth	23 ft (7m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.06	0
5.01	165
4.92	170

Date	9/9/10
Time	16:14
Sample ID	4
Depth	13 ft (4m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.89	0
4.95	165
4.89	168

Date	9/9/10
Time	16:23
Sample ID	4
Depth	23 ft (7m)
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
5.98	0
5.10	153
4.94	166
4.90	169

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 8 of 12

Date	9/9/10
Time	16:30
Sample ID	Control
Depth	13.1 ft (4m)
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A Ø131 11/11
End Point	4.9
Technician	ME
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
6.66	0
4.94	161
4.90	163

Date	9/9/10
Time	16:5
Sample ID	Control
Depth	20.5 ft (6.2m)
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A Ø131 11/11
End Point	4.9
Technician	ME
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.14	0
4.95	150
4.82	157

After Treatment

Date	9/9/10
Time	16 51
Sample ID	03
Depth	13 ft (4m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
7.22	0
4.91	180

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 9 of 12

Date	9/9/10
Time	1658
Sample ID	03
Depth	23 ft (7m)
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
6.22	0
~~5.98~~	~~976~~
4.97	176
4.90	180

Date	9/9/10
Time	17:04
Sample ID	4
Depth	4m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	6.9 mg/L

pH	Digital Titration Turns
6.70	0
4.92	138

Date	9/9/10
Time	17:10
Sample ID	2
Depth	49 ft (15m)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	24.8 mg/L

pH	Digital Titration Turns
6.32	0
4.95	486
4.92	494
4.91	496

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 10 of 12

Date	9/9/10
Time	17:21
Sample ID	2
Depth	23 ft (7m)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.2 mg/L

pH	Digital Titration Turns
~~5~~	0
6.15	0
4.95	180
4.90	183

Date	9/9/10
Time	17:29
Sample ID	2
Depth	"A" 4m?
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
~~9.0~~	0
7.11	0
4.92	164
4.85	166

Date	9/9/10
Time	17:34
Sample ID	4B
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
5.99	0
4.92	164
4.90	166

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 11 of 12

Date	9/9/10
Time	17:49
Sample ID	01A
Depth	13 ft (4m)
Sample Volume	200 mL
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.1 mg/L

pH	Digital Titration Turns
7.24	0
4.91	181

Date	9/9/10
Time	17:56
Sample ID	Ø1B
Depth	23ft (7m)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.2 mg/L

pH	Digital Titration Turns
6.24	0
4.91	184

Date	9/9/10
Time	18:01
Sample ID	Control
Depth	13 ft (4m)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.13	0
4.87	174

Alkalinity Log Sheet: Ashumet Pond
Date: 9/9/10
Page: 12 of 12

Date	9/9/10
Time	18:06
Sample ID	Control B
Depth	20.5ft (6.2m)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
6.62	0
4.89	174

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

pH meter calibration log sheet: Ashumet Pond
Date: 9/13/10

Meter Serial Number/Model/Make:

	HI 7007	HI 7004	
Calibration Solution Lot #	1782	0750	
Calibration Solution Exp. Date	7/2014	5/2013	
Std. Value	7	4	

~~HI 7007~~ HI 9025 meter

Calibration Time	8:52		
PreCal Value	6.94 / 19.4°C	3.96	
Cal Value	~~6.88~~ 7.04	4.00	
Temp	19.4°C	19.4°C	
Final Slope	NA		
Initials	ML		

(for the HI 991301 meter)

PostCal Time	1852		
PostCal Value	7.01	3.96	
Temp	16.6		
Initials	ML.		

HI 991301 pH/EC/TDS

0930 cal pH 4+7 - same solution lot as above + exp. date.

		Cal value		temp
~~9/9/10~~ 9/13/10	09:30	7.01	4.01	11.5°C

post cal
See above

- changed pH meters because wouldn't hold calibration - may be a short in temp probe.

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 1 of 12

Date	9/13/10
Time	0925
Sample ID	02
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	ML
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
5.68	0
4.68	173 *
* over	titration

switched pH [illegible]
pH unit calibra[illegible] well - issues w[illegible] turning off + requiring a re-cal.

Date	9/13/10
Time	0932
Sample ID	2
Depth	23ft ~~26ft~~ / ~~8m~~ 7m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	ML
Final Alkalinity	7.8 mg/L

pH	Digital Titration Turns
6.02	0
4.95	154
4.89	156

12 % RPD
Avg = 5.83 pH
~~7.3~~
7.4 mg/L Alk

Date	9/13/10
Time	0951
Sample ID	2
Depth	23ft / 7M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	ML
Final Alkalinity	6.9 mg/L

pH	Digital Titration Turns
5.64	0
4.92	136
4.90	138

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 2 of 12

Date	~~8/9/10~~ 9/13/10
Time	9:58
Sample ID	2
Depth	49ft / 15M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	
Final Alkalinity	23.5 mg/L

pH	Digital Titration Turns
5.64	0
4.96	~~4.~~ 456
4.93	462
4.92	465
4.91	470

Date	~~9/9/10~~ 9/13/10
Time	~~920~~ 1020
Sample ID	1
Depth	4m / 13ft
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	ME
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
6.90	0
4.92	164

Date	~~9/9/10~~ 9/13/10
Time	10²²
Sample ID	1
Depth	23ft / 7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	ME
Final Alkalinity	7.9 mg/L

pH	Digital Titration Turns
6.54	0
4.91	158

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 3 of 12

Date	~~9/9/10~~ 9/13/10
Time	10:29
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 1/11
End Point	4.9
Technician	Me
Final Alkalinity	7.7 mg/L

pH	Digital Titration Turns
6.42	0
4.94	149
4.88	153

Date	9/13/10
Time	10:35
Sample ID	3
Depth	7m (23ft)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
5.99	0
4.91	150

Date	9/13/10
Time	11:11
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.93	0
4.85	165

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 4 of 12

Date	9/13/10
Time	11:18
Sample ID	4
Depth	7m (23ft)
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.9 mg/L

pH	Digital Titration Turns
6.09	0
4.93	155
4.89	157

Date	9/13/10
Time	11:24
Sample ID	C+1
Depth	13ft / 4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.6 mg/L

pH	Digital Titration Turns
6.51	0
4.97	148
4.90	152

Date	9/13/10
Time	11:31
Sample ID	C+1
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.9 mg/L

pH	Digital Titration Turns
6.49	0
4.96	153
4.88	157

During Treatment – Mid Day

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 5 of 12

Date	9/13/10
Time	1412
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0131 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.93	0
4.92	169

- changed H_2SO_4 cartridge

106
+ 49
155

Date	9/13/10
Time	1418
Sample ID	2
Depth	7m
Sample Volume	200mL
Titration Conc.	0.1600N H2SO4
Titration Lot	AC144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.8 mg/L

(rest of 9/13/10 used this lot.)

pH	Digital Titration Turns
6.00	0
4.91	155

Date	9/13/10
Time	1425
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	23.7 mg/L

pH	Digital Titration Turns
6.03	0
4.97	450
4.94	457
—	462
4.92	471
4.90	474

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 6 of 12

Date	9/13/10
Time	1435
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
~~6.8~~ 6.90	0
4.94	164
4.91	166

Date	9/13/10
Time	1443
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.20	0
4.92	150

Date	9/13/10
Time	1520
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
6.98	0
4.92	164

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 7 of 12

Date	9/13/10
Time	15:27
Sample ID	1
Depth	7 m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.8 mg/L

pH	Digital Titration Turns
6.17	0
4.91	156

Date	9/13/10
Time	15:33
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.1 mg/L

pH	Digital Titration Turns
6.95	0
4.91	161

Date	9/13/10
Time	1539
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.7 mg/L

pH	Digital Titration Turns
6.03	0
4.97	150
4.89	154
	159

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 8 of 12

Date	9/13/10
Time	15:47
Sample ID	C+I A
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	/
End Point	4.9
Technician	Me
Final Alkalinity	7.8 mg/L

pH	Digital Titration Turns
6.63	0
4.95	152
4.91	156
4.87	158

Date	9/13/10
Time	1556
Sample ID	C+I A
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.6 mg/L

pH	Digital Titration Turns
6.53	0
4.96	149
4.91	152

– post treatment

Date	9/13/10
Time	17:22
Sample ID	4A
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
6.98	0
4.88	173

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 9 of 12

Date	9/13/10
Time	1728
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.7 mg/L

pH	Digital Titration Turns
6.33	0
4.82	154
overshot endpoint slightly	

Date	9/13/10
Time	1741
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
7.08	0
4.96	167
4.90	169

Date	9/13/10
Time	1750
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	6.9 mg/L

pH	Digital Titration Turns
5.98	0
4.85	137

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 10 of 12

Date	9/13/10
Time	1756
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ML
Final Alkalinity	23.6 mg/L

pH	Digital Titration Turns
6.21	0
4.94	467
4.93	469
4.91	472

Date	9/13/10
Time	18:11
Sample ID	C+e
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ML
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.96	0
4.89	170

Date	9/13/10
Time	18:16
Sample ID	C+l
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ML
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.80	0
4.89	165

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
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Date	9/13/10
Time	~~1623~~ 1823
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.10	0
4.90	173

Date	9/13/10
Time	1831
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.1 mg/L

pH	Digital Titration Turns
6.39	0
4.97	158
4.89	162

Date	9/13/10
Time	1842
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.09	0
4.91	174

Alkalinity Log Sheet: Ashumet Pond
Date: 9/13/10
Page: 12 of 12

Date	9/13/10
Time	1846
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
Final Alkalinity	7.7 mg/L

pH	Digital Titration Turns
6.15	0
4.94	148
~~4.93~~	~~150~~
4.89	153

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

pH meter calibration log sheet: Ashumet Pond
Date: 9/14/10

Meter Serial Number/Model/Make: HI 991301

Calibration Solution Lot #	1782	0750	
Calibration Solution Exp. Date	7/2014	5/2013	
Std. Value	7.01	4.01	

Calibration Time	09:00		
PreCal Value			
Cal Value			
Temp			
Final Slope			
Initials			

PostCal Time	1907		
PostCal Value	8.03	4.16	
Temp			
Initials			

HI 9025 - same cal solutions

cal soln	4.01	7.01
pre	4.15	6.52
cal	4.01	7.63

20.1°C

postcal	4	7
	4.14	6.97

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 1 of 12

meter = 9025

Date	9/14/10
Time	0940
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
Final Alkalinity	12.1 mg/L

pH	Digital Titration Turns
7.8	0
4.17	242

over shot sample

* Temp comp Not functionin on pH meter

Date	9/14/10
Time	0947
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.23	0
4.90	165

Date	9/14/10
Time	1006
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Sample temp	17.3
Final Alkalinity	9.7 mg/L

pH	Digital Titration Turns
7.66	0
4.80	194
slightly over.	

Cal 9025 again - with temp cal.
pre cal
4 = 4.21
7 = 7.12

So, not bad
Alk is probably accurate

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 2 of 12

Date	9/14/10
Time	10:13
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
Temp	15.2°C
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
5.81	0
5.65	130
5.06	166
4.96	169
4.91	171

Date	9/14/10
Time	10 20
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Temp	15.4 oC
Final Alkalinity	27.1 mg/L

pH	Digital Titration Turns
5.98	0
5.48	498
5.13	530
5.05	535
4.96	540
4.93	542

Date	9/14/10
Time	1042
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Temp	19.2
Final Alkalinity	8.9 mg/L

pH	Digital Titration Turns
~~5.~~ 6.35	0
5.20	~~161~~ 170
4.92	178

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 3 of 12

Date	9/14/10
Time	1050
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
temp	18.7°C
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
5.98	0
5.08	165
4.93	171

Date	9/14/10
Time	1058
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
temp	16.5°C
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
5.96	0
5.13	161
4.98	165
4.94	167
4.90	169

Date	9/14/10
Time	1106
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp.	17.4
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
5.71	0
5.08	164
4.93	171

Alkalinity Log Sheet: Ashumet Pond
Date: ~~9/13/10~~ 9/14/10
Page: 4 of 12

Date	9/14/10
Time	1113
Sample ID	Ctr A
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
temp	19.1°C
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
5.84	0
4.96	168
4.91	170

Date	9/14/10
Time	1120
Sample ID	Ctr
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp	19.5°C
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
5.92	0
5.14	165
4.93	171

mid - Treatment

Date	9/14/10
Time	1431
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp	21.2
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
6.95	0
5.00	170
4.88	172

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 5 of 12

Date	9/14/10
Time	1442
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
temp	21.0 °C
Final Alkalinity	7.9 mg/L

pH	Digital Titration Turns
5.80	0
5.04	153
4.95	156
4.92	158

Date	9/14/10
Time	1449
Sample ID	C+1
Depth	4M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp	20.7°C
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
5.87	0
5.07	168
4.92	173

Date	9/14/10
Time	1455
Sample ID	C+1
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp	19.4 °C
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
5.78	0
5.23	165
5.04	172
4.92	176

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 6 of 12

Date	9/14/10
Time	1513
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
temp °C	22.8
Final Alkalinity	9.2 mg/L

pH	Digital Titration Turns
6.23	0
4.96	180
4.91	183

Date	9/14/10
Time	1521
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp °C	21.0
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
6.25	0
~~5.08~~	~~166~~
4.92	172

Date	9/14/10
Time	1547
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp °C	22.4
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
7.07	0
4.92	169

- used 991301 as 9025 was low. on this sample (3, 4m

- used indicator & pH meter (991 appears correct.

Checked cal on 9025 meter
4 = ~4
7 = 6.76
- Reasonable.

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 7 of 12

Meter: 991301

Date	9/14/10
Time	1605
Sample ID	3
Depth	7M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.85	0
5.24	160
4.91	170

used indicator

Date	9/14/10
Time	1611
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.8 mg/L

pH	Digital Titration Turns
6.66	0
4.94	156

Date	9/14/10
Time	1617
Sample ID	2
Depth	7m
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.0 mg/L

pH	Digital Titration Turns
6.12	0
4.85	159

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 8 of 12

Date	9/14/10
Time	1624
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 4/11
End Point	4.9
Technician	Me
Final Alkalinity	25.3 mg/L

pH	Digital Titration Turns
6.14	0
5.06	488
5.02	497
~~4.96~~	502
4.94	506

checked cal on 991301
4= 4.06
7= 7.28

Post Treatment

Date	9/14/10
Time	1743
Sample ID	3
Depth	4m
Sample Volume	200 Ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
7.37	0
5.15	165
4.94	175
~~4.88~~	178
4.87	

Date	9/14/10
Time	1750
Sample ID	3
Depth	7m
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.29	0
~~8.97~~	170
4.91	

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 9 of 12

Date	9/14/10
Time	1758
Sample ID	4
Depth	4m Duplicate
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
7.14	0
4.90	180

7% RPD
Avg pH = 7.03
alk = 8.7

Date	9/14/10
Time	1808
Sample ID	4
Depth	~~9m~~ 4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.91	0
4.91	167

Date	9/14/10
Time	1814
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.62	0
4.92	167

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 10 of 12

Date	9/14/10
Time	1820
Sample ID	c+1
Depth	4M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	ME
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
7.09	0
4.99	173
4.89	176

Date	9/14/10
Time	1825
Sample ID	c+1
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.9 mg/L

pH	Digital Titration Turns
7.05	0
4.91	178

Date	9/14/10
Time	1831
Sample ID	~~c+1~~ 2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
~~9.2~~	0
7.30	0
4.93	178
4.89	180

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
Page: 11 of 12

Date	9/14/10
Time	1837
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.79	0
4.74	167
over	Shot pH.

116
51
167

Date	9/14/10
Time	1847
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	25.6 mg/L

pH	Digital Titration Turns
6.61	0
5.01	503
~~4.99~~	~~506~~
4.93	512

Date	9/14/10
Time	1854
Sample ID	1
Depth	4M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.14	0
~~4.94~~	~~172~~
4.89	174

Alkalinity Log Sheet: Ashumet Pond
Date: 9/14/10
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Date	9/14/10
Time	1901
Sample ID	1
Depth	7m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	7.8 mg/L

pH	Digital Titration Turns
6.49	0
4.98	154
4.94	156

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

pH meter calibration log sheet: Ashumet Pond

Date: 9/15/10

Meter Serial Number/Model/Make: HI 991301

	HI 7004	HI 7007	
Calibration Solution Lot #	1647	1782	
Calibration Solution Exp. Date	5/14	7/14	
Std. Value	4.01	7.01	

Calibration Time	0835		
PreCal Value	4.39	6.93	
Cal Value	4.01	7.01	
Temp	18.4	18.3	
Final Slope	Not Available		
Initials	Me		

PostCal Time	1636		
PostCal Value 4.30	~~7.49~~	7.49	
Temp	17.~~2~~7	17.3	
Initials	Ne		

cal 7 first
4 2nd

post cal chec
4 = 4.00
7 = ~~7.01~~
7.00

Right after calibration

pH meter calibration log sheet: Ashumet Pond
Date: 9/15/10

Meter Serial Number/Model/Make: HI 9025

	HI 7004	HI 7007	
Calibration Solution Lot #	1647	1782	
Calibration Solution Exp. Date	5/14	7/14	
Std. Value	4.01	7.01	

Calibration Time	0835		
PreCal Value	4.09	6.83	
Cal Value	4.01	7.01	
Temp	19.1	19.0	
Final Slope	Not Available		
Initials	ME		

CAl 4 - 1st
7 - 2nd

post CAl check
7 = 7.04

PostCal Time			
PostCal Value			
Temp			
Initials			

Didn't Need to use this meter - didn't do post CAl

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 1 of 12

Date	9/15/10
Time	0849
Sample ID	Ct1
Depth	4m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Ne
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.64	0
5.05	139
4.99	145
4.95	147
4.92	149

Date	9/15/10
Time	9:07
Sample ID	ct1
Depth	6.2m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Ne
Final Alkalinity	7.2 mg/L

pH	Digital Titration Turns
6.15	0
4.99	137
4.95	141
4.91	144

Date	9/15/10
Time	915
Sample ID	2
Depth	4m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Ne
Sample temp	16.7°C
Final Alkalinity	7.0 mg/L

pH	Digital Titration Turns
6.47	0
4.93	139

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 2 of 12

Date	9/15/10
Time	0922
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0 144 11/11
End Point	4.9
Technician	Me
Sample temp °C	
Final Alkalinity	6.7 mg/L

pH	Digital Titration Turns
5.92	0
4.99	129
4.90	133

Date	9/15/10
Time	0927
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	~~4.9~~
End Point	~~Me~~ 4.9
Technician	Me
Sample temp °C	13.9
Final Alkalinity	21.6 mg/L

pH	Digital Titration Turns
5.67	0
5.06	341
4.99	373
4.97	398
4.96	405
4.93	432

Date	9/15/10
Time	9:51
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Sample temp	18.5°C
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
7.10	0
~~5.42~~	~~155~~
4.89	164

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 3 of 12

Date	9/15/10
Time	1003
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
temp	18.4 °C
Final Alkalinity	7.4 mg/L

pH	Digital Titration Turns
6.28	0
4.99	143
4.92	147

Date	9/15/10
Time	1009
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.0 mg/L

pH	Digital Titration Turns
6.83	0
4.80	160
* slightly over end pt	

Date	9/15/10
Time	1017
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
sample temp	16.7 °C
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
6.01	0
5.23	149
5.02	170
4.92	180

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 4 of 12

Date	9/15/10
Time	1024
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Sample temp	18.2°C
Final Alkalinity	8.0 mg/L

pH	Digital Titration Turns
6.77	0
5.03	155
4.93	160

Date	9/15/10
Time	1030
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
sample temp	18.5°C
Final Alkalinity	7.6 mg/L

pH	Digital Titration Turns
6.22	0
4.95	149
4.89	151

Mid Treatment

Date	9/15/10
Time	1413
Sample ID	2
Depth	4
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
sample temp	20.1 °C
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
7.34	0
4.84	168
*slightly over end point	

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 5 of 12

Date	9/15/10
Time	1422
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.42	0
5.05	161
4.97	165
4.93	167

Date	9/15/10
Time	1428
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	25.0 mg/L

pH	Digital Titration Turns
6.17	0
4.98	488
4.95	496
4.95	498
4.93	500

Date	9/15/10
Time	1436
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.0 mg/L

pH	Digital Titration Turns
~~8.8~~	0
6.92	0
4.96	157
4.92	159

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 6 of 12

Date	9/15/10
Time	1441
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.0 mg/L

pH	Digital Titration Turns
6.55	0
4.84	160
slightly past 4.9 thus	
alk. slightly high	

Date	9/15/10
Time	1452
Sample ID	CH
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
~~6.~~	0
7.01	0
5.02	166
4.96	169
4.92	172

Date	9/15/10
Time	1458
Sample ID	CH
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.75	0
5.10	160
4.93	168

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 7 of 12

Date	9/15/10
Time	1505
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
7.18	0
4.97	167
4.89	170

Date	9/15/10
Time	1510
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	7.6 mg/L

pH	Digital Titration Turns
6.31	0
5.05	145
4.98	148
4.92	152

8% RPD

Avg
pH = 6.43
Alk = 7.9m

Date	9/15/10
Time	1515
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.2 mg/L

pH	Digital Titration Turns
6.55	0
5.09	155
4.96	161
4.91	163

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 8 of 12

Date	9/15/10
Time	1520
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
7.13	0
4.95	167
4.91	169

Date	9/15/10
Time	1525
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
7.03	0
5.00	164
4.93	167
4.90	169

— post treatment

Date	9/15/10
Time	1642
Sample ID	4
Depth	4M
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
7.57	0
4.96	173
4.91	175

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 9 of 12

Date	9/15/10
Time	1648
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	me
Sample temp	18.7°C
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.23	0
4.94	173
4.87	175

Date	9/15/10
Time	1653
Sample ID	C+1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
6.99	0
5.04	165
4.95	169
4.91	171

Date	9/15/10
Time	1659
Sample ID	C+1
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
6.77	0
4.98	167
4.95	169
4.90	171

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 10 of 12

Date	9/15/10
Time	1712
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
7.45	0
5.06	172
4.95	177
4.90	179

Date	9/15/10
Time	1717
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
6.73	0
5.21	157
5.02	170
4.94	173
4.89	175

Date	9/15/10
Time	1747
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.7 mg/L

pH	Digital Titration Turns
7.33	0
4.90	173

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 11 of 12

Date	9/15/10
Time	1752
Sample ID	2
Depth	7m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0 144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.83	0
4.96	166
4.92	168

Date	9/15/10
Time	1757
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	26.1 mg/L

pH	Digital Titration Turns
6.37	0
5.06	495
4.97	511
4.96	516
4.93	522

Date	9/15/10
Time	1825
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.9 mg/L

pH	Digital Titration Turns
7.54	0
5.31	163
5.08	173
4.96	176
4.89	178

Alkalinity Log Sheet: Ashumet Pond
Date: 9/15/10
Page: 12 of 12

Date	9/15/10
Time	1830
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	ME
Final Alkalinity	9.0 mg/L

pH	Digital Titration Turns
~~6.~~	0
7.05	0
5.02	176
4.97	178
4.92	180

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

Dave 508-274-0486
Al values < 750 µg/L Al
(dissd)

pH meter calibration log sheet: Ashumet Pond
Date: 9/16/10

Meter Serial Number/Model/Make: HI 991301

	HI 7007	HI 7004	
Calibration Solution Lot #	1782	1647	
Calibration Solution Exp. Date	7/14	5/14	
Std. Value	7.01	4.01	

Calibration Time	835		
PreCal Value	6.57	3.68	
Cal Value	7.01	4.01	
Temp	16.8 °C	16.3 °C	
Final Slope	not Available.		
Initials	NC		

post cal check

4.01	7.01
4.00	~~7.07~~ 6.98

19.8°C

PostCal Time	1446		
PostCal Value	7.53	4.39	
Temp	21.5°C		
Initials	NC.		

post CAl - New bottle
HI 7007
Lot 1782
7/14

post CAl - same bottle as cal.
HI 7004
Lot 1647
5/14

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 1 of 8

pre-treatment

Date	9/16/10
Time	9:16
Sample ID	2
Depth	4 m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	ME
Sample temp	14.5 °C
Final Alkalinity	7.2 mg/L

pH	Digital Titration Turns
6.45	0
5.04	137
4.95	142
4.92	144

Date	9/16/10
Time	0923
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	7.0 mg/L

pH	Digital Titration Turns
5.92	0
5.14	118
5.06	130
4.99	136
4.95	138
4.91	140

Date	9/16/10
Time	0928
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	
Sample temp	12°C
Final Alkalinity	22.9 mg/L

pH	Digital Titration Turns
5.65	0
5.06	302
5.06	323
5.03	362
4.97	388
4.97	403
4.96	415
4.94	430
4.94	437
4.94	445
4.92	458

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 2 of 8

Date	9/16/10
Time	0938
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	ME
Final Alkalinity	22.1 mg/L

pH	Digital Titration Turns
5.88	0
4.92	441

% RPD = 4%

Date	9/16/10
Time	1013
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	9.2 mg/L

pH	Digital Titration Turns
7.27	0
4.95	181
4.90	183

Date	9/16/10
Time	1019
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.72	0
4.94	165
4.89	167

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 3 of 8

Date	9/16/10
Time	1025
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	40144 11/11
End Point	4.9
Technician	ME
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.75	0
5.02	160
4.92	165

Date	9/16/10
Time	1030
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.3 mg/L

pH	Digital Titration Turns
6.70	0
4.93	164
4.89	166

Date	9/16/10
Time	1036
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	8.6 mg/L

pH	Digital Titration Turns
7.10	0
4.90	172

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 4 of 8

Date	9/16/10
Time	1041
Sample ID	3
Depth	7m
Sample Volume	200 ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.9 mg/L

pH	Digital Titration Turns
7.07	0
5.11	169
4.93	177
4.86	179

Date	9/16/10
Time	1048
Sample ID	c+l
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
temp sample	14.4°C
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.25	0
5.08	132
	140
4.96	147
4.90	150

Date	9/16/10
Time	1054
Sample ID	c+l
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	me
Final Alkalinity	7.5 mg/L

pH	Digital Titration Turns
6.28	0
4.91	150

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 5 of 8

Date	9/16/10
Time	1207
Sample ID	4
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/1
End Point	4.9
Technician	Ne
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
7.20	0
4.98	171
4.96	173
4.91	176

Date	9/16/10
Time	1217
Sample ID	4
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	~~4.9~~
End Point	~~Ne~~ 4.9
Technician	Ne
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.69	0
5.03	163
4.97	167
4.91	170

Date	9/16/10
Time	1225
Sample ID	C+1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Ne
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.95	0
4.94	168
4.91	170

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 6 of 8

Date	9/16/10
Time	1231
Sample ID	C+1
Depth	6.2m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	7.3 mg/L

pH	Digital Titration Turns
6.39	0
4.29	146
overshot	— alkalinity
is	over estimated

Date	9/16/10
Time	1310
Sample ID	1
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	9.1 mg/L

pH	Digital Titration Turns
7.26	0
5.09	173
5.03	176
4.96	179
4.92	181

Date	9/16/10
Time	1315
Sample ID	1
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	8.5 mg/L

pH	Digital Titration Turns
6.65	0
4.88	170

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 7 of 8

Date	9/16/10
Time	1320
Sample ID	3
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 1/11
End Point	4.9
Technician	Me
Final Alkalinity	8.8 mg/L

pH	Digital Titration Turns
6.96	0
4.94	173
4.91	175

Date	9/16/10
Time	1326
Sample ID	3
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	Me
Final Alkalinity	8.4 mg/L

pH	Digital Titration Turns
6.88	0
4.97	164
4.93	166
4.89	168

Date	9/16/10
Time	1428
Sample ID	2
Depth	4m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	Me
Final Alkalinity	9.8 mg/L

pH	Digital Titration Turns
7.62	0
4.97	193
4.91	196

Alkalinity Log Sheet: Ashumet Pond
Date: 9/16/10
Page: 8 of 8

Date	9/16/10
Time	1432
Sample ID	2
Depth	7m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	A0144 11/11
End Point	4.9
Technician	ME
Final Alkalinity	9.2 mg/L

pH	Digital Titration Turns
6.83	0
~~4.~~ 5.05	173
5.02	176
4.94	181
4.91	183

Date	9/16/10
Time	1437
Sample ID	2
Depth	15m
Sample Volume	200ml
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	4.9
Technician	ME
Final Alkalinity	27.3 mg/L

pH	Digital Titration Turns
6.60	0
5.07	524
4.93	543
4.92	545

Date	
Time	
Sample ID	
Depth	
Sample Volume	
Titration Conc.	0.1600N H2SO4
Titration Lot	
End Point	
Technician	
Final Alkalinity	mg/L

pH	Digital Titration Turns

APPENDIX E – MONITORING DATA

Table E-1
Aluminum Data at the Control Station

		Pre-treatment				Post-treatment			
Sampling Depth		**4 m**		**6.2 m**		**4 m**		**6.2 m**	
	Units		**Qual**		**Qual**		**Qual**		**Qual**
September 9, 2010									
Aluminum, Total	ug/l	50	U	50	U	778		85	
Aluminum, Dissolved	ug/l	50	U	50	U	85		50	U
September 13, 2010									
Aluminum, Total	ug/l	38.7	J	35.7	J	37.2	J	50	U
Aluminum, Dissolved	ug/l	50	U	50	U	50	U	39.5	J
September 14, 2010									
Aluminum, Total	ug/l	95		73		531		361	
Aluminum, Dissolved	ug/l	29.1	J	24.4	J	100		81	
September 15, 2010									
Aluminum, Total	ug/l	210		174		534		231	
Aluminum, Dissolved	ug/l	52		46.5	J	45	J	26.7	J
September 16, 2010									
Aluminum, Total	ug/l	236		310		219		246	
Aluminum, Dissolved	ug/l	54		79		54		88	

Table E-2
Aluminum Data at Station #1

		Post-treatment			
Sampling Depth		**4 m**		**7 m**	
	Units		**Qual**		**Qual**
September 9, 2010					
Aluminum, Total	ug/l	145		126	
Aluminum, Dissolved	ug/l	57		50	U
September 13, 2010					
Aluminum, Total	ug/l	81		153	
Aluminum, Dissolved	ug/l	33.5	J	50	U
September 14, 2010					
Aluminum, Total	ug/l	1500		383	
Aluminum, Dissolved	ug/l	255		44	J
September 15, 2010					
Aluminum, Total	ug/l	338		229	
Aluminum, Dissolved	ug/l	83		50	U
September 16, 2010					
Aluminum, Total	ug/l	288		318	
Aluminum, Dissolved	ug/l	66		123	

Table E-3
Aluminum Data at Station #2 (Deep Basin)

		Pre-treatment						Post-treatment					
Sampling Depth		**4 m**		**7 m**		**15 m**		**4 m**		**7 m**		**15 m**	
	Units		**Qual**		**Qual**		**Qual**		**Qual**		**Qual**		**Qual**
September 9, 2010													
Aluminum, Total	ug/l	50	U	50	U	50	U	50	U	50	U	50	U
Aluminum, Dissolved	ug/l	50	U	50	U	50	U	50	U	50	U	50	U
September 13, 2010													
Aluminum, Total	ug/l	44.7	J	28.5	J	50	U	435		186		104	
Aluminum, Dissolved	ug/l	23.4	J	50	U	50	U	111		50	U	50	U
September 14, 2010													
Aluminum, Total	ug/l	267		88		61	U[1]	856		476		63	
Aluminum, Dissolved	ug/l	63		50	U	50	U	218		33.8	J	50	U
September 15, 2010													
Aluminum, Total	ug/l	257		186		32	J	238		239		50	U
Aluminum, Dissolved	ug/l	61		50	U	50	U	76		24.9	J	50	U
September 16, 2010													
Aluminum, Total	ug/l	325		238		38.2	J	437		619		61	
Aluminum, Dissolved	ug/l	75		39.5	J	50	U	75		179		23.2	J

[1] Data qualified due to method blank contamination

Table E-4
Aluminum Data at Station #3

		Post-treatment			
Sampling Depth		**4 m**		**7 m**	
	Units		**Qual**		**Qual**
September 9, 2010					
Aluminum, Total	ug/l	50	U	50	U
Aluminum, Dissolved	ug/l	50	U	50	U
September 13, 2010					
Aluminum, Total	ug/l	457		208	
Aluminum, Dissolved	ug/l	103		50	U
September 14, 2010					
Aluminum, Total	ug/l	161		160	
Aluminum, Dissolved	ug/l	57		25.8	J
September 15, 2010					
Aluminum, Total	ug/l	1080		637	
Aluminum, Dissolved	ug/l	102		32.6	J
September 16, 2010					
Aluminum, Total	ug/l	317		303	
Aluminum, Dissolved	ug/l	69		111	

Table E-5
Aluminum Data at Station #4

		Post-treatment			
Sampling Depth		**4 m**		**7 m**	
	Units		**Qual**		**Qual**
September 9, 2010					
Aluminum, Total	**ug/l**	**38.9**	**J**	**50**	**U**
Aluminum, Dissolved	**ug/l**	**24.3**	**J**	**50**	**U**
September 13, 2010					
Aluminum, Total	**ug/l**	**170**		**189**	
Aluminum, Dissolved	**ug/l**	**59**		**50**	**U**
September 14, 2010					
Aluminum, Total	**ug/l**	**647**		**375**	
Aluminum, Dissolved	**ug/l**	**80**		**44.5**	**J**
September 15, 2010					
Aluminum, Total	**ug/l**	**329**		**276**	
Aluminum, Dissolved	**ug/l**	**77**		**58**	
September 16, 2010					
Aluminum, Total	**ug/l**	**224**		**244**	
Aluminum, Dissolved	**ug/l**	**53**		**58**	

Table E-6
Ashumet Pond Water Quality Profiles During Treatment

Control Station
9/9/2010 (10:24am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	22.59	9.06	7.26	114
2	22.45	8.81	7.13	114
4	22.34	8.48	6.88	114
6	21.35	5.17	6.38	115
7	19.21	3.67	6.27	116

Control Station
9/13/2010 (10:08am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.87	8.90	7.13	123
2	20.85	8.81	7.10	122
4	20.82	8.81	7.10	124
6	20.77	8.81	7.11	114
7	18.19	0.61	6.05	114

Control Station
9/14/2010 (10:00am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.89	9.43	6.98	118
2	20.71	9.45	6.96	118
4	20.63	9.14	6.89	116
6	20.53	8.92	6.89	117
8	14.54	0.27	6.68	123
8.6	12.66	0.19	6.59	119

Control Station
9/15/2010 (8:06am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.60	9.06	7.82	121
2	20.61	9.01	7.57	121
4	20.54	8.90	7.28	121
6	20.45	8.60	7.24	121
7.5	13.28	0.30	6.80	119

Control Station
9/16/2010 (8:55am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.17	8.61	7.09	121
2	20.14	8.61	7.09	122
4	20.13	8.69	7.11	122
6	19.99	8.69	7.08	123
7	19.80	8.58	7.06	123
8	13.82	0.33	6.46	121
9	12.11	0.15	6.39	120

Table E-7
Ashumet Pond Water Quality Profiles During Treatment

Station #1
9/9/2010 (11:43am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	22.78	9.05	7.20	114
2	22.53	8.92	7.16	117
4	22.42	8.84	7.10	112
6	21.34	5.65	6.44	113
8	14.25	0.28	6.35	120
10	10.32	0.17	6.37	122
10.5	10.04	0.12	6.42	124

Station #1
9/13/2010 (9:18am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.81	8.93	7.08	114
2	20.81	8.92	7.14	114
4	20.79	8.63	7.07	114
6	20.73	8.62	7.03	114
8	15.32	0.24	6.42	123
10	10.50	0.13	6.42	122
10.5	10.19	0.12	6.47	124

Station #1
9/14/2010 (9:38am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.83	9.33	6.98	116
2	20.72	9.36	7.05	115
4	20.69	9.29	7.03	120
6	20.58	9.15	6.93	116
8	14.68	0.32	6.76	123
10	10.58	0.27	6.70	122
10.5	10.45	0.19	6.61	124

Station #1
9/15/2010 (9:45am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.65	10.71	7.08	122
2	20.65	10.62	7.13	122
4	20.63	10.46	7.08	122
6	20.26	8.65	6.94	127
8	14.10	0.12	6.78	123
10	10.70	0.25	6.54	122
10.5	10.66	0.30	6.55	122

Station #1
9/16/2010 (9:18am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.18	8.67	7.04	121
2	20.16	8.65	7.07	121
4	20.15	8.68	7.07	121
6	20.11	8.61	7.07	122
8	14.42	0.37	6.47	123
10	10.75	0.10	6.44	122

Table E-8
Ashumet Pond Water Quality Profiles During Treatment

Station #2 (Deep Basin)
9/9/2010 (8:48am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	22.42	8.80	7.26	115
2	22.43	8.77	7.27	115
4	22.41	8.73	7.19	115
6	22.37	8.66	7.19	115
8	14.30	0.37	6.45	123
10	10.42	0.22	6.44	123
12	9.31	0.15	6.54	128
14	8.98	0.11	6.58	129
16	8.85	0.07	6.59	129
18	8.79	0.07	6.60	130
20	8.71	0.02	6.61	130

Station #2 (Deep Basin)
9/13/2010 (8:12am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.89	8.72	7.23	114
2	20.89	8.73	7.20	114
4	20.89	8.70	7.07	114
6	20.88	8.71	7.12	120
8	14.47	0.30	6.45	123
10	10.78	0.12	6.41	121
12	9.30	0.11	6.50	126
14	8.91	0.09	6.54	127
16	8.79	0.04	6.54	127
18	8.72	0.04	6.55	128
20	8.70	0.01	6.56	128

Station #2 (Deep Basin)
9/14/2010 (8:41am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.76	8.92	7.20	121
2	20.72	8.88	7.15	120
4	20.71	8.79	7.13	120
6	20.67	8.64	7.06	119
8	15.19	0.29	6.87	123
10	10.76	0.21	6.79	120
12	9.49	0.16	6.67	126
14	9.05	0.12	6.66	127
16	8.89	0.11	6.65	128
18	8.82	0.11	6.62	128
20	8.80	0.10	6.63	128

Station #2 (Deep Basin)
9/15/2010 (8:22am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.67	9.45	7.23	120
2	20.66	9.44	7.23	120
4	20.66	9.45	7.19	120
6	20.63	9.44	7.09	120
8	15.12	0.28	6.74	124
10	10.88	0.28	6.64	122
12	9.60	0.08	6.57	126
14	9.12	0.03	6.57	127
16	8.92	0.15	6.56	128
18	8.34	0.16	6.58	128
20	8.80	0.17	6.57	129

Station #2 (Deep Basin)
9/16/2010 (8:14am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.24	8.83	7.23	124
2	20.24	8.83	7.22	124
4	20.23	8.83	7.22	124
6	20.19	8.75	7.19	126
8	15.09	0.22	6.47	124
10	10.35	0.19	6.24	124
12	9.36	0.17	6.38	128
14	9.00	0.17	6.47	129
16	8.82	0.12	6.50	130
18	8.79	0.05	6.52	130
20	8.75	0.05	6.55	130

Table E-9
Ashumet Pond Water Quality Profiles During Treatment

Station #3
9/9/2010 (1:04pm)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	22.69	9.43	7.38	113
2	22.46	9.12	7.31	113
4	22.32	8.89	7.21	113
6	22.02	8.24	7.00	113
8	14.05	0.56	6.45	120
10	10.64	0.33	6.40	119
12	9.27	0.26	6.55	126

Station #3
9/13/2010 (8:58am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.90	8.79	7.12	114
2	20.89	8.70	7.09	114
4	20.89	8.64	7.06	114
6	20.75	8.34	6.94	115
8	15.02	0.68	6.51	124
10	10.61	0.17	6.40	120
12	9.65	0.14	6.51	127

Station #3
9/14/2010 (9:18am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.83	9.25	7.07	119
2	20.77	9.12	7.06	121
4	20.74	9.02	7.09	121
6	20.67	8.87	6.99	120
8	15.44	0.43	6.82	123
10	10.54	0.26	6.70	121
12	0.55	0.18	6.63	127

Station #3
9/15/2010 (9:20am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.69	10.47	7.07	121
2	20.70	10.45	7.12	118
4	20.69	10.38	7.07	122
6	20.55	10.04	6.97	122
8	15.38	0.38	6.86	123
10	10.31	0.33	6.63	123
12	9.28	0.24	6.57	127

Station #3
9/16/2010 (10:09am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.48	8.92	7.12	123
2	20.24	8.96	7.15	123
4	20.19	8.90	7.16	123
6	20.14	8.92	7.16	123
8	14.65	0.55	6.62	121
10	10.70	0.21	6.41	120
11.5	9.25	0.17	6.57	127

Table E-10
Ashumet Pond Water Quality Profiles During Treatment

Station #4
9/9/2010 (12:30pm)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	22.70	9.17	7.41	113
2	22.65	9.14	7.41	113
4	22.49	8.92	7.32	113
6	20.80	4.19	6.42	114
8	15.20	0.40	6.40	121
10	10.58	0.20	6.40	120
12	9.35	0.13	6.52	125
14	8.99	0.10	6.56	127

Station #4
9/13/2010 (1:20pm)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	21.11	9.26	7.34	114
2	20.91	9.24	7.29	114
4	20.84	8.82	7.23	122
6	20.61	8.25	6.94	118
8	15.15	0.19	6.40	122
10	10.34	0.22	6.40	121
12	9.33	0.19	6.50	126
14	8.99	0.12	6.51	127

Station #4
9/14/2010 8:15am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.68	9.12	7.86	120
2	20.68	9.05	7.69	120
4	20.67	9.01	7.56	121
6	20.59	8.63	7.45	117
8	14.69	0.34	7.18	123
10	10.61	0.25	7.05	121
12	9.43	0.21	6.92	126
14	9.16	0.19	6.85	128

Station #4
9/15/2010 (8:58am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.60	10.21	6.98	120
2	20.60	10.17	7.06	120
4	20.61	10.18	7.12	120
6	20.57	9.90	7.05	119
8	14.54	0.52	6.70	120
10	11.14	0.36	6.62	119
12	9.44	0.27	6.64	126
14	9.02	0.18	6.52	127

Station #4
9/16/2010 (9:41am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.35	8.82	7.10	122
2	20.24	8.84	7.13	123
4	20.14	8.26	7.00	120
6	20.14	8.29	6.98	120
8	15.55	0.34	6.44	122
10	10.56	0.15	6.42	122
12	9.36	0.11	6.54	127
13.5	9.18	0.10	6.57	127

Table E-11
Ashumet Pond Water Quality Profiles Pre- and Post-Treatment

Control Station
9/2/2010

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	26.38	9.37	8.61	116
1	26.35	9.35	8.62	116
2	23.84	12.05	9.52	118
3	23.10	11.42	9.25	117
4	21.80	8.43	7.46	114
5	20.96	7.19	6.78	115
6	20.67	6.64	6.48	117
7	16.64	0.20	6.16	113
8	11.82	0.16	6.30	117

Control Station
9/17/2010 (2:49pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.36	8.10	6.93	123
1	20.36	8.08	6.95	123
2	20.35	8.08	6.86	123
3	20.34	8.08	6.97	123
4	20.34	8.08	6.88	123
5	20.34	8.07	6.86	123
6	20.34	8.03	6.86	124
7	19.71	7.13	6.94	124
8	15.82	0.69	6.75	122
9	12.51	0.38	6.71	120

Control Station
9/24/2010 (3:45pm)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	19.89	9.00	7.05	123
1	19.88	8.97	7.03	123
2	19.86	8.90	7.00	123
3	19.61	8.85	6.97	123
4	19.50	8.70	6.95	123
5	19.59	8.65	6.94	123
6	19.55	8.60	6.92	123
7	19.24	8.08	6.89	123
8	15.77	1.07	6.71	123
8.5	13.64	0.34	6.66	123

Table E-12
Ashumet Pond Water Quality Profiles Pre- and Post-Treatment

Station #1
9/2/2010

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	26.48	9.50	8.71	116
1	26.47	9.55	8.75	116
2	23.27	11.67	9.26	116
3	22.08	10.43	8.58	115
4	21.45	9.43	7.90	114
5	21.10	7.47	7.00	114
6	20.63	5.88	6.57	115
7	19.37	4.07	6.34	115
8	15.66	0.15	6.31	118
9	11.27	0.11	6.25	115
10	10.06	0.10	6.45	123
11	9.58	0.08	6.50	127

Station #1
9/17/2010 (2:12pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.35	8.11	6.95	123
1	20.36	8.11	6.90	123
2	20.36	8.10	6.90	123
3	20.36	8.07	6.90	123
4	20.33	8.02	6.84	123
5	20.33	8.00	6.82	123
6	20.29	7.89	6.82	123
7	19.96	7.52	6.80	123
8	14.20	0.34	6.66	121
9	12.10	0.30	6.66	118
10	10.64	0.30	6.61	124

Station #1
9/24/2010 (2:35pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	19.91	9.10	6.89	123
1	19.89	9.08	6.90	123
2	19.89	9.05	6.91	123
3	19.88	9.04	6.91	123
4	19.86	8.97	6.92	123
5	19.82	8.93	6.92	123
6	19.62	8.58	6.88	123
7	19.27	8.06	6.84	123
8	18.50	6.48	6.73	123
9	12.75	0.90	6.58	120
10	11.03	0.39	6.50	122
10.5	10.65	0.28	6.48	128

Table E-13
Ashumet Pond Water Quality Profiles Pre- and Post-Treatment

Station #2 (Deep Basin)
9/2/2010

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	25.68	9.41	8.67	116
1	25.66	9.40	8.68	116
2	25.61	9.41	8.68	116
3	22.22	10.20	8.64	115
4	21.57	9.55	7.75	114
5	21.16	8.03	6.89	115
6	20.58	6.43	6.42	115
7	18.72	6.21	6.19	114
8	14.48	0.12	6.29	119
9	11.47	0.10	6.26	116
10	10.53	0.04	6.43	120
11	9.95	0.03	6.48	123
12	9.47	0.03	6.56	126
13	9.09	0.00	6.60	127
14	8.80	0.01	6.60	128
15	8.77	0.00	6.61	128
16	8.71	0.00	6.62	128
17	8.70	0.00	6.62	128
18	8.69	0.00	6.62	128
19	8.67	0.00	6.62	129
20	8.63	0.00	6.63	129

Station #2 (Deep Basin)
9/17/2010 (11:45am)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.52	8.13	7.69	124
1	20.46	8.11	7.63	124
2	20.45	8.10	7.59	124
3	20.42	8.07	7.57	124
4	20.38	8.05	7.54	124
5	20.36	8.04	7.49	124
6	20.35	8.01	7.46	124
7	19.60	6.12	7.39	122
8	15.95	0.57	7.21	123
9	12.15	0.38	7.12	118
10	11.07	0.26	6.97	120
11	9.92	0.23	6.87	125
12	9.58	0.21	6.84	127
13	9.17	0.21	6.81	127
14	9.03	0.18	6.77	128
15	8.94	0.15	6.75	128
16	8.90	0.15	6.74	128
17	8.88	0.14	6.72	128
18	8.84	0.14	6.70	129
19	8.82	0.12	6.68	129
20	8.82	0.11	6.68	129

Station #2 (Deep Basin)
9/24/2010 (8:42am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	19.65	8.70	7.07	121
1	19.65	8.69	7.07	121
2	19.65	8.67	7.05	121
3	19.65	8.67	7.04	121
4	19.65	8.66	7.03	122
5	19.65	8.66	7.01	122
6	19.63	8.61	7.00	126
7	19.52	8.30	6.97	126
8	18.20	6.20	6.79	125
9	13.63	0.37	6.64	122
10	11.04	0.13	6.51	122
11	9.98	0.13	6.41	127
12	9.58	0.10	6.44	128
13	9.32	0.08	6.47	128
14	9.20	0.04	6.50	128
15	9.13	0.01	6.51	128

Station #2 (Deep Basin)
9/24/2010 (8:42am)

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
16	9.07	0.00	6.51	128
17	8.99	0.00	6.52	128
18	8.99	0.00	6.51	128
19	9.03	0.00	6.49	128
20	9.02	0.00	6.49	128

Table E-14
Ashumet Pond Water Quality Profiles Pre- and Post-Treatment

Station #3
9/2/2010

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	26.38	9.25	8.60	116
1	26.35	9.32	8.62	116
2	26.29	9.37	8.65	116
3	22.78	10.72	7.24	114
4	21.48	9.56	7.42	114
5	21.05	7.48	6.80	115
6	20.50	5.90	6.46	115
7	18.67	3.04	6.22	115
8	14.79	0.40	6.27	120
9	11.19	0.14	6.27	117
10	10.28	0.11	6.36	121
11	9.78	0.09	6.45	124
12	9.51	0.07	6.49	125

Station #3
9/17/2010 (1:30pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.36	8.38	7.21	124
1	20.37	8.19	7.25	124
2	20.36	8.16	7.16	124
3	20.35	8.10	7.27	124
4	20.30	7.89	7.18	124
5	20.18	7.70	7.05	123
6	20.12	7.50	6.93	123
7	18.48	3.71	6.91	119
8	14.13	0.44	6.62	120
9	11.85	0.21	6.53	118
10	10.40	0.21	6.49	124
11	10.23	0.20	6.47	124

Station #3
9/24/2010 (1:27pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	19.85	9.07	6.86	122
1	19.84	9.03	6.89	122
2	19.84	9.00	6.90	122
3	19.85	8.97	6.91	123
4	19.85	8.94	6.92	-
5	19.82	8.90	6.92	123
6	19.83	8.88	6.92	-
7	19.83	8.84	6.93	-
8	19.81	8.80	6.93	123
9	12.31	0.36	6.71	-
10	10.51	0.27	6.55	123
11	10.07	0.20	6.52	-
12	9.48	0.15	6.39	-

*Conductivity probe malfunctioned, spot-checked with backup unit

Table E-15
Ashumet Pond Water Quality Profiles Pre- and Post-Treatment

Station #4
9/2/2010

Depth (m)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	26.23	9.69	8.62	115
1	26.17	9.66	8.63	115
2	25.47	10.71	9.10	116
3	22.30	11.09	9.12	115
4	21.55	9.42	7.82	114
5	21.06	7.39	6.94	114
6	20.41	5.33	6.52	115
7	19.09	3.22	6.29	114
8	15.01	0.16	6.26	119
9	11.89	0.12	6.21	115
10	10.90	0.10	6.34	119
11	9.62	0.09	6.44	123
12	9.23	0.08	6.50	126
13	8.90	0.06	6.52	127
14	8.76	0.05	6.54	127

Station #4
9/17/2010 (12:17pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	20.76	8.52	7.20	124
1	20.58	8.40	7.20	124
2	20.47	8.35	7.17	124
3	20.37	8.25	7.08	124
4	20.31	7.74	7.01	124
5	20.27	7.78	6.94	124
6	20.19	7.66	6.94	124
7	19.59	6.43	6.90	122
8	15.56	0.34	6.74	123
9	11.73	0.34	6.71	119
10	10.61	0.31	6.60	122
11	9.93	0.29	6.58	125

*Did not finish profile due to sudden storm

Station #4
9/24/2010 (12:23pm)

Depth (M)	Temp (˚C)	DO (mg/L)	pH (SU)	Cond (µS/cm)
0	19.80	8.60	7.01	123
1	19.81	8.59	7.01	123
2	19.79	8.59	7.00	123
3	19.76	8.62	6.99	122
4	19.76	8.62	6.99	122
5	19.75	8.63	6.98	122
6	19.74	8.67	6.98	122
7	19.03	7.66	6.91	122
8	18.19	6.13	6.80	120
9	12.54	0.21	6.55	120
10	11.27	0.19	6.48	258
11	10.25	0.11	6.41	278
12	9.86	0.10	6.44	286
13	9.52	0.08	6.45	447
14	9.12	0.06	6.46	457
15	9.08	0.04	6.46	466

*Conductivity probe malfunctioned