Ecological and Management Study of the DelCarte Ponds

Franklin, Massachusetts

PREPARED FOR:

Town of Franklin
355 East Central Street
Franklin, Massachusetts 02038

PREPARED BY:

ESS Group, Inc.
10 Hemingway Drive, 2nd Floor
East Providence, Rhode Island 02915

ESS Project No. F455-000

January 7, 2016

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SECTION

1.0 INTRODUCTION

ESS Group, Inc. (ESS) has prepared this Ecological and Management Study of the two main basins of the DelCarte Pond system (Figure 1) on behalf of the Town of Franklin (Town). The primary objective of the study was to provide the Town with a thorough evaluation of the ecological health of these ponds, including the flora and fauna living in the ponds or adjacent to the ponds. Based on our interaction with Town representatives for this project, ESS determined that the primary goal for these ponds is the have them provide recreational opportunities for Town residents. Opportunities that are currently afforded by this pond system include fishing, canoeing, hiking, and wildlife viewing. However, the system is significantly impacted by non-native aquatic plants (milfoil and water chestnut) which are reducing the ponds' capacity to provide the ecologically healthy habitat that these activities rely upon.

This Ecological and Management Study provides information and data on the existing conditions within the DelCarte Ponds and offers cost-effective and environmentally sound recommendations for the ponds' future management with the primary goal of improving fish and aquatic habitat and the subsequent recreational opportunity that this improvement will support.

1.1 DelCarte Ponds Description

The DelCarte Ponds (Ponds) are a series of four ponds located in the Charles River watershed in Franklin, Massachusetts. The ponds are oriented in a northeasterly fashion flowing from southwest to northeast. There is a protected conservation area immediately surrounding the ponds that serves as a buffer to the general suburban land use pattern that dominates the area. Several manmade dams impede the ponds including one on each of the two largest basins. Public access to the ponds is enhanced by the dams because they provide walking access and connect the trails surrounding the ponds. The dams also provide the primary point of access to shoreline fishing. Additional public access points also include trails and viewing points around the circumference of the ponds, fishing areas, bridges, benches, a small dock, and parking areas. The ponds are ecologically, recreationally, and aesthetically important for the Town.

Only two of the pond basins were included as a focus of this study (Figure 1). The two ponds chosen by the Town are the most readily accessible and utilized by the public. Both ponds combined comprise nearly 30 acres in total. The larger directly adjacent to the playground is referred to as the northern pond because it lies northeast of the other pond included in this study. Therefore the other pond included within the study is referred to as the southern pond.

The watershed that feeds the pond system is approximately 632 acres with more than half of this area occupied by residential development (Figure 2).

2.0 METHODS AND APPROACH

The field studies and data evaluation supporting our analysis of the DelCarte Ponds were conducted from October through November 2015 and included a review of existing reports, GIS mapping, field data collection, and data analysis. The methods and approach specific to each task are described in the following sections.

2.1 Review of Previous Studies

There is very little existing information regarding the ecology of the Ponds. All aliases of the ponds, including Pleasant Street Pond, Franklin Reservoir, and DelCarte Ponds, were thoroughly researched to ensure that all pertinent information was gathered. After speaking directly with the MA Department of Fish and Wildlife it was confirmed that no prior studies regarding the fishery of the ponds have been conducted by the State. There were three studies performed for permitting initiatives in the Town prior to this study. Two of the studies pertained to a canoe launch and the third pertained to the construction of a dam. These studies did not provide information that would greatly benefit this report.

2.2 Bathymetry Mapping

A bathymetric (water depth) survey was completed at the DelCarte Ponds on October 9, 2015. The purpose of the survey was to collect data for use in assessing the suitability of habitat for desirable fish species. A total of 104 stochastic points were sampled for total depth, water depth and substrate type throughout the two pond basins. The points were collocated with the plant mapping points (discussed in section 2.6). In order to gather bathymetry data an extendible carbon steel tile probe was used to total depth. Total depth was obtained by pushing the tile probe into soft sediments until first refusal at a harder underlying substrate was reached. The data were recorded, including the location of the sampling point, using a Global Positioning System (GPS) device with sub-meter accuracy. Bathymetry maps and substrate data are presented in Figures 3 and 4.

The volume of each pond was calculated using the bathymetry data and ESRI Geographic Information Systems (GIS) software.

2.3 Water Quality Sampling

ESS collected a single round of dry weather water quality data to establish baseline conditions in both ponds and the three tributaries during the early fall period. Water samples were collected at one location in each pond and in each tributary (Figure 5) and sent to a state-certified laboratory for analysis. In-pond water clarity (Secchi depth), temperature, dissolved oxygen, turbidity, and pH data were also measured by ESS while on site.

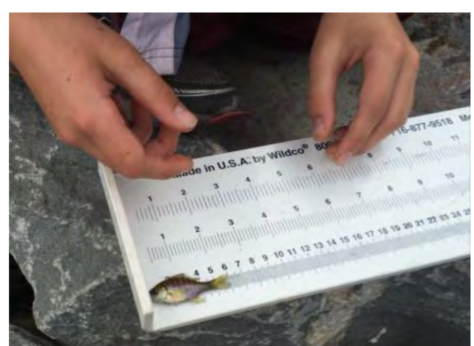
ESS also collected a round of wet weather water quality data to determine the impact of storm water runoff on the system's sediment and nutrient loading. Samples were collected during a storm on the night of December 2, 2015 from each of the three tributary locations.

2.4 Fish and Wildlife

The objective of the fish and wildlife assessment for the DelCarte Ponds was to inventory the current fish population and their habitats and to document wildlife species that are frequenting the pond. Assessments were also made for potential habitat improvements for desired fish species. Qualitative observations of other wildlife were made during field visits.

Fish Population and Habitat Suitability Assessment

Fish were surveyed using a variety of methods. Smaller forage fish (i.e. minnows) and young-of-the-year fish were sampled by deploying 10 minnow traps baited with either tuna fish or shrimp between the two ponds. Minnow traps were set on two different dates (October 21 and November 5, 2015) and collected after several hours of deployment in the shallow near-shore areas of each pond.



Sunfish caught in a minnow trap being measured for length at the DelCarte Ponds.

Larger fish were sampled using fishing poles and tackle on two separate dates (October 21 and November 5) along the shorelines of both ponds. In addition, three long gill nets were deployed on November 5th and retrieved on November 6th. Two 100-foot long multi-panel gill nets were deployed in the northern pond and a single 300-foot long multi-panel net was deployed in the southern pond (Figure 5). Gill nets were utilized because they allowed for species that are active during the twilight and nocturnal hours to also be assessed as part of the survey.

Wildlife Observations

Wildlife use of the DelCarte Ponds and adjacent habitats were observed at various times over the course of this study. Qualitative observations were made during field visits that occurred on October 9, October 21, November 5, and November 6, 2015. Groups of species observed included birds, mammals, and amphibians. Additional species anticipated to occur at the ponds were also evaluated by a wildlife biologist based on the variety of habitats present at this location.

Wetland Characterization

Hydraulically connected wetlands around the DelCarte Ponds were identified and characterized by a wetland scientist on November 18, 2015. The wetland characterization was designed to provide sufficient detail for impact assessment of potential pond vegetation and fish habitat management options.

2.5 In-lake Vegetation Assessment

ESS mapped the aquatic plant community in the DelCarte Ponds on October 9, 2015 to update current species composition, cover, and biovolume in each basin. Plant observations were made along transects at 104 points combined for both ponds. A throw rake was used to collect all plant species present at each point. Several throws were made at each point to ensure an accurate representation of the plant community present. Visual observations of plant species present made from the boat were also recorded. Percent cover and biovolume were visually ranked using the following scale; 0-24%, 25-49%, 50-74% and greater than 75%. All observed species, percent cover, and biovolume were recorded at each point and positions collected with a Trimble GeoXT GPS capable of sub-meter accuracy.

Plant species encountered were identified in the field by qualified staff. Taxonomic keys (including Crow and Hellquist 1982, New England Aquarium 1999, Crow and Hellquist 2000) were consulted as needed to assist in aquatic plant identification.

3.0 RESULTS

The results of each component of the study are presented in the following sections. Results include data acquired from field collection, desktop review, and limnological modeling.

3.1 Aerial Imagery Analysis

Mid-summer aerial imagery was obtained and analyzed from 2003, 2008, 2010, 2012, and 2014 (Figure 6). The land immediately surrounding the ponds has not changed significantly as it was and continues to be designated as conservation area. However, it is obvious from the aerial imagery that the DelCarte Ponds have increasingly been impacted by aquatic plant growth, particularly within the northern basin.

The floating leaf aquatic vegetation (e.g. water lilies, water chestnut, and similar) was mapped for each aerial image obtained from 2003 through 2014 (Figure 6). Analysis of the area of each pond impacted by this type of vegetation shows a significant loss of open-water habitat within these ponds over this eleven-year period. In 2003, there was about 10 acres of floating aquatic vegetation visible on the ponds' surface with the remaining 20 acres of pond free of vegetation. Much of this open water habitat was contained within the northern basin. By 2010, the ponds had lost an additional 5 acres of open water habitat leaving the ponds at 15 acres of open water habitat and 15 acres of floating vegetation.

Analysis of the most recent aerial images coincides well with the on-pond mapping conducted by ESS as part of this study. In 2014, there was approximately 19 acres of floating aquatic vegetation while ESS mapped nearly 22 acres in 2015. It is also important to note that the floating aquatic vegetation is only one form of aquatic vegetation and that submerged aquatic plants are not be readily observed in aerial imagery. ESS documented that the entire pond bottom was covered by aquatic vegetation in 2015 and it is likely that submerged aquatic plants were also present throughout the pond prior to this survey. Therefore, what is important to note is that the ponds aquatic plant habitat structure has shifted from an open water habitat dominated by submerged plants to an aquatic habitat dominated by plants occupying the entire water column. Both forms of aquatic plants are desirable; however, when the entire water column is occupied by aquatic plant biomass, the fish community can suffer due to reduced oxygen levels from reduced circulation by wind and from the consumption of oxygen by dying or rotting aquatic vegetation in the late fall and winter. It is also likely that during the nighttime and pre-dawn hours when the aquatic vegetation is not producing oxygen via photosynthesis, there would be a potentially detrimental depletion of oxygen from these waters.

In the 2014 aerial images you can see the improvements made to the earthen dams on the property; one on the northern pond and one on the southern pond.

3.2 Bathymetry

Results of water depth surveys were used to create a bathymetric map for the pond (Figure 3). Both ponds surveyed were shallow, with an average depth of less than 3.5 feet. The maximum depth recorded in the northern and southern pond was 4.0 and 5.0 feet respectively. The dominant substrate type throughout both ponds was muck. There were occasional areas with sand and boulder substrate however these were concentrated along the sides of the dams in both ponds and were likely added as part of the dam reconstruction. The total volume of water in the northern pond and southern pond is estimated to be approximately 14.5 million gallons and 11.9 million gallons, respectively.

3.3 In-pond Water Quality

In most freshwater systems in Massachusetts, the presence of algal blooms, excessive weed growth, and the associated low levels of oxygen that accompany these eutrophic growth conditions are typically fueled by phosphorus as the limiting nutrient. However, during this limited study of the system, ESS documented that the system is receiving relatively low levels of phosphorus from both dry weather and wet weather flows to the ponds and that the levels observed within the ponds are also relatively low (Table A). The nutrient that was found to be elevated was nitrogen (and the forms of nitrogen measured including nitrate-nitrogen and Kjeldahl nitrogen), which can also fuel algal and plant growth. Nitrogen typically is in a soluble form within freshwater systems and is directly available for uptake by plants and algae within the water column.

Total nitrogen levels in excess of 1.0 mg/L are typically associated with some form of human contributions either from septic discharges or from human activities such as agriculture or lawn fertilization. ESS documented Total nitrogen levels near or in excess of 1.0 mg/L at all three tributaries to the ponds during both dry and wet weather conditions. The results of the water quality sampling (Table A) show a system that is not significantly impacted by phosphorus, but rather more influenced by nitrogen.

Turbidity levels, the amount of suspended material including sediment, within the waters sampled were relatively low and did not increase appreciably during storm flow conditions. This indicates that the storm water conveyance system in the watershed is being managed and maintained to effectively trap sediments that would otherwise be transported to the pond and contribute to its infilling.

Table A. Water Quality Results of the In-pond and Tributary Sampling.

Basin	Temp. (°C)	DO (mg/L)	DO (%)	Turbidity (NTU)	Secchi Depth (m)	pH (SU)	Total Phos. (mg/L)	Total Nitrogen (mg/L)	Nitrate-Nitrogen (mg/L)	TKN (mg/L)	Flow (cfs)
Northern Pond	12.5	7.86	73.5	0.73	1.5 (bottom)	7.35	0.012	*<0.50*	*<0.050*	0.41	n/a
Southern Pond	12.7	7.60	72.1	0.16	1.5 (bottom)	7.11	0.028	0.89	0.054	0.84	n/a
Tributary 1 - D	5.1	11.40	87.8	1.4	n/a	7.83	*<0.010*	0.98	0.58	0.397	Not detectable
Tributary 2 - D	6.4	9.80	78.3	0.81	n/a	7.40	*<0.010*	1.3	0.86	0.404	Not detectable
Tributary 3 - D	7.0	10.03	81.6	2.2	n/a	7.05	*<0.010*	1.3	1.3	0.284	Not detectable
Tributary 1 - W	6.1	9.25	75.4	2.0	n/a	6.6	0.012	0.88	0.49	0.386	4.68
Tributary 2 - W	8.3	9.07	78.3	1.4	n/a	6.6	0.011	1.1	0.66	0.402	0.93
Tributary 3 - W	8.2	6.82	58.9	2.6	n/a	6.0	0.010	1.1	0.75	0.370	0.65

Italics indicate estimate due to one or more analytes not detected at the laboratory quantitation limit. The ponds were surveyed on November 5, 2015. The tributaries were surveyed on November 18, 2015 during dry weather, denoted by the – D. Wet weather sampling was conducted on December 2, 2015 and is denoted by the – W.

3.4 Biological Resource Assessment

3.4.1 Fish

There are no known prior fish surveys performed for the DelCarte Ponds therefore fish data evaluated were limited to the surveys performed by ESS on October 21, November 5, and November 6, 2015 (Table B). Desirable fish species were found in the ponds including; forage fish (young of year or small fish species for larger fish to consume), several species of sunfish, black and brown bullhead, bass, and perch. Carp, which are a nonnative undesirable invasive species, were also found in both ponds.

Table B. Fish Species Currently Inhabiting the DelCarte Ponds

Common Name	Scientific Name	Date Observed	Pond	Status
Bluegill Sunfish	*Lepomis macrochirus*	2	N	Fresh – warmwater
Black Bullhead	*Ameiurus melas*	3	S	Fresh – warmwater
Brown Bullhead	*Ameiurus nebulosus*	3	S	Fresh – warmwater
Carp	*Cyprinus carpio*	2, 3	N, S	Exotic Invasive
Chain Pickerel	*Esox niger*	2, 3	S	Fresh – warmwater
Green Sunfish	*Lepomis cyanellus*	1, 2	N	Fresh – warmwater
Largemouth Bass	*Micropterus salmoides*	1	S	Fresh – warmwater
Pumpkinseed	*Lepomis gibbosus*	2, 3	S	Fresh – warmwater
Smallmouth Bass	*Micropterus dolomieui*	3	N	Fresh- coldwater
White Perch	*Morone americana*	3	S	Fresh – warmwater

N and S indicate the northern and southern pond, respectively.
1. October 21, 2015
2. November 5, 2015
3. November 6, 2015

Lengths were taken for all fish collected during the survey. All fish surveyed appeared to be healthy therefore; there are no documented cases of diseases, tumors, lesions or eroded fins.

Bluegill Sunfish

Bluegill sunfish are an important species within the ponds both as a forage fish and as an attractive game fish. Because of their popularity bluegill are often introduced or stocked into pond systems. The bluegill sunfish is a greenish olive color that softens to a lighter shade on the stomach. Bluegills have a distinctive spot on the soft dorsal fin if they are greater than an inch in length. There are usually traces of six to eight double, vertical dark bars that stretch along their body. Adult sizes usually range between 4-6 inches and they can reach 11 years of age (Smith, 1985).

Typical bluegill habitats occur in standing or slow-moving water where there is vegetation or other shelter available. Bluegills require extensive littoral areas, or areas of shallow depths near the shoreline. Within the littoral zone, only 30% of the cover can be aquatic vegetation (NJ DEP, 2015). If aquatic vegetation comprises more than 30% it can interfere with feeding or cause stunted growth by reducing predation. The preferred depth for growth is 3-10 feet however deeper waters are needed for overwintering. During spawning bluegills prefer sites with firm sand or mud with some debris but limited vegetation in 1-3 feet of water (NJ DEP, 2015).

Six young of year bluegills were found within the ponds suggesting that spawning habitat within the pond is present. These ranged from 0.5 to 2 inches in length. No adult bluegills were caught, which is most likely a reflection on our survey efforts, but may also indicate that growth habitat may be the limiting the ability of fish to mature and survive. Chemical parameters within the pond support bluegill growth as both the oxygen level and pH are within their optimal range, although this may change under winter ice cover when plant biomass is decomposing and consuming oxygen.

Black Bullhead Catfish

Depending on opinion, the black bullhead can be either a desirable game fish or undesirable bycatch (US National Park Service, 2015; Rose, 2006). Many consider the black bullhead a priority game species because of the fight they provide for the angler when caught. Others describe the species as a nuisance because they create turbid waters which prevent other desirable species from thriving. The back and upper sides of the black bullhead are very dark black or brown with an abruptly lighter white or creamed colored belly. They are distinguished from other similar species by their broad head and long darkly colored barbels. Black bullheads are a smaller species usually averaging 8-10 inches in length.

Black bullheads can survive in a broad range of standing and slowly flowing waters. They are tolerant of swampy, turbid, and low-oxygen level environments. The documented presence of carp in the ponds, which are known to make waters turbid, would not negatively impact the black bullhead's survival in the ponds. The pH of both ponds is also in the range of suitable habitat for the black bullhead (6.5-8) (FishBase, 2015). Adults are strictly nocturnal feeders that typically forage in water depths of 3-10 feet (Smith, 1985). Black bullhead spawning requires considerable vegetation growth and soft substrates both of which are prevalent in the ponds.

The population within the southern pond seems to be robust as three healthy adults were caught in the southern pond. The lengths were 7.9, 10, and 10.6 inches.

Brown Bullhead

Brown bullheads seem to be more desired by anglers than other similar catfish species. The brown bullhead, much like the black bullhead, has a dark brown body with an abruptly lighter white or creamed colored belly. However, unlike the black bullhead, the brown has black mottling (spots) on the side (Guth, 2011). They typically grow to be about 8-14 inches. They are also nocturnal feeders.

The brown bullhead can survive in a variety of habitats including; the Great Lakes, small ponds, and the slow-moving streams (Smith, 1985). They can inhabit areas with a large array of environmental conditions including those with domestic and industrial pollution, warm temperatures and low dissolved oxygen concentrations. Much like the black bullhead, they prefer habitats with ample vegetation and soft substrate. During the spawning season, late May and June, brown bullheads live in shallow waters and utilize vegetation and downed logs to provide protection for their eggs (Smith, 1985). It is thought that the brown bullhead lives in deeper waters than the black bullhead.

The brown bullhead population appears to be well established in the southern pond as three healthy adults were found. The lengths were 9.4, 9.8, and 10.6 inches. It is thought that the ponds are able to support a sustainable brown bullhead population because of the abundant plant growth during their spawning season, warm water temperatures, and probable low dissolved oxygen at depth or during winter which allows them to out- compete other species.

Carp

Carp is a nonnative invasive fish species. Originally from central Asia, carp have been introduced all over the world. Carp are undesirable because they create turbid waters which degrade habitat quality for other species. Carp have a pair of distinguishable barbels extruding from each corner of their mouth. They have small eyes and thick lips. In the wild carp are usually olive green, bronze or silver colored with a paler underside. Carp exhibit a forked tail and have large, thick scales.

Carp caught in the southern basin using a gill net.

Carp prefer still or slow moving waters but can live in a variety of habitats which is why they are such a successful invader. They can thrive in highly degraded areas, with low oxygen levels and turbid waters. Areas with abundant aquatic vegetation are attractive to carp. They can grow to be very large; up to 4 feet in length and weigh up to 130 pounds (NSW Department of Primary Industries, 2015). Carp produce sticky eggs when breeding so it is likely that they adhere to the abundant aquatic vegetation in the ponds.

The main components of a carp diet include; mollusks, crustaceans, insect larva and seeds. When feeding, food items are sucked up, along with mud and water, from the pond bottom and filtered using their gill rakers. This feeding process is what causes the carp to create turbid environments that negatively harm other native fish populations. Carps will eat plant material and general organic matter if nothing else is available. Carp also degrade water quality by targeting prey that reduces algal blooms, such as water-filtering filtering mollusks (NSW Department of Primary Industries, 2015).

The largest fish species found by length in both ponds was the carp. Also, both young and mature carp were found suggesting a robust population. In total four carps were captured during the survey the lengths were as follows; 9.5, 23.6, 25.6, and 35.4 inches. Based on the abundance of aquatic vegetation and the presence of other species that create turbid environments the carp has a competitive advantage in the ponds and will most likely sustainably persist unless targeted for management action.

Chain Pickerel

Chain pickerel are a desirable species with a beautiful dark green hue and markings that resemble chain links giving them their namesake. The belly of chain pickerel is a creamy yellow and much lighter in color than the rest of the body. The average length of a chain pickerel is between 14-19 inches (Smith, 1985).

Chain pickerel prefer quiet, shallow, and warm waters with mud substrate for their habitat. Chain pickerel are also known to congregate in areas near shore, or in areas of dense aquatic vegetation or submerged grasses. Chain pickerel use the aquatic vegetation as cover while waiting to ambush their prey. They are fierce predators of other fish, snakes, frogs, ducklings, and sometimes muskrats (US Fish and Wildlife Service, 2014). Spawning takes place just after ice melt in April or May once the water reaches 47-52°F (Smith, 1985). Eggs adhere to the aquatic vegetation. Early spawning adaptations allow the young to grow large enough to feed on other fish eggs hatched later in the spring.

Measuring length of chain pickerel caught in the southern pond using a gill net.

The ponds support a healthy chain pickerel population due to the amount of near shore aquatic vegetation, shallow depths, and warm waters. Four chain pickerel were caught during the survey. The lengths were 14.2, 15.3 16.5, and 18.5 inches.

Green Sunfish

Green sunfish are common to New England waters but are not considered desirable by angler's as they do not grow large enough to be pan-fish. Their size is highly variable and stunted growth is oftentimes exhibited by overpopulation issues. The average size of a green sunfish is 4-6 inches in length however this is not usually reached due to stunting (Smith, 1985). As their name implies, they are predominantly a dark green color with scattered black dots and a white stomach. Green sunfish have dusky fins and a distinctive dark spot on the soft spinous portion of the dorsal fin.

The green sunfish is able to tolerate many aquatic conditions however they prefer small, slow moving streams and ponds (Clemons, 2006). They are able to survive in both turbid and clear water environments which allow them an advantage in ponds with carp present. During reproduction and spawning the green sunfish require sunny areas with gravel substrate of approximately 1 foot in depth. Preferably there would also be cover present in the form of logs, rocks or c lumps of grass during spawning to protect their nest. Young are not brightly colored and are meant to blend in with vegetation. The most common predators for the green sunfish are bass and bullhead catfish which are both present in the DelCarte Ponds. Because of this the spawning habitat will need to be sufficient in order to allow for the continued survival of green sunfish in the ponds.

As dietary generalists the green sunfish acquires a broader palette as it ages (Clemons, 2006). Younger green sunfish consume zooplankton but as they grow they add insect larva and small snails to their diet. Adult green sunfish eat small crayfish, fish eggs, insects, and other small fish.

Nine green sunfish were collected in the minnow traps from both ponds. They ranged from 2.1-2.5 inches. No green sunfish were collected in the gill net or by the fishing surveys. Green sunfish are typically not able to reproduce until they reach 3 inches in length so it is important to provide habitats which would condone the growth of this forage species.

Largemouth Bass

Largemouth bass may arguably be the most popular game fish in the United States. In fact, the only state in which they are not currently present is Alaska due to extensive stocking of the species throughout the country over 100 years ago (Smith, 1985). In Massachusetts, largemouth bass are not a native species, having been introduced over 120 years ago. Many give the largemouth bass credit for the continued growth of the sport of fishing. It is a favorite among fisherman because of its willingness to strike at a lure or bait with explosive force (The International Game Fish Association, 2015). The largemouth bass is also a very intelligent fish that has the ability to learn lures appearance and avoid them in the future which provides constant opportunities for ingenuity. Largemouth bass are a dark green fish with a pronounced black stripe that runs along its side. The average length of a largemouth is 18 inches but they are known to reach lengths of 24 inches or greater. Bass in the wild are expected to live up to 15 years (Curtis, 2006).

They prefer quiet, clear, warm water with abundant vegetation. Largemouth bass also prefer shallow waters and rarely swim into waters deeper than 8 feet except for overwintering purposes. Clear water is necessary for largemouth bass because they use visual cues to detect prey. Many of the other species in the ponds create turbid waters, such as the carp and catfish, which could pose problems for largemouth bass survival. Largemouth bass use the aquatic vegetation to hide from their prey and as protection from predators. Spawning occurs in water depths ranging from 1-4 feet once the water is approximately 60°F (Smith, 1985). Sandy or fine ravel substrates are preferred; however, largemouth bass will spawn on a variety of inorganic and organic substrates (Stuber et al., 1982).

Juvenile largemouth bass feed on plankton and miscellaneous insects and invertebrates. As they mature their diet shifts to other fishes or anything that creates movement as bass's are attractive to movement via sight. Their favorite dietary constituent is sunfish. Largemouth bass serve as a top predator in the food chain of smaller ponds and act as a regulator for population dynamics.

Only one largemouth bass was caught in the northern pond at 10 inches in length. The lack of gravel or sand substrates for ideal spawning habitat or the excessive aquatic vegetation in the ponds depleting oxygen levels may both be limiting the largemouth bass population in the ponds. Other factors that could be limiting bass growth may be the increased turbidity from carp and bullheads, although this is seen as a secondary influence. Parameters such as water chemistry, temperature, and depth are suitable for robust largemouth bass populations.

Pumpkinseed

Pumpkinseed sunfish are a popular game fish especially among younger fishermen. They live close to shore and have a tendency to bite on nearly any type of natural bait if it is small and a variety of small artificial lures. Pumpkinseeds are a smaller fish that average between 5-6 inches but can reach lengths of 10 inches (Cornell University, 2015). A lateral view of pumpkinseeds varies from golden brown to olive on top. There are wavy, irregular blue green lines on the body that give way to bronze or red-orange ventral surface.

Pumpkinseed sunfish prefer weedy ponds and shoreline habitat. They use weeds, logs, and docks for cover. During spawning nests are created near shore in 6-12 inches of water that is approximately 60°F (Smith, 1985). Oftentimes nests are created near aquatic vegetation. Pumpkinseeds are opportunistic feeders that eat a large variety of prey including; insects, amphipods, mollusks, larval salamanders and small fish.

Two adult pumpkinseeds were found in the southern pond. They were 6.1 and 6.7 inches in length. Although no young of year pumpkinseed sunfish were captured in the minnow traps a population must exist based on the size and health of the adults surveyed. Based on the shallow depths and abundance of aquatic vegetation the ponds create sufficient habitat for pumpkinseed sunfish.

Smallmouth Bass

Much like the largemouth bass the smallmouth bass has a legendary sporting fish status. It is among the most desirable species for anglers for many of the same reasons that the largemouth is so highly desired. Smallmouth bass are greenish bronze to brown in color with lighter siders and an off-white stomach. There are typically 8-11 vertical black bars along the midside and usually a second row of similar shorter wider bars that alternate with the first. Typical lengths are around 12 inches and lengths greater than 20 inches are rare (Wickstrom, 1994).

Smallmouth bass prefer streams with slow to moderate current or standing waters with areas of rocky shoreline and considerable shelter. They are able to tolerate a wide range of environmental conditions however they are usually found in cooler, clearer water than the largemouth bass. Much like the largemouth, they are voracious predators that feed on many types of aquatic life. Their diet includes zooplankton, tadpoles, frogs, insects, crayfish, and fish. Spawning begins once water temperatures reach 62-65°F. Smallmouth bass prefer to have gravel shorelines in depths of 2-20 feet (average 3 feet) for spawning (Smith, 1985).

Smallmouth bass was not anticipated to be in the ponds based on their habitat requirements. Only one smallmouth bass was caught in the northern pond at 10.6 inches in length. Typically smallmouth bass prefer colder waters found in northern New Hampshire and Maine. The rocky and gravel shoreline present within the ponds is along both of the updated earthen dams and does not provide a great deal of shelter for the smallmouth bass.

White Perch

White perch are a deep bodied fish with small pointed teeth. They are dark green/gray in color and have a white stomach. The average white perch grows to be 6-12 inches in length.

White perch primarily live in estuarine environments, where the water is slightly salty. They are also able to live in freshwater environments. As juveniles white perch like weeded areas but as adults they prefer deep pools. White perch are also able to breed in many types of water environments but actually prefer to breed in freshwater. They always chose to breed in waters less than 23 feet in depth (Martens, 2006). Typically eggs are laid in the evening or directly following a rain event. Eggs stick together in a clump and to the bottom of the substrate. White perch do not camouflage eggs rather they lay eggs in a large abundance and hope that some survive predation (Smith, 1985). They typically prey on other fish however the young eat a variety of items including; eggs, insects, worms, crustaceans, and small pieces of animal debris (detritus).

One adult white perch, at 6.7 inches in length, was caught during the survey in the southern pond. There is plenty of habitat for juvenile white perch that prefer weedy areas however there is not a great deal of deep pool habitat for adult white perch. The population will not continue to grow if habitat is not created for adult white perch.

3.4.2 Wildlife Observations

The wildlife community associated with DelCarte Ponds is typical for man-made (impounded) ponds located in eastern Massachusetts. Wildlife species observed at the ponds during ESS's field visits are listed in Table C below. In addition to the wildlife species directly observed at the ponds, many other species which were not observed are likely to occur there. A selection of the common species not observed but expected to occur at DelCarte Ponds has also been included in Table C. While this list is not exhaustive, it is meant to highlight the common species that are most likely to occur at DelCarte Ponds based on the habitat types available at the ponds. The list below includes species that use the open water and vegetated wetland habitats associated with the DelCarte Ponds system, as well as species which inhabit the upland forested areas surrounding the ponds. Species that are dependent upon or would commonly use the open water or wetland habitats at DelCarte Ponds are indicated in bold.

Table C. Wildlife Species Observed and Expected to Occur at DelCarte Ponds.

Common Name	Scientific Name	Observed/Expected	Dates Observed
Birds			
Mute Swan	*Cygnus olor*	Observed	1, 2, 4
Canada Goose	*Branta canadensis*	Observed	1, 4
Mallard	*Anas platyrhynchos*	Observed	4
Green-winged Teal	*Anas crecca*	Expected	N/A

Common Name	Scientific Name	Observed/Expected	Dates Observed
Ring-necked Duck	*Aythya collaris*	Expected	N/A
Hooded Merganser	*Lophodytes cucullatus*	Expected	N/A
Great Blue Heron	*Ardea herodias*	Observed	2
Green Heron	*Butorides virescens*	Expected	N/A
Osprey	*Pandion haliaetus*	Expected	N/A
Cooper's Hawk	*Accipiter cooperii*	Expected	N/A
Red-tailed Hawk	*Buteo jamaicensis*	Expected	N/A
Spotted Sandpiper	*Actitis macularius*	Expected	N/A
Mourning Dove	*Zenaida macroura*	Expected	N/A
Eastern Screech-owl	*Megascops asio*	Expected	N/A
Great Horned Owl	*Bubo virginianus*	Expected	N/A
Chimney Swift	*Chaetura pelagica*	Expected	N/A
Belted Kingfisher	*Megaceryle alcyon*	Expected	N/A
Red-bellied Woodpecker	*Melanerpes carolinus*	Expected	N/A
Downy Woodpecker	*Picoides pubescens*	Observed	3
Eastern Phoebe	*Sayornis phoebe*	Expected	N/A
Eastern Kingbird	*Tyrannus*	Expected	N/A
Red-eyed Vireo	*Vireo olivaceus*	Expected	N/A
Blue Jay	*Cyanocitta cristata*	Observed	2
American Crow	*Corvus brachyrhynchos*	Observed	1, 2
Tree Swallow	*Tachycineta bicolor*	Expected	N/A
Black-capped Chickadee	*Poecile atricapillus*	Expected	N/A
Tufted Titmouse	*Baeolophus bicolor*	Observed	2
White Breasted Nuthatch	*Sitta carolinensis*	Observed	2
Carolina Wren	*Thryothorus ludovicianus*	Expected	N/A
Hermit Thrush	*Catharus guttatus*	Expected	N/A
American Robin	*Turdus migratorius*	Expected	N/A
Gray Catbird	*Dumetella carolinensis*	Expected	N/A
Cedar Waxwing	*Bombycilla cedrorum*	Expected	N/A
Ovenbird	*Seiurus aurocapilla*	Expected	N/A
Northern Waterthrush	*Parkesia noveboracensis*	Expected	N/A
Black-and-white Warbler	*Mniotilta varia*	Expected	N/A
Common Yellowthroat	*Geothlypis trichas*	Expected	N/A
Song Sparrow	*Melospiza melodia*	Observed	2
Swamp Sparrow	*Melospiza georgiana*	Expected	N/A
White-throated Sparrow	*Zonotrichia albicollis*	Expected	N/A
Northern Cardinal	*Cardinalis*	Observed	2
Red-winged Blackbird	*Agelaius phoeniceus*	Expected	N/A

Common Name	Scientific Name	Observed/Expected	Dates Observed
Baltimore Oriole	*Icterus galbula*	Expected	N/A
Finch	*Fringillidae spp.*	Observed	2
House Sparrow	*Passer domesticus*	Expected	N/A
Mammals			
White-tailed Deer	*Odocoileus virginianus*	Expected	N/A
Coyote	*Canis latrans*	Expected	N/A
American Mink	*Neovison vison*	Expected	N/A
Northern Raccoon	*Procyon lotor*	Expected	N/A
American Water Shrew	*Sorex palustris*	Expected	N/A
Eastern Chipmunk	*Tamias striatus*	Observed	1 ,2
Eastern Gray Squirrel	*Sciurus carolinensis*	Observed	1, 2
American Beaver	*Castor canadensis*	Expected	N/A
White-footed Mouse	*Peromyscus leucopus*	Expected	N/A
Muskrat	*Ondatra zibethicus*	Observed	1, 2
Amphibians			
Green Frog	*Lithobates clamitans*	Expected	N/A
Pickerel Frog	*Lithobates palustris*	Observed	1
Wood Frog	*Lithobates sylvatica*	Expected	N/A
Eastern Red-backed Salamander	*Plethodon cinereus*	Expected	N/A
Eastern Newt	*Notopthalmus viridescens*	Expected	N/A
Reptiles			
Northern Water Snake	*Nerodia sipedon*	Expected	N/A
Black Rat Snake	*Pantherophis obsoletus*	Expected	N/A
Common Garter Snake	*Thamnophis sirtalis*	Expected	N/A
Common Snapping Turtle	*Chelydra serpentina*	Expected	N/A
Painted Turtle	*Chrysemys picta*	Expected	N/A
Eastern Musk Turtle	*Sternotherus odoratus*	Expected	N/A

1. October 9, 2015; 2. November 5, 2015; 3. November 6, 2015; 4. November 18, 2015

ESS observed 12 avian species using the pond or its immediate shoreline during our five field visits (Table C). Of these 12 species, Canada goose (*Branta canadensis*), American crow (*Turdus migratorius*), mute swan (*Cygnus olor*), and blue jay (*Cyanocitta cristat*) were the most frequently observed species, and Canada goose and American crow were the numerically dominant species. ESS directly observed three mammal species at DelCarte Ponds (Table C). In addition to the mammal species directly observed, two beaver (*Castor canadensis*) lodges were observed at the ponds. ESS also observed relatively recent beaver sign including chewed twigs, impoundment of the outlet at the southern pond, and small beaver slides, providing further evidence that beavers are present and active at DelCarte Ponds. ESS also observed northern raccoon (*Procyon lotor*) tracks along the perimeter of the pond. One species of herpetofauna (reptiles and amphibians) was directly observed by ESS at the ponds (Table C); the reduced herpetofaunal activity that would be expected at the time of year that this study was performed likely accounts for why more species were not observed. Due to the amount of appropriate habitat for herpetofauna at DelCarte Ponds, it is expected that other common herpetofauna are likely to use the ponds or their immediate surroundings. For example, while no turtles were observed, the floating plant beds at DelCarte Ponds provide sufficient daytime basking habitat for painted turtle (*Chrysemys picta*). Appropriate habitat for musk turtle (*Sternotherus odoratus*) and green frog (*Lithobates clamitans*) (mucky substrate with plant cover) was also plentiful. No state- or federally-listed threatened or endangered species were observed during any of ESS's visits to DelCarte Ponds.

Beaver evidence in the southern pond.

3.4.3 Aquatic Plant Assessment

Seventeen aquatic plant species were observed in the DelCarte Ponds (Table D), including two exotic invasive species: water chestnut (*Trapa natans*) and variable-leaf milfoil (*Myriophyllum heterophyllum*). Filamentous green algae were also found in both of the ponds. The highest number of aquatic species (15) was observed in the southern pond while the northern pond had twelve (12) different plant species. The exotic invasive plants observed during the study were much more established and dominant in the northern pond. Variable-leaf milfoil was found at 62% (32 of 52 points) of all of points surveyed in the northern pond while it was not observed in the southern pond (0 out of 50 points). Water chestnut was found at 79% (41 of 52) of all the points surveyed in the northern pond but only 18% (9 of 52) of the points surveyed in the southern pond.

Although not the primary target of the plant mapping efforts, several emergent plant species were also observed around the periphery of the ponds (Table D). While most of the species observed are generally considered to be beneficial, notable exotic invasive species included common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*), both of which were well established.

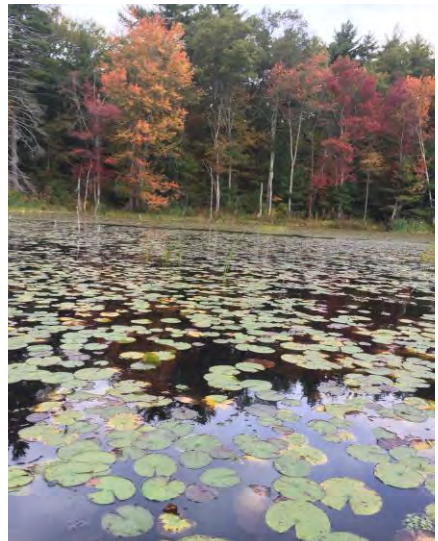
Table D. Wetland Plant Species Observed in the DelCarte Ponds

Common Name	Scientific Name	Pond	Status
Submersed and Floating Species			
Bigleaf Pondweed	*Potamogeton amplifolius*	S	Native
Canadian Waterweed	*Elodea canadensis*	S	Native
Common Bladderwort	*Utricularia macrorhiza*	N, S	Native
Coontail	*Ceratophyllum demersum*	N, S	Native
Duckweed	*Lemna minor*	S	Native
Filamentous Green Algae	*Chlorophyceae*	N, S	Native
Floating Pondweed	*Potamogeton natans*	N, S	Native
Little Floating Bladderwort	*Utricularia radiata*	N, S	Native
Snailseed Pondweed	*Potamogeton bicupulatus*	N	Native
Stonewort	*Nitella spp.*	S	Native
Thinleaf Pondweed	*Potamogeton pusillus*	N, S	Native
Variable-leaf Milfoil	*Myriophyllum heterophyllum*	N	Exotic Invasive
Water Chestnut	*Trapa natans*	N, S	Exotic Invasive
Watershield	*Brasenia schreberi*	N, S	Native
Western Waterweed	*Elodea nuttalii*	S	Native
White Water Lily	*Nymphaea odorata*	N, S	Native
Yellow Water Lily	*Nuphar lutea variegata*	N, S	Native
Emergent Species			
Awlfruit Sedge	*Carex stipata*	N, S	Native
Bayonet Rush	*Juncus militaris*	N, S	Native
Cattail	*Typha latifolia*	N, S	Native
Common Reed	*Phragmites australis*	N, S	Exotic Invasive
Fringed Sedge	*Carex crinita*	N, S	Native
Purple Loosestrife	*Lythrum salicaria*	N, S	Exotic Invasive
Soft Rush	*Juncus effusus*	N, S	Native

N and S indicate the northern and southern pond, respectively.

Aquatic plant cover was very dense (average approx. 80%) throughout both ponds (Figure 7). Approximately 18 acres of the total 30 were characterized by very dense plant cover (greater than 75%). The majority of the remaining acreage (8.45 acres) had plant cover ranging from 50-74%. No areas within the ponds were recorded as having no plant cover.

Water chestnut bed in northern pond.



White water lily bed in DelCarte Ponds.

Aquatic plant biovolume, which is defined as the percentage of the water column occupied by plants, was high throughout the ponds. Both ponds' overall plant biovolume estimates were between 50-60% (Figure 8). There are areas within both ponds that have very high biovolume ranging from 76-100%. These areas are concentrated in the southern third of the northern pond and on the east and west edges of the southern pond. The areas of high plant biovolume correspond well with the invasive water chestnut mats. Areas of lesser biovolume were also present within both ponds primarily near the dam in the northern pond and along some shoreline areas in the southern pond. These areas of reduced plant biovolume, may provide limited edge habitat and open water transit corridors for fish during the peak season of plant development.

Both invasive plant species, variable-leaf milfoil and water chestnut, were among the most commonly observed in the northern pond, often forming extensive beds (Figure 9). The invasive plant beds found in the northern pond were frequently accompanied by common bladderwort and white water lilies. The southern pond also contained water chestnut beds, although the white water lily, common bladderwort, and little floating bladderwort were the most commonly observed species.

3.4.4 Wetland Assessment

DelCarte Ponds provide valuable fish and wildlife habitat through the various vegetated wetland and open water habitats that occur within and adjacent to the pond. Based on the wetland habitat that has been preserved in and around the ponds, it is likely that the ponds have the potential to support a diverse community of fish, birds, mammals, herpetofauna, invertebrates, and plants. ESS directly observed Canada geese and mallards (*Anas platyrhynchos*) foraging in the ponds, and observed two beaver lodges along the banks of the ponds. It is expected that many other bird, mammals, reptile, and amphibian species use the wetland and open water habitats associated with the ponds. The persistent emergent vegetation present in portions of the pond may provide nesting habitat for bird species such as red-winged blackbird, and likely provides nursey habitat for juvenile fish species. The emergent wetland fringe along much of the shoreline of the pond likely provides cover, foraging, and resting habitat for a variety of reptiles, amphibians, birds, and small mammals.

While the wetland areas associated with the DelCarte Ponds system provide habitat for a variety of fish and wildlife species, expansion of exotic invasive plant species, particularly common reed has resulted in large areas being dominated by dense monotypic stands that provide suboptimal fish and wildlife habitat. These beds have encroached upon habitats that might otherwise be open water or inhabited by a more diverse matrix of native species. Further expansion of common reed stands may result in negative impacts to the fish and wildlife community at DelCarte Ponds.

Land Under Water

The land under DelCarte Ponds is considered LUW and occurs below the mean annual low water level of the ponds. The LUW within the ponds provides the substrate for plant growth and habitat for benthic organisms. A list of the aquatic plant species observed growing in the pond is provided in Table D.

Inland Bank

Inland bank confines water within DelCarte Ponds. In addition to the emergent plant species listed in Table D, other species observed growing on and along the bank of DelCarte Ponds includes sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), red maple (*Acer rubrum*), white oak (*Quercus alba*), and white pine (*Pinus strobus*).

Bordering Vegetated Wetlands

A narrow fringe of bordering vegetated wetland (BVW) is present along most of the shoreline of DelCarte Ponds. A large stand of common reed (*Phragmites australis*) is present on the southwestern shoreline of the upper pond, while an extensive cattail (*Typha latifolia*) wetland is present along the northwestern shoreline of the upper pond. Large stands of cattails are also present upstream of the upper pond, downstream of the lower pond, and along the outlet stream of the upper pond. Other emergent plant species documented in the BVW associated with DelCarte Ponds are listed in Table D.

3.5 Hydrologic and Nutrient Budget

Data generated during field and desktop assessments were used to develop a hydrologic budget and nutrient load model for the DelCarte Ponds. Determining a pond's hydrologic budget is the first step toward modeling its nutrient load because all sources of water entering the ponds carry some quantity of nutrients.

Sources of water inflow include direct precipitation onto the pond surface, direct runoff from adjacent land, and groundwater seepage along the margins of the pond. Evapotranspiration and groundwater recharge lead to losses of water from the pond.

Parameters such as the mean depth (pond volume divided by pond area), flushing rate (number of times per year that the total volume of water in the pond is renewed), areal water load (volume of water entering a pond in a year divided by the pond surface area), and settling velocity (rate at which a particle drops from the water column) influence how nutrients move through the system and were each incorporated into the in-lake nutrient model.

The simplest in-lake nutrient models are derived from mass balance equations. While useful as a first step, mass balance models tend to underestimate nutrient loads because they do not account for natural loss processes that essentially reduce in-pond concentrations over time. Therefore, results from several different in-pond models were examined (Dillon and Rigler 1974, Oglesby and Schaffner 1978, Jones et al. 1979, Kirchner and Dillon 1975, Vollenweider 1968 and 1975, Reckhow 1977, Larsen and Mercier 1976, Bachmann 1980, and Jones and Bachmann 1976).

Physical and hydrologic characteristics of the DelCarte Ponds were used to determine what are referred to as the *permissible load* and *critical load* for phosphorus (Vollenweider 1975). These values are helpful in conceptually characterizing how water quality in the pond is likely to respond to changes in nutrient loading.

The *permissible load* represents the point above which a pond can be expected to experience regular problems with excessive algal growth and rapid deterioration of water quality. Although algal blooms can occur below the permissible load, water quality deterioration significantly accelerates above this level. Therefore, maintaining or reducing nutrient inputs to a point well below the permissible load is very important.

The *critical load* represents an upper threshold, above which a pond can be expected to experience persistent problems with excessive algal growth. Above the critical load, the rate of water quality deterioration actually slows with increased inputs because the pond is already saturated with nutrients. This represents a state of advanced eutrophication (nutrient enrichment). Water bodies above the critical load are challenging to restore because large nutrient reductions are required to achieve even minimal improvements in water quality.

Hydrologic Budget

The average annual precipitation for Franklin is estimated to be 49.6 inches, based on the average of the three closest long-term climate stations (Worcester, Blue Hill, and Providence). Of this, approximately 22.9 inches is lost to evapotranspiration in an average year (NRCC 2015). Estimated average water input to the DelCarte Ponds is dominated by surface water (Table F). A little more than half of the surface water inputs enter the ponds during wet weather (watershed runoff). Direct precipitation and groundwater seepage together account for the small remaining portion of the hydrologic inputs to the pond.

Table F. Hydrologic Summary for the DelCarte Ponds

Element	Value
Watershed Area	632 acres
Pond Area	30 acres
Pond Circumference	7,973 feet
Pond Volume	3.5 million cubic feet
Pond Water Depth (Average)	2.7 feet
Average Groundwater Seepage Inputs	0.011 cfs
Average Direct Precipitation	0.092 cfs
Average Surface Water Inputs (Total)	1.706 cfs
Average Surface Water Inputs (Dry Weather)	0.791 cfs
Average Surface Water Inputs (Wet Weather)	0.926 cfs

Detention time is the length of time that a droplet of water spends within the pond, on average. Based on total pond volume (3.5 million cubic feet) and the estimated flow through the system, average detention time was calculated to be 23 days (0.06 years). Flushing rate is the inverse of detention time and represents the number of times per year the pond volume is replaced. The DelCarte Ponds flush approximately 16 times per year. These figures indicates that water moves through the system quickly, providing a relatively short period of time for water (and associated loads of nutrients and pollutants) to interact with the biological, physical, and chemical conditions in the pond.

Phosphorus Loading

For the current study, a calculation of minimum phosphorus load was made using a mass balance equation. The minimum phosphorus load delivered to the DelCarte Ponds was determined to be 0.27 $g/m^2/yr$ (32 kg/yr), based on the nutrient concentrations and hydrologic conditions observed during the study (Table G).

The actual load of phosphorus will exceed the estimated minimum load as a consequence of loss processes that reduce the in-pond concentration over time. By taking these loss processes into account, a more detailed and realistic estimate of phosphorus loading can be obtained. Modeling that incorporates loss processes yielded phosphorus loading rates between 0.29 $g/m^2/yr$ (35 kg/yr) using the Vollenweider (1975) model and 0.55 $g/m^2/yr$ (67 kg/yr) using the Reckhow General (1977) model (Table G). The average predicted phosphorus load for all models was 0.38 $g/m^2/yr$ (47 kg/yr).

The average of phosphorus loads estimated for the pond through the in-pond models (47 kg/yr) is higher than the permissible load of 44 kg/yr but lower than the critical load of 89 kg/yr. This suggests that the DelCarte Ponds may be sensitive to increases in phosphorus loading, with poor water quality conditions and algae blooms becoming more frequent and severe as additional phosphorus loading occurs. However, it also implies that small reductions in phosphorus could have a significant positive impact on preserving water quality in the ponds. In the case of the DelCarte Ponds, the model average is only 5% higher than the permissible load. Therefore, a management approach that incorporates phosphorus reduction strategies is recommended.

Table G. Summary of Nutrient Loading Model Results

Nutrient	Model Output	Value
Phosphorus	Model Minimum (Mass Balance) Load	32 kg/yr
	Model Average Load	47 kg/yr
	Model Maximum (Reckhow) Load	67 kg/yr
	Permissible Load	44 kg/yr
	Critical Load	89 kg/yr
Nitrogen	Minimum (Mass Balance) Load	921 kg/yr
	Bachmann Load	1,106 kg/yr

Nitrogen Loading

For the current study, a calculation of minimum nitrogen load was made using a mass balance equation. The minimum nitrogen load delivered to the DelCarte Ponds was determined to be 7.59 $g/m^2/yr$ (921 kg/yr), based on the conditions observed during this study (Table G).

As with phosphorus, the actual load of nitrogen will exceed the estimated minimum load as a consequence of loss processes that reduce the in-pond concentration over time. By taking these loss processes into account, a more detailed and realistic estimate of nitrogen loading can be obtained. For the DelCarte Ponds, the Bachmann (1980) model was used to derive an improved estimate of current nitrogen loading. Based on the results of the Bachmann model, nitrogen loading was estimated to be 9.11 $g/m^2/yr$ (1,106 kg/yr) (Table G).

Permissible and critical loading limits for nitrogen are not typically developed, owing to the less predictable relationship between nitrogen, pond hydrology, and production by plants and algae. However, where excessive loading results in concentrations approaching 1.0 mg/L, as observed in the DelCarte Ponds, nitrogen may become a logical target for improving water quality and fish habitat.

A common source of nitrogen in developed watersheds is domestic wastewater, which may reach the ponds through illicit discharges into the stormwater system (e.g., illegal tie-ins) or by leakage into groundwater and eventual migration into the pond. Stormwater may also contribute to excessive nitrogen levels.

4.0 MANAGEMENT GOALS

The management goals for the DelCarte Ponds have been clearly defined by the Town of Franklin and include protection or improvement of the following:

- Recreational opportunities such as fishing, wildlife viewing, non-motorized boating, and skating
- Improvement of the fish community composition and balance
- Ecological value, particularly with regard to fish habitat

Given these modest and compatible goals, the number of issues currently impacting the ponds is relatively few, but includes excessive aquatic weed growth, sedimentation, and general eutrophication. A wide range of management options were contemplated. A feasibility assessment of potential management options with respect to achieving the management goals above is presented in the following section.

5.0 MANAGEMENT OPTIONS: FEASIBILITY ASSESSMENT AND RECOMMENDATIONS

This section presents the range of options for vegetation and aquatic habitat management in the DelCarte Ponds, based on the goals stated in Section 4.0.

5.1 Recommended Short-term Options for Habitat Improvement

Short-term management options include those that either require only modest planning or have an effective period of five years or less. Some short-term management options (e.g., chemical treatment) may involve short-term actions implemented repeatedly to achieve long-term management goals. However, significant cost or effort is required each time the option is implemented.

For the aquatic habitat in the DelCarte Ponds to be restored, the most critically important action to be undertaken will be the removal of the aquatic invasive species variable leaf milfoil and water chestnut. Native aquatic plant species will need to be preserved to the extent possible. Such action will improve water quality by reducing biological oxygen demand, particularly under the ice, which should enhance survival of the more sensitive members of the fish community over winter. Removal of the excessive growth of these exotic species will also enhance recreational boating, fishing, and even skating by providing a more balanced mix of open water and weed beds within the ponds.

Short-term options for enhancing the habitat within the DelCarte Ponds are presented below as recommendations along with those options we did consider but are advising against based on the nature of the system and the weeds that must be addressed.

5.1.1 Chemical Treatment (Herbicides) – Recommended for Initial Treatments Only

Herbicides remain a controversial aquatic weed control measure in many communities because of their association with pesticides, which is generally perceived to be negative. However, as we learn more about the various negative impacts that can be associated with alternative physical and biological management options, chemical control measures continue to be used as part of many balanced lake management plans.

Although no herbicide is completely safe or harmless, a premise of federal pesticide regulation is that the potential benefits derived from use outweigh the risks when registered herbicides are applied according to label recommendations and restrictions. Current herbicide registration procedures are far more rigorous than in the past and the ability of qualified and licensed applicators to target applications of herbicides further improves the relative safety of using these chemicals for nuisance aquatic plant control. However, each of the herbicides evaluated in this Management Study present some degree of risk with regard to potential toxicity to non-target organisms and temporary recreation or water withdrawal restrictions would be needed for herbicide applications at the DelCarte Ponds. Restrictions vary by herbicide formulation. However, restrictions on fishing and other non-contact recreation are generally not required.

In the DelCarte Ponds, herbicides present a viable option for restoring the open water habitat quickly and economically by targeting only the non-native vegetation that has overrun the ponds in recent years. Although moderate levels of native vegetation are essential for fish habitat, water chestnut and variable leaf milfoil are non-native species that have grown to levels that are clearly impacting the fish populations and their habitat.

In the short-term, herbicide treatment is one of the most cost-effective means by which to rapidly achieve the goal of reducing aquatic weed biomass over a large area. Herbicides may also be used over the long-term as part of a comprehensive management plan to treat areas of recurring infestations that are not readily controllable through other means (e.g., where a winter drawdown is used to manage invasive weed growth with herbicides selectively applied to areas deeper than the drawdown can impact).

Herbicides can only be applied at DelCarte Ponds by state-licensed herbicide applicators. Therefore, this is not an option that pond residents or volunteers can undertake themselves. Costs for permitting an herbicide treatment are typically low ($3,500 to $5,000) because a Notice of Intent to the local Conservation Commission is all that is usually required. Although not typically required, some communities can also require site-specific monitoring requirements for plant management projects during the permitting process that can increase costs as well. These costs can vary greatly depending on the special conditions imposed in the Order of Conditions. A basic monitoring program involving pre-treatment, during treatment, and post-treatment monitoring of dissolved oxygen levels, non-target organisms (e.g., fish, invertebrates, etc.), and aquatic habitat could be implemented for a cost of approximately $4,500 to $6,000, depending on extent and intensity of sampling required.

The two herbicides currently recommended for use at the DelCarte Ponds are 2,4-D (trade name Navigate) and imazamox (trade name Clearcast). The method of action, contact time, and target species vary by herbicide and it is likely that more than one formulation may be needed to be used at some point to achieve desired results. More detail on the usage and costs of each of these is provided in the following sections.

2,4-D – Systemic Herbicide: The systemic herbicide known as 2,4-D is dicot-selective and frequently effective in controlling growths of variable-leaf milfoil over multiple seasons and is also very effective on water chestnut. 2,4-D mimics a member of the plant hormone group known as auxins, which are important in regulating the growth of dicot plants. An overdose of auxins causes the plant to lose control over its own growth and eventually die. The primary advantage of 2,4-D is that it has been in use for a long time and is available at a lower cost than other systemic herbicides. According to the data available from MassGIS, it does not appear that the ponds are mapped as Zone 2 or Interim Wellhead Protection Areas so 2,4-D should be able to be permitted at these ponds.

Applications of 2,4-D are typically in the range of $500/acre with Navigate (2,4-D BEE granular formulation) the more effective and expensive product available at this time. Estimated costs for a single treatment at DelCarte Ponds would be $13,000 to $17,000 assuming that most of both basins would require treatment. Liquid formulation of 2,4-D would be less expensive, but would require two applications and may be less effective. Costs for treatment with liquid 2,4-D would be about $12,000 for two treatments.

Given that 2,4-D is able to achieve the desired control of both non-native species present at the ponds, this herbicide would be the preferred short-term solution for bringing the habitat within the ponds back into balance initially. The cost outlined above is also only the cost for the initial year of control. Water chestnut produces seeds each season. Although treatments should occur in June or early July before these seeds are formed and released each year, the seeds from prior years are still likely to be viable in the sediments of the pond. Therefore, follow-up treatments or management through hand-pulling should be anticipated in year 2 and subsequent years. If the herbicide is effective in year 1, the subsequent year can be evaluated in early June to determine whether a year 2 herbicide application is required or whether the biomass and areas with regrowth are manageable through a hand-harvesting program. Many communities are successful implementing a volunteer-based hand-harvesting program for little or no cost when the acreage of plants to control is less than an acre or two. More aggressive and well-organized programs, such as that implemented by the Charles River Watershed Association, are able to control areas in excess of 10 acres when motivated.

Imazamox – Systemic Herbicide: Imazamox is the common name of the active ingredient ammonium salt of imazamox (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-5-(methoxymethl)-3-

pyridinecarboxylic acid. It was registered with EPA in 2008, and is currently marketed for aquatic use as Clearcast. It is a liquid formulation that is applied to submerged vegetation by broadcast spray or underwater hose application and to emergent or floating leaf vegetation by broadcast spray or foliar application. There is also a granular version (Clearcast 2.7G™). Imazamox is a systemic herbicide that moves throughout the plant tissue and prevents plants from producing a necessary enzyme, acetolactate synthase (ALS), which is not found in animals. Susceptible plants will stop growing soon after treatment, but plant death and decomposition will occur over several weeks.

Imazamox is considered less toxic than 2,4-D to non-target species but it is much more expensive too since it is a newer product. Both water chestnut and variable milfoil are expected to see good control with Imazamox; however, variable milfoil will require a higher application rate and will need two applications to achieve desired results at Delcarte Ponds. The estimated cost for a single year of treatment of both ponds with Imazamox would be $22,500. As with 2,4-D treatment the following year will be necessary to control the regrowth of water chestnut that is supported by the seed bank within the pond's sediment.

Permitting both 2,4-D and Imazamox for use at the ponds is recommended. The use of both may be necessary over the course of the management of the ponds since plants are known to develop resistance to some herbicides that are used repeatedly year after year.

***Diquat dibromide – Contact Herbicide*:** As a contact herbicide, diquat (trade name Reward) works by interrupting the photosynthetic process, resulting in the dieback of leaf and stem cells. It offers immediate control of variable-leaf milfoil growth (not water chestnut) and is one of the least-expensive approved herbicides available (typically less than $300/acre). However, this control would only be expected to last one season as diquat does not effectively kill rooted portions of aquatic vegetation. Furthermore, diquat is non-selective and would likely impact a broad spectrum of native plants. Each of these drawbacks reduces the apparent cost-effectiveness of diquat over the long term

However, if 2,4-D and/or Imazamox are found to be effective at controlling water chestnut to the point where it can be managed through hand-harvesting, diquat may be a useful tool for managing any regrowth of smaller patches of variable milfoil that may occur in subsequent years at a much lower cost than either of the other two herbicides recommended.

Glyphosate – Systemic Herbicide: Emergent plant growths of exotic species of (purple loosestrife, and common reed) around the DelCarte Ponds could potentially be controlled with the herbicide glyphosate (trade name Rodeo) on a selective basis, if desired. Glyphosate is fast-acting for a systemic herbicide. It works by inhibiting production of key amino acids in plants and is only selective in that it is not effective on submersed vegetation. However, non-target emergent (e.g. cattail, sedges, rushes) or upland plants may be damaged or killed if they are exposed to glyphosate.

If desired, common reed and purple loosestrife could be treated with glyphosate. The next step toward this effort would be to map the areas of common reed and loosestrife within all four of the ponds to determine the level of effort and likely costs for achieving reasonable control. Costs for conducting such an assessment and developing a long-term management approach for common reed would be about $6,000.

Based on our cursory observations, purple loosestrife appears to be advanced and dense enough that biological control may be quite effective as a primary control (Section 5.1.2). It may be possible to achieve faster control through an integrated program of appropriately timed glyphosate applications and biological control, but this would reduce the cost-effectiveness of the control program. Purple loosestrife does not currently appear to inhibit recreation, water supply, or habitat for most wildlife or fish. Therefore, incurring additional expense to speed the control process would have minimal benefit and does not appear to be justified at this time.

5.1.2 Biological Control – Recommended Only for Purple Loosestrife

Biological control involves the introduction of a predator, herbivore, parasite, or other type of agent that inhibits the growth or reproduction of the target species. Biological controls can be useful in helping to reduce the size of active infestations but rarely result in eradication of a target species. Furthermore, they usually do not work as rapidly as chemical or mechanical management techniques. Depending on the size of the infestation and the nature of the biological organism used for control, it may take five to seven years before a significant level of control is observed.

Four species of insects are known to impact the growth and sustainability of purple loosestrife stands. Minnesota received approval for release from the United States government of each of these and has conducted some of the most rigorous testing on record. The insects tested included two leaf-feeding beetles, one root-boring weevil, and one flower-feeding weevil. *Galerucella pusilla* and *G. calmariensis* are leaf-eating beetles which seriously affect growth and seed production by feeding on the leaves and new shoot growth of purple loosestrife plants. *Hylobius transversovittatus* is a root-boring weevil that deposits its eggs in the lower stem of purple loosestrife plants. Once hatched, the larvae feed on the root tissue, destroying the plant's nutrient source for leaf development, which in turn leads to the complete destruction of mature plants. The flower-feeding weevil, *Nanophyes marmoratus*, severely reduces seed production of purple loosestrife.

The next step toward evaluating whether biological controls would be a suitable option for the DelCarte Ponds would be to properly assess the loosestrife stands around the ponds and develop a management plan that includes loosestrife as well as other emergent non-native species.

5.1.3 Winter Drawdown – Not Recommended

A winter water level drawdown is technique that is occasionally used to manage aquatic weeds at much reduced cost in an impounded lake or pond system. Winter drawdown works by drying and freezing the roots of aquatic plants, effectively killing the root system that would support the next season’s growth while have little impact on vegetation that is generated from seeds each year.

Winter drawdown is very effective against milfoil, but not effective against water chestnut. This makes this option, which is quite disruptive to the ecology of the system, a less desirable option. Even if a limited winter drawdown of 1 to 1.5 feet might be considered for managing near shore milfoil, once the water chestnut is brought under control it may still be difficult to permit due to the likely impacts to fish and other aquatic organisms since there would not be sufficient water remaining in the ponds to sustain fish under the ice cover.

5.1.4 Mechanical Harvesting – Not Recommended

Mechanical harvesting is a process by which a boat with a cutter head and conveyor is used to cut weed growth off below the surface. This approach is not very effective against milfoil, and in fact it can actually encourage the spread of milfoil since the plant fragments not collected by the harvester are viable and can drift to and root elsewhere in the pond or downstream of the ponds.

Harvesting of water chestnut is a suitable option for large areas of chestnut when herbicides are being avoided and the areas to be controlled are more than can be harvested by hand. A harvesting program for the DelCarte Ponds would be expected to cost about $3,500 per acre. Given that there are approximately 19 acres of chestnut in the two main basins, this would result in an annual cost of $66,500 and would be expected to require a minimum of two, and possibly three, years of implementation to bring the chestnut under control (to exhaust the seed bank) to the point where a reasonable hand-harvesting program could be implemented.

5.1.5 Hand Harvesting – Recommended for Water Chestnut Only

Hand harvesting is a viable option for managing water chestnut if implemented annually and timed to remove the plant before its seeds are dropped each season. Unfortunately, there is just too much water chestnut in the DelCarte Ponds at present to envision an effective hand harvesting program being implemented. In addition, the hand harvesting approach is not very effective at managing variable leaf milfoil. Given that herbicides (discussed above) are recommended which could bring both milfoil and chestnut under control, it is recommended that hand harvesting be considered as a more ecologically and cost effective approach for the long-term maintenance of the ponds once the chestnut growth is brought down to a level of one to possibly 2 acres of vegetation.

Costs of hand harvesting are low, typically consisting of the costs for disposal of the vegetation that is picked. Often, the town highway department will truck the material and dispose of for free, but occasionally the rental of an appropriately sized dumpster may be required. Additional costs may also include training and organization of the volunteers by a professional to ensure that the work is clearly planned and executed the first year.

5.2 Recommended Long-term Options for Habitat Improvement

Long-term management options include those that require more extensive planning, engineering, and/or permitting but that would be expected to have long-lasting effects once implemented.

For the aquatic habitat in the DelCarte Ponds to be restored, the most critically important action to be undertaken will be the removal of the aquatic invasive species variable leaf milfoil and water chestnut. Once this has been achieved, additional improvements to the physical nature of the habitat within the ponds could be considered.

Long-term options for enhancing the habitat within the DelCarte Ponds are presented below as recommendations along with those options we did consider but are advising against based on the nature of the system and the improvements needed.

5.2.1 Artificial Aeration – Not Recommended

Aeration and/or destratification (or circulation) is used to treat problems with high algal growth and low oxygen concentrations that may occur in smaller ponds. Air diffusers, aerating fountains, and water pumps are typical types of equipment that may be installed to increase circulation in a pond. The cost of purchasing, installing, and maintaining pond circulation equipment becomes substantial as pond size increases. Likewise, the effectiveness of the equipment tends to decline with pond size as it is difficult to achieve sufficient circulation in large ponds.

Aeration is not currently recommended for either of the DelCarte Ponds, primarily because sedimentation and excessive aquatic plant growth (rather than planktonic algal growth) are the targets for restoration of the ponds. The southern basin is the only pond currently deep enough to be fully stratified during the growing season. However, algae blooms do not appear to be a significant problem at this time.

5.2.2 Dredging – Recommended to Enhance Overwintering Habitat Only

Dredging works as a plant control technique when a light limitation is imposed through increased water depth or when enough soft sediment is removed to reveal a less hospitable substrate for plant growth (e.g. hard bottom or other nutrient-poor substrate).

Conventional "dry" dredging requires pond drawdown

Light limitation through increased depth may be possible in portions of the DelCarte Ponds, in part because the natural staining of the water provides some reduction of the amount of light penetrating to the pond bottom. Dredging to depths greater than 10 feet would be necessary, and greater depths would provide additional storage volume, increase the likelihood of success in controlling nuisance plant growth, and allow for benefits to be sustained longer. In areas where thick deposits of soft sediments have accumulated, deeper dredging would have the added benefit of removing a significant nutrient source, thereby reinforcing the control of variable-leaf milfoil beds.

Because dredging involves removing pond sediments, it is considered a non-selective management technique that will affect non-target plant species and some animals (primarily invertebrates) living in the immediate dredged area.

Dredging in the DelCarte Ponds could be an effective long-term control technique for nuisance aquatic plants. The challenges of dredging projects are not unreasonable and the potential long-term benefits can be significant.

The portion of the ponds where dredging may be most beneficial is within the central portion of each basin to create maximum depths that would prevent the weed growth as well as improve over wintering habitat for fish that require deep (and thus warmer) waters to survive. The whole basin would not be recommended for dredging, but rather only select locations to create permanent open water that is deep.

The amount of material to be removed and the type of disposal or reuse will have a significant impact on the cost of dredging. Assuming that about 2 acres in each basin would be increased in depth by about 4 feet, the volume of sediment would be about 25,800 cubic yards. The cost of a dry dredging project for the entire targeted area in both basins would likely run between $775,000 and $1.5 million (including permitting and design) for removal of all of the soft sediments. Costs could increase if sediment cannot be reused or disposed of in the immediate vicinity of the ponds.

A more realistically scaled project designed to deepen only one portion of the northern basin, might reasonably yield a dredge volume of 12,000 cubic yards. Costs to dry dredge this volume of material would likely be about $450,000 including permitting and design costs.

Chemical content of the material to be dredged is an important consideration in determining the feasibility of reuse or disposal. Disposal costs could be much reduced if the material removed from the pond is clean enough for beneficial use as a soil amendment. Clean material could potentially have value to a local landscape supply, golf course, or other business which would reduce disposal costs or even help offset the cost of the project. However, material that is not suitable for beneficial use would need to be amended with clean material to lower the concentrations to suitable levels or trucked offsite for disposal. Either of these options would increase the cost of the project.

If dredging is pursued as a desirable long-term option, the next steps would be as follows:

1. Assessment of a specific scope and extent of dredge program, including possible funding options.
2. Additional chemical and physical analysis of the sediments in areas targeted for dredging – level of effort is based on the volume of material targeted to be dredged.
3. Development of an engineering design for submission to permitting authorities.
4. Initiation of the permitting process including an Environmental Notification Form filing for MEPA (Massachusetts Environmental Policy Act) review, filing a local Notice of Intent under the Wetlands Protection Act, filing for a Section 401 Water Quality Certificate and Chapter 91 Permit from MassDEP, and seeking a U.S. Army Corps of Engineers Section 404 Permit for dredging.

These four activities might be expected to cost approximately $50,000 for DelCarte Ponds given the work already completed as part of this study, but are essential if dredging is to be pursued as a management option. Additional design costs would include final engineering design following the permitting process (incorporating any accepted changes resulting from these reviews) along with the development of a bid specification package for the project.

5.2.3 Spawning Habitat Enhancement – Recommended

Fish spawning at the DelCarte Ponds will be greatly improved through the removal of the excessive plant biomass associated with the exotic weed growth as described in the short-term recommendations section. However, our observations on the fish community and measurements of bottom substrate and depths also support the possible option of enhancing the bottom substrate with the addition of areas of sand and/or very fine gravel. This material would need to be trucked in and placed into the pond, but if designed properly, could be done economically and would greatly improve the spawning habitat for bass and sunfish.

Figure 10 depicts the areas within each pond that we would recommend for consideration to improve spawning substrate for bass and sunfish. The area targeted in the northern basin is about 0.7 acres in area and is located centrally within the basin at a location that is already shallow in depth. It is recommended that about 6 inches of sandy material be placed over this entire area. The area should also be augmented with a limited amount of structure such as woody debris (logs) or boulder piles which would also afford cover.

The area recommended for the southern basin is smaller at 0.3 acres and is located off a natural peninsula to take advantage of the shallower offshore depths while also remaining close to deeper waters. As was described above, this area would also require about 6 inches of sandy material and associated cover structure.

The costs to implement would vary depending upon the method of placement of the material. Assuming 1 acre of sand at 6 inches of depth, the project would require about 800 cubic yards of material. If new material were brought in, the cost would be about $20,000 to $30,000 for the material, trucking, and placement. In order to implement such a program, permits would be required from the USACE, MassDEP, and the Town's Conservation Commission (estimated permitting cost of $15,000 combined).

It may also be possible to combine such a project with the dredging project described in Section 5.2.2 such that sandy material from central portions of the pond is excavated from beneath the mud and placed in these targeted spawning areas, thus also deepening the pond in targeted areas at the same time. This combined approach would save costs for trucking material away or to the pond as well as offer the advantage of a combined permitting effort.

5.2.4 Fish Stocking – Recommended if Needed

Stocking of fish at the DelCarte Ponds would be recommended if none of the above-described options for habitat improvement can be implemented in the near term. Stocking a pond with fish species that are already present at lower numbers will benefit recreational fishing in the short term, but the ponds will not be able to sustain the added fish biomass over the long-term since the habitat is not able offer forage, cover or water quality conditions that will meet their needs.

Fish stocking, if pursued, should be done during fall or spring when water temperatures are less stressful. The recommended stocking program for the DelCarte Ponds, based on our observations of what the pond needs and can support would be a blend of forage fish and game fish as follows:

Species	Rate per Acre	Total based on 20 acres	Cost Delivered
Bluegill (2"-3")	300	6,000 fish	$4,500
Green Sunfish (1"-2")	175	3,500 fish	$1,750
Largemouth Bass (3"-4")	100	2,000 fish	$3,600
Minnows	1,000	20,000 fish	$2,000
		Total for One Stocking =	**$11,850**

In addition to being forage fish for bass, bluegill and sunfish also forage on the eggs of carp and can effectively bring a carp population back under control which would be a benefit to water quality in these ponds.

Permitting to release fish in Massachusetts is required through the state to ensure that the fish are from a recognized Massachusetts hatchery certified to be free of disease and other exotic species. Costs to obtain this permit are minimal and often obtained by the fish hatchery delivering the fish.

5.2.5 No-action Alternative – Not Recommended

The no-action alternative at DelCarte Ponds would entail avoidance of all the management actions presented in the previous sections. If implemented, this option would allow exotic invasive plant species to continue to dominate while the ponds fill with fine sediments and water quality stagnates or becomes increasingly poor. The pond would continue to serve some ecosystem function but the availability of open water habitats would likely decline. Similarly, the pond would likely continue to function as a recreational and fishery resource but with reduced area and volume, respectively.

Although this option does have the advantage of requiring no direct monetary costs, it may have a significant cost in the form of reduced aesthetic, recreational, water quality, water quantity, and ecological value. Some of this cost may be intangible; however, loss of recreational tourism, lowered nearby property values, and the need to develop alternative recreational resources may result in real monetary costs to the Town and its residents. Therefore, the no-action alternative is not recommended.

6.0 MONITORING PROGRAM

A cost-effective monitoring program would provide continuous background data for the purpose of tracking the effectiveness of any future management practices at the DelCarte Ponds.

The key monitoring element associated with any vegetation management action program would be the mapping of aquatic plant species distribution, cover, and biovolume with particular focus on the distribution of exotic plant species. Biomonitoring of zooplankton (a key food for smaller fish) and sensitive macroinvertebrates (e.g., mussels) would also yield useful information for continued management of the pond and may be required under an Order of Conditions to implement certain management actions, particularly drawdown.

Water quality monitoring would also be useful to track in-pond conditions during the growing season each year. This could be used to identify any emerging negative trends in water quality before they become problematic as well as to document any improvements in water quality that may be realized through pond management actions or improvements in watershed management. Phosphorus and chlorophyll-*a* levels would be important in this regard, along with easily measured field parameters (pH, dissolved oxygen, temperature, specific conductance, turbidity, and clarity [Secchi depth]). Additionally, water quality monitoring would likely be required as a condition for herbicide treatment.

Evaluating water quality and plant coverage trends requires several years of continuous data, often with multiple sample dates in each year. Evaluation of management techniques would be more immediate, allowing comparisons between pre- and post-management periods. A program could be custom designed to fit within an appropriate budget, but a cost of between $5,000 and $8,000 per year should be dedicated in order to include some level of water quality and plant community assessment along with a review of data by a qualified expert. Monitoring plant cover in the ponds should be performed on at least an annual basis to track changes in beds of existing exotic species and identify any emerging infestations before they spread. Plant monitoring also allows evaluations of implemented management actions to be made and strategies adjusted, as necessary.

7.0 SUMMARY OF MANAGEMENT RECOMMENDATIONS AND CONCLUSIONS

The most critical management target identified through this study is the need to address invasive aquatic weed growth, particularly the extremely dense variable-leaf milfoil and water chestnut beds present over most of the pond area. These species grow in dense beds at biovolumes that inhibit recreational opportunities and reduce habitat for fish and wildlife that require open water or edge habitats. Purple loosestrife and common reed, while problematic and undesirable in surrounding wetlands and shorelines, do not significantly impact fish habitat, in-pond recreational opportunities, or other recreation use of the area at this time. However, management of this species can be included for ecological or aesthetic reasons.

Water quality is another concern. Dissolved oxygen and phosphorus levels are likely to be problematic at times. Addressing internal and external sources of phosphorus and preventing the excessive growth and decay of aquatic plants will be necessary to ensure that water quality continues to be supportive of recreation and fish and wildlife habitat needs.

In summary, ESS recommends that the following management options be considered for implementation at the DelCarte Ponds.

In the short term:

- Use of the herbicide 2,4-D to control milfoil and water chestnut. Alternatively, the herbicide Imazomox could be used with less toxicity, but greater cost.
- Hand harvesting of water chestnut once the initial biomass is reduced though herbicide application.
- Control of emergent exotic vegetation such as purple loosestrife and common reed though the use of the herbicide glyphosate and/or biological control using insects targeting purple loosestrife.

In the long term:

- Dredging as an option for improving overwintering habitat for fish within the ponds as well as creating permanent open water areas that would be weed free due to the increased depth. An area of approximate 2 acres would be more than sufficient within the northern basin.
- Enhancement of spawning habitat for bass and sunfish through the addition of a small area of sandy material in each of the basins.
- Implementation of a fish stocking program is only recommended as needed if the above-described actions cannot be implemented or sustained. Stocking will improve the ponds for recreational fishing temporarily, but it will not improve the resource or the habitat that is needed to sustain the fish population being stocked.
- Sustained monitoring will also be a key part of ongoing management to track progress, prevent future infestations, and ensure preservation of the pond's recreational and ecological resources. A basic monitoring program can be established for approximately $5,000 to $8,000 per year. Monitoring may also be required as a permit condition for implementation of specific management actions and may entail additional costs. However, costs can often be reduced by merging common elements of separate monitoring programs.

The management of the DelCarte Ponds system in a manner that is comprehensive and long-term will have significant initial costs. However, with clear goals, good data, proper planning and readiness to take advantage of funding opportunities as they arise, it can be accomplished. The work performed to date should be followed-up with real action as soon as possible to take advantage of the current data and momentum and ensure that progress continues.

Figures

Path: J:\F455-000 Town of Franklin - DelCarte Ponds\04 GRAPHICS\MXD\Franklin_DelcartePond_ProjectLocus.mxd

Drawing Date: 2016/01/07

environmental consulting & engineering services

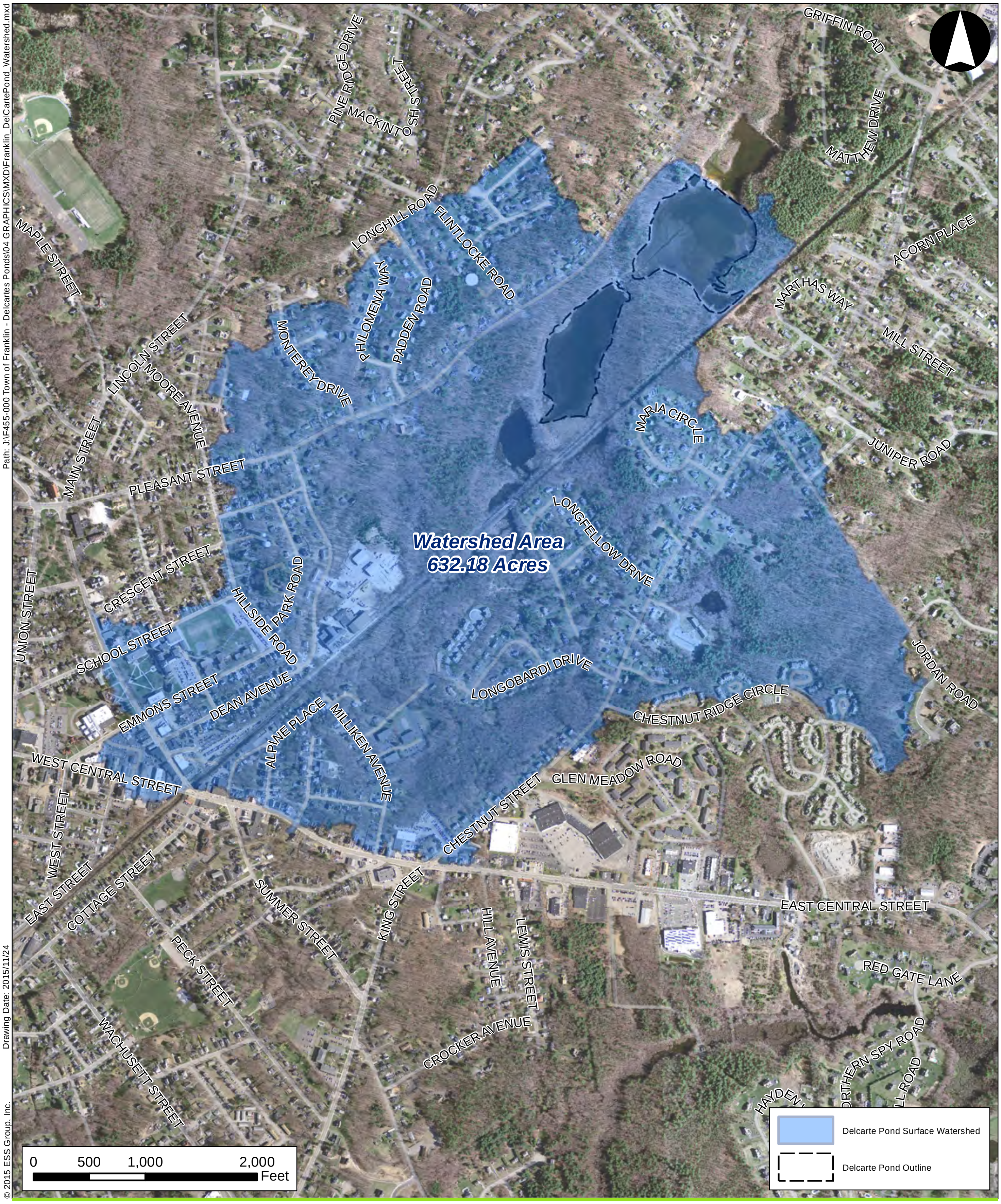
Ecological and Management Study - DelCarte Ponds
Franklin, MA

1 inch = 2,000 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) Base Map: ESRI, USGS, NGS, i-cubed, 2015

Locus Map

Figure 1



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Drawing Date: 2015/11/24

Ecological and Management Study - DelCarte Ponds

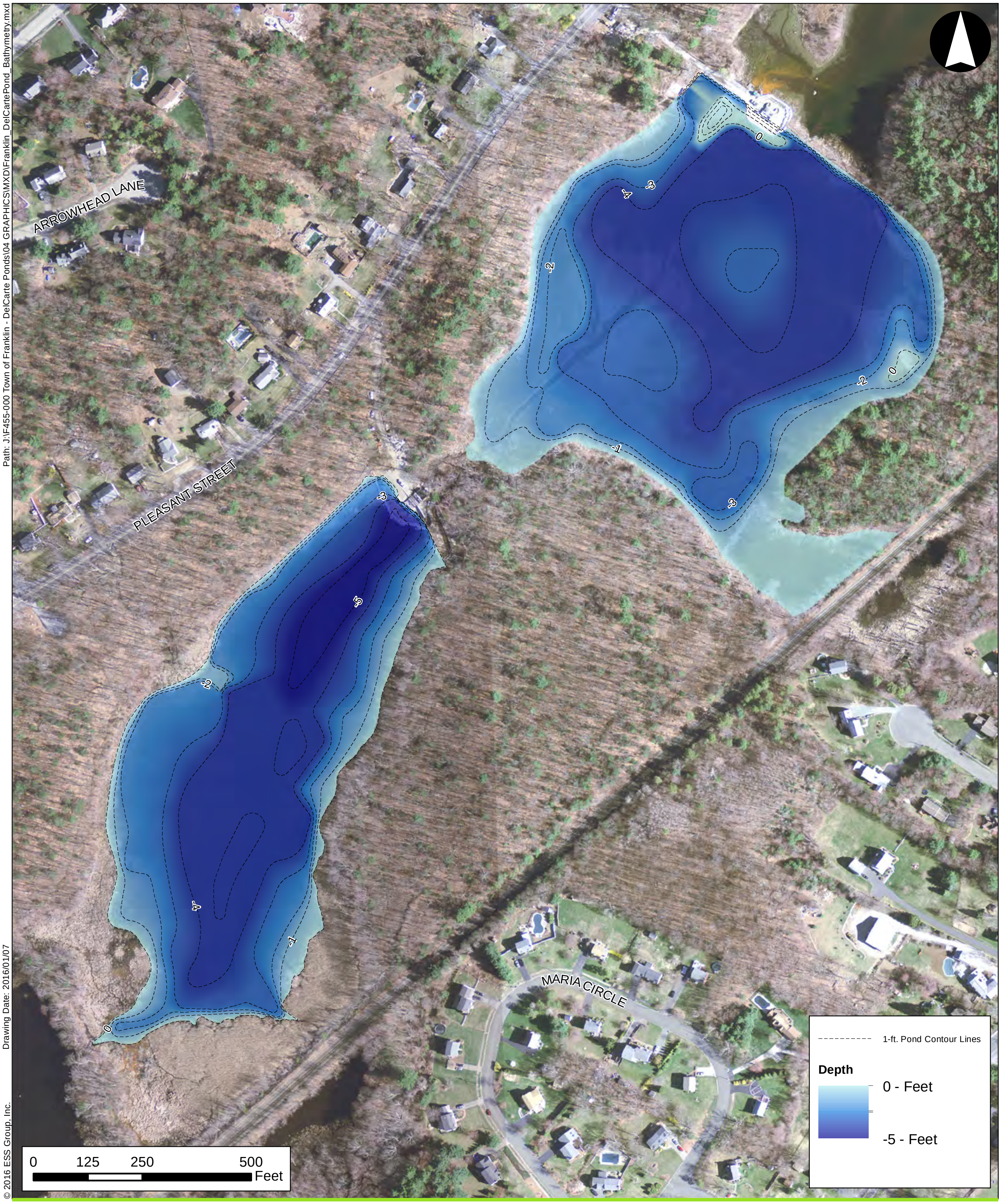
Franklin, MA

Pond Watershed

1 inch = 1,167 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) MassGIS LIDAR, 2010

Figure 2



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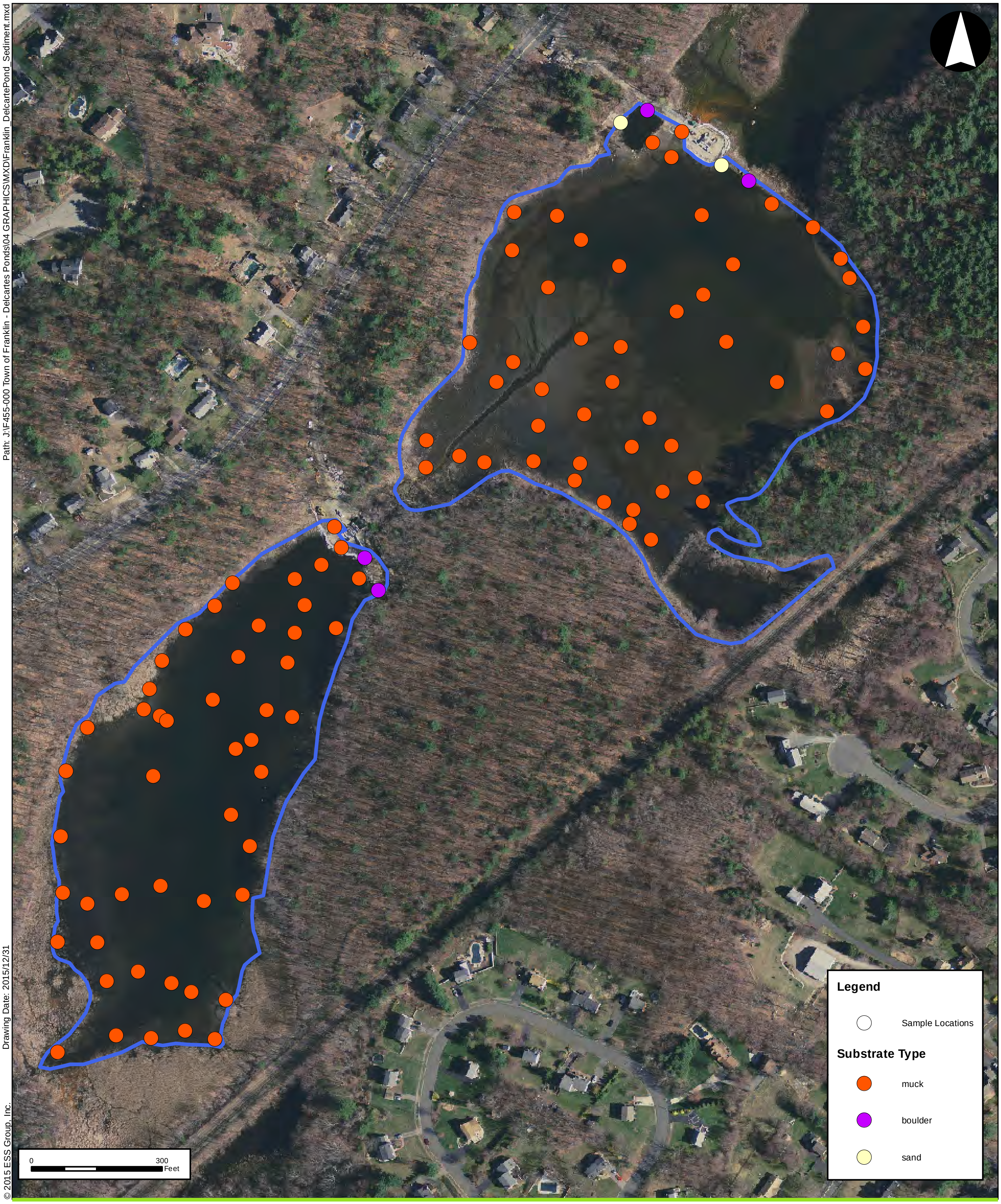
Ecological and Management Study - DelCarte Ponds
Franklin, MA

Bathymetry

1 inch = 300 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) MassGIS LIDAR, 2010

Figure 3



Drawing Date: 2015/12/31

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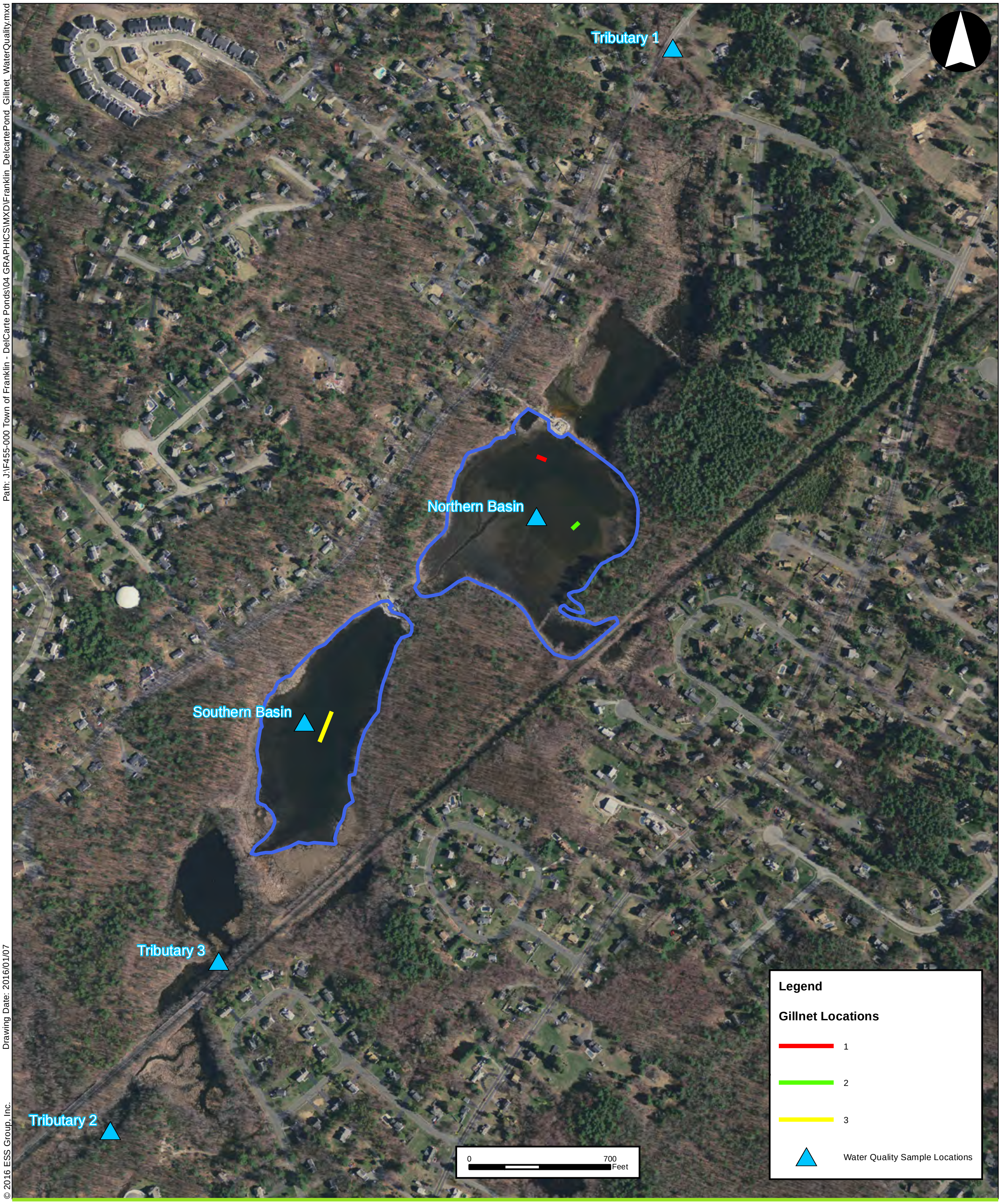
Ecological and Management Study - DelCarte Ponds
Franklin, MA

1 inch = 300 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) ESS, GPS Locations, 2015

Substrate Type

Figure 4



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Drawing Date: 2016/01/07

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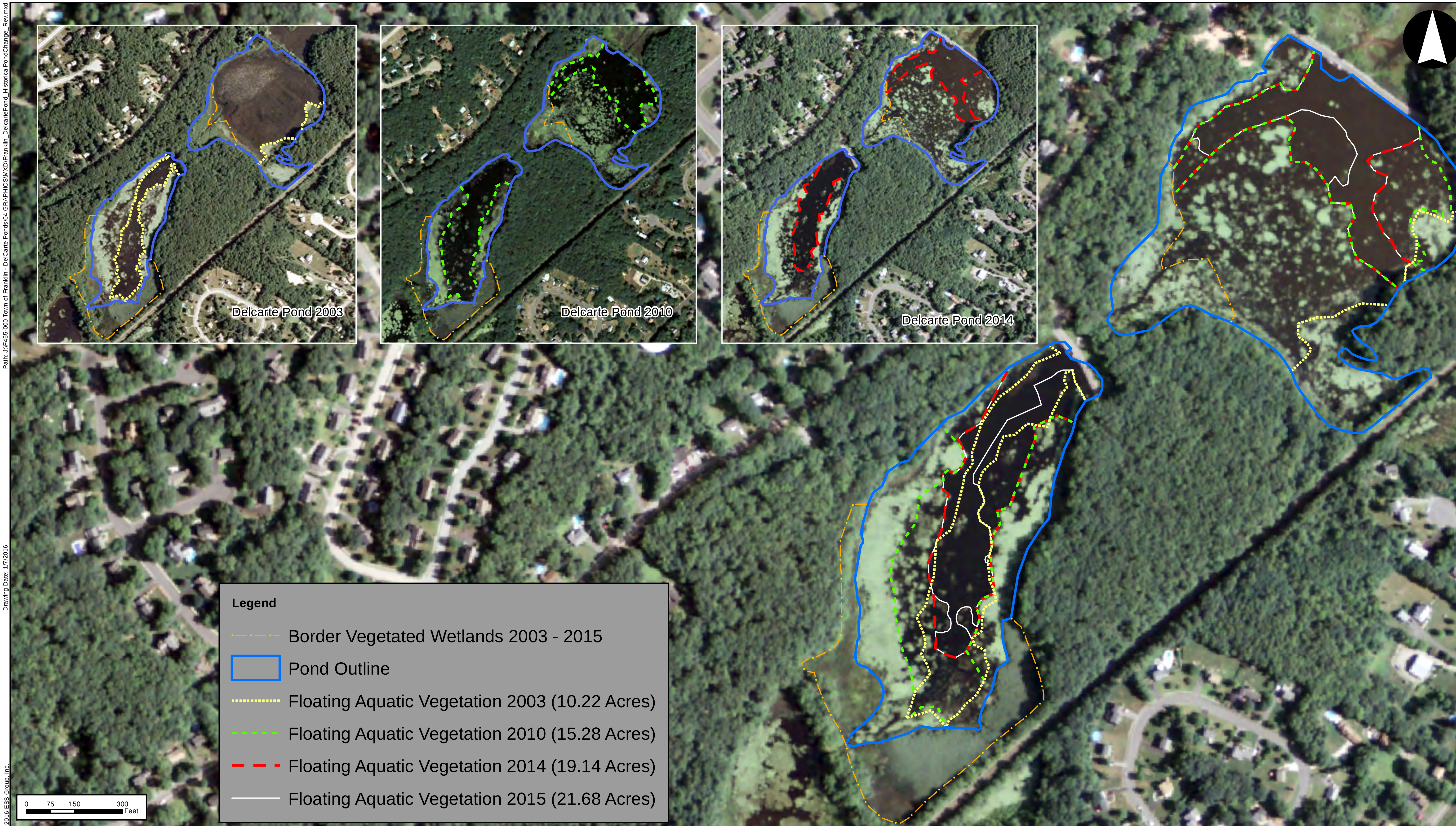
Ecological and Management Study - DelCarte Ponds
Franklin, MA

1 inch = 650 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) ESS, GPS Locations, 2015

Water Quality and Gillnet Locations

Figure 5



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Drawing Date: 1/7/2016

Ecological and Management Study - DelCarte Ponds

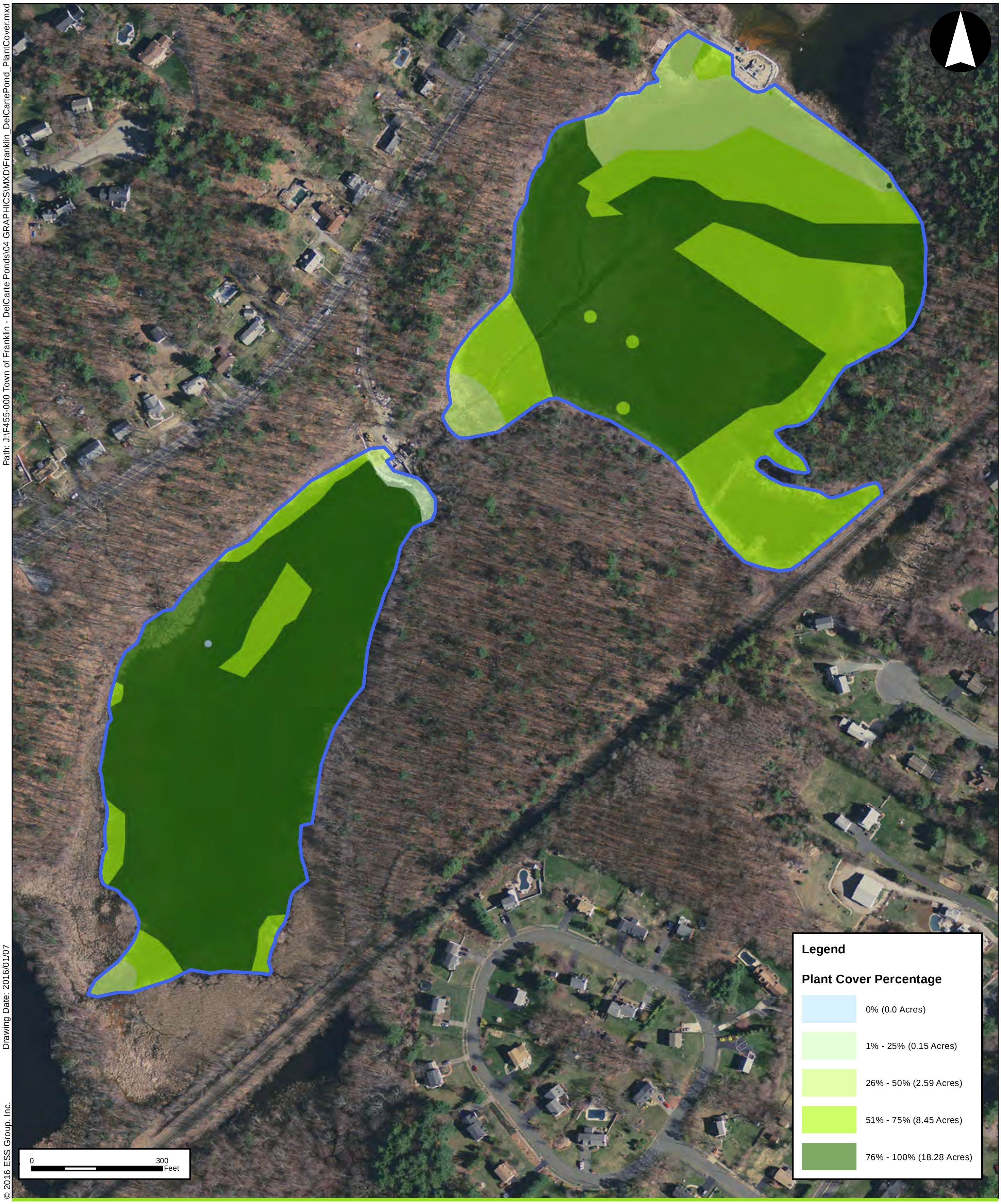
Franklin, MA

1 inch = 283 feet

Source: 1) MassGIS/USGS, Color Ortho, 2003, 2010, 2014, 2015
2) ESS, GPS Locations, 2015

Historical Weed Growth at DelCarte Ponds

Figure 6



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Drawing Date: 2016/01/07

environmental consulting & engineering services

Ecological and Management Study - DelCarte Ponds
Franklin, MA

Aquatic Plant Cover

1 inch = 300 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) ESS, GPS Locations, 2015

Figure 7

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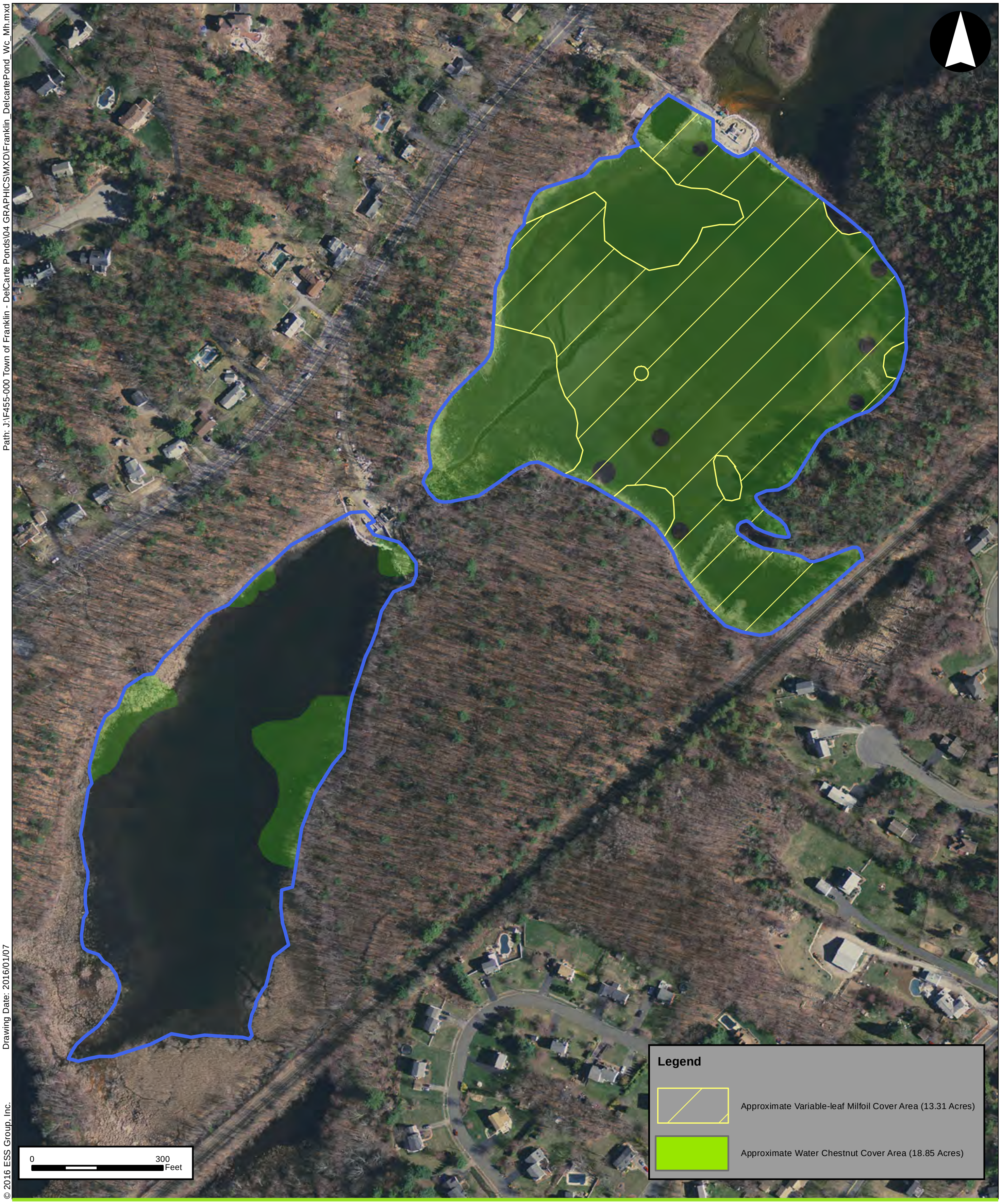
Ecological and Management Study - DelCarte Ponds
Franklin, MA

1 inch = 300 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) ESS, GPS Locations, 2015

Aquatic Plant Biovolume

Figure 8



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Drawing Date: 2016/01/07

ess group
environmental consulting & engineering services

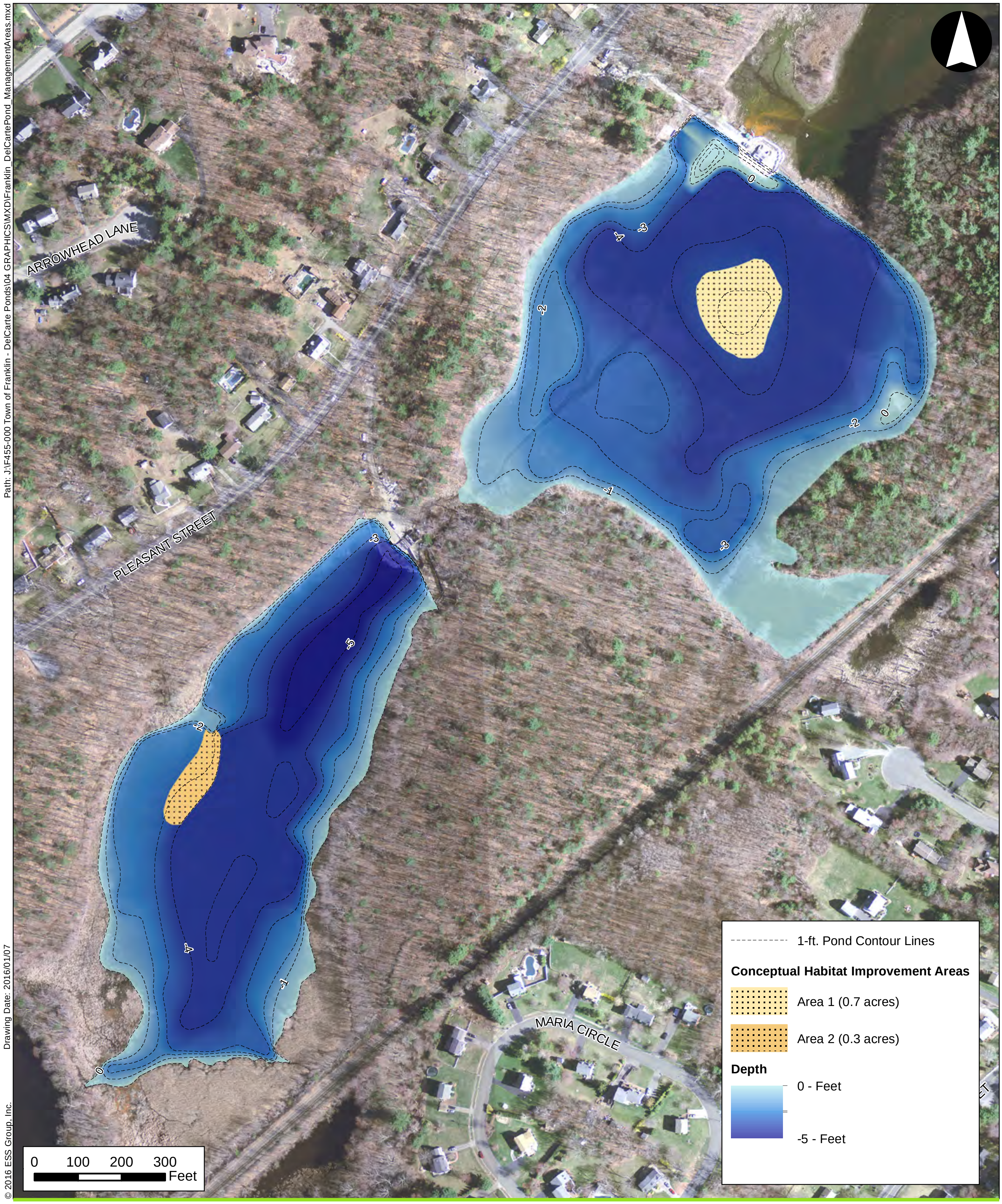
Ecological and Management Study - DelCarte Ponds
Franklin, MA

1 inch = 300 feet

Source: 1) MassGIS/USGS, Color Ortho, 2013
2) ESS, GPS Locations, 2015

Aquatic Invasive Plant Beds

Figure 9



Ecological and Management Study - DelCarte Ponds **Conceptual Habitat Improvement Areas**

Franklin, MA

1 inch = 300 feet

Source: MassGIS/USGS, Color Ortho, 2013

Figure 10

Appendix A

Laboratory Results

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Phone: 860-774-6814
Toll-Free: 800-334-0103

ANALYTICAL DATA REPORT

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David Dickinson
Technical Director

CT DPH #PH-0465 EPA #CT00008 MA DEP #M-CT008 MD #349 ME DHHS #CT0050
NH ELAP #2020 NY ELAP #11549 PA DEP #68-04413 RI DOH #LAO00346 VA #460279 VT DOH #VT11549

101-000000482770

61 Louisa Viens Drive
Dayville, CT 06241
Fax: 860-774-2689
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Toll-Free: 800-334-0103

Report No: E511776
Client: ESS Group, Inc.
Project: F455 - Franklin

CASE NARRATIVE / METHOD CONFORMANCE SUMMARY

This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included, along with a copy of the chain of custody and any subcontracted analyses reports, if applicable, for the sample(s) in this report. Subcontractor results are identified by 'SUB' next to the analysis.

Microbac Laboratories, Inc. received two samples from ESS Group, Inc. on 11/06/2015. The samples were analyzed for the following list of analyses in accordance with MA DEP regulations unless otherwise indicated:

Nitrogen: Total Nitrogen by Calculation
351.1[351.1], 351.2, SM4500-NO3-F

Phosphorus, Total as P by 365.1 in DW/WW
365.1[365.1]

Non-Conformances:

Work Order:

None

Sample:

None

Analysis:

None

Microbac Laboratories, Inc.
Analytical Data Report

Report No: E511776
Date Received: 11/06/2015 16:30

Customer: ESS Group, Inc.
Project: F455 - Franklin

Parameter	Result	DL	Units	Completed	By	Dilution
(1) Pond #2						
Date Collected: 11/05/2015 11:45 Matrix: Aqueous						
Kjeldahl Nitrogen, Total (TKN) by 351.1	0.84	0.10	mg/L	11/12/2015 11:13	JJT	
Nitrate-Nitrite as N by SM4500-NO3 F.	0.054	0.050	mg/L	11/09/2015 19:01	HEB	
Nitrogen: Total by Calculation	0.89	0.50	mg/L	11/12/2015 16:30	GMP	
Phosphorus as P by 365.1	0.028	0.010	mg/L	11/08/2015 13:10	HEB	
(2) Pond #3						
Date Collected: 11/05/2015 11:15 Matrix: Aqueous						
Kjeldahl Nitrogen, Total (TKN) by 351.1	0.41	0.10	mg/L	11/12/2015 10:24	JJT	
Nitrate-Nitrite as N by SM4500-NO3 F.	ND	0.050	mg/L	11/09/2015 19:02	HEB	
Nitrogen: Total by Calculation	ND	0.50	mg/L	11/12/2015 16:30	GMP	
Phosphorus as P by 365.1	0.012	0.010	mg/L	11/08/2015 13:12	HEB	

Wet Chemistry Duplicate/Matrix Spike Summary

E511776

Sample	Sample	Sample Duplicate	RPD	Spike Amount	LFM Result	% Recovery	Recovery Limits	LCS Result	LCS % Recovery	LCS Recovery Limits	Analysis Date
TKN											
E511766-3	2.80			***10***	13.6	108	***90-110***	9.91	99.1	***90-110***	11/12/2015
E511766-3	2.80	3.01	7.1				***20***				
E511753-2	0.706			***10***	10.3	95.5	***90-110***				
Phosphorus											
E511663-4	0.321			***1.25***	1.45	90.5	***90-110***	1.22	97.7	***90-110***	11/8/2015
E511663-4	0.321	0.326	1.5				***20***				
Nitrate											
E511780-1	3.39			***5.0***	8.37	99.4	***75-125***	5.18	104	***90-110***	11/9/2015
E511780-1	3.39	3.47	2.3				***20***				

When the sample or duplicate concentration is < 5X the DL, the control limit becomes +/- the DL.
When the sample concentration is > 4 X the spiked concentration there is no QC action limit.

MICROBAC®

Microbac Laboratories, Inc.
61 Louisa Viens Drive
Dayville, CT 06241

Chain of Custody

www.microbac.com
800-334-0103

page ____ of ____

Lab WO #: F511770

Project Manager:

Copy of Report To

CUSTOMER: ESS Group
ADDRESS: 10 Hemingway Dr.
E. Prov. RI 02915
DELIVERY:
E-MAIL: CNielsen@essgroup.com
PHONE: FAX:

Billing Information

BILL TO: –
ADDRESS:
ATTN:
PHONE:
E-MAIL:
PURCHASE ORDER #:

Project Information

Project: E455 - Franklin
Location: Franklin MA.
Project Mgr: Carl Nielsen
IN CASE WE HAVE ANY QUESTIONS WHEN SAMPLES ARRIVE WE SHOULD CALL:
E-MAIL:
PHONE:
FAX:

Sample Identification	Date Collected	Time Collected	Sample Matrix	Sample Type: Composite	Sample Type: Grab	Bottle Qty	Analysis: Total Nitrogen *	Total Phos. *								NON-PRES	HCL	HNO_3	H_2SO_4	OTHER
Pond #2	11/5 SB ~~11/5~~ ~~11/6~~	11:45	SW		X		X	X											X	
Pond #3	11/5 SB ~~11/5~~ ~~11/6~~	11:15	SW		X		X	X											X	

PRESERVATIVE VERIFIED Initials: [illegible]

CUSTODY TRANSFER		DATE	TIME
SAMPLER:	C. Nielsen	11/6 ~~11/16~~ SB	4:30pm
RECEIVED:			
RELINQUISHED:	[signature]	11/6 ~~11/16~~ SB	4:30
RECEIVED:			
RELINQUISHED:			
RECEIVED:	[signature]	11/6/15	1630

TURNAROUND TIME REQUESTED (select): Standard RUSH ____ Day

EXPEDITED SERVICE MAY BE SUBJECT TO SURCHARGE

Circle Delivery Method: E-MAIL HARD COPY OTHER

COMMENTS: low Detection limits < 0.01 mg/l
* Needed on Phosphorus
* < 0.5 mg/l needed on Nitrogen

CONDITIONS UPON RECEIPT: (CHECK ONE)

COOLED ☒ AMBIENT ☐ 10.0 °C Upon receipt at lab

ANALYTICAL REPORT

Lab Number:	L1530561
Client:	ESS Group Incorporated 10 Hemingway Dr. 2nd Fl East Providence, RI 02915
ATTN:	Carl Nielsen
Phone:	(401) 330-1224
Project Name:	DELCARTE PONDS
Project Number:	F455
Report Date:	12/02/15

Certifications & Approvals: MA (M-MA086), NY (11148), CT (PH-0574), NH (2003), NJ NELAP (MA935), RI (LAO00065), ME (MA00086), PA (68-03671), VA (460195), MD (348), IL (200077), NC (666), TX (T104704476), DOD (L2217), USDA (Permit #P-330-11-00240).

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name: DELCARTE PONDS
Project Number: F455

Lab Number: L1530561
Report Date: 12/02/15

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L1530561-01	TRIB-1 DRY	WATER	FRANKLIN, MA	11/18/15 11:32	11/20/15
L1530561-02	TRIB-2 DRY	WATER	FRANKLIN, MA	11/18/15 12:00	11/20/15
L1530561-03	TRIB-3 DRY	WATER	FRANKLIN, MA	11/18/15 12:30	11/20/15

Project Name:	DELCARTE PONDS	**Lab Number:**	L1530561
Project Number:	F455	**Report Date:**	12/02/15

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet all of the requirements of NELAC, for all NELAC accredited parameters. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. All specific QC information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY

For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

Project Name:	DELCARTE PONDS	**Lab Number:**	L1530561
Project Number:	F455	**Report Date:**	12/02/15

Case Narrative (continued)

Report Submission

All non-detect (ND) or estimated concentrations (J-qualified) have been quantitated to the limit noted in the MDL column.

Turbidity

L1530561-01 through -03 were analyzed with the method required holding time exceeded.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Cristin Walker Cristin Walker

Title: Technical Director/Representative Date: 12/02/15

INORGANICS
&
MISCELLANEOUS

Project Name: DELCARTE PONDS
Project Number: F455

Lab Number: L1530561
Report Date: 12/02/15

SAMPLE RESULTS

Lab ID: L1530561-01
Client ID: TRIB-1 DRY
Sample Location: FRANKLIN, MA
Matrix: Water

Date Collected: 11/18/15 11:32
Date Received: 11/20/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	1.4		NTU	0.20	0.06	1	-	11/20/15 23:30	30,2130B	LH
Nitrogen, Nitrate/Nitrite	0.58		mg/l	0.10	0.019	1	-	11/21/15 00:01	30,4500NO3-F	MR
Total Nitrogen	0.98		mg/l	0.30	0.30	1	-	11/30/15 10:25	41,-	JO
Nitrogen, Total Kjeldahl	0.397		mg/l	0.300	0.093	1	11/21/15 10:15	11/23/15 22:42	30,4500N-C	AT
Phosphorus, Total	ND		mg/l	0.010	0.003	1	11/24/15 13:30	11/25/15 13:46	30,4500P-E	SD

Project Name:	DELCARTE PONDS	**Lab Number:**	L1530561
Project Number:	F455	**Report Date:**	12/02/15

SAMPLE RESULTS

Lab ID:	L1530561-02	Date Collected:	11/18/15 12:00
Client ID:	TRIB-2 DRY	Date Received:	11/20/15
Sample Location:	FRANKLIN, MA	Field Prep:	Not Specified
Matrix:	Water		

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	0.81		NTU	0.20	0.06	1	-	11/20/15 23:30	30,2130B	LH
Nitrogen, Nitrate/Nitrite	0.86		mg/l	0.10	0.019	1	-	11/21/15 00:02	30,4500NO3-F	MR
Total Nitrogen	1.3		mg/l	0.30	0.30	1	-	11/30/15 10:25	41,-	JO
Nitrogen, Total Kjeldahl	0.404		mg/l	0.300	0.093	1	11/21/15 10:15	11/23/15 23:03	30,4500N-C	AT
Phosphorus, Total	ND		mg/l	0.010	0.003	1	11/24/15 13:30	11/25/15 13:48	30,4500P-E	SD

Project Name: DELCARTE PONDS
Project Number: F455

Lab Number: L1530561
Report Date: 12/02/15

SAMPLE RESULTS

Lab ID: L1530561-03
Client ID: TRIB-3 DRY
Sample Location: FRANKLIN, MA
Matrix: Water

Date Collected: 11/18/15 12:30
Date Received: 11/20/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	2.2		NTU	0.20	0.06	1	-	11/20/15 23:30	30,2130B	LH
Nitrogen, Nitrate/Nitrite	1.3		mg/l	0.10	0.019	1	-	11/21/15 00:03	30,4500NO3-F	MR
Total Nitrogen	1.3		mg/l	0.30	0.30	1	-	11/30/15 10:25	41,-	JO
Nitrogen, Total Kjeldahl	0.284	J	mg/l	0.300	0.093	1	11/21/15 10:15	11/23/15 23:04	30,4500N-C	AT
Phosphorus, Total	ND		mg/l	0.010	0.003	1	11/24/15 13:30	11/25/15 13:49	30,4500P-E	SD

Project Name: DELCARTE PONDS **Lab Number:** L1530561
Project Number: F455 **Report Date:** 12/02/15

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG842945-1										
Nitrogen, Nitrate/Nitrite	ND		mg/l	0.10	0.019	1	-	11/20/15 16:33	30,4500NO3-F	MR
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG843051-1										
Turbidity	0.11	J	NTU	0.20	0.06	1	-	11/20/15 23:30	30,2130B	LH
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG843151-1										
Nitrogen, Total Kjeldahl	ND		mg/l	0.300	0.031	1	11/21/15 10:15	11/23/15 22:35	30,4500N-C	AT
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG844050-1										
Phosphorus, Total	ND		mg/l	0.010	0.003	1	11/24/15 13:30	11/25/15 14:53	30,4500P-E	SD

Lab Control Sample Analysis
Batch Quality Control

Project Name: DELCARTE PONDS
Project Number: F455
Lab Number: L1530561
Report Date: 12/02/15

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG842945-2								
Nitrogen, Nitrate/Nitrite	102		-		90-110	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG843051-2								
Turbidity	105		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG843151-2								
Nitrogen, Total Kjeldahl	96		-		78-122	-		
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG844050-2								
Phosphorus, Total	102		-		80-120	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: DELCARTE PONDS
Project Number: F455

Lab Number: L1530561
Report Date: 12/02/15

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG842945-4 QC Sample: L1530501-03 Client ID: MS Sample												
Nitrogen, Nitrate/Nitrite	0.021J	4	4.0	100		-	-		80-120	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG843151-4 QC Sample: L1530561-03 Client ID: TRIB-3 DRY												
Nitrogen, Total Kjeldahl	0.284J	8	7.59	95		-	-		77-111	-		24
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG844050-3 QC Sample: L1530561-03 Client ID: TRIB-3 DRY												
Phosphorus, Total	ND	0.5	0.516	103		-	-		75-125	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: DELCARTE PONDS
Project Number: F455

Lab Number: L1530561
Report Date: 12/02/15

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG842945-3 QC Sample: L1530501-03 Client ID: DUP Sample						
Nitrogen, Nitrate/Nitrite	0.021J	0.020J	mg/l	NC		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG843051-3 QC Sample: L1530561-01 Client ID: TRIB-1 DRY						
Turbidity	1.4	1.4	NTU	0		13
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG843151-3 QC Sample: L1530561-03 Client ID: TRIB-3 DRY						
Nitrogen, Total Kjeldahl	0.284J	0.342	mg/l	NC		24
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG844050-4 QC Sample: L1530561-03 Client ID: TRIB-3 DRY						
Phosphorus, Total	ND	ND	mg/l	NC		20

Project Name: DELCARTE PONDS **Lab Number:** L1530561
Project Number: F455 **Report Date:** 12/02/15

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information Custody Seal

Cooler	Custody Seal
A	Absent

Container Information

Container ID	Container Type	Cooler	pH	Temp deg C	Pres	Seal	Analysis(*)
L1530561-01A	Plastic 250ml H2SO4 preserved	A	<2	3.7	Y	Absent	NO3/NO2-4500(28)
L1530561-01B	Plastic 500ml H2SO4 preserved	A	<2	3.7	Y	Absent	TKN-4500(28),TPHOS-4500(28),TNITROGEN(28)
L1530561-01C	Plastic 120ml unpreserved	A	7	3.7	Y	Absent	TURB-2130(2)
L1530561-02A	Plastic 250ml H2SO4 preserved	A	<2	3.7	Y	Absent	NO3/NO2-4500(28)
L1530561-02B	Plastic 500ml H2SO4 preserved	A	<2	3.7	Y	Absent	TKN-4500(28),TPHOS-4500(28),TNITROGEN(28)
L1530561-02C	Plastic 120ml unpreserved	A	7	3.7	Y	Absent	TURB-2130(2)
L1530561-03A	Plastic 250ml H2SO4 preserved	A	<2	3.7	Y	Absent	NO3/NO2-4500(28)
L1530561-03B	Plastic 500ml H2SO4 preserved	A	<2	3.7	Y	Absent	TKN-4500(28),TPHOS-4500(28),TNITROGEN(28)
L1530561-03C	Plastic 120ml unpreserved	A	7	3.7	Y	Absent	TURB-2130(2)

*Values in parentheses indicate holding time in days

GLOSSARY

Acronyms

EDL	- Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).
EPA	- Environmental Protection Agency.
LCS	- Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
LCSD	- Laboratory Control Sample Duplicate: Refer to LCS.
LFB	- Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.
MDL	- Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
MS	- Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.
MSD	- Matrix Spike Sample Duplicate: Refer to MS.
NA	- Not Applicable.
NC	- Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.
NI	- Not Ignitable.
NP	- Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.
RL	- Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.
RPD	- Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.
SRM	- Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.
STLP	- Semi-dynamic Tank Leaching Procedure per EPA Method 1315.
TIC	- Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

Report Format: DU Report with 'J' Qualifiers

Project Name:	DELCARTE PONDS	**Lab Number:**	L1530561
Project Number:	F455	**Report Date:**	12/02/15

Data Qualifiers

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

J - Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL) or Estimated Detection Limit (EDL) for SPME-related analyses. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

ND - Not detected at the method detection limit (MDL) for the sample, or estimated detection limit (EDL) for SPME-related analyses.

Report Format: DU Report with 'J' Qualifiers

REFERENCES

30 Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF. 18th Edition. 1992.

41 Alpha Analytical Labs Internally-developed Performance-based Method.

LIMITATION OF LIABILITIES

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 8260C: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene; Iodomethane (methyl iodide) (soil); Methyl methacrylate (soil); Azobenzene.
EPA 8270D: Dimethylnaphthalene,1,4-Diphenylhydrazine.
EPA 625: 4-Chloroaniline, 4-Methylphenol.
SM4500: Soil: Total Phosphorus, TKN, NO2, NO3.

Mansfield Facility
EPA 8270D: Biphenyl.
EPA 2540D: TSS
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.

The following analytes are included in our Massachusetts DEP Scope of Accreditation, Westborough Facility:

Drinking Water
EPA 200.8: Sb,As,Ba,Be,Cd,Cr,Cu,Pb,Ni,Se,Tl; **EPA 200.7**: Ba,Be,Ca,Cd,Cr,Cu,Na; **EPA 245.1:** Mercury;
EPA 300.0: Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT, Enterolert-QT.**

Non-Potable Water
EPA 200.8: Al,Sb,As,Be,Cd,Cr,Cu,Pb,Mn,Ni,Se,Ag,Tl,Zn;
EPA 200.7: Al,Sb,As,Be,Cd,Ca,Cr,Co,Cu,Fe,Pb,Mg,Mn,Mo,Ni,K,Se,Ag,Na,Sr,Ti,Tl,V,Zn;
EPA 245.1, SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2340B, SM2320B, SM4500CL-E, SM4500F-BC, SM426C, SM4500NH3-BH, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500NH3-BC-NES, EPA 351.1, SM4500P-E, SM4500P-B, E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, SM14 510AC, EPA 420.1, SM4500-CN-CE, SM2540D.**
EPA 624: Volatile Halocarbons & Aromatics,
EPA 608: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9222D-MF**.

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

CHAIN OF CUSTODY

PAGE 1 OF 1

Date Rec'd in Lab: 11/20/15

ALPHA Job #: L1530561

ALPHA ANALYTICAL
8 Walkup Drive, Westboro, MA 01581, Tel: 508-898-9220
320 Forbes Blvd, Mansfield, MA 02048, Tel: 508-822-9300

Project Information

Project Name: Del Carte Ponds
Project Location: FRANKLIN, MA
Project #: F455
Project Manager: CARL NIELSEN
ALPHA Quote #:

Report Information - Data Deliverables

☐ ADEx ☒ EMAIL

Billing Information

☒ Same as Client info PO #:

Client Information

Client: ESS GROUP, INC.
Address: 10 HEMINGWAY DR. 2ND FLR, EAST PROVIDENCE, RI 02915
Phone: 401-330-1224
Email: CNIELSEN@ESSGROUP.COM

Regulatory Requirements & Project Information Requirements

☐ Yes ☐ No MA MCP Analytical Methods ☐ Yes ☐ No CT RCP Analytical Methods
☐ Yes ☐ No Matrix Spike Required on this SDG? (Required for MCP Inorganics)
☐ Yes ☐ No GW1 Standards (Info Required for Metals & EPH with Targets)
☐ Yes ☐ No NPDES RGP
☐ Other State /Fed Program ______ Criteria ______

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due:

Additional Project Information:

ANALYSIS: VOC: ☐ 8260 ☐ 624 ☐ 524.2; SVOC: ☐ ABN ☐ PAH; METALS: ☐ MCP 13 ☐ MCP 14 ☐ RCP 15; METALS: ☐ RCRA5 ☐ RCRA8 ☐ PP13; EPH: ☐ Ranges & Targets ☐ Ranges Only; VPH: ☐ Ranges & Targets ☐ Ranges Only; ☐ PCB ☐ PEST; TPH: ☐ Quant Only ☐ Fingerprint; Total Phos. *; Total Nitrogen; Turbidity

SAMPLE INFO: Filtration ☐ Field ☐ Lab to do; Preservation ☐ Lab to do

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler Initials	Total Phos. *	Total Nitrogen	Turbidity	Sample Comments	TOTAL # BOTTLES
30561-01	TRIB 1 - DRY	11/18/15	11:32	SW	JT/AP	X	X	X	Total * Phos.	3
02	TRIB 2 - DRY	11/18/15	12:00	SW	JT/AP	X	X	X	Detection	3
03	TRIB 3 - DRY	11/18/15	12:30	SW	JT/AP	X	X	X	Limit	3
	~~TRIB 1 - WET~~			~~SW~~		~~X~~	~~X~~	~~X~~	Must Be	~~3~~
	~~TRIB 2 - WET~~			~~SW~~		~~X~~	~~X~~	~~X~~	0.01 mg/L	~~3~~
	~~TRIB 3 - WET~~			~~SW~~		~~X~~	~~X~~	~~X~~	or Better.	~~3~~

	Total Phos.	Total Nitrogen	Turbidity
Container Type	P	P	P
Preservative	D	D	A

Container Type: P= Plastic, A= Amber glass, V= Vial, G= Glass, B= Bacteria cup, C= Cube, O= Other, E= Encore, D= BOD Bottle

Preservative: A= None, B= HCl, C= HNO_3, D= H_2SO_4, E= NaOH, F= MeOH, G= $NaHSO_4$, H = $Na_2S_2O_3$, I= Ascorbic Acid, J = NH_4Cl, K= Zn Acetate, O= Other

Relinquished By:	Date/Time	Received By:	Date/Time
[signature]	11/20/15 11:08	Pat Cure AAL	11/20/15 11:08
Pat Cure	11/20/15	[signature]	11/20/15 1927

FORM NO: 01-01 (rev. 12-Mar-2012)

ANALYTICAL REPORT

Lab Number:	L1531722
Client:	ESS Group Incorporated 10 Hemingway Dr. 2nd Fl East Providence, RI 02915
ATTN:	Carl Nielsen
Phone:	(401) 330-1224
Project Name:	DELCARTE PONDS
Project Number:	F455-000.02
Report Date:	12/14/15

Certifications & Approvals: MA (M-MA086), NY (11148), CT (PH-0574), NH (2003), NJ NELAP (MA935), RI (LAO00065), ME (MA00086), PA (68-03671), VA (460195), MD (348), IL (200077), NC (666), TX (T104704476), DOD (L2217), USDA (Permit #P-330-11-00240).

Eight Walkup Drive, Westborough, MA 01581-1019
508-898-9220 (Fax) 508-898-9193 800-624-9220 - www.alphalab.com

Project Name: DELCARTE PONDS
Project Number: F455-000.02

Lab Number: L1531722
Report Date: 12/14/15

Alpha Sample ID	Client ID	Matrix	Sample Location	Collection Date/Time	Receive Date
L1531722-01	TRIB 1-WET	WATER	FRANKLIN, MA	12/02/15 20:34	12/03/15
L1531722-02	TRIB 2-WET	WATER	FRANKLIN, MA	12/02/15 21:02	12/03/15
L1531722-03	TRIB 3-WET	WATER	FRANKLIN, MA	12/02/15 21:16	12/03/15

Case Narrative

The samples were received in accordance with the Chain of Custody and no significant deviations were encountered during the preparation or analysis unless otherwise noted. Sample Receipt, Container Information, and the Chain of Custody are located at the back of the report.

Results contained within this report relate only to the samples submitted under this Alpha Lab Number and meet all of the requirements of NELAC, for all NELAC accredited parameters. The data presented in this report is organized by parameter (i.e. VOC, SVOC, etc.). Sample specific Quality Control data (i.e. Surrogate Spike Recovery) is reported at the end of the target analyte list for each individual sample, followed by the Laboratory Batch Quality Control at the end of each parameter. Tentatively Identified Compounds (TICs), if requested, are reported for compounds identified to be present and are not part of the method/program Target Compound List, even if only a subset of the TCL are being reported. If a sample was re-analyzed or re-extracted due to a required quality control corrective action and if both sets of data are reported, the Laboratory ID of the re-analysis or re-extraction is designated with an "R" or "RE", respectively. When multiple Batch Quality Control elements are reported (e.g. more than one LCS), the associated samples for each element are noted in the grey shaded header line of each data table. Any Laboratory Batch, Sample Specific % recovery or RPD value that is outside the listed Acceptance Criteria is bolded in the report. All specific QC information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications. Soil/sediments, solids and tissues are reported on a dry weight basis unless otherwise noted. Definitions of all data qualifiers and acronyms used in this report are provided in the Glossary located at the back of the report.

In reference to questions H (CAM) or 4 (RCP) when "NO" is checked, the performance criteria for CAM and RCP methods allow for some quality control failures to occur and still be within method compliance. In these instances the specific failure is not narrated but noted in the associated QC table. The information is also incorporated in the Data Usability format of our Data Merger tool where it can be reviewed along with any associated usability implications.

Please see the associated ADEx data file for a comparison of laboratory reporting limits that were achieved with the regulatory Numerical Standards requested on the Chain of Custody.

HOLD POLICY
For samples submitted on hold, Alpha's policy is to hold samples (with the exception of Air canisters) free of charge for 21 calendar days from the date the project is completed. After 21 calendar days, we will dispose of all samples submitted including those put on hold unless you have contacted your Client Service Representative and made arrangements for Alpha to continue to hold the samples. Air canisters will be disposed after 3 business days from the date the project is completed.

Please contact Client Services at 800-624-9220 with any questions.

Project Name:	DELCARTE PONDS	**Lab Number:**	L1531722
Project Number:	F455-000.02	**Report Date:**	12/14/15

Case Narrative (continued)

Report Submission

All non-detect (ND) or estimated concentrations (J-qualified) have been quantitated to the limit noted in the MDL column.

I, the undersigned, attest under the pains and penalties of perjury that, to the best of my knowledge and belief and based upon my personal inquiry of those responsible for providing the information contained in this analytical report, such information is accurate and complete. This certificate of analysis is not complete unless this page accompanies any and all pages of this report.

Authorized Signature: Michelle M. Morris Michelle M. Morris

Title: Technical Director/Representative

Date: 12/14/15

INORGANICS
&
MISCELLANEOUS

Project Name: DELCARTE PONDS
Project Number: F455-000.02

Lab Number: L1531722
Report Date: 12/14/15

SAMPLE RESULTS

Lab ID: L1531722-01
Client ID: TRIB 1-WET
Sample Location: FRANKLIN, MA
Matrix: Water

Date Collected: 12/02/15 20:34
Date Received: 12/03/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	2.0		NTU	0.20	0.06	1	-	12/03/15 15:10	30,2130B	KZ
pH (H)	6.6		SU	-	NA	1	-	12/03/15 15:50	1,9040C	KZ
Nitrogen, Nitrate/Nitrite	0.49		mg/l	0.10	0.019	1	-	12/04/15 21:35	30,4500NO3-F	MR
Total Nitrogen	0.88		mg/l	0.30	0.30	1	-	12/09/15 09:40	41,-	JO
Nitrogen, Total Kjeldahl	0.386		mg/l	0.300	0.093	1	12/03/15 19:00	12/07/15 21:16	30,4500N-C	AT
Phosphorus, Total	0.012		mg/l	0.010	0.003	1	12/08/15 11:15	12/09/15 12:07	30,4500P-E	SD

Project Name: DELCARTE PONDS
Lab Number: L1531722
Project Number: F455-000.02
Report Date: 12/14/15

SAMPLE RESULTS

Lab ID: L1531722-02
Client ID: TRIB 2-WET
Sample Location: FRANKLIN, MA
Matrix: Water
Date Collected: 12/02/15 21:02
Date Received: 12/03/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	1.4		NTU	0.20	0.06	1	-	12/03/15 15:10	30,2130B	KZ
pH (H)	6.6		SU	-	NA	1	-	12/03/15 15:50	1,9040C	KZ
Nitrogen, Nitrate/Nitrite	0.66		mg/l	0.10	0.019	1	-	12/04/15 21:39	30,4500NO3-F	MR
Total Nitrogen	1.1		mg/l	0.30	0.30	1	-	12/09/15 09:40	41,-	JO
Nitrogen, Total Kjeldahl	0.402		mg/l	0.300	0.093	1	12/03/15 19:00	12/07/15 21:19	30,4500N-C	AT
Phosphorus, Total	0.011		mg/l	0.010	0.003	1	12/08/15 11:15	12/09/15 12:09	30,4500P-E	SD

Project Name: DELCARTE PONDS | **Lab Number:** L1531722
Project Number: F455-000.02 | **Report Date:** 12/14/15

SAMPLE RESULTS

Lab ID: L1531722-03
Client ID: TRIB 3-WET
Sample Location: FRANKLIN, MA
Matrix: Water

Date Collected: 12/02/15 21:16
Date Received: 12/03/15
Field Prep: Not Specified

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab										
Turbidity	2.6		NTU	0.20	0.06	1	-	12/03/15 15:10	30,2130B	KZ
pH (H)	6.0		SU	-	NA	1	-	12/03/15 15:50	1,9040C	KZ
Nitrogen, Nitrate/Nitrite	0.75		mg/l	0.10	0.019	1	-	12/04/15 21:40	30,4500NO3-F	MR
Total Nitrogen	1.1		mg/l	0.30	0.30	1	-	12/09/15 09:40	41,-	JO
Nitrogen, Total Kjeldahl	0.370		mg/l	0.300	0.093	1	12/03/15 19:00	12/07/15 21:20	30,4500N-C	AT
Phosphorus, Total	0.010		mg/l	0.010	0.003	1	12/08/15 11:15	12/09/15 12:10	30,4500P-E	SD

Project Name: DELCARTE PONDS **Lab Number:** L1531722
Project Number: F455-000.02 **Report Date:** 12/14/15

Method Blank Analysis
Batch Quality Control

Parameter	Result	Qualifier	Units	RL	MDL	Dilution Factor	Date Prepared	Date Analyzed	Analytical Method	Analyst
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG846421-1										
Turbidity	0.14	J	NTU	0.20	0.06	1	-	12/03/15 15:10	30,2130B	KZ
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG846499-1										
Nitrogen, Total Kjeldahl	ND		mg/l	0.300	0.031	1	12/03/15 19:00	12/07/15 21:10	30,4500N-C	AT
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG846866-1										
Nitrogen, Nitrate/Nitrite	ND		mg/l	0.10	0.019	1	-	12/04/15 20:09	30,4500NO3-F	MR
General Chemistry - Westborough Lab for sample(s): 01-03 Batch: WG847866-1										
Phosphorus, Total	ND		mg/l	0.010	0.003	1	12/08/15 11:15	12/09/15 11:49	30,4500P-E	SD

Lab Control Sample Analysis
Batch Quality Control

Project Name: DELCARTE PONDS

Project Number: F455-000.02

Lab Number: L1531722

Report Date: 12/14/15

Parameter	LCS %Recovery	Qual	LCSD %Recovery	Qual	%Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG846421-2								
Turbidity	104		-		90-110	-		
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG846423-1								
pH	100		-		99-101	-		5
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG846499-2								
Nitrogen, Total Kjeldahl	102		-		78-122	-		
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG846866-2								
Nitrogen, Nitrate/Nitrite	102		-		90-110	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 Batch: WG847866-2								
Phosphorus, Total	95		-		80-120	-		

Matrix Spike Analysis
Batch Quality Control

Project Name: DELCARTE PONDS
Project Number: F455-000.02
Lab Number: L1531722
Report Date: 12/14/15

Parameter	Native Sample	MS Added	MS Found	MS %Recovery	Qual	MSD Found	MSD %Recovery	Qual	Recovery Limits	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846499-4 QC Sample: L1531738-02 Client ID: MS Sample												
Nitrogen, Total Kjeldahl	0.248J	8	7.54	94		-	-		77-111	-		24
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846866-4 QC Sample: L1531722-01 Client ID: TRIB 1-WET												
Nitrogen, Nitrate/Nitrite	0.49	4	4.4	98		-	-		80-120	-		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG847866-3 QC Sample: L1530889-01 Client ID: MS Sample												
Phosphorus, Total	ND	0.5	0.459	92		-	-		75-125	-		20

Lab Duplicate Analysis
Batch Quality Control

Project Name: DELCARTE PONDS
Project Number: F455-000.02
Lab Number: L1531722
Report Date: 12/14/15

Parameter	Native Sample	Duplicate Sample	Units	RPD	Qual	RPD Limits
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846421-3 QC Sample: L1531722-01 Client ID: TRIB 1-WET						
Turbidity	2.0	1.8	NTU	11		13
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846423-2 QC Sample: L1531722-01 Client ID: TRIB 1-WET						
pH (H)	6.6	6.5	SU	2		5
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846499-3 QC Sample: L1531738-02 Client ID: DUP Sample						
Nitrogen, Total Kjeldahl	0.248J	0.680	mg/l	NC		24
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG846866-3 QC Sample: L1531722-01 Client ID: TRIB 1-WET						
Nitrogen, Nitrate/Nitrite	0.49	0.50	mg/l	2		20
General Chemistry - Westborough Lab Associated sample(s): 01-03 QC Batch ID: WG847866-4 QC Sample: L1530889-01 Client ID: DUP Sample						
Phosphorus, Total	ND	ND	mg/l	NC		20

Project Name: DELCARTE PONDS
Project Number: F455-000.02

Lab Number: L1531722
Report Date: 12/14/15

Sample Receipt and Container Information

Were project specific reporting limits specified? YES

Cooler Information Cooler	Custody Seal
A	Absent

Container Information

Container ID	Container Type	Cooler	pH	Temp deg C	Pres	Seal	Analysis(*)
L1531722-01A	Plastic 250ml H2SO4 preserved	A	<2	2.5	Y	Absent	TPHOS-4500(28)
L1531722-01B	Plastic 500ml H2SO4 preserved	A	<2	2.5	Y	Absent	TKN-4500(28),NO3/NO2-4500(28),TNITROGEN(28)
L1531722-01C	Plastic 120ml unpreserved	A	7	2.5	Y	Absent	TURB-2130(2),PH-9040(1)
L1531722-02A	Plastic 250ml H2SO4 preserved	A	<2	2.5	Y	Absent	TPHOS-4500(28)
L1531722-02B	Plastic 500ml H2SO4 preserved	A	<2	2.5	Y	Absent	TKN-4500(28),NO3/NO2-4500(28),TNITROGEN(28)
L1531722-02C	Plastic 120ml unpreserved	A	7	2.5	Y	Absent	TURB-2130(2),PH-9040(1)
L1531722-03A	Plastic 250ml H2SO4 preserved	A	<2	2.5	Y	Absent	TPHOS-4500(28)
L1531722-03B	Plastic 500ml H2SO4 preserved	A	<2	2.5	Y	Absent	TKN-4500(28),NO3/NO2-4500(28),TNITROGEN(28)
L1531722-03C	Plastic 120ml unpreserved	A	7	2.5	Y	Absent	TURB-2130(2),PH-9040(1)

*Values in parentheses indicate holding time in days

GLOSSARY

Acronyms

EDL - Estimated Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The EDL includes any adjustments from dilutions, concentrations or moisture content, where applicable. The use of EDLs is specific to the analysis of PAHs using Solid-Phase Microextraction (SPME).

EPA - Environmental Protection Agency.

LCS - Laboratory Control Sample: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

LCSD - Laboratory Control Sample Duplicate: Refer to LCS.

LFB - Laboratory Fortified Blank: A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes.

MDL - Method Detection Limit: This value represents the level to which target analyte concentrations are reported as estimated values, when those target analyte concentrations are quantified below the reporting limit (RL). The MDL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

MS - Matrix Spike Sample: A sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of target analyte concentration is available.

MSD - Matrix Spike Sample Duplicate: Refer to MS.

NA - Not Applicable.

NC - Not Calculated: Term is utilized when one or more of the results utilized in the calculation are non-detect at the parameter's reporting unit.

NI - Not Ignitable.

NP - Non-Plastic: Term is utilized for the analysis of Atterberg Limits in soil.

RL - Reporting Limit: The value at which an instrument can accurately measure an analyte at a specific concentration. The RL includes any adjustments from dilutions, concentrations or moisture content, where applicable.

RPD - Relative Percent Difference: The results from matrix and/or matrix spike duplicates are primarily designed to assess the precision of analytical results in a given matrix and are expressed as relative percent difference (RPD). Values which are less than five times the reporting limit for any individual parameter are evaluated by utilizing the absolute difference between the values; although the RPD value will be provided in the report.

SRM - Standard Reference Material: A reference sample of a known or certified value that is of the same or similar matrix as the associated field samples.

STLP - Semi-dynamic Tank Leaching Procedure per EPA Method 1315.

TIC - Tentatively Identified Compound: A compound that has been identified to be present and is not part of the target compound list (TCL) for the method and/or program. All TICs are qualitatively identified and reported as estimated concentrations.

Footnotes

1 - The reference for this analyte should be considered modified since this analyte is absent from the target analyte list of the original method.

Terms

Total: With respect to Organic analyses, a 'Total' result is defined as the summation of results for individual isomers or Aroclors. If a 'Total' result is requested, the results of its individual components will also be reported. This is applicable to 'Total' results for methods 8260, 8081 and 8082.

Analytical Method: Both the document from which the method originates and the analytical reference method. (Example: EPA 8260B is shown as 1,8260B.) The codes for the reference method documents are provided in the References section of the Addendum.

Data Qualifiers

A - Spectra identified as "Aldol Condensation Product".

B - The analyte was detected above the reporting limit in the associated method blank. Flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For MCP-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank. For DOD-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte at less than ten times (10x) the concentration found in the blank AND the analyte was detected above one-half the reporting limit (or above the reporting limit for common lab contaminants) in the associated method blank. For NJ-Air-related projects, flag only applies to associated field samples that have detectable concentrations of the analyte above the reporting limit. For NJ-related projects (excluding Air), flag only applies to associated field samples that have detectable concentrations of the analyte, which was detected above the reporting limit in the associated method blank or above five times the reporting limit for common lab contaminants (Phthalates, Acetone, Methylene Chloride, 2-Butanone).

Report Format: DU Report with 'J' Qualifiers

Project Name: DELCARTE PONDS **Lab Number:** L1531722
Project Number: F455-000.02 **Report Date:** 12/14/15

Data Qualifiers

C - Co-elution: The target analyte co-elutes with a known lab standard (i.e. surrogate, internal standards, etc.) for co-extracted analyses.

D - Concentration of analyte was quantified from diluted analysis. Flag only applies to field samples that have detectable concentrations of the analyte.

E - Concentration of analyte exceeds the range of the calibration curve and/or linear range of the instrument.

G - The concentration may be biased high due to matrix interferences (i.e, co-elution) with non-target compound(s). The result should be considered estimated.

H - The analysis of pH was performed beyond the regulatory-required holding time of 15 minutes from the time of sample collection.

I - The lower value for the two columns has been reported due to obvious interference.

M - Reporting Limit (RL) exceeds the MCP CAM Reporting Limit for this analyte.

NJ - Presumptive evidence of compound. This represents an estimated concentration for Tentatively Identified Compounds (TICs), where the identification is based on a mass spectral library search.

P - The RPD between the results for the two columns exceeds the method-specified criteria.

Q - The quality control sample exceeds the associated acceptance criteria. For DOD-related projects, LCS and/or Continuing Calibration Standard exceedences are also qualified on all associated sample results. Note: This flag is not applicable for matrix spike recoveries when the sample concentration is greater than 4x the spike added or for batch duplicate RPD when the sample concentrations are less than 5x the RL. (Metals only.)

R - Analytical results are from sample re-analysis.

RE - Analytical results are from sample re-extraction.

S - Analytical results are from modified screening analysis.

J - Estimated value. The Target analyte concentration is below the quantitation limit (RL), but above the Method Detection Limit (MDL) or Estimated Detection Limit (EDL) for SPME-related analyses. This represents an estimated concentration for Tentatively Identified Compounds (TICs).

ND - Not detected at the method detection limit (MDL) for the sample, or estimated detection limit (EDL) for SPME-related analyses.

Report Format: DU Report with 'J' Qualifiers

REFERENCES

1 Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. EPA SW-846. Third Edition. Updates I - IV, 2007.

30 Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF. 18th Edition. 1992.

41 Alpha Analytical Labs Internally-developed Performance-based Method.

LIMITATION OF LIABILITIES

Alpha Analytical performs services with reasonable care and diligence normal to the analytical testing laboratory industry. In the event of an error, the sole and exclusive responsibility of Alpha Analytical shall be to re-perform the work at it's own expense. In no event shall Alpha Analytical be held liable for any incidental, consequential or special damages, including but not limited to, damages in any way connected with the use of, interpretation of, information or analysis provided by Alpha Analytical.

We strongly urge our clients to comply with EPA protocol regarding sample volume, preservation, cooling, containers, sampling procedures, holding time and splitting of samples in the field.

Certification Information

The following analytes are not included in our Primary NELAP Scope of Accreditation:

Westborough Facility
EPA 524.2: 1,2-Dibromo-3-chloropropane, 1,2-Dibromoethane, m/p-xylene, o-xylene
EPA 624: 2-Butanone (MEK), 1,4-Dioxane, tert-Amylmethyl Ether, tert-Butyl Alcohol, m/p-xylene, o-xylene
EPA 625: Aniline, Benzoic Acid, Benzyl Alcohol, 4-Chloroaniline, 3-Methylphenol, 4-Methylphenol.
EPA 1010A: NPW: Ignitability
EPA 6010C: NPW: Strontium; SCM: Strontium
EPA 8151A: NPW: 2,4-DB, Dicamba, Dichloroprop, MCPA, MCPP; SCM: 2,4-DB, Dichloroprop, MCPA, MCPP
EPA 8260C: NPW: 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene, Azobenzene, Isopropanol; SCM: Iodomethane (methyl iodide), Methyl methacrylate (soil); 1,2,4,5-Tetramethylbenzene; 4-Ethyltoluene.
EPA 8270D: NPW: Pentachloronitrobenzene, 1-Methylnaphthalene, Dimethylnaphthalene,1,4-Diphenylhydrazine; SCM: Pentachloronitrobenzene, 1-Methylnaphthalene, Dimethylnaphthalene,1,4-Diphenylhydrazine.
EPA 9010: NPW: Amenable Cyanide Distillation, Total Cyanide Distillation
EPA 9038: NPW: Sulfate
EPA 9050A: NPW: Specific Conductance
EPA 9056: NPW: Chloride, Nitrate, Sulfate
EPA 9065: NPW: Phenols
EPA 9251: NPW: Chloride
SM3500: NPW: Ferrous Iron
SM4500: NPW: Amenable Cyanide, Dissolved Oxygen; SCM: Total Phosphorus, TKN, NO2, NO3.
SM5310C: DW: Dissolved Organic Carbon

Mansfield Facility
EPA 8270D: NPW: Biphenyl; SCM: Biphenyl
EPA 2540D: TSS
EPA TO-15: Halothane, 2,4,4-Trimethyl-2-pentene, 2,4,4-Trimethyl-1-pentene, Thiophene, 2-Methylthiophene, 3-Methylthiophene, 2-Ethylthiophene, 1,2,3-Trimethylbenzene, Indan, Indene, 1,2,4,5-Tetramethylbenzene, Benzothiophene, 1-Methylnaphthalene.

The following analytes are included in our Massachusetts DEP Scope of Accreditation, Westborough Facility:

Drinking Water
EPA 200.8: Sb,As,Ba,Be,Cd,Cr,Cu,Pb,Ni,Se,Tl; **EPA 200.7**: Ba,Be,Ca,Cd,Cr,Cu,Na; **EPA 245.1:** Mercury;
EPA 300.0: Nitrate-N, Fluoride, Sulfate; **EPA 353.2**: Nitrate-N, Nitrite-N; **SM4500NO3-F**: Nitrate-N, Nitrite-N; **SM4500F-C, SM4500CN-CE, EPA 180.1, SM2130B, SM4500Cl-D, SM2320B, SM2540C, SM4500H-B**
EPA 332: Perchlorate.
Microbiology: **SM9215B; SM9223-P/A, SM9223B-Colilert-QT, Enterolert-QT.**

Non-Potable Water
EPA 200.8: Al,Sb,As,Be,Cd,Cr,Cu,Pb,Mn,Ni,Se,Ag,Tl,Zn;
EPA 200.7: Al,Sb,As,Be,Cd,Ca,Cr,Co,Cu,Fe,Pb,Mg,Mn,Mo,Ni,K,Se,Ag,Na,Sr,Ti,Tl,V,Zn;
EPA 245.1, SM4500H,B, EPA 120.1, SM2510B, SM2540C, SM2340B, SM2320B, SM4500CL-E, SM4500F-BC, SM426C, SM4500NH3-BH, **EPA 350.1**: Ammonia-N, **LACHAT 10-107-06-1-B**: Ammonia-N, **SM4500NO3-F, EPA 353.2**: Nitrate-N**, SM4500NH3-BC-NES, EPA 351.1, SM4500P-E, SM4500P-B, E, SM5220D, EPA 410.4, SM5210B, SM5310C, SM4500CL-D, EPA 1664, SM14 510AC, EPA 420.1, SM4500-CN-CE, SM2540D.**
EPA 624: Volatile Halocarbons & Aromatics,
EPA 608: Chlordane, Toxaphene, Aldrin, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, Dieldrin, DDD, DDE, DDT, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin Aldehyde, Heptachlor, Heptachlor Epoxide, PCBs
EPA 625: SVOC (Acid/Base/Neutral Extractables), **EPA 600/4-81-045**: PCB-Oil.
Microbiology: **SM9223B-Colilert-QT; Enterolert-QT, SM9222D-MF**.

For a complete listing of analytes and methods, please contact your Alpha Project Manager.

CHAIN OF CUSTODY

PAGE 1 OF 1

ALPHA ANALYTICAL

WESTBORO, MA
TEL: 508-898-9220
FAX: 508-898-9193

MANSFIELD, MA
TEL: 508-822-9300
FAX: 508-822-3288

Date Rec'd in Lab: 12/3/15

ALPHA Job #: L1531722

Client Information

Client: ESS GROUP, INC.
Address: 10 HEMINGWAY DR. 2ND FLR EAST PROVIDENCE, RI 02915
Phone: 401-330-1224
Fax:
Email: CNIELSEN@ESSGROUP.COM

☐ These samples have been previously analyzed by Alpha

Project Information

Project Name: DELCARTE PONDS
Project Location: FRANKLIN, MA
Project #: F455-000.02
Project Manager: CARL NIELSEN
ALPHA Quote #:

Turn-Around Time

☒ Standard ☐ RUSH (only confirmed if pre-approved!)

Date Due: Time:

Report Information - Data Deliverables

☐ FAX ☒ EMAIL
☐ ADEx ☐ Add'l Deliverables

Billing Information

☒ Same as Client info PO #:

Regulatory Requirements/Report Limits

State /Fed Program | Criteria

MA MCP PRESUMPTIVE CERTAINTY --- CT REASONABLE CONFIDENCE PROTO

☐ Yes ☒ No Are MCP Analytical Methods Required?
☐ Yes ☒ No Is Matrix Spike (MS) Required on this SDG? (If yes see note in Comments)
☐ Yes ☒ No Are CT RCP (Reasonable Confidence Protocols) Required?

Other Project Specific Requirements/Comments/Detection Limits:

If MS is required , indicate in Sample Specific Comments which samples and what tests MS to be performed.
(Note: All *CAM* methods for inorganic analyses require MS every 20 soil samples)

TOTAL PHOS. DETECTION LIMIT MUST BE 0.01 mg/L or BETTER

SAMPLE HANDLING

Filtration
☐ Done
☐ Not needed
☐ Lab to do
Preservation
☐ Lab to do
(Please specify below)

ALPHA Lab ID (Lab Use Only)	Sample ID	Collection Date	Collection Time	Sample Matrix	Sampler's Initials	ANALYSIS: Total Phos*	Total Nitrogen	Turbidity	pH	Sample Specific Comments	TOTAL # BOTTLES
31722-01	TRIB 1-WET	12/2/15	20:34	SW		X	X	X	X		3
-02	TRIB 2-WET	12/2/15	21:02	SW		X	X	X	X		3
-03	TRIB 3-WET	12/2/15	21:16	SW		X	X	X	X		3

PLEASE ANSWER QUESTIONS ABOVE!

IS YOUR PROJECT MA MCP *or* CT RCP?

Container Type	Poly			
Preservative	H2SO4	—	—	

Relinquished By:	Date/Time	Received By:	Date/Time
[signature]	12/2/15 @ 22:00	MGA AAL	12/3/15 1232
MGA	12/3/15 1730	[signature]	12/3/15 1305

Please print clearly, legibly and completely. Samples can not be logged in and turnaround time clock will not start until any ambiguities are resolved. All samples submitted are subject to Alpha's Terms and Conditions. See reverse side.

FORM NO: 01-01 (rev. 18-Jan-2010)

Appendix B

Glossary of Terms

APPENDIX B - GLOSSARY OF LIMNOLOGICAL TERMS

Abiotic: A term that refers to the nonliving components of an ecosystem (e.g., sunlight, physical and chemical characteristics).

Algae: Typically microscopic plants that may occur as single-celled organisms, colonies or filaments.

Anoxic: Greatly deficient in oxygen.

Aquifer: A water-bearing layer of rock (including gravel and sand) that will yield water in usable quantity to a well or spring.

Aquatic plants: A term used to describe a broad group of plants typically found growing in water bodies. The term may generally refer to both algae and macrophytes, but is commonly used synonymously with the term macrophyte.

Bacteria: Typically single celled microorganisms that have no chlorophyll, multiply by simple division, and occur in various forms. Some bacteria may cause disease, but many do not and are necessary for fermentation, nitrogen fixation, and decomposition of organic matter.

Bathymetric Map: A map illustrating the bottom contours (topography) and depth of a lake or pond.

Best Management Practices: Any of a number of practices or treatment devices that reduce pollution in runoff via runoff treatment or source control.

Biomass: A term that refers to the weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Biomass is often measured in grams per square meter of surface.

Biovolume: Analogous to biomass but expressed in terms of volume rather than mass.

Biota: All living organisms in a given area.

Chlorophyll a: A pigment used by higher plants and certain algae for photosynthesis. Measuring the level of this pigment in surface water is one way of describing the productivity of a pond and determining its trophic state (see Eutrophic).

Cultural Eutrophication: The acceleration of the natural eutrophication process caused by human activities, occurring over decades as opposed to thousands of years.

Ecosystem: An interactive community of living organisms, together with the physical and chemical environment they inhabit.

Endangered/Threatened Species: An animal or plant species that is in danger of extinction and is recognized and protected by state or federal agencies.

Erosion: A process of breakdown and movement of land surface that is often intensified by human disturbances.

Eutrophic: A trophic state (degree of eutrophication) in which a lake or pond is nutrient rich and sustains high levels of biological productivity. Dense macrophyte growth, fast sediment accumulation, frequent algae blooms, poor water transparency and periodic oxygen depletion in the hypolimnion are common characteristics of eutrophic lakes and ponds.

Eutrophication: The process, or set of processes, driven by nutrient, organic matter, and sediment addition to a pond that leads to increased biological production and decreased volume. The process occurs naturally in all lakes and ponds over thousands of years.

Exotic Species: Species of plants or animals that occur outside of their normal, indigenous ranges and environments. Populations of exotic species may expand rapidly and displace native populations if natural predators, herbivores, or parasites are absent or if conditions are more favorable for the growth of the exotic species than for native species.

Filamentous: A term used to refer to a type of algae that forms long filaments composed of individual cells.

Groundwater: Water found beneath the soil surface and saturating the layer at which it is located.

Habitat: The natural dwelling place of an animal or plant; the type of environment where a particular species is likely to be found.

Herbicide: Any of a class of chemical compounds that produce mortality in plants when applied in sufficient concentrations.

Hypoxic: Lacking sufficient dissolved oxygen to support all but the most tolerant species.

Infiltration Structures: Any of a number of structures used to treat runoff quality or control runoff quantity by infiltrating runoff into the ground. Includes infiltration trenches, dry wells, infiltration basins, and leaching catch basins.

Invasive: Spreading aggressively from the original site of planting.

Isopach Map: A map illustrating the thickness of sediments within a lake or pond.

Limnology: The study of lakes.

Littoral Zone: The shallow, highly productive area along the shoreline of a lake or pond where rooted aquatic plants grow.

Macroinvertebrates: Aquatic insects, worms, clams, snails and other animals visible without aid of a microscope. They supply a major portion of fish diets and are important consumers of detritus and algae.

Macrophytes: Macroscopic vascular plants present in the littoral zone of lakes and ponds.

Morphometry: A term that refers to the depth contours and dimensions (topographic features) of a lake or pond.

Nonpoint Source: A source of pollutants to the environment that does not come from a confined, definable source such as a pipe. Common examples of nonpoint source pollution include urban runoff, septic system leachate, and runoff from agricultural fields.

Nutrient Limitation: The limitation of growth imposed by the depletion of an essential nutrient.

Nutrients: Elements or chemicals required to sustain life, including carbon, oxygen, nitrogen and phosphorus.

pH: An index derived from the inverse log of the hydrogen ion concentration that ranges from zero to 14 indicating the relative acidity or alkalinity of a liquid.

Photosynthesis: The process by which plants use chlorophyll to convert carbon dioxide, water and sunlight to oxygen and cellular products (carbohydrates).

Phytoplankton: Algae that float or are freely suspended in the water.

Pollutants: Elements and compounds occurring naturally or man-made introduced into the environment at levels in excess of the concentration of chemicals naturally occurring.

Secchi disk: A black and white or all white 20 cm disk attached to a cord used to measure water transparency. The disk is lowered into the water until it is no longer visible (Secchi depth). Secchi depth is generally proportional to the depth of light penetration sufficient to sustain algae growth.

Sediment: Topsoil, sand, and minerals washed from the land into water, usually after rain or snowmelt.

Septic system: An individual wastewater treatment system that includes a septic tank for removing solids, and a leachfield for discharging the clarified wastewater to the ground.

Siltation: The process in which inorganic silt settles and accumulates at the bottom of a lake or pond.

Stormwater Runoff: Runoff generated as a result of precipitation or snowmelt.

Temperature Profile: A series of temperature measurements collected at incremental water depths from surface to bottom at a given location.

Thermal Stratification: The process by which a lake or pond forms several distinct thermal layers. The layers include a warmer well-mixed upper layer (epilimnion), a cooler, poorly mixed layer at the bottom (hypolimnion), and a middle layer (metalimnion) that separates the two.

Thermocline: A term that refers to the plane of greatest temperature change within the metalimnion. Often used interchangeably with metalimnion.

TKN: Total Kjeldahl nitrogen, essentially the sum of ammonia nitrogen and organic forms of nitrogen.

TSS: Total suspended solids, a direct measure of all suspended solid materials in the water.

Turbidity: A measure of the light scattering properties of water; often used more generally to describe water clarity or the relative presence or absence of suspended materials in the water.

Vegetated Buffer: An undisturbed vegetated land area that separates an area of human activity from the adjacent water body; can be effective in reducing runoff velocities and volumes and the removal of sediment and pollutant from runoff.

Water Column: Water in a lake or pond between the interface with the atmosphere at the surface and the interface with the sediment at the bottom.

Water Quality: A term used to reference the general chemical and physical properties of water relative to the requirements of living organisms that depend upon that water.

Watershed: The surrounding land area that drains into a water body via surface runoff or groundwater recharge and discharge.

Zooplankton: Microscopic animals that float or are freely suspended in the water.

Appendix C

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