



# Feasibility Study for Anadromous Fish Passage

Blackamore and Cranberry Ponds  
Cranston and Warwick, Rhode Island



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Project No. P310-000  
Revised March 3, 2017



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*Prepared in cooperation with the:*

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and the U.S. Environmental Protection Agency**  
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**NARRAGANSETT BAY  
ESTUARY PROGRAM**



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## **EXECUTIVE SUMMARY**

Anadromous river herring and American shad were nearly ubiquitous in Atlantic coastal streams, rivers, and connected pond, including the Pawtuxet River. However, construction of dams along the Pawtuxet River from the Industrial Revolution through the twentieth century resulted in exclusion of these species from most of the river and its tributaries. In 2010, the Pawtuxet Falls Dam was successfully removed, opening a seven-mile stretch of the lower Pawtuxet River to anadromous river herring and shad.

Blackamore Pond, located in Cranston, and Cranberry Pond, located in Warwick are headwater ponds in two of the tributary systems that discharge to the lower Pawtuxet River. These ponds and their outlets were identified by the Pawtuxet River Authority as potentially suitable for anadromous river herring with appropriate restoration to remove barriers to fish passage and improve habitat.

ESS Group, Inc. was contracted to assess the ability of Blackamore and Cranberry Ponds and their outlet streams to support anadromous fish passage. This study and subsequent restoration efforts will support the larger goal of improving habitat connectivity and fish passage within the greater Pawtuxet River system.

Field investigations conducted as part of this study include measurement of in-pond water quality, mapping of in-pond aquatic plant growth and sediment, characterization of streamflow and habitat in outlet streams, and identification of instream fish passage barriers.

Results of this study indicate that habitat volume is available to support spawning and growth of anadromous alewife, especially in Blackamore Pond. However, conditions are marginal for successful alewife spawning and recruitment without management to enhance habitat.

Additionally, fish passage in each system is limited by multiple barriers. The most commonly observed barriers to fish passage were culverts with one or more of the following characteristics:

- Collapsed entrance or outlet
- Limited light penetration (due to small diameter/extended length)
- Submerged outlet

However, extremely shallow stream channel depths (during low flow conditions) also pose potential impediments to the passage of anadromous fishes.

Although a number of options were examined, the recommended actions for improving fish passage and habitat include culvert retrofit or replacement, stream daylighting, and development of a lake management plan for each system. Other management options considered for fish passage, such as dam removal and fish ladder installation, were not currently deemed to be feasible for either system.

Of the two systems evaluated by this study, the Cranberry Pond system is affected by a greater number of significant barriers and provides less suitable in-pond spawning and nursery habitat for anadromous alewife. Based on the information evaluated in this study, the Blackamore Pond system appears to provide more potential habitat with fewer significant barriers to fish passage. Therefore, prioritizing fish passage and habitat restoration on the Blackamore Pond system is conditionally recommended.

## **INTRODUCTION**

### **Background**

The Pawtuxet River historically supported a population of anadromous alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) – collectively known as river herring – as well as American shad (*Alosa sapidissima*), which were nearly ubiquitous in Atlantic coastal streams, rivers, and connected ponds (ASFMC 2016). However, construction of dams along the Pawtuxet River from the Industrial Revolution through the twentieth century resulted in exclusion of river herring and American shad from most of the river and its tributaries. More generally, these species have been in decline regionwide since the 1950s.

Prior studies (e.g., Erkan 2002 and Kleinschmidt 2005) concluded that the greater Pawtuxet River system would be conditionally supportive of anadromous river herring and American shad populations with strategic removal of fish passage barriers. Removal of the first barrier on the mainstem of the Pawtuxet River (the Pawtuxet Falls Dam) was identified as a priority action in moving toward restoration of river herring and shad. However, marginal water quality, contaminated sediments, and other constraints were also identified as factors posing challenges to successful restoration.

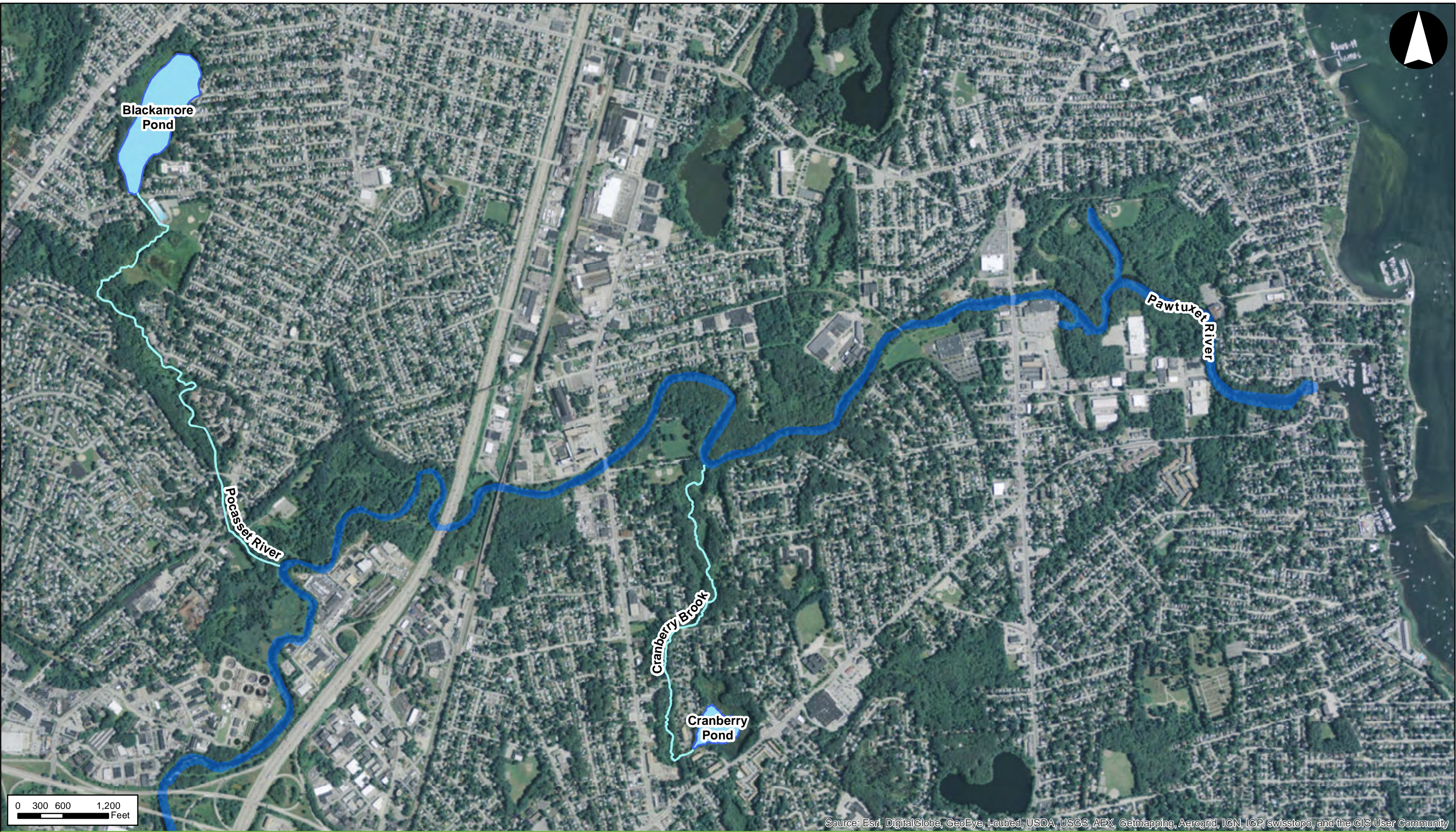
In 2010, the Pawtuxet Falls Dam was successfully removed, opening a seven-mile stretch of the lower Pawtuxet River between its mouth and the Pontiac Mills Dam to diadromous fish migration, including anadromous river herring. Kleinschmidt (2005) estimated that the lower reaches of the Pawtuxet River were capable of supporting as many as 149,100 river herring and 4,500 American shad. There are multiple pond-tributary systems that drain to the Pawtuxet River along this stretch, but fish passage to these systems is obstructed by derelict features such as old dams and buried pipes.

Blackamore Pond, located in Cranston, and Cranberry Pond, located in Warwick are headwater ponds in two of the tributary systems that discharge to the lower Pawtuxet River (Figure 1). These ponds and their outlets were identified by the Pawtuxet River Authority (PRA) as potentially suitable for anadromous river herring with appropriate restoration to remove barriers to fish passage and improve habitat.



*Blackamore Pond in Cranston, Rhode Island*





Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



## Feasibility Study for Anadromous Fish Passages to Blackamore and Cranberry Ponds

Cranston and Warwick, Rhode Island

1 inch = 1,200 feet

Source: 1) ESRI, Basemap, World Imagery 2016  
2) RIGIS, Lakes and Ponds 2015

Project Overview

Figure 1



### **Purpose and Goals of this Study**

The primary purpose of this study was to assess the ability of Blackamore and Cranberry Ponds and their outlet streams to support anadromous fish passage. This supports the larger goal of improving habitat connectivity and fish passage within the greater Pawtuxet River system.

Specific objectives of this study include the following:

- Characterize habitat in each pond, including physical, biological and water quality elements
- Observe streamflows at the outlet of each pond
- Identify and describe barriers to fish passage from the Pawtuxet River to each pond
- Develop a matrix of management options for improving anadromous fish passage and habitat

### **Anadromous Fish Species Profiles**

Although improvement of fish passage in the Blackamore and Cranberry Pond systems is likely to benefit fish and aquatic invertebrates as a whole, this study is focused on anadromous river herring and American shad. A brief profile of each target species is presented in this section.

#### ***Alewife (Alosa pseudoharengus)***

Anadromous alewife range from Newfoundland south to North Carolina and are found in coastal Atlantic waters for most of their lives (ASMFC 2009). Although blueback herring and alewife ranges overlap, alewife tend to be the more abundant species in New England.



Alewife generally move into coastal freshwater systems of southern New England in March and April, once water temperatures have increased sufficiently (ASMFC 2009). Spawning may occur in both streams and lakes, generally in waters less than 1.0 meter (3.3 feet) deep. However, where blueback herring co-occurs, alewife tend to gravitate toward headwater lake and pond habitats for spawning (Klauda 1991). Additionally, alewife typically spawn as much as a three to four weeks earlier than blueback herring (ASMFC 2009).

Alewife eggs are demersal in still water and semi-adhesive, becoming pelagic with time (ASMFC 2009). Larvae and juveniles generally remain in freshwater tributaries and impoundments until June, after which time the developing fish begin to migrate out of the nursery areas and downstream.

Adult alewife feed minimally during spawning but may consume amphipods, mysid shrimp, zooplankton, and fish eggs (ASMFC 2009). Juveniles are voracious feeders in freshwater and forage mainly on zooplankton and fish eggs, including those of river herring. Under conditions with good visibility, juveniles are selective feeders but transition to non-selective foraging strategies when visibility declines.

Anadromous alewife are tolerant of a fairly wide range of water quality conditions, although excessive warmth (warmer than 25 °C [77 °F]) and low dissolved oxygen concentrations (less than 5.0 mg/L) are generally considered to be undesirable (Pardue 1983, ASMFC 2009).

### **Blueback herring (*Alosa aestivalis*)**

Blueback herring range from Florida to Newfoundland, but are most abundant from the warmer waters of the Chesapeake Bay southward (Klauda 1991, ASMFC 2009). Adults generally move into coastal freshwater systems of southern New England in April, usually arriving a few weeks after alewife and remaining longer. Spawning primarily occurs in mainstem rivers and larger streams, often in areas with moderate flow velocity and depth.



The eggs of this species are initially demersal but become pelagic with time (ASMFC 2009). Juveniles generally remain in freshwater for a more substantial period of time than alewife but move into estuarine and nearshore coastal waters before water temperatures drop significantly, typically between September and October.

Adult blueback herring feed on a variety of benthic and terrestrial invertebrates, as well as zooplankton, and fish eggs (ASMFC 2009). Juveniles forage largely on zooplankton but benthic invertebrates also constitute a significant portion of their diet. Blueback herring juveniles appear to be selective feeders that require sufficient light and water clarity to be able to forage effectively.

Blueback herring are tolerant of a fairly wide range of water quality conditions and appear to prefer warmer conditions than alewife. However, dissolved oxygen levels less than 5.0 mg/L are generally considered to be undesirable (Pardue 1983, ASMFC 2009).

### **American Shad (*Alosa sapidissima*)**

American shad range from Florida to the St. Lawrence River in Quebec (ASMFC 2010). Adults move into coastal freshwater systems of southern New England as early as March and the spawning run may continue for two to three months. American shad may spawn multiple times as they move upstream, preferring the moderate flow velocities and water depths of runs, as opposed to faster, shallower riffles or slower, deeper pools.



The eggs of this species are semi-buoyant but eventually settle onto substrates, where survival appears to be improved on coarse substrates (Hightower and Sparks 2003, ASMFC 2010). Juveniles may move into brackish water quickly or remain in freshwater all summer. Sufficient water velocity appears to be important in determining the emigration success of juvenile shad.

Adult American shad feed on amphipods and other crustaceans during migration to spawning sites (ASMFC 2010). Juveniles forage primarily in the water column, where they are able to filter zooplankton and drifting invertebrates from the flow. However, they will also forage on benthic invertebrates, including aquatic insects.

American shad are tolerant of a fairly wide range of water quality conditions, including turbid water conditions and warm water temperatures (ASMFC 2010). However, early life stages are somewhat sensitive to low pH (Leach and Houde 1999). Additionally, dissolved oxygen levels less than 5.0 mg/L are generally considered to be undesirable for all life stages (ASMFC 2010).

## **METHODS**

A brief overview of the data collection methodology used in this study is provided below. Work was conducted under the guidance of a project-specific Quality Assurance Project Plan (QAPP), which was approved by the New England Interstate Water Pollution Control Commission (NEIWPCC) and the U.S. Environmental Protection Agency (US EPA). For a more detailed description of data acquisition, sampling, and analytical methods, refer to *Section B: Measurement and Data Acquisition* of the QAPP (ESS 2016).



*Installing water level logger downstream of Blackamore Pond*





Field investigations focused primarily on documenting the following conditions within both the Blackamore and Cranberry Pond systems:

- 1) In-pond Water Quality
  - a. dissolved oxygen
  - b. temperature
  - c. salinity/conductivity
  - d. turbidity
  - e. transparency
  - f. color
  - g. pH
- 2) In-pond Plant Community
  - a. species composition
  - b. plant coverage/biovolume
- 3) In-pond Sediment
  - a. composition/grain size
  - b. bathymetry/sediment thickness mapping
  - c. sediment quality testing
- 4) Streamflow out of Each System
  - a. streamflow observations
  - b. automated water level monitoring
- 5) Assessment of Barriers to Fish Passage
  - a. photodocumentation/description of barriers
  - b. field data collection/habitat assessment

Field work was conducted between September 26 and December 6, 2016, as summarized in Table A.



**Table A. Summary of 2016 Field Program**

Date	Water Body	Field Activities Completed
September 26	<ul style="list-style-type: none"> <li>Blackamore Pond</li> </ul>	<ul style="list-style-type: none"> <li>Water Quality</li> <li>Plant Community</li> <li>Sediment</li> </ul>
September 29	<ul style="list-style-type: none"> <li>Cranberry Pond</li> </ul>	<ul style="list-style-type: none"> <li>Water Quality</li> <li>Plant Community</li> <li>Sediment</li> </ul>
September 30	<ul style="list-style-type: none"> <li>Outlets of Blackamore and Cranberry Ponds</li> <li>Receiving streams</li> </ul>	<ul style="list-style-type: none"> <li>Streamflow (install)</li> <li>Assessment of Barriers to Fish Passage</li> </ul>
December 6	<ul style="list-style-type: none"> <li>Outlets of Blackamore and Cranberry Ponds</li> </ul>	<ul style="list-style-type: none"> <li>Streamflow (recover)</li> </ul>

## **RESULTS**

### **Blackamore Pond**

Blackamore Pond is a 20.4-acre publicly accessible pond located in a suburban portion of Cranston, Rhode Island. The pond is a Class B waterbody and listed as impaired for phosphorus (RIDEM 2015). A TMDL is currently scheduled for completion in 2023.

Blackamore Pond drains to an unnamed tributary (referred to in this report as the Blackamore Pond outlet) of the Pocasset River, which ultimately drains to the Pawtuxet River (Figure 2). The total stream length from Blackamore Pond to the Pawtuxet River is approximately 1.4 miles, over which the elevation drops approximately 17 feet. This is approximately equivalent to a 1-foot drop every 425 feet, which reflects the low gradient of the outlet stream and Pocasset River.









### **Water Quality**

The results of the Blackamore Pond water quality survey are provided in Table B. Of note, dissolved oxygen levels were marginal (state standard is 5.0 mg/L or 60% saturation for warmwater fisheries) and water clarity (Secchi) was very low.

Blackamore Pond long-term water quality monitoring results from 2001 to 2014 indicate water clarity has trended downward while chlorophyll a (a surrogate for algae) has trended upward over the period (URI Watershed Watch 2016). These have been accompanied by elevated nutrient levels (phosphorus and nitrogen) over most of the period.

**Table B: September 2016 Blackamore Pond In-Pond Water Quality Data**

Depth (m)	Temp (C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Specific Conductance (µg/L)	Salinity (ppt)	pH (SU)	Color (PCU)	Turbidity (NTU)
0.5	20.6	5.59	62.8	398.0	0.2	6.84	55	4.79
1	20.5	5.03	55.5	398.6	0.2	-	-	-
1.5	20.5	5.06	55.4	398.3	0.2	-	-	-
2	20.5	4.98	54.6	397.7	0.2	-	-	-
2.5	20.5	5.21	57.1	399.0	0.2	-	-	-
3	20.4	5.65	62.0	399.0	0.2	-	-	-
3.5	20.4	5.60	61.5	398.2	0.2	-	-	-
4	20.2	5.42	59.3	396.5	0.2	6.87	95	4.05
Max depth: 5.25 m (17.2 ft)      Secchi: 0.7 m (2.3 ft)								

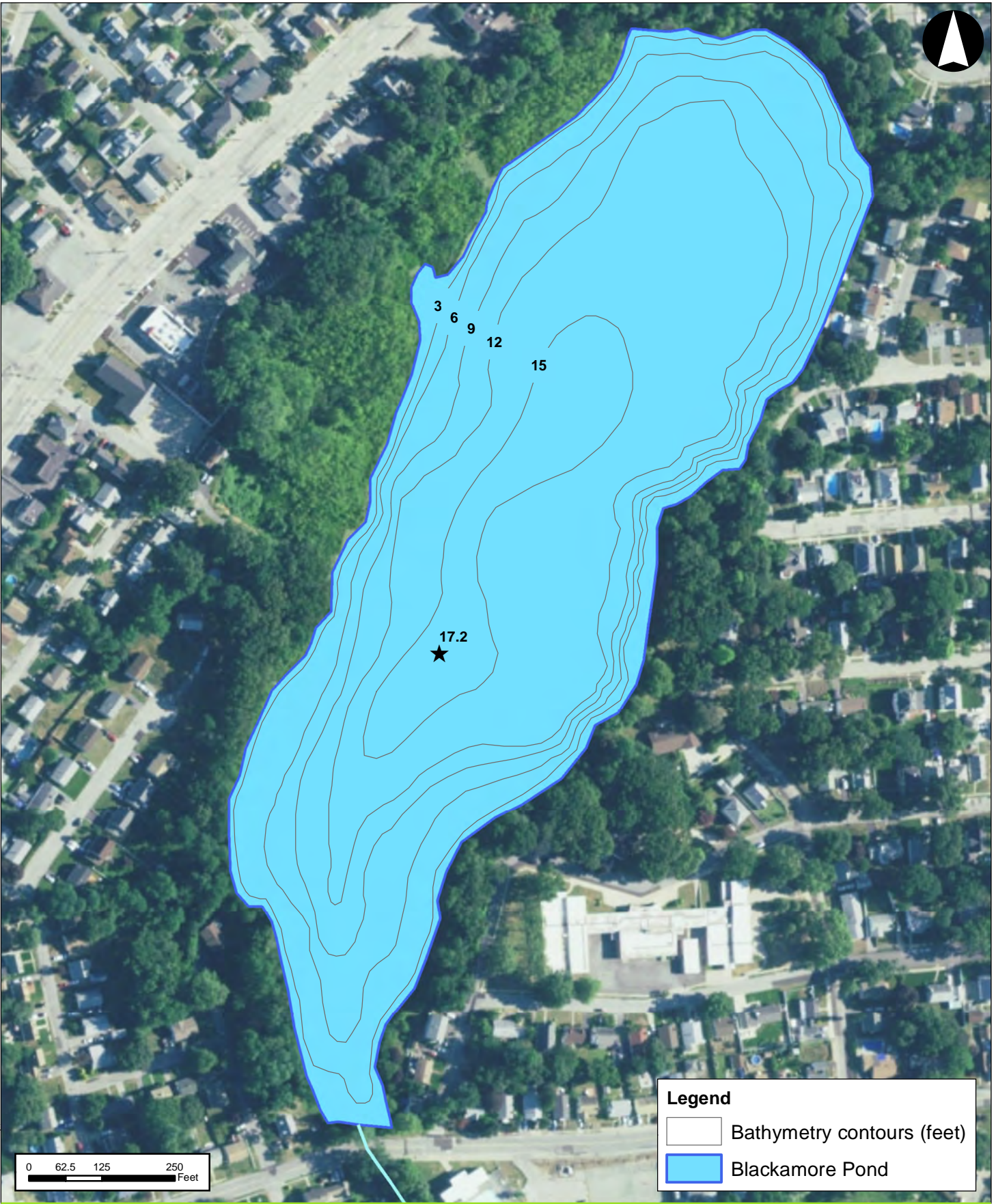
### **Bathymetry**

Blackamore Pond is a single basin characterized by steeper contours on the eastern side of the pond. The deepest waters are found in the center of the pond, with a maximum depth of more than 17 feet observed in the south-central portion of the pond. An updated map of bathymetric contours at Blackamore Pond is presented in Figure 3.

### **Plant Community**

Aquatic plant mapping was conducted at 55 point locations within Blackamore Pond. The results of the plant mapping effort are presented below in the form of an aquatic plant species list (Table C) and a map of aquatic plant cover (Figure 4).

Plant cover and biovolume were low in most portions of the pond, except for shallow waters near the outlet. No plant growth was observed in waters deeper than six feet.







Blackamore Pond appears to host a limited number of aquatic plant species. The most frequently observed were water lilies (*Nymphaea odorata* and *Nuphar lutea variegata*), primarily at the southern end of the pond near the outlet. One exotic species of aquatic plant (curly-leaf pondweed) was observed at very low levels. However, due to this species's life cycle, most plants would have senesced by the time of the field survey. Therefore, it is possible that curly-leaf pondweed is actually more widespread in the pond than observed. Several emergent plant species were also observed at the pond, including exotic purple loosestrife and common reed.



*Water lilies were the most frequently observed aquatic plant at Blackamore Pond.*

**Table C: Plant Species Observed at Blackamore Pond (September 2016)**

Common Name	Scientific Name	Growth Habit
Broadleaf arrowhead	<i>Sagittaria latifolia</i>	Emergent
Common reed*	<i>Phragmites australis</i>	Emergent
Pickernelweed	<i>Pontederia cordata</i>	Emergent
Purple loosestrife*	<i>Lythrum salicaria</i>	Emergent
Broadleaf cattail	<i>Typha latifolia</i>	Emergent
Common duckweed	<i>Lemna minor</i>	Floating
White water lily	<i>Nymphaea odorata</i>	Floating-leaved
Yellow water lily	<i>Nuphar lutea variegata</i>	Floating-leaved
Coontail	<i>Ceratophyllum demersum</i>	Submerged
Curly-leaf pondweed*	<i>Potamogeton crispus</i>	Submerged
Humped bladderwort	<i>Utricularia gibba</i>	Submerged
Thin-leaf pondweed	<i>Potamogeton pusillus</i>	Submerged

\*Exotic species



Additionally, excessive algal growth was observed at Blackamore Pond, including a cyanobacteria bloom at the time of sampling. Cyanobacteria blooms have been observed at this pond in prior years (ESS 2013), indicating that this is a recurring issue. Species observed in the blooms (such as *Aphanizomenon* spp., *Woronichinia naegeliana*, *Microcystis* spp., and *Dolichospermum* spp.) are known to be potentially toxigenic and the Rhode Island Department of Health (RIDOH) and RIDEM have issued health advisories for the pond multiple times since 2012.



*Surface scums of cyanobacteria were observed at Blackamore Pond.*

## **Sediment**

### **Quality**

Sediment sampling results are presented in Table D. These results indicate exceedance of RI Residential Direct Exposure (RDE) criteria for two metals, including arsenic and lead. Although the RDE criteria do not apply directly to *in situ* sediments, they may be helpful to interpret the relative magnitude of contaminants present. For example, sediment lead levels appear to be particularly elevated, as they are nearly five times the RDE criterion. The full laboratory report is included as Appendix A.

**Table D. Sediment Quality Results for Blackamore Pond**

Analyte	Concentration* (mg/kg)	RI RDE (mg/kg)
Arsenic	<b>10.4</b>	7.0
Cadmium	6.2	39
Chromium (Total)	42.6	390
Copper	133	3,100
Mercury	<0.21	23
Nickel	51.4	1,000
Lead	<b>709</b>	150
Zinc	710	6,000

\*All values reported as dry weight; Bold values exceed RI RDE

### **Thickness**

A total of 24 sediment thickness measurements were taken at Blackamore Pond. Sediment thickness data are absent for the center portion of the pond, where water depths were too deep to record an accurate measurement.

Soft sediment thickness generally increased from the shoreline toward the center of the pond, although sediments tended to be thinner on the eastern side of the pond than the west (Figure 5). The thickest deposits measured in the pond were more than 10 feet thick.





**Legend**

- 3' sediment thickness contour
- /// No data (depth > 10')



**Feasibility Study for Anadromous Fish Passages  
to Blackmore and Cranberry Ponds**  
Cranston and Warwick, Rhode Island

1 inch = 250 feet

Source: 1) ESRI, Basemap, World Imagery 2016  
2) ESS GPS Locations, 2016

**Blackmore Pond  
Sediment Thickness**

**Figure 5**



### **Outlet Morphology and Flow Monitoring**

A summary of the stream habitat and flow monitoring results for the Blackamore Pond outlet stream located immediately downstream of Aqueduct Road is presented below:

- A Habitat Assessment Field Data Sheet for low gradient streams was completed for the Blackamore Pond outlet. This qualitative assessment was conducted for the reach of the stream that abuts the Budlong Pool property between Aqueduct Road and the first physical barrier approximately 350 feet downstream.

This highly modified portion of the Blackamore outlet stream scored a 106 out of 200, indicating sub-optimal habitat conditions. Sediment deposition and lack of pool variability were among the lowest-scoring instream habitat elements. Channelization was also identified as a sub-optimal element of instream habitat. Riparian habitat elements, such as vegetative protection and riparian zone width were also considered marginal. See the completed habitat assessment forms in Appendix B for a detailed evaluation of stream morphology immediately downstream of Blackamore Pond.

- Flow data at the Blackamore Pond outlet could not be retrieved due to theft/vandalism of the water level logger at this location. However, the water depth observations obtained at the start (September) and end (December) of the study indicated sufficient water levels for fish passage through the outlet channel at the stream monitoring location.



*Assessed reach of the Blackamore Pond outlet stream, looking downstream. Budlong Pool is behind fence at upper left.*

### **Physical Barriers**

Development in and around the tributary between Cranberry Pond and the Pawtuxet River known as Cranberry Brook has created physical barriers to anadromous fish passage that were identified and documented during field investigations. Specifically, two significant barriers were identified along the unnamed stream (called the Blackamore Pond outlet for this purposes of this report) that connects Blackamore Pond to the Pocasset River. These barriers occur within very close together and in close proximity to Blackamore Pond itself. Each barrier is briefly described below, starting at the uppermost barrier and proceeding in sequential order downstream, and a photographic log containing photos of each barrier is included as Appendix C.

#### **Aqueduct Road (B-1)**

The first barrier is a small concrete culvert built into the base of Aqueduct Road at the mouth of Blackamore Pond, where the pond first transitions into a stream. This culvert appears to be outdated and undersized and likely acts as a significant barrier to fish passage. Table E below includes culvert dimensions and photos are included in Appendix C.

#### **Behind Budlong Pool Facility (B-2)**

A buried section of the Blackamore Pond outlet approximately 140 feet in length exists starting approximately 460 feet southeast of Blackamore Pond. The stream enters this section via a dilapidated, ribbed aluminum pipe culvert and exits through a short stone-and-mortar channel with concrete wing walls that is buried and covered with concrete slabs. This section of the outlet, especially the upstream end, likely acts as a significant barrier to fish passage. Table E below includes culvert dimensions and photos are included in Appendix C.

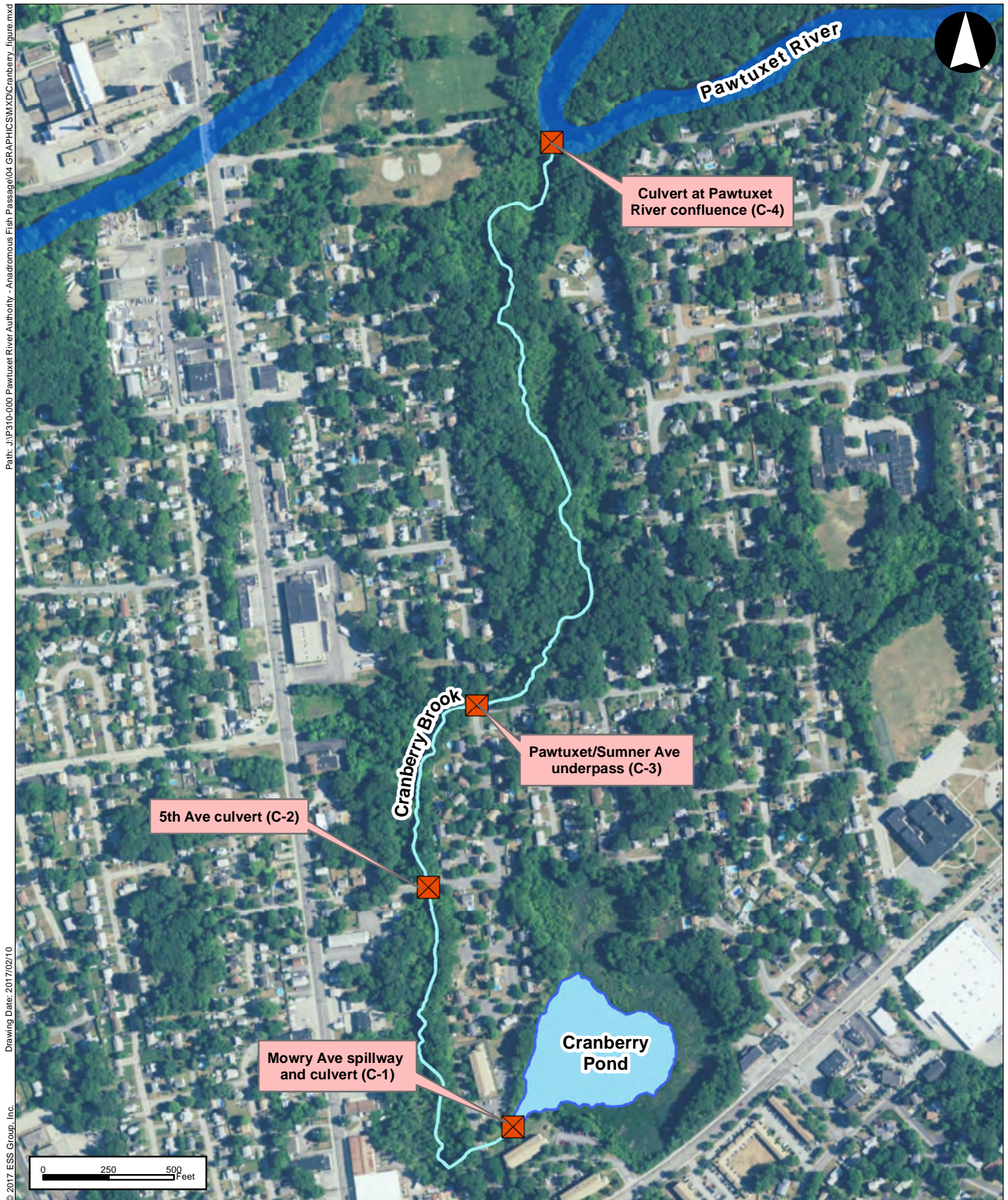
**Table E. Blackamore Pond Outlet Fish Passage Barrier Dimensions**

Location	Lat/Long	Width		Height above ground		Approximate Length	Material
Aqueduct Road	41.771308° 71.447425°	24"		6"		60'	Concrete
Behind Budlong Pool	41.770388° 71.446609°	24" Upstream	4.3' Downstream	10" Upstream	4' Downstream	140'	CMP (upstream entrance)  Concrete (downstream)

### **Cranberry Pond**

Cranberry Pond is a 5-acre pond located in Warwick, Rhode Island. Cranberry Pond drains to Cranberry Brook, which ultimately drains to the Pawtuxet River (Figure 6). The pond is surrounded by dense scrub-shrub and herbaceous vegetation along most of its perimeter, and is only accessible from the west, which is occupied by a privately-owned apartment complex. Therefore, Cranberry Pond does not appear to be heavily used for public recreation.









The total stream length from Cranberry Pond to the Pawtuxet River is approximately 1.3 miles, over which the elevation drops approximately 15 feet. This is approximately equivalent to a 1-foot drop every 450 feet, which reflects the low gradient of the Cranberry Pond outlet stream.

### **Water Quality**

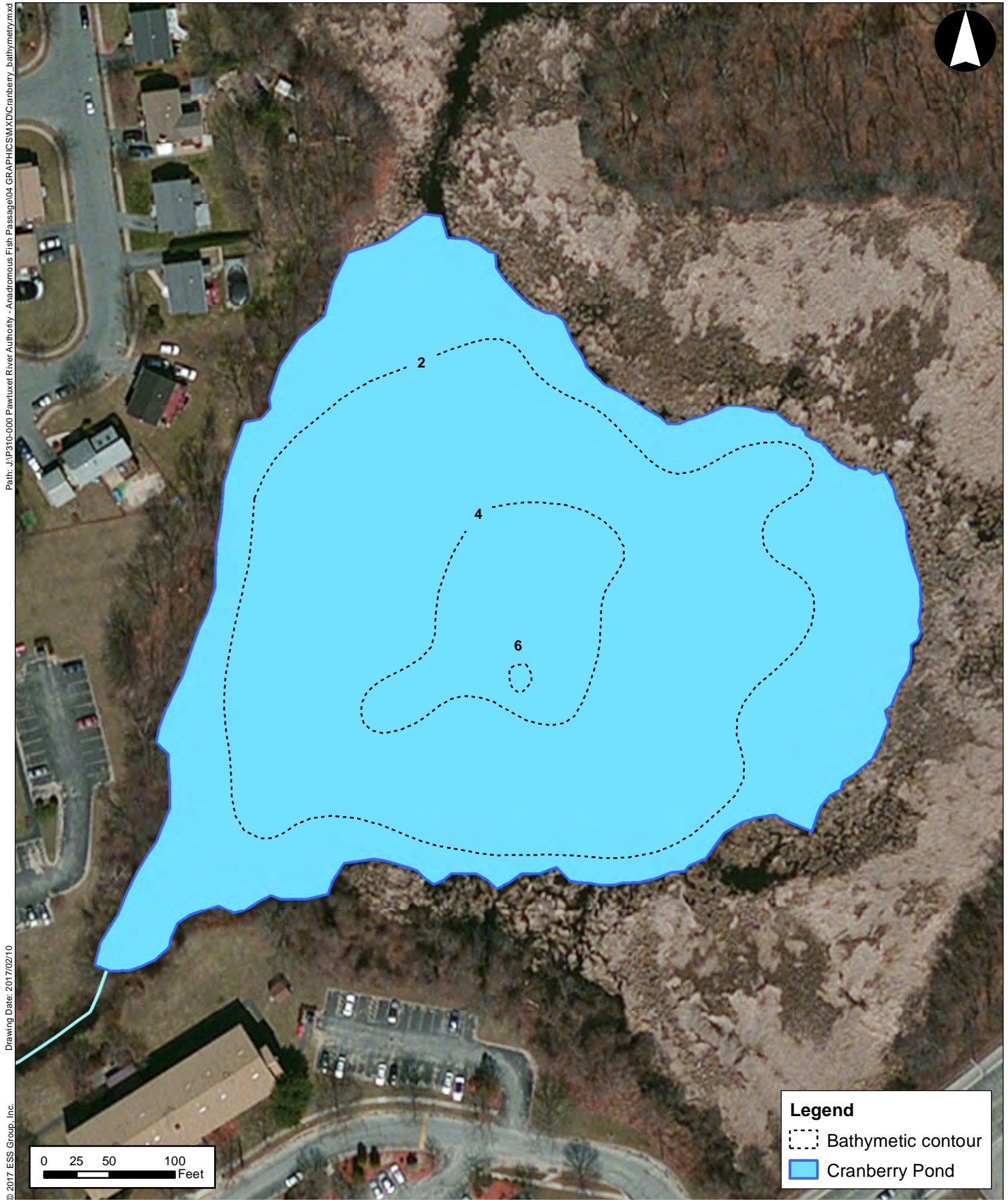
The results of the Cranberry Pond water quality survey are provided in Table F. Of note, dissolved oxygen levels were sufficient at the surface but quickly became marginal with depth (state standard is 5.0 mg/L or 60% saturation for warmwater fisheries). Additionally, turbidity was elevated while water clarity (Secchi) was very low. The high turbidity and low clarity were primarily attributed to the heavy staining of the water (as reflected in the elevated water color readings). Staining is a natural phenomenon that is caused by leaching of dissolved organic matter from decaying vegetation into the water column. Given the extensive beds of emergent cattails and other plants around the entire periphery of Cranberry Pond, heavily stained water would be expected.

**Table F. September 2016 Cranberry Pond In-Pond Water Quality Data**

Depth (m)	Temp (C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)	Specific Conductance (µg/L)	Salinity (ppt)	pH (SU)	Color (PCU)	Turbidity (NTU)
0.5	17.2	7.23	76.2	261.7	0.1	6.65	95	27.49
1	16.9	4.95	51.2	259.0	0.1	6.56	95	29.19
Max depth: 1.8 m (6 ft)		Secchi: 0.7 m (2.3 ft)						

### **Bathymetry**

Cranberry Pond is a shallow single basin with a maximum depth of approximately 6.0 feet observed in the south-central portion of the pond. An updated map of bathymetric contours at Cranberry Pond is presented in Figure 7.



## **Plant Community**

Aquatic plant mapping was conducted at 50 point locations throughout Cranberry Pond. The results of the plant mapping effort are presented below in the form of an aquatic plant species list (Table G) and a map of aquatic plant cover (Figure 8).

Plant cover and biovolume were uniformly high within a wide band of shallow water along the periphery of the pond. However, in areas deeper than 3.5 feet, aquatic plant growth was minimal. This resulted a stark boundary between habitats with abundant plant growth and those with none at all.

The plant community at Cranberry Pond appears to consist of a handful of aquatic plant species. The most frequently observed were water lilies (*Nymphaea odorata* and *Nuphar lutea variegata*), which dominated the vast majority of the pond's shallow areas. Several emergent plant species were also observed at the pond, including exotic purple loosestrife. The dominant emergent plant was broadleaf cattail (*Typha latifolia*), which forms an extensive band along the edge of the pond.



*Water lilies (foreground) and broadleaf cattail (background) formed nearly monotypic beds at Cranberry Pond.*

**Table G. Plant Species Observed at Cranberry Pond (September 2016)**

Common Name	Scientific Name	Growth Habit
Purple loosestrife*	<i>Lythrum salicaria</i>	Emergent
Broadleaf cattail	<i>Typha latifolia</i>	Emergent
Common duckweed	<i>Lemna minor</i>	Floating
White water lily	<i>Nymphaea odorata</i>	Floating-leaved
Yellow water lily	<i>Nuphar lutea variegata</i>	Floating-leaved
Big-leaf pondweed	<i>Potamogeton amplifolius</i>	Submerged
Common bladderwort	<i>Utricularia macrorhiza</i>	Submerged
Coontail	<i>Ceratophyllum demersum</i>	Submerged

\*Invasive species







## **Sediment**

### **Quality**

Sediment sampling results are presented in Table H. These results indicate exceedance of RI RDE criteria for two metals, including arsenic and lead. Although the RDE criteria do not apply directly to *in situ* sediments, they may be helpful to interpret the relative magnitude of contaminants present. The full laboratory report is included as Appendix A.

**Table H. Sediment Quality Results for Cranberry Pond**

Analyte	Concentration* (mg/kg)	RI RDE (mg/kg)
Arsenic	<b>14.4</b>	7.0
Cadmium	4.5	39
Chromium (Total)	18.9	390
Copper	78.3	3,100
Mercury	<0.22	23
Nickel	25.3	1,000
Lead	<b>227</b>	150
Zinc	506	6,000

\*All values reported as dry weight

Bold values exceed RI RDE

### **Thickness**

A total of 50 sediment thickness measurements were taken at Cranberry Pond. Thick deposits of soft sediments were found across much of the pond, with maximum thicknesses found in the north-central and south-central portions of the pond. Soft sediment thickness exceeded 14 feet in some locations. A map of sediment thicknesses in the pond is provided in Figure 9.







### **Stream Morphology and Flow Monitoring**

A summary of the stream habitat and flow monitoring results for the Cranberry Pond outlet stream located immediately downstream of Mowry Avenue is presented below:

- A Habitat Assessment Field Data Sheet for low gradient streams was completed for the Cranberry Pond outlet (Cranberry Brook). This qualitative assessment was conducted immediately downstream of Cranberry Pond, along the reach between Mowry Ave and the first physical barrier at 5<sup>th</sup> Ave, a length of approximately 400 feet.

This uppermost portion of Cranberry Brook scored a 117 out of 200, which reflects sub-optimal habitat conditions. Pool variability and channel sinuosity were the instream habitat elements characterized by marginal scores. Riparian zone width was also marginal at this location. See the completed forms in Appendix B for a detailed evaluation of stream morphology immediately downstream of Cranberry Pond.



*Cranberry Brook, looking downstream from Mowry Avenue*

- Flow data at the Cranberry Pond outlet was collected between September and December 2016 (Figure 10), a period anticipated to include typical low-flow conditions. Given the restrictive flow conditions observed on the date of the initial field visit (September 30), it is clear that at least two additional periods of restrictive low flows occurred over the period of this study. These

periods extend from October 4 to October 9 and from October 19 to October 21 (Figure 10). The minimum water level over the period of study was recorded on October 7 and was 0.14 feet below the stage observed on the date of the initial field visit.

None of the water levels recorded over the period of this study appeared to be excessively high. The peak stage of 1.27 feet was recorded on November 29 and is 0.59 feet higher than the water levels observed on the date of the initial field visit.



Figure 10. Continuous Stage Recorded at the Cranberry Pond Outlet

### **Physical Barriers**

Development in and around the area between the Cranberry Pond outlet and the Pawtuxet River has created multiple physical barriers to anadromous fish passage. In contrast to the Blackamore Pond outlet, Cranberry Brook has several barriers caused primarily by road crossings that are spread out along its length. Each barrier is briefly described below, starting at the uppermost barrier and proceeding in sequential order downstream. A photographic log containing photos of each barrier is included as Appendix C.

### **Mowry Ave (C-1)**

Approximately 150 feet downstream of Cranberry Pond, a small concrete structure impedes flow immediately upstream of the Mowry Avenue crossing. This structure is a ramp that is built into the streambed and creates an obstruction that is approximately 3 to 4 feet in height and 5 feet in length. This feature severely constricts flow under low water conditions, resulting in a very shallow water depth that may impede migration of fish into or out of the pond. Once flow passes over this impoundment, it enters an adjacent culvert beneath Mowry Avenue. Table I below includes culvert dimensions and photos are included in Appendix C.

### **Fifth Ave (C-2)**

The next barrier occurs approximately 700 feet northwest of Cranberry Pond where Cranberry Brook is crossed by Fifth Ave. This obstruction is an elongated concrete pipe culvert that likely acts as a significant barrier to fish passage, due to minimal water depths and increased velocities through the pipe. Table I below includes culvert dimensions and photos are included in Appendix C.

### **Intersection of Pawtuxet Ave and Sumner Ave (C-3)**

The next barrier occurs approximately 1,100 feet north-northwest of Cranberry Pond where Cranberry Brook is crossed by an intersection of Pawtuxet Ave and Sumner Ave. Although it is not visible from the surface, it is likely that a culvert exists beneath the road at this intersection as water clearly passes underneath. A backup of trash and debris on the upstream side suggests that this feature may partially impound flow and likely represents a significant barrier to fish passage. Table I below includes culvert dimensions and photos are included in Appendix C.

### **Belmont Park/Pawtuxet River Confluence (C-4)**

The final barrier occurs adjacent to Cranberry Brook's confluence with the Pawtuxet River, approximately 3,200 feet north of Cranberry Pond. This barrier is a concrete culvert that is embedded into an earthen walking trail where it crosses Cranberry Brook. Table I below includes culvert dimensions. Photographs are included in Appendix C.

**Table I. Cranberry Brook Fish Passage Barrier Dimensions**

Location	Lat/Long	Width		Height		Approximate Length	Material
Mowry Ave	41.751047° -71.421152°	2' Upstream	3.5' Downstream	10" Upstream	2.5' Downstream	40'	Concrete
Fifth Ave	41.753768° -71.421885°	3'		3'		80'	Concrete
Pawtuxet/ Sumner	41.755663° -71.421233°	Not visible		Not visible		40'	Concrete
Belmont Park/Pawtuxet River	41.761495° -71.420136°	3'		2.5'		20'	Concrete





## **QUALITY ASSURANCE/QUALITY CONTROL**

A narrative of quality assurance/quality control (QA/QC) results associated with the approved QAPP for this project are presented below.

### **Field-measured Water Quality and Laboratory Sediment Analyses**

No hold times were exceeded on field-measured water quality parameters. Additionally, one field duplicate measurement (10% rate) was made for each water quality parameter, which satisfies the 5% rate required in the QAPP. All measured duplicate values agreed within 10%. Therefore, no corrective measures were deemed necessary and field-measured water quality results were considered to be acceptable for use in this study.

All sediment samples arrived at the analytical laboratory in good condition and within hold times. Additionally, all laboratory analytical results conformed with internal QA/QC requirements. Therefore, no corrective measures were deemed necessary and laboratory sediment quality results were considered to be valid for use in this study.

### **Water Level Loggers**

The Cranberry Pond outlet water level logger reported water depths that agreed within 0.1 foot of physical measurements made at deployment and recovery of the logger. Additionally, the data record was complete, with no outlier data observed over the period of deployment in the outlet stream. Therefore, no corrective measures were deemed necessary and water level logger results at the Cranberry Pond outlet were considered to be valid for use in this study.

One of the water level loggers installed in the Blackamore Pond outlet was “lost” over the course of the field program. Given the short period targeted for deployment, no data were recovered from this water logger. Therefore, continuous water level data were not available for the Blackamore Pond outlet. However, measurements of water level were made at the beginning and end of the field program. Based on water level logger data obtained from the Cranberry Pond outlet, as well as nearby USGS stream gages (e.g., 01116500 Pawtuxet River at Cranston, [USGS 2016]), it is likely that water levels measured at the beginning of the study (on September 30) were the lowest present over the period of study. Given the objective of this study to document water levels representative of seasonal low-flow conditions, ESS believes that the manual measurements made at the beginning and end of the field program are sufficient to meet project needs at this time.

### **Other Field Data Collection**

No substantive data quality problems affected other field data collection efforts associated with this study. Therefore, the data collected were considered to be valid for use in this study.



## **ANADROMOUS FISH PASSAGE AND HABITAT MANAGEMENT OPTIONS**

The most commonly observed barriers to fish passage were culverts with one or more of the following characteristics:

- Collapsed entrance or outlet
- Limited light penetration (due to small diameter/extended length)
- Submerged outlet

However, extremely shallow stream channel depths also pose potential impediments to the passage of anadromous fishes.

Blackamore Pond and Cranberry Pond both discharge into small, low-gradient streams, indicating that excessive flow velocity is unlikely to be a barrier to fish passage. The primary exception to this would be where the more severe artificial constrictions (e.g., undersized culverts) occur, particularly at high flows.

In-pond habitat is less than ideal at both ponds. In Blackamore Pond, a variety of habitats are available to support spawning and growth of anadromous alewife. However, water quality in the pond is impaired and could result in marginal conditions for successful alewife spawning and recruitment. Additionally, sediment quality may be impaired by concentrations of certain heavy metals, such as lead (although the potential impact of this on spawning alewife, eggs, larvae, or juveniles is uncertain).



In Cranberry Pond, excessive growth of water lilies, naturally low water clarity, and lack of clean sand, gravel, or other coarse substrates suggests that habitat is marginal for alewife spawning and recruitment.

With these observations in mind, the following fish passage and habitat management options were considered for the Blackamore and Cranberry Pond systems.



### **Stream Daylighting**

Stream daylighting is an approach that results in complete and permanent conversion of a culvert, tunnel, or otherwise closed conveyance to an open channel. This option generally seeks to approximate natural stream conditions and therefore tends to be ideal for fish passage. However, it is not feasible in many situations, such as when existing transportation infrastructure is present. In most cases, stream daylighting would require filing a Request for Preliminary Determination from the RIDEM Freshwater Wetlands Program.



Costs of stream daylighting vary significantly by size of the stream, amount and quality of existing fill to remove, length of stream to daylight, and other site-specific factors. This approach was previously used on a Natural Resources Conservation Service (NRCS)-sponsored flood mitigation project that involved daylighting piped sections of the outlet stream near Myrtle Avenue and Fordson Avenue (NRCS 2011). These sections of the stream were realigned in a new open channel to the west that reconnected the outlet stream with the Pocasset River at its historical confluence. The construction costs associated with this project were over \$500,000.

Stream daylighting is currently recommended at one location associated with the Blackamore Pond system (Budlong Park). In this case, daylighting would likely involve the removal of concrete panels that currently cover a short channelized section of the outlet stream behind Budlong Pool. This section of the stream currently contains slots for stoplogs, presumably to allow diversion of the stream into the low-lying “pond” just south of the baseball fields at Budlong Park, which may serve both a flood storage and recreational purpose. Therefore, daylighting of the stream at this location would require additional coordination with the owner and operator of the structure to ensure that it is compatible with current uses.

### **Culvert Replacement**

This approach typically requires significant engineering design to ensure that fish passage will be enhanced while ensuring structural stability and making certain that downstream flooding will not be exacerbated by the new culvert. Significant permitting may be required, including but not necessarily limited to filing a Request for Preliminary Determination from the RIDEM Freshwater Wetlands Program.

Costs vary significantly by installation method, site characteristics, and ultimate design of the new culvert, however a cost of about \$200,000 should be anticipated for a typical scenario, inclusive of permitting and design. Roads that cannot be closed or partially closed with a lane restriction during the construction period could result in increased costs due to the need for alternative construction methods.



Culvert replacement is recommended as a possible solution for two locations associated with Blackamore Pond and four locations associated with Cranberry Pond.

### **Culvert Retrofit**

Culvert retrofitting involves minor alteration of an existing culvert or adjacent areas to enhance fish passage. Retrofitting may be appropriate where minor culvert perching or other simply corrected issues are present. Depending on the retrofit, a Request for Preliminary Determination from the RIDEM Freshwater Wetlands Program may or may not be needed.

Costs vary by nature of retrofit, although they would generally be expected to be substantially less than culvert replacement or stream daylighting.



Culvert retrofit is recommended as an interim measure to improve fish passage for at least one location associated with Blackamore Pond (Aqueduct Road). Due to the low openness ratio (area to length) of the culvert at this location, much of the existing pipe is dark, which may discourage fish passage. The addition of supplemental lighting within the culvert, such as solar powered waterproof LED strip lighting, is one low-cost retrofit option to address this issue.

### **Dam Removal or Lowering**

Dam removal and lowering can eliminate or reduce the barriers to fish passage caused by dam structures. Where dams create a significant amount of spawning habitat for anadromous alewife, dam removal or lowering would actually result in a loss of viable habitat and therefore be undesirable.

Dam removal and lowering are generally among the most costly approaches to fish passage improvement, often reaching several hundred thousand dollars in total costs.

Dams are not a primary barrier to fish passage at either of the ponds or along their tributaries. Therefore, this option is not recommended for either pond in this study.

### **Fish Ladder or Fishway**

Fish ladders and fishways are artificial structures that allow fish passage at dams by channeling flow over a more gradual slope that fish can navigate. Baffles or other features are incorporated into the design to provide resting areas for fish as they ascend. Denil fish ladders are a ubiquitous design but other styles, including nature-like fishways, have also been constructed in southern New England.

Costs for fish ladders and fishways vary significantly by type and site requirements. Some of the simpler options for low-head dams are less than \$50,000 installed. However, larger or more complex fish ladders and fishways may exceed \$100,000 in construction costs alone.



Source: USFWS

Dams are not a primary barrier to fish passage at either of the ponds or along their tributaries. Therefore, fish ladders and fishways are not recommended for either pond in this study.

### **Develop Lake Management Plan**

Lake management plans are a useful tool for assessing options and selecting a path forward for the management of a lake or pond. These plans may be holistic or specific, depending on community needs, available resources, and the nature of the management issues affecting the lake or pond of interest.

Although the specific content may vary, lake management plans generally consist of the following minimal elements:



- Statement of purpose and management goals
- Assessment of existing conditions
- Identification and evaluation of management options
- Prioritized recommendations
- Estimate of costs to implement the plan over a particular period of time (usually five years)

A primary advantage provided by a thorough lake management plan is that it can serve as the technical basis for permitting in-lake management projects. Additionally, state permitting fees are reduced for waterbodies with an approved lake management plan.

Given the work that has already been completed as part of the current study, the development of a lake management plan for either pond could likely be accomplished for less than \$10,000 each. The primary goals for the lake management plans would currently be envisioned as the improvement of water quality in each pond to meet state water quality criteria as well as the enhancement of in-pond anadromous fish habitat.

Although lake management plans are recommended for both ponds, ESS recommends that priority be given to Blackamore Pond, which hosts improved public access and appears to provide the largest volume of habitat for anadromous alewife. Blackamore Pond also suffers from reduced water quality, exotic plant growth (curly-leaf pondweed), and recurrent cyanobacteria blooms, each of which could negatively impact the success of anadromous alewife spawning success. Examples of management actions that might be considered at Blackamore Pond through the development of a lake management plan include aeration, nutrient inactivation, chemical controls (algaecides), diver harvesting, waterfowl controls, and stormwater Best Management Practices (BMPs) in the watershed among others.

Cranberry Pond appears to benefit from generally better water quality than Blackamore Pond. However, water quality could still be improved, along with fish habitat. Examples of management actions that might be considered at Cranberry Pond through the development of a lake management plan include aeration, chemical controls (herbicides), hydroraking, dredging, and stormwater Best Management Practices (BMPs) in the watershed, among others.

### **Summary of Recommendations**

Of the two systems evaluated by this study, Cranberry Pond and Cranberry Brook are affected by a greater number of significant barriers and provide less suitable in-pond spawning and nursery habitat for anadromous fishes. While fish passage in the Blackamore Pond system is hindered by at least one substantial barrier, in-pond conditions appear to provide a more significant habitat volume for spawning and foraging. Therefore, ESS conditionally recommends prioritizing fish passage and habitat restoration on the Blackamore Pond system. A summary of the options considered and recommended for Blackamore Pond is provided in Table J.



**Table J. Blackamore Pond Anadromous Fish Management Matrix**

Target	Option	Recommended?	Location	Details	Estimated Cost*
Fish Passage	Culvert replacement	Yes	Aqueduct Road	Replace partially submerged, undersized culvert with larger diameter arch or buried culvert	\$100,000 or more
Fish Passage	Culvert replacement	Yes - Priority	Budlong Park	Replace damaged CMP culvert with larger diameter arch or buried culvert	\$20,000 to \$35,000
Fish Passage	Culvert retrofit	Yes	Aqueduct Road	Add lighting to culvert interior to encourage fish passage	\$2,000 to \$4,000
Fish Passage	Stream daylighting	Yes	Budlong Park	Daylight covered channel in Budlong Park. Could be permanent or seasonal. Cost would be significantly higher if channel restoration desired.	\$10,000 to \$15,000
Fish Passage	Dam removal	No	N/A	N/A	Typically \$200,000 or more
Fish Passage	Fish ladder/fishway	No	N/A	N/A	\$50,000 to \$100,000 or more, depending on design and site conditions
In-pond Habitat	Develop lake management plan	Yes	Blackamore Pond and watershed	Would primarily target management of in-pond water quality issues, including excessive algae, low water clarity, marginal dissolved oxygen, and high nutrient levels.	\$10,000

\*Does not account for efficiencies gained by combining multiple actions into one project. Assumes each action is designed, permitted, and implemented on its own.

Although the fish passage challenges are more significant in the Cranberry Pond system, it does have potential to provide additional migration, spawning, and nursery habitat for anadromous river herring. In addition to Cranberry Pond, Cranberry Brook may provide suitable habitat, particularly for blueback herring, which tend to be river spawners. Therefore, restoration activities may still be warranted, albeit as a lower priority effort. A summary of the options considered and recommended for Cranberry Pond is provided in Table K.

**Table K. Cranberry Pond Anadromous Fish Management Matrix**

Target	Option	Recommended?	Location	Details	Estimated Cost
Fish Passage	Culvert replacement	Yes	Mowry Avenue	Replace undersized culvert with larger diameter arch or buried culvert	\$100,000 or more
Fish Passage	Culvert replacement	Yes	Fifth Avenue	Replace undersized culvert with larger diameter arch or buried culvert	\$100,000 or more
Fish Passage	Culvert replacement	Yes	Pawtuxet/ Sumner	Replace submerged culvert with larger diameter arch, box, or buried culvert.	\$100,000 or more
Fish Passage	Culvert retrofit	Yes – if culvert replacement is not feasible	Mowry Avenue	Modification of areas on either side of culvert to increase water depth.	\$5,000 to \$15,000 or more, depending on approach
Fish Passage	Stream daylighting	Yes	Belmont Park/ Pawtuxet River	Stream daylighting would require redirection of traffic or construction of a pedestrian bridge.	At least \$10,000. Likely to exceed \$50,000 if stream is spanned.
Fish Passage	Dam removal	No	N/A	N/A	Typically \$200,000 or more
Fish Passage	Fish ladder/ fishway	No	N/A	N/A	\$50,000 to \$100,000 or more, depending on design and site conditions
In-pond Habitat	Develop lake management plan	Yes	Cranberry Pond and watershed	Would primarily target management of in-pond habitat, such as enhancement of edge habitats and improvement of water quality.	\$10,000

\*Does not account for efficiencies gained by combining multiple actions into one project. Assumes each action is designed, permitted, and implemented on its own.





## **CONCLUSIONS**

Although both the Blackamore and Cranberry Pond systems offer potential migration, spawning, and nursery habitat for anadromous river herring, significant impediments to fish passage remain. Additionally, both ponds face challenges with regard to water quality and other habitat limitations.

Of the two systems, Blackamore Pond and its outlet stream appear to provide more potential habitat volume with fewer impediments to passage. Furthermore, a stream daylighting and restoration project was recently completed just downstream of the remaining barriers to fish passage. Therefore, efforts to improve fish passage through the remaining barriers would, in effect, build upon prior work. As such, our recommendation would be to prioritize actions that improve fish passage and habitat in the Blackamore Pond system.

However, Cranberry Pond and its outlet stream do have potential to provide additional migration, spawning, and nursery habitat for anadromous river herring. Although the fish passage challenges currently appear to be more significant in this system, restoration activities may still be warranted, albeit as a lower priority effort.

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## **Appendix A**

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### **Laboratory Analysis Report**



Monday, January 30, 2017

Attn: Mr Matt Ladewig  
ESS Group Inc.  
10 Hemingway Drive 2nd Floor  
Riverside, RI 02915-2224

Project ID: P310-000 PAWTUXUT RIVER  
Sample ID#s: BV60234 - BV60235

This laboratory is in compliance with the NELAC requirements of procedures used except where indicated.

This report contains results for the parameters tested, under the sampling conditions described on the Chain Of Custody, as received by the laboratory. This report is incomplete unless all pages indicated in the pagination at the bottom of the page are included.

All soils, solids and sludges are reported on a dry weight basis unless otherwise noted in the sample comments.

A scanned version of the COC form accompanies the analytical report and is an exact duplicate of the original.

Enclosed are revised Analysis Report pages. Please replace and discard the original pages. If you have any questions concerning this testing, please do not hesitate to contact Phoenix Client Services at ext. 200.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Phyllis Shiller".

Phyllis Shiller

Laboratory Director

NELAC - #NY11301  
CT Lab Registration #PH-0618  
MA Lab Registration #MA-CT-007  
ME Lab Registration #CT-007  
NH Lab Registration #213693-A,B

NJ Lab Registration #CT-003  
NY Lab Registration #11301  
PA Lab Registration #68-03530  
RI Lab Registration #63  
VT Lab Registration #VT11301





Environmental Laboratories, Inc.  
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045  
Tel. (860) 645-1102 Fax (860) 645-0823



## SDG Comments

January 30, 2017

SDG I.D.: GBV60234

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Version 3: removed "as is" comment.



Environmental Laboratories, Inc.  
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045  
Tel. (860) 645-1102 Fax (860) 645-0823

## Analysis Report

January 30, 2017

FOR: Attn: Mr Matt Ladewig  
ESS Group Inc.  
10 Hemingway Drive 2nd Floor  
Riverside, RI 02915-2224

### Sample Information

Matrix: SEDIMENT  
Location Code: ESSGRPRI  
Rush Request: Standard  
P.O.#:

### Custody Information

Collected by:  
Received by: B  
Analyzed by: see "By" below

### Date

10/09/16  
10/20/16

### Time

14:40  
16:18

## Laboratory Data

SDG ID: GBV60234  
Phoenix ID: BV60234

Project ID: P310-000 PAWTUXUT RIVER  
Client ID: EP-S1

Parameter	Result	RL/ PQL	Units	Dilution	Date/Time	By	Reference
Arsenic	10.4	5.1	mg/Kg	1	10/24/16	LK	SW6010C
Cadmium	6.2	2.5	mg/Kg	1	10/24/16	LK	SW6010C
Chromium	42.6	2.5	mg/Kg	1	10/24/16	LK	SW6010C
Copper	133	2.5	mg/kg	1	10/24/16	LK	SW6010C
Mercury	< 0.21	0.21	mg/Kg	1	10/21/16	RS	SW7471B
Nickel	51.4	2.5	mg/Kg	1	10/24/16	LK	SW6010C
Lead	709	2.5	mg/Kg	1	10/24/16	LK	SW6010C
Zinc	710	2.5	mg/Kg	1	10/24/16	LK	SW6010C
Percent Solid	13		%		11/01/16	W	SW846-%Solid
Mercury Digestion	Completed				10/21/16	W/W	SW7471B
Total Metals Digest	Completed				10/20/16	X/AG	SW3050B

B = Present in blank, no bias suspected.

RL/PQL=Reporting/Practical Quantitation Level ND=Not Detected BRL=Below Reporting Level

### Comments:

All soils, solids and sludges are reported on a dry weight basis unless otherwise noted in the sample comments.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

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Phyllis Shiller, Laboratory Director

January 30, 2017

Reviewed and Released by: Bobbi Aloisa, Vice President





Environmental Laboratories, Inc.  
587 East Middle Turnpike, P.O.Box 370, Manchester, CT 06045  
Tel. (860) 645-1102 Fax (860) 645-0823

## Analysis Report

January 30, 2017

FOR: Attn: Mr Matt Ladewig  
ESS Group Inc.  
10 Hemingway Drive 2nd Floor  
Riverside, RI 02915-2224

### Sample Information

Matrix: SEDIMENT  
Location Code: ESSGRPRI  
Rush Request: Standard  
P.O.#:

### Custody Information

Collected by:  
Received by: B  
Analyzed by: see "By" below

### Date

10/09/16  
10/20/16

### Time

13:22  
16:18

## Laboratory Data

SDG ID: GBV60234  
Phoenix ID: BV60235

Project ID: P310-000 PAWTUXUT RIVER  
Client ID: CP-S1

Parameter	Result	RL/ PQL	Units	Dilution	Date/Time	By	Reference
Arsenic	14.4	6.2	mg/Kg	1	10/24/16	LK	SW6010C
Cadmium	4.5	3.1	mg/Kg	1	10/24/16	LK	SW6010C
Chromium	18.9	3.1	mg/Kg	1	10/24/16	LK	SW6010C
Copper	78.3	3.1	mg/kg	1	10/24/16	LK	SW6010C
Mercury	< 0.22	0.22	mg/Kg	1	10/21/16	RS	SW7471B
Nickel	25.3	3.1	mg/Kg	1	10/24/16	LK	SW6010C
Lead	227	3.1	mg/Kg	1	10/24/16	LK	SW6010C
Zinc	506	3.1	mg/Kg	1	10/24/16	LK	SW6010C
Percent Solid	11		%		11/01/16	W	SW846-%Solid
Mercury Digestion	Completed				10/21/16	W/W	SW7471B
Total Metals Digest	Completed				10/20/16	X/AG	SW3050B

B = Present in blank, no bias suspected.

RL/PQL=Reporting/Practical Quantitation Level ND=Not Detected BRL=Below Reporting Level

### Comments:

All soils, solids and sludges are reported on a dry weight basis unless otherwise noted in the sample comments.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

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Phyllis Shiller, Laboratory Director

January 30, 2017

Reviewed and Released by: Bobbi Aloisa, Vice President



Environmental Laboratories, Inc.  
587 East Middle Turnpike, P.O. Box 370, Manchester, CT 06045  
Tel. (860) 645-1102 Fax (860) 645-0823

## QA/QC Report

January 30, 2017

### QA/QC Data

SDG I.D.: GBV60234

Parameter	Blank	Blk RL	Sample Result	Dup Result	Dup RPD	LCS %	LCSD %	LCS RPD	MS %	MSD %	MS RPD	% Rec Limits	% RPD Limits
QA/QC Batch 363640 (mg/kg), QC Sample No: BV59919 (BV60234, BV60235)													
<u>ICP Metals - Soil</u>													
Arsenic	BRL	0.67	1.60	1.52	NC	91.7			92.5			75 - 125	30
Cadmium	BRL	0.33	<0.35	<0.36	NC	96.7			97.4			75 - 125	30
Chromium	BRL	0.33	14.8	15.4	4.00	100			99.1			75 - 125	30
Copper	BRL	0.33	9.80	10.3	5.00	85.9			99.1			75 - 125	30
Lead	BRL	0.33	2.3	2.49	NC	93.3			98.3			75 - 125	30
Nickel	BRL	0.33	11.4	12.0	5.10	100			96.5			75 - 125	30
Zinc	0.48	0.33	21.3	22.0	3.20	96.0			95.9			75 - 125	30

QA/QC Batch 363733 (mg/kg), QC Sample No: BV60133 (BV60234, BV60235)

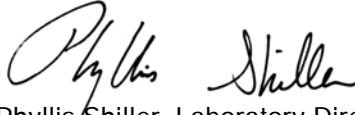
Mercury - Soil	BRL	0.02	<0.03	0.04	NC	100	101	1.0	102			70 - 130	30
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Comment:

Additional Mercury criteria: LCS acceptance range for waters is 80-120% and for soils is 70-130%. MS acceptance range is 75-125%.

If there are any questions regarding this data, please call Phoenix Client Services at extension 200.

RPD - Relative Percent Difference  
LCS - Laboratory Control Sample  
LCSD - Laboratory Control Sample Duplicate  
MS - Matrix Spike  
MS Dup - Matrix Spike Duplicate  
NC - No Criteria  
Intf - Interference

  
Phyllis Shiller, Laboratory Director  
January 30, 2017

Monday, January 30, 2017

Criteria: None

State: RI

## Sample Criteria Exceedances Report

GBV60234 - ESSGRPRI

SampNo	Acode	Phoenix Analyte	Criteria	Result	RL	Criteria	RL Criteria	Analysis Units
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\*\*\* No Data to Display \*\*\*

Phoenix Laboratories does not assume responsibility for the data contained in this report. It is provided as an additional tool to identify requested criteria exceedences. All efforts are made to ensure the accuracy of the data (obtained from appropriate agencies). A lack of exceedence information does not necessarily suggest conformance to the criteria. It is ultimately the site professional's responsibility to determine appropriate compliance.





## **Appendix B**

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### **Habitat Assessment Field Data Sheets**

# HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME <u>Cranberry Brook</u>	LOCATION <u>Mowry Ave Warwick, RI 02888</u>
STATION # _____ RIVERMILE _____	STREAM CLASS <u>1st order</u>
LAT <u>41.751049</u> LONG <u>-71.421156</u>	RIVER BASIN <u>Pawtuxet</u>
STORET # _____	AGENCY _____
INVESTIGATORS <u>J. Burgoyne, M. Mahoney</u>	
FORM COMPLETED BY <u>J. Burgoyne</u>	DATE _____ AM PM REASON FOR SURVEY <u>Fish Passage Feasibility Study</u>

	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
Parameters to be evaluated in sampling reach	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE <u>13</u>	20 19 18 17 16	15 14 <u>(13)</u> 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE <u>10</u>	20 19 18 17 16	15 14 13 12 11	<u>(10)</u> 9 8 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE <u>5</u>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	<u>(5)</u> 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE <u>15</u>	20 19 18 17 16	<u>(15)</u> 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE <u>18</u>	20 19 <u>(18)</u> 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0



# HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
<b>6. Channel Alteration</b>  Channelization or dredging absent or minimal; stream with normal pattern.						Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE <u>12</u>	20	19	18	17	16	15	14	13	<u>12</u>	11	10	9	8	7	6	5	4	3	2	1	0
<b>7. Channel Sinuosity</b>  The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)						The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.					
SCORE <u>8</u>	20	19	18	17	16	15	14	13	12	11	10	9	<u>8</u>	7	6	5	4	3	2	1	0
<b>8. Bank Stability (score each bank)</b>  Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.						Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.					Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.					Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.					
SCORE <u>7</u> (LB)	Left Bank 10 9					8 <u>7</u> 6					5 4 3					2 1 0					
SCORE <u>7</u> (RB)	Right Bank 10 9					8 <u>7</u> 6					5 4 3					2 1 0					
<b>9. Vegetative Protection (score each bank)</b>  Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.					70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.					50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.					Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.					
SCORE <u>7</u> (LB)	Left Bank 10 9					8 <u>7</u> 6					5 4 3					2 1 0					
SCORE <u>7</u> (RB)	Right Bank 10 9					8 <u>7</u> 6					5 4 3					2 1 0					
<b>10. Riparian Vegetative Zone Width (score each bank riparian zone)</b>  Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.						Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.					Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.					Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.					
SCORE <u>4</u> (LB)	Left Bank 10 9					8 7 6					5 <u>4</u> 3					2 1 0					
SCORE <u>4</u> (RB)	Right Bank 10 9					8 7 6					5 <u>4</u> 3					2 1 0					

Total Score 117



# HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME <u>Unnamed</u>	LOCATION <u>Aqueduct Rd. Cranston RI 02910</u>	
STATION # _____ RIVERMILE _____	STREAM CLASS <u>1<sup>st</sup> order</u>	
LAT <u>41.771303</u> LONG <u>-71.447488</u>	RIVER BASIN <u>Pocasset/Pawtuxet</u>	
STORET # _____	AGENCY <u>ESS Group</u>	
INVESTIGATORS <u>J. Burgoyne, M. Mahoney</u>		
FORM COMPLETED BY <u>J. Burgoyne</u>	DATE _____ TIME _____ AM PM	REASON FOR SURVEY <u>Fish Passage Feasibility Study</u>

	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
Parameters to be evaluated in sampling reach	<b>1. Epifaunal Substrate/ Available Cover</b>	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE <u>11</u>	20 19 18 17 16	15 14 13 12 <u>11</u>	10 9 8 7 6	5 4 3 2 1 0
	<b>2. Pool Substrate Characterization</b>	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE <u>9</u>	20 19 18 17 16	15 14 13 12 11	10 <u>9</u> 8 7 6	5 4 3 2 1 0
	<b>3. Pool Variability</b>	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE <u>6</u>	20 19 18 17 16	15 14 13 12 11	10 9 8 7 <u>6</u>	5 4 3 2 1 0
	<b>4. Sediment Deposition</b>	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE <u>8</u>	20 19 18 17 16	15 14 13 12 11	10 9 <u>8</u> 7 6	5 4 3 2 1 0
	<b>5. Channel Flow Status</b>	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE <u>14</u>	20 19 18 17 16	15 <u>14</u> 13 12 11	10 9 8 7 6	5 4 3 2 1 0



# HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category																				
	Optimal					Suboptimal					Marginal					Poor					
<b>6. Channel Alteration</b>  Channelization or dredging absent or minimal; stream with normal pattern.						Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.					Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.					Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.					
SCORE <u>12</u>	20	19	18	17	16	15	14	13	<u>12</u>	11	10	9	8	7	6	5	4	3	2	1	0
<b>7. Channel Sinuosity</b>  The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)						The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.					Channel straight; waterway has been channelized for a long distance.					
SCORE <u>13</u>	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
<b>8. Bank Stability (score each bank)</b>  Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.						Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.					Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.					Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.					
SCORE <u>7</u> (LB)	Left Bank					8					7					6					
SCORE <u>9</u> (RB)	Right Bank					8					7					6					
<b>9. Vegetative Protection (score each bank)</b>  Note: determine left or right side by facing downstream.						70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.					50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.					Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.					
SCORE <u>4</u> (LB)	Left Bank					8					7					6					
SCORE <u>5</u> (RB)	Right Bank					8					7					6					
<b>10. Riparian Vegetative Zone Width (score each bank riparian zone)</b>  Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.						Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.					Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.					Width of riparian zone <6 meters; little or no riparian vegetation due to human activities.					
SCORE <u>4</u> (LB)	Left Bank					8					7					6					
SCORE <u>4</u> (RB)	Right Bank					8					7					6					

Total Score 106



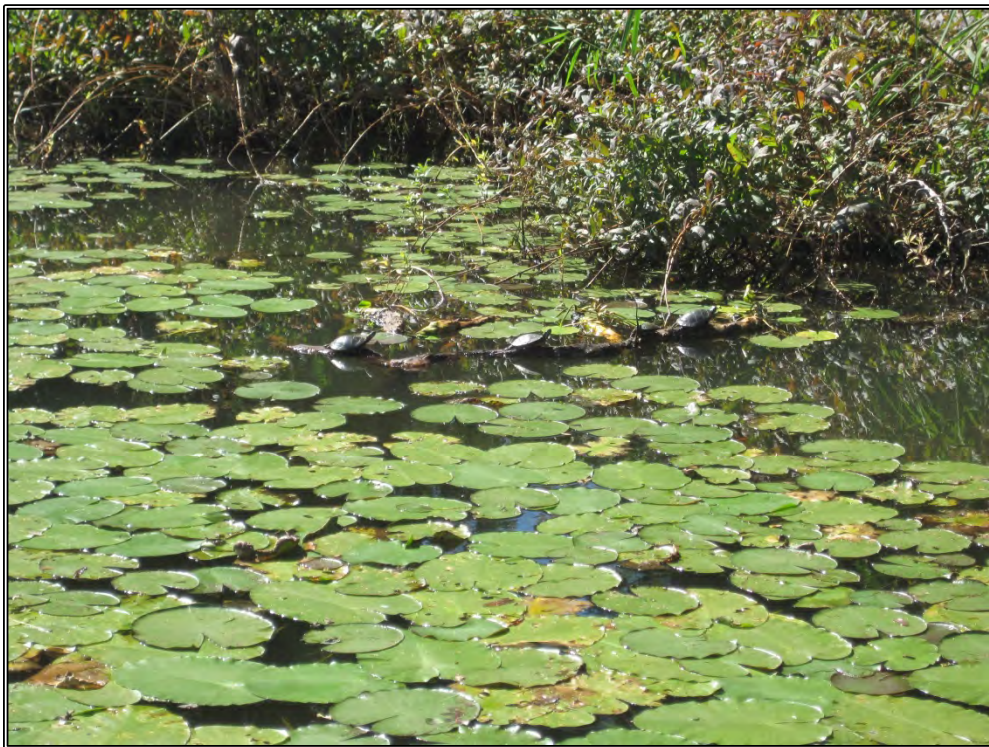
## **Appendix C**

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### **Photographic Log**



**Blackamore Pond – September 26, 2016**



**Blackamore Pond – September 26, 2016**





**B-1: Blackamore Pond outlet culvert under Aqueduct Road, downstream side – September 30, 2016**



**B-1: Blackamore Pond outlet culvert under Aqueduct Road, upstream side – September 30, 2016**





**Downstream of Blackamore Pond outlet, altered segment of stream that runs parallel to Budlong Pool – September 30, 2016**



**B-2: Culvert/underpass behind Budlong Pool facility, downstream end – September 30, 2016**





**B-2: Upstream entrance to culvert/underpass behind Budlong Pool facility – September 30, 2016**



**Pocasset River upstream of Pontiac Ave – September 30, 2016**





**Garden City Drive bridge over Pocasset River – September 30, 2016**



**Pontiac Ave bridge over Pocasset River – September 30, 2016**





**Cranberry Pond – September 29, 2016**



**Cranberry Pond densely vegetated shoreline – September 29, 2016**





**Cranberry Pond outlet– September 30, 2016**



**C-1 Obstruction at Cranberry Pond outlet – September 30, 2016**





**C-1: culvert under Mowry Ave directly downstream from spillway -- September 30, 2016**



**C-1: downstream side of culvert under Mowry Ave -- September 30, 2016**





**C-2: extended culvert under Fifth Ave, downstream end – September 30, 2016**



**Looking through extended culvert under Fifth Ave from downstream end – September 30, 2016**





**C-3: Underpass at the intersection of Sumner Ave and Pawtuxet Ave, upstream side -- September 30, 2016**



**C-3: Underpass at the intersection of Sumner Ave and Pawtuxet Ave, downstream side -- September 30, 2016**





**C-4: Culvert underneath trail at the confluence of Cranberry Brook and Pawtuxet River – September 30, 2016**



**Looking towards Cranberry Brook/Pawtuxet River confluence from mouth of culvert – September 30, 2016**