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FINAL COMPARATIVE ECOLOGICAL ASSESSMENT REPORT



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CENTREDALE MANOR RESTORATION PROJECT SUPERFUND SITE, NORTH PROVIDENCE, RHODE ISLAND

Prepared for:

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October 2008



June 15, 2009

Ms. Anna Krasko, Project Manager
United States Environmental Protection Agency
Region 1
One Congress Street
Boston, Massachusetts 02114

RE: Revision Pages for AMEC's Revised Final Comparative Ecological Assessment Report

Dear Ms. Krasko:

Enclosed are three copies of correction pages for AMEC Earth & Environmental, Inc.'s (AMEC's) October 13, 2008 Revised Final Comparative Ecological Assessment Report. This report was prepared for the Centredale Manor Restoration Project (CMRP) Superfund Site in the Town of North Providence, Rhode Island. The study was conducted on behalf of Emhart Industries, Inc., pursuant to an Administrative Settlement Agreement and Order on Consent (AOC) entered into with the United States Environmental Protection Agency (USEPA) (USEPA Region I, CERCLA Docket No. 01-2007-0163).

The enclosed replacement pages reflect edits made in response to EPA comments on the document. The changes made to the report are primarily formatting and typographical corrections. No substantive changes were required. In addition to the enclosed replacement pages, I have emailed to you a complete copy of the revised report. Receipt of these revisions fulfills Emhart's responsibilities in the above mentioned AOC regarding the comparative ecological assessment.

Sincerely,

A handwritten signature in black ink, appearing to read "Russ Keenan".

Russell E. Keenan, Ph.D.
Vice President
Technical Director, Risk Assessment

A handwritten signature in black ink, appearing to read "Patrick O. Gwinn".

Patrick O. Gwinn
Senior Environmental Scientist

cc: Lou Maccarone – RIDEM

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LIST OF ACRONYMS AND ABBREVIATIONS

ASMFC	Atlantic States Marine Fisheries Commission
BFE	Base flood elevation
CMRP	Centredale Manor Restoration Project
DO	Dissolved oxygen
EMAD	Emergent Marsh Deep
EMAS	Emergent Marsh Shallow / Wet Meadow
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FOBMA	Forested Deciduous Red Maple Swamp
GCN	Greatest conservation need
GIS	Geographical information system
HUC	Hydrologic unit code
LE	Lacustrine Eutrophic Lake / Pond
MFD	Mixed Forest Deciduous Unspecified
MS4	Municipal separate storm sewer system
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
QEA	Quantitative Environmental Analysis, LLC
RI	Remedial investigation
RIDEM	Rhode Island Department of Environmental Management
RLP	River Lower Perennial
RUP	River Upper Perennial
SSAD	Shrub Swamp Water Willow
TMDL	Total maximum daily load
U	Urban
URI	University of Rhode Island
USACOE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

1.0 INTRODUCTION

AMEC Earth & Environmental has prepared a comparative ecological assessment for the Centredale Manor Restoration Project (CMRP) Superfund Site in the Town of North Providence, Rhode Island. The assessment was conducted on behalf of Emhart Industries, Inc., pursuant to an Administrative Settlement Agreement and Order on Consent entered into with the United States Environmental Protection Agency (USEPA) (USEPA Region I, CERCLA Docket No. 01-2007-0163). The assessment was completed through a series of desk-top and field activities. Documents and reports concerning the environmental and ecological condition of the Site were first reviewed as a means of developing a preliminary understanding of the conditions at the Site. A qualitative site survey was then conducted to supplement and expand upon the existing data and information. Finally, information regarding the four remedial alternatives, including the hydrodynamic analysis (QEA, 2007), was reviewed and evaluated in connection with the preparation of this report.

The assessment and this subsequent report were intended to fulfill two primary objectives. The first objective of the assessment was to develop a basic understanding of the existing functions and values of the various habitats and ecological communities along the Woonasquatucket River that flows through the CMRP site. Second, the ecological assessment was undertaken to provide a basis for comparing and contrasting the existing functions and values of the various habitats and ecological communities within and proximate to the site with those that would likely result from implementing one of four remedial alternatives.

This comparative evaluation focuses specifically on four proposed remedies for the sediment in Allendale and Lyman Mill Ponds. The comparative evaluation does not assess what impacts may possibly occur under any other remedial configurations or implementation designs that may be proposed by EPA in the FS, such as the construction of haul roads, upland CDFs, and/or dewatering facilities. In addition, the evaluation of potential ecological impacts of remedial options in other areas of the CMRP Superfund Site, such as those that may be proposed for the source area soils, sediment upstream of Allendale Pond, the Oxbow area, or the river segment connecting Allendale and Lyman Mill Dams, is beyond the scope of this report.

1.1 Site Setting

The main part of the CMRP site is approximately 9.04 acres in size and is located on the east side of the Woonasquatucket River in the Town of North Providence, Providence County, Rhode Island; at the Brook Village and Centredale Manor apartment complex properties (2072 Smith Street and 2074 Smith Street, respectively). Figure 1 presents a site location map overlaid on a United States Geological Survey (USGS) topographic map, and Figure 2 presents a site location map overlaid on an aerial photograph of the area.

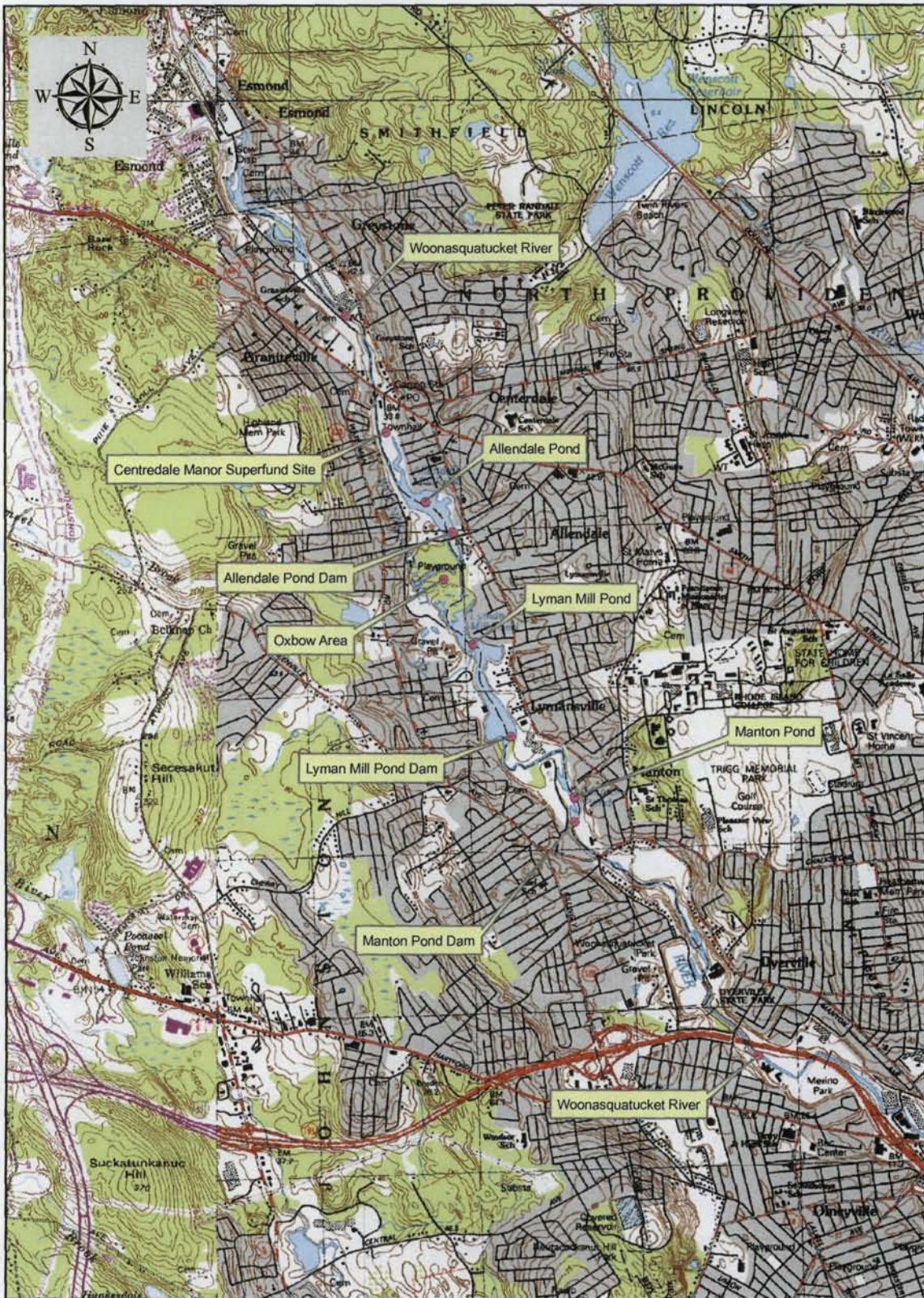
The site as defined by the USEPA encompasses both the Brook Village and Centredale Manor properties as well as the contaminated sediment in Allendale Pond, Lyman Mill Pond, the interconnecting waterway, floodplain soils, and the forested wetland area generally referred to as the "Oxbow Area". The study area for this comparative ecological assessment is primarily Allendale and Lyman Mill Ponds. The current characteristics of the Oxbow area are also discussed because it is an important ecological feature of this system. However, because the remediation alternatives evaluated in this comparative assessment do not address the Oxbow area, the discussion of the Oxbow is generally limited to the existing functions and values and any potential impacts revealed by the hydrodynamic modeling component of this evaluation.

The CMRP site is located in the Seaboard Lowland section of the New England physiographic province¹. According to the Level III and IV Ecoregions Map of Massachusetts, Rhode Island, and Connecticut (Griffith et al., n.d.), the site is also considered to be located in the Narragansett/Bristol Lowland Ecoregion (No. 59e). Within this ecoregion, the site is situated in the Woonasquatucket River subwatershed of the Providence River watershed within the Narragansett Drainage Basin. The hydrologic unit code (HUC) for the site area is HUC 01090004.

The ecological characteristics of the site are dominated by the linear stretch of the Woonasquatucket River and its bordering ecosystems. The area surrounding the site has been extensively developed for both residential and commercial purposes, with the result that the habitat associated with the river has been greatly fragmented and disturbed (Battelle, 2004). The river has been classified as an "impaired water" under Section 303(d) of the Clean Water Act. The cause of the impairment is attributed to pathogens, metals, organic compounds, depressed dissolved oxygen levels, and elevated nutrient levels (RIDEM, 2001). A portion of these parameters are associated with permitted discharges from the Smithfield Wastewater Treatment Plant (WWTP), which is located upstream of the site.

The Woonasquatucket River is non-tidal within the vicinity of the study area and is highly variable in width, depth, channel type, and sediments. The USACOE (2007a) reports that

¹ pubs.usgs.gov/wri/wri984249/pdf/4envirsettings.web.pdf



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Feet

SOURCE:
Rhode Island Geographic Information System
<http://www.edc.uri.edu/RIGIS/default.html>
USGS 7.5 Minute Topo Maps
Georgiaville, R.I., 1954
photorevised 1970 and 1975
Attleboro, Massachusetts-Rhode Island, 1967
North Scituate, R.I., 1955
photorevised 1970 and 1975
Providence, Rhode Island-Massachusetts, 1967

amec Earth & Environmental

Figure 1

Site Location Map
Centredale Manor Restoration
Project Superfund Site
North Providence, Providence Co., RI

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04/17/2008



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Feet

SOURCE:
Rhode Island Geographic Information System
<http://www.edc.uri.edu/RI/GIS/default.html>
2003-2004 RIDOT
1:5,000 digital true color orthophotography

amec Earth & Environmental

Figure 2

Aerial Photo
Centredale Manor Restoration
Project Superfund Site
North Providence, Providence Co., RI

Rev. By: PP

Project No.: 773610000.0004

04/17/2008

the Woonasquatucket River is entrenched in a valley train, a glacial feature described as graded outwash deposited by glacial streams, which fills a valley bottom from wall to wall. The river channel has been essentially unchanged in the last 50 years because it is entrenched in this valley train, and also lacks erosive material. Starting from the Centredale Manor and Brook Village Apartment complexes seven (7) low-head dams are present on the river downstream of the site, most of which are currently impassable to anadromous fish. Those dams include:

- Allendale Pond Dam
- Lyman Mill Pond Dam
- Manton Mill Pond Dam
- Dyerville² (partially breached but still impounds water)
- Atlantic Mill Pond Dam
- Paragon Pond Dam
- Rising Sun Pond Dam

A detailed discussion of the hydrology and geomorphology of the Woonasquatucket River is presented in the Remedial Investigation (RI) (USEPA, 2005) and the USACOE report titled, *"Geomorphic Identification and Verification of Recent Sedimentation Patterns in the Woonasquatucket River, North Providence, Rhode Island"* (USACOE, 2007a).

The Woonasquatucket River supports a mixed cold/warm water fishery that includes species such as white sucker (*Catostomus commersoni*), one of the community dominants, stocked rainbow trout (*Oncorhynchus mykiss*)³, bluegill (*Lepomis macrochirus*), bullhead (*Ameiurus* spp.), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), shiners (*Notropis* spp.), and numerous others. Because rainbow trout are stocked by the Rhode Island Department of Environmental Management (RIDEM), Division of Fisheries and Wildlife (DFW), their presence does not necessarily suggest that a self-sustainable population exists in the river.

1.2 Evaluation of Conceptual Options

As part of the FS for Allendale Pond and Lyman Mill Pond sediments, USEPA is evaluating a number of remedial alternatives and sediment disposal options. One series of remedial alternatives, referred to as the "dam removal" alternatives, considers the plausibility of altering the riparian habitat by removing Allendale Pond Dam and Lyman Mill Pond Dam, thereby increasing the potential floodplain of the river, possibly enhancing recreational use, and restoring anadromous fish passage.

² Existing site documents spell this dam as both "Dyerville" and "Dyreville."

³ Rainbow trout are stocked yearly by RIDEM at Smithfield.

In addition, the FS considers a remedial alternative that retains the Allendale and Lyman Mill Pond Dams and also employs a near-shore CDF for containment of contaminated sediment.

This study qualitatively examines the ecological ramifications of implementing each of these alternatives by comparing the environs of the study area as they currently exist (baseline), defined largely on site reconnaissance surveys and desktop studies, with the environs that would likely result following the implementation of one of these remedial alternatives.

From north to south, the following natural areas and their surrounding environs were examined:

- Woonasquatucket River, between the State Route 44 Bridge and Allendale Pond
- Allendale Pond
- Oxbow Area
- Lyman Mill Pond
- A forested floodplain downstream of the Lyman Mill Pond Dam.

1.3 Report Organization

This report is organized in the following manner. Section 2.0 presents the observational results of the site survey; Section 3.0 describes the various existing habitat and presents a discussion on the functions and values for each of the existing habitats. Section 4.0 presents a more detailed description of the four remedial alternatives that are evaluated for this comparative assessment. Section 5.0 provides a discussion of the potential changes to the functions and values of these habitats resulting from implementation these alternatives. Finally, a summary and conclusions are provided in Section 6.0.

2.0 OBSERVATIONS OF THE QUALITATIVE SITE SURVEY

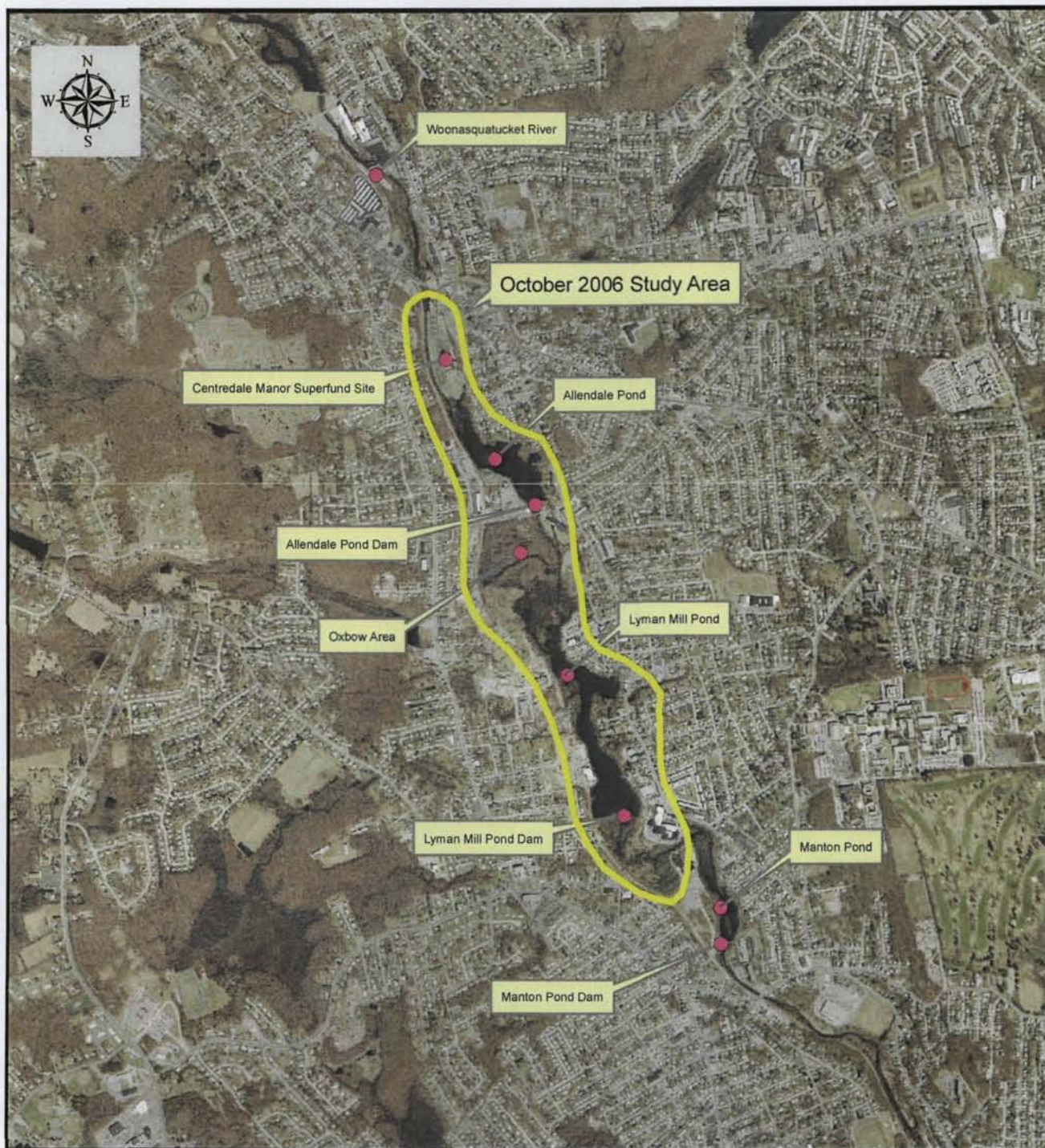
A site survey for the Comparative Ecological Assessment was conducted on October 17 and 18, 2006. The site survey was conducted by a two-person field team, traversing within or around each of five components of the study area. **Figure 3** defines the general boundaries of the site survey. The observations of the site survey and descriptions of the five components of the study area are provided below. **Appendix A** presents photographs of these areas, **Appendix B** presents a list of plant species observed during the site survey, and **Appendix C** presents a list of wildlife species observed, and expected to utilize the habitats on and around the site. **Appendix D** presents a summary of the fish observed in the River and mill ponds, as well as those that may be anticipated with some of the proposed remedial alternatives. Additional descriptions of the study area in relation to state and federal habitat classification schemes are presented in Section 3.0 of this report.

2.1 Woonasquatucket River

The Woonasquatucket River flows southeastward through a variety of land uses including residential, commercial, industrial, utility, and undeveloped areas. A large portion of the study area is composed of the impounded portions of this river, with the exception of the following three river segments:

- Upper Segment - An approximate 1,600-foot segment upstream of Allendale Pond, adjacent to Brook Village Apartments, Centredale Manor Apartments, and Caps #1 and #2. This segment is roughly equivalent to the "North Allendale Mill Reach" in the USACOE (2007a) study.
- Middle Segment - An approximate 1,400-foot segment between Allendale Pond and Lyman Mill Pond, east of the Oxbow Area described in Section 2.3. This segment is roughly equivalent to the "South Allendale Mill Reach" in the USACOE (2007a) study.
- Lower Segment - The portion of the Woonasquatucket River downstream of the Lyman Mill Pond dam. This segment was not part of the study area in USACOE (2007a).

The varied land use around the Woonasquatucket River results in a riparian corridor of variable width, although, overall, it is generally narrow. This riparian corridor is primarily a mixed-stage deciduous forest type and varies from the rear yards of private properties to wooded lots at the end of dead-end streets. The plant species composition within this corridor is mixed and exhibits an assemblage that is somewhat typical for riparian communities within developed areas. These species include black walnut (*Juglans cinerea*), red oak (*Quercus rubra*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), American elm (*Ulmus americana*), multiflora rose (*Rosa multiflora*), Oriental bittersweet (*Celastrus orbiculatus*), common greenbrier (*Smilax rotundifolia*), poison ivy (*Toxicodendron radicans*), and



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Feet

SOURCE:
Rhode Island Geographic Information System
<http://www.edc.uri.edu/RIGIS/default.html>
2003-2004 RIDOT
1:5,000 digital true color orthophotography

amec Earth & Environmental

Figure 3

October 2006 Study Area
Centredale Manor Restoration
Project Superfund Site
North Providence, Providence Co., RI

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Project No.: 773610000.0004

04/17/2008

Japanese knotweed (*Polygonum cuspidatum*). Indications of wildlife observed during the site survey included squirrel nests in trees and calls of several bird species, including the American crow (*Corvus brachyrhynchos*). However, it is known that many other species reside in or use this area. Additionally, the study area may represent a portion of a larger territory in which a species may reside (e.g., river otter, great blue heron).

Upper Segment ("North Allendale Mill Reach")

The upper segment of the river that is adjacent to the Centredale Manor and Brook Village Apartment complexes is a straight channel with rip-rap on the east bank and a narrow vegetated strip on the western side. The eastern riparian corridor includes the Centredale Manor and Brook Village Apartment complexes and the area south of the apartments, which serves as a protective cap and functions as a vegetated meadow. The apartments are constructed on floodplain deposits, and presumably fill material, which the USACOE (2007a) reports have a high probability of flooding, and a river terrace is evident east of the apartment buildings.

The western bank is slightly undercut, indicative of high river velocities, quite likely during flood events, although the valley train limits the movement of the river channel to the west (USACOE, 2007a). Both east and west banks are moderately sloped. The western riparian corridor is the utility right-of-way, which includes a wide unpaved road that parallels the river. Regardless, trees compose the dominant plant form on both sides of the river, and no fringe wetlands abut the river in this segment.

It is known that this aquatic system is prone to flash responses in stormwater flows, which will cause the current velocities to increase significantly over base flow conditions in some areas, particularly in the restricted channel (non-ponded) segments. Battelle (2004) characterized the segment south of the Route 44 Bridge and the Allendale Dam as upper perennial riverine habitat dominated by rock bottom. Normandeau (2002d) reported mean surface water velocities in this reach of the river to range from 0.2 feet per second (fps) during low flow to 2.6 fps during high flow. During the 2006 site visit, the water depth was estimated to be approximately 2 feet deep in the center of the channel. This observation is similar to the maximum mean depth of 1.4 feet reported by Normandeau (2002d).

Middle Segment ("South Allendale Mill Reach")

The middle segment of the river between Allendale and Lyman Mill Ponds forms the eastern boundary of the Oxbow Area (see Section 2.3). The Oxbow Area is an important ecological feature of the study area, comprising a mosaic of wetland and upland habitats, and a substantially wider riparian zone than along other segments of the Woonasquatucket River that were observed during the site survey. In contrast to the straight morphology of the northern segment described above, the river segment along the Oxbow Area is slightly sinuous and much wider, taking on a more naturalized channel form.

The typical channel width is approximately 50 to 60 feet and includes riffle, run, glide, and pool areas providing good habitat for benthic macroinvertebrates and fish. Both eastern and western banks are vegetated with trees as the dominant plant form, which provide shade to the water surface. No fringe wetlands are present on either side of the river, although wetland areas are located farther away within the Oxbow Area. The banks in this river segment range from gently sloping to moderately high and entrenched (suggesting the flashy nature of this stream). The water in this segment was observed to be moderately clear during the site survey.

The USACOE (2007a) reports that the segment of the river between the Allendale Mill and the northern boundary of Lyman Mill Pond (i.e. adjacent to the Oxbow Area) illustrates the most complex geologic controls on migration of the river within this study area, which is also highly disturbed by anthropogenic influences. More discussion on the Woonasquatucket River in the Oxbow Area is presented in Section 2.3.

Lower Segment

The lower segment of the river situated below the Lyman Mill Pond Dam flows through a forested deciduous floodplain before entering Manton Pond. The forested deciduous floodplain below Lyman Mill Pond Dam is described in Section 2.5. This river segment contains a mid-channel island vegetated with a small number of trees and saplings. As a result, the channel is somewhat braided in this river segment. The banks are vegetated with trees and are slightly-to-moderately undercut. The river exhibits signs of entrenchment below the dam. In this segment, the river is generally a slow-flowing pool with clear-to-moderately clear water.

2.2 Allendale Pond

Similar to the wooded riparian corridor along the river, the vegetation community around Allendale Pond is mixed-stage forested deciduous woods influenced by human development, and include species such as red oak, black oak (*Quercus velutina*), white oak (*Quercus alba*), pin oak (*Quercus palustris*), black walnut, red maple, American elm, American beech (*Fagus grandifolia*), common catalpa (*Catalpa bignonioides*), tree-of-heaven (*Ailanthus altissima*), smooth sumac (*Rhus glabra*), multiflora rose, Asiatic bittersweet, common greenbrier, Japanese knotweed, and common mugwort. It is noted that the majority of the invasive species found around Allendale Pond, including such species as common catalpa, tree-of-heaven, multiflora rose, and Asiatic bittersweet, are located along the utility right-of-way located in the Town of Johnston, on the western bank of the Woonasquatucket River. This section of the pond exhibits a high degree of human influence. In contrast, a smaller number of invasive, but equally troublesome species, such as Japanese knotweed and common mugwort, are found throughout the perimeter of the pond.

A small island or peninsula is located at the north end of Allendale Pond, as the river enters the impoundment. This land area is separated from the east bank of the river by a shallow and narrow (approximately 6-8 feet) channel (former tailrace drainage area) which may be dry during the summer, thus this island may appear to be a peninsula during drier times of the year. This island or peninsula is vegetated with a scrub-shrub wetland community and includes red maple saplings, black willow (*Salix nigra*) saplings, common elder (*Sambucus canadensis*), northern arrowwood (*Viburnum recognitum*), winterberry holly (*Ilex verticillata*), buttonbush (*Cephalanthus occidentalis*), silky dogwood (*Cornus amomum*), multiflora rose, coast pepperbush (*Clethra alnifolia*), Japanese knotweed, purple loosestrife (*Lythrum salicaria*), skunk cabbage (*Symplocarpus foetidus*), and dock-leaf smartweed (*Polygonum lapathifolium*). Similar to the two river segments described earlier, no fringe wetlands were apparent along the perimeter of Allendale Pond, and the only non-open water wetland area observed was the island/peninsula at the northern end of the pond.

Wildlife species observed within and around Allendale Pond during the 2006 site visit included mute swan (*Cygnus olor*), mallard (*Anas platyrhynchos*), blue jay (*Cyanocitta cristata*), and American robin (*Turdus migratorius*), although it is known that a larger variety of wildlife species inhabit that area. Battelle (2004) reported muskrat (*Ondatra zibethicus*), mallard, tree swallow (*Tachycineta bicolor*), killdeer (*Charadrius vociferus*), Canada goose (*Branta canadensis*), mourning dove (*Zenaidura macroura*), mink (*Mustela vison*), snapping turtle (*Chelydra serpentina*), green frog (*Rana clamitans*), American eel (*Anguilla rostrata*), brown bullhead (*Ameiurus nebulosus*), tessellated darter (*Etheostoma olmstedii*), and white sucker (*Catostomus commersoni*) in this reach of the river system.

The open waters of Allendale Pond also provide feeding and resting habitat for avian species such as double-crested cormorant (*Phalacrocorax auritus*), bufflehead (*Bucephala albeola*), common merganser (*Mergus merganser*) and hooded merganser (*Lophodytes cucullatus*). The shoreline vegetation that surrounds the open water includes an assemblage of mature trees, shrubs, and herbaceous plants that provide perching and resting habitat for other birds such as red-winged blackbird (*Agelaius phoeniceus*), wood duck (*Aix sponsa*), great egret (*Ardea alba*), black-crowned night heron (*Nycticorax nycticorax*), great blue heron, green heron (*Butorides virescens*), and belted kingfisher (*Ceryle alcyon*). This shoreline vegetation also provides cover for mammals that use the open water, such as river otter and raccoon (*Procyon lotor*).

Piscivorous wildlife using this area are likely feeding on species such as those identified by Normandeau (2002a) and others, which includes white sucker, alewife (*Alosa pseudoharengus*), American eel, golden shiner (*Notemigonus crysoleucas*), fallfish (*Semotilus corporalis*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), blacknose dace (*Rhinichthys atratulus*), banded killifish (*Fundulus diaphanus*), brown bullhead, yellow bullhead (*Ameiurus natalis*), chain

pickerel (*Esox niger*), redbfin pickerel (*Esox americanus*), northern pike (*Esox lucius*), creek chubsucker (*Erimyzon oblongus*), swamp darter (*Etheostoma fusiforme*), tessellated darter, yellow perch (*Perca flavescens*), white perch (*Morone americana*), rainbow trout (stocked) (*Oncorhynchus mykiss*), and spottail shiner (*Notropis hudsonius*).

Battelle (2005) reports that Allendale Pond has an area of approximately 11 acres, with water depths ranging from less than 0.5 feet to a maximum of about 10 feet. The deepest area of the pond is the currently submerged historic flow channel that trends in a northwest to southeast direction. The water depths in the southern portion of the pond (i.e. near the dam) are generally 4 to 6 feet. The bottom of Allendale Pond is reported to be generally composed of soft sediments underlain by relatively hard sediment or possible bedrock (Battelle, 2005).

2.3 Oxbow Area

The Oxbow Area is an approximate 30-to-40 acre rectangular area located between Allendale Pond and Lyman Mill Pond, along the western side of the Woonasquatucket River in the town of Johnston, RI. As described previously, it is an important ecological feature of the study area since it is a relatively large, undeveloped deciduous forested area surrounded by areas of residential and light industrial development.

The Oxbow Area is composed of a mosaic of forested upland and forested wetland communities, bisected by an abandoned channel and several rivulets. Most of the wetlands are within the 100-year floodplain of the Woonasquatucket River (USACOE, 2007b). The abandoned river channel is the remnant of the original channel that was relocated prior to 1939 (USACOE, 2007b). A foot path is located at the northern end of the Oxbow Area, accessible via Allendale Way. This path extends southward into the Oxbow Area.

The east bank of the river adjacent to the Oxbow Area is largely a river terrace. The river is straightened in this reach; however, the embankment consisting of cobble-sized stone is not continuous and therefore does not always serve as a barrier between the river and the adjacent floodplain. The embankment stone is also found in the river channel, suggesting that the embankment is the result of activity from dumping the spoils after the river was dredged. The height of the embankment varies from 1 to 4 feet from the river channel bed, and floodplain deposits to the west of this ridge indicate over-bank deposition (USACOE, 2007a).

Field mapping conducted by the USACOE (2007a) revealed two previous channels of the river. The earlier channel, observable on the 1888 USGS 15-minute topographic map, follows a sharp meander in response to glacial outwash; the later channel, observable on the 1935 USGS 7.5-minute topographic map, depicts a straightened channel. The area within the former meander is classified as a wetland by the state of Rhode Island and contains fine-grained sediment and

organics. The soil in the abandoned meander is classified as Adrian muck; the area north of the abandoned meander is overlain by soil of the Podunk fine sandy loam unit (USACOE, 2007a).

The Oxbow Area supports the most significant areas of sensitive habitat found within the study area. USACOE (2007b) notes that the Oxbow Area is the largest block of vegetated wetland habitat along the lower Woonasquatucket River and the largest remnant of riparian forest habitat. While much of the riparian community bordering the river and the various ponds is in general narrow due to the encroachment of surrounding development, the Oxbow Area provides a large enough habitat to support a significant population of a number of birds, mammals, reptiles, and amphibians. However, the area is too small to provide habitat for wildlife species that require large blocks of unfragmented forest. Nevertheless, the area is large enough to support edge tolerant breeding birds that nest in wooded areas, and would be important refugia for migrating species through the area. The forested portions do provide habitat for other species such as downy woodpecker, black-capped chickadee, blue jay, moles, chipmunks, squirrels, and white-tailed deer (USACOE, 2007b).

The southern end of the Oxbow Area provides the largest area of emergent and shrub/scrub wetlands present in the study area. In comparison to other segments of the study area, this section should provide excellent habitat for fish and amphibians. The Oxbow Area is the largest mosaic of natural communities found within the CMRP Site and provides the best habitat for transitory, migrating, and resident wildlife within the Site. These areas are anticipated to provide suitable breeding habitat for song sparrow (*Melospiza melodia*), American goldfinch (*Carduelis tristis*), and gray catbird (*Dumetella carolinensis*) (USACOE, 2007b).

Both the upland and wetland portions of the Oxbow Area are early to mid-stage successional deciduous woods. Some portions of the wetland areas are late stage scrub-shrub. The largest trees in these communities exhibit a typical diameter at breast height (dbh) of 10 to 12 inches. Most of the wetlands within the Oxbow Area are depressional wetlands without an obvious surficial connection to the river or the nearby abandoned channel. These wetland areas are vegetated with red maple, eastern cottonwood (*Populus deltoides*), black gum (*Nyssa sylvatica*), pin oak, ironwood (*Carpinus caroliniana*), witch hazel (*Hamamelis virginiana*), northern arrowwood, spicebush (*Lindera benzoin*), common greenbrier (*Smilax rotundifolia*), and grape (*Vitis* sp.). This depressional wetland habitat likely supports a good herptile community. Plant species noted in wetland areas that are late-stage scrub-shrub communities contain speckled alder (*Alnus rugosa*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), willow (*Salix* sp.), and branching bur-reed (*Sparganium angrocladum*). Some portions of the scrub-shrub community are densely vegetated and virtually impenetrable to humans. These densely vegetated areas likely provide ample cover for resident wildlife.

The forested uplands are predominantly a moist woods community vegetated with red oak, red maple, sassafras (*Sassafras albidum*), black birch (*Betula nigra*), silver maple (*Acer saccharinum*), coast pepperbush (*Clethra alnifolia*), and catbrier (*Smilax glauca*). Interspersed within both wetland and upland communities are some invasive species such as Japanese knotweed, Asiatic bittersweet, poison ivy, lady thumb (*Polygonum persicaria*), and Japanese barberry (*Berberis thunbergii*).

The abandoned channel bisects the area in an east-west direction and extends southward into the head of Lyman Mill Pond. It is approximately 20 to 30 feet wide with an unknown depth and potentially affords excellent habitat for amphibian species. Trees make up the dominant plant form along its banks, which are straight to slightly undercut. The water was moderately dark-stained at the time of the site investigation. In addition to the abandoned channel, several small rivulets spread throughout the southern portion of the Oxbow Area. These rivulets range from very narrow and moist linear features, to slightly larger and more sinuous stream channels. Collectively, the abandoned channel, depressional wetlands, and rivulets result in a wetland complex that dominates the southern half of the Oxbow Area.

A large number of treefalls and standing deadwood are present within the Oxbow Area, providing physical structure for wildlife, ranging from microorganisms and fungi, to insects and songbirds. These treefalls and snags provide good winter-feeding habitat for black-capped chickadee (*Poecile atricapilla*), white-breasted nuthatch (*Sitta carolinensis*), and red-breasted nuthatch (*Sitta canadensis*) (USAOCE, 2007b). They also provide nesting sites for gray squirrels, brown creeper (*Certhia americana*), eastern chipmunk (*Tamias striatus*), and northern flying squirrel (*Glaucomys sabrinus*). The snags are not considered to be large enough to provide suitable nesting habitat for red-headed woodpecker (*Melanerpes erythrocephalus*), pileated woodpecker (*Dryocopus pileatus*), or wood duck (USACOE, 2007b).

Additional descriptions of the Oxbow habitats can be found in the report titled, "Oxbow Area Wetland Delineation Report and Functions and Values Assessment" (USACOE, 2007b).

2.4 Lyman Mill Pond and Forested Floodplain

The Lyman Mill Pond is significantly more naturalized than Allendale Pond, exhibiting more community types and larger vegetated areas. Lyman Mill Pond is a shallow impoundment with most areas exhibiting less than 9 feet in water depth, with a bottom largely vegetated with water milfoil (*Myriophyllum* sp.), pondweed (*Potamogeton* sp.), and other submerged aquatic vegetation reflecting its eutrophic nature (Battelle, 2004; USACOE, 2007b). Approximately 10 to 20 percent of the bottom is unvegetated. The unvegetated areas are generally limited to confluences with tributaries (e.g., Assapumpset Brook) and immediately upstream of the Lyman Mill Dam (Battelle, 2004).

Mid-stage deciduous woods still dominate the riparian community around the pond, with the exception of an emergent marsh located near the northern end of the pond. This marsh is nearly dominated by two species, purple loosestrife (*Lythrum salicaria*) and swamp loosestrife or water willow (*Decodon verticillatus*). Other species interspersed within this loosestrife-dominated assemblage include swamp rose (*Rosa palustris*), sweetfern (*Comptonia peregrina*), tall meadow rue (*Thalictrum pubescens*), common cattail (*Typha latifolia*), climbing hempweed (*Mikania scandens*), common morning glory (Convolvulaceae), red maple (*Acer rubrum*) seedlings, and red-osier dogwood (*Cornus sericea*). This vegetation community at the northern end of Lyman Mill Pond is large enough to support breeding populations of red-winged blackbird, swamp sparrow (*Melospiza georgiana*), and yellow warbler (*Dendroica petechia*) (USACOE, 2007b). The plant community around the remaining portions of Lyman Mill Pond is similar to that described earlier, and includes species such as red maple, red oak, black gum, American elm, pin oak, Japanese knotweed, poison ivy, Asiatic bittersweet, and multiflora rose. This community is also a mid-stage deciduous woods.

The USACOE (2007a) reports that Lyman Mill Pond exhibits a more quiescent environment than Allendale Pond. Vibracore samples indicate a layer of organic muck 1 to 3 feet thick throughout much of Lyman Mill Pond. Battelle (2005) reports that Lyman Mill Pond has an area of approximately 24 acres with water depths ranging from less than 1 foot to a maximum of greater than 6 feet. The historic deep flow channel in this pond is located along its eastern side. Similar to Allendale Pond, the bottom of Lyman Mill Pond is generally composed of soft sediments underlain by relatively hard sediment or possibly bedrock.

A mid-stage, deciduous, forested floodplain community is located downstream of the Lyman Mill Pond dam. This community is vegetated with many of the same woody species as noted upstream, but the larger area of the floodplain allows a slightly richer plant community that includes green ash (*Fraxinus pensylvanica*), slippery elm (*Ulmus rubra*), common elder (*Sambucus canadensis*), false rue anemone (*Enemion biternatum*), jewelweed (*Impatiens capensis*), skunk cabbage, and beggar-ticks (*Bidens frondosa*). Battelle (2004) reported observations of osprey (*Pandion haliaetus*) in the area in 2001, and observations of American eel, brown bullhead, tessellated darter, golden shiner, bluegill, chain pickerel, white sucker, and largemouth bass (*Micropterus salmoides*).

Additional descriptions of the vegetation around Lyman Mill Pond can be found in the report titled, "Oxbow Area Wetland Delineation Report and Functions and Values Assessment" (USACOE, 2007b)

3.0 EXISTING FUNCTIONS AND VALUES

The five habitat components, described individually in Section 2.0, compose a single and relatively contiguous wetland complex that includes riverine, lacustrine, forested, scrub-shrub, and emergent systems. On a federal classification level (Cowardin et al, 1979), the wetland complex is composed of three wetland systems (riverine, lacustrine, and palustrine). Although the wetlands in some locations are traversed and bisected by roads, this wetland complex nevertheless provides an integrated set of functions and values for the natural, physical, and human resources of the Woonasquatucket River valley. The view of this wetland complex as a single natural system is not limited to just the scientific perspective, but reaches into the regulatory arena as defined by the Rhode Island Freshwater Wetlands Act (Sections 2-1-18 through 2-1-24 of the General Laws of 1956, and referred to as the "Act"). As per the *Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act* (April 1998), it is anticipated that all of the habitat components examined would be regulated as wetlands under the Act. Therefore, the discussion of existing functions and values of the complex is presented here within the context of the Act and its definition of wetlands.

To facilitate the use of the information contained in Section 3.0 to a broader audience, the habitat components are also described in accordance with the US Fish and Wildlife Service classification scheme of Cowardin et al. (1979). The use of one classification scheme or another does not add to or diminish the functions and values that are provided by the existing habitat components. However, by providing information by both the state and federal classification systems, the information may be more useable to a large audience. The use of the classification system provided under the Act also affords the ability to classify non-wetland functions. This cannot be accomplished using the federal system because it relates only to wetlands and aquatic systems.

3.1 Functions and Values

A qualitative assessment of functions and values was conducted using the *Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act* (April 1998) as a framework for defining and assessing the various environs within the study area. According to this framework, freshwater wetlands provide functions and values that protect the health, welfare, and general well being of the populace and the environment. These functions and values include, but are not limited to, the following:

- (1) Protection of life and/or property from flooding or flood flows by retaining, storing, metering, or slowing flood waters from storm events;
- (2) Providing and maintaining surface and/or groundwater supplies by acting as a recharge or discharge area;

- (3) Providing and maintaining valuable wildlife habitats;
- (4) Providing and maintaining high value recreation areas; and,
- (5) Protecting and maintaining water quality.

The above functions and values are not limited to the areas contained within the outer boundaries of wetlands, but also extend around waters and wetlands for a distance of 50 feet. These functions and values are further defined in Rule 10.02 of the Act and are reiterated here, followed by a site-specific analysis. A quantitative assessment of functions and values, however, was beyond the scope of this report.

3.1.1 Wildlife and Wildlife Habitat

Rule 10.02B(1) states, *"Freshwater wetlands are important areas for the production and diversity of wildlife. Wetlands provide habitat for individual species and communities of animals and plants. Animals include both game and nongame species, which may be either obligate or facultative, and which may be permanent residents, seasonal or transient in nature. Wetlands serve as travel corridors, nesting sites, feeding sites, resting sites, nursery and/or brood rearing sites, escape cover, and seasonal breeding, migration, and overwintering habitat for wildlife. Wetlands provide critical habitat for some plant and animal species, and provide habitat for rare animal and plant species."*

The results of the site survey indicate that the study area provides a variety of aquatic and terrestrial habitat types at various stages of succession. Although few wildlife species and wildlife signs were observed during the brief site survey in October 2006, it is anticipated that the study area does provide ample suitable habitat for numerous invertebrate and vertebrate wildlife species based on an examination of conditions that exist at the study area and a review of existing reports. According to the Rhode Island Comprehensive Wildlife Conservation Strategy (RIDEM 2005), the study area exhibits the following eight categorized key habitat types:

- Mixed Forest Deciduous Unspecified (MFD)
- Emergent Marsh Deep (EMAD) and Emergent Marsh Shallow / Wet Meadow (EMAS)
- Shrub Swamp Water Willow (SSAD)
- Forested Deciduous Red Maple Swamp (FOBMA)
- River Upper Perennial (RUP)
- River Lower Perennial (RLP)
- Lacustrine Eutrophic Lake / Pond (LE)
- Urban (U)

It should be noted that the identification of wildlife species in each habitat component does not necessarily mean that all of the listed species use the subject areas. However, it does indicate that the wildlife species are plausible given the conditions at the study area. Each of the eight key habitat types is described below.

3.1.1.1 Mixed Forest Deciduous Unspecified (MFD)

Mixed deciduous forests are those forests so classified by Anderson et al. (1976) that have a preponderance (more than 50%) of deciduous trees. Because the MFD classification is not a wetland, it does not have a specific federal classification equivalent with respect to Cowardin et al. (1979).

RIDEM (2005) indicates that the most crucial factor impacting forest wildlife is the fragmentation of habitats into smaller tracts, a process principally caused by suburban sprawl and roads. RIDEM (2005) identifies the following wildlife species as having the Greatest Conservation Need (GCN) within this key habitat:

Birds

- Black-throated Blue Warbler (*Dendroica caerulescens*)
- Chestnut-sided Warbler (*Dendroica pensylvanica*)
- Indigo Bunting (*Passerina cyanea*)
- Ovenbird (*Seiurus aurocapillus*)
- Prairie Warbler (*Dendroica discolor*)
- Scarlet Tanager (*Piranga olivacea*)

Mammals

- New England cottontail (*Sylvilagus transitionalis*)

Based on the observations of the site visit and on the information provided on the USGS Bird Breeding Survey (<http://www.mbr-pwrc.usgs.gov/bbs/bbs.html>), the forested components of the study area may provide suitable summer habitat for the scarlet tanager, and questionable suitable habitat for the New England cottontail. Black-throated blue warblers were not found to nest in Rhode Island in the last Breeding Bird Atlas conducted by RIDEM from 1982 to 1987. Chestnut-sided warblers are known to nest in Rhode Island but the habitat conditions in the study area are not considered to provide sufficient openings that are not inhabited by humans. Indigo buntings, ovenbirds, and prairie warblers typically prefer drier habitats than what is present in the study area. According to the Woonasquatucket River Watershed Council, Scarlet Tanagers have been sighted in North Smithfield (northwest of the study area) (<http://www.woonasquatucket.org/wildlife.htm>).

Appendix C presents a list of wildlife species expected to utilize the MFD habitat type which includes, but is not limited to, species such as tree swallow, wild turkey (*Meleagris gallopavo*); hawks (family Accipitridae); owls (family Strigidae); woodpeckers (family Picidae); a large variety of songbirds; American woodcock (*Scolopax minor*); eastern cottontail (*Sylvilagus floridanus*); opossum (*Didelphis virginianus*); bats (family Vespertilionidae); mice and voles (family Cricetidae); squirrels, chipmunks, and woodchucks (family Sciuridae); striped skunk (*Mephitis mephitis*), snakes (family Colubridae), and a wide variety of insects and other invertebrates.

3.1.1.2 Emergent Marsh Deep (EMAD) and Emergent Marsh Shallow / Wet Meadow (EMAS)

Emergent marshes are open wetlands (<50% cover of trees and shrubs) with substrates ranging from mineral soils or bedrock to well-decomposed organic soils (muck). Plant composition varies with depth of water during the growing season. Deep marshes have water depths ranging from 6 inches to 6.6 feet and levels may fluctuate seasonally, but the substrate is rarely dry and there is usually standing water in the fall. In shallow marshes water depths range from 6 inches to 3.3 feet during flood stages, but the level usually drops by mid to late summer, exposing the substrate during most years.

Using the federal classification (Cowardin et al., 1979), the EMAD system would be described as a palustrine, emergent wetland (PEM); persistent or nonpersistent; nontidal, intermittently exposed to semipermanently flooded. The EMAS system would be described as palustrine, emergent wetland (PEM); persistent to nonpersistent; nontidal, seasonally flooded.

RIDEM (2005) indicates that the construction of dams at numerous locations along rivers has provided opportunities for the development of marshes within the created impoundments behind these dams; however, RIDEM (2005) also indicates that the invasion of non-native plant species such as common reed (*Phragmites australis*) and purple loosestrife has been implicated in the degradation of these habitats.

RIDEM (2005) identifies the following GCN wildlife species within deep marsh habitats:

Birds

- American Bittern (*Botaurus lentiginosus*)
- Least Bittern (*Ixobrychus exilis*)
- American Black Duck (*Anas rubripes*)
- Blue-winged Teal (*Anas discors*)
- Green-winged Teal (*Anas crecca*)
- Common Moorhen (*Gallinula chloropus*)

- Pied-billed Grebe (*Podilymbus podiceps*)
- Sora (*Porzana carolina*)
- Marsh Wren (*Cistothorus palustris*)

Based on the observations of the site visit, the deep marsh components of the study area provide suitable summer habitat for the American Bittern, Blue-winged Teal, Pied-billed Grebe, Sora, and Marsh Wren. The American Black Duck may be a year-round resident in the study area, and the Blue-Winged Teal and Green-winged Teal may also occur as transient migrants; the Green-winged Teal may also occur as a winter resident. Although suitable habitat exists for the Least Bittern and Common Moorhen, their presence at this site would be a rare occurrence.

Appendix C presents a list of wildlife species expected to utilize the EMAD habitat type, which includes, but is not limited to, species such as great white egret (*Ardea alba*), tree swallow, a variety of sandpipers (family Scolopacidae) and ducks (family Anatidae), great blue heron, muskrat, river otter, bats, a variety of toads (family Bufonidae), hylid frogs (family Hylidae), true frogs (family Ranidae), turtles (family Emydidae), and a wide variety of insects and other invertebrates, including crayfish.

RIDEM (2005) identifies the following GCN wildlife species within shallow marsh habitats:

Butterflies & Moths

- Meadow fritillary (*Boloria bellona*)
- Bronze copper (*Lycaena hyllus*)
- *Macrochilo louisiana* (moth)
- Multicolored sedgeminer (*Meroplen diversicolor*)
- Mulberry wing (*Poanes massasoit*)
- Acadian hairstreak (*Satyrium acadicum*)

Mammals

- Southern bog lemming (*Synaptomys cooperi*)

Birds

- Wilson's Snipe (*Gallinago delicata*)

Bronze copper would be unlikely to occur in the study area as this species is associated with dry portions of wet meadows where curly dock (*Rumex crispus*) is abundant. The study area also does not possess the type of violets that would support populations of meadow fritillary, the abundance of tussock sedge (*Carex stricta*) and swamp milkweed (*Asclepias incarnata*) to support populations of mulberry wing, and the abundance of black willow (*Salix nigra*) to support

populations of Acadian hairstreak. However, the shallow marsh may provide wintering habitat for Wilson's Snipe.

Appendix C presents a list of wildlife species expected to utilize the EMAS habitat type, which includes, but is not limited to, species such as great white egret, tree swallow, a variety of sandpipers and ducks, great blue heron, muskrat, river otter, bats, a variety of toads, hylid frogs, true frogs, turtles, and wide variety of insects and other invertebrates.

3.1.1.3 Shrub Swamp Water Willow (SSAD)

This habitat is a subset of the shrub swamp category that is dominated by water willow (*Decodon verticillatus*), the primary food plant for the hydrangea sphinx (*Darapsa versicolor*). These wetlands are usually small and have deep mucky substrates. This wetland type is scattered throughout Rhode Island, primarily on the mainland and on Block Island. These wetlands are vulnerable to road run-off and infiltration by invasive species.

The federal classification (Cowardin et al., 1979) equivalent to the SSAD system is palustrine, scrub-shrub wetland (PSS1); broad-leaved deciduous; nontidal, permanently flooded to intermittently exposed; *Decodon verticillatus*-*Lythrum salicaria* Dominance Type.

As discussed in Section 2.4 of this report, a purple loosestrife and water willow dominated marsh is located near the head of Lyman Mill Pond. The presence of both of these species indicates the degradation scenario presented in RIDEM (2005) – that of a water willow marsh that has been infiltrated by a non-native and invasive plant species, purple loosestrife.

Appendix C presents a list of wildlife species expected to utilize the SSAD habitat type which includes, but is not limited to, species such as great white egret, great blue heron, toads, hylid frogs, true frogs, tree swallow, a variety of sandpipers, bats, river otter, and a wide variety of insects and other invertebrates, including crayfish,

3.1.1.4 Forested Deciduous Red Maple Swamp (FOBMA)

The majority of deciduous forested wetlands in Rhode Island are red maple swamps, dominated by red maple and often with a smaller percent of other tree species, most commonly black gum and/or green ash. Red maple swamps occur in poorly drained depressions, usually on mineral soils. Although the canopy dominant is always red maple, the community is broadly defined as there are many variants described throughout the state.

The federal classification (Cowardin et al., 1979) equivalent to the FOBMA system is palustrine, forested wetland (PFO1), broad-leaved deciduous; nontidal, temporarily flooded.

Other tree associates may include eastern white pine (*Pinus strobus*), eastern hemlock (*Tsuga canadensis*), Atlantic white cedar (*Chamaecyparis thyoides*), yellow birch (*Betula allegheniensis*), white ash (*Fraxinus americana*), American elm (*Ulmus americana*), or swamp white oak (*Quercus bicolor*). Forested deciduous floodplain red maple/green ash is the key habitat within this category that supports GCN species and is located within the floodplains of Rhode Island's rivers and streams. In highly urbanized communities, red maple swamps often remain as the only locally undeveloped parcels, providing an important wildlife habitat component.

RIDEM (2005) identifies the following GCN wildlife species within red maple swamps:

Birds

- Prothonotary Warbler (*Protonotaria citrea*)

Based on the observations of the site visit, the red maple swamp community within the study area provides suitable habitat for the Prothonotary Warbler which passes through during its migration.

Appendix C presents a list of wildlife species expected to utilize the FOBMA habitat type which includes, but is not limited to, species such as tree swallow, hawks, owls, woodpeckers (family Picidae), a large variety of songbirds, American woodcock, opossum, shrews (family Soricidae), bats, raccoon, striped skunk, mice and voles, woodland salamanders (family Plethodontidae), toads, hybrid frogs, true frogs, snakes, and a wide variety of insects and other invertebrates.

3.1.1.5 River Upper Perennial (RUP)

Upper perennial streams have relatively steep gradients with well-defined riffles and pools. Water flow is constant, fast, and turbulent and the normal water temperature is cold. Streambeds are narrow, shallow, with little floodplain development, and usually represent a network of 1st and 2nd order stream segments. Bottom substrates are composed of bedrock, boulder, cobble, gravel, and sand.

The federal classification (Cowardin et al., 1979) equivalent to the RUP system is riverine, upper perennial; unconsolidated bottom (R3UB). RIDEM (2005) indicates that the fish species most characteristic of coldwater streams is the brook trout (*Salvelinus fontinalis*), and that the anadromous Atlantic salmon (*Salmo salar*) migrate to this habitat to spawn. Other species also occurring in this aquatic community are eurythermal but not true indicators of coldwater such as longnose dace (*Rhinichthys cataractae*) and blacknose dace (*Rhinichthys atratulus*). Upper

perennial streams are principally found in higher elevations of the state, chiefly in the central and western portions of Providence, Kent, and Washington Counties.

RIDEM (2005) identifies the following GCN wildlife species within upper perennial rivers:

Dragonflies/Damselflies

- *Cordulegaster diastatops*
- *Cordulegaster maculata*
- *Gomphus abbreviatus*
- *Gomphus adelphus*
- *Hetaerina americana*
- *Lanthus vernalis*
- *Ophiogomphus aspersus*
- *Ophiogomphus mainensis*
- *Stylurus scudleri*

Freshwater Fish

- American brook lamprey (*Lampetra appendix*)
- Atlantic salmon (*Salmo salar*)
- Blacknose dace (*Rhinichthys corporalis*)
- Brook trout (*Salmo salar*)
- Common shiner (*Luxilus cornutus*)
- Longnose dace (*Rhinichthys cataractae*)

Mammals

- Common water shrew (*Sorex palustris*)

Mollusks

- Eastern Pearlshell (*Margaritifera margaritifera*)

Reptiles

- Wood turtle (*Clemmys insculpta*)

Based on the observations of the site visit, upper river system provides suitable habitat for all of the above wildlife species with the exception of Atlantic salmon.

Appendix C presents a list of wildlife species expected to utilize the RUP habitat type, which includes, but is not limited to, species such as white sucker, alewife, American eel, golden shiner, fallfish, bluegill, pumpkinseed, largemouth bass, black crappie, blacknose dace, banded

killifish, brown bullhead, yellow bullhead, chain pickerel, redbfin pickerel, northern pike, creek chubsucker, swamp darter, tessellated darter, yellow perch, white perch, rainbow trout (stocked), river otter, tree swallow, a variety of sandpipers, belted kingfisher, and a wide variety of insects and other invertebrates, including crayfish.

3.1.1.6 River Lower Perennial (RLP)

Lower perennial streams and rivers have relatively low gradients and poorly defined riffles and pools. Water flow is constant but sluggish and water temperature fluctuates widely. Streambeds are wide, with substrates composed of finer sands and silts, and there is usually a well-developed floodplain.

The federal classification (Cowardin et al., 1979) equivalent to the RLP system is riverine, lower perennial; unconsolidated bottom sand to mud (R2UB).

RIDEM (2005) indicates that one of the direct impacts to the habitat value of riverine systems was the historic construction of dams at the mouths of rivers that prevented the passage of anadromous fish. The loss of these fish populations greatly affected some populations of freshwater mollusks that depended on alewife and other species in the early stages of their life cycles. Although the construction of fish ladders has reestablished anadromous fish runs along several smaller drainages, most larger rivers remain blocked to fish passage by significant dam/bridge structures.

RIDEM (2005) identifies the following GCN wildlife species within lower perennial rivers:

Birds

- Eastern Kingbird (*Tyrannus tyrannus*)
- Orchard Oriole (*Icterus spurius*)

Dragonflies & Damselflies

- Arrow clubtail (*Stylurus spiniceps*)

Mollusks

- Triangle floater (*Alasmidonta undulata*)
- Brook floater (*Alasmidonta varicosa*)
- *Anodonta implicata*
- Creeper (*Strophitus undulatus*)

Freshwater Fish

- Alewife (*Alosa pseudoharengus*)

- American eel (*Anguilla rostrata*)
- American shad (*Alosa sapidissima*)
- Blueback herring (*Alosa aestivalis*)
- Creek chubsucker (*Erimyzon oblongus*)
- Rainbow smelt (*Osmerus mordax*)
- Redbreast sunfish (*Lepomis auritis*)
- Spottail shiner (*Notropis hudsonius*)

Based on the observations of the site visit, the lower river system component of the study area may provide summer habitat for the Eastern Kingbird and Orchard Oriole. The ability of the lower river system component to provide suitable habitat for the invertebrate species such as the arrow clubtail is unknown; however, there is evidence to support the view that this component is expected to provide suitable habitat for many of the above fish species.

Section 1.2 of this report indicates that various Centrarchids (i.e. sunfish), some coldwater species, and the catadromous American eel have been documented in this river. Additionally, a 2001 ichthyoplankton survey conducted in the watershed revealed the presence of larval spottail shiner in the Allendale Tailrace Reach (Normandeau 2002a), and a 2001 fishery survey conducted in the Woonasquatucket River revealed the presence of spottail shiner and American eel in Lyman Mill Pond (Normandeau 2002b).

According to the Woonasquatucket River Watershed Council, Eastern Kingbirds have been sighted in Providence and North Smithfield (northwest of the study area), and American eel have been sighted in North Providence and Johnston (<http://www.woonasquatucket.org/>).

Appendix C presents a list of wildlife species expected to utilize the RLP habitat type, which includes, but is not limited to, species such as white sucker, alewife, American eel, golden shiner, fallfish, bluegill, pumpkinseed, largemouth bass, black crappie, blacknose dace, banded killifish, brown bullhead, yellow bullhead, chain pickerel, redbfin pickerel, northern pike, creek chubsucker, yellow perch, white perch, rainbow trout (stocked), river otter, tree swallow, a variety of sandpipers, belted kingfisher, and a wide variety of insects and other invertebrates, including crayfish.

3.1.1.7 Lacustrine Eutrophic Lake/Pond (LE)

Eutrophic Lakes or Ponds are nutrient-rich ponds that are too shallow to become stratified in the summer. Water clarity is usually reduced due to accumulations of algae, and bottom substrates are usually mucky. Aquatic vegetation is abundant with characteristic submersed species. Fish populations are composed largely of warm water species though some cold water species are

also present. Eutrophic lakes and ponds are habitats under moderate stress but in relatively good condition.

The federal classification (Cowardin et al., 1979) equivalent to this system is lacustrine, limnetic to littoral; unconsolidated bottom (L1UB and L2UB) mud to muck varying to aquatic bed, rooted vascular; unconsolidated shore.

RIDEM (2005) identifies the following GCN wildlife species within lacustrine eutrophic lake/pond systems:

Freshwater Fish

- Banded sunfish (*Enneacanthus obesus*)
- Bridle shiner (*Notropis bifrenatus*)

Based on the observations of the site visit, suitable habitat for these two fish species is potentially present in the study area.

Appendix C presents a list of wildlife species expected to utilize the RLP habitat type, which includes, but is not limited to, species such as white sucker, alewife, American eel, golden shiner, fallfish, bluegill, pumpkinseed, largemouth bass, black crappie, blacknose dace, banded killifish, brown bullhead, yellow bullhead, chain pickerel, redbfin pickerel, northern pike, creek chubsucker, yellow perch, white perch, rainbow trout (stocked), river otter, tree swallow, a variety of sandpipers, sea ducks (family Anatidae), belted kingfisher, and a wide variety of insects and other invertebrates, including crayfish.

3.1.1.8 Urban (U)

Urban Habitats are defined as areas of intensive use with much of the land covered by structures including cities, towns, villages, strip developments along highways, transportation, power, and communications facilities, and areas such as those occupied by mills, shopping centers, industrial and commercial complexes, and institutions that may, in some instances, be isolated.

The Urban (U) classification is not a wetland and therefore does not have a federal classification equivalent with respect to Cowardin et al. (1979).

RIDEM (2005) identifies the following GCN wildlife species within the urban component of the study area:

Birds

- Chimney Swift (*Chaetura pelagica*)
- Common Nighthawk (*Chordeiles minor*)
- Peregrine Falcon (*Falco peregrinus*)

Based on the observations of the site visit, suitable summer habitat for the Chimney Swift and Common Nighthawk may be available for these two species, and suitable year-round habitat for the Peregrine Falcon may be present. According to the Woonasquatucket River Watershed Council, Peregrine Falcons have been sighted in Providence, Chimney Swifts have been sighted in Providence and North Providence, and Common Nighthawks have been sighted in North Smithfield (northwest of the study area) (<http://www.woonasquatucket.org/>). The common nighthawk is in deep decline and their foraging depends upon the abundance of night-flying insects.

Appendix C presents a list of wildlife species expected to utilize the U habitat type, which includes, but is not limited to species such as Canada goose, rock pigeon (*Columba livia*), mourning dove, American crow, purple martin (*Progne subis*), American robin, northern mockingbird (*Mimus polyglottos*), European starling (*Sturnus vulgaris*), common grackle (*Quiscalus quiscula*), house finch (*Carpodacus mexicanus*), American goldfinch, house sparrow (*Passer domesticus*), opossum, striped skunk, mice and rats, squirrels and woodchuck (family Sciuridae), and a wide variety of insects and other invertebrates.

3.1.2 Recreation and Aesthetics

Rule 10.02B(2) states "Freshwater wetlands provide and potentially provide a variety of important active and passive recreational and aesthetic values to the general populace. Such active and passive recreational values include, but are not limited to activities such as; hunting, fishing, trapping, cross-country skiing, ice skating, boating, waterskiing, canoeing, camping, swimming, bicycling, hiking/walking, horseback riding, harvesting of natural foods or plant materials, bird watching, education and nature studies or other animal observations and photography. Aesthetic values include, but are not limited to, the wetland's visual, aural and cultural qualities such as its prominence as a distinct feature in the local area, including its prominence as open space; whether the wetland is a rare wetland type; whether the wetland actually maintains or provides suitable habitat for any rare animal or rare plant species; whether the wetland has any outstanding or uncommon geomorphological features; and whether the wetland contains any archaeological evidence or historic significance."

It is anticipated that the study area could provide public uses such as fishing, canoeing, hiking, bird watching, education and nature studies or other animal observations and photography. Though access to the water is available for residences whose properties abut the river, there

are no designated public access points to the water. Nevertheless, public access to the river does occur at the dams, as well as along a portion of Allendale Way and at the end of Lyman Avenue. Thus, the study area does provide a significant amount of open space for the surrounding community. However, the non-designated access that is available to the waterfront is expected to limit current use of the area.

3.1.3 Flood Protection

Rule 10.02B(3) states *"Freshwater wetlands protect life and/or property from flooding and flood flows by storing, retaining, metering out, and otherwise controlling flood waters from storm events. Further, wetlands control the damaging effects of flood flows by dissipating erosive forces, providing frictional resistance to flood flows, and providing shoreline anchoring values."*

The study area currently serves the function for flood flow alteration, and subsequently a value for flood control. According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for the study area, the Oxbow Area and the lands surrounding Allendale Pond, Lyman Mill Pond, and the Woonasquatucket River are mapped as a Zone AE flood zone. Zone AE is defined as a 100-year flood zone where the base flood elevations (BFE) have been determined.

An October 1981 report from the United States Army Corps of Engineers (USACOE), New England Division, states that their evaluation of the Woonasquatucket and Pawcatuck River Basins reveals no major flooding issues and that this flood protection can be maintained through the preservation of wetlands (USACOE 1981). Similarly, the USACOE (2007b) also reports that although the magnitude of flood flow alteration provided by the Oxbow Area is unknown, the presence of wetlands may provide some flood damage reduction benefits to areas downstream of Lyman Mill Pond.

The effects of certain proposed remedial alternatives on the flood protection value of these wetlands is further evaluated in the Hydrodynamic Analysis Report (QEA, 2007) and is discussed in Section 5 of this report.

3.1.4 Surface Water and Groundwater

Rule 10.02B(4) states *"Freshwater wetlands provide and/or maintain surface and/or groundwater supplies by acting as a recharge or discharge area, or in the case of some ponds, acting as surface water reservoirs. While groundwater recharge and discharge functions and values may vary seasonally, a freshwater wetland may, either individually or cumulatively, be an important factor in replenishing ground and surface water supplies, maintaining stream flows,*

transporting surface waters, and storing or metering out surface waters and/or groundwater during seasons or periods of droughts."

According to a University of Rhode Island (URI) Geographical Information System (GIS) groundwater resources map for the Woonasquatucket River watershed, the study area is not located above a groundwater aquifer or within a groundwater recharge area which serves as a public drinking water source. The nearest groundwater aquifer mapped as a public drinking water source is located approximately two miles to the southeast (downgradient) of the study area. A groundwater recharge area is not mapped to occur anywhere within the Woonasquatucket River watershed; however, the nearest wellhead protection area is located approximately one mile to the northwest (hydrologically upgradient) of the study area, in the municipality of North Smithfield. The project area is located in a glacial valley underlain by sand and gravel deposits, which suggests that some degree of recharge could occur (USACOE, 2007b). Based on this analysis, the study area performs the function of modifying surface water supplies and provides the values of surface water storage and conveyance to downstream groundwater recharge areas.

3.1.5 Water Quality

Rule 10.02B(4) states *"Freshwater wetlands protect and/or maintain important water quality functions and values by nutrient retention or removal; pollution infiltration; sediment removal; oxygen production; turbidity reduction; maintenance or modification of stream flow; temperature and oxygen regimes in both flowing and surface water bodies, and providing and maintaining safe drinking water supplies."*

The study area comprises a river system with a series of impoundments and a large adjacent wetland area (i.e. Oxbow Area). Thus, the values listed above are all provided by the study area. Additionally, the following information is known about water quality in the study area. RIDEM has ordered a complete characterization of stretches along the Woonasquatucket River as part of its Total Maximum Daily Load (TMDL) calculations. North Providence is also one of 4 municipalities in the watershed that is required to comply with Phase II stormwater regulation as it pertains to municipal separate storm sewer systems (MS4s). Finally, the Woonasquatucket River Watershed Council is sponsoring water quality monitoring sites at the following two locations on the river:

- Cricket Park in Greystone, on the Johnston – North Providence municipal boundary (2005 to present).
- Immediately above the Rising Sun Dam, just upstream of Donigian Park (2003 to present).

The water quality parameters being measured include dissolved oxygen (DO), bacteria, pH, alkalinity, and nutrients. Dissolved oxygen and bacteria results are generally available on-line whereas physico-chemical parameters such as pH, alkalinity, and nutrients must be requested from the Watershed Council (<http://www.uri.edu/ce/wq/ww/data/Data.htm>). The on-line data indicate consistently high levels of DO throughout the year and bacterial levels that are typically above state standards for recreational use. Similarly, the water quality data reported by Normandeau (2002a) in a 2001 ichthyoplankton survey indicated high DO levels and normal pH levels.

4.0 SUMMARY OF REMEDIAL ALTERNATIVES

The existing functions and values of the various habitats and ecological communities proximate to the site were compared with those that would likely result from implementing each of the four remedial alternatives that have been proposed as part of this overall study (QEA, 2007). Descriptions of each alternative are provided below.

ALTERNATIVE 1: PARTIAL EXCAVATION – CHANNEL

Alternative 1 contemplates the removal of Allendale and Lyman Mill Dams to restore the condition of this section of the Woonasquatucket River to its pre-impoundment condition: a river channel. Impacted sediment that lies within the area of the proposed river channel inside the footprint of the existing ponds would be excavated. The excavated material would be placed adjacent to the channel, and covered with a two-foot cap. The remainder of the area within the footprint of the ponds also would be covered with a two-foot cap. A suitable substrate would be placed within the area of the proposed river channel to establish the necessary grade for the channel bed.

ALTERNATIVE 2: TOTAL EXCAVATION – CHANNEL/PONDS

Alternative 2 also contemplates the removal of Allendale and Lyman Mill Dams, and the placement of excavated sediment within near-shore CDFs. Impacted sediment within the footprint of Allendale Pond (excluding the area of the nearshore CDF) would be excavated to an average depth of 2.15 feet. Impacted sediment within the footprint of Lyman Mill Pond (excluding the areas of the CDFs) would be excavated to an average depth of 2.65 feet. The excavated sediment would be placed within the footprint of the nearshore CDFs, and covered with a two-foot cap. Once all of the impacted sediment is relocated into the CDFs, the sediment within the remainder of the footprint of each pond would be graded to maximize the size and depth of the surface water area. To maximize this area, armoring and/or timberwalls may be used along the embankments. Also, to maximize the wetted area, weirs would be placed at the locations of the removed dams.

ALTERNATIVE 3: PARTIAL EXCAVATION – CHANNEL/PONDS

Under Alternative 3, Allendale and Lyman Mill Dams would be removed, and impacted sediments would be excavated to create a constructed river channel/pond environment. Impacted sediment within the footprints of constructed river channel/ponds would be excavated and placed adjacent to the channel/ponds. The excavated material would be covered with a two-foot cap. The remainder of the area within the footprint of the ponds would also be covered with a two-foot cap. A suitable substrate would be placed within the area of the proposed river channel to establish the necessary grade of the channel bed. To maximize the area and depth of the surface water under this alternative, armoring and/or

timber walls may be used along the embankments. Also, to maximize the wetted area, weirs would be placed at the locations of the removed dams.

ALTERNATIVE 4: NEARSHORE CDF WITH DAMS IN PLACE

Alternative 4 contemplates the excavation of impacted sediments to be placed in near-shore CDFs, with the dams remaining in place. Under this alternative, impacted sediment within the footprint of Allendale Pond would be excavated to an average depth of 2.15 feet. Impacted sediment within the footprint of Lyman Mill Pond would be excavated to an average depth of 2.65 feet. The excavated sediment placed within the near-shore CDFs would be covered with a two-foot cap. The remainder of the area within the footprint of the ponds would be covered with six inches of clean fill.

Three of the four options (Alternatives 1 through 3) would result in the removal of the Allendale and Lyman Mill Pond dams and the restoration of the Woonasquatucket River to an unimpounded, river along this reach. For the three dam removal alternatives, contaminated sediments would be removed from the river channel and ponds, consolidated and capped (Alternatives 1 and 3) or placed within a CDF (Alternative 2). Table 4-1 presents a summary of the anticipated qualitative changes to the land area associated with each habitat type found on the site by the implementation of each alternative. These anticipated changes were developed based on professional judgment, the qualitative site survey, and review of scientific documentation developed for the site.

Table 4-1. Anticipated Changes to the Habitat Types from the Alternatives

Habitat Types	Alternative 1	Alternative 2	Alternative 3	Alternative 4
RIDEM (2005)				
MFD	Significant increase	Significant increase	Significant increase	Slight increase
EMAD/EMAS	Decrease	Slight decrease	Slight decrease	Slight decrease
SSAD	Decrease	Slight decrease	Slight decrease	Slight decrease
FOBMA	Slight increase	Slight increase	Slight increase	No change
RUP	Increase	Increase	Increase	No change
RLP	Slight decrease	Very slight decrease	Very slight decrease	No change
LE	Eliminate	Decrease	Decrease	Decrease
U	No change	No change	No change	No change
Cowardin et al. (1979)				
PEM	Increase	Increase	Increase	Slight decrease
PSS1	Decrease	Slight decrease	Slight decrease	Slight decrease
PFO1	Slight increase	Slight increase	Slight increase	No change
R3UB	Increase	Increase	Increase	No change
R2UB	Slight decrease	Very slight decrease	Very slight decrease	No change
L1UB/L2UB	Eliminate	Decrease	Decrease	Decrease

An assessment of the hydrodynamics of the proposed remedial alternatives was conducted to assess a variety of outcomes (QEA, 2007). The modeled outcomes included the area of inundation, average and maximum current velocities, and the average depth of the water in each pond under 7Q10 flow, average flow, 2-yr flood flow, and 100-yr flood flow. The modeling data are summarized in Table 4-2 and 4-3 for Allendale and Lyman Mill Ponds, respectively (QEA, 2007). These data are presented as a means to gauge the difference between the current conditions and those likely to occur under the alternative being evaluated. Detailed information on the hydrodynamic modeling is found in QEA (2007).

For Alternative 1, the final river configuration would be a free flowing river channel without any ponded areas. For Alternatives 2 and 3, smaller ponds would remain within the footprint of the existing ponds by constructing weirs, which will cause some of the Woonasquatucket River to back up. Although the weirs would restrict flow, they still would allow a certain degree of water

to flow between ponds thereby allowing some fish species to migrate above, below, and between these ponds.

The fourth remedial Alternative under consideration, Alternative 4, contemplates the excavation and placement of impacted sediments in nearshore CDFs, with the dams in place. The construction of nearshore CDFs would result in ponds that are approximately 25% smaller in area than the existing ponds. However, Alternative 4 retains the current dam structures, thereby resulting in an aquatic system that would function much like that which currently exists.

Thus, the changes resulting from Alternative 4 likely would not significantly alter the functions of the aquatic system or the surrounding terrestrial system, except for adverse short-term impacts resulting from remediation activities. However, there likely would be long-term benefits resulting from the removal of contaminated sediment. Upon restoration, Alternative 4 would most closely mimic the existing conditions as outlined in Sections 2.0 and 3.0.

Table 4-2. Summary Comparison of Current Conditions and Alternatives 1 through 4 - Allendale Pond.

Metric	Alternative ID	Modeled Flow Condition ^a			
		7Q10	Average	2-yr flood	100-year flood
Configuration Includes Ponds	Current Conditions	Yes	Yes	Yes	Yes
	Alternative 1	No	No	No	No
	Alternative 2	Yes	Yes	Yes	Yes
	Alternative 3	Yes	Yes	Yes	Yes
	Alternative 4	Yes	Yes	Yes	Yes
Hydrodynamic Impact Downstream of Manton Dam	Current Conditions	NA	NA	NA	NA
	Alternative 1	NA	NA	NA	Negligible
	Alternative 2	NA	NA	NA	Negligible
	Alternative 3	NA	NA	NA	Negligible
	Alternative 4	NA	NA	NA	NA
Increased Area of Floodplain Inundation	Current Conditions	NA	NA	NA	NA
	Alternative 1	No	No	No	No
	Alternative 2	No	No	No	No
	Alternative 3	No	No	No	No
	Alternative 4	No	No	No	No
Total Inundation Area (acres)	Current Conditions	6.8	7.1	7.9	8.6
	Alternative 1	0.6	0.8	1.3	4.1
	Alternative 2	2.1	2.2	4.5	5.5
	Alternative 3	2.1	2.9	3.6	7.4
	Alternative 4	5.8	6.0	6.3	6.7
Average Predicted Water Depth (ft)	Current Conditions	3.9	4.1	4.8	6.7
	Alternative 1	0.7	1.4	3.2	3.2
	Alternative 2	3.2	3.8	3.4	4.9
	Alternative 3	1.7	2.2	4.0	4.4
	Alternative 4	4.7	4.9	5.8	7.9
Maximum Predicted Water Depth (ft)	Current Conditions	7.6	7.9	8.9	11.0
	Alternative 1	1.5	2.5	5.0	8.7
	Alternative 2	4.6	5.5	7.7	11.0
	Alternative 3	2.5	3.5	5.8	9.2
	Alternative 4	8.6	8.9	9.9	12.0
Average Predicted Current Speed (ft/sec)	Current Conditions	0.3	0.3	0.4	0.9
	Alternative 1	0.5	1.5	3.3	3.0
	Alternative 2	0.3	0.4	0.8	1.7
	Alternative 3	0.3	0.3	0.9	1.3
	Alternative 4	0.3	0.3	0.4	1.0
Maximum Predicted Current Speed (ft/sec)	Current Conditions	0.3	1.2	6.0	8.3
	Alternative 1	2.3	3.7	9.3	12.5
	Alternative 2	2.5	5.1	7.6	9.6
	Alternative 3	2.3	5.1	7.8	9.6
	Alternative 4	0.3	1.2	6.5	8.0

a. Represents arithmetic average of lower- and upper-bound hydrodynamic modeling results (QEA, 2007)

Table 4-3. Summary Comparison of Current Conditions and Alternatives 1 through 4 - Lyman Mill Pond.

Metric	Alternative ID	Modeled Flow Condition ^a			
		7Q10	Average	2-yr flood	100-year flood
Configuration Includes Ponds	Current Conditions	Yes	Yes	Yes	Yes
	Alternative 1	No	No	No	No
	Alternative 2	Yes	Yes	Yes	Yes
	Alternative 3	Yes	Yes	Yes	Yes
	Alternative 4	Yes	Yes	Yes	Yes
Hydrodynamic Impact Downstream of Manton Dam	Current Conditions	NA	NA	NA	NA
	Alternative 1	NA	NA	NA	Negligible
	Alternative 2	NA	NA	NA	Negligible
	Alternative 3	NA	NA	NA	Negligible
	Alternative 4	NA	NA	NA	NA
Increased Area of Floodplain Inundation	Current Conditions	NA	NA	NA	NA
	Alternative 1	No	No	No	No
	Alternative 2	No	No	No	No
	Alternative 3	No	No	No	No
	Alternative 4	No	No	No	No
Total Inundation Area (acres)	Current Conditions	13.0	14.0	15.0	17.0
	Alternative 1	3.5	4.7	7.1	12.5
	Alternative 2	7.1	7.6	11.0	15.0
	Alternative 3	7.6	7.9	10.3	17.5
	Alternative 4	9.9	10.0	11.0	13.0
Average Predicted Water Depth (ft)	Current Conditions	3.0	3.1	4.0	5.8
	Alternative 1	0.9	1.1	1.7	2.7
	Alternative 2	3.2	4.0	4.9	6.3
	Alternative 3	1.6	2.1	3.3	4.1
	Alternative 4	4.3	4.4	5.1	6.8
Maximum Predicted Water Depth (ft)	Current Conditions	3.0	3.1	4.0	5.8
	Alternative 1	0.9	1.1	1.7	2.7
	Alternative 2	3.2	4.0	4.9	6.3
	Alternative 3	1.6	2.1	3.3	4.1
	Alternative 4	4.3	4.4	5.1	6.8
Average Predicted Current Speed (ft/sec)	Current Conditions	0.3	0.3	0.4	0.8
	Alternative 1	0.3	0.5	1.5	2.1
	Alternative 2	0.3	0.3	0.4	0.8
	Alternative 3	0.3	0.3	0.8	1.1
	Alternative 4	0.3	0.3	0.3	0.8
Maximum Predicted Current Speed (ft/sec)	Current Conditions	1.1	1.4	2.2	6.8
	Alternative 1	2.5	4.5	8.5	13.5
	Alternative 2	3.0	6.7	10.9	15.5
	Alternative 3	2.2	5.6	10.6	15.0
	Alternative 4	1.8	2.1	1.9	5.3

a. Represents arithmetic average of lower- and upper-bound hydrodynamic modeling results (QEA, 2007)

The reduction in size notwithstanding, the overall impact of Alternative 4 would be relatively small. Therefore, this section of the report focuses primarily on the potential effects to the existing riverine/wetland systems' functions and values identified in Section 3.0 as they pertain to Alternatives 1, 2 and 3.

Detailed engineering and design of the dam removal options have not been conducted. As a result, the comparative ecological assessment is based on conceptual models of the dam removal options and a qualitative assessment of the probable outcomes from the implementation of these alternatives. The stream flows, depths, substrate types, vegetation species, or other factors used in a final design may differ from those that are probable with the conceptual models. It is possible that any such differences could have an influence on the ecological disposition of the Allendale and Lyman Mill Pond areas if one of the dam removal alternatives were implemented. Nevertheless, the comparative assessment provides an overview of the changes that could result if one of the dam removal alternatives were implemented using standard engineering practices and principals that are aimed at restoring the system and providing the habitats discussed below.

4.1 Other Public Benefits

An issue that is immediately apparent to any visitor to the study area is the lack of designated public access to the waterfront and its associated open space. As indicated in Section 3.1.2, recreation and aesthetics are codified wetland values under the RIDEM Freshwater Wetland Act Rules. The surrounding land use is a mosaic of residential, commercial, and light industrial; thus a large local population currently cannot utilize the Woonasquatucket River and surrounding woodlands for passive outdoor activities. Needless to say, the feasibility of public use is contingent upon the assurance that public health and safety are not compromised and that all site-associated hazards have been addressed in order to minimize risk.

To date, the potential human health risk has been minimized by the implementation of time-critical and non-time-critical removal actions, which have included soil capping, removal of certain flood plain soils, reconstructing Allendale Dam, and capping sediments within the former tail-race. The FS will present remedial options to further mitigate potential human and ecological risk from possible exposure to contaminants in Allendale and Lyman Mill Ponds as well as other areas of the site.

The removal of the Allendale and Lyman Mill Pond Dams can be a component of the development of a naturalized open space and passive recreation area for the surrounding community. The return of this segment of the Woonasquatucket River to pre-impoundment conditions (Alternative 1), or reducing the overall size of the ponds yet providing for a free flowing system (Alternatives 2 and 3), would allow for the re-establishment of a contiguous open

space area by increasing, and, in some places establishing, a new contiguous riparian corridor along this stretch of the river. The rationale is that, within an urban land use setting, a riverine wetland complex with a substantial riparian corridor is more effective at providing useful wildlife habitat and water quality functions than a series of impoundments with little or no riparian area. The integration of the existing Oxbow Area with additional restored and/or created wetlands would also substantially increase the width of the riparian corridor. Though not included in the alternatives assessment, if coupled with careful planning for passive recreational use by means of low-impact trails, elevated boardwalks, and nature observation areas, the study area could be restored to a riverine wetland complex that serves as a multiple-use greenway between Allendale Pond to the north and Manton Pond to the south.

The proposed conceptual approach that incorporates removal of the Lyman Mill and Allendale Pond Dams and the restoration of the Woonasquatucket River as a largely unimpounded river is considered here for purposes of contrasting the existing functions and values to those that could be realized if one of the dam removal options were implemented at this site. As stated above, the FS evaluates a series of three dam removal alternatives. Each of the dam removal alternatives differ in the extent of sediment removal, sediment capping, and the method and location chosen for sediment treatment and/or disposal. However, each of the dam removal alternatives that are evaluated in the FS would, if implemented, result in an unimpounded river system that differs significantly from the existing river/mill pond configuration and would more closely resemble the other segments of the system that are consistent with the River Upper Perennial (RUP) habitat type. Therefore, the qualitative assessment of the probable changes in functions and values provided in Section 5.0 will generally hold true for any of the dam removal options being considered in the FS.

5.0 POTENTIAL EFFECTS OF REMEDIAL ALTERNATIVE ON EXISTING FUNCTIONS AND VALUES

The function of wildlife habitat would not be lost as a result of implementation of the dam removal alternatives approach; however the value of the newly created habitats would vary among different species. This section discusses the probable ecological effects of each Alternative and the anticipated shifts in species assemblage for the various natural communities currently found on the site.

5.1 Alternative 1

The implementation of Alternative 1 would result in the greatest changes to the existing community types, as this alternative replaces the currently impoundment-dominated system with a riverine-dominated system. In contrast to Alternatives 2 and 3, Alternative 1 returns the system to a River Upper Perennial (RUP)/River Lower Perennial (RLP) stream complex to the greatest extent, with segments that exhibit characteristics consistent with the two. Under this alternative, plant and animal species that prefer a Lacustrine Eutrophic Lake/Pond (LE) habitat would experience a dramatic reduction in the availability of this habitat type, and plant and animal species that prefer flowing environments will experience a subsequent increase in the availability of this habitat type. An example of this shift in species assemblage may be a reduction in the use of the site area by waterfowl such as mute swan and Canada goose, but an increase in the use of the site area by wood duck, various songbirds (including tree swallow), bats, and cool-water fish, such as white sucker. Warm-water fish, due to their adaptability, are expected to continue to thrive under Alternative 1. The species composition for groups such as amphibians, reptiles, emerging insects, and other invertebrates may shift to an assemblage that prefers river systems.

According to the *Strategic Plan for the Restoration of Anadromous Fishes to Rhode Island Coastal Streams*, RIDEM (2002), restoration of the Woonasquatucket River to an unimpounded river would provide for the reintroduction of American Shad, Blue Herring, and Alewife to these reaches of the River. These species were historically present on rivers like the Woonasquatucket, but the local populations were extirpated when the need for generating power resulted in the construction of mill ponds and low head dams. Reintroduction of anadromous species to the river would be a significant net benefit to the river from an ecological and historical perspective.

The habitats for cold/cool-water, catadromous, and anadromous fish species such as white sucker, alewife, American eel, blacknose dace, longnose dace, and tessellated darter would be improved under Alternative 1. This is because dam removal would decrease water temperatures and improve oxygenation of the river, which would support these cooler water

species. Moreover, to the extent that alewife, shad and herring are reintroduced to the upper sections of the Woonasquatucket River by movement from the lower sections, the prey base for piscivorous mammals and birds would be improved over current conditions.

Naturally-created riffle and run areas developed by the river under Alternative 1 would also provide critical spawning and nest-building habitat for many of the cold and cool-water fish species.

The ponds along the Woonasquatucket River currently support zooplankton populations that are a primary food source for early life stages of fish species in the current fishery. Much of this food source would be reduced under this alternative, and as such, the early life stages of some fish species may not be as successful when compared to current conditions. However, in contrast, this change may increase the success of the anadromous and catadromous species because there would be less competition with warm-water species.

Under this alternative, water velocities would increase under all flow regimes evaluated (Tables 4-1 and 4-2) and sediment transport processes would be restored to this portion of the river. The higher flows would result in bed scouring which would tend to push fine sediments downstream leaving a coarse, gravelly substrate exposed. A gravel substrate is required for some anadromous and catadromous species that utilize the interstitial spaces of coarse substrate for protection and to maintain their position in a flowing environment. Certain periphyton and macroinvertebrates require coarse substrates to survive as well, and a change in those assemblages would likely change from a lentic to a lotic community. Overall, these changes would support anadromous and catadromous species or fish species that do well in lotic environments.

The current macroinvertebrate community in the ponded areas of the site are dominated by the narrow winged damselfly (*Enallagma* sp.) and non-biting midge (family: Chironomidae) (Normandeau Associates, 2002c and 2002d). The narrow winged damselfly commonly occurs in marginal vegetation of lakes and slow moving streams (McCafferty, 1998). Chironomid midge are found in various types of habitat from lakes to streams. Adjacent lotic habitats are dominated by the net-spinning caddis fly (*Hydropsyche betteni*), various midge (family Chironomidae), and black fly (*Simulium* sp.). A relatively undisturbed offsite control was dominated by the flatworm (*Dugesia tigrina*), the net spinning caddis fly and two Chironomid species (Normandeau Associates 2002d). The change from a lentic, ponded habitat, to a lotic stream habitat would likely cause a change in the macroinvertebrate community from the current damselfly/midge-dominated community to a community dominated by semi-aquatic insect species including mayfly, stonefly, caddisfly, black flies, and other species of midge. The community that would exist likely would be composed primarily of benthic, rock dwelling macroinvertebrates that attach to rocks and large woody debris to maintain position in the

current. Fish that can locate and feed on these macroinvertebrates likely would be favored. The American eel likely would benefit from such a change and may increase in abundance.

During various times of the year, nearly adult forms of the macroinvertebrate community would emerge from the water in order to reproduce. When this happens, large numbers of sub-adult and adult black flies, caddis flies, and midge would potentially be available as food to migrating anadromous species such as American shad, hickory shad, blueback herring, and alewife.

These types of improvements have been noted in other river environments, such as the Manatawny Creek in Pennsylvania (Heinz Center, 2003) and the Souadabscook River in Hampden, Maine (American Rivers, et. al., 1999).

The effect of Alternative 1 on the River Otter may also result in population enhancements. For example, according to the USEPA Wildlife Exposure Factors Handbook (USEPA, 1993), the River Otter may prefer flowing water habitats (such as would be increased under Alternative 1) over stationary water habitats such as mill ponds (as currently exists). The result is an increase in foraging area for this species that would extend along a greater length of the Woonasquatucket River.

With regards to the terrestrial communities, Alternative 1 would significantly increase the amount of wooded (both upland and wetland) and emergent marsh areas along the river. This increase in habitat would result in a significant enhancement to the system providing habitat for a myriad of wildlife species such as terrestrial birds (e.g., tree swallow), marsh birds (e.g., herons), predatory birds (e.g., owls and hawks), small mammals, amphibians (e.g., frogs, toads, and salamanders), reptiles (e.g., snakes), and a variety of plants. The increase in small mammals and amphibian populations would provide a food base for the aforementioned predatory birds and mammals.

5.2 Alternatives 2 and 3

The anticipated changes to the plant and animal communities from implementation of Alternatives 2 and 3 likely would be intermediate between that expected under Alternatives 1 and 4. The reduction in open water area under Alternatives 2 and 3 may reduce the numbers of ducks, geese, and swans utilizing the site area, and likely would result in an increase in the use of the area by wood duck, various songbirds, bats, and cool-water fish. Additionally, Alternatives 2 and 3 would not result in a significant enhancement of channel bottom characteristics (i.e. greater proportion of coarse channel bed materials) or channel morphology (i.e. riffles); therefore, fish breeding may not increase under Alternatives 2 and 3 when compared to Alternative 1.

Tables 4-1 and 4-2 summarize the difference between the current pond configuration and what is anticipated with Alternatives 2 and 3. These tables show that overall area of inundation would be slightly diminished with these alternatives. As a result, there likely would be a shift in the fishery as the proportions of lotic and lentic habitats changes. Fish that characterize lentic habitats would experience some alterations to their current habitat in terms of area, depths, and possibly ambient water temperatures, and fish species that characterize lotic habitats would experience a slight increase in available habitat and a possible lowering of ambient water temperatures. However, the overall change in the fishery is not likely to be significant with this alternative.

Under these alternatives, increases in anadromous and catadromous fish abundance may occur because passage from Manton Pond to the study area waters would be improved through the use of weirs, although it is important to note that many species would continue to find the weirs impassable due to the high flow. This is particularly true for small fish such as alewife, blacknose dace, longnose dace, and tessellated darter. Larger and/or more robust fish, such as American eel and white sucker may display relatively greater freedom of movement up and down the river. Additionally, it is anticipated that the dispersal of fish larvae and eggs would be similar to that expected under Alternative 1 with only the smaller area of the weir causing some limitation of downstream dispersal.

The resulting changes in dissolved oxygen, and temperature would be intermediate. The surface area of fine sediments would be reduced but still present in smaller ponded areas. Periphyton and macroinvertebrate community structure would remain as it is now in ponded areas, but change in newly created lotic areas. Overall, shad and herring still would have access to the area, and it potentially may be used for spawning.

The prey base for piscivorous birds and mammals is expected to change little under Alternatives 2 and 3. The system would continue to provide both ponded and flowing water for the resident fish and wildlife thus continuing to provide similar opportunities for river otter, belted kingfisher, herons, and other piscivorous wildlife.

Similar to Alternative 1, with regards to the terrestrial communities, Alternatives 2 and 3 would generally increase the amount of wooded (both upland and wetland) and emergent marsh areas along the river, although not to the extent as Alternative 1. This increase in habitat would result in a significant enhancement to the system providing habitat for a myriad of wildlife species such as terrestrial birds (e.g., tree swallow), marsh birds (e.g., herons), predatory birds (e.g., owls and hawks), small mammals, amphibians (e.g., frogs, toads, and salamanders), reptiles (e.g., snakes), and a variety of plants. The increase in small mammals and amphibian populations would provide a food base for the aforementioned predatory birds and mammals.

As mentioned above, the conceptual plan for dam removal would result in a reduction in Lacustrine Eutrophic Lake/Pond (LE) habitat for Alternatives 2 and 3. However, this habitat would not be lost entirely under these two conceptual dam removal alternatives because smaller ponds would be constructed that would continue to support the same variety of species that are present in the existing ponds of the LE habitat and its surrounding environs. These species include a variety of warm-water and cool-water fish, river otter, tree swallows, sandpipers, and belted kingfisher. These smaller ponds would provide habitat for fish spawning and fish nest-building areas. The smaller size of the ponds may preclude the use of the area by species such as sea ducks and fish that require larger areas of ponded water, such as northern pike. The State also may choose to cease the stocking of this area with rainbow trout unless the water depths were determined to be sufficient to provide adequate oxygen levels for this species. However, the smaller ponds would also provide a soft sediment substrate for macrophytes, which would serve as food (e.g., for macroinvertebrates and waterfowl), or as a substrate itself for macroinvertebrates and many wildlife species that utilize EMAD and EMAS habitat types.

5.3 Alternative 4

Alternative 4 is expected to result in the smallest changes to the plant and animal communities as this alternative does not alter the dams; however, the placement of excavated material in near shore CDFs would result in a slight increase in terrestrial habitats and a potential decrease in the shoreline marsh communities. The increase in terrestrial communities would provide additional habitat for songbirds, small mammals, and perching areas for herons, kingfishers, and tree swallows. The loss of some shoreline marsh communities is not anticipated to have a large effect, and wildlife currently using these areas likely would relocate to other suitable communities.

Dissolved oxygen would remain steady or may increase slightly because sediments with elevated organic matter and oxygen demand would be removed. The slightly deeper depths also would provide pockets of higher dissolved oxygen that would be beneficial by the stocked rainbow trout.

Water temperatures likely would remain consistent with the current water temperature regime. The current warm water fish community would continue to be supported by increasing the surface area exposed to light, and allowing warmer surface water to flow over the dams to downstream areas.

The ponded areas allow phytoplankton and zooplankton, which would be pushed downstream in a free flowing river, to persist. Phytoplankton would mainly support the zooplankton community but may be utilized directly by some fish species. Zooplankton would include mainly various crustacean organisms such as copepods and cladocerans. Zooplankton is an important food

source for most fish during early (larval and juvenile) life-stages, and also by some fish through adulthood. The zooplankton community would remain if the ponds are left in place and would continue to support the current fishery.

Substrate composition may change slightly from a mud and silt bottom to a fine sand, silt or clay bottom initially, but overall net sediment transport processes would continue to be impeded. The initial change would be temporary as fine particles and organic matter should redeposit behind the dams after excavation. The initial change may reduce the amount of vascular aquatic vegetation in the ponds. This may have a temporary effect on the fishery as bluegill, largemouth bass, chain pickerel, and crappie all utilize the vegetation for cover. After finer sediments redeposit, vegetation should grow again and provide the same cover, thereby supporting/restoring the warm water fishery to the current condition.

The current macroinvertebrate community in the ponded areas of the site are dominated by the narrow winged damselfly (*Enallagma* sp.) and non-biting midge (family: Chironomidae) (Normandeau Associates 2002c, 2002d). The narrow winged damselfly commonly occurs in marginal vegetation of lakes and slow moving streams (McCafferty, 1998). Therefore, during the initial excavation, an initial decline likely would occur in damselfly abundance associated with the removal of aquatic vegetation and substrate. As fine substrate and organic matter accumulates behind the dams, however, the damselfly should repopulate. Chironomid midge are found in various types of habitat from lakes to streams. They generally inhabit the benthic areas of lakes and streams. An initial decline in Chironomid abundance associated with the excavation is likely to occur, but Chironomid of some species are likely to repopulate soon after the excavation process is complete.

The temporary alterations in the macroinvertebrate community may impact the fishery on a short-term basis. Macroinvertebrates are the main component of the diet for many centrarchids like bluegill and sunfish. The initial decline in macroinvertebrate food abundance may cause starvation of some fish. However, centrarchids are generally a hardy group of fish that can utilize a variety of food resources. Therefore, the potential impacts on the current warm-water fishery of this alternative would not be expected to be severe or long-term.

To summarize, the fishery under Alternative 4 may be temporarily altered by excavation activities. However the system would continue to support the current fishery, possibly with some slight temporary changes in community composition. Improved water quality from the removal of contaminated sediments may cause changes in the lower food web (phytoplankton and zooplankton) but would be less pronounced at the level of the fish community. Largemouth bass likely would remain as the top predator and other fish species that currently exist in the system still likely would persist.

6.0 CONCLUSIONS

The results of the comparative ecological assessment of the CMRP site suggest that the implementation of remedial Alternatives 2, 3, or 4 at this site can result in an ecologically sound and publicly usable open space area without significant losses in wetland functions and values. Alternative 1 likely would result in some loss of wetland functions and values because it returns the river flow to pre-impoundment conditions, but, as a trade-off, it restores a riverine system to a more natural hydraulic state with improved fish and wildlife movement and sediment transport processes.

Alternatives 1, 2, and 3 would result in the restoration of this segment of the Woonasquatucket River as an unimpounded river, with a resulting significant increase in a naturalized riparian corridor. The removal of the dams would create the conditions for the movement of anadromous and catadromous fish into the upper reaches, allow for the net downstream movement of fish larvae and eggs, provide the necessary habitat(s) for the potential reintroduction of extirpated anadromous fish species, and create improvements in the function and values of the surrounding environs, particularly as they relate to wildlife habitat. This restored corridor, coupled with the existing Oxbow Area, could serve as an important contiguous greenway along this reach of the Woonasquatucket River, particularly when integrated with the successful restoration of the lower reaches of the River.

Under all three alternatives, the conceptual dam removal plans would improve both the River Upper Perennial (RUP) and the River Lower Perennial (RLP) habitats of the river corridor. Both habitat types are expected to exist following dam removal, with many portions of the river exhibiting characteristics that are intermediate between these two. The habitats for cold/cool water, catadromous, and anadromous fish species such as white sucker, alewife, American eel, blacknose dace, longnose dace, and tessellated darter would be improved under Alternatives 1, 2, and 3 with the greatest benefits realized under Alternative 1. This is because weirs that are a component of Alternatives 2 and 3 are expected to continue to exclude the free movement of some fish.

Removal of the Allendale and Lyman Mill Pond Dams and restoration of the river as illustrated in Alternatives 1, 2, and 3 would also create a large flood plain area on the banks of the river. These flood plain areas would significantly augment the existing Emergent Marsh Deep (EMAD) and Emergent Marsh Shallow / Wet Meadow (EMAS) that exist in the area. Increasing the size of the emergent marsh habitat would have the positive effect of increasing the ecological diversity and abundance when compared to the existing emergent wetlands. Species that would benefit from an increase in emergent marsh area include wading birds, ducks, and numerous amphibians. During high water events (i.e., spring), the large emergent wetlands would provide nursery areas and food items for fish species. During this same time of year,

these areas could provide additional habitat for fish spawning and fish nest-building areas. Also, insectivorous birds would benefit from an enlarged emergent wetland area which would support diverse populations of insects that would serve as a prey base for insectivorous birds.

The additional emergent marsh habitat would provide more habitats suitable for insects and amphibians when compared to the existing system. The increased insect populations would serve as prey for insectivorous birds, thereby creating the potential for a more diverse and abundant avian ecology. Additionally, mammals such as muskrats, raccoons, and river otters would use this habitat for forage.

One exception to the aforementioned habitat improvements may arise from decreasing the overall size of the ponds. Whereas the existing ponds could serve as winter-over habitats for sea birds, the reduction in pond size may not provide sufficient habitat for this purpose if the dams were removed. However, dam removal likely would not exert a negative effect on the winter-over sea bird population. Allendale and Lyman Mill ponds are not the only suitable habitat available in the general North Providence area. In fact, these ponds represent only a tiny fraction of available habitat that is used by the winter-over birds. Therefore, the reduction of the ponds' size likely would not have a negative impact on the population of winter-over sea birds in this part of the state. Overall, ecological diversity and abundance likely would increase if a dam removal alternative were employed, with increases occurring in the diversity of fish species, avian species, and mammalian species.

Alternative 4 would maintain the Allendale Pond Dam and Lyman Mill Pond Dam. Although the overall areas of the ponds would be somewhat diminished with this alternative, and the depths of the ponds would be slightly increased, the functions and values of the study area would not change significantly and the sediment transport processes would continue to be altered. Similarly, the fishery would remain relatively unchanged.

The detailed design of all the alternatives considered here could include engineering a clean bank that would act as a barrier between the water course and any capped sediment. It may be plausible to construct the clean bank barrier of clean soil in which shrubs and/or trees could grow and provide shading for the flowing water, aid in erosion prevention, and provide habitat for a variety of birds and mammals. The clean barrier option may be viable along much of the full length of the floodplain capping remedy. The appropriate place for fully evaluating the details regarding this option would be in the latter stages of the Feasibility Study, or in the remedy design phase of the project. If a clean barrier option is viable, then shading of sunlight would occur, which would promote a relatively cooler water system than would be expected without such a barrier.

Hydrodynamic modeling demonstrates that all four alternatives would result in continued intermittent inundation, which would maintain the Oxbow Area as a forested wetland (QEA, 2007). Assuming that the forested wetland remains intact, the function of the Oxbow Area would be essentially unchanged. Thus, it would continue to provide suitable breeding habitat for birds such as song sparrow, American goldfinch, and gray catbird; and nesting habitat for wildlife such as gray squirrels, brown creeper, eastern chipmunk, and northern flying squirrel.

In addition, though not specifically evaluated above, the hydrodynamic modeling results suggest that the hydrology of Manton Pond would not change significantly with any of the four remedial alternatives evaluated. Thus, it is anticipated that the terrestrial and aquatic habitats within Manton Pond would not change. However, it is possible that Alternatives 1, 2, and 3 could deliver, cooler, more highly oxygenated water to Manton Pond, thereby increasing the water quality in that river segment. It is also possible that under Alternatives 1, 2, and 3, the dispersal of fish larvae and eggs may extend downstream to Manton Pond.

All of the four evaluated remedial alternatives, if implemented, would have short-term, direct impacts on the ecosystem as a result of the earthwork activities. However, all alternatives involve the removal of contaminated sediment from the site, which would have a large positive effect on the ecosystem. Following remedial activities, the ecosystem is expected to return to a functional urban riverine system supporting many if not all of the existing functions, and possibly supporting additional species of anadromous and catadromous fish. In short, all of the alternatives are viable options from an ecological perspective.

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APPENDIX A

Photographs of the Study Area

Photos of the Allendale Pond Area



Photo 1: Allendale Pond Dam, viewed from the south, facing north.



Photo 2: Southwestern shoreline of Allendale Pond.

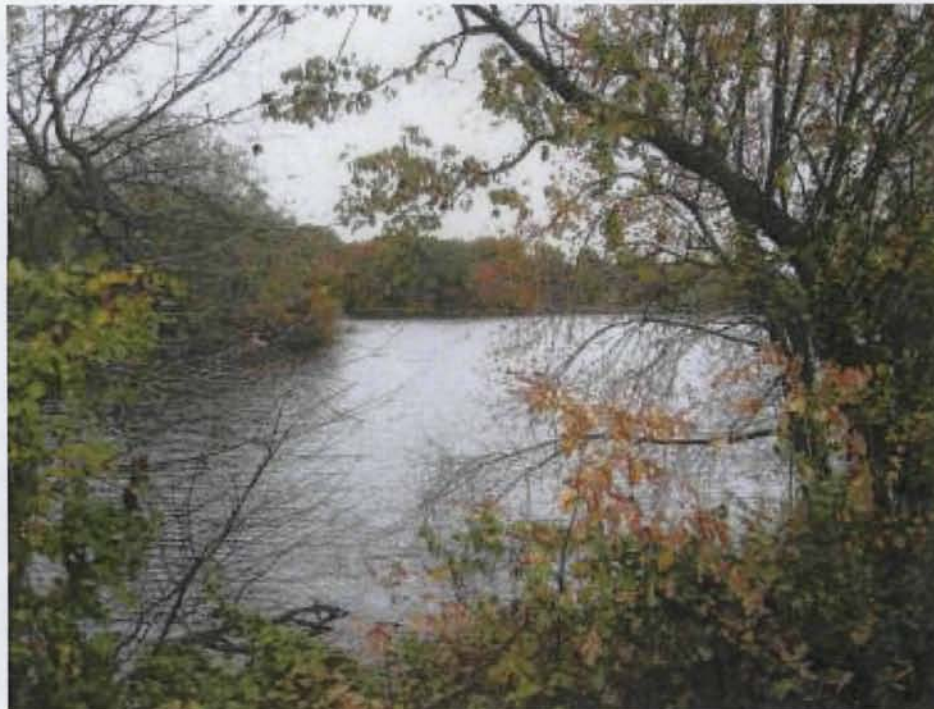


Photo 3: Western shoreline of Allendale Pond with peninsula visible on left side of photograph. The view is from the west, facing southeast.



Photo 4: Rip-rap lined portion of the Woonasquatucket River, upstream of Allendale Pond. The southern end of the parking lot for the Centredale Manor Apartments is visible in the background. The view is from the west, facing east.

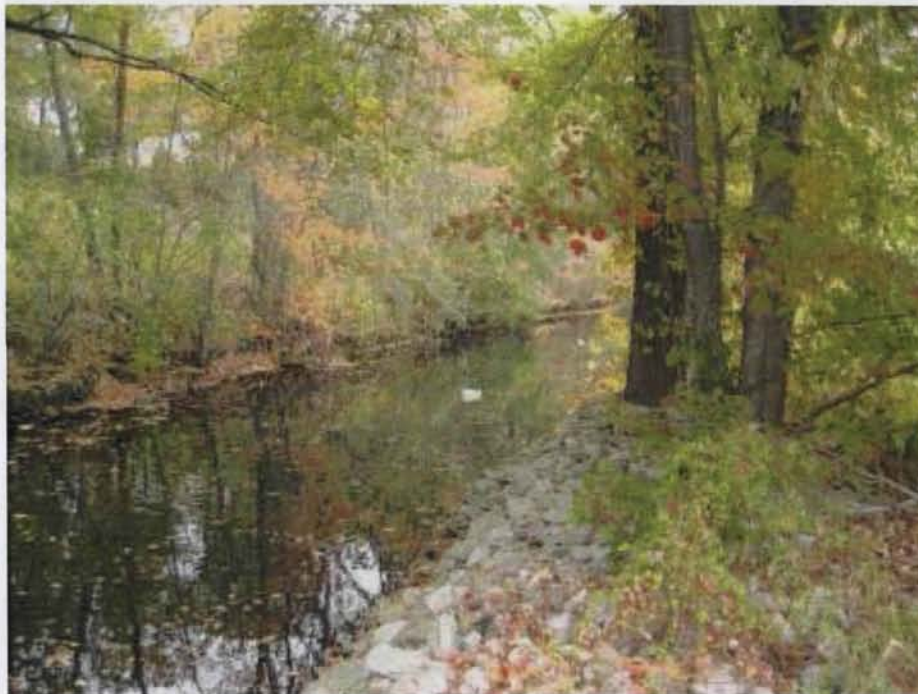


Photo 5: Alternate view of the rip-rap lined portion of the Woonasquatucket River upstream of Allendale Pond, viewed from the east, facing northwest.



Photo 6: Woonasquatucket River/head of Allendale Pond. The view is from the north, facing south.



Photo 7: Maintained lawn portion of the western shoreline.

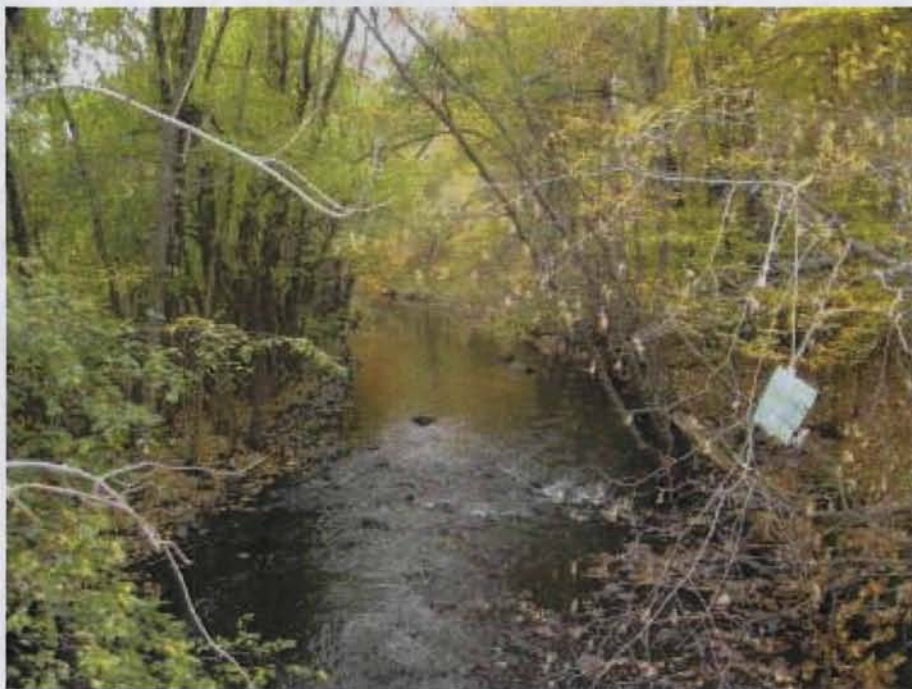


Photo 8: Woonasquatucket River, downstream of the Allendale Pond Dam. The view is from the north, facing south.

The following 9 photos present general views of the vegetation surrounding Allendale Pond.





Photos of the Lyman Mill Pond Area



Photo 1: Lyman Mill Pond Dam, viewed from the east, facing west.

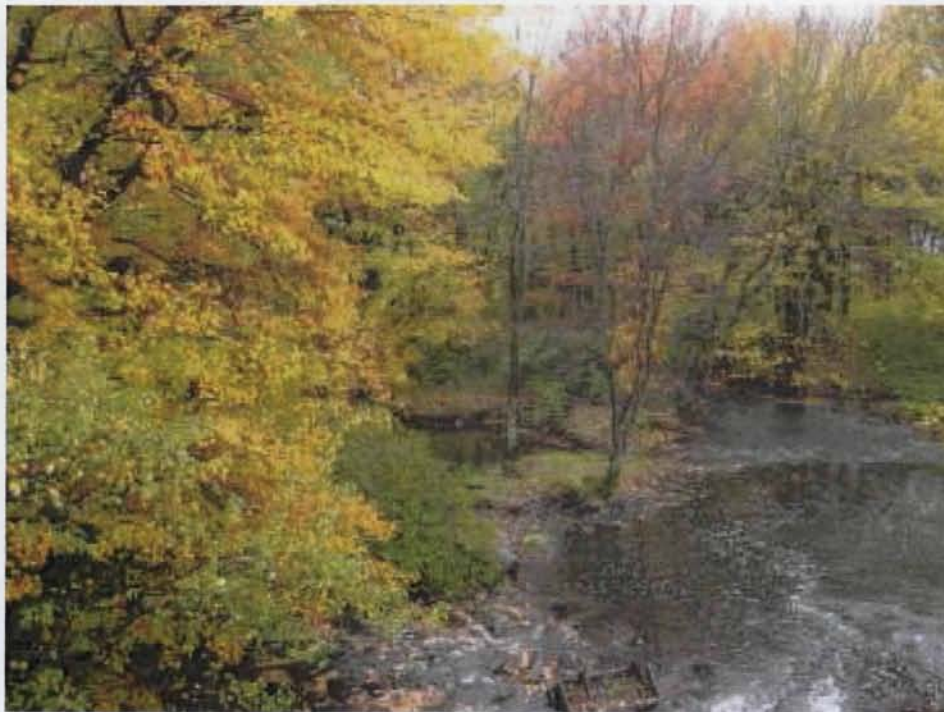


Photo 2: Woonasquatucket River, downstream of the Lyman Mill Pond Dam. The view is from the north, facing southwest.



Photo 3: Emergent marsh, located in the northeastern portion of Lyman Mill Pond. The view is from the eastern shoreline, facing northwest.



Photo 4: Alternate view of the emergent marsh, viewed from the eastern shoreline, facing west.



Photo 5: Alternate view of the emergent marsh, viewed from the eastern shoreline, facing southwest.



Photo 6: Closer view of the emergent marsh.



Photo 7: Downstream (i.e. southern) portion of the emergent marsh community.

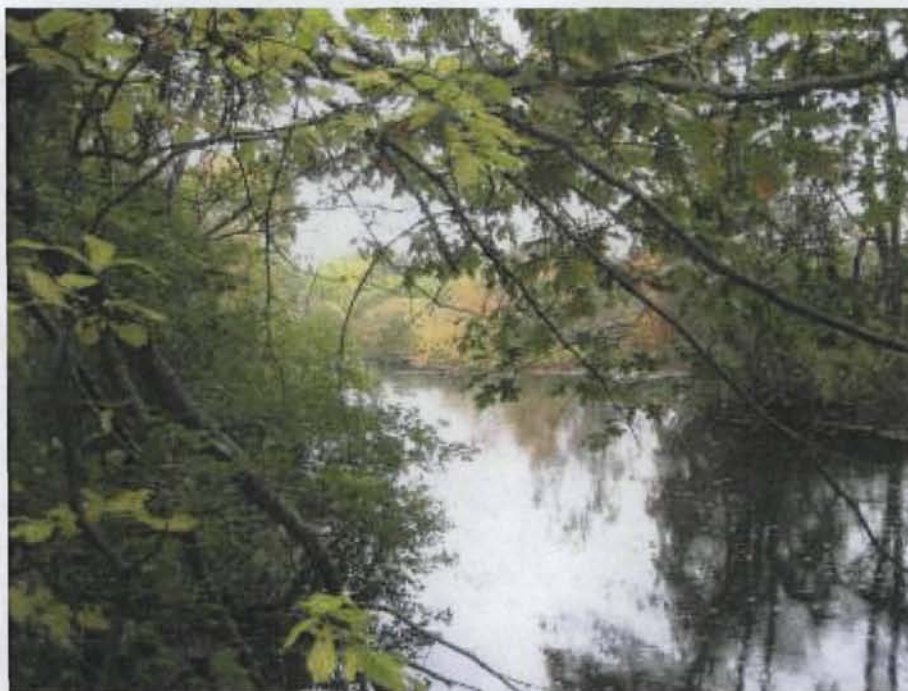


Photo 8: Middle portion of Lyman Mill Pond, viewed from the eastern shoreline, facing southwest.



Photo 9: Alternate view of the middle portion of Lyman Mill Pond, viewed from the eastern shoreline, facing west.



Photo 10: Southern portion of Lyman Mill Pond, viewed from the Lyman Mill Pond Dam, facing west/northwest.



Photo 11: Southern portion of Lyman Mill Pond, viewed from the Lyman Mill Pond Dam, facing north.



Photo 12: Woonasquatucket River located south of the Lyman Mill Pond Dam. The view is from the eastern shoreline, facing northwest towards the dam (visible in the background).



Photo 13: Floodplain forest community located south of the Lyman Mill Pond Dam.



Photo 14: Woonasquatucket River, south of the Lyman Mill Pond Dam.



Photo 15: Alternate view of the Woonasquatucket River, south of the Lyman Mill Pond Dam. The view is from the eastern shoreline, facing northwest.



Photo 16: Alternate view of the Woonasquatucket River, south of the Lyman Mill Pond Dam. The view is from the eastern shoreline, facing southwest.

The following 6 photos present general views of the vegetation around the Lyman Mill Pond Area.



Photos of the Oxbow Area



Photo 1: Walking path located in the northern portion of the Oxbow Area.

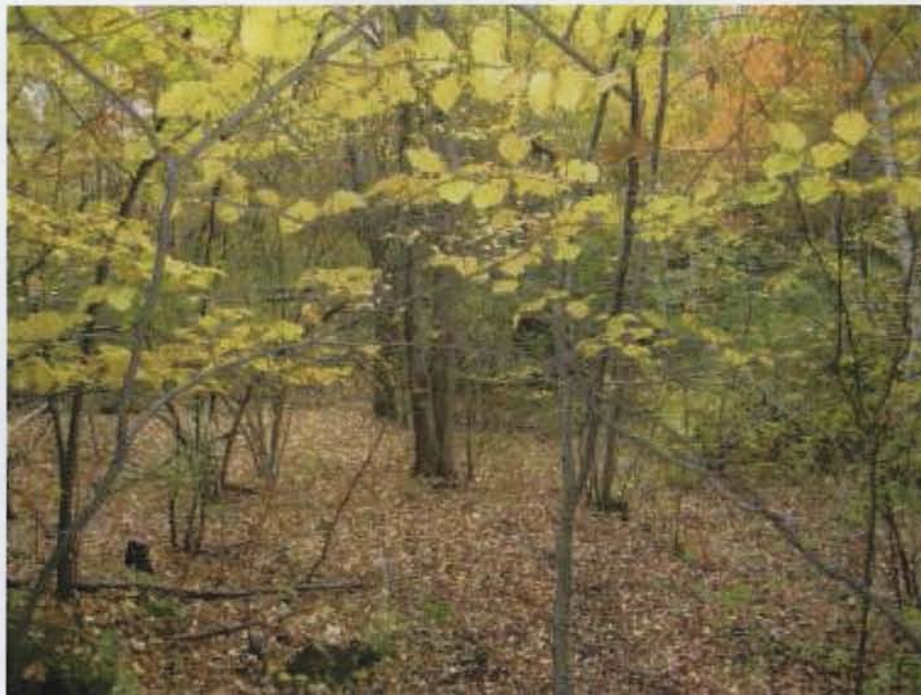


Photo 2: General view of the vegetation community in the northern portion of the Oxbow Area.



Photo 3: Woonasquatucket River within the northern portion of the Oxbow Area.



Photo 4: Alternate view of the Woonasquatucket River in the northern portion of the Oxbow Area.



Photo 5: Typical view of depressional forested wetlands community within the Oxbow Area.



Photo 6: Alternate view of typical depressional forested wetlands community within the Oxbow Area.

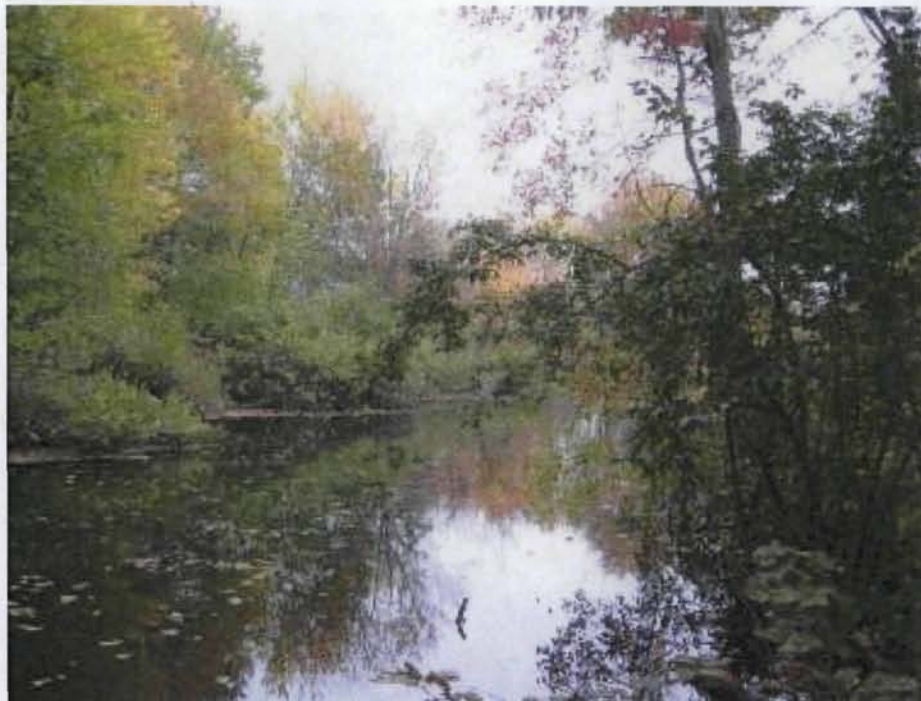


Photo 7: Woonasquatucket River in the southern portion of the Oxbow Area.



Photo 8: Alternate view of the Woonasquatucket River in the southern portion of the Oxbow Area.



Photo 9: General view of the late-stage scrub-shrub/early woods community in the southern portion of the Oxbow Area. The view is from atop a vantage point, facing south.



Photo 10: Alternate view of the late-stage scrub-shrub/early woods community in the southern portion of the Oxbow Area. The view is from atop a vantage point facing southeast.



Photo 11: Moist woods community in the southwestern portion of the Oxbow Area.



Photo 12: Alternate view of the moist woods community in the southwestern portion of the Oxbow Area.

Appendix B

APPENDIX B

Lists of Plant Species Observed in the Study Area

PLANT SPECIES LIST - Allendale Pond Peninsula

The following is a list of plant species identified on the Allendale Pond peninsula during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Aceraceae (Maple Family)			
Acer rubrum	Red maple		FAC
Acer saccharinum	Silver maple		FACW
Alismataceae (Water Plantain Family)			
Sagittaria latifolia	Common arrowhead		OBL
Anacardiaceae (Cashew Family)			
Toxicodendron radicans	Poison ivy		FAC
Aquifoliaceae (Holly Family)			
Ilex verticillata	Common winterberry		FACW+
Araceae (Arum Family)			
Symplocarpus foetidus	Skunk cabbage		OBL
Asteraceae (Aster Family)			
Bidens frondosa	Beggar-ticks		FACW
Caprifoliaceae (Honeysuckle Family)			
Sambucus canadensis	Common elder	Elderberry, American elder	FACW-
Viburnum recognitum	Northern arrowwood		FACW-
Clethraceae (White Alder Family)			
Clethra alnifolia	Coast pepperbush		FAC+
Cornaceae (Dogwood Family)			
Cornus amomum	Silky dogwood		FACW
Lythraceae (Loosestrife Family)			
Lythrum salicaria	Purple loosestrife		FACW+
Oleaceae (Olive Family)			
Fraxinus pennsylvanicum	Green ash		FACW
Polygonaceae (Smartweed Family)			
Polygonum cuspidatum	Japanese knotweed	Pale smartweed	FACU-
Polygonum lapathifolium	Dock-leaf smartweed		FACW+
Polygonum sagittatum	Arrow-leaved tearthumb		OBL

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Scientific Name	Common Name	Synonyms	USFWS Indicator
Rosaceae (Rose Family) <i>Rosa multiflora</i>	Multiflora rose		FACU
Rubiaceae (Madder Family) <i>Cephalanthus occidentalis</i>	Buttonbush		OBL
Salicaceae (Willow Family) <i>Salix nigra</i>	Black willow		FACW+

USFWS Wetland Indicators:

OBL = Obligate wetland plants - species that occur almost exclusively in wetlands (>99% of the time).

FACW = Facultative wetland plants - species that usually occur in wetlands (67-99% of the time).

FAC = Facultative plants - species that are equally likely to occur in wetlands or non-wetlands (34-66% of the time).

FACU = Facultative upland plants - species that usually occur in non-wetlands (67-99% of the time).

UPL = Upland plants - species that occur almost exclusively in uplands (>99% of the time).

Literature used for taxonomic identification:

Aulback-Smith and Kozlowski (1990); Boyd (1991); Brown (1979); Brown (1976); Campbell et al. (1975); Cobb (1963); Fergus (2002); Harrington (1977); Knobel (1980); Little (1995); Newcomb (1977); Peterson & McKenny (1968); Petrides (1972); Phillip (n.d.); Rhoads and Block (2000); Rhoads and Block (2005); Swearingon et al. (2002); Symonds (1958); Symonds (1963); Tiner (1987); Uva et al. (1997)

PLANT SPECIES LIST - Allendale Pond Area

The following is a list of plant species identified around the Allendale Pond area, during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Aceraceae (Maple Family)			
<i>Acer nigrum</i>	Black maple		FACU
<i>Acer platanoides</i>	Norway maple		NL
<i>Acer rubrum</i>	Red maple		FAC
<i>Acer saccharinum</i>	Silver maple		FACW
Anacardiaceae (Cashew Family)			
<i>Toxicodendron radicans</i>	Poison ivy		FAC
<i>Rhus glabra</i>	Smooth sumac		NL
Asclepiadaceae (Milkweed Family)			
<i>Asclepias syriaca</i>	Common milkweed		FACU
Asteraceae (Aster Family)			
<i>Artemisia vulgaris</i>	Common mugwort		NL
<i>Aster divaricatus</i>	White wood aster		NL
<i>Cichorium intybus</i>	Chicory		NI
Balsaminaceae (Touch-me-not Family)			
<i>Impatiens capensis</i>	Jewelweed		FACW
Bignoniaceae (Trumpet Creeper Family)			
<i>Catalpa bignonioides</i>	Common catalpa		NL
Caprifoliaceae (Honeysuckle Family)			
<i>Lonicera morrowii</i>	Morrow's honeysuckle		FACU
Celastraceae (Staff-tree Family)			
<i>Celastrus orbiculatus</i>	Asiatic bittersweet		NL
Clethraceae (White Alder Family)			
<i>Clethra alnifolia</i>	Coast pepperbush		FAC+
Cornaceae (Dogwood Family)			
<i>Nyssa sylvatica</i>	Black gum		FAC
Cyperaceae (Sedge Family)			
<i>Carex pensylvanica</i>	Sedge		NL
Ericaceae			

PLANT SPECIES LIST - Allendale Pond Area

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Scientific Name	Common Name	Synonyms	USFWS Indicator
(Health Family) <i>Vaccinium angustifolium</i>	Low blueberry	Lowbush blueberry	NL
Euphorbiaceae (Spurge Family) <i>Euphorbia esula</i>	Leafy spurge		NL
Fagaceae (Beech Family) <i>Fagus grandifolia</i> <i>Quercus alba</i> <i>Quercus palustris</i> <i>Quercus rubra</i> <i>Quercus velutina</i>	American beech White oak Pin oak Red oak Black oak		FACU FACU FACW FACU- NI
Hamamelidaceae (Witch Hazel Family) <i>Hamamelis virginiana</i>	Witch hazel		FAC-
Juglandaceae (Walnut Family) <i>Carya tomentosa</i> <i>Juglans nigra</i>	Mockernut hickory Black walnut		NL FACU
Lauraceae (Laurel Family) <i>Sassafras albidum</i>	Sassafras		FACU-
Liliaceae (Lily Family) <i>Smilax glauca</i> <i>Smilax rotundifolia</i>	Glaucous greenbrier Common greenbrier	Catbrier	FACU FAC
Moraceae (Mulberry Family) <i>Morus alba</i>	White mulberry		NL
Phytolaccaceae (Pokeweed Family) <i>Phytolacca americana</i>	Common pokeweed		FACU+
Poaceae (Grass Family) <i>Panicum clandestinum</i> <i>Schizachyrium scoparium</i>	Deer-tongue grass Little bluestem		FAC+ FACU-
Polygonaceae (Smartweed Family) <i>Polygonum cuspidatum</i>	Japanese knotweed		FACU-
Rosaceae (Rose Family) <i>Prunus serotina</i>	Black cherry		FACU

PLANT SPECIES LIST - Allendale Pond Area

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Scientific Name	Common Name	Synonyms	USFWS Indicator
<i>Rosa multiflora</i>	Multiflora rose		FACU
<i>Rubus idaeus</i>	Red raspberry		FAC-
Scrophulariaceae (Figwort Family)			
<i>Linaria vulgaris</i>	Butter-and-eggs		NL
<i>Verbascum thapsus</i>	Common mullein		NL
Simaroubaceae (Quassia Family)			
<i>Ailanthus altissima</i>	Tree of heaven		FACU-
Solanaceae (Nightshade Family)			
<i>Solanum dulcamara</i>	Bittersweet nightshade		FAC-
Ulmaceae (Elm Family)			
<i>Ulmus americana</i>	American elm		FACW-

USFWS Wetland Indicators:

OBL = Obligate wetland plants - species that occur almost exclusively in wetlands (>99% of the time).

FACW = Facultative wetland plants - species that usually occur in wetlands (67-99% of the time).

FAC = Facultative plants - species that are equally likely to occur in wetlands or non-wetlands (34-66% of the time).

FACU = Facultative upland plants - species that usually occur in non-wetlands (67-99% of the time).

UPL = Upland plants - species that occur almost exclusively in uplands (>99% of the time).

Literature used for taxonomic identification:

Aulback-Smith and Kozlowski (1990); Boyd (1991); Brown (1979); Brown (1976); Campbell et al. (1975); Cobb (1963); Fergus (2002); Harrington (1977); Knobel (1980); Little (1995); Newcomb (1977); Peterson & McKenny (1968); Petrides (1972); Phillip (n.d.); Swearingon et al. (2002); Rhoads and Block (2000); Rhoads and Block (2005); Symonds (1958); Symonds (1963); Tiner (1987); Uva et al. (1997)

PLANT SPECIES LIST - Oxbow Area

The following is a list of plant species identified within the Oxbow Area during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Aceraceae (Maple Family)			
<i>Acer rubrum</i>	Red maple		FAC
<i>Acer saccharinum</i>	Silver maple		FACW
Alismataceae (Water Plantain Family)			
<i>Sagittaria latifolia</i>	Common arrowhead		OBL
Anacardiaceae (Cashew Family)			
<i>Toxicodendron radicans</i>	Poison ivy		FAC
<i>Rhus copallina</i>	Winged sumac		NI
Araliaceae (Ginseng Family)			
<i>Aralia nudicaulis</i>	Wild sarsaparilla		FACU
Asteraceae (Aster Family)			
<i>Artemisia vulgaris</i>	Common mugwort		NL
<i>Aster divaricatus</i>	White wood aster		NL
<i>Bidens frondosa</i>	Beggar-ticks		FACW
Berberidaceae (Barberry Family)			
<i>Berberis thunbergii</i>	Japanese barberry		FACU
Betulaceae (Birch Family)			
<i>Alnus rugosa</i>	Speckled alder		FACW+
<i>Betula lenta</i>	Black birch		FACU
<i>Carpinus caroliniana</i>	Ironwood		FAC
Caprifoliaceae (Honeysuckle Family)			
<i>Sambucus canadensis</i>	Common elder	Elderberry, American elder	FACW-
<i>Viburnum recognitum</i>	Northern arrowwood		FACW-
Celastraceae (Staff-tree Family)			
<i>Celastrus orbiculatus</i>	Asiatic bittersweet		NL
Clethraceae (White Alder Family)			
<i>Clethra alnifolia</i>	Coast pepperbush		FAC+
Cornaceae (Dogwood Family)			
<i>Nyssa sylvatica</i>	Black gum		FAC
Cupressaceae			

PLANT SPECIES LIST - Oxbow Area

The following is a list of plant species identified within the Oxbow Area during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
(Cypress Family) <i>Juniperus virginiana</i>	Eastern red cedar		FACU
Ericaceae (Heath Family) <i>Chimaphila maculata</i> <i>Lyonia ligustrina</i> <i>Vaccinium angustifolium</i> <i>Vaccinium corymbosum</i>	Striped wintergreen Maleberry Low blueberry Highbush blueberry	Spotted wintergreen Privet andromeda Lowbush blueberry	NL FACW NL FACW-
Fagaceae (Beech Family) <i>Fagus grandifolia</i> <i>Quercus alba</i> <i>Quercus palustris</i> <i>Quercus rubra</i>	American beech White oak Pin oak Red oak		FACU FACU FACW FACU-
Ferns (Currently Under Taxonomic Revision) <i>Asplenium trichomanes</i> <i>Athyrium filix-femina</i> <i>Onoclea sensibilis</i> <i>Osmunda cinnamomea</i>	Maidenhair fern Lady fern Sensitive fern Cinnamon fern		NL FAC FACW FACW
Hamamelidaceae (Witch Hazel Family) <i>Hamamelis virginiana</i>	Witch hazel		FAC-
Juglandaceae (Walnut Family) <i>Carya ovata</i>	Shagbark hickory		FACU-
Lauraceae (Laurel Family) <i>Lindera benzoin</i> <i>Sassafras albidum</i>	Spicebush Sassafras		FACW- FACU-
Liliaceae (Lily Family) <i>Smilax glauca</i> <i>Smilax rotundifolia</i>	Glaucous greenbrier Common greenbrier	Catbrier	FACU FAC
Magnoliaceae (Magnolia Family) <i>Magnolia tripetala</i>	Umbrella magnolia		FACU
Oleaceae (Olive Family) <i>Fraxinus americana</i>	White ash		FACU
Oxalidaceae (Wood-sorrel Family) <i>Oxalis europaea</i>	Yellow wood sorrel		NL

PLANT SPECIES LIST - Oxbow Area

The following is a list of plant species identified within the Oxbow Area during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Pinaceae (Pine Family) <i>Pinus strobus</i>	Eastern white pine		FACU
Polygonaceae (Smartweed Family) <i>Polygonum cuspidatum</i> <i>Polygonum persicaria</i>	Japanese knotweed Lady thumb		FACU- FACW
Rosaceae (Rose Family) <i>Malus</i> sp. <i>Prunus serotina</i>	Apple (various) Black cherry		NA FACU
Salicaceae (Willow Family) <i>Populus deltoides</i> <i>Salix</i> sp.	Eastern cottonwood Willow		FAC NA
Scrophulariaceae (Figwort Family) <i>Verbascum thapsus</i>	Common mullein		NL
Solanaceae (Nightshade Family) <i>Solanum dulcamara</i>	Bittersweet nightshade		FAC-
Sparganiaceae (Bur-reed Family) <i>Sparganium angrocladum</i>	Branching bur-reed		OBL
Urticaceae (Nettle Family) <i>Boehmeria cylindrica</i>	False nettle		FACW+
Vitaceae (Grape Family) <i>Vitis</i> sp.	Grape		NA

USFWS Wetland Indicators:

OBL = Obligate wetland plants - species that occur almost exclusively in wetlands (>99% of the time).
 FACW = Facultative wetland plants - species that usually occur in wetlands (67-99% of the time).
 FAC = Facultative plants - species that are equally likely to occur in wetlands or non-wetlands (34-66% of the time).
 FACU = Facultative upland plants - species that usually occur in non-wetlands (67-99% of the time).
 UPL = Upland plants - species that occur almost exclusively in uplands (>99% of the time).

Literature used for taxonomic identification:

PLANT SPECIES LIST - Oxbow Area

The following is a list of plant species identified within the Oxbow Area during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Aulback-Smith and Kozlowski (1990); Boyd (1991); Brown (1979); Brown (1976); Campbell et al. (1975); Cobb (1963); Fergus (2002); Harrington (1977); Knobel (1980); Little (1995); Newcomb (1977); Peterson & McKenny (1968); Petrides (1972); Phillip (n.d.); Swearington et al. (2002); Rhoads and Block (2000); Rhoads and Block (2005); Symonds (1958); Symonds (1963); Tiner (1987); Uva et al. (1997)			

PLANT SPECIES LIST - Lyman Mill Pond Area

The following is a list of plant species identified around the Lyman Mill Pond area, during field surveys of the Centredale Site, located in the Town of North Providence, Providence County, Rhode Island. Wetland indicator classification nomenclature follows USFWS (1988 & 1996). In addition, NA = not applicable, NI = no indicator, and NL = not listed. The field surveys occurred on October 17 & 18, 2006.

Scientific Name	Common Name	Synonyms	USFWS Indicator
Aceraceae (Maple Family) <i>Acer rubrum</i> <i>Acer saccharinum</i>	Red maple Silver maple		FAC FACW
Alismataceae (Water Plantain Family) <i>Sagittaria latifolia</i>	Common arrowhead		OBL
Anacardiaceae (Cashew Family) <i>Toxicodendron radicans</i>	Poison ivy		FAC
Araceae (Arum Family) <i>Symplocarpus foetidus</i>	Skunk cabbage		OBL
Asteraceae (Aster Family) <i>Aster divaricatus</i> <i>Bidens frondosa</i>	White wood aster Beggar-ticks		NL FACW
Balsaminaceae (Touch-me-not Family) <i>Impatiens capensis</i>	Jewelweed		FACW
Berberidaceae (Barberry Family) <i>Berberis thunbergii</i>	Japanese barberry		FACU
Bignoniaceae (Trumpet Creeper Family) <i>Catalpa bignonioides</i>	Common catalpa		NL
Caprifoliaceae (Honeysuckle Family) <i>Lonicera japonica</i> <i>Lonicera morrowii</i> <i>Sambucus canadensis</i> <i>Viburnum recognitum</i>	Japanese honeysuckle Morrow's honeysuckle Common elder Northern arrowwood	Elderberry, American elder	FAC- FACU FACW- FACW-
Celastraceae (Staff-tree Family) <i>Celastrus orbiculatus</i>	Asiatic bittersweet		NL
Cornaceae (Dogwood Family) <i>Cornus amomum</i>	Silky dogwood		FACW
Fagaceae (Beech Family) <i>Quercus palustris</i>	Pin oak		FACW

PLANT SPECIES LIST - Lyman Mill Pond Area

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Scientific Name	Common Name	Synonyms	USFWS Indicator
<i>Quercus rubra</i>	Red oak		FACU-
Ferns (Currently Under Taxonomic Revision)			
<i>Athyrium filix-femina</i>	Lady fern		FAC
<i>Onoclea sensibilis</i>	Sensitive fern		FACW
<i>Osmunda cinnamomea</i>	Cinnamon fern		FACW
Juncaceae (Rush Family)			
<i>Juncus tenuis</i>	Path rush		FAC-
Lemnaceae (Duckweed Family)			
<i>Lemna minor</i>	Lesser duckweed		OBL
Lythraceae (Loosestrife Family)			
<i>Decodon verticillatus</i>	Swamp loosestrife	Water willow	OBL
<i>Lythrum salicaria</i>	Purple loosestrife		FACW+
Moraceae (Mulberry Family)			
<i>Morus alba</i>	White mulberry		NL
Oleaceae (Olive Family)			
<i>Fraxinus americana</i>	White ash		FACU
<i>Fraxinus pennsylvanicum</i>	Green ash		FACW
Pinaceae (Pine Family)			
<i>Pinus strobus</i>	Eastern white pine		FACU
Polygonaceae (Smartweed Family)			
<i>Polygonum cuspidatum</i>	Japanese knotweed		FACU-
<i>Polygonum persicaria</i>	Lady thumb		FACW
Ranunculaceae (Buttercup Family)			
<i>Enemion</i> (formerly <i>Isopyrum</i>) <i>biterdatum</i>	False rue anemone		FACU-
Rosaceae (Rose Family)			
<i>Prunus serotina</i>	Black cherry		FACU
<i>Rosa multiflora</i>	Multiflora rose		FACU
Simaroubaceae (Quassia Family)			
<i>Ailanthus altissima</i>	Tree of heaven		FACU-
Ulmaceae			

PLANT SPECIES LIST - Lyman Mill Pond Area

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Scientific Name	Common Name	Synonyms	USFWS Indicator
(Elm Family) <i>Ulmus americana</i> <i>Ulmus rubra</i>	American elm Slippery elm		FACW- FAC
Vitaceae (Grape Family) <i>Ampelopsis brevipedunculata</i>	Porcelain-berry	Porcelainberry	NL

USFWS Wetland Indicators:

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FAC = Facultative plants - species that are equally likely to occur in wetlands or non-wetlands (34-66% of the time).

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UPL = Upland plants - species that occur almost exclusively in uplands (>99% of the time).

Literature used for taxonomic identification:

Aulback-Smith and Kozlowski (1990); Boyd (1991); Brown (1979); Brown (1976); Campbell et al. (1975); Cobb (1963); Fergus (2002); Harrington (1977); Knobel (1980); Little (1995); Newcomb (1977); Peterson & McKenny (1968); Petrides (1972); Phillip (n.d.); Swearington et al. (2002); Rhoads and Block (2000); Rhoads and Block (2005); Symonds (1958); Symonds (1963); Tiner (1987); Uva et al. (1997)

Appendix C



APPENDIX C

List of Wildlife Species Observed or Expected to Utilize the Study Area

Table C-1.

Wildlife Species Observed or Expected to Utilize the Habitats around the Centredale Manor Restoration Project Superfund Site

Common Name	Scientific Name	STUDY AREAS (2006)					RIDEM KEY HABITAT TYPES								
		WR	AP	OX	LP	FP	MFD	EMAD	EMAS	SSAD	FOBMA	RUP	RLP	LE	U
BIRDS															
American crow	<i>Corvus brachyrhynchos</i>	1	2	2	2	2	2								2
Great blue heron	<i>Ardea herodias</i>	2	2	2	2	2	2	2	2	2	2		2	2	
Mute swan	<i>Cygnus olor</i>	2	1		2								2	2	
Mallard	<i>Anas platyrhynchos</i>	2	1,3		2			2	2				2	2	
Blue jay	<i>Cyanocitta cristata</i>	2	1	2	2	2	2								
American robin	<i>Turdus migratorius</i>	2	1	2	2	2	2								2
Tree swallow	<i>Tachycineta bicolor</i>	2	3	2	2	2	2	2	2	2	2	2	2	2	
Killdeer	<i>Charadrius vociferus</i>	2	3		2										
Canada goose	<i>Branta canadensis</i>	2	3		2			2	2	2			2	2	2
Mourning dove	<i>Zenaida macroura</i>	2	3	2	2		2				2				2
Double-crested cormorant	<i>Phalacrocorax auritus</i>	2	2		2			2					2	2	
Bufflehead	<i>Bucephala albeola</i>	2	2		2			2					2	2	
Common merganser	<i>Mergus merganser</i>	2	2		2								2	2	
Hooder merganser	<i>Lophodytes cucullatus</i>	2	2		2								2	2	
Red-winged blackbird	<i>Agelaius phoeniceus</i>	2	2	2	2	2	2		2	2	2				
Wood duck	<i>Aix sponsa</i>	2	2	2	2	2	2	2	2		2		2	2	
Great egret	<i>Ardea alba</i>		2		2				2	2		2	2	2	
Black-crowned night heron	<i>Nycticorax nycticorax</i>		2	2	2	2	2		2	2			2	2	
Green heron	<i>Butorides virescens</i>		2	2	2	2	2		2	2			2	2	
Belted kingfisher	<i>Ceryle alcyon</i>	2	2	2	2	2	2	2	2	2		2	2	2	
Black-capped chickadee	<i>Poecile atricapilla</i>	2	2	2	2	2	2								
Song sparrow	<i>Melospiza melodia</i>		2	2	2	2	2								
American goldfinch	<i>Carduelis tristis</i>		2	2	2	2	2								2
Gray catbird	<i>Dumetella carolinensis</i>	2	2	2	2	2	2			2		2			
White-breasted nuthatch	<i>Sitta carolinensis</i>		2	2	2	2	2								
Red-breasted nuthatch	<i>Sitta canadensis</i>		2	2	2	2	2								
Brown creeper	<i>Certhia americana</i>		2	2	2	2	2								
Swamp sparrow	<i>Melospiza georgiana</i>		2	2	2	2	2				2				
Yellow warbler	<i>Dendroica petechia</i>	2	2	2	2	2	2								
Osprey	<i>Pandion haliaetus</i>		2		3								2	2	
Black-throated blue warbler	<i>Dendroica caerulescens</i>						GCN								
Chestnut-sided warbler	<i>Dendroica pensylvanica</i>						GCN								
Indigo bunting	<i>Passerina cyanea</i>						GCN								
Ovenbird	<i>Seiurus aurocapillus</i>						GCN								
Prairie Warbler	<i>Dendroica discolor</i>						GCN								
Scarlet tanager	<i>Piranga olivacea</i>						GCN								
Wild turkey	<i>Meleagris gallopavo</i>						2								
American bittern	<i>Botaurus lentiginosus</i>								GCN						
Least bittern	<i>Ixobrychus exilis</i>								GCN						
American black duck	<i>Anas rubripes</i>								GCN						
Blue-winged teal	<i>Anas discors</i>								GCN						
Green-winged teal	<i>Anas crecca</i>								GCN						
Common moorhen	<i>Gallinula chloropus</i>								GCN						
Pied-billed grebe	<i>Podilymbus podiceps</i>								GCN						
Sora	<i>Porzana carolina</i>								GCN						
Marsh wren	<i>Cistothorus palustris</i>								GCN						
Great white egret	<i>Ardea alba</i>		2		2				2	2	2				
Sandpipers (various)	Family Scolopacidae	2	2	2	2	2	2	2	2	2	2		2		
Wilson's snipe	<i>Gallinago delicata</i>									GCN					
Prothonotary warbler	<i>Protonotaria citrea</i>										GCN				
Northern flicker	<i>Colaptes auratus</i>		2	2	2	2									
Hawks (various)	Family Accipitridae	2	2	2	2	2	2				2		2		
Owls (various)	Family Strigidae	2	2	2	2	2	2				2		2		

Table C-1.
Wildlife Species Observed or Expected to Utilize the Habitats around the Centredale Manor Restoration Project Superfund Site

Common Name	Scientific Name	STUDY AREAS (2006)					RIDEM KEY HABITAT TYPES								
		WR	AP	OX	LP	FP	MFD	EMAD	EMAS	SSAD	FOBMA	RUP	RLP	LE	U
Woodpeckers (various)	Family Picidae	2	2	2	2	2	2				2	2			
American woodcock	<i>Scolopax minor</i>			2		2	2								
Eastern kingbird	<i>Tyrannus tyrannus</i>				2								GCN		
Orchard oriole	<i>Icterus spurius</i>												GCN		
Chimney swift	<i>Chaetura pelagica</i>														GCN
Common nighthawk	<i>Chordeiles minor</i>														GCN
Peregrine falcon	<i>Falco peregrinus</i>														GCN
Rock pigeon	<i>Columba livia</i>														2
Purple martin	<i>Progne subis</i>														2
Northern mockingbird	<i>Mimus polyglottos</i>	2	2	2	2	2	2								2
European starling	<i>Sturnus vulgaris</i>	2													2
Common grackle	<i>Quiscalus guiscula</i>	2	2	2	2		2								2
House finch	<i>Carpodacus mexicanus</i>														2
House sparrow	<i>Passer domesticus</i>														2
MAMMALS															
Gray squirrel	<i>Sciurus carolinensis</i>	1	2	2	2	2	2				2				2
Red squirrel	<i>Tamiasciurus hudsonicus</i>	1	2	2	2	2	2				2				2
River otter	<i>Lutra canadensis</i>	2	2		2			2	2	2		2	2	2	
Muskrat	<i>Ondatra zibethicus</i>		3	2	2		2	2	2	2			2		
Mink	<i>Mustela vison</i>		3	2	2	2	2						2		
Raccoon	<i>Procyon lotor</i>	2	2	2	2	2	2		2	2	2				
Eastern chipmunk	<i>Tamias striatus</i>	2	2	2	2	2	2								
Northern flying squirrel	<i>Glaucomys sabrinus</i>			2			2								
New England cottontail	<i>Sylvilagus transitionalis</i>						GCN								
Eastern cottontail	<i>Sylvilagus floridanus</i>	2	2	2	2	2	2								
Opossum	<i>Didelphis virginianus</i>	2	2	2	2	2	2				2				2
Bats (various)	Family Vespertilionidae	2	2	2	2	2	2	2	2	2	2				
Mice and voles	Family Cricetidae	2	2	2	2	2	2				2				2
Woodchuck	<i>Marmota monax</i>	2	2		2		2				2				2
Striped skunk	<i>Mephitis mephitis</i>	2	2	2	2	2	2				2				2
Southern bog lemming	<i>Synaptomys cooperi</i>								GCN						
Shrews	family Soricidae	2	2	2	2	2	2	2	2	2	2				
Common water shrew	<i>Sorex palustris</i>											GCN			
REPTILES															
Snapping turtle	<i>Chelydra serpentina</i>	2	3		2				2				2	2	
Turtles (various)	Family Emydidae	2	2	2	2			2	2				2	2	
Snakes (various)	Family Colubridae		2	2	2	2	2		2	2	2			2	
AMPHIBIANS															
Toads (various)	Family Bufonidae	2	2	2	2	2		2	2	2	2		2	2	
Hylid frogs (various)	Family Hylidae	2	2	2	2	2		2	2	2	2		2	2	
True frogs (various)	Family Ranidae	2	2	2	2	2		2	2	2	2		2	2	
Woodland salamanders	Family Plethodontidae	2	2	2	2	2					2		2	2	

Table 2-1.

Common Name	Scientific Name	STUDY AREAS (2006)					RIDEW KEY HABITAT TYPES								
		WR	AP	OX	LP	FP	MFD	EMAD	EMAS	SSAD	FOBMA	RUP	RLP	LE	U
BUTTERFLIES & MOTHS															
Meadow fritillary	<i>Boloria bellona</i>								GCN						
Bronze copper	<i>Lycaena hylus</i>								GCN						
Lousiana snout-moth	<i>Macrochilo louisiana</i>								GCN						
Multicolored sedgeminer	<i>Meropleon diversicolor</i>								GCN						
Mulberry wing	<i>Poanes massasoit</i>								GCN						
Acadian hairstreak	<i>Satyrrium acadicum</i>								GCN						
Hydrangea sphinx	<i>Darapsa versicolor</i>									GCN					
DRAGONFLIES/ DAMSELFLIES															
Delta-spotted spiketail	<i>Cordulegaster diastatops</i>											GCN			
Tiwn-spotted spiketail	<i>Cordulegaster maculata</i>											GCN			
Spine-crowned clubtail	<i>Gomphus abbreviatus</i>											GCN			
Mustached clubtail	<i>Gomphus adelphus</i>											GCN			
American rubyspot damselfly	<i>Hetaerina americana</i>											GCN			
Southern pygmy clubtail	<i>Lanthus vernalis</i>											GCN			
Brook snaketail	<i>Ophiogomphus aspersus</i>											GCN			
Maine snaketail	<i>Ophiogomphus mainensis</i>											GCN			
Zebra clubtail	<i>Stylurus scudder</i>											GCN			
Arrow clubtail	<i>Stylurus spiniceps</i>											GCN	GCN		
MOLLUSKS															
Triangle floater	<i>Alasmidonta undulata</i>												GCN		
Brook floater	<i>Alasmidonta varicosa</i>												GCN		
Alewife floater	<i>Anodonta implicata</i>												GCN		
Freshwater pearl mussel	<i>Margaritifera margaritifera</i>											GCN			
Creeper	<i>Strophitus undulatus</i>												GCN		
FISH															
White sucker	<i>Catostomus commersoni</i>	2	3		3							2	2	2	
Rainbow trout (stocked)	<i>Oncorhynchus mykiss</i>	2	3		2							2	2	2	
Bluegill	<i>Lepomis macrochirus</i>	2	3		3			2				2	2	2	
Brown bullhead	<i>Ameiurus nebulosus</i>	2	3		3			2				2	2	2	
Chain pickerel	<i>Esox niger</i>	2	3		3			2				2	2	2	
Largemouth bass	<i>Micropterus salmoides</i>	2	2		3			2				2	2	2	
American eel	<i>Anguilla rostrata</i>	2	3		3			2				2	GCN	2	
Tessellated darter	<i>Etheostoma olmsted</i>	2	3		3							2			
Alewife	<i>Alosa pseudoharengus</i>	2	3		2							2	GCN		
Golden shiner	<i>Notemigonus crysoleucas</i>	2	3		3							2	2	2	
Fallfish	<i>Semotilus corporalis</i>	2	3		2							2	2	2	
Pumpkinseed	<i>Lepomis gibbosus</i>	2	3		2			2				2	2	2	
Black crappie	<i>Pomoxis nigromaculatus</i>	2	3		2			2				2	2	2	
Blacknose dace	<i>Rhinichthys atratulus</i>	2	3		2							2	2	2	
Banded killifish	<i>Fundulus diaphanus</i>	2	3		2			2				2	2	2	
Yellow bullhead	<i>Ameiurus natalis</i>	2	3		2			2				2	2	2	
Redfin pickerel	<i>Esox americanus</i>	2	3		2							2	2	2	
Northern pike	<i>Esox lucius</i>	2	3		2							2	2	2	
Creek chubsucker	<i>Erimyzon oblongus</i>	2	3		2							2	GCN		
Swamp darter	<i>Etheostoma fusiforme</i>	2	3		2							2			
Yellow perch	<i>Perca flavescens</i>	2	3		2							2	2	2	
White perch	<i>Morone americana</i>	2	3		2							2	2	2	
Spottail shiner	<i>Notropis hudsonius</i>	2	3		2								GCN		

Table C-1.
Wildlife Species Observed or Expected to Utilize the Habitats around the Centredale Manor Restoration Project Superfund Site

Common Name	Scientific Name	STUDY AREAS (2006)					RIDEM KEY HABITAT TYPES								
		WR	AP	OX	LP	FP	MFD	EMAD	EMAS	SSAD	FOBMA	RUP	RLP	LE	U
Brook trout	<i>Salvelinus fontinalis</i>											GCN			
Atlantic salmon	<i>Salmo salar</i>											GCN			
Longnose dace	<i>Rhinichthys cataractae</i>											GCN			
American brook lamprey	<i>Lampetra appendix</i>											GCN			
Common shiner	<i>Luxilus cornutus</i>											GCN			
American shad	<i>Alosa sapidissima</i>												GCN		
Blueback herring	<i>Alosa aestivalis</i>												GCN		
Rainbow smelt	<i>Osmerus mordax</i>												GCN		
Redbreast sunfish	<i>Lepomis auritis</i>							2					GCN		
Banded sunfish	<i>Ennaecanthus obesus</i>							2						GCN	
Bridle shiner	<i>Notropis bifrenatus</i>													GCN	

Footnotes:

WR = Woonasquatucket River

AP = Allendale Pond

OX = Oxbow Area

LP = Lyman Mill Pond

FP = A forested floodplain downstream of the Lyman Mill Pond Dam

MFD = Mixed forest deciduous unspecified

EMAD = Emergent marsh deep

EMAS = Emergent marsh shallow/ wet meadow

SSAD = Shrub swamp water willow

FOBMA = Forested deciduous red maple swamp

RUP = River upper perennial

RLP = River lower perennial

LE = Lacustrine eutrophic lake/pond

U = Urban

1 = Observed on the site in 2006.

2= Expected to utilize the habitat type.

3 = Observed in previous studies.

APPENDIX D

Fisheries

APPENDIX D - FISHERIES

This Appendix presents the existing fisheries.

Existing Fishery

The Woonasquatucket River as it exists today in the study area consists of a variety of stream and pond habitats (see Section 2.1 for a more detailed description). This mosaic of habitat types results in a fishery that exhibits both warm-water and cold-water species assemblages. This fishery may be more accurately described as a cool-water transition fishery, which parallels the RIDEM habitat types observed on the site – RUP and RLP, with many river segments exhibiting characteristics that are intermediate between these two. Although the river flows over the Lyman Mill and Allendale Dams, the flow is too strong for fish to move freely up and downstream in this system; therefore, a series of isolated communities has resulted. With the exception of American eel, which may on occasion traverse terrestrial areas to circumvent a dam, little movement of fish species is expected between the Lyman Mill Pond and Allendale Ponds.

The movement of fish up and down the Woonasquatucket River is only one factor that governs the distribution of fish species in this system. Even if fish populations remain localized to their respective river segments, the net movement of eggs and larvae downstream under Alternatives 1, 2, and 3 will allow for the dispersal of fish species. Normandeau (2002b) reports in their ichthyoplankton survey that the majority of eggs collected across their sampling stations in this section of river belonged to Centrarchidae (i.e. sunfish), with some eggs of chain pickerel and white perch also collected¹. The majority of larvae collected in May from Lyman Mill Pond belonged to white sucker and sunfish. In June, tessellated darter was dominant, followed by sunfish, Cyprinid minnows, white sucker, smallmouth bass, and crappie (both black and white). Samples collected from the Allendale tailrace were dominated by larvae of white sucker and spottail shiner. These ichthyoplankton survey results suggest that the existing fishery will likely remain unchanged under all of the Alternatives since the dominant species would be expected to continue to thrive under each of the Alternatives. The survey results also suggest that a net downstream dispersal of eggs and larvae will occur under Alternatives 1 to 3. An accurate prediction of fish dispersal and potential distribution under the alternatives cannot be made however, based on the extent of information known to date. Nevertheless, such generalizations can be safely made based.

Based on data provided by the Woonasquatucket River Watershed Council, the dissolved oxygen content of the water is high enough to support most fish species, as there is adequate mixing in the shallow ponds and between the ponds in the flowing

¹ It is important to note that a single ichthyoplankton survey result is a snapshot of the fishery nursery and that time of year will play a large role in the results obtained.

water². These data also suggest that current water temperatures are generally too high to support a natural trout or salmon population throughout the summer months; however, the RIDEM-stocked fish survive for most of the year. Trout found in the area are part of a put-and-take fishery provided by the RIDEM, whereby fishable sized trout are stocked annually in the system. These trout will still require highly oxygenated water during the warmer months which will be provided under Alternative 1 as flowing well-aerated water, under Alternatives 2 and 3 as a combination of flowing well-aerated water and deep pools and the historic submerged channel beds, and under Alternative 4 within deep pools and the historic submerged channel bed.

A description of each fish species found in the CMRP study area is described below including a determination of the importance of each species in the overall fishery as it exists today. Two components were used to qualitatively describe and evaluate the species comprising the fishery: (1) Are there adequate numbers of species to support angling activities?, and (2) Is it a species that is traditionally targeted by anglers? For a fishery to exist, there must be an adequate stock of individual fish and the species must be a targeted species by anglers. Other fish are described as forage fish if they exist in large numbers, but are not targeted by anglers.

American Eel (*Anguilla rostrata*)

The American eel is a catadromous fish, which means that it lives in freshwater streams and migrates to the ocean to spawn. It is found in streams all along the eastern coast of the United States, the Gulf of Mexico, and in the Mississippi River Drainage. The morphometric characteristics of the American eel include an "eel-like", slippery body, protruding lower jaw, gape extending to below the eye or beyond, and a continuous dorsal, anal, and caudal fin. This species was once thought to be the same as the European eel (*Anguilla Anguilla*) but differences in the number of vertebrae and chromosome number have been used to separate the two species.

The American eel has a unique coloration scheme that changes ontogenetically (with age) and consequently location. Recently hatched eels occur in the Sargasso Sea near the Caribbean in the Atlantic Ocean (ASMFC,



Top: Leptocephalus
Middle: Glass eel
Bottom: Adult American eel

² <http://www.woonasquatucket.org/waterquality.htm>

1999) and have a less eel-like body that is described as leaf-like. This stage of the American eel life cycle is called the leptocephalus. At this stage the young eel is colorless and transparent and migrates via ocean currents. Just before reaching the seashore, the eel gains the traditional eel-like shape and the eyes darken, but the rest of the body remains colorless and transparent. Some people refer to this stage as a "glass eel". Once the eels reach fresh or brackish water, they become an olive color and are referred to as "elvers". After several years in fresh water the adults are yellowish, greenish, or olive-brown depending on the habitat in which the eel is found. Immediately prior to spawning, the sexually mature adult has a metallic shine with a nearly black back, bronze or silvery sides, and a light or silvery belly. This stage is commonly referred to as a "silver eel".

Adult eels are carnivorous and primarily feed at night on a variety of fish species and invertebrate creatures. Their diet has been found to consist of small fish, mayfly, stonefly, and dragonfly nymphs, chironomid larvae, crayfish, snails, and earthworms.

In the Woonasquatucket River, habitat is available for the elver and adult American eel life stages. The entire river is suitable habitat for these fish. The impoundments currently found on the river are small and the structures do not appear to prevent the upstream migration of the American eel, although they do stop migrations of anadromous species (fish that live at sea and migrate upstream to spawn) that might prey upon the eel. This may present a situation whereby the American eel is able to thrive without many natural predators. Predation currently is restricted to large freshwater predatory fish species, piscivorous birds, and mammals. These may include largemouth bass, chain pickerel, Osprey, eagles, herons, kingfishers, and raccoons. The impact of predation on the adult American eel populations is expected to be minimal as the size of an adult eel protects it against significant predation.

American eel was commonly collected at most fishing sites surveyed during the RI (Normandeau, 2002a).

Black Crappie (*Pomoxis nigromaculatus*) & White Crappie (*Pomoxis annularis*)

Black and white crappie are members of the sunfish family, centrarchidae, and have a wide range across the United States because of artificial introductions. Crappie are a game fish that can be found in schools in shallow water around submerged structure such as trees. They are generally found in ponds, lakes, and low flow area of larger rivers.

Spawning generally occurs when water temperature is between 66°-68°F (19°-20°C). Males clear shallow



Black crappie



White crappie

depressions or just clear a section of the bottom of sand, gravel, or mud in water 10" to 2' deep where there is some vegetation. Males guard the nest and fan the eggs until they mature. Eggs are slightly less than 1 mm in diameter and hatch within 3-5 days. The male guards the larvae for a few days until the larvae leave the nest. Growth varies with size of the population and habitat productivity, but is rapid during early life stages. Young-of-year are 1"-3" in October.

In the study area, three crappies were collected in Lymanville pond, consisting of one white and two black crappies. The fish collected were healthy adults of a fishable size class (Normandeau Associates, 2002a). No other sites included in the survey had crappie, therefore the fishery is considered to be nominal.

Bluegill (*Lepomis macrochirus*) & Pumpkinseed (*Lepomis gibbosus*)

Bluegill and pumpkinseed are also members of the sunfish family, centrarchidae, and have a wide distribution across the Eastern United States and are found locally in the Western United States due to many introductions. A popular sport fish, bluegill and pumpkinseed sunfish are among the most recognizable fish in freshwaters of the Midwest.

Spawning takes place in late spring to early and mid-summer usually when water temperatures reach 50°F and may continue until temperatures reach 76°F. The male creates a shallow depression down to a firm bottom using fin action. The male then guards the nest before and after spawning. Eggs are small, demersal, adhesive, and amber in color. Incubation takes 3-5 days.



In the study area, bluegill and sunfish were common at most sites. The fish collected were generally healthy and ranged in age from young-of-year (YOY) to adults. Some fish collected had hook scars indicating that an angler had caught and released them (Normandeau Associates, 2002a). This indicates that the bluegill and sunfish fishery in the study area is important.

Brown Bullhead (*Ameiurus nebulosus*) & Yellow Bullhead (*Ameiurus natalis*)

Brown bullhead and yellow bullhead are members of the catfish family, ictaluridae. Bullheads are common in freshwaters throughout the eastern North America. Like other North American catfishes they have large sensory organs called barbels that are commonly referred to as "whiskers". They normally attain sizes of 8"-14". Bullheads, like many other catfishes, are active during nighttime hours using their barbels to sense food on or near the substrate. They are omnivorous, feeding on offal, waste, mollusks, insect larvae, terrestrial insects, leeches, crustaceans, worms, algae, plant material, fishes, and fish eggs. The young feed mainly on chironomid larvae, mayfly nymphs, and zooplankton. Bullheads are a tolerant species that can survive in harsh environments. They have been shown to survive in low oxygen conditions down to 0.2 ppm oxygen. They are generally present in warm water ponds, lakes, and slow moving streams with abundant aquatic vegetation and sand or mud substrates.



Bullheads were collected at various locations surveyed by Normandeau Associates (2002a). Most fish collected were small (2"-7") and not likely to be sought after as a sport fish or as food. Therefore the bullhead fishery in the study area is considered to be nominal.

Chain Pickerel (*Esox niger*)

The chain pickerel is a member of the pike family, Esocidae. It resembles the northern pike in many characteristics, but is generally smaller, has a chainlike pattern on the sides, and has a black tear-like pattern under its eye. It typically reaches 24" in length. It is found mainly in freshwater tributaries of the Atlantic coast of North America and nearby lakes and ponds. It is a popular sport fish due to its relatively large size and fighting capability second only to largemouth bass in popularity of freshwater sport fishes.



Spawning takes place in the springtime shortly after ice melts. Spawning occurs in flooded areas during high water in 3'-10' of water. No nest is built and the eggs are not protected. The newly hatched young feed on zooplankton and small insects. After they

reach lengths of 4"-6" they begin feeding mainly on other fish species. They do not show much preference for any single fish species.

In the study area, chain pickerel were found at most locations sampled by Normandeau Associates (2002a) and varied in length from 82-350mm (about 3"-14"). Although they were not found in high numbers their importance as a sport fish in the region makes this an important game species in the study area.

Largemouth Bass (*Micropterus salmoides*)

Largemouth bass are one of the most sought after sport fish in the country, although they are not so commonly sought after as food. Nationwide, largemouth bass represent a major sport fishery.



Spawning generally takes place in the late spring or early summer. Like other fish species in the sunfish family, centrarchidae, the male largemouth bass creates a small clearing or depression in shallow water as a nest. The male will defend the eggs and larvae for a short period after hatching. Adults commonly prey on small fish, frogs, macroinvertebrates, and crayfish.

In the study area, largemouth bass were collected at most sites. The fish were generally healthy and ranged in size from young-of-year (YOY) to adults (1"-16"). Rhode Island's 12" minimum size limit was exceeded by many fish surveyed (Normandeau Associates, 2002a). Hook marks indicated that some catch-and-release angling had occurred in the areas surveyed. Due to the popularity of largemouth bass as a sport fish and the presence of adult fish in the area, the fishery is considered to be very important.

White Perch (*Morone americana*)

The white perch is a member of the temperate bass family, Moronidae (previously Percichthyidae). The other two common members, which are capable of hybridizing with the white perch, are white bass (*Morone chrysops*) and striped bass (*Morone saxatilis*). The white perch is a generalist that can survive in a variety of aquatic habitats of variable substrates, flows regimes, water quality, and salinities. Although it can survive in many habitats, it prefers habitats of brackish to fresh water with high dissolved oxygen. Because of the affinity to brackish waters, it is found mainly near the Atlantic coast in



ponds, lakes, rivers and estuaries. It has been artificially introduced in other bodies of water and is now present in much of the Great Lakes and the Ohio River drainage.

In the study area, white perch larvae and eggs were collected during an ichthyoplankton survey of the area (Normandeau Associates, 2002b). No juveniles or adults were collected during fish surveys of the same area (Normandeau Associates, 2002a). The lack of juveniles or adults collected during sampling indicates that either adults or juveniles are rare or only seasonally present in the study area. For that reason the species is considered to constitute a nominal fishery.

White Sucker (*Catostomus commersoni*)

The white sucker is a common fish that occurs throughout almost all of North America. It has a robust, cylindrical body shape and can reach lengths of about 23". It has a mouth adapted for feeding on the benthos. The mouth is sub-terminal with thick, fleshy, papillate lips. This species is not generally considered a sport fish, but it is edible. Young white sucker can be used as bait for more desirable predacious sport fish like largemouth bass and chain pickerel. White sucker are generally one of the most important food items in the diets of such fish when present.



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Spawning occurs in the spring from May to early June. Adults generally run up streams and rivers to gravelly areas where they spawn, however some will spawn in lakes. The eggs are fertilized by nearby males when released by a female. The eggs then adhere to the gravel or drift downstream until they reach quieter areas. The eggs hatch after about two weeks and the young remain in the interstitial spaces of the gravel for another 1-2 weeks before drifting downstream to the lake. The fry initially have a terminal mouth that allows the fish to feed on zooplankton and small insects. The mouth shifts to a sub-terminal position when the larva reaches 16-18mm, at which point the fish begins to feed on the bottom. The diet of adults generally consists of chironomid larvae, stonefly nymphs, mollusks, zooplankton, and other dipteran larvae. They do not tend to feed on eggs of other fish species.

In the study area, adult white suckers (17"-20") were commonly collected in ponds, whereas areas of flowing water contained young-of-year (YOY) white suckers. There is some potential for recreational catch of white suckers in the study area; however, the fishery is considered to be nominal when compared to the other species that present and more highly valued by recreational anglers. Though somewhat limited, the data suggest that white sucker are the predominant species in the study area.

Golden Shiner (*Notemigonus crysoleucas*)

The golden shiner is a member of the minnow family, Cyprinidae. The average length of a golden shiner is 3"-5". The fish occurs in lakes and ponds throughout eastern North America. This fish is not normally found in flowing water. It is an important forage fish for larger sport fish including largemouth bass and chain pickerel.



The Normandeau Associates fish survey found this species at three sites in the study area (Normandeau Associates, 2002a). One golden shiner was found in flowing water downstream of Allendale Pond. The golden shiner is a forage fish preyed upon by sport fishes that are present in the water body including largemouth bass and chain pickerel. Fishermen will sometimes use it as a baitfish.

Spottail Shiner (*Notropis hudsonius*)

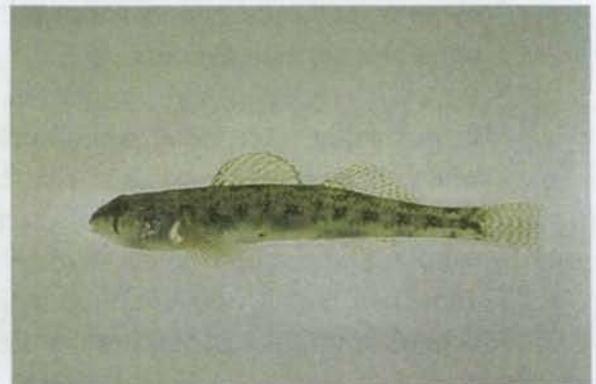
The spottail shiner is a common minnow (family Cyprinidae). It occurs in larger lakes and rivers throughout northern North America. Most spottail shiners are between 2.5"-3" in total length. Larger predators extensively feed upon these small fish. Like the golden shiner, it is an important forage fish.



In the study area, only one specimen of this species was found at a single site – Lyman Mill Pond- during the Normandeau Associates fish survey. The spottail shiner is a forage fish and is preyed upon by sport fishes where it occurs. Fishermen commonly use it as a baitfish when it is present. This fish is uncommon in the study area, an observation consistent with the lack of suitable habitat for this species.

Tessellated Darter (*Etheostoma olmstedii*)

The tessellated darter is a member of the perch and darter family, Percidae. This is a small fish that generally reaches a maximum length of 2.5". The tessellated darter closely resembles the Johnny darter with the exception of slight and overlapping differences in morphometric and meristic characteristics including fin ray counts, body shape, and "X" and "W" markings on its side. Side markings are the most distinguishing characteristic



with 9 to 11 markings present in the tessellated darter compared with 6 or 7 in the Johnny darter.

This fish inhabits a variety of aquatic habitats from lakes to swift streams with variable substrates, although it is most commonly found in rivers with moderate to slow current with sand or gravel substrates. Like the minnows described above, they are a forage fish and not targeted by anglers.

The fishery as it is today supports a warm water fishery dominated by American eel, bluegill/sunfish, bullheads, chain pickerel, and largemouth bass. Forage fish also exist including the tessellated darter, golden shiners, and white sucker. Anadromous fish such as American shad, hickory shad, and blueback herring do not migrate beyond the dams. Even if access was granted, these species may not be able to successfully spawn in the study area under the current temperature and flow regimes of the river.

Other Fish

The comparative assessment evaluates fish that have been identified within the study area. However, the other portions of the Woonasquatucket River provide suitable habitat for the aforementioned species as well as others. The following fish have been noted to occur within the Woonasquatucket River by RIDEM. Though these species may be present in the study area, they were not specifically identified in the fisheries studies performed as part of the RI. Likewise, it is possible, and quite likely, that the species identified in the study area also reside in other areas of the Woonasquatucket River:

- Blacknose Dace
- Banded Killfish
- Creek Chubsucker
- Fallfish
- Northern Pike
- Redfin Pickerel
- Swamp Darter
- Rainbow Trout.

Shad and River Herring

Shad and river herring are comprised of four anadromous species of fish. The fish included in this family, Clupeidae, include American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), blueback herring (*Alosa aestivalis*), and alewife (*Alosa pseudoharengus*). These fish spend



Hickory shad, *Alosa mediocris*

most of their life at sea, but return to coastal rivers to spawn. After spawning, eggs hatch within days and larvae remain in the river system while slowly migrating downstream through the summer in order to return to the sea by fall. In the sea they feed primarily on zooplankton such as copepods and mysids (Scott and Crossman, 1973).

In some locations, shad and river herring are commercially caught in rivers and estuaries during the spawning migration (Froese and Pauly, 2007; Scott and Crossman, 1973). Shad and river herring species once spawned in virtually every accessible tributary along the east coast. However, blockage to spawning habitat and water quality degradation have depleted stocks (ASMFC, 1999). River herring are managed by the Atlantic States Marine Fisheries Commission (ASMFC). Recent efforts to rehabilitate dwindling stocks have been a focus of the ASMFC.

Atlantic Sturgeon (*Acipenser oxyrinchus*)

The Atlantic sturgeon is a large relict species that has existed on the planet for millions of years. They often reach length greater than 10 feet (3.05 m), have an elongate snout with a sub-terminal mouth adapted for benthic feeding. The body is not covered in scales, but with large bony plates called scutes (Scott and Crossman, 1973). The



The fish was once distributed all along the east coast from Labrador, Canada to Florida (ASMFC, 1998). However, overfishing, habitat degradation, and barriers to spawning habitat caused a decline in the population. It was submitted by United States Fish and Wildlife Service (USFWS) for status as a candidate for endangered species status in 1998 but the ensuing review concluded that this status was not warranted at the time (ASMFC 1998).

Shortnose Sturgeon (*Acipenser brevirostrum*)

The shortnose sturgeon is also a relict species that has a similar appearance as the Atlantic sturgeon but reaches much smaller sizes of around 36 inches or 912 mm. The snout is also shorter relative to its body size than the Atlantic sturgeon. It has bony plates, or scutes, and is an



anadromous fish. The shortnose sturgeon has been listed as endangered under the Endangered Species Act (ESA) since 1967 (USFWS, no date).

Atlantic Salmon (*Salmo salar*)

The Atlantic salmon is an anadromous salmonid (related to trout and salmon) with a typical elongate trout-like body. The average length is about 18 inches (457 mm). In the sea, Atlantic salmon have silvery sides with dark spots on the dorsal side of the body. Once they enter rivers to spawn, they take on a bronze or brown color, sometimes with reddish spots on the head and body.



Suitable spawning habitat consists of coarse substrate (gravel or rubble) in areas of moving water (NMFS and USFWS, 2004). The original range was generally the North Atlantic Ocean including the coast of Iceland south to Portugal in Europe and from the Arctic Circle south to the Connecticut River in North America. The Atlantic salmon has been listed as endangered under the ESA since November 17, 2000. It is currently only found in Maine within the United States. Threats faced by the Atlantic salmon include poor water quality, by-catch by commercial fisherman, incidental capture of adults and parr by recreational fisherman, and avian predation (NMFS and USFWS, 2004).