COMPARATIVE ECOLOGICAL ASSESSMENT REPORT

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

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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
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

This study was performed by AMEC Earth & Environmental, Inc. (AMEC) 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 (U.S. EPA) (U.S. EPA Region I, CERCLA Docket No. 01-2007-0163) concerning the Centredale Manor Restoration Project (CMRP) Superfund Site. AMEC conducted a comparative ecological assessment of Allendale and Lyman Mill Ponds as they currently exist (baseline) and their condition should one of four remedial alternatives be implemented for the study area. This assessment was conducted to serve two important functions. First, the analysis was completed to gain a better 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.

The information in this report is being provided to the participating stakeholders to help evaluate the benefits and drawbacks of various future land use options that would integrate well within the larger remediation framework being considered for this site in the Feasibility Study (FS). Existing site documents and reports were first reviewed to gather information for the development of this comparative ecological assessment. In addition, a detailed site survey was then conducted to supplement and expand upon the existing data and information. Finally, information, including the hydrodynamic analysis (QEA, 2007), for each alternative was considered in preparing 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 at the Brook Village (2072 Smith Street) and Centerdale Manor (2074 Smith Street) apartment complex properties in the Town of North Providence, Providence County, Rhode Island. The CMRP site is located in the Seaboard Lowland section of the New England physiographic province[1]. According to the Level III and IV Ecoregions Map of Massachusetts, Rhode Island, and Connecticut (Griffith et al., n.d.), the site is also 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.

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

The site proper as defined by the U.S Environmental Protection Agency (USEPA) encompasses both the Brook Village and Centerdale Manor properties as well as the contaminated sediment in Allendale Pond, Lyman Mill Pond, the interconnecting waterway, and the forested wetland area referred to as the "Oxbow Area". The study area for this comparative ecological assessment focuses on the more "natural" portions of the site area which include Allendale Pond, Lyman Mill Pond, and the Oxbow Area. The Oxbow Area is located adjacent to the west side of the Woonasquatucket River, southwest of Allendale Pond and northwest of Lyman Mill Pond.

The Woonasquatucket River is a low-gradient stream that supports a warm-water fishery which includes species such as bluegill (Lepomis macrochirus), bullhead (Ameiurus sp.), chain pickerel (Esox niger), largemouth bass (Micropterus salmoides), pumpkinseed (Lepomis gibbosus), and shiners (Notropis spp.). Some cold-water species such as rainbow trout (Oncorrhynchus mykiss) and white sucker (Catostomus commersoni) have also been found in the river.

The Woonasquatucket River is non-tidal within the vicinity of the study area and is highly variable in width, depth, channel type, and bottom sediments. Starting from the Centerdale Manor and Brook Village Apartment complexes, the following six (6) lowhead dams are present on the river downstream of the site, most of which are currently impassable to anadromous fish:

- Allendale Pond Dam
- Lyman Mill Pond Dam
- Manton Mill Pond Dam
- Atlantic Mill Pond Dam
- Paragon Pond Dam
- Rising Sun Pond Dam

The catadromous American eel (Anguilla rostrata), is found throughout the river including the aforementioned ponds. This species enters freshwater systems as juveniles and reside in these areas to adulthood, returning to the sea to breed. They are capable of traversing the lowhead dams and small waterfalls that act as obstructions to most anadromous fish.

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 option. 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.

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

This study qualitatively examines the ecological ramifications of implementing one of these alternatives by comparing the environs of the study area as they currently exist (baseline), defined largely on site reconnaissance surveys, 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
- 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 presents a discussion on the functions and values of the existing habitats. Section 4.0 presents a more detailed description of the four remedial alternatives that are evaluated for this comparative assessment and provides a discussion of the potential changes to the functions and values of these habitats resulting from implementation these alternatives. Section 5.0 presents a more detailed qualitative evaluation of the fisheries in the study area and the potential effects that the remedial alternatives may have on the current fisheries. Finally, a summary and conclusions are provided in Section 6.0.

2.0 OBSERVATIONS OF THE SITE SURVEY

A site survey was conducted on October 17 and 18, 2006, which focused primarily on the terrestrial portions of the study area. The site survey was conducted by a two-person field team, traversing within or around each of five components of the study area. The observations of that survey are reported here.

A description of the five component of the study area is provided below. **Appendix A** presents photographs of these areas, and **Appendix B** presents a list of plant species observed during the site survey.

2.1 Woonasquatucket River

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

- An approximate 1,600-foot segment upstream of Allendale Pond, adjacent to Brook Village Apartments, Centredale Manor Apartments, and Caps #1 and #2.
- An approximate 1,400-foot segment between Allendale Pond and Lyman Mill Pond, east of the Oxbow Area described in Section 2.3.
- The portion of the Woonasquatucket River downstream of the Lyman Mill Pond dam.

The varied surrounding land use around the Woonasquatucket River results in a riparian corridor of variable width, although, overall, it is narrow. This riparian corridor is primarily 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*), Asiatic bittersweet (*Celastrus orbiculatus*), common greenbrier (*Smilax rotundifolia*), poison ivy (*Toxicodendron radicans*), and Japanese knotweed (*Polygonum cuspidatum*). Indications of wildlife included squirrel nests in trees and calls of American crow (*Corvus brachyrhynchos*).

The northern 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 western bank is slightly undercut, and both banks are moderately sloped. 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 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. The river exhibited imperceptible flow during the time of the site investigation. The water was moderately clear and the depth was estimated to be approximately 2 feet deep in the center of the channel.

The middle segment of the river between Allendale and Lyman Mill Ponds forms the eastern boundary of the Oxbow Area (see Section 2.3). In contrast to the straight morphology of the northern segment described above, this river segment is slightly sinuous and much wider. The typical channel width is approximately 50 to 60 feet and includes riffle, run, glide, and pool areas. Both eastern and western banks are vegetated with trees as the dominant plant form. No fringe wetlands are present on either side of the river, although wetland areas are located farther within the Oxbow Area which abuts the western side of the river. The banks in this river segment range from gently sloping to moderately high and entrenched. The water was moderately clear during the site investigation.

The southern segment of the river situated below the Lyman Mill Pond dam flows through a forested deciduous floodplain, which 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 included 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. However, it should be noted that most of the invasive species such as common catalpa, tree-of-heaven, multiflora rose, and Asiatic bittersweet are located along the utility right-of-way, an area exhibiting a high degree of human influence. In contrast, a smaller number of invasive species, but equally troublesome, 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 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*).

Wildlife species observed within and around Allendale Pond included mute swan (*Cygnus olor*), mallard (*Anas platyrhynchos*), blue jay (*Cyanocitta cristata*), and American robin (*Turdus migratorius*). 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.

2.3 Oxbow Area

The Oxbow Area is an approximate 30-acre rectangular area located between Allendale Pond and Lyman Mill Pond, along the western side of the Woonasquatucket River. It is an undeveloped deciduous forested area surrounded by areas of residential and light industrial development. The area is composed of a mosaic of forested upland and forested wetland communities, bisected by an abandon channel and several rivulets. 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.

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 abandon 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.). 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 cinnamonea*), willow (*Salix* sp.), and branching bur-reed (*Sparganium androcladum*). Some portions of the scrub-shrub community are densely vegetated and virtually impenetrable.

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 abandon 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. 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 abandon 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 abandon 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.

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. Mid-stage deciduous woods still dominate the riparian community around the pond, with the exception of an emergent marsh located near the head of the pond. This marsh is nearly dominated by two species, purple loosestrife (*Lythrum salicaria*) and swamp loosestrife or water willow (*Decodon verticillatus*). The plant community around the remaining portions of Lyman Mill Pond is similar to that described earlier, including 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.

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*).

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. However, the wetlands are in some locations traversed and bisected by roads. This wetland complex 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.

3.1 Functions and Values

A quantitative functions and values assessment was not conducted for this report. However, a qualitative assessment is presented that uses 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 which 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.

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, it is anticipated that the study area does provide ample suitable habitat for numerous invertebrate and vertebrate wildlife species. According to the Rhode Island Comprehensive Wildlife Conservation Strategy (RIDEM 2005), the study area exhibits the following seven 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 Lower Perennial (RLP)
- Lacustrine Eutrophic Lake / Pond (LE)
- Urban (U)

Each of these 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. 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:

<u>Birds</u>

- 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, the forested components of the study area provides suitable summer habitat for all of the above bird species, and questionable suitable habitat for the New England cottontail. 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).

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.

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.

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 (*Meropleon diversicolor*)
- Mulberry wing (*Poanes massasoit*)
- Acadian hairstreak (*Satyrium acadicum*)

Mammals

- Southern bog lemming (*Synaptomys cooperi*)

Birds

- Wilson's Snipe (*Gallinago delicata*)

Based on the observations of the site visit, the shallow marsh components of the study area provide suitable habitat for the bronze copper and mulberry wing; however, the suitability of these habitats for *Macrochilio louisiana*, multicolored sedgeminer, and Acadian hairstreak is unknown. The shallow marsh may also provide wintering habitat for Wilson's Snipe.

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.

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.

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.

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:

<u>Birds</u>

- 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.

3.1.1.5 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. 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 spurious*)

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 is undocumented; 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/)

3.1.1.6 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 of water-water species. Eutrophic lakes and ponds are habitats under moderate stress but in relatively good condition.

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.

3.1.1.7 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.

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/).

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. However, public access to the water is virtually non-existent within the study area; therefore public use is expected to be highly limited. Other than a single canoe moored to a private residence with waterfront property, there was no evidence of the above anticipated public uses that were seen at the time of the site visit. However, the study area does provide a significant amount of open space for the surrounding community. What little access there is available to the waterfront is expected to limit the use of the area to possibly an occasional visit during the warmer months.

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).

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 4 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 (upgradient) of the study area, in the municipality of North Smithfield. 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 POTENTIAL EFFECTS OF REMEDIAL ALTERNATIVES TO EXISTING FUNCTIONS AND VALUES

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; LEA, 2007). Descriptions of each alterative 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 confined disposal facilities (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, a weir 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, a weir 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, free flowing river. For all three of the dam removal alternatives, contaminated sediments would be removed from the river channel and ponds, consolidated and capped or placed within a CDF. For Alternative 1, the final river configuration would be a free flowing river channel without any ponded areas. For Alternatives 2 and 3, Allendale and Lyman Mill smaller ponds would remain within the footprint of the existing ponds by constructing weirs. The weirs would restrict flow, but allow water to free flow between ponds thereby allowing fish to freely migrate above, below, and between these ponds. Though there are variations in these three options, the overall effect of the dam removal options would likely be relatively consistent on a macro scale.

The fourth remedial Alternative under consideration, Alternative 4, contemplates the excavation of impacted sediments to be placed in nearshore CDFs with the dams in place. The construction of nearshore CDFs would result in ponds that are approximately 25% smaller in area. 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 would not likely significantly alter the functions of the aquatic system, except for short-term impacts resulting from remediation activities. Upon restoration, Alternative 4 would likely closely mimic the existing conditions as outlined in Section 3.0.

The reduction in size not withstanding, the overall impact of Alternative 4 would be relatively small. Accordingly, 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. The stream flows, depths, substrate types, vegetation species, or other factors used in a final design may differ from those used in 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 should one of the dam removal alternatives be implemented. Nevertheless, the comparative assessment provides an overview of the changes that would 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 Proposed Conceptual Approach

An issue that is immediately apparent to any visitor to the study area is the lack of 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 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.

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. 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 should one of the dam removal be 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. Therefore, the assessment of functions and values provided below for the dam removal alternatives will generally hold true for any of the dam removal options being considered in the FS.

4.2 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. For example, wildlife species that benefit most from Lacustrine Eutrophic Lake/Pond (LE) habitat would likely experience the greatest alterations to their current habitat, whereas wildlife species that benefit most from River Lower Perennial (RLP), Mixed Forest Deciduous Unspecified (MFD), Emergent Marsh Deep (EMAD), Emergent Marsh Shallow/Wet Meadow (EMAS), Shrub Swamp Water Willow (SSAD), and Forest Deciduous Red Maple Swamp (FOBMA) would see an increase in available habitat and habitat quality. Regardless, the wildlife species endemic to an LE habitat would not be excluded from or deterred by the new open space, and many GCN avian and fish species would experience a habitat improvement over the current conditions.

As mentioned above, the conceptual plan for dam removal would result in moderate 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. These ponds would provide habitat for fish spawning and fish nest-building areas and provide soft sediment substrate for macrophytes. The macrophytes populations would serve as food (e.g., for macroinvertebrates and waterfowl), or substrates for food items for macroinvertebrates. Finally, the ponds would continue to support the existing warm water fishery (e.g., bass, sunfish, etc).

In contrast to Alternatives 2 and 3, Alterative 1 would likely result in a significant reduction in LE habitat. The reduction would be caused by the elimination of the dams, allowing the river to flow within its banks through the study area. Under Alternative 1, the river would flow in a manner more indicative of days prior to the construction of the mill ponds. As such, under this alternative the area would likely return to a River Lower Perennial (RLP) stream habitat.

Overall, the effect of dam removal on mammalian populations would not likely be negative and may be enhanced. For example, mammalian species such as River Otter would range over an area that provides a suitable habitat for food and reproduction. According to the USEPA Wildlife Exposure Factors Handbook (USEPA, 1993), the River Otter may prefer flowing water habitats over stationary water habitats such as mill ponds. Such an area would likely be much larger than Allendale Pond and Lyman Mill Pond and may possibly extend the full length of the Woonasquatucket River. Therefore, the restoration of the river without the dams would potentially improve the habitat for mammals such as River Otter. Moreover, to the extent that alewife, shad and herring are reintroduced to the upper sections of the Woonasquatucket River, the prey base for piscivorous mammals would be improved over current conditions.

Under all three alternatives, the conceptual dam removal plans would improve the River Lower Perennial (RLP) habitat of the river corridor. Cold water, catadromous, and anadromous fish habitats would be improved by removal of the dams when compared to the existing system or Alternative 4. The unfortunate consequence of the mill dams on small rivers such as the Woonasquatucket River is to eliminate the RLP habitat and with it, the possibility of anadromous fish populations using the river as a spawning area. However, 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 low head dams at Allendale Pond and Lyman Mill Pond spill water over the tops of the dam structures. The water that is spilled over the dams is usually the warmest waters, so the water temperatures downstream of the dams are higher than what would be expected from an unimpounded, free flowing river system. Additionally, the free flow of water through areas of riffle and run would improve oxygenation levels when compared to an impounded river. It is anticipated that dam removal would decrease water temperatures and improve oxygenation of the river which would support cooler water species (e.g., trout). If contaminated sediment is consolidated and capped within the floodplain of the river, it is possible that trees or shrubs would not be allowed to grow along the river bank. The absence of trees and shrubs within the

riparian zone would potentially allow the river water to experience some solar warming. However, the overall effect of restoring a river system would be a cooler aquatic system because water stagnation would be minimized and the surface area exposed to solar warming would be effectively reduced. Therefore, a slightly cooler aquatic environment than that which exists currently will result.

The detailed design of all the alternatives considered here would 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 tress 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 an even cooler water system than would be expected without such a barrier.

Riffle and run areas created by Alternative 1 could provide habitat for fish spawning and some fish nest-building areas. Additionally, habitat for semi-aquatic insect species such as mayfly, stonefly, caddisfly, and black fly should improve. 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). Finally, riffle and run segments promote macroinvertebrate production and are primary production habitat for filamentous algae and diatoms.

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. 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.

Finally, 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, mammalian populations would use this habitat for forage.

One exception to 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 should the dams be removed. However, this would not likely 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, and, in fact, represent only a tiny fraction of available habitat that is used by the winter over birds. Therefore, the reduction of the pond size would not likely have a negative impact on the population of winter over sea birds.

Hydrodynamic modeling demonstrates that all four alternatives would result in continued intermittent inundation of this area, which would maintain it as a forested wetland area (QEA, 2007). Assuming that the forested wetland remains intact, the function of the Oxbow Area would be essentially unchanged.

Overall, ecological diversity and abundance would likely increase if the dam removal alternative were employed, with increases in the diversity of fish species, avian species, and possibly mammalian species.

If any of Alternatives 1 through 3 were implemented, the role that the Woonasquatucket River would play extend beyond the benefits gained by passive users. As indicated in the RIDEM Freshwater Wetland Act Rules, aesthetic values include the wetland's visual, aural, and cultural qualities such as its prominence as a distinct feature in the local area. The current lack of adequate public access to the river preempts this value from being obtained.

The proposed alternatives would not eliminate the function of flood flow alteration for the study area. As demonstrated by the hydrodynamic modeling (QEA, 2007), all four alternatives would maintain or improve the current flood protection value because they would not reduce the land area of the current open space and may increase the pervious surface area within the open space.

5.0 FISHERIES ASSESSMENT

This section of the report presents a discussion on the existing fisheries and a qualitative assessment of the fisheries under each of the four remedial alternatives under consideration.

5.1 Fishery - Current Conditions

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). 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 water[2]. These data also suggest that current water temperatures are generally too high to support trout or salmon throughout the summer months. However, stocked fish can survive for most of the year. Trout found in the area are likely part of a put-and-take fishery provided by the RIDEM, whereby fishable sized trout are stocked annually in the system. The water temperature regime would be considered cool, but not cold water habitat. Generally, this type of habitat would support smallmouth bass, rock bass, chain pickerel, and limited trout. However, the species present in the ponds are more indicative of a warm water fishery consisting of largemouth bass, chain pickerel, bluegill, bullheads, and American eel.

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.

5.1.1 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.

[2] http://www.woonasquatucket.org/waterquality.htm

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, 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".

Top: Leptocephalus
Middle: Glass eel
Bottom: Adult American 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 Remedial Investigation (2002a).

5.1.2 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.

Top: Black crappie
Bottom: White crappie

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

5.1.3 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.

5.1.4 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.

5.1.5 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.

5.1.6 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.

5.1.7 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 ichtyoplankton 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.

5.1.8 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.

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 larvae 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.

5.1.9 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.

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.

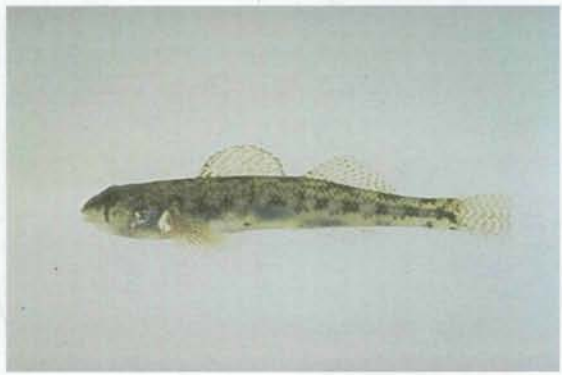
5.1.10 Spottail Shiner (Notropis hudsonius)

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.

5.1.11 Tesselated Darter (Etheostoma olmstedi)



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.

5.2 Fishery - Alternative 1

Under Alternative 1, both Allendale Pond Dam and Lyman Mill Pond Dam would be completely removed. Contaminated sediments would be excavated from the stream channel, placed on site, and capped. This alternative would remove the ponds that are currently on the site and would restore this section of the Woonasquatucket River to pre-impoundment conditions. By

removing the ponds, several changes to the habitat would likely occur as the system changes from a lentic to a lotic habitat.

The lack of dams at the CMRP site would allow for upstream migration of anadromous species if they could bypass structures further down stream. There are currently two dams located downstream of the CMRP site that prevent migration of anadromous species to the study area, including the Rising Sun Mill Dam and the Paragon Dam. The Woonasquatucket River is not currently a priority for dam removal projects by RIDEM because of the current poor water quality in upstream locations (Erkan, 2002). However, if this alternative is selected, the potential removal of dams or installation of fish ladders in lower reaches may become a priority because it would allow access to potential spawning habitat for anadromous species.

Species that would benefit from access to the upper portions of the Woonasquatucket River would likely include American eel, American shad (Alosa sapidissima), hickory shad (Alosa mediocris), blueback herring (Alosa aestivalis), and alewife (Alosa pseudoharengus). The potential for rare or endangered anadromous species such as Atlantic salmon, shortnose sturgeon (Acipenser brevirostrum), or Atlantic sturgeon to utilize the newly accessible habitat is likely to be remote as it would require these rare fish to venture into unknown rivers to find suitable available habitat. However, a stocking program may increase the likelihood of utilization by rare or endangered species.

Changes in water quality and habitat associated with this alternative include:

- increased levels of dissolved oxygen on average in the study area and downstream;
- decreased average temperatures in much of the river;
- decrease in zooplankton and phytoplankton abundance and a change in community structure;
- reduction in mud or silt substrates and a corresponding increase in coarser substrates;
- changes in the periphyton and macroinvertebrate community compositions; and
- changes in fish assemblages

Dissolved oxygen in water bodies is primarily controlled by two factors, mixing and temperature. However, other factors such nutrient inputs from as point and non-point sources and eutrophication commonly play a role.

Mixing is important because the majority of dissolved oxygen in a river or lake is obtained as a result of oxygen transfer from the air. Therefore, if the water is well mixed , low oxygen waters near the bottom of the lake will rise to the surface where they come in contact with the air and dissolve oxygen.

Temperature controls the solubility of oxygen in the water. Colder waters can dissolve more oxygen than warmer waters. Therefore, the best conditions for having high dissolved oxygen are cold, well mixed waters. If nutrients are present or there is a high chemical or biological oxygen demand from the sediment, dissolved oxygen can be rapidly depleted through microbial respiration.

Dissolved oxygen would be expected to increase in the Woonasquatucket River under Alternative 1. In addition, temperatures would decrease in the study area with the removal of ponded waters. Implementing Alternative 1 would also benefit the river below Lyman Mill Pond as cooler, more highly oxygenated waters would flow from the study area into downstream sections of the Woonasquatucket River.

Currently, the Woonasquatucket River appears to have adequate dissolved oxygen to support most fish species. A change in dissolved oxygen alone will not likely impact the fishery directly. However, such a change could have impacts on the lower trophic levels, such as periphyton and macroinvertebrates, and influence the fishery indirectly by changing the availability and types of food that the fish eat. The change would generally be expected to support anadromous species and fish that do well in lotic systems such as trout, herring, shad, and eels.

Zooplankton is a term used to describe the many small animals (mainly crustaceans) that have limited swimming ability. Because of the limited swimming ability, their location is primarily a function of currents. Streams and rivers generally have currents that immediately push zooplankton downstream, therefore zooplankton is generally found in ponded water. 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 warm-water fishery. Much of this food source will be eliminated with this alternative, and early life stages of some fish species in the current system may not be as successful when compared to current conditions. In contrast, this change may increase the success of the anadromous species because there would be fewer warm water fish to compete with for food.

Under this alternative, water velocities during flood events would result in bed scouring which would tend to push fine sediments downstream leaving a course, gravely substrate exposed. A gravel substrate is required for some anadromous 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 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 net spinning caddis flies, black flies, and other species of midge. The community that would exist would likely 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 would likely be favored. The American eel would likely benefit from such a change and may increase in abundance.

During various times of the year, nearly adult forms of the macroinvertebrate community will 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. There would also be the potential for currently rare or endangered species such as Atlantic salmon, Atlantic sturgeon or shortnose sturgeon to utilize the macroinvertebrates during spawning migrations should these fish have access to the restored habitat.

5.2.1 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 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

Hickory shad, *Alosa mediocris*

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.

5.2.2 Atlantic Sturgeon (Acipenser oxyrhynchus)

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 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).

5.2.3 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).

5.2.4 Atlantic Salmon (Salmo salar)

The Atlantic salmon is an anadromous salmonid (related to trout and salmon) with a typical

elongate troutlike body. The average length is about 18 inches (457 mm). In the sea, Atlantic salmon have silvery sides with dark sports 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).

5.3 Fishery - Alternative 2 and 3

Alternatives 2 and 3 both include breaching the dams and construction of weirs that would maintain some ponded areas while restoring some of the historic stream channel and flow to allow fish passage. Contaminated sediments would be removed from the stream channel and pond areas, and capped within the footprint of the ponds or placed in a CDF.

These alternatives would create a system that is intermediate between a completely free flowing river and the current ponded system. There would likely be reductions in warm water species and potential increases in anadromous fish abundance. 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 would still have access to the area, and it may potentially be used for spawning. However, the current warm-water species would still maintain some habitat in a reduced area.

5.4 Fishery - Alternative 4

Under Alternative 4, dams would not be removed and somewhat smaller versions of the current ponds would remain in the area after contaminated sediments were excavated and placed in CDFs. The excavation would result in a slight increase in depth of the ponds and a decrease (~25%) in inundation area. However the flow regime would not likely change significantly.

Dissolved oxygen would remain steady or may increase slightly because sediments with elevated organic matter and oxygen demand would be removed. Dissolved oxygen concentration as it currently exists is adequate for the survival of most fish species. Therefore,

there would not likely be direct changes in the fishery associated with increased dissolved oxygen.

Water temperatures would likely 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 warm water fishery.

Substrate composition may change slightly from a mud and silt bottom to a fine sand, silt or clay bottom initially. 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, there would likely be an initial decline in damselfly abundance associated with the removal of aquatic vegetation and substrate during the initial excavation. 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. There is likely to be an initial decline in Chironomid abundance associated with the excavation, 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 warm water fishery, possibly with some slight 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 would likely remain as the top predator and other fish species that currently exist in the system would still likely 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 would likely result in a loss of wetland functions and values because it returns the river flow to pre-impoundment conditions.

The end result of Alternatives 1, 2, and 3 would be the restoration of this segment of the Woonasquatucket River as a free flowing river, with a resulting significant increase in a naturalized riparian corridor. The restoration of a free flowing river would create the necessary habitat(s) for the reintroduction of extirpated anadromous fish species and improvements in the overall wetlands function and values. 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.

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, the functions and values of the study area would not change significantly. In addition, the fishery would remain a warm water fishery that is dominated by the existing fish species.

Any of the four remedial alternatives evaluated herein, if implemented, would have short-term impacts on the ecosystem as a result of the earthwork activities. However, once established, the ecosystem would be expected to return to a functional and viable urban system, supporting many if not all of the existing functions and possibly supporting additional species of anadromous fish. In short, all of the alternatives are viable options from an ecological standpoint.

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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.

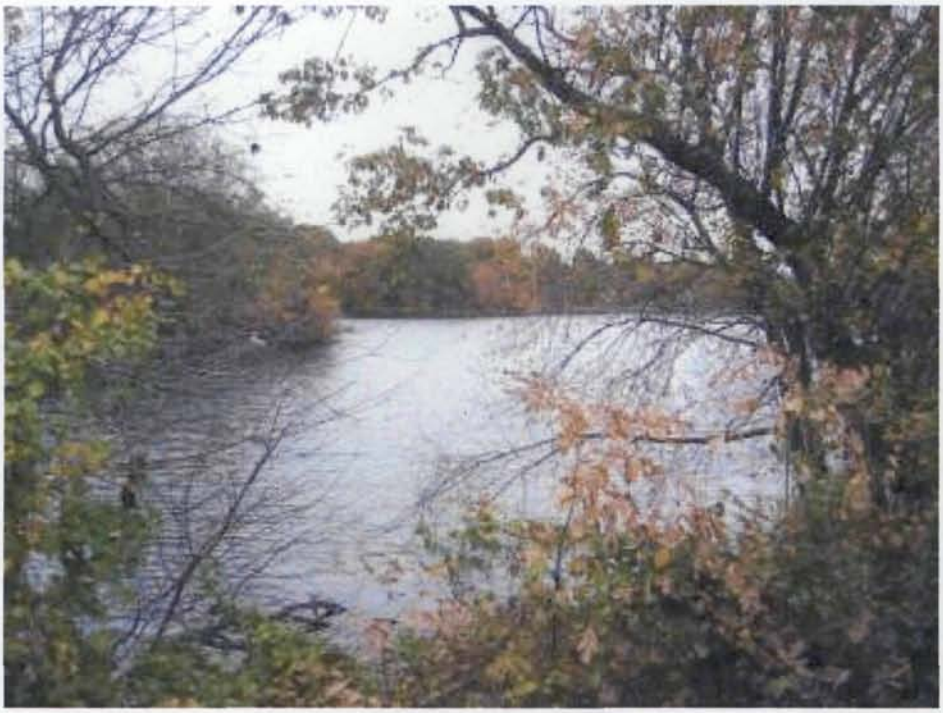

Photo 3: Western shoreline of Allendale Pond with peninsula visible on left side of photograph. The view is from the west, facing southeast.

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.

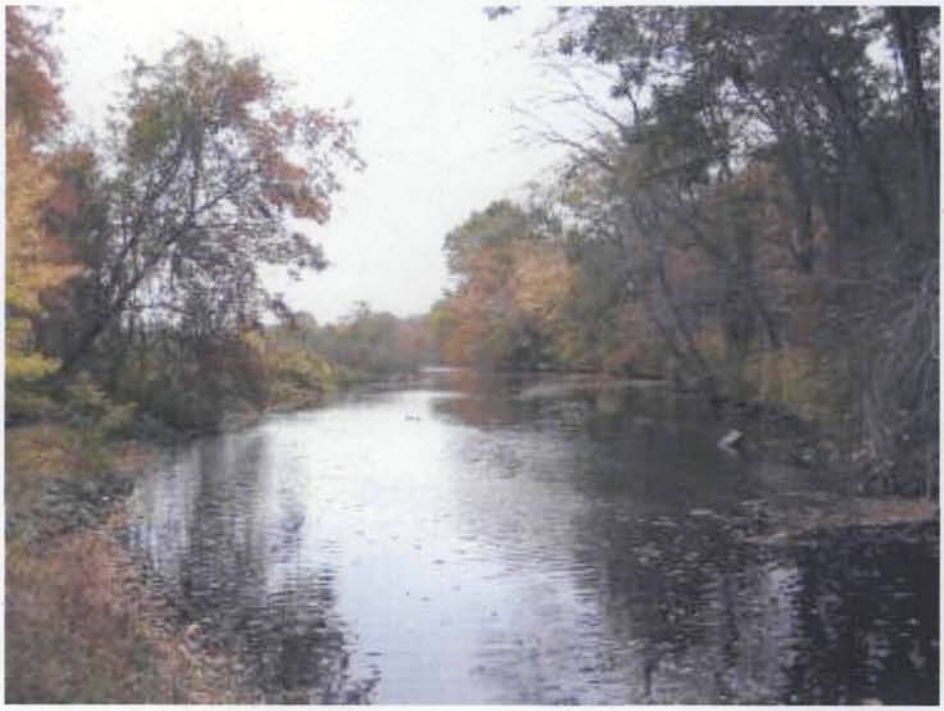

Photo 6: Woonasquatucket River/head of Allendale Pond. The view is from the north, facing south.

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.

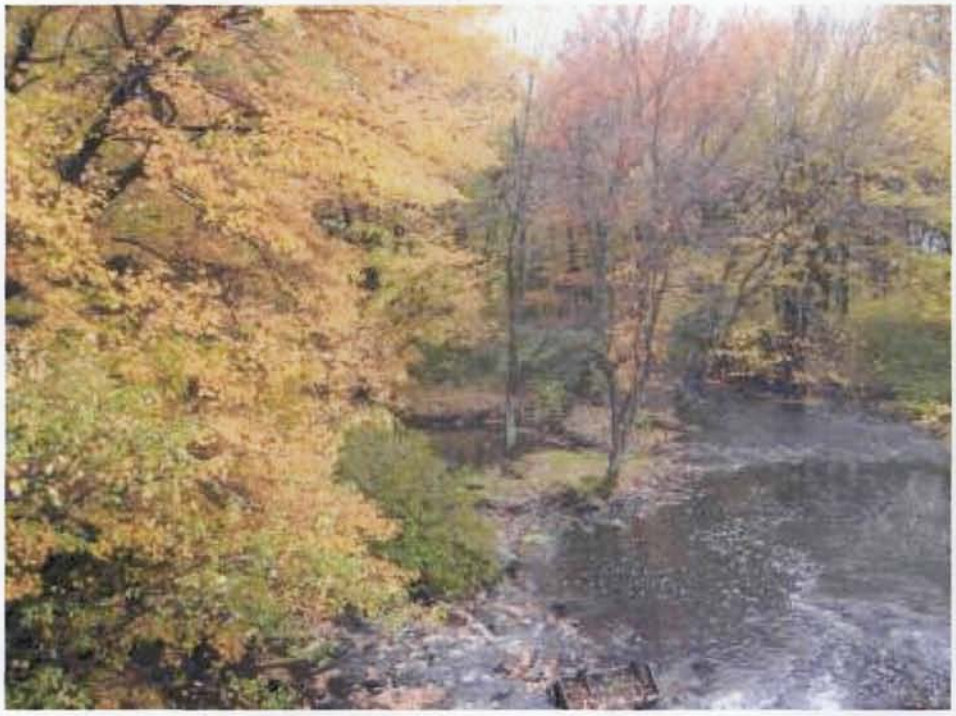

Photo 2: Woonasquatucket River, downstream of the Lyman Mill Pond Dam. The view is from the north, facing southwest.

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.

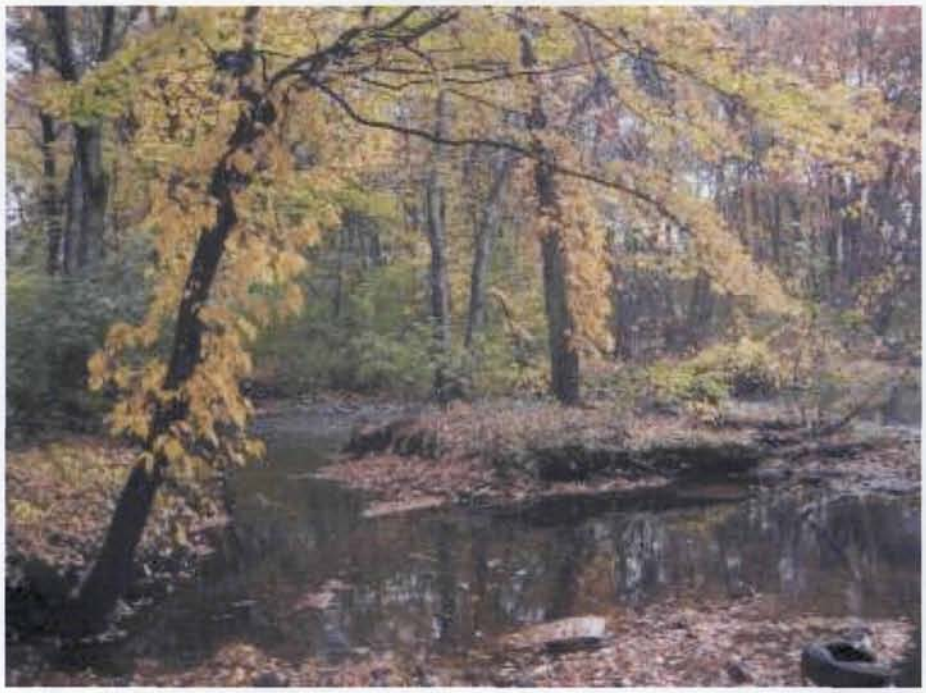

Photo 14: Woonasquatucket River, south of the Lyman Mill Pond Dam.

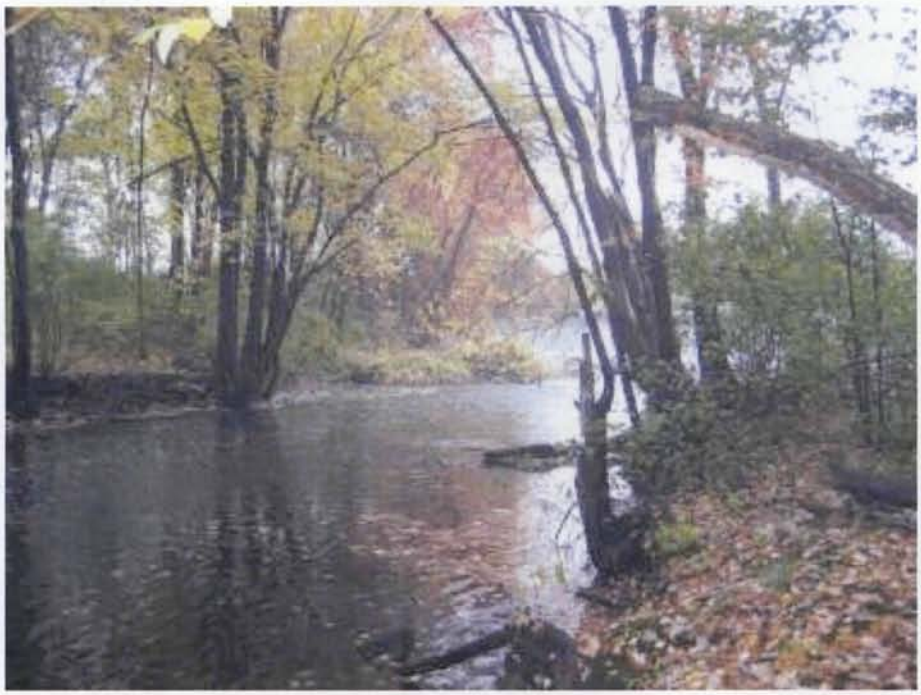

Photo 15: Alternate view of the Woonasquatucket River, south of the Lyman Mill Pond Dam. The view is from the eastern shoreline, facing northwest.

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.

Photo 13: General view of a portion of the oxbow lake.

Photo 14: Alternate view of the oxbow lake.

The following 4 photos present general views of the vegetation within the Oxbow Area.

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		FACU-
Polygonum lapathifolium	Dock-leaf smartweed	Pale smartweed	FACW+
Polygonum sagittatum	Arrow-leaved tearthumb		OBL

PLANT SPECIES LIST - Allendale Pond Peninsula

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

PLANT SPECIES LIST - Allendale Pond Area

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

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
Rosa multiflora	Multiflora rose		FACU
Rubus idaeus	Red raspberry		FAC-
Scrophulariaceae (Figwort Family)			
Linaria vulgaris	Butter-and-eggs		NL
Verbaxcum thapsus	Common mullein		NL
Simaroubacceae (Quassia Family)			
Ailanthus altissima	Tree of heaven		FACU-
Solanaceae (Nightshade Family)			
Solanum dulcamara	Bittersweet nightshade		FAC-
Ulmaceae (Elm Family)			
Ulmus americana	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 Kozlowsi (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)			
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
Rhus copallina	Winged sumac		NI
Araliaceae (Ginseng Family)			
Aralia nudicaulis	Wild sarsaparilla		FACU
Asteraceae (Aster Family)			
Artemisia vulgaris	Common mugwort		NL
Aster divaricatus	White wood aster		NL
Bidens frondosa	Beggar-ticks		FACW
Berberidaceae (Barberry Family)			
Berberis thumbergii	Japanese barberry		FACU
Betulaceae (Birch Family)			
Alnus rugosa	Speckled alder		FACW+
Betula lenta	Black birch		FACU
Carpinus caroliniana	Ironwood		FAC
Caprifoliaceae (Honeysuckle Family)			
Sambucus canadensis	Common elder	Elderberry, American elder	FACW-
Viburnum recognitum	Northern arrowwood		FACW-
Celastraceae (Staff-tree Family)			
Celastrus orbiculatus	Asiatic bittersweet		NL
Clethraceae (White Alder Family)			
Clethra alnifolia	Coast pepperbush		FAC+
Cornaceae (Dogwood Family)			
Nyssa sylvatica	Black gum		FAC
Cupressaceae			

PLANT SPECIES LIST - Oxbow Area

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

PLANT SPECIES LIST - Oxbow Area

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

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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

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Scientific Name	Common Name	Synonyms	USFWS Indicator

Aulback-Smith and Kozlowsi (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 - 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)			
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
Araceae (Arum Family)			
Symplocarpus foetidus	Skunk cabbage		OBL
Asteraceae (Aster Family)			
Aster divaricatus	White wood aster		NL
Bidens frondosa	Beggar-ticks		FACW
Balsaminaceae (Touch-me-not Family)			
Impatiens capensis	Jewelweed		FACW
Berberidaceae (Barberry Family)			
Berberis thumbergii	Japanese barberry		FACU
Bignoniaceae (Trumpet Creeper Family)			
Catalpa bignonioides	Common catalpa		NL
Caprifoliaceae (Honeysuckle Family)			
Lonicera japonica	Japanese honeysuckle		FAC-
Lonicera morrowii	Morrow's honeysuckle		FACU
Sambucus canadensis	Common elder	Elderberry, American elder	FACW-
Viburnum recognitum	Northern arrowwood		FACW-
Celastraceae (Staff-tree Family)			
Celastrus orbiculatus	Asiatic bittersweet		NL
Cornaceae (Dogwood Family)			
Cornus amomum	Silky dogwood		FACW
Fagaceae (Beech Family)			
Quercus palustris	Pin oak		FACW

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

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Literature used for taxonomic identification:

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