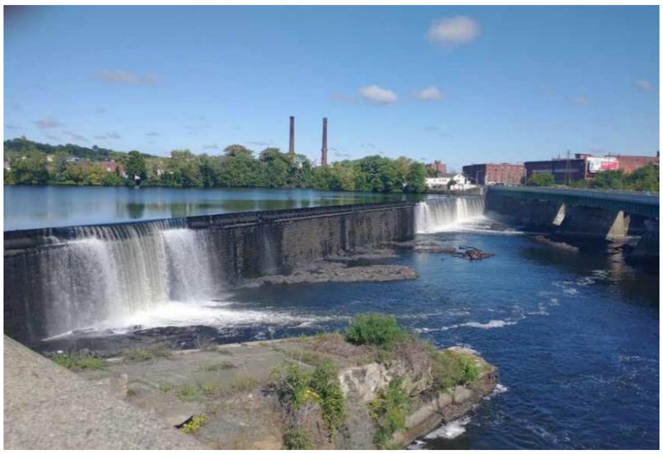

Volume II of II

Exhibit E Environmental Report

Lawrence Hydroelectric Project (FERC No. 2800)

July 6, 2026

Prepared for:

Essex Company, LLC,

a subsidiary of Patriot Hydro, LLC

PATRIOT HYDRO

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List of Acronyms

ºC	degrees Celsius
°F	degrees Fahrenheit
µS/cm	micro siemens per centimeter
ACES	Alliance of Climate and Environmental Stewards
ACHP	Advisory Counsil on Historic Preservation
ADA	Americans with Disabilities Act
ADW	Animal Diversity Web
AIS	Aquatic invasive species
APE	Area of Potential Effects
ASA	ASA Analysis & Communications
ASMFC	Atlantic States Marine Fisheries Commission
ASSRT	Atlantic Sturgeon Status Review Team
ATS	Advanced Telemetry Systems
AVIS	Andover Village Improvement Society
AWS	Auxiliary Water Supply
B.P.	before present
CFD	Computational Fluid Dynamics
CFPP	Comprehensive Fish Passage Plan
cfs	cubic feet-per-second
CMR	Code of Massachusetts Regulations
CPUE	catch per unit effort
CRF	Code of Federal Regulations
CSO	combined sewer overflows
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DLA	Draft License Application
DO	Dissolved Oxygen
DPS	Distinct Population Segments
EFH	essential fish habitat
El.	elevation
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ESA	Endangered Species Act
Essex	Essex Company, LLC
FERC	Federal Energy Regulatory Commission
FLA	Final License Application
FOMP	Fishways Operation and Maintenance Plan
FPA	Federal Power Act
fps	feet per second
GLSD	Greater Lawrence Sanitary District
GWL	Groundwork Lawrence
HAPC	habitat areas of particular concern
HDR	HDR Engineering, Inc.
HP	horsepower
HPMP	Historic Properties Management Plan
HYDROGP	Hydroelectric Generating Facility General Permit

Hz	hertz
ILP	Integrated Licensing Process
IPaC	Information for Planning and Consultation
IPANE	Invasive Plant Atlas of New England
ISR	Initial Study Report
km	kilometer
kV	kilovolt
kVA	kilovolt-amperes
LCW	Lawrence Community Works
LHA	Lawrence Hydroelectric Associates
LMRLAC	Lower Merrimack River Local Advisory Committee
LOE	loss of equilibrium
MA DMF	Massachusetts Division of Marine Fisheries
MACRIS	Massachusetts Cultural Resources Information System
MACZM	Massachusetts Office of Coastal Zone Management
MADCR	Massachusetts Department of Conservation and Recreation
MADEP	Massachusetts Department of Environmental Protection
MDEQC	Massachusetts Department of Environmental Quality Engineering
MDFW	Massachusetts Division of Fisheries and Wildlife
MDPW	Massachusetts Department of Public Works
MEOEEA	Massachusetts Executive Office of Energy and Environment Affairs
MESA	Massachusetts Endangered Species Act
MF	malady-free
mg/L	milligrams per liter
MIPAG	Massachusetts Invasive Plant Advisory Group
MRTC	Merrimack River Technical Committee
MRWC	Merrimack River Watershed Council
MW	megawatt
MWh	megawatt-hours
NAI	Normandeau Associates, Inc.
NEFMC	New England Fishery Management Council
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NHDES	New Hampshire Department of Environmental Services
NHDFG	New Hampshire Department of Fish and Game
NHESP	Natural Heritage and Endangered Species Program
NHFG	New Hampshire Fish and Game Department
NHPA	National Historic Preservation Act
NLCD	National Land Cover Database
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRHP	National Register of Historic Places
NRI	Nationwide Rivers Inventory
NTU	Nephelometric Turbidity Units
NWI	National Wetlands Inventory
NWIS	National Water Information Systems

OSRP	Open Space and Recreation Plan
PAD	Pre-Application Document
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyl
PM&E	protection, mitigation, and enhancement
ppt	parts per thousand
PSP	Proposed Study Plan
Project	Lawrence Hydroelectric Project (FERC No. 2800)
RM	river mile
ROR	run-of-river
ROW	right-of-way
RPM	revolutions per minute
RTE	rare, threatened, and/or endangered
RSP	Revised Study Plan
SAV	submerged aquatic vegetation
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SD1	Scoping Document 1
SD2	Scoping Document 2
SHPO	State Historic Preservation Officer
SPD	Study Plan Determination
SRHP	State Register of Historic Places
SSS	side-scan sonar
TBSA	Turbine Blade Strike Analysis
TCP	traditional cultural properties
TFS	The Fish Site
THPO	Tribal Historic Preservation Officer
TMDL	total maximum daily load
TNC	The Nature Conservancy
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USC	United States Code
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USR	Updated Study Report
VIE	Visual Implant Elastomer
WQC	Water Quality Certification

E.1. Introduction

Essex Company, LLC (Essex), a subsidiary of Patriot Hydro, LLC, is the Licensee, owner, and operator of the Lawrence Hydroelectric Project (FERC No. 2800) (Project or Lawrence Project). The Lawrence Project is located at river mile (RM) 29 on the Merrimack River in the City of Lawrence in Essex County, Massachusetts (Figure E.1-1). Essex operates and maintains the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Commission, under the authority of the Federal Power Act (FPA), 16 United States Code (USC) §791(a), et seq., may issue a license for up to 50 years for the construction, operation, and maintenance of non-federal hydroelectric developments. The existing license was issued by FERC on December 4, 1978 (with an effective date of December 1, 1978), and expires on November 30, 2028. Essex is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (CFR) Part 5. In accordance with 18 CFR §16.9(b), Essex must file its final application for a new license (Final License Application or FLA) with the Commission no later than November 30, 2026.

The existing Lawrence Project consists of:

1) The 35-foot-high by 900-foot-long gravity Essex Dam of stone masonry construction (also known as the Great Stone Dam), with a five-foot-high pneumatic crest gate system mounted on the spillway crest;
2) A 9.8-mile-long impoundment having a surface area of 655 acres at a normal water elevation of 44.2 feet, National Geodetic Vertical Datum of 1929 (NGVD29)[1] at the top of the crest gates, and a gross storage capacity of approximately 19,900 acre-feet;
3) A powerhouse located at the end of a small forebay adjacent to the south abutment of the Essex Dam, containing two 8.4 MW generating units, and a tailrace channel extending into the Merrimack River channel;
4) Fish passage facilities integral with the powerhouse, including a fish elevator and downstream fish bypass, an eel ladder at the right abutment of the dam, and an eel lift at the left abutment of the dam;
5) The North Canal, approximately 5,300 feet long by 95 feet wide by 15 feet deep, originating at the north abutment of the dam and paralleling the Merrimack River downstream of the Essex Dam;
6) The South Canal, approximately 2,750 feet long by 35 feet wide by 10 feet deep, originating near the south abutment of the Essex Dam and generally paralleling the Merrimack River downstream of the Essex Dam;
7) A single-circuit, underground/underwater 23.0-kilovolt (kV) transmission line; and
8) Appurtenant facilities.

The Lawrence Project is operated in run-of-river (ROR) mode. The crest gate control system works in concert with the powerhouse pond level control system to maintain the impoundment water level at 44.2 feet NGVD29. In accordance with the existing license Article 32, Essex maintains a continuous downstream minimum flow of 951 cfs, unless the reservoir surface elevation is reduced

[1] Unless otherwise noted, all elevations in this license application reference the National Geodetic Vertical Datum of 1929 (NGVD29).

below the crest of the dam; thereupon, the minimum flow equals inflow to the reservoir. By operating the Project in ROR mode, the Licensee always meets and exceeds the requirements of Article 32 by maintaining outflow equal to inflow and by maintaining the impoundment level at or above the top of the crest gates.

Essex initiated the ILP by filing the Pre-Application Document (PAD) and Notice of Intent (NOI) on June 16, 2023. The PAD provided a description of the Project and summarized existing, relevant, and reasonably available information to assist resource agencies, federally recognized Indian tribes, and other interested parties (collectively, “stakeholders”) in identifying issues, determining information needs, and preparing study requests. The Commission issued Scoping Document 1 (SD1) for the Project on August 15, 2023. On September 13 and 14, 2023, the Commission held public scoping meetings in Lawrence, Massachusetts. FERC issued Scoping Document 2 (SD2) on November 28, 2023. In accordance with 18 CFR §5.11, Essex developed a Proposed Study Plan (PSP) that was filed with the Commission on November 28, 2023. A PSP meeting was held on January 4 and 5, 2024, to describe the intent and contents of the PSP, initial information gathering needs, and address outstanding issues associated with the proposed studies. In response to comments from stakeholders, Essex filed the Revised Study Plan (RSP) on April 10, 2024.

The Commission issued its Study Plan Determination (SPD) on May 10, 2024. In accordance with 18 CFR §5.15, Essex initiated studies in 2024 and 2025 as provided in the study plan and schedule approved by the Commission. On April 28, 2025, Essex filed the Initial Study Report (ISR) for the Project. Essex held an ISR Meeting on May 7 and 8, 2025, to discuss the status of studies and results for completed studies, and on May 27, 2025, filed the ISR Meeting Summary. Stakeholders were provided a 30-day period to provide comments on the ISR Meeting Summary, recommend study modifications, and/or to propose new studies. On April 27, 2026, Essex filed its Updated Study Report (USR) and held USR Meetings on May 6 and 7, 2026. The USR Meeting Summary was filed on May 22, 2026. Stakeholders had until June 25, 2026, to file comments or disagreements with the USR. Table E.1-1 below summarizes the FERC-approved relicensing studies and their respective status.

This Environmental Report (Exhibit E) of the Draft License Application (DLA) has been prepared in accordance with 18 CFR § 5.18 and is intended to support the Commission’s analysis pursuant to the National Environmental Policy Act of 1969 (NEPA), as amended. This exhibit provides a description of the existing environmental setting of the Project and presents a preliminary assessment of the potential effects associated with continued operation of the Project, as proposed by the Licensee. The analysis of potential effects is based on the results of the FERC-approved relicensing studies and consultation conducted to date, as well as relevant information compiled from the ILP filings.

Essex is proposing to continue to operate the Project in the same manner as it is currently operated. Under the new Project license, Essex is proposing to remove the North and South Canals from the FERC Project boundary. This proposed action will not change the Project’s installed capacity, overall mode of operation, or any of the Project’s environmental resource values. Given that studies and associated consultation are ongoing, in the FLA, Essex will further evaluate Project-related effects along with potential protection, mitigation, and enhancement measures (PM&Es) developed from the results of ongoing relicensing studies and continued consultation. As appropriate, the FLA may also include additional measures to address any unresolved issues identified during the consultation process.

Figure E.1-1. Lawrence Hydroelectric Project Location and Existing Project Boundary.

Table E.1-1. FERC-Approved Relicensing Studies Summary Status.

No.	Study Report	Filed with ISR	Filed with USR	Anticipated Additional Filing with FLA, or before
1	Upstream Anadromous Fish Passage Assessment		X	
2	Upstream American Eel Passage Assessment	X		X
3	American Eel Upstream Passage Siting Study	X		
4	Desktop Entrainment, Impingement, and Turbine Passage Survival Study		X	
5	Sturgeon Distribution and Project Interaction Study		X	
6	Diadromous Fish Behavior, Movement, and Project Interaction Study	X	X	
7	Project Operations and Fish Stranding Study		X	X
8	Freshwater Mussel Habitat Assessment Study	X		
9	Water Quality Study		X	
10	Three-Dimensional Computational Fluid Dynamics Modeling		X	X
11	Recreation Facilities, Use, and Aesthetics Study		X	X
12	Historically Significant Waterpower Equipment Study	X		
13	Condition Assessment of Historic Properties and Associated Canal System	X		
14	Downstream Juvenile Alosine Passage Assessment	X	X	
15	Sturgeon Habitat Mapping and Assessment Study		X	
16	Fish Assemblage Assessment		X	
17	Invasive Plants Survey		X	

The following sections summarize the existing environmental setting of the Project and the baseline conditions under which this environmental assessment is being undertaken. Essex has performed this environmental assessment using the Project's existing FERC Project boundary, and the figures and data throughout generally represent the existing Project boundary.

E.2. General Description of the River Basin (18 CFR § 5.18 (b)(1))

E.2.1 Drainage Area and Length of River

The Merrimack River Basin extends from the White Mountain region of northern New Hampshire to southeastern Massachusetts (Figure E.2-1). The Merrimack River Basin has a total drainage area of approximately 5,010 square miles and is the fourth largest river basin in New England (MEOEEA 2001). The majority of the watershed lies within New Hampshire (3,800 square miles) (MEOEEA

2001). The drainage area of the Lawrence Project has a gross drainage area of 4,672 square miles and a net drainage area of 4,460 square miles after accounting for the 214 square-mile watershed attributed to the Boston and Worcester water supply (U.S. Geological Survey [USGS] 2023a).

The 115-mile-long Merrimack River is formed by the confluence of two major rivers, the Pemigewasset and Winnipesaukee, in Franklin, New Hampshire. From the confluence, it flows southward for approximately 78 miles in New Hampshire, turns abruptly eastward at the New Hampshire-Massachusetts border, and flows in a northeasterly direction for approximately 40 miles before draining into the Atlantic Ocean near Newburyport, Massachusetts. The final 22 miles of the river, downstream of Haverhill, Massachusetts, are tidally influenced (U.S. Army Corps of Engineers [USACE] 2003, New Hampshire Department of Environmental Services [NHDES] 2019).

E.2.2 Tributary Rivers and Streams

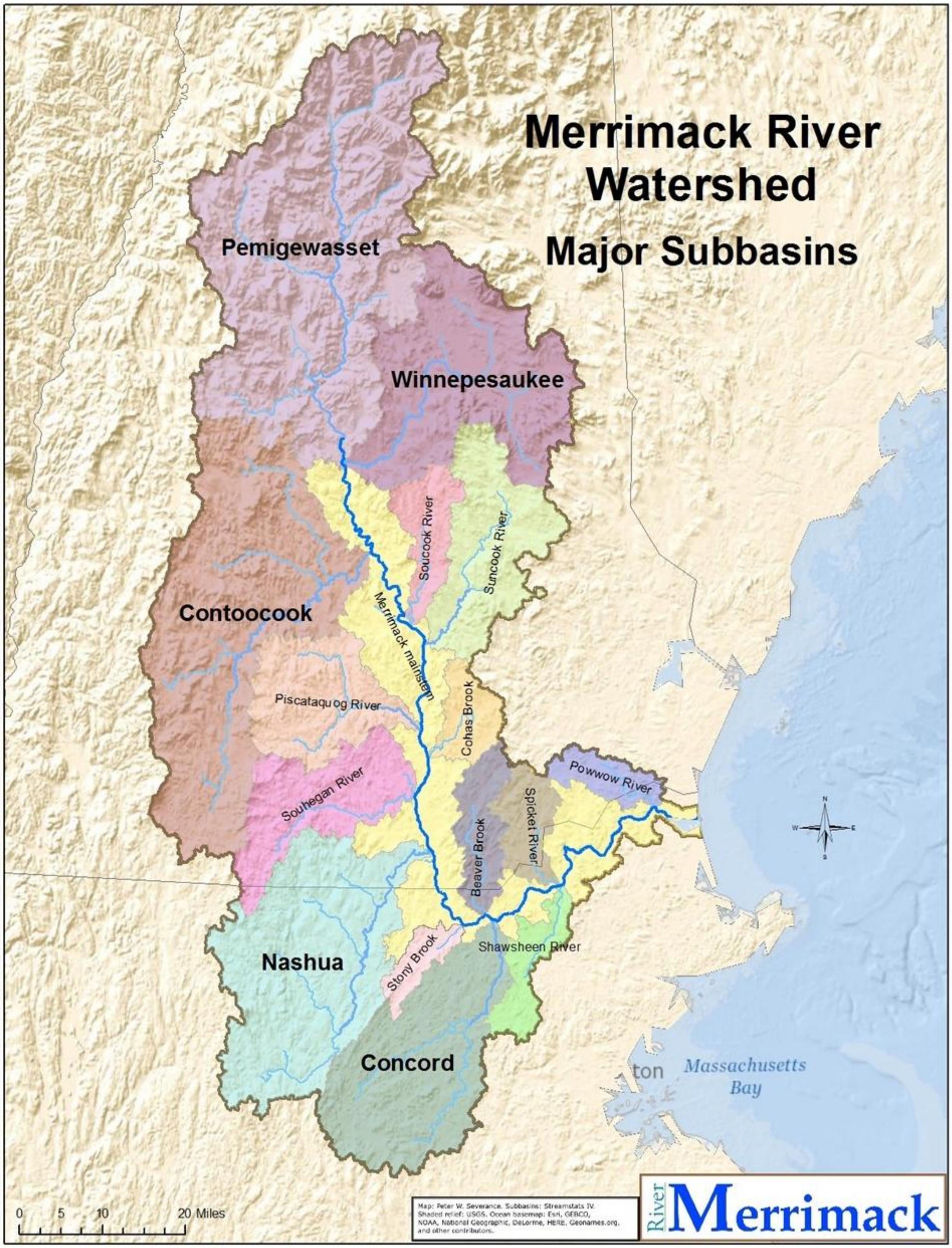
Outside of the Pemigewasset and Winnipesaukee Rivers, four major tributaries contribute to the Merrimack River flow: the Contoocook, Piscataquog, Nashua, and Concord Rivers (USACE 2003, MEOEEA 2001). The Merrimack River watershed and major subbasins are shown in Figure E.2-1. Several other smaller streams flow into the Merrimack River within the Project boundary, including Fish Brook, Griffin Brook, Sawyer Brook, Nickel Mine Brook, Trout Brook, Bartlett Brook, and other unnamed tributaries. The Spicket River flows south to the North Canal outlet and into the Merrimack River approximately 1 mile downstream of the Essex Dam. The Shawsheen River flows into the Merrimack River approximately 1.5 miles downstream of the Essex Dam.

E.2.3 Topography

The terrain of the Merrimack River Basin ranges from the steep, rugged conditions of the northern New Hampshire White Mountain region to the estuarine coastal basin of northeastern Massachusetts. The Merrimack River Basin is located in the New England Province, which is further divided into the White Mountains, the New England Uplands, and the Seaboard Lowlands. The majority of the Merrimack River Basin is located in the New England Uplands, characterized by rolling hills, narrow valleys, and elevations ranging from below 1,000 feet to above 2,000 feet. The Project is located in the Seaboard Lowlands, which is less hilly than the New England Upland area and has a topographical relief limited to less than 200 feet in most places (Flanagan et al. 1999). The local relief at the Project is generally characterized as low, open hills.

The U.S. Environmental Protection Agency (USEPA) has further defined ecoregions that share similarities in ecosystems and in the type, quality, and quantity of environmental resources (Griffith et al. 2009). The Project is located within the Gulf of Maine Coastal Plain ecoregion of the Northeastern Coastal Zone. This region is characterized by rolling plains with hills, where glacial drumlins are common. Some ponds, small lakes, wetlands, low and moderate gradient streams, and large rivers with sand, gravel, boulder, and bedrock substrates exist in this ecoregion. The local relief is mostly between 100 and 600 feet (Griffith et al. 2009).

Figure E.2-1. Merrimack River Watershed and Major Subbasins.



E.2.4 Dams and Diversions within the Basin

There are a total of five hydroelectric developments comprising three separate Projects on the Merrimack River that are licensed by FERC. In New Hampshire, there are four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River Basin; Essex and the other licensees on the Merrimack pay FERC Headwater Benefits annual charges to offset the operational costs of the USACE flood storage facilities. Table E.2-1 presents information on the five hydroelectric developments on the Merrimack River. All the hydroelectric facilities on the Merrimack River operate in ROR mode.

Table E.2-1. FERC-regulated Developments on the Merrimack River.

Facility	FERC Project #	Licensee	River Mile (RM)	Generation Capacity (Megawatts [MW])
Garvins Falls (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	87	12.3
Hooksett (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	81	1.6
Amoskeag (Merrimack River Project)	1893	CRP NH Amoskeag, LLC	73	16
Lowell	2790	Boott Hydropower, LLC	40	15
Lawrence	2800	Essex Company, LLC	29	16.8

E.2.5 Wetland and Vegetative Cover

Wetlands and vegetative cover along the Merrimack River primarily occur in low-lying areas adjacent to the river, with additional wetlands located farther from the river corridor. The wetlands directly surrounding the Lawrence Project are largely considered riverine wetlands with an unconsolidated bottom. Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater) (Cowardin et al. 1979). The majority of the wetlands near or adjacent to the Project area are palustrine wetlands. Palustrine wetlands, often called fens, swamps, marshes, or bogs, are nontidal wetland. These wetlands are dominated by trees, shrubs, and/or persistent plants/mosses. These wetlands may also be composed of shallow, open-water ponds (Cowardin et al. 1979).

Dominant canopy tree species of the region are white pine (*Pinus strobus*), eastern hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), and red maple (*Acer rubrum*). Predominant understory trees within the region include black cherry (*Prunus serotina*), black birch (*Betula nigra*), yellow birch (*Betula alleghaniensis*), and bigtooth aspen (*Populus grandidentata*). Common understory shrubs and shrub-like trees include sassafras (*Sassafras albidum*), witch hazel (*Hamamelis virginiana*), maple-leaf viburnum (*Viburnum acerfolium*), and sheep laurel (*Kalmia angustifolia*). Common herbaceous plants likely to occur in the

Project vicinity include Canada mayflower (*Maianthemum canadense*), eastern skunk cabbage (*Symplocarpus foetidus*), spotted wintergreen (*Chimaphila maculata*), and bunchberry (*Cornus canadensis*).

E.2.6 Climate

The Project is within a climate region typical of north-central New England and inland New Hampshire, as it is characterized by moderately warm summers, cold winters, and adequate precipitation. The climatic conditions of the Basin vary significantly from its headwaters in the White Mountains to its discharge along the Atlantic Ocean (USACE 2003). The Basin is located partially within the Northern and Coastal Climatic divisions, but the majority of the watershed falls within the Central Climatic division. The Central division is generally more moderate than the Northern division due to its lower elevation and latitude; this division experiences some climate modification due to maritime influences (USACE 2003; National Oceanic and Atmospheric Administration [NOAA] 2020a). Precipitation in the watershed is evenly distributed throughout the year, and weather systems throughout the Basin operate primarily from prevailing westerly winds and the confluence of many continental weather patterns in North America. The Basin’s climate is classified as a humid continental climate (Dfa/Dfb) according to the Köppen-Geiger climate classification.

NOAA data from 1897 to 2020 for the Boston, Massachusetts weather station indicates an average temperature of 52.1°F, with an average maximum temperature of 96°F and an average minimum temperature of 2.0°F. The warmest temperatures occur in July, and the coolest temperatures occur in January. NOAA 1897 to 2020 data for Boston, Massachusetts shows an average annual precipitation of 41.45 inches with relatively even monthly averages (NOAA 2020b).

Three predominant storm patterns occur in the Merrimack River Basin: continental, coastal, and local summer thunderstorms. Continental storms are associated with the usual easterly or northeasterly air flows that bring western or central storm disturbances to the Northeast. These continental storms occur in all months of the year. Coastal storms originate in the Gulf or southeast coastal states and bring moist, generally warmer air into the region.

E.2.7 Major Land and Water Uses

E.2.7.1 Major Land Use

The area around the Merrimack River, originally occupied by Native Americans, became populated by European settlers in the 17th century. Beginning in the 1800s, the Merrimack River Basin shifted from predominantly agricultural and forested lands to an industrial setting. During this time, several urban areas formed along the Merrimack River, supported by the emerging water-powered textile mills of the Industrial Revolution (National Park Service [NPS] undated-b). The cities forged by the Industrial Revolution remain as major urban cities today, including Manchester and Nashua in New Hampshire, and Lowell, Lawrence, and Haverhill in Massachusetts (USACE 2003).

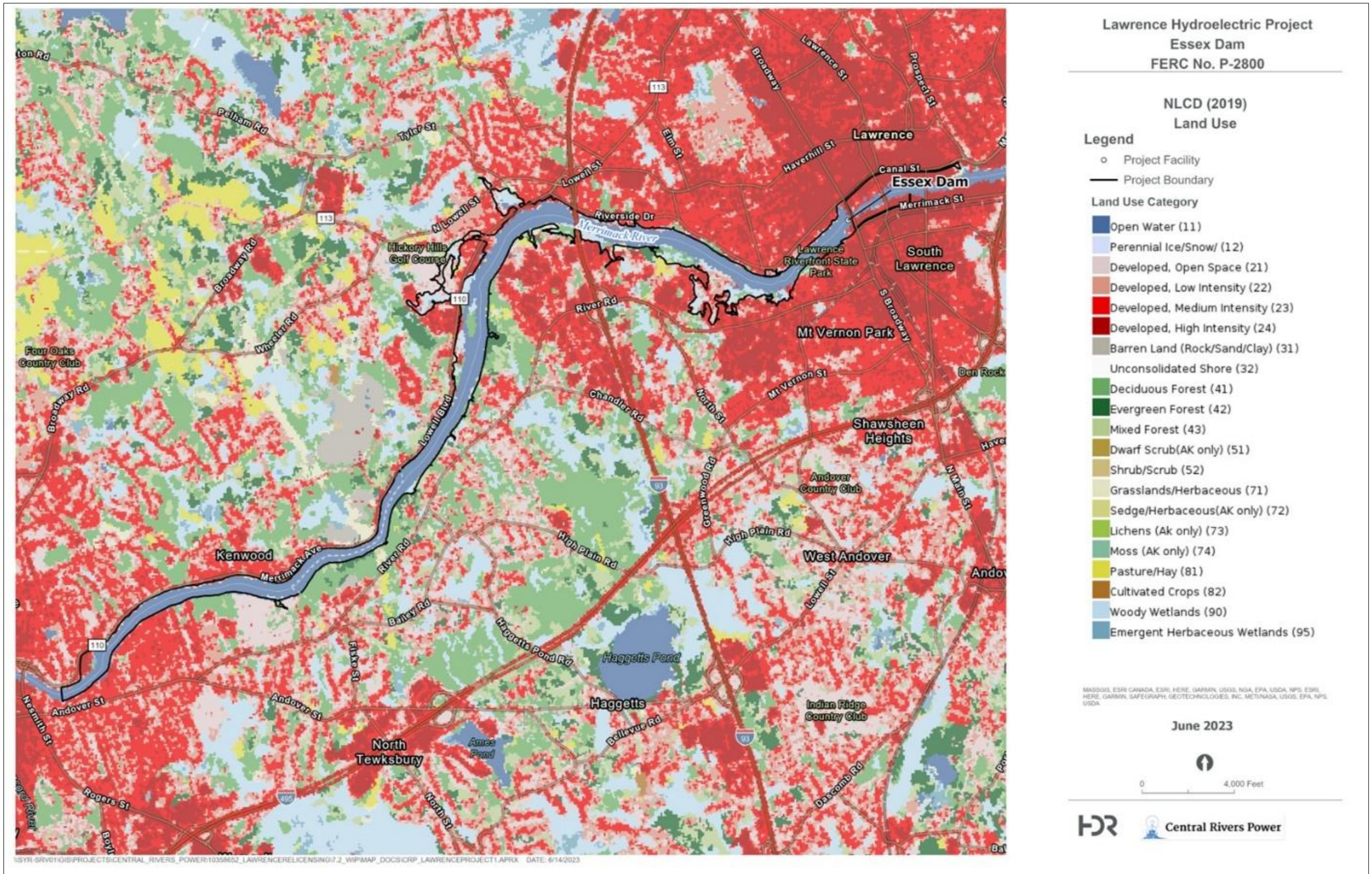
The Merrimack River Basin supports 200 communities and 2.6 million people and is the primary drinking water source for about 500,000 people in Massachusetts and New Hampshire (U.S. Environmental Protection Agency [USEPA] 2022a). There are four municipal water intakes that draw water from the Project impoundment. Land use is also discussed in further detail in Section E.7.4.

Land use within the Project boundary is primarily open water, followed by developed land, woody wetlands, and deciduous forest. Table E.2-2 lists the land uses in the Project boundary. Figure E.2-2 depicts major land use in the vicinity of the Project.

Table E.2-2. Land Use Within the Project Boundary.

Description	Acreage	Percent of total
Open Water	703.9	64.45%
Developed, Open Space	49.2	4.51%
Developed, Low Intensity	66.8	6.12%
Developed, Medium Intensity	60.2	5.52%
Developed, High Intensity	39.1	3.58%
Barren Land	1.9	0.17%
Deciduous Forest	52.6	4.83%
Evergreen Forest	8.0	0.73%
Mixed Forest	6.9	0.63%
Shrub/ Scrub	0.2	0.01%
Grassland/ Herb	5.8	0.53%
Pasture/ Hay	1.4	0.13%
Woody Wetlands	90.7	8.30%
Emergent Herbaceous Wetlands	5.4	0.49%
Total	**1,092.1**	**100.00%**

Figure E.2-2. Land Use in the Vicinity of the Lawrence Project.



E.2.7.2 Major Water Use

The Merrimack River is used for recreation, fishing, and hydropower generation, in addition to supporting numerous public and industrial water users. Many municipalities use the river as a potable water source, including Merrimack, Litchfield, Hollis, Milford, Nashua, Hudson, and Pelham of New Hampshire, and Tyngsborough, Dracut, Methuen, Lawrence, Lowell, Andover, North Reading, and Tewksbury of Massachusetts (USEPA 2020). Recreational use of the river includes paddling, boating, swimming, fishing, rowing, and other activities (Alliance of Climate and Environmental Stewards [ACES] 2022).

E.2.7.3 Economic Activities

The City of Lawrence is currently supported by a mix of industries including: educational services, health care, and social assistance (20%), manufacturing (18%), professional, scientific, management, administrative, and waste management services (12%), and retail trade (11%) (U.S. Census Bureau 2026a). The majority of civilians have occupations in production, transportation, and material moving (30%), followed by service (26%), management, business, science, and arts (22%), sales and office (18%), and natural resources, construction, and maintenance (9%) (U.S. Census Bureau 2026a). The median household income for the City of Lawrence, estimated in 2024, was $62,061, with approximately 16.7% of the population in poverty (U.S. Census Bureau 2026b, 2026c).

The area surrounding the City of Lawrence is currently populated with other large urban centers and small communities. Essex County is supported by a mix of industries including: educational services, health care, and social assistance (26%), professional, scientific, management, administrative, and waste management services (15%), manufacturing (11%), and retail trade (10%) (U.S. Census Bureau 2026a). The majority of civilians have occupations in management, business, science, and arts (46%), followed by sales and office (19%), service (16%), production, transportation, and material moving (11%), and natural resources, construction, and maintenance (7%) (U.S. Census Bureau 2026a). The median household income for Essex County is $103,048, with approximately 9.2% of the population in poverty (U.S. Census Bureau 2026b, 2026c).

E.3. Cumulative Effects (18 CFR § 5.18(b)(2))

According to the Council on Environmental Quality's regulations for implementing NEPA (40 CFR 1508.7), a cumulative effect is defined as the effect on the environment that results from the incremental effect of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time, including hydropower and other land and water development activities.

E.3.1 Resources That Could Be Cumulatively Affected

Based on information in the PAD and preliminary Commission staff analysis, the Commission identified in its SD2 that migratory fish, including American shad, river herring, American eel, sea lamprey, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, and mussel species, as resources that could be cumulatively affected by the proposed continued operation and maintenance of the Lawrence Project in combination with other dams on the Merrimack River.

E.3.2 Geographic Scope

The geographic scope of analysis for cumulatively affected resources is defined by the physical limits or boundaries of (1) the proposed action's effect on the resources, and (2) contributing effects from other dams within the river basin. In the SD2, the Commission identified the geographic scope for the following resources:

- Migratory Fish: geographic scope for migratory fish includes the Merrimack River (and its tributary watersheds) from where it empties into the Gulf of Maine in Newbury, Massachusetts, upstream to Lakeport Dam on the Winnipesaukee River in Franklin, New Hampshire, and the confluence of the Pemigewasset and Squam Rivers in Holderness, New Hampshire. The Eastman Falls Dam (at RM 1 of the Pemigewasset River) and the Lakeport Dam (at RM 17 of the Winnipesaukee River and 4 miles downstream from the outlet of Lake Winnipesaukee) are migration barriers that represent the upstream limits to which river herring and American eel are managed within the river basin.
- Mussels: The geographic scope for mussels includes the entire Merrimack River Basin and its tributary watersheds from the headwaters of the Winnipesaukee River in Franklin, New Hampshire, and the headwaters of the Pemigewasset River at Profile Lake in Franconia, New Hampshire, through the Merrimack River downstream to Haverhill, Massachusetts.
- Atlantic sturgeon: the geographic scope for Atlantic sturgeon critical habitat includes the Merrimack River from the toe of Essex Dam downstream to where the Merrimack River empties into the Gulf of Maine in Newburyport, Massachusetts.

E.3.3 Temporal Scope

The temporal scope of the analysis of cumulative effects for this Project addresses past, present, and reasonably foreseeable future actions and their effects on each resource that may be cumulatively affected. Based on the potential term of the new license, a reasonable temporal scope would be 30-50 years into the future, concentrated on the effects on the resources from reasonably foreseeable future actions. As described in SD2, the quality and quantity of information are diminished as resources that are further away in time from the present are analyzed.

E.4. Compliance with Applicable Laws (18 CFR § 5.18(b)(3))

E.4.1 Section 401 of the Clean Water Act

Under Section 401 of the Clean Water Act (CWA), any federal license or permit to conduct any activity that may result in a discharge into navigable waters requires a certification from the state in which the discharge originates, that such discharge will comply with the applicable provisions of the CWA, unless such certification is waived. Therefore, a state Water Quality Certification (WQC) or waiver is a prerequisite for obtaining a license from FERC. The Massachusetts Department of

Environmental Protection (MADEP) is the state agency designated to carry out the certification requirements as prescribed in Section 401 of the CWA for waters of the Commonwealth of Massachusetts. Pursuant to 18 CFR § 5.23(b), Essex will file an application for a WQC with the MADEP within 60 days of FERC's Notice of Acceptance and Ready for Environmental Analysis. The MADEP must act on the request for a WQC within the one-year time frame allowed under the CWA.

E.4.2 Endangered Species Act

Section 7 of the Endangered Species Act (ESA) (19 U.S.C. § 1536(c)), as amended, requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or result in the destruction or adverse modification of the critical habitat of such species. Under the ESA, the United States Fish and Wildlife Service (USFWS) is responsible for freshwater and terrestrial species, and the National Marine Fisheries Service (NMFS; NOAA Fisheries) is responsible for marine and anadromous species.

In the Notice of the Licensee's Intent to File a License Application, Filing of the PAD, Commencement of the Pre-filing Process, and Scoping Document 1 issued on August 15, 2023, the Commission designated Essex as the Commission's non-federal representative for carrying out informal consultation, pursuant to Section 7 of the ESA. Information from the USFWS and the Massachusetts Division of Fisheries and Wildlife (MDFW) has been used to identify rare, threatened, and/or endangered (RTE) species in the Project area. A discussion of the RTE species relevant to this Project is provided in Section E.7.5 of this Exhibit.

E.4.3 Magnuson-Stevens Fishery Conservation Management Act

The 1996 amendments to the Magnuson-Stevens Act authorized NMFS, in coordination with regional fisheries management councils, to delineate essential fish habitat (EFH) for the protection of habitat of marine, estuarine, and anadromous finfish, mollusks, and crustaceans. EFH includes "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

Based on a review of the NMFS online database, the Lawrence Project reach of the Merrimack River is designated EFH under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (NOAA undated). This EFH was defined as "all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut" (New England Fishery Management Council [NEFMC] 1998).

E.4.4 Coastal Zone Management Act

Section 307(c)(3) of the Coastal Zone Management Act (CZMA) requires that activities conducted or supported by a federal agency that affect the coastal zone be consistent with the enforceable policies of the federally approved state coastal management plan to the maximum extent practicable. Section 307(c)(3) of the CZMA also requires that federally licensed activities that affect a state's coastal zone be consistent with the enforceable policies of the state's federally approved coastal management plan.

The Massachusetts Office of Coastal Zone Management (MACZM) is the lead policy and planning agency on coastal and ocean issues within the MEOEEA. In the preparation of the PAD, Essex initiated consultation with MACZM, but has not received a response. Coastal zone maps and spatial data available through the Massachusetts Ocean Resource Information System indicate that the Project is located outside of the delineated coastal zone.[2] Accordingly, the Project is not expected to affect coastal zone resources or require review under the Coastal Zone Management Program as part of the relicensing process. Essex will provide additional copies of correspondence with MACZM with the FLA, if applicable.

E.4.5 National Historic Preservation Act

Section 106 of the National Historic Preservation Act (NHPA) (Section 106) requires federal agencies to take into account the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on such actions. Historic properties include significant sites, buildings, structures, districts, and individual objects that are listed in, or eligible for listing in, the NRHP. FERC's issuance of a new license for the Project is considered an undertaking subject to the regulations and requirements of Section 106 and its implementing regulations at 36 CFR Part 800. In accordance with 36 CFR § 800.14(b), FERC typically fulfills its responsibilities pursuant to Section 106 by entering into a Programmatic Agreement with the appropriate State and/or Tribal Historic Preservation Officer(s) (SHPO/THPO), and in some cases, the ACHP.

FERC initiated consultation under Section 106 with federally recognized Indian tribes by letter dated December 1, 2022. The letter formally invited the Wampanoag Tribe of Gay Head–Aquinnah, Mashpee Wampanoag Tribe, and the Stockbridge-Munsee Community to participate in the Project's relicensing process. The Project is not located on Native American lands.

By notice dated August 15, 2023, FERC designated Essex as its non-federal representative for purposes of conducting informal consultation pursuant to Section 106. Early in the relicensing process, Essex contacted prospective stakeholders to determine their interest in this relicensing proceeding. As part of this outreach, Essex corresponded with representatives of the Massachusetts SHPO and the federally recognized Indian tribes listed above with a potential interest in the effects of this relicensing on historic properties.

A discussion of historical properties within the Project's Area of Potential Effects (APE) and the consultation under Section 106 conducted to date for the relicensing of the Project is provided in Section E.7.9 of this Exhibit.

E.4.6 Wild and Scenic Rivers and Wilderness Act

There are no river segments designated under the Wild and Scenic Rivers Act within or adjacent to the Project boundary; therefore, this act is not applicable to the relicensing of the Project. No Project facilities are located within any designated wilderness areas.

[2] Google Earth File of Massachusetts Coastal Zone Boundary

E.5. Project Facilities and Operation (18 CFR § 5.18(b)(4))

E.5.1 Project Maps

The existing Lawrence Project boundary is provided in Figure E.1-1. The proposed Project boundary is shown in Exhibit G located in Volume I of this DLA. Essex may further modify the proposed Project boundary and Exhibit G maps in the FLA. The physical composition, dimensions, and generation configuration of the facilities that comprise the Project are described in the following subsections.

E.5.2 Existing Project Configuration

The Lawrence Project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts. The Project is the first dam on the Merrimack River, approximately 29 RM from the Atlantic Ocean, and is located approximately 11 RM downstream of the Lowell Hydroelectric Project (FERC No. 2790).

As currently licensed, the Project works consist of (1) the 35-foot-high by 900-foot-long gravity Essex Dam of stone masonry construction (also known as the Great Stone Dam), with a five-foot-high pneumatic crest gate system mounted on the spillway crest; (2) a 9.8-mile-long impoundment having a surface area of 655 acres at a normal water elevation of 44.2 feet, National Geodetic Vertical Datum of 1929 (NGVD29) at the top of the crest gates, and a gross storage capacity of approximately 19,900 acre-feet; (3) a powerhouse located at the end of a small forebay adjacent to the south abutment of the Essex Dam, containing two 8.4 MW generating units, and a tailrace channel extending into the Merrimack River channel; (4) fish passage facilities integral with the powerhouse, including a fish elevator and downstream fish bypass, and an eel ladder at the right abutment of the dam; (5) the North Canal, approximately 5,300 feet long by 95 feet wide by 15 feet deep, originating at the north abutment of the dam and paralleling the Merrimack River downstream of the Essex Dam; (6) the South Canal, approximately 2,750 feet long by 35 feet wide by 10 feet deep, originating at the south abutment of the Essex Dam and generally paralleling the Merrimack River downstream of the Essex Dam; (7) a single-circuit, underground/underwater 23.0-kilovolt (kV) transmission line; and (8) appurtenant facilities.

Below are details providing the physical description of the Project. A summary of these Project features is provided in Table E.5-1.

Table E.5-1. Lawrence Project Features List.

Description	Number or Fact
Project Total Capacity	16.8 MW
Project River Mile (RM)	29
Impoundment	
Normal Surface Area	732 (as proposed)
Normal Surface Elevation	44.2 feet NGVD29
Useable Storage Capacity	0 acre-feet

Description	Number or Fact
Gross Storage Capacity	19,900 acre-feet at elevation (El.) 44.2
Essex Dam	
Spillway Length	900 feet
Spillway Crest Elevation	39.2 feet NGVD29
Non-overflow Length	0 feet
Intake Forebay	
Intake Forebay	170 feet long
Trashracks	6-inch clear-spacing
Powerhouse	
Construction Type	Concrete
Dimensions	72 feet wide by 128 feet long
Turbines	
Number	2
Type	Horizontal Kaplan bulb units
Rating	8.4 MW (each)
Maximum Hydraulic Capacity	4,000 cubic feet-per-second (cfs) (each)
Minimum Hydraulic Capacity	600 cfs (each)
Gross Head	26.5 feet
Transmission Line	
Transmission Line	Single circuit underwater/underground 23-kV transmission line

E.5.2.1 Essex Dam

The Essex Dam, also known as the Great Stone Dam, is a 900-foot-long gravity structure constructed of stone masonry. The dam is 35 feet in height from the crest elevation of 39.2 feet to the downstream foundation bedrock. The spillway crest is topped by a 5-foot-high Obermeyer pneumatic crest gate system with three independently controllable zones, with a crest elevation of 44.2 feet when fully elevated. Each 300-foot-long zone consists of fifteen 20-foot-long, hinged, steel panel sections supported by a tubular rubber air bladder. Restraining straps attached to each gate panel prevent the panels from being raised above the approved five-foot effective height above the dam crest. The crest gate system is operated by air compressors and associated control system located within an approximately 18 ft by 25 ft masonry building adjacent to the dam's right abutment. Air lines lead from the compressor building to each of the three crest gate zones within a pipe trench embedded in the dam crest upstream of the crest gates.

E.5.2.2 Intake Forebay

River flows are directed to the powerhouse via a short intake forebay located adjacent to the south abutment of the dam. The forebay is approximately 170 feet long by 80 feet wide. The exit channel for the Project's fish lift system is located on the river left side of the forebay.

E.5.2.3 Powerhouse

The Project powerhouse is a 72-foot-wide by 128-foot-long building constructed of concrete and contains the Project's two generating units. The structure is approximately 90 feet high. The intake for the turbines is integral with the powerhouse and includes trashracks with 6-inch clear spacing. The powerhouse contains two horizontal, double-regulated Kaplan bulb turbines. Each turbine is rated at 11,260 horsepower (HP), operating at a speed of 128.6 revolutions per minute (RPM) at a rated head of 26.5 feet. Each unit's bulb contains a horizontal shaft, air-cooled, synchronous generator directly connected to the turbine shaft. Each generator is rated at 8,842 kilovolt-amperes (kVA), 0.95 power factor, 4,160 volts, 3-phase, 60 hertz (Hz), 80 degrees Celsius (ºC) temperature rise (LHA 1983). The generating units are each rated at 8.4 MW with a minimum and maximum hydraulic capacity of approximately 600 cubic feet per second (cfs) and 4,000 cfs, respectively (Essex 2020). The Project has a total installed authorized capacity of 16.8 MW.

E.5.2.4 North Canal

The North Canal originates at the Essex Dam impoundment, upstream of the northern abutment of the Essex Dam. The North Canal is approximately 95 feet wide and 15 feet deep, extending parallel to the Merrimack River for a distance of approximately 5,300 feet (FERC 1978). The North Canal flows are controlled by the North Canal Gatehouse located near the canal entrance opposite the Essex Dam. The North Canal is capable of carrying controlled flows up to 3,000 cfs (LHA 1977). At the terminus of the North Canal is a gated spillway known as the "Lower Locks." Several historical mills are located along the North Canal.

E.5.2.5 South Canal

The South Canal originates at the south abutment of Essex Dam, adjacent to the entrance of the intake canal. The South Canal is approximately 35 feet wide and 10 feet deep, extending parallel to the Merrimack River for a distance of approximately 2,750 feet (FERC 1978). The South Canal flows are controlled by the South Canal Gatehouse located near the canal entrance. Approximately 1,000 feet downstream from Essex Dam along the South Canal are the former Aquamac Project (FERC No. 2927) and the Merrimac Paper Company Project (FERC No. 2928). The South Canal discharges to the Merrimack River via an underground conduit. Several historical mills are located along the South Canal.

E.5.2.6 North Canal and South Canal Gatehouses

The North Canal Gatehouse (also referred to as the Gatehouse at the Great Stone Dam and a contributing resource to the North Canal Historic District), constructed in 1848, is positioned at the head of the North Canal and acts as a water-retaining structure which controls flows into the North Canal. The North Canal gatehouse is 80 feet long, 20 feet wide, and constructed mainly of wood. The gatehouse contains six sluiceways, each 9 feet wide by 12 feet high and separated by 3-foot-thick, cut-stone piers. The leaf gates are of timber construction, consisting of gate panels with braced stems. Combined with their stems, from upstream to downstream, the individual gates panels are 24 feet, 10 inches; 21 feet, 5 inches; 18 feet, 5 inches; and 15 feet, 5 inches in height. In 1961, the hoisting mechanisms were augmented with electric motors joined to the lifting gears with rubber belts. In 2012, metal stoplogs were installed across four of the sluiceways; the center two sluiceways have no stoplogs emplaced.

The South Canal Gatehouse, completed in 1868, is virtually identical in design to the North Canal Gatehouse, but constructed on a smaller scale. Similar to the northern structure, the South Canal Gatehouse is positioned at the head of the South Canal and acts as a water-retaining structure, which controls flows into the South Canal. The South Canal Gatehouse is 16 feet wide by 56.5 feet long, and is constructed primarily of a wooden frame, with 8 by 8 and larger timbers mortised and tenoned with cast iron columns in the substructure. The gatehouse contains four sluiceways constructed of dressed granite with mortared joints, founded on bedrock. Timber leaf gates control water flow into the canal. Each gate panel is 3 feet, 3 inches in height; 9 feet, 9 inches in width; and 9 inches thick. Combined with their stems, from downstream to upstream, the gate panels with their stems are 24 feet, 5 inches; 21 feet, 5 inches; 18 feet, 5 inches; and 15 feet, 5 inches in height, respectively. In 1961, the lifting mechanisms were augmented with electric motors joined to the lifting gears with rubber belts. Between 2010-2012, metal stoplogs were installed across all four of the sluiceways.

Under the new FERC license, Essex is proposing to remove the North and South Canals from the Lawrence Project boundary as they do not serve any Project purpose. It is questionable whether the canals ever served any Project purpose, because they were only used to convey flow to hydroelectric facilities operated under separate licenses held by others[3], but never conveyed flow to any hydroelectric unit authorized under the Lawrence Project's license. As a result, Essex is proposing to remove the North and South canals from the Lawrence Project boundary under the new FERC license. This proposed action will not change the Project's installed capacity, overall mode of operation, or any of the Project's environmental resource values. The gatehouses associated with each canal will remain in the license as water retaining structures, and because the North Canal Gatehouse and associated Gatekeeper's House and Carriage House are included in the Project's current Recreation Plan.

E.5.2.7 Tailrace

Flows from the Project's powerhouse discharge to the Merrimack River via an approximately 130-foot-long by 100-foot-wide tailrace channel. The tailrace channel is bordered on the river side by bedrock and the concrete remains of a former fish ladder, and on the land side by bedrock and undeveloped lands leading to the south abutment of the Route 28 (Broadway) bridge.

E.5.2.8 Fish Passage Structures

Upstream passage is provided by the fish lift hopper system, with two entrances located at the downstream (northwest) side of the powerhouse. The fish lift system has a designed total

[3] The North Canal was historically used to convey water for power generation at several mills located between the canal and the Merrimack River, including the non-Project North Canal Waterworks Project (FERC No. P-5906) until that license was surrendered by order dated September 19, 1995. The South Canal was also historically used to convey water for power generation at several former mills, including at the former non-Project Aquamac Project (FERC No. P-2927) and Merrimac Project (FERC No. P-2928). The Commission terminated both of these licenses by order dated July 26, 2012.

operational flow (both entrances) of 200 cfs, with 50 cfs supplied through a pipe into the lower fishway, and the remaining 150 cfs supplied through floor diffusers in the lower fishway attraction channel. The collection gallery has two entrances located in the tailrace. The “river side” entrance, located on the northwest side of the powerhouse, or river-left of the tailrace, is the fishway’s primary entrance. The ”street side” entrance, located on river-right in the tailrace, was closed following an evaluation of internal efficiency in 1996 and recommissioned in 2023 at the request of the Merrimack River Technical Committee (MRTC).[4] With the river side entrance (primary) open, the attraction flow is approximately 120 cfs or more, which attracts fish into the crowding channel. A pair of pneumatically operated “V” gates closes to trap the fish and then moves upstream to crowd them into the lift bay, which lifts the fish into the upstream exit channel. Per the terms of the CFPP (at Section I.A.3. “Fishery Statistics”), monitoring of fish passage and maintaining passage counts has been performed by the fishery agencies, primarily MDMF. In recent years Essex has assumed responsibility for maintaining fish counts, consisting of visual estimates of fish in each lift supplemented by video recording at the exit flume counting window (Essex 2019a). The fish lift is typically operated from late April through mid-July. The final operation schedule is determined in consultation with resource agencies throughout each season. Upstream fish passage lifts generally occur hourly between 8:00 a.m. to 4:00 p.m. daily during operational periods and maintain operations at river flows between 500 cfs and 25,000 cfs (LHA 1999). In early 2022, a trapping facility was installed within the upper lift fishway to facilitate the trapping, sorting, and trucking of migratory species to upper portions of the Merrimack River watershed by the MRTC. Through routine consultation and evaluation of the fishway, periodic modification(s) to the original fishway design have been implemented in consultation with the MRTC.

The downstream fish bypass facility consists of a concrete bypass chute that is typically operated annually from April 1 through July 15 and from September 1 through November 15, on a 24-hour basis; the final schedule is determined in consultation with the MRTC. The mechanically driven bypass gate creates surface spill from the forebay, providing 2% of turbine flow up to a maximum of 160 cfs.

The upstream eel passage system consists of an eel ramp located adjacent to the powerhouse at the toe of Essex Dam, and an eel elevator located at the left (north) abutment of the dam. The ramp consists of a concrete ramp and a 120-gallon, flow-through, plastic collection box. The ramp includes four switch-backed, concrete ramp sections of various lengths that total approximately 40 feet and have a slope that does not exceed 40 degrees. Ramp sections are fitted with 18-inch, Milieu plastic elver substrate (1-inch stud spacing) on all ramp surfaces. The ramp is supplied with water by a 300-gallon-per-minute, submersible pump located in the headpond. A distribution valve system allows flow balancing between the tank and ramp attraction water. An enclosed attraction flow pipe is available if high flows damage the ramp or regular flow pipe. The eel elevator is installed at the left (north) abutment of Essex Dam, which supplements the eel ramp. The eel elevator consists of a collection/transport hopper connected to an integral ramp at the dam toe. Eel ramp and elevator

[4] The MRTC oversees and guides the diadromous fishery restoration efforts throughout the Merrimack River basin. It consists of representatives from the USFWS; the NMFS; the New Hampshire Fish and Game Department (NHFG); the Massachusetts Division of Marine Fisheries (MADMF); and the Massachusetts Division of Fisheries and Wildlife (MDFW).

operations occur annually between May 1 and September 30; the final schedule is determined each year in consultation with the MRTC.

E.5.3 Impoundment Characteristics

The Project operates in ROR mode and has no usable storage capacity. The 9.8-mile-long impoundment is bordered by urban development and forested shoreline. The impoundment has a surface area of 732 acres (as proposed) and a gross storage capacity of approximately 19,900 acre-feet at the impoundment's normal elevation of 44.2 feet NGVD29. See Exhibit G in Volume I of this DLA for a description of Essex's proposed Project impoundment.

E.5.4 Generating Equipment

The powerhouse contains two horizontal, double-regulated Kaplan bulb turbines. Each turbine is rated at 11,260 horsepower (HP), operating at a speed of 128.6 RPM at a rated head of 26.5 feet. Each unit's bulb contains a horizontal shaft, air-cooled, synchronous generator directly connected to the turbine shaft. Each generator is rated at 8,842 kVA, 0.95 power factor, 4,160 volts, 3-phase, 60 Hz, 80 ºC temperature rise (LHA 1983). The generating units are each rated at 8.4 MW with a minimum and maximum hydraulic capacity of approximately 600 cfs and 4,000 cfs, respectively (Essex 2020). The Project has a total installed, authorized capacity of 16.8 MW.

E.5.5 Estimated Dependable Capacity and Average Annual Energy Production

E.5.5.1 Estimated Dependable Capacity

Dependable capacity is generally defined as the amount of load a hydroelectric plant can carry under adverse hydrologic conditions during a period of peak demand; for example, during the hot, dry conditions typical of August in the Project area. The estimated dependable capacity is also determined by any minimum flow or fish passage flow requirements included in the existing license. Under the Project's current license, the dependable capacity is estimated to be 4.2 MW during peak summer season, corresponding to the August median flow of approximately 2,100 cfs at the Project.

E.5.5.2 Average Annual Energy Production

The average annual energy generation of the Lawrence Hydroelectric Project for the period of 2012 to 2025 was 72,736 megawatt-hours (MWh). The Project operates in ROR mode and, therefore, experiences seasonal and annual variations in generation based on natural hydrologic conditions in the Merrimack River watershed. Table E.5-2 provides a summary of monthly Project generation for a 14-year period from 2012 through 2025 in MWh.

Table E.5-2. Lawrence Annual and Average Monthly Generation 2012-2025 (MWh).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Totals
2012	9,331	7,934	9,706	6,278	9,101	7,848	2,578	3,614	2,750	5,357	6,638	6,998	78,133
2013	7,733	7,070	9,230	8,237	7,070	7,661	8,006	5,141	4,291	3,226	4,133	6,048	77,846
2014	6,324	5,557	8,322	5,871	7,752	5,486	6,019	3,960	2,419	4,863	6,357	7,011	69,941
2015	7,546	5,823	7,185	7,733	5,695	5,976	4,630	2,404	1,897	4,162	4,867	6,797	64,715
2016	7,891	7,718	9,134	8,716	6,932	3,340	1,814	1,181	436	1,854	3,586	6,163	58,765
2017	8,438	6,107	8,012	7,330	8,726	7,918	6,616	2,871	3,061	2,174	7,488	7,328	76,069
2018	7,961	6,065	9,560	6,736	9,896	3,986	2,546	3,440	3,015	4,196	6,920	9,324	73,645
2019	9,303	7,313	8,489	8,028	7,666	7,301	5,620	2,740	2,290	3,650	4,168	5,726	72,294
2020	6,933	7,640	7,769	7,093	7,566	2,761	3,306	1,152	736	2,676	3,756	4,770	56,158
2021	8,388	6,037	8,228	8,959	7,313	4,099	8,235	7,931	6,544	4,713	7,995	9,638	88,080
2022	8,477	7,529	8,209	9,393	8,354	4,376	1,719	1,142	1,941	2,940	3,230	8,525	65,835
2023	9,087	8,058	9,808	9,007	8,068	6,151	8,566	4,676	7,876	7,807	7,732	7,375	94,210
2024	7,466	8,881	7,543	8,028	9,154	4,979	1,943	3,889	1,786	2,109	2,929	6,422	65,128
2025	5,450	3,637	8,373	8,730	8,338	7,994	3,033	1,575	1,311	2,163	4,171	4,094	58,869
Average	**7,334**	**6,859**	**8,575**	**8,588**	**8,520**	**6,375**	**4,514**	**3,380**	**3,658**	**4,026**	**4,944**	**5,964**	**72,736**

E.5.6 Current and Proposed Project Operations

The Lawrence Project operates in ROR mode using automatic pond level control of the generating units. The crest gate control system works in concert with the powerhouse pond level control system to maintain the impoundment water level (Essex 2020). Essex is proposing to continue to operate the Project in the same ROR manner as it is currently operated.

In accordance with the existing license Article 32, Essex is required to maintain a continuous downstream minimum flow of 951 cfs, unless the reservoir surface elevation is reduced below the crest of the dam; thereupon, the minimum flow equals inflow to the reservoir (FERC 1978). By operating the Project in ROR mode, the Licensee always meets and exceeds the requirements of Article 32 by maintaining outflow equal to inflow and by maintaining the impoundment level at or above the top of the crest gates. Essex is proposing to continue to operate the Project in ROR mode, consistent with current operations.

E.5.6.1 Pneumatic Crest Gate Operations

The crest gate control system works in concert with the powerhouse pond level control system to maintain the impoundment water level (Essex 2020). Under normal operations, the Project’s turbines are operated in automatic pond level control mode, with the control setpoint established at the top of the crest gates (± 44.2 feet). When river flows are within the hydraulic capacity of the turbines (between 600 and 8,000 cfs), the pond level control system adjusts the turbines' output to maintain the impoundment level at the control setpoint, thereby matching inflow and maintaining ROR operation. Separately, the crest gate system also has an automatic pond level control system that regulates the elevation of each of the system's three zones to control the upstream impoundment water level. If inflow increases and the turbines are operating at their maximum available capacity, the water level at the dam will begin to rise above the normal pond level. The crest gate control system will sense the initial rise in the pond level and respond by incrementally lowering the crest gate panels to maintain the normal pond level. If inflow then begins to decrease, the crest gate control system will sense the resulting drop in water level and will start to raise the crest gate panels. Thus, these two control systems work together to minimize impoundment level fluctuations so that inflows into the Project's impoundment approximate outflows. The Project's crest gate system operational scheme contained within the Crest Gate System Operation Plan (LHA 2008) is summarized below in Table E.5-3.

Table E.5-3. Pneumatic Crest Gate System Operational Scheme.

Approximate River Flow (cfs)	Crest Gate Status	Target Pond Level (ft NGVD)	Unit Operation
0 – 8,000	Full elevation	44.2 (Normal pond)	Pond level control
8,001 – 52,000	Crest gate lowers as flow over the spillway increases, maintaining water level at normal pond	± 44.2 ft	Full available output
>52,000	Fully lowered	Rises above 44.2 feet as flows over spillway increase	Full available output

E.5.6.2 Operations During High Flow and Adverse Flow Conditions

During periods when inflow exceeds the maximum hydraulic capacity of the Project's main turbines (8,000 cfs combined), the Project normally operates at maximum capacity, and any excess flows are discharged over the spillway. Under extreme flood conditions, the crest gate system is fully lowered using manual or automatic control to pass river flows in excess of the turbines' available capacity and is adjusted up to restore normal pond height after any high-flow or flood event has receded.

E.5.6.3 Operations During Low Flow Conditions

Under low inflow conditions, Project operations are adjusted to ensure that fish passage flow requirements are maintained. The Project's turbines can only be operated when there is sufficient inflow to operate one of the turbines at its minimum hydraulic capacity of approximately 600 cfs.

E.5.6.4 Fish Passage Operations

The MRTC oversees the management of the Lawrence Project for the restoration of diadromous fish to the Merrimack River as directed by the Project's Comprehensive Fish Passage Plan (CFPP), which was filed pursuant to Article 31 of the Project's existing license and approved by FERC in July 2000. Since that time, Essex and the MRTC have developed and maintained the Fishways Operation and Maintenance Plan (FOMP) to support implementation of the Project's CFPP and optimize fishway operations for target species. The FOMP serves as a living, adaptive management document that has been periodically updated and shared through the parties' ongoing cooperative efforts. The CFPP and subsequent FOMP includes details of operational measures undertaken by Essex to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project consist of a fish lift, downstream fish bypass, an upstream eel ladder, and an upstream eel elevator. The Project's fish lift and downstream fish bypass were originally designed in consultation with the USFWS. Current fish passage operations of the structures are guided by both state and federal fishery agencies (i.e., the MRTC) per the CFPP and FOMP. Essex provides annual post-season updates to the MRTC. The Project's upstream eel ladder and elevator were designed in consultation with the MRTC and are subject to the same guidance and annual reporting.

In accordance with the FOMP, the fish lift is typically operated annually from late April through mid-July, however the start of the season varies slightly and is also based on downstream fish movement activity and thus, the seasonal operation schedule is determined in consultation with the MRTC. Operation of the upstream fish passage lift generally occurs hourly between 8:00 a.m. and 4:00 p.m. daily during operational periods and during river flows of 500 cfs to 25,000 cfs (LHA 1999). The downstream fish bypass facility is a concrete bypass chute that is typically operated annually from April 1 through July 15 and from September 1 through November 15, on a 24-hour basis. Upstream eel passage operations occur annually between May 1 and September 30 (Essex 2014). Upstream passage is provided by a combination of the Project's upstream eel ladder, which is located adjacent to the powerhouse at the toe of Essex Dam, and the Project's eel elevator (or "eel lift"), which is located at the left (north) abutment of Essex Dam. The elevator consists of a collection/transport hopper connected to an integral ramp at the toe of Essex Dam.

Essex collects information regarding the abundance of diadromous fishes using the fishways annually. This activity is a monitoring effort to inform the Technical Committee that manages these fishery resources. Essex staff records diadromous fish counts at the fish lift throughout the upstream migration season and provides a summary of these counts as part of its annual fishway operations report to the MRTC.

E.6. Proposed Action and Action Alternatives (18 CFR § 5.18(b)(5))

E.6.1 Summary of Existing Measures

Essex currently implements the following PM&E measures for the protection of aquatic, water quality, geologic/soil, recreation, and cultural resources pursuant to the existing license for the Project.

- **Article 17 (Ordered December 4, 1978):** requires the licensee to construct, maintain, and operate or arrange for recreational facilities.

- **Article 29 (Ordered December 4, 1978, Approved May 16, 1979)**: requires the licensee to cooperate with the Massachusetts SHPO in order to avoid any adverse impact on identified historic structures at the project.
- **Article 30 (Ordered December 4, 1978; Approved October 26, 1992**): requires the Licensee to file a revised Exhibit S to include functional design drawings of the fish lift and passage facilities at the Project.
- **Article 31 (Ordered December 4, 1978; Approved July 20, 2000, June 28, 2001, June 29, 2001)**: requires the Licensee to conduct an operational study to determine the effectiveness of the fish passage facilities in assisting the migration of anadromous fish.
- **Article 32 (Ordered December 4, 1978)**: requires the Licensee to maintain a continuous minimum flow of 951 cfs unless and until the reservoir water surface elevation is reduced below the crest of the dam; thereupon, the minimum flow shall equal the inflow to the reservoir.
- **Article 33 (Ordered December 4, 1978):** requires the Licensee to monitor or arrange for the monitoring of the fish lift and passage facilities to determine the presence of threatened or endangered fish species and, if any are found, implement measures to protect and conserve any such species.

Essex also adheres to the following plans, described further within this DLA:

Crest Gate System Operation Plan: Under normal operations the Project's turbines are operated in automatic pond level control mode, with the control setpoint established at the top of the crest gates (± 44.2 feet). When river flows are within the hydraulic capacity of the turbines (8,000 cfs or less), the pond level control system adjusts the turbines' output to maintain the impoundment level at the control setpoint, thereby matching inflow and maintaining ROR operation. As inflow rises above the available capacity of the Project's turbines, the crest gate control system automatically lowers the gates to maintain the impoundment level until they are fully lowered at a flow of approximately 52,000 cfs.

Comprehensive Fish Passage Plan (CFPP): Filed pursuant to Article 31 of the Project's existing license and approved by FERC in July 2000. The CFPP includes details of operational measures undertaken by Essex to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project include a fish lift, downstream fish bypass, eel ladder and eel lift.

Recreation Plan: A Recreation Plan was filed with FERC on June 30, 1977, and supplemented on November 15, 1977, and January 27, 1978, which was subsequently approved in the license order issued December 4, 1978. Under the Recreation Plan, Essex provides a handicap-accessible parking area, tours, and interpretive displays at the North Canal Carriage House.

E.6.2 Summary of Proposed Measures

The Project is operated in ROR mode with no useable storage capacity. The comprehensive studies, consultation, and evaluation of the Project during the initial licensing of the Project resulted in the development and implementation of multiple comprehensive PM&E measures; therefore, Essex is proposing PM&E measures consistent with the measures required by the Project's existing license.

Essex is proposing a continuation of ROR operations, and to continue implementing and adhering to the Crest Gate Operation Plan, the CFPP, and the Recreation Plan.

Under the new FERC license, Essex is proposing to remove the North and South Canals from the Lawrence Project boundary as they do not serve any Project purpose. It is questionable whether the canals ever served any Project purpose, because they were only used to convey flow to hydroelectric facilities operated under separate licenses held by others, but never conveyed flow to any hydroelectric unit authorized under the Lawrence Project's license. As a result, Essex is proposing to remove the North and South canals from the Lawrence Project boundary under the new FERC license. This proposed action will not change the Project's installed capacity, overall mode of operation, or any of the Project's environmental resource values. The gatehouses associated with each canal will remain in the license as water retaining structures, and because the North Canal Gatehouse and associated Gatekeeper's House and Carriage House are included in the Project's current Recreation Plan.

In its PSP filed on November 28, 2023, Essex proposed to develop a narrow-spaced trashrack design to replace the existing trashrack system, in lieu of performing most of the requested studies related to downstream passage impacts. Essex may consider alternative methods for providing downstream passage and protection at the intake for outmigrating fish, such as replacing the existing turbine runners with new "fish friendly" designed runners. Any proposed downstream passage and protection measures will be developed in consultation with the MRTC.

In addition, the continued operation of the Project may require maintenance of buildings and structures or ground-disturbing activities, which have the potential to affect historic properties. As such, Essex proposes to develop an updated Historic Properties Management Plan (HPMP) for the Project. The HPMP will be developed in accordance with the *Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects* promulgated by FERC and the ACHP on May 20, 2002.

However, Essex notes that studies required by the Commission are ongoing, and subsequent to completion of the study activities, Essex anticipates additional consultation with stakeholders regarding the potential PM&E measures to be proposed by Essex in the Final License Application to be filed with the Commission by November 30, 2026.

E.7. Environmental Analysis by Resource Area (18 CFR § 5.18(b))

Pursuant to 18 CFR § 5.18(b), this section discusses the existing Project-related resources in more detail and analyzes the effects of the proposed action on these Project area resources. This section incorporates by reference all relevant prior relicensing materials, including the resource study reports. The most important and relevant information from the reports and prior documentation is summarized herein as part of the analysis of the effects.

This section is divided into the following major resource areas:

- Geology and Soil Resources
- Water Quantity and Quality

- Fish and Aquatic Resources
- Terrestrial Resources
- RTE Species
- Recreation and Land Use
- Aesthetics
- Socioeconomic Resources, and
- Cultural Resources

Each of the above resource areas is further divided into the following major subsections:

- **Affected Environment** - This subsection presents information on the affected environment using the information filed in the Licensee’s PAD, information developed through the Licensee’s FERC-approved study plans, and other information otherwise developed or obtained by the Licensee.

- **Environmental Analysis** - This subsection describes the beneficial and potential adverse effects of continued operation of the Project as proposed. Where appropriate, this subsection addresses both site-specific and reasonably foreseeable Project effects. The environmental analysis for each resource area is based on information presented in the PAD, the results of studies conducted in support of the license application, professional expertise, and other information obtained by the Licensee. This subsection also describes the Licensee’s proposed environmental measures designed to address potential Project effects, and how the Licensee’s proposed measures would protect or enhance the existing environment. The measures are listed above and described in greater detail in these subsections, as appropriate.

- **Proposed Environmental Measures** - This subsection describes any proposed new environmental measures, including, but not limited to, changes in the project design or operations, to address the environmental effects identified above and the basis for proposing the measures.

- **Unavoidable Adverse Effects** - This subsection describes any adverse impacts that would occur despite the Licensee’s proposed environmental measures.

E.7.1 Geology and Soil Resources

The subsections below describe geology and soil resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on geological and soil resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee’s PAD and other existing information. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.1.1 Affected Environment

E.7.1.1.1 Physiography and Topography

The terrain of the Merrimack River Basin ranges from the steep, rugged conditions of the northern New Hampshire White Mountain region to the estuarine coastal basin of northeastern Massachusetts. The Merrimack River Basin is located in the New England Province, which is further divided into the White Mountains, the New England Uplands, and the Seaboard Lowlands sections. The majority of the Merrimack River Basin is located in the New England Uplands, characterized by rolling hills, narrow valleys, and elevations ranging from below 1,000 feet to above 2,000 feet. The Project is located in the Seaboard Lowlands, which is less hilly than the New England Upland area and has topographical relief limited to less than 200 feet in most places (Flanagan et al. 1999). The local relief at the Project is generally characterized as low, open hills.

The USEPA has further defined ecoregions that share similarities in ecosystems and in the type, quality, and quantity of environmental resources (Griffith et al. 2009). The Project is located within the Gulf of Maine Coastal Plain ecoregion of the Northeastern Coastal Zone. This region is characterized by rolling plains and hills, where glacial drumlins are common. Some ponds, small lakes, wetlands, low- and moderate-gradient streams, and large rivers with sand, gravel, boulder, and bedrock substrates exist in this ecoregion. As shown in Figure E.7-1, the local relief is mostly between 100 and 600 feet (Griffith et al. 2009).

E.7.1.1.2 Bedrock Geology

The Project is located within the New Hampshire-Maine Sequence and Avalon Belt Geologic Province. The New Hampshire-Maine Sequence covers eastern Connecticut, central Massachusetts, eastern New Hampshire, and central Maine and is principally Siluro-Devonian metasedimentary rocks and Siluro-Devonian and younger igneous rocks (principally granite). The Avalon Belt is localized in eastern Massachusetts, Rhode Island, and coastal Connecticut and is principally Precambrian granite and granitic gneiss and metasedimentary rocks of the Precambrian to Ordovician age. The Avalon Belt is intruded by Ordovician to Devonian granites (Robinson and Kapo 2003). The bedrock geology in the Gulf of Maine Coastal Plain ecoregion is generally described as Devonian, Silurian, and Ordovician granite; Devonian and Silurian metapelite, metasandstone, granofels, and quartzites; Precambrian gneiss, schist, and amphibolite; and some Permian biotite granite (Griffith et al. 2009).

The bedrock in the vicinity of the Project is composed of metamorphic gneiss and igneous granite. The Project is founded on the Merrimack Belt, which extends across the northern border of Massachusetts and New Hampshire. The Merrimack Belt in the vicinity of the Project is composed primarily of calc-granofels of the Silurian Berwick Formation and Paleozoic intrusive mafic rocks of Ayer Granite. Immediately south of the City of Lawrence is the Nashoba Zone, which is separated from the Merrimack Belt by the Clinton-Newbury fault system. The formation of stratified rock within the area of the Nashoba Zone that borders the Project boundary is Silurian and Ordovician Andover Granite intrusive rock (Hatch 1991).

E.7.1.1.3 Surficial Geology

Surficial materials in the general vicinity of the Project are glaciofluvial ice-contact sediments, which are mostly sand and gravel with lesser silt that form a continuous cover on underlying rocks less than 100 feet in thickness. In addition to glaciofluvial ice-contact sediments, there are glacial till sediments, predominantly sandy till less than 100 feet in thickness, and alluvial deposits (Soller et al. 2009). The surface geology in the Merrimack Valley is characterized as Quaternary sandy till, ice-contact sand and gravel, and lake sand and pebbles (Griffith et al. 2009). In the Project area beneath the floodplain of the Merrimack River are floodplain alluvium deposits, which are characterized as sand, gravel, silt, and some organic material that is stratified and well sorted to poorly sorted. The floodplain alluvium deposits overlie thick glacial stratified deposits. Deposits adjacent to the Project boundary are primarily coarse deposits and thin till, with a lesser extent of thick till, swamp deposits, and artificial till. Coarse deposits are characterized as gravel, sand and gravel, and sand. Thin till is characterized as less than 10 to 15 feet of non-sorted, non-stratified matrix of sand, some silt, and little clay containing scattered pebbles, cobbles, and boulder clasts. Large boulders are common. The deposits are loose to moderately compact, generally sandy, commonly stony (Stone et al. 2019).

E.7.1.1.4 Mineral Resources

There are no mapped oil, gas, or mineral resources within the Project boundary (USGS undated). Permitted/reclaimed mines for stone, sand, and gravel exist in the vicinity of the Project, including the Brox Quarry (stone), Dracut Pit and Mill (sand and gravel, construction), and Rocco Zambino and Sons, Inc. Pit (sand and gravel, construction). Several mine features are located adjacent to the impoundment near the Nickel Mine Conservation Land and Brox Industries.

E.7.1.1.5 Soils

Soil types within the Project boundary are variable and reflect the diversity of parent materials, local topography, and physiographic position of landforms. The Project boundary soils primarily consist of sandy loams, loamy sands, and silt loams, including Belgrade very fine sandy loam, Saco variant silt loam, Udorthents, Winooski very fine sandy loam, Unadilla very fine sandy loam, Deerfield loamy fine sand, and Windsor loamy sand. Some human-altered map units include urban land. Mapped soils in the existing Project boundary are presented below in Figure E.7-2, Figure E.7-3, and Figure E.7-4.

E.7.1.1.6 Shoreline and Stream Banks

The shoreline around the impoundment is relatively low and flat with some small hills (less than 200 feet), composed primarily of forest, developed land, and woody wetlands as described in Section E.2.2. Residential properties commonly occur along the length of the impoundment, particularly near the cities of Lawrence and Lowell. In the immediate vicinity of the Project, the shoreline is low and flat and largely characterized by urban development.

E.7.1.1.7 Seismicity

Based on data provided from the USGS/National Earthquake Information Center, there have been four reported earthquakes in the general area of the Project (within 25 miles) exceeding magnitude 3.0 on the Richter scale since reporting began in 1900 (Table E.7-1) (USGS 2023b).

Table E.7-1. Earthquakes Within 25 miles of the Project (>3.0 magnitude) since 1900.

Distance from Project (miles)	Magnitude	Date	Latitude	Longitude
22	3.0	10/15/1985	42.493°N	71.502°W
21	3.0	1/27/2000	43.000°N	71.180°W
14	3.1	1/10/1999	42.840°N	70.980°W
13	3.0	1/10/1999	42.840°N	70.995°W

Source: USGS 2023b.

Figure E.7-1. Topography in the Vicinity of the Lawrence Project.

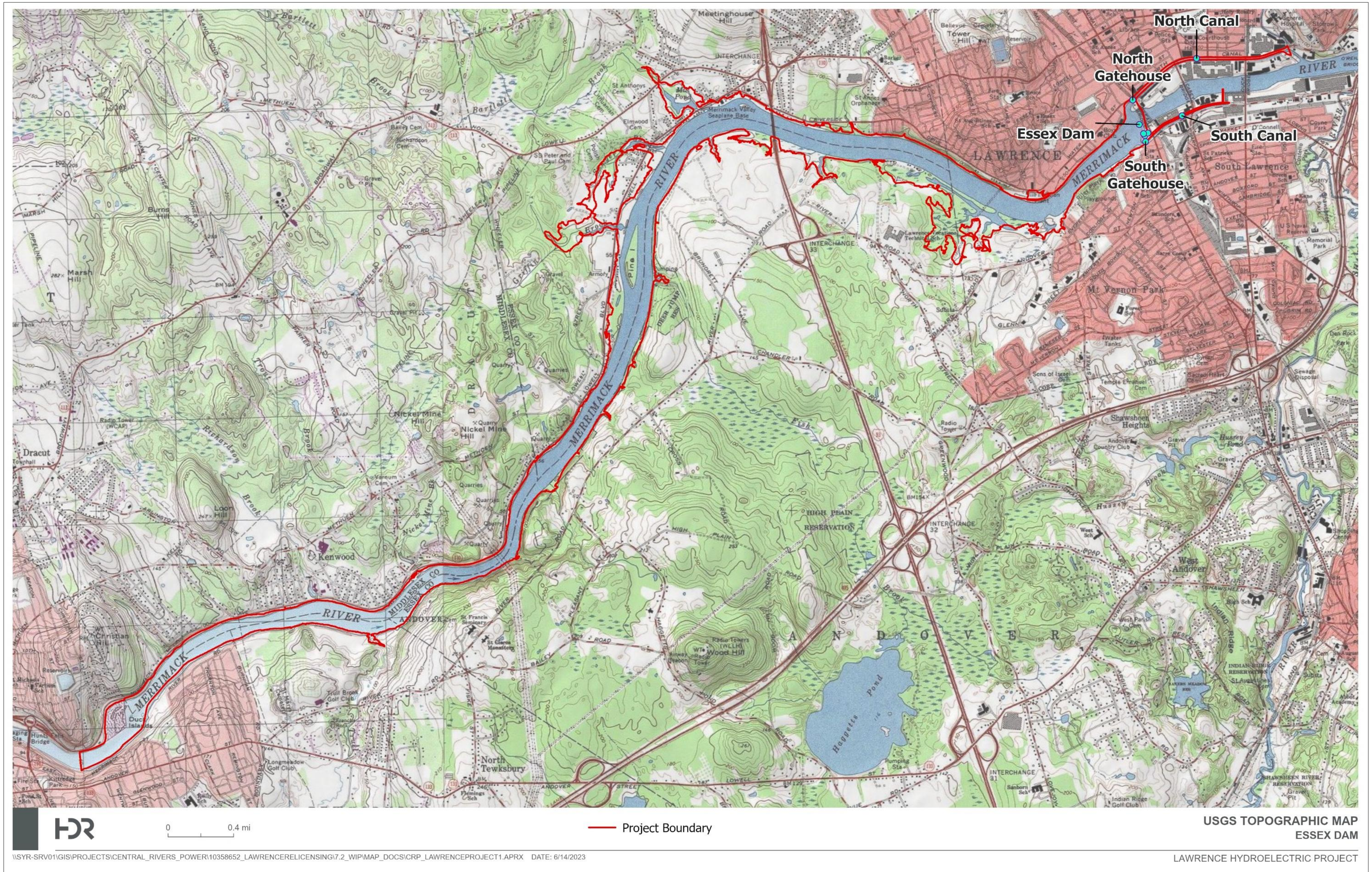


Figure E.7-2. Mapped Soils in the Lawrence Project Boundary.

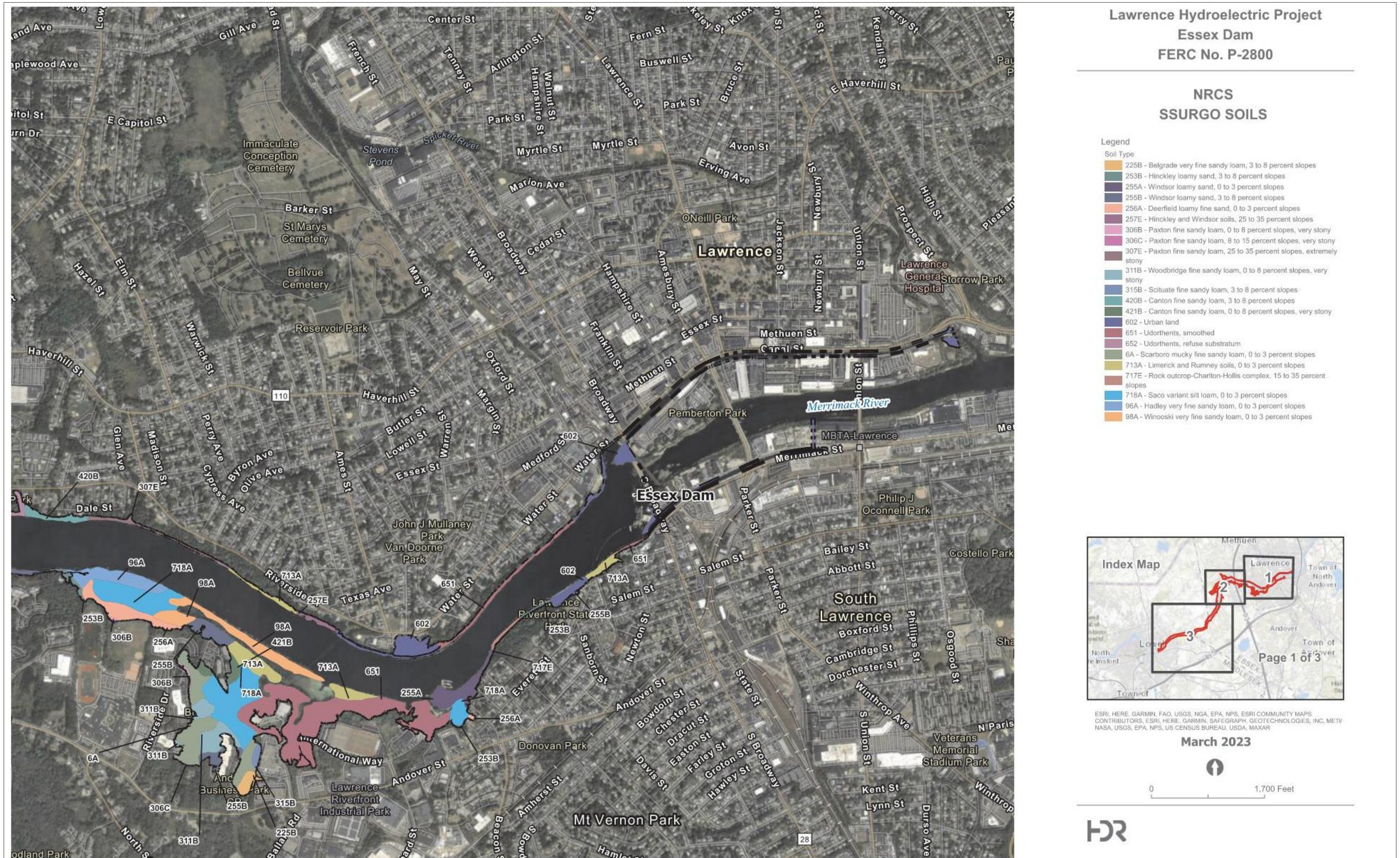


Figure E.7-3. Mapped Soils in the Lawrence Project Boundary.

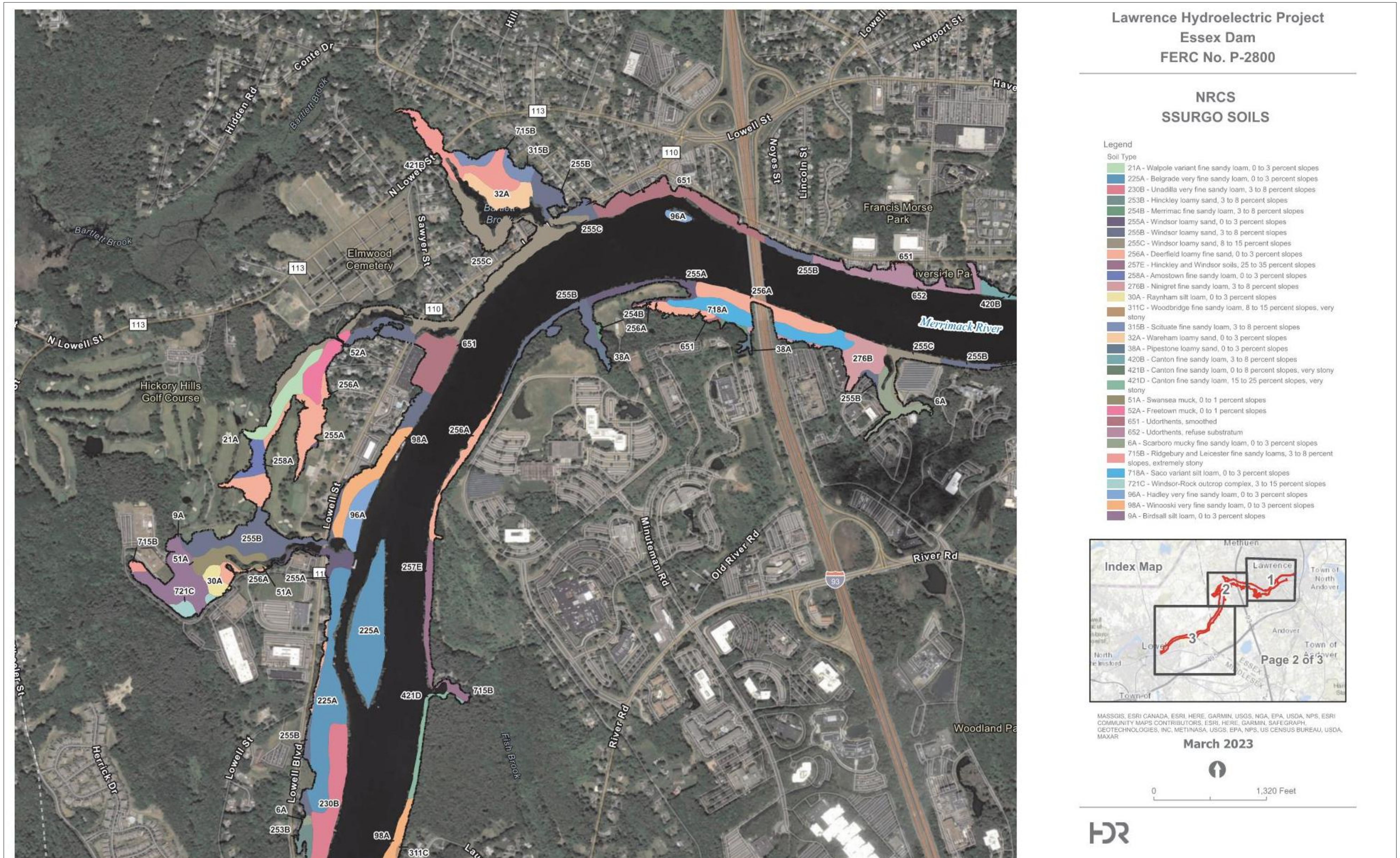
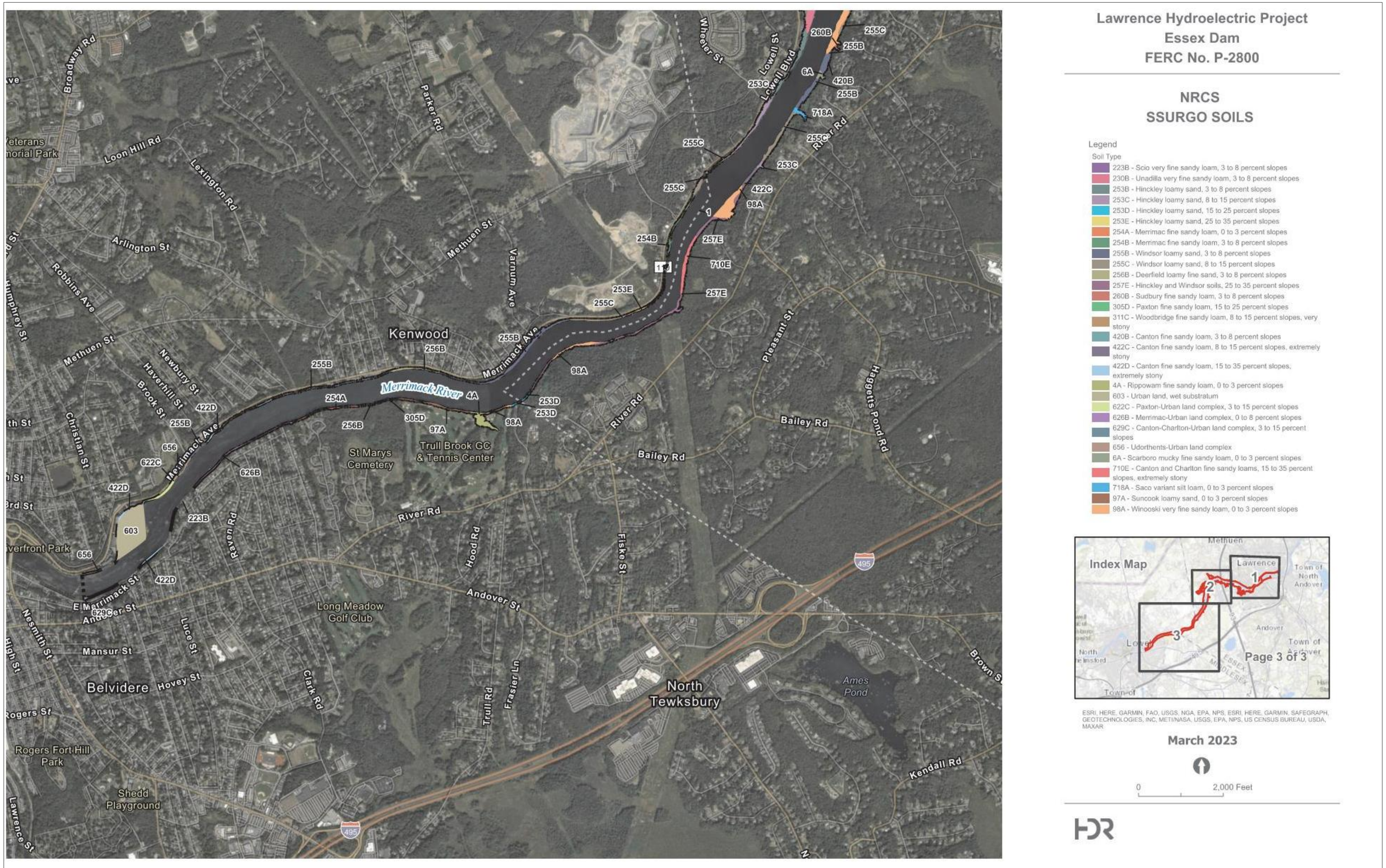


Figure E.7-4. Mapped Soils in the Lawrence Project Boundary.



E.7.1.2 Environmental Analysis

FERC's SD2 did not identify any specific resource issues related to geologic or soil resources. No effects on geologic or soil resources are anticipated as a result of the continued operation of the Project as a ROR facility, as proposed. There are currently no adverse Project effects on geology or soils, and Essex is not proposing operational changes to the Project.

Essex implements measures to prevent soil erosion when performing construction or maintenance activities on lands adjacent to Project waters. There are many natural processes and anthropogenic factors that contribute to bank erosion, which makes it difficult to isolate or quantify any potential contribution from Project operations. However, there is no evidence that the Project has contributed to either large-scale or localized erosion in the Project vicinity.

E.7.1.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license.

E.7.1.4 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on geologic or soil resources.

E.7.2 Water Quantity and Quality

The subsections below describe water resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on water quantity and quality. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and water resources data collected from:

- Water Quality Study (Normandeau Associates, Inc. [NAI] 2026a)
- Sturgeon Habitat Mapping and Assessment Study (ASA Analysis & Communications [ASA] 2026a)
- Phase 1 Project Operations and Fish Stranding Study (HDR 2026a)

These reports are included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.2.1 Affected Environment

E.7.2.1.1 Water Quantity

The Lawrence Project is in the Merrimack River Basin, which extends from the White Mountain region of northern New Hampshire to southeastern Massachusetts. The Merrimack River Basin has a total drainage area of approximately 5,010 square miles and is the fourth largest river basin in New England (MEOEEA 2001). The majority of the watershed lies within New Hampshire (3,800 square miles) (MEOEEA 2001). The Lawrence Project has a gross drainage area of 4,674 square miles and a net drainage area of 4,460 square miles after accounting for the 214-square-mile watershed attributed to the Boston and Worcester water supply.

Project Hydrology

The Project operates in ROR mode, and therefore, experiences seasonal and annual variations in flows based on natural hydrologic conditions in the Merrimack River watershed. Table E.7-2 provides Project hydrologic data from 1923-2021.

Table E.7-2. Summary of Annual and Monthly Flows from October 1923 through September 2021.

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
January	367	2,852	7,624	13,518	47,314
February	636	3,176	7,646	13,518	47,112
March	1,422	5,206	12,953	23,606	162,420
April	2,512	8,603	19,416	32,484	83,530
May	672	4,822	11,746	20,176	92,105
June	407	2,240	6,698	12,721	60,025
July	251	1,352	3,879	7,397	34,401
August	235	1,079	3,143	6,073	31,778
September	221	1,019	3,203	5,751	119,041
October	216	1,311	4,666	9,606	52,660
November	322	2,119	7,147	14,325	66,784
December	381	2,862	8,356	16,545	45,901
Annual	216	1,705	8,031	17,755	162,420

Source: USGS 2023c.

Existing Instream Flow Uses

Existing instream flow uses of the Merrimack River include hydroelectric generation, industrial uses, and recreation (e.g., fishing and boating). There are five FERC-regulated hydroelectric projects on the Merrimack River and two additional projects on the main stem of the Pemigewasset River. The Project is located approximately 11 miles downstream of the Lowell Hydroelectric Project (FERC No. 2790). There are also four USACE flood storage dams within the Merrimack River Basin. Essex does not propose to make any changes to Project facilities or operation that would affect these uses.

Through a number of legal and duly recorded agreements dating back to 1845, Essex granted “mill powers” to landowners along the North and South Canals. The mill powers detail the allocation of Merrimack River flow from the impoundment created by Essex Dam. Mill powers are the right to draw water from the nearest canal, where one mill power is equivalent to 30 cfs delivered at a head of 25 feet for a period of 12 hours per day.

As development in Lawrence has occurred, various mill powers have been transferred or are presently unusable (conveyances demolished, equipment removed, etc.). Originally, about 145 mill powers were assigned throughout Lawrence to power 19th-century mills or businesses. Approximately 131 mill powers are held by Essex for use at the Project powerhouse; about 49 are owned by Essex in fee while about 82 mill powers are leased. The City of Lawrence possesses mill powers from the South Canal at the former Merrimac Paper site. A small number of mill powers, presently unused, remain attached to their granted canal-adjacent parcels.

Additional flow of the Merrimack River as seasonally occurs (beyond the mill powers described above) is utilized at the Project powerhouse for generation and is termed “surplus mill powers.”

Existing and Proposed Uses of Project Waters

Pursuant to the Massachusetts Water Management Act, the MADEP regulates the amount of water withdrawn from ground and surface water resources to ensure adequate supplies for current and future water needs (MADEP 2023a). The USEPA is the permitting authority in Massachusetts for issuing National Pollutant Discharge Elimination System (NPDES) permits, which are required whenever a municipality, industry, or other entity wishes to discharge pollutants to a surface water of the United States (MADEP 2023b). In Massachusetts, NPDES permits are typically co-issued by the USEPA and MADEP (MADEP 2023b).

Available registrations and permits were reviewed. Four regulated water withdrawals were identified from the Merrimack River within the Lawrence Project boundary. These withdrawal users were identified as the Tewksbury Water Treatment Facility (Permit #9P31329501), the Andover Water Treatment Facility (Permit #9P31300901), the Lawrence Water Treatment Facility[5], and the Methuen Water Treatment Facility.[6]

The USEPA is the permitting authority in Massachusetts for issuing NPDES permits, which are required whenever a municipality, industry, or other entity wishes to discharge pollutants to a surface water of the United States (MADEP 2023c). In Massachusetts, NPDES permits are typically co-issued by the USEPA and MADEP (MADEP 2023c). Available NPDES permits were reviewed for the Project vicinity in Massachusetts (MADEP 2023d, MADEP 2023e, USEPA 2023).

Three active NPDES permits were identified within the Project vicinity, which were issued for the Greater Lawrence Sanitary District (Permit No. MA0100447), Andover Water Treatment Plant (Permit No. MAG640058), and Lawrence Hydroelectric Facility (Permit No. MAG250948). On June 8, 2023, a Notice of Intent was submitted for the Lawrence Hydroelectric Project for authorization to discharge under the NPDES Hydroelectric Generating Facility General Permit (HYDROGP) for the Commonwealth of Massachusetts (MAG360000) (Permit No. MAG360023) (USEPA 2023). There are five authorized combined sewer overflows (CSOs) within the Project vicinity under NPDES Permit No. MA0100447. The five CSOs are permitted for the Greater Lawrence Sanitary District (GLSD) in the Merrimack River Segment MA84A-04 (CSO outfalls #002, 003, 004, and 005) and the Spicket River Segment MA84A-10 (CSO outfall #006) (USEPA 2019). The CSO outfalls associated with the GLSD are one of five areas along the Merrimack River with CSOs: Manchester and Nashua, NH, and Lowell, GLSD, and Haverhill, MA (MRWC 2022). The total annual CSO volume, in millions of gallons, from the five areas is summarized in Table E.7-3. In 2021, the CSO volume from GLSD near the Project was 93 million gallons (Table E.7-3).

[5] The permit number for this facility is unknown.

Table E.7-3. Total Annual CSO Volume (million gallons).

Year	Haverhill	GLSD	Lowell	Nashua	Manchester	Total
2013	32	34	200	44	257	**566**
2014	43	6	278	51	322	**701**
2015	8	13	113	6	157	**296**
2016	21	36	118	10	131	**316**
2017	31	26	108	10	227	**401**
2018	50	93	292	18	364	**816**
2019	44	58	285	19	160	**565**
2020	15	50	157	5	154	**380**
2021	48	93	447	17	217	**822**
Average	**32**	**45**	**222**	**20**	**221**	**540**
Percent (%)	**6**	**8**	**41**	**4**	**41**	

Source: MRWC 2022.

E.7.2.1.2 Water Quality

Massachusetts Water Quality Standards

Water quality standards for the Commonwealth of Massachusetts are contained in the Code of Massachusetts Regulations (CMR) at 314 CMR 4.00: Massachusetts Surface Water Quality Standards. Inland surface waters of Massachusetts are classified by appropriate use Class (A, B, or C) as defined in 314 CMR 4.05. Qualifiers applied to these classifications indicate special considerations and uses applicable to a waterbody segment that may affect the application of criteria or antidegradation provisions. The classification of surface water in Massachusetts is provided in 314 CMR 4.06.

The MADEP's Division of Water Pollution Control has classified waters within the Project vicinity as Class B with specific qualifiers (Table E.7-4). As defined in 314 CMR 4.05(3)(b), Class B waters are designated as:

> *[A] habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06(1)(d)6. and (6)(b) as a "Treated Water Supply" these waters shall be suitable as a source of public water supply with appropriate treatment. Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.*

A summary of the standards applicable to Class B waters with the Warm Water qualifier is provided in Table E.7-5.

Table E.7-4. Water Quality Classification Applicable to the Lawrence Project.

Segment Boundary	Mile Point	Class	Qualifiers
From Pawtucket Dam to Essex Dam, Lawrence	40.6 – 29.0	B	Warm Water[1] Treated Water Supply[2] CSO[3]
From Essex Dam, Lawrence to confluence with the Little River, Haverhill	29.0-21.9	B	Warm Water[1] CSO[3]

Source: 314 CMR 4.06.

[1] In these waters, dissolved oxygen and temperature criteria for warm water fisheries apply.

[2] Denotes those Class B waters that are used as a sources of public water supply after appropriate treatment. These waters may be subject to more stringent site-specific criteria established by the Department as appropriate to protect and maintain the use. See 310 CMR 22.00: *Drinking Water.*

[3]Denotes those waters are identified as impacted by the discharge of CSOs; however, a long-term control plan has not been approved or fully implemented for CSO discharges.

Table E.7-5. Water Quality Standards for Class B Waters with the Warm Water Qualifier.

Parameter	Class B Warm Water Standard
Dissolved Oxygen (DO)	Shall not be less than 5.0 milligrams per liter (mg/L) in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.
Temperature	Shall not exceed 83 degrees Fahrenheit (°F) (28.3°C) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month). Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions, or growth of aquatic organisms.
pH	Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
Color and Turbidity	These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.

Source: 314 CMR 4.05(3)(b).

Existing Water Quality Data

Prior to the CWA in 1972, the Merrimack River was among the top ten most polluted rivers in the country. Subsequently, there have been numerous water quality monitoring efforts conducted on the Merrimack River in the vicinity of the Project, including DO, pH, temperature, specific conductance, turbidity, and other nutrients. Existing water quality data within the Project vicinity are presented here from: (1) two USEPA water quality monitoring sites in the Lower Merrimack River; (2) eight USGS sites upstream and downstream of the Project; and (3) two locations sampled as part of the MRWC's Water Quality Monitoring Program (Figure E.7-5).

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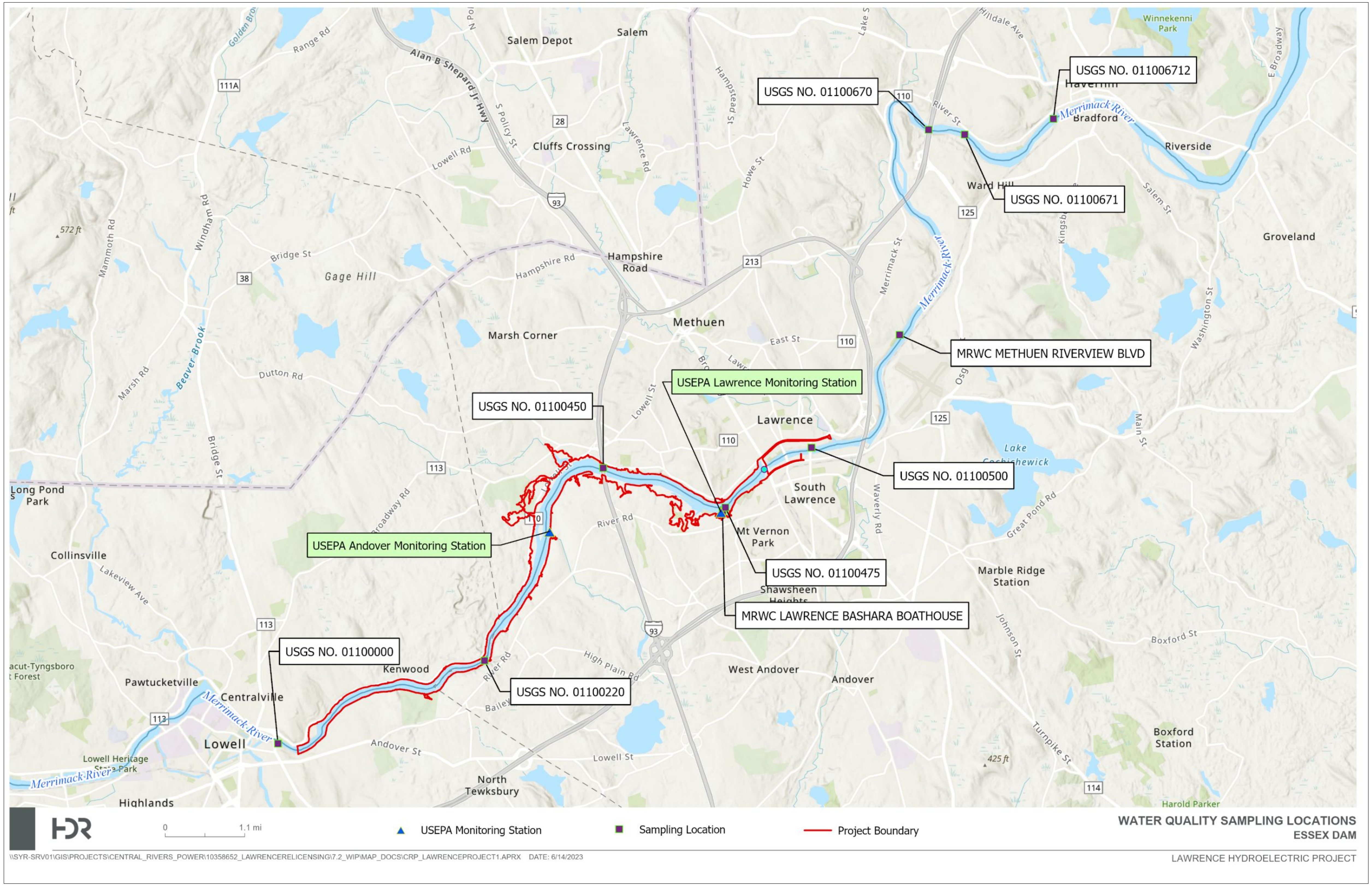
Figure E.7-5. Water Quality Sampling Locations near the Project.



USEPA Data in the Project Vicinity

The USEPA deployed two water monitoring stations in the Lower Merrimack River to collect water quality data; one just upstream of the Abe Bashara Boathouse in Lawrence and one near Pine Island in Andover (Figure E.7-5); both stations were located within the Project impoundment. Every 15 minutes from January 2018 to November 2018 and from June 2019 to October 2019, the Lawrence monitoring station received information from an instrument in the Merrimack River equipped with environmental sensors to measure temperature, DO, specific conductance (conductivity), pH, turbidity, chlorophyll, and phycocyanin (USEPA 2022b). Similarly, the Andover monitoring station collected water quality data from December 2016 to November 2017. The sensors were located approximately 1 meter below the water's surface (USEPA 2022b). Relevant environmental data from the Lawrence station are summarized in Table E.7-6 and from the Andover station in Table E.7-7.

Between the two sites, water temperatures were recorded up to 30.3°C, DO concentrations ranged from 0.5 to 15.5 mg/L, and pH ranged from 4.5 to 8.1. The average monthly water temperatures were within the state standards (i.e., below 28.3°C), however, discrete temperature measurements were recorded above this standard in some months. Generally, DO concentrations exceed the daily minimum state criterion of 5.0 mg/L. However, discrete DO concentrations were recorded below this threshold in different seasons. Similarly, while pH values were generally within the state standards (i.e., 6.5 to 8.3 standard units), there were times when the recorded pH value was lower than 6.5 standard units.

Table E.7-6. Surface Water Quality Data Summary from USEPA Lower Merrimack River Monitoring Stations in Lawrence.

Month	Dissolved Oxygen (DO) (% Saturation)				DO (mg/L)				Temperature (C)				pH				Specific Conductance (µS/cm)				Turbidity (fnu)			
	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N
January	115.5	95.1	106.7	1674	15.3	9.6	13.6	1674	15.1	2.4	5.2	1674	6.8	6.3	6.6	1674	0.3	0.1	0.2	1674	12.8	1.5	3.8	1674
February	114.7	102.4	107.6	2517	14.7	13.2	13.9	2517	8.4	3.2	4.5	2517	7.6	6.4	6.8	2517	0.3	0.2	0.2	2517	7.1	1.5	2.4	2517
March	112.7	100.4	106.4	2941	13.8	11.9	13.2	2941	8.6	4.6	6.1	2941	7.0	6.5	6.8	2941	0.3	0.2	0.2	2941	6.4	1.3	2.0	2940
April	110.3	98.3	104.0	2865	12.9	10.6	11.9	2865	14.4	6.8	9.3	2865	7.0	6.6	6.7	2865	0.2	0.1	0.2	2865	10.7	1.5	2.8	2865
May	107.6	77.1	93.2	2958	11.3	7.0	9.0	2958	22.3	11.4	17.4	2958	7.4	6.4	6.8	2958	0.3	0.1	0.2	2958	19.4	1.7	3.1	2958
June	123.2	52.7	81.7	3927	10.2	4.5	7.1	3927	24.6	20.5	22.4	3927	8.1	6.5	6.8	3927	0.3	0.2	0.3	3927	178.4	1.5	2.5	3927
July	125.4	40.8	77.5	5890	9.8	3.3	6.2	5890	29.5	23.7	26.6	5890	7.6	6.0	6.7	5890	0.4	0.2	0.2	5890	13.6	1.4	2.2	5890
August	124.8	52.0	80.2	5881	9.9	4.2	6.5	5881	28.4	23.2	25.8	5881	7.8	6.5	6.8	5881	0.3	0.2	0.2	5881	35.7	1.6	2.4	5881
September	105.7	51.1	82.7	5713	9.1	4.2	7.2	5713	27.2	18.2	22.2	5713	7.3	6.5	6.8	5713	0.3	0.2	0.2	5713	8.6	1.4	2.2	5713
October	104.0	58.1	93.0	3538	12.1	5.5	9.4	3538	21.0	8.8	15.2	3538	7.0	6.2	6.7	3538	0.3	0.2	0.2	3538	16.3	1.8	2.6	3538
November	108.9	100.4	104.8	537	12.1	11.4	11.8	537	11.4	8.8	10.0	537	6.6	6.3	6.5	537	0.2	0.1	0.1	537	13.4	2.6	5.5	537
December	115.5	95.1	106.7	1674	15.3	9.6	13.6	1674	15.1	2.4	5.2	1674	6.8	6.3	6.6	1674	0.3	0.1	0.2	1674	12.8	1.5	3.8	1674

[1]Shaded cells do not meet Massachusetts standards.

Table E.7-7. Surface Water Quality Data Summary from USEPA Lower Merrimack River Monitoring Stations in Andover.

Month	Dissolved Oxygen (DO) (% Saturation)				DO (mg/L)				Temperature (C)				pH				Specific Conductance (µS/cm)				Turbidity (fnu)			
	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N	Max	Min	Average	N
January	101.1	90.7	96.8	2941	14.3	12.7	13.6	2941	2.7	0.2	1.3	2941	7.1	6.6	6.9	2941	1.1	0.3	0.5	2941	6.7	0.9	1.9	2941
February	104.7	86.4	94.1	2677	13.7	12.1	13.0	2677	5.7	0.4	1.8	2677	7.1	6.7	7.0	2677	1.1	0.4	0.8	2677	13.7	0.9	2.4	2677
March	103.9	90.8	100.0	2893	15.5	12.0	13.6	2893	6.6	-3.6	2.7	2893	7.1	4.5	6.8	2893	0.8	0.0	0.4	2893	81.8	1.1	2.1	2893
April	110.1	89.6	99.3	2775	13.6	9.6	11.2	2775	16.1	2.3	10.4	2775	7.2	6.8	6.9	2775	0.8	0.2	0.5	2775	10.9	1.0	3.3	2775
May	107.6	32.9	88.0	2939	10.8	2.8	8.7	2939	30.3	11.9	16.2	2939	7.3	5.7	6.8	2939	0.7	0.0	0.4	2939	347.5	0.6	2.1	2939
June	102.4	79.6	93.7	2869	9.8	6.8	8.4	2869	26.4	14.2	21.0	2869	7.0	6.3	6.7	2869	0.4	0.2	0.2	2869	7.7	0.9	2.2	2869
July	110.2	6.1	80.4	2956	9.1	0.5	6.8	2956	30.1	19.4	24.0	2956	7.1	5.8	6.5	2956	0.3	0.1	0.2	2956	19.7	0.5	3.2	2956
August	133.3	74.8	93.4	2953	10.8	6.3	7.8	2953	26.7	21.8	24.4	2953	8.0	6.6	6.9	2953	0.3	0.2	0.3	2953	3.2	1.3	1.7	2953
September	120.6	74.6	90.5	2863	10.3	6.7	8.0	2863	25.0	19.3	21.3	2863	7.9	6.4	6.8	2863	0.3	0.2	0.2	2863	4.6	1.0	1.6	2863
October	110.9	29.7	86.8	2748	10.1	2.8	8.2	2748	21.6	13.9	18.0	2748	7.4	6.3	6.8	2748	0.4	0.1	0.3	2748	7.6	1.2	2.2	2748
November	98.9	16.6	73.9	1149	12.2	1.7	8.4	1149	21.7	5.7	11.3	1149	6.9	5.3	6.4	1149	0.5	0.1	0.2	1149	6.1	2.5	3.6	1149
December	100.2	65.5	92.7	2235	14.2	7.7	12.8	2235	11.1	0.7	2.2	2235	7.2	6.4	6.9	2235	0.8	0.2	0.5	2235	5.5	1.0	2.1	2235

[1]Shaded cells do not meet Massachusetts standards.

USGS Data in the Project Vicinity

The USGS National Water Information Systems (NWIS) Mapper was queried for water quality data in the vicinity of the Project on the Merrimack River (USGS 2023d). There were numerous active and inactive sites near the Project on the main stem of the Merrimack River and its tributaries. A summary of USGS water quality data locations within the Project vicinity on the main stem of the Merrimack River is provided in Table E.7-8. Additional information about other USGS water quality monitoring locations can be accessed on the USGS NWIS Mapper.

Table E.7-8. USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Site Name	USGS Site Number	Distance from Project	Status	Years of Water Quality Data	Samples
Merrimack River below Concord River at Lowell, MA	01100000	9.4 Miles Upstream	Active	1953 - 2023	312
Merrimack River at Lawrence, MA	01100500	0.72 Mile Downstream	Active	2020 - 2023	15
Merrimack River near Haverhill, MA	011006712	9.7 Miles Downstream	Active	2020 - 2023	5
Merrimack River near Power Lines, Methuen, MA	01100220	6.0 Miles Upstream	Inactive	2020	10
Merrimack River at I93, near Methuen, MA	01100450	2.5 Miles Upstream	Inactive	1973 – 1974	2
Merrimack River at Abe Bashara Boat House Lawrence, MA	01100475	0.74 Mile Upstream	Inactive	2020	13
Merrimack River at I495, near Haverhill, MA	01100670	7.57 Miles Downstream	Inactive	1973 – 1974	2
Merrimack River DS Stanley Island, Haverhill, MA	01100671	8.08 Miles Downstream	Inactive	2020	5

Source: USGS 2023d.

Water quality data from the USGS locations are summarized in Table E.7-9 to Table E.7-14 and includes turbidity (Table E.7-9), pH (Table E.7-10), specific conductance (Table E.7-11), temperature (Table E.7-12), DO measured in % saturation (Table E.7-13), and DO measured in mg/L (Table E.7-14) for each site. The sampling year(s) do not directly coincide between sites; data at these sites were not collected at the same time. Additionally, not all sites collected each individual parameter. The applicable USGS locations are included in the following tables.

The two locations closest to the Project Dam were USGS 01100500 (0.72 mile downstream) and USGS 01100475 (0.74 mile upstream) and generally had pH values within state standards.

However, isolated events were measured at USGS 01100500 where average pH values were 6.4 standard units in January and 6.1 standard units in October (i.e., 6.5 to 8.3 standard units). Temperature (°C) readings were within state standards at both sites (i.e., below 28.3°C) with an average monthly range from 12.7°C to 27.4°C at USGS 01100475 and 1.5°C to 24.7°C at USGS 01100500. DO concentrations (mg/L) at both sites exceed the daily minimum state criterion of 5.0 mg/L. Turbidity data at these sites appears to remain stable with a maximum at both sites of 2.1 Nephelometric Turbidity Units [NTU] and a minimum of 1.3 NTU (Table E.7-9.). Specific conductivity (micro-siemens per centimeter [µS/cm]) also was stable at both sites, with an average monthly range of 172 to 325 µS/cm at USGS 01100475 and 173 to 315 µS/cm at USGS 01100500. There are no quantitative standards for turbidity or specific conductivity in Massachusetts.

Table E.7-9. Turbidity (NTU) Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	Turbidity (NTU)																											
	USGS 01100000				USGS 01100220				USGS 01100475				USGS 01100500				USGS 01100671				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	3.4	1.0	2.0	3	--	--	--	--	--	--	--	--	1.8	1.6	1.7	11	--	--	--	--	1.7	1.7	1.7	1	**3.4**	**1.0**	**1.8**	**15**
February	1.4	1.2	1.3	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.4**	**1.2**	**1.3**	**2**
March	1.9	1.9	1.9	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.9**	**1.9**	**1.9**	**1**
April	2.2	1.5	1.9	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**2.2**	**1.5**	**1.9**	**2**
May	2.6	1.4	2.0	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**2.6**	**1.4**	**2.0**	**2**
June	1.7	1.7	1.7	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**1.7**	**1.7**	**1.7**	**2**
July	4.3	2.0	3.4	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**4.3**	**2.0**	**3.4**	**3**
August	2.5	1.7	2.2	3	--	--	--	--	1.3	1.3	1.3	1	1.3	1.3	1.3	1	--	--	--	--	1	1	1	1	**2.5**	**1.0**	**1.7**	**6**
September	3.2	2.6	2.8	3	1.6	1.4	1.5	2	2.1	2.1	2.1	1	2	2	2	1	0.3	0.3	0.3	1	1.9	1.9	1.9	1	**3.2**	**0.3**	**2.0**	**9**
October	2.5	1.6	2.0	3	--	--	--	--	1.4	1.4	1.4	1	2.1	1.7	1.9	2	--	--	--	--	2.6	2.0	2.3	2	**2.6**	**1.4**	**2.0**	**8**
November	15.	1.7	8.4	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**15.**	**1.7**	**8.4**	**2**
December	3.2	1.6	2.4	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**3.2**	**1.6**	**2.4**	**2**

Table E.7-10. pH Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	pH																																			
	USGS 01100000				USGS 01100220				USGS 01100450				USGS 01100475				USGS 01100500				USGS 01100670				USGS 01100671				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	7.4	5.9	6.8	15	--	--	--	--	--	--	--	--	--	--	--	--	6.6	6.2	6.4	11	--	--	--	--	--	--	--	--	6.8	6.8	6.8	1	**7.4**	**5.9**	**6.6**	**27**
February	7.5	5.6	6.8	13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.5**	**5.6**	**6.8**	**13**
March	7.4	5.9	6.7	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.4**	**5.9**	**6.7**	**16**
April	7.3	6.0	6.7	16	--	--	--	--	6.9	6.9	6.9	1	--	--	--	--	--	--	--	--	6.4	6.4	6.4	1	--	--	--	--	--	--	--	--	**7.3**	**6.0**	**6.7**	**18**
May	7.6	6.0	6.9	15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.6**	**6.0**	**6.9**	**15**
June	7.7	6.4	7.0	20	7.1	6.8	6.9	4	--	--	--	--	7.4	7.1	7.2	4	--	--	--	--	--	--	--	--	7.2	7.0	7.1	2	--	--	--	--	**7.7**	**6.4**	**7.0**	**30**
July	7.7	6.0	6.8	17	6.8	6.8	6.8	2	--	--	--	--	6.9	6.8	6.9	2	--	--	--	--	--	--	--	--	7.1	7.1	7.1	1	--	--	--	--	**7.7**	**6.0**	**6.9**	**22**
August	7.9	6.1	7.0	19	--	--	--	--	7.3	7.3	7.3	1	7.0	6.9	7.0	3	7.0	7.0	7.0	1	6.5	6.5	6.5	1	--	--	--	--	--	--	--	--	**7.9**	**6.1**	**7.0**	**25**
September	8.4	5.9	6.9	23	7.3	6.6	7.0	4	--	--	--	--	7.9	6.9	7.3	3	7.9	7.9	7.9	1	--	--	--	--	6.9	6.7	6.8	2	6.9	6.9	6.9	1	**8.4**	**5.9**	**7.0**	**34**
October	7.6	6.2	6.9	14	--	--	--	--	--	--	--	--	6.8	6.8	6.8	1	6.1	6.1	6.1	1	--	--	--	--	--	--	--	--	6.4	6.4	6.4	1	**7.6**	**6.1**	**6.8**	**17**
November	7.7	6.1	7.0	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.7**	**6.1**	**7.0**	**12**
December	7.3	6.1	6.8	17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**7.3**	**6.1**	**6.8**	**17**

[1]Shaded cells do not meet Massachusetts pH standard

Table E.7-11. Specific Conductance (µS/cm) Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	Specific Conductance (µS/cm)																																			
	USGS 01100000				USGS 01100220				USGS 01100450				USGS 01100475				USGS 01100500				USGS 01100670				USGS 01100671				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	399	90	192	21	--	--	--	--	--	--	--	--	--	--	--	--	175	172	174	11	--	--	--	--	--	--	--	--	195	195	195	1	399	90	186	33
February	328	80	214	18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	328	80	214	18
March	290	55	154	23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	290	55	154	23
April	218	46	124	26	--	--	--	--	69	69	69	1	--	--	--	--	--	--	--	--	82	82	82	1	--	--	--	--	--	--	--	--	218	46	121	28
May	240	56	137	25	--	--	--	--	--	--	--	--	--	--	--	-	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	240	56	137	25
June	299	91	169	27	294	188	247	4	--	--	--	--	295	213	255	4	--	--	--	--	--	--	--	--	319	245	282	2	--	--	--	--	319	91	193	37
July	336	89	192	25	274	258	266	2	--	--	--	--	230	230	230	2	--	--	--	--	--	--	--	--	250	250	250	1	--	--	--	--	336	89	201	30
August	309	86	190	29	-	-	-	-	175	175	175	1	312	311	312	3	286	286	286	1	138	138	138	1	--	--	--	--	--	--	--	--	312	86	201	35
September	347	83	180	31	316	305	309	4	--	--	--	--	329	318	325	3	315	315	315	1	--	--	--	--	354	332	343	2	357	357	357	1	357	83	218	42
October	275	88	176	22	--	--	--	--	--	--	--	--	172	172	172	1	173	173	173	1	--	--	--	--	--	--	--	--	192	192	192	1	275	88	177	25
November	320	102	166	24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	320	102	166	24
December	225	93	147	21	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	225	93	147	21

Table E.7-12. Temperature (°C) Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	Temperature (C)																																			
	USGS 01100000				USGS 01100220				USGS 01100450				USGS 01100475				USGS 01100500				USGS 01100670				USGS 01100671				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	2.7	-0.1	0.6	24	--	--	--	--	--	--	--	--	--	--	--	--	1.6	1.5	1.5	11	--	--	--	--	--	--	--	--	1.9	1.9	1.9	1	2.7	-0.1	0.9	36
February	4.0	-0.1	0.9	17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.0	-0.1	0.9	17
March	10.0	0.0	3.8	19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	10.0	0.0	3.8	19
April	15.0	2.0	9.2	26	--	--	--	--	15	15	15	1	--	--	--	--	--	--	--	--	14.3	14.3	14.3	1	--	--	--	--	--	--	--	--	15.0	2.0	9.6	28
May	21.0	9.0	14.7	23	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21.0	9.0	14.7	23
June	25.8	10.0	20.7	19	25.0	20.3	22.7	4	--	--	--	--	24.9	20.5	23.1	4	--	--	--	--	--	--	--	--	24.9	22.0	23.5	2	--	--	--	--	25.8	10.0	21.5	29
July	29.0	20.0	24.0	23	27.7	27.2	27.5	2	--	--	--	--	27.8	27.0	27.4	2	--	--	--	--	--	--	--	--	28.8	28.8	28.8	1	--	--	--	--	29.0	20.0	24.7	28
August	28.6	20.6	24.1	28	--	--	--	--	25	25	25	1	23.8	22.7	23.2	3	24.7	24.7	24.7	1	24.0	24.0	24.0	1	--	--	--	--	--	--	--	--	28.6	20.6	24.0	34
September	24.5	14.5	20.0	28	23.2	17.4	21.0	4	--	--	--	--	20.7	18.3	19.4	3	19.6	19.6	19.6	1	--	--	--	--	23.0	21.0	22.0	2	20.0	20.0	20.0	1	24.5	14.5	20.1	39
October	17.0	2.5	13.3	19	--	--	--	--	--	--	--	--	12.7	12.7	12.7	1	12.7	12.7	12.7	1	--	--	--	--	--	--	--	--	12.6	12.6	12.6	1	17.0	2.5	13.2	22
November	13.5	2.0	7.0	24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13.5	2.0	7.0	24
December	7.0	0.1	2.9	18	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.0	0.1	2.9	18

[1] Shaded cells do not meet Massachusetts temperature standards.

Table E.7-13. DO (% Saturation) Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	DO (% Saturation)																							
	USGS 01100000				USGS 01100220				USGS 01100475				USGS 01100500				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	105	87	96	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**105**	**87**	**96**	**8**
February	104	92	97	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**104**	**92**	**97**	**7**
March	105	94	101	5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**105**	**94**	**101**	**5**
April	114	90	102	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**114**	**90**	**102**	**8**
May	131	93	102	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**131**	**93**	**102**	**8**
June	121	89	102	11	--	--	--	--	86	82	84	2	--	--	--	--	--	--	--	--	**121**	**82**	**99**	**13**
July	98	73	89	8	86	77	82	2	--	--	--	--	--	--	--	--	--	--	--	--	**98**	**73**	**88**	**10**
August	102	26	85	9	--	--	--	--	--	--	--	--	97	97	97	1	--	--	--	--	**102**	**26**	**86**	**10**
September	122	91	100	11	103	47	75	2	99	99	99	1	109	109	109	1	95	95	95	1	**122**	**47**	**97**	**16**
October	102	84	94	6	--	--	--	--	84	84	84	1	91	91	91	1	85	85	85	1	**102**	**84**	**91**	**9**
November	103	89	97	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**103**	**89**	**97**	**8**
December	104	76	94	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	**104**	**76**	**94**	**8**

Table E.7-14. DO (mg/L) Collected from USGS Water Quality Data Locations on the Main Stem of the Merrimack River.

Month	DO (mg/L)																																			
	USGS 01100000				USGS 01100220				USGS 01100450				USGS 01100475				USGS 01100500				USGS 01100670				USGS 01100671				USGS 011006712				TOTAL			
	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N	Max	Min	Avg	N
January	14.5	12.4	13.8	9	-	-	-	-	-	-	-	-	-	-	-	-	15.0	14.2	14.4	11	-	-	-	-	-	-	-	-	14.3	14.3	14.3	1	**15.0**	**12.4**	**14.1**	**21**
February	15.3	12.8	13.9	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**15.3**	**12.8**	**13.9**	**8**
March	14.8	12.6	13.4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**14.8**	**12.6**	**13.4**	**5**
April	13.0	9.5	11.3	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**13.0**	**9.5**	**11.3**	**8**
May	12.9	8.5	10.2	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**12.9**	**8.5**	**10.2**	**9**
June	9.8	7.4	8.6	13	7.7	7.4	7.5	4	-	-	-	-	9.2	6.7	7.8	4	-	-	-	-	-	-	-	-	8.8	7.3	8.1	2	-	-	-	-	**9.8**	**6.7**	**8.2**	**23**
July	8.3	5.8	7.3	9	6.7	6.0	6.4	2	-	-	-	-	7.8	6.8	7.3	2	-	-	-	-	-	-	-	-	8.3	8.3	8.3	1	-	-	-	-	**8.3**	**5.8**	**7.2**	**14**
August	8.8	2.2	7.0	12	-	-	-	-	10.3	10.3	10.3	1	7.4	6.2	6.9	3	8.0	8.0	8.0	1	2.4	2.4	2.4	1	-	-	-	-	-	-	-	-	**10.3**	**2.2**	**7.0**	**18**
September	10.4	6.3	8.5	13	9.1	4.4	6.7	4	-	-	-	-	10.2	6.3	8.5	3	10.0	10.0	10.0	1	-	-	-	-	7.0	5.1	6.1	2	8.6	8.6	8.6	1	**10.4**	**4.4**	**8.1**	**24**
October	10.3	5.8	8.9	8	-	-	-	-	-	-	-	-	8.9	8.9	8.9	1	9.7	9.7	9.7	1	-	-	-	-	-	-	-	-	9.1	9.1	9.1	1	**10.3**	**5.8**	**9.0**	**11**
November	12.7	8.7	11.3	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**12.7**	**8.7**	**11.3**	**9**
December	13.8	11.1	12.6	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**13.8**	**11.1**	**12.6**	**9**

[1] Shaded cells do not meet Massachusetts DO (mg/L) standards.

Merrimack River Watershed Council Data in the Project Vicinity

In 2021, the MRWC's volunteer water quality monitoring program collected water quality data at 13 sites along the Merrimack River from Manchester, NH, to Salisbury, MA, from January to December (MRWC 2022). Data was collected on pH, salinity, total dissolved solids, specific conductivity, and temperature. Monitoring in the greater Lawrence area includes two sites: Lawrence Bashara Boathouse and Methuen Riverview Boulevard (Blvd) (Figure E.7-5). The Lawrence Bashara Boathouse is located 0.82 mile upstream of the Project and is located upstream of the five GLSD CSO outfalls. The Methuen Riverview Boulevard is located 3.13 miles downstream of the Project and is located downstream of the five GLSD CSO outfalls.

The recorded water temperatures at both monitoring locations were within the state standards (i.e., below 28.3°C) ranging from 2.5°C to 23.9 °C at the Lawrence Bashara Boathouse site and 4.4°C to 25.5°C at the Methuen Riverview Boulevard site (Table E.7-15). pH values were generally within the state standards (i.e., 6.5 to 8.3 standard units) with a median of 7.2 at the Lawrence Bashara Boathouse site and 7.1 at the Methuen Riverview Boulevard site. However, pH values recorded at the Methuen Riverview Boulevard site show a maximum pH of 8.8, which exceeds the state standards.

Table E.7-15. 2021 MRWC Volunteer Water Quality Monitoring Program Data.

Site	River Mile (RM)	Temperature (°C)			pH			Specific Conductivity (µS/cm)		
		Min	Max	Median	Min	Max	Median	Min	Max	Median
Lawrence Bashara Boathouse	29.02	2.5	23.9	17.3	6.8	8.0	7.2	141.1	271.3	200.3
Methuen Riverview Blvd	26.20	4.4	25.5	20.7	6.8	8.8	7.1	160.4	922.0	228.2

Source: MRWC 2022.

Relevant Studies Performed in Support of Relicensing

Water Quality Study (NAI 2026a)

Methodology

In support of this relicensing, Essex conducted a Water Quality Study (NAI 2026a) to collect sufficient data to understand current water quality conditions at the Project, assess the designated uses for the three Assessment Units (MA84A-03, MA84A-04, MA84A-10) potentially affected by the Project, and assess any effects of Project operations on water quality in the affected Assessment Units.

The study was conducted over a four-month period from June 2, 2025, through October 1, 2025, and documented water quality conditions in the Project area under a range of flow and operating conditions. The study included continuous monitoring of DO, water temperature, and pH at 16 monitoring stations (See Figure E.7-6) under various river flow, river temperature, and Project operation conditions; weekly measurements of DO, water temperature, and pH as a vertical profile, as well as Secchi disk depth at the deepest known spot in the Project impoundment; collection of water samples for laboratory analysis of nutrients and chlorophyll-a at 3 monitoring stations (one location above the Project impoundment [LH-US-01] and two stations within the Project impoundment [LH-IM-02 and LH-IM-03) upstream of the Project dam; and collection of water samples for laboratory analysis of turbidity, Total Suspended Solids (TSS), and true color at 4 monitoring stations above and below the Project dam; and collection and analysis of benthic macroinvertebrate samples within a 500-m reach both above and below the dam. Supplemental spot measurements were also conducted with mobile water quality data sondes.

Results

Water Temperature

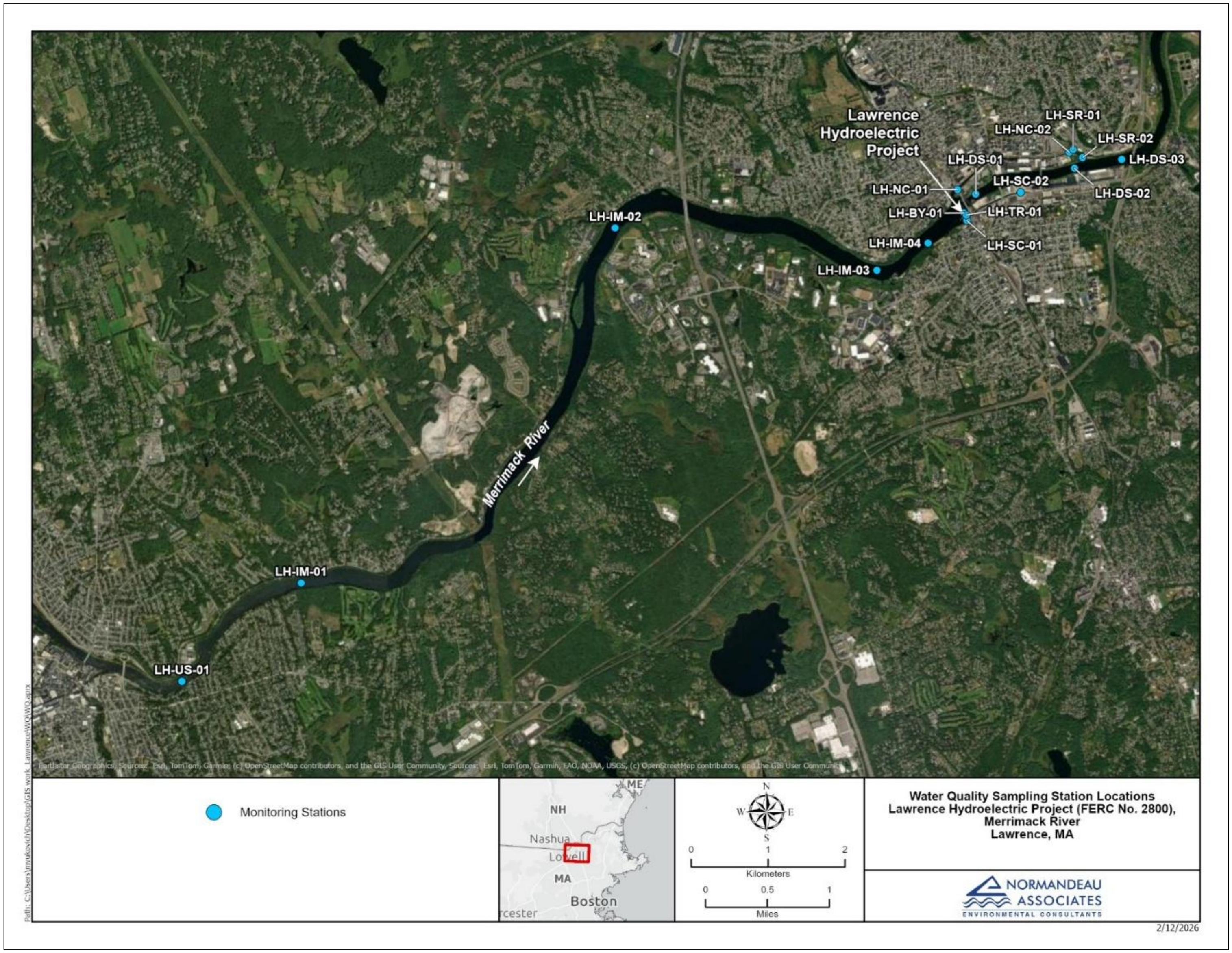
Water temperatures and river flows followed typical seasonal patterns during the 2025 study. The highest flows and lowest temperatures in the Merrimack River occurred during the start of the study period in June; flows decreased and temperatures increased from the end of June through mid-August, and from mid-August through September flows were lowest and temperatures gradually cooled.

Water temperatures across the 16 monitoring stations ranged from 16.06 to 30.22 °C with an average of approximately 23 °C. Water temperatures were generally comparable between stations throughout the study period, and there were similar temperature values, daily ranges, and trends among stations. Water temperatures reached three distinct peaks during the study, with values approaching or exceeding the 28.3°C water quality standard at multiple stations in the third and last week of July and the second week of August.

Daily temperature ranges were variable in time and between stations and were associated with flows, water depth, and reach type. Daily temperature variations were primarily influenced by flow conditions and water depths, with the highest fluctuations associated with low flows and shallower water depths/monitoring depths with shallow riverine reaches, and the lowest fluctuations associated with rising and high flows in deeper impounded water. Fluctuations were greatest upstream of the Project in the shallow riverine reach at station LH-US-01 and near the head of the impoundment at station LH-IM-01.

At the start of the study in June flows in the Merrimack River were high with flows generally greater than 10,000 cfs and as high as 25,000 cfs through June 25. Water temperatures remained in the middle-upper teens °C during the high flow period and then rose to the mid-20s °C by June 26, while flows decreased to less than 5,000 cfs in the same period. Temperatures then remained in the mid- to upper-20s °C from June 25 to August 19, corresponding with flows of approximately 1,000–2,000 cfs. A gradual cooling trend began at the end of August and extended through September, with temperatures by the end of the study cooling to about 20 °C. Water temperatures reached three distinct peaks during the study, with values approaching or exceeding the 28.3°C water quality standard at multiple stations in the third and fourth week of July and the second week of August. Flows in the Merrimack River reached a seasonal minimum in September, with average flows frequently less than 1,000 cfs outside of two precipitation events that resulted in minor but temporary increases in flows above 2,000–3,000 cfs. Maximum water temperatures were mostly associated with low river flows of less than 3,000 cfs, although the lowest flows occurred in September after water temperatures had peaked and began to cool for the season.

Figure E.7-6. Site Map of Water Quality Sampling Locations.



While temperatures in the main channel areas of the Merrimack River and the canals were comparable throughout the study, temperatures in the river reach immediately downstream of Essex Dam and the Spicket River were more variable. The station immediately downstream of the dam, LH-BY-01, was characterized by significant increases and decreases in temperature over short periods of time during the month of July and included temperature spikes outside of the expected water temperature range.

Temperature fluctuations were driven by changes in turbine outflows, which affected water levels downstream of Essex Dam and whether the logger was submerged or exposed. High outflows kept the logger in deeper, free-flowing water, while low outflows reduced water levels, sometimes leaving the logger in shallow or dewatered conditions that caused greater temperature variations.

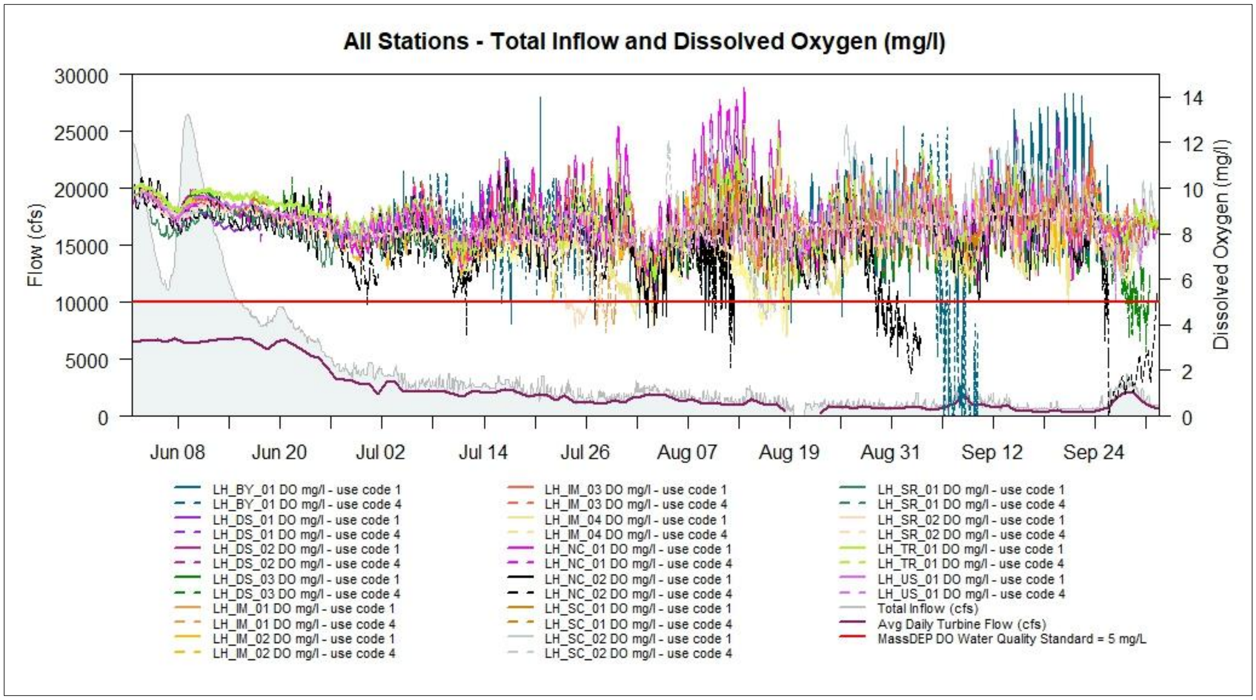
Dissolved Oxygen (DO)

DO was generally measured at high levels among all stations and throughout the study period, with few exceedances of the 5 mg/L DO water quality standard. Low DO events were spatially limited and temporary. Multiple apparent low DO events were determined to be invalid data due to biofouling on the loggers and accumulation of organic material between calibration events; the invalid data was omitted from station statistics. DO concentration varied from 3.45 to 14.41 mg/L among all stations during the study, with a global average DO concentration of about 8.5 mg/L. DO saturation varied from 42.59 to 189.61% and averaged about 99.4%, while daily average DO saturation varied from 60.95 to 156.58% and averaged about 99.8% among all stations. DO levels were variable over the course of the study period and between stations and exhibited seasonal variations as well as short-term trends and daily patterns.

Water temperatures and river flows followed typical seasonal patterns during the 2025 study, with high flows early in the study in June and low flows from July through the end of the study in September. During high-flow conditions in June, with flows in the Merrimack River at Lawrence generally greater than 10,000 cfs, DO levels were consistently high and relatively uniform among stations, with limited daily variation (See Figure E.7-7 below). Flows started receding after June 20, and by the start of July were below 5,000 cfs in the Merrimack River at Lawrence. During this flow recession period, DO became more variable between stations and showed more variability during diel cycles. From the middle of July through the end of the study, coinciding with a prolonged low flow period, DO was highly variable between stations, and diel DO cycles were pronounced at nearly all stations, increasing during daylight hours and decreasing during the evening.

Upstream of the Project impoundment (at Station LH-US-01), DO remained stable, consistently exceeded water quality standards, and DO saturation was consistently between 80 and 120% with pronounced diel DO cycles that fluctuated 2-3 mg/L during low-flow conditions. The data collected during this study suggest the inflow to the Project impoundment is sufficient for supporting uses based on DO criteria.

Figure E.7-7. Time Series of Dissolved Oxygen Concentration (mg/L) at all Stations.



Within the Project impoundment, there were four monitoring stations (Stations LH-IM-01, LH-IM-02, LH-IM-03, and LH-IM-04), with instruments deployed at mid-depth positions, between 7 and 17 feet deep (increasing depth from upstream to downstream). At stations LH-IM-01, LH-IM-02, and LH-IM-03, DO concentration was measured consistently above the WQ standard of 5 mg/L, while at Station LH-IM-04 there were several exceedances of the 5 mg/L DO standard as measured at the 17 feet depth at that station. Station LH-IM-01 had DO values and diel variations that were very similar to the upstream station LH-US-01, while the other three impoundment stations were characterized by highly variable DO conditions, likely related to the depth effects of flows through the impoundment. DO saturation was generally less than 125% at stations LH-IM-01, LH-IM-02, and LH-IM-04, while at station LH-IM-03 there were multiple instances of supersaturation above that level.

Downstream of the dam and within the tailrace, DO concentrations were generally well above the standard, with only one brief exceedance observed. Daily DO variations were low at the beginning of the study when inflow and spill over the dam were highest, while DO became more variable at all three stations after June 26 with decreasing inflow and spill. Daily variations of 2-3 mg/L DO were typical under low flow conditions at the downstream stations and in the most extreme case were as high as 5 mg/L on August 17. DO saturation at the downstream stations varied between 70 and 140% with mean daily averages of 97–104% for the full study period. The tailrace station had DO patterns and values comparable to those observed at the downstream stations. Under low inflow/spill conditions, turbine outflows through the tailrace were the primary source of flow to the downstream stations during normal Project operations. No exceedances of the 5 mg/L DO standard were measured at the tailrace station and average DO saturation was approximately 105% for the duration of the study. Similar to the downstream stations, at the tailrace station daily DO variations of 2-3 mg/L were typical and DO saturation typically varied between 80 and 140%.

A single monitoring station, located in the river reach immediately downstream of Essex Dam, documented conditions below the dam and above the confluence with the tailrace. DO was highly variable in the river reach immediately downstream of Essex Dam, although generally above the 5 mg/L standard, with only 4 discrete exceedances of the standard (10 total 15-minute measurement points below 5 mg/L) with a minimum DO value of 4.11 mg/L. This monitoring was heavily influenced by turbine outflows to the tailrace as evidenced by highly variable water levels that would rise and fall with turbine outflow. DO was highly variable over short timeframes in the river reach immediately downstream of Essex Dam, and daily variations of DO greater than 7 mg/L were documented, coinciding with DO saturation varying between 70 and 160%. The rapid changes in DO are likely explained by the combination of changing water sources between turbine outflow and spill/leakage to the river reach immediately downstream of Essex Dam, as well as the documented presence of large algae mats that developed in the river reach immediately downstream of Essex Dam which have known effects on DO. A total of four monitoring stations were established in the North and South Canals at positions near the canal inlets and near the outlets. The North and South Canals showed highly variable DO conditions, particularly in the North Canal, where large diel fluctuations and a few brief exceedances of the 5 mg/L standard occurred. Despite this variability, most measurements met water quality criteria. In contrast, the two monitoring stations in the Spicket River maintained consistently high and stable DO concentrations with no documented exceedances of the standard, and the influence of the North Canal discharges did not appear to adversely affect downstream DO conditions despite being characterized by highly variable DO.

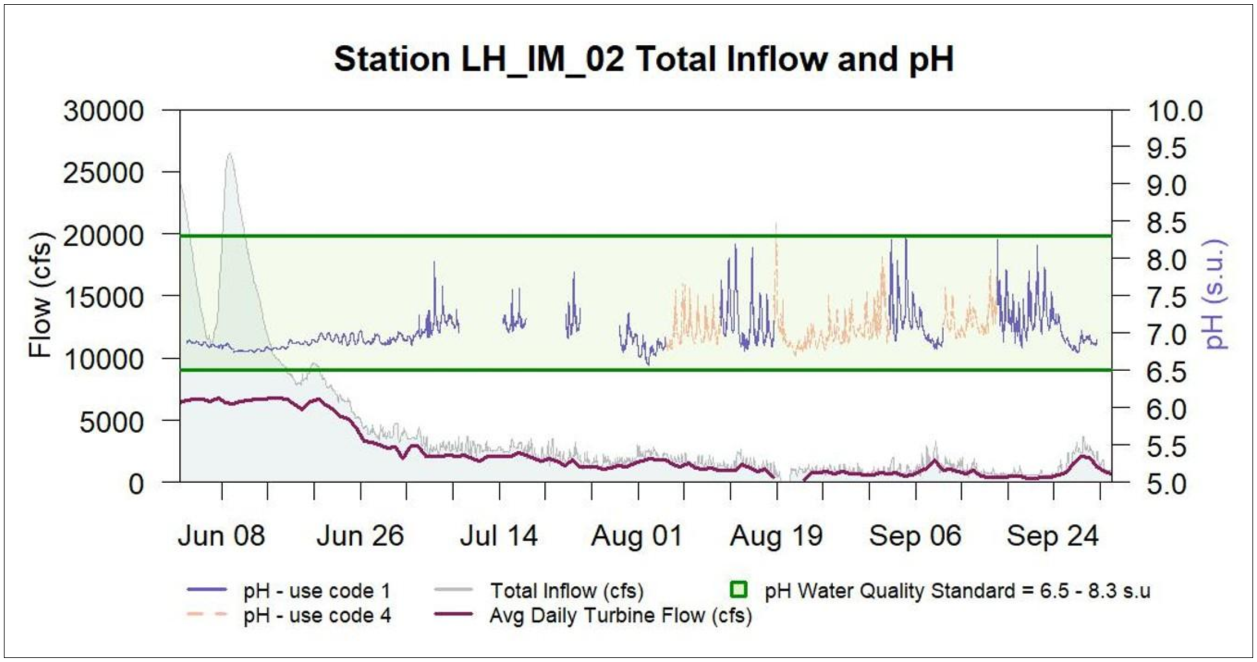
Potential of Hydrogen (pH)

PH was measured at variable levels among all stations and throughout the study period with multiple exceedances of the 8.3 SU water quality standard and only a single exceedance of the 6.5 SO pH standard. The pH loggers were affected by fouling and the presence of algae on and around the sensor which resulted in invalid data that was omitted from station statistics. PH varied from 6.43 to 9.80 SU among all stations during the study, with a global average pH value of about 7.1 SU. PH varied between stations and exhibited seasonal variations as well as short term trends and daily patterns that were associated with flow and algae effects.

Similar to water temperature and DO, pH was associated with flow conditions during the study, exhibiting relatively uniform pH among stations during the high flow period in June when flows exceeded 10,000 cfs in the Merrimack River, increasingly variable pH during the transition to low flows, and highly variable pH at low flows below 3,000 cfs. Runoff events that temporarily increased flows resulted in temporary periods of more uniform pH at all stations, e.g. the flow events on August 01 and September 24.

Above the Project dam, pH generally became more variable from upstream to downstream with consistent diel pH cycles at LH-US-01 and LH-IM-01 and more variable pH patterns at LH-IM-02 (See Figure E.7-8 below), LH-IM-03, and LH-IM-04. Daily pH variations of 0.5 – 2.0 SU were seen in the upstream and impoundment stations, with somewhat less variation at LH-IM-04, likely explained in part by the 17 feet monitoring depth at that station. Below the dam, the greatest variability in pH and the greatest number of exceedances of the 8.3 SU pH standard were documented at LH-BY-01 in the river reach immediately downstream of Essex Dam. The documented presence of significant algae at this monitoring location likely explains the high values and variability in pH measured there. The tailrace station had less pH variability than the station immediately downstream of Essex Dam and was similar to the downstream stations LH-DS-01, LH-DS-02, and LH-DS-03. The tailrace is the primary flow source to the downstream reach under low flows and typical operating conditions so it would be expected to have similar pH conditions (barring localized effects). There were fewer exceedances of the 8.3 SU pH standard progressing downstream from the tailrace through the downstream stations, which may be partially explained by the deeper instrument deployment depths at LH-DS-02 and LH-DS-03 compared to the tailrace and upper part of the reach.

Figure E.7-8. Time Series of pH (SU) at Station LH-IM-02.



In the North Canal and South Canal, pH was generally quite variable and was affected by shallow water and algae growth. There were multiple exceedances of the 8.3 SU pH standard at each of the four monitoring stations in the canals with the highest pH values and greatest number of exceedances at LH-SC-02 and LH-NC-01, with the fewest number of exceedances at LH-NC-01. The Spicket River monitoring stations were characterized by more stable pH values compared to the Merrimack River and canal stations, with typical daily variations of less than 0.5 SU and infrequent periods of greater variability in excess of 1 SU. The Spicket River below the confluence with the North Canal had patterns and values of pH that were similar to the station above the confluence and differed from the North Canal outlet station; therefore, it appears that outflow from the canal did not have a pronounced effect on pH at that station.

Vertical Profiles (Dissolved Oxygen and Water Temperature)

Vertical profile monitoring indicated that thermal stratification was uncommon within the impoundment during the study period. Water temperatures were relatively uniform throughout the water column (See Figure E.7-9 below), with most variation occurring in the upper 2 meters. When surface water temperatures exceeded approximately 24°C, temperature differences of 1–2°C were commonly observed between the surface and 2 m depth, while temperatures below 2 m remained relatively consistent. More pronounced thermal stratification occurred only twice, on August 11 and August 18, when surface-to-bottom temperature differences exceeded 3.5°C during low-flow conditions (<1,500 cfs). Water temperatures generally met the applicable 28.3°C standard, except on July 29 and August 11 when temperatures in the upper 0.5 m equaled or exceeded the standard when surface-to-bottom temperature differences exceeded 3.5°C during low-flow conditions (<1,500 cfs). Water temperatures generally met the applicable 28.3°C standard, except on July 29 and August 11 when temperatures in the upper 0.5 m equaled or exceeded the standard.

In contrast, DO stratification was more evident than temperature stratification. DO concentrations showed substantial vertical variability, with differences greater than 5 mg/L between surface and bottom waters on several occasions. The strongest stratification occurred on August 11 and August 18, when surface-to-bottom DO differences reached 9.5 mg/L and 11.1 mg/L, respectively. During cooler, high-flow conditions in June, DO concentrations were relatively uniform throughout the water column, indicating well-mixed conditions. Low DO concentrations below the 5 mg/L water quality standard were observed in three profile events (August 18, August 25, and September 16) at depths greater than 5 m, suggesting periodic oxygen depletion in deeper waters during late summer conditions. Low DO concentrations below the 5 mg/L water quality standard were observed in three profile events (August 18, August 25, and September 16) at depths greater than 5 m, suggesting periodic oxygen depletion in deeper waters during late summer. Secchi depths ranged from 4 to 8 feet (1.2–2.4 m), exceeding the Massachusetts screening criterion of 3.9 feet (1.2 m) on all sampling dates. These results indicate that the impoundment generally maintained water clarity levels above the MADEP screening threshold for lakes and impoundments. See Figure E.7-9.

Figure E.7-9. Vertical Water Temperature (℃) Profiles at Station LH-IM-04.

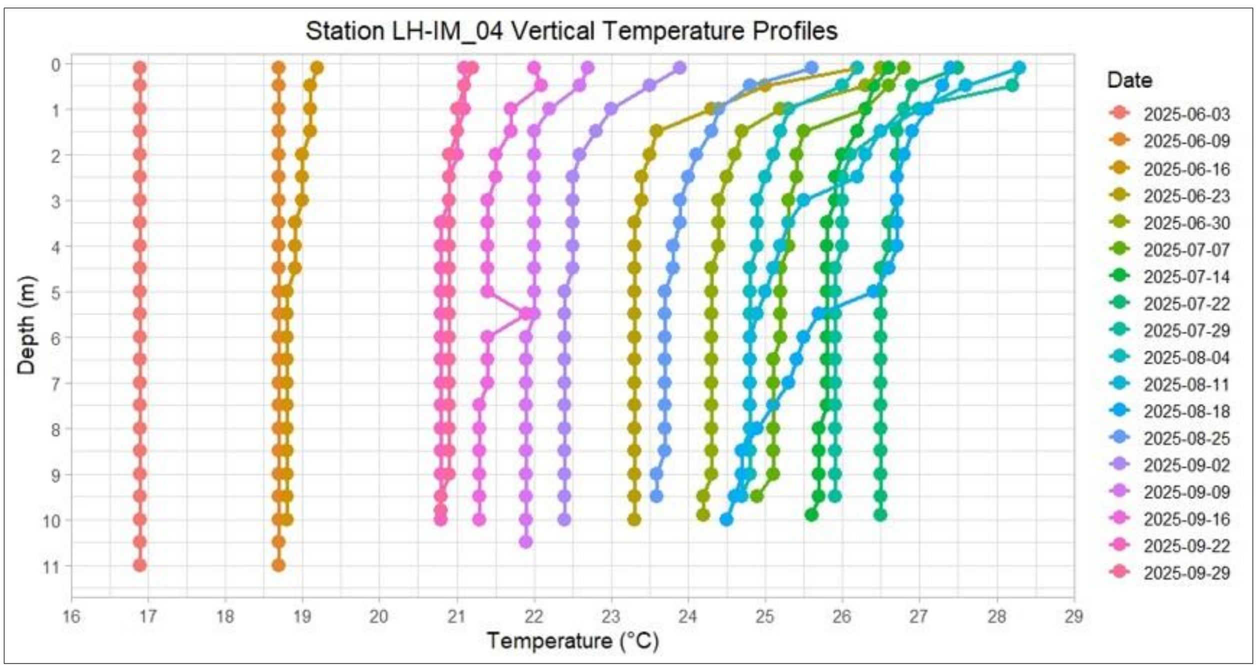
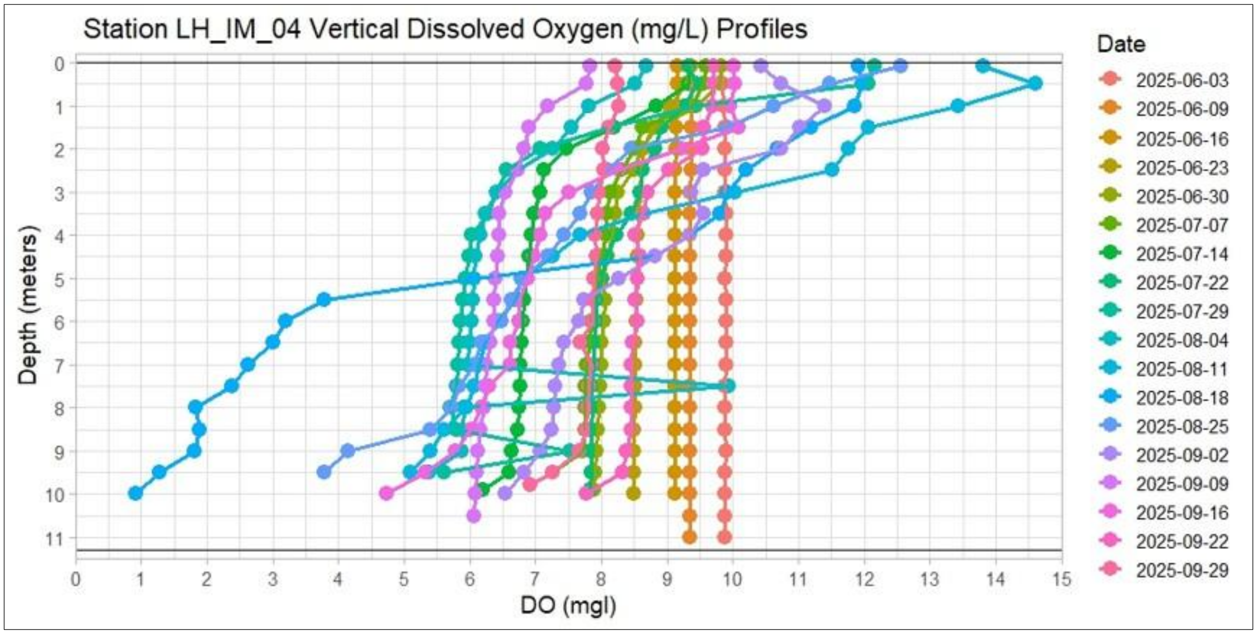


Figure E.7-10. Dissolved Oxygen Concentrations (mg/L) Profiles at Station LH-IM-04.



Laboratory Analysis (Nutrients, Chlorophyll-a, TSS, and True Color)

Nutrient and water quality monitoring suggests the impoundment experiences nutrient enrichment, particularly from phosphorus, leading to elevated chlorophyll-a concentrations and increased algal production relative to upstream conditions. Despite elevated nutrient and chlorophyll-a levels, water clarity indicators remained relatively low and turbidity did not exceed regional reference conditions.

Benthic Macroinvertebrates

Macroinvertebrate samples were collected using the LR-BP methodology (Flotemersch et al. 2006) at reaches identified in consultation with Mass Wildlife and located at points upstream and downstream of Essex Dam. Sampling downstream of Essex Dam was completed on August 20, 2025 and sampling upstream of the dam was completed on August 21, 2025. Weather conditions were consistent throughout the two sampling days, with partly cloudy to cloudy conditions and intermediate periods of rain. Land use at the downstream station was characterized as primarily industrial and commercial whereas the upstream station was characterized as primarily industrial and residential. Both sampling reaches had an estimated riparian zone width varying from 0 to 12 -m and had areas of shoreline armored with rock or concrete walls and rip-rap. Riparian vegetation consisted mostly of trees, shrubs and woody vines and had low to medium coverage at most transects across both sites. Overall, shoreline and riparian habitat was reflective of riverine reaches that have been altered by human activity. Sand substrate was present in varying percent coverage at all sampling zones downstream and only absent from one zone upstream. The coarse mineral substrates at the upstream zones were primarily boulder and cobble whereas downstream it was primarily smaller cobble and gravel. Aquatic vegetation, primarily in the form of rooted submerged plants, were present throughout the upstream and downstream reaches in varying degrees of percent coverage. Snags and woody debris represented generally between 10 and 20% of available habitat in 5 of 12 upstream sampling zones and 7 of the 12 downstream sampling zones.

For the upstream sampling reach, in general, the surrounding land use was characterized primarily as industrial and residential, with estimated riparian zone width varying from 0 to 12 -m and some areas of shoreline displaying heavy armoring with rip-rap and, in one instance, a concrete retaining wall. The upstream sampling reach yielded 526 individuals representing 53 taxa, compared to 501 individuals and 42 taxa at the downstream sampling reach. EPT Ephemeroptera [7], Plecoptera [0], and Trichoptera [10]) taxa represented 32.1% and 21.7% of the total taxa richness for BMI samples collected upstream and downstream of Essex Dam, respectively. The Shannon diversity index values were similar between the two stations (upstream = 2.81; downstream = 2.45), indicating a similar degree of dominance within taxa for both reaches. The most abundant taxon, *Gammarus fasciatus*, was the same for each site comprising 28.7% of specimens upstream and 38.3% of specimens downstream. *Gammarus fasciatus* is an amphipod with moderate tolerance of nutrient enrichment and is a collector-gatherer, opportunistically feeding on available detritus or benthic debris. HBI values were 5.98 upstream and 6.42 downstream, both values supporting a finding of “fair” water quality in terms of nutrient input or organic pollution.

For the downstream sampling reach, surrounding land use was primarily industrial and commercial, with estimated riparian zone width varying from 0 to 12 -m with some areas of the shoreline armored with rip-rap or consisting of sand. A cumulative total of 501 specimens were identified from the composite sample collected from the reach downstream of Essex Dam, representing 42 genus-level taxonomic classifications. EPT (Ephemeroptera [2], Plecoptera [0], and Trichoptera [7]) represented 9 of the 42 total taxa, comprising 21.4% of total taxa richness. The dominant taxon identified in the sample was *Gammarus fasciatus*, which represented 38.3% of all individuals within the assemblage. Collector-gatherers comprised 58.3% of individuals in the downstream sample. The Shannon Diversity index (H’) score of 2.45 indicates a trend towards balance in the distribution of individuals within the community and limited dominance among taxa. The calculated HBI value for the downstream reach was 6.42, supporting a finding of “Fair” water quality in terms of organic pollution and nutrient enrichment (Hilsenhoff 1987).

Sturgeon Habitat Mapping and Assessment (ASA 2026a)

As part of the Sturgeon Habitat Mapping and Assessment Study, water quality measurements (temperature, conductivity, dissolved oxygen [DO]) were collected during the verification sampling survey with an In Situ Aqua Troll 500 (“CTD” or “sonde”). The conductivity sensor was calibrated prior to the site reconnaissance survey. The DO sensor was calibrated each day, prior to launching the vessel. Upon arriving at each verification station, water quality measurements were collected prior to the other sampling activities. Due to the shallow depths encountered, spot measurements were collected at approximately mid-depth in the water column, as judged by the vessel’s depth-finder and the length of the sonde’s cable. Data were logged using the Bluetooth® controller for the sonde which stored a data record for each station, along with GPS information. Summary statistics of the data from the verification transects are provided below in Table E.7-16. Water temperature ranged from 25.9 to 28.4 °C, specific conductance ranged from 249 to 284.4 µS/cm and DO ranged from 7.2 to 9.98 mg/L. Temperature and DO generally decreased from upriver to downriver, while specific conductance increased from upriver to downriver.

Table E.7-16. Summary Statistics of Water Quality Measurements During the Sturgeon Habitat Survey on the Merrimack River July 22-24, 2025.

Verification Transect	Temperature (°C)					Specific Conductance (µS/cm)					Dissolved Oxygen (mg/L)				
	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
1[1]															
2	3	26.89	27.14	26.98	0.14	3	249.1	250.9	249.8	1.0	3	9.63	9.98	9.75	0.20
3	3	27.54	28.40	27.83	0.49	3	249.0	284.4	268.4	17.9	3	9.30	9.83	9.56	0.26
4	3	27.12	27.22	27.19	0.06	3	262.8	269.5	266.8	3.5	3	8.51	8.69	8.59	0.09
5	3	26.75	26.95	26.82	0.11	3	260.8	266.3	264.1	2.9	3	8.02	8.43	8.23	0.21
6	3	26.47	26.70	26.55	0.13	3	255.4	265.7	261.5	5.5	3	8.15	8.64	8.33	0.27
7[1]															
8[2]	1	26.62	26.62	26.62		1	279.9	279.9	279.9		1	8.13	8.13	8.13	
9	3	26.26	26.57	26.40	0.16	3	278.2	279.2	278.7	0.5	3	7.41	8.27	7.79	0.44
10	3	25.90	26.07	25.96	0.10	3	277.8	281.5	279.4	1.9	3	7.20	8.21	7.56	0.57
All	22	25.90	28.40	26.81	0.59	22	249.0	284.4	267.5	11.5	22	7.20	9.98	8.53	0.82

[1] Transects 1 and 7 were not accessible due to low water.
[2] One Station was sampled on Transect 8; the others were not accessible due to low water.

Phase 1 Project Operations and Fish Stranding Study (HDR 2026a)

The Phase I Project Operations and Fish Stranding Study provides a review of Project operations over the six-year period from January 1, 2019 through December 31, 2024. The study evaluated Project inflows, impoundment elevations, turbine flows, minimum flows, fish passage operations, and downstream conditions to characterize ROR operations and assess potential relationships between Project operations and observed fish stranding events.

The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Figure E.7-11 illustrates the total Project outflow in cfs throughout the study period in relation to the inflow from the Merrimack River gage at Lowell. In general, the inflow rates and total Project discharge rates are closely aligned, with rises and falls in inflow rates having direct proportional effects on the total Project discharge rates. Annual trends include a spike in flow rates in May during spring snowmelt and often another spike again in December.

Similarly, total Project outflow is closely tracked by tidally filtered flows recorded at the USGS Gage No. 011006988 Haverhill, approximately 12.83 miles downstream of the Project site. For the period of record, the Haverhill gage only has data available from 2022 through the end of 2024. Annual comparisons of the total Project discharge rates and the recorded tidally filtered flow rates at Haverhill for 2023 and 2024 indicate that Project outflows generally line with the pattern of recorded flows at USGS Gage No. 011006988 Haverhill (Figure E.7-12 and Figure E.7-13).

Figure E.7-11. Total Project Flows and USGS Lowell Gage Hourly Discharge from 2019 through 2024.

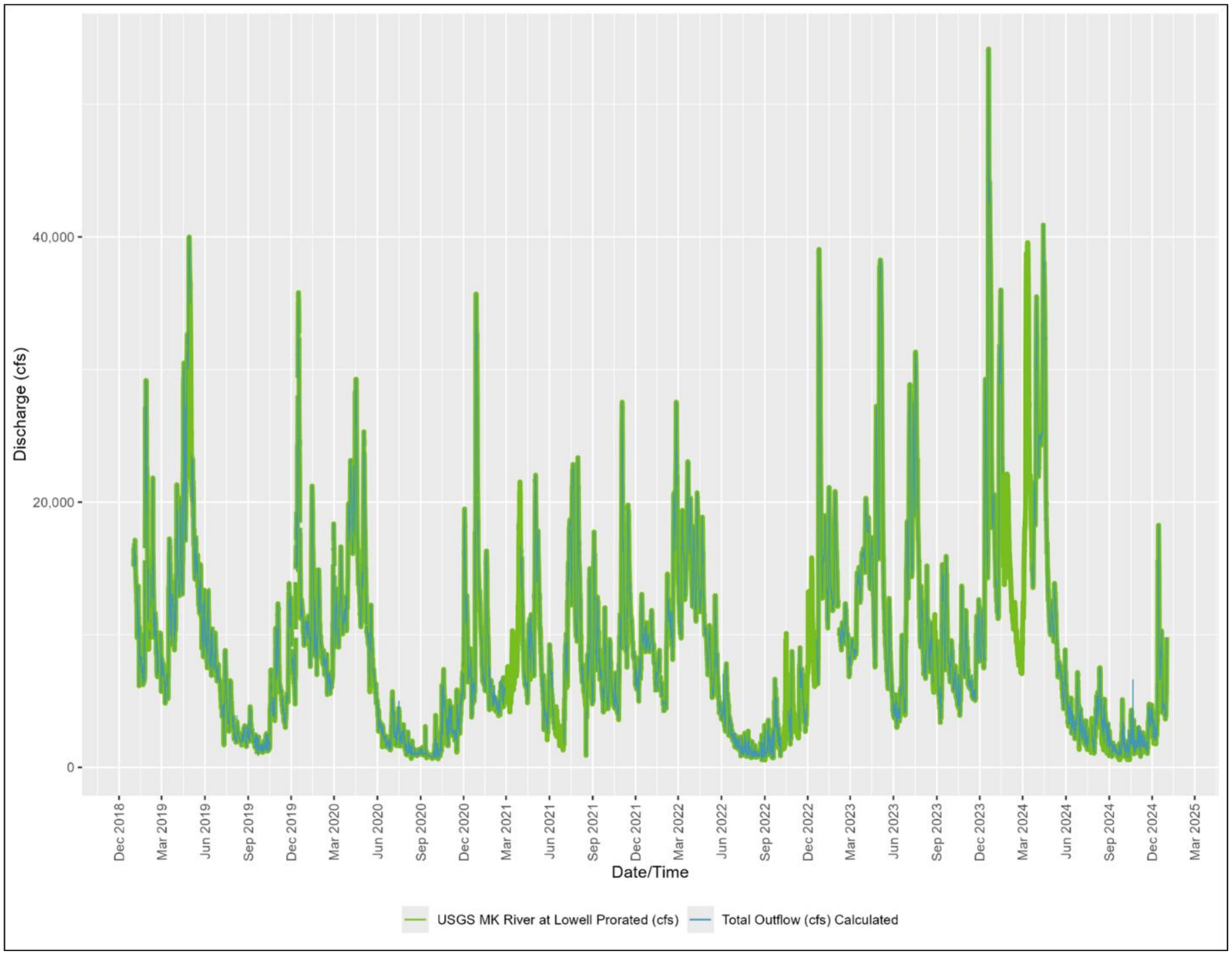


Figure E.7-12. Total Project Discharge and Merrimack River Downstream Flow (USGS No. 011006988) 2023.

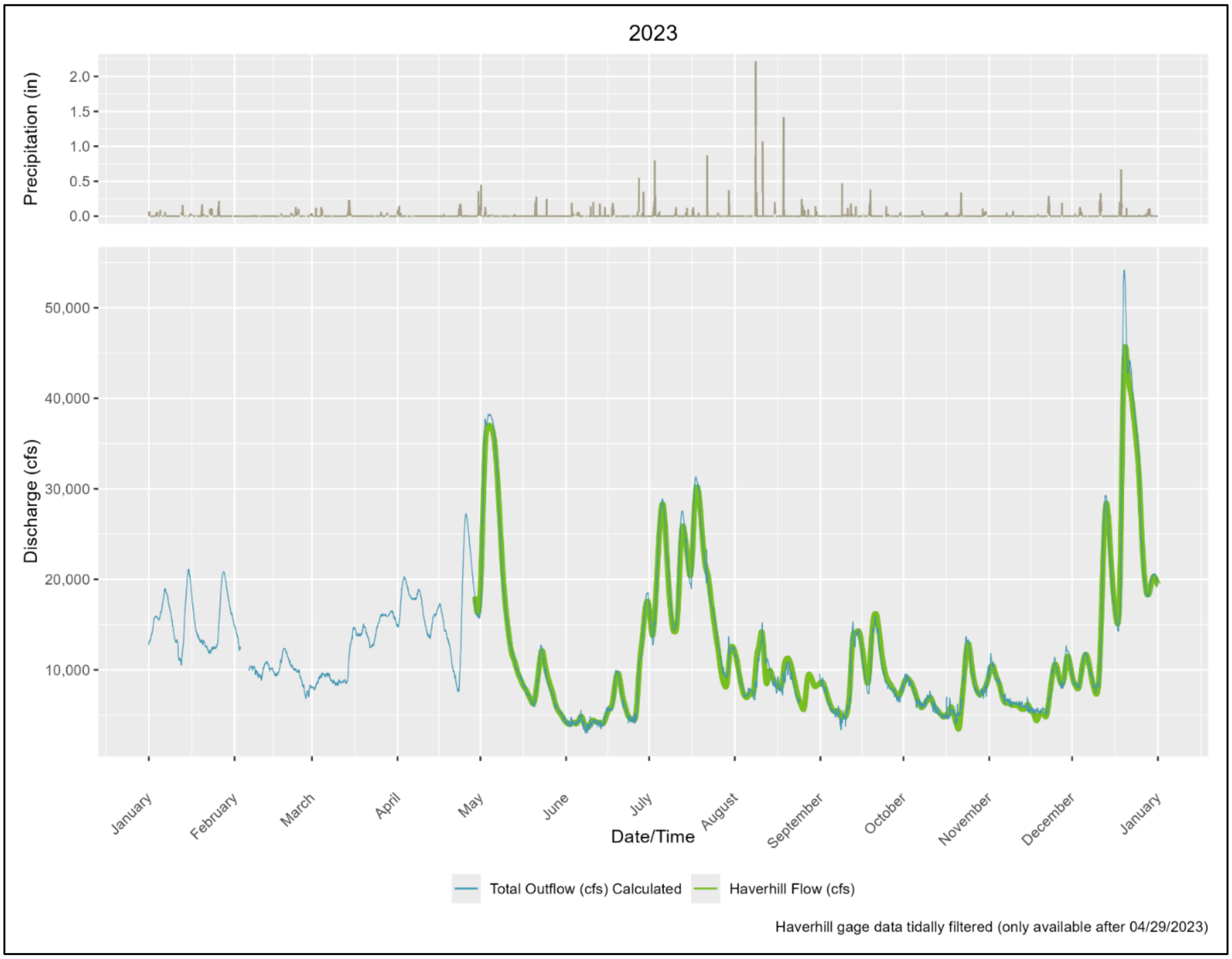
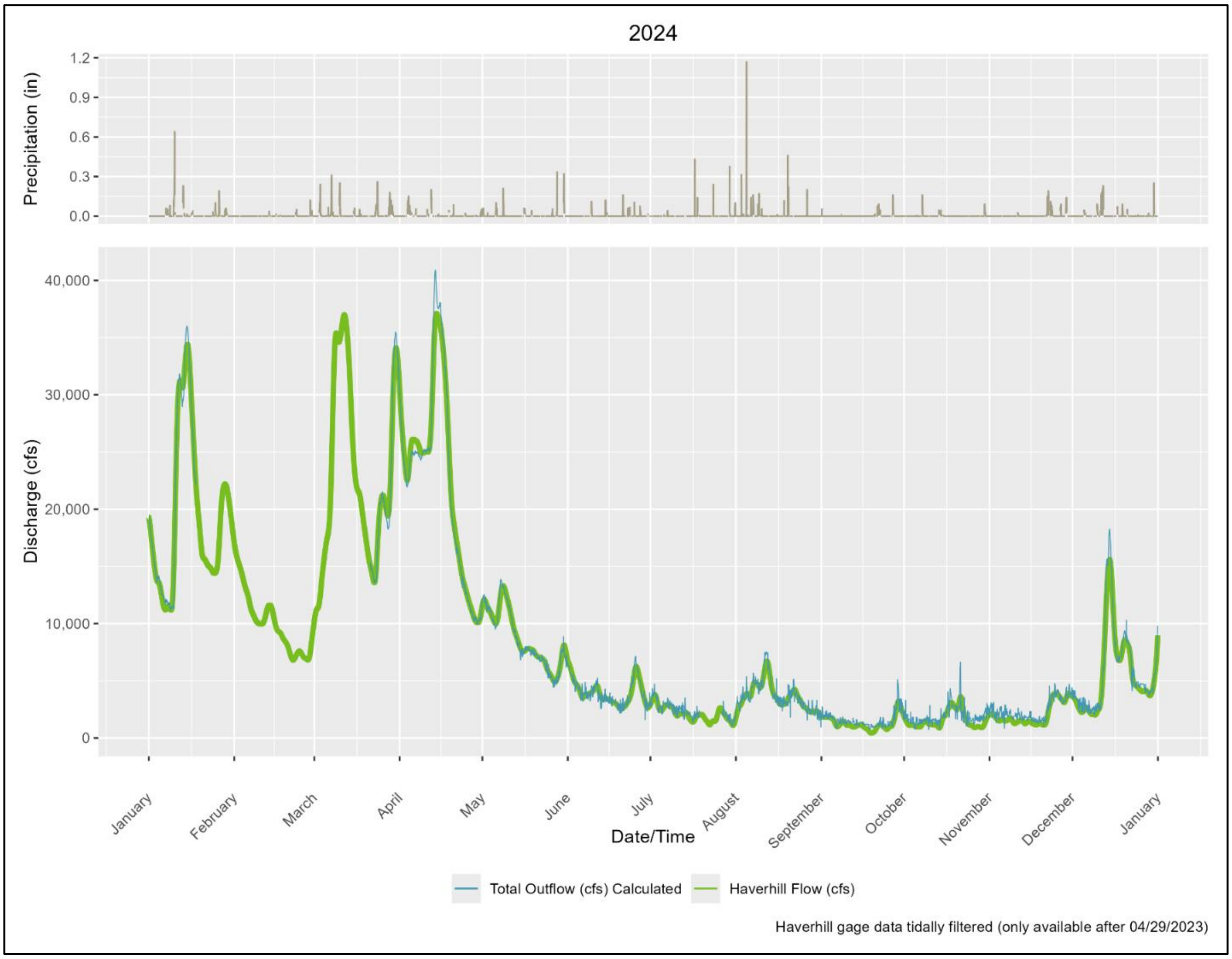
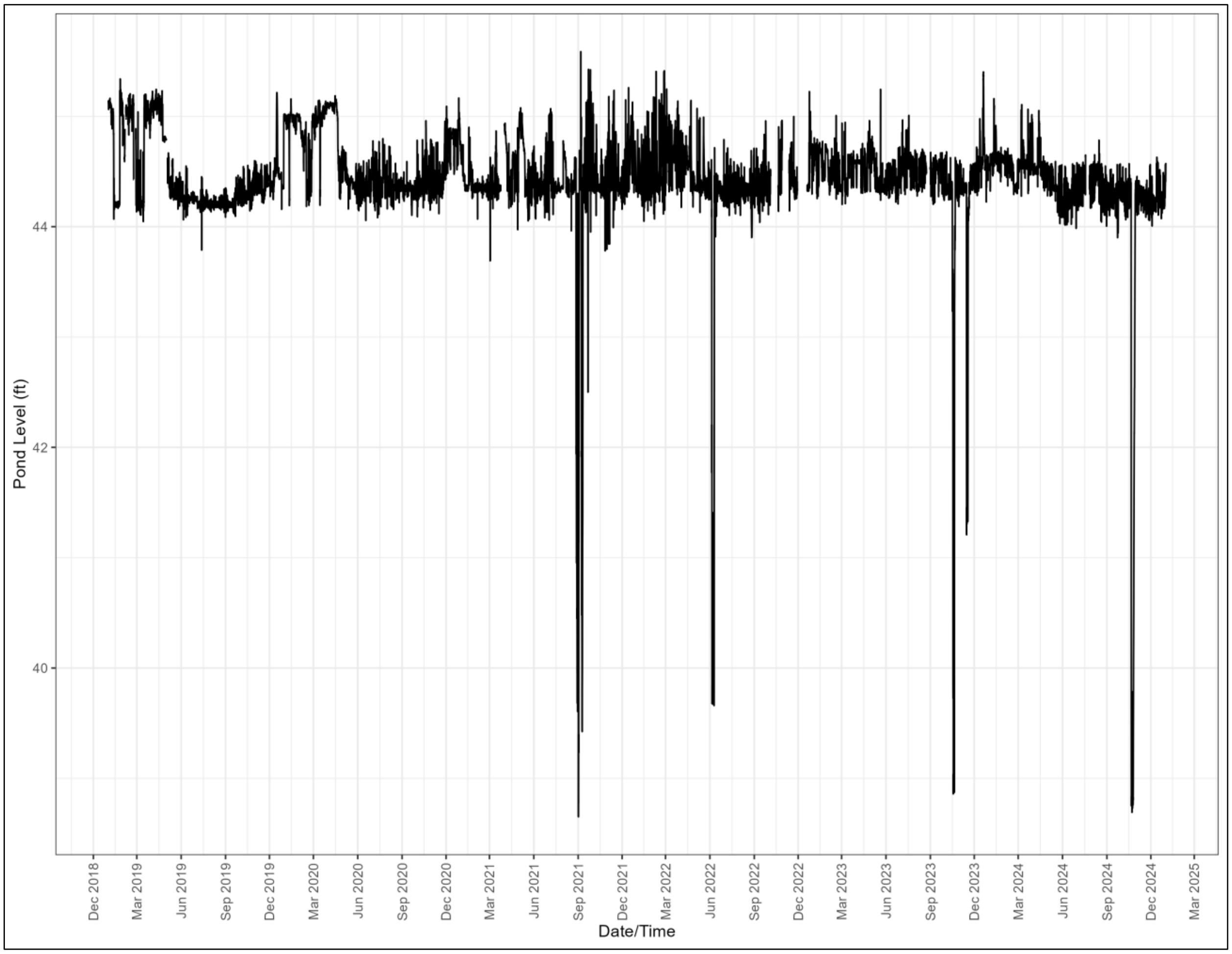


Figure E.7-13. Total Project Discharge and Merrimack River Downstream Flow (USGS No. 011006988) 2024.



Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system with the exception of five drawdown periods (Figure E.7-14). The average pond level during the study period was 44.4 feet with average monthly levels ranging from 43.3 to 44.7 feet (Figure E.7-14). Pond levels were typically highest in the winter from December through April (Figure E.7-14). There were four drawdowns of the impoundment to below the spillway crest (± 5.5 feet), which were necessary to perform maintenance and repairs on the crest gate system, and one of about 3 feet below normal pond required to facilitate installation of the eel elevator at the left abutment. Each of these drawdowns was conducted in consultation with the resource agencies and notification to potentially affected stakeholders.

Figure E.7-14. Impoundment Elevations (ft NVGD 29) from 2019 through 2024.



E.7.2.1.3 Impaired Waters

As required by the Federal CWA, every two years MADEP develops a list of waters that do not meet water quality standards. Waters in the vicinity of the Project were listed on the MADEP Section 303(d) list of waters requiring a total maximum daily load (TMDL) (MADEP 2021). Section 303(d) of the CWA requires states to identify waterbodies that are not expected to meet surface water quality standards after the implementation of technology-based controls and to prioritize and schedule them for the derivation of TMDLs (MADEP 2021). The specific impairments for waters in the Project vicinity are provided in Table E.7-17.

Table E.7-17. Impaired Water Segments in the Vicinity of the Lawrence Project.

Segment Boundary	Segment ID	Length (miles)	Impairments
Pawtucket Dam, Lowell to Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell.	MA84A-02	3.2	Dewatering[1] Fish Passage Barrier[1] *Escherichia Coli (E. Coli)* Mercury in Fish Tissue Phosphorus, Total

Segment Boundary	Segment ID	Length (miles)	Impairments
Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell to Essex Dam, Lawrence	MA84A-03	8.8	Fish Passage Barrier[1] *E. Coli* Mercury in Fish Tissue polychlorinated biphenyls (PCBs) in Fish Tissue Phosphorus, Total
Essex Dam, Lawrence to confluence with Little River, Haverhill	MA84A-04	10.0	*E. Coli* PCBs in Fish Tissue Phosphorus, Total

Source: MADEP 2021.
[1] TMDL not required (non-pollutant).

E.7.2.1.4 Reservoir Data

The Project's reservoir is 9.8 miles long and has a surface area of 732 acres (as proposed) at the normal impoundment elevation of 44.2 NGVD29 and a gross storage capacity of approximately 19,900 acre-feet. There is no useable storage capacity.

E.7.2.1.5 Downstream Reach Gradients

The hydraulic gradient of the Merrimack River immediately downstream of the Essex Dam drops from approximately 15.0 feet NGVD29 at the toe of the dam to approximately 12.0 feet NGVD29 at the Duck Bridge approximately 3,700 feet downstream, resulting in an average river gradient of 0.08% within this reach. The Merrimack River becomes tidally influenced about 6.2 miles downstream of the Essex Dam, in Haverhill, MA.

E.7.2.2 Environmental Analysis

FERC's SD2 identified the following potential resource issues related to Water Quantity and Quality:

- Effects of project operation and maintenance on water quantity in the impoundment, canal system, bypassed reach[6], and in the Merrimack River downstream of the project.
- Effects of project operation and maintenance on water quality in the impoundment, canal system, bypassed reach, and in the Merrimack River downstream of the project.
- Effects of project operation and maintenance on greenhouse gas emissions from the project impoundment, including carbon dioxide and methane.

Effects of Project Operation and Maintenance on Water Quantity in the Impoundment, Canal System, Bypassed Reach, and in the Merrimack River Downstream of the Project.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations and maintenance over the six-year period from January 1, 2019,

[6] The "bypassed reach" is defined herein as the area between the toe of the Essex Dam and a line parallel to the dam extending from the northeasterly tip of the old fish ladder to the north bank of the Merrimack River.

through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system. Given the seasonal and annual flows of the Merrimack River, and that there is no significant bypassed reach, the residence time of water flowing through the Project and its impoundment is limited, and effects on water quantity are minimal.

Effects of Project Operation and Maintenance on Water Quality in the Impoundment, Canal System, Bypassed Reach, and in the Merrimack River Downstream of the Project.

The Project is operated in ROR and there is no bypassed reach. Essex conducted a Water Quality Study (NAI 2026a) with a focus on DO, water temperature, and pH under various river flows, river temperatures, and Project operating conditions to determine the spatial and temporal effects of Project operations on water quality during late spring and summer (i.e., June 2 to October 1). Monitoring conducted from June 2 through October 1, 2025 documented generally good water quality conditions across the Project area, with most measurements meeting applicable standards most of the time.

As identified in the report, a significant limitation in evaluating Project specific effects is the influence of cumulative watershed inputs in the Project vicinity, including a wastewater treatment facility discharge immediately upstream of the impoundment, significant CSO discharges from the upstream cities of Lowell and Manchester, as well as nonpoint pollution sources throughout the watershed. Project influences on water quality include impoundment effects to the Merrimack River, variation in flow sources and pathways through the Project infrastructure (as spill, turbine flow, and flows through the upstream and downstream fish passage structures), flow diversions to the canals, and discharges from the canals to the Merrimack River and Spicket River.

The Water Quality Study (NAI 2026a) indicated that impoundment effects to the Merrimack River (MA84A-03) were periodic occurrences of temperature and DO stratification with development of low DO water at lower depths of the impoundment. Thermal and chemical stratification are known phenomena in impounded rivers, and it is unsurprising that stratification would develop in the Project impoundment. Stratification events were uncommon and transient with occurrences primarily during low flow/high temperature periods. While low DO bottom water did develop in the impoundment, there was no evidence that it was entrained into the Project intake and transmitted downstream (i.e., to MA84A-04) as the tailrace monitoring station did not have any documented exceedances of the 5 mg/L DO standard during this study and there was only one documented exceedance of the DO standard at any of the three downstream monitoring stations, in MA84A-04. In summary, continuous monitoring demonstrated that DO levels throughout the Project area were generally high and supportive of aquatic life. Low DO events were spatially limited and temporary.

Variation in flow sources at the dam (including spill, turbine outflow, and diversion of flows to the canals and fish passage structures) influenced downstream water quality conditions at MA84A-04. The most pronounced effect was at the river reach immediately downstream of Essex Dam, where variations in turbine outflows to the tailrace were associated with changes in water level in the river reach immediately downstream of Essex Dam, including periods of low water level and low flow through the “bypass” area. Low water levels in the river reach immediately downstream of Essex Dam were associated with accumulation of algae in this area, which likely affected DO and pH, as evidenced by the pronounced diel pH and DO cycles at the monitoring station in the river reach immediately downstream of Essex Dam.

The monitoring stations in the downstream reach were also affected by variations in flow sources including a transition from spill over the dam as the primary flow source to outflow from the tailrace as the primary flow source. Temperature, DO, and pH were most stable under conditions where spill was the primary flow source to the downstream reach below the Project dam. However, temperature, DO, and pH were most stable at all monitoring stations under high flow conditions, so the effect of spill on downstream water quality is unlikely to be the most significant factor. Exceedances of temperature, DO, and the lower pH standards were uncommon downstream of the dam, regardless of operations. In contrast, there were multiple exceedances of the upper pH standard of 8.3. The high pH measurements in the downstream reach are consistent with measurements at the tailrace monitoring station and indicate that this water quality condition likely results from upstream conditions passing through the turbines to the tailrace and downstream reach. Highly variable pH measurements and pH exceedances were also documented in the impoundment and, to a lesser extent, the upstream monitoring station, and likely indicate a watershed pH issue related to the nutrient impairments in the watershed. Overall, continuous monitoring demonstrated that pH conditions throughout the Project area were strongly influenced by seasonal flow patterns, water depth, and algal productivity. Although exceedances of the upper pH standard occurred at several locations, particularly during low-flow conditions and in areas with significant algae growth, pH conditions were generally consistent with expected natural and site-specific environmental processes.

Water quality in the North and South Canals was directly affected by Project operations, as flows to the canals are primarily controlled by diversions and/or leakage from the impoundment, estimated at 100 cfs combined between the two canals. Both canals were characterized by multiple exceedances of the upper pH water quality standard, and the North Canal also had exceedances of the temperature and DO standards. Water quality monitoring was limited in the South Canal due to the canal being dewatered for construction for multiple weeks during the summer. The elevated water temperatures measured in the North Canal were likely a result of the shallow water in the canal, which would be prone to more amplified daily temperature cycles compared to deeper water environments in the Project study area. The high pH values measured in the canals, as well as the pronounced diel pH/DO cycles and high DO supersaturation values, are all consistent with excess nutrient issues in the canals (which are a known impairment in the watershed) and heavy algal/plant growth (which were documented as persistent and extensive in the canals during the study).

The Project may affect a reach of the Lower Spicket River (MA84A-10) and the Merrimack River below the Project dam (MA84A-04) at and below the North Canal and South Canal discharges, respectively. The Spicket River below the North Canal discharge did not have any exceedances of the DO or lower pH water quality standards but did have several exceedances of the upper pH standard and the temperature standard. Data are limited from the Spicket River monitoring station above the North Canal discharge (due to low flows and logistical challenges for using deployed loggers), so it is difficult to make a direct comparison, yet the Spicket River below the North Canal has water quality that is comparable to or better than the other riverine monitoring stations utilized.

The South Canal discharges to the Merrimack River between two monitoring stations in the reach downstream of the dam (LH-DS-01 and LH-DS-02). Water quality was similar between downstream stations, with exceedances of the high pH standard at all three downstream monitoring stations and a single exceedance of the DO standard and two exceedances of the temperature standard below the South Canal discharge. Water quality at LH-DS-03, which was the lowermost station used in this study, can be used to characterize the aggregate downstream effects of Project operations. During the study, there were no exceedances of the DO or lower pH water quality standards at Station LH-DS-03, there were two exceedances of the temperature standard, and there were seven exceedances of the upper pH standard. These results are similar to the upstream station, located above the Project influence, with the caveat of data gaps in water quality records at both stations.

The Water Quality Study demonstrates that the Project influences certain localized water quality conditions; however, observed impacts were generally minor, temporary, and site-specific. While conclusive statements of the effects of Project operations on water quality are challenging due to the urbanized watershed in which the Project is located, the data collected for this study indicate that excess nutrients are the primary water quality issue in the Project area, as evidenced by high nutrient values, documented excessive algal growth at multiple sites, exaggerated diel cycles of DO and pH, high pH and high DO supersaturation during daylight hours, as well as periodic episodes of temperature/DO stratification in the impoundment. Nutrient pollution is a watershed-wide issue rather than a direct consequence of Project operations and is best addressed through a watershed approach to nutrient management. It is unlikely that Project operations can unilaterally be used to manage nutrient issues in the watershed or the immediate Project area. Consequently, the available data support the conclusion that continued Project operation under existing PM&E measures is unlikely to cause significant adverse effects on water quality and quantity, while meaningful improvements will depend primarily on reducing nutrient inputs across the broader watershed.

Effects of Project Operation and Maintenance on Greenhouse Gas (GHG) Emissions from the Project Impoundment, including Carbon Dioxide and Methane.

The Project is operated in ROR mode and passes inflows through the impoundment, indicating limited retention time of water within the Project area. Based on the Project's operational mode and lack of extended water storage, effects of Project operation and maintenance on greenhouse gas emissions from the impoundment would be expected to be minimal. GHG emissions from impoundments are often calculated based on user-provided inputs and those inputs include water residence time in years (Prairie et al. 2021).

E.7.2.3 Proposed Environmental Measures

Essex proposes continued operation of the Project in ROR mode with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit any potential effects on water quality and quantity.

E.7.2.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to have any unavoidable adverse impacts on water quality or quantity.

E.7.3 Fish and Aquatic Resources

The subsections below describe fish and aquatic resources in the vicinity of the Project and consider the effects of Essex's proposed continued operation of the Project on fish and aquatic resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and data collected from:

- Upstream Anadromous Fish Passage Assessment (NAI 2026b)
- Upstream American Eel Passage Assessment (NAI 2025a)
- American Eel Upstream Passage Siting Study (NAI 2025b)
- Desktop Entrainment, Impingement, and Turbine Passage Survival Study (NAI 2026c)
- Sturgeon Distribution and Project Interaction Study (ASA 2026b)
- Phase I and II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2025c; NAI 2026d)
- Phase 1 Project Operations and Fish Stranding Study (HDR 2026a)
- Three-Dimensional Computational Fluid Dynamics (CFD) Modeling Study Report (HDR 2026b)
- Downstream Juvenile Alosine Passage Assessment (NAI 2026e)
- Sturgeon Habitat Mapping and Assessment Study (ASA 2026a)
- Fish Assemblage Assessment (NAI 2026f)
- Freshwater Mussel Habitat Assessment and Survey (NAI 2025d)
- Invasive Plant Survey (HDR 2026c)

These reports are included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.3.1 Affected Environment

The Lawrence Project is located at RM 29 of the Merrimack River. The Merrimack River is formed by the confluence of the Pemigewasset and Winnipesaukee rivers in Franklin, New Hampshire, from which it flows 115 miles to the Atlantic Ocean (MEOEEA 2001). The Merrimack River is part of the Merrimack River watershed, which includes several smaller watersheds (Powwow River, Little River, Spicket River, Beaver Brook, Stony Brook, and Salmon Brook) and has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts.

Historically, the Merrimack River served as a major resource for fisheries; however, an increase in industrial and urban pollution coupled with the construction of numerous dams along its length during the past two hundred years has resulted in decreased value of the Merrimack River as an important aquatic habitat. Fish populations most affected by these changes have been sensitive migrating species, such as anadromous fish that live in salt water and spawn in fresh water, and catadromous species that inhabit rivers and spawn in the ocean.

In more recent years, the quality of the Merrimack River has improved, and state and federal fish and wildlife agencies have made a concerted effort to restore diadromous fish populations in the Merrimack River. While present-day abundance of migratory species remains relatively low compared to historical levels, restoration efforts over the past 40 years have improved habitat and connectivity conditions, resulting in a modest increase in diadromous fish abundance. Restoration efforts have included stocking the headwaters of the river with juvenile Atlantic salmon (*Salmo salar*) and building fish ladders at dams to allow target fish species access to the upper reaches of the Merrimack River. Other anadromous fish that return to the Merrimack River include alewife (*Alosa pseudoharengus*), blueback herring (*A. aestivalis*), American shad (*Alosa sapidissima*) and sea lamprey (*Petromyzon marinus*). The only catadromous species reported in the lower portion of the Merrimack River is the American eel (*Anguilla rostrata*).

E.7.3.1.1 Aquatic Habitat

Aquatic habitat within the Merrimack River watershed includes quickwaters in the northern portion of the watershed and an estuarine environment in the lower reaches of the Merrimack River, with both coldwater and warmwater fisheries occurring in the watershed. The Merrimack River watershed provides critical habitat for anadromous, catadromous, and resident fish species as well as numerous other aquatic species (USACE 2003). Some of these species and their habitat have been impacted by poor water quality, stream channel alterations, development, and agriculture. The tidally influenced lower 22 miles of the mainstem river also support a wide range of aquatic species, including extensive shellfish beds, but this area is considered a vulnerable resource since it is located at the downstream end of the watershed. Impacts to the resources of the estuary result from nutrient and bacterial loading, sedimentation, shoreline erosion, and changes in populations of anadromous and catadromous fish species. The Merrimack River in the vicinity of the Lawrence Project is on the 303(d) list of impaired waters for pathogens and nutrients (MEOEEA 2001).

Natural reproduction of anadromous species in the Merrimack River was limited due to several previously impassable barriers that blocked access to historic spawning sites, with the first impediment to upstream fish passage being Essex Dam in Lawrence. Fish passage facilities have been maintained at Essex Dam since 1848, and anadromous fish, specifically Atlantic salmon, American shad, and river herring (alewife and blueback herring) are managed by the MRTC.

The MRTC oversees the management of the Lawrence Project fisheries as guided by the Project's CFPP, which was filed pursuant to Article 31 of the Project's existing license and approved by FERC in July 2000. Since that time, Essex and the MRTC have developed and maintained the Fishways Operation and Maintenance Plan (FOMP) to support implementation of the Project's CFPP and optimize fishway operations for target species. The FOMP serves as a living, adaptive management document that has been periodically updated and shared through the parties' ongoing cooperative efforts. The CFPP and subsequent FOMP includes details of operational measures undertaken by Essex to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project include a fish lift, downstream fish bypass, eel lift and eel ladder. The fish passage facilities at the Project were designed in consultation with the USFWS and current fish passage operations are guided by MRTC's state and federal fishery agencies per the CFPP/FOMP.

In accordance with the FOMP, the fish lift is typically operated annually from late April through mid-July, however the start of the season varies slightly and is also based on downstream fish movement activity and thus, the seasonal operation schedule is determined in consultation with the MRTC. Operation of the upstream fish passage lift generally occurs hourly between 8:00 a.m. and 4:00 p.m. daily during operational periods and during river flows of 500 cfs to 25,000 cfs (LHA 1999). The downstream fish bypass facility is a concrete bypass chute that is typically operated annually from

April 1 through July 15 and from September 1 through November 15, on a 24-hour basis. Upstream eel passage operations occur annually between May 1 and September 30 (Essex 2014). Upstream passage is provided by a combination of the Project's upstream eel ladder, which is located adjacent to the powerhouse at the toe of Essex Dam, and the Project's eel elevator (or "eel lift"), which is located at the left (north) abutment of Essex Dam. The elevator consists of a collection/transport hopper connected to an integral ramp at the toe of Essex Dam.

Essex collects information regarding the abundance of diadromous fishes using the fishways annually. This activity is a monitoring effort to inform the Technical Committee that manages these fishery resources. Essex staff records diadromous fish counts at the fish lift throughout the upstream migration season and provides a summary of these counts as part of its annual fishway operations report to the MRTC.

E.7.3.1.2 Existing Fish and Aquatic Resources

The Merrimack River basin contains 34 native fish species, 9 of which are diadromous, and at least 14 introduced species, the majority of which are game species (Table E.7-18) (MEOEEA 2001). Common freshwater game species currently found in the Lower Merrimack River include yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), northern pike (*E. lucius*), brown bullhead (*Ameiurus nebulosus*), smallmouth and largemouth bass (*Micropterus dolomieu* and *M. salmoides,* respectively), walleye (*Sander vitreus*), common carp (*Cyprinus carpio*) and Centrarchid sunfishes (Lower Merrimack River Local Advisory Committee [LMRLAC] 2008). The fisheries and aquatic resources of the Merrimack River in the vicinity of the Lawrence Project are managed jointly by MDFW, NHDFG, and the USFWS. These agencies jointly manage the Merrimack River, including the Lawrence Project, as a warm water recreational fishery, as well as for conservation of diadromous species. Alewife, American eel, American shad, striped bass, and sea lamprey are currently managed diadromous species that are found at the Lawrence Project during certain life stages.

Table E.7-18. Fish Species of the Merrimack River Watershed.

Family	Common Name	Scientific Name
Acipenseridae	Atlantic sturgeon	*Acipenser oxyryhnchus*
	shortnose sturgeon	*Acipenser brevirostrum*
Amiidae	bowfin	*Amia calva*
Ammodytidae	sand lance	*Ammodytes hexapterus*
Anguillidae	American eel	*Anguilla rostrata*
Atherinopsidae	Atlantic silverside	*Menidia menidia*
Catostomidae	white sucker	*Catostomus commersoni*
Centrarchidae	banded sunfish	*Enneacanthus obesus*
	black crappie	*Pomoxis nigromaculatus*
	bluegill	*Lepomis macrochirus*
	largemouth bass	*Micropterus salmoides*
	pumpkinseed	*Lepomis gibbosus*
	redbreast sunfish	*Lepomis macrochirus*
	smallmouth bass	*Micropterus dolomieu*
Cyprinidae	blacknose dace	*Rhinichthys atratulus*
	bridle shiner	*Notropis bifrenatus*

Family	Common Name	Scientific Name
	common carp	*Cyprinus carpio*
	common shiner	*Luxilis cornutus*
	fallfish	*Semotilus corporalis*
	golden shiner	*Notemigonus crysoleucas*
	goldfish	*Carassius auratus*
	longnose dace	*Rhinichthys cataractae*
	spottail shiner	*Notropus hudsonius*
Clupeidae	alewife	*Alosa pseudoharengus*
	American shad	*Alosa sapidissima*
	blueback herring	*Alosa astivalis*
	gizzard shad	*Dorosoma cepedium*
Esocidae	chain pickerel	*Esox niger*
	northern pike	*Esox lucius*
Fundulidae	banded killifish	*Fundulus diaphanus*
	mummichog	*Fundulus heteroclitus*
Gasterosteidae	3-spine stickleback	*Gasterosteus aculeatus*
	4-spine stickleback	*Apeltes quardracus*
	9-spine stickleback	*Pungitius pungitius*
Ictaluridae	brown bullhead	*Ictalurus nebulosus*
	channel catfish	*Ictalurus punctatus*
	margined madtom	*Noturus insignis*
	white catfish	*Ictalurus catus*
	yellow bullhead	*Ictalurus natalis*
Moronidae	striped bass	*Morone saxatilis*
	white perch	*Morone americana*
Osmeridae	Atlantic smelt	*Osmerus mordax*
Percidae	swamp darter	*Etheostoma fusiforme*
	tessellated darter	*Etheostoma olmstedi*
	walleye	*Sander vitreus*
	yellow perch	*Perca flavescens*
Petromyzontidae	sea lamprey	*Petromyzon marinus*
Salmonidae	Atlantic salmon	*Salmo salar*
Syngnathidae	northern pipefish	*Syngnathus fuscus*

Source: MEOEEA 2001.

E.7.3.1.3 Fish Passage and Protection Studies

The first dam on the Merrimack River, the Essex Dam in Lawrence, has been equipped with fish passage facilities since the mid-19th century. These facilities have been upgraded on several occasions. In the early 1980s, the existing fish lift was constructed along with the powerhouse, as a requirement under the current FERC license. The Essex lift was designed to pass 11,000 Atlantic salmon and 840,000 shad annually.

Diadromous upstream fish passing through the Lawrence Project via the fish lift have been counted through the viewing windows since 1983. River herring (alewife and blueback herring) counts have varied, with an annual low of 51 documented fish passing through the Lawrence lift in 1996 and a record high of 417,420 in 2016. American shad counts have been relatively more stable throughout the duration of the period of record, peaking at 89,467 in 2015 at Lawrence. A summary of diadromous fish counts passing through the Lawrence Project is provided in Table E.7-19.

In accordance with Article 31 of the Project license, multiple studies have been conducted at the Lawrence and Project to assess the movement behavior, passage route use, and survival of migratory fish species during the past three decades. Studies of migratory fish passage previously completed at Lawrence are described in the following sections for each major species, and summarized in Table E.7-20.

Table E.7-19. Lawrence Hydroelectric Project Diadromous Fish Passage Counts, 1983 – 2025.

Year	River Herring	American Shad	American Eel	Atlantic Salmon	Total
1983	4,794	5,629	--	114	10,537
1984	1,769	5,497	--	115	7,381
1985	23,112	12,793	--	213	36,118
1986	16,265	18,173	--	103	34,541
1987	77,209	16,909	--	139	94,257
1988	361,012	12,359	--	65	373,436
1989	387,973	7,875	--	84	395,932
1990	254,242	6,013	--	248	260,503
1991	379,588	16,098	--	332	396,018
1992	102,166	20,796	--	199	123,161
1993	14,027	8,599	--	61	22,687
1994	88,913	4,349	--	21	93,283
1995	33,425	13,861	--	34	47,320
1996	51	11,322	--	76	11,449
1997	403	22,661	--	71	23,135
1998	1,362	27,891	--	123	29,376
1999	7,898	56,461	--	185	64,544
2000	19,405	72,800	--	82	92,287
2001	1,550	76,717	--	83	78,350
2002	526	54,586	--	56	55,168
2003	10,866	55,620	--	147	66,633
2004	15,051	36,593	--	129	51,773
2005	99	6,382	--	34	6,515
2006	1,257	1,205	--	91	2,553

Year	River Herring	American Shad	American Eel	Atlantic Salmon	Total
2007	1,169	15,876	--	74	17,119
2008	108	25,116	--	119	25,343
2009	1,456	23,199	--	81	24,736
2010	518	10,442	--	85	11,045
2011	740	13,835	--	402	14,977
2012	8,992	21,396	6,969	137	37,494
2013	17,359	37,149	915	22	55,445
2014	57,213	38,107	1,788	75	97,183
2015	128,692	89,467	8,124	13	226,296
2016	417,240	67,528	1,981	6	486,755
2017	91,616	62,846	17,738	5	172,205
2018	449,346	28,302	267,353	10	745,011
2019	43,108	19,450	81,179	15	143,752
2020	87,150	52,239	93,058	1	232,448
2021	96,429	64,162	9,296	0	169,887
2022	19,319	36,731	48,648	0	104,698
2023	10,315	28,438	17	14	38,784
2024	13,467	17,550	168	2	31,187
2025	17,021	26,374	34,129	5	77,529
Total	**3,264,221**	**1,249,396**	**571,363**	**3,871**	**5,088,851**

Table E.7-20. Major Findings of Historical Fish Passage Studies Performed at and/or in the Vicinity of the Lawrence Project.

Year	Study Title	Author	Major Study Objectives and Findings
1993	Lawrence Hydroelectric Project Upstream Fish Passage Efficiency Study 29 May - 16 June 1993	Normandeau Associates, Inc.	<u>Study Findings:</u> • The internal efficiency of the Lawrence fish lift for passing adult American shad was studied using underwater videography. • The system was studied in its original design configuration, i.e., with both entrance weirs operating, 200 cfs attraction flow, and a 12 inch V trap crowder gate configuration. • The internal lift efficiency for shad was 10%. However, because shad would make repeated attempts before being lifted (on average 33 attempts), the overall lift efficiency for shad was 30%. It took an average of 5 days for shad to be lifted upstream. • Internal lift efficiency for adult Atlantic salmon was 5%. • Problem areas identified in the fish lift system which may limit efficiency included the crowder gates, attraction flow entering the fishway downstream of the crowder gates, entrained air in the attraction water, and a low velocity “resting area" downstream of the crowder gates.
1994	Use of the Fish Bypass System at the Lawrence Hydroelectric Project During Spring 1993	Normandeau Associates, Inc.	<u>Major Findings:</u> • The Lawrence bypass was very effective in passing spent adult American shad downstream. Of 8,599 adult shad lifted upstream of the Lawrence Project during 1993, 1,564 (18%) passed downstream through the Lawrence bypass after completing their spawning run. The bypass was sampled only 30% of the time during this period. • Peak passage rates for river herring and salmon smolts were 33 fish/hour and 1.2 fish/hour, respectively. Passage rates for salmon were probably higher due to problems with the bypass net. • The highest passage rates for Atlantic salmon, American shad and river herring occurred when bypass flows were between 40 and 80 cfs. • Passage rates were greatest when the triple leaf gate at the entrance to the downstream bypass was set in a spill mode, which prevented fish from escaping back into the forebay and increased entrance velocities. • The Lawrence fish bypass effectively passes adult American shad and river herring and salmon smolts. • The bypass should be operated with the triple leaf gate at the entrance set in a spill mode.

Year	Study Title	Author	Major Study Objectives and Findings
1994	Use of the Fish Bypass at the Lawrence Hydroelectric Facility During Fall 1993	Normandeau Associates, Inc.	<u>Major Findings:</u> • Percent use of the downstream fish bypass by juvenile clupeids (shad, alewives and blueback herring) was conservatively estimated at 67.4% and 42.5% during two separate tests, respectively. • Juvenile clupeids moved downstream predominantly between dusk and midnight. • Juvenile clupeids began emigrating at water temperatures below 20°C, and peaked at temperatures between 12° and 10°C. Emigration continued into the second week of November. • Increases in river flow were usually followed by an increase in bypass usage. • The Lawrence fish bypass effectively passes juvenile American shad and river herring.
1996	Lawrence Hydroelectric Project Internal Fish Lift Efficiency Monitoring Program Spring 1994 and 1995	Normandeau Associates, Inc.	<u>Major Findings:</u> • The internal efficiency of the Lawrence fish lift for passing adult American shad was studied using underwater videography. • The system was tested using several modifications, including closing off entrance weir 2, attraction flow reduced to 100 cfs, a prototype brail floor was installed downstream of the crowder gate, the main entrance channel was split in half, and the crowder was fished with only one gate open. • Internal efficiency was much higher with the prototype modifications, reaching high as 72%. • Changing crowder gate openings did not significantly affect passage efficiency. <u>Conclusions & Recommendations:</u> • The lift system should be operated using weir 1 only, and weir 2 should be closed off; • The total system flow should be reduced from 200 cfs to 100 cfs, and air entrained In the attraction flow should be eliminated; • The main entrance channel should be split in half to reduce the area that shad can congregate in downstream of the crowder gate; • The crowder should be fished using a single crowder gate, keeping one gate partially open; • A brail floor should be installed between the crowder gate and entrance weir 1, to further restrict congregation of fish in that area; • A constant water flow should be provided to the hopper to prevent mortality due to overcrowding.

Year	Study Title	Author	Major Study Objectives and Findings
1996	Downstream Passage Routes of Radio-Tagged Atlantic Salmon Smolts at the Lowell and Lawrence Hydroelectric Projects on the Merrimack River	Normandeau Associates, Inc.	Study Objective: • Conduct a radio telemetry study to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. Study Findings: • The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not very effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. • At the Lawrence Project, only 1 (5%) of the radio-tagged salmon smolts that passed the site during this study used the bypass - the remainder went through the turbines. • Of the 22 fish that passed the Lawrence Project, 77% continued downstream movement 2 miles below the project. • Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites.

Prior Fish Passage Studies Under Article 31

Downstream American Eel Passage

The downstream passage for silver-phase American eels was evaluated by NAI in 2017 (NAI 2018). As part of that evaluation, fourteen radio-tagged eels passing downstream of the Amoskeag Project (located approximately 41 miles upstream of Lawrence) were detected at Pawtucket Dam at the Lowell Project, and 13 of the 14 study eels arriving at Lowell were subsequently detected downstream at Lawrence. The transit times between Amoskeag and Pawtucket Dam ranged from 10–244 hours. Travel times varied for radio-tagged eels moving through the approximately 11-mile stretch of river from Pawtucket Dam to Essex Dam (range = 3.3–130.7 hours). Residence durations were short at both the Lawrence Project, suggesting the majority of tagged eels continued downstream rapidly following passage at Lowell.

A radio-telemetry assessment of the downstream passage success for adult silver-phase American eels was performed during the fall of 2019, primarily focused on passage at the Lowell Project (NAI 2021a). Following the release of 102 radio-tagged individuals into the Merrimack River 11 miles upstream of the Lowell impoundment, their movements were monitored using a series of stationary radio-telemetry receivers in place along the stretch of the Merrimack River from Amoskeag to downstream of the Lawrence Project. Downstream passage survival was estimated for all radio-tagged eels from the point of initial detection upstream of the Lowell Project Pawtucket Dam, downstream to Lawrence. This resulted in an estimated downstream passage survival for silver-phase American eel at Lowell of 75.5%.

During the fall of 2019, Essex installed a series of stationary radio-telemetry receivers at its Lawrence Project (FERC No. 2800) to assess the arrival and downstream passage of tagged adult silver-phase American eels released both upstream of the Lowell Project (FERC No. 2790) boundary and upstream of Garvins Falls Dam (Bow, NH; FERC No. 1893). A total of 111 radio-tagged adult eels were determined to have approached the Essex Dam and were available for the evaluation of downstream passage route. The majority of radio-tagged individuals passed downstream at Lawrence via the turbine units (51.4%) or on spill (38.7%). Usage of the downstream bypass was limited to a single individual (0.9% of those approaching the Essex Dam). Modeled estimates resulted in an estimated downstream passage survival for silver-phase American eel at Lawrence of 90.3% (NAI 2024a).

Alosine Passage

In the spring of 2020, radio-tagged adult river herring and American shad were released by Normandeau at four locations within the Merrimack River watershed as part of the relicensing of the Lowell Project (P-2790) (NAI 2024b). Receivers were also installed at locations around the Lawrence Project to enable downstream passage routing and survival. Releases of radio-tagged adult alosines at locations upstream of Lawrence were initiated on May 8, 2020. A total of 500 adult river herring and 330 adult American shad were radio-tagged and released upstream of Lawrence and had the potential to pass downstream of Lawrence following time spent upstream. Of those individuals, a total of 233 adult river herring and 158 adult American shad were determined to have approached Essex Dam and had the opportunity to pass downstream of the Project. In general, arrival dates for adult river herring at Lawrence peaked during the last week of May and first week of June 2020. Arrival dates for radio-tagged adult shad occurred slightly later with a peak in numbers of returns during early and mid-June, 2020.

The majority of radio-tagged adult alosines utilized the downstream bypass for passage at the Project with 67% of adult river herring and 92% of adult American shad recorded in the exit flume of the facility prior to subsequent detection downstream. Turbine passage was limited to 16% of radio-tagged adult river herring and only 4% of radio-tagged adult shad. A percentage of adult herring were determined to have passed downstream of Lawrence via the limited spill which occurred for the duration of the monitoring period (6% of all individuals that approached the Project).

Downstream passage survival was calculated for the section of the Merrimack River from Lawrence to the downstream station and resulted in an estimated downstream passage survival for adult herring at Lawrence of 38.7%. Despite high utilization of the downstream bypass facility by adult herring (~ 2/3 of outmigrants) overall survival for downstream passage at Lawrence was poor. These estimates of downstream passage survival for adult river herring at Lawrence includes background mortality (i.e., natural mortality including predation) for the species in the reach from the dam to the first downstream receiver, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival for adult river herring at Lawrence.

Similar to adult herring, downstream passage survival was calculated for adult shad for the section of the Merrimack River from Lawrence to the downstream station. The estimated downstream passage survival for all adult American shad at Lawrence was 94.8%. These estimates of downstream passage survival for adult shad includes background mortality (i.e., natural mortality) for the species in the reach from the dam to the first downstream receiver, along with any tagging-related mortalities or tag regurgitations. As a result, this estimate should be viewed as a minimum estimate of total project survival.

Atlantic Salmon Passage

In 1996, a radio telemetry study was performed to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not found to be effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. At the Lowell Project, 13% of the radio-tagged salmon used the bypass, a significant increase compared to the 4% bypass usage by radio-tagged salmon in 1990. Only four (15%) of the radio-tagged salmon that passed the Lowell Project made it downstream to the Lawrence Project's headpond, and of these, none were recorded passing the Lawrence site. Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites (NAI 1996).

Efforts to restore Atlantic salmon to the Merrimack River were abandoned in 2013 after consistently low return numbers were observed, but the species may still occasionally be present in the vicinity of the Project. Since 2013, efforts have shifted towards the restoration of other migratory fish species, notably river herring and shad (Cleantech Analytics 2017). Atlantic salmon counts are available for the Lawrence Project downstream passage (Table E.7-19).

Sturgeon Passage

A biotelemetry study was conducted to track the movement of adult shortnose sturgeon (*Acipenser brevirostrum*) and subadult Atlantic sturgeon through the lower 28.5 miles of the Merrimack River between 1987 and 1990 (Kieffer and Kynard 1993). Historically, the Merrimack River supported an important sturgeon fishery between the 18th and mid-19th centuries; however, only occasional and/or anecdotal sightings were reported in the Merrimack River prior to the start of the study in 1987.

Kieffer and Kynard (1993) found that spawning of shortnose sturgeon occurred from April to May at RM 19-22 (Haverhill area) and overwintering at RM 12-16 (the Amesbury area); Essex Dam is at RM 29 and thus movements of shortnose sturgeon from their wintering to spawning and post-spawning areas do not approach the Project boundary. Additionally, despite the fish lift passing anadromous fish upriver of Essex Dam since 1983, no sturgeon have been reported passing through the lift.

The biotelemetry study by Kieffer and Kynard (1993) was designed to use gill nets to initially survey for sturgeon and then use telemetry on any found individuals to determine annual movements; identify spawning, summering, and wintering areas; and investigate the spatial distribution of sturgeon relative to salinity. Spawning was verified by sampling for drifting eggs and larvae with plankton nets. Between August 1987 and May 1990, 25 shortnose sturgeon were captured and later recaptured. Two fish were captured 6 times each, and 12 fish were only captured once. Between July 1988 and June 1990, 36 Atlantic sturgeon were captured, and 9 were recaptured.

The upriver spawning migration pattern of shortnose sturgeon, however, was found to depend on the distance the fish must move from wintering to spawning areas. If the distance was greater than 31 miles, most fish migrated in fall and fewer migrated in spring. If the distance was less than 15.5 miles, all fish migrated to the spawning areas in spring. Unlike shortnose sturgeon documented in other rivers, no pre-spawning shortnose sturgeon in the Merrimack River migrated upriver in fall and overwintered in the spawning areas, even if water temperatures were similar. (Kieffer and Kynard 1993).

Sexually mature shortnose sturgeon began moving upriver from freshwater wintering areas to their spawning site in April, when increasing water temperatures reached 7 °C and decreasing river discharge reached approximately 570 cubic meters per second (m^3/s). Following spawning in late April or early May, fish moved downriver either to a freshwater reach where they remained all year, or farther downriver to a saline reach where they remained for up to 6 weeks. After fish used the saline reach, they returned upriver to freshwater. Shortnose sturgeon were found to use two freshwater reaches and one saline reach annually. (Kieffer and Kynard 1993).

During the three years of tracking, Atlantic sturgeon used the same general area although a different cohort of fish was tracked each year as no tagged Atlantic sturgeon were observed in the Merrimack River in successive years. Atlantic sturgeon entered the Merrimack River from coastal waters by mid-late May when increasing water temperatures reached between 14.8-19.0 °C and decreasing river discharge reached 303-675 m^3/s and occupied a saline reach with 0.0-27.5 parts per thousand (ppt). After using the same saline reach visited briefly by shortnose sturgeon in spring months, Atlantic sturgeon emigrated from the river by October when maximum river temperatures were 12.0-18.4 °C. The within-river distribution of adult shortnose sturgeon and subadult Atlantic sturgeon in rivers of the Northeast appear to be generally correlated with salinity. Shortnose sturgeon occupy freshwater reaches, and subadult Atlantic sturgeon occupy saline reaches. In the Merrimack River, shortnose sturgeon usually occupied reaches with salinity less than 1.0 ppt, and Atlantic sturgeon typically occupied reaches exposed to salinity greater than 10.0 ppt at high tide. (Kieffer and Kynard 1993).

Relevant Studies Performed in Support of Relicensing

Upstream Anadromous Fish Passage Assessment (NAI 2026b)

As outlined in their April 10, 2024 Revised Study Plan (RSP), and approved with modification by FERC in their May 10, 2024, SPD, Essex conducted the Upstream Anadromous Fish Passage Assessment during the 2025 spring diadromous fish passage season at Lawrence.

Essex employed radio telemetry for the evaluation of upstream passage of American shad and sea lamprey at the Lawrence Project. Approach, residence, and passage of radio-tagged American shad and sea lamprey were evaluated using a set of 15 stationary radio telemetry receivers installed at specific locations at and in the vicinity of the Essex Dam and Project powerhouse (See Figure E.7-15 and Figure E.7-16). Receivers were configured to receive transmitter signals from a designated area continuously throughout the study period. The operation of the system was confirmed during installation and throughout the study period by using beacon tags stationed at strategic locations within the detection range of either multiple or single antennas, that were programmed to emit a signal at a fixed time interval.

A total of 404 American shad and 51 sea lamprey were radio-tagged and released within the section of the Merrimack River downstream of Essex Dam extending from just upstream of the confluence with the Spicket River to the Lawrence I-495 Bridge (approximately 1.0 to 1.4 miles downstream of Essex Dam). Collection efforts varied by species, with American shad collected from the Merrimack River via boat electrofishing sampling and sea lamprey obtained from the Lawrence fish lift. Releases of tagged fish took place over a range of dates: between May 20 and June 13 for American shad and on June 15 and 17 for sea lamprey. Movements of tagged fish were monitored via a series of telemetry receivers installed both at the Essex Dam and Lawrence fish lift from those locations approximately 10 miles upstream of Essex Dam to locations 6.6 miles downstream of Essex Dam.

Figure E.7-15. Stationary radio telemetry receiver locations associated with the Upstream Anadromous Fish Passage Assessment.

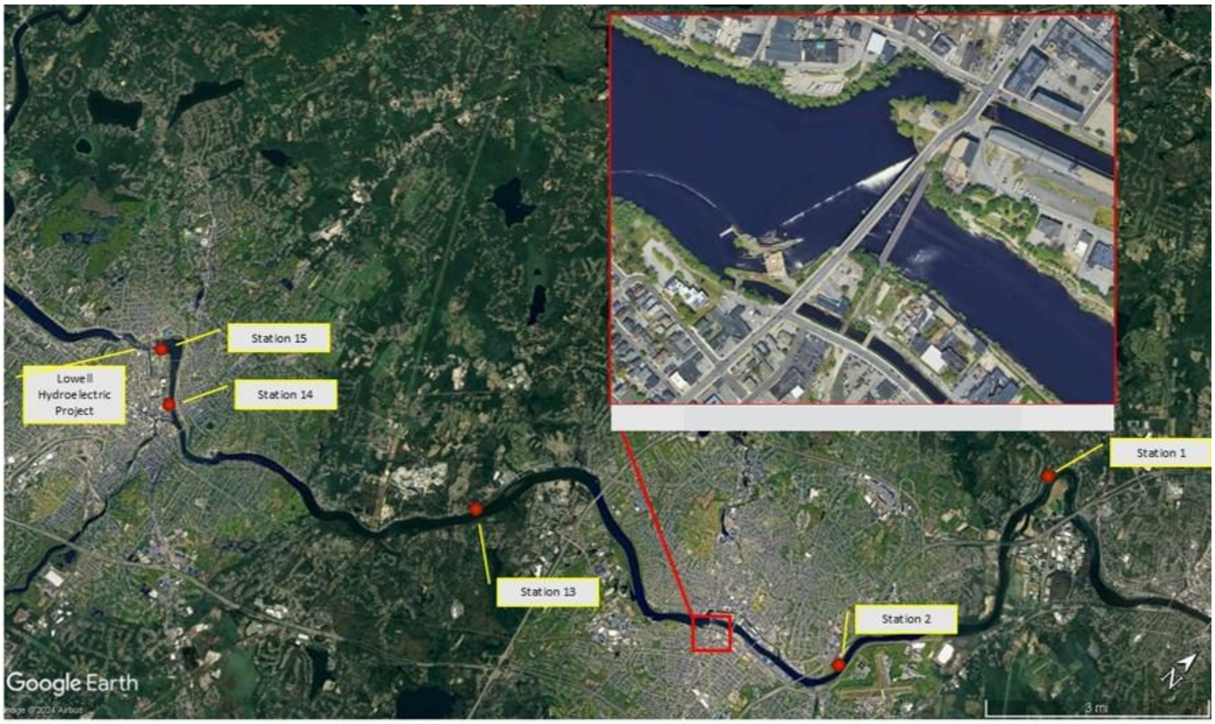


Figure E.7-16. Stationary radio telemetry receiver locations relative to Essex Dam and Powerhouse.

Data were downloaded at least once weekly during the period from the initial tag and release date until completion of the monitoring period (July 15). Tag detections in each downloaded stationary telemetry data file were validated through a series of site-specific and logical criteria, including a signal strength threshold level of the detection, frequency of the radio tag signals per unit of time, and spatial and temporal characteristics of each individual detection with respect to the full series of detections at monitoring stations within the entire detection array.

In addition to stationary radio telemetry data, mainstem river temperature was recorded via a continuous logger installed at the Project. Hourly records of inflow, discharge (canal, fish lift, downstream bypass, turbine, and spill), and tailwater and impoundment elevations were recorded. During the upstream passage season, Essex completed a daily fishway inspection log, which included information related to river conditions, flow allocation, unit status, and fishway conditions, and information specific to attraction flows and fishway operations (i.e., daily Auxiliary Water Supply (AWS) gate setting, AWS discharge in cfs, entrance gate setting [feet], entrance drop [feet], and v-trap opening [inches].

The RSP identified that the Upstream Anadromous Fish Passage Assessment would be conducted with both entrances (river side and street side) to the lower entrance flume of the Lawrence fish lift open. Both gates were operationally available for the duration of the study, and prioritization was given to the river side entrance gate under tailwater conditions which permitted at least three feet of water depth at the entrance. Use of the street side gate was limited to periods when the target three-foot minimum entrance depth could not be met at the river side entrance. FERC identified a target sample size of radio-tagged American shad of 430 individuals. Tagging efforts for shad were timed to coincide with manageable flow conditions for safe and effective electrofish sampling downstream of the Project, and a total of 404 American shad were successfully tagged and released during this study.

American Shad

Despite a high rate of fallback following tagging and release (~75% of individuals), a subset of 53 radio-tagged shad moved upstream and interacted with the receiver array at the Lawrence fish lift and, as a result, provided information on passage effectiveness. Approach events for tagged shad occurred over a range of dates from May 23 through June 23, peaking during mid-June. Upon arrival at Lawrence, the median duration of time spent downstream prior to either upstream passage or movement downstream and away from the Project was 52.6 hours. Upstream passage attempts at Lawrence were recorded for twelve tagged shad, which made a total of 26 unique passage attempts at the lift. Approximately 40% of passage attempts by shad reached the lift hopper, with 45% of those attempts resulting in successful upstream passage. When all successful shad passage attempts at the Lawrence fish lift are considered, the median foray duration was 0.7 hours. All fish lift passage attempts were initiated by tagged American shad during the daylight hours, with most events taking place during the morning. Regarding the component of tagged shad which did not ascend upstream to the fish lift, observations of individuals carrying acoustic transmitters and monitored as part of the Diadromous Fish Behavior, Movement, and Project Interaction Study (i.e., Project Interaction Study), indicated that adult shad showed a tendency to spend a larger percentage of time at large in the downstream end of the reach from Essex Dam to the Lawrence I-495 Bridge. A similar observation was also noted for blueback herring during the Project Interaction Study, and both species were tagged during the latter part of May and early June. High flow conditions, which prevented tagging during early- to mid-portion of May, and persisted well into June, were likely an influence on upstream movement of both species through the 1-1.4 mile reach between the tagging location and the fish lift.

Nearfield attraction for tagged American shad (i.e., the probability of movement from the downstream end of the tailrace channel to the attraction water region located immediately adjacent to the entrance gates of the lower fish lift entrance flume) was high, with 100% of tagged shad which reached Station 4 ascending to Station 5. However, the entrance efficiency for tagged shad was only 34.3%, demonstrating a reluctance of fish to move from the nearfield attraction water region through the entrance gate and into the lower entrance flume.

Overall passage effectiveness was evaluated as the probability of a tagged shad initially detected at the point approximately 200 m downstream of the fish lift to successfully move upstream and reach the exit from the power canal (i.e., enter the lower impoundment). For shad, the overall passage effectiveness rate was calculated at 9.4%. When evaluated by components, the probability for shad to move from the initial approach area 200 m downstream of the dam to the area at the immediate downstream end of the tailrace channel was 66.0% likely influenced by competing spill flow over the inflatable dam sections for the duration of the residence period for tagged shad downstream of the dam.

The poor entrance efficiency and failure of individual shad to move from the entrance to the hopper (33.3% failure rate) and for those in the hopper to be successfully lifted (37.5% failure rate) also influenced the overall performance of the Lawrence lift for upstream shad passage. For the subset of shad exiting the Project power canal, all individuals ascended upstream to the upper extent of the Lawrence impoundment.

Sea Lamprey

The majority of tagged sea lamprey released downstream of Essex Dam (71%) moved quickly upstream following release, with a median duration of time from release until arrival of 6.8 hours. All arrivals of tagged sea lamprey in the region extending up to 200 m downstream of the dam took place over a six-day window between June 15 and 20, with arrivals at the dam occurring during the late afternoon and nighttime hours. Upon arrival at Lawrence, the median duration of time spent downstream prior to either upstream passage or movement downstream and away from the Project was 72.9 hours. Upstream passage attempts at Lawrence were recorded for 28 tagged lamprey, which made a total of 62 unique passage attempts at the lift. Although 55% of passage attempts by sea lamprey reached the lift hopper, only 3% of those attempts resulted in successful upstream passage. Nearly all (81%) sea lamprey passage attempts took place outside of the regular hours of operation for the Lawrence fish lift (i.e., after 1600 and before 0800).

Similar to observations for tagged American shad, the nearfield attraction for tagged sea lamprey was high, with 100% of the individuals which reached Station 4 ascending to Station 5. Entrance efficiency for tagged lamprey was 80%, indicating that the species is locating the entrance and moving upstream and into the lower entrance flume of the lift facility. However, the overall passage effectiveness for lamprey (i.e., the probability of a tagged individual initially detected at the point approximately 200 m downstream of the fish lift to successfully move upstream and reach the exit from the power canal) was only 2.8%. When the overall passage effectiveness is evaluated by its components, the probability for tagged lamprey to move from the initial approach area 200 m downstream of the dam to the area at the immediate downstream end of the tailrace channel was high (97.2%). Similarly, once in the lower entrance flume, tagged lamprey successfully transitioned from the entrance upstream into the hopper area (89.3% success rate). However, the probability for tagged lamprey to successfully transition from entry in the hopper to release at the upstream end of the upper exit flume was poor (4.0%). Overall, sea lamprey are successfully locating the Lawrence fish lift entrance and navigating upstream to the hopper. However, the short duration of entry attempts into the downstream entrance flume coupled with the high percentage of attempts occurring outside of normal hours of daily lift operations impacts the estimate of overall effectiveness. The single sea lamprey successfully passing at the Lawrence fish lift was subsequently detected at the upstream end of the Lawrence impoundment.

Upstream American Eel Passage Assessment (NAI 2025a)

In support of this relicensing, Essex conducted the field component of the Upstream American Eel Passage Assessment to evaluate the effectiveness of the existing upstream American eel (Anguilla rostrata) passage facilities at the Project.

Essex conducted a quantitative evaluation of internal efficiency of the south side eel ladder by tagging eels, sealing them within the eel ladder, and recovering the tagged eels after 24 hours. Essex evaluated the internal efficiency of the south eel ladder collection tank in a similar manner by tagging eels with a Visual Implant Elastomer (VIE), placing them in the collection tank at the top of the ladder, and recovering tagged eels after 24 hours. Essex evaluated the north side eel lift internal efficiency by tagging eels with a VIE, placing them in the hopper, lifting the hopper, and recovering tagged eels in the catchment basin at the top of the lift. Essex conducted a qualitative assessment of nearfield attraction efficiency by conducting nighttime visual surveys of the areas downstream of the south side eel ladder and the north side eel lift and enumerating the number of observed eels in downstream areas at both facilities.

The nearfield and internal effectiveness of the south side eel trap and north side eel lift at the Lawrence Project were evaluated during the 2024 upstream passage season. Assessment of nearfield effectiveness was conducted in a qualitative manner utilizing a series of nighttime visual surveys to examine habitat and structures in the vicinity of the entrances to the two currently operated upstream eel passage facilities at the Project. Internal efficiency of both structures was assessed quantitatively using a mark-recapture approach.

Visual observations made during all three survey events at the south side eel trap indicated adequate flow in the approach channel providing access for juvenile American eels to the ramp entrance. Approach pools in the nearfield area consistently had the highest number of eels during each of the three survey events, with the peak in observed abundance within the approach pools occurring during the July survey. Conditions during the July survey coincided with the warmest recorded water temperature as well as a station-wide outage, which led to a reduction in discharge downstream of the powerhouse and increased spill over the crest gates and into the attraction channel. This increase in flow through the approach channel may have contributed to the increased juvenile eel abundance during the July survey. Leakage observed from the south side eel trap structure as well as the adjacent section of the dam was observed during all three survey events and likely resulted in sources of competitive flow for eels attempting to locate the entrance. A gradual decrease in the volume of discharge provided by the hose providing attraction water at the ramp entrance was observed over the three survey dates and may have been caused by debris fouling the supply pump.

Observations were made inside the south side eel trap structure during all three survey events. Juvenile eels were observed utilizing the ramp sections and resting pools, as well as ascending gaps between the milieu substrate and ramp wall. Leakage originating from the ramp was noted on many sections, most notably from the resting pools. This leakage provided wetted areas of false attraction outside the ramp for eels to ascend the dam structure and away from the ramp entrance. Due to the observed ramp leakage, the internal conveyance flow originating at the top of the ramp decreased with each descending section and resulted in markedly less internal flow at the entrance of the structure. Eels belonging to all three size classes were observed within the south side eel trap during the 2024 upstream evaluation. Among all three survey events at the south side eel trap, the majority, about 85%, belonged to the <6” class, around 15% belonged to the 6-12” class, and one eel was observed belonging to the >12” size class.

Similar to the south side eel trap, juvenile eels were readily observed in the nearfield area of the north side eel lift during all three survey dates. At the north side eel lift, most juvenile eels were observed in the approach channel leading to the base of the eel lift. A large number were also observed congregating in the river, just below the attraction channel. After advancing to the base of the lift, eels appeared to be attracted over a large area that was wetted by the external attraction hoses. Eels of all size classes were observed during the 2024 night surveys, with the greatest number of observations occurring during the August visit. The lowest observed abundances of juvenile eels in the nearfield region of the north side eel lift occurred during the July survey and coincided with the station outage, which resulted in most of the river flow passing downstream via spill. Flow provided by the supplemental attraction hoses appeared to falsely attract a proportion of eels away from the north side eel lift entrance and towards leakage coming down the dam face. Among all three survey events at the north side eel trap, the majority, about 93.2%, belonged to the <6” class, around 6.7% belonged to the 6-12” class, and one eel was observed belonging to the >12” size class.

A quantitative evaluation to assess the internal passage effectiveness of the south side eel trap was conducted over the course of two days in mid-July, during which a total of 272 marked juvenile eels were placed at the sealed entrance of the ramp. Following the completion of a 24-hour period, the collection tank was checked, and no marked eels were found, suggesting high levels of escapement and poor internal effectiveness of conveying eels from the ramp entrance up to the collection tank. In addition to evaluating the effectiveness of the climbing structure, a retention test of the collection tank at the south side eel trap was also conducted. During two separate tests, a total of 50 marked juvenile eels were placed in the tank, and the 24-hour retention effectiveness was estimated at 58%, suggesting a measurable amount of escapement of collected eels from the collection tank is occurring.

Similar to the internal passage evaluation conducted at the south side eel trap, a quantitative evaluation was conducted at the north side eel lift in order to assess the internal efficiency of that structure. Over the course of two days in the beginning of August, 260 marked juvenile eels were placed into the collection hopper of the north side eel lift. Of that total, 259 (over 99%) were successfully transported to the top of the dam, indicating high internal effectiveness for this facility.

American Eel Upstream Siting Study (NAI 2025b)

In support of this relicensing, Essex conducted a total of ten nighttime visual surveys targeting juvenile American eels between June 20 and August 19, 2024, at the Project. As defined in the RSP, surveys were conducted from a series of shoreline positions on-site at the Project, as well as several vantage points positioned along the North and South Canals. Each survey was conducted by a pair of biologists equipped with red spotlights and binoculars to facilitate the viewing of juvenile eels attempting upstream passage. Over the course of the ten surveys, juvenile eels were observed most frequently in the Project tailrace, within the entrance of the lower entrance flume associated with the existing fish lift, and at the upstream end of the North Canal. No juvenile eels were observed from vantage points surveying the areas upstream or downstream of the South Canal gatehouse during any of the ten weekly survey events. Greater than 5,000 juvenile eels were observed across all surveys, with over 3,000 observed during a single survey on the night of July 16, 2024.

The eel pots deployed during the ten-week sampling period were successful in collecting information on juvenile eel presence and relative abundance. The control site, located on the near-field ledge areas associated with the existing south side eel trap, had a total catch of greater than 20,000 juvenile eels across the full ten-week period. Relative abundance of juvenile eels at that location peaked between early July and early August. The deployment of mesh-lined eel pots in the North Canal resulted in regular observations of small numbers of juvenile eels at the downstream end and near the discharge gates (n = 15 over the 10-week period). Juvenile eel collections in eel pots fished at the downstream end of the North Canal occurred from late June through early August. A single juvenile eel was observed in the ten weeks of eel pot sampling conducted at the upstream end of the North Canal. Similarly, the ten weeks of eel pot sampling within the South Canal produced only a single juvenile eel. Eel pot collections suggest some presence of juvenile American eels within the North Canal.

Electrofishing was conducted twice (once in July and once in August) in the main stem Merrimack River from the point just downstream of Essex Dam to the confluence with the Spicket River and in the Spicket River from its confluence with the Merrimack to the discharge from the North Canal. Additionally, backpack electrofish sampling was conducted in the North Canal during a single event in August. Electrofish effort (all sites and dates) yielded a total of 309 fish with 172 of those being

American eels. A total of 57 juvenile eels were collected within the main stem Merrimack River, 43 within the lower Spicket River, and 72 within the North Canal. The highest catch per unit effort (CPUE) occurred in the North Canal with a high of 1.26 eels per minute. The highest CPUE values for juvenile eels within the main stem Merrimack River were noted from sample areas located adjacent to the confluence with the Spicket River and the region located on the powerhouse shoreline closest to Essex Dam. This trend was observed during both the July 26 and August 21 sampling events. CPUE values for juvenile eels in the Spicket River were similar to those observed at main stem Transect 1 during both the July and August sampling events.

Sampling methodologies employed during this study provided valuable information on the presence and relative abundance of juvenile eels in the Project area. Nighttime surveys conducted during the ten-week period revealed a high relative abundance of juvenile eels within the powerhouse tailrace and lower entrance flume associated with the existing fish lift. These areas are adjacent to the existing south side eel trap, which was evaluated during several nighttime surveys associated with the Upstream American Passage Assessment Study and produced observations of large numbers of juvenile eels on the near-field ledges of the existing eel trap. Similarly, boat electrofish sampling conducted in the main stem Merrimack River from downstream of Essex Dam to its confluence with the Spicket River demonstrated relatively high catch rates from the sample transect located closest to Essex Dam and on the powerhouse side of the river.

Main stem boat electrofish sampling also produced relatively high catch rates of juvenile eels from the sample transect located adjacent to the confluence with the Spicket River. These same relatively high catch rates were also observed during electrofish sampling conducted within the lower Spicket River during both the July and August sampling events. As demonstrated by eel surveys conducted at the first dam on the Spicket River (Methuen Falls Dam; Normandeau 2024), large numbers of juvenile American eels entering the Spicket River continue upstream in that system. However, nighttime surveys, eel pot collections, and backpack electrofish sampling conducted within the North Canal, suggest that juvenile eels are accessing that waterway. Over 400 juvenile eels were observed at the upstream end of the North Canal over survey events conducted during late July and early August. Captures of juvenile eels in pots set at the downstream end of the North Canal occurred between late June and early August, and CPUE rates for juvenile eels in the North Canal were the highest observed for areas sampled by electrofishing.

Due to safety issues associated with egress of Project staff from the South Canal in the event of an emergency during sampling, electrofish sampling was not performed in that reach. However, both nighttime visual surveys and use of fine-mesh eel pots were conducted over the 10-week sampling period. Despite this considerable effort, observations of juvenile eels in the South Canal were limited to a single individual, suggesting minimal use of this reach. The single eel captured in the South Canal fell into the 6-12 inch length class.

Desktop Entrainment, Impingement, and Turbine Passage Survival Study (NAI 2026c)

In support of this relicensing, Essex conducted a desktop-based evaluation and summary of the potential for entrainment, impingement, and turbine passage survival at the Project to evaluate the potential risk of impingement and entrainment and to provide estimates of passage survival for out-migrating diadromous fish species.

A desktop approach utilizing a blend of field-derived and calculated parameter values was used to develop estimates of total Project survival for target species at Lawrence. Estimates of survival were developed for a series of operational regimes representative of the fish passage seasons at the Project (i.e., spring: April 1 to July 15, and fall: September 1 to November 15). Each of these estimates was developed using the TBSA Tool and incorporated a mix of user-entered route-specific survival estimates and calculated turbine blade strike probabilities to develop a predicted total Project survival rate specific to a singular operational condition. Passage route selection was assumed to be proportionate to the amount of flow dedicated to each passage route under each scenario. Following development of the set of representative survival estimates, site-specific flow duration curves were used to quantify the proportion of a passage season during which each hypothetical operating regime was occurring. This allowed for the associated estimates from each regime to be proportioned such that the sum provided an estimate of total Project survival over the course of the full passage season.

This approach resulted in estimates of total Project survival of 93.6% for adult river herring, 89.4% for adult American Shad, 96.8% for juvenile alosines, and 60.4% for adult American eels. It is important to note that for all estimates of survival associated with each operational scenario considered in this assessment, fish route utilization was proportional to flow discharge (e.g., if 50% of inflow was being passed via spill then 50% of fish would pass via spill). This approach assumes that fish passage at the Project is proportional to the distribution of inflow among potential passage routes. Prior passage route results associated with the downstream passage of adult herring and shad at Lawrence do not support this assumption as, under the flow conditions present during the 2020 radio telemetry assessment, 67% of tagged herring and 92% of tagged shad were determined to have passed downstream via the bypass, despite that route conveying only 160 cfs.

In the 2021 Merrimack River Watershed Comprehensive Plan for Diadromous Fishes (Technical Committee 2021), Objective 14 states “Improve passage efficiency at all fish passage facilities in the watershed to achieve safe, timely and effective passage that meets or exceeds the following performance criteria.” Relative to downstream passage, Objective 14 stated that “*For alosines and American Eel, achieve and maintain a minimum of 95% downstream passage survival*.” When the total Project survival rates estimated in this desktop assessment are compared to the “performance criteria” of 95% downstream passage survival for alosines and American eel, only juvenile alosines met the criteria.

The total Project survival estimates for adult river herring and adult American shad both approached the 95% criteria, with estimates of 93.6% and 89.4%, respectively. The desktop estimate for adult river herring was greater than that estimated during the single season downstream telemetry study conducted under inflow conditions during the spring of 2020 (38.7%) (NAI 2024b). The field-based estimate of herring passage survival was not corrected for background mortality (i.e., predation), and as a result, was very likely impacted by the known presence of striped bass in the reach immediately downstream of the Project. The field-based estimate for adult American shad obtained during the single season downstream telemetry study conducted under inflow conditions during the spring of 2020 (94.8%) was comparable to that estimated via this desktop approach. The desktop total project survival estimate for silver-phase American eel (60.4%) did not attain the written passage criteria and was also lower than that estimated during the single season downstream telemetry study conducted under the available set of inflow conditions during the fall of 2019 (90.3%) (NAI 2024a).

Sturgeon Distribution and Project Interaction Study (ASA 2026b)

In support of this relicensing, Essex conducted a Sturgeon Distribution and Project Interaction Study to determine if Atlantic or shortnose sturgeon are interacting with the Lawrence Project.

Mobile side-scan sonar (SSS) surveys

Mobile side-scan sonar (SSS) surveys were conducted within the 1.5-mile reach of the Merrimack River between Essex Dam and the Lawrence I-495 Bridge. Six surveys were conducted between the Project and the Lawrence I-495 Bridge for approximately 1.5 RM (2.4 kilometers [km]) from April 4 through May 20, 2025. The vicinity of the tailrace upriver of the O'Leary Bridge and downstream to approximately the boat ramp at Pemberton State Park was not surveyed due to safety concerns and navigation hazards. The SSS data were imported into SonarWiz software for processing, visualization, and exporting data and images, and manually inspected for sturgeon-like targets in the SSS imagery.

Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence between April 10 and 30, through a process involving assessment by three independent reviewers. None were identified upriver of the Joseph W. Casey Bridge (Amesbury St.), which is located approximately 0.4 miles downriver of the Project Dam. The potential sturgeon targets were observed between 500 feet downriver of the Joseph W. Casey Bridge and approximately 1,000 feet upriver of the I-495 Lawrence Bridge. The sturgeon targets observed by SSS were comparable in time and space as the acoustic receiver detections of a USGS sturgeon acoustically tagged in 2016 and the one individual observed during electrofishing in 2025.

The mobile SSS survey was not able to identify sturgeon to the species level and was not able to quantify duration or seasonality of either species in the sampled river reach. However, repeated surveys were able to detect and classify sturgeon during mid to late April (April 10, 17, 23, and 30), but no sturgeon were detected on April 4 or May 20.

No Project-related effects were identified in the SSS survey results. However, natural fluctuations in river flow, non-navigable rocky shallows, and turbulent conditions affected vessel access and controllability of the survey vessel underway in some areas.

Sturgeon were likely identified in the river reach between 1 and 1.5 miles downstream of the Project, but direct evidence of sturgeon observed in the mobile SSS surveys could not determine if the tailrace structure or flow conditions related to the Project dam created a barrier to upriver movement.

Fixed Location Sonar Pilot Study

A pilot study was conducted to determine the feasibility of using fixed-location sonar to detect and identify artificial targets of similar size and shape as sturgeon in the Project tailrace and, if feasible, to monitor for the presence of sturgeon in the tailrace from mid-March through early November 2026. Key objectives for fixed sonar monitoring include: (1) determining if sturgeon are present in the tailrace from mid-March through early November and, if present, (2) determining how they are distributed in the tailrace for purposes of informing the potential design and location of a fishway.

The pilot study evaluated deployment options and suitable locations in the tailrace for a fixed-location sonar installation and tested target detection and identification performance of two sonars at multiple sampling configurations. The study was completed between October 28 and November 10, 2025.

No sturgeon were observed in the Project tailrace using either device. The study demonstrates that it is not feasible to detect or identify sturgeon-shaped targets using these two sonar technologies at suitable ranges for a long-term deployment of a fixed-location sonar monitoring in the Project tailrace, due to a variety of factors. These factors include mounting capability, geographical layout, high flows, entrained bubbles, submerged debris, turbulence in the tailrace, safety, site-specific limitations to sonar performance, and logistical challenges of prolonged operation. As a result, no fixed-location sonar monitoring data were collected to describe the duration or seasonality of sturgeon.

Project layout, flow conditions, and logistics within the tailrace limited the feasibility of deploying fixed-location sonar in specific locations and for long-term monitoring of sturgeon. It was impractical to keep a target within the sonar field of view for an adequate amount of time for both detection, and more importantly, for identification. Woody debris and trash in the tailrace float or churn underwater, making long-term sonar monitoring deployment impractical due to potentially causing excessive false sturgeon detections, as well as a high risk of physical damage to fixed-location sonar systems over time. Fixed-location monitoring using ARIS and BlueView high-resolution imaging sonars to detect and identify sturgeon within the Project tailrace is not feasible, as indicated by the pilot study under controlled conditions, due to the high abundance of floating and submerged drift debris, entrained bubbles, strong eddies and currents, and upwelling.

The fixed-location sonar monitoring varied in both instrumentation and approach from the SPD, which resulted in a two-phase approach using imaging multibeam sonars instead of a SSS as described in the ISR and the accompanying Study Plan. The pilot study varied from the Study Plan in two ways. After challenges related to overall logistics, safety considerations, equipment protection, site accessibility, and reliable performance of the monitoring devices were encountered, the pilot study focused on testing the performance of two sonar technologies and develop the best suited, most reliable mounting solution. This created a variance from mounting the sonar out at the tip of the old fish ladder structure, to mounting the frame and devices on the river-side fish lift entrance weir structure.

The other variance resulted from implementation of the study, which revealed that it was not feasible to execute a controlled experiment of deploying known targets at distant ranges, known depths, and known times for an analyst to independently process targets to measure sonar performance. Environmental conditions (e.g., flows, bubbles, debris) and personnel safety prevented this from working adequately. Instead, atypical low-flow Project operations and unrealistic close ranges were necessary to enable identifying artificial sturgeon targets.

Acoustic Telemetry

Sturgeon were tagged with acoustic transmitters and recorded using acoustic receivers in the tailrace and downstream reach to monitor from mid-March to early-November (as river conditions allowed). Seasonal use and movement of tagged sturgeon was evaluated in the downstream Project reach using a series of acoustic receivers.

Acoustic receivers were installed in the section of the Merrimack River extending from the Essex Dam downstream to the I-495 Lawrence Bridge as part of the Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d), which were available to collect detection information on any sturgeon carrying a 416.7kHz JSATS transmitter which entered the detection zone. The array operated from April through mid-July, and then a subset of the acoustic receivers was extended into late September to provide an extended period of monitoring for tagged sturgeon. In addition, InnovaSea acoustic receivers were deployed at the I-495 Lawrence Bridge, Duck Bridge, 28 Bridge, and the tailrace to provide coverage from mid-March through late November 2025.

A total of 55 transmitters were deployed on tagged adult shortnose sturgeon, 15 on sub-adult Atlantic sturgeon, and 15 on juvenile Atlantic sturgeon. A limited number of tagged adult shortnose sturgeon (n = 2) were confirmed as present during the survey in the monitored area, one of which had been tagged by others in previous years. One individual ascended far enough upstream to be detected at the downstream end of the tailrace channel. The second individual was not detected at any stationary receivers located upstream of the Lawrence I-495 Bridge. There were no detections of tagged Atlantic sturgeon (juvenile or sub-adult) at any stationary receiver location during the 2025 monitoring period.

No Project related effects were identified in the acoustic telemetry study results. A limited number of individuals were detected in the monitored reach downstream of Essex Dam, and the seasonal timing of these detections is in line with previously reported shortnose sturgeon movements within the Merrimack River.

Results of the 2025 acoustic tag monitoring do not provide conclusive evidence to support the current need for upstream passage for sturgeon at the Project. Observations in the immediate vicinity of Essex Dam were limited to a single adult Shortnose sturgeon detected only by the receiver at the downstream end of the tailrace channel (i.e., undetected by the two acoustic receivers positioned at the downstream face of the powerhouse and in the vicinity of the upstream fish lift entrances).

Phase I and II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2025c; NAI 2026d)

In support of this relicensing, Essex conducted a Diadromous Fish Behavior, Movement, and Project Interaction Study. The goal of the study was to assess Project-related effects on the behavior of diadromous fish species in and around the Lawrence Project. The study was conducted in two phases. Phase I, conducted in 2024, sought to determine the appropriate acoustic tool and validate the detection range. Phase II, conducted in 2025, sought to assess tagged fish distribution and movement in the Project tailrace and downstream reach; evaluate overall passage effectiveness of the existing fish lift for alewife and blueback herring; and evaluate alosine movement through the Project as it relates to predator presence.

Phase I

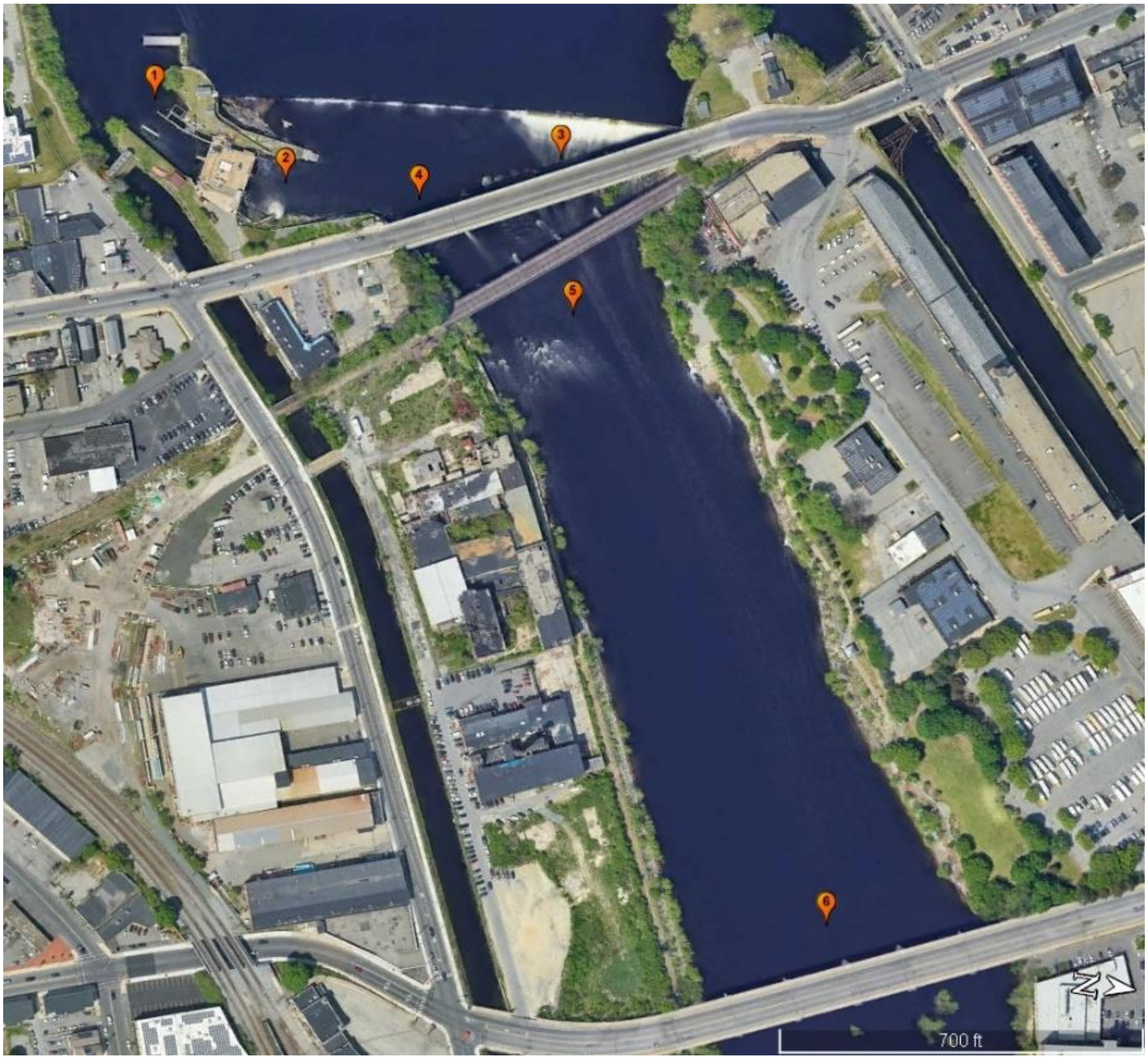
A feasibility study to assess the use of JSATS telemetry transmitters and receivers for a future evaluation of diadromous fish movements in the areas upstream and downstream of Essex Dam was conducted. This Phase 1 evaluation consisted of two primary components: a tank-based evaluation to examine transmitter retention and post-tagging survival rates of adult river herring (alewife and blueback herring) and a field evaluation to determine the functionality (as measured by detection range and rate) of JSATS receivers at different locations in the vicinity of the dam. The Phase 1 components were completed during the 2024 field season, and findings from these studies were used to update the Phase 2 methodology with respect to target fish species, transmitter selection, receiver selection, and the placement/anticipated resolution of receivers.

Two species of river herring, alewife and blueback herring, were targeted as test species for the study. Collection and tagging of adult river herring took place during late May 2024. A blend of sampling techniques was employed, and although they produced enough alewives to meet the RSP sample size, the total number of blueback herring for evaluation was lower than targeted. Two acoustic transmitter models were evaluated during the Phase 1 assessment: Advanced Telemetry Systems (ATS) model SS300 and ATS model SS400. The SS300 transmitters were inserted gastrically, and a hollow needle was used to insert SS400 transmitters into the body cavity.

In general, both herring species demonstrated high transmitter retention rates for the SS300 tag (97% in alewife and 100% in blueback herring) and the SS400 tag (100% in both species). Based on the observations, it appears that the adults of both alewife and blueback herring are compatible with the two ATS transmitters assessed during this study. Both retention and latent survival rates were relatively high and did not show any strong differences between the two transmitter methods. In addition, the life span of the SS400 transmitter at a comparable transmission rate is longer than that of the SS300. However, the SS400 does not currently support additional sensor information to be included in each tag transmission. The SS300 allows for the collection of pressure information with each tag detection, allowing the user to determine fish depth for each recorded transmission.

The RSP identified a total of six locations representing a cross section of conditions under which the performance of JSATS receivers was to be evaluated (identified in this report as pilot deployment locations 1 through 6 (Figure E.7-17). Field conditions at the time of data collection prevented sampling at pilot deployment location 3.

Figure E.7-17. Pilot Deployment Locations 1 through 6 Identified for Evaluation of JSATS Acoustic Receivers in the RSP for Phase 1 of the Project Interaction Study at Lawrence.



Six general regions upstream and downstream of the Lawrence Dam were identified (Figure E.7-18). A general characterization of each region relative to in-river conditions (depth, flow, etc.) is summarized below.

- Regions A (lower impoundment) and F (downstream reach) can be characterized as relatively deep and low velocity areas with limited surface turbulence, which remain relatively steady under a range of inflow conditions. Phase 1 data collection at pilot deployment location 6 is most representative of these regions.
- The powerhouse forebay (Region B) and tailrace (Region C) are both relatively deep, and flow conditions range from moderate to high depending on the level of generation. There is a larger degree of surface turbulence present in Region C due to the downstream bypass discharge. These two regions are generally steady with regards to water depth and flow

under a range of inflow conditions. Phase 1 data collection at pilot deployment location 1 is representative of the powerhouse forebay, and pilot deployment locations 2 and 4 are most representative of the powerhouse tailrace.

- The dam spill zone (Region D) is relatively shallow and characterized by high flow conditions and surface turbulence. Conditions in this region vary considerable depending on river conditions, from periods of no spill, shallow depths, and a lack of connectivity to periods of high velocity and turbulent conditions. This region was not suitable for collection of Phase 1 data due to no flow.
- The downstream confluence zone (Region E) is also relatively shallow and characterized by high flow conditions and surface turbulence. As this area receives flow from both the powerhouse tailrace and spillway, conditions in the downstream confluence zone are fairly consistent (relative to the dam spill zone). Phase 1 data collection at pilot deployment location 5 is most representative of this region.

The 1D and 2D evaluations considered both transmitter models (SS300 and SS400) as well as receivers manufactured by Lotek and ATS. Based on the higher detection rates observed for the ATS receivers, the Lotek receivers will not be discussed any further in this report or considered for inclusion in Phase 2.

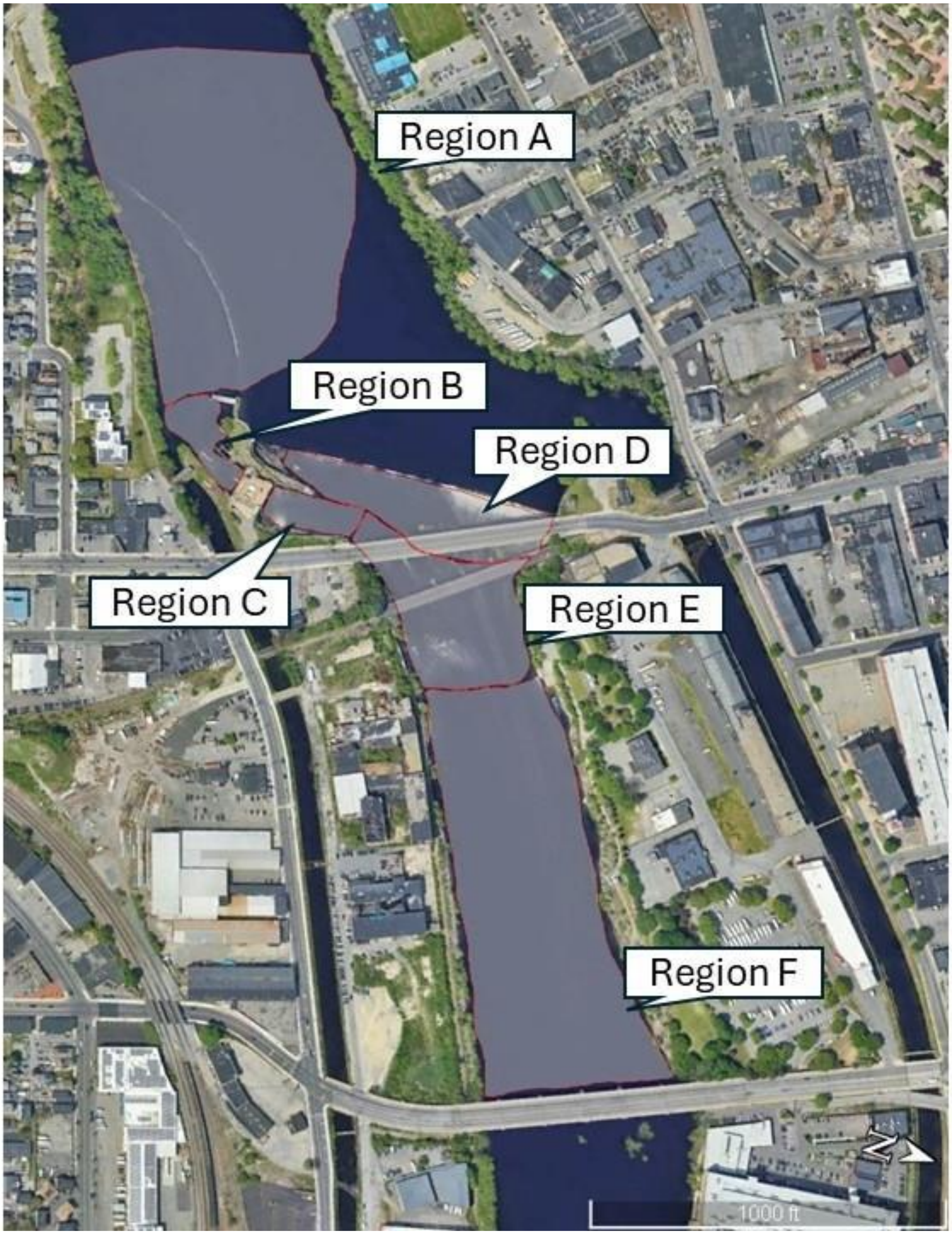
Based on observations made during the Phase 1 evaluation of JSATS transmitters and receivers at Lawrence, installation of a 2D array in the area downstream of the powerhouse (i.e., Region C; Figure E.7-18) appeared feasible and likely to produce meaningful positional information for fish carrying either the SS300 or SS400 transmitters. Phase 1 field testing of these units occurred during October 2024 when powerhouse discharges were around 1,500 cfs.

Based on results the study, the use of the SS300 transmitters on a subset of study fish would allow for the collection of depth information for those individuals which may enter the Region C array. Given the relatively poor detection rates for acoustic receivers evaluated during Phase 1 from areas characterized by shallower water depths and higher flow velocities, collection of viable 2D positional data has a low probability of success in the area immediately downstream of the dam spillway and in the downstream confluence zone (i.e., Regions D and E), although results indicated that careful positioning of receivers in these areas might yield meaningful 1D detections of tagged fish to inform on presence/absence. Findings from the Phase 1 evaluation confirmed that deployment of acoustic receivers within the forebay (Region A) and at locations in the mainstem downstream reach (Region F) would provide sufficient detection rates of either transmitter model to indicate fish presence.

The RSP identified the inclusion of several cross-river downstream checkpoints to inform on passage of tagged fish to and from the upstream 2D array. Observations from the pilot deployment location 6 suggested that a maximum receiver spacing of 40 m should allow for 6-9 detections per minute (depending on transmitter type and at an assumed 3-second PRI) for fish passing through those areas.

The RSP indicated that adult alewife and blueback herring for the tank evaluation of transmitter retention would be collected at the Lawrence upstream fishway and would total 50 test fish of each species. Since herring passage at the Lawrence fish lift at the time of collection was insufficient to provide an adequate number of test fish, Essex coordinated with the state fisheries agencies (Massachusetts and New Hampshire) to obtain samples via boat electrofishing downstream of Essex Dam and at the fish ladder trap and truck facility at Amoskeag Dam in Manchester, NH. Alewife collections met the minimum sample sizes identified in the RSP. Although blueback herring collections did not meet the minimum sample sizes identified in the RSP, enough individuals were obtained to evaluate both tagging methods and maintain some control fish to understand potential collection and handling effects.

Figure E.7-18. General Regions Based on Hydraulic and Bathymetric Conditions in the Vicinity of the Lawrence Project.



Phase II

Essex undertook field efforts associated with the execution of Phase 2 of the Diadromous Fish Behavior, Movement, and Project Interaction Study during the 2025 passage season at Lawrence. Prior to the initiation of the release of tagged fish downstream of the Project, a total of 31 JSATS acoustic receivers were installed at locations upstream and downstream of the Essex Dam over three dates during late April and one date during early May. As installed, the array was intended to inform on fish movement to and from the Project via a series of “gate” receivers at points upstream and downstream of the dam and on fish behaviors via a concentrated region with significant overlap, intended to provide 2D positioning in the powerhouse tailrace. Receiver placement was informed using information collected during Phase 1 of the Project Interaction Study completed during the 2024 study season.

Tagging took place on 12 dates from late April through early June 2025, and a total of 335 alewife, 300 blueback herring, 199 American shad, and 100 striped bass were successfully tagged with an acoustic JSATS transmitter. High flow conditions in the river of up to 46,500 cfs eliminated the ability to safely boat electrofish for test fish for a 16-day period during the first part of May. Sample collection for test fish resumed when flows receded to a point conducive to on-water sampling on May 20. Tagging efforts were concluded on June 1, and monitoring efforts via the deployed autonomous receivers in-river extended into July.

In addition to hampering tagging efforts for part of May, flow conditions downstream of Lawrence (and the presence of spill flows at the dam) completely eliminated any access to autonomous receivers installed as part of the underwater 2D array in the powerhouse tailrace and reduced visibility of and access to autonomous receivers installed at mainstem locations intended to inform on 1D positioning of tagged fish. During receiver retrieval efforts, it was determined that the high discharge and non-laminar flow conditions in the Lawrence powerhouse tailrace during the 2025 upstream passage season were unsuitable for the deployment and operation of autonomous JSATS receivers, and that those conditions had resulted in catastrophic damage to and/or loss of 10 of the 13 autonomous receivers installed as part of the array intended to collect 2D information from the Project tailrace. The magnitude of this receiver loss prevented any ability to inform on 2D fish positions within the tailrace at Lawrence.

Despite the significant damage to receivers associated with the 2D array, all autonomous receivers installed at mainstem locations (with the exception of one) were successfully recovered in working condition, and data from these locations were utilized to provide some descriptive data to characterize species movement in the reach downstream of Essex Dam. Initial arrivals of tagged fish at the Lawrence tailrace took place from late April through early June. The initial detection of nearly all tagged fish at the Lawrence tailrace occurred during the daylight hours (i.e., 0600 to 2000). Probabilities of upstream movement for each test species were estimated using a series of Cormack Jolly Seber models. These models estimated the probability of passage for tagged fish from the release location (located just upstream of the confluence with the Spicket River) to the Project tailrace (downstream entrance and upstream extent [i.e., vicinity of the fish lift entrance]), and then upstream of the dam.

Estimates of passage probabilities for tagged alewife were consistent for the full reach from release to the downstream face of the powerhouse. The estimate of passage success for tagged alewife using the Project fish lift was 1.9%. Passage probabilities for tagged blueback herring to ascend the downstream reaches were slightly lower than that observed for alewife. Of the blueback reaching the receiver positioned at the downstream extent of the tailrace channel, approximately 26% were subsequently detected at the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance). American shad showed a relatively low probability to ascend upstream following tagging (consistent with the known fallback behavior of this species following handling). Despite this, nearly 70% of individuals which reached the downstream end of the tailrace channel were subsequently detected at the next station upstream along the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance) and passage success for those fish via the upstream fish lift was estimated at 26.9%. Striped bass showed movements upstream through the reach below the dam but no individuals were detected passing upstream via the lift.

Time at large was estimated for each tagged fish as the duration from release until final detection within the monitoring array. Based on evaluation of median estimates for time at large, tagged alewife and striped bass were present longer after tagging than were observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). Spatial and temporal patterns in the relative proportion of time spent among the downstream regions defined by the stationary receivers were evaluated for each species. In general, alewife and striped bass showed use of all of the downstream regions, whereas blueback herring and American shad were somewhat more limited to regions towards the downstream end of the reach. Tagging efforts for both species occurred during the latter part of May and early June. High flow conditions, which prevented tagging during the early to mid-portion of May and persisted well into June, were likely an influence on upstream movement of both species through the 1.0-1.4 mile reach between the tagging location and the fish lift.

The temporal review of species use of the downstream reach indicated presence of tagged river herring (both species) into early June. American shad presence was notable from late May through early June, and individuals tended to spend a higher proportion of time in the lower portion of the monitored reach. Tagged striped bass were present throughout the downstream reach from initial tagging for the species in late May through June.

The updated study plan identified total sample sizes for alewife (n=345), blueback herring (n=345), American shad (n=200), and striped bass (n=100). The final numbers of tagged fish released in the reach downstream of Essex Dam were slightly lower for alewife (n=335), blueback herring (n=300), and American shad (n = 199). Significant efforts to collect fish via boat electrofish for tag and release downstream of the Project took place over 12 days between late April and early June 2025. Merrimack River flow conditions prevented safe and effective sampling downstream of Lawrence for a two-week period during early to mid-May.

Phase 2 of the Project Interaction Study was intended to collect data to inform on the two-dimensional positions of tagged fish within the tailrace channel region downstream of the Lawrence powerhouse. The full 2D receiver array was installed and operational on April 28. Shortly thereafter, Merrimack River flows increased significantly, and spill was present at the Lawrence Project well into June, eliminating access to autonomous receivers installed as part of the 2D array in the powerhouse tailrace and reducing visibility of and access to autonomous receivers installed at mainstem locations intended to inform on 1D positioning of tagged fish. The high discharge and non-laminar flow conditions in the Lawrence powerhouse tailrace during the 2025 upstream passage season were unsuitable for the deployment and operation of autonomous JSATS receivers and resulted in catastrophic damage to and/or loss of 10 of the 13 autonomous receivers installed as part of the array intended to collect 2D information from the Project tailrace. As a result, no two-dimensional information is available to include in the study.

Phase 1 Project Operations and Fish Stranding Study (HDR 2026a)

The Phase I Project Operations and Fish Stranding Study provides a review of Project operations over the six-year period from January 1, 2019 through December 31, 2024. The study evaluated Project inflows, impoundment elevations, turbine flows, minimum flows, fish passage operations, and downstream conditions to characterize ROR operations and assess potential relationships between Project operations and observed fish stranding events.

The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Figure E.7-19 illustrates the total Project outflow in cfs throughout the study period in relation to the inflow from the Merrimack River gage at Lowell. In general, the inflow rates and total Project discharge rates are closely aligned, with rises and falls in inflow rates having direct proportional effects on the total Project discharge rates. Annual trends include a spike in flow rates in May during spring snowmelt and often another spike again in December.

Similarly, total Project outflow is closely tracked by tidally filtered flows recorded at the USGS Gage No. 011006988 Haverhill, approximately 12.83 miles downstream of the Project site. For the period of record, the Haverhill gage only has data available from 2022 through the end of 2024. Annual comparisons of the total Project discharge rates and the recorded tidally filtered flow rates at Haverhill for 2023 and 2024 indicate that Project outflows generally align with the pattern of recorded flows at USGS Gage No. 011006988 Haverhill (Figure E.7-19 and Figure E.7-20).

Figure E.7-19. Total Project Flows and USGS Lowell Gage Hourly Discharge from 2019 through 2024.

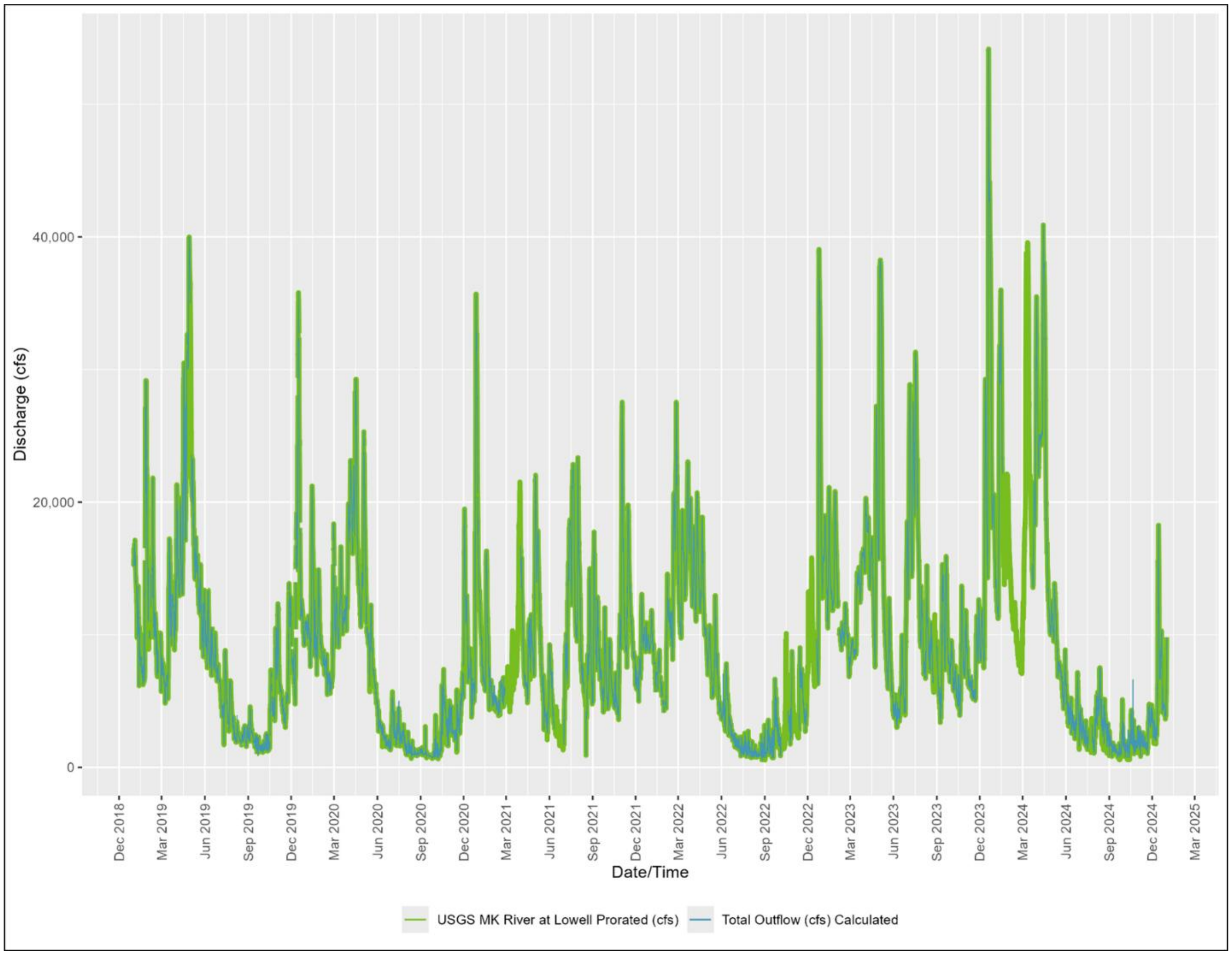


Figure E.7-20. Total Project Discharge and Merrimack River Downstream Flow (USGS No. 011006988) 2023.

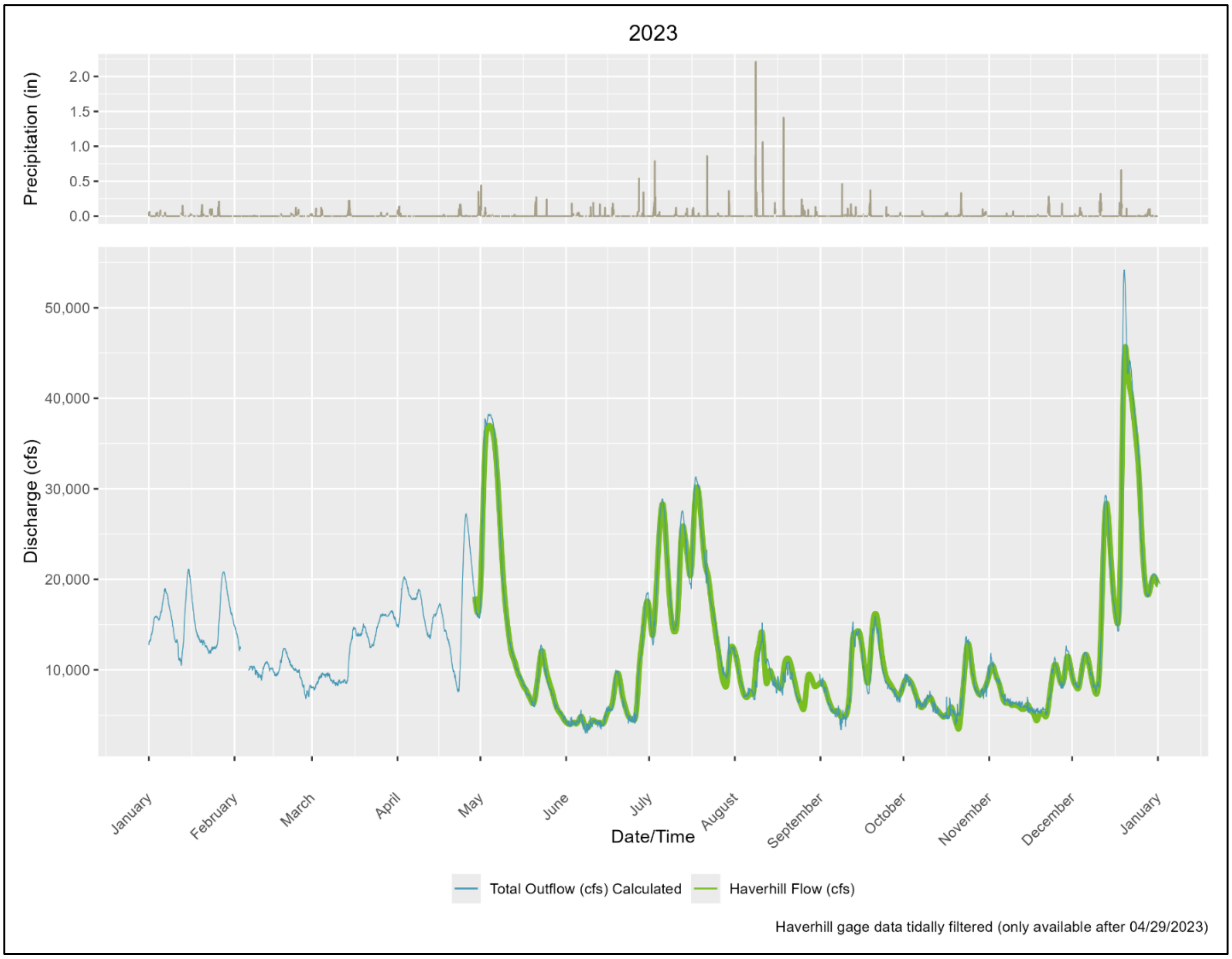
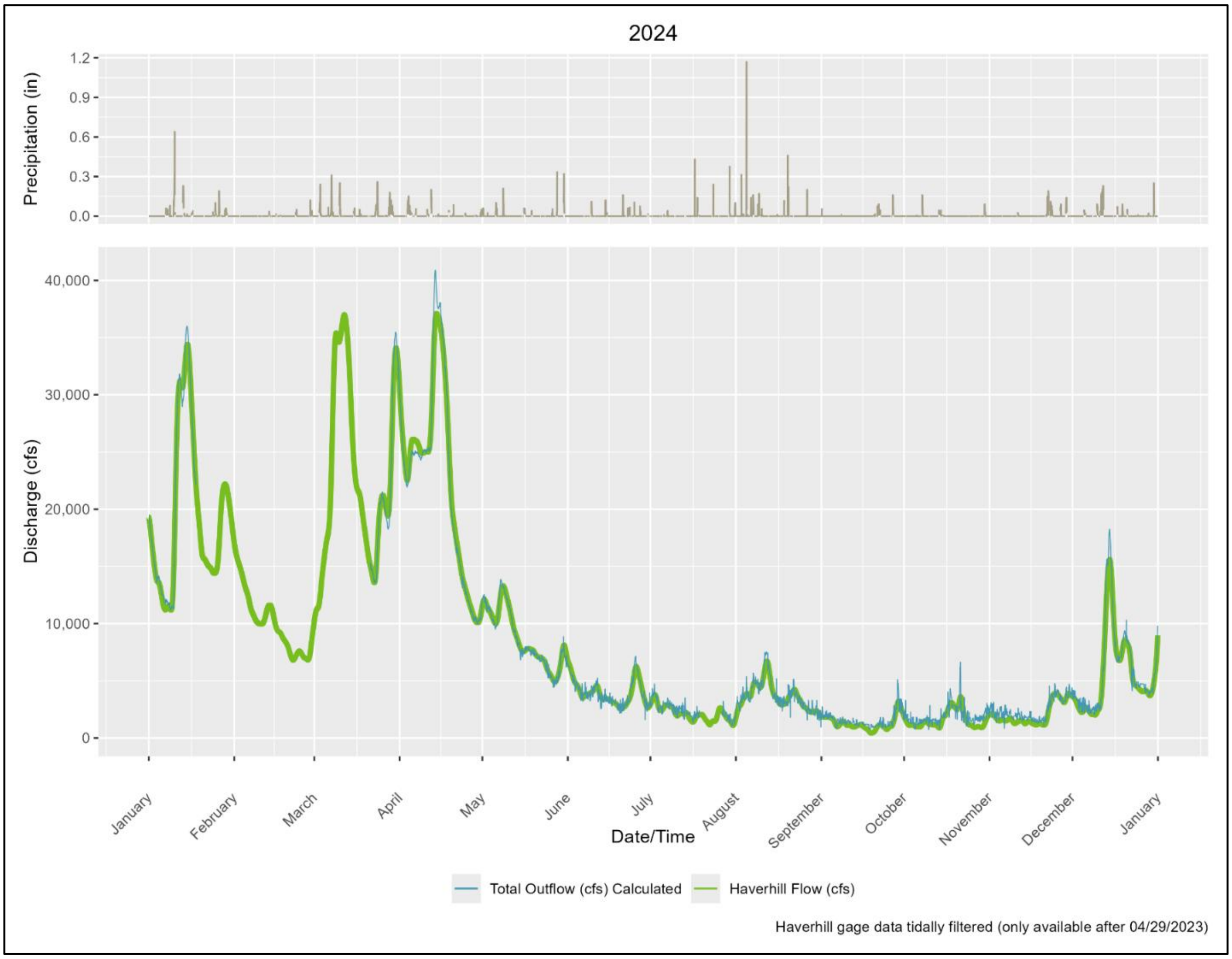
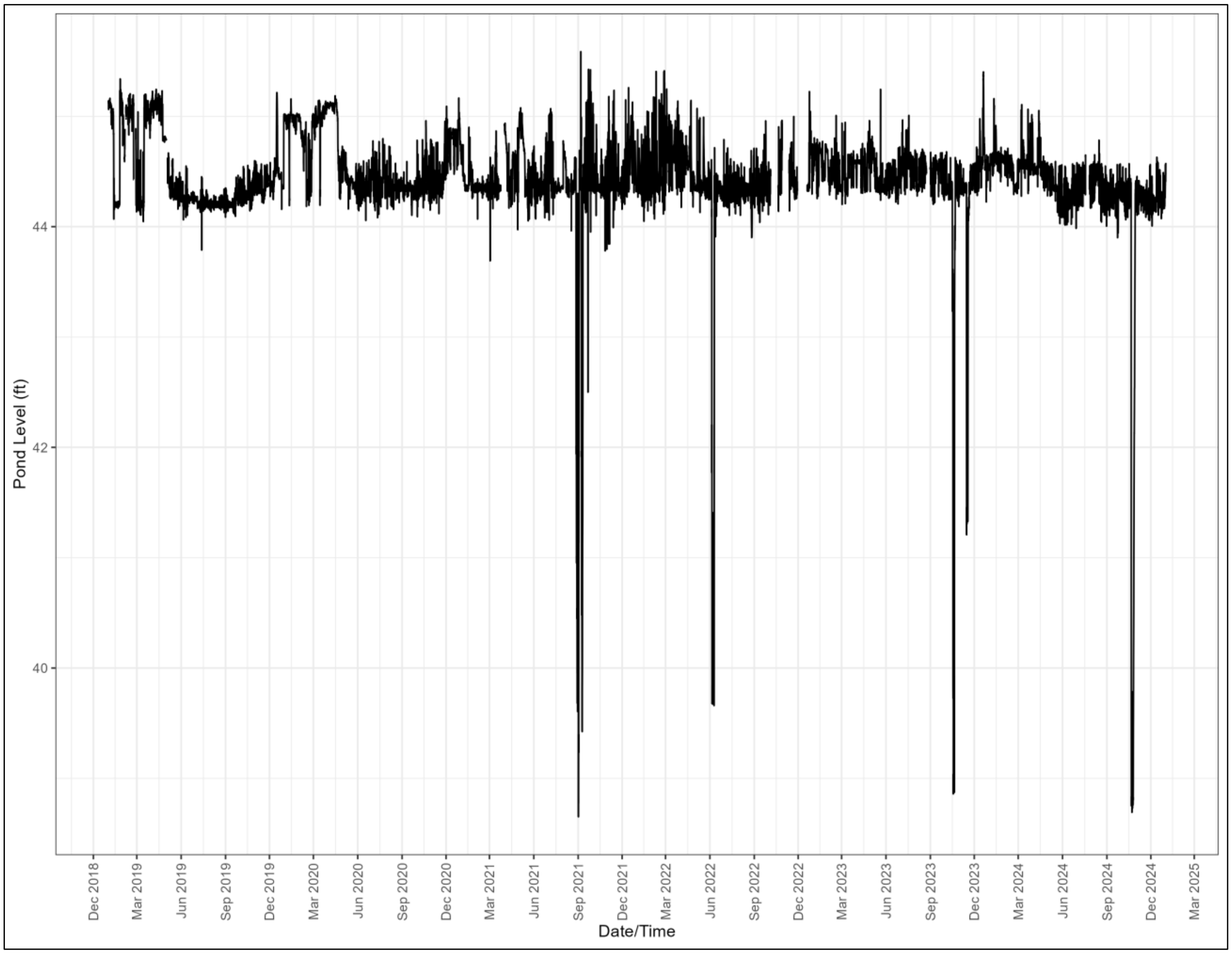


Figure E.7-21. Total Project Discharge and Merrimack River Downstream Flow (USGS No. 011006988) 2024.



Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system, with the exception of five planned drawdown periods (Figure E.7-22). The average pond level during the study period was 44.4 feet with average monthly levels ranging from 43.3 to 44.7 feet (Figure E.7-22). Pond levels were typically highest in the winter from December through April (Figure E.7-22). There were four drawdowns of the impoundment to below the spillway crest (± 5.5 feet), which were necessary to perform maintenance and repairs on the crest gate system, and one of about 3 feet below normal pond required to facilitate installation of the eel elevator at the left abutment. Each of these drawdowns was conducted in consultation with the resource agencies and notification to potentially affected stakeholders.

Figure E.7-22. Impoundment Elevations (ft NVGD 29) from 2019 through 2024.



Downstream Juvenile Alosine Passage Assessment (NAI 2026e)

In support of this relicensing, Essex conducted a Downstream Juvenile Alosine Passage Assessment in 2025. The goal of this study was to determine if Project operations negatively affect juvenile alosine survival. Specifically, direct survival of alosines passed downstream through the spillway and fish bypass was estimated using a high-visibility balloon tag (also known as HI-Z tag) recapture evaluation.

For the purposes of this study, target releases of 60 treatment fish for all experimental groups (spillway, bypass, control) were selected to obtain survival estimates with a precision (ε) of ±10% with 90% confidence. This sample size assumed 95% control survival, a recapture rate of ≥99%, and an expected passage survival rate between 85-90%. During these HI-Z evaluations, the sample sizes can be adjusted in the field to obtain survival estimates that meet the study-specific precision goal.

Wild juvenile alosines were collected by electrofishing from Pawtuckaway Lake, Lamprey River Watershed on October 10, 2025. Although no effort was made to identify individuals to species, only alewife are stocked at this location. For the purposes of this evaluation, the collected individuals are assumed to be representative of juvenile American shad, alewife, and blueback herring. Fish were transported to the Project in a 300-gallon insulated tank supplied with aeration and filled with 7.5 ppt brackish saltwater. Onsite, fish were held in a 1,000-gallon flexible vinyl circular tank maintained at approximately 600 gallons. Ambient river water was continuously supplied via two electric pumps powered by separate 110 outlets for redundancy. Fish were held for one week prior to testing and checked daily to ensure adequate holding conditions. No mortality was documented.

Prior to tagging, two airlift post-recapture recovery tanks were prepared, one for the treatment fish and one for the control fish. Tanks were filled with 175 gallons of ambient river water mixed with fine, aquarium-grade sea salt to achieve a concentration of 7.5 ppt saltwater. The tank was held static without inflow and fitted with an aeration stone within a standpipe to create gentle directional flow for fish orientation. Treatment and control fish were placed in designated recovery tanks after recapture for 24 hours. After that holding period, for the remainder of the 48-hour assessment, ambient river water was supplied to the tanks in a similar flow-through manner as the 1,000-gallon flexible circular tank.

Fish tagging, release, and recapture techniques were similar to those used in HI-Z studies for juvenile alosines at other hydroelectric stations on the east coast (Heisey et al. 1992; RMC 1994; Normandeau Associates 1996, 2016; Normandeau Associates, Inc. and Gomez and Sullivan Engineers, P.C. 2012). Differing from those previous evaluations, anesthetizing juvenile alosines in a solution of MS-222 in 7.5 ppt brackish saltwater was used, a method that has been shown to improve survival during holding (Deters et al. 2024). As described in Section 4.1, a total of 120 juvenile alosines were released as part of the evaluation. Sixty fish were released into the bypass, while an additional sixty were released into the tailrace as a control group. Each fish was fitted with a neutrally buoyant miniature radio transmitter and one HI-Z Tag.

Fish were concentrated using a seine net and transferred into a source fish container for tagging using a water-to-water transfer to minimize stress and handling. Fish were then placed into an aerated 5-gallon bucket filled with 7.5 ppt saltwater. Fish were placed individually in an anesthetic bath prior to tagging. Once fish displayed a total loss of equilibrium, fish were examined for any injuries prior to tagging and for any observed pre-existing conditions, and the total length of the fish was recorded. A unique fin clip was also made to distinguish treatment and control fish. Fish showing erratic behavior or external injuries and/or fungal infections were rejected and not used.

Following sedation, measurement, and fin clipping, fish were tagged with a 0.5-gram radio transmitter paired with a deflated HI-Z Tag. The tagging process included one HI-Z Tag attached via stainless steel pin inserted through the musculature beneath the dorsal fin, allowing for fish to surface and ensuring rapid recapture after release. Fish were then placed in fresh water to recover prior to release as either a control or treatment individual.

Treatment and control fish were both released through a fish injection system consisting of an elevated holding basin fitted with a 4-in discharge hose. River water was continuously supplied with a 3-in trash pump to ensure swift transport of fish to the designated release point. The release hose was lowered into the fish bypass and fixed in place approximately 5 meters downstream of the forebay entrance.

After release (treatment or control) recapture crews situated in the tailrace were notified via two-way radio as each fish was released into the bypass. To eliminate crew bias, boat crews were not assigned to recapture specific groups of fish (treatment or control). Fish were tracked by boat within the tailrace and downstream of the fish bypass system and retrieved once buoyed to the surface by an inflated HI-Z Tag using an Advanced Telemetry System R2000 receiver coupled with a loop antenna.

After recapture, the HI-Z Tag was removed, and each fish was immediately examined for maladies consisting of visible injuries and/or loss of equilibrium (LOE or disorientation). Recaptured fish were then transported and placed into their designated airlift tank to assess potential delayed effects of passage through the downstream bypass. The immediate post-passage statuses of individual recaptured fish were designated as either alive, dead, predation, or unknown. Mortality of recaptured fish after 1 hour post-passage was considered 48-hour mortality. The condition of fish was evaluated at intervals of approximately 12 hours. Dead fish were examined for descaling and injury and were necropsied to determine the probable cause of mortality.

Recaptured fish were transferred to onsite 8-ft-diameter circular holding tanks held for 48-h to monitor delayed mortality A final thorough injury examination occurred at the end of the 48-h holding period to detect injuries that may not have been apparent or were overlooked during the initial evaluation at recapture. However, all fish were recaptured alive and remained so for the 48-hour assessment. Injuries were categorized by type, extent, and area of body, and they were documented with digital photographs. A malady classification was established to include fish with injuries, scale loss >20%, and/or LOE. Fish without maladies were designated “malady-free” (MF). Probable causes of injury (e.g., mechanical, shear, or pressure-related) were ascribed to each injured fish depending on the observed injury characteristics. Survival and MF estimates were calculated for the bypass.

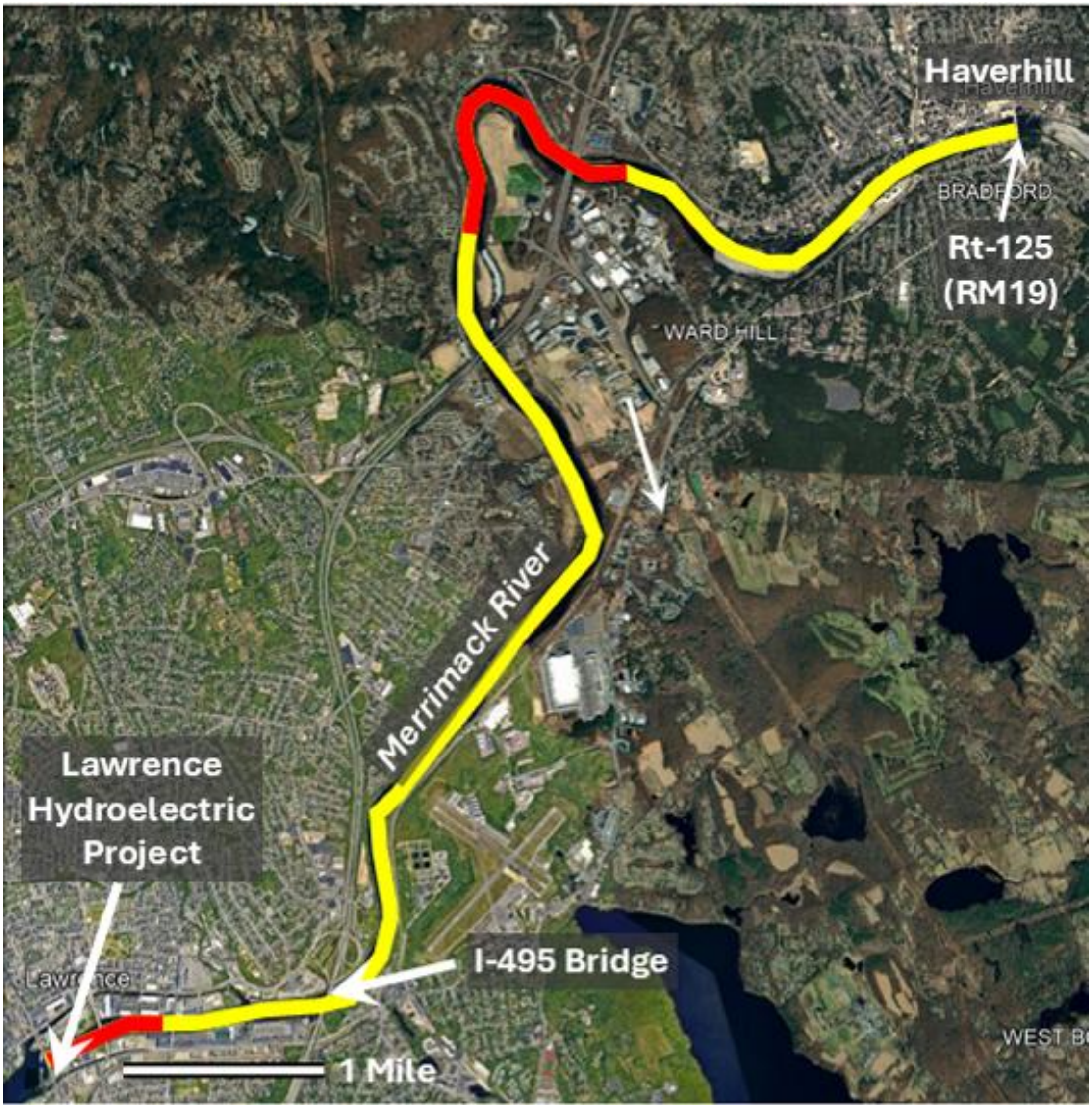
This study was intended to estimate the immediate (1-hour) and latent (48-hour) survival and malady-free rates with a precision of ±10% with 90% confidence for juvenile alosines passed downstream via the Project spillway and through the downstream fish bypass. Determination of the type, severity, and probable cause of observed injuries were assessed for all recaptured fish. Low Merrimack River flows during the entirety of the fall downstream migration period (i.e., September 1 to November 15) prevented testing of the spillway. Despite low inflow, downstream passage survival and injury rates for juvenile alosines passing downstream via the Project downstream bypass facility was completed during 2025.

A total of 60 HI-Z tagged fish were released at the upstream end of the downstream bypass facility on October 18, 2025, and flows through that facility were at 2% of station capacity (160 cfs) during testing. Of the 60 fish released, 54 were recaptured and survived the initial 1-hour immediate survival period and the 48-hour latent survival period. All 60 control fish were recaptured alive and remained alive through the 48-hour latent survival period. Six treatment fish were documented as having minor passage related injuries attributable to either shear or mechanical causes. HI-Z tag-recapture testing completed during fall of 2025 demonstrated latent (i.e., 48-hour) survival and malady-free rates for juvenile alosines of 90% (±6.2% with 90% confidence) and 93.6%, respectively.

Sturgeon Habitat Mapping and Assessment Study (ASA 2026a)

Essex conducted a Sturgeon Habitat Mapping and Assessment Study in support of this relicensing. The Sturgeon Habitat Mapping and Assessment Study was designed to (1) map the benthic habitat features of the Merrimack River downstream from the Project Dam (Essex Dam) to RM 19 (Basiliere Bridge on Route 125) (See Figure E.7-23 below), and (2) quantify the area of juvenile rearing habitat, spawning habitat, and foraging habitat for Atlantic *(Acipenser oxyrinchus oxyrinchus)* and shortnose sturgeon (*A. brevirostrum*) in this reach based on substrate type and water depth.

Figure E.7-23. The 10-river-mile reach (yellow and red polylines) for the Sturgeon Habitat Mapping and Assessment Survey.



Note: red polylines indicate areas that were not accessible

The Sturgeon Habitat Mapping and Assessment Study was designed to use SSS to collect data for mapping benthic habitat features and quantifying the nursery, spawning, and foraging habitat for Atlantic and shortnose sturgeon, based on substrate type and depth. Substrate type, size, and embeddedness, as inferred from visual classification of SSS imagery, was planned to be verified by underwater video and sediment grab samples. Additionally, bathymetric data were planned to be collected to create a gridded GIS depth and substrate layer.

Substrate classification (type, size, and embeddedness) of the SSS imagery was designed to be informed and verified by two direct sampling methods: underwater video and sediment grab sampling. The verification samples were collected along 10 transects through the survey area ("verification transects"), where each verification transect consisted of three sampling stations: one near each riverbank and one approximately in the center of the river channel, as navigation allowed. The initial goal was to collect 30 sediment grab samples and underwater video recordings to supplement the SSS and bathymetric data. The survey was planned to be completed following this study plan, with real-time field adjustments to the methods described herein only if needed (e.g., navigational hazards, safety, data quality, and coverage).

Water quality measurements (temperature, conductivity, DO) were collected during the verification sampling survey with an In Situ Aqua Troll 500 ("CTD" or "sonde"). After recording the water quality measurements at a station, underwater video was collected with a GoPro Hero 13 underwater camera model, mounted in a custom-fabricated aluminum frame in a downward-facing orientation, approximately 24 inches above the river bottom. At each verification station, the video frame system was lowered to the river bottom to collect short video recordings (15-30 seconds). After recording the underwater video at a station, sediment grabs were collected with a 6x6-inch (0.024 m^2) stainless steel Petite Ponar grab). At each station, at least three valid grab attempts were made before determining whether or not a sediment sample could be collected. Notes were recorded with each grab attempt (e.g., empty, void, or sample collected, along with description of the environment and/or if grass or single rocks were found in a grab). A subsample of approximately 100 mL of the upper 2 cm layer of the sediment grab was transferred to a 250 mL jar to be sent to a laboratory for sediment grain size analysis.

Modification to the planned survey design and data processing was required due to the environmental conditions encountered during the sturgeon habitat mapping survey. The main limitation was an environmental constraint, specifically low water due to low river flows, which was generally 4 feet below the recent 5-year average for the survey period. The planned study design described in the Study Plan focused on collecting SSS data for the 10-mile survey reach along three axial transects (i.e., along the river axis), to be combined with bathymetric survey data collected along "zig-zag" transects throughout the 10-mile survey reach, and supplemented with verification sampling/ground truthing at stations along 10 cross-river transects (approximately one transect with three stations per RM).

Due to the extremely low water levels encountered during the surveys, it was not practicable or safely navigable to fully perform the sonar surveys as intended, and as a result, some portions of the surveys could not be completed (i.e., SSS and bathymetry). The vessel could not sample along transects for SSS and bathymetry because the vessel was consistently having to navigate to avoid shallow and/or exposed rocks. This presented a hazard not only to navigation but to equipment as well, as the over-the-side mounted equipment (single-beam sonar and SSS) and the vessel's propeller struck rocks multiple times. Because of this, the habitat survey primarily focused on conducting verification sampling with bathymetry at each station to provide insight into the distribution and quantity of sturgeon habitat where possible.

River conditions during the survey (i.e., stage and flow) were assessed from data gathered by the Project. River stage (ft, NAVD88) and river flow (cfs) were plotted for assessment of conditions encountered during the survey and for the rest of the 2025 field season. Water quality measurements were downloaded from the instrument following each field day, and data were compiled in Excel and reviewed for suspect data/quality issues. Summary statistics for water temperature, conductivity, and DO were determined for each verification transect and all water quality data collected. Still shots ("frames") of underwater video files were used both to classify benthic substrate types by particle size and to quantify percent area covered by the identified substrates. A single substrate type was considered “dominant” if it covered 50% or more of the observed stream bed surface, “sub-dominant” if it covered 10-49% of the stream bed surface, or “other” if it covered <10% of the stream bed surface. Embeddedness was determined by estimating percent area covered by grain particles <2 mm in size (sand and finer particles, collectively). Depth soundings were merged with the GPS data during data collection in HYPACK Survey software. MATLAB was used to post-process the HYPACK data files to extract water surface elevation (ft, NAVD88), river bottom elevation (ft, NAVD88), and water depth at time of sample collection (ft) for each station from the HYPACK data files. Data were then smoothed with a box-car filter and linked to each station by timestamp for an estimate of depth and elevation to associate with the substrate data for the purpose of sturgeon habitat classification.

Suitable habitat area for Atlantic and shortnose sturgeon foraging, juvenile rearing, and spawning between the Lawrence Hydroelectric Project and RM 19 was determined using depths and dominant and sub-dominant substrate types identified during this study compared against species-specific literature-based values for foraging, juvenile rearing, and spawning habitat in fresh waters of the northeastern U.S. and Canada (see Table 3-2 in ASA 2026a).

Data were collected by direct sampling during July 22-24, 2025, between the Project tailrace and Basiliere Bridge at RM 19 in Haverhill, MA. Data collection resulted in the findings below.

Benthic habitat features, such as dominant and sub-dominant substrate type and depth, were collected and mapped across the Merrimack River in one-third segments (left, middle and right) along the study reach by each mile where valid sample information could be safely collected. Depths ranged from 4.7 to 16.0 ft. Dominant substrates were pebble, cobble and SAV. Substrate appeared to be minimally embedded (0-18%) into the riverbed by sand and silt. Substrate classification by size and embeddedness were estimated from data collected by a Petite Ponar Grab and underwater video.

The total surveyed area from the railroad bridge near the Project tailrace downstream to Basiliere Bridge (RM19) was approximately 596.7 acres. Within the surveyed area, Atlantic sturgeon habitat comprised 16% for both foraging and juvenile rearing purposes, while spawning habitat accounted for 65%. Shortnose sturgeon habitat area was classified as 19% for foraging, 3% for juvenile rearing, and 52% for spawning. Habitat classification was not assigned to approximately 28% of the total surveyed area due to a lack of available data. Sturgeon were not observed while sampling during July 22-25, 2025.

Fish Assemblage Assessment (NAI 2026f)

Essex conducted a Fish Assemblage Assessment in support of this relicensing. The objectives of the study were to compile information from existing fish assemblage data, summarize fisheries data from required fishery studies for the Project, and assess the information for any data gaps in fisheries information.

Existing information on fish and aquatic resources was previously summarized in the PAD prepared by Essex and filed with the Commission on June 16, 2023. Information previously presented within the PAD was used as a starting point for characterizing known and historically present fish species within the Merrimack River Basin. Where available, additional fish assemblage information was used to supplement the breadth of information available to describe the existing community in the Project reaches upstream and downstream of Essex Dam. Data searches targeted online information either not included in or released following issuance of the PAD. In addition, available fish community information collected as part of additional Project relicensing studies was considered. Available information was screened to ensure both proximity to the Lawrence Project, as well as timeliness (i.e., targeted studies within the last 20 years (2005 to 2025).

Following compilation of fish assemblage information from all included resources, a comprehensive list of fish species was assembled to provide a description of the Project area fish community. Fish species were assessed relative to a number of classifications, including:

- Native vs. nonnative species,
- Diadromous vs. resident species, and
- Spatial distribution in relation to Essex Dam (i.e., upstream, downstream, or both).

In addition, life history descriptions for family groups were assembled using available literature sources.

Current existing fish species found in the Project area and the greater Merrimack River watershed, along with data collected from additional sources and past studies, were reviewed. When available records reported over the last 20 years are considered, a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project. The Merrimack River is home to a diverse assemblage of fish species, including both cold water and warm water species, and provides a migratory corridor for many diadromous species. Eight resident fish species were reported from previously sampled locations located only upstream of Essex Dam. An additional 23 species were reported as being present in Merrimack River reaches both upstream and downstream of Essex Dam, with those individuals representing ten families and including both native and introduced species as well as freshwater resident and diadromous species. Six fish species were reported only downstream of Essex Dam, representing four freshwater resident species (brown bullhead, blacknose dace, redfin pickerel, and white catfish) and two native diadromous species (shortnose and Atlantic sturgeon).

The study characterized the general fish assemblage found in the vicinity of the Lawrence Hydroelectric Project area. Information is available on both resident and diadromous species located within the Project area, both upstream and downstream of Essex Dam, and a review of this information does not indicate any significant data gaps at this time (Table E.7-21).

Table E.7-21. Merrimack River Fish Assemblage for the Lawrence Project Region as Summarized from Available Information Sources.

Common Name	Scientific Name	Freshwater Resident	Diadromous	Native	Introduced	Records for Upstream Only	Records for Downstream Only	Records for Upstream and Downstream
Alewife	*Alosa pseudoharengus*		X	X				X
American Eel	*Anguilla rostrata*		X	X				X
American Shad	*Alosa sapidissima*		X	X				X
Atlantic Salmon	*Salmo salar*		X	X				X
Atlantic Sturgeon	*Acipenser oxyrinchus*		X	X			X	
Black Crappie	*Pomoxis nigromaculatus*	X			X	X		
Blueback Herring	*Alosa aestivalis*		X	X				X
Bluegill	*Lepomis macrochirus*	X			X			X
Brown Bullhead	*Ameirius nebulosus*	X		X			X	
Brown Trout	*Salmo trutta*	X			X	X		
Chain Pickerel	*Esox niger*	X		X				X
Channel Catfish	*Ictalurus punctatus*	X			X	X		
Common Carp	*Cyprinus carpio*	X			X			X
Eastern Blacknose Dace	*Rhinichthys atratulus*	X		X			X	
Fallfish	*Semotilus coporalis*	X		X				X
Golden Shiner	*Notemigonus crysoleucas*	X		X		X		
Green Sunfish	*Lepomis cyanellus*	X			X			X
Largemouth Bass	*Micropterus salmoides*	X			X			X
Longnose Dace	*Rhinichthys cataractae*	X		X		X		

Common Name	Scientific Name	Freshwater Resident	Diadromous	Native	Introduced	Records for Upstream Only	Records for Downstream Only	Records for Upstream and Downstream
Margined Madtom	*Noturus insignis*	X			X	X		
Northern Pike	*Esox lucius*	X			X			X
Pumpkinseed	*Lepomis gibbosus*	X		X				X
Redbreast Sunfish	*Lepomis auritus*	X		X				X
Redfin Pickerel	*Esox americanus*	X		X			X	
Rock Bass	*Ambloplites rupestris*	X			X			X
Sea Lamprey	*Petromyzon marinus*		X	X				X
Shortnose Sturgeon	*Acipenser brevirostrum*		X	X			X	
Smallmouth Bass	*Micropterus dolomieu*	X			X			X
Spottail Shiner	*Hudsonius hudsonius*	X			X			X
Striped Bass	*Morone saxtillus*		X	X				X
Tessellated Darter	*Etheostoma olmstedi*	X		X				X
Walleye	*Sander vitreus*	X			X	X		
White Catfish	*Amerius catus*	X			X		X	
White Perch	*Morone americana*	X		X		X		
White Sucker	*Catostomus commersoni*	X		X				X
Yellow Bullhead	*Ameiurus natalis*	X			X			X
Yellow Perch	*Perca flavescens*	X		X				X
Total		**28**	**9**	**22**	**15**	**8**	**6**	**23**

Downstream Juvenile Alosine Passage Assessment (NAI 2026e)

The goal of this study was to determine if Project operations negatively affect juvenile alosine survival, using a HI-Z tag-recapture (i.e. balloon tag) evaluation to estimate direct survival of alosines passed downstream through the spillway and fish bypass. During the fall downstream migration period (i.e., September 1 through November 15) the downstream bypass is opened and provides 2% of turbine flow. The bypass is most often operated at 2% (or 160 cfs) of the Project's turbine capacity (8,000 cfs) and is not typically altered with any reduced turbine outflow.

HI-Z tag-recapture testing was conducted on October 18, 2025. A total of 60 juvenile test fish were successfully tagged and released at the upstream entrance of the downstream bypass facility, and 60 juveniles were tagged and released directly into the tailrace as controls. The recapture rates for juvenile alewife released for the fish bypass treatment was 90% (54 out of 60 released fish). All fish recaptured (i.e., 54 treatment and 60 control) were alive and remained alive for the duration of the 48-hour delayed assessment period. Six of 54 treatment fish were documented as having passage-related injuries. Additionally, three control fish were recaptured with minor maladies. This resulted in a malady-free estimate of 93.6%. HI-Z tag-recapture testing completed during the fall of 2025 demonstrated latent (i.e., 48-hour) survival and malady-free rates for juvenile alosines of 90% (±6.2% with 90% confidence) and 93.6%, respectively.

Three-Dimensional Computational Fluid Dynamics Model Study Report (HDR 2026b)

Essex performed a Three-Dimensional Computational Fluid Dynamics (3D CFD) Model of the Project's fish passage facilities, approaches, and routes. The goal of this study was to determine the flow field conditions that exist in and around the Lawrence Project's upstream and downstream migratory fish passage routes. This was intended to aid in the interpretation of conditions for the guidance of migrating fish to and through the fish passage facilities. Three 3D CFD models were created:

1. **Essex Powerhouse Forebay and Downstream Fish Bypass Model (Upstream/Forebay Model):** the upstream model, consisting of the reservoir, powerhouse forebay, dam, guidance boom, fish lift flow entrance (diffuser, fish lift), and downstream fish bypass.
2. **Essex Powerhouse Tailrace Model (Tailrace Model):** the tailrace model consisting of the powerhouse draft tubes, tailrace, fish bypass, auxiliary water supply (AWS) diffuser, and fish lift entrance gates.
3. **Essex Fishway Model/Downstream:** A downstream model, consisting of the same geometry as the tailrace model and approximately 1,500 feet of the downstream reach.

Upstream/Forebay Model

Five upstream simulations were identified in the Project scope (one case is a test validation case). Plots showing velocity contours and vectors are presented in plan and profile views. Note the profile views are cut through the center of the powerhouse units. Streamlines through the fish lift, diffuser and in the immediate upstream region are presented in plan, profile, and isometric view. Plan view of the full model depth averaged velocity is also presented.

Results of Case 3 are shown here as a representative example of results. Case 3 simulates a generation discharge of 3,000 cfs and normal fish passage operations. Streamlines colored by velocity are shown on Figure E.7-24. Figure E.7-25 shows velocity contours for slices through each unit centerline. Figure E.7-26 presents plan views of velocity contours and vectors at the diffuser bench elevation in the forebay vicinity, and Figure E.7-27 shows the overall model in plan view, with depth-averaged velocity contours.

Results of the four simulations for the Upstream/Forebay Model indicate that the upstream model shows high velocities in the forebay, while velocities at the fish lift and fish lift exit are relatively consistent across the 4 simulations that modeled fish passage facilities. Generally, flows are pushed to the right side of the forebay, regardless of flowrate through the units, due to the approach conditions to the powerhouse. In all simulations, there was a large recirculation area present near the upstream end of the fish lift, also called the fish exit. Adding spill to the model creates a more uniform flow pattern through the center of the reservoir, slightly increasing velocities throughout.

Figure E.7-24. Streamlines Colored by Velocity Showing Flow Patterns for Case 3.

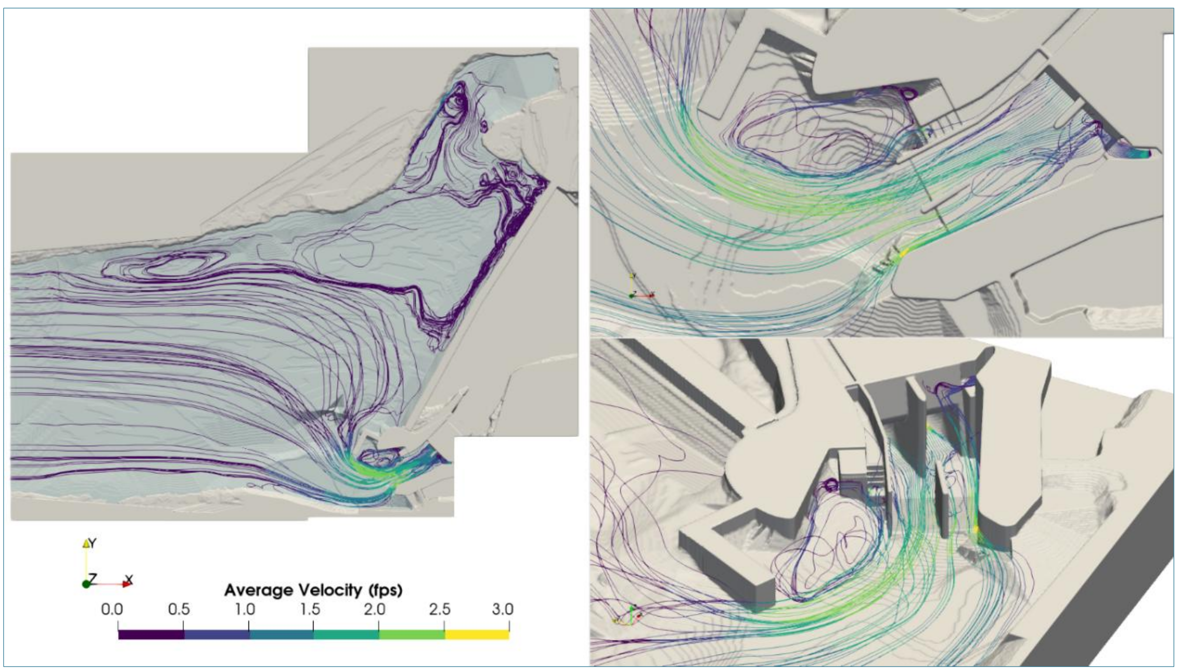


Figure E.7-25. Unit Centerline Intake Velocity Contours for Case 3.

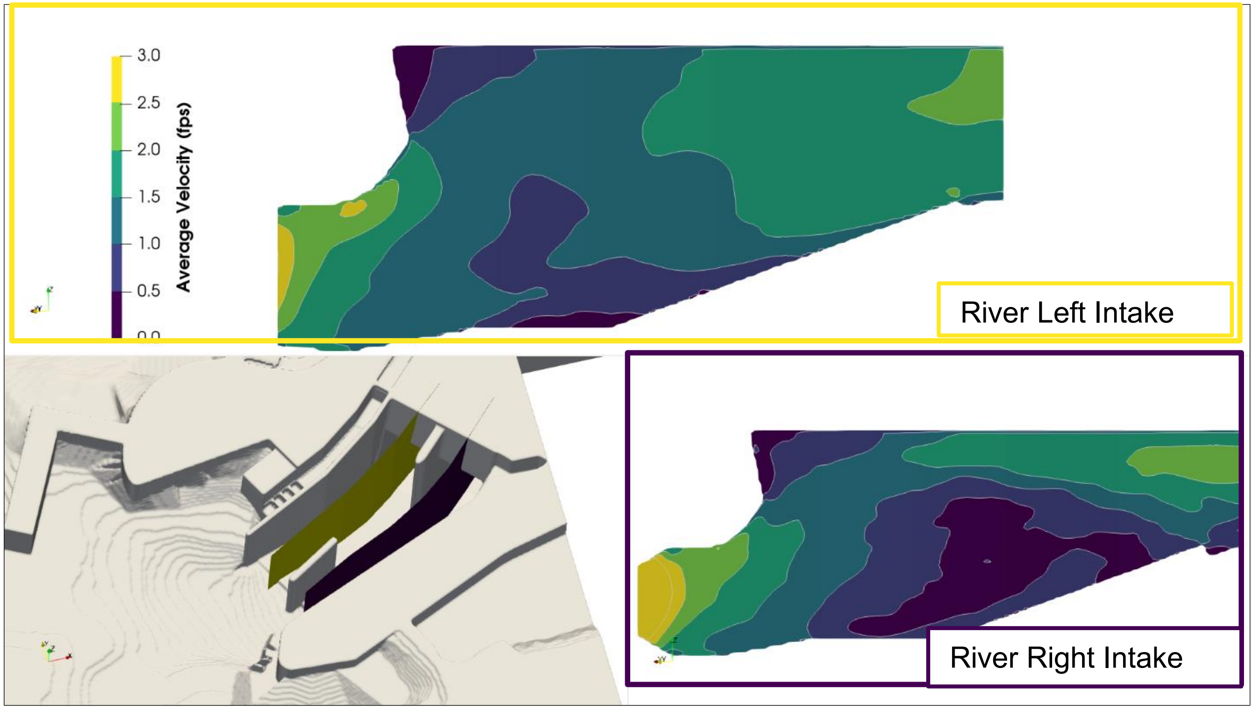


Figure E.7-26. Plan Views of Velocity Contours and Vectors in the Forebay Vicinity.

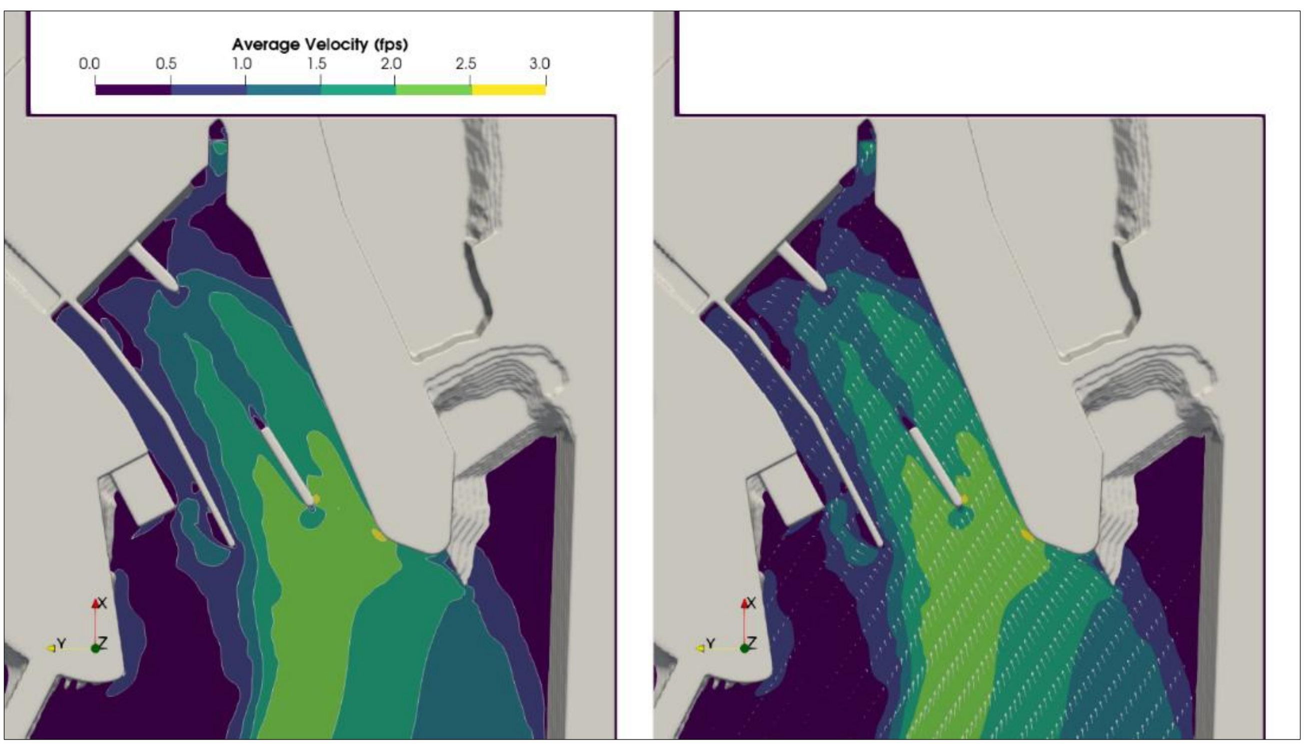
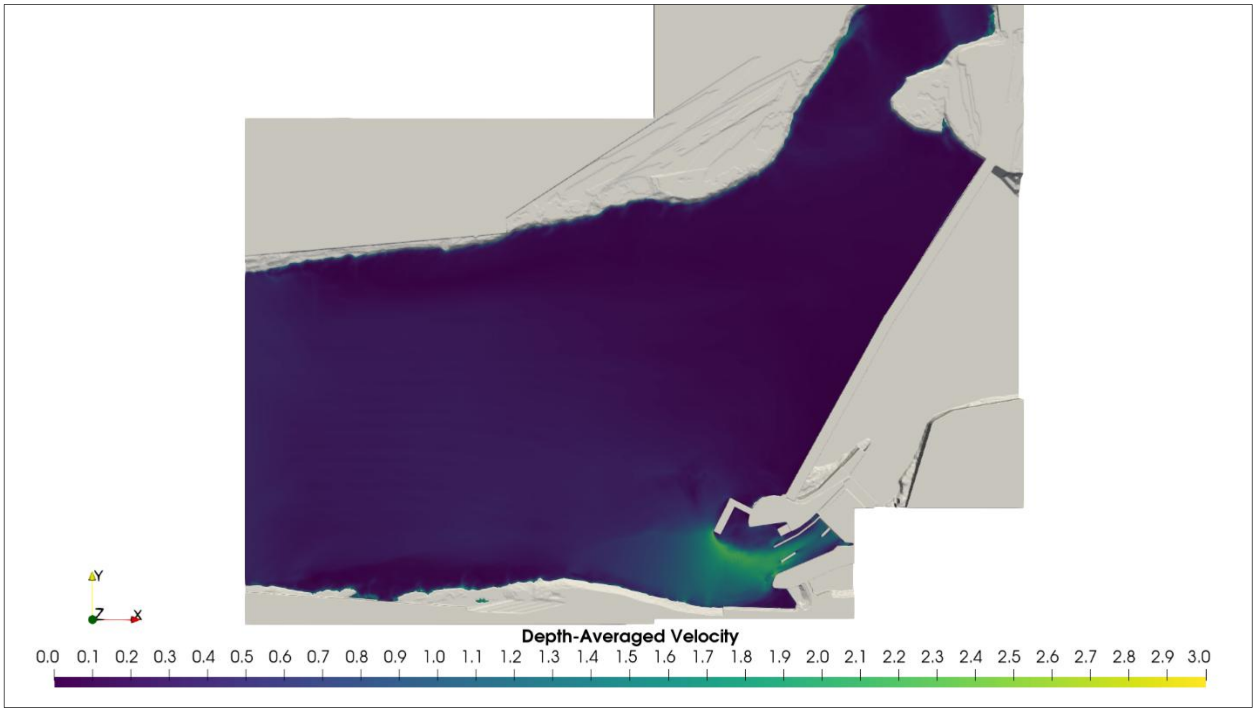


Figure E.7-27. Plan View of Depth-Averaged Velocity for Case 3.



Powerhouse Tailrace Model

Four tailrace simulations were identified in the Project scope. Plots showing velocity contours and vectors are presented in plan and profile views. Note the profile views are cut through the center of the powerhouse units and the bypass chute. Streamlines through the fish lift, diffuser, bypass chute, and unit centerlines are presented in plan and isometric view. Plan view of the full model depth averaged velocity is also presented.

Results of Case 7 are shown here as a representative example results. Case 7 simulates a generation discharge of 3,000 cfs and normal fish passage operations. Streamlines colored by velocity are shown on Figure E.7-28. Figure E.7-29 shows velocity contours for slices through each AWS centerline and the centerline of the bypass chute. Figure E.7-30 presents plan views of velocity contours and vectors in the tailrace, and Figure E.7-31 shows the overall model in plan view with depth-averaged velocity contours.

Results of the four simulations for the tailrace model shows that at low flowrates, there are distinct flowpaths to the fish lift entrance gates and the bypass chute. As generation flows increase, these flowpaths are entrained in the large recirculation area above the draft tube exits, and the distinct flowpaths to the fish lift entrance gates are reduced. A large recirculation area is present for all cases between the units and the bypass chute. Spill over the dam creates higher tailwater and serves to slightly reduce velocities in the tailrace when comparing cases with similar powerhouse and fish passage operations.

Figure E.7-28. Streamlines Colored by Velocity Showing Flow Patterns for Case 7.

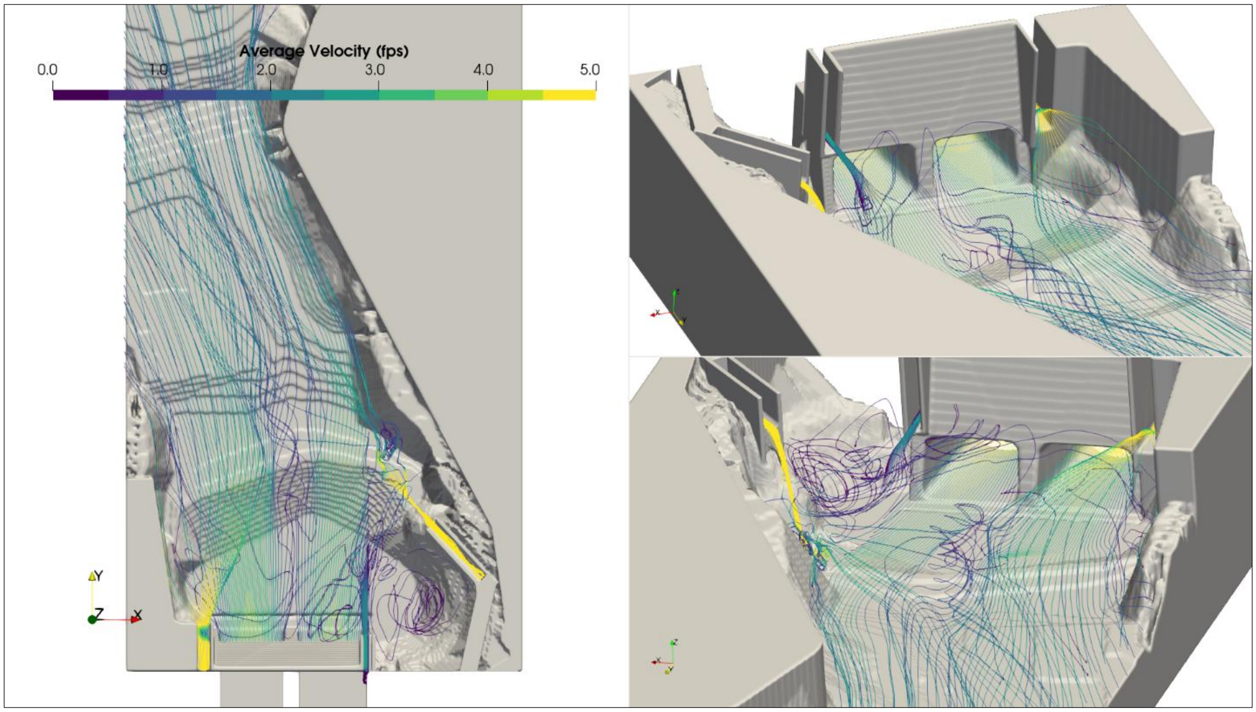


Figure E.7-29. AWS & Bypass Chute Centerline Velocity Contours for Case 7.

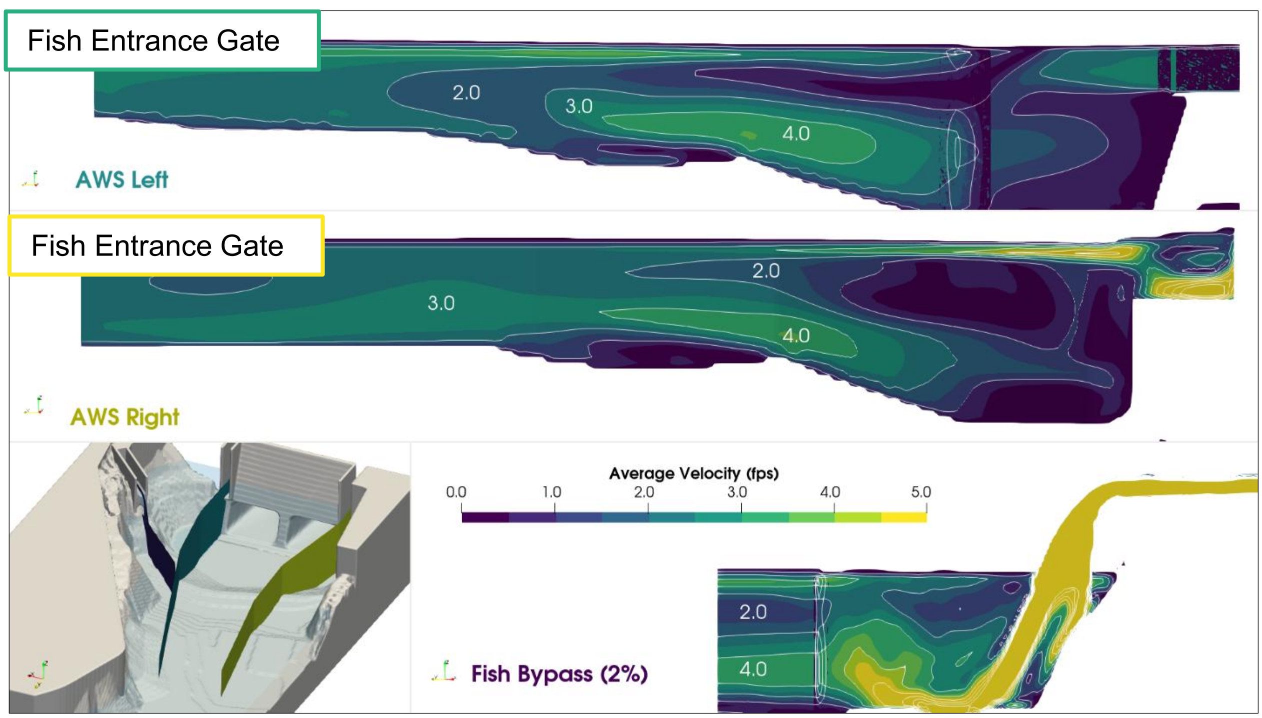


Figure E.7-30. Plan Views of Velocity Contours & Vectors in the Tailrace for Case 7.

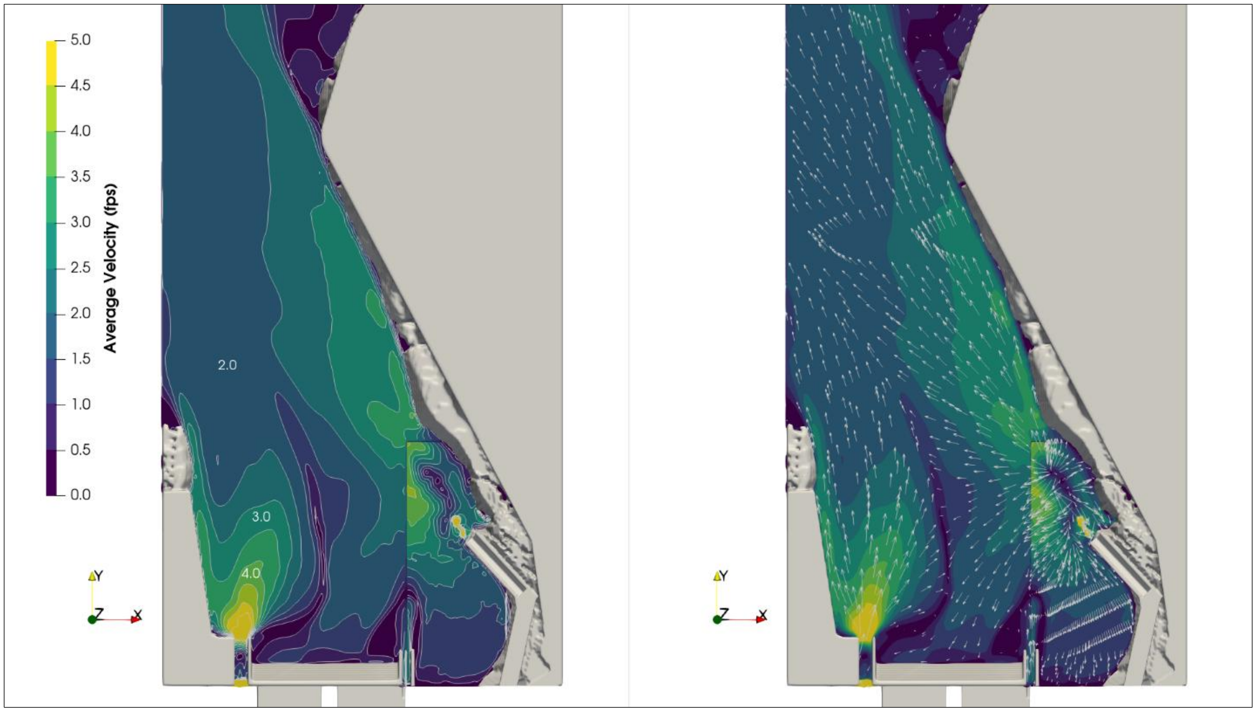
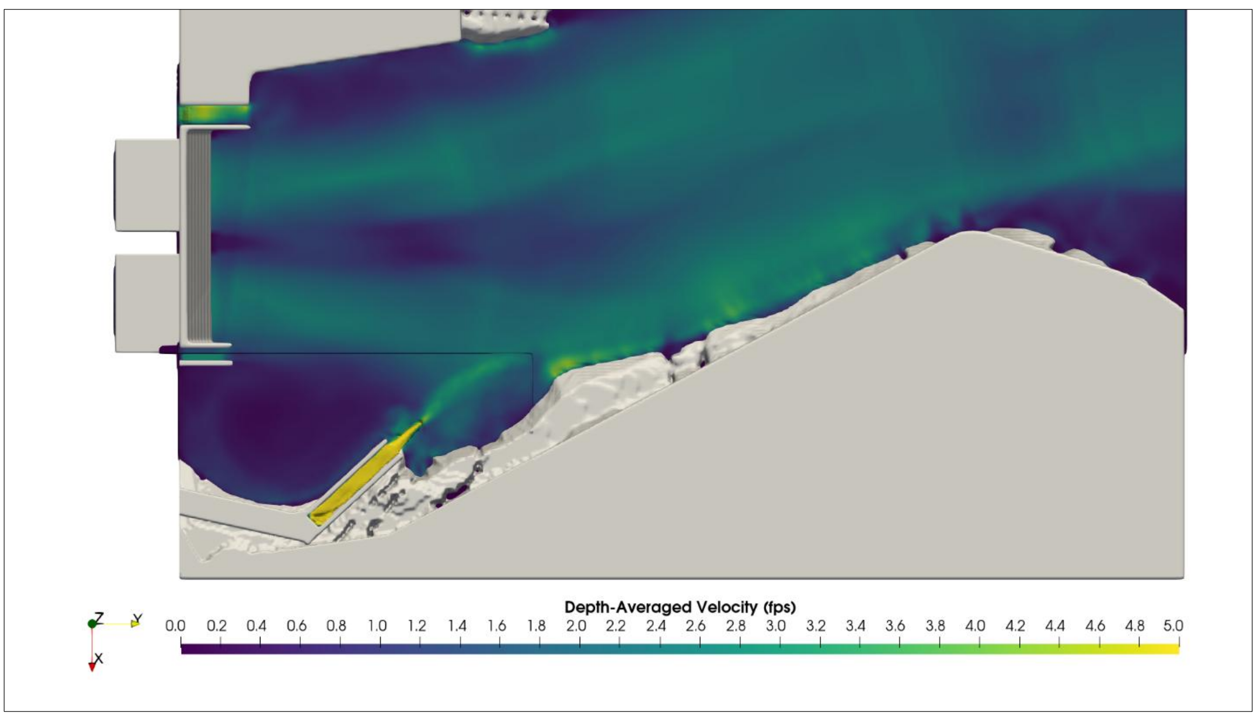


Figure E.7-31. Plan Views of Velocity Contours & Vectors in the Tailrace for Case 7.



Essex Fishway Model/Downstream Model

Four downstream simulations were identified in the Project scope. Plots showing velocity contours and vectors are presented in plan and profile views. Note the profile views are cut through the center of the powerhouse units. Streamlines through the fish lift, diffuser, bypass chute, and unit centerlines and in the downstream reach are presented in plan, profile, and isometric view. Plan view of the full model depth-averaged velocity is also presented. Note all views for the downstream model are rotated approximately 90 degrees from north.

Results of Case 11 are shown here as a representative example of results. Case 11 analyzes maximum flow through the units (8,000 cfs) and normal diffuser, eel way, and fish lift operations. Streamlines colored by velocity are shown on Figure E.7-32. Figure E.7-33 shows plan views of velocity contours. Figure E.7-30 presents plan views of velocity contours and vectors in the tailrace, and Figure E.7-34 shows the overall model in plan view with depth-averaged velocity contours.

Results of the four simulations for the Essex Fishway Model/Downstream Model show that at low flowrates, there are relatively uniform flowpaths to the tailrace area and overall low velocities. As generation flows increase, the flowpath to the tailrace and fish passage facilities become well-defined, with velocities around 5 fps. Adding spill to the maximum unit discharge elevates the tailwater, and the flow paths in the downstream reach are maintained with slightly reduced velocities. As spill increases to 16,000 cfs, the flowpath definition is further reduced and the spill combines with the unit discharge to form a large area of high velocity just downstream of the tailrace.

Figure E.7-32. Streamlines Colored by Velocity Showing Flow Patterns for Case 11.

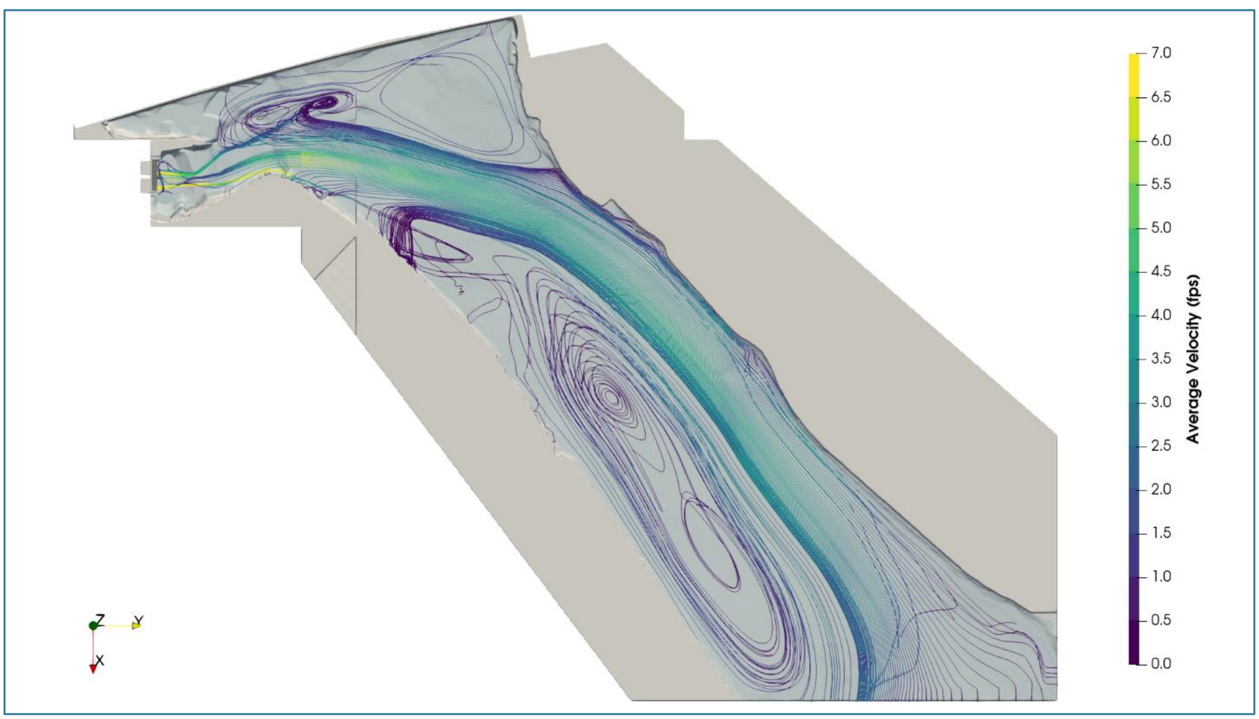


Figure E.7-33. Plan Views of Velocity Contours (0.5 fps) for Case 11.

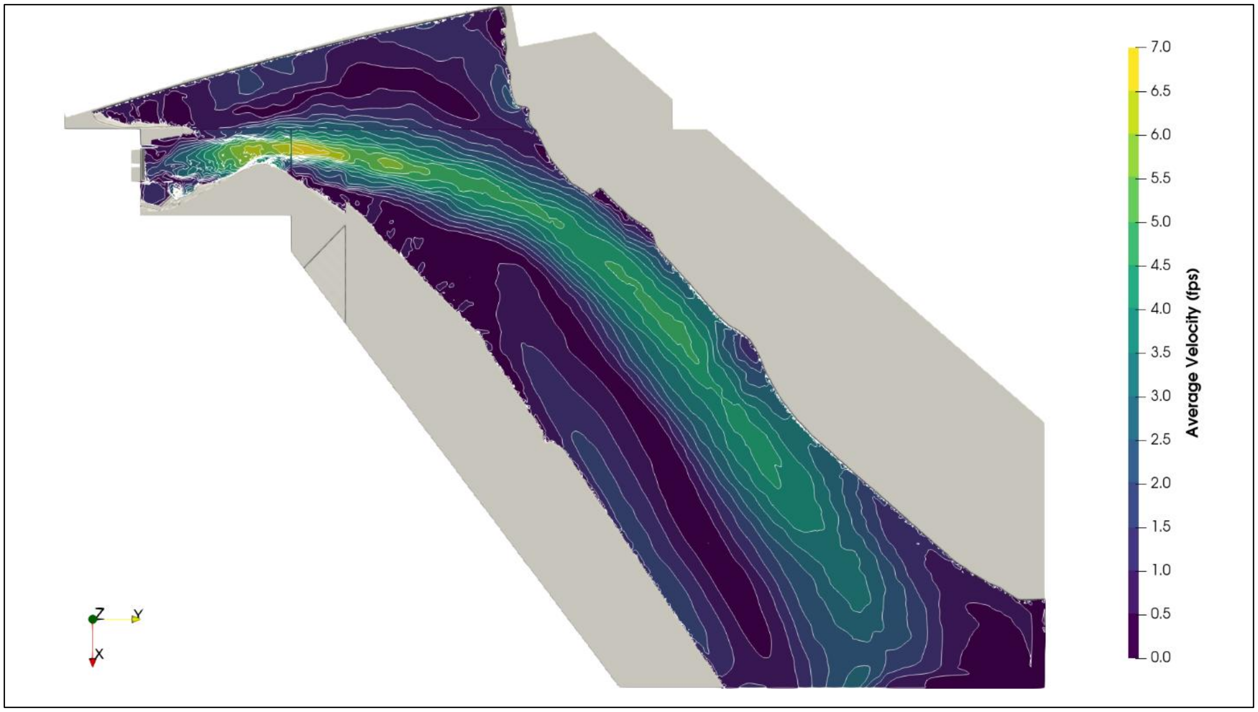
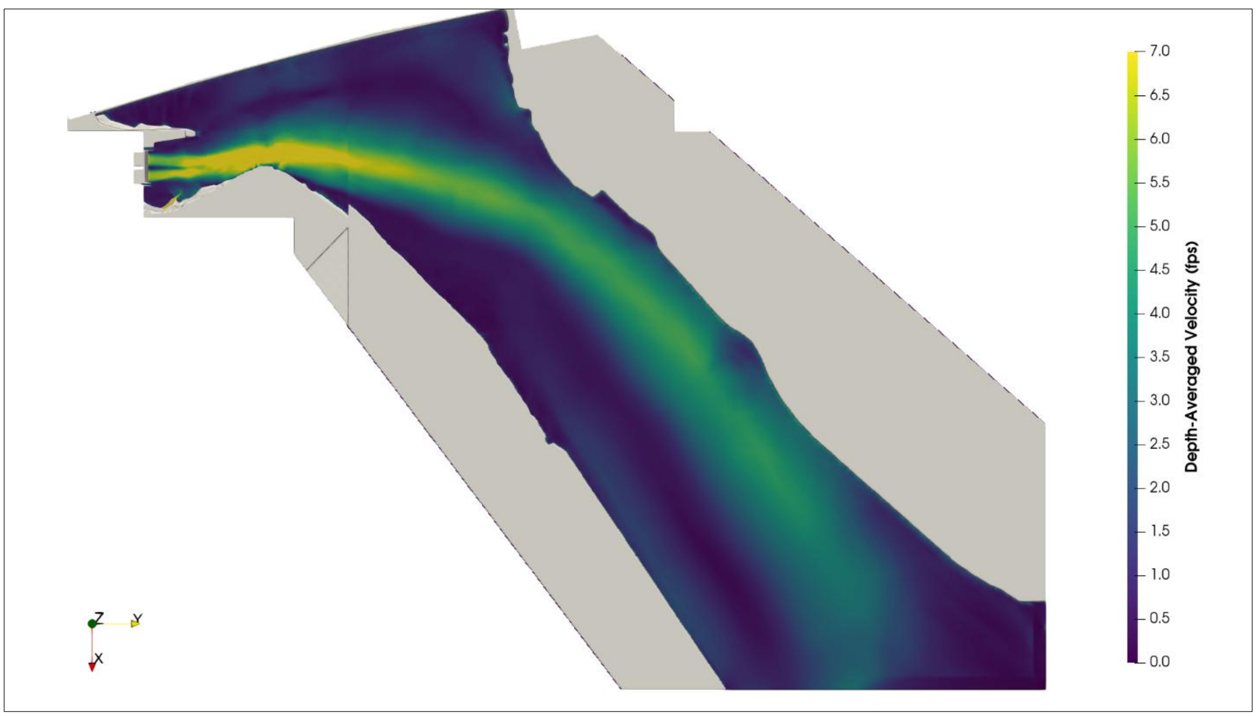


Figure E.7-34. Plan View of Depth-Averaged Velocity for Case 11.



E.7.3.1.4 Essential Fish Habitat

In conformance with the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (as amended 1996) an assessment was conducted to describe EFH within the Project area. EFH is defined as those waters with substrates necessary to fish for spawning, breeding, feeding, or growth to maturity (16 U.S.C. 1802, 50 CFR § 600.10). The Magnuson-Stevens Act requires NMFS to work with federal and state agencies, regional fishery management councils, and the fishing community to protect, conserve, and enhance EFH.

A desktop review of the NMFS EFH mapper (NOAA 2023a) was used to develop a list of EFH types, habitat areas of particular concern (HAPC), and species of interest based on the New England/North Atlantic Region. The Lawrence Project boundary within the Merrimack River contains EFH for Atlantic salmon. No HAPC were identified within the Project boundary.

EFH for the freshwater life history stages of Atlantic salmon includes all rivers, streams, lakes, and ponds in designated drainage systems from Connecticut to Maine, including the Merrimack River watershed ([NEFMC 1998). All six life stages of Atlantic salmon (eggs, larvae [alevins], recently-hatched juveniles [fry], older juveniles [parr and smolts], spawning adults, and spent adults [kelts]) utilize freshwater habitats, either exclusively or at some point during their life history. Intra-gravel habitat in the stream bed is essential for Atlantic salmon eggs and alevins, whereas EFH for the juveniles and spawning adults is the stream itself. Only parr and smolts utilize non-riffle and run habitats. Freshwater spawning and rearing EFH includes riffle and run habitats in shallow, well-oxygenated, freshwater streams with gravel and/or rocky substrates, as well as pools and vegetated riverine areas of lower velocity. These habitats occur in a range from first order streams (headwaters) to some third or fourth order streams with low temperatures. EFH for migrating smolts and kelts includes streams, rivers, and estuaries from first to fifth order, as well as lakes, ponds, and impoundments.

A variety of riverine, lacustrine, estuarine, and coastal marine habitats are used by older juvenile Atlantic salmon during their downstream migration to the sea, by mature adult salmon during their upstream spawning migration, and by kelts following spawning, before they return to the ocean (NEFMC 1998). EFH for migrating smolts and kelts includes streams, rivers, and estuaries from first to fifth order, as well as lakes, ponds, and impoundments, all of which are generally characterized by salinities below 25 ppt.

E.7.3.1.5 Temporal and Spatial Distribution/Life History Information of Fish Communities

The life history strategies of fish species (such as, but not limited to, the timing and habitat requirements of spawning, hatching, recruitment, dispersal, feeding) determines the behavior and movement over the life of a fish. The Merrimack River is home to a diverse assemblage of fish species, including both cold-water and warm-water species, and provides a migratory corridor for many diadromous species. The Merrimack River basin is home to approximately 50 species of fish, 9 of which are anadromous (Stolte 1982, Technical Committee 1997). The slower-moving, ponded reaches within the basin contain the majority of the warm water species, while those areas having steeper gradients contain the majority of the cold-water species.

This section details the life history characteristics of several of the most common species or species of interest (such as sportfish) in the Lower Merrimack River in the vicinity of the Lawrence Project.

Largemouth Bass

Largemouth bass are native to the eastern United States but have been introduced widely as an important sportfish species (Stuber et al. 1982). The preferred habitat for largemouth bass includes lacustrine environments with an ample littoral zone, but also open water and deeper areas for predation on forage fish and overwintering. They are also found in riverine habitats of slow-moving rivers or in pools of streams with soft bottoms, some aquatic vegetation, and clear water.

Spawning typically begins when water temperature reaches 12-15.5 °C in May and June (Stuber et al. 1982). Gravel substrate is needed for spawning habitat, though other substrates such as vegetation, roots, sand, mud, or cobble may also be used. Males guard the nest and fan the eggs until hatching after approximately 3 to 4 days; larvae are also guarded until they disperse as fry after about a month. Fry feed mainly on microcrustaceans and small aquatic insects before shifting to mostly insects and small fish as juveniles, then primarily fish, crayfish, and other small animals as adults. Largemouth bass mature and spawn as early as one year of age, however, maturity can be delayed in northern populations.

Smallmouth Bass

Smallmouth bass are native to freshwaters of eastern-central North America, including the Ohio, Tennessee, upper Mississippi basins, Saint-Lawrence River, and Great Lakes, although they have been introduced throughout North America (Brown et al. 2009). Smallmouth bass inhabit large lakes (> 100 acres), where they are often associated with littoral drop-offs and substrates comprised of gravel and cobble, and wide rivers or streams (> 10.5 meters wide) with cool and clear water of moderate current. Areas of abundant shade and cover, substrates of gravel and other large materials, and large pools are also utilized by smallmouth bass. In the northern portions of their range, smallmouth bass spawn in June or July. In lake environments, nests are constructed near the shoreline; in rivers and streams, nests are typically constructed downstream of large boulders or other obstructions that offer protection against strong currents. Males begin constructing nests when water temperatures reach 12.5°C and spawning occurs at 16°C. Eggs hatch after 4-10 days and larvae remain at the nest for 10-12 days until the yolk is absorbed; however, nests may be abandoned if water temperatures drop below 14°C. Juvenile prey primarily on zooplankton until they are large enough to consume crayfish and small fish. Adults consume mostly fish, insects, and crayfish.

Northern Pike

Northern pike are widely distributed through New England in lakes, ponds, and rivers, and are typically associated with aquatic vegetation in clear, quiet, slow-moving water between 15-18°C; however, they can tolerate a range of temperatures and some turbidity (USFWS 2023a). The diet of northern pike consists primarily of other fishes, including other pikes, but they may also consume ducks, mice, rats, frogs, snakes, and crayfish.

Spawning migrations occur in late winter or early spring, when adults migrate into shallower tributary streams, flooded grassy lowlands, or lake shallows (USFWS 2023a). Spawning occurs in April and May when water temperatures are around 4-10°C. Northern pike do not construct nests but females do look for vegetation amongst which to spread adhesive eggs. After spawning, adults return to deeper waters. Eggs hatch after approximately 10-14 days, and fry remain in the spawning area until they reach 2-3 inches long, when they move to deeper habitats. Fry consume phytoplankton and aquatic insects, but will begin consuming small fishes once they are large enough.

Yellow Perch

Yellow perch are a temperate species with a range that extends from west-central Canada and the Hudson Bay, east to New Brunswick, down to South Carolina, and west to Kansas (Animal Diversity Web [ADW] 2023). Yellow perch are primarily found in lakes but sometimes occur in impoundments of larger rivers. Yellow perch require clear waters and are intolerant of excessive turbidity; however, they have a high tolerance for low oxygen conditions. They typically inhabit waters with moderate temperatures and avoid both cold, deep water and warm surface waters during the summer. Young perch generally inhabit shallower water than adults, but as temperatures increase, they all move to cooler water. Overwintering occurs in deeper waters, and spawning occurs in spring in shallow water areas.

Reproductive maturity is typically reached between the ages of 2 and 4, with spawning occurring in the spring (April through early May) when water temperatures reach 7.2 – 11.1 °C (ADW 2023). Females release a gelatinous strand of eggs, which may be fertilized by several males before settling to the streambed or becoming entangled in vegetation or debris (The Fish Site [TFS] 2007). Fecundity varies with size, age, and nutritional status, but most females lay about 120 to 250 eggs per millimeter of their length. Eggs hatch within 8-10 days, after which larvae first appear nearshore before becoming pelagic (ADW 2023). Young yellow perch feed on zooplankton, then eventually benthic invertebrates, and other fishes as they age.

Walleye

Walleye distribution was and is largely influenced by glacial events and stocking, and this species is currently found in freshwater river systems and lakes throughout North America (Bozek et al. 2011). They are found in both rivers and lakes varying in geography, geology, and land use across a wide latitudinal range, which largely affects growing season and life history strategies. Habitat preference is generally given to large (>100-hectare), cool-water bodies with high turbidity, gravel and/or sandy substrate, extensive littoral areas, and ample cover such as boulders, logs, and vegetation (Scott and Crossman 1973). In lake environments, walleye can coexist with other predatory fishes such as northern pike, muskellunge (*Esox masquinongy*), lake trout (*Salvelinus namaycush*), and smallmouth bass; however, in smaller lakes, competition may be intense among other predatory species (Bozek et al. 2011).

In northern latitudes, walleye spawn in spring when water temperatures range between 5-7°C and may begin spawning under ice or just following ice-out (Bozek et al. 2011). In lake environments, warm water along the bottom of shallow areas or warmer water from tributary streams mixes with lake water, acting as a stimulus to initiate spawning movements and migration to spawning rivers, although there are also lake-resident and river-resident populations. Spawning typically occurs along shorelines in shallow mid-lake reefs or in rapids and riffles of rivers where there is adequate flow and oxygen for egg development. Walleye are broadcast spawners, and adhesive eggs sink into crevices within the substrate. No parental care is provided, and first-year survival is generally low (< 1%). After hatching, larvae are negatively buoyant and can only withstand minimal water velocities. Feeding on small zooplankton begins before the yolk sac is completely absorbed. Once free-swimming, young walleye move into open water and feed on zooplankton, then eventually benthic invertebrates and other fishes as they grow in size.

Atlantic Salmon

Atlantic salmon are an anadromous species native to most coastal rivers northeast of the Hudson in New York; however, overfishing and dams that impede their migratory pathways have greatly reduced populations (NOAA 2023b). The last remaining wild anadromous populations of Atlantic salmon in the U.S. are found in a few rivers in Maine, comprising the Gulf of Maine Distinct Population Segment, which is listed as endangered under the Endangered Species Act (ESA). Landlocked populations are typically found in large, glacial lakes with deep, cold water in the summer and tributary rivers or streams with riffle/pool habitat and gravel substrate for spawning.

Anadromous Atlantic salmon have a complex life cycle that begins with spawning and juvenile rearing in freshwater rivers (NOAA 2023b). After one to three years, juveniles out-migrate to the ocean, where adults remain until returning to their natal rivers to spawn. Peak spawning typically occurs in late October and November, with optimal temperatures ranging from 4 to 10°C. Females create depressions in gravel streambeds (redds) downstream of riffles where eggs are deposited. Eggs hatch in late March and April, and hatchlings known as alevins remain in the redd typically until mid-May, until they emerge as fry once the yolk sac has been absorbed. In freshwater, fry feed on plankton, but as they grow, their diet shifts to aquatic insects and small fish. In the ocean, smolts and adults feed on insects, squid, shrimp, and fishes such as herring, sand lances, and capelin. Habitat for early life stages generally consists of relatively large and cool rivers with extensive gravel substrate.

American Eel

American eel (*Anguilla rostrata*) is a catadromous species with a complex life cycle. Adults spend their life in freshwater, migrating to the Sargasso Sea in the western Atlantic Ocean at sexual maturity, which can be between 5 to 20 years old (Lee 1980, Simon 1999, Smith 1997). The American eel is described as being a panmictic species, with all members mating as a collective breeding population. Spawning typically occurs during autumn or winter, after which the adult eels die. Eels hatch from eggs and the larvae are carried to the Atlantic coast after about one year of drifting through currents, during which time they transform into the “glass eel” stage. When the glass eels reach the estuary along the Atlantic coast, they become pigmented “elvers,” many of which remain in the estuary, but others continue upriver to freshwater. The young larvae spend the majority of this life stage in close proximity to shelter such as plant masses, burrows, snags, and tubes (Fahay 1978; Van Den Avyle 1984). After several months, they enter into the “yellow eel” stage, an adult form that is sexually immature. During this phase, they are primarily nocturnal carnivores feeding on insects, fish, fish eggs, crabs, worms, clams, frogs, and dead animal matter (Lookabaugh and Angermeier 1992).

As adults, American eels prefer to live in freshwater streams with continuous flow or in muddy, silt bottom lakes. While small eels are found in faster flowing water, larger eels are associated with slow, deep, and muddy habitats (Fahay 1978; Van Den Avyle 1984; Meffe and Sheldon 1988). The American eel possesses the ability to breathe through its skin, allowing for travel over land and to move around barriers in streams. American eels can tolerate a wide range of temperatures between 4 and 25°C, but are sensitive to low dissolved oxygen levels (Baensch and Riehl 1995). American eels reach reproductive maturity based on size, regardless of age. Individuals that live primarily in freshwater will grow more slowly than those that live in brackish waters, meaning freshwater-dwelling individuals will take longer to reach sexual maturity.

Atlantic Sturgeon

Atlantic sturgeon are widely distributed along the Atlantic Coast of the United States, occurring in major estuaries and riverine environments within their respective native ranges, or Distinct Population Segments (DPS). The ESA listing status for sturgeon is based on their DPS. Atlantic sturgeon originating from the New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPSs are listed as federally endangered; those originating from the Gulf of Maine DPS are listed as federally threatened (NOAA 2023b). Currently, a portion of the Project boundary is listed by NOAA as critical habitat for Atlantic sturgeon. The critical habitat for Atlantic sturgeon includes waters “from the Essex Dam (also known as the Lawrence Dam) downstream to where the main stem river discharges at its mouth into the Atlantic Ocean” (NOAA 2016).

Atlantic sturgeon utilizing the Merrimack River as spawning habitat most likely would have originated from the Gulf of Maine DPS, which includes 152 miles of aquatic habitat (NOAA 2023b). The Gulf of Maine DPS includes all anadromous Atlantic sturgeon spawned in the watersheds from the Maine/Canada border and extending southward to include all associated watersheds draining into the Gulf of Maine as far south as Chatham, MA (NMFS 2017).

The Atlantic sturgeon is a long-lived, late-maturing, estuarine-dependent, anadromous species. Adults spend most of their life in the marine environment but migrate upriver in the spring/early summer (April-May in mid-Atlantic systems) to spawn. Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers, where optimal flows are 46–76 centimeters per second with depths of 11–27 meters. Atlantic sturgeon likely do not spawn every year; multiple studies have shown that spawning intervals range from 1–5 years for males and 2–5 years for females. Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (e.g., cobbles).

Eggs typically hatch in 4–7 days depending on temperature (Gilbert 1989; Hildebrand and Schroeder 1928). At hatching, Atlantic sturgeon larvae are large bodied (e.g., 7.8 millimeters [mm] total length) and are assumed to undertake a demersal existence in the same areas where they were spawned (Smith et al. 1980, Bath et al. 1981, Atlantic States Marine Fisheries Commission [ASMFC] 2012). Following yolk-sac absorption, larvae move downstream to rearing grounds. During the day, larvae use benthic structure (e.g., gravel matrix) as refugia. During the latter half of migration when larvae are more fully developed, movement to rearing grounds occurs both day and night. Late-stage larvae transition into the juvenile phase as they move downstream into brackish waters and take up residence in estuarine waters (ASMFC 2012). Snyder (1988) reports that Atlantic sturgeon complete yolk absorption by 13–14 millimeters standard length in 6-7 days.

Subadult Atlantic sturgeon (greater than 50 centimeters, but not yet sexually mature) swim among coastal and estuarine habitats, undergoing rapid growth. These migratory subadults, as well as adult sturgeon, are normally captured in shallow (10–50 meters) nearshore areas dominated by gravel and sand substrate. Despite extensive migration in coastal waters, Atlantic sturgeon return to their natal river to spawn, as indicated from tagging records and the relatively low rates of gene flow reported in population genetic studies (Atlantic Sturgeon Status Review Team [ASSRT] 2007).

E.7.3.1.6 Aquatic Macroinvertebrates

Aquatic benthic macroinvertebrates are small aquatic invertebrate animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. They lack a backbone, are visible without the aid of a microscope, and are found in and around water bodies during some period of their lives. Benthic macroinvertebrates are often found attached to rocks, vegetation, logs and sticks, or burrowed into the bottom sand and sediments (USEPA 2022c). These organisms provide a link between a system’s primary productivity and its aquatic consumers through the conversion of plant biomass to consumable energy.

Freshwater macroinvertebrates serve a number of roles in riverine ecosystems, including acting as a vital food source for other organisms, breaking down and cycling organic matter and nutrients, and serving as bioindicators for ecosystem health (Voshell 2002). Macroinvertebrates exhibit a range of stress tolerance to pollution, habitat modification, or severe natural events, and the presence of certain taxa can serve as an indicator for local water quality condition and stream health. Specifically, the species richness and abundance of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) taxa can indicate the water quality of a stream; the taxa richness of EPT taxa generally decreases with decreasing water quality (USGS 2002). Additionally, EPT species are high-quality forage for a variety of freshwater fish species.

Biomonitoring of aquatic benthic macroinvertebrate and habitat assessments were conducted as part of the MADEP Division of Watershed Management’s 2004 Merrimack River Watershed Assessments. A total of 13 tributary streams were sampled following the USEPA Rapid Bioassessment Protocols for wadeable streams and rivers. Fish Brook and Bartlett Brook are hydrologically connected to the Project impoundment approximately 4.0 and 2.9 RM upstream of the Essex Dam. Only 4 of the 13 streams were found to be “non-impacted” and support a balanced and diverse benthic aquatic community. The remaining eight streams were considered “slightly” or “moderately impacted” a result of habitat degradation and/or nonpoint source-related water quality impairment. A summary of the benthic taxa collected is described in Table E.7-22.

Table E.7-22. Taxa Lista and Counts, Functional Feeding Groups, and Tolerance Values for Macroinvertebrates Collected from Stream Sites During the 2004 Merrimack River Watershed Survey – July and August 2004

Taxon	FFG[1]	TV[2]	South Branch Sougegan River[3]	Richardson Brook	Trull Brook	Martins Pond Brook	Powwow River	Fish Brook	Creek Brook	Bartlett Brook	Peppermint Brook	Black Brook	Bridge Meadow Brook	Tadmuck Brook	Bennets Brook
Laevapex fuscus	SC	7					4								
Pseudosuccinea columella	GC	6												1	
Planorbula armigera	SC	6						1							
Pisidiidae	FC	6			1		2	1				1	1	1	5
Enchytraeidae	GC	10					1								
Nais behningi	GC	6													5
Nais communis	GC	8						11							
Pristinella osborni	GC	10						1							
Limnodrilus hoffmeisteri	GC	10				1									
Tubificidae IWB	GC	10					1				3				
Tubificidae IWH	GC	10				1									
Lumbriculidae	GC	7			2		1	4	2		1				6
Erpobdella sp.	PR	8				1									
Caecidotea sp.	GC	8			4					1					
Caecidotea communis	GC	8				15					2			4	
Caecidotea racovitzai racovitzai	CG	8				30						5			
Crangonyx sp.	GC	6		3	1	3		3		2					
Gammarus sp.	GC	6			7	1	5		2	5	38	56			
Hydrachnidia	PR	6		1										1	
Baetidae	GC	4							3	1					
Baetis (subeq. term.) sp.	GC	6	1				3								

Taxon	FFG[1]	TV[2]	South Branch Sougegan River[3]	Richardson Brook	Trull Brook	Martins Pond Brook	Powwow River	Fish Brook	Creek Brook	Bartlett Brook	Peppermint Brook	Black Brook	Bridge Meadow Brook	Tadmuck Brook	Bennets Brook
Leptophlebiidae	GC	2													3
Boyeria vinosa	PR	2												1	
Plecoptera	GC	3												5	
Acroneuria sp.	PR	0	2					5					1		
Nigronia serricornis	PR	0	2					2		2		1	1		1
Adicrophleps hitchcocki	SH	2												1	
Glossosoma sp.	SC	0			1										
Cheumatopsyche sp.	FC	5	3	9	7	24	5	1	4	6	15	9	8	2	7
Diplectrona sp.	FC	0							3					1	
Hydropsyche sp.	FC	4			47								40		
Hydropsyche betteni	FC	6	16	19		4	37	16	32	17	10	8		17	16
Hydropsyche morosa gr.	FC	6												5	
Ceraclea sp.	GC	3		1											
Oecetis sp.	PR	5		2											
Limnephilidae	SH	4												1	
Pycnopsyche sp.	SH	4								2					
Psilotreta sp.	SC	0				1		2							
Chimarra sp.	FC	4	10	28			10		20	10		2	18		12
Wormaldia sp.	FC	0												1	
Lype diversa	GC	2			1										
Rhyacophila sp.	PR	1												1	
Neophylax sp.	SC	3							1						
Microcylloepus pusillus	GC	3		8			8	1							
Oulimnius latiusculus	SC	4	1	2				1	2						
Promoresia sp.	SC	2		2					1						

Taxon	FFG[1]	TV[2]	South Branch Sougegan River[3]	Richardson Brook	Trull Brook	Martins Pond Brook	Powwow River	Fish Brook	Creek Brook	Bartlett Brook	Peppermint Brook	Black Brook	Bridge Meadow Brook	Tadmuck Brook	Bennets Brook
Stenelmis sp.	SC	5		4		3	11	10	8	13	4		12	24	7
Stenelmis crenata	SC	5			10							19			
Ectopria nervosa	SC	5												1	
Psephenus herricki	SC	4		2				3	5	7					
Bezzia sp.	PR	6													1
Probezzia sp.	PR	6													2
Microtendipes pedellus gr.	FC	6					1								
Microtendipes rydalensis gr.	FC	6		5				1		3					
Paratendipes sp.	GC	6		1											
Polypedilum flavum	SH	6		10	7	16	4	6	4	13	16		18		4
Polypedilum illinoense	SH	6			1										
Polypedilum scalaenum gr.	SH	6												1	
Xenochironomus sp.	PR	0				1									
Micropsectra sp.	GC	7				3									
Micropsectra polita gr.	GC	7						4			4	1			
Paratanytarsus sp.	FC	6													1
Rheotanytarsus exiguus gr.	FC	6	13				11				2		1		
Rheotanytarsus pellucidus	FC	5	5								1			2	1
Tanytarsus sp.	FC	6	12											2	1
Diamesinae	GC	2								1					
Diamesa sp.	GC	5							1						
Orthocladiinae	GC	5											1		
Brillia sp.	SH	5			1										
Cardiocladius sp.	PR	5													1
Eukiefferiella claripennis gr.	GC	8			1										

Taxon	FFG[1]	TV[2]	South Branch Sougegan River[3]	Richardson Brook	Trull Brook	Martins Pond Brook	Powwow River	Fish Brook	Creek Brook	Bartlett Brook	Peppermint Brook	Black Brook	Bridge Meadow Brook	Tadmuck Brook	Bennets Brook
Orthocladius sp.	GC	6					1								2
Parametriocnemus sp.	GC	5	1	2	1			4			1	1		1	11
Rheocricotopus sp.	GC	6		1											
Tvetenia paucunca	GC	5	4		1			8	3	11		1	1	12	1
Tanypodinae	PR	7													1
Conchapelopia sp.	PR	6					1	1		2				1	3
Nilotanypus sp.	PR	6											1		
Thienemannimyia sp.	PR	6	1							1	1			1	2
Clinocera sp.	PR	6													4
Hemerodromia sp.	PR	6	1			1		2					1		
Simulium sp.	FC	5	2	1	3		2	11	4	6				8	12
Antocha sp.	GC	3									2				
Dicranota sp.	PR	3	7											3	
Tipula sp.	SH	6										1			1
Total number of organisms			**97**	**101**	**96**	**105**	**108**	**99**	**95**	**103**	**100**	**105**	**104**	**98**	**110**

[1] Functional Feeding Group (FFG): the feeding habit of each taxon. SH-Shredder; GC-Gathering Collector; FC-Filtering Collector; SC-Scraper; PR-Predator.
[2] Tolerance Value (TV): an assigned value used to calculate the biotic index. Tolerance values range from 0 for organisms very intolerant of organic wastes to 10 for organisms very tolerant.
[3] Reference Station.

Water Quality Study (NAI 2026a)

As part of the water quality study, macroinvertebrate sampling was completed on August 20, 2025, at the station downstream of Essex Dam and on August 21, 2025, at the station upstream of Essex Dam, consistent with the study objective to evaluate the current macroinvertebrate community at locations upstream and downstream of the Project dam. A cumulative total of 526 specimens were identified from the composite sample collected upstream of Essex Dam, representing 53 genus-level taxonomic classifications. EPT (Ephemeroptera [7], Plecoptera [0], and Trichoptera [10]) represented 17 of the 53 total taxa, comprising 32.1% of the total taxa richness. The dominant taxon identified in the sample was Gammarus fasciatus, which represented 28.7% of all individuals within the assemblage. Collector-gatherers comprised 45.8% of individuals in the upstream sample. Functional feeding group composition can reflect trophic structure (interaction, production and food source availability) and provide information on the balance of feeding strategies in benthic assemblages. The Shannon Diversity Index (H') score of 2.81 indicates a trend towards diversity in the distribution of individuals within the community and limited dominance among taxa. The calculated Hilsenhoff Biotic Index (HBI) value for the upstream reach was 5.98, supporting a finding of "Fair" water quality in terms of organic pollution and nutrient enrichment (Hilsenhoff 1987).

A cumulative total of 501 specimens were identified from the composite sample collected from the reach downstream of Essex Dam, representing 42 genus-level taxonomic classifications. EPT (Ephemeroptera [2], Plecoptera [0], and Trichoptera [7]) represented 9 of the 42 total taxa, comprising 21.4% of total taxa richness. The dominant taxon identified in the sample was *Gammarus fasciatus*, which represented 38.3% of all individuals within the assemblage. Collector-gatherers comprised 58.3% of individuals in the downstream sample. The Shannon Diversity Index (H') score of 2.45 indicates a trend towards balance in the distribution of individuals within the community and limited dominance among taxa. The calculated HBI value for the downstream reach was 6.42, supporting a finding of "Fair" water quality in terms of organic pollution and nutrient enrichment (Hilsenhoff 1987).

The Shannon diversity index values were similar between the two stations (upstream = 2.81; downstream = 2.45), indicating a similar degree of dominance within taxa for both reaches. The most abundant taxon, *Gammarus fasciatus*, was the same for each site, comprising 28.7% of specimens upstream and 38.3% of specimens downstream. *Gammarus fasciatus* is an amphipod with moderate tolerance of nutrient enrichment and is a collector-gatherer, opportunistically feeding on available detritus or benthic debris. HBI values were 5.98 upstream and 6.42 downstream, both values supporting a finding of "fair" water quality in terms of nutrient input or organic pollution.

E.7.3.1.7 Freshwater Mussels

Limited information is available describing the freshwater mussel community of the lower portion of the Merrimack River in the vicinity of Lawrence; however, there are 12 species of freshwater mussels representing 2 families in Massachusetts, of which 6 are protected under the Massachusetts Endangered Species Act (MESA) (Massachusetts Department of Environmental Quality Engineering [MDEQC] 1986). The family Margaritiferidae is represented by a single species, the freshwater pearl mussel (*Margaritifera margaritifera*), which is widespread throughout New England. The other family is Unionidae, of which 11 species live in Massachusetts and comprise a zoogeographical assemblage called the Atlantic Slope fauna. The freshwater mussels of Massachusetts are further described in Table E.7-23.

Table E.7-23. Freshwater Mussels of Massachusetts.

Common Name	Scientific Name	Habitat Requirements
freshwater pearl mussel	*Margaritifera margaritifera*	Creeks to large rivers with moderate gradient with clean, mixed stable substrate
eastern elliptio	*Elliptio complanta*	Stable shoals of lakes or river-lakes with substrates composed of clay mixed with marl and fine sand
dwarf wedgemussel	*Alasmidonta heterodon*	Waters with slow to moderate currents that have muddy sand to sand/gravel substrate
triangle floater	*Alasmidonta undulata*	Smaller streams to large rivers with low gradients and coarse to fine gravel with sand and mud
brook floater	*Alasmidonta varicosa*	Creeks and small rivers with riffles and moderate rapids with sandy shoals, or riffles with gravel substrates
eastern floater	*Pyganodon cataracta*	Found in variety of habitats including small streams, rivers, ponds, and lakes; usually confined to slow-moving water with sandy or muddy substrates
alewife floater	*Anodonta implicata*	Coastal streams and lakes in sand and gravel substrates with low to moderate gradient
creeper	*Strophitus undulatus*	Found in riffles and pools of streams and rivers of moderate gradient
eastern pondmussel	*Ligumia nasuta*	Protected areas of coastal lakes and ponds, slackwater areas of rivers, slow moving streams, and canals in a wide range of substrates
tidewater mucket	*Leptodea ochracea*	Ponds, canals, and slow-moving sections of rivers, including impoundments, with a variety of substrates such as silt, sand, gravel, cobble, and occasionally clay
yellow lampmussel	*Lampsilis cariosa*	Larger streams and rivers with sand and gravel with moderate current
eastern lampmussel	*Lampsilis radiata radiata*	Smalls streams, large rivers, ponds, and lake with sand or gravel substrate

Many species of freshwater mussels rely on a host species as a part of their life cycle. During the larval phase, mussels are expelled into the water column and must attach to a host (typically a fish) as an external parasite. Some mussel species rely on specific fish species for the parasitic phase, but few mussel-host relationships are currently known.

Freshwater Mussel Habitat Assessment and Survey (NAI 2025d)

In support of this relicensing, Essex conducted a Freshwater Mussel Habitat Assessment and Survey. The goal of the Mussel Study was to determine the presence, location, and species of freshwater mussels that inhabit Project-affected aquatic habitats within the Merrimack River.

The study consisted of both field and desktop-based tasks. Field efforts focused on surveys to characterize the distribution, composition, and relative abundance of freshwater mussels and non-native bivalves in the Lawrence Project area. The desktop analysis focused on a review of potential host fish for documented mussel species through review of relevant publications and concurrent fish data collected in the Project area. The study area included the mainstem Merrimack River from the upper extent of the Project impoundment (9.8 miles upstream of Essex Dam and immediately downstream of the Lowell hydroelectric project [FERC No. 2790]) to the Lawrence I-495 Bridge, located approximately 1.5 miles below Essex Dam.

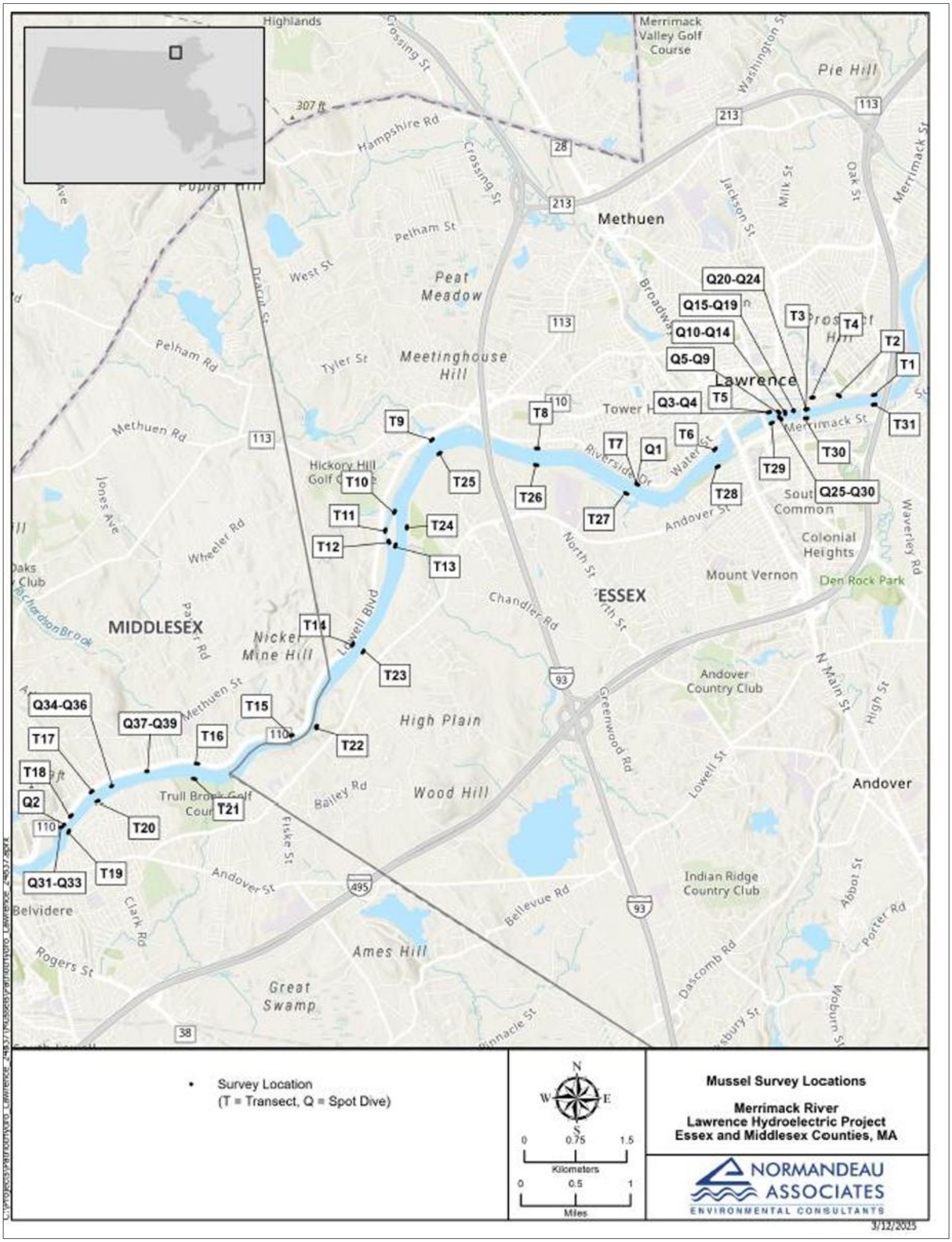
A semi-quantitative freshwater mussel survey at 31 sites, above and below the hydroelectric facility, was initiated on August 19-23 and completed on September 10-11, 2024 (See Figure E.7-35). These surveys consisted of visual and tactile surveys of the river bottom by several biologists using mask and snorkel and diving where necessary. For search locations within the Project impoundment, the targeted survey range covered up to seven (7) feet of water depth from the existing water level at the time of survey. This represented the likely range of effects when considering both operation and maintenance related effects for crest gate repairs. Survey crews dove selected areas where water depths exceeded three feet. Search locations downstream of the Essex Dam also covered up to seven feet of water depth.

A total of 31 transects were established at representative locations within the Project area reach. Survey teams reviewed each reach before selecting the final transect location in search of either heterogeneous substrate suitable to support mussel communities or the best available substrate present in that reach. Site selection was adjusted in the field to cover suitable and productive mussel habitat areas to best maximize the mussel distribution assessment and characterization of the mussel community. Center channel areas that remain watered during operation and maintenance events (i.e., deeper than 7 feet) were not targeted as part of this survey. Qualified biologists surveyed each search location to assess available habitat as well as search for evidence of live mussel populations using both visual and tactile search methods. Habitat and mussel catch were recorded for each 10-meter transect interval.

An additional 39 spot dives (i.e., serpentine transects) were conducted to further assess observed mussel communities adjacent to or in between transect areas. Spot dives conducted as part of this study were intended to further define mussel distributions in the Project area by following productive habitat to detect additional species. Spot dives were conducted in 10-minute intervals in areas where notable species were observed or where habitat suitable for those species was documented.

Given the shallow areas, transects and spot dives were oriented parallel to the shoreline to maximize the search areas along the shallower margins at selected locations. Areas of fine or loose substrates were probed by hand, and aquatic and emergent vegetation was moved or probed in search of mussels. No diving or survey occurred in areas 500 feet or closer to the dam, in the South Canal, or in areas where water velocities exceeded 2.0 feet per second (fps).

Figure E.7-35. Transect and Spot Dive Locations for Mussel Survey.



A total of 20 search hours yielded approximately 12,610 live mussels, representing six live species in the Merrimack River at the Project area. A variety of substrate compositions were observed throughout the Project area. Downstream of the dam, available habitat consisted of cobble, gravel, and sand, with high proportions of submerged aquatic vegetation. Habitat in the impoundment consisted of sand/silt dominated shoreline margins, with steep slopes to the thalweg. The upstream portion of the Project area exhibited similar substrate characteristics to those of the downstream section, although lacking the dense submerged aquatic vegetation (SAV) beds. Key findings from the 2024 survey include:

- Suitable habitat was widespread though the Project area and readily available for fish host and mussel colonization.
- Robust mussel communities were observed downstream of the dam and in the upper portion of the impoundment where flow was observed, and substrate was suitable for mussel colonization and juvenile recruitment.
- Mussel communities were dominated by common species including eastern elliptio, eastern floater, and alewife floater. Live rare species including triangle floater, creeper, eastern lampmussel, and yellow lampmussel shell were also observed.
- Yellow lampmussel and creeper are present in very low numbers amongst a robust mussel community dominated by more common species.
- No evidence of federal or state listed threatened or endangered species was observed in the Project area during this survey.
- *Asiatic clams (Corbicula fluminea)* were observed throughout the Project area in low densities. No transects or spot dives indicated that they occurred in dense communities. Live *Corbicula*, or shell material, were observed in low numbers at 19 of the transects surveyed upstream and downstream of the dam, and most spot dive locations. No corbicula were observed within the North canal.

In mussel communities of this size and density, rare species in low numbers are difficult to detect. Additional rare species may be present outside of those observed in this study. It is unlikely that Project operations, under normal conditions, negatively affect freshwater mussel communities based on the observed distributions of mussel communities observed upstream and downstream of the dam. The existing community is dense and robust throughout this system with active recruitment. The combination of ideal habitat and robust actively recruiting populations in nearly all areas of the study area make this community not only stable but resilient.

E.7.3.1.8 Aquatic Invasive Species

Aquatic invasive species (AIS) are non-indigenous plants and animals that were introduced to an area outside of their native range and are now causing ecological or economic harm. AIS typically have few or no natural predators in their introduced environments, which results in rapid population growth that quickly outcompetes native species. Invasive species can be introduced intentionally for management objectives (e.g., grass carp [*Ctenopharyngodon idella*] for the control of aquatic invasive weeds), illegally (e.g., angler-introduced sportfish species), or accidentally (e.g., invasive plant parts or mussels on boats and boat trailers).

The Merrimack River supports a relatively large number of invasive species. The Invasive Plant Atlas of New England (IPANE), NHDES, and the MRWC identified the species listed in Table E.7-24 as potentially occurring in vicinity of the Lowell Hydroelectric Project located approximately 11 miles upstream of the Lawrence Project.

Table E.7-24. Aquatic Invasive Species Likely to Occur in the Lawrence Project Vicinity.

Common Name	Scientific Name
common reed	*Phragmites australis*
curly-leaved pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
Carolina fanwort	*Cabomba caroliniana*
purple loosestrife	*Lythrum salicaria*
twoleaf milfoil	*Myriophyllum heterophyllum*
European water chestnut	*Trapa natans*
yellow iris	*Iris pseudacorus*
European water-clover	*Marsilea quadrifolia*
watercress	*Nasturtium officinale*
reed canarygrass	*Phalaris arundinacea*
yellow iris	*Iris pseudacorus*
flowering rush	*Butomus umbellatus*
yellow floating heart	*Nymphoides peltata*
Asian clam	*Corbicula fluminea*

Invasive Plant Survey (HDR 2026c)

Essex conducted a qualitative review of terrestrial and aquatic invasive plant species within the study area. In order to document the presence of invasive species throughout the Project, a botanist revisited the survey locations that had been previously established for the Freshwater Mussel Habitat Assessment and Survey (NAI 2025d).

The majority of points were accessed from the mainstem of the river and were surveyed using a small, flat-bottomed boat. At each point, the immediately adjacent shoreline was reviewed for the presence of terrestrial invasive species, and the immediate surroundings were reviewed for all submerged and floating-leaved aquatic vegetation. Terrestrial invasive species located below the top of bank were identified to the species level, if possible, and a representative shoreline photo was taken at each location. If submerged aquatic vegetation was visible from each point, vegetation was viewed through a view tube and, if necessary for identification, samples were collected and examined by hand. Voucher photographs were taken of each species found during the survey.

The majority of the aquatic vegetation observed was native; only one invasive (or potentially invasive) species of aquatic vegetation was observed at the study locations: curly pondweed (*Potamogeton crispus*, invasive). This site is located directly downstream of the north abutment of the Union Street Bridge, i.e., downstream of the Project Dam and outside of the Project boundary. The bridge abutment may shelter the curly pondweed population from scour that occurs elsewhere in this riverine section of the Project.

Three additional aquatic invasive species were observed incidentally away from transects at the mouth of a backwater: water caltrop (*Trapa natans*), brittle naiad (*Najas minor*), and variable water-milfoil (*Myriophyllum heterophyllum*). These three species are associated with slow-moving water, and the adjacent backwater is likely the source of this population.

E.7.3.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on fish and aquatic resources as potential resource issues. Specifically, SD2 identified the following as needing to be analyzed for site-specific effects:

- Effects of Project operation and maintenance on aquatic habitat for fish and other aquatic organisms (including mussels) in the Project impoundment, bypassed reach, and the Merrimack River downstream of the Project.
- Effects of Project operation and maintenance on aquatic habitat (including spawning habitat) for migratory fish species in the Project impoundment, bypassed reach, and the Merrimack River downstream of the Project.
- Effects of Project operation and maintenance on mussel species in the Project impoundment, bypassed reach, and the Merrimack River downstream of the Project.
- Effects of Project operation and maintenance on designated essential fish habitat for Atlantic salmon.
- Effects of Project operation on fish impingement and turbine entrainment in the Merrimack River.
- Effects of Project operation and maintenance on the aquatic macroinvertebrate community in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of Project operation and maintenance on resident and migratory fish species in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of Project operation and maintenance on the passage of migratory fish species.
- Effects of Project operation and maintenance on aquatic invasive species.

E.7.3.2.1 Site-Specific Effects

Considering that certain studies and analyses are ongoing, Essex will provide additional analysis of any relevant data pertaining to potential site-specific effects on fish and aquatics in the FLA to be filed with the Commission by November 30, 2026.

Effects of Project Operation and Maintenance on Aquatic Habitat for Fish and Other Aquatic Organisms (Including Mussels) in the Project Impoundment, Bypassed Reach, and the Merrimack River Downstream of the Project.

The Merrimack River is home to a diverse assemblage of fish species, including both cold-water and warm-water species, and provides a migratory corridor for many diadromous species. Stolte (1982; as cited in the Merrimack River Technical Committee for Anadromous Fishery Management of the Merrimack River Basin, 1997) noted that during the last 150 years, over 15 non-indigenous species, such as largemouth bass, smallmouth bass, walleye, common carp, rainbow trout, brown trout, various catfish species, and goldfish, have established through human introductions within the Merrimack River. At that time, the Merrimack River was identified as home to approximately 50 species of fish, nine of which were anadromous. The slower moving, ponded reaches of the

Merrimack contain a higher predominance of warm-water species, whereas those areas with higher gradient contain the majority of cold-water species. Hartel et al. (2002) identified a total of 57 reproducing fish species within the drainage; 21 primary species (i.e., those living full life cycle in freshwater), 8 secondary species (i.e., those with the physiological capacity to move between fresh and salt water), 18 introduced species, and 10 diadromous species.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations and maintenance over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system.

Project operation and maintenance may affect aquatic habitat at the Lawrence Project primarily through the conditions created in the impoundment and immediately downstream of Essex Dam. Because the Lawrence Project does not create a distinct bypassed reach in the same manner as a diversion project, the principal Project-affected areas for aquatic habitat are the impoundment upstream of Essex Dam and the Merrimack River downstream of the Project.

The Fish Assemblage Assessment (NAI 2026f) found a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project. Eight resident fish species were reported from previously sampled locations located only upstream of Essex Dam. An additional 23 species were reported as being present in Merrimack River reaches both upstream and downstream of Essex Dam, with those individuals representing ten families and including both native and introduced species, as well as freshwater resident and diadromous species. Six fish species were reported only downstream of Essex Dam, representing four freshwater resident species (brown bullhead, blacknose dace, redfin pickerel, and white catfish) and two native diadromous species (shortnose and Atlantic sturgeon).

The Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) found that mussel habitat quality and abundance varied within the impoundment according to depth, flow, and substrate. In the lower impoundment, researchers observed no live mussels from the shoreline to approximately 2.5-3 feet in depth, with live mussels generally observed beginning at about three feet depth and deeper. In contrast, farther upstream in the impoundment, the study found more substantial resources. The study found that the impoundment assemblage primarily consisted of moderately dense populations and that robust mussel communities were observed downstream of the dam and in the upper portion of the impoundment where flow was observed, and substrate was suitable for mussel colonization and juvenile recruitment. The study also concluded that, because the Project is operated as ROR, it is not anticipated that any direct impacts to mussels would occur during normal water fluctuations and Project operations. These findings support the conclusion that normal Project operations maintain existing impoundment habitat conditions and are not likely to cause substantial adverse effects on mussels or other benthic organisms under normal conditions.

For aquatic habitat in the impoundment, the Fish Assemblage Assessment (NAI 2026f) and the Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) together indicate habitat conditions that support both resident and migratory species. The persistence of these fish and mussel communities, combined with the stable water-surface elevations documented in the Phase I Project Operations and Fish Stranding Study Report (HDR 2026a), indicates that routine operation supports aquatic habitat in the impoundment. The Phase I Project Operations and Fish Stranding Study Report (HDR 2026a) identified five drawdowns of the impoundment below the spillway crest during the 2019-2024 study period, including four drawdowns for crest gate maintenance and repairs and one drawdown to facilitate installation of the eel elevator. Accordingly, while normal ROR operation is not expected to substantially affect impoundment aquatic habitat, maintenance drawdowns have the potential to temporarily reduce shallow-water habitat availability. These drawdowns were episodic rather than routine operating conditions, so the likely effect on impoundment aquatic habitat is short-term and localized rather than chronic. Each of these drawdowns was conducted in consultation with the resource agencies and notification to potentially affected stakeholders.

Downstream of Essex Dam, Project operation affects aquatic habitat through the distribution of flow among the powerhouse, spillway, fish passage facilities, and canals. The Phase I Project Operations and Fish Stranding Study Report (HDR 2026a) found that those Project outflows generally track the tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill, which indicates that ROR operation maintains downstream flow continuity and does not produce the large, peaking-type fluctuations that often cause repeated habitat instability. The Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) found aquatic habitat downstream of Essex Dam, with substrate in the downstream reach consisting of heterogeneous cobble, gravel, sand, and silt, with submerged aquatic vegetation in some locations. The habitat downstream of the dam was ideal for mussel colonization and recruitment, with high densities of adult and juvenile mussels observed during sampling. The Sturgeon Habitat Mapping and Assessment Study (ASA Analysis 2026a) was designed to quantify the area of juvenile rearing habitat, spawning habitat, and foraging habitat for Atlantic and shortnose sturgeon in the Merrimack River downstream from Essex Dam to RM 19. It further found that within the surveyed area (from the railroad bridge near the Project tailrace downstream to Basiliere Bridge), Atlantic sturgeon habitat comprised 16% for both foraging and juvenile rearing purposes, while spawning habitat accounted for 65%. Shortnose Sturgeon habitat area was classified as 19% for foraging, 3% for juvenile rearing, and 52% for spawning. These findings document spawning habitat for migratory species in the Merrimack River downstream of Essex Dam.

Based on these studies, normal ROR operation maintains a relatively stable water surface and generally preserves existing habitat conditions for fish, mussels, and other aquatic organisms. Downstream of Essex Dam, normal operations maintain flow continuity in the Merrimack River.

Effects of Project Operation and Maintenance on Aquatic Habitat (Including Spawning Habitat) for Migratory Fish Species in the Project Impoundment, Bypassed Reach, and the Merrimack River Downstream of the Project.

The Merrimack River is home to a diverse assemblage of fish species and provides a migratory corridor for many diadromous species. Stolte (1982; as cited in the Merrimack River Technical Committee for Anadromous Fishery Management of the Merrimack River Basin, 1997) identified the Merrimack River as home to approximately 50 species of fish, nine of which were anadromous. Hartel et al. (2002) identified a total of 57 reproducing fish species within the drainage; 21 primary species (i.e., those living full life cycle in freshwater), 8 secondary species (i.e., those with the physiological capacity to move between fresh and salt water), 18 introduced species, and 10 diadromous species. The Fish Assemblage Assessment (NAI 2026f) found a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system. As a result, normal operation is not likely to cause the kind of frequent water-level fluctuation that would repeatedly dewater broad areas of migratory fish habitat or spawning substrate in the impoundment.

Project operation and maintenance affect aquatic habitat for migratory fish species at the Lawrence Project primarily through the hydraulic conditions created in the impoundment and immediately downstream of Essex Dam. Because the Lawrence Project does not create a distinct bypassed reach in the same manner as a diversion project, the principal Project-affected areas for migratory fish habitat are the impoundment upstream of Essex Dam and the Merrimack River downstream of the Project.

In the impoundment, Project operation maintains a 9.8-mile-long waterbody that migratory fish must enter, traverse, and in some cases use for habitat after upstream passage. The Upstream Anadromous Fish Passage Assessment (NAI 2026b) specifically evaluated fish movement after passage into the impoundment. That study found that, for the subset of fish that successfully passed upstream, there were no observed instances of immediate entrainment and discharge back downstream for American shad, and all individuals successfully passed upstream through the Project impoundment and approached the upstream Lowell Project. Similarly, the single sea lamprey that passed upstream via the fish lift was subsequently detected at the upstream end of the Lawrence impoundment. These results indicate that once migratory fish successfully enter the impoundment, the impoundment provides adequate habitat, depth, and continuity to support upstream transit.

Downstream of Essex Dam, the Project creates a hydraulically complex environment where migratory fish concentrate during upstream movement. The Upstream Anadromous Fish Passage Assessment (NAI 2026b) and the Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d) show that the immediate downstream reach is heavily used by migratory fish. Together, these studies indicate that Project operation affects migratory fish habitat downstream not by eliminating habitat, but by influencing the distribution and effectiveness of attraction and approach conditions in the mainstem river and tailrace. Additionally, the attraction and approach conditions in the mainstem Merrimack River and Lawrence tailrace affect migratory species differently, reflecting differences in migratory behavior, swimming mode, response to hydraulic cues, and timing of movement.

For American shad, the Upstream Anadromous Fish Passage Assessment (NAI 2026b) found that 13% of tagged fish (53 out of 404) released 1.0 to 1.4 miles downstream of Essex Dam were determined to have approached the Project. Of the subset that did approach, approach events occurred under discharges ranging from 6,798 to 26,214 cfs, and tagged fish spent a median of 52.6 hours in the Project area after arrival. Upstream passage attempts at Lawrence were recorded for twelve tagged shad, which made a total of 26 unique passage attempts at the lift. Approximately 40% of passage attempts by shad reached the lift hopper, with 45% of those attempts resulting in successful upstream passage. Although nearfield attraction to the fish lift was high once fish reached the tailrace, the study calculated overall passage efficiency for American shad at 9.4%. The Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d) similarly found that American shad spent a larger proportion of time in the lower portion of the monitored downstream reach than in the upper tailrace area.

For sea lamprey, the Upstream Anadromous Fish Passage Assessment (NAI 2026b) found that the majority of tagged lamprey released downstream of Essex Dam approached the Project quickly, and nearfield attraction and entrance efficiency were both high. However, overall passage efficiency was 2.8%, because few lamprey that entered the fish lift successfully transitioned from the hopper to the upstream exit flume. The study found that nearly all sea lamprey passage attempts took place outside of the regular hours of operation for the Lawrence fish lift. This demonstrates that the effect of Project operation on migratory habitat for sea lamprey is not physical habitat availability, but is rather about the hours of the fish lift operation.

The Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d) found that use of available habitat varied by species. Tagged alewife and striped bass were present longer after tagging than was observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). In general, alewife and striped bass showed use of all of the downstream regions whereas blueback herring and American shad were somewhat more limited to regions towards the downstream end of the reach. The temporal review of species use of the downstream reach indicated presence of tagged river herring (both species) into early June. American shad presence was notable from late May through early June and individuals tended to spend a higher proportion of time in the lower portion of the monitored reach. Tagged striped bass were present throughout the downstream reach from initial tagging for the species in late May through June.

For American eel, studies performed in support of relicensing indicate that the Project area provides downstream and nearfield habitat for juvenile eels. The American Eel Upstream Siting Study (NAI 2025b) found that juvenile eels were concentrated in the powerhouse tailrace, the lower entrance flume area, and portions of the North Canal, demonstrating use of Project-influenced habitat downstream of the dam.

The Sturgeon Habitat Mapping and Assessment Study (ASA Analysis 2026a) was designed to quantify the area of juvenile rearing habitat, spawning habitat, and foraging habitat for Atlantic and shortnose sturgeon in the Merrimack River downstream from Essex Dam to RM 19. It further found that within the surveyed area (from the railroad bridge near the Project tailrace downstream to Basiliere Bridge) Atlantic sturgeon habitat comprised 16% for both foraging and juvenile rearing purposes, while spawning habitat accounted for 65%. Shortnose Sturgeon habitat area was classified as 19% for foraging, 3% for juvenile rearing, and 52% for spawning. These findings document spawning habitat for migratory species in the Merrimack River downstream of Essex Dam.

The current operation of the Project has been designed to consider and support ongoing efforts to maintain resident and migratory fisheries in the Merrimack River Basin. Based on the results of studies, normal ROR operation maintains a relatively stable water surface and generally preserves existing habitat conditions for fish, mussels, and other aquatic organisms. Downstream of Essex Dam, normal ROR operations maintain flow continuity in the Merrimack River and support aquatic life downstream of the Project, including aquatic habitat and migratory fish species.

Effects of Project Operation and Maintenance on Mussel Species in the Project Impoundment, Bypassed Reach, and the Merrimack River Downstream of the Project.

Project operation and maintenance affect mussel species at the Lawrence Project primarily through the water level and flow conditions maintained in the impoundment and downstream Merrimack River, as well as through episodic maintenance-related drawdowns. Because the Lawrence Project does not create a distinct bypassed reach in the same manner as a diversion project, the principal Project-affected areas for mussel species are the 9.8-mile impoundment upstream of Essex Dam and the Merrimack River downstream of Essex Dam.

The Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) provides the primary basis for evaluating Project effects on mussel species. The study area extended from the upstream extent of the Lawrence Project impoundment to the I-495 Bridge approximately 1.5 miles downstream of Essex Dam. The study documented approximately 12,610 live mussels representing six species in the Project area. Species observed included eastern floater, eastern elliptio, alewife floater, eastern lampmussel, triangle floater, and creeper, and a yellow lampmussel shell was also observed downstream of Essex Dam. The study further concluded that suitable mussel habitat was widespread throughout the Project area, that robust mussel communities were observed downstream of the Essex dam and in the upper portion of the impoundment where flow was observed, and substrate was suitable for mussel colonization and juvenile recruitment, and that the existing community is dense and robust throughout this system with active recruitment.

In the impoundment, the Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) found that habitat conditions and mussel abundance vary according to substrate and flow. In the lower and middle impoundment areas, mussels were present, but the assemblage was composed primarily of common species occurring in moderate or low densities. The mussel assemblage in the impoundment primarily consisted of moderately dense populations of eastern elliptio, eastern floater, and alewife floater. In contrast, farther upstream where higher flows were observed and substrate shifted to more heterogeneous cobble, gravel, and sand, the study observed higher proportions of juvenile eastern elliptio, eastern floater, and alewife floater, along with eastern lampmussel, creeper, and relic shells of triangle floater along the left descending bank in the upper section of the impoundment. The Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) noted that normal operations do not appear to have a substantial effect on the existing mussel community and that this community appears to be thriving at this location.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system.

The Phase I Project Operations and Fish Stranding Study Report identifies five drawdowns of the impoundment below the spillway crest during the 2019-2024 study period, including four drawdowns for crest gate maintenance and repairs and one drawdown to facilitate installation of the eel elevator. Accordingly, while normal ROR operation is not expected to substantially affect impoundment mussel populations, maintenance drawdowns have the potential to temporarily reduce shallow-water habitat availability, expose nearshore mussel beds, and alter habitat conditions for fish and other aquatic organisms along the margins of the impoundment. These drawdowns were episodic rather than routine operating conditions, so the likely effect on the community is short-term and localized rather than chronic. Each of these drawdowns was conducted in consultation with the resource agencies and notification to potentially affected stakeholders.

In the Merrimack River downstream of Essex Dam, the Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) found high quality mussel habitat in the Project area. The study describes the substrate in the downstream reach as consisting of heterogeneous proportions of cobble, gravel, sand, and silt, with some areas of dense submerged aquatic vegetation, and concluded that habitat downstream of the dam was ideal for mussel colonization and recruitment, with high densities of adult and juvenile mussels observed during sampling. The study reports that downstream transects contained very dense mussel communities, and that the assemblage downstream of Essex Dam was dominated by eastern elliptio, eastern floater, and alewife floater, with low numbers of triangle floater, creeper, and eastern lampmussel, plus one yellow lampmussel shell. The downstream Merrimack River supports the most abundant and diverse mussel community documented in the study area and includes evidence of active recruitment and at least some species of conservation interest.

The Freshwater Mussel Habitat Assessment and Survey and other available data indicate that it is unlikely that Project operations, under normal conditions, will negatively affect freshwater mussel communities based on the observed distributions of mussel communities upstream and downstream of the dam. The mussel community is not only stable but resilient because of the combination of ideal habitat and robust, actively recruiting populations. The Phase I Project Operations and Fish Stranding Study Report (HDR 2026a) supports this conclusion by documenting that the Project's crest gate and turbine control systems work together to minimize impoundment fluctuations and maintain outflow approximately equal to inflow. Therefore, the studies and available data support the conclusion that routine Project operation does not appear to be causing ongoing adverse effects on mussel species.

Effects of Project Operation and Maintenance on Designated Essential Fish Habitat for Atlantic Salmon.

The Lawrence Project boundary within the Merrimack River contains EFH for Atlantic salmon. In 1996, a radio telemetry study was performed to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not found to be effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. At the Lowell Project, 13% of the radio-tagged salmon used the bypass, a significant increase compared to the 4% bypass usage by radio-tagged salmon in 1990. Only four (15%) of the radio-tagged salmon that passed the Lowell Project made it downstream to the Lawrence Project's headpond, and of these, none were recorded passing the Lawrence site. Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites (NAI 1996).

Efforts to restore Atlantic salmon to the Merrimack River by the MRTC ceased in 2013 after consistently low return numbers were observed, but the species may still occasionally be present in the vicinity of the Project. Since 2013, efforts have shifted towards the restoration of the remaining migratory fish species, notably river herring and shad.

Project operation affects Atlantic salmon EFH first by maintaining the existing impounded hydraulic environment upstream of Essex Dam and providing flow continuity downstream. The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system. Normal ROR operation generally maintains the physical presence of freshwater EFH within the impoundment and downstream Merrimack River by avoiding large routine fluctuations and preserving flow continuity downstream.

EFH for the freshwater life history stages of Atlantic salmon includes all rivers, streams, lakes, and ponds in designated drainage systems from Connecticut to Maine, including the Merrimack River watershed (NEFMC 1998). All six life stages of Atlantic salmon (eggs, larvae [alevins], recently-hatched juveniles [fry], older juveniles [parr and smolts], spawning adults, and spent adults [kelts]) utilize freshwater habitats either exclusively or at some point during their life history. Intra-gravel habitat in the stream bed is essential for Atlantic salmon eggs and alevins, whereas EFH for the juveniles and spawning adults is the stream itself. Only parr and smolts utilize non-riffle and run habitats. Freshwater spawning and rearing EFH includes riffle and run habitats in shallow, well-oxygenated, freshwater streams with gravel and/or rocky substrates, as well as pools and vegetated riverine areas of lower velocity. These habitats occur in a range from first order streams (headwaters) to some third or fourth order streams with low water temperatures. EFH for migrating smolts and kelts includes streams, rivers, and estuaries from first to fifth order, as well as lakes, ponds, and impoundments.

Accordingly, for the impoundment, the principal Project effect on Atlantic salmon EFH is the long-term maintenance of an impounded migratory habitat rather than the maintenance of spawning and rearing habitat. The available studies do not identify current Atlantic salmon spawning or juvenile rearing use of the Lawrence impoundment, but the Project nevertheless occupies waters designated as EFH because those waters are historically accessible freshwater habitats for Atlantic salmon within the Merrimack system.

Effects of Project Operation on Fish Impingement and Turbine Entrainment in the Merrimack River.

Hydroelectric facilities have the potential for some level of entrainment of biota into intake structures. The potential for fish to become entrained or impinged at a hydroelectric facility is dependent on a variety of factors, such as fish life history, size, and swimming ability, as well as operating regimes, inflow, magnitude and duration of intake velocities, trashrack bar spacing, and intake/turbine configurations. Operation of the Project may continue to result in the delay in migration or entrainment of American eels, American shad, river herring, Atlantic salmon, striped bass, sea lamprey, and other resident species, but these effects are expected to be limited in scope and will not have an adverse effect at the population level.

The Desktop Entrainment, Impingement, and Turbine Passage Survival Assessment (NAI 2026c) evaluates the potential risk of impingement and entrainment for American shad, river herring, juvenile alosines, and adult American eel. American Eel was only considered as an entrainment/impingement risk during the adult life stage when they are actively out-migrating. Project interactions for alosines occur most frequently during the spring/early summer when post-spawn adults return downstream and during the fall/early winter when juveniles are migrating to the marine environment. Similar to juvenile alosines, the outmigration period for adult eels occurs during the fall time period.

A desktop approach utilizing a blend of field-derived and calculated parameter values was used to develop estimates of total Project survival for target species at Lawrence. The Desktop Entrainment, Impingement, and Turbine Passage Survival Assessment (NAI 2026c) calculated an intake approach velocity of 3.5 feet per second under full generation and compared that velocity to burst swim speeds for the target species and life stages. The study found that burst speeds for each of target species/life stages considered in this assessment are in excess of the calculated intake velocity at the powerhouse, which suggests the potential for involuntary impingement or entrainment is low. Fish whose burst swim speeds exceed the approach velocity are capable of moving away from the intake flow field to avoid interaction, at least for short durations. These findings indicate that, for the diadromous species evaluated, Project operation does not appear to create a strong risk of routine, involuntary impingement at the trashracks solely due to hydraulic conditions. The study found that estimates of total Project survival of 93.6% for adult river herring, 89.4% for adult American shad, 96.8% for juvenile alosines, and 60.4% for adult American eels.

In the 2021 Merrimack River Watershed Comprehensive Plan for Diadromous Fishes (Technical Committee 2021), Objective 14 states “Improve passage efficiency at all fish passage facilities in the watershed to achieve safe, timely and effective passage that meets or exceeds the following performance criteria”. Relative to downstream passage, Objective 14 stated that “*For alosines and American eel, achieve and maintain a minimum of 95% downstream passage survival*”. When the total Project survival rates estimated in this desktop assessment are compared to the “performance criteria” of 95% downstream passage survival for alosines and American eel, only juvenile alosines met the criteria. The total project survival estimates for adult river herring and adult American Shad both approached the 95% criteria with estimates of 93.6% and 89.4%, respectively. The desktop total project survival estimate for silver-phase American eel (60.4%) did not attain the written passage criteria and was also lower than that estimated during the single season downstream telemetry study conducted under the available set of inflow conditions during the fall of 2019 (90.3%) (NAI 2024a).

Essex is proposing to develop, in consultation with the MRTC, a narrow-spaced trashrack design to replace the existing trashrack system. Essex may consider alternative methods for providing downstream passage and protection at the intake for outmigrating fish, such as replacing the existing turbine runners with new "fish friendly" designed runners. Any proposed downstream passage and protection measures will be developed in consultation with the MRTC. Essex believes this proposed PM&E measure would result in reduced fish mortality during downstream passage.

Effects of Project Operation and Maintenance on the Aquatic Macroinvertebrate Community in the Impoundment, Canal System, Bypassed Reach, and Merrimack River.

Hydroelectric projects may influence benthic macroinvertebrate communities by altering flow conditions and thereby habitat, water quality, and instream transport processes. The severity of impact on aquatic resources is largely influenced by the extent of flow regulation. The Project operates as a ROR facility, which uses the natural flow of the water to produce electricity. As such, flow regulation is minimal at ROR projects, which are often considered low impact facilities compared to peaking and storage hydroelectric projects. Although hydropower operations may affect macroinvertebrate communities to some degree, the Licensee's macroinvertebrate study indicates that the existing ROR operation of the Project does not adversely affect macroinvertebrate communities.

As part of the Water Quality Study (NAI 2026a) macroinvertebrate sampling was performed at a station downstream of Essex Dam and at a station upstream of Essex Dam. The upstream sampling reach yielded 526 individuals representing 53 taxa, compared to 501 individuals and 42 taxa at the downstream sampling reach. Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa represented 32.1% and 21.7% of the total taxa richness for benthic macroinvertebrate samples collected upstream and downstream of Essex Dam, respectively. The Shannon Diversity Index values were similar between the two stations (upstream = 2.81; downstream = 2.45), indicating a similar degree of dominance within taxa for both reaches. The most abundant taxon, *Gammarus fasciatus*, was the same for each site, comprising 28.7% of specimens upstream and 38.3% of specimens downstream. *Gammarus fasciatus* is an amphipod with moderate tolerance of nutrient enrichment and is a collector-gatherer, opportunistically feeding on available detritus or benthic debris. Hilsenhoff Biotic Index (HBI) values were 5.98 upstream and 6.42 downstream, both values supporting a finding of "fair" water quality in terms of nutrient input or organic pollution. The similarities in findings between the upper and lower sampling locations indicate that ROR Project operations have a minimal effect on the macroinvertebrate community. There is limited information pertaining to macroinvertebrate communities in the North and South Canals, and the Project does not have a distinct bypassed reach in the same manner as a diversion project.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system. The Phase I Project Operations and Fish Stranding Study Report (HDR 2026a) identified five drawdowns of the impoundment below the spillway crest during the 2019-2024 study period, including four drawdowns for crest gate maintenance and repairs and one drawdown to facilitate installation of the eel elevator. There is some potential for short-term disturbance in the impoundment during maintenance drawdowns as maintenance can temporarily expose nearshore substrate and disturb benthic habitat. These drawdowns were episodic rather than routine operating conditions, so the likely effect on the impoundment macroinvertebrate community is short-term and localized rather than chronic. Each of these drawdowns was conducted in consultation with the resource agencies and notification to potentially affected stakeholders.

Effects of Project Operation and Maintenance on Resident and Migratory Fish Species in the Impoundment, Canal System, Bypassed Reach, and Merrimack River.

The Merrimack River is home to a diverse assemblage of fish species, including both cold-water and warm-water species, and provides a migratory corridor for many diadromous species. Stolte (1982; as cited in the Merrimack River Technical Committee for Anadromous Fishery Management of the Merrimack River Basin, 1997) noted that during the last 150 years, over 15 non-indigenous species, such as largemouth bass, smallmouth bass, walleye, common carp, rainbow trout, brown trout, various catfish species and goldfish have established through human introductions within the Merrimack River. At that time, the Merrimack River was identified as home to approximately 50 species of fish, nine of which were anadromous. The slower moving, ponded reaches of the Merrimack contain a higher predominance of warm-water species whereas those areas with higher gradient contain the majority of cold-water species. Hartel et al. (2002) identified a total of 57 reproducing fish species within the drainage; 21 primary species (i.e., those living full life cycle in freshwater), 8 secondary species (i.e., those with the physiological capacity to move between fresh and salt water), 18 introduced species, and 10 diadromous species.

The Fish Assemblage Assessment (NAI 2026f) found that a total of 37 fish species across 13 families were identified from the general region of the Merrimack River encompassing the Lawrence Project. Eight resident fish species were reported from previously sampled locations located only upstream of Essex Dam. An additional 23 species were reported as being present in Merrimack River reaches both upstream and downstream of Essex Dam with those individuals representing ten families and including both native and introduced species, as well as freshwater resident and diadromous species. Six fish species were reported only downstream of Essex Dam, representing four freshwater resident species (brown bullhead, blacknose dace, redfin pickerel, and white catfish) and two native diadromous species (shortnose and Atlantic sturgeon).

Project operation and maintenance affect resident and migratory fish species at the Lawrence Project primarily through the hydraulic conditions created in the impoundment and immediately downstream of Essex Dam via the routing of flow among the spillway, powerhouse, fish lift, downstream bypass, and canals, as well as the timing and availability of passage conditions during the migration season. Because the Lawrence Project does not create a distinct bypassed reach in the same manner as a diversion project, the principal Project-affected areas for migratory fish habitat are the impoundment upstream of Essex Dam and the Merrimack River downstream of the Project. FERC also requested an analysis migratory fish in the canal system.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations and maintenance over the six-year period from January 1, 2019 through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Impoundment elevations are consistently maintained near the normal pond level of approximately 44.2 feet NGVD29 through coordinated operation of the powerhouse pond level control system and the pneumatic crest gate system.

The Upstream Anadromous Fish Passage Assessment (NAI 2026b) specifically evaluated fish movement after passage into the impoundment. That study found that, for the subset of fish that successfully passed upstream, there were no observed instances of immediate entrainment and discharge back downstream for American shad, and all individuals successfully passed upstream through the Project impoundment. Similarly, the single sea lamprey that passed upstream via the fish lift was subsequently detected at the upstream end of the Lawrence impoundment. These results indicate that once migratory fish successfully enter the impoundment, the impoundment provides adequate depth and continuity to support upstream transit. Within the impoundment, Project effects on fish are tied mainly to passage opportunity and route availability rather than operational instability, given that the headpond is maintained at 44.2 feet NGVD29. The Phase II Diadromous Project Interaction Study (NAI 2026d) found that fish successfully reaching and passing the lift could move into the lower Lawrence impoundment, but upstream passage success varied by species. The Fish Assemblage Assessment (NAI 2025d), Phase II Diadromous Project Interaction Study (NAI 2026d), and the Upstream Anadromous Fish Passage Assessment (NAI 2026b) indicate impoundment conditions that support both resident and migratory species.

The American Eel Upstream Siting Study (NAI 2025b) found that juvenile eels were observed most frequently in the Project tailrace, within the entrance of the lower entrance flume associated with the existing fish lift, and at the upstream end of the North Canal. No juvenile eels were observed from vantage points surveying the areas upstream or downstream of the South Canal gatehouse during any of the ten weekly survey events. Across ten nighttime visual surveys conducted between June 20 and August 19, 2024, observers counted more than 5,000 juvenile eels, including more than 3,000 during a single survey on July 16. The eel pots deployed during the ten-week sampling period were successful in collecting information on juvenile eel presence and relative abundance. The control site, located on the near-field ledge areas associated with the existing south side eel trap, had a total catch of greater than 20,000 juvenile eels across the full ten-week period. However, the deployment of mesh-lined eel pots in the North Canal resulted in regular observations of small numbers of juvenile eels at the downstream end and near the discharge gates (n = 15 over the 10-week period). A single juvenile eel was observed in the ten weeks of eel pot sampling conducted at the upstream end of the North Canal. Similarly, the ten weeks of eel pot sampling within the South Canal produced only a single juvenile eel. Eel pot collections suggest some presence of juvenile American eels within the North Canal. Electrofishing effort (all sites and dates) yielded a total of 309 fish with 172 of those being American eels. A total of 57 juvenile eels were collected within the main stem Merrimack River, 43 within the lower Spicket River, and 72 within the North Canal. The highest catch per unit effort (CPUE) occurred in the North Canal with a high of 1.26 eels per minute. Nighttime surveys, eel pot collections, and backpack electrofish sampling conducted within the North Canal, suggest that juvenile eels are accessing that waterway. Over 400 juvenile eels were observed at the upstream end of the North Canal over survey events conducted during late July and early August. Captures of juvenile eels in pots set at the downstream end of the North Canal occurred between late June and early August, and CPUE rates for juvenile eels in the North Canal were the highest observed for areas sampled by electrofishing.

Nighttime surveys, eel pot collections and backpack electrofishing conducted within the North Canal do suggest that juvenile eels are accessing that waterway. However, despite considerable effort sampling in the South Canal, observations of juvenile eels in the South Canal were limited to a single individual (6-12 inch length class) suggesting minimal use of this reach. Under the current FERC license, Essex is not required to maintain a specific water level in either of the canals, or to allocate downstream flows between the canals and the main channel of the Merrimack River. Operations of the canal levels typically do not result in large changes in inflow, water surface elevation, or outflow. In the past, the respective gatehouses were typically operated to maintain a steady state pool at a standard level of approximately 42.2 ft NGVD29, which is two (2) feet below the normal water level in the impoundment and the top of the North Canal and South Canal walls. Historically, Essex Company maintained inflows into the canals to match observed outflows (e.g. withdrawals by the mills or leakage) or needs as requested by the mill power owners. For periods of construction or inspection, the North Canal is drawn down using the North Canal Wasteway which limits outflow from the North Canal gatehouse to leakage.

Below the Essex Dam, migratory fish approach and attempt to pass the Project. The Phase II Diadromous Project Interaction Study (NAI 2026d) documented species-specific patterns of movement for alewife, blueback herring, American shad, and striped bass in the river reach extending from downstream of the powerhouse to the I-495 bridge. A total of 934 fish were tagged, and valid detections were recorded for 95% of them, demonstrating extensive use of the downstream Merrimack River by migratory fishes approaching Essex Dam. Initial arrivals of tagged fish at the Lawrence tailrace took place from late April through early June. The initial detection of nearly all tagged fish at the Lawrence tailrace occurred during daylight hours. Probabilities of upstream movement for each test species were estimated using a series of Cormack Jolly Seber (CJS) models. Estimates of passage probabilities for tagged alewife were consistent for the full reach from release to the downstream face of the powerhouse. The estimate of passage success for tagged alewife using the Project fish lift was 1.9%. Passage probabilities for tagged blueback herring to ascend the downstream reaches were slightly lower than that observed for alewife. Of the blueback herring reaching the receiver positioned at the downstream extent of the tailrace channel, approximately 26% were subsequently detected at the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance). American shad showed a relatively low probability to ascend upstream following tagging (consistent with the known fallback behavior of this species following handling). Despite this, nearly 70% of individuals that reached the downstream end of the tailrace channel were subsequently detected at the next station upstream along the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance) and passage success for those fish via the upstream fish lift was estimated at 26.9%. Striped bass showed movements upstream through the reach below the dam, but no individuals were detected passing upstream via the lift.

Based on evaluation of median estimates for time at large, tagged alewife and striped bass were present longer after tagging than was observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). Spatial and temporal patterns in the relative proportion of time spent among the downstream regions defined by the stationary receivers were evaluated for each species. In general, alewife and striped bass showed use of all of the downstream regions whereas blueback herring and American shad were somewhat more limited to regions towards the downstream end of the reach.

Overall, the available Lawrence studies indicate that Project operation and maintenance have potential to affect migratory fish in the downstream Merrimack River, tailrace, and fish passage approach areas, where hydraulic conditions, spill, turbine discharge, and bypass operations influence attraction, delay, and passage success. The Upstream Anadromous Fish Passage Assessment (NAI 2026b) and the Phase II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d) show that the immediate downstream reach is heavily used by migratory fish. Additionally, the attraction and approach conditions in the mainstem Merrimack River and Lawrence tailrace affect migratory species differently, reflecting differences in migratory behavior, swimming mode, response to hydraulic cues, and timing of movement.

The current operation of the Project has been designed to consider and support ongoing efforts to maintain resident and migratory fisheries in the Merrimack River Basin. Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on fish and aquatic resources. Essex proposes to continue to operate the Project in an ROR mode, adhere and operate fish passage facilities consistent with the CFPP approved by FERC on approved by FERC in July 2000.

As a component of the CFPP/FOMP, Essex collects information regarding the abundance of diadromous fishes using the fishways annually. This activity is a monitoring effort that supports the MRTC, which manages these fishery resources. Essex staff works to record diadromous fish counts at the fish lift throughout the upstream migration season. Essex provides a summary of these counts as part of its annual fishway operations report to the MRTC.

Effects of Project Operation and Maintenance on the Passage of Migratory Fish Species.

Overview of Current Fish Passage Operations

The MRTC oversees the management of the Lawrence Project for the restoration of diadromous fish to the Merrimack River as directed by the Project's CFPP, which was filed pursuant to Article 31 of the Project's existing license and approved by FERC in July 2000. Since that time, Essex and the MRTC have developed and maintained the Fishways Operation and Maintenance Plan (FOMP) to support implementation of the Project's CFPP and optimize fishway operations for target species. The FOMP serves as a living, adaptive management document that has been periodically updated and shared through the parties' ongoing cooperative efforts since 2000. The CFPP/FOMP includes details of operational measures undertaken by Essex to protect upstream and downstream migrating diadromous fish. Upstream and downstream fish passage facilities at the Project consist of a fish lift, downstream fish bypass, an upstream eel ladder, and an upstream eel elevator (or eel lift). The Project's fish lift and downstream fish bypass were originally designed in consultation with the USFWS. Current fish passage operation of the structures are guided by both state and federal fishery agencies (i.e., the MRTC) per the FOMP. Essex provides annual post-season updates to the MRTC. The Project's upstream eel ladder and elevator were designed in consultation with the MRTC and are subject to the same supervision and annual reporting.

In accordance with the FOMP, the fish lift is typically operated annually from late April through mid-July, however the start of the season varies slightly and is also based on downstream fish movement activity and thus, the seasonal operation schedule is determined in consultation with the MRTC. Operation of the upstream fish passage lift generally occurs hourly between 8:00 a.m. and 4:00 p.m. daily during operational periods and during river flows of 500 cfs to 25,000 cfs (LHA 1999). The downstream fish bypass facility is a concrete bypass chute that is typically operated annually from April 1 through July 15 and from September 1 through November 15, on a 24-hour basis. Upstream eel passage operations occur annually between May 1 and September 30 (Essex 2014). Upstream passage is provided by a combination of the Project's upstream eel ladder, which is located adjacent to the powerhouse at the toe of Essex Dam, and the Project's eel elevator (or "eel lift"), which is located at the left (north) abutment of Essex Dam. The elevator consists of a collection/transport hopper connected to an integral ramp at the toe of Essex Dam. Essex records diadromous fish counts at the fish lift throughout the upstream migration season. Essex provides the MRTC with a summary of the seasonal counts as part of its annual fishway operations report.

Upstream Passage of American Eel

The Upstream American Eel Passage Assessment (NAI 2025a) evaluated nearfield and internal effectiveness of the south side eel trap and north side eel lift at the Lawrence Project during the 2024 upstream passage season. Visual observations made during all three survey events at the south side eel trap indicated adequate flow in the approach channel providing access for juvenile American eels to the ramp entrance. Juvenile eels were observed utilizing the ramp sections and resting pools, as well as ascending gaps between the milieu substrate and ramp wall. A quantitative evaluation to assess the internal passage effectiveness of the south side eel trap was conducted over the course of two days in mid-July, during which a total of 272 marked juvenile eels were placed at the sealed entrance of the ramp. Following the completion of a 24-hour period, the collection tank was checked, and no marked eels were found, suggesting high levels of escapement and poor internal effectiveness of conveying eels from the ramp entrance up to the collection tank. In addition to evaluating the effectiveness of the climbing structure, a retention test of the collection tank at the south side eel trap was also conducted. During two separate tests, a total of 50 marked juvenile eels were placed in the tank, and the 24-hour retention effectiveness was estimated at 58%, suggesting a measurable amount of escapement of collected eels from the collection tank is occurring. Similar to the south side eel trap, juvenile eels were readily observed in the nearfield area of the north side eel lift during all three survey dates. At the north side eel lift, most juvenile eels were observed in the approach channel leading to the base of the eel lift. Similar to the internal passage evaluation conducted at the south side eel trap, a quantitative evaluation was conducted at the north side eel lift to assess the internal efficiency of that structure. Over the course of two days at the beginning of August, 260 marked juvenile eels were placed into the collection hopper of the north side eel lift. Of that total, 259 (over 99%) were successfully transported to the top of the dam, indicating high internal effectiveness for this facility. The results of this study indicate that both the south side eel trap and north side eel lift have nearfield effectiveness and juveniles are readily observed, but the south side eel trap suffers from high levels of escapement and poor internal effectiveness of conveying eels from the ramp entrance up to the collection tank. The north side eel lift however has high internal effectiveness (99%).

The American Eel Upstream Siting Study (NAI 2025b) found that juvenile eels were observed most frequently in the Project tailrace, within the entrance of the lower entrance flume associated with the existing fish lift, and at the upstream end of the North Canal. No juvenile eels were observed from vantage points surveying the areas upstream or downstream of the South Canal gatehouse during any of the ten weekly survey events. Across ten nighttime visual surveys conducted between June 20 and August 19, 2024, observers counted more than 5,000 juvenile eels, including more than 3,000 during a single survey on July 16. The eel pots deployed during the ten-week sampling period were successful in collecting information on juvenile eel presence and relative abundance. The control site, located on the near-field ledge areas associated with the existing south side eel trap, had a total catch of greater than 20,000 juvenile eels across the full ten-week period. However, the deployment of mesh-lined eel pots in the North Canal resulted in regular observations of small numbers of juvenile eels at the downstream end and near the discharge gates (n = 15 over the 10-week period). A single juvenile eel was observed in the ten weeks of eel pot sampling conducted at the upstream end of the North Canal. Similarly, the ten weeks of eel pot sampling within the South Canal produced only a single juvenile eel. Eel pot collections suggest some presence of juvenile American eels within the North Canal. Electrofishing effort (all sites and dates) yielded a total of 309 fish with 172 of those being American eels. A total of 57 juvenile eels were collected within the main stem Merrimack River, 43 within the lower Spicket River, and 72 within the North Canal. The highest CPUE occurred in the North Canal with a high of 1.26 eels per minute. Nighttime surveys, eel pot collections, and backpack electrofish sampling conducted within the North Canal, suggest that juvenile eels are accessing that waterway. Over 400 juvenile eels were observed at the upstream end of the North Canal over survey events conducted during late July and early August. Captures of juvenile eels in pots set at the downstream end of the North Canal occurred between late June and early August, and CPUE rates for juvenile eels in the North Canal were the highest observed for areas sampled by electrofishing.

Nighttime surveys, eel pot collections and backpack electrofish sampling conducted within the North Canal do suggest that juvenile eels are accessing that waterway. However, despite considerable effort sampling in the South Canal, observations of juvenile eels in the South Canal were limited to a single individual (6-12 inch length class) suggesting minimal use of this reach.

Upstream Passage of American Shad

For American shad, the Upstream Anadromous Fish Passage Assessment (NAI 2026b) found that 13% (53 out of 404) of tagged fish released 1.0 to 1.4 miles downstream of Essex Dam approached the Project. Approach events for tagged shad occurred from May 23 through June 23 2025, peaking during mid-June. Upon arrival at Lawrence, the median duration of time spent downstream prior to either upstream passage or movement downstream and away from the Project was 52.6 hours. Upstream passage attempts at Lawrence were recorded for twelve tagged shad which made a total of 26 unique passage attempts at the lift. Approximately 40% of passage attempts by shad reached the lift hopper, with 45% of those attempts resulting in successful upstream passage. When all successful shad passage attempts at the Lawrence fish lift are considered, the median foray duration was 0.7 hours. The modeled performance metrics showed nearfield attraction of 100%, entrance efficiency of 34.3%, and overall passage efficiency of 9.4%.

As part of the Phase II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d), a total of 199 American shad were acoustically tagged following collection via boat electrofishing in the section of the Merrimack River downstream of Essex Dam. American shad showed a relatively low probability to ascend upstream following tagging (consistent with the known fallback behavior of this species following handling). Despite this, nearly 70% of individuals which reached the downstream end of the tailrace channel were subsequently detected at the next station upstream along the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance) and passage success for those fish via the upstream fish lift was estimated at 26.9%. American shad presence was notable from late May through early June 2025, and individuals tended to spend a higher proportion of time in the lower portion of the monitored reach.

Upstream Passage of Sea Lamprey

For sea lamprey, the Upstream Anadromous Fish Passage Assessment (NAI 2026b) found that the majority of tagged lamprey released downstream of Essex Dam approached the Project quickly, and nearfield attraction and entrance efficiency were both high. Of the 51 sea lamprey collected at the Lawrence fish lift, radio-tagged and released into the Merrimack River approximately 1.4 miles downstream of Essex Dam, 71% (36 out of 51) approached the Project. The median approach duration for tagged sea lamprey to ascend from the release location at the Lawrence I-495 Bridge to the Project area was 6.8 hours. Of the 36 radio-tagged sea lamprey determined to have moved upriver and in the direction of Essex Dam, 97% (35 out of 36) were observed within ~25 feet of the fish lift entrances. Of those individuals, 28 made at least one upstream passage attempt based on detection at one of the two lift entrances and one of those individuals (4%; 1 out of 28) successfully passed upstream. The modeled performance metrics showed nearfield attraction of 100%, entrance efficiency of 80%, and overall passage efficiency of 2.8%. The study found that nearly all sea lamprey passage attempts took place outside of the regular hours of operation for the Lawrence fish lift (i.e., between 8:00 a.m. and 4:00 p.m.).

Upstream Passage of Alewife

As part of the Phase II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d), a total of 335 alewife were acoustically tagged following collection via boat electrofishing in the section of the Merrimack River downstream of Essex Dam. Estimates of passage probabilities for tagged alewife were consistent for the full reach from the release point to the downstream face of the powerhouse. The estimate of passage success for tagged alewife using the Project fish lift was 1.9%. Based on median estimates for time at large, tagged alewife and striped bass were present longer after tagging than was observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). Spatial and temporal patterns in the relative proportion of time spent among the downstream regions defined by the stationary receivers were evaluated for each species. In general, alewife and striped bass showed use of all downstream regions whereas blueback herring and American shad were somewhat limited to regions towards the downstream end of the reach.

Upstream Passage of Blueback Herring

As part of the Phase II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d), a total of 300 individuals were tagged. Passage probabilities for tagged blueback herring to ascend the downstream reaches were slightly lower than that observed for alewife (1.9%). Of the blueback reaching the receiver positioned at the downstream extent of the tailrace channel, approximately 26% were detected at the downstream face of the powerhouse (i.e., vicinity of the fish lift entrance). Based on median estimates for time at large, tagged alewife and striped bass were present longer after tagging than was observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). Spatial and temporal patterns in the relative proportion of time spent among the downstream regions defined by the stationary receivers were evaluated for each species. In general, alewife and striped bass showed use of all downstream regions whereas blueback herring and American shad were somewhat limited to regions towards the downstream end of the reach. The peak of tailrace arrival for both blueback herring and striped bass was May 29-30 2025.

Upstream Passage of Striped Bass

As part of the Phase II Diadromous Fish Behavior, Movement, and Project Interaction Study (NAI 2026d), a total of 100 individuals were tagged. Estimates of passage probabilities for tagged striped bass varied by reach in the study zone from immediately upstream of the release location to the lower end of the tailrace channel, ranging between 0.296 to 0.979. Striped bass moved upstream through the reach below the dam but no individuals were detected passing upstream via the lift. Based on median estimates for time at large, tagged alewife and striped bass were present longer after tagging than was observed for either blueback herring or American shad (both “fragile” species more prone to fallback following handling). Spatial and temporal patterns in the relative proportion of time spent among the downstream regions defined by the stationary receivers were evaluated for each species. In general, alewife and striped bass showed use of all downstream regions whereas blueback herring and American shad were somewhat limited to regions towards the downstream end of the reach. The peak of tailrace arrival for both blueback herring and striped bass was May 29-30. Tagged striped bass were present throughout the downstream reach from initial tagging for the species in late May through June 2025.

Upstream Passage of Atlantic and Shortnose sturgeon

The Sturgeon Distribution and Project Interaction Study (ASA 2026b) found that the Project is within the historical range of both Atlantic and shortnose sturgeon and lies at the upstream boundary of designated Atlantic sturgeon critical habitat. However, 2025 monitoring documented only limited shortnose sturgeon presence in the river reach between Essex Dam and the I-495 bridge, and no Atlantic sturgeon detections at stationary receivers. Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence, but none occurred upriver of the Joseph W. Casey Bridge, about 0.4-mile below the dam. A limited number of tagged adult shortnose sturgeon (n = 2) were confirmed as present during the survey in the monitored area. One individual ascended far enough upstream to be detected at the downstream entrance of the tailrace channel. The residence time was around two days. The second individual was not detected at any stationary receivers located upstream of the Lawrence I-495 Bridge. There were no detections of tagged Atlantic sturgeon (juvenile or sub adult) at any stationary receiver location during the 2025 monitoring period. This suggests that, under the conditions observed, Project operation had relatively limited direct interaction with sturgeon immediately below the dam.

No Project-related effects were identified during the Sturgeon Distribution and Project Interaction Study (ASA 2026b). A limited number of individuals were detected in the monitored reach downstream of Essex Dam, and the seasonal timing of these detections is in line with previously reported shortnose sturgeon movements within the Merrimack River. Results of the acoustic tag monitoring portion also do not provide conclusive evidence to support the current need for upstream passage at the Project for sturgeon. Observations in the immediate vicinity of Essex Dam were limited to a single adult shortnose sturgeon detected only by the receiver at the downstream end of the tailrace channel (i.e., undetected by the two acoustic receivers positioned at the downstream face of the powerhouse and in the vicinity of the upstream fish lift entrances).

Downstream Passage of Adult American Eel

During the fall of 2019, Essex installed a series of stationary radio-telemetry receivers at the Lawrence Project (FERC No. 2800) to assess the arrival and downstream passage of tagged adult silver-phase American eels released both upstream of the Lowell Project (FERC No. 2790) boundary and upstream of Garvins Falls Dam (Bow, NH; FERC No. 1893). A total of 111 radio-tagged adult eels approached the Essex Dam and were available for the evaluation of downstream passage route. The majority of radio-tagged individuals passed downstream at Lawrence via the turbine units (51.4%) or via the spillway (38.7%). Usage of the downstream bypass was limited to a single individual (0.9% of those approaching Essex Dam). Estimated downstream passage survival for the silver-phase American eel at Lawrence was 90.3% (NAI 2024a).

Downstream Passage of Adult Alosines

In the spring of 2020, radio-tagged adult river herring and American shad were released by Normandeau at four locations within the Merrimack River watershed (NAI 2024b). A total of 500 adult river herring and 330 adult American shad were radio-tagged and released upstream of Lawrence and had the potential to pass downstream of Lawrence following time spent upstream. Of those individuals, a total of 233 adult river herring and 158 adult American shad approached Essex Dam and had the opportunity to pass downstream of the Project.

The majority of radio-tagged adult alosines utilized the downstream bypass for passage at the Project with 67% of adult river herring and 92% of adult American shad recorded in the exit flume of the facility prior to subsequent detection downstream. Turbine passage was limited to 16% of radio-tagged adult river herring and only 4% of radio-tagged adult shad. Approximately 6% of adult herring passed downstream of Lawrence via the limited spill which occurred for the duration of the monitoring period.

Downstream passage survival was calculated for the section of the Merrimack River from Lawrence to the downstream monitoring station and resulted in an estimated downstream passage survival for adult herring of 38.7%. Despite high utilization of the downstream bypass facility by adult herring (~ 2/3 of outmigrants) overall survival for downstream passage at Lawrence was poor. These estimates of downstream passage survival for adult river herring include background mortality (i.e., natural mortality including predation) from the dam to the first downstream receiver, along with tagging-related mortalities and tag regurgitations. As a result, this estimate should be viewed as a conservative (i.e., minimum) estimate of total project survival for adult river herring at Lawrence.

Similar to adult herring, downstream passage survival was calculated for adult shad from Lawrence to the downstream monitoring station. The estimated downstream passage survival for all adult American shad at Lawrence was 94.8%. These estimates of downstream passage survival for adult shad include background mortality (i.e., natural mortality) from the dam to the first downstream receiver, along with tagging-related mortalities and tag regurgitations. As a result, this estimate should be viewed as a conservative (i.e., minimum) estimate of total project survival.

Downstream Passage of Juvenile Alosines

In support of the Downstream Juvenile Alosine Passage Assessment (NAI 2026e), a total of 60 HI-Z tagged fish were released at the upstream end of the downstream bypass facility on October 18, 2025, and flows through that facility were at 2% of station capacity (160 cfs) during testing. Of the 60 fish released, 54 were recaptured and survived the initial 1-hour immediate survival period and the 48-hour latent survival period. All 60 control fish were recaptured alive and remained alive through the 48-hour latent survival period. Six treatment fish were documented as having minor passage related injuries attributable to either shear or mechanical causes. HI-Z tag-recapture testing completed during the fall of 2025 demonstrated latent (i.e., 48-hour) survival and malady-free rates for juvenile alosines of 90% (±6.2% with 90% confidence) and 93.6%, respectively.

Desktop Entrainment, Impingement, and Turbine Passage Survival Assessment

The Desktop Entrainment, Impingement, and Turbine Passage Survival Assessment (NAI 2026c) evaluated the potential risk of impingement and entrainment for American shad, river herring, juvenile alosines, and adult American eel. The study found that burst speeds for each of target species/life stages considered in this assessment are in excess of the calculated intake velocity at the powerhouse, which suggests the potential for involuntary impingement or entrainment is low. Fish whose burst swim speeds exceed the approach velocity are capable of moving away from the intake flow field to avoid interaction, at least for short durations. These findings indicate that, for the diadromous species evaluated, Project operation does not appear to create a strong risk of routine, involuntary impingement at the trashracks solely due to hydraulic conditions. The study found that estimates of total Project survival of 93.6% for adult river herring, 89.4% for adult American shad, 96.8% for juvenile alosines, and 60.4% for adult American eels.

In the 2021 Merrimack River Watershed Comprehensive Plan for Diadromous Fishes (Technical Committee 2021), Objective 14 states "Improve passage efficiency at all fish passage facilities in the watershed to achieve safe, timely and effective passage that meets or exceeds the following performance criteria". Relative to downstream passage, Objective 14 stated that "*For alosines and American eel, achieve and maintain a minimum of 95% downstream passage survival*". When the total Project survival rates estimated in this desktop assessment are compared to the "performance criteria" of 95% downstream passage survival for alosines and American eel, only juvenile alosines met the criteria. The total project survival estimates for adult river herring and adult American Shad both approached the 95% criteria with estimates of 93.6% and 89.4%, respectively. The desktop total project survival estimate for silver-phase American eel (60.4%) did not attain the written passage criteria and was also lower than that estimated during the single season downstream telemetry study conducted under the available set of inflow conditions during the fall of 2019 (90.3%), as noted above (NAI 2024a).

Effects of Project Operation and Maintenance on Aquatic Invasive Species.

Continued operation and maintenance of the Lawrence Project is expected to have minimal effects on aquatic invasive species given that it operates in ROR mode. Surveys conducted across 2024 and 2025 confirmed the presence of numerous terrestrial invasive species (e.g., Japanese knotweed, tree-of-heaven, Oriental bittersweet, multiflora rose, glossy buckthorn, common buckthorn, reed canary-grass, Phragmites, black swallow-wort, Japanese barberry), along with several aquatic invasive species (e.g., variable-leaved milfoil, curly-leaf pondweed, water caltrop, brittle naiad). These species occur across nearly every surveyed habitat type, including uplands, riverbanks, canal walls, landscaped parks, and disturbed urban corridors, which illustrates the pervasive and persistent nature of invasive plant species. Aquatic invasive species in the Merrimack River basin are primarily associated with existing regional vectors such as river and stream corridors, boating and other recreation, adjacent urban and commercial land uses, and incidental transport of plant fragments or organisms.

Accordingly, continued operation and maintenance of the Lawrence Project would be expected to have minor effects on aquatic invasive species. Existing invasive species occurrences in the Merrimack River basin would likely continue to be influenced primarily by basin-wide transport mechanisms and surrounding land uses, not by Project operation. Any effects from Project maintenance would likely be short-term, localized, and limited to disturbance at active work areas.

E.7.3.2.2 Cumulative Effects

In the SD2, the Commission identified migratory fish, including American shad, river herring, American eel, sea lamprey, shortnose sturgeon, Atlantic sturgeon, Atlantic salmon, and mussel species as resources that could be cumulatively affected by the proposed continued operation and maintenance of the Project in combination with other hydroelectric projects on the river. The Commission noted the following effects to be analyzed for cumulative effects:

- Effects of Project operation and maintenance on aquatic habitat (including spawning habitat) for migratory fish species in the Project impoundment, bypassed reach, and the Merrimack River downstream of the Project.
- Effects of Project operation and maintenance on mussel species in the Project impoundment, bypassed reach, and the Merrimack River downstream of the Project.
- Effects of Project operation and maintenance on resident and migratory fish species in the impoundment, canal system, bypassed reach, and Merrimack River.
- Effects of Project operation and maintenance on the passage of migratory fish species.

The Commission established the geographic scope of the potential cumulative effects below.

- Migratory Fish: The geographic scope for migratory fish includes the Merrimack River (and its tributary watersheds) from where it empties into the Gulf of Maine in Newbury, Massachusetts, upstream to Lakeport Dam on the Winnipesaukee River in Franklin, New Hampshire, and the confluence of the Pemigewasset and Squam Rivers in Holderness, New Hampshire. The Eastman Falls Dam (at RM 1 of the Pemigewasset River) and the Lakeport Dam (at RM 17 of the Winnipesaukee River and 4 miles downstream from the outlet of Lake Winnipesaukee) are migration barriers that represent the upstream limits to which river herring and American eel are managed within the river basin.

- Mussels: The geographic scope for mussels includes the entire Merrimack River Basin and its tributary watersheds from the headwaters of the Winnipesaukee River in Franklin, New Hampshire, and the headwaters of the Pemigewasset River at Profile Lake in Franconia, New Hampshire, through the Merrimack River downstream to Haverhill, Massachusetts.

- Atlantic sturgeon: The geographic scope for Atlantic sturgeon critical habitat includes the Merrimack River from the toe of Essex Dam downstream to where the Merrimack River empties into the Gulf of Maine in Newburyport, Massachusetts.

Essex has undertaken substantial enhancements in the form of upstream and downstream passage measures at the Project, which should continue to minimize any cumulative effects to fisheries resources in the Merrimack River resulting from operation of the Project. Similarly, Essex has undertaken a number of fisheries studies at the Project that are designed to assess not only direct Project effects on fishery resources, but also to examine the potential cumulative effects of the Project on the overall migratory fish restoration efforts.

Operation of the Project may cumulatively affect migratory fish species, including American eel, American shad, and river herring (alewife and blueback herring). Upstream and downstream fish passage facilities including a fish lift, an eel ramp and elevator, and downstream fish bypass, are currently in place at the Project. Any mortality that may occur from entrainment or impingement of fish species at the Project would contribute to the cumulative effects on fisheries resources in the Merrimack River. Notably, in its 2007 finding on the petition to list the American eel (USFWS 2007), the USFWS found that:

- The species is highly resilient.
- The reproductive contribution of eels from coastal and estuarine habitat is substantial, and habitat in the lower reaches of a watershed produces more eels than habitat higher in the watershed.
- Loss of habitat resulting from dams does not threaten the long-term persistence of the American eel.
- American eel are able to navigate many barriers.
- Turbines can affect the regional abundance of eel, but no evidence indicates that turbines are affecting the species at the population level (USFWS 2007).

The Sturgeon Distribution and Project Interaction Study (ASA 2026b) found that the Project is within the historical range of both Atlantic and shortnose sturgeon and lies at the upstream boundary of designated Atlantic sturgeon critical habitat. However, 2025 monitoring documented only limited shortnose sturgeon presence in the river reach between Essex Dam and the I-495 bridge, and no Atlantic sturgeon detections at stationary receivers. Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence, but none occurred upriver of the Joseph W. Casey Bridge, about 0.4 mile below the dam. A limited number of tagged adult shortnose sturgeon (n = 2) were confirmed as present during the survey in the monitored area. One individual ascended far enough upstream to be detected at the downstream entrance of the tailrace channel. The second individual was not detected at any stationary receivers located upstream of the Lawrence I-495 Bridge. There were no detections of tagged Atlantic sturgeon (juvenile or sub-adult) at any stationary receiver location during the 2025 monitoring period. This suggests that sturgeon have limited interactions with the Project, and any cumulative effects on sturgeon would be limited.

In the impoundment, the Freshwater Mussel Habitat Assessment and Survey (NAI 2025d) found that normal operations do not appear to have a substantial effect on the existing mussel community and that this community appears to be thriving. The downstream Merrimack River supports the most abundant and diverse mussel community documented in the study area and includes evidence of active recruitment and at least some species of conservation interest. The Freshwater Mussel Habitat Assessment and Survey and other available data indicate that it is unlikely that Project operations, under normal conditions, will negatively affect freshwater mussel communities based on the observed distributions of mussel communities upstream and downstream of the dam. The mussel community is not only stable but resilient because of the combination of ideal habitat and robust, actively recruiting populations. Therefore, it is anticipated there are limited, if any, cumulative effects of Project operation on mussels in the Merrimack River.

Considering that certain studies and analyses are ongoing, Essex will provide additional analyses, where relevant and appropriate, of the potential cumulative effects on fish passage for migratory species in the FLA to be filed with the Commission by November 30, 2026.

E.7.3.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on fish and aquatic resources. Essex proposes to continue to operate the Project in ROR mode, and adhere to and operate fish passage facilities consistent with the CFPP approved by FERC in July 2000.

Essex is proposing to develop, in consultation with the MRTC, a narrow-spaced trashrack design to replace the existing trashrack system. Essex may consider alternative methods for providing downstream passage and protection at the intake for outmigrating fish, such as replacing the existing turbine runners with new "fish friendly" designed runners. Any proposed downstream passage and protection measures will be developed in consultation with the MRTC. Essex believes this proposed PM&E measure would result in reduced fish mortality during downstream passage.

E.7.3.4 Unavoidable Adverse Impacts

Unavoidable adverse impacts are those effects that may still occur after implementation of PM&E measures. Operation of the Project may continue to result in the delay of American eels, American shad, river herring, Atlantic salmon, striped bass, sea lamprey, and other resident species, but these effects are expected to be limited in scope and will not have an adverse effect at the population level.

Considering that studies related to aquatic habitat as well as fish passage are ongoing, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.4 Terrestrial Resources

The subsections below describe terrestrial resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the:

- Invasive Plants Survey (HDR 2026c)

This report is included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.4.1 Affected Environment

E.7.4.1.1 Wildlife and Botanical Resources

The Lower Merrimack River corridor, including the Lawrence Project, provides habitats for diverse botanical and wildlife species. Diverse habitats such as wetlands, forests, grasslands, and the river offer essential habitats for a variety of mammals, birds, reptiles, and amphibians in sufficient quantity and quality to ensure sustainable conditions for these species (LMRLAC 2008). The quality and quantity of these habitats have changed over time. Since early European settlement, forests were cleared for agricultural lands and then heavily modified for industrial purposes. Eventually, these agricultural lands were abandoned, and natural forest succession replaced many of them (NHDFG 2015). Current botanical resources that provide wildlife habitat along the Merrimack River are a patchwork of forests comprised of vegetation typical to the Northeast and grasslands that are agricultural remnants or associated with modern development.

The Project is situated in the Northeastern Highlands ecoregion and the Northeastern Coastal Zone. The north and westerly portions of the Merrimack River watershed are in the Northeastern Highlands, characterized by low mountains and ungrazed forests and woodlands. The southern part of the river's watershed is in the Northeastern Coastal Zone, characterized by modified woodlands and forests. Geographically, the Project falls under the New England Physiographic Province umbrella. The Taconic Mountains to the West, the Green Mountains to the Northwest, and the White Mountains to the North-Northeast all factor into water movement within the Merrimack River watershed.

Specifically, the Lawrence Project is in the Seaboard Lowlands Section of the New England Physiographic Province. The Seaboard Lowlands Section is generally lower in elevation and less hilly than the adjacent New England Upland Section. In the vicinity of the Project, the Merrimack River flows through a region of rapid population growth and development heavily influenced by the Lawrence metropolitan area. The local relief in the Merrimack River Valley in the Project vicinity is generally characterized as low, open hills.

The Project is in a more urbanized area with medium to high-density development along the shores of the Merrimack River. The City of Lawrence is heavily urbanized, with many businesses capitalizing on the City's recent renewal.

E.7.4.1.2 Land Use

There are several land use classifications within the Project boundary, including developed land, woody wetlands, and deciduous forest (see Section E.2.2). These land use classifications are described in more detail below.

Developed

Developed, Open Space areas account for 4.51% of land cover (12.7% of land use) in the Project boundary and are described as a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. Generally, these areas most commonly include large-lot, single-family housing units; parks; golf courses; and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes (National Land Cover Database [NLCD] 2019).

Developed, Low Intensity areas account for 6.12% of land cover (17.2% of land use) in the Project boundary and are described as a mixture of constructed materials and vegetation. Impervious surfaces account for 20 to 49% of total cover. These areas most commonly include single-family housing units (NLCD 2019).

Developed, Medium Intensity areas account for 5.52% of land cover (15.5% of land use) in the Project boundary and are described as a mixture of constructed materials and vegetation.

Impervious surfaces account for 50 to 79% of total cover. These areas most commonly include single-family housing units (NLCD 2019).

Developed, High Intensity areas account for 3.58% of land cover (10.1% of land use) in the Project boundary and are described as highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 to 100% of the total cover (NLCD 2019).

Wetlands and Forests

Woody Wetlands account for 8.30% of land cover (23.4% of land use) within the Project boundary. Woody wetlands are described as areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water (NLCD 2019).

Emergent Herbaceous Wetlands account for 0.49% of land cover (1.4% of land use) within the Project boundary. Emergent herbaceous wetlands are described as areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water (NLCD 2019).

Deciduous Forest accounts for 4.82% of land cover (13.6% of land use) within the Project boundary. Deciduous forests are described as areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change (NLCD 2019).

Evergreen Forest accounts for 0.73% of land cover (2.1% of land use) within the Project boundary. Evergreen forests are described as areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage (NLCD 2019).

Mixed Forest accounts for 0.63% of land cover (1.8% of land use) within the Project boundary. Mixed forests are described as areas dominated by trees generally greater than 5 meters tall and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover (NLCD 2019).

Herbaceous

Grassland/Herbaceous vegetation accounts for 0.53% of land cover (1.5% of land use) within the Project boundary. Grassland and herbaceous land is described as areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing (NLCD 2019).

Barren Land

Barren Land accounts for 0.17% of land cover (0.5% of land use) within the Project boundary. Barren land is described as areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover (NLCD 2019).

Shrubland

Shrub/Scrub accounts for 0.01% of land cover (0.04% of land use) within the Project boundary. Shrub/scrub land is described as areas dominated by shrubs; less than 5 meters tall, with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions (NLCD 2019).

Planted/Cultivated

Pasture/Hay accounts for 0.13% of land cover (0.4% of land use) within the Project boundary. Pasture and hay land is described as areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation (NLCD 2019).

E.7.4.1.3 Natural Communities

Natural communities within the Merrimack River corridor vary between urban and non-urban areas. The vicinity of the Lawrence Project is dominated by hemlock-hardwood-pine, Appalachian oak pine, grasslands, major-river floodplain forest, and ruderal herbaceous/scrub-shrub/forested (NHDFG 2015). These habitat types are discussed below in further detail.

Hemlock-Hardwood-Pine Forest

The hemlock-hardwood-pine forest is a widespread habitat in the Lower Merrimack River corridor. It is a transitional forest between Appalachian oak-pine and northern hardwood, found at elevations less than 400 feet and more than 1,500 feet, respectively. White pine (*Pinus strobus*) and eastern hemlock (*Tsuga canadensis*) are the dominant trees. In addition, American beech (*Fagus grandifolia*) and patches of sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and red oak (*Quercus rubra*) contribute to a variable species mix of this forest type. The understory contains small trees and shrubs such as witch hazel (*Hamamelis virginiana*), maple-leaved viburnum (*Viburnum acerifolium*), black birch (*Betula nigra*), black cherry (*Prunus serotina*), and ironwood (*Ostrya virginiana).* Typical plants found on the forest floor include starflower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadensis*), and wild sarsaparilla (*Aralia nudicaulis*).

Most white pine stands grown from abandoned pastures are examples of this type of hemlock-hardwood pine forest habitat. White pine is replaced by hemlock or hardwoods over time on fertile soils. Older forests that have succeeded to later stages contain patches of larger diameter trees (>18 inches) hemlock or beech in the canopy, layers of young trees and shrubs in the understory, many standing dead trees, and abundant decaying wood on the forest floor. Large-sized cavity trees, pockets of wetlands, patches of acorn-rich oaks, seeps, and tall pine trees make some patches of this forest type especially rich for wildlife (NHDFG 2015; Swain and Kearsley 2001).

Appalachian Oak-Pine Forest

Appalachian oak-pine forests, with their abundance of nut-bearing oaks such as red oak, white oak (*Quercus alba*), black oak (*Q. velutina*), and hickories such as shagbark (*Carya ovata*), pignut (*C. glabra*), and sweet pignut (*C. ovalis*), provide a rich food source for wildlife such as ruffed grouse (*Bonasa umbellus*), turkey (*Meleagris gallopavo*), gray squirrels (*Sciurus carolinensis*), and eastern chipmunks (*Tamias striatus*). Common understory shrubs and smaller trees of this forest type include black birch (*Betula lenta*), bigtooth aspen (*Populus grandidentata*), sassafras (*Sassafras albidum*), and yellow birch (*Betula alleghaniensis*). Blueberries (*Vaccinium angustifolium* and *V. pallidum*), black huckleberry (*Gaylussacia baccata*), sheep laurel (*Kalmia angustifolia*), and Pennsylvania sedge (*Carex pennsylvanica*) are typical understory plants. Raptors such as the northern goshawk (*Accipiter gentilis*) feed on small mammals and find nesting and perching sites in white pines in the tree canopy. White pines adjacent to the Merrimack River provide critical nest and perch sites for bald eagles (*Haliaeetus leucocephalus*), great blue herons (*Ardea herodias*), and osprey (*Pandion haliaetus*) (NHDFG 2015).

Many stands of Appalachian oak-pine forest are of the same age, approximately 80-100 years. They grew after farms were abandoned throughout the last century. Many wildlife species in this forest type are attracted to patches of old or young trees within the larger forested landscape. Historically, this region's dry soils and warm temperatures have caused occasional low-intensity fires to burn in these forests. Without fire, these forests have white pine, hemlock, sugar maple, and birch species (*Betula* spp.) rather than nut-bearing trees. Mature Appalachian oak-pine forests may also be denser due to a lack of low-ground fires to maintain an open understory (NHDFG 2015).

Grasslands

The most common grassland habitats in the Lower Merrimack River corridor are agricultural fields such as hayfields, pastures, and fallow fields. Grassland vegetation is a mixture of grass species or a combination of grasses, sedges, and wildflowers. Most plants found in grasslands are non-native grasses introduced for agricultural use. These include timothy grass (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), orchard grass (*Dactylis glomerata*), and perennial ryegrass (*Lolium perenne*). Common native plants include big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and a variety of species of the wildflower genera, including goldenrod (*Solidago* spp.) and various aster species. Vegetation growing in grassland habitats ranges from less than six inches to over four feet in height. Vegetation height is vital in determining which wildlife species will use it. Few, if any, trees or shrubs are found in grasslands. Unless maintained, most grasslands will return to forest habitat (NHDFG 2015).

Major-River Floodplain Forest

The immediate shoreline of the Merrimack River within the Project boundary includes areas of floodplain forest. Some of these areas have characteristics of Major-River Floodplain Forest as described by Swain and Kearsley (2001). Major-river floodplain forests are deciduous forested wetland communities that develop along rivers and streams and receive annual (or semi-annual) overbank flooding and alluvial silt deposition. Soils are predominantly sandy loams without soil mottles and a surface organic layer. Flooding at these sites occurs annually and can be severe. An island variant of Major-River Floodplain Forests occurs on elevated sections of riverine islands and riverbanks of significant rivers, with high levels of both natural and human disturbance. All floodplain forest communities in Massachusetts have silver maple (*Acer saccharinum*) as the defining tree, but associated plant species vary depending on the intensity and duration of the flooding and geographic location. Common plant species occurring with silver maple include cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and/or slippery elm (*U. rubra*) in the subcanopy, and shrubs are generally lacking. A thick shrub to herbaceous layer, generally 3-6 feet tall, dominates the forest floor. A tall (1-2 meters), dense cover of wood nettles (*Laportea canadensis*) and ostrich fern (*Matteuccia struthiopteris*) is sometimes abundant. Other species growing along the upland margins include the tree of heaven (*Ailanthus altissima*), staghorn sumac (*Rhus typhina*), the non-native bittersweet (*Celastrus orbiculatus*), riverbank grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*), Siberian elm (*Ulmus pumila*), purple loosestrife (*Lythrum salicaria*), poison ivy (*Toxicodendron radicans*), Boston ivy (*Parthenocissus tricuspidata*), mullein (*Verbascum thapsus*), and common ragweed (*Ambrosia artemisiifolia*).

Ruderal Herbaceous/Scrub-Shrub/Forested

Ruderal Herbaceous/Scrub-Shrub/Forested areas in the Project vicinity are largely anthropogenic communities of herbaceous or mixed scrub-shrub and forested vegetation resulting from succession following complete or partial removal of native woody cover. These communities are found in areas where the native forest vegetation has been cleared or partially cleared, in old fields, hedgerows, pedestrian walkways, along Project canals, roadways, etc. Characteristic species can include red maple (*Acer rubrum*), American elm, Siberian elm, bush honeysuckles (*Lonicera* spp.), tree of heaven, Boston ivy, goldenrods (*Solidago* spp.), and various grass species.

E.7.4.1.4 Botanical Resources

The Project vicinity is in a more urbanized area with medium to high-density development along the shores of the Merrimack River. Botanical resources correlate with current anthropogenic features and historical land uses. Early successional forest and wetland botanical species are more likely to be found in the lower section of the Merrimack River when compared to the Merrimack's headwaters in the White Mountains of New Hampshire. A description of botanical resources within the Project vicinity or localized region is further discussed below.

Trees and Herbaceous Plants

Dominant canopy tree species of the region are white pine (*Pinus strobus*), eastern hemlock (*Tsuga canadensis*), red oak (*Quercus rubra*), white oak (*Quercus alba*), shagbark hickory (*Carya ovata*), and red maple (*Acer rubrum*). Predominant understory trees within the region include black cherry (*Prunus serotina*), black birch (*Betula nigra*), yellow birch (*Betula alleghaniensis*), and bigtooth aspen (*Populus grandidentata*). Common understory shrubs and shrub-like trees include sassafras (*Sassafras albidum*), witch hazel (*Hamamelis virginiana*), maple-leaf viburnum (*Viburnum acerfolium*), and sheep laurel (*Kalmia angustifolia*). Common herbaceous plants likely to occur in the Project vicinity include Canada mayflower (*Maianthemum canadense*), eastern skunk cabbage (*Symplocarpus foetidus*), spotted wintergreen (*Chimaphila maculate*), and bunchberry (*Cornus canadensis*). An extended list of potential botanical species that may occur in the Project vicinity is listed in Table E.7-25 below.

Table E.7-25. List of Potential Botanical Species in the Project Vicinity (Common Name).

Trees and Shrubs		Herbaceous Plants	
sugar maple	red pine	starflower	common milkweed
silver maple	pitch pine	nodding trillium	pink lady's slipper
scarlet oak	common juniper	common plantain	poison ivy
eastern black oak	American elm	Indian pipe	wild mint
swamp oak	slippery elm	white turtlehead	swamp candles
dwarf chinkapin oak	black tupelo	false Solomon's-seal	wintergreen
American beech	American basswood	moth mullein	wild sarsaparilla

Trees and Shrubs		Herbaceous Plants	
quaking aspen	pignut hickory	common mullein	wild oats
paper birch	sweet birch	common dandelion	Indian cucumber
beaked hazelnut	speckled alder	spotted jewelweed	fringed bindweed
American hazelnut	flowering dogwood	bloodroot	bottlebrush grass
staghorn sumac	gray dogwood	trout-lily	white-wood aster
winged sumac	large pussy-willow	wild geranium	bracken fern
common elderberry	mountain laurel	herb Robert	partridgeberry
boxelder	lowbush blueberry	wild licorice	
black willow	huckleberry	maidenhair fern	

Source: Kaufman and Kaufman 2012; Padgett 2016, Natural Heritage & Endangered Species Program (NHESP) 2016b; NHESP 2016c; NHESP 2016d.

Invasive Plant Species

Invasive plant species are generally defined as both non-indigenous and aggressive habitat monopolizers at scales ranging from a small patch to hundreds of continuous acres (Massachusetts Department of Conservation and Recreation, Division of Water Supply Protection [MDCR] 2011). Invasive species often outcompete native species, severely impacting the integrity of the general ecological landscape, reducing recreational opportunities, degrading human health, and straining the economic environment. Invasive species' presence directly correlates with historical land use and environmental disturbance. Depending on the level of aggression, invasive species have evolved to maximize their growth and reproductive production when resources are limited (MDCR 2011). Aggressive, out-competing tendencies enable invasive species to invade existing ecosystems at rates beyond what is capable of other competing and present native plant species.

In 2004, the Massachusetts Invasive Plant Advisory Group (MIPAG), a committee where the Massachusetts Natural Heritage and Endangered Species Program (NHESP) and other state agencies are represented, completed a report providing recommendations on invasive plant species management in the Commonwealth. Offered in the report, the committee designated 72 species of the known 2,263 plant species in the Commonwealth as invasive, likely invasive, or potentially invasive (MIPAG 2005a). This "living" list looks to properly manage, identify, control, and eradicate invasive plant species, when possible, with broader hopes of protecting and preserving the Commonwealth's natural environments. Invasive plant species found in the Commonwealth of Massachusetts that have the potential to occur within the Project's vicinity are listed in Table E.7-26 below.

Table E.7-26. Invasive Plant Species Potentially Occurring in the Project Vicinity (MIPAG).

Common Name	Scientific Name	Habitat
	Terrestrial Plants	
autumn olive	*Elaeagnus umbellata*	Right-of-way (ROWs) and disturbed sites. Can establish along forest edges or in canopy openings in riparian corridors.
bell's honeysuckle	*Lonicera bella*	Shrub occurs in upland, wetland, and coastal habitats. High seed production and longevity.
black locust	*Robinia pseudoacacia*	A tree occurring in upland habitats. Invasive behavior occurs in sandy soils.
black swallow-wort	*Cynanchum louiseae*	Perennial vines occur in upland, wetland, and coastal habitats.
burning bush	*Euonymous alatus*	Shrubs occur in many different habitats.
common buckthorn	*Rhamnus cathartica*	Forest edges, ROWs, canopy openings, and open forested wetlands. More common in dry sites.
dame's rocket	*Hesperis matronalis*	Biennial and perennial herbs occur in upland and wetland habitats.
fig buttercup	*Ficaria verna*	Perennial herbs occur on stream banks and in lowland and upland woods.
garlic mustard	*Alliaria petiolata*	Grows in upland habitats. Spreads aggressively by seed, especially in wooded areas.
goutweed	*Aegopodium podagraria*	A perennial herb found in upland and wetland habitats. Spreads aggressively by roots; forms dense colonies in flood plains.
Japanese barberry	*Berberis thunbergii*	A shrub found in open and wooded uplands and wetlands.
Japanese honeysuckle	*Lonicera japonica*	A perennial vine in upland, wetland, and coastal habitats. Seeds are spread by bird dispersal.
Japanese knotweed	*Fallopia japonica*	A perennial herbaceous subshrub or shrub in wetland, upland, and coastal habitats. Spreads aggressively and control of knotweed is laborious and expensive.
leafy spurge	*Euphorbia esula*	Perennial herbs occur in all state regions in grassland and coastal habitats. Exceptionally difficult to control or eradicate. Thrives on disturbances, especially on dry, sandy soils.
mile-a-minute vine	*Polygonum perfliatum*	An annual herbaceous vine, highly aggressive; bird and human dispersed.
morrow's honeysuckle	*Lonicera morowii*	A shrub occurring in upland, wetland, and coastal habitats. Escape cultivation through bird dispersal.
multiflora rose	*Rosa multiflora*	In upland, wetland, and coastal habitats, perennial vine/shrub occurs in all state regions.
Norway maple	*Acer platanoides*	Found in upland and wetland habitats and is especially common in woodlands and colluvial soils.

Common Name	Scientific Name	Habitat
oriental bittersweet	*Celastrus orbiculatus*	A perennial vine occurring in upland habitats Berries spread by birds and humans; overwhelms and kills vegetation.
European buckthorn	*Frangula alnus*	A shrub or tree occurring in upland, wetland, and coastal habitats. Seed dispersal over broad areas by birds through quick digestive processes.
sycamore maple	*Acer pseudoplatanus*	Found primarily in woodlands and especially near the coast. Tolerant to a range of soils, and salty and exposed conditions.
tree of heaven	*Ailanthus altissima*	Found in upland, wetland, and coastal habitats. Spreads aggressively from root suckers, especially in disturbed areas.
weeping lovegrass	*Eragrostis curvula*	A perennial warm-season bunchgrass occurs on road edges, agricultural grasslands, sandplain grasslands, and coastal heathland areas, mainly in coastal and island counties.
Wetland Plants		
broad-leaved pepperweed	*Lepidium latifolium*	Perennial herbs along the coastal and upper edge of wetlands. Introduced as a contaminant of sugar beet imported from eastern Europe.
common reed	*Phragmites australis*	A perennial grass grown in predominately wetland habitats but can be found in upland areas. Difficult to eradicate and tends to emerge earlier and be less susceptible to insect herbivory than the native strains.
large gray willow	*Salix atrocinerea*	A large shrub or small tree is mostly found in Massachusetts's eastern and southeastern areas. Found primarily near pond shores but can also be found in other wetland types, rarely in uplands.
reed canary-grass	*Phalais arundinacea*	A perennial grass occurring in wetlands and open uplands. Planted for forage and erosion control. Quickly overtakes environments.
yellow iris	*Iris pseudacorus*	Perennial herbs occurring in wetland habitats. Found mostly in marshes, shores of rivers or lakes, and wetland margins.
creeping jenny	*Lysimachia nummularia*	Perennial herbs occurring in upland and wetland habitats.
purple loosestrife	*Lythrum salicaria*	A perennial herb or subshrub occurring in upland and wetland habitats. Very aggressive invader of sunny wetlands. Displaces native species and reduces plant and animal diversity.
Aquatic Plants		
Carolina fanwort	*Cabomba caroliniana*	A perennial herb occurring in aquatic habitats. Aggressive aquatic weed in New England.
curly pondweed	*Potamogeton crispus*	Perennial herbs occurring in aquatic habitats. High tolerance of low light conditions.

Common Name	Scientific Name	Habitat
Eurasian watermilfoil	*Myriophyllum spicatum*	Open, cool water typically up to 13 feet deep but can be found up to 33 feet deep. Thrives in various conditions and outcompetes native plants and animals.
two-leaved water-milfoil	*Myriophyllum heterophyllum*	Perennial herb found in aquatic habitats. Spreads rapidly by seed and fragmentation.
water-chestnut	*Trapa natans*	Aquatic annual herb found in aquatic habitats. Grows in shallow waters of lakes and rivers. Difficult to control because of seed longevity.

Source: MIPAG 2005b and GoBotany 2023.

Invasive Plant Survey (HDR 2026c)

In support of this relicensing, Essex conducted an Invasive Plant Survey to document invasive plants within the vicinity of the Project. Pursuant to the Commission's SPD, terrestrial invasive plant data were collected during three (3) field efforts within the Recreation Facilities, Use, and Aesthetics Study:

- A field inventory in up to 16 sites as part of the Recreation Facilities, Use, and Aesthetics Study (Inventory Assessment),
- field reconnaissance and visitor-intercept surveys at 10 of the 16 inventory sites, and
- three vegetation surveys along Project canal shorelines.

Invasive plant species data were collected during on-foot observational surveys using commonly accepted botanical survey methods to visually search the study area. Biologists identified, mapped, photographed, and georeferenced invasive plant species.

The sixteen recreation areas surveyed in the Assessment and Inventory field effort included: Abe Bashara Boathouse, Strazzula Reservation, Boys and Girls Club, Lawrence Heritage State Park, Campagnone Common, Merrimack River Trail, Pemberton State Park, Nunzio DiMarca Park, Methuen Boat Ramp, Philips Academy Boathouse, Raymond J. Martin Riverside Park, Sewer Interceptor, Spicket River Greenway-Manchester Street Park, Riverfront State Park, Bay Circuit Trail, and Oxford Park.

In these 16 areas comprising 87.7 acres, biologists observed and mapped eighteen invasive or partially invasive plant species as defined by MIPAG[7] on October 10, 2024. Most invasive species had a widespread distribution pattern throughout the study area and are known to be widespread throughout this region of the state. Common species found include oriental bittersweet, Japanese knotweed, common buckthorn, black locust, garlic mustard, Japanese barberry, Norway maple, winged euonymus, Morrow's honeysuckle, purple loosestrife, reed canary-grass, tree-of-heaven, and common reed.

[7] Massachusetts Invasive Plant Advisory Group (MIPAG). undated. Annotated Species List. Massachusetts Invasive Plant Advisory Group, Boston, Massachusetts. Available online [URL]: https://massnrc.org/MIPAG/. Accessed December 2025.

Observation of invasive plant species within the ten recreation areas was performed in conjunction with the Recreation Visitor Use Survey activities during 24 days from May 15, 2025, through September 30, 2025. The 10 recreation areas include: Abe Bashara Boathouse, Boys and Girls Club, Lawrence Heritage State Park, Campagnone Common, Merrimack River Trail, Pemberton State Park, Nunzio DiMarca Park, Spicket River Greenway-Manchester Street Park, Riverfront State Park, and Oxford Park. Twenty-four invasive and likely invasive plant species as defined by MIPAG were observed in the ten recreation sites covering approximately 62.2 acres.

The North Canal was surveyed in the fall of 2024 and the spring of 2025. Biologists identified 35 species of invasive or potentially invasive plant species within the North Canal. The dominant species observed were oriental bittersweet, tree-of-heaven, Japanese knotweed, and black locust. The South Canal was surveyed in summer 2024 and spring of 2025. Biologists identified 18 species growing in and along the South Canal wall. The dominant species included spotted knapweed, black locust, Japanese knotweed, and oriental bittersweet.

The invasive plant data collected over two growing seasons in select locations throughout the Project area provide a baseline understanding of invasive plant species present in the vicinity of the Project. The invasive species found in the three combined field efforts provide data similar to data gathered across the state in other urban areas. Of the areas surveyed, the North and South Canals are the only areas within the Project boundary. Essex maintains the vegetation in these areas, including regular invasive species removal.

Wildlife Resources

The Merrimack River corridor provides extensive habitats for mammals, avian species, reptiles, and amphibians. The three main habitat types that dominate the Project area are hemlock-hardwood-pine, Appalachian oak-pine, and grasslands (Section E.7.4.1.3). Common wildlife species within these habitats are eastern chipmunk (*Tamias stratus*), gray squirrel (*Sciurus carolinensis*), Virginia opossum (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), black-capped chickadee (*Poecile atricapillus*), common raven (*Corvus corax*), American toad (*Anaxyrus americana*), spring peeper (*Pseudacris crucifer*), and painted turtle (*Chrysemys picta*). A description of wildlife resources within the Project’s vicinity or localized region is further discussed below.

Mammals

Mammals found in the Project vicinity are those commonly found throughout the region and adapted to living near humans and urban areas. Common small to medium-sized mammals associated with ecological environments in the Lower Merrimack River corridor are raccoon (*Procyon lotor*), gray squirrel, eastern chipmunk, porcupine (*Erethizon dorsatum*), red squirrel (*Tamiasciurus hudsonicus*), striped skunk (*Mephitis mephitis*), river otter (*Lontra canadensisi*), beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and mink (*Mustela vison*). Medium to large mammals have the potential to occur in the Project vicinity, but occurrence is likely rare.

Medium to large mammals that may potentially occur in the Project vicinity include white-tailed deer, eastern coyote (*Canis latrans*), red fox (*Vulpus vulpus*), gray fox (*Urocyon cinereoargenteus*), and black bear (*Ursus americanus*). Large mammals that require extensive habitat areas, or species that require solitude, such as moose (*Alces alces*) and bobcat (*Lynx rufus*), prefer less developed environments that are scarce in the Lower Merrimack River corridor and the Lawrence Project. Table E.7-27 lists the mammalian species that may potentially occur in the vicinity of the Lawrence Project.

Table E.7-27. Mammalian Species Potentially Occurring in the Project Vicinity.

Common Name	Scientific Name
beaver	*Castor canadensis*
big brown bat	*Eptesicus fuscus*
black bear	*Ursus americanus*
black rat	*Rattus rattus*
bobcat	*Lynx rufus*
coyote	*Canis latrans*
deer mouse	*Peromyscus maniculatus*
eastern chipmunk	*Tamias striatus*
eastern red bat	*Lasiurus borealis*
ermine	*Mustela ermina*
fisher	*Pekania pennanti*
gray fox	*Urcyon cinereoargenteus*
gray squirrel	*Sciurus carolinensis*
hairy-tailed mole	*Parascalops breweri*
hoary bat	*Lasiurus cinereus*
house mouse	*Mus musculus*
little brown bat	*Myotis lucifugus*
long-tail weasel	*Mustela frenata*
long-tailed shrew	*Sorex dispar*
masked shrew	*Sorex cinereus*
meadow jumping mouse	*Zapus hudsonicus*
meadow vole	*Microtus pennsylvanicus*
mink	*Mustela vison*
moose	*Alces alces*
muskrat	*Ondatra zibethicus*
northern flying squirrel	*Glaucomys sabrinus*
northern short-tailed shrew	*Blarina brevicauda*
Norway rat	*Rattus norvegicus*
porcupine	*Erethizon dorsatum*
pygmy shrew	*Sorex hoyi*
raccoon	*Procyon lotor*
red fox	*Vulpes vulpes*
red squirrel	*Tamiasciurus hudsonicus*
river otter	*Lontra canadensis*
silver-haired bat	*Lasionycteris noctivagans*

Common Name	Scientific Name
small-footed bat	*Myotis leibii*
smoky shrew	*Sorex fumeus*
snowshoe hare	*Lepus americanus*
southern bog lemming	*Synaptomys cooperi*
southern flying squirrel	*Glaucamys volans*
southern red-backed vole	*Clethrionomys gapperi*
star-nosed mole	*Condylura cristata*
striped skunk	*Mephitis mephitis*
tricolored bat	*Perimyotis subflavus*
Virginia opossum	*Didelphis virginiana*
water shrew	*Sorex palustris*
white-footed mouse	*Peronyscus leucopus*
white-tailed deer	*Odocoileus virginianus*
woodchuck	*Marmota monax*
woodland jumping mouse	*Napaeozapus insignis*
woodland vole	*Microtus pinetorum*

Source: NHDFG 2015 and MassWildlife 2023a.

Birds

The diversity of habitats within the Lawrence Project and Lower Merrimack River corridor provide breeding, migratory stopover, and wintering habitat for a high diversity of avian fauna, including neotropical songbirds, resident species, water birds, terrestrial game birds, and waterfowl. Commonly associated avian species that utilize riverine and stream-residing environments within the Lower Merrimack River corridor and have the potential to utilize areas of forested/urban habitats within the Project vicinity include hairy woodpecker (*Leuconotopicus villosus*), downy woodpecker *(Dryobates pubescens*), American kestrel (*Falco sparverius*), bald eagle (*Haliaeetus leucocephalus*), double-crested cormorant (*Nannopterum auritum*), great blue heron (*Ardea Herodias*), fish crow (*Corvus ossifragus*), black-crowned night-heron (*Nycticorax nycticorax*), chimney swift (*Chaetura pelagica*), cooper's hawk (*Accipiter cooperii*), cedar waxwing (*Bombycilla cedrorum*), and osprey (*Pandion haliaetus*). An extended list of avian species, including those listed above, potentially occurring in the vicinity of the Lawrence Project is included in Table E.7-28.

Table E.7-28. Avian Species Potentially Occurring in the Project Vicinity.

Common Name	Scientific Name
alder flycatcher	*Empidonax alnorum*
American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*

Common Name	Scientific Name
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American woodcock	*Scolopax minor*
bald eagle	*Haliaeetus leucocephalus*
Baltimore oriole	*Icterus galbula*
barn swallow	*Hirundo rustica*
belted kingfisher	*Megaceryle alcyon*
black-billed cuckoo	*Coccyzus erythropthalmus*
blackburnian warbler	*Dendroica fusca*
black-capped chickadee	*Poecile atricapillus*
black-throated blue warbler	*Dendroica caerulescens*
black-crowned night heron	*Nycticorax nycticorax*
black-throated green warbler	*Dendroica virens*
blue jay	*Cyanocitta cristata*
blue-gray gnatcatcher	*Polioptila caerulea*
blue-headed vireo	*Vireo solitarius*
bobolink	*Dolichonyx oryzivorus*
broad-winged hawk	*Buteo platypterus*
brown creeper	*Certhia americana*
brown-headed cowbird	*Molothrus ater*
brown thrasher	*Toxostoma rufum*
bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
canvasback	*Aythya valisineria*
Carolina wren	*Thryothorus ludovicianus*
cedar waxwing	*Bombycilla cedrorum*
chestnut-sided warbler	*Dendroica pensylvanica*
chimney swift	*Chaetura pelagica*
chipping sparrow	*Spizella passerina*
common goldeneye	*Bucephala clangula*
common grackle	*Quiscalus quiscula*
common merganser	*Mergus merganser*
common nighthawk	*Chordeiles minor*
common raven	*Corvus corax*

Common Name	Scientific Name
common redpoll	*Acanthis flammea*
common yellowthroat	*Geothlypis trichas*
cooper’s hawk	*Accipiter cooperii*
dark-eyed junco	*Junco hyemalis*
double-crested cormorant	*Phalacrocorax auritus*
downy woodpecker	*Picoides pubescens*
eastern bluebird	*Sialia sialis*
eastern kingbird	*Tyrannus tyrannus*
eastern phoebe	*Sayornis phoebe*
eastern screech owl	*Megascops asio*
eastern wood-pewee	*Contopus virens*
European starling	*Sturnus vulgaris*
evening grosbeak	*Coccothraustes vespertinus*
gadwall	*Mareca strepera*
golden-crowned kinglet	*Regulus satrapa*
golden eagle	*Aquila chrysaetos*
gray catbird	*Dumetella carolinensis*
great blue heron	*Ardea herodias*
greater scaup	*Aythya marila*
great crested flycatcher	*Myiarchus crinitus*
great horned owl	*Bubo virginianus*
great egret	*Ardea alba*
green heron	*Butorides virescens*
hairy woodpecker	*Picoides villosus*
hermit thrush	*Catharus guttatus*
herring gull	*Larus argentatus*
horned grebe	*Podiceps auritus*
house finch	*Carpodacus mexicanus*
house sparrow	*Passer domesticus*
house wren	*Troglodytes aedon*
indigo bunting	*Passerina cyanea*
killdeer	*Charadrius vociferus*
least bittern	*Ixobrychus exilis*
least flycatcher	*Empidonax minimus*
long-eared owl	*Asio otus*
Louisiana waterthrush	*Seiurus motacilla*

Common Name	Scientific Name
magnolia warbler	*Dendroica magnolia*
mallard	*Anas platyrhynchos*
mourning dove	*Zenaida macroura*
mourning warbler	*Oporornis philadelphia*
northern cardinal	*Cardinalis cardinalis*
northern flicker	*Colaptes auratus*
northern goshawk	*Accipiter gentilis*
northern parula	*Setophaga americana*
northern saw-whet owl	*Aegolius acadicus*
northern shrike	*Lanius borealis*
northern shoveler	*Spatula clypeata*
northern waterthrush	*Seiurus noveboracensis*
olive-sided flycatcher	*Contopus cooperi*
orchard oriole	*Icterus spurius*
osprey	*Pandion haliaetus*
ovenbird	*Seiurus aurocapilla*
pied-billed grebe	*Pied-billed grebe*
pileated woodpecker	*Dryocopus pileatus*
pine siskin	*Spinus pinus*
purple finch	*Carpodacus purpureus*
red-bellied woodpecker	*Melanerpes carolinus*
red-breasted nuthatch	*Sitta canadensis*
red crossbill	*Loxia curvirostra*
red-eyed vireo	*Vireo olivaceus*
redhead	*Aythya americana*
red-shouldered hawk	*Buteo lineatus*
red-tailed hawk	*Buteo jamaicensis*
red-winged blackbird	*Agelaius phoeniceus*
ring-billed gull	*Larus delawarensis*
ring-necked duck	*Aythya collaris*
rock pigeon	*Columba livia*
rose-breasted grosbeak	*Pheucticus ludovicianus*
ruby-crowned kinglet	*Regulus calendula*
ruby-throated hummingbird	*Archilochus colubris*
ruddy duck	*Oxyura jamaicensis*
ruffed grouse	*Bonasa umbellus*

Common Name	Scientific Name
sandhill crane	*Antigone canadensis*
savannah sparrow	*Passerculus sandwichensis*
scarlet tanager	*Piranga olivacea*
sharp-shinned hawk	*Accipiter striatus*
short-eared owl	*Asio flammeus*
snow bunting	*Plectrophenax nivalis*
snow goose	*Anser caerulescens*
snowy owl	*Bubo scandiacus*
song sparrow	*Melospiza melodia*
sora	*Porzana carolina*
spotted sandpiper	*Actitis macularius*
swainson’s thrush	*Catharus ustulatus*
swamp sparrow	*Melospiza georgiana*
tree swallow	*Tachycineta bicolor*
tufted titmouse	*Baeolophus bicolor*
turkey vulture	*Cathartes aura*
veery	*Catharus fuscescens*
virginia rail	*Rallus limicola*
warbling vireo	*Vireo gilvus*
white-breasted nuthatch	*Sitta carolinensis*
white-winged crossbill	*Loxia leucoptera*
wild turkey	*Meleagris gallopavo*
wilson’s warbler	*Cardellina pusilla*
willow flycatcher	*Empidonax traillii*
wood duck	*Aix sponsa*
wood thrush	*Hylocichla mustelina*
yellow warbler	*Dendroica petechia*
yellow-bellied flycatcher	*Empidonaz flaviventris*
yellow-bellied sapsucker	*Sphyrapicus varius*
yellow-billed cuckoo	*Coccyzus americanus*
yellow-rumped warbler	*Dendroica coronata*
yellow-throated vireo	*Vireo flavifrons*

Source: NHDFG 2015 and eBird 2023.

Amphibians and Reptiles

Diverse aquatic, semi-aquatic, and terrestrial habitats that line the Lower Merrimack River corridor have the potential to support reptile and amphibian species. Permanent wetlands and seasonal vernal pools are significant breeding habitats for amphibians. Upland wooded habitats and riparian zones are also important for terrestrial and semi-aquatic reptiles and amphibians during the non-breeding periods of their respective life cycles. Common reptile and amphibian species that use the Lower Merrimack River corridor and have the potential to occur within the Project's vicinity include spotted salamander (*Ambystoma maculatum*), blue-spotted salamander (*Ambystoma laterale*), eastern red-backed salamander (*Plethodon cinereus*), four-toed salamander (*Hemidactylium scutatum*), American toad (*Anaxyrus americanus*), spring peeper (*Pseudacris crucifer*), snapping turtle (*Chelydra serpentina*), wood turtle (*Glyptemys insculpta*), blanding's turtle (*Emydoidea blandingii*), eastern box turtle (*Terrapene Carolina*), eastern ribbon snake (*Thamnophis sauritus*), DeKay's brownsnake (*Storeria dekayi*), and ring-necked snake (*Diadophis punctatus*). An extended list of reptile and amphibian species, including those listed above, with the potential to occur within the Project's vicinity, is in Table E.7-29.

Table E.7-29. List of Amphibians and Reptiles Potentially Occurring in the Project Vicinity.

Common Name	Scientific Name
Reptiles	
black racer	*Coluber constrictor*
Blanding's turtle	*Emydoidea blandingii*
brown snake	*Storeria dekayi*
common garter snake	*Thamnophis sirtalis*
common musk turtle	*Sternotherus odoratus*
eastern box turtle	*Terrapene carolina*
eastern hognose snake	*Heterodon platirhinos*
milk snake	*Lampropeltis triangulum*
northern water snake	*Nerodia sipedon*
painted turtle	*Chrysemys picta*
red-bellied snake	*Storeria occipitomaculata*
ribbon snake	*Thamnophis sauritus*
ringneck snake	*Diadophis punctatus*
smooth green snake	*Liochlorophis vernalis*
snapping turtle	*Chelydra serpentina*
spotted turtle	*Clemmys guttata*
wood turtle	*Glyptemys insculpta*
Amphibians	
American toad	*Anaxyrus americana*
blue-spotted salamander	*Ambystoma laterale*
bullfrog	*Lithobates catesbeiana*
dusky salamander	*Desmognathus fuscus*
four-toed salamander	*Hemidactylium scutatum*

Common Name	Scientific Name
fowler's toad	*Anaxyrus fowleri*
gray treefrog	*Hyla versicolor*
green frog	*Lithobates clamitans melanota*
marbled salamander	*Ambystoma opacum*
northern leopard frog	*Lithobates pipiens*
pickerel frog	*Lithobates palustris*
redback salamander	*Plethodon cinereus*
red-spotted newt	*Notophthalmus viridescens*
spotted salamander	*Ambystoma maculatum*
spring peeper	*Pseudacris crucifer*
two-lined salamander	*Eurycea bislineata*
wood frog	*Lithobates sylvatica*

Source: NHDFG 2015 and MassWildlife 2023b.

Invasive Mammalian Species

Due to the Project's proximity to a major urban metro area, house mouse (*Mus musculus*) and Norway rat (*Rattus norvegicus*) are two prominent invasive mammalian species likely to occur within the Project's vicinity. Both species are prolific breeders and have evolved through evolutionary processes to rapidly increase and sustain their populations. Most habitat types in the Project's vicinity suit these rodents, as they can thrive in urban and rural environments. Both rodent species can become a nuisance and often threaten the broader ecological systems. According to NHDFG (2015), these rodent species could spread and circulate foreign diseases in ecological systems when they infest places where there are human encounters.

E.7.4.1.5 Wetlands, Riparian, and Littoral Habitats

Wetlands are generally defined as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Most formal wetland definitions emphasize three primary components that define wetlands: the presence of water, hydric soils, and hydrophytic vegetation. The USFWS (Cowardin et al. 1979) defines wetlands as:

> …lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have been one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some point during the growing season of the year.

The USFWS, USACE, and MADEP have jurisdiction over wetlands within Massachusetts. The MADEP's wetland definition is consistent with that of the USFWS.

Riparian habitats are lands that support unique vegetation around water bodies such as lakes, impoundments, rivers, and streams. The boundary of the riparian area and the adjoining uplands is gradual and not always well defined. However, riparian areas differ from uplands because of their high levels of soil moisture, frequent flooding, and their unique assemblage of plant and animal communities. These habitats support a diversity of unique vegetation communities. Riparian wetlands are valuable to wildlife because they are extremely productive and provide corridors for wildlife migration and dispersal. They also process large fluxes of energy and materials from upstream systems, stabilize streambanks, provide recreation opportunities, and protect against flooding and drought conditions.

Several wetlands are in the Project boundary, the most predominant being freshwater forested/shrub wetland. Potential vernal pools and vernal pools certified by the Massachusetts NHESP are in the Project vicinity, with at least one appearing to be within the Project boundary (MassGIS 2022). Several Riverine Natural Community Systems are within the Project boundary. Riverine Natural Community Systems are one of Massachusetts's Priority Natural Vegetation Communities, which are biodiversity conservation interests in Massachusetts based on the NHESP database (MassGIS 2022). A wetland core is defined as the most intact, least disturbed wetlands within resilient, less-developed landscapes, with fewer stressors such as pollution. Two wetland cores are in the vicinity of the Project, one being a 30.77-acre core along Fish Brook, and another 102.27-acre core north of Dracut (MassWildlife and The Nature Conservancy [TNC] 2022).

Wetlands, Riparian, and Littoral Vegetation

Floodplain forests of the Gulf of Maine Coastal Plain (Level IV) ecoregion are comprised primarily of silver maple (*Acer saccharinum*), green ash (*Fraxinus pennsylvanica*), and American elm (*Ulmus americana*) (Griffith et al. 2009). The 1977 license application notes that the lower, moister areas of the Project area are dominated by red maple (*Acer rubrum*) (LHA 1977). According to NHESP, alluvial red maple swamps typically occur along mainstem sections of low gradient rivers and streams that flood periodically and are the most common deciduous forest type in eastern Massachusetts (NHESP 2016a). Characteristic overstory species include a mixture of red maple and silver maple, with lesser amounts of American elm, sugar maple (*Acer saccharum*), green ash, shagbark hickory (*Carya ovata*), and swamp white oak (*Quercus bicolor*). The subcanopy often includes the canopy dominants, as well as hornbeam (*Carpinus* sp.), northern arrow-wood (*Viburnum dentatum*), American hazelnut (*Corylus americana*), silky dogwood (*Cornus amomum*), buttonbush (*Cephalanthus occidentalis*), meadowsweet (*Spiraea alba*), glossy buckthorn (*Frangula alnus*), and poison ivy (*Toxicodendron radicans*). The herbaceous layer is often dominated by sensitive fern and false nettle (*Boehmeria cylindrica*), with lesser amounts of cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), goldenrods (*Solidago* sp.), jewelweeds (*Impatiens* sp.), beggar-ticks (*Bidens* sp.), bugleweeds (*Ajuga* sp.), awned sedge (*Carex atherodes*), rice cutgrass (*Leersia oryzoides*), bluejoint grass (*Calamagrostis canadensis*), and woodreed (*Cinna arundinacea*). Common wetland vegetation reported to occur in Essex County are listed in Table E.7-30 below.

Table E.7-30. Common Wetland Vegetation in Essex County.

Common	Scientific	Growth habit	Wetland Status
red maple	*Acer rubrum*	Tree	FAC
silver maple	*Acer saccharinum*	Tree	FACW
American elm	*Ulmus americana*	Tree	FACW
American hornbeam	*Carpinus caroliniana*	Shrub/ Tree	FAC

Common	Scientific	Growth habit	Wetland Status
sweet gale	*Myrica gale*	Shrub	OBL
white meadowsweet	*Spiraea alba*	Shrub	FACW
swamp rose	*Rosa palustris*	Subshrub	OBL
carrion-flower	*Smilax herbacea*	Forb/ Herb/ Vine	FAC
common horsetail	*Equisetum arvense*	Forb/ Herb	FAC
interrupted fern	*Osmunda claytoniana*	Forb/ Herb	FAC
cinnamon fern	*Osmunda cinnamomea*	Forb/ Herb	FACW
grassy arrowhead	*Sagittaria graminea*	Forb/ Herb	OBL
blue-eyed grass	*Sisyrinchium montanum*	Forb/ Herb	FAC
tall meadow-rue	*Thalictrum pubescens*	Forb/ Herb	FACW
garden yellow rocket	*Barbarea vulgaris*	Forb/ Herb	FAC
bog white violet	*Viola lanceolata*	Forb/ Herb	OBL
purple loosestrife	*Lythrum salicaria*	Forb/ Herb	OBL
swamp milkweed	*Asclepias incarnata*	Forb/ Herb	OBL
white vervain	*Verbena urticifolia*	Forb/ Herb	FAC
rattlesnake mana grass	*Glyceria canadensis*	Graminoid	OBL
Virginia wildrye	*Elymus virginicus*	Graminoid	FACW

Source: LHA 1977, U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRC) 2023a.

Wetlands, Riparian, and Littoral Wildlife

Although many animal species are wide-ranging generalists and make use of all floodplain habitats, including wetlands, others of limited range have distinct habitat preferences. The Merrimack River corridor provides habitat for water-dependent furbearers, including beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), and mink (*Neovison vison*) (USACE 2003). Muskrat have been reported to use open waters and wetlands near littoral zones of the Project (LHA 1977). The Merrimack River corridor supports over 117 species of birds and waterfowl (USACE 2003). Avian species that are supported by riverine, littoral, and wetland habitats were recorded near the Project and may be present within the boundary: species of duck, geese, heron, shore birds, osprey, peregrine falcon, belted kingfisher, yellow warbler, and bald eagle (LHA 1977, City of Lawrence 2017). Vernal pools are within the vicinity of the Project, which provide important breeding habitat for amphibians (NHESP 2016a). In addition, any of the macroinvertebrates, mammals, birds, amphibians, reptiles, or fish discussed in Sections E.7.3.1.2 or E.7.4.1.1 are likely to utilize the wetland resources within the Project boundary.

Wetlands, Riparian, and Littoral Mapping

The National Wetlands Inventory (NWI) was the primary source for describing the wetland habitats for the Project. Wetlands currently mapped by the NWI within the boundary of the Project are summarized in Table E.7-31 and presented in Figure E.7-36, Figure E.7-37, Figure E.7-38, Figure E.7-39, and Figure E.7-40. This data includes approximately 824.3 acres of NWI wetlands within the Project boundary.

Table E.7-31. NWI Wetland Classifications and Acreage Within the Project Boundary.

Wetlands Code[1]	System[1]	Subsystem[1]	Class[1]	Subclass[1]	Regime[1]	Special Modifier(s)	NWI Acreage
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	-	Permanently Flooded	-	733.28
PFO1A	Palustrine	-	Forested	Broad-Leaved Deciduous	Temporarily Flooded	-	21.30
PFO1E	Palustrine	-	Forested	Broad-Leaved Deciduous	Seasonally Flooded/ Saturated	-	17.28
R2UBHx	Riverine	Lower Perennial	Unconsolidated Bottom	-	Permanently Flooded	Excavated	12.85
PUBHh	Palustrine	-	Unconsolidated Bottom	-	Permanently Flooded	Diked/ Impounded	12.72
PEM1E	Palustrine	-	Emergent	Persistent	Seasonally Flooded/ Saturated	-	12.42
PSS1E	Palustrine	-	Scrub-Shrub	Broad-Leaved Deciduous	Seasonally Flooded/ Saturated	-	3.71
PEM1/UBF	Palustrine	-	Emergent / Unconsolidated Bottom	Persistent	Semi permanently Flooded	-	3.60
R4SBC	Riverine	Intermittent	Streambed	-	Seasonally Flooded	-	2.32
PSS1A	Palustrine	-	Scrub-Shrub	Broad-Leaved Deciduous	Temporarily Flooded	-	1.00
PFO1Eh	Palustrine	-	Forested	Broad-Leaved Deciduous	Seasonally Flooded/ Saturated	Diked/ Impounded	0.80
PEM1C	Palustrine	-	Emergent	Persistent	Seasonally Flooded	-	0.61
R5UBH	Riverine	Unknown Perennial	Unconsolidated Bottom	-	Permanently Flooded	-	0.58
PUBHx	Palustrine	-	Unconsolidated Bottom	-	Permanently Flooded	Excavated	0.49
R4SBCx	Riverine	Intermittent	Streambed	-	Seasonally Flooded	Excavated	0.48
PEM1A	Palustrine	-	Emergent	Persistent	Temporarily Flooded	-	0.45
PEM1/UBFx	Palustrine	-	Emergent / Unconsolidated Bottom	Persistent	Semi permanently Flooded	Excavated	0.36
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	-	Permanently Flooded	-	0.04
						Total	824.3

Source: NWI.

[1.] Wetland codes and classifications as defined by Cowardin et al. (1979).

Figure E.7-36. Mapped NWI Wetlands in the Lawrence Project Boundary.

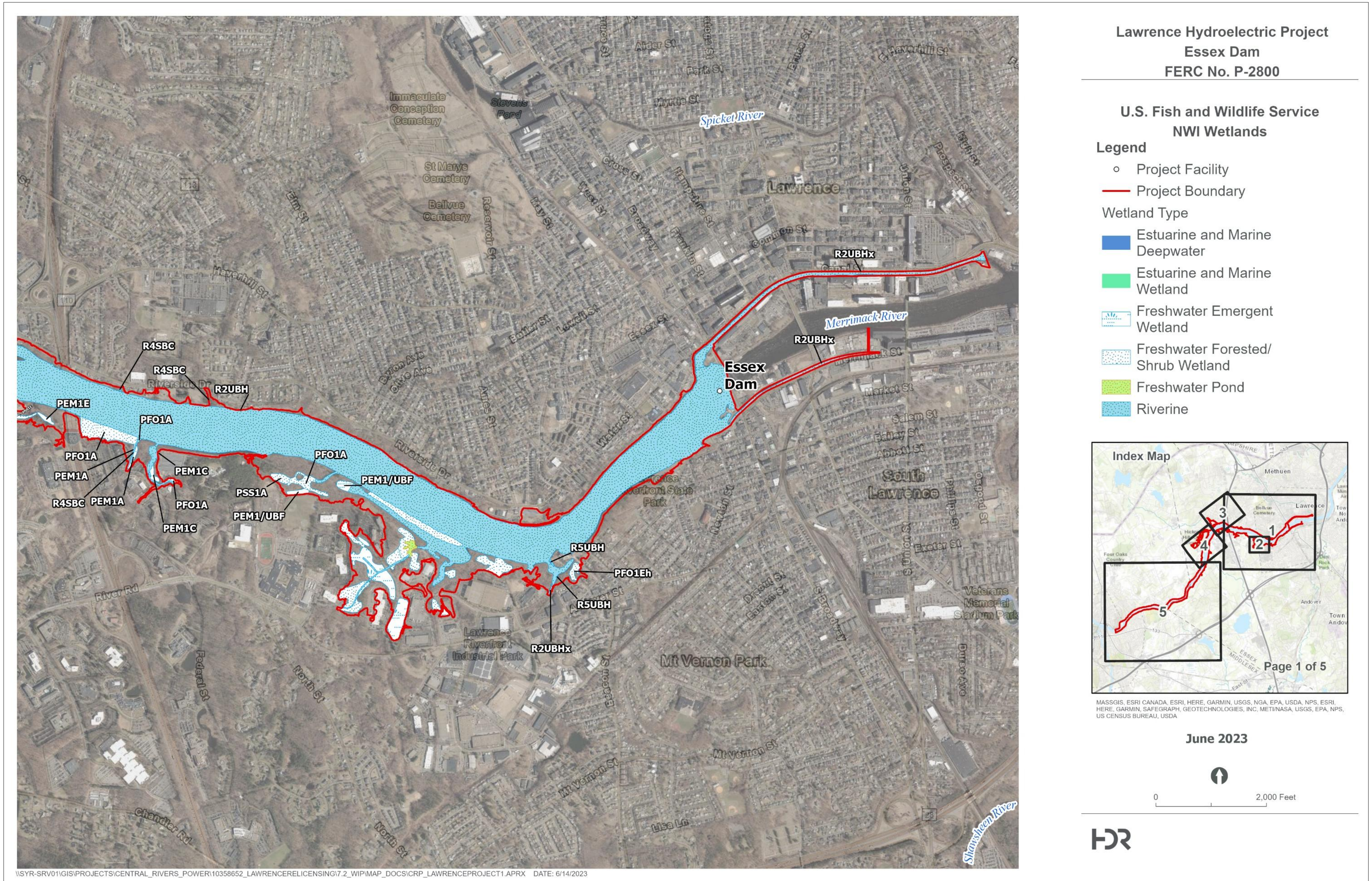


Figure E.7-37. Mapped NWI Wetlands in the Lawrence Project Boundary.

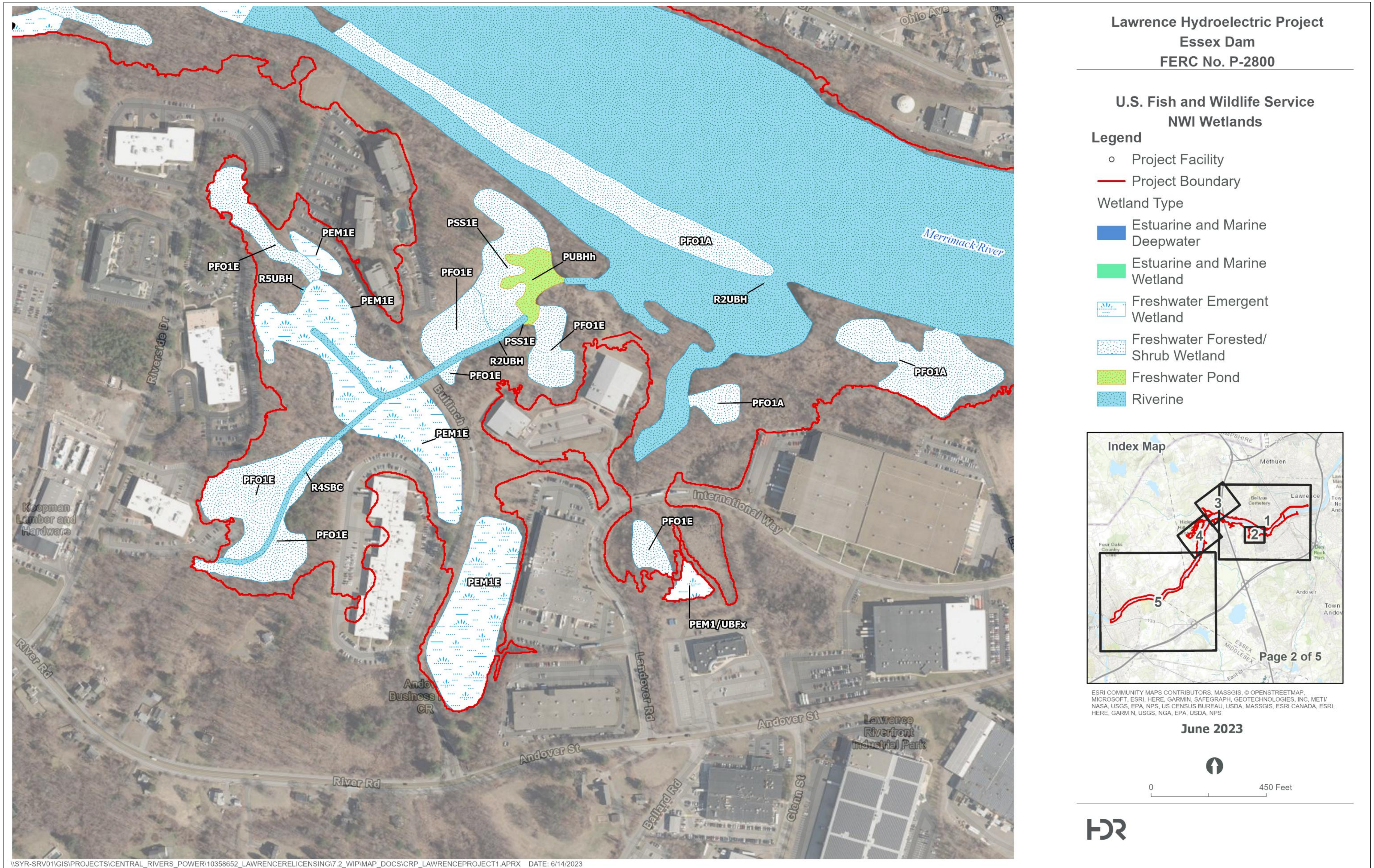


Figure E.7-38. Mapped NWI Wetlands in the Lawrence Project Boundary.

Figure E.7-39. Mapped NWI Wetlands in the Lawrence Project Boundary.

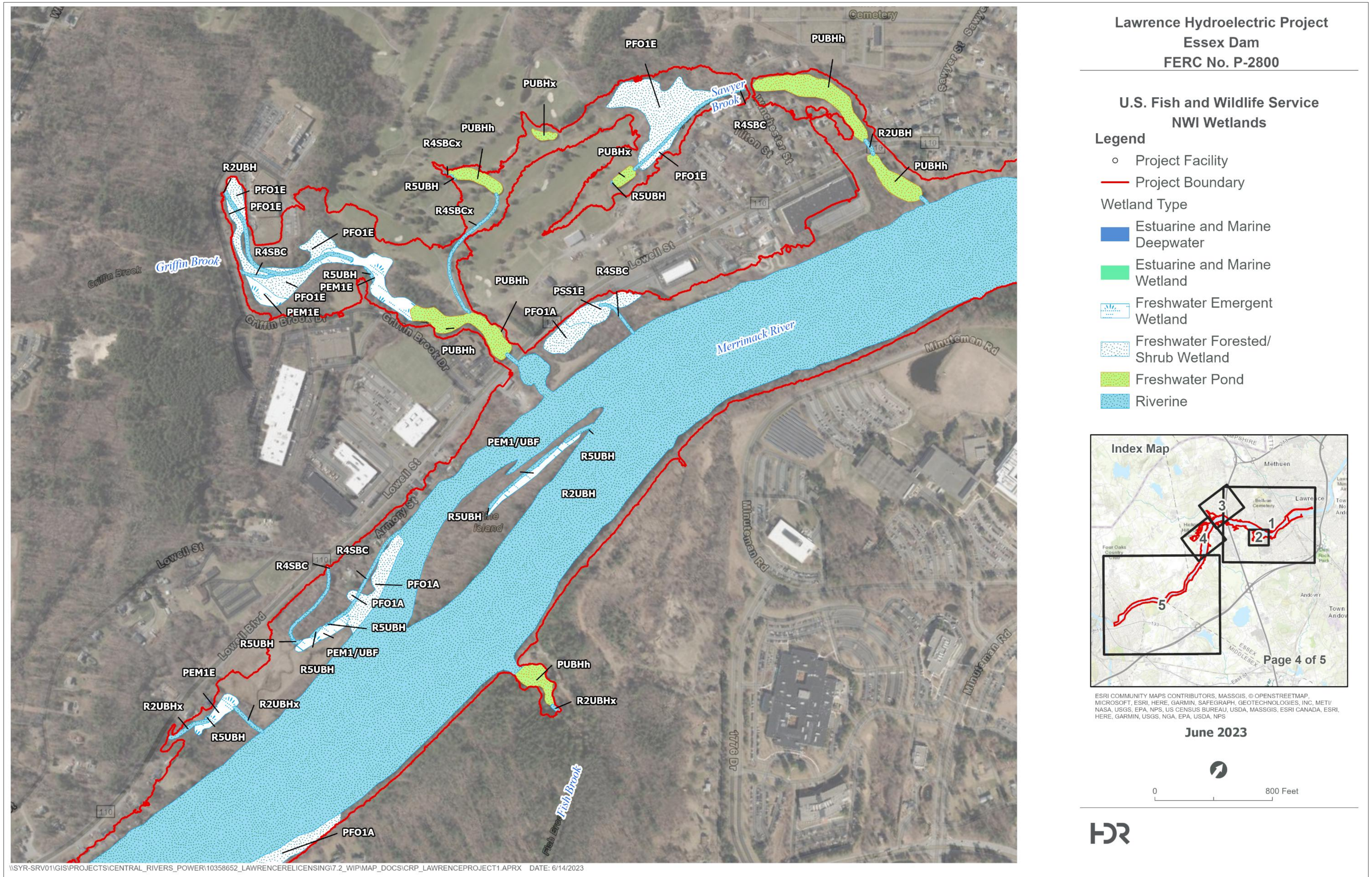
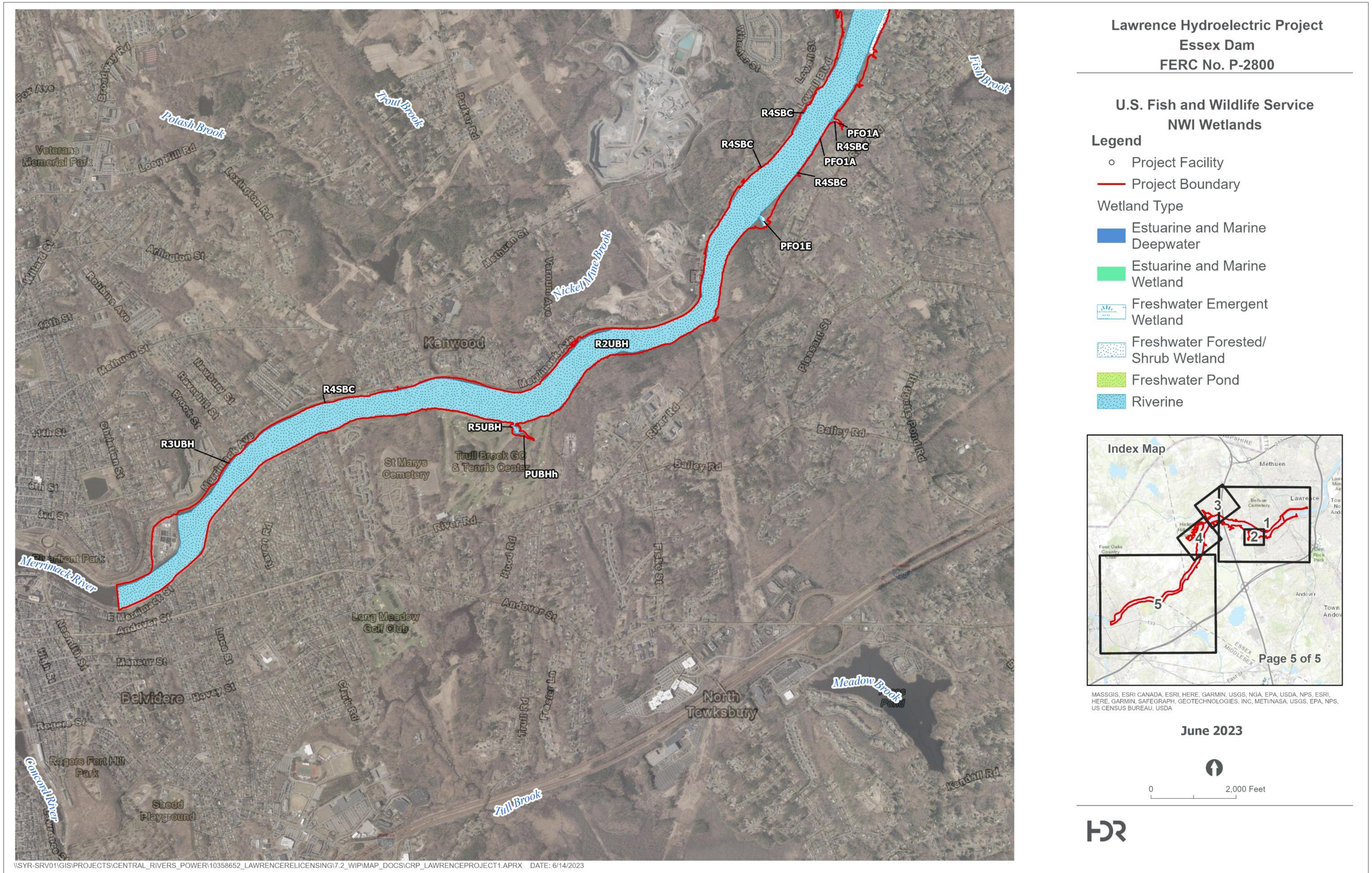


Figure E.7-40. Mapped NWI Wetlands in the Lawrence Project Boundary.



E.7.4.2 Environmental Analysis

FERC's SD2 identified effects of continued Project operations on terrestrial resources as potential resource issues. Specifically, SD2 identified the following as needing to be analyzed for site-specific effects:

- Effects of Project operation and maintenance on riparian, littoral, and wetland habitat and associated wildlife.
- Effects of Project operation, including maintenance activities (e.g., vegetation management) on vegetation, wildlife, and associated wildlife habitat.
- Effects of Project operation and maintenance on the introduction and persistence of invasive plants within the Project boundary.

Effects of Project Operation and Maintenance on Riparian, Littoral, and Wetland Habitat and Associated Wildlife.

Wetlands within the vicinity of the Project mapped by the NWI are generally expected to occur in an area like the Project. Essex operates the Project in ROR mode and minimizes impoundment fluctuations according to Article 32 of the existing license, maintaining impoundment elevations at or above the elevation of the crest gates. Existing habitats were established under the current ROR mode of operation, and Essex is not proposing any changes to Project operations or maintenance as part of the new license. Continued Project operation and maintenance activities are not expected to have any significant impact on riparian, littoral, and wetland habitats and associated wildlife.

Effects of Project Operation, Including Maintenance Activities (e.g., Vegetation Management) on Vegetation, Wildlife, and Associated Wildlife Habitat.

Vegetation management and other maintenance activities at the Project are limited to the immediate area of the Project infrastructure, along the North Canal and South Canal shorelines, and typically do not include activities along the Project impoundment. Vegetation management occurs seasonally and typically includes regular mowing, limited herbicide use at Project facilities, and occasional localized removal of hazard trees.

The Project operates in ROR mode, and wildlife and associated habitat has established itself under current operating standards. Continued operation and routine maintenance within the Project boundary are not anticipated to adversely affect adjacent vegetation, terrestrial habitat, or wildlife.

Effects of Project Operation and Maintenance on the Introduction and Persistence of Invasive Plants within the Project boundary.

A variety of land use types can contribute to the invasion and spread of non-native invasive plant species. Urban centers with residential and commercial surroundings typically have high vegetation disturbance, which contributes to the dispersal of invasive botanical species. Roads, rivers, streams, agriculture, farming/ranching, recreation, residential, and commercial developments all contribute to the spread of invasive species.

The area around the Project is an urban center with industrial, residential, and agricultural land use history that has provided a foundation habitat for invasive plant species. As noted in Section E.7.4.1, invasive plant communities are well established throughout the study area, suggesting they have occupied the urban area for a long time. Essex is not proposing any changes to the Project such as construction or tree-clearing activities that could facilitate invasive species spread. Continued Project operations are not expected to promote the introduction or persistence of invasive plant species.

E.7.4.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on terrestrial resources.

E.7.4.4 Unavoidable Adverse Impacts

Continued operation of the Project as proposed by the Licensee will not result in any unavoidable adverse effects on terrestrial botanical or wildlife resources.

E.7.5 Rare, Threatened, and Endangered Species

The subsections below describe RTE species in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and the:

- Sturgeon Habitat Mapping and Assessment Study (ASA 2026a)
- Sturgeon Distribution and Project Interaction Study (ASA 2026b)

These reports are included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.5.1 Affected Environment

On January 11, 2023, Essex conducted an informal USFWS Information for Planning and Consultation (IPaC) search for the Lawrence Project. The IPaC search generates a report listing species and other resources, such as critical habitats under the USFWS's jurisdiction that are known or expected to be on or near the Project boundary. Essex will conduct formal RTE consultation with USFWS during the licensing process.

E.7.5.1.1 Federally Listed Threatened, Endangered, and Candidate Species

According to the January 11, 2023, informal IPaC search, the federally endangered northern long-eared bat (*Myotis septentrionalis*) and the candidate monarch butterfly (*Danaus plexippus*) are listed as potentially affected by activities in the Project area. In addition, NMFS is responsible for the protection of threatened and endangered anadromous and marine fish species. Atlantic sturgeon in the Gulf of Maine DPS is listed as threatened under the ESA, and shortnose sturgeon is listed under the ESA as endangered (NOAA 2023b) (Table E.7-32). No other federally listed species or critical habitats were listed in the informal search. Descriptions of identified species in the Project vicinity are provided below.

Table E.7-32. ESA-Listed Threatened, Endangered and Candidate Species.

Common Name	Scientific Name	Federal Status	State Status
northern long-eared bat	*Myotis septentrionalis*	Endangered	Endangered
monarch butterfly	*Danaus plexippus*	Candidate	-
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Threatened	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered	Endangered

Source: USFWS 2023b.

Northern Long-eared Bat

The northern long-eared bat is found across much of the eastern and north-central United States, and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and British Columbia. It is a medium-sized bat, measuring 3 to 3.7 inches, with a wingspan of 9 to 10 inches. Its fur color can be medium to dark brown on the back and tawny to pale brown on the underside. The bat is distinguished by its long ears relative to other bats in the genus Myotis (USFWS 2015).

The northern long-eared bat spends winters hibernating in caves and mines, preferring hibernacula with very high humidity. During the summer, the northern long-eared bat prefers to roost singly or in colonies underneath bark, cavities, or in the crevices of live or dead trees. Breeding begins in late summer or early fall when males swarm near hibernacula. After delayed fertilization, pregnant females migrate to summer colonies where they roost and give birth to a single pup. Young bats begin flying 18 to 21 days after birth, and adult northern long-eared bats can live up to 19 years (USFWS 2015).

Northern long-eared bats emerge at dusk and fly through the understory of forested hillsides feeding on moths, flies, leafhoppers, caddisflies, and beetles. They also feed by gleaning motionless insects from vegetation and water (USFWS 2015).

White-nose syndrome is the most severe and immediate threat to northern long-eared bats. As a result of this disease, based on hibernacula data, northern long-eared bats have declined by 97-100% across the species range (USFWS 2023c). Northern long-eared bats are also susceptible to habitat loss, specifically the loss of wintering and summer roosting hibernacula through anthropogenic activities. Highway construction, commercial development, surface mining, and wind facility construction permanently remove summer roosting habitat, leading to widespread mortality among individuals and colonies (USFWS 2023c).

Monarch Butterfly

A recent review of the USFWS IPaC database indicates that the monarch butterfly, listed as a candidate species in December 2020, can potentially occur in the Project area. In North America, the eastern population of the monarch butterfly migrates north to the United States and Canada in March from the mountains of central Mexico. This species is typically found in open grass areas during the breeding season. Adult monarchs use a wide variety of flowering plants throughout migration and breeding. Important nectar sources during the spring migration typically include tickseeds (*Coreopsis* spp.), *Viburnum* spp., *Phlox* spp., and early blooming milkweeds. Important nectar sources during fall migration include goldenrods (*Solidago* spp.), asters (*Symphyotrichum* spp. and *Eurybia* spp.), gayfeathers (*Liatris* spp.), and coneflowers (*Echinacea* spp.). The optimal survey window for this species is August-December (USFWS 2020).

Within the past decade, monarch butterfly populations have decreased significantly. The decrease in native plants, including milkweed, on which their caterpillars' feed has been and continues to be the greatest threat for the monarch butterfly moving forward (USDA NRCS 2023b). Depletion of native plants and milkweed within the butterflies' native range is partly due to anthropogenic activities, including but not limited to; road construction, herbicide treatment, habitat degradation, grazing and farming pressures, and mowing (USFWS 2020). In general, monarch butterflies are susceptible to insecticide treatment, logging/tree loss, collection/tourism, climate change, disease, and natural predation (USFWS 2020). With the known threats to monarchs, the preservation of current and future population dynamics rests largely on the quality and quantity of milkweed availability.

A candidate species listing indicates that the USFWS has sufficient information on a species' biological status and threats to propose it as endangered or threatened, but for which other higher priority listing activities preclude the development of a proposed listing regulation. Candidate species receive no statutory protection under the ESA.

Shortnose sturgeon

Shortnose sturgeon live in rivers and coastal waters from Canada to Florida. They hatch in the freshwater of rivers and spend most of their time in the estuaries, and spawning adults generally migrate upriver from April to May. After spawning, the adults typically move quickly back downstream to the lower river and estuaries. Unlike Atlantic sturgeon, shortnose sturgeon tend to spend relatively little time in the ocean. When they do enter marine waters, they generally stay close to shore. Shortnose sturgeon use their four barbels to search for food in the sandy, muddy bottom of rivers. They use a vacuum-like mouth to suck up a variety of prey from the substrate, typically invertebrates such as insects, crustaceans, worms, and mollusks (NOAA 2023c).

In general, habitats can be altered, degraded, or destroyed because of various human activities, such as dredging, damming, and groundwater pumping. Industrialization and development have also impacted water quality through the introduction of nutrients and other contaminants. Fishermen may accidentally capture shortnose sturgeon while trying to catch something else (i.e., bycatch). Shortnose sturgeon are primarily bycaught in gillnet fisheries. Shortnose sturgeon have also been captured in pound nets, fyke/hoop nets, catfish pots, shrimp trawls, and even recreational hooks and lines (NOAA 2023c).

Atlantic sturgeon

Atlantic sturgeon are widely distributed along the Atlantic Coast of the United States, occurring in major estuaries and riverine environments within their respective native ranges, or DPS. The ESA listing status for sturgeon is based on their DPS. Atlantic sturgeon originating from the New York Bight, Chesapeake Bay, South Atlantic, and Carolina DPSs are listed as federally endangered; those originating from the Gulf of Maine DPS are listed as federally threatened (NOAA 2023b).

Atlantic sturgeon utilizing the Merrimack River as spawning habitat most likely would have originated from the Gulf of Maine DPS, which includes 152 miles of aquatic habitat. The Gulf of Maine DPS includes all anadromous Atlantic sturgeon spawned in the watersheds from the Maine/Canada border and extending southward to include all associated watersheds draining into the Gulf of Maine as far south as Chatham, MA (NMFS 2017).

The Atlantic sturgeon is a long-lived, late-maturing, estuarine-dependent, anadromous species. Adults spend most of their life in the marine environment but migrate upriver in the spring/early summer (April-May in mid-Atlantic systems) to spawn. Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers, where optimal flows are 46–76 centimeters per second (1.5 - 2.5 feet per second) with depths of 11–27 meters (36 – 88 feet).

Biological Opinions, Status Reports, and Recovery Plans

The recovery actions identified in NOAA's Final Recovery Plan for the Shortnose Sturgeon, dated December 1998, have the following components to protect existing populations and rehabilitate habitat:

- Reduce bycatch of shortnose sturgeon;
- Formulate a public education program to increase awareness of shortnose sturgeon and their status;
- Mitigate/eliminate impact of adverse anthropogenic actions on shortnose sturgeon population segments;
- Restore habitats and their functions in the life histories of each population segment;
- Develop a breeding and stocking protocol for shortnose sturgeon;
- Reintroduce shortnose sturgeon into river ecosystems where they have been extirpated.

Using these strategies and following the listed actions, NOAA has a goal to reclassify the species to threatened and eventually delist it from the Federal list of Endangered and Threatened Wildlife (NOAA 1998).

No recovery plans have been developed for the other ESA-listed species potentially occurring in the Project vicinity (Table E.7-32). Multiple biological opinions have been developed for the northern long-eared bat, but none are specific to the Project.

E.7.5.1.2 State-listed, Threatened, Endangered, and Candidate Species

The Massachusetts NHESP provided map and database information based on Essex's request on applicable state-listed threatened, endangered, and candidate species, as well as species of special concern and communities (RTE species). In addition, habitat information was provided by the Massachusetts NHESP's fact sheets and flora manuals. Specific to the Project area, the potential presence of RTE species was determined by consulting with Massachusetts NHESP (see Appendix B). Table E.7-33 lists the state-listed species that the Commonwealth of Massachusetts lists as potentially occurring within the Project boundary.

Table E.7-33. State-Listed Threatened, Endangered and Candidate Species.

Common Name	Scientific Name	State Status
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered

Common Name	Scientific Name	State Status
Bald Eagle	*Haliaeetus leucocephalus*	Special Concern
Wood Turtle	*Glyptemys insculpta*	Special Concern

Massachusetts NHESP Priority and Estimated Habitats

The Massachusetts NHESP identifies Priority Habitat based on the known geographical extent of habitat for all state-listed rare species, both plants and animals, and is codified under the MESA. Habitat alteration within Priority Habitat may result in a take of a state-listed species and is subject to regulatory review by the Massachusetts NHESP. Currently, a portion of the Project boundary is listed as Massachusetts NHESP Priority Habitat for sturgeon (PH 2154) (Commonwealth of Massachusetts 2023). This area starts from just upstream of the Essex Dam and extends the length of the Project, and includes the boundaries of the North and South canals. These areas are included as Priority Habitat not because they provide potential sturgeon habitat, but because the operation of the dam and canals could affect downstream sturgeon habitat (Massachusetts NHESP, personal communication). Additionally, the Massachusetts NHESP identified Priority Habitat for bald eagle (PH 1985), which is located adjacent to the Project impoundment approximately 4.5 miles upstream of the Essex Dam. Wood turtle Priority Habitat (PH 2002) is in the vicinity of the Project, located adjacent to the Project impoundment approximately 4 miles upstream of the Essex Dam.

The Massachusetts NHESP also identified Estimated Habitats, which are a subset of the Priority Habitats that are based on the geographical extent of habitat of state-listed rare wetland wildlife and are codified under the Wetlands Protection Act (WPA), which does not protect plants. State-listed wetland wildlife species are protected under the MESA as well as the WPA. Currently, a portion of the Project boundary is listed as Massachusetts NHESP Estimated Habitat (EH 1362). This area starts just upstream of the Essex Dam and extends the length of the Project, and includes the boundaries of the North and South canals. Estimated Habitat is located within the vicinity of the Project for bald eagle (EH 1272) and wood turtle (EH 1284). These areas are adjacent to the Project impoundment approximately 4 to 4.5 miles upstream of the Essex Dam.

E.7.5.1.3 Critical Habitat

Currently, a portion of the Project boundary is listed by NOAA as critical habitat for Atlantic sturgeon. The critical habitat for Atlantic sturgeon includes waters “from the Essex Dam (also known as the Lawrence Dam) downstream to where the main stem river discharges at its mouth into the Atlantic Ocean” (NOAA 2016). Critical habitat for shortnose sturgeon has not been designated.

According to the January 2023 IPaC search, the USFWS has not designated critical habitats in the vicinity of the Lawrence Project.

E.7.5.1.4 Relicensing Studies

Sturgeon Distribution and Project Interaction Study (ASA 2026b)

In support of this relicensing, Essex conducted a Sturgeon Distribution and Project Interaction Study to determine if Atlantic or shortnose sturgeon are interacting with the Lawrence Project.

Mobile Side-Scan Sonar (SSS) surveys

Mobile side-scan sonar (SSS) surveys were conducted within the 1.5-mile reach of the Merrimack River between Essex Dam and the Lawrence I-495 Bridge. Six surveys were conducted between the Project and the Lawrence I-495 Bridge for approximately 1.5 RM (2.4 kilometers [km]) from April 4 through May 20, 2025. The vicinity of the tailrace upriver of the O'Leary Bridge and downstream to approximately the boat ramp at Pemberton State Park was not surveyed due to safety concerns and navigation hazards. The SSS data were imported into SonarWiz software for processing, visualization, and exporting data and images, and were manually inspected for sturgeon-like targets in the SSS imagery.

Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence between April 10 and 30, based on a process involving assessment by three independent reviewers. None were identified upriver of the Joseph W. Casey Bridge (Amesbury St.), which is located approximately 0.4 miles downriver of the Project Dam. The potential sturgeon targets were observed between 500 feet downriver of the Joseph W. Casey Bridge and approximately 1,000 feet upriver of the I-495 Lawrence Bridge. The sturgeon targets observed by SSS were comparable in time and space to the acoustic receiver detections of a USGS sturgeon acoustically tagged in 2016 and the one individual observed during electrofishing in 2025.

The mobile SSS survey was not able to identify sturgeon to the species level and was not able to quantify duration or seasonality of either species in the sampled river reach. However, repeated surveys were able to detect and classify sturgeon during mid to late April (April 10, 17, 23, and 30), but no sturgeon were detected on April 4 or May 20.

No Project-related effects were identified in the SSS survey results. However, natural fluctuations in river flow, non-navigable rocky shallows, and turbulent conditions affected vessel access and controllability of the survey vessel underway in some areas.

Sturgeon were likely identified in the river reach between 1 and 1.5 miles downstream of the Project, but direct evidence of sturgeon observed in the mobile SSS surveys could not determine if the tailrace structure or flow conditions related to the Project dam created a barrier to upriver movement.

With the exception of initiating data collection on April 4, rather than late March, and the inability to safely access non-navigable waters in close proximity to the Project dam, there have been no variances from the approved study plan or the SPD for this portion of the study.

Fixed Location Sonar Pilot Study

A pilot study was conducted to determine the feasibility of using fixed-location sonar to detect and identify artificial targets of similar size and shape as sturgeon in the Project tailrace and, if feasible, to monitor for the presence of sturgeon in the tailrace from mid-March through early November 2026. Key objectives for fixed sonar monitoring include: (1) determining if sturgeon are present in the tailrace from mid-March through early November and, if present, (2) determining how they are distributed in the tailrace for purposes of informing the potential design and location of a fishway.

The pilot study evaluated deployment options and suitable locations in the tailrace for a fixed-location sonar installation and tested target detection and identification performance of two sonars at multiple sampling configurations. The study was completed between October 28 and November 10, 2025.

No sturgeon were observed in the Project tailrace using either device. The study demonstrates that it is not feasible to detect or identify sturgeon-shaped targets using these two sonar technologies at suitable ranges for a long-term deployment of a fixed-location sonar monitoring in the Project tailrace, due to a variety of factors. These factors include mounting capability, geographical layout, high flows, entrained bubbles, submerged debris, turbulence in the tailrace, safety, site-specific limitations to sonar performance, and logistical challenges of prolonged operation. As a result, no fixed-location sonar monitoring data were collected to describe duration or seasonality of sturgeon.

Project layout, flow conditions, and logistics within the tailrace limited the feasibility of deploying fixed-location sonar in specific locations and for long-term monitoring of sturgeon. It was impractical to keep a target within the sonar field of view for an adequate amount of time for both detection and, more so, for identification. Woody debris and trash in the tailrace float or churn underwater, which makes a long-term sonar monitoring deployment impractical due to potentially causing excessive false sturgeon detections as well as high risk of physical damage to fixed-location sonar systems over time. Fixed-location monitoring using ARIS and BlueView high-resolution imaging sonars to detect and identify sturgeon within the Project tailrace is not feasible as indicated by the pilot study under controlled conditions, due to the high abundance of floating and submerged drift debris, entrained bubbles, strong eddies and currents, and upwelling.

The fixed-location sonar monitoring varied in both instrumentation and approach from the SPD, which resulted in a two-phase approach using imaging multibeam sonars instead of SSS as described in the ISR and the accompanying Study Plan. The pilot study varied from the Study Plan in two ways. After challenges related to overall logistics, safety considerations, equipment protection, site accessibility, and reliable performance of the monitoring devices were encountered, the pilot study focused on testing the performance of two sonar technologies and chose the best suited, most practical mounting solution. This created a variance from mounting the sonar out at the tip of the old fish ladder structure, to mounting the frame and devices leveraging the river-side fish lift entrance weir structure. The other variance resulted from the actual implementation revealing that it was not feasible to execute a controlled experiment of deploying known targets at distant ranges, known depths, and known times for an analyst to independently process targets to measure sonar performance. Environmental conditions (e.g., flows, bubbles, debris) and personnel safety prevented this from working adequately. Instead, atypical low-flow Project operations and unrealistic close ranges were used to focus on identifying artificial sturgeon targets.

Acoustic Telemetry

Sturgeon were tagged with acoustic transmitters and recorded using acoustic receivers in the tailrace and downstream reach to monitor from mid-March to early-November (as river conditions allowed). Seasonal use and movement of tagged sturgeon were evaluated in the downstream Project reach using a series of acoustic receivers.

Acoustic receivers were installed in the section of the Merrimack River extending from the Essex Dam downstream to the I-495 Lawrence Bridge as part of the Diadromous Fish Behavior, Movement, and Project Interaction Study, which were available to collect detection information on any sturgeon carrying a 416.7kHz JSATS transmitter which entered the detection zone. The array operated from April through mid-July, then a subset of the acoustic receivers were extended into late September to provide an extended period of monitoring for tagged sturgeon. In addition, InnovaSea acoustic receivers were deployed at I-495 Lawrence Bridge, Duck Bridge, Route 28 Bridge, and in the tailrace to provide coverage from mid-March through late November 2025.

A total of 55 transmitters were deployed on tagged adult shortnose sturgeon, 15 on sub-adult Atlantic sturgeon, and 15 on juvenile Atlantic sturgeon. A limited number of tagged adult Shortnose Sturgeon (n = 2) were confirmed as present during the survey in the monitored area. One individual ascended far enough upstream to be detected at the downstream entrance of the tailrace channel. The second individual was not detected at any stationary receivers located upstream of the Lawrence I-495 Bridge. There were no detections of tagged Atlantic sturgeon (juvenile or sub-adult) at any stationary receiver location during the 2025 monitoring period.

Seasonal presence of adult shortnose sturgeon across the full array occurred from late-April through mid-June. Shortnose sturgeon presence in the region closest to Essex Dam was limited to a two-day duration during late-April. The remainder of detections were from the receiver immediately downstream of the Lawrence I-495 Bridge.

No Project-related effects were identified in the acoustic telemetry study results. A limited number of individuals were detected in the monitored reach downstream of Essex Dam, and the seasonal timing of these detections is in line with previously reported shortnose sturgeon movements within the Merrimack River.

Results of the 2025 acoustic tag monitoring do not provide conclusive evidence to support the current need for upstream passage at the Project. Observations in the immediate vicinity of Essex Dam were limited to a single adult shortnose sturgeon detected only by the receiver at the downstream end of the tailrace channel (i.e., undetected by the two acoustic receivers positioned at the downstream face of the powerhouse and in the vicinity of the upstream fish lift entrances).

Sturgeon Habitat Mapping and Assessment Study (ASA 2026a)

Essex conducted a Sturgeon Habitat Mapping and Assessment Study in support of this relicensing. The Sturgeon Habitat Mapping and Assessment Study was designed to (1) map the benthic habitat features of the Merrimack River downstream from Essex Dam to RM 19 (Basiliere Bridge on Route 125), and (2) quantify the area of juvenile rearing habitat, spawning habitat, and foraging habitat for Atlantic *(Acipenser oxyrinchus oxyrinchus*) and shortnose sturgeon (*A. brevirostrum*) in this reach based on substrate type and water depth.

The Sturgeon Habitat Mapping and Assessment Study was designed to use SSS to collect data for mapping benthic habitat features and quantifying the nursery, spawning, and foraging habitat for Atlantic and shortnose sturgeon, based on substrate type and depth. Substrate type, size and embeddedness, as inferred from visual classification of SSS imagery, were planned to be verified by underwater video and sediment grab samples. Additionally, bathymetric data were planned to be collected to create a gridded GIS depth and substrate layer.

Substrate classification (type, size, and embeddedness) of the SSS imagery was designed to be informed and verified by two direct sampling methods: underwater video and sediment grab sampling. The verification samples were collected along 10 transects through the survey area (“verification transects”), where each verification transect consisted of 3 sampling stations: one near each riverbank and one approximately in the center of the river channel, as navigation allowed. The initial goal was to collect 30 sediment grab samples and underwater video recordings to supplement the SSS and bathymetric data. The survey was planned to be completed following this study plan with real-time field adjustments to the methods described herein only if needed (e.g., navigational hazards, safety, data quality, and coverage).

Water quality measurements (temperature, conductivity, DO) were collected during the verification sampling survey with an In Situ Aqua Troll 500 ("CTD" or "sonde"). After recording the water quality measurements at a station, underwater video was collected with a GoPro Hero 13 underwater camera model, mounted in a custom-fabricated aluminum frame in a downward-facing orientation, approximately 24 inches above the river bottom. At each verification station, the video frame system was lowered to the river bottom to collect short video recordings (15-30 seconds). After recording the underwater video at a station, sediment grabs were collected with a 6-inch x 6-inch (0.024 m^2) stainless steel Petite Ponar grab). At each station, at least three valid grab attempts were made before determining whether or not a sediment sample could be collected. Notes were recorded with each grab attempt (e.g., empty, void, or sample collected, along with description of the environment and/or if grass or single rocks were found in a grab). A subsample of approximately 100 mL of the upper 2 cm layer of the sediment grab was transferred to a 250 mL jar to be sent to a laboratory for sediment grain size analysis.

Modification to the planned survey design and data processing were required due to the environmental conditions encountered during the sturgeon habitat mapping survey. The main limitation being an environmental constraint, specifically low water due to low river flows, which was generally 4 feet below the recent 5-year average for the survey period. The planned study design described in the Study Plan focused on collecting SSS) data for the 10-mile survey reach along three axial transects (i.e., along the river axis), to be combined with bathymetric survey data collected along "zig-zag" transects throughout the 10-mile survey reach, and supplemented with verification sampling/ground truthing at stations along 10 cross-river transects (approximately one transect with three stations per RM).

Due to the extremely low water levels encountered during the surveys, it was not practicable or safely navigable to fully perform the sonar surveys as intended, and as a result some portions of the surveys could not be completed (i.e., SSS and bathymetry). The vessel could not sample along transects for SSS and bathymetry because it was consistently having to navigate to avoid shallow and/or exposed rocks. This presented a hazard not only to navigation but to equipment as well, as the over-the-side mounted equipment (single-beam sonar and SSS) and the vessel's propeller struck rocks multiple times. Because of this, the habitat survey primarily focused on conducting the verification sampling with bathymetry at each station to provide insight into the distribution and quantity of sturgeon habitat where possible.

River conditions during the survey (i.e., stage and flow) were assessed from data gathered by the Project. River stage (feet, NAVD88) and river flow (cfs) were plotted for assessment of conditions encountered during the survey and for the rest of the 2025 field season. Water quality measurements were downloaded from the instrument following each field day, and data were compiled in Excel and reviewed for suspect data/quality. Summary statistics for water temperature, conductivity, and DO were determined for each verification transect and all water quality data collected. Still shots ("frames") of underwater video files were used both to classify benthic substrate types by particle size and to quantify percent area covered by the identified substrates. A single substrate type was considered "dominant" if it covered 50% or more of the observed stream bed surface, "sub-dominant" if it covered 10-49% of the stream bed surface, or "other" if it covered <10% of the stream bed surface. Embeddedness was determined by estimating percent area covered by grain particles <2 mm in size (sand and finer particles, collectively). Depth soundings were merged with the GPS data during data collection in HYPACK Survey software. MATLAB was used to post-process the HYPACK data files to extract water surface elevation (ft, NAVD88), river bottom elevation (ft, NAVD88), and water depth at time of sample collection (ft) for each station from the HYPACK data files. Data were then smoothed with a box-car filter and linked to each station by timestamp for an estimate of depth and elevation to associate with the substrate data for the purpose of sturgeon habitat classification.

Suitable habitat area for Atlantic and shortnose sturgeon foraging, juvenile rearing, and spawning between Lawrence Hydroelectric Project and RM 19 was determined using depths and dominant and sub-dominant substrate types identified during this study compared against species-specific literature-based values for foraging, juvenile rearing, and spawning habitat in fresh waters of the northeastern U.S. and Canada.

Data were collected by direct sampling during July 22-24, 2025, between the Project tailrace and Basiliere Bridge at RM 19 in Haverhill, MA. Data collection resulted in the findings below.

Benthic habitat features, such as dominant and sub-dominant substrate type and depth, were collected and mapped across the Merrimack River in one-third segments (left, middle and right) along the study reach by each mile where valid sample information could be safely collected. Depths ranged from 4.7 to 16.0 feet. Dominant substrates were pebble, cobble and SAV. Substrate appeared to be minimally embedded (0-18%) into the riverbed by sand and silt. Substrate classification by size and embeddedness was estimated from data collected by a Petite Ponar Grab and underwater video.

The total surveyed area from the railroad bridge near the Project tailrace downstream to Basiliere Bridge (RM19) was approximately 596.7 acres. Within the surveyed area, Atlantic sturgeon habitat comprised 16% for both foraging and juvenile rearing purposes, while spawning habitat accounted for 65%. Shortnose sturgeon habitat area was classified as 19% for foraging, 3% for juvenile rearing, and 52% for spawning. Habitat classification was not assigned to approximately 28% of the total surveyed area due to a lack of available data. Sturgeon were not observed while sampling during July 22-25, 2025.

E.7.5.2 Environmental Analysis

E.7.5.2.1 Site-Specific Effects

FERC's SD2 identified effects of continued Project operations on threatened and endangered species as potential resource issues. Specifically, SD2 identified the following as needing to be analyzed for site-specific effects:

- Effects of Project operation and maintenance on species designated as federally threatened, endangered, proposed, or candidates for listing, and designated critical habitat (proposed and final), under the Endangered Species Act (ESA), including the endangered northern long-eared bat and shortnose sturgeon, and the threatened Atlantic sturgeon; designated critical habitat for Atlantic sturgeon; the tricolored bat, a species proposed for listing as endangered under the ESA; and the monarch butterfly, a candidate species for listing under the ESA.

- Effects of Project operation and maintenance on Massachusetts state-listed species.

The results of the Sturgeon Distribution and Project Interaction Study (ASA 2026b) indicate that sturgeon have limited interactions with Essex Dam. Mobile side-scan sonar (SSS) surveys to detect Atlantic sturgeon or shortnose sturgeon were conducted within the 1.5-mile reach of the Merrimack River between Essex Dam and the Lawrence I-495 Bridge. Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence between April 10 and 30, based on a process involving assessment by three independent reviewers. None were identified upriver of the Joseph W. Casey Bridge (Amesbury St.), which is located approximately 0.4 miles downriver of the Project Dam. The potential sturgeon targets were observed between 500 feet downriver of the Joseph W. Casey Bridge and approximately 1,000 feet upriver of the I-495 Lawrence Bridge. Additionally, sturgeon were tagged with acoustic transmitters and recorded using acoustic receivers in the tailrace and downstream reach to monitor from mid-March to early November (as river conditions allowed). A total of 55 transmitters were deployed on tagged adult shortnose sturgeon, 15 on sub-adult Atlantic sturgeon, and 15 on juvenile Atlantic sturgeon. A limited number of tagged adult shortnose sturgeon (n = 2) were confirmed as present during the survey in the monitored area. One individual ascended far enough upstream to be detected at the downstream entrance of the tailrace channel. This presence was limited to a two-day duration in late April. The second individual was not detected at any stationary receivers located upstream of the Lawrence I-495 Bridge. There were no detections of tagged Atlantic sturgeon (juvenile or sub-adult) at any stationary receiver location during the 2025 monitoring period.

No Project-related effects were identified during the Sturgeon Distribution and Project Interaction Study (ASA 2026b). A limited number of individuals were detected in the monitored reach downstream of Essex Dam, and the seasonal timing of these detections is in line with previously reported shortnose sturgeon movements within the Merrimack River. Results of the acoustic tag monitoring portion also do not provide conclusive evidence to support the current need for upstream passage at the Project for sturgeon. Observations in the immediate vicinity of Essex Dam were limited to a single adult shortnose sturgeon detected only by the receiver at the downstream end of the tailrace channel (i.e., undetected by the two acoustic receivers positioned at the downstream face of the powerhouse and in the vicinity of the upstream fish lift entrances).

One ESA-designated mammal species, the northern long-eared bat, may occur within the Project area. This aerial insectivore may forage adjacent to Project waters in forested habitats in the summer but is not expected to be adversely affected as a result of Project operation. This bat species roosts in upland areas (live or snag trees, caves, etc.), outside of the range of potential Project operational effects. This bat species spends winters months in hibernacula and is not expected to be adversely affected by Project operations. There are no known hibernacula or roost trees for northern long-eared bats in the immediate vicinity of the Project's facilities. Evidence of the presence of the northern long-eared bat was not found during any of the field studies performed as part of this relicensing. Additionally, the occurrence and distribution of terrestrial wildlife resources in the Project area is generally unrelated to operation of the Project. The operation of the Project as proposed is not expected to have any adverse effects on the northern long-eared bat; however, in the event Essex performs maintenance activities at the Project that could affect bat habitat, Essex will perform the required consultation and implement protection measures pursuant to applicable federal and state laws and regulations, including the ESA. Similarly, operation of the Project as proposed is not expected to have any adverse effects on the tricolored bat, nor have they been observed at the Project or observed during relicensing studies.

Bald eagles (State-listed) are known to use the Merrimack River Watershed for winter perching, roosting, and feeding activities and have been documented along the Merrimack River. Project operations as proposed by the Licensee have a very low potential to impact bald eagles or roost trees. Project operations have little effect on terrestrial habitat, thus occurrence and distribution of terrestrial wildlife resources in the study area are generally unrelated to Project operations. Project maintenance activities are generally localized and minor in nature.

Project operations are not expected to adversely affect the monarch butterfly (*Danaus plexippus*) or its habitat. The Project area does not contain significant concentrations of milkweed (the primary host plant for monarch reproduction) or high-quality nectar resources that would support breeding or migration stopover habitat. Project operations are not expected to adversely affect the State-listed wood turtle (*Glyptemys insculpta*) or its habitat. All activities will occur within previously disturbed and/or actively maintained areas, minimizing the potential for impacts to aquatic or riparian environments.

E.7.5.2.2 Cumulative Effects

In the SD2, the Commission identified designated critical habitat for Atlantic sturgeon as a resource that could be cumulatively affected by the proposed continued operation and maintenance of the Project in combination with other hydroelectric projects on the river. The Commission noted the following effects to be analyzed for cumulative effects:

- Effects of Project operation and maintenance on designated critical habitat for Atlantic sturgeon

The geographic scope for Atlantic sturgeon critical habitat includes the Merrimack River from the toe of Essex Dam downstream to where the Merrimack River empties into the Gulf of Maine in Newburyport, Massachusetts. The Sturgeon Habitat Mapping and Assessment Study (ASA Analysis 2026a) was designed to quantify the area of juvenile rearing habitat, spawning habitat, and foraging habitat for Atlantic and shortnose sturgeon in the Merrimack River downstream from Essex Dam to RM 19. It further found that within the surveyed area (from the railroad bridge near the Project tailrace downstream to Basiliere Bridge) Atlantic sturgeon habitat comprised 16% for both foraging and juvenile rearing purposes, while spawning habitat accounted for 65%. These findings document habitat for Atlantic sturgeon in the Merrimack River downstream of Essex Dam.

The results of the Phase I Project Operations and Fish Stranding Study (HDR 2026a) provide a review of Project operations over the six-year period from January 1, 2019, through December 31, 2024. The results of this study demonstrate that the Project operated in ROR mode throughout the study period and met or exceeded the requirements of Article 32 of the existing license. Project inflows (as prorated from USGS Gage No. 01100000 Lowell) are closely tracked by total Project outflows through a combination of turbine discharge, fish passage flows, canal leakage, and spill over the Essex Dam. Similarly, total Project outflow is closely tracked by tidally filtered flows recorded downstream at the USGS Gage No. 011006988 Haverhill. Downstream of Essex Dam, normal operations maintain flow continuity in the Merrimack River. As a result, normal ROR operation is not likely to affect downstream critical habitat, and ROR operations serve to provide protection for fish and aquatic resources downstream.

Additionally, the results of the Sturgeon Distribution and Project Interaction Study (ASA 2026b) indicate that sturgeon have limited interactions with Essex Dam. The Sturgeon Distribution and Project Interaction Study (ASA 2026) found that the Project is within the historical range of both Atlantic and shortnose sturgeon and lies at the upstream boundary of designated Atlantic Sturgeon critical habitat. However, 2025 monitoring documented only limited shortnose sturgeon presence in the river reach between Essex Dam and the I-495 bridge, and no Atlantic sturgeon detections at stationary receivers. Ten targets were classified as sturgeon with relatively low (32%) to medium (68%) confidence, but none occurred upriver of the Joseph W. Casey Bridge, about 0.4 mile below the dam.

Considering that certain studies are ongoing, Essex will provide additional analyses, where relevant and appropriate, of the potential cumulative effects on fish passage for migratory species in the FLA to be filed with the Commission by November 30, 2026.

E.7.5.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project’s existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on rare, threatened, and endangered species resources.

E.7.5.4 Unavoidable Adverse Impacts

The occurrence and distribution of terrestrial and aquatic wildlife and RTE resources in the study area is generally unrelated to Project operations, and outside of Essex’s control.

E.7.6 Recreation and Land Use

The subsections below describe recreation and land use in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee’s PAD and the:

- Recreation Facilities, Use, and Aesthetics Study (HDR 2026d)

This report is included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

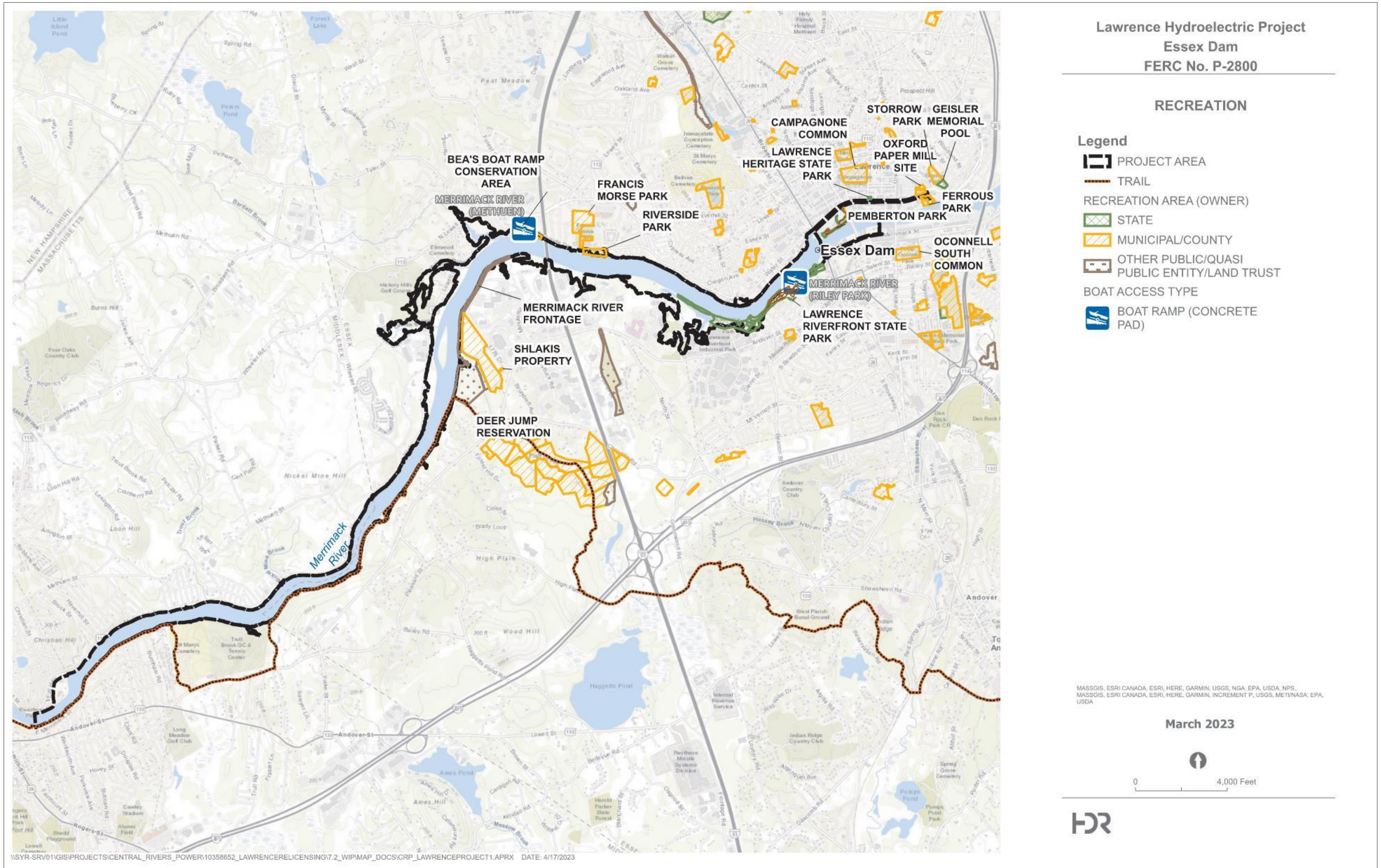
E.7.6.1 Affected Environment

The Lawrence Project is located in a culturally rich region that offers educational opportunities surrounding the American Revolution, the Industrial Revolution, and the American textile industry. The Merrimack River is a focal point across the region, providing drinking water, hydroelectric power, recreation opportunities, food production, and aquatic habitat. Land use within the Project boundary is primarily open water, followed by developed land, woody wetlands, and deciduous forest.

The Project is situated in a distinct ecoregion and environmental setting that directly influences the nature and type of recreational opportunities available. The Lawrence Project is located in the Gulf of Maine Coastal Plain (Level IV) ecoregion as defined by the USEPA. The Gulf of Maine Coastal Plain region is characterized by rolling plains with hills and glacial drumlins. The region contains some ponds, small lakes, wetlands, low and moderate gradient streams, and large rivers with sand, gravel, boulder, and bedrock substrates. The local relief is mostly between 100 and 600 feet (Griffith et al. 2009).

Recreation at the Project has been developed to provide specific opportunities based on the Project location and setting (see Figure E.7-41). Boating, paddling, and hiking are the primary recreational opportunities that occur in the Project area. The Project provides recreational opportunities at the North Canal Carriage House. Various recreational facilities that are not Project-related are within the vicinity of the Project. River access is provided both upstream and downstream of the Project.

Figure E.7-41. Recreational Facilities Within the Vicinity of the Lawrence Project.



E.7.6.1.1 Existing Recreation Facilities and Opportunities

The Merrimack River provides recreational opportunities to the 200 communities it supports as well as residents of other major cities in the region. The Merrimack River is commonly used for boating, canoeing, kayaking, fishing, rowing, and swimming. The surrounding land is used for walking, biking, hiking, fishing, picnicking, bird watching, photography, skiing, and more.

E.7.6.1.2 FERC-Approved Recreational Facilities at the Project

A Recreation Plan was filed June 30, 1977, and supplemented on November 15, 1977, and January 27, 1978, which was subsequently approved in the license order issued December 4, 1978. An amendment to Exhibit R was proposed in a letter dated March 5, 1992, and was supplemented on August 31, 1992. This license amendment requested the picnic area and access to the North Canal Gatehouse be removed from the Recreation Plan, the interpretive programs be revised, and the South Canal Gatehouse to remain in its present location. The revised Exhibit R was approved in an order issued August 1, 1995. On August 10, 1995, a clarification was made to the revised Exhibit R that tours would be provided at the Carriage House, as opposed to the powerhouse and fish lift. This revision was approved in an order dated September 8, 1995.

Under the Recreation Plan, Essex provides a handicap-accessible parking area, tours, and interpretive displays at the North Canal Carriage House. Tours cover the following topics: 1) how electricity is generated from waterpower; 2) the purpose and operation of the fish passage facilities; and 3) the role of The Essex Company, the Great Stone Dam canals and gatehouses (recognized on the National Register of Historic Places) in the development of the City, and early industrialization using hydromechanical power. The interpretive displays explain different aspects of the Project's operation. Figure E.7-41 provides a map of recreation facilities associated with the Project. Non-Project recreation facilities and opportunities are discussed in Section E.7.6.1.9 below.

Following a FERC inspection on May 16, 2019, signage was added to better advertise public tours of the North Canal Carriage House. Additionally, flyers advertising the public tours were distributed to the Lawrence History Center, the Massachusetts Department of Conservation & Recreation's Lawrence Heritage State Park, and Lawrence City Hall for posting to public bulletin boards.

E.7.6.1.3 Non-Project Recreation Facilities and Opportunities

Numerous non-Project recreation facilities and opportunities exist in the vicinity of the Lawrence Project. The Lawrence Redevelopment Authority, on behalf of the Department of Environmental Management of the Commonwealth of Massachusetts, developed a greenway and pedestrian walkway along the length of the North Canal. On the north side of the North Canal is the Lawrence Heritage State Park, which features a Visitors Center and Visitor Center Park. Between the North Canal and the Merrimack River is Pemberton State Park, maintained by the City of Lawrence, which provides a trailer boat ramp, fishing access, a gazebo, park benches, and walking trails. Further downstream of Pemberton State Park is Ferrous Park, which has walking trails, a picnic area, and a gazebo. The Spicket River Greenway is a 3.5-mile-long walking path with connecting parks that extends from Manchester Street Park to Ferrous Park. The Riverwalk Complex has been undergoing redevelopment since 2003 and has included renovation of the mill buildings along Merrimack Street and development of the Riverwalk multi-use recreational trail.

Upstream of the Project is Lawrence Riverfront State Park, which provides extensive trails, pedestrian bridges, a trailer boat launch, picnic area, playground, gazebo, basketball court, and a street hockey rink. The Abe Bashara Boathouse is located within Lawrence Riverfront State Park and provides sailing lessons, watercraft rentals, and a docking system. The Methuen Riverside Boat Ramp is located approximately 2.7 miles upstream and provides a trailer boat launch and fishing access. The Merrimack River Trail extends on the south shore of the impoundment and includes part of the Bay Circuit Trail, a 230-mile-long trail that traverses the outskirts of Boston. Several municipal parks, conservation lands, boathouses, private boat docks, and athletic facilities are located along the impoundment. A complex of conservation lands is located on river-right approximately 4 miles upstream. Additionally, the Boys and Girls Club of Lawrence, Raymond J. Martin Riverside Park, Phillips Academy Boathouse, Merrimack College Boathouse, Trull Brook Golf Club, and Hickory Hill Golf Course are located along the impoundment. The Clean River Project is located on river-left of the impoundment and offers boat tours of the Merrimack River. The Merrimack Valley Seaplane Base is located west of the Merrimack-Methuen Bridge.

The City of Lawrence contains several recreational opportunities, including parks, athletic facilities, youth facilities, and public pools. There are several plans for redevelopment by various stakeholders in the vicinity of the Project that would provide greater access to the Merrimack River and surrounding area. The Lawrence Rail Trail is proposed as a multi-use recreational path with connecting greenspaces that would cross the Merrimack River, providing pedestrian access to Downtown Lawrence and facilities along the Merrimack River (MassDOT undated). Several other trails are proposed, including a trail along the northern shoreline of the impoundment (City of Lawrence 2017).

The upstream Lowell Hydroelectric Project (FERC No. 2790) and surrounding area offers recreational opportunities covering a wide range of facilities and opportunities including a visitors' center, interpretive displays, boat tours, boating access, conservation areas, state parks, the Lowell National Historical Park, whitewater rapids, a swimming beach, trails, and walking tours.

A list of the recreational facilities in the vicinity of the Project is provided in Table E.7-34 along with a brief description of each facility.

Table E.7-34. Recreation Facilities in the Vicinity of the Project.

Recreation Area	Description
North Canal Carriage House	Located between the left abutment of Essex Dam and the North Canal entrance. Provides tours and includes a visitor center with a parking area, video displays, lighting, seating, display panels, and other interactive exhibits.
Lawrence Riverfront State Park	Located immediately adjacent to the Project on the south shoreline of the impoundment. Provides trails, pedestrian bridges, a trailer boat launch, picnic area, playground, gazebo, basketball court, and a street hockey rink.
Pemberton Park	Located between the North Canal and the Merrimack River. Provides trails, picnic tables, and a gazebo.
North Canal pedestrian walkway	Located along the north side of the North Canal. Provides a walkway.

Recreation Area	Description
Ferrous Park	Located at the southern terminus of the North Canal. Provides walking trails, a picnic area, and a gazebo.
Spicket River Greenway	Extends from Ferrous Park northwest to Manchester Street Park. Is a 3.5-mile-long walking path with connecting parks.
Oxford Park	Located at the northern terminus of the North Canal. Includes a trail and open greenspace.
Storrow Park	Located east of Ferrous Park and Oxford Park. Provides a playground, basketball court, lawn area, and parking lot.
Geisler Memorial Pool	Located east of Ferrous Park and Oxford Park. Provides a public swimming pool and a parking lot.
Campagnone Common	Located north of the North Canal on Common Street. Provides lawn area, baseball field, playground, walking trails, portable restrooms, fountain, and spectator seating.
O'Connell South Common	Located south of the South Canal on Market Street. Provides a baseball field, walking trails, street hockey rink, basketball court, bandstand, playground, and lawn area.
Lawrence Heritage State Park	Located north of the North Canal. Provides a visitor center and park.
Abe Bashara Boathouse	Located approximately 0.75 mile upstream of Essex Dam. Provides sailing lessons, watercraft rentals, and a docking system.
Clean River Project	Located approximately 2.3 miles upstream of Essex Dam. Provides boat tours of the Merrimack River.
Merrimack Valley Seaplane Base	Located west of the Merrimack- Methuen Bridge on the southern shore of the impoundment. Is a public-use seaplane base.
Boys and Girls Club of Lawrence	Located upstream of Essex Dam. Provides game rooms, gymnasiums, a swimming pool, and a large field.
Raymond J. Martin Riverside Park	Located approximately 2.2 miles upstream of Essex Dam on the northern shoreline of the impoundment. Provides walking trails, playground, and a gazebo.
Francis Morse Park	Located north of the Raymond J. Martin Riverside Park. Provides a baseball field, soccer field, a parking lot, and a walking trail.
Methuen Riverside Boat Ramp	Located approximately 2.7 miles upstream of Essex Dam. Provides a trailer boat launch and fishing access.
Merrimack River Frontage/ Bay Circuit Trail	Located along the southern shoreline of the impoundment from the Lawrence Riverfront State Park to the City of Lowell.
Strazzula Reservation	Located approximately 1.7 miles upstream of Essex Dam on the southern shoreline of the impoundment, west of the Lawrence Riverfront State Park. Provides trails.

Recreation Area	Description
Deer Jump Reservation	Located approximately 3.7 miles upstream of Essex Dam on the southern shoreline of the impoundment. Provides trails, parking areas, provides fishing access, contains the Harold R. Rafton Memorial, and allows hunting.
Albert Retelle Reservation/ Shlakis Property	Located approximately 3.7 miles upstream of Essex Dam on the southern shoreline of the impoundment at the northern section of the Deer Jump Reservation. Provides trails, picnic tables, and a parking area.
Spalding Reservation	Located approximately 6.5 miles upstream of Essex Dam on the southern shoreline of the impoundment. Provides trails and allows hunting.
Behrakis Reservation	Located approximately 6.7 miles upstream of Essex Dam on the southern shoreline of the impoundment. Provides trails.
Rolling Green Reservation	Located approximately 6.3 miles upstream of Essex Dam on the southern shoreline of the impoundment. Provides trails.
Nickel Mine Conservation Land	Located approximately 6.4 miles upstream of Essex Dam north of the impoundment and encompasses Nickel Mine Brook. Provides trails.

E.7.6.1.4 Specially Designated Recreation Areas in Close Proximity to the Project

Nationwide Rivers Inventory and Wild and Scenic River System

National-level River protection programs include the National Wild and Scenic River System and Nationwide Rivers Inventory (NRI). The National Wild and Scenic River System was created to preserve rivers with outstanding natural, cultural, or recreational values in a free-flowing condition for the enjoyment of present and future generations (National Park Service [NPS] 2016). The NRI is a program that lists river segments that are believed to possess one or more “outstandingly remarkable” natural or cultural values; river segments listed on the NRI are eligible for inclusion in the National Wild and Scenic River System (NPS undated-a).

The Merrimack River is not designated as part of, and is not under study for inclusion in, the National Wild and Scenic River System (NPS undated-a). The NPS’s 1999 Upper Merrimack Wild and Scenic River Study found that 26 miles of the river are eligible for inclusion in the National Wild and Scenic River System based on free-flowing character and the presence of outstanding recreation, fish and aquatic, wildlife, cultural, and geological and natural feature values. The study recommended no designation due to lack of support for designation by the affected riverfront communities.

No waters within the Lawrence Project boundary are NRI-listed (NPS 2016). However, portions of the Merrimack River outside of the Project boundary are designated in the NRI. A segment of the Upper Merrimack River is listed based on outstanding resource values in recreation, fish, cultural, and geologic features. The eligible portion comprises the 26-mile section of river between its origin and Concord, NH. Additionally, a 3-mile reach of the Merrimack River downstream of Concord, NH, is listed for outstanding cultural, fish, and recreational values. A 16-mile section of the Merrimack River from Manchester, NH, to Nashua, NH, is listed for outstanding fish, historic, recreational, and wildlife values (NPS 2016).

Scenic Byways

There are no national or state scenic byways in the vicinity of the Project.

National Trails System and Wilderness Areas

National Trails are established under the authorities of the National Trails System Act (16 USC 1241-51) and consist of three types: National Scenic Trails, National Historic Trails, and National Recreation Trails. There are no national trails in the vicinity of the Lawrence Project (NPS 2020).

The Wilderness Act of 1964 established the National Wilderness Preservation System and instructs federal land management agencies, such as the NPS, Bureau of Land Management, USFWS, and USFS to manage wilderness areas and preserve wilderness character. There are no nationally designated wilderness areas located near the Lawrence Project (Wilderness Connect undated).

State Protected River Segments

A 45-mile segment of the Merrimack River in New Hampshire is a designated community river under the New Hampshire Rivers Management and Protection Program (NHDES 2019). Community rivers are defined by the New Hampshire Revised Statutes Title L Section 483:7-a as "those rivers or river segments which flow through populated areas of the state and which possess actual or potential resource values. Such rivers have some residential or other building development near their shorelines, are readily accessible by road or railroad, and may include some impoundments or diversion." The LMRLAC develops and implements a river management plan and coordinates activities affecting the river on a regional basis.

E.7.6.1.5 Existing Recreation Use Data

FERC Form 80

Section 10(a)(1) of the FPA requires the Commission to ensure that any licensed project is best adapted to a comprehensive plan for improving and developing a waterway for a variety of beneficial public uses, including recreational use. FERC Form 80 solicits information on the use and development of recreation facilities at hydropower projects licensed by the Commission under the FPA. Form 80s have since been eliminated due to the increase in project-specific license conditions for approved recreation plans. However, past Form 80s act as a valuable tool in determining recreation usage for the present. Table E.7-35 provides FERC Form 80 report data from 2002 through 2014.

Table E.7-35. Lawrence FERC Form 80 Report Data.

Year	Annual Total Recreation Days	Peak Weekend Average Recreation Days	Capacity Utilization
2002	25,610	137	Access Areas: 23% Boat Launch Areas: 27% Boat Launch Lanes: 27% Marinas: 10% Tailwater Fishing Facilities: 30% Parks: 25% Playground Areas: 25% Trails: 5% Wildlife Areas: 40% Visitor Centers: 2% Other (Sailing Club): 60%
2008	14,326	175	Access Areas: 25% Boat Launch Areas: 30% Boat Launch Lanes: 50% Marinas: 25% Tailwater Fishing Facilities: 30% Parks: 50% Playground Areas: 30% Trails: 20% Wildlife Areas: 40% Visitor Centers: 5% Other: 75%
2014	21,355	278	Boat Launch Areas: 30% Marinas: 40% Portages: 15% Tailwater Fishing Facilities: 30% Trails: 20% Active Recreation Areas: 30% Picnic Areas: 40% Visitor Centers: 20% Informal Use Areas: 20%

Source: LHA 2003, LHA 2009, Essex 2015.

Recreation Facilities, Use, and Aesthetics Study (HDR, 2026d)

In support of this relicensing, Essex conducted a Recreation and Aesthetics Study to identify existing recreation use, as well as recreation resources and activities that may be affected by the continued operation of the Project. The methods and results of the Recreation and Aesthetics Study are described in detail in Essex's Recreation and Aesthetics Study Report filed with the Commission on April 27, 2026.

Focus Group Discussions

In accordance with the approved study plan, Essex established a Focus Group of representatives from community organizations and governmental agencies to assist in the selection of recreation facilities to be included in the study. Essex hosted recreation Focus Group discussions with representatives from the following community organizations and government agencies: GWL, NPS, Lawrence Redevelopment Authority, City of Lawrence, Massachusetts Department of Conservation and Recreation (MADCR), Lawrence Community Works (LCW), Greater Lawrence Community

Boating, Andover Village Improvement Society (AVIS), Lawrence Conservation Commission, City of Lawrence Recreation Department, the Town of Andover, and the Town of Methuen.

On July 15, 2024, Essex sent a data request letter to the Focus Group participants for documentation (visitor use records, guidance documents, maintenance records, engineering plans, etc.) of recreational facilities and uses within the Project area.

Essex requested input from the Focus Group on the identification and selection of recreation sites and facilities by letter dated September 3, 2024, and invited the Focus Group to participate in a virtual meeting held on September 19, 2024. Essex also invited Focus Group participants to attend the October 2024 field inventory assessment. Focus Group participants from four organizations (GWL, NPS, LCW, and AVIS) attended the September 2024 meeting and described several recreational sites, all of which were included in the October 2024 field inventory assessment. Essex sent out an invitation to the Focus Group and anticipates holding a meeting to discuss the study results and solicit additional views and opinions on the Project's recreation facilities by July 1, 2026.

Field Inventory Assessment

Essex conducted a field inventory to document existing non-Project recreation facilities within the Project's vicinity in October 2024. Recreation sites inventoried included Abe Bashara Boathouse, Merrimack River Trail, Lawrence Riverfront State Park, Pemberton State Park, Campagnone Common/North Common, Lawrence Heritage State Park, Oxford Park, Nunzio DiMarca Park/Ferrous Park , Sewer Interceptor, Spicket River Greenway at Manchester Street Park, Boys and Girls Club of Lawrence, Raymond J. Martin Riverside Park, Methuen Boat Launch, Phillips Academy Boathouse, Strazzula Reservation, and Bay Circuit Trail. As noted above, these recreation sites were selected in consultation with the Focus Group.

The field inventory included a brief description of the site, a catalog of the facilities and amenities provided at the site, photographs of the site, and an estimate of parking capacity provided at the site. Locations of recreational facilities were recorded and mapped using GPS. Additional information recorded during the field inventory included a description of the type and location of existing recreation facilities, the type of recreation provided (e.g., boat access, angler access, picnicking), existing amenities and sanitation, the type of vehicular access and parking (if any), the suitability of facilities to provide recreational opportunities and access for persons with disabilities (i.e., compliance with current Americans with Disabilities Act [ADA] standards for accessible design), GPS location data, representative photographic documentation of recreation facilities, and any on-site comments provided by Focus Group participants.

The physical condition of amenities at each recreation site was evaluated using a condition rating system to rate the site's intended function and ability to support recreation use. Field inventory documentation, including a map of non-Project recreation facilities; representative photographs; and a description of the amenities available at each facility, are included in the study report filed with the Commission on April 27, 2026. The field inventory results indicate that the Project area contains a substantial number of existing recreational resources and use opportunities. The majority of the recreation sites inventoried were reported in good condition, with most offering sufficient parking, signage, and amenities for both active and passive recreation types.

Field Reconnaissance and Visitor-Intercept Surveys

Essex conducted visitor-intercept surveys and field reconnaissance at ten recreational sites from May 1 to October 1, 2025. As per the SPD, Essex conducted visitor-intercept surveys and field reconnaissance at ten recreation sites within the study area (Figure E.7-42). Recreation sites were selected in consultation with the Focus Group participants. Focus Group participants were provided with the draft final list of ten sites on April 3, 2025, for review and comment; no comments were received on the final selection of sites.

Surveys were administered on two randomly selected weekdays and two weekend days each month during the peak recreation season (May 1–October 1, 2025). In addition, surveys were conducted on three federal holidays occurring within the study period: Memorial Day, Juneteenth, and Independence Day.

Survey questions were developed using the general concepts and guidance outlined in the USFS National Visitor Use Monitoring Handbook (USFS 2007), as well as question formats applied in recreation studies for other FERC hydropower relicensing projects. The personal interview questions included the following topics: general user information; age group; resident/visitor; purpose and duration of visit; distance traveled; history of visiting the site or area; types of recreational activities respondents participated in or planned to participate in during their visit; other recreational sites that respondents visited or intended to visit during their trip; general satisfaction with recreational opportunities, facilities, and the respondents overall visit, and/or areas that need improvement; and day use/overnight lodging during their visit.

Surveys were conducted during daylight hours between approximately 8:00 am and 9:00 pm. Individual survey locations were visited on a rotating schedule to capture recreation use occurring at different times of the day. At each site, a team of two survey technicians conducted interviews with individual recreationists and groups. The survey team included a bilingual English–Spanish technician to ensure effective communication with Spanish-speaking respondents. Respondents provided verbal answers to survey questions, and a technician recorded responses in real time using the Jotform survey platform. Survey responses given in Spanish were translated into English by the bilingual survey technician. Hard copies of the survey form (in both English and Spanish) were also available to respondents upon request.

Technicians remained at each site for approximately one hour to conduct interviews and collect field reconnaissance data. Reconnaissance activities included documenting (a) the types of recreation activities observed, (b) the approximate count of vehicles present, and (c) the approximate numbers of recreationists at each site. Technicians also recorded the date, time, and observed weather conditions during each survey period.

A total of 228 visitor-intercept surveys were administered across the ten recreational sites during the study period. The most survey responses were collected from the Lawrence Riverfront State Park and Campagnone (North) Common, each accounting for 21% of all completed surveys, followed by Pemberton State Park at 18%. This distribution aligns with respondents' reported visitation over the past 12 months, with 41% reporting visits to Lawrence Riverfront State Park, 35% to Campagnone Common, and 29% to Pemberton State Park. At all facilities, technicians generally reported less activity during the early daylight hours and during rainy, cool parts of the day. Respondents reported that their visits to the recreational sites typically occurred between May and August. The average time respondents spent at the surveyed site was approximately 2 hours.

The majority of survey respondents (97%) reported traveling between 0 and 25 miles to access the study area, the same percentage of respondents also characterized themselves as frequent, repeat visitors, reporting visitation rates of three or more times per year. Only 3% of respondents reported staying overnight in accommodations other than their own home. The most common modes of transportation used by respondents to arrive at the site were travel by foot (39%) and arrival by a single vehicle (58%).

Regarding party size, most respondents reported visiting the study area either alone (58%) or in parties of two (24%). Overall, respondents reported no significant crowding issues at the surveyed recreation sites, with 82% reporting that the surveyed site was "not crowded" or "slightly crowded." Among the respondents who reported crowding, extremely crowded conditions were reported at Pemberton State Park (24%), Lawrence Heritage State Park (7%), Lawrence Riverfront State Park (5%), and Abe Bashara Boathouse (2%).

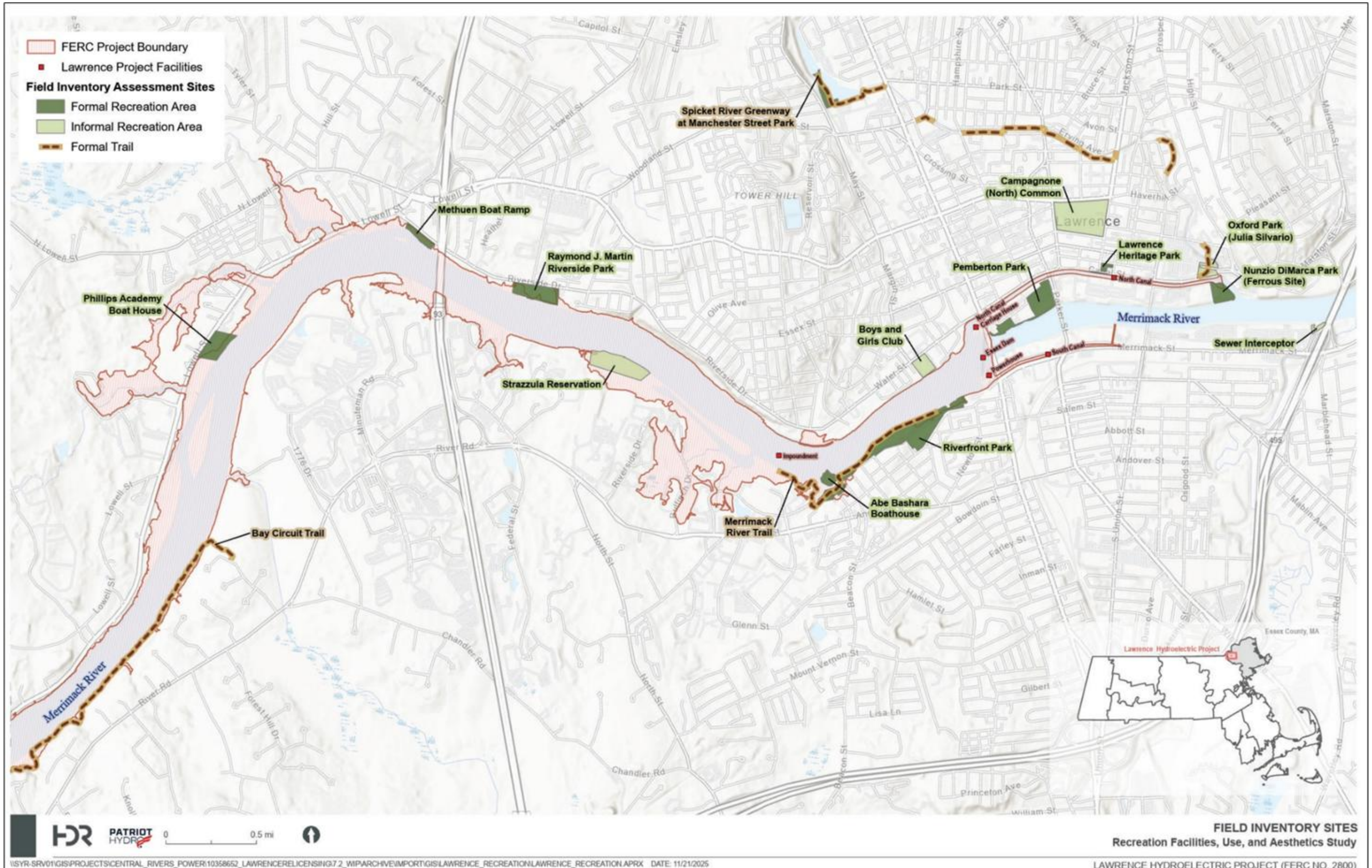
Respondent ages were relatively evenly distributed, with 55% of respondents aged 40 years or older and 45% younger than 40. The most common recreational activities participated in across the recreation sites were forms of exercise (walking, jogging, running, biking), day use activities (picnicking, playground, lounging) and fishing (onshore and boat). The majority of respondents (71%) did not transport recreational equipment to the surveyed site. Among respondents who reported transporting equipment, the most common items were fishing gear, sports equipment (baseball, basketball, tennis racket), and boats (motorized and non-motorized). Respondents who reported boating mostly used jet skis or motored boats (42%) or kayaking or scull boats (31%). Of the 35 participants who responded to the survey question pertaining to boat launches, 66% reported that they experienced no difficulties launching either hand-carry or motorized boats. Difficulties launching both motorized and hand-carry boats were reported at Abe Bashara Boathouse and Merrimack River Trail. Difficulties specific to motorized boats were reported at Lawrence Riverfront State Park and Pemberton State Park, and difficulties launching hand-carry boats were reported at Nunzio DiMarca/Ferrous Park.

In terms of facility conditions, 81% of respondents reported being either "satisfied" or "very satisfied" with the condition of the surveyed site. Of the 24 respondents who reported being "dissatisfied" or "very dissatisfied" with facility conditions, 33% of those were associated with Pemberton State Park. Overall, dissatisfaction reported by participants was largely related to public safety and trash/litter accumulation, along with overgrown vegetation, and a lack of amenities.

Four survey respondents reported visiting and/or participating in a guided tour at the Project recreational facility, the North Canal Carriage House. Minimal feedback was received from the Recreational Study participants regarding the Project's recreational facility. Two participants provided comments suggesting more public outreach and partnerships with schools, and improving public accessibility.

When asked about observations of vegetation and waterborne trash along the canals, over half of respondents acknowledged trash in or around the canals. Respondents generally expressed satisfaction with routine trash clearing and vegetation maintenance performed. Approximately 12% of respondents reported that they did not observe trash in the canals at the time of the survey (corresponding to dates at the beginning of August, the middle of May and June, and the end of July and September). Approximately 12% of respondents expressed interest in increased frequency of trash clearing efforts. Of the 105 participants who responded to the survey question, 38% of respondents commented on vegetation in or around the canals. Of those respondents, approximately 43% were generally satisfied with the condition of the vegetation around the canals and canal walls. Respondents who were dissatisfied with vegetation along the canals reported observation of vegetation overgrowth and non-native species, along with the effect of trash and vegetation on fishing access in the canals, as well as a need for improved water quality and canal water levels.

Figure E.7-42. Recreation Inventory Assessment Sites.



E.7.6.1.6 Existing Shoreline Buffer Zones

At normal pool elevation of 44.2 feet NGVD29, there are approximately 20 shoreline miles bordering the impoundment impounded by the Essex Dam. In Massachusetts, the Wetlands Protection Act (Massachusetts General Laws Chapter 131, Section 40) protects important wetlands and other resource areas such as land subject to flooding, riverfront area[8], and land under water bodies. MADEP oversees administration of the Wetland Protection Act through its regulations (310 Code of Massachusetts Regulations 10.00). These regulations define the buffer zone as 100 feet around any bank, wetland, beach, dune, or flat bordering the ocean, any estuary, creek, river, stream, pond or lake; land under any waterbody; land subject to tidal action, coastal storm flowage, or flooding; and riverfront area (200 feet from the river or 25 feet in some urban areas). Activities that remove, fill, dredge, or alter an area in the buffer zone must be permitted by the local conservation commission that protects wetland interests.

The General Ordinances for the City of Lawrence include the Wetlands Protection Ordinance, which protects additional resource areas, for additional values, with additional standards, and procedures stricter than those of the Wetland Protection Act. The buffer zone is defined as “the area of land extending one hundred (100) feet horizontally outward from the boundary of the following resource areas: Freshwater Wetlands, Marshes, Wet Meadows, Bogs, Swamps, Lakes, Ponds, Rivers, Streams, Creeks, Banks, Beaches, Vernal Pools, large isolated wetlands, lands under water bodies, lands subject to flooding or inundation by groundwater or surface water as specified in 310 CMR 10.02 (1).”

E.7.6.1.7 Shoreline Development Policy

The Licensee does not currently have or anticipate the need for a shoreline management plan.

E.7.6.1.8 Recreation Needs Identified in Management Plans

The Massachusetts Statewide Comprehensive Outdoor Recreation Plan (SCORP) was completed in 2017 and covers the period from 2017-2022. The 2017 Massachusetts SCORP guides the distribution of federal money from the Land and Water Conservation Fund to state agencies and municipalities for the acquisition of open space, renovation of parks, development of new parks, and trail construction. The SCORP examined the current supply of outdoor recreation and examined Massachusetts’ residents’ outdoor recreation needs. Outdoor recreation demand was evaluated through three online surveys (one for recreation users, one for municipal recreation providers, and one for land trusts), public meetings throughout the state, and a statistically relevant phone survey. The results of public participation were analyzed and used to formulate the SCORP’s goals and objectives, which are prioritized in the grant rating system.

As described within the SCORP, the direction for recreation in the state is guided by four overarching initiatives with associated goals and recommendations:

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[8] Human-made canals, such as the North and South Canals in Lawrence, do not have a riverfront area under Massachusetts’ Wetlands Protection regulations. 310 Mass. Reg. 10.58 (2)g.

1. Access for Underserved Populations;
2. Support the Statewide Trails Initiative;
3. Increase the Availability of Water-based Recreation; and,
4. Support the Creation and Renovation of Neighborhood Parks.

The City of Lawrence Open Space and Recreation Plan (OSRP) was completed in 2017 and covers the period from 2017 to 2024. The OSRP was developed by Groundwork Lawrence to manage the City's existing park assets while creating new parks. Through outreach to residents and Geographic Information System analysis, the City of Lawrence developed the following goals and objectives to provide an excellent park system with passive and active recreational opportunities that is equitable for all residents, enhances important natural resources, and values the preservation of the City's historic resources:

- Meet the recreational needs of all residents by providing a diverse range of park amenities that appeal to all ages, genders, and abilities.
- Increase resident awareness about the natural, cultural, recreational, and historic resources provided by Lawrence's park system.
- Preserve and maintaining Lawrence's historic resources and its rich cultural heritage.
- Provide residents with alternative transportation options through the establishment of an interconnected system of rail trails, riverwalks, and greenways.
- Continue to provide opportunities for urban agriculture as a source of local, fresh food for residents.
- Meet the evolving needs of residents by maintaining and renovating existing parks and open spaces.

E.7.6.1.9 Non-Recreational Land Use and Management

Within the Lawrence Project boundary, land cover is a mixture of open water, woody wetlands, urban development, and deciduous forest. There are residential homes and commercial properties along the shoreline of the Project impoundment. Figure E.2-2 in Section E.2.7.1 provides a map of the land cover types within the Lawrence Project boundary.

Essex manages Project lands to provide for safe and efficient operation of the Project and to provide for the protection of scenic, forestry, and natural resources. As described above in Section E.7.6.1.1, recreation areas provided are located at the Project that provide river access.

E.7.6.2 Environmental Analysis

FERC's SD2 identified the following potential resource issues related to Recreation and Land Use:

- Effects of continued Project operation and maintenance of the Project on recreation resources.
- Adequacy of existing recreational access and facilities to meet recreational demand.

Effects of continued Project operation and maintenance of the Project on recreation resources.

The Project is in an urbanized area with medium to high-density development along the shores of the Merrimack River. Land cover within the Project boundary consists of open water, woody wetlands, urban development, and deciduous forest. Commercial and residential development, public parks, trails, and conservation areas are located along the shoreline of the Project's most apparent recreation resource, the impoundment. The maintenance of stable impoundment levels by Essex enhances these river-dependent activities. Essex has recently implemented a subscription e-mail notification system to facilitate timely communication of anticipated impoundment conditions to recreationists, river dependent businesses and the four municipalities with water intakes on the impoundment. The principal facilities that comprise the Project are located in a heavily urbanized setting within the City of Lawrence. The Lawrence Project is a ROR facility with limited impoundment fluctuations and downstream influences, which, among other benefits, support a variety of river-dependent recreation activities.

Adequacy of existing recreational access and facilities to meet recreational demand.

Recreation within the Project area has been extensively documented in regional, municipal, and local planning documents and community surveys. The types of recreational opportunities and facilities are influenced by the Project location and setting. Boating, fishing, paddling, and hiking are some of the most popular recreational activities that occur in the Project area.

In support of this relicensing, Essex conducted a Recreation Facilities, Use, and Aesthetics Study to assess the recreational resources within the Project area. Recreational facilities included in the Recreation Study were selected in consultation with stakeholders. Findings from the Recreation Study in terms of the type of recreational activities participated in, availability of recreational resources, facility demand, and community concerns were generally consistent with the existing information on recreational resources in the Project area.

Overall, the recreational facilities included in the Field Inventory Assessment were observed to be in good condition, with most providing amenities such as public parking, signage, restrooms, and picnic areas. Recreational use during the Field Reconnaissance and Visitor-Intercept Surveys was mostly observed at developed facilities where there were various public amenities such as boat launches, playgrounds, sports facilities, etc. as opposed to undeveloped recreation areas.

Dissatisfaction with overall conditions of the non-Project recreation facilities was mostly due to trash and litter accumulation, public safety, and need for facility improvements. As is common within any urban environment, trash control and collection were particularly noted as concerns along the North and South Canals, where trash and other river-borne and wind-blown debris commonly accumulate upstream of the canal gatehouses.

Pursuant to Article 17 and the FERC-approved Recreation Plan, Essex provides a handicap-accessible parking area, tours, and interpretive displays at the North Canal Carriage House. Essex typically hosts several tours each year, primarily for school-age children as part of a class tour or extracurricular activities. Feedback received from study participants on the Project's recreational facilities was minimal. Two Recreational Study participants recommended more public outreach to improve public awareness of, and accessibility to, the facility.

Essex has remained proactive in managing trash within the canals. In 2019, Essex began implementing a Trash Removal Plan, in which debris is removed at each canal gatehouse twice a year (Essex 2019b). Additionally, weekly inspections of debris accumulation are performed at each canal gatehouse. When necessary, additional removal efforts are arranged. Vegetation maintenance is an ongoing task, and Essex has contracted with a third party to provide regular vegetation management work.

Under the Recreation Plan, Essex provides a handicap-accessible parking area, tours, and interpretive displays at the North Canal Carriage House, from about May 15-October 15 annually. Tours cover the following topics: 1) how electricity is generated from waterpower; 2) the purpose and operation of the fish passage facilities; and 3) the role of The Essex Company, the Great Stone Dam, North Canal and North Canal Gatehouse (recognized on the National Register of Historic Places) and the South Canal plus South Canal Gatehouse (eligible for National Register listing) in the development of the City, and early industrialization using hydromechanical power. The interpretive displays explain different aspects of the Project's operation.

Additionally, Essex has recently implemented a subscription email notification system to facilitate timely communication of anticipated impoundment conditions to recreationists, river dependent businesses, and the four municipalities with water intakes on the impoundment.

Continued Project operations as proposed by the Licensee is not expected to result in any changes to the adequacy, availability, and accessibility of the non-Project-related recreational facilities or land use within the Project's vicinity.

E.7.6.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on recreation resources.

E.7.6.4 Unavoidable Adverse Impacts

Continued Project operations as proposed by the Licensee are not expected to result in any changes to recreation or land use.

E.7.7 Aesthetic Resources

The subsections below describe aesthetic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the:

- Recreation Facilities, Use, and Aesthetics Study (HDR 2026d)
- Historically Significant Waterpower Equipment Study (HDR 2025a)
- Condition Assessment of the North and South Canals (HDR 2025b)

These reports are included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.7.1 Affected Environment

The Lawrence Project is located in an urban industrial setting with various commercial and residential properties as well as recreation facilities. The Project operates in ROR mode, which maintains the aesthetic qualities of the Merrimack River. Several residential properties along the impoundment and the historic districts of the City of Lawrence are provided scenic views of the river. The Essex Dam, a 35-foot-high by 900-foot-long stone masonry dam built in 1848, is clearly visible from the Broadway Street Bridge. The concrete powerhouse is also visible from Broadway Street, however, the powerhouse is largely below ground and the exposed portions of the powerhouse are screened by a berm (LHA 1977). Appropriate trees and shrubs were planted to soften the Project structures (LHA 1977). The exposed walls of the Project were constructed of materials designed to be compatible with the adjacent rough-cut granite blocks of the dam and canal embankments (LHA 1977). The utility connector is located in a corridor already containing overhead utility lines. The North and South Canals and associated structures contribute to the aesthetic qualities of the area and are visible from the adjacent roadways, pedestrian walkways, and recreation areas.

Several observation/picnic areas and trails in the Project area provide views of the Merrimack River and historical structures, including multiple textile mills, gatehouses, and canals. See Figure E.7-43. Of note, the North Canal Carriage House is a recreation area provided by Essex that provides an opportunity for viewing the Carriage House and Essex Dam. Downstream of Essex Dam, Pemberton Park and the Riverwalk are popular access areas for viewing the Merrimack River. Ferrous Park and Oxford Park provide access for viewing the North Canal spillway, Spicket River, and Merrimack River. The Merrimack River upstream of the Essex Dam is enjoyed by recreationists at the Riverfront State Park and various conservation areas that border the Project impoundment.

Figure E.7-43. Aerial View of North Canal.

An allegation of non-compliance was filed by Complainants in 2017 regarding the visual quality of the North and South Canals. Complainants were concerned about the vegetation growing from the Canal walls, the water levels within the Canals, and trash accumulation in the Canals. Essex was not found to be in violation of its license (FERC 2019). As a follow-up item to the inspection performed by FERC staff in response to the complaint, Essex maintains a Trash Removal Plan, in which debris is removed at each canal gatehouse twice a year (Essex 2019b). Additionally, weekly inspections of debris accumulation are performed at each canal gatehouse. When necessary, additional removal efforts are arranged. Vegetation maintenance is an ongoing task, and Essex has contracted with a third party to provide regular vegetation management work. Vegetation survey results performed in support of relicensing indicated that the canal corridor (North and South Canals) vegetation was dominated by invasive species, with native species occurring only in limited abundance.

Studies Performed in Support of Relicensing

<u>Recreation Facilities, Use, and Aesthetics Study (HDR 2026d)</u>

Pursuant to the RSP, on October 30, 2024, June 28, 2024, and May 20, 2025, Essex surveyed the North and South Canals on foot and by vehicle to visually inspect and document waterborne trash as part of the Recreation Facilities, Use, and Aesthetics Study (HDR 2024d). Observations were recorded regarding the evidence and location of waterborne trash. Data collected during this portion of the survey included field notes, digitized locations of waterborne trash, and photographic documentation. Waterborne trash was characterized by dominant type (i.e., plastics, wood, or metal). Trash distribution was classified in the field based on visual assessment, with debris documented as scattered when items were dispersed over an area without clear accumulation, and as a clump when multiple pieces of trash were physically clustered or concentrated at a single location. Accumulated waterborne trash includes material floating on the water's surface, observed on the surface of the canal wall, or on the surface of the canal bed. While Essex was not required to document observed canal bed trash, if it was exposed, Essex documented it and included it in the analysis.

The total study area encompassed approximately 29.6 acres (e.g. the total acreage of the North and South canals). In total, over the three surveys, the mapped waterborne and canal bed trash acreage approximated 0.722 acres (representing 2.4% of the total study area). Given that most trash distribution was classified as "scattered" over an area, this is an overly conservative estimate, and the actual percentage is most likely much lower.

For the purposes of this survey, "trash" was defined very broadly. Any anthropogenic or non-native foreign object observed was classified as trash. Surveyors did not attempt to differentiate between legacy debris or traditional litter. Most of the waterborne trash accumulation within the North and South Canals appears to be derived from upstream inputs (the Merrimack River) as well as direct canal inputs (accidental and intentional littering) and from runoff events (also likely from accidental and intentional littering). Observed trash primarily consisted of common consumer debris and woody material, with accumulation influenced by upstream sources, stormwater runoff, and surrounding land use. Project operation and maintenance activities were not identified as a meaningful contributor to trash distribution patterns within the canals.

When asked about observations of vegetation and waterborne trash along the canals, over half of respondents acknowledged trash in or around the canals. Respondents generally expressed satisfaction with routine trash clearing and vegetation maintenance performed. Approximately 12% of respondents reported that they did not observe trash in the canals at the time of the survey (corresponding to dates at the beginning of August, the middle of May and June, and the end of July and September). Approximately 12% of respondents expressed interest in an increased frequency of trash clearing efforts. Of the 105 participants that responded to the survey question, 38% of respondents commented on vegetation in or around the canals. Of those respondents, approximately 43% were generally satisfied with the condition of the vegetation around the canals and canal walls. Respondents who were dissatisfied with vegetation along the canals reported observation of vegetation overgrowth and non-native species, along with the effect of trash and vegetation on fishing access in the canals, as well as a need for improved water quality and canal water levels.

Historically Significant Waterpower Equipment Study (HDR 2025a)

In accordance with the approved study plan, a historic waterpower equipment study was performed of the Project's APE. Essex retained HDR to conduct the survey. The methods and results of the historic waterpower equipment study are detailed in Essex's report, entitled *Historically Significant Waterpower Equipment Study Report, Lawrence Hydroelectric Project (FERC No. 2800).*

HDR architectural historians conducted desktop and in-person archival research to develop a regional hydropower historic context and prepare property histories for the Lawrence Project. A reconnaissance survey of the APE was conducted by HDR in October 2024 and consisted of photographing Project-related waterpower equipment and facilities, including the former North Canal locks and various penstock gates along both canals. Based on background literature and field reconnaissance, HDR identified a total of thirty pieces of historically significant waterpower equipment, twenty-six of those being penstock headgate systems. The penstock headgate systems and equipment built into the walls of the canals are owned by their respective mill owners and are not licensed Project structures. Essex does not own the penstock headgate systems and has no associated rights to these structures. Each component identified in this study was recommended as contributing to its related NRHP-listed or recommended-eligible property.

HDR concluded that ongoing Project operations have a low potential to affect the integrity of historic properties within the APE. However, activities such as replacing mechanical equipment or controls or discontinuing maintenance of equipment that is no longer required for safe and efficient Project operations have the potential to affect historically significant waterpower equipment.

Condition Assessment of Historic Properties and Associated Canal System (HDR 2025b)

In support of this relicensing, Essex conducted the Condition Assessment of Historic Properties and Associated Canal System Study (HDR 2025b) to determine the extent to which Project operations, including water flow in the North and South Canals, have an effect on historic properties, to conduct a condition and structural assessment of the canals, and to identify potential impacts of current and proposed Project operations on historic resources.

In accordance with the approved study plan, Essex reviewed available operational data, engineering evaluations, and other relevant documentation (including the 2019 North Canal Condition Assessment) to identify areas of deterioration and disrepair previously documented along the North and South Canal walls that could lead to potential collapse or failure of the historic structures. In October 2024, Essex conducted a field survey of the historic canal structures to document the current conditions of the canals. Observations from the survey were compared to the conditions identified in the existing documentation, as well as qualitative historic water level, flow, and operational data. Collectively, this information was used to assess potential Project-related effects on the historic canal system infrastructure.

The canal walls are comprised of various materials and construction types ranging from dry-laid stone (without mortar), masonry (dry-laid stone with mortar connecting stones), various types of concrete, brick-and-mortar, and combinations of the aforementioned. The conditions observed are typical for walls of this age. Detailed information on the construction of the walls is limited. Most of the condition and structural assessment was limited to observations made of the exposed portions of the walls during the field visit.

Based on the observed conditions during the site visit, Essex assigned a risk level category between Risk Level 1 (heavily impacted and in a state of heavy disrepair) and Risk Level 5 (structures that are in great condition). Risk Levels 1 and 2 are generally reserved for conditions that impact stability, plumbness, or heavy deterioration/erosion. Risk Levels 3, 4, and 5 usually indicate the wall section is stable and generally plumb.

Most of the observed wall sections in the North and South Canals were assigned Risk Levels 3, 4, and 5, indicating that the walls were stable and generally plumb. Effects on the canal walls and historic properties that were observed during the site visit appeared consistent with long-term weathering, erosion, and corrosion associated with age and long-term submergence, and runoff/seepage from surrounding features. Intake structures abandoned by their associated mill owners were typically observed in a state of disrepair associated with Risk Levels 1 and 2.

Effects on the canal walls and historic properties that were observed during the site visit appear consistent with long-term weathering, erosion, and corrosion associated with age and long-term submergence, and runoff/seepage from surrounding features. Project operations have had a limited effect on the historic properties along the North and South Canals. Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure where there are voids or erosion. Intake structures anchored to the canal wall section can pull the stones with them as they lean into the canal. Maintenance and removal of unused intakes are the responsibility of the mill owner and are not associated with Project operations.

E.7.7.2 Environmental Analysis

FERC's SD2 identified the following potential resource issue related to aesthetics:

- Effects of Project operation and maintenance on land use and aesthetic resources, including the historic industrial context of the Project structures and features.

Project facilities such as the dam and canal system have been in place since the mid-1800s, while the hydroelectric facilities have been in place since the late 1900s. The aesthetic resources of the Project largely reside in the historic infrastructure of the Project, which is located in an urban industrial setting. The potential effects of Project operation and maintenance on land use and aesthetic resources were assessed through each of the three studies summarized above in Section E.7.7.1.

As noted above, trash accumulation affects the visual character of the North and South Canals. The combination of past and present land use activities (e.g., industrialization, commercial development, residential areas) in and around the Project area have contributed and will likely continue to contribute to the accumulation of waterborne trash within the Project's canals. However, the complexity and diversity of historical and current land use activities in the study area create a problem with tracing and identifying the sources of waterborne trash and its movement and distribution within the canals. Observed trash primarily consisted of common consumer debris and woody material, with accumulation influenced by upstream sources, wind, stormwater runoff, and surrounding urban land use. Project operation and maintenance activities have not been identified as a meaningful contributor to trash distribution patterns within the canals. Essex regularly removes trash from the canals through implementation of the Trash Removal Plan.

The presence of the historic Great Stone Dam, canal system, including gatehouses, wasteways, and numerous penstock headgate systems all contribute to a visual character typical of nineteenth century mill and waterpower developments in New England. Effects on the canal walls and historic properties that were observed during the Condition Assessment of Historic Properties and Associated Canal System (HDR 2025b) indicate that the North and South Canals appear consistent with long-term weathering, erosion, and corrosion associated with their age and long-term submergence and runoff/seepage from surrounding features. Project operations have had a limited effect on the historic properties along the canals.

Under the current FERC license, Essex is not required to maintain a specific water level in either of the Canals, or to allocate downstream flows between the canals and the main channel of the

Merrimack River. Typically, large changes in water surface elevations and flows have the most impact on structures. However, in recent years, flow through the Canals has been limited to leakage through the gatehouses. In the North Canal, large changes in either water surface elevation or flow have been limited to canal water level management. In the South Canal, large changes in either water surface elevation or flow have been limited to large storm events.

Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure or pulling stones with them as they lean into the canal. Maintenance and removal of unused intakes or intakes in a state of disrepair are the responsibility of the mill owner and are not associated with Project operations.

Existing Project facilities are an integral part of the river's aesthetic character. Essex is not proposing to modify Project operations. However, Essex proposes to remove the North and South Canals from the FERC Project boundary. Continued operation of the Project will help maintain the aesthetic quality of the Merrimack River by providing a continuous flow in the Project's downstream areas, including the North and South Canals, as well as reducing fluctuations of water level in the impoundment. Removal of the Canals from the FERC Project boundary will not have any effect on the aesthetics of the canal system. No impacts on aesthetic resources are expected as a result of continued Project operations.

E.7.7.3 Proposed Environmental Measures

Essex proposes continued operation of the Project with certain environmental PM&E measures consistent with the measures required by the Project's existing license. Essex believes that the continued operation of the Project, as proposed, will limit effects on aesthetic resources.

E.7.7.4 Unavoidable Adverse Impacts

The continued operation of the Project as proposed by the Licensee is not expected to have any unavoidable adverse effects on aesthetic resources.

E.7.8 Cultural Resources

The subsections below describe cultural resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by the Licensee on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD, other existing information, and from the results of the:

- Historically Significant Waterpower Equipment Study (HDR 2025a)
- Condition Assessment of Historic Properties and Associated Canal System (HDR 2025b)

These reports are included in Appendix A of this exhibit. However, Essex notes that certain study activities and analyses are ongoing. As appropriate, further discussion of any relevant data will be provided in the FLA to be filed with the Commission by November 30, 2026.

E.7.8.1 Affected Environment

In considering a new license for the Project, FERC has the lead responsibility for compliance with applicable federal laws, regulations, and policies pertaining to historic properties, including the National Historic Preservation Act of 1966 (NHPA), as amended. Section 106 of the NHPA (Section 106) requires federal agencies to consider the effects of their undertakings on historic properties and to afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment.

The regulations implementing Section 106 (36 CFR Part 800 – The Protection of Historic Properties) define a "historic property" as any precontact or historic period district, site, building, structure, or individual object listed in, or eligible for inclusion in, the National Register of Historic Places (NRHP). This term includes artifacts, records, and remains that are related to and located within historic properties, as well as properties of traditional religious and cultural significance (often referred to as "traditional cultural properties" or "TCPs") that meet the NRHP criteria. The Section 106 process is intended to accommodate historic preservation concerns with the needs of federal undertakings through a process of consultation with agency officials, the State Historic Preservation Officer (SHPO), Tribal Historic Preservation Officers, federally recognized Indian tribes, and other parties with a potential interest in an undertaking's effects on historic properties. Concurrent with the filing of the PAD and the NOI, Essex requested designation as the Commission's non-federal representative for purposes of conducting informal consultation pursuant to Section 106. By notice dated August 15, 2023, FERC designated Essex its non-federal representative for purposes of conducting informal consultation pursuant to Section 106.

The Secretary of the Interior has established the National Register Criteria for evaluating properties for inclusion in the NRHP (36 CFR Part 60). In accordance with the criteria, properties are eligible if they are significant in American history, architecture, archaeology, engineering, or culture. The quality of significance is present in historic properties that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:

- Criterion A: Are associated with events that have made a significant contribution to the broad patterns of our history; or
- Criterion B: Are associated with the lives of persons significant in our history; or
- Criterion C: Embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant or distinguishable entity whose components may lack individual distinction; or
- Criterion D: Have yielded or may be likely to yield information important in prehistory or history.

E.7.8.1.1 Cultural Context - Cultural Sequence of the Project Area

The archaeological record of Precontact and Historic period populations in Massachusetts begins 13,000 years ago before present (B.P.) at the end of the last Ice Age. This section provides a brief overview of the cultural context of the region.

Precontact Period

The Precontact Period is divided into three major cultural stages or periods that define Precontact cultural behaviors and developments in northeastern Massachusetts. The cultural stages or periods are defined as Paleoindian (13,000 to 10,000 B.P.), Archaic (10,000 to 3,000 B.P.), and Woodland (3,000 to 500 B.P.). The Archaic and Woodland periods are each comprised of three subperiods, designated as Early, Middle, and Late, based on defined cultural and technological traits. The cultural stages or periods of the Precontact Period are as follows:

- Paleoindian Period (13,000 to 10,000 B.P.)
- Archaic Period (10,000 to 3,000 B.P.)
    - Early Archaic Period (10,000 to 8,000 B.P.)
    - Middle Archaic Period (8,000 to 6,000 B.P.)
    - Late Archaic Period (6,000 to 3,000 B.P.)
- Woodland Period (3,000 to 500 B.P.)
    - Early Woodland Period (3,000 to 2,000 B.P.)
      Middle Woodland Period (2,000 to 1,000 B.P.)
      Late Woodland Period (1,000 to 500 B.P.)

The Paleoindian Period (13,000 to 10,000 B.P.) is defined as the earliest evidence of peopling and human occupation in present-day Massachusetts occurring during the Late Glacial Interstadial warming period after the Last Glacial Maximum, which is temporally defined as the Late Pleistocene and Early Holocene epochs. The Younger Dryas (12,900 to 11,600 B.P.) reversed gradual climatic warming during the Late Glacial Interstadial, creating a tundra environment with spruce parkland flora and an ideal environment for a variety of Pleistocene megafauna (e.g., mastodons, giant beaver) (Newby et al. 2005, Lothrop et al. 2011, Ridge 2003). Paleoindian subsistence practices relied heavily on a hunter-gather strategy with an emphasis on large migratory animals and migrating caribou populations (Ritchie and Funk 1973, Lothrop et al. 2016). Movement, mobility, and settlement patterns of Paleoindian peoples have been associated with seasonal fauna migratory routes, select topographic features, and procurement of high-quality lithic materials from select sources (Lothrop et al. 2011, 2018). Paleoindian Period archaeological sites in New England and the Canadian Maritime Provinces typically consist of a sparse lithic tool assemblage that includes fluted projectile points, endscapers, gravers, and blade technology (Robinson 2011, Robinson and Ort 2013, Singer 2017). Previous archaeological investigations of Paleoindian archaeological sites in Essex County include the Bull Brook and Bull Brook II sites in Ipswich, Massachusetts (Grimes et al. 1984, Robinson et al. 2009). The Memorial Park 2 Locus Site (19-ES-758) located to the southeast of the Project site along the Shawsheen River in Lawrence, Massachusetts, yielded an untyped projectile point and chert graver associated with Paleoindian occupation (Waller and Ritchie 2003, Bell 2012). No Paleoindian Period sites have been identified within the Project boundary.

The Archaic Period (10,000 to 3,000 B.P.) is a cultural stage or period that seriates from the preceding Paleoindian Period (13,000 to 10,000 B.P.) based on a variety of differing cultural material assemblages and settlement and subsistence patterns concurrent with the temporal shift from Pleistocene to Holocene geological epochs (e.g., Ellis et al. 1998; Spiess 1992). Archaeologists have temporally subdivided the Archaic Period into Early Archaic (10,000 to 8,000 B.P.), Middle

Archaic (8,000 to 6,000 B.P.), and Late Archaic (6,000 to 3,000) subperiods. Each subperiod is discussed separately below.

Archaeological sites and materials relating to the Early Archaic Period (10,000 to 8,000 B.P.) are comparatively rare compared to the other periods of the cultural chronology and characterized as small social groups occupying riverine and lacustrine settings with an inclination to inhabit mosaic landscapes within former glacial lake basins that influenced increased generalized subsistence strategies (Nicholas 1987, 1988). Three cultural and lithic traditions are diagnostically assigned to the Early Archaic Period and include the Late-Paleoindian, the Piedmont (bifurcated base lithic technology), and the Gulf of Maine Archaic Tradition (Jones 1999; Funk 1997; Robinson and Petersen 1993). The Morrill Mound Site (19-ES-281) located at the mouth of the Merrimac River in Salisbury, Massachusetts, contained red ochre cremation burials associated with full-channel gouges, stone rods, celts, and atypical serrated and notched projectile points with the oldest ^{14}C radiocarbon date at 8,500 ± 80 B.P. (AA 21974) (Robinson 1992, 2006). No Early Archaic Period sites have been identified within the Project boundary.

The Middle Archaic Period (8,000 to 6,000 B.P.) is ecologically defined as a dry and warm climate containing a diversity of flora and fauna that influenced increased foraging behaviors compared to preceding cultural periods (Dincauze and Mulholland 1977). Archaeological sites of this period are represented by permanent or semi-permanent riverine-located settlement strategies where social groups would seasonally convene to exploit anadromous and catadromous fishes (Dincauze 1974,1976; Nassaney 1999). Dincauze (1976) proposes an “Atlantic Slope Macrotradition” ranging from North Carolina to New Hampshire that establishes an early broadpoint stylization beginning during the Early Archaic Period and regionally manifesting into Neville and Neville-variant projectile points. Other diagnostic technologies of the Middle Archaic Period include Stark projectile points, atlatls, knives, ulu (semi-lunar knives), perforators, axes, adzes, celts, scrapers, abraders, gouges, and harpoons. The Lawrence Stadium Site (19-ES-200) to the southeast of the Project site, along the Shawsheen River in Lawrence, Massachusetts, identified a Middle Archaic component, while no Middle Archaic Period sites have been identified within the Project boundary.

The latter portion and terminus of the Archaic Period is defined as the Late Archaic Period (6,000 to 3,000 B.P.) and represents an increase of flora and fauna diversity, comparable to present-day populations; increased population densities and settlement strategies as evidenced by a higher density of archaeological sites in close proximity to riverine, lacustrine, and coastal locales (e.g., coastal shell middens); and evidence of arboriculture and sylviculture in mast forest settings (e.g., Hart and Asch-Sidell 1997, Snow 1980: 187-259). Archaeologists have identified three separate cultural and technological traditions during the Late Archaic Period and includes the Laurentian (6,000 to 4,500 B.P.), the Susquehanna (4,100 to 2,700 B.P.), and the Small Stemmed/Mast Forest Archaic (6,000 to 1,000 B.P.) (Deal et al. 2022, Dincauze 1975, Ritchie 1969:79-83, Snow 1980: 223-233). Archaeologists do not fully comprehend the complexity of the relationships between the three identified cultural traditions yet are distinguished via projectile point stylizations and lithic toolkits, expressing differing subsistence adaptations, while the Susquehanna tradition is distinct for the development of steatite vessel technology, broadpoint technology, a ceremonial cremation burial tradition, and regional incorporation of copper usage (e.g., Dincauze 1968, Campbell 2016, Leveillee 1999). Late Archaic components have been identified at the Lawrence Stadium Site (19-ES-200), the Den Rock Site (19-ES-203), and the Shawsheen River 2 Site (19-ES-204) along the Shawsheen

River in southeastern Lawrence, Massachusetts. No Late Archaic Period sites have been identified within the Project boundary.

The Woodland Period (3,000 to 500 B.P.) represents a cultural stage or period that differs from the preceding Archaic Period (10,000 to 3,000 B.P.) based on the development of ceramic and bow-and-arrow technologies, the introduction of horticultural practices creating semi-permanent settlements, vast trade networks (e.g., Hopewell Interaction Sphere), complex mortuary ceremonialism (e.g., Orient, Meadowood, Middlesex, and Adena), and defined political systems (e.g., Hasenstab 1999, Mulholland 1988, Snow 1980: 261-344). Archaeologists have temporally subdivided the Woodland Period into the Early Woodland (3,000 to 2,000 B.P.), the Middle Woodland (2,000 to 1,000 B.P.), and the Late Woodland (1,000 to 500 B.P.) subperiods. Each subperiod is discussed briefly below.

The Early Woodland Period (2,000 to 1,000 B.P.) has been defined as a declined population in the wake of the Late Archaic Period (6,000 to 3,000 B.P.) cultural florescence, the introduction of ceramic vessel technology (Vinette I), bow-and-arrow technology, the development of vast trade networks, and increased complex mortuary ceremonialism (Snow 1980). Some archaeologists have argued that cultural ethnicity and the Algonquian language were established as early as this subperiod (Fiedel 1987, 2013). The Den Rock Site (19-ES-203) has been identified as having a Woodland Period component that may date to Early Woodland occupation, but no definitive Early Woodland sites have been identified in the City of Lawrence.

Cultural trends stemming from the Early Woodland Period continue into the Middle Woodland Period (2,000 to 1,000 B.P.) with cultural and technological differences in ceramic decoration and stylization, diagnostic projectile point typologies (e.g., Jack's Reef Horizon [1,500 to 1,100 B.P.] and Fox Creek Phase [1,600 to 1,250 B.P.]), increased presence of exotic lithic materials, and an emphasis on coastal riverine and coastal settings (e.g., Boudreau 2016, Luedtke 1987, Strauss 1993, Snow 1980). The Shattuck Farm site (19-ES-196) in neighboring Salisbury, Massachusetts, contained Fox Creek and Jack's Reef Middle Woodland Period diagnostic projectile points (Luedtke 1985).

In comparison, the Late Woodland Period (1,000 to 500 B.P.) is defined by spatially expanding horticultural practices centered on maize, beans, and squash (Three Sisters), increased permanent village settlements along positioned landforms in major riverine and coastal settings, intricate ceramic vessel design, vast trade networks, and the presence of European exploration and initial settlement beginning by the late 15th century (e.g., Bragdon 1996; Lavin 1987, 2002; Leveillee 2006).

Two archaeological sites: the Village Site 1 (19-ES-182) and Village Site 2 (19-ES-191) do not have a temporal affiliation as referenced on the Massachusetts Cultural Resources Information System (MACRIS); however, both archaeological sites are referenced during the Merrimac River Archaeological Survey conducted in 1930 by Warren K. Moorehead for the Peabody Museum (now the Peabody Essex Museum) in Salem, Massachusetts (Moorehead 1931). Moorehead mentions that "below the dam at Lawrence are extensive sand flats, particularly on the south side of the river. During the construction of the American Woolen Company mills many Indian objects were found [Village Site 2]," additionally noting that "before the textile companies of Lawrence erected the present thirty-foot dam, there were falls opposite the Shattuck site, and great quantities of shad and salmon were taken each spring" (Moorehead 1931:13,23). Village Site 1 (19-ES-182) and Village

Site 2 (19-ES-191) are located along the northern and southern banks of the Merrimac River, in proximity to the Great Stone Dam (LAW. 907), with Village Site 1 located within the northwestern edge of the Project site, and Village Site 2 abutting the southwestern Project boundary.

Historic Period

Ephemeral contact between Native Americans and Europeans along the Gulf of Maine and locally at the mouth of the Merrimack River at modern-day Salisbury and Newburyport, Massachusetts, may have begun as early as the 16th century (e.g., Faulkner 1985, Fisher 2008). Historically, the Pawtucket or Naumkeag Tribe, an Algonquian-speaking population consisting of a loose confederation of villages, lived along the southern extents of the Merrimack River and were allied with the Pennacook Tribe, another Algonquian-speaking population residing along the northern extents of the Merrimac River with extended relations with the northern Wabanaki Confederacy. Due to poor European documentation of Indigenous populations of northeastern Massachusetts in the 17th century, a variety of endonyms have been assigned to potentially the same or differing Indigenous cultural groups. European incursion along the eastern seaboard had direct and indirect ramifications for Native American populations across northeastern North America. Disease and illness, intra and inter-competition for resources, and Atlantic World trade systems altered the Indigenous landscape by the mid-17th century. The earliest settlement of the general area was in 1640 when a group of men from Newbury and Ipswich, Massachusetts, created a settlement in modern-day Haverhill, Massachusetts, and created meadow lots along the western edge of the Spicket River, but no records can be found of who the first settlers were and when they settled in Lawrence, Massachusetts (Wadsworth 1880).

Although there is lacking evidence of historic settlement and development of Lawrence, Massachusetts, the city was originally part of the 1640 Haverhill settlement and the 1642 Andover settlement; and over two centuries later, Lawrence was founded in 1845 and incorporated in 1847 as a “planned mill town based on the textile industry” (Massachusetts Historical Commission [MHC] 1986). The city began with the incorporation of the Essex Company in 1845, which was headed by the company’s President and Chief Stockholder Abbot Lawrence, the city’s namesake, who wanted to harness the power of Bodwell Falls on the Merrimack River (MHC 1986). The Essex Company acquired 4,313 acres, helping the company to secure rights and leases to waterpower, creating a boom in the construction of mills and mill worker housing and associated infrastructural developments within the following decades (MHC 1986). The development of textile and paper mills, with the heavy influx of immigration during the mid-19th to 20th centuries created the expanse and identity of Lawrence, Massachusetts.

The MHC, through the use of MACRIS, has identified one 19th to 20th century historic period archaeological site, known as the Shattuck Street Dump (LAW.HA.1) along the southwestern edge of the Project boundary, while 180 historic architectural resources, mainly 19th to 20th century mill complexes, mill worker housing, and religious institutions have been located within and outside of the Project site (MACRIS 2023). All historic architectural resources located within the Project site are associated with the North Canal Historic District (LAW.A/W), where all contributing elements are also listed in the NRPH.

Lawrence Hydroelectric Project

The Lawrence Hydroelectric Project is located along the Merrimac River in Lawrence, Massachusetts, and the Project consists of 11 facilities including the Essex Dam, or the Great Stone Dam (LAW.907), the Project impoundment, intake canal, powerhouse, turbines and generators, the North Canal (LAW.906), the South Canal (LAW.908), tailrace, fish passage structures, transmission line, and recreational facilities (see Section E.5). The City of Lawrence was founded in 1845 and later incorporated in 1847 with the incorporation of the Essex Company as a planned mill town. Between 1845 and 1896 the construction of the Great Stone Dam (1848), the North Canal (1848), the Locks and Wasteway (LAW.931) (1845), and the South Canal (1866/1896) was conducted to secure rights and leases to waterpower. All of the initial construction by the Essex Company was designed by Charles Storrow, Chief Engineer and Treasurer of the Essex Company, and was constructed by Storrow's successor, Charles Bigelow. The hydroelectric plant, including the Project impoundment, intake canal, powerhouse, turbines and generators, tailrace, fish passage structures, transmission line, and recreational facilities were commissioned in 1981.

The City of Lawrence is named after Abbott Lawrence, the Essex Company's President and Chief Stockholder, who oversaw the design and development of Lawrence into a mill city. Abbott Lawrence later served as United States Minister to the United Kingdom from 1849 to 1852 and provided $50,000 to establish the Lawrence Scientific School at Harvard College (now the Harvard John A. Paulson School of Engineering and Applied Sciences). Certain facilities such as, the Great Stone Dam, the North Canal, and the Locks and Wasteway are listed in the NRHP and are contributing elements to the North Canal Historic District (LAW.A/W) listed in the NRHP on November 13, 1984, and later amended to include the Morehouse Bakery (LAW.789) on May 8, 2009. The South Canal (LAW.908) may be potentially eligible for listing in the NRHP according to Criterion C, given the canal's distinctive type, period, and method of construction. The remaining facilities do not meet the criteria for listing in the State Register of Historic Places (SRHP) or for the NRHP.

E.7.8.1.2 Area of Potential Effects

An area of potential effects (APE) is defined as the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist. The APE is influenced by the scale and nature of an undertaking and may be different for different kinds of effects caused by the undertaking. Although the nature of the Project's potential effects is limited by the nature of this undertaking (the relicensing and continued operation of an existing hydroelectric Project), the Project has the potential to affect historic properties directly or indirectly.

The Commission has not yet defined an APE for the relicensing of the Project. In the context of the FERC relicensing process, the Commission typically defines the APE to include all lands within the existing Project boundary and any lands outside a Project's boundary where cultural resources may be affected by project-related activities that are conducted in accordance with a FERC license.

An APE as typically defined by the Commission for relicensing, is consistent with the potential scope of the Project effects. Accordingly, Essex proposes to adopt this definition of the APE for this undertaking.

E.7.8.1.3 Existing Discovery Measures

Article 29 of the Lawrence Hydroelectric Project license requires the Licensee to consult with the MHC prior to any future construction to assess the need for a cultural resource survey and salvage work.

E.7.8.1.4 Cultural Resources Studies and Consultation

- Based on a review of the MHC's MACRIS database, a portion of the Lawrence Hydroelectric Project is within a National Register Historic District (North Canal National Register Historic District). A total of six (6) archaeological surveys were identified via MHC's MACRIS database occurring within and in the vicinity of the Project boundaries:
- The Phase II Archaeology Survey, Methuen Wastewater Project, Town of Methuen, Essex County, Massachusetts.
- The Phase I Intensive (Locational) Survey, Spicket River Facilities Plan, City of Lawrence, Essex County, Massachusetts.
- The Phase I Archaeological Reconnaissance and Intensive (Locational) Survey, Urban State Heritage Park, City of Lawrence, Essex County, Massachusetts.
- The Phase I Archaeological Reconnaissance and Intensive (Locational) Survey, Lawrence Hydroelectric Project, City of Lawrence, Essex County, Massachusetts.
- The Phase I Intensive (Locational) Survey, Phase II Archaeological Survey, and Phase III Data Recovery, The Shattuck Street Dump Site, City of Lawrence, Essex County, Massachusetts.
- The Phase I Intensive (Locational) Survey, Merrimack Congregation Plant, City of Lawrence, Essex County, Massachusetts.

Studies Performed in Support of Relicensing

<u>Historically Significant Waterpower Equipment Study (HDR 2025a)</u>

In accordance with the approved study plan, a historic waterpower equipment study was performed of the Project's APE. Essex retained HDR to conduct the survey. The methods and results of the historic waterpower equipment study are detailed in Essex's report, entitled *Historically Significant Waterpower Equipment Study Report, Lawrence Hydroelectric Project (FERC No. 2800).*

HDR architectural historians conducted desktop and in-person archival research to develop a regional hydropower historic context and prepare property histories for the Lawrence Project. A reconnaissance survey of the APE was conducted by HDR in October 2024 and consisted of photographing Project-related waterpower equipment and facilities, including the former North Canal locks and various penstock gates along both canals. Based on background literature and field reconnaissance, HDR identified a total of thirty pieces of historically significant waterpower equipment, twenty-six of those being penstock headgate systems. The penstock headgate systems and equipment built into the walls of the canals are owned by their respective mill owners and are not licensed Project structures. Essex does not own the penstock headgate systems and has no associated rights to these structures. Each component identified in this study was recommended as contributing to its related NRHP-listed or recommended-eligible property.

HDR concluded that ongoing Project operations have a low potential to affect the integrity of historic properties within the APE. However, activities such as replacing mechanical equipment or controls, or discontinuing maintenance of equipment that is no longer required for safe and efficient Project operations, have the potential to affect historically significant waterpower equipment.

Condition Assessment of Historic Properties and Associated Canal System (HDR 2025b)

In support of this relicensing, Essex conducted the Condition Assessment of Historic Properties and Associated Canal System Study (HDR 2025b) to determine the extent to which Project operations, including water flow in the North and South Canals, have an effect on historic properties, to conduct a condition and structural assessment of the canals, and to identify potential impacts of current and proposed Project operations on historic resources.

In accordance with the approved study plan, Essex reviewed available operational data, engineering evaluations, and other relevant documentation (including the 2019 North Canal Condition Assessment) to identify areas of deterioration and disrepair previously documented along the North and South Canal walls that could lead to potential collapse or failure of the historic structures. In October 2024, Essex conducted a field survey of the historic canal structures to document the current conditions of the canals. Observations from the survey were compared to the conditions identified in the existing documentation, as well as qualitative historic water level, flow, and operational data. Collectively, this information was used to assess potential Project-related effects on the historic canal system infrastructure.

The canal walls are comprised of various materials and construction types ranging from dry-laid stone (without mortar), masonry (dry-laid stone with mortar connecting stones), various types of concrete, brick-and-mortar, and combinations of the aforementioned. The conditions observed are typical for walls of this age. Detailed information on the construction of the walls is limited. Most of the condition and structural assessment was limited to observations made of the exposed portions of the walls during the field visit.

Based on the observed conditions during the site visit, Essex assigned a risk level category between Risk Level 1 (heavily impacted and in a state of heavy disrepair) and Risk Level 5 (structures that are in great condition). Risk Levels 1 and 2 are generally reserved for conditions that impact stability, plumbness, or heavy deterioration/erosion. Risk Levels 3, 4, and 5 usually indicate the wall section is stable and generally plumb.

Most of the observed wall sections in the North and South Canals were assigned Risk Levels 3, 4, and 5, indicating that the walls were stable and generally plumb. Effects on the canal walls and historic properties that were observed during the site visit appeared consistent with long-term weathering, erosion, and corrosion associated with age and long-term submergence, and runoff/seepage from surrounding features. Intake structures abandoned by their associated mill owners were typically observed in a state of disrepair associated with Risk Levels 1 and 2.

Effects on the canal walls and historic properties that were observed during the site visit appear consistent with long-term weathering, erosion, and corrosion associated with age and long-term submergence and runoff/seepage from surrounding features. Project operations have had a limited effect on the historic properties along the North and South Canals. Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure where there are voids or erosion. Intake structures anchored to the canal wall section can pull the stones with them as they lean into the canal. Maintenance and removal of unused intakes are the responsibility of the mill owner and are not associated with Project operations.

E.7.8.1.5 Reported Archaeological and Historic Resources

Essex reviewed publicly available information regarding previously reported historic and archaeological resources within or adjacent to the proposed APE. This review provides information to better characterize the nature and types of known resources located within the vicinity of the proposed APE.

Archaeological Resources

Essex conducted a review of the MHC's MACRIS database to identify previously reported archaeological resources within the Project's vicinity. Table E.7-36 summarizes the reported archaeological resources within approximately 1,000 feet of the Project boundary.

Table E.7-36. Archaeological Sites within Approximately 1,000 Feet of the Project.

Site Name/Identifier	Period	NRHP Status	Relationship to Project Boundary
Village Site I (19-ES-182)	Prehistoric	Undetermined	Within Project Boundary
Village Site II (19-ES-191)	Prehistoric	Undetermined	Outside of Project Boundary
Shattuck Street Dump Site (LAW.HA.1)	Historic	Undetermined	Outside of Project Boundary

Historic Architectural Resources

Based on a review of MACRIS, 180 total historic architectural resources comprised of 141 NRHP and 39 State Inventoried Properties were identified within approximately 1,000 feet of the Project boundary. Of these, 140 of the identified NRHP properties are contributing elements to four National Historic Districts (North Canal Historic District [LAW.A/W], Downtown Lawrence Historic District [LAW.B], American Woolen Mill Housing District [LAW.E], and American Woolen Company Townhouses [LAW.Z]), one Historic Commercial District (Blakeley and Bicknell Buildings Commercial District [LAW.P]) and one Local Historic District (North Common Local Historic District [LAW.M]). Eight of the identified State Inventoried Properties are contributing elements to three Local Historic districts (North Common Local Historic District [LAW.M], Mechanics Block Local Historic District [LAW.N], and Blakeley and Bicknell Buildings Commercial District [LAW.P]). Table E.7-37 summarizes the reported historic architectural resources within approximately 1,000 feet of the Project boundary.

Table E.7-37. Historic Architectural Resources within Approximately 1,000 Feet of the Project.

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
North Canal Historic District (LAW.A/W)	Essex Company Machine Shop (LAW.4)	1846	Yes	Yes	Outside of Project Boundary
	Pemberton Manufacturing Company Main Mill (LAW.4)	1861	Yes	Yes	Outside of Project Boundary
	Essex Company Offices and Yard (LAW.10)*	1883	Yes	Yes	Outside of Project Boundary
	Atlantic Cotton Mills Boarding House (LAW.61)	1847	Yes	Yes	Outside of Project Boundary
	Washington Mills – Building #1 (LAW.217)	1868	Yes	Yes	Outside of Project Boundary
	Bay State Woolen Mills Boarding House (LAW.219)	1847	Yes	Yes	Outside of Project Boundary
	Everett Mills Company Weaving and Spinning Mill #5 (LAW.255)	1909	Yes	Yes	Outside of Project Boundary
	North Canal Gatekeeper's House (LAW.263)	1845	Yes	Yes	Within Project Boundary
	Upper Pacific Cotton Mill Weave Shed and Office (LAW.264)	1887	Yes	Yes	Outside of Project Boundary
	Upper Pacific Cotton Mill Turbine House Fragments (LAW.265)	1852	Yes	Yes	Outside of Project Boundary
	Upper Pacific Storehouse #5 (LAW.266)	1860	Yes	Yes	Outside of Project Boundary
	Merrimack Valley United Fund (LAW.267)	1960	Yes	Yes	Outside of Project Boundary
	Merrimac Valley United Fund (LAW.268)	1959	Yes	Yes	Outside of Project Boundary
	Kid Start (LAW.269)	1955	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Atlantic Mill Company Spinning Mill #5 (LAW. 270)	1906	Yes	Yes	Outside of Project Boundary
	Upper Pacific Cotton Yarn Mill # 5 (LAW.272)	1902	Yes	Yes	Outside of Project Boundary
	Goodyear Store (LAW.273)	1895	Yes	Yes	Outside of Project Boundary
	Upper Pacific Cotton Yarn Mill (LAW.274)	1896	Yes	Yes	Outside of Project Boundary
	Upper Pacific Worsted Mill #10 (LAW.275)	1889	Yes	Yes	Outside of Project Boundary
	Upper Pacific Storehouse #7 (LAW.276)	1896	Yes	Yes	Outside of Project Boundary
	New England Telephone Building (LAW.277)	1950	Yes	Yes	Outside of Project Boundary
	Lower Pacific Cotton Mill (LAW.278)	1883	Yes	Yes	Outside of Project Boundary
	Lower Pacific Worsted Mill (LAW.279)	1864	Yes	Yes	Outside of Project Boundary
	Lower Pacific Cotton Mill Power House (LAW.280)	1885	Yes	Yes	Outside of Project Boundary
	Lower Pacific Finishing Mill (LAW. 281)	1911	Yes	Yes	Outside of Project Boundary
	Lower Pacific Finishing and Packing Mill (LAW.282)	1882	Yes	Yes	Outside of Project Boundary
	Lower Pacific Worsted Weaving Mill (LAW.283)	1895	Yes	Yes	Outside of Project Boundary
	American Woolen Company Dye House (LAW.285)	1887	Yes	Yes	Outside of Project Boundary
	American Woolen Company-Mill #7 (LAW. 286)	1887	Yes	Yes	Outside of Project Boundary
	American Woolen Company Storehouse (LAW.287)	1919	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
North Canal Historic District (LAW.A/W)	American Woolen Company Office (LAW.288)	1900	Yes	Yes	Outside of Project Boundary
	Washington Mills Company – Building #6 (LAW.289)	1887	Yes	Yes	Outside of Project Boundary
	Pemberton Powerhouse (LAW.290)	-	Yes	Yes	Outside of Project Boundary
	American Woolen Company Storehouse (LAW.291)	1890	Yes	Yes	Outside of Project Boundary
	Pemberton Company Offices and Warehouse #3 (LAW.292)	1890	Yes	Yes	Outside of Project Boundary
	Walton School (LAW.293)	1860	Yes	Yes	Outside of Project Boundary
	Pemberton Company Stable (LAW.294)	1880	Yes	Yes	Outside of Project Boundary
	American Woolen Company Power Plant (LAW.295)	1923	Yes	Yes	Outside of Project Boundary
	Bay State Mills Railroad Shed (LAW.296)	1848	Yes	Yes	Outside of Project Boundary
	Pemberton Mill Picker House (LAW.297)	1850	Yes	Yes	Outside of Project Boundary
	Lawrence Duck Company Mill #3 (LAW.298)	1853	Yes	Yes	Outside of Project Boundary
	Everett Mills Company Storehouse #8 (LAW. 300)	1900	Yes	Yes	Outside of Project Boundary
	Everett Mill Company Waving Mill #4 (LAW.302)	1892	Yes	Yes	Outside of Project Boundary
	Everett Mill Company Picker (LAW.303)	1892	Yes	Yes	Outside of Project Boundary
	Everett Mill Company Cloth Room (LAW.304)	1892	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Everett Mill Storehouse #6 (LAW.305)	1863	Yes	Yes	Outside of Project Boundary
	Everett Mills Storehouse (LAW.306)	1905	Yes	Yes	Outside of Project Boundary
	Kunhardt, George E. Woolen Mill #1 and Office (LAW.307)	1890	Yes	Yes	Outside of Project Boundary
	Kunhardt, George E. Woolen Shop and Boiler House (LAW.308)	1896	Yes	Yes	Outside of Project Boundary
	Kunhardt, George E. Woolen Mill #4 (LAW.309)	1896	Yes	Yes	Outside of Project Boundary
	Kunhardt, George E. Warehouse (LAW.310)	1896	Yes	Yes	Outside of Project Boundary
	Hamblet Machine Company (LAW.311)	1859	Yes	Yes	Outside of Project Boundary
	Ferrous Technology (LAW.312)	1960	Yes	Yes	Outside of Project Boundary
	Ferrous Technology (LAW.313)	1978	Yes	Yes	Outside of Project Boundary
	Ferrous Technology (LAW.314)	1940	Yes	Yes	Outside of Project Boundary
	Lawrence Experimental Sanitation Station (LAW.315)	1886	Yes	Yes	Outside of Project Boundary
	North Canal Lockkeeper’s House (LAW.316)	1848	Yes	Yes	Outside of Project Boundary
	Kunhardt, George E. Corporation (LAW.581)	1890	Yes	Yes	Outside of Project Boundary
	Morehouse Bakery Company (LAW.789)	1907	Yes	Yes	Outside of Project Boundary
	Museum Square Garage (LAW.792)	1995	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Kunhardt, George E. Woolen Mill #9 (LAW.795)	1896	Yes	Yes	Outside of Project Boundary
	U.S. Citizenship Center (LAW.796)	2008	Yes	Yes	Outside of Project Boundary
	Fenton Judicial Center (LAW.797)	1995	Yes	Yes	Outside of Project Boundary
	Central Bridge (LAW.901)	1918	Yes	Yes	Within Project Boundary
	Prospect Street Bridge (LAW.904)	1855	Yes	Yes	Outside of Project Boundary
	North Canal Bridge-Central Bridge (LAW.905)	1918	Yes	Yes	Within Project Boundary
North Canal Historic District (LAW.A/W)	North Canal (LAW.906)	1848	Yes	Yes	Within Project Boundary
	Great Stone Dam (LAW.907)	1848	Yes	Yes	Within Project Boundary
	Upper Pacific Bridge (LAW.909)	1864	Yes	Yes	Within Project Boundary
	Lower Pacific Bridge (LAW.910)	1870	Yes	Yes	Within Project Boundary
	Washington Mills Canal Bridge (LAW.911)	1923	Yes	Yes	Within Project Boundary
	Spicket Penstock (LAW.912)	1855	Yes	Yes	Outside of Project Boundary
	Union Street Bridge over North Canal (LAW.915)	1938	Yes	Yes	Within Project Boundary
	Washington Mills Gate House (LAW.924)	1886	Yes	Yes	Outside of Project Boundary
	Boston and Maine North Canal Railroad Bridge (LAW.928)	1888	Yes	Yes	Within Project Boundary
	Locks and Wasteway (LAW.931)	1845	Yes	Yes	Within Project Boundary
	Broadway Bridge (LAW.998)	1854	Yes	Yes	Within Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Upper Pacific Cotton Mill Pedestrian Bridge (LAW.999)	1849	Yes	Yes	Within Project Boundary
	Amesbury Street Pedestrian Bridge (LAW.9000)	1880	Yes	Yes	Within Project Boundary
	Washington Mills Building #1 Bridge (LAW. 9001)	2007	Yes	Yes	Within Project Boundary
	Pemberton Mill Bridge (LAW.9002)	1902	Yes	Yes	Within Project Boundary
	Pemberton Mill Bridge II (LAW.9003)	1920	Yes	Yes	Within Project Boundary
	Lawrence Heritage State Park (LAW.9005)	1985	Yes	Yes	Outside of Project Boundary
Downtown Lawrence Historic District (LAW.B)	Currier, Ebenezer – Hosmer, Abner Building (LAW.220)	1850	Yes	Yes	Outside of Project Boundary
	Bachelder, Otis – John Building (LAW.221)	1854	Yes	Yes	Outside of Project Boundary
	Smith Charles – Perkins, Andrew Building (LAW.222)	1856	Yes	Yes	Outside of Project Boundary
	Currier, James Building (LAW.223)	1857	Yes	Yes	Outside of Project Boundary
	Sharpe, Andrew Building (LAW.224)	1866	Yes	Yes	Outside of Project Boundary
	(LAW.225)	1863	Yes	Yes	Outside of Project Boundary
	(LAW.226)	1863	Yes	Yes	Outside of Project Boundary
	Boardman, William H. Block (LAW.227)	1854	Yes	Yes	Outside of Project Boundary
	Boardman, William H. Building (LAW.228)	1854	Yes	Yes	Outside of Project Boundary
	Lawrence Savings Bank (LAW.229)	1911	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Saunders, Daniel Building (LAW.230)	1856	Yes	Yes	Outside of Project Boundary
	Morse, Julius Building (LAW.231)	1855	Yes	Yes	Outside of Project Boundary
	Morse, Julius Block (LAW.232)	1853	Yes	Yes	Outside of Project Boundary
	Smith, Charles Building (LAW.233)	1852	Yes	Yes	Outside of Project Boundary
	Eagle Tribune Building (LAW.234)	1929	Yes	Yes	Outside of Project Boundary
	(LAW.235)	1913	Yes	Yes	Outside of Project Boundary
	Appleton, Nathanial Block (LAW.237)	1854	Yes	Yes	Outside of Project Boundary
	Stearns Building (LAW.238)	1854	Yes	Yes	Outside of Project Boundary
	(LAW.239)	1906	Yes	Yes	Outside of Project Boundary
	Adams Block (LAW.240)	1890	Yes	Yes	Outside of Project Boundary
	Godfrey Building (LAW.241)	1891	Yes	Yes	Outside of Project Boundary
	Oswald, William Building (LAW.242)	1912	Yes	Yes	Outside of Project Boundary
	Merchants National Bank (LAW.243)	1889	Yes	Yes	Outside of Project Boundary
	(LAW.244)	1869	Yes	Yes	Outside of Project Boundary
	Bay State Merchant National Bank (LAW.245)	1926	Yes	Yes	Outside of Project Boundary
	(LAW.246)	1868	Yes	Yes	Outside of Project Boundary
	Sweeny, Patrick Building (LAW.247)	1874	Yes	Yes	Outside of Project Boundary
	(LAW.248)	1872	Yes	Yes	Outside of Project Boundary
	Sullivan Building (LAW.249)	1923	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
Downtown Lawrence Historic District (LAW.B) and North Common Local Historic District (LAW.M)	Calvary Baptist Church (LAW.202)	1923	Yes	Yes	Outside of Project Boundary
	Lawrence City Hall (LAW.211)	1849	Yes	Yes	Outside of Project Boundary
	Essex County Superior Courthouse (LAW.212)	1903	Yes	Yes	Outside of Project Boundary
	Bay State Building (LAW.236)	1904	Yes	Yes	Outside of Project Boundary
	Goldberg, Benjamin Building (LAW.250)	1895	Yes	Yes	Outside of Project Boundary
	Pride Upholstering Company (LAW.251)	1898	Yes	Yes	Outside of Project Boundary
	(LAW.252)	1885	Yes	Yes	Outside of Project Boundary
	(LAW.253)	1865	Yes	Yes	Outside of Project Boundary
	New England Telephone Building (LAW.322)	1924	Yes	Yes	Outside of Project Boundary
	Bay State Building (LAW.694)	1904	Yes	Yes	Outside of Project Boundary
	Lawrence World War II Monument (LAW.987)	1948	Yes	Yes	Outside of Project Boundary
	Lawrence Civil War Monument (LAW.988)	1881	Yes	Yes	Outside of Project Boundary
	Lawrence Spanish Wars Veteran Statue (LAW.989)	1913	Yes	Yes	Outside of Project Boundary
American Woolen Mill Housing District (LAW.E)	American Woolen Mills Worker Housing #1 (LAW.435)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #2 (LAW.436)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #3 (LAW.437)	1909	Yes	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	American Woolen Mills Worker Housing #4 (LAW.438)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #5 (LAW.439)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #6 (LAW.440)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #7 (LAW.441)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #8 (LAW.442)	1909	Yes	Yes	Outside of Project Boundary
	American Woolen Mills Worker Housing #9 (LAW.443)	1909	Yes	Yes	Outside of Project Boundary
American Woolen Company Townhouses (LAW.Z)	American Woolen Company Townhouse (LAW.799)	1907	Yes	Yes	Outside of Project Boundary
	American Woolen Company Townhouse (LAW.1000)	1907	Yes	Yes	Outside of Project Boundary
	American Woolen Company Townhouse (LAW.1001)	1907	Yes	Yes	Outside of Project Boundary
	American Woolen Company Townhouse (LAW.1002)	1907	Yes	Yes	Outside of Project Boundary
	American Woolen Company Townhouse (LAW.1003)	1907	Yes	Yes	Outside of Project Boundary
	American Woolen Company Townhouse (LAW.1004)	1907	Yes	Yes	Outside of Project Boundary
	(LAW.18)	1855	Undetermined	Yes	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
North Common Local Historic District (LAW.M)	Grace Episcopal Church (LAW.204)	1852	Yes	Yes	Outside of Project Boundary
	Bongi's Market (LAW.682)	1875	Undetermined	Yes	Outside of Project Boundary
	Daysi's Restaurant (LAW.683)	1960	Undetermined	Yes	Outside of Project Boundary
	Stella, Michael T. Lawyer Office (LAW.684)	1970	Undetermined	Yes	Outside of Project Boundary
	(LAW.695)	1940	Undetermined	Yes	Outside of Project Boundary
Mechanics Block Local Historic District (LAW.N)	Garden Street Methodist Episcopal Church (LAW.203)	1855	Undetermined	Yes	Outside of Project Boundary
Blakeley and Bicknell Buildings Commercial District (LAW.P)	Blakeley Building (LAW.764)	1898	Yes	Yes	Outside of Project Boundary
	Bicknell Brothers Clothing Store (LAW.765)	1880	Undetermined	Yes	Outside of Project Boundary
None	Gleason Building (LAW.254)	1891	Yes	No	Outside of Project Boundary
	Ayers Mills (LAW.2)	1909	Undetermined	No	Outside of Project Boundary
	Plymouth Mills (LAW.257)	1913	Undetermined	No	Outside of Project Boundary
	Plymouth Mills (LAW.2580)	1920	Undetermined	No	Outside of Project Boundary
	Merrimac Paper Company (LAW.564)	1872	Undetermined	No	Outside of Project Boundary
	McCabe Boiler Company (LAW.567)	1865	Undetermined	No	Outside of Project Boundary
	Prospect Mile (LAW.568)	1872	Undetermined	No	Outside of Project Boundary
	United States Worsted Company Dyeing Plant (LAW.572)	1915	Undetermined	No	Outside of Project Boundary
	Lewis, E. Frank Company (LAW.576)	1895	Undetermined	No	Outside of Project Boundary
	Truell Building (LAW.766)	1909	Undetermined	No	Outside of Project Boundary

Historic District	Site Name/Identifier	Construction	NRHP Status	Contributing Element	Relationship to Project Boundary
	Broadway Savings Bank Building (LAW.791)	1927	Undetermined	No	Outside of Project Boundary
	South Canal (LAW.908)	1866	Eligible	No	Within Project Boundary
	Car Hill Bridge-Old Colony Railroad (LAW.920)	1945	No	No	Outside of Project Boundary
	Munroe Paper Company Bridge (LAW.921)	1867	Undetermined	No	Outside of Project Boundary
	Manchester and Lawrence Railroad Bridge (LAW.923)	1871	Undetermined	No	Outside of Project Boundary
	Salem Street Bridge (LAW.926)	1928	Undetermined	No	Outside of Project Boundary
	Boston and Maine South Canal Railroad Bridge (LAW.927)	1907	No	No	Outside of Project Boundary
	Boston and Maine Parker Street Railroad Bridge (LAW.930)	1930	No	No	Outside of Project Boundary
	Ayer Mill Clock Tower (LAW.9006)*	1909	Undetermined	No	Outside of Project Boundary

*= Preservation Restrictions

E.7.8.1.6 Traditional Cultural Properties

At this time, Essex is not aware of any information regarding TCPs within the Project boundaries or in the vicinity of the Project.

E.7.8.1.7 Identification of Indian Tribes

By letter dated December 1, 2022, the Commission invited the Mashpee Wampanoag Tribe, the Wampanoag of Gay Head (Aquinnah) Tribe, and the Stockbridge-Munsee Tribe to participate in the relicensing process for the Project. Essex is not aware of any other Native American Tribes with a potential interest in Project relicensing.

E.7.8.2 Environmental Analysis

The NHPA establishes the statutory responsibility of federal agencies to consider historic properties under their jurisdiction. Section 106 requires federal agencies to consider the effects of their undertakings on historic properties listed in, or eligible for inclusion, in the NRHP. The Commission's issuance of a new license for the Project is defined as an undertaking under the NHPA and is, therefore, subject to the provisions of Section 106 and its implementing regulations at 36 C.F.R. Part 800.

FERC's SD2 identified the following environmental resource issues to be analyzed in the EA for the Project relicensing:

- Effects of Project operation and maintenance on historic resources, archaeological resources, and traditional cultural properties that are included or may be eligible for inclusion in the National Register of Historic Places.
- Effects of Project operation and maintenance on properties of traditional religious and cultural importance to an Indian Tribe.

At present, the ongoing operation and maintenance of the Project are not adversely affecting any architectural, archaeological, or historical resources. Essex is not currently proposing modifications to Project operations or Project-related land-clearing or land-disturbing development activities within the APE that would result in impacts on any historic properties or archaeological resources. Under the new Project license, Essex is proposing to remove the North and South Canals from the FERC Project boundary. This proposed action will not change the Project's installed capacity, overall mode of operation, or any of the Project's historic character.

Pursuant to the approved study plan, Essex conducted a Historically Significant Waterpower Equipment Study (HDR 2025a) and a Condition Assessment of the North and South Canals (HDR 2025b). Concurrence on both studies was received by MHC on November 4, 2024. At present, based on preliminary study results, Essex suggests there are no adverse effects to historic properties or archaeological resources within the APE. Essex has not identified any historic properties that are being adversely affected by the ongoing operation and maintenance of the Project. Essex is not currently proposing modifications to the Project's operations or any land-clearing or land-disturbing development activities within the APE that would result in impacts on any archaeological sites, historic architectural resources, or areas that have been identified as having moderate to high potential for containing archaeological sites.

In addition, none of the three tribes responded to FERC's initial tribal consultation letter dated December 1, 2022; therefore, no tribal concerns related to the Project pertaining to cultural resources have been raised at this time.

E.7.8.3 Proposed Environmental Measures

The continued operation of the Project may require maintenance of buildings and structures or ground-disturbing activities, which have the potential to affect historic properties. As such, Essex proposes to develop an updated HPMP for the Project. The HPMP will be developed in accordance with the *Guidelines for the Development of Historic Properties Management Plans for FERC Hydroelectric Projects* promulgated by FERC and the ACHP on May 20, 2002. The HPMP will take into account the results of the Architectural (Cultural) Resources Survey and describe measures for the management and protection of historic properties within the Project's APE through the term of the new license, including measures to avoid adverse effects. As such, continued operation of the Project as proposed by the Licensee is not expected to adversely affect historic or archaeological resources.

E.7.8.4 Unavoidable Adverse Impacts

Currently, the continued operation and maintenance of the Project is not expected to have unavoidable adverse effects to historic properties or archaeological resources. Further, Essex is not proposing Project-related land-clearing or land-disturbing activities within the APE that would result in impacts on architectural or cultural resources.

E.7.9 Socioeconomic Resources

The subsections below describe socioeconomic resources in the vicinity of the Project and consider the effects of continued operation of the Project as proposed by Essex on these resources. Descriptions of the affected environment, the environmental analysis, the proposed environmental measures, and the identification of unavoidable adverse effects were developed based on available data presented in the Licensee's PAD and other existing information.

E.7.9.1 Affected Environment

E.7.9.1.1 Existing Socioeconomic Conditions

Economic development in Essex County historically was centered around the growing manufacturing economy of the Industrial Revolution. The City of Lawrence was at the forefront of the Industrial Revolution, being one of the first planned industrial cities. Beginning in 1845, the Essex Dam transformed the landscape into a prominent industrial center, harnessing the water of the Merrimack River for energy production and textile manufacturing. The economic opportunity arising from the mills of the City of Lawrence attracted successive waves of immigrants. Known as the "Immigrant City," Lawrence has remained a multi-ethnic and multicultural gateway city. The City of Lawrence is now a diversified industrial city, supporting a population that is largely Hispanic or Latino (U.S. Census Bureau 2021a).

Population

The Project is located in the City of Lawrence within Essex County, Massachusetts. The 2020 census reported that 809,829 people reside in Essex County, which encompasses approximately 492.52 square miles (U.S. Census Bureau 2020). Compared to the 2010 census population of 743,159 people, the current population has increased by 1.09% (U.S. Census Bureau 2010). There was an estimate of 307,959 households in 2021 (U.S. Census Bureau 2021b). The population density is 1,644.3 people per square mile (U.S. Census 2020). The City of Lawrence, an area of 6.93 square miles, supported a population of 89,143 people in 2020, a 1.17% increase since 2010 (U.S. Census Bureau 2020). The number of estimated households in 2021 was 30,291 (U.S. Census Bureau 2021b). The population density is 12,861.5 people per square mile (U.S. Census Bureau 2020).

Employment and Income

The Essex Dam and associated textile mills transformed the City of Lawrence into a major industrial center. The City of Lawrence is currently supported by a mix of industries, including: educational services, health care, and social assistance (20%), manufacturing (18%), professional, scientific, management, administrative, and waste management services (12%), and retail trade (11%) (U.S. Census Bureau 2026a). The majority of civilians have occupations in production, transportation, and material moving (30%), followed by service (26%), management, business, science, and arts (22%), sales and office (18%), and natural resources, construction, and maintenance (9%) (U.S. Census Bureau 2026a). The median household income for the City of Lawrence, estimated in 2024, was $62,061, with approximately 16.7% of the population living in poverty (U.S. Census Bureau 2026b, 2026c).

The area surrounding the City of Lawrence is currently populated with other large urban centers and small communities. Essex County is supported by a mix of industries including: educational services, health care, and social assistance (26%), professional, scientific, management, administrative, and waste management services (15%), manufacturing (11%), and retail trade (10%) (U.S. Census Bureau 2026a). The majority of civilians have occupations in management, business, science, and arts (46%), followed by sales and office (19%), service (16%), production, transportation, and material moving (11%), and natural resources, construction, and maintenance (7%) (U.S. Census Bureau 2026a). The median household income for Essex County is $103,048, with approximately 9.2% of the population living in poverty (U.S. Census Bureau 2026b, 2026c).

Environmental Justice Communities

Pursuant to Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, and Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, as amended, FERC is required to complete an analysis of potential impacts from Project operations on the local community in the vicinity of the Project. The goal of this analysis is to understand the impacts to human health and the environment as they relate to environmental justice communities, or communities that stand to be disproportionately impacted by the construction of a new facility or the continued operation of an existing facility, including socioeconomic and/or sociocultural impacts.

Although FERC is not required to comply with Executive Order 13985, *Advancing Racial Equity and Support for Underserved Communities Through the Federal Government*, FERC has voluntarily elected to participate in the process. In response to Executive Order 13985, FERC has developed an Equity Action Plan to promote equity and remove barriers that underserved communities face in the context of hydropower project licensing processes (FERC 2022). The information compiled in this section is intended to support FERC's consideration of environmental justice communities as they relate to the relicensing process.

The Massachusetts Executive Office of Energy & Environmental Affairs provides an environmental justice map with the latest U.S. Census data (MEOEEA 2022). Environmental justice communities are identified based on criteria set forth in Chapter 8 Section 56 of the Acts of 2021: *An Act Creating a Next-Generation Roadmap for Massachusetts Climate Policy* (Commonwealth of Massachusetts 2021). This act defines an environmental justice population as a census block group that meets one or more of the following criteria: (i) the annual median household income is not more than 65% of the statewide annual median household income; (ii) minorities comprise 40% or more of the population; (iii) 25% or more of households lack English language proficiency; or (iv) minorities comprise 25% or more of the population and the annual median household income of the municipality in which the neighborhood is located does not exceed 150% of the statewide annual median household income. Within the Project boundary, thirteen block groups were identified as environmental justice communities based on minority population, and of those, six were also identified by income and language isolation, and two by income (Table E.7-38).

Table E.7-38. Environmental Justice Communities Within the Project Boundary.

Census Tract	Block Group	Minority Population (%)	Medium Household Income (% of statewide annual median household income)	Households with Language Isolation (%)
2501	1	88.7*	14.4*	40.1*
2501	2	82.2*	41.9*	40.5*
2508	3	78.5*	52.5*	13.8
2513	3	91.3*	63*	23.6
2514	3	92.6*	59.8*	30.7*
2515	1	89.5*	83.6*	34.5*
2515	4	84.5*	85.4	0
2515	5	91.3*	55.8*	34.5*
2516	4	93.1*	49.0*	43.1*
2521.01	3	34.6*	69.4	3.1
2521.02	3	24.9*	107.6	0.9
2544.02	4	49.3*	215	20.9
3102	3	70.6*	90.9	15

* denotes an environmental justice community as defined by MEOEEA.

Source: MEOEEA 2022.

E.7.9.2 Environmental Analysis

FERC's SD2 identified the following potential resource issue related to socioeconomics:

- Effects of Project operation and maintenance on identified environmental justice communities.

Existing Project operations and facilities are part of the current socioeconomic context of the Project vicinity. The Project area is urban industrial and highly developed with residential, commercial, and industrial development. The Merrimack River in the vicinity of the Project is also used for boating, canoeing, kayaking, fishing, rowing, and swimming. The surrounding land is used for walking, biking, hiking, fishing, picnicking, bird watching, photography, skiing, and more. Project operations have an economic benefit to the community, as the reservoir supports free recreation. Essex is not proposing any changes to Project operations or facilities. Therefore, continued operation of the Project is not expected to adversely affect socioeconomic resources in the Project vicinity. Hydropower represents a valuable carbon-free, renewable energy resource that provides reliable baseload electricity to the community.

The continued operation of the Project is also not expected to adversely impact identified environmental justice communities. Project-related construction is not proposed, therefore there will be no construction-related air quality, noise, or traffic impacts. As discussed, the Project provides benefits to the community, and in turn, environmental justice communities through opportunities for free recreation and reliable renewable energy.

E.7.9.3 Proposed Environmental Measures

The continued operation and maintenance of the Project is not anticipated to have a material or incremental adverse effect on socioeconomic resources or environmental justice communities. Accordingly, Essex does not propose additional PM&E measures related to these resources at this time.

E.7.9.4 Unavoidable Adverse Impacts

Essex's continued operation of the Project as proposed is not expected to have any adverse effects on socioeconomic resources or environmental justice communities.

E.8. Economic Analysis

FERC's SD2 identified the following potential resource issue related to Developmental Resources:

- Effects of any recommended environmental measures on the Project's economics.

Essex will provide the information required by 18 C.F.R §5.18(b)(5)(ii)(E) in the Final License Application to be filed with the Commission by November 30, 2026 (Table E.8-1).

Table E.8-1. Estimated Costs for Proposed PM&E Measures for the Lawrence Project.

Proposed PM&E Measure	One Time Implementation/ Construction Costs (2026 Dollars)	Incremental Operations and Maintenance (O&M) Costs or Annual Costs (2026 Dollars)
To be provided with the FLA	To be provided with the FLA	To be provided with the FLA
To be provided with the FLA	To be provided with the FLA	To be provided with the FLA
To be provided with the FLA	To be provided with the FLA	To be provided with the FLA
To be provided with the FLA	To be provided with the FLA	To be provided with the FLA

E.9. Consistency with Comprehensive Plans

Section 10(a)(2) of the FPA, 16 U.S.C. §803(a)(2)(A), requires the Commission to consider the extent to which a project is consistent with federal and state comprehensive plans for improving, developing, or conserving a waterway or waterways affected by a project. Under 18 CFR §5.18(b)(5)(ii)(F) each license application must identify relevant comprehensive plans and explain how and why the proposed project would, would not, or should not comply with such plans. In addition, the license application must include a description of any relevant resource agency or Native American Tribe determination regarding the consistency of the project with any such comprehensive plan.

The Commission's SD2 identified nineteen comprehensive plans for Massachusetts that are potentially relevant to the Lawrence Hydroelectric Project. Essex has reviewed the Commission's list of available comprehensive plans and will further consider the Project's consistency with these plans during the development of the Final License Application.

E.9.1 Federal Plans

- Atlantic States Marine Fisheries Commission. 1995. Interstate fishery management plan for Atlantic striped bass. (Report No. 24). March 1995.
- Atlantic States Marine Fisheries Commission. 1998. Amendment 1 to the Interstate Fishery Management Plan for Atlantic sturgeon (Acipenser oxyrhynchus oxyrhynchus). (Report No. 31). July 1998.
- Atlantic States Marine Fisheries Commission. 1998. Interstate fishery management plan for Atlantic striped bass. (Report No. 34). January 1998.
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- Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American eel (Anguilla rostrata). (Report No. 36). April 2000.
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Atlantic herring Fishery Management Plan for Essential Fish Habitat. Volume 1. October 7, 1998.
- National Marine Fisheries Service. 1998. Final Recovery Plan for the shortnose sturgeon (Acipenser brevirostrum). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. December 1998.
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- U.S. Fish and Wildlife Service. 1989. Atlantic salmon restoration in New England: Final environmental impact statement 1989-2021. Department of the Interior, Newton Corner, Massachusetts. May 1989.
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E.9.2 Massachusetts Comprehensive Plans

- Massachusetts Department of Environmental Management. n.d. Commonwealth connections: A greenway vision for Massachusetts. Boston, Massachusetts.
- Massachusetts Division of Fisheries and Wildlife. 2015. Massachusetts State Wildlife Action Plan 2015. Westborough, Massachusetts. October 2015.

E.10. Consultation Documentation

In accordance with 18 C.F.R § 5.18(b)(5)(G), a list containing the name and address of every Federal, state, and interstate resource agency, Indian tribe, and member of the public with which the Licensee consulted in preparation of Exhibit E is presented in the distribution list attached to the DLA cover letter. A preliminary correspondence log is provided in Appendix B and will be finalized with the FLA.

E.11. Literature Cited

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Appendix A – Study Reports [Filed Separately Due to File Size]

Appendix B – Correspondence Log

Lawrence Hydroelectric Project (FERC No. 2800)
Correspondence Log

Date	Type	From	To	Subject
April 20, 2023	Email, Letter	HDR/ Essex	Stakeholder Distribution List[1]	PAD Questionnaire
April 20, 2023	Email	FWS (K. Hogan)	HDR/ Essex	PAD Questionnaire
April 20, 2023	Email	HDR/ Essex	FWS (D. Smithwood)	RTE Species Information Request
April 20, 2023	Email	HDR/Essex	Massachusetts Office of Coastal Zone Management (R. Boeri)	CZM Coastal Zone Determination
April 20, 2023	Email	HDR/Essex	Massachusetts Office of Coastal Zone Management (P. Bordonaro)	CZM Coastal Zone Determination
April 20, 2023	Email	USEPA (E. Reiner)	HDR/ Essex	PAD Questionnaire
April 24, 2023	Email	Town of Andover (B. Pena)	HDR/ Essex	Inquiry into PAD Questionnaire

[1] The stakeholder list includes over 120 parties including federal and state agencies, municipalities, Indian tribes, and other interested parties.

Date	Type	From	To	Subject
May 1, 2023	Email	Berkeley Investments (K. Longo)	HDR/ Essex	PAD Questionnaire
May 4, 2023	Email	NMFS (B. German)	HDR/ Essex	PAD Questionnaire
May 5, 2023	Email	MRWC (John Macone)	HDR/ Essex	PAD Questionnaire
May 8, 2023	Email	Mass Wildlife Natural Heritage & Endangered Species Program (NHESP) (Misty-Anne Marold)	HDR/ Essex	PAD Questionnaire
May 16, 2023	Email	Michele L. Tremblay, Chair (Upper Merrimack River Local Advisory Committee)	HDR/ Essex	PAD Questionnaire
April 27, 2023	Email	Town of Rowley (A. Lydon)	HDR/ Essex	Inquiry into PAD Questionnaire
May 22, 2023	Email	Lawrence Redevelopment Authority (B. Corrigan)	HDR/ Essex	PAD Questionnaire

Date	Type	From	To	Subject
May 22, 2023	Email	Groundwork Lawrence (B. Buschur)	HDR/ Essex	PAD Questionnaire
May 22, 2023	Letter	Town of Georgetown	HDR/ Essex	PAD Questionnaire
June 1, 2023	Email	Natural Heritage & Endangered Species Program	HDR/ Essex	Massachusetts Endangered Species Act Information Request
June 1, 2023	Email	Tewksbury Department of Public Works Water Treatment Division	HDR/ Essex	PAD Questionnaire
June 16, 2023 Accession No. 20230616-5234	Submittal	HDR/ Essex	FERC	PAD and NOI
June 21, 2023	Email	Stakeholders	HDR/ Essex	PAD and NOI
February 7, 2024	Email	HDR/Essex	USFWS, NOAA-NMFS, NHFGD	PSP Meeting Coordination
February 9, 2024	Email	HDR/Essex	City of Lawrence	PSP Meeting Coordination Follow-up
February 17, 2024	Email	HDR/Essex	City of Lawrence	Response to PSP Meeting Invite

Date	Type	From	To	Subject
March 25, 2024	Email	HDR/Essex	USFWS, NOAA-NMFS, NHFGD	March 28, 2024 Meeting Agenda
April 5, 2024	Email	HDR/Essex	DEP, NHFGD	Lawrence Project Call and Agenda
April 11, 2024	Email, Letter	HDR/Essex	Stakeholder Distribution List	RSP Filing
July 15, 2024	Email	HDR/Essex	Stakeholder Distribution List	Recreation Study Data Request
July 23, 2024	Email	HDR/Essex	City of Lawrence; Lawrence Historical Commission; MassSHPO	Request for consultation and concurrence on the APE for the Condition Assessment Study and the Historical Equipment Study
September 3, 2024	Email	HDR/Essex	Recreation Focus Group Participants	Request for participation in recreation study
September 3, 2024	Email	HDR/Essex	Recreation Focus Group Participants	Response to Recreation Study Data Request
October 7, 2024	Email	HDR/Essex	Stakeholder Distribution List	Site Visit Coordination
November 1, 2024	Email	HDR/Essex	City of Lawrence; Lawrence Historical Commission; MassSHPO	Request for consultation and concurrence on the APE for the Condition Assessment Study and the Historical Equipment Study

Date	Type	From	To	Subject
November 5, 2024	Email	HDR/Essex	Stakeholder Distribution List	Lawrence Study Progress Report.
November 11, 2024	Letter	MassSHPO	Essex, HDR	Concurrence on the APE for the Condition Assessment Study and the Historical Equipment Study
April 3, 2025	Email/Letter	HDR/Essex	Recreation Focus Group Participants	Consultation regarding selection of recreation sites for the visitor intercept surveys for summer 2025.
May 2, 2025	Email	HDR/Essex	Stakeholder Distribution List	Updates regarding the Initial Study Report Meeting.
May 5, 2026	Email	HDR/Essex	Stakeholder Distribution List	Updates regarding the Updated Study Report Meeting.
June 17, 2026	Email	HDR/Essex	Focus Group Participants	Consultation regarding Focus Group Discussion for the Recreation Study.